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Ministry of Labor and Skills

Road Construction and Maintenance

LEVEL – III

Based on September 2023, Curriculum Version II

Module Title: **Minor Drainage Structures & Retaining Walls**

Module Code: **EIS RCM M06 0923**

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

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Addis Ababa, Ethiopia

Bridges to Prosperity

HELVETAS Swiss Intercooperation | ETHIOPIA

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ACRONYMS

AAWSA	Addis Ababa Water and Sewage Authority
ASTM	American Standard for Testing Material
EBCS	Ethiopian Building Code Standard
EIS	Economy Infrastructure Subsector
ERA	Ethiopian Road Authority (Currently: Ethiopian Road Administration)
FRC	Fiber Reinforced cement
LAP Test	Learning Activity Performance Test
LG	Learning Guide
M	Module
OS	Occupational Standard
OSH	Occupational Safety and Health
PPE	Personal Protective Equipment
RCM	Road Construction and Maintenance
TTLM	Teaching, Training and Learning Materials
PVC	Flexible polyvinyl chloride

INTRODUCTION TO THE MODULE

This module covers the knowledge, attitude and skills required Concrete bridges is a vital part of our transportation infrastructure, providing safe passage for vehicles and pedestrians over rivers, valleys, and other obstacles. This module aims to introduce you to the fascinating world of concrete bridge design and construction. In this module, we will deliver into the key aspects of Plan and prepare constructing and maintaining minor concrete bridges, Conduct masonry work abutment and Wing wall, Conduct concreting work, Maintain minor drainage and retaining walls structures, Inspect, clear, repair culverts and Bridge We will also explore various bridge types, such as beam bridges, and discuss their advantages and limitations.

MODULE UNITS

- Constructing concrete bridges requirement
- Masonry Work for Abutment and Wing Wall
- Concreting Work
- Minor Drainage and Retaining Walls Structures
- Inspecting , clearing , repairing culverts and Bridge

LEARNING OBJECTIVES OF THE MODULE

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

- Construct concrete bridges requirement
- Identify Masonry work abutment and Wing wall construction
- Identify Concert Work
- Maintain Minor drainage and retaining walls structures
- Inspecting , clearing , repairing culverts and Bridge

MODULE LEARNING INSTRUCTIONS

1. Read the specific objectives of this learning guide (LG).
2. Follow the instructions described below.
3. Read the information written in the information sheet.
4. Accomplishment the self-check questions.

5. Accomplishment operation sheet.
6. Accomplishment learning activity performance (LAP)test

Unit One: Minor concrete bridges requirement

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

- Basic concept minor concrete bridges
- work instructions and compliance document
- Safety Requirements
- Tools and equipment
- water diversion requirement
- Environmental protection requirements

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:

- Identifying Basic concept minor concrete bridges
- work instructions and compliance document
- Identifying Safety Requirements
- Identifying Tools and equipment
- Identifying water diversion requirement
- Apply Environmental protection requirements

1.1 Basic concept minor concrete bridges

Basic concept of a minor concrete bridge refers to the fundamental principles and design considerations for constructing smaller and relatively simple structures that are made of reinforced concrete. These bridges are typically used in rural areas, where traffic loads and spans are relatively low.

The basic concept of a minor concrete bridge involves the following key elements:

- Foundation: The bridge structure rests upon the foundation, which is designed to safely distribute the loads coming from the bridge to the underlying soil or bedrock. Suitable foundation types for minor concrete bridges may include shallow spread footings or pile foundations depending on the soil conditions.
- Abutments: These are the supporting structures at the ends of the bridge that resist the horizontal and vertical forces. Abutments are usually massive and made of reinforced concrete, providing stability and support for the bridge. They transfer the loads from the bridge to the foundation.
- Piers or Intermediate Supports: In case the span of the bridge is too long, piers or intermediate supports are added to provide additional support at specific locations along the bridge. These supports can be designed as reinforced concrete piers or similar structures.
- Deck or Superstructure: The deck of the bridge is the roadway surface that vehicles travel on. It is typically made of reinforced concrete slabs or beams, which are supported by the abutments and piers. The deck is designed to withstand the loads imposed by vehicles, including live loads such as trucks and pedestrians.
- Reinforcement: Reinforcing steel bars or meshes are used within the concrete elements to enhance their strength and ability to resist tensile forces. Reinforcement is placed strategically to counteract potential cracking in concrete due to shrinkage, temperature variations, or applied loads.
- Waterway Considerations: For bridges crossing over rivers, creeks, or other water bodies, additional design elements need to be considered, such as providing adequate clearance for water flow, erosion protection, and designing appropriate wing walls or flow deflectors.

- Construction Techniques: Construction methods for minor concrete bridges involve the placement of formwork, pouring and curing of concrete, and installation of reinforcement. Pre-cast concrete elements can also be used to accelerate construction.

These are the basic concepts involved in the design and construction of minor concrete bridges. However, it is important to note that the specific design requirements and standards may vary depending on local regulations, site conditions, and bridge purpose.

1.1.2 Main Parts & Types of Bridges

The bridge, a connecting structure, creates bonding between different disconnected parts of a country, two banks of the ocean or parts of two countries. A Bridge is a structural marvel which is generally used to pass any type of obstruction that can slow the life of people. From the very beginning, engineers were trying to win over nature and consequently, they have invented bridge structure which can use to overcome the mentioned natural obstacles.

1.1.3 Main Parts of a Bridge

There are different types of bridge. Different bridge types contain different parts.
Followings are the main parts of a bridge:

- Deck
- Abutment
- Pile

To give a preliminary idea of these bridge parts a brief description of each part is given below.

- **Deck bridge**

A deck bridge is a type of bridge that has a flat deck or roadway for vehicles and pedestrians to cross over a body of water, valley, or other obstacle. It is typically supported by piers or abutments on either side. Deck bridges can be made of various materials such as concrete, steel, or wood, depending on the span and load requirements. They provide a safe and convenient passage for transportation and are commonly found on highways, roads, and pedestrian walkways.

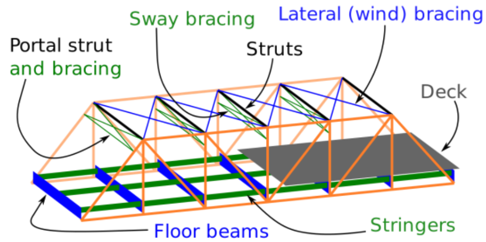

Fig 1.1 Deck Bridge

- **Abutment**

An abutment bridge is a type of bridge structure that is commonly used in civil engineering to support the ends of a bridge span. It consists of several components, including the abutment walls, abutment footings, and a deck or roadway. The abutment walls are vertical load-bearing structures located at each end of the bridge span. They are typically made of reinforced concrete and are designed to resist the forces imposed by the bridge. The abutment walls also serve to retain the earth or slope behind them and prevent erosion. The abutment footings are placed beneath the abutment walls to distribute the loads from the bridge and transfer them to the underlying soil or rock. These footings are designed based on the soil conditions and the magnitude of the forces acting on the bridge. The deck or roadway is the part of the bridge that connects the two abutment walls and carries the vehicles, pedestrians, or other loads. It is constructed using various materials such as concrete, steel, or timber, depending on the design requirements and the expected traffic loads. Abutment bridges can be found in various locations, including rural and urban areas, highways, railways, and pedestrian walkways. They provide a safe and stable crossing for people and vehicles over obstacles such as rivers, valleys, or roadways. Overall, abutment bridges are essential components of transportation infrastructure, allowing for the efficient movement of people and goods while ensuring safety and durability.

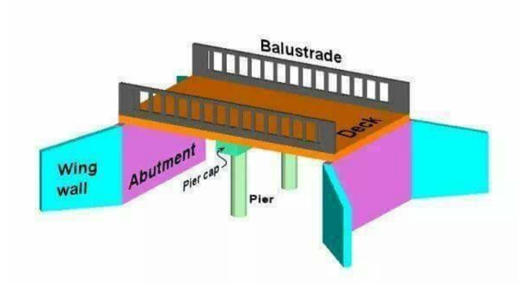

Fig 1.2 abutment

- **Pile is** bridge is a type of bridge that is supported by piles or columns driven into the ground. The piles provide the support and stability for the bridge structure. Pile bridges are commonly used in areas with soft or unstable soil conditions, as the piles help distribute the weight of the bridge and prevent sinking or shifting. Pile bridges can be made from various materials such as wood, steel, or concrete, depending on the specific requirements and location. They are often used for small to medium-scale bridges such as pedestrian bridges or short span road bridges.

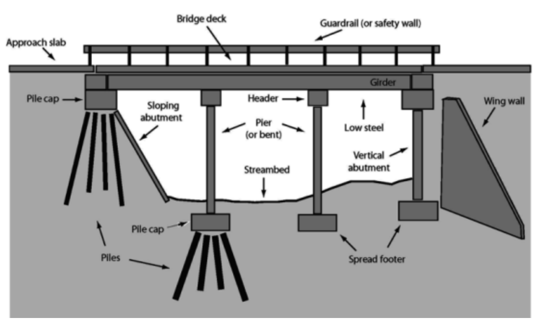

Fig 1.3 Piles

A pier bridge is a type of bridge that is supported by piers or columns, which are vertical structures that act as supports for the bridge deck. These piers are typically located at regular intervals along the length of the bridge and provide stability and strength to the structure. Pier bridges can be found in various form, including beam bridges, arch bridges, and suspension bridges. The design and construction of a pier bridge depend on factors such as the location, purpose, and load capacities required for the bridge. One advantage of using piers in bridge construction is that they allow for longer spans between supports. This can be especially beneficial when crossing bodies of water or other obstacles where building additional supports may not be feasible. Pier bridges have been used for centuries and are still commonly used today.

They play a crucial role in transportation infrastructure, providing safe and efficient passage for vehicles, pedestrians, and other modes of transportation.

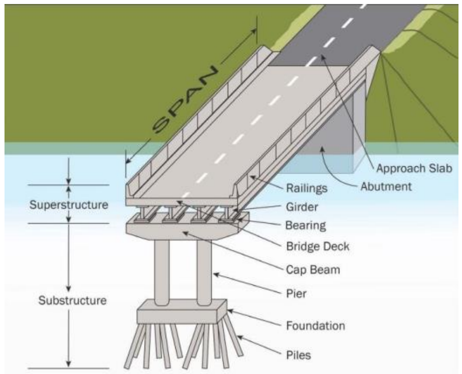

Fig 1.4 Pier Bridge

1.2 Work instructions and compliance document

1.2.1 Work instructions

Work instructions for bridge construction are step-by-step guidelines that outline the specific tasks and processes involved in building a bridge. These instructions provide detailed information on everything from site preparation and foundation construction to erecting support structures, adding decking, and completing finishing touches. They typically include information on required tools and materials, safety precautions, quality standards, and any specific regulations or codes that need to be followed. The work instructions ensure that the construction process is executed accurately, efficiently, and in compliance with engineering specifications.

1.2.2 Compliance Documentation

Compliance documentation in bridge construction refers to the various documents and records that are required to ensure that the construction project complies with all relevant codes, regulations, standards, and specifications. This documentation is typically submitted by the construction team to demonstrate that the bridge has been built according to the approved plans and meets all necessary safety and quality requirements.

Common examples of compliance documentation in bridge construction include:

A. **Permits and approvals**: Documents that demonstrate that all necessary permits and approvals have been obtained from regulatory authorities, such as environmental permits, building permits, or permits for temporary structures.
B. **Design and engineering documents**: These include drawings, calculations, and specifications that detail the design of the bridge and its various components. These documents are used to verify that the bridge has been built as planned and that it meets the required structural integrity and load-bearing capacity.
C. **Material certifications**: Documentation that provides evidence of the quality and compliance of materials used in bridge construction, such as steel, concrete, or asphalt. These certifications typically include test reports, batch numbers, and material certificates.
D. **Inspection reports**: Reports that detail the results of regular inspections conducted by qualified personnel throughout the construction process. These inspections verify that the bridge construction adheres to the specified requirements and highlight any deviations or non-compliance issues that need to be addressed.
E. **Quality control records**: Records that track the quality control measures implemented during bridge construction, including material testing, welding inspections, concrete strength tests, and other quality assurance procedures. These records are essential in ensuring the construction work meets the required standards and specifications.
F. **Progress reports**: Regular reports that document the progress of bridge construction, including milestones achieved, work completed, and any delays or issues encountered. These reports help keep stakeholders informed and ensure compliance with construction project schedules.

Compliance documentation plays a crucial role in ensuring that bridge construction projects are completed safely, in accordance with regulations, and to the satisfaction of regulatory authorities, project owners, and other stakeholders.

1.3 Safety Requirements

Safety requirements in bridge construction are specific measures and guidelines put in place to ensure the safety and well-being of workers, materials, and the general public during the construction process. Some common safety requirements in bridge construction include:

A. **Work Zone Safety**: Ensuring proper signage, barricades, and warning lights to alert drivers and pedestrians of the construction site, and establishing designated pathways to separate foot and vehicle traffic.

B. **Fall Protection**: Implementing fall protection systems such as guardrails, scaffolding, safety harnesses, and nets to prevent workers from falling while working at heights.

C. **Personal Protective Equipment (PPE):** Enforcing the mandatory use of personal protective equipment such as hard hats, safety glasses, gloves, steel-toed boots, and high-visibility vests to minimize injuries from potential hazards.

D. **Heavy Machinery Safety**: Providing training and certifications for operators of heavy machinery involved in the construction process, and ensuring that machinery and equipment are properly maintained and inspected regularly.

E. **Material Handling Safety**: Implementing proper procedures for lifting, moving, and storing construction materials to prevent injuries caused by improper handling or falling objects.

F. **Fire Safety**: Establishing fire prevention and fire response protocols, including the availability and accessibility of fire extinguishers, hose reels, and emergency exits.

G. **Electrical Safety**: Ensuring that all electrical installations and equipment comply with relevant safety standards and codes, and providing proper grounding and insulation to prevent electrical hazards.

H. **Hazardous Materials Management**: Implementing appropriate measures to handle, store, and dispose of hazardous materials used during bridge construction, such as chemicals, fuels, and solvents, in accordance with safety regulations.

I. **Environmental Protection**: Adhering to environmental regulations and guidelines to minimize the impact of bridge construction on the surrounding ecosystem, including proper disposal of construction debris and prevention of pollution.

J. Emergency Preparedness: Developing and implementing emergency response plans, including evacuation procedures, first aid stations, and trained personnel, to handle accidents, natural disasters, and other unforeseen incidents on the construction site.

1.2.2 Personal Protective Equipment (PPE)

Personal protective equipment (PPE) refers to clothing, helmets, goggles, or other equipment designed to protect the wearer's body from injury or infection. PPE is commonly used in various industries and occupations, including healthcare, construction, manufacturing, and agriculture, to ensure the safety and health of workers. Types of PPE may include gloves, masks, gowns, face shields, safety glasses, helmets, and earplugs, among others. PPE is essential in preventing and reducing the risk of injuries, illnesses, and other health hazards in the workplace.

Fig. 1.3 Personal protective equipment

1.1.3 Construction Site Safety

Construction site safety refers to the measures and practices put in place to ensure the well-being and protection of construction workers and visitors on a construction site. It is crucial to prioritize safety in the construction industry due to the potential hazards and risks involved.

Here are some key aspects of construction site safety:

Hazard identification and risk assessment: Identifying potential hazards and assessing risks specific to the construction site is essential. This includes evaluating the risk of falls from height, electrical hazards, exposure to hazardous materials, and machinery-related risks. Thorough risk assessments help in implementing necessary control measures.

Fig. 1.4 **Risk assessment procedures**

Fall protection: Falls from height are a leading cause of fatalities and injuries on construction sites. Fall protection measures should be implemented, such as guardrails, safety nets, personal fall arrest systems, and scaffolding, to prevent falls and protect workers working at elevated levels.

Fig. 1.5 Personal fall protection equipment

Safe access and egress: Proper access and egress routes should be established and maintained throughout the construction site to ensure safe entry and exit for workers and emergency responders. This includes keeping walkways clear, marking exits clearly, and providing proper lighting in walkways and stairwells.

Fig. 1.6 Safe access and egress

Fire safety: Construction sites often involve flammable materials and equipment, making fire safety a critical concern. Fire prevention measures should be in place, including adequate fire extinguishers, fire alarms, emergency evacuation plans, and designated fire assembly points.

Fig. 1.7 5 fire safety

Training and supervision: Proper training and regular safety briefings should be provided to workers to ensure they are aware of the potential risks and how to mitigate them. Supervisors and managers are responsible for enforcing safety protocols and maintaining a safe working environment.

Fig. 1.8 Training and regular

Machinery and equipment safety: Construction sites utilize various types of machinery and equipment, such as cranes, excavators, and power tools. Regular inspection, maintenance, and operator training are essential to minimize accidents related to machinery and equipment.

Fig. 1.9 Steps to machine safety

1.4 Plant, Tools and Equipment

A. **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.

Fig1. 9 Leveling equipment

B. **Shovels**: is a tool used for digging, lifting, and moving bulk materials, such as soil, coal, gravel, snow, sand, or ore.

Fig1. 10 Shovels

C. **Crow Bars**: is used as a lever either to force apart two objects or to remove nails.

Figure 1. 11 Crow bar

D. **Hammers**: is a tool, most often a hand tool, consisting of a weighted "head" fixed to a long handle that is swung to deliver an impact to a small area of an object.

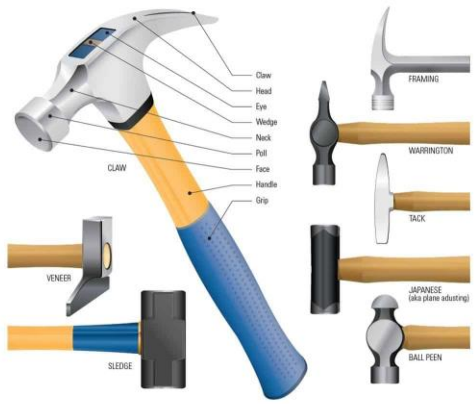

Figure 1. 12 Hammers

E. **Scaffolding**: are a temporary structure used to support a work crew and materials to aid in the construction, maintenance and repair of buildings, bridges and all other man-made structures.

Fig1. 13 Scaffolding

F. **Saws**: is a tool consisting of a tough blade, wire, or chain with a hard-toothed edge. It is used to cut through material, very often wood, though sometimes metal or stone.

Fig1. 14 Saws

G. **Floats** are specially designed devices used in construction projects to assist in the placement and finishing of concrete.

Figure 1.15 Floats

H. **Trowel** is small hand tool consisting of a flat blade with a handle used for spreading and smoothing mortar or plaster

Figure 1.16 Trowels

I. **Edging tools**, as the name suggests, are designed to finish the edges of freshly placed concrete to create a clean edge. They are also often used to create an attractive highlight on the face of the concrete near the edge to transition between a textured surface and the edge of the concrete.

Figure 1.17 Edging tools

J. **Wheelbarrows** a small usually single-wheeled vehicle that is used for carrying small loads and is fitted with handles at the rear by which it can be pushed and guided

Figure 1.18 Wheelbarrows

K. **A concrete mixer** (also cement mixer) is a device that homogeneously combines cement, aggregate (e.g. sand or gravel), and water to form concrete. A typical concrete mixer uses a revolving drum to mix the components.

Figure 1.19 concrete mixer

L. V**ibrators** is wet concrete is poured, air bubbles become trapped within the mixture creating cavities or honeycomb-like spaces. Left untouched, "honeycombing" can compromise the cement's longevity and strength. Vibrators force the trapped air out of the mixture leaving the final product a more compact and level slab.

Figure 1.20 V**ibrators**

M. **Rakes** to gather, loosen, or smooth with or as if with a rake.

Figure 1.20 Rakes

N. **Tape Measures** also known as a tape measure is a versatile tool used to measure length

Figure 1.21 Tape Measures

O. **Rods** a length of iron that is mainly used in heavy construction projects. Reinforced concrete is intertwined with iron rods, also called rebar, to strengthen the tension of the build. An iron rod can be purchased with or without a ribbed design.

Figure 1.22 Rods

P. **Buckets** an open, round container with a handle is a bucket. You might take a bucket and shovel to the beach for making sand castles. Buckets are usually made of metal or plastic, and are typically used to carry liquids.

Figure 1.22 Bucket

Q. **Kibbles** Extensive range of fast to use robust equipment for concrete pouring for sites where crane is available as well as for projects using a forklift.

Figure 1.23Kibbles

R. **Reinforcement benders** rebar bender is a machine that is used to bend bars made of steel and other heavy metals.

Figure 1.24 Reinforcement benders

1.3.1 Construction materials

Construction materials are materials used in the construction or building of structures such as buildings, bridges, roads, and dams. They can be natural materials, such as wood, stone, and clay, or manufactured materials, such as concrete, steel, and asphalt. Other materials commonly used in construction include glass, plastic, gypsum, and insulation materials. The choice of construction materials is determined by factors such as cost, durability, strength, availability, and the specific requirements of the project.

1.3.1 Cement

Cement is a binding material used in construction that hardens, sets, and adheres to other materials to bind them together. It is made by grinding a mixture of limestone, clay, and other materials and heating it at a high temperature in a kiln. Cement is commonly used in the production of concrete, mortar, and grout, providing strength and durability to structures such as buildings, bridges, roads, and dams.

