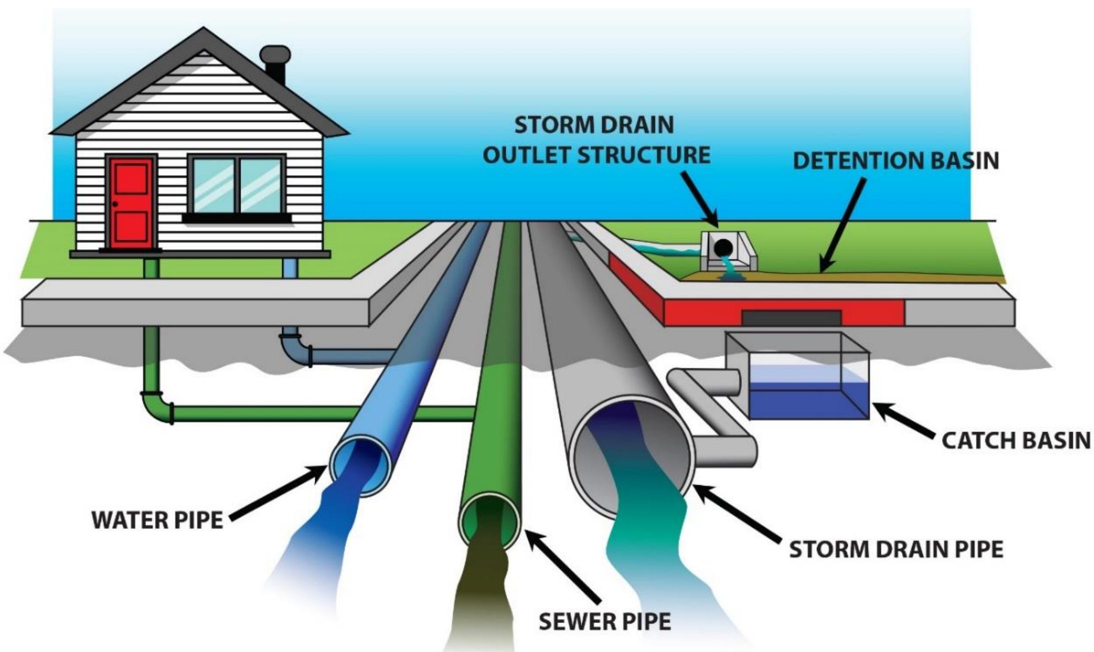
Road Construction and Maintenance

LEVEL – III

Based on September 2023, Curriculum Version 2



Module Title: **Water Main, Storm, and Sewer Pipeline**

Module Code: **EIS RCM M05 0923**

Nominal Duration: **80 Hours**

Prepared by: **Ministry of Labor and Skill**

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Addis Ababa, Ethiopia

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ACRONYMS

AAWSA	Addis Ababa Water and Sewage Authority
ASTM	American Standard for Testing Material
CI	Cast Iron
EBCS	Ethiopian Building Code Standard
EIS	Economy Infrastructure Subsector
EMP	Environmental Management Plan
ERA	Ethiopian Road Authority (Currently: Ethiopian Road Administration)
HDPE	High-Density Polyethylene
ISO	International Organization for Standardization
LAP Test	Learning Activity Performance Test
LG	Learning Guide
M	Module
OS	Occupational Standard
OSH	Occupational Safety and Health
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
RCM	Road Construction and Maintenance
TBM	Temporary Bench Mark
TTLM	Teaching, Training and Learning Materials
WBS	Work Breakdown Structure

TABLE OF CONTENTS

INTRODUCTION TO THE MODULE

This module is prepared to support training of specific unit of competence, which contains knowledge, skills and attitude required to water main, storm, and sewer pipeline. A water main is a primary underground pipe in a municipal water distribution system. It is a major artery that supplies water to smaller pipes on the way to homes and businesses. Storm drains are used to convey runoff in locations where streets or other drainage facilities exceed their designated capacity or are otherwise unable to drain. A sewer pipe is a conduit for the elimination of waste materials. Sewer pipes come in a wide variety of sizes and are made of various materials. In this module water main, storm, and sewer system requirements, setting out and excavation site, and installation and testing pipeline will be presented.

MODULE UNITS

- Water Main, Storm, and Sewer System Requirement
- Setting Out and Excavation Site
- Installation and Testing Pipeline

LEARNING OBJECTIVES OF THE MODULE

At the end of this session, the students will able to:

- Identify water main, storm, and sewer system requirement
- Set out and excavate site
- Install and test pipeline

MODULE LEARNING INSTRUCTIONS

- Read the specific objectives of this learning guide (LG).
- Follow the instructions described below.
- Read the information written in the information sheet.
- Accomplishment the self-check questions.
- Accomplishment operation sheet.
- Accomplishment learning activity performance (LAP) test

Unit One: Water Main, Storm, and Sewer System Requirement

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

- Basic Concept of Water Main, Storm, and Sewer System
- Compliance Documentation
- Safety Requirements
- Signage Requirements
- Tools, Equipment, and Plant
- Environmental Protection Requirements

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

- Introduce basic concept of water main, storm, and sewer system
- Interpret and apply compliance documentation
- Follow safety requirements
- Identify & implement signage requirements
- Select and use tools, equipment, and plant
- Identify, confirm and apply environmental protection requirements

1.1 Water Main, Storm, and Sewer System

1.1.1 Water Main Pipelines

A water main is a primary underground pipe in a municipal water distribution system. It is a major artery that supplies water to smaller pipes on the way to homes and businesses. Water mains take clean water from a city's water treatment plant to communities that need it and is, therefore, a critical part of a nation's utility infrastructure. The pipes transport a high volume of water under pressure to neighborhoods that are depending on water mains to bring them clean water from the city's water treatment facility.

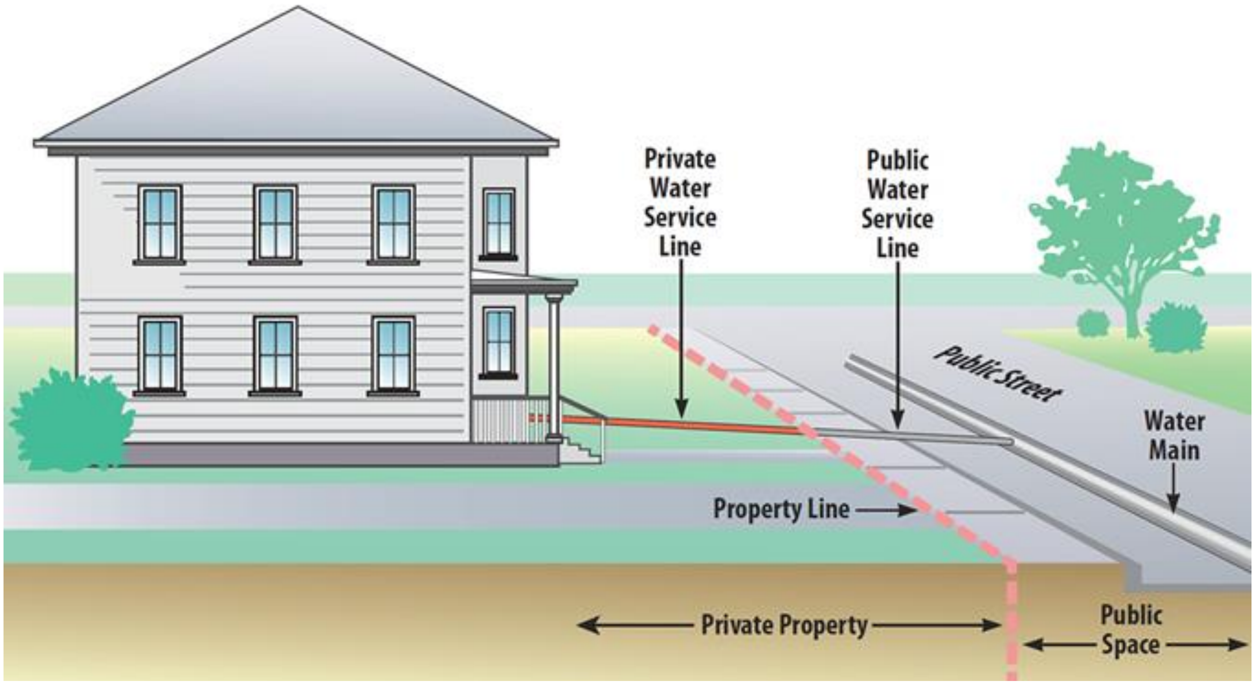


Figure 1. 1 Water main

1.1.2 Storm Drains

Storm drains are used to convey runoff in locations where streets or other drainage facilities exceed their designated capacity or are otherwise unable to drain. The most common method for the introduction of water into a storm drain is the street inlet. However, water may also enter the system via grated area inlets, culvert-type inlets (typically for the conveyance of drainage-channel flow into the drain), pump stations, or other entry points. The design of a storm drain system is dependent on topography, street rights-of-way and drainage easements, the need to convey flows from multiple locations, existing and proposed structures and utilities, outfall locations, local hydrology, and regional and local design criteria.

Typically, storm drains are sized to convey the peak runoff from the minor storm in excess of the contributing street flow capacity. This means the upper end of a storm drain branch will usually be located at the first inlet encountered by runoff in a given sub-watershed. The first inlet will either be located at the point where street flow from the design storm exceeds street capacity for that storm (on-grade inlet) or where there is a vertical sag in the street (sump inlet). In some cases, however, street inlets discharge their intercepted flow to drainage facilities other than a storm drain (e.g., a drainage channel). Storm drains shall be sized to carry the maximum difference between street capacity and peak runoff for any given design storm. This could be the difference between the major storm peak runoff and the allowable street capacity for the major storm, or it could be the difference between the minor storm runoff and allowable street capacity for the minor storm.

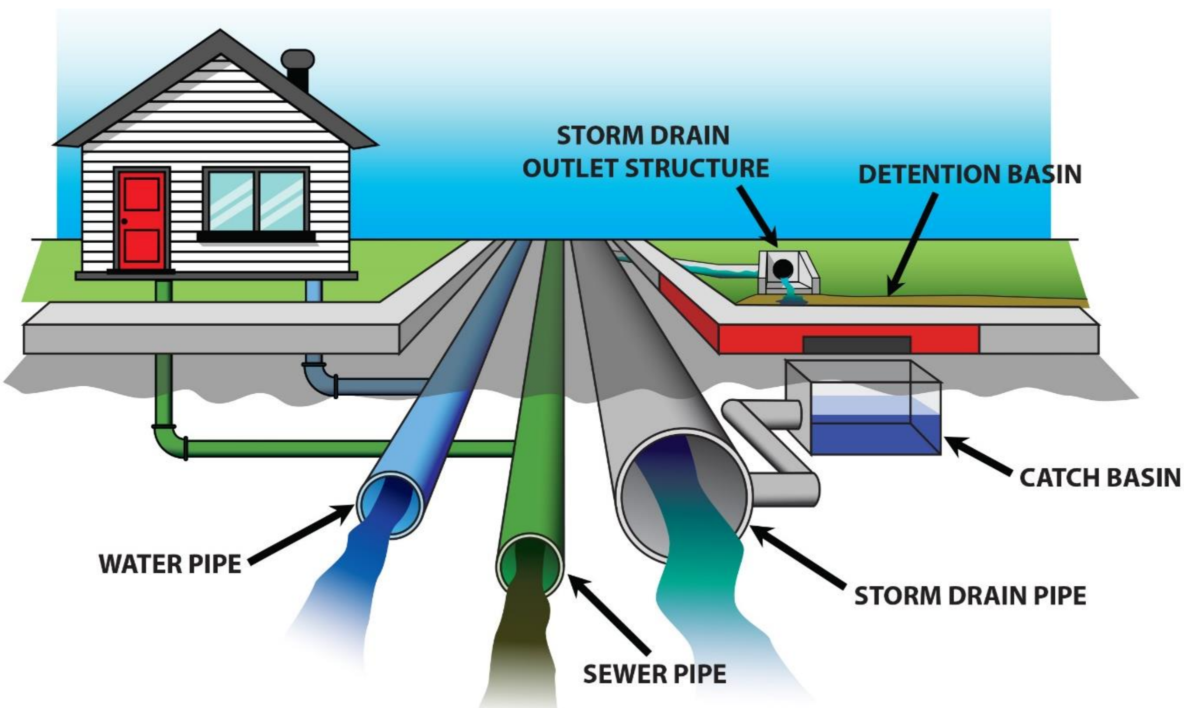


Figure 1. 2 Water, sewer, and storm drain pipe

1.1.3 Sewer Pipelines

A sewer pipe is a conduit for the elimination of waste materials. Sewer pipes come in a wide variety of sizes and are made of various materials. The primary purpose of a sewer pipe is to transport wastewater or sewage from homes or commercial buildings through the sewer system for treatment or disposal. Over time, these sewage ducts can decay or become damaged, requiring repair or replacement. Trenchless technology is often used for this work.

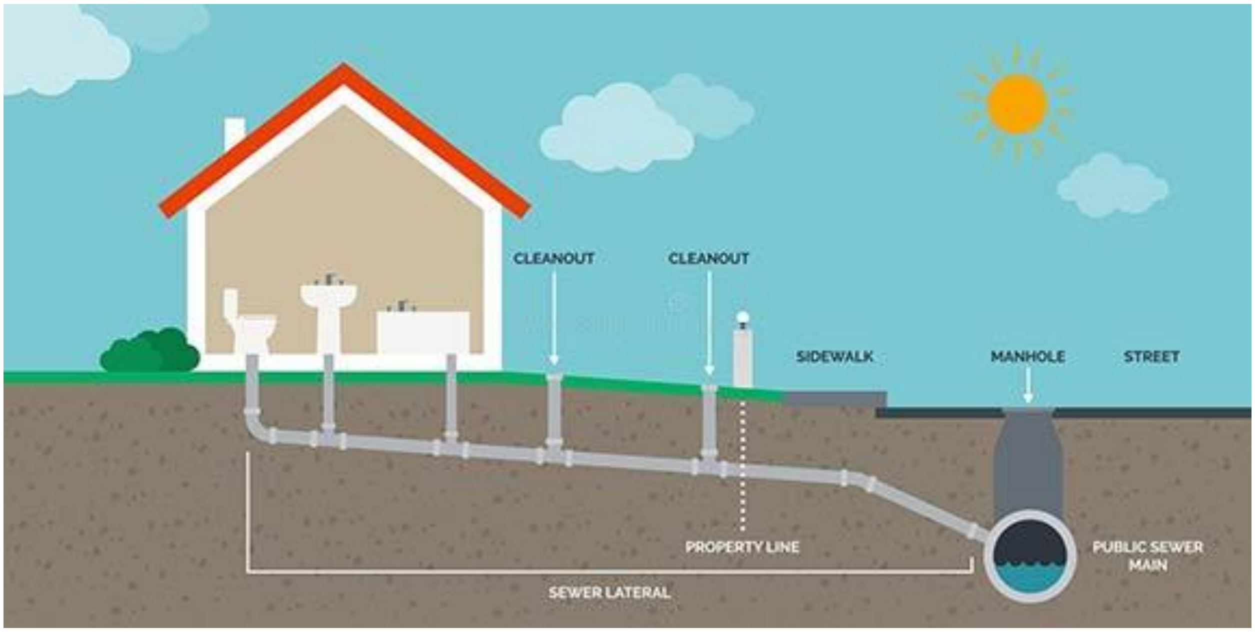


Figure 1. 3 Sewer and water main crossing detail drawing

1.2 Compliance Documentation

1.2.1 Code, Standard, and Responsible Bodies

Compliance Documentation means specific documents or information including records, reports, observations and verbal responses required to verify compliance with standards by a facility or program. For design and implementation of water main, storm, and sewer pipelines Addis Ababa Water Supply and Sewerage Authority (AAWSSA) proclamation 68/1963 and revised edition proclamation number 10/87, Ethiopian Road Authority (currently: Ethiopian Road Administration) ERA manual 8. Drainage Design Manual (Version: 2013) and Ethiopian Building Code Standard 9 (Version: 2013) for plumbing services of buildings, Addis Ababa City Roads Authority (AACRA) Drainage Design Manual (Version: 2003) and American Standard for Testing Material (ASTM) will be referred. [Note: Regions and city administrations will use their own codes, standards, and proclamations.]

