Manufacturing Sanitation Product and Latrine Construction

Basic Short Term Training

Based on May 2023, Curriculum Version I

Module Title: Prepare Bill of Quantity

Module code: **EIS SCW3 02 0322**

Nominal duration: 4 Hours

Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

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Acknowledgment

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Introduction to the Module

This module helps the short-term trainee's to know how to calculate the quantity of simple latrine construction work only. The module cover material, labor, and cost estimation for substructure work (excavation work, stonework, concrete work).

The short-term trainee doesn't expect to perform complex calculations (take-off, bill of quantity, and others). To carry out the latrine construction work a simple calculation of materials, labor, and cost estimation for specified latrines is expected from the trainees.

This module covers the units:

- Substructure Work

Learning Objective of the Module:

- Estimate substructure work

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the "LAP test" giver at the end of each unit and
5. Read the identified reference book for Examples and exercise.

Unit One: Substructure Work

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

      1.1.   Excavation Work

      1.2.   Stone Masonry

      1.3.   Concrete Ring Cover

      1.4.   Rectangular Slab

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

- Determine Excavation Work
- Estimate Stone Masonry
- Calculate concrete ring cover
- Calculate Rectangular Slab

Raw material calculation

a) Introduction to Bill of Quantities (BOQ)

Bill of Quantities also referred to as BOQ, is a document formulated in the construction industry to specify materials, labors, and their cost. Before starting any construction one has to have a thorough knowledge about the volume of the work and the probable cost that may be required for the completion of the project. Otherwise, the construction will be stopped before its completion due to shortage of money or materials.

b) Types of Estimates

Approximate/Rough estimate

- To get an idea for the probable expenditure in a short time
- To prepare a preliminary estimate before drawing up a detailed estimate.
- This rough estimation is required to know the financial position of the client before detailed designs are carried out.
- It's based on practical knowledge and cost of similar previous works.

A detailed estimate

- This is the best method and includes the quantities and cost of everything required for the work.
- This is the most reliable and accurate type of estimate.
- The quantities of items are carefully prepared from the drawings and the total cost worked out from up to date market rates.
- Requirements are drawings and specification.

c) Unit of Measurement for construction work

Unit of measurement indicates the quantity of material and works. The following table shows the common unit of measurement for different construction activities.

Table-1: Unit of measurement for construction work

Sl. No.	Civil Construction Works	Measurement Unit
1	Site clearance	m^2
2	Earthwork (Excavation)	m^3
3	Back filling	m^3
4	RCC Concrete ground floor Slab with given thickness	m^2
5	RCC Concrete (Footing, Column, Beam, Slab)	m^3
6	Reinforcement Steel	Kg
7	Hollow concrete block	m^2
8	Brick work	m^2
9	Stone masonry	m^3
10	Flooring	m^2
11	Plastering	m^2
12	Painting	m^2

d)   Calculation of volume for concrete materials:

The given work may be in any shape, either it may be in rectangular or circular or hexagonal etc.

The volume of concrete = Surface Area x Depth

Here is general formula to estimate material breakdown;

1:2:3

CEMENT   SAND   GRAVEL

The general formula for quantizing concrete making materials is given below. You can use this formula for more calculation over any concrete of your need.

$$\text{Vol. of } "Z" = \frac{"Z" \text{ Ratio}}{\text{Sum of Ratio}} \; x \; \text{Vol. of } "Z" \; x \; \text{Density of Cement x Shrinkage x Wastage}$$

Where;

- Density of cement is = 1400 kg/ m^3

- Density of sand = 1840 kg/ m^3

- Density of aggregate is = 2250 kg/m^3

- Mix ratios are given based on concrete grade

- Volume of "Z" = Cement /Sand /Aggregate

- Shrinkage and wastage are given.