Figure 1.25 Cement

1.3.2 Water

Water is a liquid substance that is essential for all forms of life. It is composed of two hydrogen atoms bonded to one oxygen atom, giving it the chemical formula H2O. Water is known for its unique properties such as its ability to exist in all three states of matter (solid, liquid, and gas) at ambient temperatures, high specific heat capacity, and high surface tension. It plays a crucial role in various biological processes, acts as a solvent, helps regulate temperature, and supports the transportation of nutrients and waste in living organisms.

Figure 1.26 Water

1.3.3 Prefabricated steel pipes

Prefabricated steel pipes, also known as pre-fabricated or pre-fab steel pipes, are steel pipes that are manufactured off-site and then assembled or installed at the desired location. These pipes are produced in factories, where various standard sizes and lengths are manufactured using automated processes.

Prefabricated steel pipes offer several advantages over traditional methods of construction:

Time-saving: These pipes are pre-made and ready to install, allowing for quick and efficient assembly at the construction site. This can significantly reduce construction time and project duration.

Cost-effective: Prefabricated steel pipes often result in cost savings due to reduced labor and construction time. Additionally, the streamlined manufacturing process in factories helps optimize material usage, reducing waste.

Quality control: Being manufactured in controlled factory environments allows for better quality control and adherence to industry standards. This ensures that the pipes meet specific specifications and safety requirements.

Durability and strength: Steel pipes are known for their inherent strength and durability. Prefabricated steel pipes are engineered and designed to meet specific structural requirements, making them suitable for a wide range of applications, including industrial, commercial, and residential construction.

Versatility: Prefabricated steel pipes can be used for various purposes, such as water supply, drainage, gas pipelines, HVAC systems, and even structural applications like building frames.

Overall, prefabricated steel pipes provide a convenient and efficient solution for construction projects, offering benefits in terms of time, cost, quality, durability, and versatility.

Aggregate

Aggregate stone refers to a crushed or granular material made from a variety of rock types, such as limestone, granite, or gravel. It is commonly used in construction projects, such as roadways, driveways, and sidewalks, as a base or foundation material. Aggregate stone can also be used in concrete and asphalt production or as decorative landscaping stones. The size and composition of aggregate stone can vary, depending on the specific application and requirements.

Figure 1.27 Aggregate

1.3.5 Sand

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is formed through the erosion and weathering of rocks such as granite, limestone, and quartz. The particles of sand range in size from very small grains to larger pieces, typically between 0.0625 millimeters to 2 millimeters in diameter. Sand can be found in various environments such as beaches, deserts, riverbeds, and dunes.

Figure 1.28 Sand

1.3.6 Reinforcement

Reinforcement steel, also known as rebar or reinforcing bar, is a type of steel used in construction for reinforcing concrete structures. It is commonly used in structures such as buildings, bridges, highways, and tunnels to provide additional strength and stability. Reinforcement steel is typically made of carbon steel and has a ribbed surface to provide better adhesion with concrete. It is available in various sizes and grades to meet the specific requirements of different construction projects. The primary purpose of reinforcement steel is to enhance the structural integrity of concrete by resisting and absorbing tensile forces. Concrete is strong in compression but weak in tension, so the addition of reinforcement steel helps to distribute the tensile forces throughout the concrete, preventing cracks and enhancing its durability and load-carrying capacity. Reinforcement steel is usually placed in concrete forms or molds before pouring the concrete. It is carefully positioned and tied together to form a mesh or grid pattern to provide uniform distribution of the reinforcing bars throughout the structure. Once the concrete cures and hardens the reinforcement steel and concrete work together to resist external forces and maintain the structural stability of the construction.

Figure 1.29 Reinforcement steel

1.3.7 Formwork components

Formwork components refers to the various parts and materials that are used to construct temporary molds or structures to hold and shape wet concrete until it hardens and becomes self-supporting. These components are designed to provide support, stability, and shape to the concrete during the construction process.

Common formwork components include:

A. **Panels:** These are the primary components that make up the formwork system. Panels can be made of wood, metal, or plastic and are used to create the outer form or mold for the concrete.

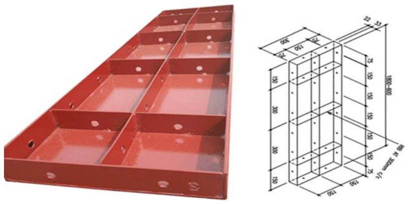

Fig 1.30 Panels

B. **Shoring:** Shoring refers to the temporary support system that is used to hold the formwork in place and provide stability. It can include vertical props, horizontal beams, or braces.

Fig 1.31 Shoring

C. **Wedges and pins**: These small components are used to lock the formwork panels together and secure them in place. Wedges are inserted between the panels and then tightened with pins to hold them firmly.

Fig 1.32 Wedges and pins

D. Ties and clamps: Ties are used to hold the formwork panels together and maintain the desired distance between them. Clamps are used to connect the panels horizontally or vertically, providing additional strength and stability.

Fig1. 32 Ties **and clamps**

E. Hinges: Hinges are used to create adjustable connections between formwork panels, allowing for flexibility in shaping the concrete structure.

Fig 1.33 Hinges

F. Corner pieces: These are special components used to create corners or angles in the formwork system, ensuring that the concrete structure has the desired shape.

Fig 1.34 Corner pieces

G. **Brackets and supports**: Brackets and supports are used to secure the formwork system to existing structures or the ground, providing additional stability and safety.

H. **Concrete release agents**: These are substances or coatings applied to the formwork components to prevent the concrete from sticking to the surface. This enables easy removal of the formwork once the concrete has hardened.

Formwork components are crucial in ensuring the proper construction of concrete structures, as they provide support, shape, and stability to the wet concrete until it gains sufficient strength.

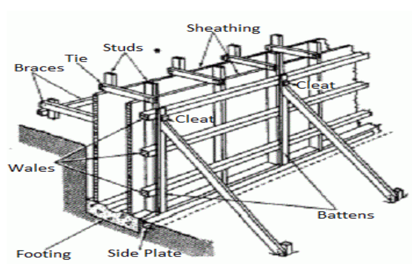

Figure 1.30 Formwork components

I. **Curing agents**

Curing agents, also known as hardeners or cross linkers, are substances that are added to a material to promote or accelerate the process of curing. Curing refers to the chemical reaction or process by which a material solidifies or becomes more rigid. Curing agents are commonly used in industries such as adhesives, coatings, composites, and polymers. Curing agents can react with the material they are added to, causing it to undergo a chemical reaction, which results in the formation of stronger bonds or a cross linked network of molecules. This process helps to enhance the mechanical, thermal, and chemical properties of the material

J. Adhesives

Adhesives are substances that are used to stick or bind materials together. They are designed to provide strong and durable bonds between various surfaces. Adhesives can be in the form of liquids, pastes, tapes, or films and they can be used in numerous applications such as construction, manufacturing, automotive, aerospace, and household repairs. There are different types of adhesives available, including epoxy, polyurethane, cyanoacrylate, and silicone, each with its own specific properties and recommended uses.

K. Admixtures

Admixtures refer to a group of chemical ingredients that are added to concrete or other construction materials during the mixing process. These ingredients are added in small quantities and are used to enhance the properties of the material, such as workability, strength, durability, setting time, and resistance to chemical attack. Admixtures can be in the form of liquids, powders, or granules, and they are generally categorized into different types based on their specific functions, such as water-reducing agents, set-retarding agents, air-entraining agents, and plasticizers.

Masonry stone

Masonry stone, also known as masonry units or natural stone, refers to a type of building material made from natural stone that is specifically designed and shaped for use in masonry construction. These stones are commonly used to build walls, buildings, and other structures. Masonry stone offers durability, strength, and appeal due to its natural, textured appearance. It can be sourced from various types of stone such as granite, limestone, sandstone, and marble, and is available in different sizes, shapes, and colors to suit different architectural designs and preferences.

Figure 1.31 Formwork components

L. Gabion box

A gabion box is a wire mesh container filled with rocks, concrete, or other materials. It is typically used in construction and civil engineering projects for erosion control, retaining walls, slope stabilization, and landscaping. The wire mesh of the gabion box provides structural support while allowing water to freely flow through. It is a cost-effective and environmentally friendly solution that provides strength and durability in various applications.

Figure 1.32 Gabion box

1.5 Storm water diversion requirement

Storm water diversion requirements refer to regulations and standards set in place to manage and control storm water runoff. The specific requirements vary depending on the location and jurisdiction, but generally aim to prevent pollutants and contaminants from entering water bodies and causing pollution.

1.5.1 Some common storm water diversion requirements include:

Implementing storm water management measures:

This involves implementing measures such as rain gardens, permeable pavement, or detention basins to capture and treat storm water runoff before it enters water bodies.

A. **Designing storm water infrastructure**: Develop and design storm water infrastructure systems such as drainage networks, swales, and channels to divert storm water away from sensitive areas and prevent flooding.

B. **Implementing erosion and sediment control measures**: These measures are implemented to prevent soil erosion and sedimentation during construction activities that could negatively impact water quality.
C. **Implementing best management practices (BMPs)**: These are specific practices or measures that are implemented to reduce the amount of pollutants in storm water runoff, such as installing oil and grease separators or using filtering systems.

Compliance with local regulations: It is important to understand and comply with local and regional storm water management regulations, guidelines, permits, and reporting requirements.

These requirements aim to protect water quality, reduce flooding, and safeguard the natural environment from the negative impacts of storm water runoff. Compliance with storm water diversion requirements may be mandatory and failure to comply may result in fines or penalties.

1.6 Environmental Protection Requirements

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**: 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**: 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**: 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:** 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.

Self-Check-1

Part I: choose the correct answer

1. What do identification signs in bridge construction typically include?
   A. The weight limit of the bridge
   B. Emergency contact information
   C. Prohibited vehicles on the bridge
   D. The name and location of the bridge
2. Who should be consulted to determine the precise signage requirements for bridge construction?
   A. Other motorists on the bridge
   B. The bridge construction company
   C. Local authorities or engineering professionals
   D. Pedestrians using the bridge
3. What is the purpose of floats in construction projects?
   A. To support a work crew and materials
   B. To assist in the placement and finishing of concrete
   C. To dig and move bulk materials
   D. To set up level points and check elevations
4. What is the importance of regular inspection, maintenance, and operator training for machinery and equipment safety on construction sites?
   A. To explain the importance of hazard identification and risk assessment
   B. To ensure machinery and equipment safety
   C. To identify key aspects of construction site safety
   D. To recognize fall protection measures
5. What is essential to minimize accidents related to machinery and equipment on construction sites?
   A. Proper lighting in walkways
   B. Regular inspection, maintenance, and operator training
   C. Adequate fire extinguishers

D. Thorough risk assessments

Part II: Matching

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

A	B
1. Traffic conditions signage	A. An improvised barrier erected across a street or other thoroughfare to prevent or delay the movement of opposing forces.
2. Barricades	B. are substances that are added to concrete, mortar, or grout before or during the mixing process to modify its properties and improve its performance
3. gabion box	C. units or natural stone, refers to a type of building material made from natural stone that is specifically designed and shaped for use
4. Masonry stone	D. are used to create adjustable connections between formwork panels, allowing for flexibility in shaping the concrete structure
5. Admixtures	E. is a wire mesh container filled with rocks, concrete, or other materials.
6. Hinges	F. Are used to identify warnings and provide information to ensure others are safe from serious accidents.

Part III: Short Answer Questions

Instructions: Answer all the following questions accordingly.

1. What are the common signage requirements for bridges?
2. What information is typically included on identification signs for bridges?
3. Why are weight limit signs important for bridges?
4. What information do clearance signs provide for drivers?
5. What types of vehicles or activities may be prohibited on a bridge?

Unit Two: Masonry work

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

- Preparation of masonry work
- Construct of masonry work
- Finishing of masonry work

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 of masonry work
- Construct of masonry work
- Finish of masonry work

2.1 Preparation

2.1.1 Set and lay out minor bridge structure

Setting and laying out a minor bridge structure refers to the process of planning and positioning the components of a smaller bridge. This includes determining the location, aligning and preparing the foundations, arranging the beams, and constructing the abutments and piers.

A. **The following steps are involved in setting and laying out a minor bridge structure:**
B. **Site selection**: Choose a suitable location for the bridge considering factors such as hydraulic conditions, topography, environmental impact, and structural requirements.
C. **Foundation preparation**: Prepare the foundation by clearing vegetation, excavating the area, and ensuring stable soil conditions.
D. **Layout and alignment:** Establish the desired alignment and layout of the bridge by marking reference points and dimensions on the ground, taking into account the span length and orientation.
E. **Abutment and pier construction**: Construct the abutments and piers according to the design specifications and plans. This involves placing concrete footings, forming the walls, and reinforcing them with steel bars.
F. **Beam arrangement:** Position and secure the bridge beams on top of the abutments and piers, ensuring proper alignment and connection between the components.
G. **Deck installation**: Install the bridge deck, which is the surface that vehicles or pedestrians will use to cross the bridge. The deck can be made of concrete, steel, or timber depending on the design and requirements.
H. **Finishing touches**: Complete any additional components such as railings, barriers, or drainage systems as required for safety and functionality.

2.1.2 Minor bridge structure

A minor bridge is a small bridge or structure that spans a narrow stream, ditch, or ravine. It is typically designed for pedestrian or light vehicle use and is smaller in size and scale compared to major bridges. Minor bridges are commonly found in rural areas or residential neighborhoods, where they provide access across smaller water bodies or obstacles. These bridges are usually made of materials such as wood, concrete, or steel, and may have basic designs without complex engineering features.

A minor bridge structure typically refers to a small-scale bridge that is used to span a gap or obstacle, such as a stream or small river, walking path, or driveway. It is typically made from materials such as wood, concrete, or steel, and has a simple design that is appropriate for lighter loads and lower traffic volumes. These bridges often have a single span, meaning they do not have any intermediate supports or piers, and they may have a flat or curved deck depending on the specific requirements of the site. Minor bridge structures are commonly used for pedestrian or light vehicle traffic, such as bicycles or small cars. Due to their smaller size and simpler design, minor bridge structures are typically easier and less expensive to construct and maintain compared to larger, more complex bridges. They are often found in rural or residential areas, where there is a need to provide safe passage over a small watercourse or other obstacles.

A minor bridge is a bridge having a total length of from 6 m to 60 m. b. Major Bridge. A major bridge is a bridge having a total length of above 60 m.

A minor bridge structure refers to a small bridge that is typically constructed over small water bodies, such as streams, ditches, or canals. These structures are commonly used in rural areas or on local roads for crossing relatively smaller gaps.

The layout and set up of a minor bridge structure involve several steps, including:

A. **Survey**: Conduct a site survey to determine the alignment, elevation, and dimensions of the bridge structure. This includes measuring the width, depth, and slope of the water body.
B. **Design**: Based on the survey data, design the bridge structure. Consider factors such as the required load capacity, hydraulic considerations (flood levels, flow velocities), and the geological conditions of the site.
C. **Obtain approvals**: Obtain necessary approvals and permits from the local authorities or relevant agencies before proceeding with the construction.
D. **Material selection**: Select appropriate construction materials based on the bridge's span, load requirements, and environmental factors. Common materials include concrete, steel, timber, or a combination of these.

E. **Foundation**: Construct stable and sturdy foundations for the bridge, taking into account the soil conditions. Foundations can be built using piles, spread footings, or abutments depending on the site requirements.

F. **Substructure**: Build the substructure of the bridge, which includes abutments and piers. Abutments provide support at the ends of the bridge, while piers are constructed within the water body.

G. **Superstructure**: Construct the superstructure, which includes the bridge deck and supports the load-carrying capacity of the bridge. This can be done using precast/prestressed concrete girders, timber slabs, or steel beams.

H. **Deck placement**: Install the bridge deck on top of the superstructure, ensuring proper alignment, leveling, and reinforcement. The deck provides a surface for vehicles or pedestrians to cross the bridge.

I. **Utilities**: Install necessary utilities such as guardrails, drainage systems, lighting, and signage for user safety and convenience.

J. **Finishing and landscaping**: Finish the bridge by installing any required surface treatments, coatings, or waterproofing. Additionally, consider landscaping the surrounding area for aesthetic and ecological purposes.

It is crucial to engage qualified engineers and construction professionals to ensure the safety, durability, and compliance of the minor bridge structure with relevant design codes and regulations.

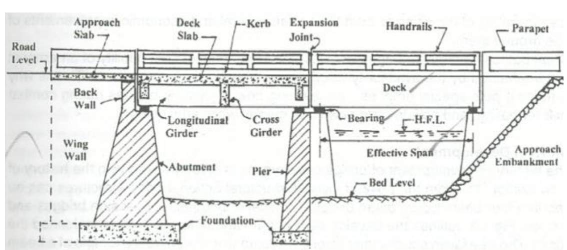

Fig 2.1 Minor bridge structure

2.2 Determine masonry structures

2.2.1 Carry out clearing bridge foundation

Carry out clearing bridge foundation refers to the process of removing any obstacles or obstructions that may be present in the area where a bridge foundation is to be constructed. This typically involves clearing vegetation, debris, or any existing structures that may hinder or interfere with the construction of the foundation. The objective is to create a clean and suitable site for the construction of the bridge foundation.

To carry out clearing a bridge foundation, the following steps can be taken:

A. Prepare necessary safety measures: Ensure proper safety gear and precautions are taken for the personnel involved in the clearing process. This may include hard hats, safety vests, gloves, and protective eyewear.

B. Assess bridge foundation condition: Inspect the bridge foundation for any damage, debris, or obstacles that need to be cleared. This may involve a visual inspection as well as using specialized equipment such as ground penetrating radar or sonar to check for any obstructions below the surface.

C. Remove vegetation and debris: Clear any vegetation, trees, shrubs, or other natural growth that may be obstructing the bridge foundation. This can be done manually by cutting and removing the vegetation or by using equipment like chainsaws or brush cutters.

D. Clear debris from the foundation: Remove any debris like rocks, gravel, branches, or garbage that may have accumulated around or underneath the bridge foundation. This can be done manually using rakes, shovels, or by employing heavy machinery like excavators or loaders.

E. Remove sediment or silt buildup: If there is sediment or silt buildup around the foundation, it may need to be removed to ensure proper water flow and structural integrity. This can be done using dredging equipment, vacuum trucks, or by manual excavation.

F. Repair or reinforce the foundation: If any damage is discovered during the clearing process, it may be necessary to repair or reinforce the bridge foundation. This can involve patching cracks, replacing corroded or damaged elements, or installing additional supports as required.

G. Perform regular maintenance: Establish a maintenance schedule to regularly inspect and clear the bridge foundation to prevent future buildup of debris or vegetation. This may include periodic inspections, vegetation control, and sediment removal.

It is important to note that clearing a bridge foundation can be a complex task and may require the expertise of professional engineers, contractors, or construction personnel experienced in bridge maintenance and inspection.

2.2.1 Remove vegetation from the site

"Remove vegetation from the site" refers to the process of clearing or getting rid of any plants or vegetative growth that may be present on a particular area or piece of land. This can be done for various reasons, such as preparing the land for construction, agriculture, or to create a bare or empty space for other purposes.

To remove vegetation from a site, you can follow these steps:

- Assess the area: Determine the type and density of vegetation present on the site. This will help plan the appropriate removal method.
- Manual removal: For small areas or delicate plants, manual removal might be suitable. Use tools like pruners or shears to cut down plants at the base, remove any roots if possible, and dispose of them properly.
- Mowing or cutting: For larger areas with grass or small plants, using a lawnmower, brush cutter, or scythe can be effective. Cut the vegetation as close to the ground as possible and collect and dispose of the cut plants.
- Herbicides: If vegetation is dense or difficult to remove by manual methods, herbicides can be used. However, be cautious and use appropriate herbicides that are safe for the environment and follow instructions carefully. Apply the herbicide based on the recommended dosage and method.

- Tilling or digging: For areas with deep-rooted or stubborn vegetation, tilling the soil or digging it out using appropriate equipment, like a spade or excavator, can help remove the plants and roots more effectively.
- Stump removal: If trees or shrubs need to be removed, stumps can be ground using a stump grinder or completely removed using an excavator or other machinery.
- Mulching or covering the area: To prevent new vegetation from growing, consider covering the cleared area with a non-permeable material like plastic or applying a thick layer of mulch. This will suffocate any remaining seeds or roots.
- Regular maintenance: To prevent the regrowth of vegetation, regular inspections and maintenance will be necessary. Monitor the site for any new growth and promptly remove it to prevent re-establishment.

Remember to always follow any local regulations or guidelines regarding vegetation removal and disposal. Additionally, consider the ecological impact of vegetation removal and the need for any ecological restoration or replanting efforts.

2.2.3 Excavating the ground to the required depth

Excavating the ground to the required depth refers to the process of removing soil, rocks, or other materials from a specific area until reaching a predetermined depth. This is commonly done in construction and civil engineering projects such as building foundations, underground utilities installation, road construction, or landscaping. Excavation can be performed by using heavy machinery such as excavators, backhoes, or bulldozers, or by manual labor using shovels and hand tools. The depth of excavation is typically specified in the project plans or according to the specific requirements of the task at hand.

Excavating the ground to the required depth involves several steps.

Here is a general outline of the process:

- Assess the site: Before beginning excavation, assess the site for any potential hazards, such as underground utilities, unstable soil, or environmental factors. Obtain any necessary permits or permissions.

