Ethiopian TVET-System

Irrigation and Drainage Design and Construction

Level II

Based on Mar, 2017G.C. Ethiopian Occupational Standard

Module Title: Carrying Out Concrete Work

TTLM Code: EIS IDC2 TTLM 09 20v2

This module includes the following learning guides

LG 65: Plan and Prepare

LG Code: EIS IDC2 M16 LO1-LG-60

LG 66: Select Materials

LG Code: EIS IDC2 M16 LO2-LG-61

LG 67: Set Out for Concrete Work

LG Code: EIS IDC2 M16 LO3-LG-62

LG 68: Construct and Fit Reinforcement

LG Code: EIS IDC2 M16 LO4-LG-63

LG 69: Erect Formwork

LG Code: EIS IDC2 M16 LO5-LG-64

LG 70: Carry Out Concrete Work

LG Code: EIS IDC2 M16 LO6-LG-65

LG 71: Strip Formwork

LG Code: EIS IDC2 M16 LO7-LG-66

LG 72: Clean Up

LG Code: EIS IDC2 M16 LO8-LG-67

Instruction Sheet	Learning Guide 60: Plan and Prepare

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Understanding Concrete work instruction
- Obtaining concrete work safety requirements
- Identifying signage requirements
- Selecting and using concrete work plant, tools and equipment
- Maintaining concrete work plant, tools and equipment
- Identifying environmental protection requirements

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Obtain, confirm and apply work instructions, including plans, specifications, quality requirements, operational details and materials relevant to the allotted task
- Obtain safety requirements from the site safety plan and organizational policies and procedures, confirmed and applied to the allotted task
- Identify and obtain signage requirements from the project traffic management and implementation plan.
- Select plant, tools and equipment to carry out tasks consistent with the requirements of the job, checked for serviceability and any faults are rectified or reported
- Identify environmental protection requirements from the project environmental management plan, confirmed and applied to the allotted task.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 5”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3,4 and,5 ” in each information sheets on pages 7, 9, 14,18 and 21.

5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2, 3 and 4 on pages 2 and 23 and do the LAP Test on page 24”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Understanding Concrete Work Instruction

1.1 Introductions to concrete

Concrete is a composite material which is made up of filler and a binder. Typical concrete is a mixture of fine aggregate (sand), coarse aggregate (rock), cement, and water. Concrete's versatility, durability, sustainability, and economy have made it the world's most widely used. The term concrete refers to a mixture of aggregates, usually sand, and either gravel or crushed stone, held together by a binder of cementitious paste. The paste is typically made up of Portland cement and water and may also contain supplementary cementing materials (SCMs), such as fly ash or slag cement, and chemical admixtures.

Figure 1: Concrete components: cement, water, coarse aggregate, fine aggregate, supplementary cementing materials, and chemical admixtures.

Understanding the fundamentals of concrete is necessary to produce quality concrete. This publication covers the materials used in concrete and the essentials required to design and control concrete mixtures for a wide variety of structures.

1.1.1 Components of concrete

Concrete, an artificial stone-like mass, is the composite material that is created by mixing binding material (cement or lime) along with the aggregate (sand, gravel, stone, brick chips,

etc.), water, admixtures, etc in specific proportions. The strength and quality are dependent on the mixing proportions.

Concrete = Binding Material + Fine & Coarse Aggregate + Water + Admixture (optional)
Concrete is a very necessary and useful material for construction work. Once all the ingredients -cement, aggregate, and water unit of measurement mixed inside the required proportions, the cement and water begin a reaction with one another to bind themselves into a hardened mass. This hardens rock-like mass is the concrete.

There are four basic ingredients within the concrete mix:

- Binding materials like cement or lime
- Aggregates or Inert Materials
  - ✓ Fine aggregate (sand)
  - ✓ Coarse aggregate (stone chips, brick chips)
- Water
- Admixture (e.g. Pozzolana

Binding Materials: Binding material is the main element of a concrete mix. Cement is the most commonly used binding material. Lime could also be used. When water is mixed with the cement, a paste is created that coats the aggregates within the mix. The paste hardens, binds the aggregates and forms a stone-like substance.

Aggregates: Sand is the fine mixture. Gravel or crushed stone is the coarse mixture in most mixes.

Water: Water is required to chemicals react with the cement (hydration) and to supply workability with the concrete. The number of water within the combine in pounds compared with the number of cement is named the water/cement quantitative relation. The lower the w/c quantitative relation, the stronger the concrete. (Higher strength, less permeability)

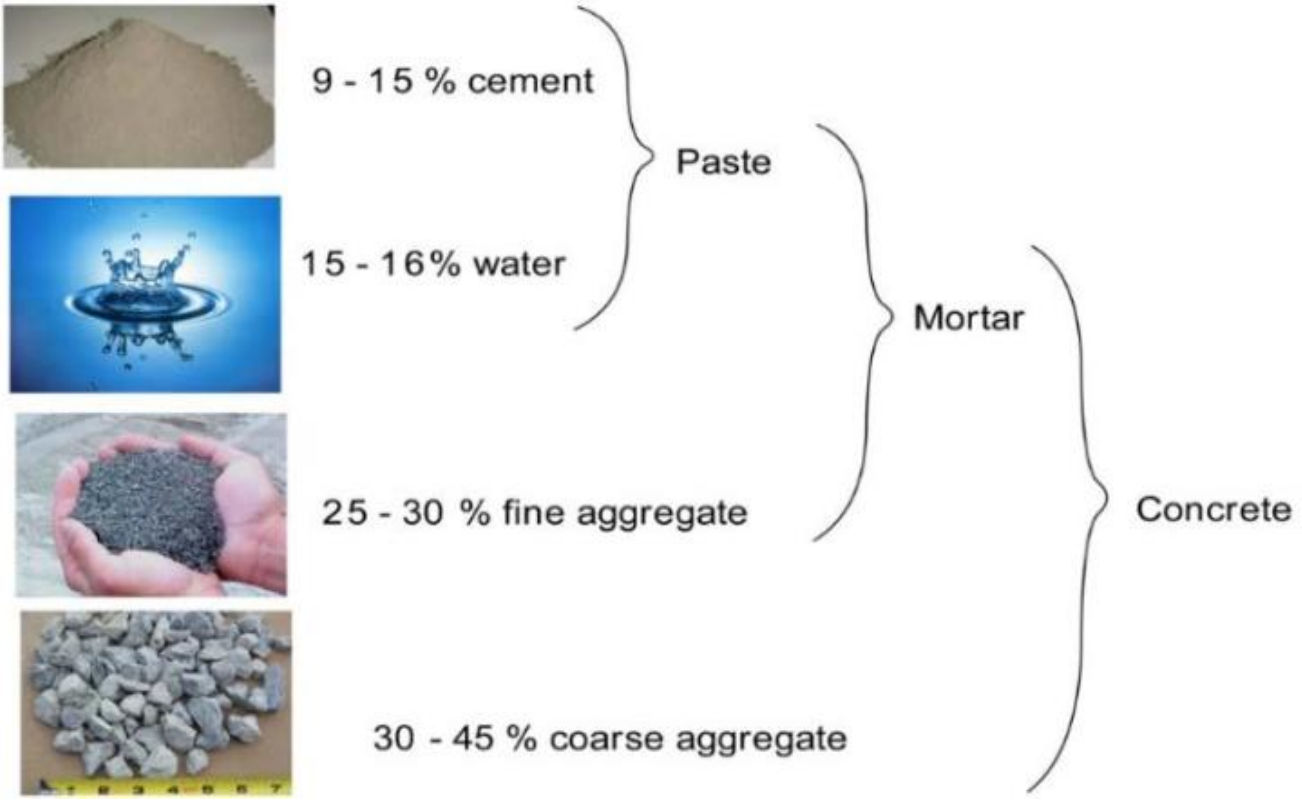


Figure 2: Basic ingredients of concrete

1.1.2 Types of concrete mix

Concrete is employed for various projects starting from little homemade comes to large subject field buildings and structures. It is used for sidewalks, basements, floors, walls, and pillars at the side of several alternative uses. Many sorts of concrete are utilized in the development works.

Based on the variations in materials and purposes, concrete can be classified into three basic categories-

- Lime Concrete
- Cement Concrete
- Reinforced Cement Concrete

Lime Concrete: Lime concrete uses Lime as the binding material. Lime is usually mixed with surki and khoa or stones in the proportion 1:2:5 unless otherwise specified. The khoa or stones are soaked in water before mixing. Lime concrete is used mainly in foundation and terrace roofing.

Cement Concrete: Most engineering construction uses cement concrete composites as the main building material. It consists of cement, sand, brick chips or stone chips of the required size. The usual proportion is 1:2:4 or 1:3:6. After mixing the required amounts of materials, the concrete mix is cured with water for 28 days for proper strength building.

Reinforced Cement Concretes: For enhancing the tensile strength of concrete, steel reinforcements are added. Sometimes, RCC is pre stressed under compression to eliminate or reduce tensile stresses. The resulting concrete is known as pre stressed Concrete.

1.1.2 Properties of Concrete

Concrete has many properties that make it a popular construction material. The correct proportion of ingredients, placement, and curing are needed in order for these properties to be optimal. The following are common properties of concrete:

I. Strength

Strength of concrete are of the following types:

a. Compressive strength
b. Tensile strength
c. Flexural strength
d. Shear strength

a. Compressive strength: or **compression strength** is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently.

b. Tensile strength: Concrete is very weak in tension. The tensile strength of ordinary concrete ranges from about 7 to 10 percent of the compressive strength.

c. **Flexural strength:** The flexural strength of plain concrete is almost wholly dependent upon the tensile strength. However, experiments show that the modulus of rupture is considerably greater than the strength in tension.

d. **Shear strength:** It is the real determining factor in the compressive strength of short columns. The average strength of concrete in direct shear varies from about half of the compressive strength for rich mixtures to about 0.8 of the compressive strength for lean mixtures.

II. Workability

The strength of concrete of a given mix proportion is very seriously affected by the degree of its compaction. It is therefore vital that the consistency of the mix be such that the concrete can be transported, placed and finished sufficiently easily and without segregation. A concrete satisfying these conditions is said to be workable.

Factors affecting the workability of concrete are:

- Water Content
- Mix Proportions
- Size of Aggregates
- Shape of Aggregates
- Grading of Aggregates
- Surface Texture of Aggregates
- Use of Admixtures
- Use of Supplementary Cementitious Materials
- Time
- Temperature

Usually, Slump test is done to indirectly determine the workability of a concrete mix.

III. Elastic Properties

Concrete is not perfectly elastic for any range of loading, an appreciable permanent setting taking place for even low loads. The deformation is not proportional to the stress at any stage of loading. The elastic properties of concrete vary with the richness of the mixture and with the intensity of the stress. They also vary with the age of concrete.

IV. Durability

Durability is the property of concrete to withstand the condition for which it has been designed, without deterioration over a period of years. Lack of durability can be caused by external agents arising from the environment or by internal agents within the concrete.

Causes can be categorized as physical, mechanical and chemical. Physical cause arises from the action of frost and from differences between the thermal properties of aggregate and of the cement paste, while mechanical causes are associated mainly with abortion.