1.2.2 Technical Data

The design drawings and technical specifications should include:

- Design drawings – these set out design information and procedures which are required to be used on the works.
- Bill of Quantities – this itemizes the quantity of materials to enable a tendered to accurately cost the work for which they are bidding.
- Material specifications – such as diameter, type and grade of material for pipes (e.g. polyethylene pipes or UPVC), joining methods (e.g. electro-fused or compression fittings etc.), or 28-day compressive strength of concrete.
- Requirements for Material Testing e.g. testing required for earthworks (i.e. minimum required compaction and moisture range to be achieved), frequency of testing (e.g. one soil density test per 1,000 m^3 of bulk earthworks) or the number of tests per 1,000 m^2 of area for hydraulic conductivity tests in sedimentation ponds.
- Construction and installation methods.
- Development approval conditions that have to be complied with throughout the construction.

1.2.3 Design Drawings

Design drawings for construction contain all the information necessary for the construction contractor to bid on and build a particular project. Typically, the preparation of design drawings provides a detailed record of the design and structural requirements of the works. A contract or tender document often references design drawings. Design drawings should show details on layout, measurements, plan, cross-sectional and vertical profiles. This information is prepared as scale drawings of the works to be constructed. Design drawings should be presented in such a way that the project can easily be understood, they visually communicate the concept to the lot feeder and the construction contractor, and they are legible.

They include all information from previous revisions and updates. The design drawings should include the following aspects:

- Site layout and the location of the works to be constructed
- Plan views, Dimensions and units' gradients
- Detailed designs and cross-sectional profiles of the works
- Titles and scales that meet the required standards and units
- Adequate labeling and elevations that are referenced to meters

- Be dated and signed by the designer

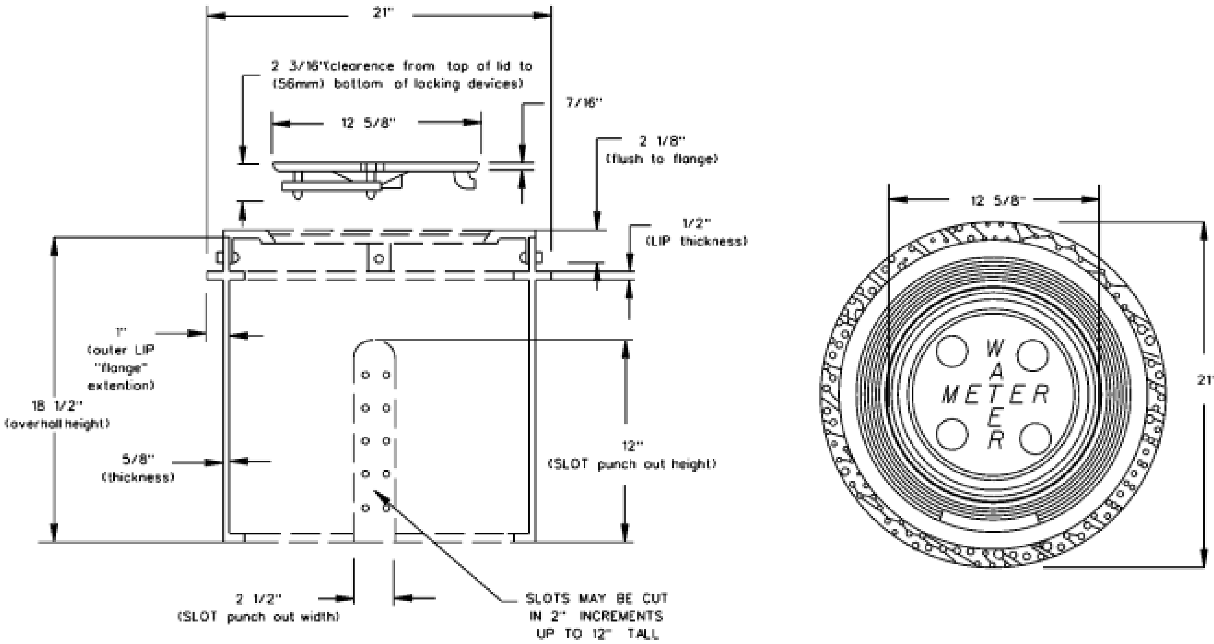


Figure 1. 4 Road cross section drawings

1.2.4 Technical Specifications

A contract or tender document often references technical specifications about the specific requirements and construction standards for various elements of a project. This includes how the work will be done, the quality of workmanship and methods of testing. Typically, construction projects require construction of various elements and use of various materials. More than one technical specification may be required for the whole project. For example, a construction project may require individual technical specifications for Earthworks, erosion and sediment controls, concrete works, fencing, building works, roads, electrical systems, and water reticulation systems. For small projects, the material and construction specifications may be documented in the form of notes on the design drawings. For larger projects, a separate specification document is more practical. Designers will usually have suitable standard technical specification documents. However, as a guide a specification might include:

- Descriptive title, number, identifier etc. of the specification
- Date of last effective revision and revision designation
- A logo or trademark to indicate the document copyright, ownership and origin
- Person or office responsible for questions on the specification, updates and deviations

- The significance, scope or importance of the specification and its intended use
- Terminology, definitions and abbreviations to clarify the meanings of the specification
- References and standards used or to be complied with
- Test methods for measuring all specified characteristics
- Material requirements: physical, mechanical, electrical, chemical
- Targets and tolerances
- Acceptance testing, including performance testing requirements and tolerances
- Workmanship certifications required
- Safety and Environmental considerations and requirements
- Approval authority considerations and requirements
- Quality control requirements, acceptance sampling, inspections, acceptance criteria
- Person or office responsible for enforcement of the specification
- Completion and delivery
- Provisions for rejection, reinspection, rehearing, corrective measures

1.3 Safety Requirements

1.3.1 Occupational Safety and Health (OSH)

Occupational safety and health are concerned with preserving and protecting human and facility resources in the workplace. Safety is the state of being "safe", the condition of being protected from harm or other danger. Safety can also refer to the control of recognized hazards in order to achieve an acceptable level of risk.

1.3.2 Construction Site Safety

Construction site safety is an aspect of construction-related activities concerned with protecting construction site workers and others from death, injury, disease or other health-related risks. Construction is an often hazardous, predominantly land-based activity where site workers may be exposed to various risks, some of which remain unrecognized. Site risks can include working at height, moving machinery (vehicles, cranes, etc.) and materials, power tools and electrical equipment, hazardous substances, plus the effects of excessive noise, dust and vibration. The leading causes of construction site fatalities are falls, electrocutions, crush injuries, and caught-between injuries.

These are the general safety rules for construction site:

- Always wear PPE: PPE is your last line of defense against danger. It protects you if something goes wrong and helps make sure you are seen. Wear it.
- Get Your Induction: Most workers get an induction when they start a new job. In construction, you should get one every time you start work on a new project. Each site has its unique hazards and work operations. No two sites are the same. Make sure you know what is happening so that you can work safely. Inductions are a legal requirement on every construction site you work on. Get the construction site induction checklist to carry out and record your inductions. Your induction is important. It tells you where to sign in, where to go, what to do, and what to avoid. Don't start work without one.
- Be Tidy: Construction work is messy. Slips and trips might not seem like a major problem compared to other high-risk work happening on the site, but don't be fooled. Remember to keep your work area tidy throughout your shift to reduce the number of slip and trip hazards. Pay particular attention to areas such as access and escape routes.
- Act Safe: On a construction site, one wrong move could put you in harm's way. So, create simple construction site. Actions speak louder than words. Set a good example, think safe and act safely on site. You are responsible for your behavior. Construction sites are dangerous places to work - make sure you remain safety aware throughout your shift.
- Follow Signs: Follow construction safety signs and procedures. The safety rules and procedures for your site should be explained to you in your induction (rule number 2). You should also have a risk assessment for your activities. Make sure you read and understand it - it tells you what the hazards are and how to control the risks. Control measures are put in place for your safety. Make sure they are in place and working before you start.
- Do Not Enter: Make sure your work area is safe. Know what is happening around you. Be aware. Don't work at height without suitable guard rails or another fall prevention. Don't enter unsupported trenches. Make sure you have safe access. Don't work below crane loads or other dangerous operations. Check that the area is safe before you enter.
- Report: If you notice a problem, don't ignore it; report it to your supervisor immediately. Fill out a near-miss report, an incident report, or simply tell your supervisor. Use whatever procedure is in place on your site for reporting health and safety concerns. Action can only

be taken quickly if the management has been made aware of the problem. The sooner problems are resolved the less chance for an accident to occur.

- Do not Tamper: If something's not working or doesn't look right, follow rule number 7 and report it. Don't try and force something, or alter something, if you're not trained to or supposed to. Never remove guard rails or scaffold ties. Do not remove machine guards. Do not attempt to fix defective equipment unless you are competent to do so. You'll get the blame if something goes wrong. You could get hurt Someone else could get hurt Do not ever tamper with equipment without authorization.
- Use the Right Equipment: One tool does not fit all. Using the correct tool for the job will get it done quicker, and most importantly, safer. Visually check equipment is in good condition and safe to use before you start. Because of the possibility of wet conditions (both with outside work and wet trades), you should only use 110v equipment on construction sites. 240v equipment is strictly prohibited without prior authorization from management and will only be used if no 110v alternative is available and additional safety precautions are taken.
- If in Doubt Ask: Unsure what to do? Or how to do something safely? Or do you think something is wrong? Stop working, and ask. It takes 5 minutes to check, but it might not be so easy to put things right if things go wrong. It's better to be safe than sorry. Mistakes on construction sites can cost lives, don’t let it be yours. If you need help or further information speak to your supervisor.

1.3.3 Personal Protective Equipment (PPE)

Figure 1. 5 Personal Protective Equipment

To stay safe, workers may have to wear PPE such as safety helmets, gloves, eye or hearing protection, high-visibility clothing, safety footwear and harnesses. PPE may then be needed to reduce the risk of injury from breathing in dust, mist, gas or fume, falling materials hitting people flying particles or splashes of corrosive liquids getting into people's eyes, skin contact with corrosive materials, excessive noise, and extremes of heat or cold. Some of PPE are listed below.

- Overall Cloth: Protects the normal clothes from dust, grease and other spilling materials.
- Hard Hat: Protects head of the worker from any falling objects dropping from high level during construction.
- Safety Shoe (Boot): Protects the worker form nail, sharp objects and heavy falling objects by hard-rolled leather shoes with metal toe caps.
- Mask: Protects eyes of the worker from other endangering object and dust during construction.
- Goggle: Protects eyes of the workers during welding of metal works and when placing reinforcement in the form work.
- Glove: Protects the workers from oils, chemicals, and dust and other dangerous material that affect the skin.
- Safety Belt: Secures laborers working in a plane where the construction is done at high level.

1.3.4 First Aid

All workplaces, leisure centers, homes and cars should have first aid kits. The kits for workplaces or public places must conform to legal requirements and be clearly marked in a green box with a white cross and easily accessible. Any first aid kit must be kept in a dry place, and checked and replenished regularly. All first aid kits should contain essential equipment to protect yourself and client from harm in an emergency.

Figure 1. 6 First Aid Kit

A construction site should have a first and kit which as minimum containers plaster, bandage, ointment, and disinfector. Someone on the site should be in charge of the kit and know how to deal with broken boned, bowls and effective strikes. First aid kit should be placed at convenient location at the site so that worker can pick it up early.

1.3.5 Excavation Safety

A. Excavation Safety Requirement

Excavation work is defined as the removal of earth, rock or other material in connection with construction or demolition works using tools, machinery or explosives to form an open face, hole or cavity. Excavation work includes any earthwork, trenching, cofferdam, caisson, well, shaft, tunnel or underground working. The person appointed to plan the lifting work should have adequate practical and theoretical knowledge and experience of the lifting work being undertaken. Any construction work (including any work connected with an 'excavation') that is carried out in or near: A shaft, cofferdam, caisson or trench with an excavated depth of greater than 1.5 meters, or a tunnel can be considered as a 'high risk construction work' for which preparation of a written safe work method statements encouraged. Prevent danger to workers in or near excavations. To maintain the required precautions, a competent person must inspect excavation supports or battering at the start of the working shift and at other specified times. No work should take place until the excavation is safe. Commercial clients must provide certain information to contractors before work begins. This should include relevant information on ground conditions:

- Underground structures or water courses; and
- The location of existing services.

This information should be used during the planning and preparation for excavation work.

Key issues are:

- Collapse of excavations
- Falling or dislodging material
- Falling into excavations
- Undermining nearby structures
- Underground and overhead services
- Inflow of ground and surface water
- Damage to trees
- Other aspects of excavation safety
- Inspection

Every year people are killed or seriously injured by collapses and falling materials while working in excavations. They are at risk from:

- Excavations collapsing and burying or injuring people working in them;
- Material falling from the sides into any excavation; and
- People or plant falling into excavations.

B. Collapse of Excavations

Temporary support: Before digging any trench pit, tunnel, or other excavations, decide what temporary support will be required and plan the precautions to be taken. Make sure the equipment and precautions needed (trench sheets, props, baulks etc.) are available on site before work starts. Battering the excavation sides - Battering the excavation sides to a safe angle of repose may also make the excavation safer. In granular soils, the angle of slope should be less than the natural angle of repose of the material being excavated. In wet ground a considerably flatter slope will be required.

C. Falling or Dislodging Material

Loose materials - may fall from spoil heaps into the excavation. Edge protection should include toe boards or other means, such as projecting trench sheets or box sides to protect against falling materials. Head protection should be worn. Effect of plant and vehicles - Do not park plant and vehicles close to the sides of excavations. The extra loadings can make the sides of excavations more likely to collapse.