- Mark the area: Clearly mark the boundaries of the excavation area with stakes or paint. Use surveying equipment if necessary to accurately map out the required depth.
- Clear the area: Remove any existing structures, trees, or vegetation from the excavation area. This may involve cutting down trees, removing roots, or clearing debris.
- Establish safety measures: Install proper safety measures to protect workers and passersby. This may include fencing, signs, or barriers to prevent unauthorized access to the excavation area.
- Excavation equipment: Choose the appropriate excavation equipment based on factors such as the soil type, the depth required, and the space constraints. Common excavation equipment includes excavators, backhoes, or trenchers.
- Excavate in layers: Start by removing the top layer of soil or any obstructions to reach the desired depth. Excavate in gradual layers, checking for stability, and adjusting the excavation process if needed.
- Support walls or slopes: If necessary, install support walls or slopes to prevent soil collapse. This is especially crucial when excavating in loose or unstable soil.
- Manage spoils: Disposed of excavated material or excess soil properly. It can be used for landscaping, removed off-site, or stored for later use.
- Inspections and compaction: Regularly inspect the excavation site for quality control and to ensure the required depth is achieved. Properly compact the excavated soil if needed to ensure stability.
- Restore the area: Once the desired depth has been achieved, backfill the site with suitable material. Compact each layer of backfill to maintain stability.
- Site cleanup: Remove any debris, equipment, or temporary structures from the excavation site. Restore the area as needed, taking into consideration site drainage and landscaping requirements.

Remember, excavation work can be complex and requires professional knowledge and expertise. It is important to adhere to local regulations and safety practices to ensure a successful and safe excavation process.

2.2.4 Erect a work platform

An Erect Work Platform is a type of temporary structure that is used to provide a safe elevated working platform for workers in construction, maintenance, or other industries. It is commonly used in situations where workers need to perform tasks at heights, such as painting, repairs, or installation work. The erect work platform typically consists of a secure and stable base, supporting frames, platforms, guardrails, and other safety features. The platform is carefully designed and constructed to meet safety standards and regulations, ensuring that workers can perform their tasks with stability and fall protection. Erect work platforms can be adjustable or fixed in height, and they are often constructed using materials such as steel or aluminum. They are lightweight, portable, and versatile, allowing them to be easily moved and set up at different locations as needed. These platforms provide a secure and stable surface for workers to stand on, reducing the risk of falls and accidents. They can be used in various industries, including construction, manufacturing, warehouses, and maintenance operations. It is important to note that erecting and using work platforms should follow proper safety guidelines and regulations to ensure the well-being of workers and compliance with occupational health and safety standards.

2.3. Construction

2.3.1 Set out masonry structure.

Setting out a masonry structure bridge refers to the process of determining the precise positioning and layout of the various components of a bridge made of masonry materials (such as bricks or stones) before construction begins. The setting out process involves marking the ground or foundation where the bridge will be built, laying out reference lines, and determining the exact locations and dimensions of the piers, abutments, arches, and other structural elements of the bridge. This is typically done based on engineering and architectural plans. By properly setting out the masonry structure bridge, the construction process can be more efficient, accurate, and ensure that the final bridge is built to the intended design and specifications.

A masonry structure bridge is a type of bridge that is made primarily of masonry materials, such as stone or brick. These bridges have been used for centuries and are known for their strength and durability. Masonry structure bridges can come in various forms, including arch bridges, beam bridges, or a combination of the two. Arch bridges are characterized by their curved shape, which distributes weight evenly and efficiently to the supports on either end. Beam bridges, on the other hand, consist of a straight beam supported by piers or abutments at each end. The stones or bricks used in masonry bridges are carefully laid and bonded together using mortar or cement to create a strong and stable structure. The use of arches or beams helps to distribute the load and minimize stress on individual components.

A masonry structure in an abutment typically consists of a combination of bricks or stones, mortar, and reinforcing elements. The specific set out of a masonry structure in an abutment will depend on the design and construction requirements, but some common elements may include:

A. **Foundation:** The masonry structure in the abutment starts with a well-designed and properly constructed foundation that provides stability and support. It could be a reinforced concrete footing or a deep foundation system depending on the soil conditions and loads.
B. **Walls:** The abutment walls are usually made of bricks or stones bonded together with mortar. The walls are constructed in accordance with the design specifications, taking into consideration the anticipated vertical and lateral loads.
C. **Buttresses**: To support and strengthen the abutment, buttresses may be incorporated. Buttresses are vertical or inclined projections of masonry or reinforced concrete that provide additional stability and prevent horizontal movement.
D. **Tie rods**: In some cases, tie rods are used to connect the abutment walls together and resist lateral forces. These rods pass through the masonry structure and are anchored in the foundation.
E. **Headers and bond beams**: Headers and bond beams are horizontal members made of reinforced concrete or masonry that provide structural integrity. They are typically placed at regular intervals along the height of the abutment walls to distribute loads and enhance stability.
F. **Mortar joints**: Mortar is used to bond the bricks or stones together and fill the gaps between them. The mortar joints must be properly filled and cured to ensure a strong and durable masonry structure.

G. **Waterproofing**: Depending on the design requirements and the location of the abutment, a waterproofing system may be applied to protect the masonry structure from moisture ingress, which can lead to deterioration.

It is important to note that the specific details and construction techniques for a masonry structure in an abutment can vary depending on the design standards, local building codes, and site-specific factors. Consulting with a qualified structural engineer or architect is crucial to ensure the proper construction of such structures.

2.3.2 Prepare and mixing Mortar

Mixing mortar is the process of combining the different ingredients required to make mortar, which is a mixture used in construction for bonding bricks, stones, or other materials together. The main ingredients of mortar are cement, sand, and water. These ingredients are mixed in specific proportions to form a paste-like consistency that can be easily spread and used to hold building materials in place. Mixing mortar involves thoroughly blending the cement, sand, and water together until a uniform and workable mixture is achieved. This can be done by using a shovel, mixer, or any suitable tool that can effectively combine the ingredients.

Preparing and mixing mortar involves the following steps:

A. **Gather the necessary materials:** You will need cement, sand, water, and a mixing container or wheelbarrow.

B. **Determine the mortar ratio:** The ratio of cement to sand in mortar varies depending on the type of construction work. Common ratios are 1:3 or 1:4 (1 part cement to 3 or 4 parts sand).

C. **Measure the required amount of cement and sand**: Use a shovel or measuring container to measure the appropriate amount of cement and sand according to the desired ratio.

D. **Add the measured cement and sand to the mixing container**: Pour the cement and sand into the mixing container or wheelbarrow. Ensure that the container is clean and free from debris.

E. **Mix the cement and sand**: Use a shovel or hoe to thoroughly mix the cement and sand together. Make sure they are evenly distributed and there are no clumps.

F. **Gradually add water**: Start adding water to the mixture while continuously mixing it. Gradually add water until the mortar reaches the desired consistency. The consistency should be like thick paste, not too dry or too runny.

G. **Mix thoroughly**: Continue mixing the mortar for several minutes to ensure it is well blended and any dry spots are eliminated. Use a shovel or hoe to mix and turn the mixture until it becomes a uniform, workable mortar.

H. **Let the mixed mortar rest**: After mixing, let the mortar rest for a few minutes to allow it to hydrate and settle.

It is important to follow safety guidelines and wear appropriate protective gear, such as gloves and eye goggles, when working with mortar. Also, be mindful of the working time of the mortar, as it will start to harden after a certain period, and avoid excessive exposure to direct sunlight or extreme weather conditions while using the mortar.

2.3.3 Lay masonry wall structure

A lay masonry wall structure refers to a construction technique in which individual masonry units, such as bricks or stone blocks, are arranged in horizontal layers or courses, with each unit being stacked on top of the previous one. This type of wall structure is commonly used in building walls, fences, or other structures where strength, durability, and aesthetic appeal are desired. The units are typically held together by mortar, a bonding material that fills the gaps between the units and hardens over time, creating a solid and stable wall. Lay masonry wall structures can be constructed in various patterns, such as running bond, stack bond, or Flemish bond, depending on the desired design and structural requirements.

To construct a masonry wall structure, follow these steps:

- Gather the necessary materials: bricks or concrete blocks, mortar mix, a trowel, a level, a masonry saw (if needed), safety goggles, and gloves.
- Prepare the foundation: Ensure that the ground is level and compact. Dig a trench wide and deep enough to accommodate the foundation of the wall.

- Lay the first course: Begin by applying a thick layer of mortar on the foundation. Place the first row of bricks or concrete blocks on top, using a level to ensure they are straight and even. Apply mortar to the ends of each brick/block before placing the next one.
- Continue laying subsequent courses: Apply mortar to the top of the first course, then lay the next row of bricks/blocks. Use a trowel to scrape off excess mortar. Make sure to stagger the joints between each course for added strength.
- Check for level and plumb: Continuously use a level to check for horizontal alignment and a plumb line or level to check for vertical alignment. Adjust as necessary by tapping the bricks/blocks with a rubber mallet.
- Cut bricks/blocks if needed: Use masonry saw to cut bricks/blocks to the required size. Always wear safety goggles and follow manufacturer instructions while operating the saw. **7.** Install corner bricks/blocks: When reaching a corner, install corner bricks or blocks perpendicularly to create a stable joint. Apply mortar to the sides and ends of the corner brick/block, ensuring they align correctly.
- Install reinforcement (if needed): Depending on the height and purpose of the wall, you may need to add reinforcement, such as steel bars or wire mesh, between courses. Follow local building codes and best practices.
- Finish the top of the wall: The top course should be finished with a capstone or brick soldiers to provide a neat and sturdy finish. Apply mortar to the top of the last course and carefully place the capstones or bricks, ensuring they are level.
- Clean up: Once the mortar has cured (usually about 24 hours), remove excess mortar with a wire brush. Rinse the wall with water to remove any remaining debris or stains.

Remember to consult local building codes and regulations before starting any masonry wall construction project. It may also be helpful to seek guidance from experienced professionals or masonry contractors.

2.3.4. Masonry bond

Masonry bond is the arrangement or pattern of laying bricks or stones in a masonry structure. It refers to the way in which the individual units are overlapping or interlocking with each other to create a solid and stable wall or structure. The most common types of masonry bonds include stretcher bond, header bond, English bond, Flemish bond, and bond patterns such as basket weave, herringbone, and diagonal bond. Each bond pattern has its own aesthetic appeal and structural advantages, ensuring durability and strength in the masonry construction.

2.3.5 Construct masonry wall maintaining bond

In masonry construction, maintaining bond refers to the practice of ensuring a continuous and uniform pattern of bricks or stones in a wall. This ensures structural integrity and aesthetic appeal. A bond pattern in masonry refers to the arrangement and alignment of bricks or stones in a wall. Different bond patterns, such as the common bond, English bond, Flemish bond, or stack bond, dictate how individual units are placed and interlocked with each other. Maintaining bond involves various considerations, including properly aligning each unit horizontally and vertically, maintaining consistent joint thickness, and ensuring proper bonding with mortar. It also involves maintaining uniformity in the placement of headers and stretchers (types of bricks placed along the width or length of the wall, respectively) to provide stability and prevent weaknesses. Maintaining bond is crucial to prevent the collapse or failure of a masonry wall, as a strong bond disperses the loads evenly and enhances the structural integrity of the wall. Additionally, maintaining a neat and uniform bond pattern enhances the overall appearance of the wall.

2.4. Install tie down

An install tie-down and lateral support system is typically used in construction or engineering to secure and stabilize structures. It involves fastening various components to prevent displacement or movement due to external forces such as wind, earthquakes, or other pressures. Tie-down systems provide resistance against uplift forces, preventing the structure from lifting off the ground. This is particularly important for structures like roofs, walls, or towers that are susceptible to wind loads. Lateral support systems aim to prevent lateral movement or swaying of the structure. They are commonly used in tall buildings, bridges, or towers to resist lateral forces caused by wind, seismic activities, or other external factors. These systems include bracing, diagonal members, or shear walls that help distribute and transfer the loads to the foundations. The specific design and installation of tie-down and lateral support systems may vary depending on the type of structure and the magnitude of the expected forces. Engineers consider factors such as wind speeds, seismic zones, building codes, and structural analysis to determine the most appropriate system for each project.

2.4.1 Tie down prevent the abutment and wing wall

Tie-down prevents the abutment and wing wall from uplift forces or displacement due to external loads. It is a structural element that connects the abutment or wing wall to the foundation and provides resistance against vertical or horizontal forces. Tie-downs are typically made of steel straps, rods, or cables that are anchored into the foundation and then attached to the abutment or wing wall to keep them in place. By securing the structure firmly to the foundation, tie-downs ensure stability and prevent the abutment and wing wall from being lifted or moved.

2.5 Finish joints to laid face brickwork

Finishing joints in laid face brickwork refers to the process of filling the gaps between individual bricks with mortar and creating a neat and uniform appearance. This is done to enhance the structural integrity of the wall, as well as improve its overall visual appeal.

Here are the steps involved in finishing joints in laid face brickwork:

- Preparing the mortar: Mix the mortar according to the manufacturer's instructions, ensuring the correct ratio of cement, sand, and water. The consistency should be smooth and workable.
- Applying mortar: Begin by wetting the edges of the bricks to prevent excessive absorption of moisture from the mortar. Then, using a trowel, apply a layer of mortar to the joint gaps. Make sure to fill the gaps completely and ensure the mortar is evenly distributed.
- Tooling the mortar: Once the mortar is applied, use a jointing tool to smooth and shape the joints. This creates a uniform appearance and helps in creating a strong bond between adjacent bricks. The jointing tool can be a pointed trowel, a concave jointer, or a professional jointer tool.
- Striking the joints: After the mortar has set slightly, but not hardened completely, strike the joints using a striking tool or a rounded stick. This process involves removing excess

mortar from the joints and creating a neat finish. The striking tool should be held at an angle to the joints and moved along them in a smooth, consistent motion.

- Cleaning the surface: After striking the joints, wipe away any excess mortar on the face of the bricks using a damp cloth or sponge. This step ensures that the brickwork's surface is clean and free of any smudges or stains.

Remember to work in small sections at a time to prevent the mortar from drying too quickly. It is also important to follow safety precautions and wear protective gear such as gloves and safety glasses while working with mortar.

2.5.1 Joints finish bricks smooth

Joints are the spaces between bricks or other masonry units. When bricks are laid, the joints are typically filled with mortar to create a smooth and seamless surface. The process of finishing the joints involves applying and shaping the mortar to create a uniform appearance. This can be done using various techniques, such as striking the joints with a jointer tool to create a concave finish or smoothing the joints with a trowel for a flush or slightly rounded finish. The purpose of finishing the joints is to enhance the aesthetics of the brickwork and to improve its overall durability and weather resistance.

Joints finish bricks smooth

2.6 Brush down masonry stone work prior to drying.

Brushing down masonry stone work prior to drying refers to the process of using a brush or broom to remove excess mortar or debris from the surface of the stones before they are allowed to dry. This is typically done to achieve a cleaner and more even appearance, as well as to prevent any hardened mortar from staining the stones or interfering with the grouting process. It is an important step in masonry construction to ensure the final result is of high quality.

To brush down masonry stone work prior to drying, you can follow these steps:

Gather the necessary tools: a soft bristle brush, a stiff bristle brush, a bucket of warm water, and a clean cloth. Start by using the soft bristle brush to gently remove any loose dirt or debris from the surface of the stone work. Lightly brush in a circular motion to avoid scratching or damaging the stone. If there are any stubborn stains or dirt, switch to the stiff bristle brush. Apply a bit of water to the brush and scrub the affected areas more vigorously. Be careful not to scrub too hard, as this could potentially damage the stone. Once you have removed most of the dirt, dampen the clean cloth with warm water and gently wipe down the entire surface of the stone work. This will help remove any remaining dust or residue. Allow the stone work to air dry completely before applying any sealant or finishing products. Remember to always use caution when working with masonry stone work and test any cleaning method on a small, inconspicuous area first to ensure that it does not cause any damage or discoloration.

Self-Check-1

Part I: choose the correct answer

1. What is the first step in carrying out an excavation for a bridge?

   A. Utilities and Services C. Planning and Design

   B. Clearing vegetation D. Clearing vegetation

2. What is the purpose of foundation preparation in setting and laying out a minor bridge structure?

   A. To determine the span length and orientation

   B. To ensure stable soil conditions

   C. To construct the abutments and piers

   D. To choose a suitable location for the bridge

3. What should be considered during excavation regarding underground utilities and services?

   A. Relocate them to a different area C. Increase their capacity

   B. Avoid damaging them D. Remove them completely

4. What is the total length range of a minor bridge?

   A. 6 m to 60 m B. 2 m to 10 m C. 100 m to 500 m D. Above 60 m

5. What is the purpose of a minor bridge structure?

   A. To carry heavy loads and high traffic volumes

   B. To connect two major cities

   C. To provide access to major highways

   D. To span a gap or obstacle

Part II: Matching

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

	A	B
_______	1. Pedestrian or light vehicle traffic	A. the purpose of deck installation in setting and laying out a minor bridge structure
_______	2. provide a surface for vehicles or pedestrians to cross the bridge	B. It has a single span
_______	3. the process of carrying out an excavation for a bridge	C. A bridge made from wood, concrete, or steel
_______	4. a minor bridge structure	D. Clearing vegetation and excavating the area
_______	5. a characteristic of a minor bridge structure	E. the typical traffic volume for a minor bridge structure

Part III: Short Answer Questions

Instructions: Answer all the following questions accordingly.

1. What steps are involved in setting and laying out a minor bridge structure?
2. How is the location for a minor bridge selected?
3. What is involved in the construction of abutments and piers for a minor bridge?
4. How are the bridge beams positioned and secured on top of the abutments and piers?
5. What materials can be used for the bridge deck of a minor bridge?
6. What additional components may be included in a minor bridge structure for safety and functionality?

Operation Sheet 1

Operation title: Carry out excavation for foundation for masonry work

Purpose:

- To practice and demonstrate the knowledge and skill required to carry out excavation

Instruction:

Use given tools and equipment to carry out excavation. 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 Set and Carry out excavation

1. Project Overview:

- Describe the purpose and scope of the excavation project.
- Specify any specific requirements or objectives.

2. Site Preparation:

- Identify the area to be excavated.
- Mark boundaries and ensure the safety of the surrounding environment.
- Clear any obstacles, vegetation, or debris in the excavation area.
- Install safety barriers, fencing, and warning signs.

3. Equipment and Resources:

- List the machinery and equipment required for the excavation.

- Assign qualified operators for each piece of equipment.
- Ensure availability of necessary tools, fuel, and maintenance supplies.
- Identify any additional resources or personnel required.

4. Safety Measures:

- Establish safety protocols and guidelines to be followed.
- Conduct safety briefings and provide necessary personal protective equipment (PPE) to workers.
- Implement a system for monitoring and maintaining safe working conditions.
- Identify emergency exits, first aid stations, and fire extinguishers on site.

5. Excavation Operations:

- Determine the excavation method (e.g., open cut, trenching, or tunneling).
- Follow engineering plans, drawings, or specifications for excavation depth, width, and slope.
- Ensure proper shoring or support systems are in place for deep excavations.
- Excavate the area systematically, removing the soil or material as needed.
- Monitor soil conditions and groundwater levels during excavation.

6. Materials Handling and Disposal:

- Establish a system for handling and disposing of excavated materials.
- Determine appropriate locations for stockpiling materials on site.
- Arrange for transportation and disposal of excess materials as per environmental regulations.

7. Quality Control and Inspections:

- Conduct regular inspections to ensure compliance with project specifications.
- Test soil samples for compaction, moisture content, and stability as necessary.
- Address any issues or deviations promptly and in accordance with project requirements.

8. Site Cleanup and Restoration:

- Remove all equipment, debris, and unused materials from the excavation site.

- Restore the site to its pre-excavation condition, including grading and reseeding if applicable.
- Repair any damages or disturbances caused during excavation.

9. Documentation and Reporting:

- Keep a record of daily progress, activities, and any incidents that occur on site.
- Document any changes, modifications, or deviations from the original plan.
- Prepare a final report summarizing the excavation operations and outcomes.

Quality Criteria:

- Accuracy in setting out pipeline
- Speed in setting out pipeline
- Create Teamwork

Operation Sheet 2

Operation title: Masonry Structure Installation

Purpose:

- To practice and demonstrate the knowledge and skill required to Masonry Structure Installation
- **Instruction:**
- Use given tools and equipment to Masonry Structure Installation. 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.

Preparation:

1. Gather all necessary tools and materials: bricks, mortar mix, trowels, spirit level, masonry hammer, measuring tape, safety equipment (goggles, gloves), and any additional equipment specific to the project requirements.
2. Ensure the work area is clean, safe, and accessible.

Foundation Preparation:

1. Excavate the foundation area to the required depth and dimensions, following any architectural plans or local building codes.
2. Lay a compacted layer of gravel or crushed stone as a base for the foundation.
3. Install formwork to define the shape and dimensions of the foundation.
4. Check the formwork for level and squareness before proceeding.

Masonry Structure Construction:

1. Prepare the mortar mix according to the manufacturer's instructions.
2. Begin laying the first course of bricks, starting from the corners and working towards the center.
3. Apply a layer of mortar on the foundation, using the trowel.
4. Place the bricks firmly into the mortar bed, ensuring even spacing between bricks.
5. Check the alignment and level of each brick using the spirit level.