V. Impermeability

Penetration of concrete by materials in solution may adversely affect its durability, for instance, when $Ca(OH)_2$ is being leached out or an attack by aggressive liquids (acids) takes place. Permeability has an important bearing on the vulnerability of concrete to water and frost. In the case of reinforced cement concrete, the penetration of moisture and air will result in the corrosion of steel. This leads to an increase in the volume of the steel, resulting in cracking and spalling of the concrete. Permeability of concrete is also of importance for liquid retaining and hydraulic structures;

VI. Segregation

The tendency of separation of coarse aggregate grains from the concrete mass is called segregation. It increases when the concrete mixture is lean and too wet. It also increases when rather large and rough-textured aggregate is used. The phenomenon of segregation can be avoided as follows.

- Addition of little air-entraining agents in the mix.
- Restricting the amount of water to the smallest possible amount.
- All the operations like handling, placing and consolidation must be carefully conducted.
- Concrete should not be allowed to fall from large heights.

VII. Bleeding

The tendency of water to rise to the surface of freshly laid concrete is known as *bleeding*. The water rising to the surface carries with it, particles of sand and cement, which on hardening form a scum layer is popularly known as *laitance*. Concrete bleeding can be checked by adopting the following measures.

- By adding more cement
- By using more finely ground cement
- By properly designing the mix and using the minimum quantity of water
- By using little air entraining agent
- By increasing the finer part of fine aggregate

VIII. Fatigue

Plain concrete when subjected to flexure, exhibits fatigue. The flexure resisting ability of concrete of a given quality is indicated by an endurance limit whose value depends upon the number of repetitions of stress. In concrete pavement design, the allowable flexural working stress is limited to 55% of the modulus of rupture.

1.2 Understanding plan and specification

1.2.1 Definition of plans and specifications

A key part of the process of designing and constructing water tight homes is having a solid base of detailed plans, specifications and documents. They are a means of communicating between parties, and of ensuring that the appropriate designs, materials and construction techniques are used.

Good documentation can reduce:

- time delays in consent applications
- inaccuracies in prices and quotes
- disputes between the builder and the owner/designer
- the need for extras (the cost of carrying out work not originally included is usually greater than that if it had been there at the start)
- the need for amendments during construction.

Plans and specifications include:

- the drawings, specification and other documents from which the construction is to be constructed, altered, demolished or removed
- the proposed procedures for inspection during construction
- the definition of the intended construction use

- details of specified systems and procedures for their inspection and maintenance.

1.2.2 Requirements for plans and specifications

A good set of documents:

- accurately represents the extent and content of the project by defining:
  - ✓ the scope of work to be done
  - ✓ the materials and products to be used by product name and manufacturer identification number or reference
  - ✓ acceptable standards of workmanship
  - ✓ levels of finish required by the client
- shows sufficient detail so that the main contractor or sub trades do not have to guess what is required is presented:
  - ✓ clearly and concisely
  - ✓ neatly and legibly
  - ✓ in a logical sequence
  - ✓ with consistency between drawings and specifications
  - ✓ with the drawings of different consultants coordinated to prevent conflicts, ambiguity or contradictions
  - ✓ with all dimensions shown and drawn to scale

1.2.3 Producer statements

Producer statements (including structural design certificates, durability assessments, weather tightness opinions, thermal design calculations and specific fire engineering design) must:

- be made by suitably qualified, independent, competent persons
- confirm that material quality, design standards or construction standards comply with the Building Code
- confirm design assumptions as the work proceeds, where the work is an alteration.

1.2.4 Common omissions from plans and specifications

Some sets of drawings show the easy, straightforward aspects of construction (which both the designer and builder could reasonably be expected to know) and do not include the

complicated or non-standard parts of the construction. Where a particular construction detail is required, it must be shown in sufficient detail so that the builder can understand what is intended.

1.3 Identifying concrete work quality requirement

Quality is the adherence and conformance to properly developed requirements. Requirements for quality design in concrete construction include conformance with applicable codes, standards, guidance, regulations, laws, and statues referenced in the specifications.

Quality requirement is a common term in project management. It is defined as the condition used to assess the conformance of the project by validating the acceptability of an attribute or characteristic for the quality of a particular result.

The quality requirements in project management are defined in terms of the quality criteria, quality factors, and quality metrics. The quality criteria document the internal process and attributes of the product that will be monitored all throughout the project life cycle. The quality factors document the perceived aspects of the user regarding the deliverables of the project to determine if the project satisfies the expectations from customers.
Project quality management encompasses the processes and activities that are used to figure out and achieve the quality of the deliverables of a project. However, quality can be an elusive word.

What is quality? While we could go on forever about the “true” meaning of quality and use the Socratic method to dialogue on its many possible meanings, for project management the answer is more defined.

Quality is simply what the customer or stakeholder needs from the project deliverables. By keeping the definition tied to the customer or stakeholder, quality management can have a narrower focus, which means it’s more likely to achieve its goals.

Quality of concrete construction on site can be accomplished in three distinct stages as follow

- Quality control before concreting
- Quality control during concreting
- Quality control after construction

Stage-1 (Quality control before concreting)

This stage of quality control consists of two steps.

- Checking of specification requirements regarding excavation, forms, reinforcement and embedded fixtures etc.
- Control test on concrete ingredients (i.e. on cement, aggregate & water)

Cement

Quality of cement is ascertained by making compressive strength tests on cement cubes. However, for effective control cement:

- Should be tested initially once for each source and subsequently once for every two months
- Should be protected from moisture
- Should be retested after 3 months of storage, if long storage in unavoidable
- Should be rejected if large lump are found in cement bags.

Aggregate

Concrete aggregates should confirm to specified values as per standard specification.

The quality of concrete is affected by different physical and mechanical properties of aggregate, i.e. shape, grading, durability, specific gravity and water absorption etc. these properties of aggregated should be tested before using it for concrete production.

The quantity of deleterious materials and organic impurities should also be tested.

Bulking of sand is also an important property in several ways. It gives wrong results when volume batching is done. It increases water cement ratio which in turn reduces strength.

For effective control aggregates:

- Are required to be tested once initially for approval of source
- Should subsequently be tested once or twice daily for moisture content and allowance should be made for moisture content of aggregates.

Water

The quality of water should be checked for the requirements as specified in respective standard. Chemical analysis shall be conducted for approval of source. In case of suspended

impurities, it is necessary to store water for some time to allow them to settle down. In case of doubt concrete cubes made with this water are tested. Average 28 days compressive strength of at least three cubes or cylinders or specified size, prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distilled water.

Stage-2 (Quality Control during Concreting)

Careful supervision during concrete manufacture is necessary for all concreting operations such as batching, mixing, transporting, laying, compacting and curing. Following precautions should be taken during concreting operation.

Stage-3 (Quality Control after Construction)

Once the concrete is laid and compacted, compression tests are made on the cubes made out of this concrete. For ordinary concrete, cubes are made out of the concrete made at work site.

The hardened concrete has to be checked for trueness in dimensions, shape and sizes as per design specification. General surface appearance of concrete should also be checked. Dimensions are ascertained by different measurements. Reinforcement should have adequate concrete cover and if the reinforcement is visible in part of a structure, the part should be rejected or necessary actions should be taken accordingly.

Concrete strength is normally to be ascertained from cube or cylinder samples tested at 28 days. In case the strength obtained is less than the specific minimum, one or more of following steps may be taken.

- Load test and measurement of deflection and / or strain (the quality of the structure can then be ascertained by calculating back the concrete strength)
- Cutting cores from the structures and testing them for strength
- Nondestructive tests like Schmidt rebound hammer or ultrasonic pulse velocity test. These tests give only a very rough idea and are primarily used to ascertain the uniformity of construction.
- Chemical analysis of hardened concrete.

1.4. Identifying concrete work materials

Aggregate consists of large chunks of material in a concrete mix, generally a coarse gravel or crushed rocks such as limestone, or granite, along with finer materials such as sand. A cement, most commonly Portland cement, is the most prevalent kind of concrete binder. The following are common concrete materials:

- Cement
- Water
- Coarse aggregates / fine aggregates
- Admixtures

The proportion of the materials should maintain in a correct way, as the materials affect the final concrete product. Mainly the water cement ratio should be considered carefully. When the water cement ratio increases, the strength of the final product will be decreased. Concrete is prepared with the consideration of time and placement area. If good -quality concrete is to be produced, then not only must the constituents of the mix be up to standard, but also the equipment used in mixing, transporting, placing and compacting must be suitable for the task. The general properties of concrete mostly coincide with the properties of rock. Concrete is the main component of construction material as it resists compression, flexible to get multiple shapes and reinforced concrete is resistant to the tensile stress too.

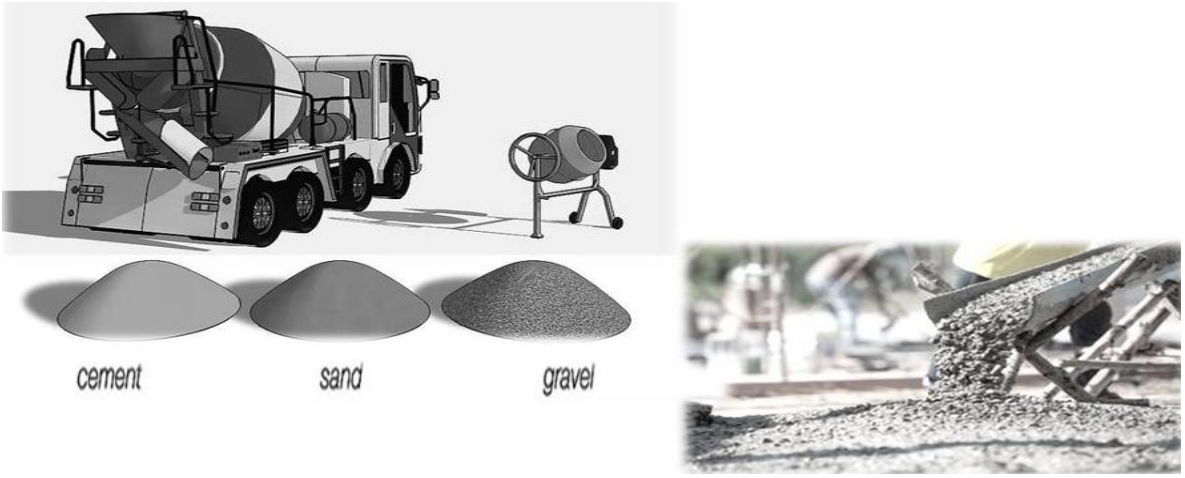


Figure 3: Concrete materials

Self-Check -1	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided:

1. One of the following concrete mixing materials is used as a binding element. (2 pts)
   A. Water
   B. Cement
   C. Aggregate
   D. Sand

2. Which type of concrete added for enhancing the tensile strength of concrete? (2 pts)
   A. Lime Concrete
   B. Cement Concrete
   C. Reinforced Cement Concretes
   D. Masonry concrete

3. The type of concrete strength which resists compression (being pushed together) is: (2 pts)
   A. Shear strength
   B. Compressive strength
   C. Tensile strength
   D. Flexural strength

4. The property of concrete to withstand the condition for which it has been designed, without deterioration over a period of years is: (2 pts)
   A. Workability
   B. Durability
   C. Elastic Properties
   D. Impermeability
   E. Strength

5. Which activity should be done at quality control before concreting stage? (2 pts)
   A. Control test on concrete ingredients
   B. Supervise batching, mixing, transporting

C. Compression tests

D. Checking hardness of concrete

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1._____

2. _____

3. _____

4. _____

5. _____

Information Sheet-2	Obtaining Concrete Work Safety Requirements

2.1. Identifying hazards and risks

Concrete is a common building material that can be used in a variety of ways. It's generally made by combining cement, sand, aggregate (small stones) and water. When these materials are mixed in the correct amounts and if they're further strengthened by adding re-bar, fiberglass strands or plastic rods, the concrete can be used to build roads, bridges, buildings, septic tanks, floors, concrete blocks, and even countertops for homes. However, anyone who uses or works around concrete and cement should understand the potential health hazards and follow safe handling procedures to prevent harmful exposures.

