Republic of Rwanda
Ministry of Education

RTB | RWANDA TVET BOARD

EARTHWORK COMPUTATION

LSVEC402

Perform Earthwork Computation

Competence

RQF Level: 4

Learning Hours

100

Credits: 10

Sector: Construction and Building Services

Trade: **Land Surveying**

Module Type: **Specific**

Curriculum: **CBSLSV4001 –TVET certificate IV in land surveying**

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<table>
<tr><td>Purpose statement</td><td colspan="5">This module describes knowledge, skills, and attitude required to perform earthwork computations. It is designed for students pursuing RQF level 4 in land surveying. At the end of this module a student will be able to: prepare for earthwork measurement survey data, collect earthwork measurement survey data, compute area, compute volume and produce earthwork diagrams.</td></tr>
<tr><td>Learning assumed to be in place</td><td colspan="5">Linear distance measurement, application of leveling survey, coordinate measurement, basic survey computation and adjustment, applied mathematics, surveying tools and equipment, angular measurement.</td></tr>
<tr><td rowspan="6">Delivery modality</td><td colspan="2">Training delivery</td><td>100%</td><td colspan="2">Assessment</td><td>Total 100%</td></tr>
<tr><td colspan="2">Theoretical content</td><td>30%</td><td rowspan="4">Formative assessment</td><td>30%</td><td rowspan="4">50%</td></tr>
<tr><td colspan="2">Practical work:</td><td rowspan="3">70%</td><td rowspan="3">70%</td></tr>
<tr><td>• Group work and presentation</td><td>30%</td></tr>
<tr><td>• Individual work</td><td>40%</td></tr>
<tr><td colspan="3"></td><td colspan="2">Summative Assessment</td><td>50%</td></tr>
</table>

Elements of Competency and Performance Criteria

Elements of competency	Performance criteria
1. Prepare for earthwork measurement survey data	1.1 Types of data are properly identified according to the project requirements.
	1.2 Tools, materials and equipment are appropriately selected in accordance to the work to be done.
	1.3 Survey equipment are properly checked according to the manufacturer's specifications.
2. Collect earthwork measurement survey data	2.1 Surveying instruments are accurately set up according to their types.
	2.2 Survey data are properly collected according to their uses.
	2.3 Survey data are well saved and shared according to their formats.
3. Compute Area	3.1 Collected data are accurately checked according to the surveying

	method.
	3.2 Methods of area computation are well selected according to the types of data.
	3.3 Area is accurately calculated with respect to the selected area computation method.
4. Compute volume	4.1 Collected data are accurately checked according to the surveying method.
	4.2 Methods of volume computation are well selected according to the types of data.
	4.3 Volume is accurately calculated with respect to the selected area computation method.
5. Produce earthwork diagrams	5.1 Volume to be cut and filled is appropriately tabulated according to the design.
	5.2 Mass Haul Diagram (MHD) elements are adequately identified with respect to design.
	5.3 Mass Haul Diagram is well drawn according to work specifications.

Intended knowledge, skills and attitude

Knowledge	Skills	Attitude
✓ Identify the types of earthwork data ✓ Read instrument manual ✓ Describe the geometrical shapes ✓ Identify instruments and tools ✓ Describe methods of area computation ✓ Identify methods of volume computation	✓ Check instrument functionality ✓ Interpret instrument manual ✓ Apply measurement skills ✓ Apply figures in earthwork computation ✓ Perform graphical presentation ✓ Apply methods of area computation ✓ Apply methods of volume	✓ Demonstrate risk awareness by putting on proper PPE ✓ Demonstrate flexibility and punctuality during the data collection. ✓ Pay attention to projects details ✓ Use analytical skills to draw mass haul diagrams ✓ Demonstrate team working spirit in earthwork computation ✓ Demonstrate resourcefulness in

✓ Identify elements of MHD ✓ Identification of appropriate scale	computation ✓ Demonstrate drawing skills ✓ Apply analytical skills ✓ Use appropriate scale	mass haul diagrams calculations, drawing and interpretation ✓ Demonstrate decision marking attitude during the computation of area and volume

Course content

Learning outcomes	At the end of these module the student will be able to: 1. Prepare for earthwork measurement survey data 2. Collect earthwork measurement survey data 3. Compute Area 4. Compute volume 5. Produce earthwork diagrams
Learning outcome 1: Prepare for earthwork measurement survey data	**Learning hours: 10**
Indicative content	