6. Continue laying subsequent courses of bricks, staggering each course to improve structural stability.
7. Butter and pack mortar between the bricks using the trowel and masonry hammer as necessary.
8. Use the measuring tape to ensure the masonry structure conforms to the required dimensions throughout the construction process.
9. Install any necessary reinforcement, such as steel rods or ties, following structural engineering guidelines.
10. As the masonry structure reaches the desired height, allow each course to set and cure according to the mortar instructions.

Finishing:

1. Clean excess mortar off the bricks using the trowel or damp cloth before it sets.
2. Brush away any loose debris from the masonry structure.
3. Apply a waterproofing or weather-resistant coating, if desired or required.
4. Conduct a final inspection of the masonry structure, checking for stability, alignment, and any potential safety concerns.
5. Properly dispose of any waste materials and clean up the work area.

Safety:

1. Wear appropriate personal protective equipment (PPE), such as goggles and gloves, to prevent injury.
2. Follow safe lifting techniques when handling heavy materials.
3. Be cautious of sharp edges and potential falling hazards.
4. Use scaffolding or ladders when necessary, ensuring proper stability and adherence to safety guidelines.
5. Adhere to all local building codes and regulations to ensure a safe and compliant structure.

Quality Criteria:

- Accuracy in setting out pipeline
- Speed in setting out pipeline

LAP Test 1

Practical Demonstration

Name: ___________________________ Date: ________________________

Time started: _____________________ Time finished: ________________

Instruction I: Setting Out Masonry wall and structure

Task 1. Prepare setting out masonry wall and structure

Task 2. Setting out masonry wall and Installation

Unit Three: Concert work

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

- Preparation of Concert work
- Erection of Formwork
- Set out Reinforcement Concert work
- Concrete Pouring

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 concert work
- Prepare Erection of Formwork
- Prepare Reinforcement Concert work
- Identify Concrete Pouring

3.1 Inspection

3.1.1Determining, location footing and formwork

Determining the location of footing and formwork refers to the process of identifying and marking the exact positions where the footings (which provide structural support for a building's foundation) and formwork (which is used to create temporary molds for pouring concrete) will be constructed on a construction site.

This process involves several steps:

A. **Design review**: The structural engineer or architect reviews the construction plans to determine the required location and dimensions of the footings and formwork.

B. **Site survey**: A surveyor or engineer accurately measures the site's boundaries and existing structures to determine the precise location for the footings and formwork.

C. **Site preparation:** Once the locations have been determined, the site is cleared of any obstacles, debris, or vegetation that may hinder the construction process.

D. **Marking**: The exact positions of the footings and formwork are marked on the ground using stakes, strings, or other markers. This helps guide the construction team during the excavation and construction process.

E. **Excavation:** The marked areas are then excavated to the required depth and shape for the footings and formwork.

F. **Installation of formwork:** The formwork is constructed according to the design specifications, using materials such as wood, steel, or aluminum, to create the molds for the concrete.

G. **Reinforcement:** If necessary, reinforcing steel bars (rebar) are installed within the formwork to provide additional strength to the concrete.

H. **Pouring concrete**: Finally, the concrete is poured into the formwork and allowed to cure, creating the permanent footing or foundation structure.

I. Accurate determination of the location of footing and formwork is crucial for ensuring the stability and structural integrity of a building.

Fig 3.1 Footing and formwork

3.1.2 Drawings and reinforcement schedule

In spread footing construction, drawings refer to the detailed plans and specifications that provide information about the footing design and dimensions, reinforcement requirements, and any other relevant details. These drawings act as a guide for contractors and builders to ensure that the footing is constructed correctly according to the design requirements. Reinforcement schedule, on the other hand, is a part of the drawings that specifically details the type, size, spacing, and arrangement of reinforcement bars or steel in the spread footing. It specifies where the bars need to be placed, how many are needed, and their configuration. The reinforcement schedule is crucial for ensuring that the footing has the necessary structural strength and can withstand the anticipated loads. As for the type of formwork used in spread footing construction, it typically depends on various factors such as the size and shape of the footing, the construction method, and site conditions.

Some common types of formwork for spread footings include:

- Wooden formwork: Constructed using timber or plywood, this is a traditional and cost-effective formwork method commonly used for small to medium-sized footings.
- Steel formwork: Made of steel panels or frames, this formwork is durable and provides excellent stability. It is often used for larger foundations or when a high level of accuracy is required.
- Aluminum formwork: Similar to steel formwork, aluminum formwork is lightweight, easy to handle, and allows for fast construction. It is often preferred for large-scale projects.

- Insulating concrete formwork (ICF): This type of formwork consists of interlocking foam panels that act as insulation and are filled with concrete to create the footing. ICF formwork is energy-efficient, provides good insulation properties, and is often used in cold climates.

It is important to select the appropriate formwork based on the specific requirements of the footing design, construction timeline, budget, and other relevant factors.

3.1.3 Selecting Formwork components/materials

Select formwork components/materials refer to the specific components or materials used in formwork systems for various construction purposes. These components and materials are carefully chosen or selected based on the specific requirements of a construction project, including the type of structure, load-bearing capacity, desired surface finish, and duration of usage.

Some common select formwork components/materials include:

- **Formwork panels:** These are usually made of plywood, timber, or steel sheets. They provide the necessary support and shape to the concrete during the casting process.
- **Formwork props:** These are telescopic or adjustable metal props used to support the formwork panels and transfer the loads to the ground. They help maintain the formwork stability during the concrete pouring and curing stages.
- **Formwork ties:** These are used to secure the formwork panels together and ensure that they remain in position during the concrete casting process. They can be made of steel wires, steel bars, or plastic cones.
- **Formwork anchors:** These are used to fix the formwork system to the existing structure or ground to prevent movement or displacement during the concrete pouring. They can be mechanical or chemical anchors.
- **Formwork release agents**: These are used as coatings or sprays to prevent the concrete from sticking to the formwork surfaces, allowing easy de-molding and reducing the risk of surface defects.

- **Formwork accessories:** These include various additional components such as formwork corners, chamfers, clamps, connectors, and brackets. They are used to achieve specific shapes, corners, or details in the concrete structure.
- Selecting the appropriate formwork components and materials is crucial for ensuring safety, efficiency, and quality in concrete construction. Proper selection can help save time, reduce costs, and achieve the desired results in terms of structural integrity and surface finish.

3.1.4 Formwork components materials

Formwork components and materials must be selected based on the size and weight of the structure being constructed. The selection of appropriate components and materials is crucial to ensure the stability and safety of the formwork system.

Some common formwork components include:

- Formwork panels: These are the main structural elements that provide support to the concrete during pouring and curing. The size and weight of the panels should be chosen based on the dimensions and load requirements of the structure.
- Formwork supports: These are used to provide vertical support to the formwork panels. The height and weight-bearing capacity of the supports should be selected based on the height and load requirements of the formwork.
- Formwork ties: These are used to hold the formwork panels together and prevent them from shifting during the concrete pouring. The size and strength of the ties should be chosen based on the lateral pressure exerted by the concrete.
- Formwork wedges and clamps: These are used to tighten and secure the formwork components. The size and strength of the wedges and clamps should be selected based on the requirements for stability and load-bearing capacity.
- Formwork release agents: These are used to prevent the concrete from sticking to the formwork panels. The appropriate type and quantity of release agents should be selected based on the type of formwork material and concrete mix.

The selection of materials for formwork components should also consider factors like durability, reusability, and ease of handling. Commonly used materials include timber, steel, aluminum, or composite materials. The choice of material should be based on factors such as the desired lifespan of the formwork, the need for rapid assembly and disassembly and the desired surface finish of the concrete.

Fig 3.1 Formwork components/materials

3.1.5 Selecting fixing/fasteners

When selecting fixing/fasteners, there are several factors to consider ensuring you choose the appropriate ones for your specific application. Here are some key considerations:

A. **Material:** Determine the material of the surfaces you are connecting, such as wood, metal, concrete, plastic, etc. Different materials may require different types of fixing/fasteners.

B. **Load capacity:** Evaluate the weight and load-bearing capacity of the objects you are fixing together. This will help determine the strength and size of the fixing/fasteners needed.

C. **Environmental conditions**: Consider the environment in which the fixing/fasteners will be used. Factors like temperature, moisture, and exposure to chemicals or UV rays can affect the durability and corrosion resistance of the chosen fasteners.

D. **Type of connection:** Decide whether you need a temporary or permanent connection. Temporary connections may require quick-release fasteners or adjustable clamps, while permanent connections may need screws, bolts, or nails.

E. **Installation method**: Determine the installation method you prefer or have access to. Some fixing/fasteners, like self-drilling screws or adhesive tapes, may require specific tools or equipment.

F. **Aesthetics**: If the fixing/fasteners will be visible, consider the aesthetic aspect and choose options that match the overall design or finish of the objects being connected.

G. **Cost:** Finally, consider your budget and factor in the cost of the fixing/fasteners. Some fasteners may be more expensive but offer better performance or longevity, while others may be more affordable but still meet your requirements.

Always follow the manufacturer's guidelines and recommendations when selecting and using fixing/fasteners to ensure safe and secure connections. If unsure, consult with a professional or expert in the field for guidance.

3.1.6 Fixings and fasteners

To ensure formwork is secure and will not collapse during concrete pouring, the following fixings and fasteners should be selected:

- Form Ties: These are used to hold together opposite faces of formwork, preventing it from bulging or shifting. Common form ties include taper ties, she-bolts, coil ties, and snap ties.
- Wedges: Wedges are used in conjunction with form ties to secure the formwork system and maintain its position during concrete pouring.
- Form Anchors: These are used to anchor the formwork to existing structures or the ground to counteract the outward pressure exerted by the concrete. Examples include ground anchors, wall plates, and deadman anchors.
- Turnbuckles: These are used to adjust the tension and alignment of formwork by connecting two plates or rods, ensuring stability during concrete pouring.
- Support Braces: These components help reinforce and support the formwork system, maintaining its shape and structure under the weight of the concrete. This includes diagonal braces, horizontal struts, and vertical shores.

- Clamps and Clips: These are used to secure formwork panels or boards together, preventing them from shifting or separating during concrete pouring. Examples include spring clips, swivel clips, and panel clamps.
- Nails, Screws, and Bolts: Depending on the formwork material (such as wood, metal, or plastic), appropriate nails, screws, or bolts should be chosen to provide additional reinforcement and secure components in place.
- Adhesives and Sealants: In some cases, adhesives or sealants are used to bond formwork components or seal joints, preventing leaks or movement during concrete pouring.

It is crucial to consider the load capacity, material compatibility, and proper installation techniques when selecting and using these fixings and fasteners to ensure the stability and safety of the formwork system.

3.1.7 Set up string lines and grades.

Setting up string lines and grades refers to the process of establishing reference lines and levels on a construction site to ensure accurate alignment and elevation of various elements, such as foundations, walls, floors, etc. It involves creating a network of strings that are stretched tightly between designated points, called benchmarks, and using a leveling instrument to determine the desired elevations or grades along those strings. The string lines serve as a visual guide for construction workers to follow during the construction process, helping them ensure that the building components are correctly positioned and aligned. The grades, which are typically measured using a transit or laser level, provide the desired elevation or slope for different parts of the project. By setting up string lines and grades accurately, construction professionals can achieve proper alignment, levelness, and consistent elevation throughout the construction site, resulting in a structurally sound and visually appealing final product.

3.1.8 Mark out location of footing grades

The string lines are used as a guide to mark out the exact location and dimensions of the spread footing before pouring the concrete. It helps to ensure that the footing is positioned accurately according to the design plans. Grades, on the other hand, are used to determine the correct level at which the concrete should be poured. The grades indicate the elevation or height at which the concrete should be placed in order to match the desired level as indicated in the plans or specifications. By using string lines and grades together, construction workers can ensure that the spread footings are positioned correctly and that the concrete is poured at the appropriate level, thereby maintaining the accuracy and integrity of the structural foundation.

3.1.9 Setting string lines:

The string lines are used as a guide to mark out the exact location and dimensions of the spread footing before pouring the concrete. It helps to ensure that the footing is positioned accurately according to the design plans. Grades, on the other hand, are used to determine the correct level at which the concrete should be poured. The grades indicate the elevation or height at which the concrete should be placed in order to match the desired level as indicated in the plans or specifications. By using string lines and grades together, construction workers can ensure that the spread footings are positioned correctly and that the concrete is poured at the appropriate level, thereby maintaining the accuracy and integrity of the structural foundation.

3.1.10 Identifying services prevent damage.

Identifying services that prevent damage involve measures or actions taken to identify potential risks or hazards that could lead to damage and implementing preventative measures to minimize or eliminate those risks. Some examples of such services include:

A. **Security services:** These services involve measures to protect physical assets, such as buildings, equipment, or infrastructure, from theft, vandalism, or other forms of damage. This may include installing surveillance cameras, access control systems, or employing security personnel.

B. **Maintenance services:** Regular maintenance is crucial to prevent damage to equipment or infrastructure. Identifying preventative maintenance schedules and conducting inspections can help identify potential issues before they escalate into more severe damage or breakdowns.

C. **Risk assessment services:** These services involve evaluating potential risks and hazards in a specific environment or process. This could include identifying potential fire hazards, electrical risks, or environmental factors that could lead to damage. Once these risks are identified, appropriate safeguards can be implemented.

D. **Alarm and monitoring services:** Alarm systems are designed to detect and alert individuals or authorities about potential threats or dangers. These could include intrusion alarms, smoke detectors, or temperature sensors. Monitoring services can further enhance the effectiveness by providing continuous monitoring and immediate response in case of an emergency.

E. **Emergency preparedness services**: These services involve preparing for potential emergencies and disasters. This includes developing emergency response plans, conducting drills or training, and ensuring access to necessary emergency equipment or resources.

F. **Insurance services:** While not directly preventing damage, insurance services can provide financial protection in the event of damage or loss. By identifying the appropriate insurance coverage and ensuring adequate coverage, individuals or organizations can mitigate the financial impact of potential damage.

Overall, these identification services help to identify potential risks and implement preventative measures to reduce the likelihood of damage occurring.

3.2 Erection of Formwork

3.2.1 Set out the formwork

Setting out formwork refers to the process of accurately positioning and aligning formwork (temporary structures that support and shape concrete during construction) before pouring concrete. It involves determining the exact dimensions, location, and orientation of the formwork to ensure that the concrete elements are constructed as per the design and specifications. This involves measuring and marking the positions, leveling and aligning the formwork, and securing it in place before concrete placement. Setting out formwork is a crucial part of construction as it ensures the accuracy, quality, and structural integrity of concrete structures. Setting out is the process of surveying were the positions and levels of buildings, roads, drainages, sewers, and all other engineering projects are already marked on a plan are transferred to the ground by a variety of methods and by specifically manufactured instruments or is the process by which information is taken. Setting out formwork refers to the process of accurately positioning and installing the wooden or metal framework that will support wet concrete until it is sufficiently hardened and able to support itself. This process is essential in construction projects to ensure that the formwork is correctly aligned and built to the specified dimensions and shape.

Here are the general steps involved in setting out formwork:

A. **Study the design drawings**: Understand the requirements of the project by carefully examining the construction drawings, including dimensions, elevations, angles, and any specific details related to the formwork.

B. **Survey the site:** Conduct a detailed site survey to determine the correct location and configuration of the formwork. This may involve measuring the site, checking the ground level, and identifying any obstructions or existing structures that might affect the formwork installation.

C. **Stake the corners**: Use surveying tools and instruments to accurately mark the corners of the formwork. Drive stakes into the ground at these locations and ensure they are properly aligned with the design dimensions.

D. **Establish the levels and alignment**: Use surveying instruments like levels, theodolites, or laser levels to establish the correct levels and alignment of the formwork. Vertical and horizontal references should be established to ensure accuracy throughout the installation.

E. **Install the formwork panels**: Install the formwork panels based on the design specifications, making sure they are securely fastened, correctly aligned, and properly braced. This may involve cutting, shaping, and joining the formwork panels to create the desired shape and size.

F. **Incorporate necessary reinforcements and accessories**: If required by the design, add any necessary reinforcements, such as steel bars or mesh, as well as additional accessories like brackets or structural supports. These elements will increase the strength and stability of the formwork.

G. **Check and adjust:** Regularly inspect the formwork to ensure it remains in the correct position during the concrete pouring process. Make any necessary adjustments if there are deviations or movements.
H. **Pour concrete:** Once the formwork is set and checked, concrete can be poured into the designated area. Ensure that the concrete is properly compacted and evenly distributed to avoid weak spots or air pockets.
I. **Cure and remove formwork:** Allow the concrete to cure and gain sufficient strength before removing the formwork. The curing time will depend on various factors such as temperature, humidity, and the type of concrete used.

It's important to note that setting out formwork requires skilled workers with knowledge of construction techniques and equipment to ensure the safety and accuracy of the process.

A common example of the 3-4-5 method is by setting out a triangle shape. One side measures three feet long (the straight line), the second four feet long (the perpendicular line) and the last five feet long (across) – hence the perfectly suited name '3-4-5 method'.

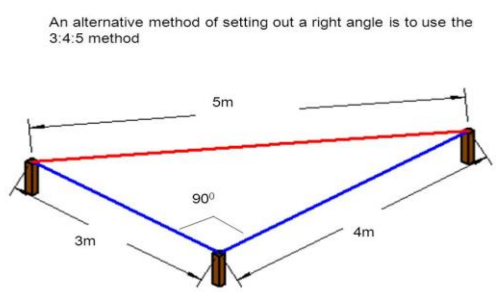

Fig 3.2 setting out 3-4-5 method

3.2.2 Assembling/erecting and bracing formwork

Assembling/erecting and bracing formwork refers to the process of constructing temporary structures known as formwork or molds to support concrete during its curing process. This formwork helps shape the concrete into the desired shape and provides support until it gains enough strength to stand independently.

3.2.3 Formwork Erection

Adequate temporary bracing must be in place while initially setting formwork. Assure that formwork is properly braced and stabilized against wind and other external forces. Safe working platforms must be installed as per applicable safety standards and as stated in following sections.

- **There are three stages in formwork operations:**
  A. Assembly and erection
  B. Concrete placement
  C. Stripping and dismantling.

3.2.4 Assembly and erection

Assembly and erection in bridge construction refers to the process of putting together and positioning the components of a bridge to create the final structure.

A. Assembly: This involves fabricating and joining the different elements of the bridge, such as beams, girders, and trusses, either off-site or on-site. The assembly process may include welding, bolting, or riveting the individual parts together.

B. Erection: Once the components are assembled, they are lifted and positioned into place to form the complete bridge structure. The erection process may involve the use of cranes, specialized lifting equipment, or temporary supports to lift and maneuver the heavy components into their designated positions.

During the erection process, precise alignment and connection of the bridge elements are crucial to ensure structural integrity and safety. It requires careful planning, engineering expertise, and skilled labor to execute the assembly and erection process efficiently. Assembly and erection are critical stages in bridge construction as they lay the foundation for the bridge's strength and functionality. The completed bridge must withstand loads imposed by traffic, environmental factors, and other factors relevant to its purpose. Therefore, meticulous attention to detail is necessary during assembly and erection to ensure a durable and safe bridge structure.

3.2.5 Position expansion joints

Position expansion joints in formwork are gaps created in construction joints to allow for movement and expansion of the concrete. These joints are typically formed by leaving a space between adjacent sections of formwork and are filled with a compressible material such as a foam or rubber strip. The purpose of these expansion joints is to accommodate the natural expansion and contraction of the concrete due to temperature changes and other factors, preventing cracking or damage to the structure.

Expansion Joints are a bellows type device. Expansion joints are used to absorb thermal expansion. They can also be used to absorb contraction in cryogenic lines and to reduce vibration in piping systems. Materials of construction for the bellows can be stainless steel or rubber or even a composite material.

Fig 3.3 Expansion Joints

3.2.6 Sleeve joints with adhesives

Sleeve joints with adhesives in bridge construction refer to a joining method used to connect individual bridge segments or elements together. This technique involves using sleeves or tubes made of materials like steel or carbon fiber, which are placed around the ends of the bridge segments. Adhesive materials, such as epoxy or polyurethane resin, are then applied inside the sleeves to bond the segments together. Sleeve joints with adhesives provide several advantages in bridge construction. They enhance load transfer, distribute forces evenly, and provide resistance against environmental factors like moisture and corrosion. This joining method also allows for flexibility and movement, accommodating the expansion and contraction of the bridge due to temperature changes. Overall, sleeve joints with adhesives offer a structurally sound and durable solution for connecting bridge elements while maintaining their integrity and longevity.

Joints such as tube-in-tube and butt joints are commonly used in shaft and coupling applications such as golf clubs or drive shafts. Cylinder is an improved adhesive version of the butt joint.

Fig 3.4 Sleeve joints with adhesives

3.2.7 Socket and spigot with adhesives

In bridge construction, a socket refers to a cylindrical hole or recess created in a structure, such as a pier or abutment, for a specific purpose. It is usually a pre-determined space where another component can fit snugly. On the other hand, a spigot refers to a projecting part, usually cylindrical in shape that is meant to fit into a corresponding socket or hole. It is designed to be inserted into the socket, creating a secure connection between two components. Adhesives, in the context of socket and spigot connections in bridge construction, are used to provide additional strength and stability to the joint. They are applied between the contacting surfaces of the socket and spigot to enhance their bond and ensure a tight fit. Commonly used adhesives include epoxy resin and polyurethane adhesive, which can provide strong, durable connections. Adhesives are particularly useful in situations where mechanical fasteners, such as bolts or screws, may not be sufficient or practical.