Note:

1.05 is given for the shrinkage and 1.3 is given for the probability of bulking &

e) **Cost Estimation**

General formula for cost estimation
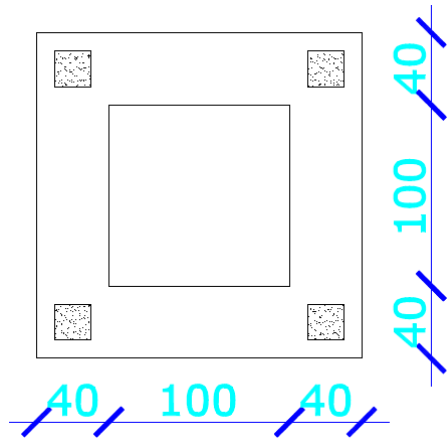
- Total cost (TC)   = Direct Cost (DC) + Indirect Cost (IC)
- Direct Cost (DC)   = Material Cost (MC) + Labor Cost (LC)
- Indirect Cost (IC)   = (15% overhead and overhead) of DC = 15 % of DC

1.1. Excavation Work

Trench excavation:

The depth of Foundation wall is 0.80m from NGL. Find the length of wall from the foundation plan. Assume 10cm working space in both sides.

Total volume of trench excavation is:

$$V = L*W*h$$

First the total length of foundation wall should be calculated using wall method:

$$L = 2(1) + 2(1.8) = 5.60m$$

Then; V= 5.60m x 0.6m x 0.80m

V= 2.688m³

Pit Excavation:

Pit excavations are made for concrete ring; the internal diameter of the ring is 1m and thickness of the ring is 8cm. the concrete ring has the depth of 1m (refer foundation layout). The volume of pit excavation for the ring is;

$$V = \pi r^2 \text{ x } h = 3.14 \text{ x } 1.16^2 \text{ x } 1 = 4.23 \text{ m}^3$$

Note: No working space is considered during estimation. But payment is made at construction site for the extra excavations the contractor makes.

1.2. Stone Masonry

The stone for the foundation wall is measured by its volume. The volume is then calculated by the product of the length, the width and the height. From the given drawing the depth of the foundation wall is 40cm, the length of the foundation is 5.60m and the width of foundation wall is 0.40m. Therefore, the volume of foundation wall will be;

$$V= l*w*h$$
$$V= 5.60m * 0.40m * 1m = \textbf{2.24m}^3$$

Calculate the amount of material for 40cm stone masonry wall bedded in cement mortar of 1:3 ratios. Assuming the crew consists of a mason, and two daily helpers and a productivity of 5 m^3 per day. Take 15% overhead and profit and Use 30% wastage & bulk age (sand & aggregates) and 5 % shrinkage (for cement), 10% wastage for cement.

Assume the following materials for the stone masonry wall:

Daily wage for labor

    a) For mason   = 450 Birr/day

    b) For helper   = 250 Birr/day

Market price of materials

    a) Stone   = 1000 Birr/m^3

    b) Cement   = 20 Birr/Kg

    c) Sand   = 900 Birr/m^3

Acceptable Answers for stone masonry materials

    a) Stone   = 2.24m^3 x 1 m^3/m^3 = **2.24 m3**

    b) Cement   = 1/4x 2.24m^3 x 1400 kg/m^3 x 1.1 x 1.05

                         = 905.52 kg   = **0.647 m³**

    c) Sand   = 3/4 x 2.24m^3 x 1.3

                         = **2.184 m³**

Water/cement ratio   = 0.55 × 905.52kg   = **498.036 Liter**

Labor Cost

Acceptable Answers for labor cost

$$1 \text{ day.} = 5 \text{ m}^3$$
$$X = 2.24 \text{ m}^3$$

$X = 0.\underline{\textbf{448 day}}$. Time required complete the total volume of concrete

Labor cost per day.

a) Mason = 0.448 day x 450 Birr/day. = 201.60 Birr

b) Helpers = 2*(0.448 day x 250 Birr/day) = <u>224.00 Birr</u>

Total Labor Cost = <u>425.60 Birr</u>

Cost Estimation

Acceptable Answers for Cost

Total material cost

→ Stone = 2.24m³ x 1000Birr/m³ = 2,240.00 Birr

→ Cement = 905.52kg x 20Birr/kg = 18,110.40 Birr

→ Sand = 2.18m³ x 900Birr/m³ = <u>1,968.60 Birr</u>

Total Material Cost = <u>22,316.00 Birr</u>

→ Direct Cost (DC) = Material Cost (MC) + Labor Cost (LC)