- **Identification of earthwork measurement survey data types**
  - ✓ Earthwork terminologies
  - ✓ Earthwork measurement survey data types
    - Coordinates (easting, northing, elevation)
    - Distances
    - Secondary site data (parcels, plots….)
- **Selection of tools, materials and equipment**
  - ✓ Selection factors
  - ✓ Tools
    - Hummer
    - Tape measure
    - Laser meter
    - Measuring wheel
    - Ranging rod
    - Arrow
    - Staff
    - Panga
    - Hand saw
  - ✓ Materials
    - Pegs
    - Building lines
    - Nails
    - Warning tape
  - ✓ Equipment
    - Surveying level
    - Theodolite
    - Total station
    - DGNSS
    - PPE

- **Checking of surveying equipment**
  - ✓ Functionality of instrument components
  - ✓ Check the parts and accessories of instrument
  - ✓ Line of collimation

Resources required for the learning outcome	
Equipment	Dumpy level, theodolite, total station, DGNSS, computer, white board,PPE
Materials	Pegs, building lines, nails, dry piles, flip chart, marker pen, chalks, note books, warning tape
Tools	Hummer, tape measure, arrows, ranging rod, measuring wheel, hand saw, panga
Facilitation techniques	Group discussion, Trainer guided, Demonstration and simulation, brainstorming
Formative assessment methods /(CAT)	Written assessment, Oral assessment

Learning outcome 2: Collect earthwork measurement survey data	**Learning hours: 20**
Indicative content	

- **Set up of surveying instruments**
  - ✓ Dumpy level
  - ✓ Theodolite
  - ✓ Total station
  - ✓ DGNSS receiver
- **Collection of earthwork surveying data**
  - ✓ Distances
  - ✓ Elevations
  - ✓ Coordinate
- **Saving and sharing of collected data**
  - ✓ Data formats
  - ✓ Saving data
  - ✓ Downloading data
  - ✓ Ways of sharing data

Resources required for the learning outcome	
Equipment	• Total station, levels, DGNSS, computer, white board, PPE
Materials	• Dry piles, pegs, chalks, note books, pens, building line, paper, marker pen, warning tape
Tools	• Tape measures, ranging rods, measuring wheel, laser meter
Facilitation techniques	• Group discussion, Trainer guided, practical work, Demonstration, brainstorming
Formative assessment methods /(CAT)	• Written assessment, oral assessment, performance assessment

Learning outcome 3: Compute Area	**Learning hours: 25**
Indicative content	

- **Checking of Collected data**
  - ✓ Data incompleteness
  - ✓ Inconsistency of data
  - ✓ Checking of accuracy
- **Selecting methods of area computation**
  - ✓ Methods of calculating area of regular figures
  - ✓ Methods of calculating area of irregular figures
    - Average ordinate
    - Middle ordinate
    - Trapezoidal rule
    - Simpson's rule
    - Cross-section
    - Area from coordinate
    - Area from planimeter
- **Calculation of area**
  - ✓ Regular figures
  - ✓ Irregular figures

Resources required for the learning outcome	
Equipment	▪ Computer, projector, planimeter, white board
Materials	▪ Note book, papers, marker pen, chalks
Tools	▪ Calculator, duster
Facilitation techniques	▪ Group discussion, practical work, application exercises, demonstration
Formative assessment methods /(CAT)	▪ Written assessment, oral assessment, performance assessment

Learning outcome 4: Compute Volume	Learning hours: 30

Indicative content
• **Checking of Collected data** ✓ Data incompleteness ✓ Inconsistency of data ✓ Checking of accuracy • **Selection of methods of volume computation** ✓ End Area Method ✓ Trapezoidal method ✓ Simpson's rule ✓ Cross section method ✓ Spot height method ✓ Contour method • **Calculating volume** ✓ Regular figures ✓ Irregular figures

Resources required for the learning outcome	
Equipment	Computer, projector, Total station, GPS, DGPS, Level, planimeter, white board,
Materials	▪ Pegs, note book, nails, dry piles, papers, marker pen, chalks
Tools	▪ Plumb bob, tape measure, hammer, laser meter, ranging rod, tripod, panga, hand saw, calculator
Facilitation techniques	▪ Individual and Group discussion, practical work, application exercises, demonstration
Formative assessment methods /(CAT)	▪ Written assessment, oral assessment

Learning outcome 5: Produce Earthwork Diagrams	Learning hours: 15

Indicative content

- **Tabulation of volumes of fill and cut**
  - ✓ Cut and fill volumes
  - ✓ Computation of cumulative volumes
  - ✓ Cut and fill volumes correction
- **Identification of Mass Haul Diagram**
  - ✓ Element of mass haul diagram
    - Line stations
    - Cumulative material volume
    - Mass line (excavation, embankment)
    - Point of maximum earthwork
    - Point of minimum earthwork
    - Base line
    - Borrow (or waste)
  - ✓ Characteristics of a Mass haul diagram
- **Drawing of Mass haul diagram**
  - ✓ Scaling
  - ✓ Elevation and chainage axis
  - ✓ Plotting grade
  - ✓ Draw alignment of the curve
  - ✓ Marking Volume of cut and fill on the diagram

