DESIGN OF WASTEWATER COLLECTION AND TREATMENT INFRASTRUCTURE

UNIT CODE: CON/CU/CET/CR/09/6/A

Relationship to Occupational Standards
This unit addresses the unit of competency: Design Wastewater Collection and Treatment Infrastructure

Duration of Unit: **200 hours**

Unit Description

This unit covers the competencies required to design waste water collection and treatment infrastructure. It involves collection of wastewater infrastructure design data, analysis of wastewater infrastructure design data, and calculation of wastewater infrastructure design parameters, drawing wastewater infrastructure units and compiling wastewater infrastructure design report.

Summary of Learning Outcomes

1. Apply hydraulic engineering principles
2. Analyse structural elements
3. Design structural elements
4. Collect wastewater infrastructure design data
5. Analyse wastewater infrastructure design data
6. Calculate wastewater infrastructure design parameters
7. Draw wastewater infrastructure units
8. Compile wastewater infrastructure design report

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods

1. Apply hydraulic engineering principles	• Fluid properties
	  ○ Viscosity
	  ○ Density
	  ○ Mass
	  ○ Volume
	  ○ Compressibility
	  ○ Pressure
		• Written test
		• Interview
		• Oral question
		• Assignments
		• Supervised exercises
		• Practical tests

	○ Surface tension ○ Specific gravity ○ Specific ○ weight • Fluid pressure measurement ○ Manometers ○ piezometer, ○ mechanical gauges, ○ Hydraulic bench ○ Statement of Pascal's law ○ Application of Pascal's Law Total pressure and centre of pressure;horizontally immersed plane surface, vertically immersed plane surface, inclined immersedplane surface) ○ Basic definitions; area of flow, mean velocity, rate of flow. ○ Types of flow; ○ steady and unsteady ○ uniform and non-uniform, ○ laminar and turbulent (Reynold's experiment) ○ Compressible and incompressible flow. ○ Flow equations; discharge equation, continuity equation, Bernoulli's equation)	

	• Discharge and velocity measurement
	  ○ Venturimeters
	  ○ Pitot and pitot static tubes
	  ○ Orificmeter
	  ○ Orifices and mouthpieces
	  ○ Weirs and notches
	  ○ Flow in pipes
	• Head losses in pipes; major losses (Darcy's formula, Chezy's formula, Manning's formula, Hazen Williams formula)
	  ○ Minor losses (due to fittings, enlargement, contractions),
	  ○ Hydraulic grade line, total head loss.
	  ○ Total energy line
	  ○ Flow in open channels
	• Simple channel sections; rectangular, triangular, trapezoidal, circular.
	  ○ Parameters of open channel; wetted perimeter, hydraulic mean depth/radius, hydraulic gradient.
	  ○ Application of Chezy's and Manning's equations to open channel flow problems; simple sections and compound sections	

	○ Design of most economical channel sections ; rectangular, trapezoidal	
2. Analyse structural elements	○ Properties material ○ Stress, strain, ductility, malleability, ○ Types of Stresses, Working Stress: Types of Strain, ○ Stress-strain relationship**:** Stress-strain diagram, ○ Hooke's law, Young's modulus, Definition • Moments in beams ○ Types of beams: Simple, Cantilever, Overhanging, ○ Type of beam supports, Hinged or pinned supports, Fixed or encastre supports, Rollers and simple supports, ○ Types of loads/Forces and loading systems: Point loads, Uniformity distributed loads, uniformly varying loads, combination of point loads and uniformly distributed loads, ○ Support reactions: Calculation of support reactions, signs and taking moments at a given reaction point, ○ Calculation of Shear forces and bending moments: Definitions,	• Written test • Interview • Oral question • Assignments • Supervised exercises • Practical Tests