DC = 22,316.00 Birr + 425.60 Birr = **<u>22,741.60 Birr</u>**

→ Indirect Cost (IC) = (15% overhead + 20% Profit) of DC = 35 % of DC

IC = 0.35 x 22,741.60 Birr = **<u>7,959.56 Birr</u>**

→ Total cost (TC) = Direct Cost (DC) + Indirect Cost (IC)

TC = 22,741.60 Birr + 7,959.56Birr = **<u>30,701.16 Birr</u>**

1.3. Concrete Ring Cover

Calculate material break down for 140 cm diameter of concrete ring cover. Assume 1:2:3 proportions and grade C-25 concrete. Use water/cement ratio for hand mix is 0.4 - 0.65, take 15% overhead and profit and Use 30% wastage & bulk age (sand & aggregates) and 5 % shrinkage (for cement), 10% wastage for cement. The crew consists of a mason, and two daily helpers will have a productivity of 4.36 m^3 per day.
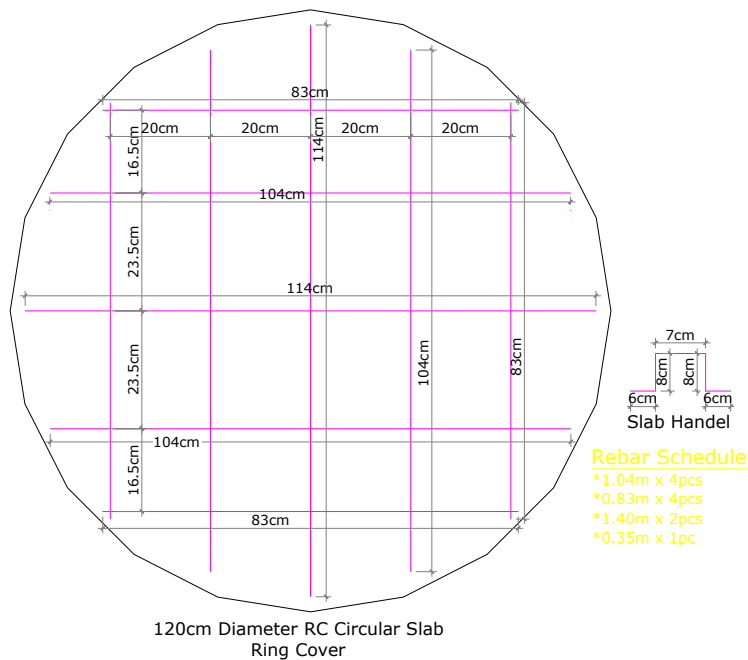
120cm Diameter RC Circular Slab Ring Cover

Assume the following materials for the stone masonry wall:

Daily wage for labor

    a)   For mason   = 450 Birr/day

    b)   For helper   = 250 Birr/day

Market price of materials

    a)   Cement   = 20 Birr/Kg

    b)   Sand   = 900 Birr/m^3

    c)   Aggregate   = 700 Birr/m^3

Material Calculation

Acceptable Answers for concrete ring volume

$V = \pi r^2 \times h$ $= 3.14 \times 0.60^2 \times 0.05$ $= \underline{\mathbf{0.057\ m^3}}$

Sum of mix ratio $= 1 + 2 + 3 = \underline{\mathbf{6}}$

Acceptable Answers for concrete ring materials

a) Cement $= 1/6 \times 0.057\ m^3 \times 1400\ kg/m^3 \times 1.1 \times 1.05$

               $= 15.36\ kg$ or $= \underline{\mathbf{0.011\ m^3}}$

b) Sand $= 2/6 \times 0.057\ m^3 \times 1.3$

               $= \underline{\mathbf{0.0.25\ m^3}}$

c) Aggregate $= 3/6 \times 0.057\ m^3 \times 1.3$

               $= \underline{\mathbf{0.037\ m3}}$

Water/cement ratio $= 0.55 \times 15.36 kg$ $= \underline{\mathbf{8.45\ Liter}}$

Labor Cost

Acceptable Answers for labor cost

1day   =   0.228 m3 $X = \underline{\mathbf{0.25\ day}}$ Time required complete the

X   =   0.057 m^3 total volume of concrete

Labor cost per hr.