Resources required for the learning outcome

Equipment	▪ Computer, projector, white board, printer
Materials	▪ Pens, marker pen, paper, chalks, flipchart, note book, cartridge
Tools	▪ Ruler, calculator, duster
Facilitation techniques	▪ Group discussion, brainstorming, demonstration, application exercises

Formative assessment methods /(CAT)	▪ Written assessment, oral assessment, performance assessment, product based assessment

Integrated/Summative assessment

Integrated situation

KIM owner of Real Investment Company Ltd wants to construct its headquarter in HUYE District, Southern province, where its plot of land is located. As an earthwork survey estimator of the mentioned company, you are requested to determine:

a) The cut and fill volumes basing on spot levels computed.

b) The graphical representation of the Mass haul diagram on A4 paper.

- ❖ The size of plot is (40*40) m, the assumed benchmark as formation level is 10m.
- ❖ The plot is subdivided into a number of grids each having **8m x 8m**.
- ❖ All tools, equipment and materials are available on the site
- ❖ The tasks must be completed within 12 hours

Resources

Tools	▪ Tape measure, hammer, ruler, calculator, ranging rod, plumb bob, reading staff, prism reflector
Equipment	▪ Dumpy level, DGNSS, Total station
Materials/ Consumables	▪ Pegs, mark pen, note book, paper, warning tape

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator	Observation		Marks allocation
			Yes	No	
1. Prepare for earthwork measurement	1.1. Types of data are properly identified	1. Benchmarks are identified			2
		2. Grid's interval is respected			2

survey data (10%)	1.2. Tools, materials and equipment are appropriately selected	1. Tools are selected			1
		2. Materials are selected			1
		3. Equipment are selected			2
	1.3. Survey equipment are properly checked	1. Instrument is checked			2
2. Collect earthwork measurement survey data (20%)	2.1. Surveying instruments are accurately set up	1. Setting up is well done			2
		2. 2. Levelling is correctly done			3
		3. Focusing is well done			2
	2.2. Survey data are properly collected	1. Distances are correctly measured			4
		2. Readings are perfectly recorded			3
		3. Spot levels are reduced			4
	2.3. Survey data are well saved and shared	1. Data are well saved			1
		2. Data are well shared			1
3. Compute Area (15%)	3.1. Collected data are accurately checked	1. Data for area computation are well checked			3
	3.2. Methods of area computation are well selected	1. Method of area computation is well selected			3
	3.3. Area is accurately calculated with respect to the selected method	1. Area is computed correctly			5
		2. Checking is properly performed			4
	4.1. Collected data are accurately checked	1. Data for volume computation are well checked			3

4. Compute volume (25%)	3.4. Methods of volume computation are well selected	1. Method of volume computation well selected			5
	3.5. Volume is accurately calculated	1. Volume is correctly computed			9
		2. Checking is properly performed			8
5. Produce earthwork diagrams (30%)	5.1. Volume to be cut and filled is properly identified	1. Volume of cut is identified			2
		2. Volume of fill is identified			2
	5.2. Mass haul diagram elements are adequately identified	1. Elements of Mass haul diagram are well identified			6
	5.3. Mass haul diagram is well drawn	1. Elevation and chainage axis are well plotted			3
		2. Proposed grade is accurately plotted			3
		3. Alignment of the curve is correctly drawn			5
		4. Volume of cut and fill are well marked on the diagram			5
		5. Appropriate scale is well used			4
Total marks					100
Percentage Weightage					100%
Minimum Passing line % (Aggregate): 70%					

References

1. Easa, S. (1988). Selection of Roadway Grades that Minimize Earthwork Cost Using Linear Programming. Transportation Research.
2. Goktepe, A.B., & Lav, A.H. (2003). Method for Balancing Cut-Fill and Minimizing the Amount of Earthwork in the Geometric Design of Highway. Journal of Transportation Engineering. 2003.129(5):564571p.
3. Easa, S. (1989). Journal of Surveying Engineering.
4. Selcuk Gumus H. Hulusi Acar, Metin Tunay and Ayhan Atesoğlu. Calculation of Cut and Fill Volumes by GIS in Forest Road Projecting.
5. Seyed Ataollah et. al. Comparing the expenses of forest road cut and fill operations with standard rules (Study Area: Northern Forests of Iran).