There are some applications of concrete that necessitate the addition of other materials that could adversely affect health if improperly handled. Additions may include alkaline compounds (such as lime) that are corrosive to human tissue, small amounts of crystalline silica that are abrasive to skin and causes damage to lungs or small amounts of chromium that can cause allergic reactions. The risk of illness or injury from these additions in the concrete depends on the level and length of exposure and the sensitivity of the individual.
Adverse health effects from concrete or cement are generally the result of exposure through skin contact, eye contact or inhalation.

- **Skin Contact –** getting cement dust or wet concrete on your skin can cause burns, rashes, and skin irritations. Sometimes workers become allergic if they've had skin contact with cement over a long period of time.
- **Eye Contact –** getting concrete or cement dust in your eyes may cause immediate or delayed irritation of the eyes. Depending upon how much and for how long you get the dust in your eyes, effects to your eyes can range from redness to painful chemical burns.
- **Inhalation –** inhaling cement dust may occur when workers use empty bags of cement to make concrete. When sanding, grinding, cutting, drilling or breaking up concrete, the dust generated has the same hazards as the dust from cement. Exposure to cement or concrete dust can cause nose and throat irritation. Long term

exposure to concrete dust containing crystalline silica can lead to a disabling lung disease called silicosis.

There are ways to prevent or control negative health effects when working with concrete and cement. First of all, dress for protection. Wear alkali resistant gloves, long sleeves and pants to reduce skin exposure to concrete or cement dust, and waterproof boots that are taller than the concrete is deep. Wear safety glasses with side shields to protect the eyes or if it's very dusty, goggles. Don't wear contact lenses. When dust can't be avoided, wear employer-approved respiratory protection. And remember to wash your hands and face before eating, drinking, smoking or using the toilet at the end of the day.

Secondly, follow all safe work practices and procedures. Work in ways that minimize the release of cement dust. Stay out of dusty areas, when possible. Mix dry cement in well-ventilated areas. Wet down the work to keep dust out of the air and use wet cut rather than dry cut masonry products. If it's necessary to kneel on fresh concrete, use a dry board or waterproof kneepads. Finally, if wet or dry concrete gets on your skin, wash it off as soon as possible.

The above evaluations and/or recommendations are for general guidance only and should not be relied upon for legal compliance purposes. They are based solely on the information provided to us and relate only to those conditions specifically discussed. We do not make any warranty, expressed or implied, that your workplace is safe or healthful or that it complies with all laws, regulations or standards.

2.2. Understanding site safety plan

A Safety Plan is a written document that describes the process for identifying the physical and health hazards that could harm workers, procedures to prevent accidents, and steps to take when accidents occur. Written safety plans can be comprehensive, such as an injury and illness prevention program, or they can be specific to a particular activity, hazard, or piece of equipment. The written safety plan is your blueprint for keeping workers safe. Many organizations compile their activity-specific safety plans into a single safety manual.Many organizations adopt voluntary safety plans to prevent injuries and illnesses, increase worker productivity, prepare for special emergencies, and enhance workplace security.

OSHA Mandatory Written Plans Elements

Written Safety plan include the following basic elements:

- Policy or goals statement
- List of responsible persons
- Hazard identification
- Hazard controls and safe practices
- Emergency and accident response
- Employee training and communication
- Recordkeeping

2.3. Following safe operating procedures

- **Housekeeping:**
  - ✓ Empty the mixer drum of all contents.
  - ✓ While still wet, wash out with clean water.
  - ✓ Allow the mixer to revolve to wash the interior and carefully clean off the exterior.
  - ✓ Disconnect the electrical AC power source.
  - ✓ Clean up the work area.
  - ✓ Return the mixer to a secured storage area.

Table 1: Safety Rules

DO NOT use this machine unless a teacher has instructed you in its safe use and operation and has given permission	
 Safety glasses must be worn at all times in work areas.	 Appropriate hearing protection (*Class 5-* SLC_{80}*>26 dB*) must be worn.
 Appropriate protective footwear with substantial uppers must be worn.	 Wear close fitting protective clothing, overalls, leather gloves, etc.
 Rings and jewellery must not be worn.	 A mask *should* be worn when excessive airborne dusts or fumes are created.

2.4 Understanding organizational policies and procedures

A health and safety policy set out how health and safety is managed within an organization and demonstrates a commitment to the health and safety of staff and others. All employers

have a duty of care to protect their employees and others from harm arising from work activities.

Employers must comply with occupational safety and health standards established by federal and state laws. State laws require all employers to provide a safe place of employment, reasonably free from danger to life or health and to maintain a written Injury and Illness Prevention Program (IIPP).

2.4.1 Plan: Identify hazards, assess risks, and select control measures

Work has the potential to harm a person's health, and a person's health can affect safety at work. Identify hazards which could injure or harm anyone during any stage of precast concrete work. Risks need to be controlled effectively even though harm may not be evident for months or years.

Identify hazards, risks and the related control measures before work begins so that the control measures are ready to put in place when needed.
Look at the following areas when considering the effects of work on people's health:

- physical hazards (eg noise, vibration)
- biological hazards (eg bacteria, viruses)
- chemical hazards (eg adhesives)
- ergonomic hazards (eg manual handling)
- Psychosocial hazards (eg bullying, tight deadlines, other stress factors).

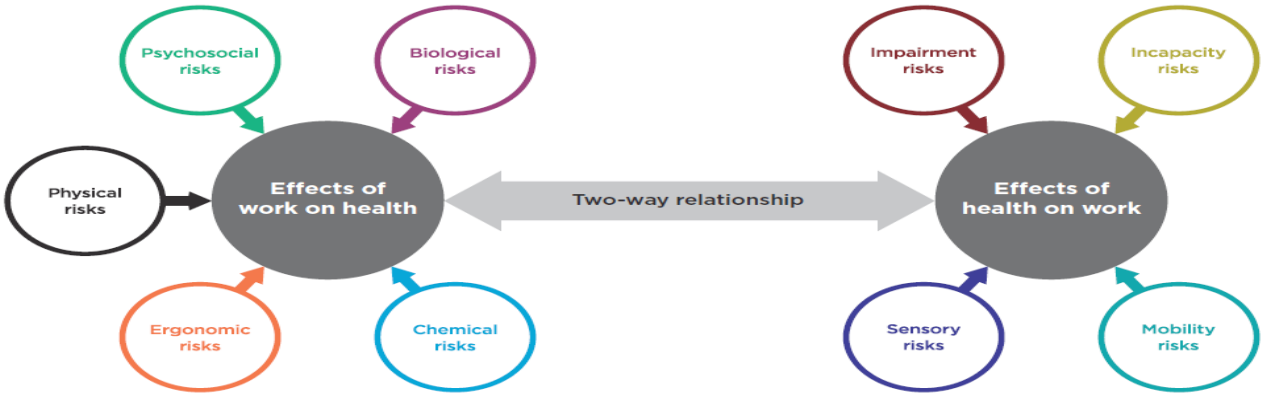


Figure 4: Examples of work-related health risks and health-related safety risks

Consider all hazards on the site, including places where people could fall, hazardous materials and hazards associated with underground and overhead services (eg gas, water,

storm water, sewerage, telecommunications, electricity). Other hazards associated with precast concrete work are shown in the *What could go wrong?* tables throughout these guidelines. There may be hazards at your workplace that are not identified in these tables. You will still need to identify and assess health and safety risks arising from your own work.
Know and understand the hazards and risks associated with manufacturing and construction work in general, for example:

- **Noise:** many manufacturing and construction tasks, tools and equipment produce high noise levels, which can lead to hearing damage.
- **Vibration:** repeated vibrations from hand and power tools can cause permanent injuries to blood vessels, nerves and joints.
- **Silica dust:** silica is found on construction sites in materials such as concrete, bricks, rocks, stone, sand and clay. Dust containing silica is created when these materials are cut, ground, drilled or otherwise disturbed. Exposure to respirable crystalline silica can cause serious lung disease.
- **Fatigue:** fatigue is a state of physical and/or mental exhaustion (extreme tiredness) which reduces a person's ability to stay alert and work safely. Workers must take reasonable care of their own health and safety. Fatigued workers may make mistakes that lead to work incidents and injuries. Everyone should learn to recognize the signs and symptoms of fatigue.

Hazard identification methods

Methods to identify hazards include:

- Workplace inspections – could someone be injured by precast concrete activities, or could your work create hazards for others on-site?
- looking at guidance, standards and industry resources
- studying records of incidents, accidents and near misses at your own and other workplaces
- reading instruction manuals and chemical safety data sheets
- asking qualified professionals (eg engineers, occupational hygienists) to assist
- looking at:
    - ✓ Your work processes (eg what harmful substances do you use or generate?)
    - ✓ The workplace itself (eg ground conditions, underground services)
    - ✓ Worker behavior, including how equipment is used.

The organization must assess and manage work risks, taking the views of workers and their representatives into account. Decide which work risks need to be dealt with first and choose effective control measures to manage them.

It is good practice to keep written records of how work risks are being managed. When reviewing your risks, look at these records. You can also refer to the records when training workers about risks and control measures.

2.4.2 Do: Put control measures in place

Put the most effective control measures in place. If the risk is not specified in regulations, the organization decides how to manage the risk. Organization should:

- find out if there are widely used control measures (eg industry standards) for particular risks, and
- check whether these control measures will effectively manage their risks.

Risk control measures in the work place are:

- **Elimination:** Elimination is the most effective control measure. First the PCBU should always try to eliminate a risk by removing the source of harm, if this is reasonably practicable. For example, by removing faulty lifting equipment or a broken A-frame.
- **Minimization:** If elimination is not reasonably practicable, the PCBU minimizes the risk so far as is reasonably practicable. One or a combination of the following approaches can be used:
- **Substitution:** Use an alternative design, product, or work practice that decreases the risk. For example:
  - ✓ with the crane controller, consider using a different crane
  - ✓ use a different product.
- **Isolation:** Isolation prevents contact with or exposure to the hazard. For example:
  - ✓ stand (erect) precast concrete panels on a day when the only workers on the site are the team doing the erection.
- **Engineering control measures:** Use physical control measures that include mechanical devices or processes. For example:
  - ✓ build panels of a different size or shape
  - ✓ change the propping design to reduce the risk.