→   Mason $= 0.25\ day \times 450\ Birr/day$ $= 112.50\ Birr$

→   Helper $= 2*(0.25\ day \times 250\ Birr/day)$ $= 125.00\ Birr$

                                 Total Labor Cost $= \underline{\mathbf{237.50\ Birr}}$

Cost Estimation

Acceptable Answers for Cost

Total material cost

→	Cement	= 15.362 kg x 20 Birr/kg	= 307.24Birr
→	Sand	= 0.025 m^3 x 900 Birr/ m^3	= 22.50 Birr
→	Aggregate	= 0.037 m^3 x 700 Birr/ m^3	= 25.90 Birr

Total Material Cost = 355.64 Birr

→ Direct Cost (DC) = Material Cost (MC) + Labor Cost (LC)

= 355.64 Birr + 237.50 Birr **= 593.14 Birr**

→ Indirect Cost (IC) = (15% overhead and Profit) of DC = 15 % of DC

= 0.15 x 593.14 Birr **= 88.971 Birr**

→ Total cost (TC) = Direct Cost (DC) + Indirect Cost (IC)

= 593.14Birr + 88.971Birr **= 682.111 Birr**

1.4. Rectangular Slab

Calculate material break down, labor and cost estimation for the following 120 cm x 120 cm rectangular slab of 1:2:3 proportions and grade C-25 concrete. Assume water/cement ratio for hand mix is 0.4 - 0.65 and the crew consists of a mason, and two daily helpers and a productivity of 0.288 m^3 per day. Take 15% overhead and profit and Use 30% wastage & bulk age (sand & aggregates) and 5 % shrinkage (for cement), 10% wastage for cement.

Daily wage for labor

    a) For mason   =   450 Birr/day
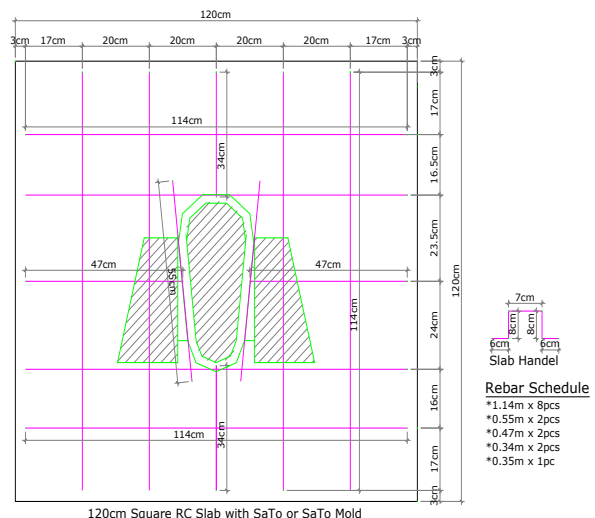
    b) Helper   =   250Birr/day

Market price of materials

    a) Cement   = 20 Birr/Kg

    b) Sand   = 900 Birr/m^3

    c) Aggregate   = 700 Birr/m^3

Solution:

Given:

- Mix ratios for C-25 concrete = 1:2:3

- Density of cement = 1400 kg/ m3

- Density of sand = 1840 kg/ m3

- Density of aggregate = 2250 kg/m3

120cm Square RC Slab with SaTo or SaTo Mold

Slab Handel

Rebar Schedule
*1.14m x 8pcs
*0.55m x 2pcs
*0.47m x 2pcs
*0.34m x 2pcs
*0.35m x 1pc

Material Calculation

Acceptable Answers for Volume of work

Volume of concrete = 1.20 m x 1.20m x 0.05m = **0.072 m³**

Sum of mix ratio = 1 + 2 + 3 = **6**

Acceptable Answers for materials

Cement = 1/6 x 0.072 m³ x 1400 kg/m³ x 1.1 x 1.05

= 19.404 kg = **0.0139 m³**

Sand = 2/6 x 0.072 m³ x 1.3

= **0.0312 m³**

Aggregate = 3/6 x 0.072 m³ x 1.3

= **0.0468 m³**

Water/cement ratio = 0.55×19.404 = **10.67 Liter**.

Labor Cost Calculation

Acceptable Answers for labor cost

1 hr. = 0.288 m3

X = 0.072 m³

X = **0.25 hrs**. Time required complete the total volume of concrete

Labor cost per hr.