D. Inflow of Ground and Surface Water

Depending on the permeability of the ground, water may flow into any excavation below the natural groundwater level. The supports to the side of the excavation should be designed to control the entry of groundwater and the design should take any additional water loading into account. Particular attention should be given to areas close to lakes, rivers and the sea. Water entering the excavation needs to be channeled to sumps from where it can be pumped out; however, the effect of pumping from sumps on the stability of the excavation should be considered. Alternative techniques for de-watering (such as ground freezing and grout injection) could also be used. Designers will need to consider these issues.

E. Other Aspects of Excavation Safety

Provide a safe means of getting into and out of an excavation. If a risk assessment identifies that ladders are a reasonable means of access and egress from an excavation, they must be suitable and of sufficient strength for the purpose. They must be on a firm level base, secured to prevent slipping and, unless a suitable alternative handhold is provided, extend to a height of at least 1 m above the landing place. Consider hazardous fumes - do not use petrol or diesel engines in excavations without arranging for the fumes to be ducted safely away or providing for forced ventilation. Do not site petrol or diesel-engine equipment (such as generators or compressors) in or near the edge of an excavation; exhaust gases can collect and accumulate.

F. Inspection

A competent person who fully understands the dangers and necessary precautions should inspect the excavation at the start of each shift. Excavations should also be inspected after any event that may have affected their strength or stability, or after a fall of rock or earth. A record of the inspections will be required and any faults that are found should be corrected immediately.

1.4 Signage Requirements

1.4.1 Highway Traffic Signs

Highway traffic signs are signs erected at the side of or above roads to give instructions or provide information to road users. The earliest signs were simple wooden or stone milestones.

Figure 1. 7 Highway traffic signs

1.4.2 Site Safety Signage

Site safety signage warn employees and visitors of the potential hazards associated with demolition.

Figure 1. 8 Site safety notice

1.4.3 Barricades

Barricades are an improvised barrier erected across a street or other thoroughfare to prevent or delay the movement of opposing forces.

Figure 1. 9 Barricades

1.4.4 Traffic Conditions Signage

Traffic conditions signage are used to identify warnings and provide information to ensure others are safe from serious accidents. Traffic include congested urban environments, low traffic rural areas, off-road un-trafficked areas, buildings, parking sites, and pedestrian areas.

Figure 1. 10 Traffic conditions signage

1.5 Tools, Equipment, and Plant

1.5.1 Tools

The word "tool" is used to describe general items that people use to do work in any situation. The usage of the word connotes a generic object that can be used for a variety of purposes. A tool is typically a single object designed in a way that makes it suitable for multiple purposes. It is obvious that any object you use to solve a problem is a tool. It doesn't matter if the object is built for that specific purpose or not. Going by this generic definition, it might be safe to say that every machine or equipment is a tool in some way. However, more specifically, people use the word "tools" to refer to handheld items used to do work or solve problems.

1.5.2 Equipment

Equipment is a general time with a broader definition compared to tools and equipment. It refers to a set of tools needed to perform a specific task. People often use the word equipment as the plural form of tool. In this case, a collection of tools will be called equipment. However, tools differ from equipment in some respect. The word equipment can be used to describe objects or items that are not used to do work. For instance, a set of safety devices such as gloves, helmets, or goggles are often referred to as safety equipment. At a construction site, for instance, the set of machines that the engineers use for different stages of the project would be described as construction equipment. Examples of these include excavator hire, mixing & pouring equipment, concrete finishing equipment, cutting and compaction equipment, and surface preparation.

1.5.3 Plant

Plant refers to machinery, equipment or apparatus used for an industrial activity. In construction, plant typically refers to heavy machinery and large equipment used on construction sites – think cranes, excavators and bulldozers. Construction plant is used in many types of construction projects, from rail and road works to housebuilding. An essential part of large and complex construction projects is getting sites ready for building and moving materials from A to B. This is the primary function of construction plant and why it is so important; without it, work would rarely be able to get off the ground.

The tools, equipment, and plant which are used for installation of water main, storm, and sewer pipeline systems will be mention on each task of operation.

1.6 Environmental Protection Requirements

1.6.1 Environment

The term environment has been derived from a French word "Environia" means to surround. It refers to both Abiotic (physical or non-living) and Biotic (living) environment. The word environment means surroundings, in which organisms live. Environment and the organisms are two organized and complex components of nature.

1.6.2 Environmental Protection

Environmental protection is the practice of protecting the natural environment by individuals, groups and governments. Its objectives are to conserve natural resources and the existing natural environment and, where it is possible, to repair damage and reverse trends. Due to the pressures of overconsumption, population growth and technology, the biophysical environment is being degraded, sometimes permanently. This has been recognized, and governments have begun placing restraints on activities that cause environmental degradation.

1.6.3 Environmental Management Plan (EMP)

A project's environmental management plan (EMP) consists of the set of mitigation, monitoring, and institutional measures to be taken during implementation and operation to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels.

A. Waste Management

It includes the processes and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment, and disposal of waste, together with monitoring and regulation of the waste management process and waste-related laws, technologies, and economic mechanisms.

B. Water quality protection

These include temperature, acidity (pH), dissolved solids (specific conductance), particulate matter (turbidity), dissolved oxygen, hardness and suspended sediment.

C. Noise

Noise is the propagation of noise or sound with ranging impacts on the activity of human or animal life, most of which are harmful to a degree. The source of outdoor noise worldwide is mainly caused by machines, transport and propagation systems.

D. Vibration

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The oscillations may be periodic, such as the motion of a pendulum, or random, such as the movement of a tire on a gravel road.

E. Dust and Clean-Up Management

It is the system implemented to reduce or eliminate dust emissions from the activities that generate airborne and fugitive dust and cause erosion. The amount of dust generated depends on several factors, including the nature of the surface, to what degree the surface is disturbed and climactic conditions.

1.6.4 Environmental Protection in Pipeline Construction

Pipeline constructors and operators must find a way to meet environmental codes and regulations while continuing to run efficient, cost-effective pipelines. Fortunately, there are a number of ways companies can avoid or offset the environmental impact of pipeline construction. With a little extra effort and innovation, operators can create pipeline systems that do their job while upholding environmental standards.

A. Plan Pipeline Routes Carefully

Habitat loss and fragmentation is a key environmental concern of pipeline placement. If you plan a pipeline route carelessly, you could be laying pipe over crucial ecosystems containing endangered species or vegetation. Even if the pipeline itself doesn't cause too much damage, the excavation and heavy equipment involved in placing it will. When deciding where to lay your pipeline, keep the environment in mind. Avoid areas of high concern instead try to lay the pipeline over previously disturbed areas to minimize habitat destruction. You should also try to make use of existing access roads, as this will help you minimize the negative impact of construction. As you plan your pipeline, carefully assess multiple routes so that you can create the most environmentally friendly course possible.

B. Maintain Safe and Functioning Pipelines

Once you construct and start running a pipeline, you have a responsibility to ensure it doesn't cause further harm to the environment. Leaks, emissions, and other damage from pipelines can destroy vegetation, harm local wildlife, and add to local water and air pollution levels. Operators can help avoid these issues by strict inspection and maintenance routines. When you stay on top of pipeline repairs, you can help prevent major problems and environmental damage.

Self-Check-1

Part I: True or False question

Instruction: Say true if the statement is correct and false if the statement is incorrect.

______ 1. Excavation work is defined as the removal of earth, rock or other material in connection with construction or demolition works using tools, machinery or explosives to form an open face, hole or cavity.

______ 2. Safety is the state of being "safe", the condition of being protected from harm or other danger.

______ 3. Construction site safety **isn't** an aspect of construction-related activities concerned with protecting construction site workers and others from death, injury, disease or other health-related risks.

Part II: Matching

Instruction: Match Terms in column A with its meanings in column B.

	A	B
______	1. Saws	A. a water main is a primary underground pipe in a municipal water distribution system.
______	2. Sewer pipe	B. used to convey runoff in locations where streets or other drainage facilities exceed their designated capacity or are otherwise unable to drain.
______	3. Storm drains	C. a conduit for the elimination of waste materials
______	4. Water main	D. specific documents or information including records, reports, observations and verbal responses required to verify compliance with standards by a facility or program
______	5. Compliance Document	E. a tool consisting of a tough blade, wire, or chain with a hard-toothed edge

Part III: Short Answer Questions

Instructions: Answer all the following questions accordingly.

1. What is the signage requirement for pipeline construction?
2. Discuss the tools needed for pipeline construction.
3. Describe environmental protection requirement for pipeline construction.

Unit Two: Setting Out and Excavation

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

- Preparation for Setting out and Excavation
- De-Watering Requirements
- Setting Out Pipeline System
- Excavation Pipeline System
- Supporting Mechanism

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

- Prepare for setting out and excavation
- Determine and apply de-watering requirements
- Determine location, alignment direction, and set out works
- Advise plant operator of excavation requirements and monitor levels
- Install pipeline system support mechanism

2.1 Preparation for Setting out and Excavation

The laying of the pipe system and its associated accessories to prepare it for fluid transfer is referred to as piping installation or erection. Proper piping installation following regulations and specifications is critical to safety and operation. The next step in piping fabrication is to make pipe spools at the fabrication shop by cutting the pipes to the exact lengths and requirements. These prefabricated pipe spools are delivered to the job site or plant and installed. Pipe erection is the installation of piping spools on-site following isometric or piping general arrangement drawings. During pipe installation, the piping coordinates are matched with the designs. At the construction site, piping is installed using proper engineering work techniques and drawings. During pipe installation, the following are the primary inputs:

- Structure drawings,
- Piping drawings,
- Piping isometrics, and
- Drawings from the pipe support standard.

Process and physical data, operational conditions, stream flow details, equipment numbers, and so on. Proportionate drawings with correct dimensions are represented, as are pipe fittings, valves, flanges, special components, tables with a list of all fittings in the drawings, and so on. The Piping drawings show the locations of the plant's main equipment, main piping items, fittings and valves, nozzle orientation of the concerned equipment, and so on. Piping installation typically begins after civil supports and significant equipment has been installed on the construction site.

Basic requirement for installation of the pipeline work

- Selecting size, type and materials of pipe based on drawing and specification
- Setting out
- Excavation
- Bedding down pipes
- Positioning pipes
- Flanges for piping, valves, flange connections, and equipment installation
- Checking and amending alignment, level and grade
- Pressure testing
- Identification and marking

- Installation of pipe supports
- Constructing backfill

2.2 De-Watering Requirements

2.2.1 Definition of Dewatering

Standing water in an open trench greatly increases the likelihood of reduced structural capacity & make proper pipe placement & backfill compaction nearly impossible. Standing water should always be removed prior to pipe installation to provide a stable trench bottom. Dewatering is often a critical component of construction projects. Dewatering of a site improves safety by preventing the formation of mud and eliminating hazards to electrical equipment posed by water. Removing water also improves the stability of soils and mitigates erosion.

Dewatering is the removal of water from solid material or soil. Construction dewatering, un watering, or water control are common terms used to describe removal or draining groundwater or surface water from a riverbed, construction site, caisson, or mine shaft, by pumping or evaporation. On a construction site, this dewatering may be implemented before subsurface excavation for foundations, shoring, or cellar space to lower the water table. This frequently involves the use of submersible "dewatering" pumps, centrifugal ("trash") pumps, educators, or application of vacuum to well points.

2.2.2 Dewatering Tips

Without adequate supervision or planning, dewatering can cause soil erosion and other problems at the construction site. Here are some tips to consider when choosing a discharge area:

- Selecting a proper discharge area is crucial.
- Watch for signs of instability or erosion in the discharge area during dewatering.
- Don’t pump water directly into slopes.
- When possible, the dewatering discharge should be directed to a forest buffer zone.
- Channels used for dewatering must be stable and protected with vegetation.
- Avoid dewatering under heavy rain.
- Water contaminated with oils, greases, or chemical products must be treated before discharge. Never discharge contaminated water.
- Investigate the locals permits and requirements for dewatering.

- Analyze the water table conditions in the project area.

2.2.3 Construction Dewatering Techniques

There is a wide variety of methods used to control groundwater during an excavation. Selecting the right dewatering method is a critical step in almost any construction project. Every job and its conditions vary and therefore must be carefully assessed.

- Well point: In well point, wells are drilled around the excavation area with submersible pumps installed in the well shaft. These pumps are connected to a header pipe allowing the groundwater to be drawn up by the pumps into the well point and then discharged.
- Deep wells: In deep well, one or several individual wells are drilled, and submersible pumps are placed in each shaft. The deep well technique is best suited for deep excavations where large water volumes need to be discharged.
- Bypass dewatering: When sewer lines need maintenance, the sewage flow is pumped around the damaged pipe section using dewatering pumps. The pumps are installed upstream of the maintained pipe section. Bypass technique is also common in irrigation and construction projects.
- Flood control: Flood control refers to all methods used to reduce or prevent harmful effects of flooding from for example storm water and heavy rainfall. Be it construction, tunneling or mine work, site managers need to be prepared for potential site flooding, keeping pumps that can move high volumes of water against low head pressure nearby. The same applies to elevated water levels in channels, that could have a major impact on local communities when roads and houses get flooded. It is important that municipalities have good flood protection and are prepared to act quickly on these occasions.
- Tunneling dewatering: Tunnel constructions are complex worksites where many variables need to be taken into consideration. Significant volumes of water from the construction site need to be removed in order to stabilize the ground or prevent flooding of the work area. Tunnel boring machines and drilling equipment require a reliable supply of cooling water, which must be recovered, extracted and treated after use. Tunneling projects require many dewatering pumps on site, ranging from small submersible pumps to very large units for large volume dewatering applications. For more detailed information, we recommend reading the article Keeping the water where you want it in tunnel construction.