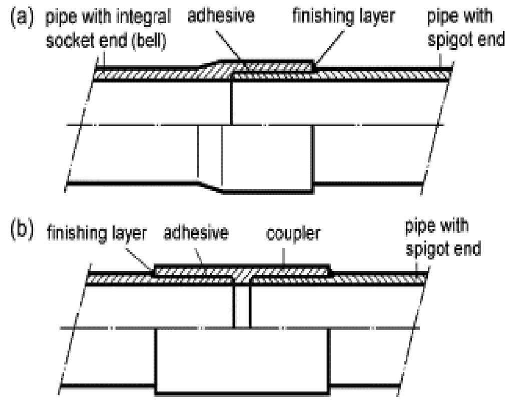

Fig 3.5 Socket and spigot with adhesives

3.2.8 Socket and spigot with rubber rings

In construction, a socket and spigot joint refers to a method of connecting two cylindrical pipes or conduits together. The socket is a female end with an inner recess, while the spigot is a male end with an external projection. The socket and spigot joint allows the pipes to be inserted and joined securely, creating a sealed connection. Rubber is commonly used in socket and spigot joints to enhance the water tightness and flexibility of the connection. Rubber gaskets or seals are placed between the socket and spigot surfaces to prevent water leakage and provide resistance against movement or vibration. The rubber material acts as a cushion and helps to absorb any external forces or shocks, maintaining the integrity of the joint.

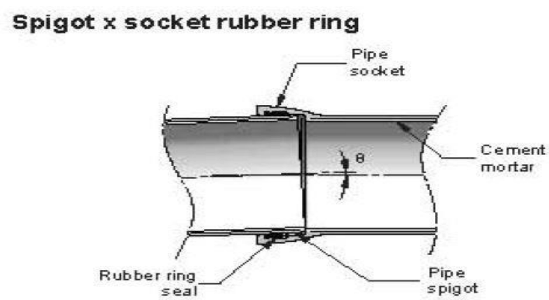

Fig 3.6 Socket and spigot with rubber rings

3.2.9 Butt Joints with outside bands

Butt joints with outside bands in construction are a type of joint connection commonly used in woodworking and carpentry. In this method, two boards are joined together by butting them against each other at a 90-degree angle, forming a right angle. To reinforce and strengthen this joint, an additional piece of material, known as an outside band, is added along the outside edge of the joint. The outside band serves as a support or reinforcement to prevent the joint from separating or twisting under stress. It can be made of the same or different type of material as the boards being joined, such as plywood, solid wood, or metal. The outside band is typically glued and nailed or screwed into each of the boards, ensuring a secure and durable connection. Butt joints with outside bands are commonly used in constructing cabinets, furniture, and other wooden structures where additional strength and stability are required at the joint. The use of outside bands helps to distribute the load evenly across the joint, minimizing the risk of failure or damage.

Fig 3.7 Butt joints with outside bands

3.2.10 Butt Joints with inside rendering

Butt joints with inside rendering in construction refer to a specific method of joining two structural elements together, typically in masonry or concrete work. A butt joint is a type of joint where two elements, such as walls or slabs, meet each other at a 90-degree angle without any overlapping or protrusion. In this type of joint, the two elements essentially butt against each other. Inside rendering is the process of applying a layer of renders or plaster on the inner side of the joint to create a smooth and seamless finish. Rendering involves applying a mixture of cement, sand, and water onto the surface to improve its appearance and protect it against moisture and weathering. By combining these two techniques, the butt joints with inside rendering create a strong and visually appealing joining method that is commonly used in construction. This technique helps to ensure structural stability while also enhancing the overall aesthetics of the finished structure.

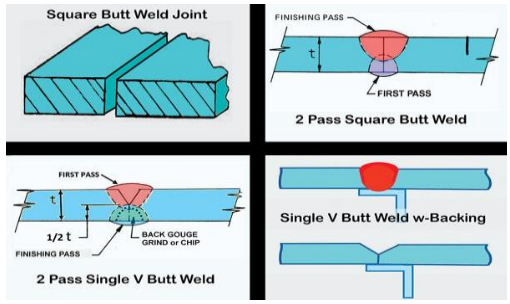

Fig 3.7 Butt joints with inside rendering

3.2.6 Remove debris from the formwork.

Removing debris from the formwork refers to the process of removing any dirt, concrete remnants, or other debris that may have accumulated on or inside the formwork structures, such as panels or molds used for concrete pouring. This is typically done before the next concrete pouring or when dismantling the formwork system. It helps ensure that the formwork is clean, in good condition, and ready for reuse or storage. Debris removal may involve manual cleaning using tools like brooms, brushes, or scrapers, or it could involve using equipment such as pressure washers or vacuums to remove the debris more efficiently.

3.3 Reinforcement

3.3.1 Cut and bend the reinforcing fabric and bars.

The reinforcing fabric, also known as reinforcement mesh or rebar mesh, is a material made up of steel bars arranged in a grid pattern. These bars are cut and bent to the required shape and dimensions according to the specific structural design and engineering requirements. The purpose of the reinforcing fabric is to provide strength and stability to concrete structures, such as foundations, walls, slabs, and columns.

3.3.2 Tie or fix the reinforcing material

Cut and bent tied/fixed reinforcing fabric and bars refer to the process of altering the shape and size of steel reinforcement materials used in bridge construction. In bridge construction, it is common to reinforce the concrete structures with steel reinforcements such as rebars or mesh fabric. However, these reinforcements need to be customized and shaped as per the design and specifications of the bridge. The process involves cutting the steel bars or fabric to the required length using specialized cutting tools. After cutting, the bars or fabric are bent using bending machines to match the specified angles and curved shapes required for the bridge construction. Once the reinforcements are cut and bent to the desired shapes, they are then tied or fixed together using steel wires or other connecting devices. This ensures that the reinforcement materials are securely held in place before and during the concrete pouring. Cutting and bending tied/fixed reinforcing fabric and bars are essential processes in bridge construction as they allow the steel reinforcements to fit precisely into the structural elements of the bridge, providing strength and support to the overall structure.

Fig 3.4 Cut and bent tied/fixed reinforcing

3.4 Concrete Pouring

3.4.1 Mix the concrete to the required.

Ready-mix concrete is a type of concrete that is manufactured and delivered to construction sites in a freshly mixed and unhardened state. It is created by combining various ingredients, such as cement, aggregates (such as sand and gravel), water, and sometimes admixtures (chemical additives), in specific proportions according to the desired strength and characteristics of the final product. This mixture is then transported to the construction site in specialized trucks called concrete mixers and can be poured or pumped directly into forms or molds for various construction purposes. Ready-mix concrete offers advantages in terms of quality control, convenience, and speed of construction. To mix concrete to the required consistency, you will need to follow these general steps:

- Gather the necessary materials: cement, sand, gravel, and water. The specific quantities needed will depend on the project and the proportions specified in the concrete mix design.
- Prepare your mixing equipment. This can be a concrete mixer, a wheelbarrow, or a mixing box. Make sure it is clean and free from any hardened concrete or debris.
- Measure the required amounts of cement, sand, and gravel according to the concrete mix design. The amounts can be measured using a shovel, a bucket, or by using specific weight ratios.
- Start by adding the measured amount of cement to the mixing container. Spread it evenly.
- Add the sand to the cement and mix them thoroughly until they are combined evenly.
- Gradually add the gravel into the mixture and continue mixing. Ensure that the gravel is evenly distributed throughout the cement and sand.
- Slowly add water to the mixture while continuing to mix. The amount of water should be added in increments to achieve the desired consistency.
- Thoroughly mix the concrete until it reaches a uniform consistency. The desired consistency can vary depending on the specific application, but it should generally be a thick and workable mixture that can hold its shape.
- Check the consistency by performing a slump test, where you scoop up a sample of the concrete in a cone-shaped mold and remove the mold to see how the concrete slumps. Adjust the water or dry ingredients as necessary to achieve the desired consistency.

It is important to note that the required consistency may vary depending on the specific project or application of the concrete. Therefore, it is recommended to consult the project specifications or consult with a professional to determine the specific requirements.

3.4.2 Place the concrete in the formwork.

Placing concrete in formwork refers to the process of pouring concrete into the predetermined formwork structures before it sets and hardens. This can be done by following these steps:

- Prepare the formwork: Set up the formwork according to the desired shape and dimensions of the structure that needs to be created. This typically involves positioning the panels or frames and securing them in place.
- Install reinforcing materials: If required, add steel reinforcement bars or other reinforcing materials inside the formwork to increase the strength and durability of the final concrete structure.
- Mix the concrete: Prepare a concrete mix by combining cement, aggregates (such as sand and gravel), water, and any required additives or admixtures according to the design specifications. Mix the concrete until it reaches a uniform consistency.
- Transport the concrete: Once the concrete mixture is ready, transport it to the construction site using wheelbarrows, concrete pumps, or other appropriate methods.
- Pour the concrete: Starting from one end of the formwork, gradually pour the concrete into the structure. Use tools like shovels, rakes, or vibrators to properly distribute and compact the concrete within the formwork, filling all cavities and ensuring there are no air pockets or voids.
- Level and finish: Use straightedges, screeds, or trowels to level and smooth the surface of the concrete. This will help achieve a uniform and even result.
- Curing: After placing and finishing the concrete, it needs to be properly cured to ensure it gains strength and durability. This typically involves keeping the concrete moist and protected from extreme temperatures for a certain period of time.

Note: It is important to follow local building codes, guidelines, and proper safety measures while working with formwork and placing concrete.

3.3.3 Compact the concrete.

Compacting concrete refers to the process of removing air voids from the freshly poured concrete mixture. This is done to improve the overall density and strength of the material. Compaction can be achieved using different methods such as vibration, tamping, or using specialized compacting equipment. The goal is to ensure that the concrete is evenly distributed, any trapped air is eliminated, and that it properly adheres to the reinforcement materials or forms being used. Adequate compaction is essential for achieving a durable and long-lasting concrete structure.

Fig.3.5 compacting concrete

3.3.4 Finish the concrete.

Finishing the concrete refers to the process of creating a smooth and even surface on a freshly poured concrete slab. It involves various techniques and tools to achieve the desired result. This can include using a bull float or trowel to level and settle the concrete, adding texture or pattern using stamps or other tools, and applying a final finish such as a broom finish or a smooth trowel finish depending on the intended use and aesthetic preference. The finishing process helps improve the durability, appearance, and functionality of the concrete surface.

It's a bit unclear what you mean when you say "finish the concrete." However, assuming you are referring to the process of completing or adding final touches to a concrete project, here are some possible steps involved:

- Curing: Allow the concrete to cure for the appropriate amount of time, typically around 28 days, so it can reach its maximum strength.
- Cleaning: Remove any debris, dirt, or loose particles from the concrete surface.
- Grinding or leveling: If necessary, grind or level uneven areas of the concrete to achieve a smooth and even surface.
- Sealing: Apply a concrete sealer to protect the concrete from stains, moisture, and other potential damages. This can be done using a brush, roller, or sprayer, depending on the type of sealer being used.

- Finishing techniques: Depending on the desired look, various finishing techniques can be applied to the concrete surface. Some common options include stamping, staining, or adding texture.
- Jointing: Create control or expansion joints in the concrete to allow for expansion and contraction as it ages and to prevent cracking.
- Final touches: Inspect the concrete for any imperfections, such as air bubbles or rough spots, and make necessary repairs or touch-ups.

It's important to note that specific steps may vary depending on the type and purpose of the concrete project. Consulting with a professional or referring to project-specific guidelines is recommended for accurate instructions.

Fig 3.6 finishing the concrete

3.5 Curing

3.5.1 Cover the concrete prevent from drying

Covering concrete to prevent it from drying out too quickly is a common practice in construction. Here are a few methods frequently used:

- Plastic Sheets: Plastic sheets are the most common and cost-effective way to cover concrete. Polyethylene sheets can be laid over the concrete surface, creating a barrier that slows down evaporation. The sheets should be secured properly at the edges to prevent wind from blowing them away.

- Wet Curing: After pouring the concrete, it can be periodically wetted with water to prevent rapid evaporation. Sprinklers or misting systems can be set up to ensure the concrete stays moist throughout the curing process. This method is especially effective in hot and dry climates.
- Moisture-retaining Sprays: There are commercial sprays available that can be directly applied to the concrete surface. These sprays create a thin film that helps to seal in moisture and reduce evaporation. They are particularly useful for small-scale projects where plastic sheets may not be convenient.
- Curing Compounds: Curing compounds are liquid substances specially designed to slow down moisture loss from the concrete surface. These compounds are applied after the concrete has set but is still damp. They form a thin membrane that prevents evaporation and allows the concrete to cure gradually.

It's important to note that while covering concrete slows down the drying process, it does not replace proper curing. Adequate curing involves maintaining the concrete's moisture for an extended period to achieve maximum strength and durability.

3.5.2 Concrete to cure for required amount of time.

It is important to allow the concrete to cure for the required amount of time to ensure its strength and durability. Depending on the specific concrete mix and environmental conditions, the curing time can vary. Typically, it is recommended to let the concrete cure for at least 7 days before subjecting it to heavy use or loading. However, for optimal strength, allowing the concrete to cure for 28 days is preferred. During the curing period, it is essential to protect the concrete from excessive moisture loss, extreme temperatures, and heavy traffic. This can be done by covering the concrete with a curing compound, plastic sheeting, or wet burlap, and by avoiding foot traffic or heavy loads. Following the recommended curing time will help the concrete reach its full strength and ensure its long-lasting performance.

Self-Check-1

Part I: choose the correct answer

1. What is formwork ties used for?
   A. To prevent surface defects C. To shape the concrete
   B. To support the formwork panels D. To secure the formwork panels together
2. What are some common materials used for formwork panels?
   A. Concrete B. Bricks C. Glass D. Plywood
3. What factors are considered when selecting formwork components and materials?
   A. Site survey, design review, and marking
   B. Excavation and installation of formwork
   C. Pouring concrete and reinforcement
   D. Type of structure, load-bearing capacity, desired surface finish, and duration of usage
4. What criteria should be considered when selecting formwork components and materials?
   A. Type of structure and load-bearing capacity
   B. Desired surface finish and duration of usage
   C. Both A and B
   D. None of the above
5. What is the first step in determining the location of footing and formwork?
   A. Design review B. Marking C. Site preparation D. Site survey

Part II: Short Answer Questions

Instructions: Answer all the following questions accordingly.

1. How is the location of footing and formwork determined on a construction site?
2. What is the importance of accurately determining the location of footing and formwork for building stability and structural integrity?
3. What steps are involved in determining the location of footing and formwork?
4. How do select formwork components/materials contribute to the safety, efficiency, and quality of concrete construction?
5. What factors should be taken into consideration when selecting fixing/fasteners for construction projects?

Operation Sheet 1

Operation title:

- Footings and formwork

Purpose:

- To practice and demonstrate the knowledge and skill required to erect scaffolding

Instruction:

- Use given tools and equipment to erect and dismantle the scaffolding. 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
- Graphite pencil
- Timber
- Eucalyptus wood
- Nail
- Tri square
- Mould oil
- Claw hammer
- Bow saw
- Spirit level
- plumb bobs

Procedures for Erecting framed scaffolding:

6. Layout: Mark the positions of the footings and formwork according to the approved construction drawings. Use string lines or marking paint to outline the boundaries of the footings.

7. Excavation: Use appropriate machinery, such as an excavator or backhoe, to dig the trenches for the footings. Ensure that the trenches are dug according to the specified dimensions and depths mentioned in the construction drawings.
8. Level and compact: Level the base of the trenches using a leveler and compact the soil using a plate compactor. This will provide a stable foundation for the footings.
9. Install formwork: Place the formwork panels along the marked outlines of the footings. Ensure that the panels are securely braced and aligned properly. Use wedges and stakes to maintain the correct position and angles.
10. Reinforcement placement: Install the reinforcing bars (rebar) inside the formwork according to the design specifications. Use tie wires to secure the bars together and provide proper reinforcement.
11. Pouring the concrete: Prepare the concrete mix according to the approved mix design. Ensure that the concrete is of the correct consistency and temperature. Pour the concrete carefully into the formwork, making sure to avoid any air pockets or voids.
12. Finishing: Use a trowel to smooth the top surface of the poured concrete. Check for any irregularities or imperfections and correct them immediately.
13. Curing: Once the concrete is poured and finished, cover the formwork with damp burlap or plastic sheets to ensure proper curing. This helps in preventing rapid moisture loss and ensures the concrete attains its required strength.
14. Formwork removal: After the concrete has cured for the specified period, remove the formwork panels carefully. Start from the top and work your way down, ensuring that the structure remains stable and intact.
15. Inspection: Conduct a thorough inspection of the footings and formwork to ensure that they comply with the required standards and specifications.

Quality Criteria:

- Accuracy in in constructing scaffold
- Speed in making scaffold
- Create Teamwork

LAP Test 3

Practical Demonstration

Name: ___________________________ Date: ________________________

Time started: _____________________ Time finished: ________________

Instruction I: Set out and footings and formwork operation

Task 1. Setting out for footings and formwork operation

Task 2. Erecting framed footings and formwork operation

Task 3. Perform footings and formwork operation

Unit Four: Maintain minor drainage and retaining walls structures

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

- Preparation of maintain minor drainage structures
- Maintenance and Repair minor drainage structures
- Completion of minor drainage structures

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 maintain minor drainage structures
- Maintain and Repair maintain minor drainage structures
- Couplet maintain minor drainage structures

4.1 Preparation

4.1.2 Schedule of maintenance repairs

The Obtain and Apply Schedule of Maintenance Repairs for bridge construction is a structured plan that outlines the process of obtaining necessary materials and resources, as well as scheduling and conducting maintenance and repair activities for bridges.

A. **Evaluation and Inspection**: The first step is to evaluate and inspect the bridge for any damages or necessary repairs. This can include visual assessments, structural analysis, and testing.

B. **Identifying Repair Needs**: Based on the evaluation and inspection, the specific repair needs are identified. This can include repairing or replacing damaged structural components, fixing cracks or potholes, strengthening the foundation, or addressing any other issues that could affect the integrity of the bridge.

C. **Obtaining Permits and Approvals**: Before starting any repair work, the necessary permits and approvals from relevant authorities may need to be obtained. This ensures compliance with regulations and safety standards.

D. **Procurement of Materials and Resources:** Once the repair needs are identified and permits obtained, the next step is to procure the required materials, equipment, and resources for the repair work. This can include purchasing construction materials, hiring skilled workers or contractors, and arranging for necessary machinery or tools.

E. **Scheduling Repairs**: After obtaining the materials and resources, a schedule is created to plan the sequence of repair activities. This includes determining the start date, estimated completion time, and allocating tasks to various teams or contractors involved in the repair project.

F. **Implementing Repair Work**: Once the schedule is finalized, the repair work begins as per the planned sequence. This involves executing the necessary repairs, which can include activities like concrete pouring, steel reinforcement, grouting, sealing, or any other required tasks to restore or enhance the bridge's structural integrity.

G. **Quality Control and Monitoring**: Throughout the repair process, quality control measures are implemented to ensure that the work meets the required standards, specifications, and safety regulations. Regular monitoring, testing, and inspections are conducted to verify the effectiveness of the repairs.

H. **Completion and Handover**: Once all the repairs are completed, a final inspection is conducted to ensure that the bridge is safe and operational. Once approved, the completed repair work is handed over to the bridge owner or relevant authority.

I. **Ongoing Maintenance**: After completing the repairs, an ongoing maintenance plan is often recommended to prevent future deterioration and ensure the long-term integrity of the bridge. This can include regular inspections, monitoring, minor repairs, and periodic maintenance activities.

4.1.2 Reviewing the schedule of maintenance

Reviewing the schedule of maintenance means examining the planned schedule of maintenance activities. This involves assessing the proposed time frames for conducting maintenance tasks, ensuring that they are optimal and efficient. It also involves checking the frequency and duration of the maintenance activities to make sure they align with the needs of the equipment or systems requiring maintenance. Reviewing the schedule of maintenance helps to identify any potential issues or conflicts and make necessary adjustments to ensure smooth and effective maintenance operations.

4.1.3 Locating fault, inspect and repair drainage components

The specific term "locate fault, inspect and repair drainage components bridge construction" may not be commonly used, but it appears to refer to the process of identifying and fixing any issues or malfunctions related to the drainage systems in bridge construction projects.

Here is a breakdown of each component mentioned:

A. **Locate Fault**: This refers to finding the exact location or source of a problem or fault within the drainage components of a bridge. It could involve identifying leaks, blockages, cracks, or any other issues affecting the drainage system.

B. **Inspect**: After locating the fault, a thorough inspection is conducted to assess the condition and extent of the problem. Inspecting involves examining the drainage components, such as pipes, channels, gutters, or collection basins, to determine the cause and determine the necessary repairs.

C. **Repair:** Once the fault is identified and the inspection is complete, the repair process begins. This includes fixing or replacing damaged drainage components, applying sealants or coatings, clearing blockages, or resolving any issues that may hinder the proper functioning of the drainage system.

Overall, "locate fault, inspect and repair drainage components bridge construction" describes the process of identifying, assessing, and fixing drainage-related problems in a bridge construction project to ensure effective water management and prevent potential damage or deterioration to the structure.