→ Mason = 0.25 hr. x 450 Birr/ day = 112.50 Birr

→ Forman = 2(0.25 hr. x 250 Birr/day) = 125.00 Birr

Total Labor Cost = **237.50 Birr**

Cost Estimation

Acceptable Answers for Cost

Total material cost

→	Cement	= 19.404 kg x 20 Birr/kg	= 388.08 Birr
→	Sand	= 0.0312 m³ x 900 Birr/ m³	= 28.08 Birr
→	Aggregate	= 0.0468 m³ x 700 Birr/ m³	= <u>32.76 Birr</u>

**Total Material Cost = <u>448.92 Birr</u>**

→ Direct Cost (DC)   = Material Cost (MC) + Labor Cost (LC)

= 448.92 Birr + 237.50 Birr

= **<u>686.42 Birr</u>**

→ Indirect Cost (IC)   = (15% overhead and Profit) of DC = 15 % of DC

= 0.15 x 686.42 Birr

= **<u>102.96 Birr</u>**

→ Total cost (TC)   = Direct Cost (DC) + Indirect Cost (IC)

= 686.42Birr + 102.96Birr

= **<u>789.38 Birr</u>**

Cost /Price Summary of Improved Latrine

S. No	Description	Unit	Quantity	Unit price	Total price
1	Trench excavation	m³	2.688	300.00	806.40
2	Pit excavation	m³	4.23	400.00	1,692.00
	Total Excavation Cost				2,498.40
3	Stone masonry work	m³	2.24	-	0.00
	Stone	m³	2.24	1000.00	2,240.00
	Cement	kg	1070.16	20.00	21,403.20
	Sand	m³	2.293	900	2,063.70
	Labor	Day	0.448	950.00	425.60
	Total Cost Including DC and IC				35,278.88
4	Ring cover	m³	0.226	-	0.00
	Cement	kg	71.981	20.00	1,439.62
	Sand	m³	0.103	900.00	92.70
	Aggregate	m³	0.154	700.00	107.80
	Labor	Day	0.052	950.00	49.40
	Total Cost Including DC and IC				2,280.85
5	Rectangular slab	m³	0.072	-	0.00
	Cement	kg	22.932	20.00	458.64
	Sand	m³	0.0328	900.00	29.52
	Aggregate	m³	0.0491	700.00	34.37
	Labor	Day	0.25	1,300.00	325.00
	Total Cost Including DC and IC				1,144.17
	Grand Total				41,202.30