- **Administrative control measures:** Use safe methods of work, processes or procedures designed to minimize risk. For example:
  - ✓ complete a lift plan
  - ✓ develop a policy for dealing with fatigue.
- **Personal Protective Equipment (PPE):** Wear PPE appropriate for the task to reduce exposure to, or contact with, the hazard. For example:
  - ✓ wear hearing protection for work in noisy areas
  - ✓ wear safety helmets in any area where workers could be hit or struck by falling objects.

PPE is the least effective type of control measure. It should not be the first or only control measure considered.

As soon as possible after deciding what the most effective control measures are:

- put the control measures in place
- make sure that workers know:
  - ✓ the potential risks
  - ✓ the control measures to manage the risks
  - ✓ why it's important to use the control measures, and
  - ✓ how to apply them
- review and update emergency procedures/plans if needed.

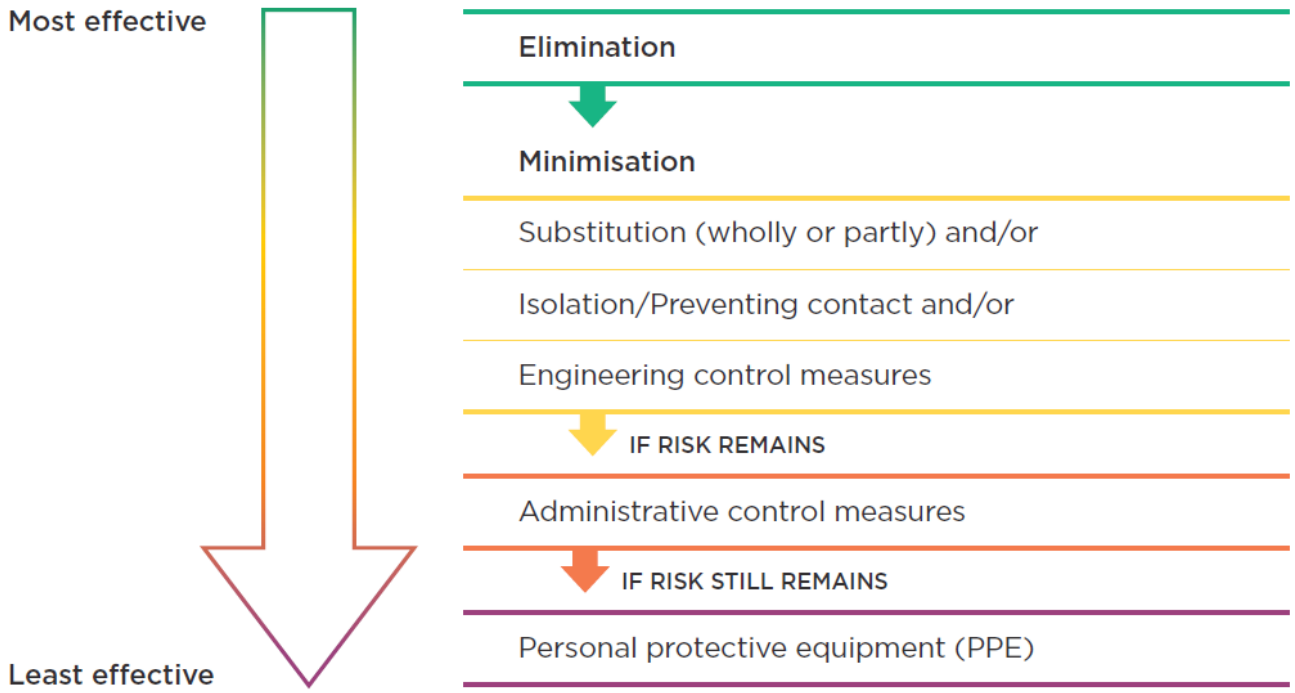


Figure 5: The hierarchy of controls or ranks of control measures from most to least effective

2.4.3 Check: Monitor performance of control measures

Control measures should remain effective, be fit for purpose, be suitable for the nature and duration of the work, and be used correctly by workers. Monitor the performance of control measures to confirm their effectiveness. Encourage appropriate reporting. Make it easy for workers to report incidents, near misses, or health and safety concerns. This is likely to involve engaging often with workers and their representatives to check if the control measures are eliminating/minimizing work risks. All policies, processes and systems should have a scheduled date for a review/audit process to check that they're being followed and are still fit for purpose.

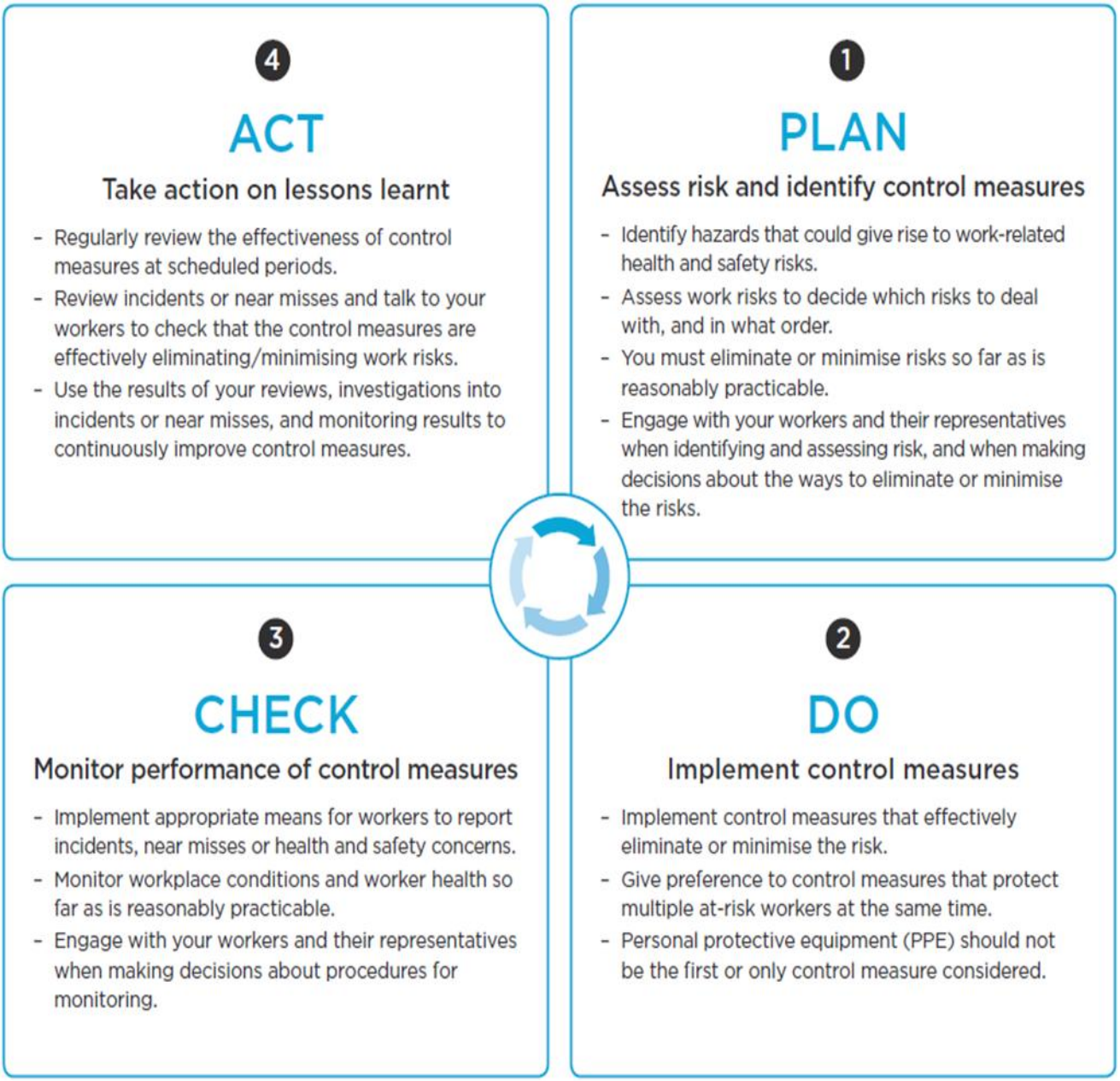


Figure 6: Activities to manage risks in the work place

Self-Check -2	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided:

1. One of the following hazards is occurred by concrete. (3 pts)
   A. Irritation of the eyes
   B. Nose and throat irritation
   C. Skin can cause burns, rashes
   D. All

2. Which one of the following is **not** included in written safety plan? (3 pts)
   A. Hazard identification
   B. Hazard controls and safe practices
   C. Workplace inspections
   D. Policy or goals statement

3. The most effective risk control measure is: (3 pts)
   A. Substitution
   B. Elimination
   C. Minimization
   D. Personal Protective Equipment (PPE)

4. One of the following is pre-operational safety check for concrete mixer: (3 pts)
   A. Never leave the mixer running unattended
   B. Confirm the mixer has a current electrical safety tag
   C. Return the mixer to a secured storage area
   D. Never insert your hands into a rotating mixer bowl

Note: **Satisfactory rating - 6 points** **Unsatisfactory - below 6 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answers

1. _____
2. _____
3. _____
4. _____

Information Sheet-3	Identifying Signage Requirements

3.1 Safety signage requirements

Safety signs are erected to warn workers or the public of specific hazards and to communicate necessary precautionary measures and emergency actions. Safety signage is required for:

- construction sites;
- confined spaces;
- asbestos;
- hazardous areas;
- hazardous chemicals;
- site specific Personal Protective Equipment (PPE) requirements;
- fire protection equipment;
- emergency and first aid information;
- emergency eyewash shower; and
- traffic management and pedestrian control.

3.1.1 Signage classification and use

Safety signages are classified and shall be used according to their function as follows:

Type	Use	Example
1. **Regulatory Signs** – Signs containing instructions that if ignored could either be an offence at law, or a breach of site safety rules, safety procedures or other directions.		
Principal contractor construction site signage	Any principal contractor for a construction project must be identified with signage. At a minimum, the sign must: • Identify the principal contractor's name and telephone contact numbers (including an after hours telephone number); • Identify the location of the site office for the project, if any; and • Be clearly visible from outside the workplace, or the work area of the workplace, where the construction project is being undertaken.	

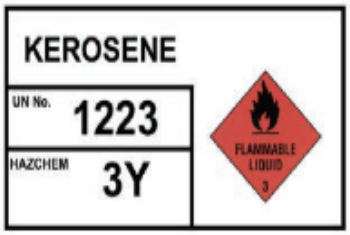
Type	Use	Example
Mandatory Signs	Signs that specify that an instruction MUST be carried out. Symbols (or pictograms) are white on a blue circular background and indicate the minimum standard of compliance required for the workplace where it is displayed. The sign's wording is in black lettering on the white background. Multiple symbols may be on the sign.	 

Prohibition Signs	Signs that specify behaviour or actions, which are not permitted. The round shape with a slash should be depicted in red over the action symbol in black. The sign's wording is in black lettering on the white background.	
Limitation or Restriction Signs	Signs that place a numerical or other defined limit on an activity. The most common signs are speed restriction signs. The signs have a symbolic Red circle shape with black writing or symbol on it and may also be on the roadway surface.	