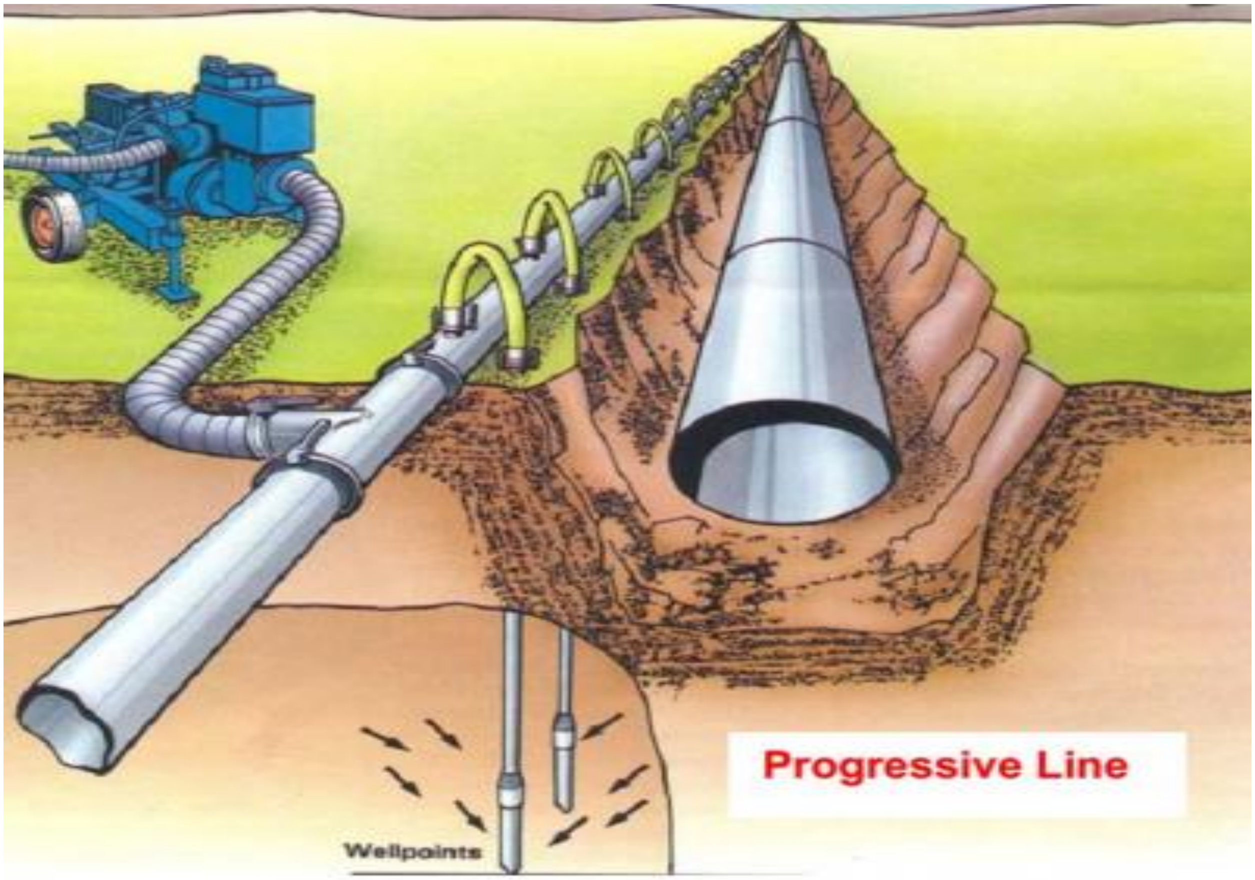


Figure 2. 1 Dewatering Technique

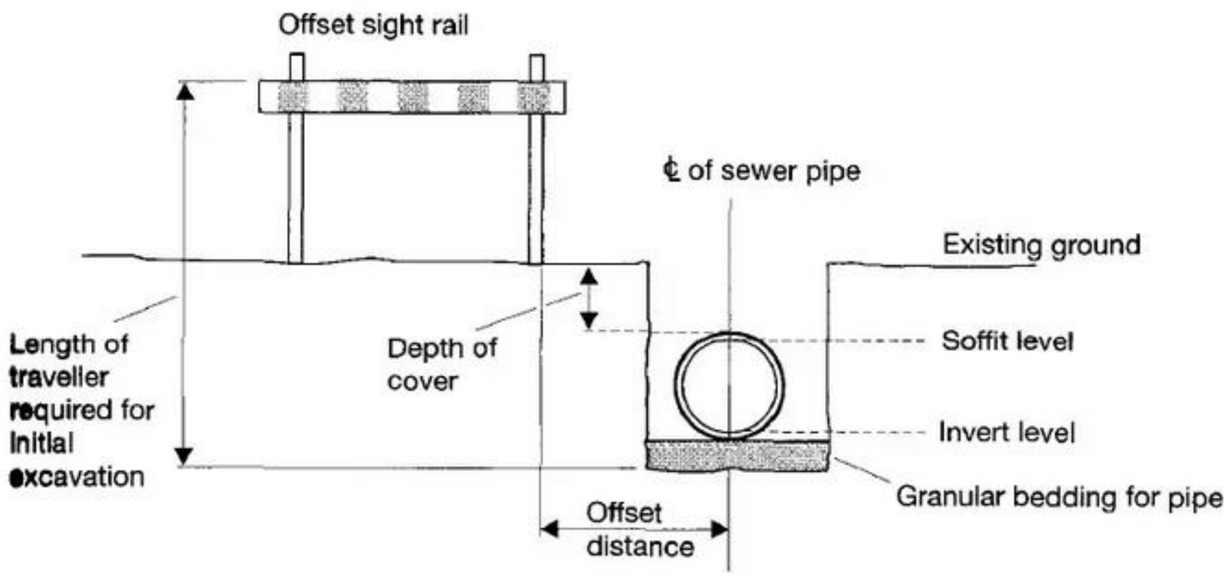
2.3 Setting Out of Main Pipe System

2.3.1 Introduction to Setting out

Setting Out is the establishment of the marks and lines to define the position and level of the elements for the construction work so that works may proceed with reference to them. This process may be contrasted with the purpose of surveying which is to determine by measurement the positions of existing features. A definition of setting out, often used, is that it is the reverse of surveying. Whereas surveying is a process for forming maps and plans of a particular site or area, setting out begins with plans and ends with the various elements of a particular plan correctly positioned on site. However, most techniques and equipment used in surveying are also used in setting out i.e. while surveying may be the opposite of setting out, the processes and instruments are almost identical. The International Organization for Standardization (ISO) define setting out as: Setting out is the establishment of the marks and lines to define the position and level of the elements for the construction work so that works may proceed with reference to them.

2.3.2 Setting Out of Pipeline

This operation falls into the first category of setting out. General considerations: sewers normally follow the natural fall in the land and are laid at gradients which induce self-cleansing velocity. The figure below shows a sight rail offset at right angles to a pipe line laid in a granular bedding trench.



Setting out using sight rail

- Horizontal control: the working drawings will show the directions of the pipelines and the positions of the manholes. The line of the sewer is normally pegged at 20 to 30m intervals using coordinate methods of positioning from reference points or in relation to existing detail. The direction of the line can be sighted using a theodolite and pegs.
- Vertical control: involves the erection of sight rails some convenient height above the invert level of the pipe.
- Erection and use of sight rails: the sight rail uprights are hammered firmly into the ground, usually offset from the line rather than straddling it. Using a nearby temporary bench mark (TBM) and leveling equipment, the reduced levels of the tops of the uprights. Where the natural slope of the ground is not approximately parallel to the proposed pipe gradient, double sight rails can be used. Often it is required to lay water pipelines in adjacent trenches.

- Pressurized main water system: Pressurized water pipes are used for the drinking water that comes into your home and for carrying out waste.

2.3.3 Setting Out Tools and Equipment

The tools and equipment used for setting outs are tape, folding rule, tri square, sprit level, plumb bob, alignment string, graphite pencil, hose level, leveling equipment, and total station.

A. Tapes rule: is the most basic important measuring tool that is used for short measurements that do not require any great accuracy. The common lengths are 150 mm and 300 mm. Metric steel rules are graduated in millimeters (mm) and centimeters (cm).

Figure 2. 2 Tapes rule

B. Folding Rules: These folding rules are usually from two to six feet long. The folding rules cannot be relied on for extremely accurate measurements because a certain amount of play develops at the joints after continued use.

Figure 2. 3 Folding rules

C. Try Square: IS made of a steel or wood stock (1) and a blade (2). The blade is from 2 to 12 inches long and is graduated in eighths. The try square is used to set or check lines which are at right angles (90 degrees) to each other.

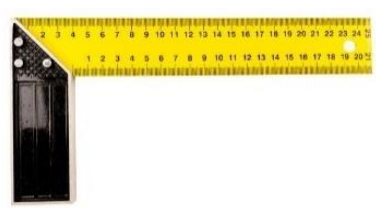


Figure 2. 4 Try square

D. Spirit Level: used to check whether the surfaces are level (horizontal) or plumb (vertical). Available in various length with either traditional bubble gauges or electronic display.

Figure 2. 5 Sprit level

E. Plum bob: is made of metal. When suspended from a vertically attached string, it is employed to check the vertical alignment of corners and surface of walls. A freely hanging plumb bob gives exactly the vertical alignment, because any undisturbed freely hanging mass points to the center of the earth.

Figure 2. 6 Plum bob

F. Alignment string: is a rope used to transfer horizontal & vertical alignments or lines, i.e., use to mark base line on the floor or vertical point alignments of wall.

Figure 2. 7 Alignment string

G. Graphite Pencil: This is used for marking in wall construction. It is specially produced for this purpose in such a way that it will not wear out fast.

Figure 2. 8 Graphite pencil

H. Hose level: It is a transparent PVC hose. It is used to transfer or mark vertical levels on surface of wall when it is filled with water, but without any air bubbles. The water level in each end of the hose is equal. It is an instrument to mark equal levels on site. It is very accurate but not eases to handle.

Figure 2. 9 Hose level

I. Leveling Equipment: is used in the construction field to set up level points and to check elevations. It is an optical instrument used mainly in surveying and building but is also useful for transferring, setting, or measuring horizontal levels.

Figure 2. 10 Leveling equipment

J. Total station: A total station can measure angles and distances electronically and process trigonometrically to give us, at a minimum, position coordinates in space.

Figure 2. 11 Total station

2.3.4 Pipe Laying-Setting Out

Setting out is a crucial step in the pipe-laying process that involves marking the precise locations and alignments of pipes before their installation. It ensures accurate positioning and alignment of pipes to meet design specifications. Here are key aspects of the setting out process in pipe laying:

A. Design Reference: Refer to the engineering drawings and design plans to understand the intended layout, alignment, and elevations of the pipes. These documents provide the necessary information for setting out the pipe network accurately.
B. Surveying and Measurement: Utilize surveying equipment, such as total stations, GPS receivers, or laser levels, to accurately measure distances, angles, and elevations. Conduct surveys to establish control points and reference markers for the pipe network.
C. Alignment and Grades: Determine the desired alignment and grade of the pipe network, considering factors such as the topography, drainage requirements, and connectivity to existing infrastructure. Mark the centerline and alignment of the pipes along the designated route.
D. Benchmarks and Levels: Establish benchmarks or reference points to ensure consistent elevation throughout the pipe network. Use laser levels or automatic levels to measure and set the required elevations for the pipes.
E. Marking and Staking: Use paint, flags, or stakes to mark the locations of pipe fittings, bends, junctions, and connection points. Install stakes at regular intervals along the alignment to guide the pipe installation process accurately.
F. Trench Excavation: Use the marked locations as a guide for trench excavation. Excavate the trench along the marked alignment, ensuring the correct width and depth to accommodate the pipes and any required bedding materials.
G. Alignment Checks: Regularly check and adjust the alignment of the pipes during the installation. Use string lines, laser levels, or other alignment tools to verify that the pipes are correctly positioned and aligned according to the design specifications.
H. Elevation and Gradient Control: Monitor and control the elevation and gradient of the pipes throughout the installation. Ensure that the pipes have the appropriate slope to facilitate proper flow and drainage.
I. Quality Control and Documentation: Document the setting out process, including measurements, alignment checks, and any adjustments made. This documentation helps ensure quality control and provides a reference for future maintenance or modifications.

J. Compliance and Standards: Adhere to local codes, regulations, and industry standards when setting out the pipe network. Consider factors such as pipe material specifications, jointing methods, and safety requirements during the setting-out process.

2.4 Excavation Requirements

2.4.1 Excavation for Pipeline

Excavation plays a fundamental role in the construction industry: it is a practice that involves the removal of rocks or soil from the ground in order to prepare foundations for buildings, by excavation, splitting, trench digging and also for wells and tunnels.

Figure 2. 12 Pipeline excavation

Preparations for pipeline construction

Before the work can begin, a plan for the project must be prepared. The plan should include at least the following details:

- The location and depth of the main that is to be installed
- The location of valves, hydrants, and all fittings that can be anticipated
- The location and depth of all sewer and gas pipes, electric, telephone, television and streetlight cables in the line of the new construction
- Details of any other obstructions that must be protected or avoided

2.4.2 Basic Design Principles

A. Trench width: If work is done by a backhoe, the appropriate bucket width to use is based on pipe size, trench depth and local experience concerning soil conditions. On the other hand, the trench width should be minimized to save time and possible site damages, yet, as already mentioned, wide enough to allow proper installation, i.e. there should be enough room to make up the pipe joints, tamp backfill under and around the pipe, and maintain the trench wall. Generally, the trench width should be no more than 0.3 to 0.6 m greater than pipe diameter. Especially under paved areas, it is important to keep the trench width as narrow as possible to minimize the traffic load that will be transmitted down through the backfill and exerted on the pipe. If there are unusually heavy surface loads, special installation recommendations should be considered.

B. Trench depth: In warmer climates, the depth is designed to sufficiently spread surface loading and protect the pipe from damage. The minimum cover for mains is typically 0.8 m, and 0.5 m for water services. In colder areas, the depth is dependent on the maximum depth of frost (knowledge of local conditions necessary). If the pipes are too shallow in such climates, water services will freeze at the point of connection. If adequate burial depth is not possible, the main can be insulated (e.g. closed-cell Styrofoam insulation).

C. Excavation: The excavated material should be piled at least 0.6 meters from shallow trenches. For deeper trenches, it must be piled even further away. This minimizes the risk that dirt or stones are kicked into the construction down to a worker or that excavated material falls back. Furthermore, there must be enough space for the laborer to walk along the construction. A safe deposit distance also prevents someone from tripping and falling into the trench. Moreover, the weight of the excavated material must be considered. If it is not deposited correctly, it could lead to a cave-in of the trench. The bottom of the trench should be buried as close as possible to the specified grade so that it provides a continuous, even support for the pipe. After the pipe has been placed, high points must be levelled out and low points should be filled to provide a good support for the pipe.

D. Cost considerations: The costs for excavation depend on various criteria. Rocky ground, for example, slows down the excavation, while very sandy and unstable ground must be shored, which requires extra material and knowledge. Furthermore, of course, the size of the trench (depth, width) affects the costs. For very deep and wide trenches, heavy machinery is necessary.

E. Safety: The excavation should not be started much ahead of pipe laying. The main reason for this is that the longer the construction stays open, the more likely it is to have a cave-in (especially during heavy rainfall). At the end of the day, it is best to be completely backfilled or at least protected by barricades and lights. If there is traffic and the trench cannot be filled, it should be covered with heavy steel plates. If the trench is very deep or soil conditions are bad, the construction should be protected to prevent a cave-in.

Figure 2. 13 Vertical shores to prevent a cave-in

2.4.3 Excavation Tools and Equipment

A. Shovel: is tool which is used for the purpose of lifting of excavated soil. It is also similar to spade the difference between spade and shovel is the difference in leading edge. The curvature of metal plate of shovel is generally higher when compared to spade so we can hold the soil easily and lifted it. Shovel can also be used for digging purpose in case of soft soils, sand etc.