4.1.4 Locate access devices and check for safe operation

Locate access devices typically refer to physical devices or equipment that provide access to certain areas or systems. This can include security keypads, card readers, biometric readers, or any other method used to authorize and grant access. Checking for safe operation implies routinely inspecting and testing these access devices to ensure they are functioning properly and securely. This includes verifying that they correctly authenticate users, grant access only to authorized individuals, and have appropriate security measures in place to prevent unauthorized access. Regular checks may involve testing the functionality of the devices, inspecting for any physical damage, ensuring proper installation, and evaluating if they comply with safety regulations or guidelines. The goal is to identify and rectify any issues or vulnerabilities, ensuring the devices are operating safely and providing the intended level of security.

4.1.5 Locate the defect

"Locate the defect or fault and prepare the area for rectification" refers to the process of identifying and finding the problem or malfunction in a certain area or system, and then making necessary preparations before attempting to fix or correct it. This could apply to various scenarios such as repairing a machine, a mechanical system, an electrical system, or even a physical structure. In order to rectify the problem, one must first locate the exact location and nature of the defect or fault. Once identified, the area needs to be prepared for rectification, which may involve cleaning, removing obstacles, ensuring safety measures, and gathering the necessary tools or materials for the repair process. It is an important step in the troubleshooting and repair process, as it helps in ensuring a systematic approach towards resolving the issue effectively and efficiently.

4.2 Maintenance and Repair

4.2.1 Inspect and maintain drainage components.

Inspecting and maintaining drainage components refers to the process of regularly checking and preserving the various elements of a drainage system to ensure its proper functioning. It involves conducting a thorough examination of the system to identify any signs of damage or blockage, as well as taking appropriate measures to clean, repair, or replace the components as needed. This can include cleaning out debris from drains and gutters, checking for leaks or cracks in pipes, ensuring proper grading and slope for effective water flow, and maintaining proper functioning of drainage fixtures such as sump pumps or septic tanks. Regular inspection and maintenance of drainage components are essential to prevent water damage, flooding, or other drainage-related issues.

4.2.3 Drainage components

A drainage component in bridge construction refers to the various systems and features incorporated into the bridge design to manage and control the flow of water. These components are necessary to prevent the accumulation of water on or around the bridge structure, which can cause damage, erosion, or other safety hazards.

Some common drainage components used in gully/silt traps in bridge construction include:

A. **Gully Pots**: Gully pots are small chambers or basins placed strategically along the bridge or roadway to collect and temporarily store runoff water. These pots usually have grates or slots to allow water to flow in while capturing larger debris and sediments.

B. **Silt Traps/Fore bays**: Silt traps, also known as fore bays, are larger storage basins located at the downstream end of the drainage system. They are designed to slow down the flow of water, allowing sediments and pollutants to settle out before the water is discharged into water bodies or further treatment. Silt traps often have a series of baffles and settling compartments to enhance sedimentation and trap larger particles.

C. **Sediment Filters**: Sediment filters are devices placed within the drainage system to capture finer particles and sediments not captured by the gully pots or silt traps. These filters can consist of geotextiles fabric or other permeable materials that allow water to pass through while retaining sediments.

D. **Oil/Water Separators**: In some cases, oil/water separators may be included in the drainage system to remove hydrocarbons and other pollutants that may be present. These separators use various techniques such as gravity settling, coalescing, and filtration to separate oil and water.

It is essential to regularly maintain and clean gully/silt traps to ensure their effective functioning. This may involve regular debris removal, sediment and pollutant disposal, and periodic inspections.

Fig 4.3Gully/Silt Traps

A. **Manholes**

Manholes are large, open holes or access points in the ground that provide access to underground utility systems such as sewers, storm drains, and telecommunications infrastructure. They are typically covered with a heavy lid made of metal or concrete to prevent unauthorized access and to ensure the safety of pedestrians and vehicles. Manholes are commonly found in urban areas, particularly in streets and sidewalks, and are used for maintenance, inspection, and repair of underground utility line

Fig 4.3 Manholes

B. Benches

Benches in drainage components refer to flat areas or steps created in pipe or channel walls. They are designed to provide stability and promote flow efficiency within the drainage system. Benches help to control the velocity of water, prevent sediment accumulation, and reduce turbulence. They are commonly used in sewer pipes, manholes, and channels to facilitate the smooth movement of wastewater or storm water.

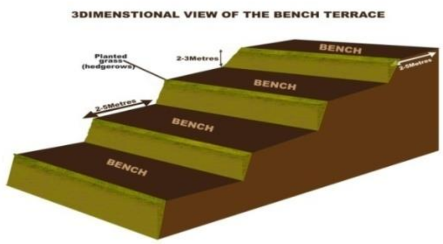

Fig 4.4 Benches in drainage components

C. Lining

Lining in drainage components refers to the process of applying a protective layer or coating to the interior surface of drains, pipes, or other drainage components. This lining is typically made from materials such as epoxy, polymers, or cement mortar, and it serves to repair any damages or defects in the existing drain, as well as prevent further deterioration or blockages. The lining process involves cleaning and preparing the drainage component, applying the lining material to the interior surface, and allowing it to cure or harden. This creates a new, smooth, and durable surface inside the drain, improving its flow capacity and extending its lifespan. Lining can be done on various types of drainage components, including sewer pipes, storm water systems, culverts, and manholes.

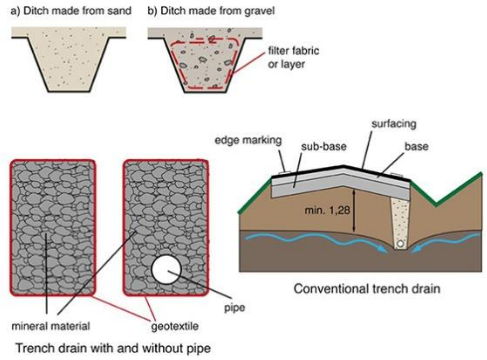

Fig 4.5 Lining in drainage components

D. Step Irons

Step irons in drainage components refer to the iron bars or steps that are installed in drainage systems to facilitate access and maintenance. These steps are typically bolted or welded to the drainage walls or channels and create a ladder-like structure to allow personnel to descend into the drains or sewage pipes for inspection, cleaning, and repairs. Step irons are commonly used in large underground drainage systems, such as wastewater treatment plants and municipal sewer networks. They improve the safety and efficiency of drainage maintenance activities by providing stable footholds for workers and enabling them to navigate through the depth of the system.

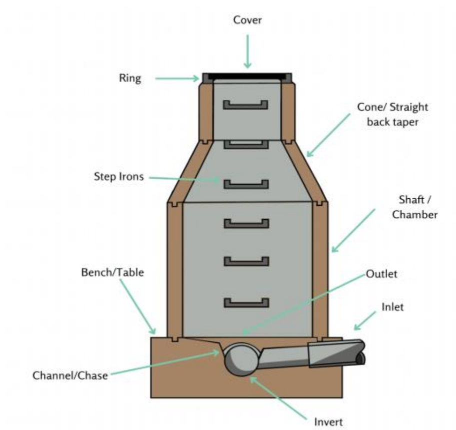

Fig 4.6 Step irons in drainage components

E. Lids

Lids drainage components are parts of a drainage system that are installed on top of manholes or catch basins to help manage the flow of storm water. These components typically include features such as grates, filters, and inlet inserts that prevent debris, sediment, and pollutants from entering the drainage system while still allowing water to flow through. Lids drainage components play a crucial role in reducing the amount of pollutants that enter natural water bodies, improving water quality, and preventing flooding.

Fig 4.7 Lids drainage

F. Headstones

A headstone's drainage components refer to the elements included in the construction of a headstone or gravestone that help manage and direct water flow away from the grave site, preventing water from pooling around the burial plot. This can include features such as:

A. **Base Slope**: The base of the headstone is designed with a slight slope to allow water to drain away easily.
B. **Gravel Fill**: A layer of gravel is often placed beneath the headstone to promote drainage and prevent water from accumulating.
C. **Drain Holes**: Drilled holes are sometimes incorporated into the base of the headstone to facilitate water drainage.
D. **Angled Surface**: The upper surface of the headstone may be angled to prevent water from pooling on top.

These drainage components help ensure that water does not collect around the headstone, which can cause erosion, moss growth, or other damage.

G. Back stones

Black stones drainage components refer to the various materials and structures used in a drainage system that involve the use of black stones or aggregates. These components are designed to effectively collect, direct, and remove excess water from an area, preventing water accumulation and potential damage.

Some common black stones drainage components include:

A. **Permeable paving**: It consists of black stones or gravel that allows water to permeate through the gaps between the stones, facilitating drainage and reducing runoff.

B. **French drains**: These are trenches filled with black stones or gravel to create a path for water to flow away from a specific area. They are commonly used to prevent water accumulation around buildings or in low-lying areas.

C. **Catch basins**: These are structures made of concrete or plastic that collects and redirects surface water into a drainage system. Black stones or gravel may be used as a filter material to prevent debris from entering the drainage pipe.

D. **Infiltration trenches**: Similar to French drains, infiltration trenches are excavated channels filled with black stones or gravel that allow water to infiltrate into the ground slowly, promoting natural drainage and groundwater recharge.

E. **Drywells**: These are underground structures filled with black stones or gravel that collect and store storm water runoff, allowing it to gradually infiltrate into the surrounding soil. It is important to note that while black stones drainage components are often used for their aesthetic appeal and versatility, the functionality and effectiveness of a drainage system depend on various factors such as local regulations, site conditions, and the expertise of professionals involved in its design and installation.

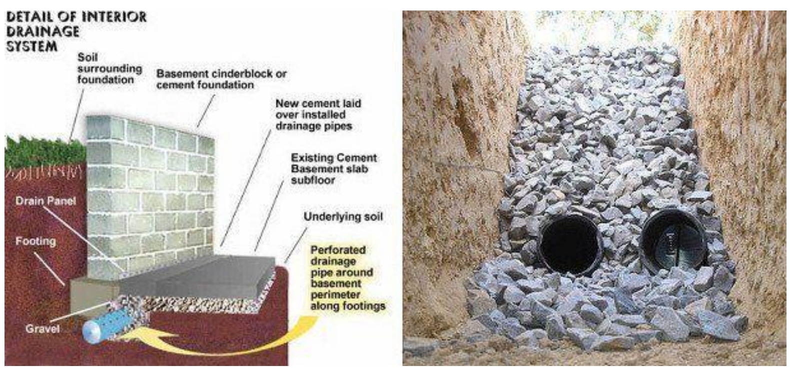

Fig 4.8 Back stones

H. Grates

Grates are drainage components used to cover and protect the openings of drainage systems. They are designed to allow the flow of water into the drainage system while preventing larger objects, debris, and potential hazards from entering. Grates can be found in various forms and materials, depending on the application and location. Some common materials used for grates include cast iron, galvanized steel, stainless steel, and plastic. They are typically designed with a pattern of holes or slots to permit water to flow through while providing sufficient coverage. Grates are commonly used in a range of drainage systems, including storm water drains, sewer systems, and outdoor surface drains. They can be found in different sizes and shapes, depending on the intended purpose and the amount of water expected to flow through. In addition to their primary function of allowing water flow, grates also provide safety benefits by preventing people and animals from accidentally falling into the drainage system. They are often designed with anti-slip surfaces to enhance pedestrian safety. Overall, grates are essential components of drainage systems that provide effective water flow while ensuring the safety of the surrounding environment.

Fig 4.9 Grates are drainage components

I. Kerbs

Kerbs drainage components refer to the various elements that make up a roadside curb and gutter system designed to collect and direct surface water runoff. These components typically include:

A. **Kerb**: It is a raised edge or barrier constructed along the side of a road or pavement to separate the road from the roadside. The kerb prevents vehicles from driving off the road and also helps to channelize the flow of surface water.

B. **Gutter:** The gutter is the channel or trough located behind the kerb that collects and carries the water runoff from the road and safely directs it towards drainage systems or designated outlets.

C. **Inlet**: Inlets are openings or structures typically placed along the kerb or gutter line to allow the water to enter the underground drainage system. Inlets can be box-shaped or grate-like and are designed to prevent the passage of larger debris while allowing water to flow through.

D. **Outlet**: The outlet is the point where the collected runoff water is discharged into a drainage system, storm water pipe, or designated drainage area. The outlet ensures that the water is safely transported away from the road and surrounding infrastructure.

E. **Slope**: The kerb and gutter system is usually sloped to facilitate the flow of water towards the inlet and outlet. The slope helps to ensure that the water does not pool on the road surface and efficiently drains away.

These components work together to collect, channelize, and manage surface water runoff along roads and pavements, preventing flooding and ensuring the safety and functionality of the transportation infrastructure.

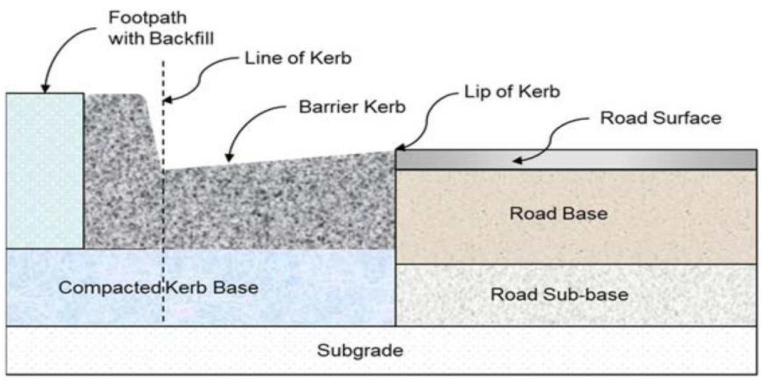

Fig 4.10 Kerbs drainage components

J. Inlets And Outlets

Inlets and outlets are drainage components used to manage the flow of water in a drainage system. - Inlets: These are openings or structures that allow the water to enter the drainage system. They are typically located at low points or areas where water accumulates. Inlets can be designed to accommodate different types of runoff, such as surface water from rain or storm water runoff, or sub-surface water like groundwater. Common types of inlets include catch basins, trench drains, or grated openings on sidewalks or roads. - Outlets: These are structures that allow the water to exit the drainage system. They are typically located at the end of the drainage network and can include components like pipes, culverts, or open channels. Outlets help convey the water away from the drainage area to a suitable discharge point, such as a creek, river, or storm water detention basin. Both inlets and outlets play crucial roles in providing effective drainage to prevent flooding, erosion, and water logging. The design, size, and placement of these components are important considerations in drainage system planning and engineering.

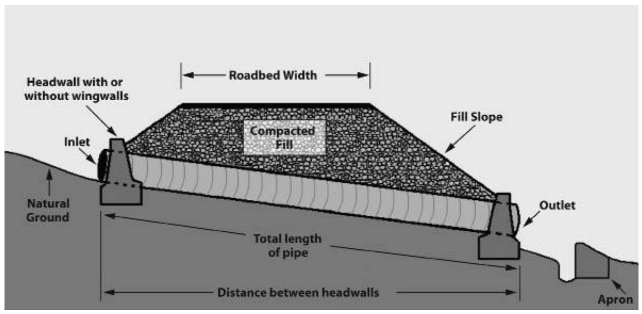

Fig 4.11 Inlets and outlets

K. Gabion Baskets

Gabion baskets are primarily used for erosion control and retaining wall purposes. While they can serve as effective retaining structures, they also facilitate drainage through various components. Here are the drainage elements commonly found in gabion baskets:

A. **Stone Fill**: The primary component of a gabion basket is the stone fill. The stones used are typically of a specific size range to ensure proper drainage. The size and type of stones used can be specified based on the project requirements.

B. **Geotextiles Fabric**: A geotextiles fabric is used to line the inside of the gabion basket. This fabric allows water to freely pass through while preventing the migration of fine particles and soil. It keeps the stone fill in place and provides additional strength to the gabion structure.

C. **Drainage Pipes**: Drainage pipes can be incorporated within a gabion basket system to enhance drainage. These pipes are perforated and placed within the stone fill. They help to collect and channel water away from the structure, preventing excessive water build-up and hydrostatic pressure.

D. **Weep Holes**: Weep holes are small openings or gaps left intentionally in the gabion structure. They allow water to escape from behind the retaining wall or erosion control structure, thereby maintaining good drainage.

Overall, the combination of stone fill, geotextiles fabric, drainage pipes, and weep holes ensures effective drainage within gabion baskets. These elements help to prevent water logging, soil saturation, and potential structural damage caused by hydrostatic pressure.

Fig 4.12 Gabion Baskets

L. Rip Rap

Rip rap refers to a type of stone or rock material that is used in drainage systems for erosion control and to prevent the washing away of soil. It consists of large, durable stones that are typically placed along riverbanks, shorelines, or slopes to dissipate the energy of flowing water and protect the underlying ground.

Rip rap drainage components include:

A. **Filter Fabric**: This is a geotextiles material that is often used as an underlayment to prevent fine soils from clogging the gaps between the rip rap stones. It allows water to pass through while retaining the soil particles.

B. **Geogrids**: These are synthetic materials designed to stabilize the rip rap layer and prevent movement or shifting of the stones. Geogrids are commonly used when constructing slopes or embankments with rip rap.

C. **Geotextile Bags**: In situations where a more flexible and moldable solution is required, geotextile bags can be filled with rip rap and used for erosion control. These bags allow water to pass through while offering a more customizable solution for specific project needs.

D. **Toe Key**: A toe key is a foundational component placed at the base of the rip rap layer to anchor and stabilize it. It is often constructed using larger, heavier stones that can withstand high water flow and facilitate proper drainage.

Fig 4.13 Rip rap

M. Wing walls

Wing walls are vertical or slightly inclined reinforced concrete walls that are built on both sides of a bridge or culvert. They are used to provide support to the bridge structure and to guide the flow of water in the drainage system. Wing walls form an integral part of the drainage system of a bridge and are designed to direct the water flow away from the bridge structure, preventing damage and erosion. The main purpose of wing walls is to control the flow of water in the drainage system and to prevent the accumulation of debris near the bridge or culvert. They help in maintaining the stability of the structure by preventing erosion and scouring around the foundation.

The design and construction of wing walls include the following components:

A. **Wall structure:** Wing walls are typically made of reinforced concrete to provide strength and durability. They are designed to withstand the hydraulic forces exerted by flowing water.

B. **Abutment:** Wing walls are connected to the abutments of the bridge or culvert. The abutments provide lateral support to the wing walls and help in distributing the loads from the bridge structure.

C. **Wing wall toe**: The toe of the wing wall is the lower end of the wall that comes in contact with the ground surface. It is designed to resist the hydraulic forces and prevent soil erosion.

D. **Wing wall apron:** The apron is a concrete extension at the base of the wing wall that helps in diverting the flow of water away from the foundation and prevents erosion.

E. **Weep holes**: Weep holes are small openings provided in the wing walls to allow the drainage of water from behind the walls. They help in preventing the buildup of hydrostatic pressure, which can cause structural damage.

F. **Wing wall cap**: The cap is the topmost part of the wing wall that provides a smooth surface for the flow of water. It also adds strength to the structure by distributing the loads from the bridge superstructure.

Fig 4.14 Wing walls

E. End walls

End walls are structural components used in drainage systems to facilitate the flow of water from one area to another. They can be found at the ends of drainage ditches, channels, or culverts and are designed to provide a smooth transition for the water as it exits the system. End walls typically consist of precast concrete or metal structures that are installed at the terminus of the drainage system. They are designed with openings or outlets through which water can be discharged, and are often equipped with grates or screens to prevent debris from entering the system. Some end walls may also include features such as flaps or gates that can be adjusted to control the water flow. The purpose of end walls is to prevent erosion at the outlet point of the drainage system and to ensure that the water is efficiently and safely discharged. They play a crucial role in managing storm water runoff and preventing flooding or damage to surrounding areas.

F. Aprons

Aprons drainage components typically refer to the elements used in the construction of drainage systems, specifically for aprons or extended concrete surfaces. These components are designed to efficiently collect and direct water away from these surfaces to prevent pooling, erosion, or damage.

Some common aprons drainage components include:

A. **Apron drains**: These are trenches or channels constructed at the edge of aprons or paved surfaces to collect and channel water away from the area.

B. **Grates**: These are typically placed over the openings of apron drains to prevent debris from entering the system while allowing water to pass through.

C. **Pipes or culverts**: Along with apron drains, these underground structures collect and transport water to another location, such as a storm water retention pond or municipal drainage system.

D. **Catch basins**: These are structures with a great or solid cover that act as collection points for surface runoff, allowing sediment and debris to settle while directing water into the drainage network.

E. **Outlet structures:** These may include pipes, culverts, or other structures that serve as the endpoint of the drainage system, where water is discharged safely into natural water bodies or other designated areas.

Fig 4.15 Aprons drainage components

G. Reno-Mattresses

Reno-mattresses are wire mesh containers filled with stones or rocks used in civil engineering projects for erosion control and drainage purposes. They are commonly used for stabilizing riverbanks, lakeshores, and other water bodies to prevent soil erosion. The drainage components of Reno-mattresses include the gaps in the wire mesh material, which allow water to flow through the structure. These gaps facilitate the proper drainage of water, preventing the accumulation of excessive moisture behind the structure. The stones or rocks fill within the wire mesh also help in the drainage process by allowing water to pass through and preventing the build-up of hydrostatic pressure.