2. Hazard Signs – Signs advising of hazards.		
Danger Signs	Signs warning of a particular hazard or hazardous condition that is likely to be life-threatening. (The word 'DANGER' shall be in white featured inside a red ellipse inside black rectangle. The sign's wording shall be in black lettering on the white background.)	
Warning Signs	Signs warning of a hazard or hazardous condition that is **not** likely to be life-threatening. (The hazard symbol shall be black on a yellow background and a triangle should be depicted around the hazard symbol. The sign's wording shall be in black lettering on the yellow background.)	

Type	Use	Example

3. Emergency Information Signs		
Muster Point, First Aid Locations, etc	Signs indicating the location of, or directions to, emergency related facilities such as exits, safety equipment or first aid facilities. (They feature a white symbol and/or wording on a green background.)	 
4. Fire Signs		
Fire-fighting Equipment Locations, etc	Signs advising the location of the alarms and fire-fighting facilities. (Fire signs shall comprise a red rectangle with white symbol and/or wording.)	 

5. Hazardous Chemicals Placards		
Placards	Placards alert the emergency services and other persons to the presence of hazardous chemicals and provide information about them.	 
6. General Information Signs		
Other signs not contained within the categories listed above	These signs are used to communicate information of a general nature (e.g. housekeeping)	

3.1.2 Installation and maintenance of signage

Signs other than those painted directly on existing surfaces, shall be constructed and erected so that they do not create a hazard (e.g. signs projecting into passageways at such heights those persons, vehicles or mobile plant may strike them). All signs should be removed immediately if the information they contain is no longer relevant.

This is especially important for signs warning of temporary hazards. When erecting signage, the following shall be considered:

- **Visibility –** Signs should be located so the message is legible, they attract attention and are clearly visible.
- **Placement of signs –** Signs should be mounted as close as practicable to the observer's line of sight in the vertical plane.
- **Regulatory and hazard signs –** These should be so sited in relation to a particular hazard as to allow a person ample time after first viewing the sign to avoid the hazard. The distance will vary, e.g. signs warning against the touching of switches or other electrical equipment should be placed close to the equipment, whereas signs used in plant yards or on construction work should be placed sufficiently in advance of the hazard to permit the warning to be perceived before the hazard is reached.
- **Signs on moveable objects –** Signs should not be placed on moveable objects such as doors, windows or racks where a change in position would void the purpose of the sign or cause it to be out of sight. This does not apply to signs intended to be portable or moveable.
- **Illumination of signs –** External or internal illumination of signs should be considered where the general lighting, either natural or artificial, does not provide for adequate visibility of signs. Glare from lighting should be avoided.
- **Number of signs –** Care should be taken when considering the placement of several signs close together. The result may be that there is so much information in one place that little or none is absorbed, or the visual effect may be so confusing as to make it difficult to distinguish individual messages.

3.1.3. Accident prevention tags

An accident prevention tag is a miniature sign on card, paper, pasteboard or similar temporary or semi-permanent material, which can be attached to plant, equipment or other objects for the purpose of imposing a regulatory requirement, or for advising or informing users about some safety aspect of the item.

Figure 7: Example of tags

Self-Check -3	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided:

1. Signs that specify an instruction must carried out is: (2 pts)
   B. Danger signs
   C. Mandatory signs
   D. Warning signs
   E. Prohibition signs

2. Which one of the following is true about safety signs? (2 pts)
   A. Mounted as close as to the observer's line of sight
   B. They attract attention and clearly visible
   C. Should be sited in relation to a particular hazard
   D. Should be placed on moveable objects

3. A miniature sign on card, paper, pasteboard which can be attached to plant and equipment for the purpose of imposing a regulatory requirement is: (2 pts)
   A. Accident prevention tag
   B. Prohibition sign
   C. Mandatory signs
   D. Warning signs

4. A miniature sign on card, paper, pasteboard which can be attached to plant and equipment for the purpose of imposing a regulatory requirement is: (2 pts)
   A. Accident prevention tag
   B. Prohibition sign
   C. Mandatory signs
   D. Warning signs

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answers

1._____

2. _____

3. _____

4. _____

Information Sheet-4	Selecting And Using Concrete Work Plant, Tools and Equipment

4. 1 Tools and equipment for concrete work

There different tools and equipment for concrete work:

Screed

A screed is used to help smooth out your concrete once you have put it where it needs to be. This tool is going to be really helpful when you need to get rid of excess concrete from the surface. It is really easy to use, and you won't need to be a professional to handle this tool properly. Just scrape it across the surface, and use it to get the concrete as smooth as it can possibly be.

Figure 8: Concrete screening

Come-Along Rake

You need to be able to move the concrete that you have poured around. In order to get the concrete where it needs to be, you will have to use a tool to push it around a bit. You could use a normal rake for this purpose, but using a come-along rake would work even better. These rakes have been specially designed for the purpose of moving concrete around.

When you take a look at these rakes, you will see that they have a scooped blade. This makes them really good at doing pre-leveling work on fresh concrete. If you are

going to be pouring concrete, then it will be a good idea to seek out one of these rakes. You may have to look around to find one, but if you can get your hands on one, it will definitely make your concrete job a lot simpler.

Figure 9: Come-along rake

Circular Saws

You will find that people use circular saws pretty often on construction sites where concrete or cement work is being done. The reason for this is that it is sometimes necessary to cut into slabs and remove certain things. Certain aspects of the job can go wrong, and you may need to make some cuts to remedy a problem. Having access to a good saw that is going to be able to make the cuts quickly is imperative. Circular saws work perfectly for this. They are easy to use and can cut through anything that you need them to rather quickly.

Figure 10: Circular saws

Shovels

Shovels are obviously one of the most common types of tools that exist. You will be able to make use of a good shovel in many different ways. When it comes to helping with concrete and cement jobs, these shovels are going to be used to help move the concrete around. You may need to fill in small gaps that exist after the concrete has been poured, and you're going to need a good shovel to accomplish this.

Finding a shovel won't prove to be a problem. Buy a shovel that is very sturdy, and everything should work out quite nicely. You will be able to get the concrete or cement where it needs to go, and the job will be that much closer to completion. Just be sure to have enough shovels for all of your helpers as well.

Figure 11: Shovels

Compactor

The compactor isn't something that will immediately come to mind when you are thinking of tools for concrete and cement jobs. These compactors are used to prepare the ground where the concrete is going to go. Sometimes it is necessary for the stone or aggregate on the surface to be compacted into a proper position. This compactor will work well for those purposes and is going to come in handy.

This is a pretty expensive machine, but it can be worth your while to purchase one. If you need to make sure that the aggregate or stone on the ground is settled into place properly, then buying a good compactor makes sense. It is possible that you may not need one of these, too. Everything really depends on your specific situation, so take everything into account before deciding if you need to make a purchase.

Figure 12: Compactor

Wheelbarrows

It makes sense that wheelbarrows would be necessary when working with concrete and cement. You need to have a reliable way to move your materials back and forth on the job site. Whether you are an amateur who is trying to install a patio, or if you are a professional who is working a large-scale job, you will want to have a wheelbarrow. They are going to make everything a whole lot easier for you, and it won't cost you a lot of money to get a nice one.

You may want to purchase several wheelbarrows if you are planning on doing a large cement or concrete job. It can be convenient for you to have something to hold your materials when they aren't in use, and one wheelbarrow may simply not be enough. You should also do your best to buy a heavy-duty wheelbarrow. Purchasing something that is going to be able to handle a heavy workload is highly recommended.

Figure 13: Wheelbarrows

Mixers

Mixing concrete and cement is one of the most important aspects of this job. If you can't mix things properly, then you aren't going to be getting very far with your job. The mixer being shown off here is a very nice cement mixer that can be used by both professionals and amateurs alike. You will be able to mix concrete very effectively using this tool and will love how good it works.

This may seem like an expensive tool to some, but when you consider the utility of the cement mixer, it is actually very cost-effective. You will be able to make use of this cement mixer in order to complete many home projects. If you are a do-it-yourself enthusiast who wants to install a patio, then this is going to be the perfect mixer to help you accomplish that. It is a high-quality mixer that will do a great job for you.

Figure 14: Mixer

Bull Float

People typically use the bull float after the screed work has been completed. You will make use of this bull float to fill in any empty spaces that have been left in the concrete after using the screed. This shouldn't be a difficult process, but it is definitely an important one. Most bull floats have wide blades and long handles, so you'll be able to reach wherever you need to without too many issues.

You can also find some bull floats on the market that have telescopic handles. This can be really convenient because they will be able to be moved around at different angles. If you are worried about being able to reach certain positions with your bull float comfortably, then it might be worthwhile to purchase one with a telescopic handle. Otherwise, a normal bull float should do the job superbly.

Figure 15: Bull float

Magnesium Float

The magnesium float will wind up being among the first tools that you use when working with concrete. This float will be able to level things out when the concrete is wet. Some people make use of excess boards to level out the wet concrete. This isn't going to be nearly as effective as using a proper magnesium float, so you will want to have the tool available to use.

If you want your concrete to look good, then you need to level it out during different steps of the process. Getting your wet concrete leveled is essential, so you will want to use the magnesium float to its full potential. These tools will be crucial to have when you want to have your concrete project turn out properly. Take the time to purchase one so that you can have good results.

Figure 16: Magnesium Float

Finishing Trowel

The finishing trowel is one of the most iconic concrete tools that you can think of. People often think of a finishing trowel right away when concrete tools are brought up. This trowel is very useful for helping you to finish up your concrete project. It will allow you to have a smooth finish on your concrete area.

All you need to do is run the finishing trowel across the concrete surface. It is simple in concept and is very effective at what it does. Using this trowel is going to bring

some of the water to the surface of the concrete. You will keep smoothing things out, and it will be set up nicely to harden.

Figure 17: Finishing Trowel

Concrete Edger

Concrete edging tools are used right when the concrete is starting to harden up. You will run this edger across the concrete and away from the boards that you have set up. This is an important part of the process, and you will want to pay attention to the concrete itself to determine exactly when it begins to harden. In order to finish the concrete properly, you will need to use this edger well.

Thankfully, this is a really easy process overall. It may feel a bit tedious to run the concrete edger across the concrete, but the results are going to be worth your efforts. You will be able to help ensure that the concrete will be finished properly by doing this. Concrete edging tools are very affordable, so you will want to be sure to purchase them before you start your concrete project.

Figure 18: Concrete Edger

Concrete Control Joint Hand Groover

You will notice that concrete will crack sometimes when you are working with it. To keep this from happening, you will need to grab your concrete control joint hand groover to take care of the problem. The process of making use of this tool involves using 2x4s. You need to run the tool across the edge of the board and smooth out the surface of the concrete.

This will help to keep the concrete from cracking on you. Generally, if the concrete does crack, you will be forcing it to crack around the joint rather than somewhere in the middle. This will keep your concrete looking as nice as it can. You need to be diligent when you are working with concrete and keep things smooth in order to get the best results.

Figure 19: Concrete Control Joint Hand Groover

Pressure Washer

Pressure washers come in handy for so many different things around the house. Even professionals make use of these pressure washers to help them with certain parts of the process. You will want to bring out your pressure washer in order to clean up concrete surfaces before they are resurfaced. Resurfacing jobs are a big part of the concrete business, so you will want to be able to clean off the old concrete effectively.