Figure 2. 14 Shovel

B. Hoe: is an excavating tool which consists a metal plate attached to a long handle with acute angle. The plate having sharp edge is used to excavate the soil. For small work of excavation, it is widely preferred tool. Sometimes metal plate is replaced by fork type plate.

Figure 2. 15 Hoe

C. Rake is a tool which is having a horizontal rod having metal teeth and is used to remove the small layers of soil.

Figure 2. 16 Rake

D. Pick axe consists hard spike attached perpendicular to handle. They are used for excavating small trenches in soil. Pick axe can cut the soil even if the soil is of hard type. The metal spike is pointed on one side and wide blade is provided on the other side.

Figure 2. 17 Pick axe

E. Mattock: This looks like pickaxe. But serious digging is not possible with mattock. Generally, it is used as lifting tool because of its curve shapes metal at its bottom.

Figure 2. 18 Mattock

F. Excavators: are heavy construction equipment consisting of a boom, dipper, bucket and cab on a rotating platform known as the "house". The house sits atop an undercarriage with tracks or wheels.

Figure 2. 19 Excavator

2.4.2 Pipeline Excavation Techniques

Excavation plays a crucial role in the pipe-laying process as it involves carefully and precisely digging trenches or excavating areas where pipes will be installed. Here are some key aspects of excavation in pipe laying:

A. Trenching: Trenching is the primary excavation method used for pipe laying. It involves the excavation of a trench along the designated path for the pipes. The width and depth of the trench depend on the pipe size, soil conditions, and any specific requirements or regulations.
B. Surveying and marking: Before excavation begin, surveying is done to mark the alignment and depth of the trench accurately. This ensures that the trench is dug in the correct location and follows the desired grade and slope.
C. Soil classification: The type of soil encountered during excavation plays a significant role in determining the excavation method, trench support requirements, and backfilling considerations. Soil conditions can range from cohesive soils (clay) to granular soils (sand and gravel) or a combination of both.
D. Excavation equipment: Excavation for pipe laying is typically performed using excavators, which come in different sizes and configurations depending on the scale and complexity of the project. Excavators equipped with buckets or specialized attachments are used to dig and remove soil from the trench.
E. Sloping and benching: Proper sloping or benching techniques are employed to ensure the stability and safety of the trench walls. Sloping involves angling the sides of the trench, while benching creates horizontal platforms at intervals along the trench.
F. Shoring and trench support: In situations where the soil conditions are unstable or the trench depth exceeds a certain threshold, shoring or trench support systems may be required. These systems provide temporary support to prevent cave-ins and protect workers during excavation.
G. Safety considerations: Excavation work presents inherent risks, such as cave-ins, falling objects, or contact with utilities. It is crucial to follow proper safety protocols, including the use of protective barriers, ensuring adequate ventilation, and conducting regular inspections to maintain a safe work environment.
H. Spoil management: Soil or excavated material, known as spoil, needs to be managed appropriately. It may be stockpiled nearby for later use as backfill material or transported off-site for disposal or reuse, depending on the project requirements and local regulations.

I. Environmental considerations: Excavation activities should consider any potential environmental impacts, such as the protection of water bodies, sensitive habitats, or cultural heritage sites. Erosion control measures should be implemented to prevent sediment runoff and contamination.

2.5 Supporting Mechanism to Install Main Pipe System

2.5.1 Shoring

Shoring methods are used in pipe laying to provide temporary support and prevent the collapse of trenches or excavations. The selection of the appropriate shoring method depends on factors such as soil type, trench depth, adjacent structures, and safety requirements. Here are some common shoring methods used in pipe laying:

A. Timber shoring: Timber shoring involves using timber planks or boards to support the trench walls. Vertical members called soldier piles are installed at intervals along the trench, and horizontal timber planks are placed between them. This method provides effective support and is relatively simple and cost-effective.
B. Hydraulic shoring: Hydraulic shoring utilizes hydraulic jacks and vertical steel or aluminum hydraulic cylinders to provide support to the trench walls. These cylinders, also known as hydraulic shores or trench jacks, are placed against the trench walls and adjusted to provide the necessary support. Hydraulic shoring is flexible and allows for easy installation and adjustment.
C. Trench boxes: Trench boxes, also known as trench shields or trench sheets, are prefabricated steel or aluminum structures that are placed in the trench to support the walls. They consist of two vertical sidewalls connected by horizontal panels. Trench boxes are available in different sizes and configurations and provide a safe working space within the trench.
D. Slide rail systems: Slide rail systems consist of vertical steel posts (rails) that are installed in the trench using a track and panel method. The rails are inserted as the trench is excavated, and horizontal panels are inserted between the rails to provide continuous support. Slide rail systems offer versatility and ease of installation and can be used in a wide range of soil conditions.

E. Sheet piling: Sheet piling involves driving interlocking steel or vinyl sheets into the ground along the trench walls. This method provides lateral support to the excavation and prevents soil movement. Sheet piling is commonly used in areas with loose or sandy soils.

F. Soil nailing: Soil nailing is a technique where reinforcing bars or grouted anchors are installed into the soil at an inclined angle to provide stability to the trench walls. The bars or anchors are grouted or bonded to the soil to create a composite mass. Soil nailing is suitable for cohesive soils and can provide long-term stability.

G. Braced excavation: Braced excavation involves installing structural supports, such as steel or aluminum beams, against the trench walls to prevent collapse. These supports are typically combined with diagonal braces or whalers to provide additional stability. Braced excavation is used for deeper trenches or when encountering unstable soil conditions.

2.5.2 Pipe Bedding

A. Bedding, in the context of trenchless technology, is the material laid below a pipe that supports the pipe against the top and adjacent soil load on the pipe. To prevent pipe failure, proper, graded bedding materials need to be compacted and laid all along the trench so that the load is evenly distributed. The greater the difference between the width of the trench and the pipe, the greater the load on the pipe. Bedding and filling materials are used in the sewage and pipeline construction in order to substantially contribute to the structural stability of the underground building and where appropriate to the building on the street, as part of the pipe/ ground structural support system.

Figure 2. 20 Pipe bedding

B. **Bedding Material:** Pipe Bedding Materials, as their name implies, are usually used in trenches, underlaying precast concrete, plastic, or other types of pipe. Pipe bedding materials must be capable of supporting loads without deflection or settling, but also must be free-draining to prevent water build-up near the pipe zone. For this reason, pipe bedding materials are usually a mix of crushed or natural gravels and a washed sand product. Although some variation in aggregate properties is expected, a few of the characteristics that should be considered when selecting Pipe Bedding Materials include: size and grading, toughness and hardness, and cleanliness.

Figure 2. 21 Bedding material

C. **Hard foundations:** If hard or unyielding material cannot be removed, increase the bedding depth to 6"-10" or as directed by a geotechnical engineer.

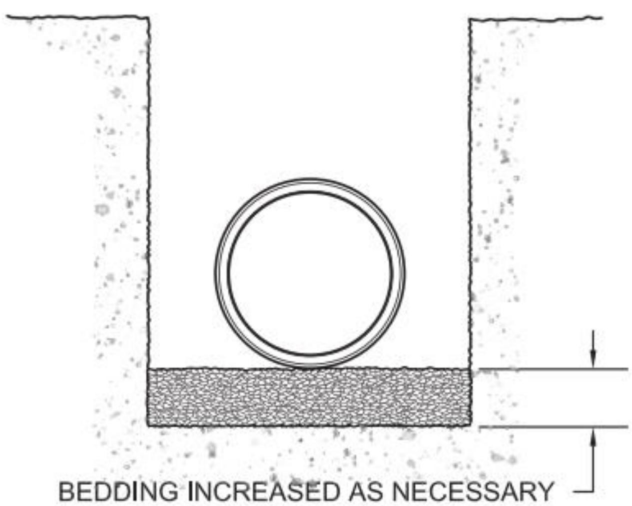


Figure 1. 11 Hard foundations

The foundation must be dry, supportive and stable to provide long-term uniform pipe support. If foundation material is unable to provide adequate pipe support, corrective measures should be taken to remove, displace, or reinforce the soils.

Self-Check-2

Part I: True or False question

Instruction: Say true if the statement is correct and false if the statement is incorrect.

___________ 1. Dewatering is often a critical component of construction projects.

___________ 2. Setting Out is the establishment of the marks and lines to define the position and level of the elements for the construction work so that works may proceed with reference to them.

___________ 3. The foundation must be wet, unsupportive and unstable to provide short-term uniform pipe support.

Part II: Matching

Instruction: Match Terms in column A with its meanings in column B.

	A	B
______	1. Sprit level	A. is used for measurements
______	2. Tapes rule	B. is used to check lines at right angles (90 degrees)
______	3. Hose level	C. is used to transfer or mark vertical levels
______	4. Try square	D. is a rope used to transfer horizontal & vertical alignments
______	5. Alignment string	E. is used to check whether the surfaces are level or plumb

Part III: Short Answer Questions

Instructions: Answer all the following questions accordingly.

1. During pipe installation, what are the primary inputs?
2. List pipe installation stages.
3. List basic materials for installation of the pipeline work.

Operation Sheet 1

Operation title:

- Set out and excavate trench pipeline and manholes

Purpose:

- To practice and demonstrate the knowledge and skill required to set out and excavate trench for pipeline and manholes.

Instruction:

- Use given tools and equipment to set out and excavate trench for pipeline and manholes. For this operation you have given 6 Hour and you are expected to provide the answer on the given table.

Precautions:

- Follow OSH safe work practice standards.

Tools and requirement:

- Measuring tape
- Earth nail
- Leveling equipment
- Tri square
- Claw hammer
- Bow saw
- Spirit level

Procedures for setting out and Excavation Trench for pipeline and manholes:

Preparation for Setting out

1. Ensuring that control station and levelled benchmarks have been traversed and checked.
2. Ensuring that the instruments have been checked, levels are 2 pegs tested and that they have current instrument calibrated recorded.
3. Checking that the proposed work area has been checked with a cable avoidance tool.
4. Its advisable to use a non-metallic staff when working near electricity.
5. Check local authority and utility company drawings for existing services, use hand dug trial holes if required to locate and mark known services, if theses are found then the method statement should mansion this and the safe work method to be used.

Setting out and excavate trench for pipeline and manholes accurately

1. Setting out drains is to set out the baselines which is usually the centerline of the pipeline.
2. A plan showing the lines of existing and proposed pipelines, the line of the new pipelines is then marked on the ground by placing a peg at each manhole or inspection chamber position obtained by setting out scaled or recorded dimensions from the plan.
3. Manholes will be built at the following positions:
    a. At the maximum of every 100m or straight runs.
    b. At all changes of direction
    c. At all pipeline junctions.
    d. At the head of each pipelines.
    e. At interceptions near junctions of pipeline.
4. Once the position is located, line pegs are placed every 20 or 30 along the length lines as a guide to the excavation.
5. After pegging, longitudinal sections are run and sections are also drawn indicating the ground profile and any features or other services crossing the path of the new pipeline to provide all information necessary for the pipeline scheme design and so that the depth of excavation and any problem peculiar to the site may be evaluated and costed.
6. From longitudinal section, working profiles are prepared showing the gradient of pipeline run and invert levels (level of bottom of the inside of any pipe or channel or in manhole, the level of the channel floor of the outgoing pipe of all manholes and junctions.
7. After pegging, the position of manholes and inspection chambers which are required at every change of direction or gradient in all drainage runs (except very large diameter pipes) should be established. The limit of these manholes should be marked with pegs from manual excavation or set with cutting blades where machines are used. There should be proper control for position, level, and excavation works.
8. After excavation, pegs are referenced to mark the final manhole positions.

Quality Criteria:

- The levelling error must be $e \leq \pm 24 \frac{mm}{km}\sqrt{d}$ for normal leveling.
- Check the excavation area is excavated according to drawing and specification.

LAP Test 1

Practical Demonstration

Name: ___________________________ Date: ________________________

Time started: ____________________ Time finished: _______________

Allotted Time: 8 Hours

Instruction I: Setting Out Pipeline and Manhole

Task 1. Prepare tools and equipment for setting out pipeline and manhole

Task 2. Setting out pipeline and manhole

Task 3. Excavate trench for pipeline and manhole

Unit Three: Installation and Testing Pipeline

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

- Lowering, Placing and Joining Pipeline
- Placing Pipes and Fit Valves, Fittings and Flow Control Devices
- Checking Alignment Level and Grade
- Positioning and Checking Pipeline Support
- Backfill Procedure
- Constructing Valve Chambers, Minor Structures and Thrust Blocks
- Constructing Manholes
- Test for Pipelines Performance
- Cleaning Up Work Area

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

- Place and join pipes in position
- Place pipes and fit valves, fittings and flow control devices
- Check alignment level and grade
- Position and check pipeline support
- Monitor backfill procedure
- Construct valve chambers, minor structures and thrust blocks
- Construct manholes
- Identify test for pipelines performance
- Apply clean-up work area

3.1Lowering, Placing and Joining Pipeline

3.1.1 Material for Pipelines Installation

The materials which used for pipe installations are pipes, fittings, jointing, and backfill materials.

A. Pipes: The choice of pipe material depends on the specific application. Common pipe materials include PVC (Polyvinyl Chloride), HDPE (High-Density Polyethylene), ductile iron, steel, and concrete.

- **Polyvinyl Chloride (PVC) Pipes**: The polyvinyl chloride (PVC) pipe can be made of a mix of vinyl and plastic. It is strong, and is not easily damaged and also long-lasting. It won't get rusty, or rot, or wear out with time. Because of this, PVC Pipe Uses is noteworthy in water systems, Underground Cables, and sewers.

Figure 3. 1 Polyvinyl Chloride (PVC) Pipes

- **High-Density Polyethylene (HDPE) Pipes**: is a polyethylene thermoplastic made from petroleum. HDPE is commonly recycled and made into composite wood or plastic lumber. The density of HDPE can range from 930 to 970 kg/m^3. Although the density of HDPE is only marginally higher than that of low-density polyethylene, HDPE has little branching, giving it stronger inter-molecular forces and tensile strength than low-density polyethylene.

Figure 3. 2 High-density polyethylene (HDPE) pipe

- **Ductile Iron Pipes**: is pipe made of ductile cast iron commonly used for potable water transmission and distribution. This type of pipe is a direct development of earlier cast iron pipe, which it has superseded. Water based pipe coatings, are an environmentally friendly coating that is applied to the inner & outer diameter of ductile iron pipe. They protect against corrosion from the outside and inside, and also protect the product from contamination. The coating is an emulsion manufactured using asphaltene and water primarily, with other raw materials.