Fig 4.16 Reno-mattresses

H. Geo-fabric

Geo-fabric drainage components refer to products that are designed to enhance water drainage and filtration in various applications. They are typically made from geo-synthetic materials such as geotextiles or geo-composites, which are specially engineered to provide the necessary functions of drainage, filtration, and separation.

Fig 4.17 Geo-fabric drainage components

I. Drain Blocks

Drain blocks or drainage components refer to various materials or parts used in a drainage system to facilitate the smooth flow of water and prevent clogging. These components are designed to remove excess water from surfaces, structures, or underground areas, preventing water accumulation and potential damage. Some common drainage components include:

Fig 4.18 Drain Blocks

J. Check Dams

Check dams are small structures built across a river or a channel to reduce the flow velocity of water and prevent soil erosion. They are typically made of rocks, timber, or concrete.

The drainage components of a check dam include:

A. **Gravel Filter**: It is placed at the upstream side of the dam to filter out fine particles from water, preventing clogging and allowing water to pass through.

B. **Spillway**: It is a structure designed to control the water level behind the dam. It allows excess water to flow safely over the dam, preventing overtopping and potential damage.

C. **Toe Drain**: It is a perforated pipe placed at the downstream toe of the dam to collect seepage water and carry it away from the structure, preventing erosion.

D. **Gabions:** These are wire baskets filled with stones or rocks, used to construct the dam. They help in retaining the soil and providing stability to the structure.

E. **Baffle:** It is a barrier built inside the dam to redirect water flow and reduce its velocity, aiding in sedimentation and preventing erosion.

F. **Outlet Pipe**: It is a pipe that allows controlled release of water from behind the dam. It helps in maintaining the desired water level and prevents excessive buildup of water pressure.

G. **Toe Wall**: It is a vertical or slightly inclined wall constructed at the downstream toe to stabilize the dam and prevent erosion due to water flow.

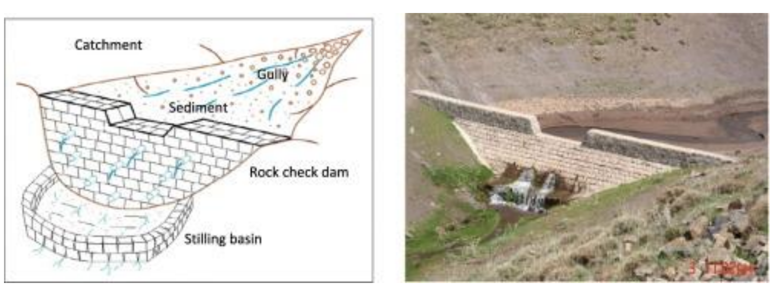

Fig 4.19 Check Dams

K. Sediment

Sediment drainage components refer to the various elements and structures designed to manage the drainage of sediment in a particular system or environment. These components can include:

A. **Sediment basins or traps**: These are large ponds or reservoirs where water flows during construction or land-disturbing activities. Sediment settles in these basins, allowing cleaner water to exit through the outlet structure.
B. **Sediment filters**: These are physical barriers that allow water to pass through while retaining sediment particles. Examples include geotextile fabric, straw wattles, or sediment fences.
C. **Sediment ponds**: These are temporary or permanent ponds built to capture and retain sediment-laden water. They help in settling out sediments by allowing water to slow down and sediment to settle before the water is released.
D. **Sediment barriers**: These are structures that prevent the movement of sediment either within a water body or between different areas. They can include artificial berms, embankments, or natural barriers like vegetation.
E. **Sediment control structures**: These are engineered structures that help manage the flow of water and sediment. Examples include sediment retention ponds, check dams, sediment sumps, or sediment for bays.
F. **Sediment removal equipment**: This includes machinery and equipment used to mechanically remove sediment from water bodies, such as dredgers or suction pumps.

These sediment drainage components, when used effectively, help to reduce sediment deposition in water bodies, prevent erosion, and maintain water quality. They are often utilized in construction sites, agricultural areas, and other areas where sediment control is necessary.

L. Silt Control

Silt control in drainage components refers to the management and prevention of silt buildup in drainage systems. Silt is fine particles of soil or sediment that can accumulate and clog drainage pipes, channels, or other components of a drainage system. To control silt in drainage components, various measures can be taken, including:

A. **Silt traps**: Installing silt traps or sediment basins at strategic points in the drainage system to capture and settle the silt before it can enter and clog the components.
B. Silt fences: Erecting silt fences around construction sites or areas with exposed soil to prevent the silt from entering the drainage system.
C. **Silt socks**: Using silt socks, also known as sediment socks or filter socks, which are fabric tubes filled with sediment-filtering materials. These socks can be placed around drainage outlets or ditches to filter out silt and prevent it from entering the components.
D. **Regular maintenance**: Conducting regular inspections and maintenance of drainage components to identify and remove any silt accumulations.
E. **Vegetation and erosion control**: Implementing erosion control measures, such as establishing vegetation cover or using erosion control blankets, to prevent soil erosion and silt runoff into the drainage system.

By implementing silt control measures, the functionality and efficiency of drainage components can be maintained, preventing clogs and ensuring proper water flow through the system.

Fig 4.20 Silt Control

4.2.4 Flush out the drainage system

Flushing out the drainage system to clear blockages involves using a high-pressure water flow to eliminate any obstacles or debris hindering the proper flow of water through pipes, sewers, or drains. This process aims to clear blockages by forcefully pushing the materials causing the obstruction out of the system. This method is commonly done with specialized equipment such as jetters or hydro-jetters to effectively remove and clean the pipes, ensuring the smooth operation of the drainage system.

A. **To flush out the drainage** system and clear blockages, you can follow these steps:
B. **Identify the blockage**: Determine which drains or pipes are blocked. This can be done by observing where the water is backing up or by using a drain camera to inspect the pipes.
C. **Organize necessary tools**: Gather a plunger, plumber's snake (also known as a drain auger), and a bucket. You may also need protective gloves.
D. **Plunge the drain**: If the blockage is in a sink, bathtub, or toilet, start by using a plunger. Place the plunger over the drain and create a strong seal. Push and pull the plunger vigorously to create suction, which can help dislodge the clog.
E. **Use a drain auger**: If plunging doesn't clear the blockage, try using a plumber's snake. Insert the snake into the drain until you feel resistance, then rotate the handle to break up the clog. Keep pushing and rotating until the snake goes through the blockage or you can pull out the clog.
F. **Flush hot water:** After clearing the blockage, run hot water down the drain for a few minutes to flush away any remaining debris and ensure the pipes are clear.
G. **Perform preventative maintenance**: To prevent future blockages, use drain guards or screens to catch hair, food particles, or other debris that could lead to a clog. Regularly pour boiling water down the drains to help dissolve grease and prevent buildup.

4.2.5 Maintain open drains to the correct line

Maintaining open drains to the correct line refers to the practice of ensuring that drains or culverts are kept clear and unobstructed, following the proper alignment or path. This typically involves regular inspection and clearing of debris, silt, or any other materials that may accumulate in the drain, potentially causing blockages or hindering the efficient flow of water. Clearing the drains to the correct line is essential to prevent flooding, water logging, or damage to surrounding areas, as the drains need to effectively channel water away from the desired area.

4.2.6 Finish the surfaces adjoining open drains

Finishing the surfaces adjoining open drains refers to applying materials or techniques to ensure a smooth and durable surface around the edges of the drain. This is done to improve the aesthetics, prevent damage to the drain, and provide a safe and accessible environment for pedestrians or vehicles.

Some common methods of finishing the surfaces adjoining open drains include:

- **A.** Paving: Using materials such as concrete, asphalt, or pavers to create a flat and stable surface around the drain.
- **B.** Grating: Installing grates or grids that cover the drain opening, allowing water to flow through while providing a solid platform for walking or driving.
- **C.** Kerbing: Constructing a curb or raised edge along the sides of the drain to contain the flow of water and provide a delineated boundary.
- **D.** Landscaping: Using vegetation or decorative materials to create an aesthetically pleasing and functional border around the drain.
- **E.** Sealants: Applying sealant or waterproofing agents to the surfaces adjoining the drain to protect against water infiltration and deterioration.

4.2.7 Under take adequate erosion control methods

To undertake adequate erosion control methods during bridge construction, several measures can be implemented:

A. **Site Preparation**: Before construction, the site should be properly surveyed to identify potential erosion areas. Adequate measures should be taken to clear vegetation, remove loose soil, and stabilize the ground if necessary.

B. **Sediment Barriers**: Install sediment barriers such as silt fences, sediment ponds, or sediment traps to catch and retain sediment runoff. These barriers should be strategically placed to intercept and filter sediment-laden water before it reaches sensitive areas like water bodies.

C. **Soil Stabilization**: Implement techniques to stabilize exposed soils. This may include using erosion control blankets, geotextiles, or erosion control mats to cover and protect vulnerable soils from erosion caused by rainfall or storm water runoff.

D. **Storm water Management**: Implement appropriate storm water management techniques to control the flow of water during construction. This may involve constructing temporary diversions, channels, or drainage systems to direct water away from sensitive areas and prevent soil erosion.

E. **Vegetative Measures**: Planting vegetation such as grasses, shrubs, or trees can help stabilize the soil, reduce erosion, and promote infiltration of storm water. Vegetation also provides habitat for birds and other wildlife.

F. **Construction Practices**: Implement construction practices that minimize soil disturbance and erosion potential. This includes minimizing the use of heavy machinery near sensitive areas, constructing temporary access roads, or limiting construction activities during heavy rainfall.

G. **Monitoring and Maintenance**: Regularly inspect erosion control measures to ensure their effectiveness. Sediment barriers should be checked and cleaned regularly, while vegetation should be monitored and maintained for healthy growth.

By implementing these erosion control methods during bridge construction, the impact on the surrounding environment can be mitigated, and the habitat for birds and other wildlife can be protected.

Fig 4.2Erosion in bridge construction

4.4. Completion

4.4.1. Selecting resources and carry out excavation

Selecting resources and carrying out excavation is the process of identifying and choosing the appropriate resources, tools, and equipment needed for excavating a particular area or site. It involves careful planning, research, and evaluation of available resources to ensure that the excavation is carried out efficiently and effectively.

The following steps are involved in selecting resources and carrying out excavation:

A. **Site assessment**: This involves conducting a detailed survey and assessment of the area to be excavated. It includes analyzing the ground conditions, soil type, potential obstacles, and any existing structures or utilities that may be present.

B. **Planning and design**: Based on the site assessment, a plan and design for the excavation process are developed. This includes determining the required equipment, tools, and manpower needed.

C. **Resource selection**: Once the plan is in place, the appropriate resources are selected. This may include heavy machinery such as excavators, bulldozers, cranes, or backhoes. Other resources may involve hand tools, safety equipment, temporary facilities like fencing or lighting, and any necessary permits or licenses.

D. **Equipment mobilization**: After selecting the resources, the equipment is mobilized to the site. This involves transporting, assembling, and setting up the necessary machinery and tools.

E. **Excavation process**: The actual excavation work begins following the plan and design. This may involve digging, removing soil and debris, breaking rocks or concrete, and clearing the area as required. The excavation process is typically carried out carefully to avoid damage to underground utilities or existing structures.

F. **Monitoring and adjustment**: Throughout the excavation, the progress and quality of the work are continually monitored. Adjustments may be made to the resources or excavation techniques based on the changing conditions or unforeseen challenges encountered.

G. **Completion and restoration**: Once the excavation is complete, the site is restored to its original or desired condition. This may involve backfilling, compaction, and reseeding or replanting vegetation as needed.

Overall, the selection of appropriate resources and the careful execution of the excavation process are crucial to ensure a successful and safe excavation project.

4.4.2 Prepare pipes and accessories.

In road construction, prepare pipes and accessories refers to the process of installing underground pipes and related components. These pipes are necessary for various utilities such as water supply, drainage systems, electrical and telecommunication cables.

Here are the steps involved in preparing pipes and accessories in road construction:

A. **Surveying and Planning**: A survey is conducted to determine the exact alignment and location where the pipes will be installed. This helps in creating a detailed plan for the construction process.

B. **Excavation:** Trenches are dug along the planned route to accommodate the pipes. The depth and width of the trenches depend on the size of the pipes and the specific requirements of the utility being installed.

C. **Pipe Installation**: Once the trenches are ready, the pipes are laid in alignment. Different types of pipes are used based on the purpose, such as PVC pipes for water supply or corrugated metal pipes for drainage systems.

D. **Jointing and Coupling**: The individual pipe sections are joined using various methods, such as solvent welding for PVC pipes or rubber gaskets for concrete or metal pipes. This ensures a secure connection between the pipe sections.

E. **Backfilling**: After the pipes are installed and checked for any leaks or defects, the trenches are backfilled with soil or other approved materials. This provides structural support and stability to the pipes.

F. **Manholes and Access Points**: Along the pipeline route, manholes and access points are constructed at regular intervals. These provide access for maintenance and repair works in the future.

G. **Accessories and Components**: Various accessories and components are installed along with the pipes to ensure efficient functioning of the utility. These include valves, hydrants, meters, pressure regulators, and other control devices.

H. **Testing and Inspection**: Once the pipes and accessories are installed, they undergo various tests and inspections to ensure their functionality and compliance with industry standards. This includes pressure testing, flow testing, and visual inspections.

I. **Surface Restoration**: After completing the pipe installation and testing, the trenches are fully backfilled and compacted. The surface is then restored by reinstating the road or pavement to its original condition.

Overall, preparing pipes and accessories in road construction involves careful planning, excavation, pipe installation, jointing, and backfilling, installation of accessories, testing, and surface restoration. These steps ensure the efficient functioning and longevity of the utility infrastructure in the road network.

A. Reinforced concrete

Reinforced concrete pipes are cylindrical structures made of concrete with a steel reinforcement, typically used in storm water drainage systems, sewage systems, and culverts. The concrete provides strength and durability, while the steel reinforcement helps to enhance the load-bearing capacity and prevent cracking or failure under pressure. These pipes are generally precast, meaning they are manufactured off-site in a controlled environment and then transported to the desired location for installation. Reinforced concrete pipes are designed to withstand the external loads imposed by the soil, traffic, and any other forces occurring in the given application.

Fig 4.21Reinforced concrete pipes

B. Rigid PVC

Rigid PVC pipes are a type of piping made from polyvinyl chloride (PVC) resin. They are also known as PVC-U or unplasticized PVC pipes. Rigid PVC pipes are characterized by their stiffness and inability to flex or bend easily. They are commonly used in plumbing, irrigation, and other applications where a strong and durable pipe is required. Rigid PVC pipes offer excellent resistance to chemicals, corrosion, and abrasion and have a long lifespan. They are lightweight, easy to install, and cost-effective compared to other types of pipes.

Fig 4.22Rigid PVC pipes

C. Flexible PVC

Flexible PVC, also known as flexible polyvinyl chloride, is a type of plastic that provides a combination of flexibility, durability, and chemical resistance. It is made by adding plasticizers to rigid PVC, which helps to soften the material and make it more pliable. Flexible PVC is commonly used in various applications where flexibility is required, such as in plumbing, wiring, automotive parts, upholstery, inflatable products, and medical devices. Its ability to resist corrosion, withstand harsh environments, and bend without breaking makes it a popular choice for these applications. It offers several advantages over other materials, including low cost, lightweight, good electrical insulation properties, and ease of processing. However, it may have limited resistance to high temperatures and certain chemicals compared to other types of plastic.

Fig 4.23Flexible PVC

D. Steel box culverts

Steel box culverts are rigid structures used for the conveyance of water, storm water, and other fluids. They are typically rectangular or square in shape and are made from steel plates or reinforced concrete. These culverts are prefabricated and assembled on-site.

Steel box culverts offer several advantages over other types of culverts. They are strong, durable, and able to withstand heavy loads and traffic. They are also resistant to corrosion, making them suitable for a wide range of environments. Additionally, steel box culverts can be quickly and easily installed, reducing construction time and costs.

These culverts are commonly used in various applications such as road or railway crossings, pedestrian tunnels, storm water management systems, and drainage systems. They are designed to efficiently channel water flow while providing structural support for the area above.

Overall, steel box culverts provide an effective and reliable solution for the safe and efficient transportation of fluids, making them a popular choice in civil engineering and infrastructure projects.

Fig 4.25 Steel box culverts

E. Clay pipes

Clay pipes are smoking devices that have been used for centuries. They are made from clay or earthenware and are typically used for smoking tobacco, herbs, or other substances. Clay pipes have a bowl at one end where the material is placed and a stem that allows the smoke to be inhaled. They are known for their simplicity and affordability, and they can provide a unique smoking experience due to clay's natural properties. However, they are relatively fragile compared to alternative materials like wood or metal.

F. Fiber Reinforced cement (FRC)

Fiber Reinforced Cement (FRC), also known as Fiber Reinforced Concrete, is a composite material made of cement, aggregates, and discrete fiber reinforcements. The purpose of adding fibers, typically made of materials like glass, steel, or synthetic fibers, is to enhance the properties and performance of the concrete. Fiber reinforcements distribute the load more evenly within the concrete matrix, increasing its toughness, ductility, and resistance to cracking. FRC typically exhibits improved flexural strength, impact resistance, and durability compared to traditional concrete. The fibers act as reinforcement, helping to control crack propagation and enhance the overall structural integrity of the concrete. FRC is commonly used in various construction applications, such as structural elements like beams, columns, and slabs, as well as in panels, pipes, and precast components. It is also used for repair and rehabilitation purposes, providing added strength and improving the performance of existing structures. Overall, FRC offers numerous advantages over conventional concrete, including increased resistance to shrinkage, reduced permeability, improved resistance to weathering and chemical attacks, and enhanced durability.

Fig 4.26 Fiber Reinforced Cement

4.5.1 Back fill

Back filling refers to the process of filling the space behind a retaining wall or minor drainage structure with a suitable material, such as soil or gravel. This is done to provide support and stability to the structure, preventing it from shifting or collapsing. The back fill material is compacted in layers as it is placed behind the structure to ensure proper compaction and prevent settlement. The type and placement of back fill material depends on the specific design requirements and the type of structure being back filled.

Backfill refers to the process of refilling an excavated area, such as a hole or trench, with soil or other materials. This is done to restore the ground surface to its original level or to provide stability and support for structures, such as foundations or pipes. Backfilling helps prevent the collapse of the excavation and can also be used to improve the drainage and stability of the surrounding area. Various materials, such as gravel, sand, or crushed stone, may be used

4.5.1 Conduct inspect and testing.

Conducting inspection and testing in maintaining minor drainage and retaining walls structures involves assessing the condition of these structures to ensure their proper functioning and safety. The process typically includes the following steps:

A. **Visual Inspection**: This involves a thorough examination of the retaining walls and drainage systems to identify any signs of damage, deterioration, cracks, or structural instability. Visual inspection can reveal issues such as blockage, leakage, soil erosion, or signs of poor maintenance.

B. **Moisture Testing:** Conducting moisture testing helps determine the presence of any excessive moisture or water accumulation in the drainage systems or behind the retaining walls. This can help detect possible drainage problems or potential damage to the walls caused by water seepage.

C. **Leakage Testing**: Using appropriate equipment and tools, leakage testing is performed to check any points of water leakage in the drainage system or seepage through the retaining walls. This helps identify areas that require repair or maintenance to prevent further damage to the structure.

D. **Load Testing**: Load testing assesses the structural capacity and stability of the retaining walls to ensure they can withstand the expected load or pressure. This involves applying a predetermined load or pressure to the walls and measuring their deflection or displacement to determine their safety factor.

E. **Material Testing**: Quality checks on the materials used in the construction of drainage and retaining walls structures are essential to ensure their integrity and durability. Material testing involves examining the quality of concrete, steel reinforcements, or any other materials used in the construction process.

F. **Documentation**: Proper documentation and recording of inspection and testing results are vital for future reference and tracking maintenance activities. This includes recording the findings, measurements, defects observed, and recommended repairs or maintenance actions.

By conducting routine inspection and testing, potential issues can be identified and addressed promptly, ensuring the proper functioning and longevity of minor drainage and retaining walls structures.

4.6 Report drainage fault

A report on drainage fault maintenance for minor drainage and retaining wall structures would typically include information on identifying and addressing drainage issues and maintaining the integrity of the retaining walls. The report may cover the following aspects:

A. **Introduction:** Provide an overview of the purpose of the report and the scope of the assessment.

B. **Site Assessment**: Describe the site conditions, including the type of drainage system and retaining walls present. Assess the current condition of the drainage system and retaining walls, noting any faults or signs of deterioration.

C. **Identification of Drainage Issues**: Identify any drainage faults, such as blocked or damaged drains, inadequate slope or gradient, insufficient capacity, or improper alignment. Explain how these issues may affect the overall drainage performance.

D. **Maintenance Recommendations**: Provide specific recommendations for addressing the identified drainage faults. This may include cleaning or unclogging drains, repairing or replacing damaged sections, improving the slope or alignment, or increasing the capacity of the drainage system. Recommend regular maintenance activities to prevent future issues.

E. **Retaining Wall Assessment**: Evaluate the condition of the retaining walls, including signs of settlement, erosion, cracking, or bulging. Assess the adequacy of the walls in terms of stability and function.

4.6.1 Retaining Wall Maintenance Recommendations:

Recommend appropriate maintenance measures for the retaining walls based on the assessment findings. This may involve repairing cracks, addressing erosion or settling issues, improving drainage behind the walls, or reinforcing the structure if needed.