A powerful pressure washer is going to be capable of getting rid of all sorts of debris that is on the top layer of the old concrete. It will pretty much completely remove the top layer of the concrete. This will ensure that everything is completely ready for the resurfacing process to begin. You won't want to neglect cleaning the old concrete thoroughly because you want the resurfacing to look as good as it possibly can.

Buying a pressure washer for these purposes shouldn't be too difficult, but you will want to make sure that you're buying a powerful one. Purchasing one of the gas-powered pressure washers is generally going to give you better results than the electric options. Gas-powered units are far more powerful than the electric ones, and you will be able to clean the concrete surface much more swiftly. You should be able to find a good deal on a nice gas-powered pressure washer, so you won't have to fret over the price too much.

Figure 20: Pressure Washer

Concrete Finishing Broom

These concrete finishing brooms are a very important tool to have around. Using this broom is going to help to provide texture to the concrete. You do this by running the broom up and down the surface of the concrete. This will help your concrete to become more skid-resistant while also giving it the proper look.

The bristles of this broom are made out of horsehair, and this is a very fine product. You won't want to use just any old broom for this purpose. You should definitely seek out a specific concrete finishing broom. Working with concrete is something that takes a lot of time, so you don't want to waste all of that hard work by doing things improperly when you're right at the finish line.

Finding one of these brooms shouldn't be too tough. You will be able to purchase them at major hardware stores and can always order one online if you need to. They will be a bit more expensive than a traditional broom, but it is going to be a worthwhile purchase. Make good use of it to finish your concrete, and you will be able to enjoy the results soon enough.

Figure 21: Concrete Finishing Broom

Concrete Polishers/Grinders

Once your concrete has dried, and it is properly set up, you may want to look into making it look a bit nicer. It is possible to use a polisher or a grinder to increase the

overall aesthetic appeal of your concrete. This will make the concrete look like it is finished and completely smooth. Concrete that has been properly polished will generally shine quite nicely.

If you use the grinder, then you will be able to create an effect that looks a bit different. The finish will be more distressed and some people find this to be even more appealing. The tool being shown off here is both a polisher and a grinder, so you will be able to use it for whatever purpose you would like. This is going to allow your concrete to look its best, and you will be able to sit back and admire your work once it's done.

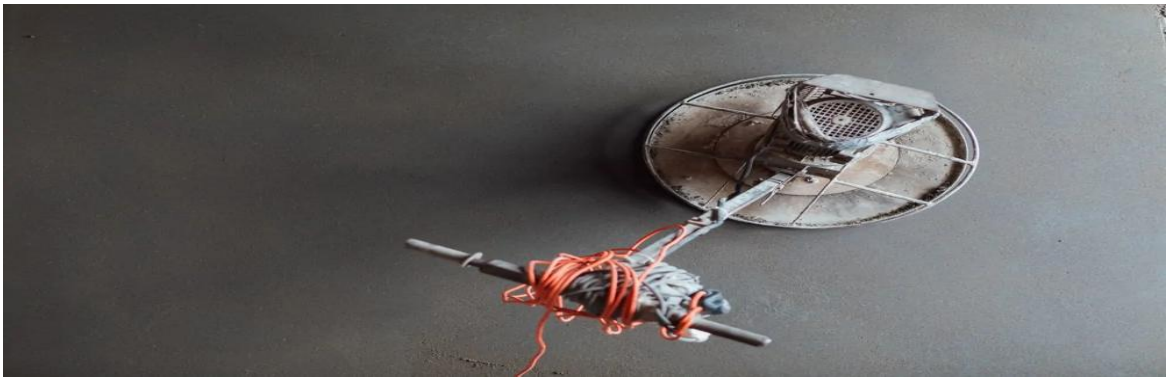


Figure 22: Concrete Polishers/Grinders

Concrete Vibrators

Concrete vibrators are something that will work very well to strengthen your concrete. They can help you to get rid of excess water and any pockets of air that will cause problems for the concrete. These concrete vibrators are fairly pricey, so it isn't going to be an easy tool for you to purchase. Regardless, the benefits of using one are great, and it is something that you will want to consider.

Making use of a concrete vibrator is something that could help you avoid potentially big problems with the concrete itself. The unit being shown here is very lightweight, and you will be able to make use of it with ease. It has many convenient safety features that will prevent overloading, and you can rely on it to do its job well. If you want to look into strengthening your concrete, then this is going to be a good option to consider.

Figure 23: Concrete Vibrators

Work Gloves

Work gloves are going to be part of your daily routine while you are working on a concrete or cement job. You need to keep your hands from coming into contact with either the concrete or the cement. This stuff is really nasty when it gets on your skin, and you want to avoid it whenever possible. A good set of work gloves won't restrict your dexterity, but it will keep you safe.

You don't need to spend an exorbitant sum of money to get a good set of work gloves, either. Buying these work gloves will help to keep you from getting burned by the caustic concrete mixes. You won't get nearly as many blisters when you're using a good set of gloves, either. Buy some today to make your work experience a lot more comfortable.

Figure 24: Work Gloves

Rubber Boots

Rubber boots are absolutely essential for anyone who is planning on working with concrete or cement mixing. This is a process that can get quite messy, and you need to be able to protect yourself. Wearing a good pair of rubber boots will help to keep the cement or concrete from making contact with your skin. You don't want to ruin a pair of normal boots, so buying rubber boots that are waterproof and meant for these purposes is highly recommended.

A good pair of these boots may cost you a little bit of money, but it is going to be worthwhile. This will allow your feet to stay dry and your workday is going to be significantly more comfortable. Buying the stuff that you need for the job is going to make things go better. Get yourself some good rubber boots to make sure that you have a good experience.

Figure 25: Rubber Boots

Laser Level

This may not be the first thing that you think about when working with concrete and cement, but buying a laser level is hugely important. You need to be sure that your concrete is being poured onto a level surface. For this reason, it is crucial that you use a laser level to determine if everything is level and whether the elevation is correct. Using a laser level is best because these are highly accurate and will give you all of the necessary information.

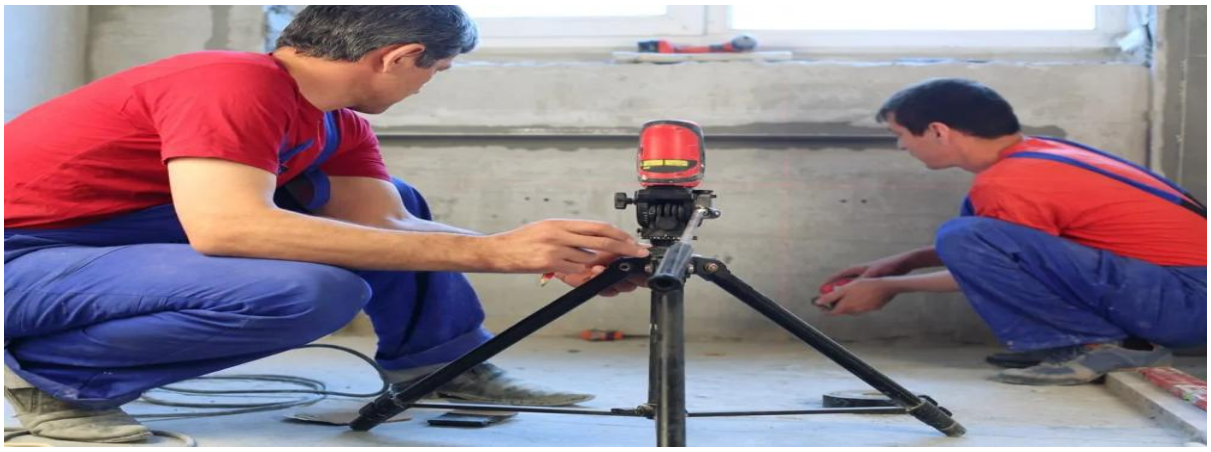


Figure 26: Laser Level

Self-Check -3	Written Test

Directions: Much concrete tools and equipment at column B with their function at column A. Use the spaces provided. (2 pts each)

A	B
____1. Sure, that your concrete is being poured onto a level surface ____2. Keep your hands from coming into contact with concrete ____3. Prepare the ground where the concrete is going to go ____4. Mix concrete very effectively ____5. Fill in any empty spaces of concrete ____6. Level things out when the concrete is wet ____7. Smooth finish on your concrete area ____8. Provide texture to the concrete ____9. Rid of excess water and any pockets of air	A. Finishing Trowel B. Bull Float C. Concrete Edger D. Concrete Finishing Broom E. Laser Level F. Concrete Vibrators G. Mixers H. Compactor I. Screed J. Rubber Boots **K.** Work Gloves

Note: **Satisfactory rating - 9 points** **Unsatisfactory - below 9 points**

Score = _____

Rating: _____

Information Sheet-5	Maintaining concrete work plant, tools and equipment

5.1 Maintenance, servicing and cleaning

Maintenance servicing and cleaning of plant can present additional risks to personnel, for example personnel may be required to:

- work on remote-controlled plant or plant subject to automatic start-up
- by-pass or defeat interlocks or safety circuits
- test the operation of guards, remove guards or render guards ineffective
- force control device inputs or outputs
- perform adjustments or measurements in proximity to hazards (moving parts, pressure, and electricity).

All plant is to be maintained, serviced and cleaned according to the manufacturer's specifications or, in the absence of such specifications, in accordance with the Safe Work Procedures developed.

Plant is to be isolated before maintenance, service or cleaning commences. Where plant is isolated and any total or partial shutdown results this must be managed to prevent hazardous situations being created.

Where plant cannot be isolated, alternate means of preventing accidental operation are to be implemented and work conducted under controlled procedures such as a permit to work system.

Plant-specific controls relate to the risks arising from the plant or the interaction between the plant and the environment in which it is located. They may be integrated with or form part of other risk management tools. The specific controls for maintenance can be set out in:

- engineering instructions or procedures

- manufacturers' and designers' documents including handbooks, specifications, manuals and guidance material for operation and maintenance
- Safe Work Method Statements / Safe Working Instructions

5.2 Repair

Before any repairs are undertaken on plant, personnel are to make sure the plant is isolated and in a safe condition for the work to commence. Follow the basic shutdown and isolation procedure:

- **Notification –** notify all affected employees that lockout and tag out is about to occur for servicing and maintenance of plant and equipment; and in preparation for shutdown.
- **Shutdown –** this is the normal procedures used to shut down an item of plant or equipment using the operating controls. It may be pushing a stop button, opening a switch or closing a valve.
- **Isolation –** this involves the activation of energy-isolating devices that have been identified as being capable of preventing any hazard to those who will be working on the plant.
- **Application of isolation equipment –** this is where we physically apply the isolating devices locks and tags that have previously been discussed. This is called 'securing the point of control'. The point of control or part at which energy isolating, blocking or dissipating devices are controlled. It is necessary to ensure that the isolation and lockout devices are only applied by the authorized person(s) doing the work. The point of attachment ensures that the energy control devices will safely and securely remain in the OFF or SAFE position. Tags must be positioned so that they can be clearly read.

Personal Danger Tags are used to control risks arising from situations where equipment is undergoing maintenance, is under repair or is being constructed or tested. The purpose of which is to ensure equipment is not operated in order to prevent injury to those working on or operating the equipment and to also prevent damage to the equipment.