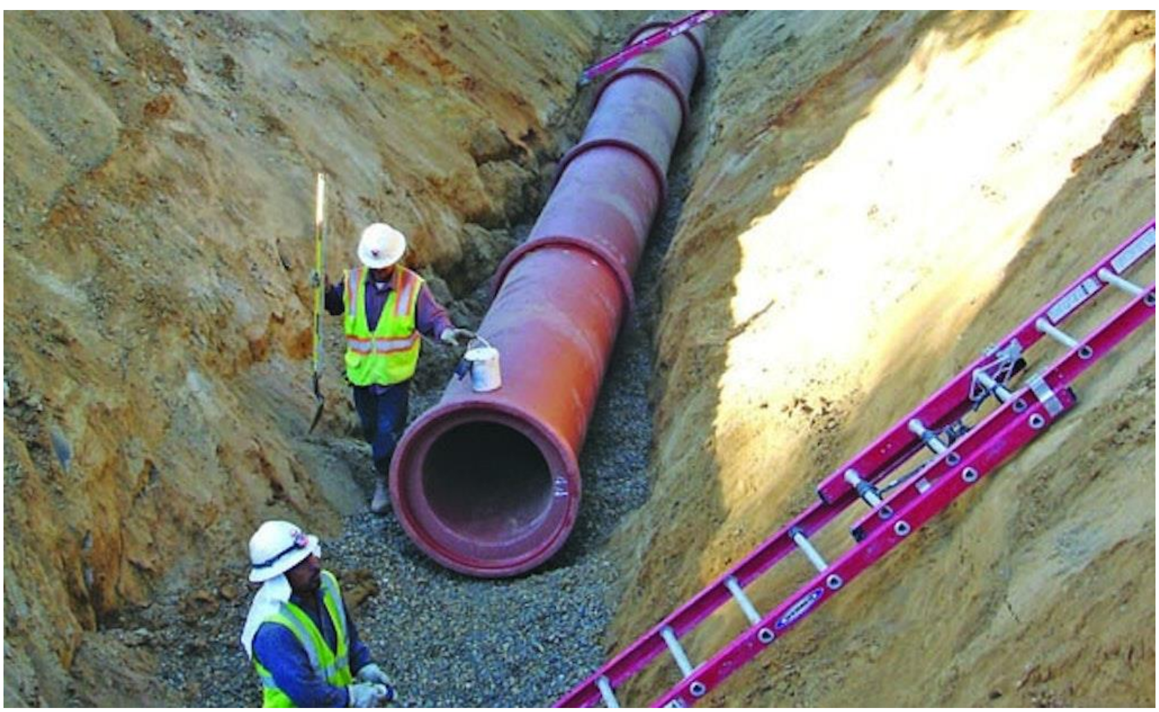


Figure 3. 3 Ductile iron pipes

- **Steel Pipes**: cylindrical tubes made from steel that are used many ways in manufacturing and infrastructure. They're the most utilized product made by the steel industry. The primary use of pipe is in the transport of liquid or gas underground including oil, gas, and water.

Figure 3. 4 Steel pipe

- **Concrete Pipes**: Concrete pipes are pipes made from concrete. They provide various advantages including, easy installation, superior corrosion resistance, highly durable, environmentally friendly, sustainable, custom-designed fittings, high strength, and low maintenance costs. Because of all these benefits, concrete pipes have become a popular choice for storm sewers, culverts, underground detention and retention systems, sanitary sewers, and sometimes water pipelines.

Figure 3. 5 Concrete pipe

B. Fittings: Fittings are used to connect and join pipe sections, allowing for changes in direction, size, and branching. Common fittings include elbows, tees, couplings, valves, and flanges.

Figure 3. 6 Fittings

C. Jointing Materials: Depending on the pipe material, jointing materials such as solvent cement, adhesives, gaskets, or welding rods may be required to ensure secure and watertight connections between pipe sections.

Figure 3. 7 Jointing materials

D. Backfill Materials: After pipes are laid in the trench, suitable backfill materials like sand, gravel, or a specified engineered material are used to cover and support the pipes, providing stability and protection.

Figure 3. 8 Backfill materials

3.1.2 Tools and Equipment for Pipelines Installation

The tools and equipment for pipelines installation are excavators, pipe layers, trenching machines, pipe cutters, welding equipment, compactors, and testing equipment.

A. Excavators: Excavators are used to dig trenches or excavate areas for the installation of pipes. They come in various sizes and configurations to suit different project requirements.

Figure 3. 9 Excavators

B. Pipe Layers: Pipe layers are specialized machines designed to lift and position pipes into the trench. They ensure accurate placement and alignment of pipes during installation.

Figure 3. 10 Pipe Layers

C. Trenching Machines: Trenching machines, such as trenchers or backhoes, are used to excavate the trench in which the pipes will be laid. They come in different sizes and types, including chain trenchers and wheel trenchers.

Figure 3. 11 Trenching machines

D. Pipe Cutters: Pipe cutters, such as reciprocating saws or cut-off saws, are used to cut pipes to the required lengths during installation.

Figure 3. 12 Pipe cutters

E. Welding Equipment: In cases where pipe joints require welding, welding equipment such as welding machines, electrodes, or fusion equipment may be necessary to create strong and secure welded connections.

Figure 3. 13 Welding equipment

F. Compactors: Compactors, such as vibratory compactors or plate compactors, are used to compact the backfill material around the laid pipes, ensuring stability and preventing settlement.

Figure 3. 14 Compactors

G. Testing Equipment: Various testing equipment, including pressure gauges, leak detection devices, and cameras, are used to inspect and test the integrity of the installed pipes, ensuring they meet the required standards.

Figure 3. 15 Pressure testing

3.1.3 Pipeline Installation

The laying of pipes is a vital step in the construction of a functional pipeline system. It involves the installation of pipes and related components to ensure the efficient and reliable transmission of water. The process includes various stages, such as planning, excavation, pipe placement, jointing, and backfilling. Careful consideration is given to factors like pipe materials, diameter, route selection, and connectivity to ensure the longevity and effectiveness of the pipeline infrastructure. Proper installation and maintenance of pipes are crucial.

A. Pipe Lowering and Laying Procedures

Pipe laying between two adjacent manholes/chainages shall be started from the lower elevation to higher elevation for easy draining of ground water in the trench. However, there can be case where need to lay pipes in opposite direction also.

- All pipes shall be laid to lines and grades shown on the drawings.
- Open ends of the installed pipes shall be plugged with a watertight plug/other approved way when there is no pipe laying in progress.
- When the pipes are to be ready for joining the plug shall be taken off.
- Material used for plugging shall be approved type that shall adequately protect the pipe from damage, prevent dirt, debris and water from entering the pipe.
- All pipes shall be checked for defects and cleaned before joining.

B. Ductile Iron Pipe Laying

- All pipes shall be carefully inspected for defects before installation.
- Proper installation of pipe shall be carried following steps.
  - ➢ Excavation
  - ➢ Preparation of the bed for pipe
  - ➢ Placing the pipe without damage
- The section of the pipe shall be fitted together correctly.
- Pipe shall be laid true to line and grade.
- As far as possible pipe shall be lowered by a crane.
- Whenever the work ceases for any reason the unfinished end of the pipeline shall be securely closed.

- Where the water table is encountered, shall be kept below the sockets when joining by pumping or any other mean.
- Concrete Protection: Encased Concrete for pipes shall not be placed until the joints at each end of the pipe have been completed.

C. UPVC Pipe Laying

- Pipes shall be stored out of direct sunlight but ventilation shall be provided.
- Cutting of the pipe shall be kept to a minimum.
- Cuts shall be perpendicular to the axis of the pipe and smooth.

3.1.4 Joining of Pipelines

Pipe joints are connections used to join individual pipes together, creating a continuous flow path in plumbing and piping systems. These joints are designed to provide secure and leak-free connections, ensuring the efficient transfer of fluids or gases. Different types of pipe joints are used based on factors like the pipe material, application, and required strength and flexibility. Properly selected and installed pipe joints are vital for the integrity and functionality of piping systems. These methods include:

A. Threaded Joints: Pipes with threaded ends can be joined by screwing them together using compatible fittings. This method is commonly used for smaller-diameter pipes and is typically made of materials such as steel or brass.

Figure 3. 16 Threaded joints

B. Solvent Welding: For plastic pipes, solvent welding is a common joining method. It involves applying a solvent adhesive to the pipe ends, which chemically bonds and fuses them together, creating a strong and watertight connection.

Figure 3. 17 Solvent welding

C. Compression Joints: Compression fittings are used to join pipes without the need for specialized tools or heat. These fittings consist of a compression nut, an insert, and a compression ring, which are tightened to create a seal between the pipe and the fitting.

Figure 3. 18 Compression joints

D. Heat Fusion: Heat fusion is primarily used for joining polyethylene (PE) pipes. It involves heating the pipe ends to a specific temperature and then joining them together, allowing the melted material to cool and create a solid and permanent connection.

Figure 3. 19 Heat fusion

3.2 Placing Fit Valves, Fittings and Flow Control Devices

Pipe fittings are components used to join pipe sections to each other or other fluid control components (e.g., pumps and valves) to construct pipelines. Pipe valves are a type of pipe fitting designed to control the flow of fluid through a pipeline.

3.2.1 Stop Valves: are used to shut off flow of hot or cold water in plumbing fixture. Stop valve is a valve system which is designed to stop flow of liquid through a pipe it is generally used in important machinery or a human workstation.

Figure 3. 20 Stop valves

3.2.2 Non-Return Valves: also known as a check valve, clack valve, one-way valve or retention valve, is designed to allow fluid to flow in one direction only, therefore preventing the liquid or gas from flowing back upstream of the valve.

Figure 3. 21 Non-return valves

3.2.3 Flow Control Valves: are regulates the flow or pressure of a fluid. Control valves normally respond to signals generated by independent devices such as flow meters or temperature gauges.

Figure 3. 22 Flow control valves

3.2.4 Air Release Valves: are designed to discharge air pockets from the pipeline in order to maintain efficient water flow. An air release valve is typically used in water or irrigation schemes to ensure that any entrained air in the water system is automatically released in order to maximize the system performance. Entrained air pockets in pipes can cause excessive head loss and flow reductions if air is not effectively released.

Figure 3. 23 Air release valves

3.2.5 Waste and Leak Detection Meters: Activated when the flow of water passing through the water meter or data logger is at a flow rate above a pre-set maximum for a pre-set period of time. This usually involves installing a system which detects higher than normal flow rates at meters or sub-meters.

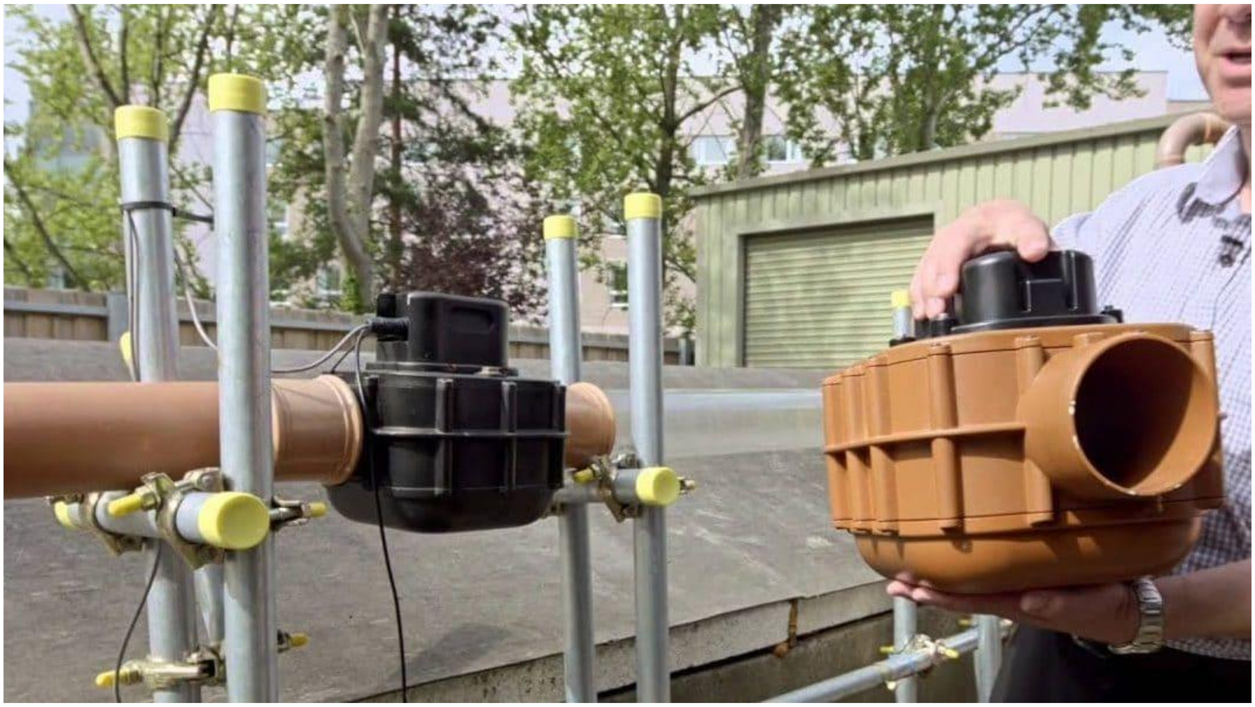


Figure 3. 24 Waste and leak detection meters

3.2.6 Pressure Control Valves: are used in hydraulic systems to deal with and control the actuator force. The actuator force is produced by a hydraulic actuator that consists of a cylinder or fluid motor, which uses hydraulic power to enable a mechanical operation.

Figure 3. 25 Pressure control valves

3.3 Checking Alignment Level and Grade

The pipeline should be laid to the correct alignment and gradient by setting the positions and levels of sewers so as to ensure a smooth gravity flow. This is done with the help of suitable boning rods and sight rails, and a levelling instrument. Modified levels of invert are first obtained by adding a suitable vertical length to the invert levels mentioned on the longitudinal section.

These modified levels of invert are marked on the sight rail. These levels are marked either by fixing nails on sight rails or by adjusting the top of sight rails to the modified invert levels of pipeline. Thus, an imaginary line parallel to the proposed pipeline is obtained on the ground. In order to check the invert level of sewer boning rod, traveller, or levelling instrument is used. The boning rod is a vertical wooden post fitted with a cross-head or tee at top and an iron shoe at bottom. The boning rod is moved to and for in the trench so as to obtain the invert-line of the pipeline on the prepared bed of the trench.

As such the length of the boning rod has to be equal to the height of the sight rail above the invert-line of the sewer which, however, varies along the pipeline line, and hence boning rods of various lengths are prepared. Both the boning rod and the sight rail have their center lines accurately marked with thin saw-cut and painted black and white for proper visibility. A levelling instrument is used in levelling along the invert-line of the pipe. The use of sight rails, boning rods and dumpy level for laying sewers at the desired gradient. The checking must include the horizontal and vertical alignment level and grade.

3.4 Positioning Support Structure

A pipe support or pipe hanger is a designed element that transfer the load from a pipe to the supporting structures. The load includes the weight of the pipe proper, the content that the pipe carries, all the pipe fittings attached to pipe, and the pipe covering such as insulation. The four main functions of a pipe support are to anchor, guide, absorb shock, and support a specified load. Pipe supports used in high or low temperature applications may contain insulation materials. The overall design configuration of a pipe support assembly is dependent on the loading and operating conditions.