Latrine Detail Drawings
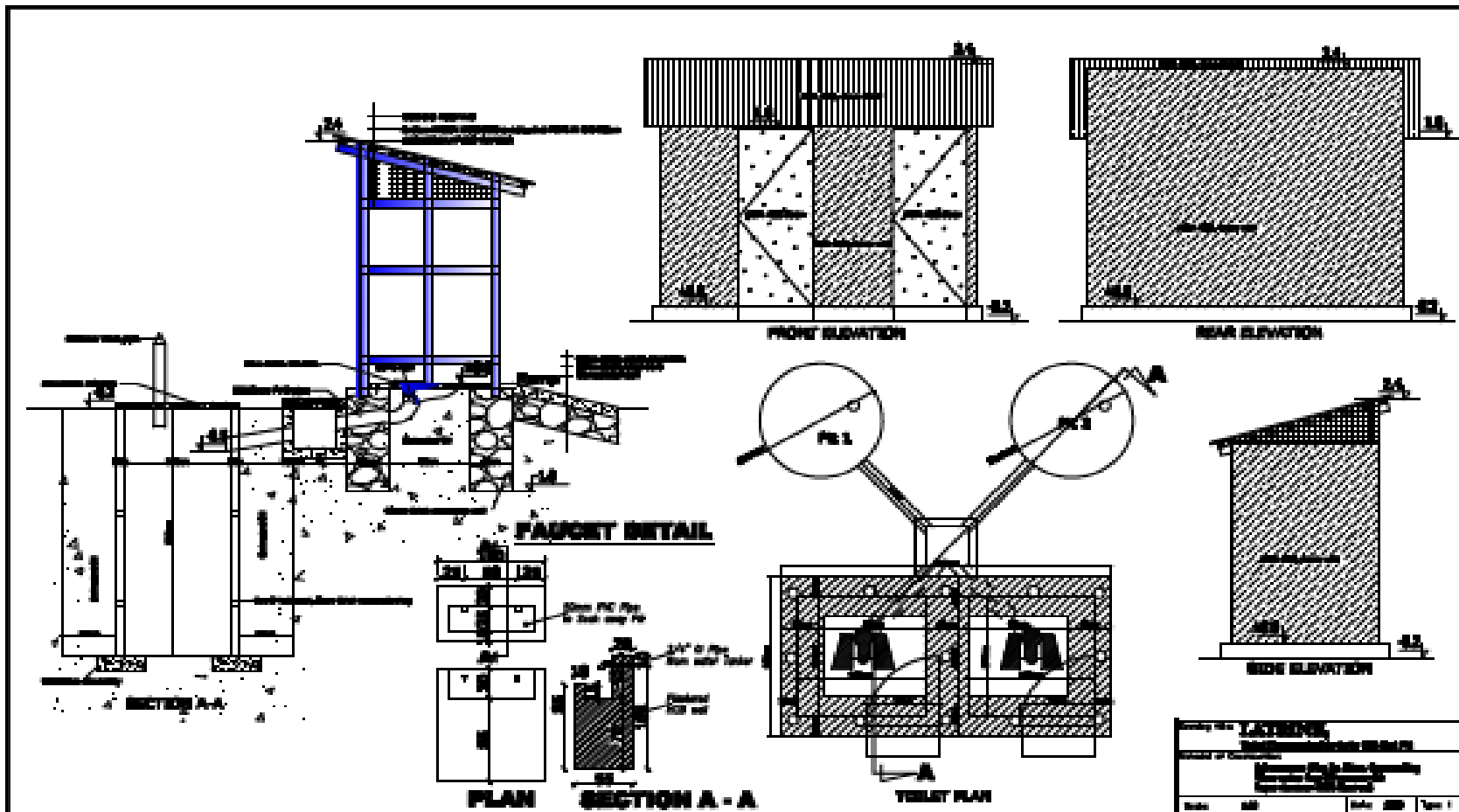
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Participants of This Module (Training Material) Preparation

No	Name	Qualification (Level)	Field of Study	Organization/ Institution	Mobile number	E-mail
1	Andualem Abebayehu	MSc	Hydraulics and Water Resource Engineering	Debark PTC	0982095105	andualemabebayhu@gmail.com
2	Mesfin Wondimu	BSc	Construction Technology and Management	Aleta Wondo PTC	0916981613	mesifinwondimu@gmail.com
3	Girema Moges	BSc	Civil Engineering	Wolayita PTC	0911530068	girmamoges@gmail.com
4	Dagim Fekadu	MSc	Construction Technology and Management	Ambo PTC	0910140914	dag.astu.2005@gmail.com
5	Solomon Tadesse	BSc	Construction Technology and Management	GWPTC	0921414347	soletadss@gmail.com
6	Esmael Mohammed	BSc	Water Work construction technology	Kombolcha PTC	0915543225	Bad9565@gmail.com
7	Desalegn Alemu	BSc	Construction Technology and Management	Woliso PTC	0926771683	desalgnalen@gmail.com
8	Tesfaye Assegidew	MSc	Construction Technology and Management	Butajira PTC	0913442444	tesfayeassegidew@gmail.com
9	Mulualem Misganaw	BSc	PLSC	MOLS	0910463950	mulu9192@gmail.com
10	Bacha Kitesa	MPH, MA	Environmental Health since, public health, Project Management	PSI	0910757797	bachakitesa@gmail.com
11	Mesfin Habtemariam	MA, BSc	Civil Engineering	PSI	0911124992	mesfinhabtemariam@gmail.com
12	Fisum G/Egizeebiher	MPH	Environmental Health Science	PSI	0913222354	fegziabher@psiet.org
13	Ziyade Ahmed	MPH	Environmental Health Science	MOH	0916586603	
14	Wondayehu Wube	BSc, MPH	Environmental Health Science	MOH	0972651005	wondayehuwube@gmail.com