Out of Service Tags are placed on plant and equipment that is out of service for repair, alteration, commissioning or decommissioning. Tags can be purchased from any industrial or equipment safety provider. Those persons attaching a tag must include their name, contact telephone number, date and reason for attaching the tag. Only the person authorized to carry out the repairs or the Facility Manager may remove the Out or Service Tag when it has been determined that the equipment is safe to operate.

Release of stored energy – once isolation of the main energy source has occurred, and it has been physically locked and tagged out at the point of control, it then becomes necessary to make sure there are no hidden dangers. It is important to relieve, disconnect or restrain any and all of the potential, stored or residual energy. This may include, for example, completing the cycle of a flywheel, releasing steam and bleeding valves.

Repairs are to be undertaken by a competent person only, and are to be carried out:

- according to the manufacturer's instructions and documented procedures
- in accordance with relevant Standards.

5.3 Modification

Modifications of plant may result in the modifier assuming the obligations of a designer or manufacturer. In the case of plant that requires design registration any modifications may require a new plant design registration certificate to be issued by Work Cover.

Modifications that require a change in design registration include all those that affect the safety of the plant, including for instance changes such as:

- alteration of running speed (e.g. of lifts, conveyor belts, etc)
- changes that affect the stability, reach, capacity, working load limit, etc
- changes to drive systems
- relocation of fixed plant to new premises (e.g. major plant machinery).

Where Supervisors/Line Managers are unsure about whether modifications affect the registration of an item of plant they are to contact the supplier of the plant to confirm, or liaise with a qualified engineer.

Before undertaking modifications, the modifier is to consult with the designer, manufacturer or relevant design authority to make sure that all safety issues have been considered. If the original designer and manufacturer cannot be contacted the modifications are to be designed and fitted by a competent person.

A person modifying the design of plant fulfills the roles of the designer of plant, under the WHS Act and WHS Regulation. This requires a risk assessment to identify hazards with the altered design.

Modification to plant is to be carried out:

- as recommended by the manufacturer or in other documented procedures
- in accordance with relevant Standards.

Before being returned to service after maintenance, service, cleaning, repair or modification plant is to:

- have control measures in place to prevent or reduce risks
- be inspected and tested having regard to the modified design specifications and relevant Standards
- be resubmitted for design registration (where applicable).

Self-Check -3	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided:

1. The specific controls for maintenance concrete equipment can be set out: (3 pts)
   A. Safe Working Instructions
   B. Manufacturers' and designers' documents
   C. Engineering instructions or procedures
   D. All

2. Which procedure should be done first to repair concrete equipment? (3 pts)
   A. Isolation
   B. Notification
   C. Shutdown
   D. Application of isolation equipment

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answers

1.

2.

Information Sheet-6	Identifying environmental protection requirements

6.1 Understanding organizational/project environmental management plan

The Environmental Management Plan (EMP) provides performance-based environmental requirements to be met by the contractor in conducting the work in accordance with the specifications. The EMP provides the basis for preparation of site-specific Environmental Protection Plans (EPPs) to be prepared by the Contractor.

6.2 Waste management

Concrete waste at construction sites comes in two forms: 1) excess fresh concrete mix, including residual mix washed from trucks and equipment, and 2) concrete dust and concrete debris resulting from demolition. Both forms have the potential to impact water quality through storm water runoff contacts with the waste. The objective of concrete waste management is to dispose of these wastes in a manner that protects surface and ground water.

Concrete waste management is used to prevent the discharge of concrete wash water and waste into storm water runoff. A number of water quality parameters can be affected by the introduction of concrete, especially fresh concrete. Concrete affects the pH of runoff, causing significant chemical changes in water bodies and harming aquatic life. Suspended solids in the form of both cement and aggregated dust are also generated from both fresh and demolished concrete waste.

Concrete waste management is applicable to all construction sites where existing concrete is being demolished or new concrete is being placed, regardless of the size of the total area disturbed. It is also applicable on repair and maintenance projects that may not be required to implement erosion and sediment controls.

Design Criteria

- The discharge of washout water to an inlet, swale, or any portion of the storm drainage system or a natural drainage system (e.g. channel) shall be prohibited.
- Construction plan notes shall state that the discharge of concrete washout to anything except a designated containment area is prohibited.
- Show the location of the concrete washout containment on the drawings, or require the contractor to provide this information.
- The contractor should be required to designate the site superintendent, foreman, or other person who is responsible for concrete placement to also be responsible for concrete waste management.

Unacceptable waste concrete disposal practices:

- Dumping in vacant areas on the job-site.
- Illicit dumping onto off-site lots or any other placed not permitted to receive construction demolition debris.
- Dumping into ditches, drainage facilities, or natural water ways.
- Using concrete waste as fill material or bank stabilization.

6.3 Water quality protection

Cement, concrete and grouts are highly alkaline and corrosive and can cause serious pollution to the ground and watercourses. Water wildlife, such as invertebrates and fish, are very sensitive to changes in pH (acid/alkaline) levels. Whereas oil in water is easy to see, changes to pH are not, so pollution can occur for some time before the extent of damage to wildlife is noticed. Whether storing, making, mixing or using, take care with all works involving cement, concrete and grout.

You also need suitable arrangements to deal with the wash-out of concrete mixing plant, ready mix concrete lorries and tool and equipment washings to prevent pollution. Never allow washings or wastes to enter into any drain or surface waters.

Concrete and cement mixing should be:

- Sited on an impermeable designated area

- At least 10 metres away from a watercourse or surface water drain, to reduce the risk of runoff entering a watercourse.
- Surplus dry concrete, cement and grout should be used elsewhere on site if possible, or as inert rubble; if not, it will need to be disposed of off-site and transported using a registered waste carrier.
- Equipment, batching and ready-mix lorry washing and cleaning should be washed out on site into a designated area that has been designed to contain wet concrete / wash waters.
- Wherever possible, excess concrete should be sent back to the batching plant. With design concrete this may not be possible, so you should build a designated area to allow the concrete to cure without polluting the ground or watercourses.

Instruction Sheet	Learning Guide 61: Select Materials

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Determining location of steel reinforcement and formwork
- Checking reinforcement against reinforcement drawings and specifications
- Selecting formwork components
- Selecting fixing/fasteners for consistent

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Determine location of steel reinforcement and formwork from drawings and reinforcement schedule.
- Check reinforcement against reinforcement drawings and specifications
- Select formwork components consistent with job
- Select and use fixing/fasteners consistent with requirements of the

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4” in page 2, 11, 21, and 29respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3, and Self- check 4” -” in page 10, 20,28 and 33respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3 and Operation Sheet 4” in page (34, 34, 34 and 35 respectively).
6. Do the “LAP test” in page 36

Information Sheet-1	Determining Location of Steel Reinforcement and Formwork

1.1 Introduction to steel reinforcement and formwork

1.1.1. Steel reinforcement

Steel reinforcement are steel bars that are provided in combination with plain cement concrete to make it reinforced concrete. Hence these structures form steel reinforced cement concrete structure (R.C.C). Steel reinforcement is commonly called as 'rebars'.

Plain concrete is weak in tension and strong in compression. Tensile property for concrete structures is obtained by incorporating steel reinforcement. The steel reinforcement is strong in both tension and compression. The tensile property provided by the steel reinforcement will prevent and minimize concrete cracks under tension loads.

The coefficient of thermal expansion of steel reinforcement and concrete are similar in that they undergo similar expansions during temperature changes. This property will ensure that the concrete is subjected to minimal stress during temperature variations.

The surface of the steel reinforcement bars is patterned to have a proper bond with the surrounding concrete material. The two main factors that provide strength to the concrete structures are steel and concrete. The design engineer will combine both the elements and design the structural element such a way that the steel resists the induced tensile and shear force, while the concrete takes up the compressive forces.
Steel reinforcement is a reinforcing choice compared to other reinforcing materials due to its unique advantages. They are:

- **Compatibility with Concrete**: The fresh concrete is placed on the formwork mold already prepared with reinforcement. The steel reinforcement won't float in

concrete during the concrete placing procedure. Hence, steel reinforcement does not demand special tying up with formworks.

- **Robustness of Steel Reinforcement**: The steel bars are robust in nature that they have the ability to withstand the rigors, the wear and tear during the construction activities.
- **Bent Property of Steel Reinforcement**: The steel bars once manufactured to standard size; it can be bent to the required specifications. Hence fabricated steel bars are delivered easily at the site.
- **Recycling Property**: The steel reinforced left over after the service life of a structure is recycled again and used for new construction.
- **Easily Available**: Every region of a country will have a steel supplier or manufacturer. Hence steel reinforcement is easily available.

The main disadvantages of steel reinforcement are mentioned below:

- **Reactive Nature of Steel Reinforcement**: In concrete structures where the cover is small and subjected to external moisture and salt action, the reinforcement undergoes reaction and starts to corrode. These can lessen the strength of concrete and finally to failure.
- **Expensive**: The cost of steel reinforcement in high. This will increase the cost of construction
- **Melts at high temperature**: At higher temperatures, the steel reinforcement may melt. This is the reason why the steel reinforcement is tied up and not welded.

Types of steel reinforcement used in concrete structures

There are mainly 4 types of steel reinforcement used in concrete structures:

- **Hot rolled deformed bars:** This is the most common type of reinforcement for regular RCC structures. Hot rolling is done in the mills which involves giving it deformations on the surface i.e. ribs so that it can form bond with concrete. The stress - strain curve shows a distinct yield point followed by a plastic stage in which strain increases without increase in stress. This is followed by a strain hardening stage. It has typical tensile yield strength of 60,000 psi.

Figure 27: Hot rolled deformed bars

- **Mild Steel Plain bars:** These are plain bars and have no ribs on them. These are used in small projects where economy is the real concern. As plain bars cannot bind very well with concrete hence hooks have to be provided at the ends. In this type of steel too stress - strain curve shows a distinct yield point followed by a plastic stage in which strain increases without increase in stress. This is followed by a strain hardening stage. Plastic stage in Mild Steel Bars is even more pronounced than Hot Rolled Deformed Bars. Typical tensile yield strength is 40,000 psi.

Figure 27: Plain mild steel bars

- **Cold Worked Steel Reinforcement:** When hot rolled steel bar undergoes process of cold working, Cold worked reinforcement is produced. Cold working

involves twisting or drawing the bars at room temperature. This effectively eliminates the Plastic Stage in the Stress-Strain curve, although it gives more control over the size and tolerances of bars. Due to removal of plastic stage it has lower ductility than Hot Rolled bars. Its use is specific to projects where low tolerances and straightness are a major concern. The stress – strain curve does not show a distinct yield point as plastic stage is entirely eliminated. Yield point is determined by drawing a line parallel to the Tangent Modulus at 0.2% strain. Yield stress is the point where this line intersects the stress – strain curve. This is known as 0.2% proof stress. If yield stress is determined at 0.1% strain it is called 0.1% proof stress. Typical tensile yield strength is 60,000 psi.