3.4.1 Rigid Support

Rigid supports are used to restrict pipe in certain direction(s) without any flexibility (in that direction). Main function of a rigid support can be Anchor, Rest, Guide or both Rest & Guide.

Figure 3. 26 Pipe guides (cylinder pipe guides - spider guides) and Pipe Anchors

A. Stanchion/pipe shoe: Rigid support can be provided either from bottom or top. In case of bottom supports generally a stanchion or Pipe Clamp Base is used. It can be simply kept on steel structure for only rest type supports. To simultaneously restrict in another direction separate plate or Lift up Lug can be used. A pipe anchor is a rigid support that restricts movement in all three orthogonal directions and all three rotational directions, i.e. restricting al the 6 degrees of freedom This usually is a welded stanchion that is welded or bolted to steel or concrete. In case of anchor which is bolted to concrete, a special type of bolt is required called Anchor Bolt, which is used to hold the support with concrete. In this type of support, normal force and friction force can become significant. To alleviate the frictional effect Graphite Pad or PTFE plates are used when required.
B. Rod hanger: It is a static restraint i.e. it is designed to withstand tensile load only (no compression load should be exerted on it, in such case buckling may take place). It is rigid vertical type support provide from top only. It consists of clamp, eye nut, tie rod, beam attachment. Selection of rod hanger depends on pipe size, load, temperature, insulation, assembly length etc. As it comes with hinge and clamp, no substantial frictional force comes into play.
C. Rigid strut: It is a dynamic component i.e. designed to withstand both tensile and compression load. strut can be provided in vertical as well as horizontal direction. V-type Strut can be used to restrict two degrees of freedom. It consists of stiff clamp, rigid strut, welding clevis. Selection depends on pipe size, load, temperature, insulation, assembly length. As it comes with hinge and clamp, no substantial frictional force comes into play.

3.4.2 Spring Support

Spring supports (or flexible supports) use helical coil compression springs (to accommodate loads and associated pipe movements due to thermal expansion). They are broadly classified into variable or constant effort support. The critical component in both the type of supports are helical coil compression springs. Spring hanger & supports usually use helical coil compression springs.

3.4.3 Snubber or Shock Absorber

Dynamic Restraints: The restraint system performs an entirely different function to that of the supports. The latter is intended to carry the weight of the pipe work and allow it to move freely under normal operating conditions. The restraint system is intended to protect the pipe work, the plant and the structure from abnormal conditions; it should not impede the function of the supports. Conditions that necessitate the use of restraints are as follows: earthquake, fluid disturbance, certain system functions, and environmental influences. In areas that are situated on or near to geological fault lines it is common practice to protect the plant from potential earthquake activity. In such plant there will be a very large requirement for dynamic restraints. Fluid disturbance can be caused by the effect of pumps and compressors or occasionally fluid in a liquid state entering a pipe intended for the transportation of gas or steam. Some system functions such as rapid valve closure, pulsation due to pumping and the operation of safety relief valves will cause irregular and sudden loading patterns within the piping system. The environment can cause disturbance due to high wind load or in the case of offshore oil and gas rigs, impact by ocean waves. The restraint system will be designed to cater for all of these influences. A restraint is a device that prevents either the pipe work or the plant to which the pipe work is connected being damaged due to the occurrence of any one or more of the above phenomena. It is designed to absorb and transfer sudden increases in load from the pipe into the building structure and to deaden any opposing oscillation between the pipe and the structure. Therefore, dynamic restraints are required to be very stiff, to have high load capacity and to minimize free movement between pipe and structure.

3.5 Backfill Procedure

Backfilling of the pipeline trench is an important consideration in laying of pipelines. However, the trench should be backfilled only after the laid pipeline has been tested and approved for water tightness of joints. Further when class A bedding is used the backfilling should be carried out only after the concrete has set. The work of backfilling should be carried out with due care, particularly the selection of the soil used for backfilling around the pipeline, so as to ensure the future safety of the pipeline. The method of backfilling to be used varies with the width of the trench, the character of the material excavated, the method of excavation and degree of compaction required. In developed streets, a high degree of compaction is required to minimize the load while in less important streets, a more moderate specification for backfill may be justified. In open country it may be sufficient to mound the trench with the filling material which after natural settlement would return to the original ground level.

The refilling should proceed around and above the pipes. Soft material screened free from stones or hard substances should be first used and hand pressed under and around the pipes up to half of their height. Similar soft material should then be put up to a height of 30 cm above the top of the pipe and this should be moistened with water and well rammed. The remainder of the trench may be filled with hard material, in stages, each not exceeding 60 cm. At each stage the filling should be well rammed, consolidated and completely saturated with water and then only further filling should be continued. Before and during the backfilling of a trench, precautions should be taken against the floatation of the pipeline due to the entry of large quantities of water into the trench causing an uplift of the empty or the partly filled pipeline. After completion of the backfill, the excavated top soil, turf, pavement or road metal should be replaced and surface should be restored fully to the level that existed prior to the laying of the pipeline.

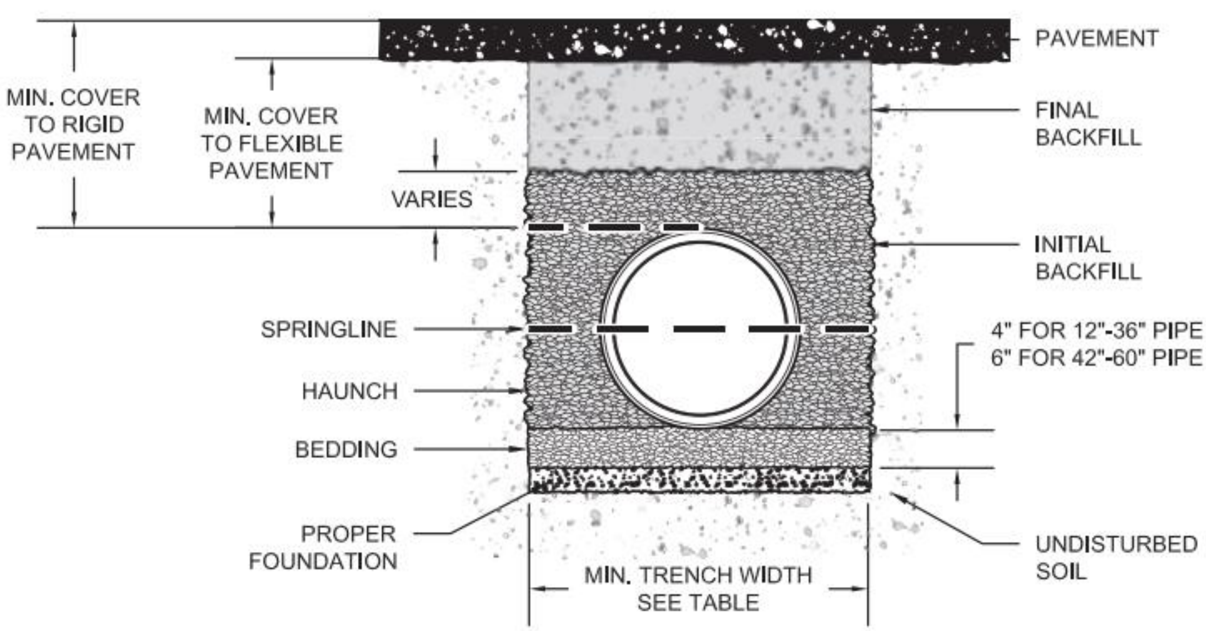


Figure 3. 27 Backfill Material

Table 3. 1 Minimum Cover Heights

Pipe Diameter (in)	Minimum Cover Required[1] (in)
12 - 48	12
60	18

Note:

1. Minimum cover is measured from the top of the pipe to bottom of flexible pavement or to the top of rigid pavement.

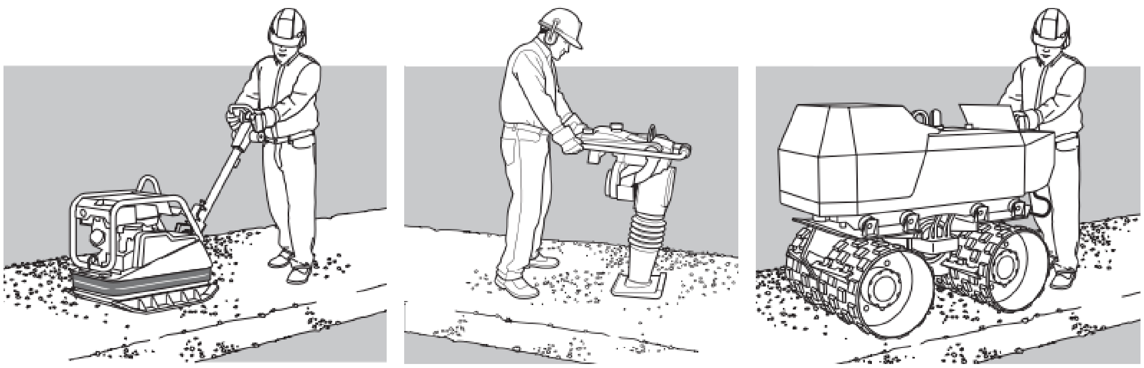


Figure 3. 28 Compacting the backfill

3.6 Constructing Valve Chambers, Minor Structures and Thrust Blocks

3.6.1 Valve Chambers and Minor Structures

Valve chambers are used to open and close water supply and sewerage pipelines. The diameter of the valve chamber is selected depending on the diameter of the pipelines, the number and dimensions of valves. This is a complete chamber with internal piping and suitable valves.

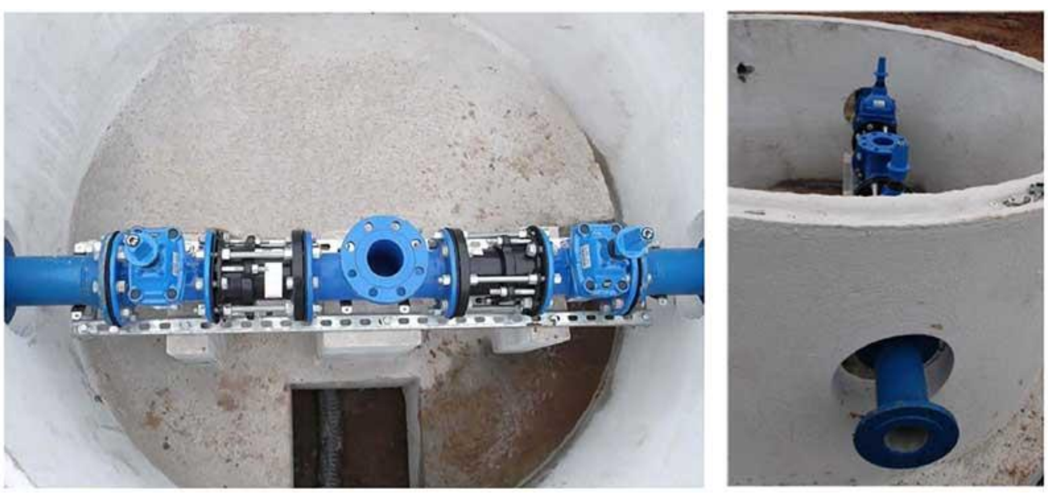


Figure 3. 29 Valve chambers

3.6.2 Thrust Blocks

A thrust block is a concrete pipe restraint that prevents the mainline from moving by transferring pipe loads (mainly due to pressure thrust) to a wider load-bearing surface. Usually, thrust blocks are provided for buried pipelines at fittings requiring branching or direction change. A thrust block prevents separation of joints and pipe movement by transferring the resultant thrust force at a bend to the undisturbed soil behind the thrust block. The bearing strength of the soil is expressed in pounds per square foot. Thrust blocking prevents pipe movement when a pressure system is activated and pressurized thrust blocking is required at all points of change of direction in the pipe line. Most blocking is done where a fitting valve or hydrant is installed.

Figure 3. 30 Thrust blocks

Note:

- For detail reading of constructing concrete materials, please read competencies on concrete and masonry work.

3.7 Constructing Manholes

Manholes are round doorways into the City's water, stormwater, and sanitary sewers. The City's water & sewer crews access manholes to inspect and maintain the pipes that carry water, stormwater and wastewater. Sewer crews rarely enter the manhole - inspections are done from the top, using cameras to inspect the pipes. A manhole (utility hole, maintenance hole, or sewer hole) is an opening to a confined space such as a shaft, utility vault, or large vessel. Manholes are often used as an access point for an underground public utility, allowing inspection, maintenance, and system upgrades. Manholes can be constructed using steel, concrete, and other construction material.

Figure 3. 31 Manhole

3.8 Test for Pipelines Performance

3.8.1 Water Main Pipeline

Hydrostatic Test: After laying the new pipe line, jointing and back filling, it is subjected to the tests. During the laying of pipe line, its hydrostatic test is done in parts. In this way any error of workmanship will be found immediately and can be rectified at the minimum cost. Usually the length of the section to be tested is kept up to 500 m.

A. Pressure Test

Pressure test at a pressure of at least double the maximum working pressure-pipe and joints shall be absolutely watertight under the test. A pressure test on a water pipe is a method of testing newly fitted pipelines for leak tightness. A leak is bad for two reasons. Firstly, a valuable resource is wasted and secondly, it can contaminate the drinking water. Leak tightness is a prerequisite for acceptance and commissioning of the pipe. The test involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurization of the vessel to the specified test pressure. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss.

B. Leakage Test

Leakage test (to be conducted after the satisfactory completion of the pressure test) at a pressure to be specified by the authority for a duration of two hours. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valve section there of necessary to maintain the specified leakage test pressure after the pipe has been filled with water and the air is expelled.

3.8.2 Testing of Pipe Sewers

Sewers are normally subjected to the following tests before they are put into service:

A. Tests for Straightness and Obstruction

As soon as a section of sewer is laid it is tested for straightness and obstruction. These tests are carried out in the following two ways:

- At the high end of the sewer a smooth ball of diameter 13 mm less than the pipe bore is inserted. If there is no obstruction such as yarn or mortar projecting through the joints, the ball will roll down the invert of the pipe and emerge at the lower end.
- A mirror is placed at one end of the sewer line and a lamp is placed at the other end. If the sewer line is straight, the full circle of light will be observed. If the sewer line is not straight, this would be apparent. The mirror will also indicate any obstruction in the sewer line.

B. Water Test

Water test is carried out to find out the water tightness of the joints. This test is carried out after giving sufficient time for the joints to set. In the case of concrete and stoneware pipes with cement mortar joints, pipes are tested three days after the cement mortar joints have been made. It is necessary that the pipelines are filled with water for about a week before commencing the application of pressure to allow for the absorption by the pipe wall.