	Sign conventions, Calculations of shear force and bending moments at critical points. ○ Determination of maximum Sheaf forces and Bending moments: Graphical representations: Shear force and bending moment diagrams. • Section properties ○ Centre of gravity and Centroid: Definition of centre of gravity and centroid, Determination of centre of gravity and centroid by (Calculation, Graphical) Solve simple problems involving centre of gravity or centroid ○ Second moment of area (I): Definition, Derivation of second moment of area formula. ○ Section modulus (Z)**:** Definition, Calculation of section modulus ○ Radius of gyration • Theory of simple bending ○ Basic assumptions: General principles**:** Bending tendency, Neutral axis, Variation of stress/strain in a beam	

	section, General theory of bending equation:, Moment of resistance (rectangular beam) :
	• Forces in frames
	  ○ Types of Frames: Perfect frame, imperfect frame, redundant frame, Nature of forces in frames: Tension and compression forces,
	  ○ Analysis of forces in frames: Methods of analysis: method of sections, method of joint resolution
	• Deflection In Beams
	  ○ General Principles: Effects of deflection, General differential equation for deflection, Derivation of the general slope and deflection formula, double integration.	

3. Design structural elements	○ Design of Reinforced Concrete Structures ○ Beams: simply supported beams ○ Columns: short columns, centrally axially loaded and eccentrically loaded-uniaxial and biaxial bending ○ Floors/slabs: one way spanning and two way spanning suspended slabs	• Written test • Interview • Oral question • Assignments • Supervised exercises • Practical tests

	○ Foundations: isolated footing/pad footing and strip footing • Design of Timber Structures ○ Timber grading: Visual / machine grading, Stress grading, Stresses: Grade, Basic, Dry, Wet, Permissible, Strength class • Design of Steel ○ Struts ○ Ties ○ Purlins ○ Joists	
4. Collect wastewater infrastructure design data	• Mapping the area • Tools preparation • Data collection/ Quantity of Wastewater • Quantity of wastewater (Design periods, wastewater generation rates (urban, periurban, rural) • Storm water infiltration and exfiltration.	• Written test • Interview • Oral question • Assignments • Supervised exercises • Practical tests •
5. Analyze wastewater infrastructure design data	• Categorize population into various classes • Analyse and clean climatic and hydrological data • Produce topographical maps and ground profiles from survey data	• Written test • Interview • Oral question • Assignments • Supervised exercises • Practical tests

6. Calculate wastewater infrastructure design parameters	• Population projection • Population equivalent • Discharge /volume • Velocities • Load estimation (BOD, TSS,FC) • Computations of profile data • Sizing of the pipes • Hydraulic flow in pipes • Depth of flow • Gradient • Sizing of treatment units	• Written test • Interview • Oral question • Assignments • Supervised exercises • Practical tests

7. Draw wastewater infrastructure units	• Draw profiles
	• Draw:
	  ○ Sewer Line
	  ○ Sewer Appurtenances
	  ○ Screens
	  ○ Grit Chamber
	  ○ Sedimentation Tanks
	  ○ Trickling Filters
	  ○ Activated Sludge Unit
	  ○ Stabilization Ponds
	  ○ Oxidation Ditch
	  ○ Aerated Lagoons
	  ○ Storm Water Drains
	  ○ Sludge Treatment Units
	• Legal requirements for approvals
		• Written test
		• Interview
		• Oral question
		• Assignments
		• Supervised exercises
		• Practical tests

8. Compile wastewater infrastructure design report	• Technical report writing • Legal requirements	• Written test • Interview • Oral question • Assignments • Supervised exercises • Practical tests

Suggested Methods of Instruction

- Group discussions
- Demonstration by trainer
- Online videos

- Power point presentation
- Exercises by trainee

Recommended Resources

- Scientific calculators
- Relevant reference materials
- Stationeries
- GPS
- CAD and GIS Software
- Computer lab
- Relevant practical materials
- Laboratories (chemical, biological & soils)
- Internet
- Concrete workshop
- Hydraulics laboratory
- Design codes
- Printers
- Workstation
- Plumbing and pipe fitting workshop