A. **Cost Estimation:** Provide an estimated cost for implementing the recommended maintenance actions, including materials, equipment, and labor.

B. **Conclusion:** Summarize the main findings of the assessment and emphasize the importance of regular maintenance for ensuring the long-term functionality and safety of the drainage system and retaining walls.

Self-Check-4

Part I: True or False question

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

1. Quality checks on the materials used in the construction of drainage and retaining walls structures are essential to ensure their integrity and durability
2. ____________ Conducting moisture testing helps determine the presence of any excessive moisture or water accumulation in the drainage systems or behind the retaining walls.
3. ____________ Clay pipes are smoking devices that have been used for centuries.

____

Part II: Matching

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

A	B
1. Flexible PVC	A. also known as flexible polyvinyl chloride
2. Reinforced concrete pipes	B. are cylindrical structures made of concrete with a steel reinforcement, typically used in storm water drainage systems
3. Backfilling:	C. After the pipes are installed and checked for any leaks or defects, the trenches are backfilled
4. Planning and design	D. Based on the site assessment

Unit Five: Inspect, clear, repair culverts and Bridge

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

- Inspection of culverts and Bridge
- Repairing and Maintenance culverts and Bridge
- Bridge Inspection

Repair and Maintenance of Bridge Structure

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:

- Inspect culverts and Bridge
- Repair and Maintenance culverts and Bridge
- Inspect Bridge

5.1 Inspection

5.1.1 Faults in culverts

Identifying faults in culverts involves a systematic inspection and assessment of their structural integrity and functionality. Here are some common faults to look for:

A. **Blockage or Obstruction**: Look for any signs of debris, sediment buildup, vegetation growth, or any objects blocking the flow of water through the culvert. This can cause water backup and potential flooding.

B. **Cracks or Fractures**: Inspect for any visible cracks or fractures in the culvert walls, joints, or any other areas. These can compromise the culvert's strength and lead to further damage.

C. **Corrosion**: Check for signs of corrosion on metal culverts, such as rust or pitting. Corrosion weakens the structural integrity of the culvert over time.

D. **Erosion or Scour**: Assess the surrounding areas for signs of erosion or scouring around the culvert. This can indicate water flow issues and potential collapse.

E. **Settlement or Subsidence**: Look for any settling or sinking of the culvert, as it can disrupt proper water flow or cause structural instability.

F. **Collapsed Sections**: Identify any sections of the culvert that have collapsed or caved in. This can obstruct water flow and cause significant drainage problems.

G. **Joint Separation**: Inspect for any separation or misalignment of joints between culvert segments. Displaced or improperly connected joints can affect the culvert's ability to function correctly.

H. **Inadequate Capacity**: Evaluate the culvert's diameter and capacity in relation to the water flow in the area. If the culvert is too small for the volume of water, it may cause frequent blockages and overflow. Regular inspections, conducted by trained professionals, are necessary to identify faults in culverts promptly.

5.1.2 Reinforced concrete pipe sections

Reinforced concrete pipe sections or reinforced concrete pipes are cylindrical structures used in various applications including drainage, sewer systems, culverts, and other underground structures. These pipes are made by casting a mixture of concrete and reinforcement bars (steel bars) inside a mold or formwork. The reinforcement bars, typically made of steel, are placed within the mold before the concrete is poured. This reinforcement helps to enhance the structural strength and durability of the pipe sections. The concrete used in reinforced concrete pipes is typically a mix of cement, sand, aggregate (such as crushed stone or gravel), and water. Reinforced concrete pipes come in different shapes and sizes, ranging from small diameters of a few inches to large diameters of several feet. The lengths of these pipe sections can also vary depending on the specific application and project requirements. These pipes have several advantages, including:

1. **Structural strength**: The combination of concrete and steel reinforcement provides high strength and load-bearing capacity, making them suitable for various applications.
2. **Durability**: Reinforced concrete pipes have excellent resistance to corrosion, weathering, and other environmental factors, ensuring long-term service life.
3. **Rigidity:** These pipes have a rigid structure, providing resistance against external loads, ground movements, and pressure from flowing fluids.
4. **Easy installation**: The standardized shapes and sizes facilitate easy installation and connection of pipe sections.

   Cost-effective: Reinforced concrete pipes are relatively cost-effective compared to other materials, considering their long service life and low maintenance requirements.

These pipe sections are produced in precast concrete plants and are typically transported to the construction site for installation. Installation methods may vary depending on the specific project requirements, including trenching, backfilling, and jointing techniques.

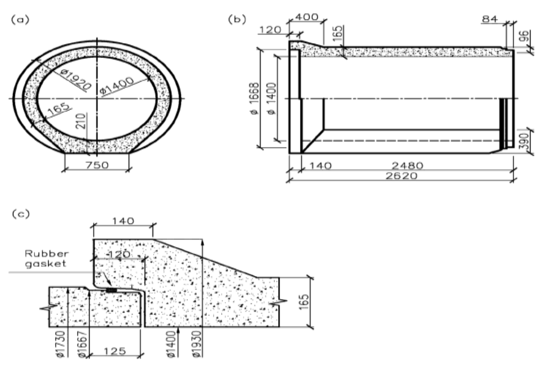

Fig 5.1 Reinforced concrete pipe sections

5.1.3 Reinforced concrete box sections

Reinforced concrete box sections are structural elements used in construction, consisting of concrete walls forming a rectangular or square box shape, with reinforcement added to enhance its strength and durability. The reinforcement typically includes steel bars or mesh embedded within the concrete to provide resistance against bending, flexural forces, and cracking. Reinforced concrete box sections are commonly used for various applications, including:

A. **Beams and columns in buildings and bridges**: These box sections provide load-bearing capacity and help distribute the loads efficiently, ensuring the structure's stability and strength.
B. **Underground tunnels and culverts**: Reinforced concrete box sections are utilized to create durable and robust structures for transportation systems, drainage systems, and utility tunnels.
C. **Retention structures**: These box sections are used in retaining walls and underground tanks to withstand the pressure exerted by soil or water.

The reinforcement in the concrete box sections helps to prevent cracking and maintain structural integrity, even under heavy loads or adverse environmental conditions. Overall, reinforced concrete box sections offer significant advantages regarding strength, versatility, and long-term performance.

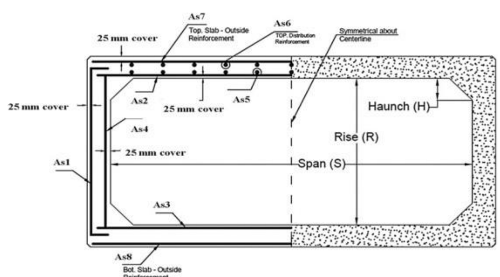

Fig 5.2 Reinforced concrete box sections

A. Steel pipe

Steel pipe culverts refer to large, tunnel-like structures made of steel pipes that are used to allow water to pass through, typically under roadways, railways, canals, or embankments. They are commonly used in drainage systems to redirect water flow and prevent flooding by providing a stable and efficient channel for water to bypass obstacles. Steel pipe culverts are preferred for their strength, durability, longevity, and resistance to corrosion. They are manufactured in different sizes and configurations to meet specific requirements for water volume and site conditions.

Fig 5.3 Steel pipe culverts

B. Fiber Reinforced Concrete(FRC)

FRC culverts are culverts made from Fiber Reinforced Concrete (FRC). Culverts are structures that allow water to flow under roads, railways, or other obstructions. FRC culverts are constructed using concrete reinforced with fibers, such as steel or synthetic fibers, to enhance the strength and durability of the culvert. These culverts are commonly used for drainage purposes and are designed to withstand heavy traffic loads and environmental conditions.

C. PVC

PVC culvert refers to a type of pipe used for drainage or water management purposes. PVC, or polyvinyl chloride, is a synthetic plastic material known for its durability and resistance to corrosion. PVC culverts are commonly used to create underground channels for storm water runoff or to redirect water flow in various applications, such as roads, highways, agriculture, or residential areas. These culverts are easy to install, lightweight, and offer a cost-effective solution for managing water flow. They are available in different sizes and can be joined together using various fittings to create a continuous system.

Fig 5.4 PVC culvert refers

5.2 Repairing sections and joint

Repairing sections and joints typically refers to the process of fixing or restoring damaged or worn-out areas or connections in various structures or objects. This can involve repairing cracks, fractures, or breaks in different materials, such as wood, metal, or concrete. For example, in construction or engineering, repairing sections and joints may include fixing damaged parts of a building, bridge, or road. This can involve replacing or reinforcing weakened areas, filling gaps with suitable materials, or reattaching disconnected sections to restore the structural integrity. In the context of human anatomy, repairing sections and joints can pertain to the medical procedures or treatments aimed at repairing and healing injured or degenerated joints in the body. This could involve surgical interventions, such as joint replacement or fusion, or non-surgical methods like physical therapy or injections to alleviate pain and restore function. Overall, repairing sections and joints involve identifying and addressing the specific damage or wear in order to restore the structural or functional integrity of an object or system.

Repairing sections and joint culverts and bridges involves the following steps:

A. **Inspection**: Conduct a thorough inspection of the sections, joints, culverts, and bridges to assess the extent of damage and identify the repair needs. This inspection may include visual examination, structural evaluation, and testing.
B. **Planning:** Develop a repair plan based on the inspection findings. Consider the required materials, equipment, and estimated time for repairs.
C. **Procurement**: Purchase the necessary materials and equipment for the repairs, including concrete, asphalt, steel reinforcements, waterproofing membranes, joint fillers, and any specialized tools or machinery.
D. **Clearing and preparation**: Clear the area around the damaged sections, joints, culverts, or bridges. Remove any debris, vegetation, or unstable elements that could hinder the repair process. Prepare the surface by cleaning, scraping, or applying a suitable primer or adhesive if required.
E. **Repairs**: Depending on the specific damage, various repair techniques may be employed. These can include:

F. **Patching or resurfacing**: Repairing small cracks, spalls, or surface defects by applying suitable materials such as concrete, asphalt, or epoxy-based products.

G. **Joint repairs**: Replacing damaged expansion joints, joint fillers, or sealants to maintain proper functionality and prevent water infiltration.

H. **Culvert repairs:** Fixing or replacing damaged culvert sections, including the pipe or box culvert, connections, or end sections. This may involve excavation, backfilling, and compaction of the surrounding soil.

I. **Bridge repairs**: Addressing structural issues in bridges such as corrosion, cracks, delaminating, or bearing replacement. This may involve concrete repair, steel reinforcement, waterproofing, or strengthening techniques.

J. **Quality control**: Conduct tests and inspections during and after the repair process to ensure the quality and integrity of the repaired sections, joints, culverts, or bridges. This can include non-destructive testing, load testing, or visual inspections.

K. **Maintenance:** Develop a maintenance plan following repairs to ensure the longevity and durability of the rehabilitated sections, joints, culverts, or bridges. Regular inspections and scheduled maintenance activities should be implemented to detect and address any maintenance needs promptly.

It is important to follow engineering guidelines, local regulations, and industry best practices while repairing sections, joint culverts, and bridges to ensure safety and longevity.

Fig 5.6 Repairing sections and joints

5.3 Repairing inlet and outlet

Repairing inlet and outlet typically refers to fixing any issues or damage with the connections and components that allow the flow of fluids or gases into and out of a system or device. This can involve various tasks such as repairing or replacing valves, fittings, pipes, hoses, or other components that are responsible for the intake or discharge of fluids or gases. The purpose of repairing the inlet and outlet is to restore proper functionality and prevent any leaks or disruptions in the flow. Therefore, the inlet control capacity depends primarily on the geometry of the culvert entrance. Outlet control flow occurs when the culvert flow capacity is limited by downstream conditions (high tail water) or by the flow carrying capacity of the culvert barrel.

Repairing inlet and outlet culverts and bridges typically involves several steps. Here is a general overview of the process:

A. **Inspection**: A thorough inspection of the culverts and bridge is conducted to identify any damage or deterioration. This may include assessing the condition of the structure, checking for cracks or leaks, and measuring the levels of sediment or debris build-up.
B. **Clearance:** Any accumulated debris, sediment, or vegetation is cleared from the culverts and bridge to ensure smooth water flow and prevent blockages.
C. **Cleaning:** The culverts and bridge are cleaned using high-pressure water jets or other appropriate equipment to remove dirt, rust, and any loose materials from the structure. This may also involve removing and replacing corroded parts or components.
D. **Structural repairs:** Depending on the extent of damage, structural repairs may be necessary. This could involve patching or sealing cracks, reinforcing weakened areas, or replacing damaged sections of the culverts or bridge.
E. **Replacement of components:** If any components such as pipes, grates, or gates are found to be faulty, they may need to be replaced with new ones that meet the necessary specifications.
F. **Strengthening:** In some cases, the culverts or bridge may require strengthening measures to ensure their long-term stability and resilience. This could involve adding protective coatings, reinforcing structures, or implementing erosion control measures.
G. **Maintenance:** Regular maintenance is crucial to ensure the ongoing functionality and safety of the inlet and outlet culverts and bridge. This may involve periodic

inspections, cleaning, and minor repairs to address any emerging issues and prevent further deterioration.

It is important to note that the specific repair process may vary depending on the type and size of the culverts or bridge, as well as the extent of the damage. In some cases, specialized equipment and techniques may be required, and it is recommended to consult with engineering professionals or contractors experienced in culvert and bridge repair before undertaking any major repairs.

Fig 5.7 Repairing inlet and outlet

5.4 Repair and Maintenance

5.4.1 Maintenance of bridge structure

Carrying out repairs and maintenance of bridge structures involves various steps and procedures. Here is a general overview of the process:

A. **Initial Assessment**: A thorough inspection of the bridge structure is conducted to identify any damage, deterioration, or maintenance needs. This can include visual inspections, non-destructive testing, and structural analysis.
B. **Planning**: Based on the assessment, a detailed plan is developed to address the identified issues. This plan includes the scope of repair and maintenance work, timeline, resources required, and cost estimation.
C. **Permits and Approvals**: Obtaining the necessary permits and approvals from relevant authorities is essential before initiating any repair or maintenance work on a bridge structure. This may involve coordination with government agencies or local transportation departments.

D. **Safety Measures**: Ensuring the safety of workers and the public is a crucial aspect during repairs and maintenance. Measures such as traffic control, working platforms, fall protection, and hazard signage are implemented to maintain a safe work environment.

E. **Repairs and Structural Maintenance**: Repairs can include fixing cracks, replacing damaged components, strengthening the structure, or addressing any other problems that may compromise the integrity of the bridge. Structural maintenance involves tasks like cleaning, painting, waterproofing, and corrosion protection.

F. **Method Selection**: Depending on the specific requirements and condition of the bridge, suitable repair methods and techniques are chosen. These can include concrete repair, steel reinforcement, welding, or specialized bridge maintenance technologies.

G. **Execution:** Skilled workers, such as engineers, technicians, and contractors, carry out the repairs and maintenance work according to the plan. The actual execution may involve tasks like concrete pouring, welding, retrofitting, or installation of new components.

H. **Quality Control**: Regular inspections and quality checks are performed throughout the repair and maintenance process to ensure compliance with specifications and standards. These checks can include material testing, monitoring, and verification of workmanship.

I. **Documentation and Reporting**: All activities, findings, and changes made during the repairs and maintenance are documented. This information is used for future reference, asset management, and reporting purposes.

J. **Post-Maintenance Evaluation**: After completing the repairs and maintenance, a final evaluation is conducted to assess the effectiveness of the work performed, long-term durability, and sustainability of the bridge structure. Any necessary adjustments or follow-up actions are identified and addressed.

It is important to note that the specific procedures and techniques involved in bridge repairs and maintenance may vary depending on the type of bridge, materials used, local regulations, and project requirements.

5.4.2 Compacting backfill

Compacting backfill inspect refers to the process of examining the compacted backfill material used in construction projects, such as filling trenches or utility installations. During inspection, the quality and compaction level of the backfill are evaluated to ensure it meets the required engineering specifications. Clearing culverts and bridges involves the removal of any debris, vegetation, or other obstructions that may hinder the flow of water or traffic through these structures. Regular clearing is essential to maintain their functionality and prevent blockages or flooding. Repairing culverts and bridges refers to fixing any damages, defects, or deterioration that may have occurred in these structures over time. This includes addressing issues such as cracks, leaks, erosion, or structural weaknesses, to ensure their safe and reliable operation. Overall, these activities are important maintenance measures that help ensure the proper functionality, structural integrity, and safety of culverts and bridges.

Compacting backfill is an important step in the construction of culverts and bridges as it helps to provide stability and support to the structures. Here are some key points to consider regarding compacting backfill in these construction projects:

A. **Purpose**: The purpose of compacting backfill is to remove any voids and increase the density of the soil material, ensuring it can provide a strong and stable foundation for the culverts and bridges.

B. **Material**: The backfill material used should ideally be granular in nature, consisting of sand, gravel, or crushed stone. This type of material allows for better compaction compared to more cohesive soils.

C. **Compaction methods**: Various methods are utilized for compacting backfill, including the use of heavy machinery such as compactors, rollers, and plate compactors. These machines apply pressure and vibrations to the backfill material, causing it to become denser.

D. **Construction specifications**: The degree of compaction required is typically specified in the construction plans and specifications. This ensures that the backfill material is compacted to the required density and provides the necessary support to the culverts and bridges.

E. **Compaction testing**: Quality control measures often include compaction testing during the construction process. This involves taking samples of the backfill material at various depths and conducting laboratory tests to determine the density and compaction achieved.

F. **Backfill layers**: Backfilling is usually done in layers, with each layer being compacted before the next one is placed. The thickness of each layer and the number of passes required for compaction depend on the specific project and soil conditions.

G. **Moisture content**: The moisture content of the backfill material must be controlled during compaction. The moisture content affects the level of compaction achievable. Usually, a specified moisture range is targeted to facilitate optimal compaction.

Overall, compacting backfill in construction culverts and bridges is crucial to ensure the longevity and stability of the structures. It helps to minimize settling and provides support against external loads and environmental factors.

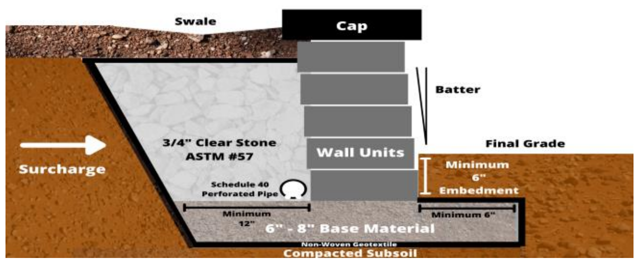

Fig 5.8 Compacting backfill renting wall

5.4.3 Clean up

After completing construction work in an area, it is common practice to clear the work area and properly dispose of any materials that were used or generated during the construction process. This generally includes the following steps:

A. **Removal of construction equipment and tools**: Any machinery, equipment, or tools that were used during the construction work are removed from the work area.

B. **Scrap and waste material removal**: Any scrap materials, such as excess building materials, demolition debris, packaging waste, or other construction-related waste, are collected and properly disposed of. This often involves sorting and separating different types of waste materials for recycling or landfill disposal.

C. **Cleaning the work area**: The work area, including the floors, walls, and any other surfaces, is cleaned thoroughly to remove any dirt, dust, or debris that may have accumulated during the construction process. This may involve sweeping, mopping, or vacuuming the area.

D. **Restoration and repair**: If any damage or disruption to the surroundings occurred during the construction work, efforts are made to restore or repair those areas to their original condition. This may involve repairing landscape features, repairing or repainting walls, or other necessary repairs.

E. **Final inspection**: A final inspection is often conducted to ensure that the work area is clear, cleaned, and restored properly. This inspection ensures that all necessary tasks have been completed and that the area is safe and ready for use.

Overall, the clearing and disposal of materials in construction aim to ensure a clean and safe environment while minimizing the environmental impact and complying with local regulations.

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. Quality checks on the materials used in the construction of drainage and retaining walls structures are essential to ensure their integrity and durability

_________ 2. Conducting moisture testing helps determine the presence of any excessive moisture or water accumulation in the drainage systems or behind the retaining walls.

_________ 3. Clay pipes are smoking devices that have been used for centuries.

____

Part II: Matching

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

A	B
1. Flexible PVC	A. also known as flexible polyvinyl chloride
2. Reinforced concrete pipes	B. are cylindrical structures made of concrete with a steel reinforcement, typically used in storm water drainage systems
3. Backfilling:	C. After the pipes are installed and checked for any leaks or defects, the trenches are backfilled
4. Planning and design	D. Based on the site assessment

Part III: choose the correct answer

1. What is the purpose of reinforced concrete box sections?

   A. To enhance structural strength and durability

   B. To reduce cost

   C. To increase water flow capacity

   D. To improve ease of installation

1. What is the potential consequence of a blockage or obstruction in a culvert?

   A. Reduced erosion **C.** Increased water flow capacity

B. Flooding D. Improved structural strength

2. What should be evaluated in relation to water flow when assessing the capacity of culverts?
   A. Vegetation growth C. Sediment buildup
   B. Diameter and capacity D. Structural stability
3. What is a visible sign of settling or sinking of culverts?
   A. Visible cracks C. Exposed soil
   B. Collapsed sections D. Uneven surface
4. What are reinforced concrete pipe sections made of?
   A. Wood and plastic C. Brick and stone
   B. Metal and glass D. Concrete and reinforcement bars

REFERENCE

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