- The test is carried out by plugging the lower end of the pipe-sewer by a rubber bag equipped with a canvas cover and inflated by blowing air. The upper end is plugged with a provision for an air outlet pipe with stop cock, and a connection to a hose ending in a funnel which can be raised or lowered till the required pressure head is maintained for observation.
    - The water is filled in the pipe-sewer through the funnel and after the air has been expelled through the air outlet, the stop cock is closed and the water level in the funnel is raised to 2.5 m above the invert at the upper end. Water level in the funnel is noted after 30 minutes and the quantity of water required to restore the original water level in the funnel is determined.
    - The pipeline under pressure is then inspected while the funnel is still in position. There should not be any leaks in the pipe or the joints (small sweating on the pipe surface is permitted). Any sewer or part there of that does not meet the test shall be emptied and repaired or re-laid as required and tested again.
    - The leakage or quantity of water to be supplied to maintain the test pressure during the period of 10 minutes shall not exceed 0.2 liters per mm diameter of pipes per kilometer length per day.
    - For non-pressure pipes it is better to observe the leakage for a period of 24 hours if feasible.
    - Exfiltration test for detection of leakage should be carried out at a time when the groundwater table is low.
    - For concrete, R.C.C., and asbestos cement pipes of more than 600 mm diameter the quantity of water inflow can be increased by 10% for each additional 100 mm of pipe diameter.
    - For brick sewers regardless of their diameter the permissible leakage of water should not exceed 10 m3 for 24 hours per kilometer length of sewer.

C. Air Test

Air test becomes necessary, particularly in pipes of large diameter when the required quantity of water is not available for testing. The air test is done by subjecting the stretch of pipe to an air pressure of 100 mm of water by means of a hand pump. If the pressure is maintained at 75 mm the joints may be assumed to be water tight.

- In case the drop-in pressure is more than 25 mm, the leaking joints should be traced and suitably treated to ensure water tightness. The exact point of leakage can be detected by applying soap solution to all the joints in the line and looking for air bubbles.

D. Smoke Test

Smoke test is carried out for drainage pipes located in buildings. The smoke is produced by burning oil waste, tar paper, etc., in the combustion chamber of a smoke machine. The pipes are approved gas-tight by the smoke test conducted under a pressure of 25 mm of water maintained for 15 minutes after all trap seals have been filled with water.

3.9 Cleaning Up Work Area

3.9.1 Maintenance

The maintenance of buildings and equipment may be the most important element of good housekeeping. Maintenance involves keeping buildings, equipment, and machinery in safe, efficient working order and in good repair. It includes maintaining sanitary facilities and regularly painting and cleaning walls. Broken windows, damaged doors, defective plumbing, and broken floor surfaces can make a workplace look neglected; these conditions can cause incidents and affect work practices. It is important to replace or fix broken or damaged items as quickly as possible. A good maintenance program provides for the inspection, maintenance, upkeep, and repair of tools, equipment, machines, and processes.

3.9.2 Dust and Dirt Removal

Enclosures and exhaust ventilation systems may fail to collect dust, dirt and chips adequately. Vacuum cleaners are suitable for removing light dust and dirt that is not otherwise hazardous. Industrial models have special fittings for cleaning walls, ceilings, ledges, machinery, and other hard-to-reach places where dust and dirt may accumulate. Special-purpose vacuums are useful for removing hazardous products. For example, vacuum cleaners fitted with HEPA (high-efficiency particulate air) filters may be used to capture fine particles of asbestos or fiberglass. Dampening (wetting) floors or using sweeping compounds before sweeping reduces the amount of airborne dust. The dust and grime that collect in places like shelves, piping, conduits, light fixtures, reflectors, windows, cupboards, and lockers may require manual cleaning. Compressed air should not be used for removing dust, dirt, or chips from equipment or work surfaces.

3.9.3 Employee Facilities

Employee facilities need to be adequate, clean and well-maintained. Lockers may be necessary for storing employees' personal belongings. Washroom facilities require cleaning once or more each shift. They also need to have a good supply of soap, towels plus disinfectants, if needed. If workers are using hazardous products, employee facilities should provide special precautions as needed such as showers, washing facilities and change rooms. Some facilities may require two locker rooms with showers between. Using such double locker rooms allows workers to shower off workplace contaminants and reduces the chance of contaminating their "street clothes" by keeping their work clothes separated from the clothing that they wear home. Smoking, eating or drinking in the work area should not be allowed where hazardous products are handled. The eating area should be separate from the work area and should be cleaned properly each shift.

3.9.4 Surfaces

Poor floor conditions are a leading cause of incidents so cleaning up spilled oil and other liquids at once is important. Allowing chips, shavings, and dust to accumulate can also cause incidents. Trapping chips, shavings and dust before they reach the floor or cleaning them up regularly can prevent their accumulation. Areas that cannot be cleaned continuously, such as entrance ways, should have anti-slip flooring. Light-colored walls reflect light while dirty or dark-colored walls absorb light. Contrasting colors warn of physical hazards and mark obstructions such as pillars. Paint can highlight railings, guards and other safety equipment, but should never be used as a substitute for guarding. The program should outline the regulations and standards for colors.

3.9.5 Aisles and Stairways

Aisles should be wide enough to accommodate people and vehicles comfortably and safely. Aisle space allows for the movement of people, products and materials. Warning signs and mirrors can improve sight lines in blind corners. Arranging aisles properly encourages people to use them so that they do not take shortcuts through hazardous areas. Keeping aisles and stairways clear is important. They should not be used for temporary "overflow" or "bottleneck" storage. Stairways and aisles also require adequate lighting.

3.9.6 Spill Control

The best way to control spills is to stop them before they happen. Regularly cleaning and maintaining machines and equipment is one way. Another is to use drip pans and guards where possible spills might occur. When spills do occur, it is important to clean them up immediately. Absorbent materials are useful for wiping up greasy, oily or other liquid spills. Used absorbents must be disposed of properly and safely.

3.9.7 Tools and Equipment

Tool housekeeping is very important, whether in the tool room, on the rack, in the yard, or on the bench. Tools require suitable fixtures with marked locations to provide an orderly arrangement. Returning tools promptly after use reduces the chance of it being misplaced or lost. Workers should regularly inspect, clean, and repair all tools and take any damaged or worn tools out of service.

3.9.8 Waste Disposal

The regular collection, grading and sorting of scrap contribute to good housekeeping practices. It also makes it possible to separate materials that can be recycled from those going to waste disposal facilities. Allowing the material to build up on the floor wastes time and energy since additional time is required for cleaning it up. Placing scrap containers near where the waste is produced encourages orderly waste disposal and makes collection easier.

3.9.9 Storage

Good organization of stored materials is essential for overcoming material storage problems whether on a temporary or permanent basis. There will also be fewer strain injuries if the amount of handling is reduced, especially if less manual material handling is required. The location of the stockpiles should not interfere with work but they should still be readily available when required. Stored materials should allow at least one meter of clear space under sprinkler heads. Stacking cartons and drums on a firm foundation and cross-tying them, where necessary, reduces the chance of their movement. Stored materials should not obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations. Flammable, combustible, toxic and other hazardous materials should be stored in approved containers in designated areas that are appropriate for the different hazards that they pose.

Self-Check-3

Part I: True or False question

Instruction: Say true if the statement is correct and false if the statement is incorrect.

___________ 1. Valve chambers are used to open and close water supply and sewerage pipelines.

___________ 2. A thrust block is a concrete pipe restraint that prevents the mainline from moving by transferring pipe loads to a wider load-bearing surface.

___________ 3. Backfilling of the pipeline trench **isn't** an important consideration in laying of pipelines.

Part II: Matching

Instruction: Match Terms in column A with its meanings in column B.

	A	B
______	1. Concrete pipes	A. can be made of a mix of vinyl and plastic
______	2. Excavators	B. are used to dig trenches or excavate areas
______	3. Polyvinyl Chloride	C. are pipes made from concrete
______	4. Pipe layers	D. used to cut pipes to the required lengths
______	5. High-density polyethylene	E. designed to lift and position pipes into the trench
		F. a polyethylene thermoplastic made from petroleum

Part III: Short Answer Questions

Instructions: Answer all the following questions accordingly.

1. What are the steps in lowering, laying and joining pipelines?
2. Discuss the joining of pipelines and their types.
3. Describe testing of pipe sewers.
4. List and describe fit valves, fittings and flow control devices.
5. Define support structure f pipelines.

Operation Sheet 3

Operation title:

- Laying and joining of pipelines

Purpose:

- To practice and demonstrate the knowledge and skill required to laying and joining of pipelines

Instruction:

- Use given tools and equipment to laying and joining of pipelines. For this operation you have given 8 Hour and you are expected to provide the answer on the given table.

Precautions:

- Follow OSH safe work practice standards.

Tools and requirement:

- Measuring tape
- Graphite pencil
- Timber
- Eucalyptus wood
- Pick axe
- Tri square
- Shovel
- Claw hammer
- Bow saw
- Spirit level

Procedures for laying and joining of water supply pipes:

Pipes are generally laid below the ground level, but sometimes when they pass in open areas, they may be laid over the ground. The pipes are laid in the following way:

1. First of all, detailed map showing all roads, steels, lanes etc. is prepared. On this map the proposed pipe line with as sizes and length will be marked. The position of existing pipe lines, curb lines, sewer lines etc. will also be marked on it. In addition to this position of valves and other pipe specials, stand posts etc. will also be made so that at the time of laying there should be no difficulty in this connection.

2. After the general planning the center line of the pipe line will be transferred on the ground from the detailed plan. The center line will be marked by means of stakes driven at 30 m interval on straight lines. On curves the stakes will be driven at 7 m to 15 m spacing. If the roads or streets have curbs, the distance of center of pipe line from the curb will be marked.
3. When the center line has been marked on the ground the excavation for the trenches will be started. The width of the trends will be 30 cm to 45 cm more than the external diameter of the pipe. At every joint the depth of excavation will be 15-20 cm more for one-meter length for easy joining of the pipes. The excavation of the trends is done in such a way that only pipe should be supported and its joint portion should remain over-hanging. The pipe line should be laid more than 90 cm below the ground so that pipe may not break due to impact of heavy traffic moving over the road or ground if the excavation is to be done in soft soils, the sides of the trenches should be protected by means of timber planks, so that it may not fall or collapse.
4. After the excavation of trenches the pipes are lowered in it. Generally, in practice, the pipes are stacked on the opposite side fixed on derricks, but lighter pipes are lowered manually. The pipe laying should be started from the lower level and proceed towards higher level with socket end towards higher side. The jointing of pipes should also be done along with the laying of pipes.
5. After laying the pipes in position, they are tested for water leakage and pressure.
6. When the pipe line is tested, the back filling of the excavated material will be done. The soil which was excavated is filled back in the trenches all around the pipes and should be well rammed. All the surplus soil will be disposed of and the site should be cleaned.

Quality Criteria:

- The setting out alignment must check with arithmetic check with no tolerance to the arithmetic check result of zero (0).
- Brocken or malfunctioned pipes must be removed before backfilling the pipes. This will happen leakage to the pipeline in the future.
- The compaction of backfill must be tested with proctor and field density test with accuracy of 95% compaction effort must be achieved.

Operation Sheet 4

Operation title:

- Laying and testing of sewers

Purpose:

- To practice and demonstrate the knowledge and skill required to laying and testing of sewers

Instruction:

- Use given tools and equipment to laying and testing of sewers. For this operation you have given 8 Hour and you are expected to provide the answer on the given table.

Precautions:

- Follow OSH safe work practice standards.

Tools and requirement:

- Measuring tape
- Graphite pencil
- Timber
- Eucalyptus wood
- Pick axe
- Tri square
- Shovel
- Claw hammer
- Bow saw
- Spirit level

Procedures for laying and testing of sewers:

The various steps involved in the laying and testing of sewers are:

1. Setting out Sewer Center Line: The laying of sewers is generally carried out by starting from the tail end or the outfall end, and proceeding upwards. From the longitudinal section of the sewer line, the positions of manholes are located on the ground because it is the general practice to lay sewer line between two manholes at a time.
2. Alignment and Gradient of Sewers: The sewers should be laid to the correct alignment and gradient by setting the positions and levels of sewers so as to ensure a smooth gravity flow.

3. Excavation of Trenches: The work of excavation is usually carried out in the form of open cut trenches but in certain situations as indicated later tunneling is also adopted. The excavation is made so as to have trenches of such lengths, widths and depths which would enable the sewers to be properly constructed. The excavation is carried out manually through pick axes and shovels. The trenches may be excavated either with sloping sides or with vertical sides. Where enough space is available, especially in undeveloped areas or open country, and when the soil is such that vertical sides cannot be sustained, the excavation may be made with sloping sides so that the sides are stable.
4. Timbering: the depth of the trench exceeds 1.5 to 2 m, and the excavation has to be made with vertical sides which cannot be sustained, it becomes necessary to support the sides of the trench by sheeting and bracing. This operation is known as timbering of trench.
5. Dewatering of Trenches: the sub-soil water level is very near the ground surface; the trench becomes wet and muddy because of water oozing in the trench from the sides and bottom. In such cases the construction of sewer becomes difficult. As such trenches for sewer construction needs to be dewatered to facilitate the placement of concrete and laying of pipe sewer or construction of concrete or brick sewer and kept dewatered until the concrete foundations, pipe joints or brick work or concrete have cured.
6. Laying and Jointing of Pipe Sewers: Before laying the pipe sewer it should be ensured that the trench has been excavated up to the level of the bottom of the bed of concrete or the bed of compacted granular material if such a bed is to be provided, or up to the invert level of the pipe sewer if no such bed is to be provided.
7. Testing of Pipe Sewers: Sewers are normally subjected to the following tests before they are put into service:
   - 7.1. Tests for Straightness and Obstruction: As soon as a section of sewer is laid it is tested for straightness and obstruction. These tests are carried out in the following two ways:
   - 7.2. Water Test: Water test is carried out to find out the water tightness of the joints.
   - 7.3. Air Test: Air test becomes necessary, particularly in pipes of large diameter when the required quantity of water is not available for testing. The air test is done by subjecting the stretch of pipe to an air pressure of 100 mm of water by means of a hand pump. If the pressure is maintained at 75 mm the joints may be assumed to be water tight.

7.4. Smoke Test: Smoke test is carried out for drainage pipes located in buildings. The smoke is produced by burning oil waste, tar paper, etc., in the combustion chamber of a smoke machine.

8. Backfilling of Trenches: Backfilling of the sewer trench is an important consideration in laying of sewers. However, the trench should be backfilled only after the laid sewer has been tested and approved for water tightness of joints.

Quality Criteria:

- The setting out alignment must check with arithmetic check with no tolerance to the arithmetic check result of zero (0).
- Brocken or malfunctioned pipes must be removed before backfilling the pipes. This will happen leakage to the pipeline in the future.
- The compaction of backfill must be tested with proctor and field density test with accuracy of 95% compaction effort must be achieved.

LAP Test 2

Practical Demonstration

Name: ___________________________ Date: ________________________

Time started: ____________________ Time finished: _______________

Allotted time: 8 Hours for Each Task

Instruction I: Install and test pipeline

Task 1. Install and test water supply pipeline

Task 2. Install and test sewer pipeline

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