Figure 28: Cold worked bars

- **Pre stressing Steel:** Prestressing steel is used in the form of bars or tendons which are made up of multiple strands, however, tendons / strands are more frequently used as these can be laid in various profiles, which is a primary requirement of pre stressing steel. Prestressing strands are, in turn, made up of multiple wires (typical 2, 3 or 7 wire strands). Typical seven wire strand consists of six wires spun around the seventh wire which has a slightly larger diameter, thus forming a helical strand. These wires are cold drawn and have very high tensile ultimate strength (typically 250,000 - 270,000 psi). Their high tensile strength makes it possible to effectively pre stress concrete even after undergoing short term and long-term losses. These are used in pre stressed concrete in bridges or pre stressed slabs in buildings. Prestressing steel is also

available as non-bonded strands encased in PVC sheath. It is used in Post-Tensioning of members. Prestressing strands are also available as Low Relaxation Strands which exhibit low relaxation losses after pre stressing. These are typically used in pre stressing members with large spans.

The steel found in many concrete structures is called reinforcement. Determining reinforcement helps concrete resist tensile and shears forces, and helps to control cracking in concrete.

Weight of Reinforcement

The formula given below helps us to find out weight of reinforcement in kilo gram per meter.

$$\frac{D^2}{36} \times 0.222$$

Where D = Diameter of the required

of the reinforcement

Example = Weight of Ø 12

$$= \frac{12x12}{36} \times 0.222 = 0.888 \text{ kg/m}$$

$$\text{Number of bars} = \text{length} \frac{- 2 \text{ end cover}}{\text{Spacing}} + 1$$

Table 2: Recording reinforcement sample format

S.N.	Description (Location)	Ø	Shape	length	No	Total Length	Weight	Total Weight

1.1.2 Formwork

Formwork is a die or a mould including all supporting structures, used to shape and support the concrete until it attains sufficient strength to carry its own weight. It should be capable of carrying all imposed dead and live loads apart from its own weight.

The term ‘formwork’ includes the actual material contact with the concrete, known as form face, and all the necessary associated supporting structure.

Formwork gives concrete its shape. Formwork provides a mold, into which concrete is placed. When concrete has hardened the formwork is removed.

Formwork must be:

- accurate
- strong, and
- Well made.

Formwork that is not will leak from the joints, may sag, bulge or move and, especially in large construction, will not be safe. The surface of the forms in contact with concrete affects how concrete will look. If the final look of the concrete is important choose a material which will leave the surface texture wanted.

Placement: Be sure that formwork is placed so it can be removed. If formwork is placed in awkward positions or tight corners it may be difficult to remove when the concrete had hardened.

It is helpful if formwork is:

- simple to build,
- easy to hand, and
- Re-useable.

Formwork sections should be of simple design, not too big and of standard sizes if they are to be re-used.

In order to successfully carry out its function, formwork must achieve a balance of following requirements:

- Containment
- Strength
- Resistance to Leakage
- Accuracy
- Ease of Handling
- Finish and Reuse Potential
- Access for Concerted
- Economy

1.2 Location of steel reinforcement and formwork

Reinforcement can be placed horizontally and/or vertically. Horizontal and/or vertical reinforcement is used in all types of concrete structures where tensile or shear forces may crack or break the concrete. Horizontal reinforcement helps resist tension forces. Vertical reinforcement helps resist shear forces. Below are some examples of reinforcement use in a suspended (off-the-ground) concrete slab, horizontal reinforcement resists tension and vertical reinforcement (in say supporting beams) resists shear forces.

Locating reinforcement is important to identify components, such as steel bar, stirrups and different tie wires. In a slab-on-ground, reinforcement increases the tensile strength and helps control the width of shrinkage cracks. It does not prevent cracks but controls the width that cracks can open. Uses of reinforcement include: increasing the spacing of control joints odd shaped slabs with re-entrant corners.

Figure 29: Location of reinforcement

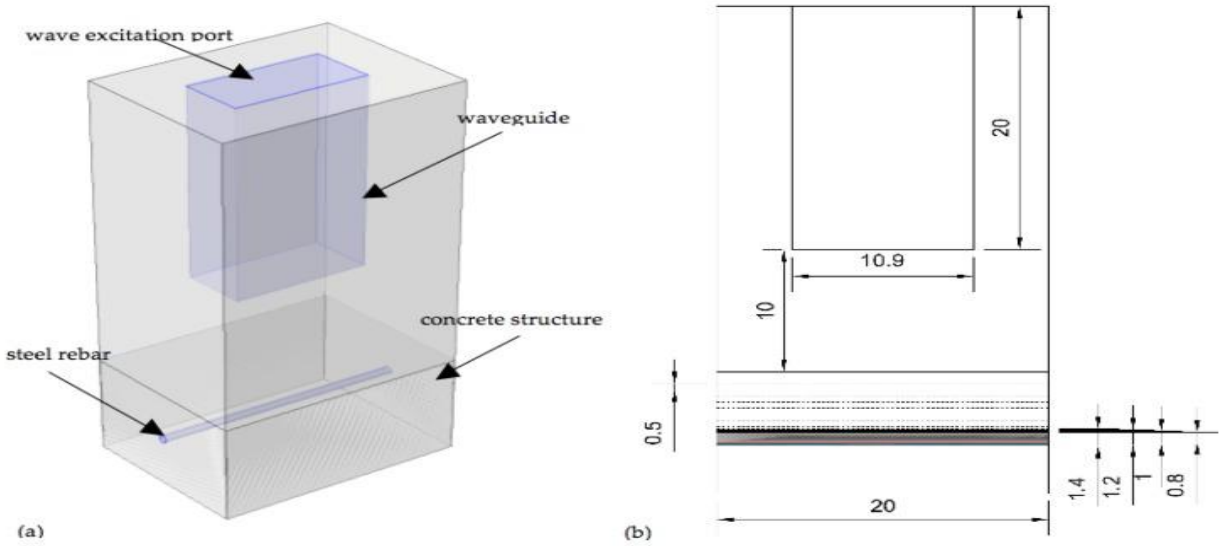


Figure 30: (**a**) The geometry used for 3D numerical modelling (**b**) problem parameterization: the chosen diameters of steel rebar and its position below the concrete surface are shown.

Self-Check -1	Written Test

Direction I: Multiple choice items

Instruction: Choose the best answer for the following questions and write the letter of your answer in the spaces provided on the answer sheet. Use bold letter (2 pts each).

1. One of the following is the advantage of steel reinforcement(2 pts)
   A. Melts at high temperature
   B. Expensive
   C. Reactive Nature of Steel Reinforcement
   D. Compatibility with Concrete

6. The most common type of reinforcement for regular RCC structures is: (2 pts)
   A. Mild Steel Plain bars
   B. Cold Worked Steel Reinforcement
   C. Hot rolled deformed bars
   D. Prestressing Steel

7. _____ is used to shape and support the concrete until it attains sufficient strength to carry its own weight. (2 pts)
   A. Reinforcement C. Formwork
   B. RCC D. Aggregate

8. Tensile property for concrete structures is obtained by: (2 pts)
   A. Reinforcement C. Formwork
   B. Aggregate D. Water
   C.

9. Formwork is not helpful if it is: (2 pts)
   A. Simple to build C. Easy to hand
   B. Re-useable D. Easily broken

Note: Satisfactory rating – 5 and above pts Unsatisfactory - below 5 pts

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

1. _____

2. _____

3. _____

Information Sheet-2	Checking Reinforcement against Reinforcement Drawings and Specifications

2.1. Reinforcement against Reinforcement Drawings and Specifications

Reinforcement detailing of a slab is done based on its support conditions. Slab may be supported on walls or beams or columns. Slab supported directly by columns are called flat slab.

The construction parts shall be provided with the main dimensions, the concrete reinforcement shall be drawn and all parts shall be represented unambiguously and clearly in scaled plans, elevations and sections. The representations shall correspond with the indications in the structural calculations and should, where applicable, contain all dimensions required for the construction of the members and the verification of the calculations.

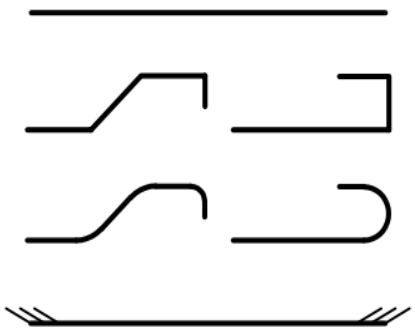
Reference shall be referred to accessory drawings. For drawings modified later, all concerned drawings shall be modified as well. The following characterizations (general information and placement information) of the reinforcement bars shall be given on the drawing:

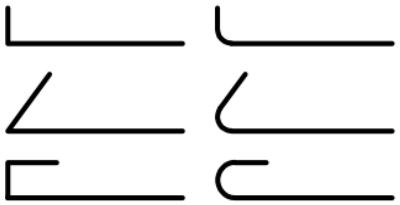
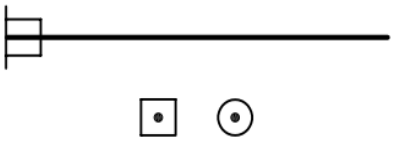
- Required concrete strength class, the exposure class and further requirements to the concrete given in reference standards;
- Type of reinforcing steel and pre stressed steel given in reference standards;
- Bar mark, number, diameter, shape and position of the reinforcement bars; distance between the bars and overlap length at joints; arrangement, dimensions and development of welding points by specification of the joining metal, jarring plates, position of the concreting gap;
- Type of the prestressing system; number, type and position of the tendons; number, type and position of the tendon anchoring and tendon coupling; bar mark, number, diameter, shape and position of the accessory not prestressed concrete reinforcement; type and diameter of the encasing tubes; specification of the intrusion grout;
- Measures for securing the position of the concrete reinforcement and the tendons (e.g. Kind and arrangement of the bar chairs, as well as arrangement,

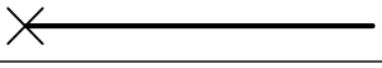
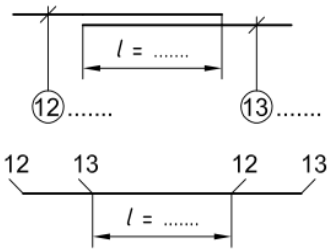
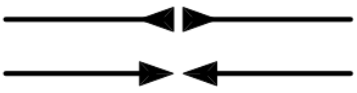
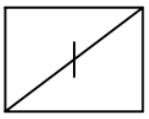
dimensions and shape for the support of the upper concrete reinforcement layer and the tendons);

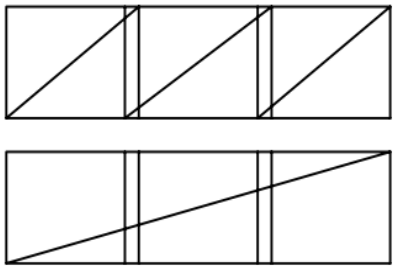
- The joint development;
- Special measures for quality assurance, if required.
- The following information on bending the reinforcement bars shall be given on the drawing or on separate documents such as a bar schedule:
- If the shape coding system is applied, bending shapes of the reinforcement bars shall
- Refer unambiguously to the shape numbers, hence the graphical representation may be unsealed;
- Single length, sectional lengths and, if applicable, bending angles of the reinforcement bars shall be indicated (for typifying bending shapes, table 5 shall be taken into account, and in every case the reference standard mandrel or radii shall be represented on the drawing);
- The mandrel diameters or radii.

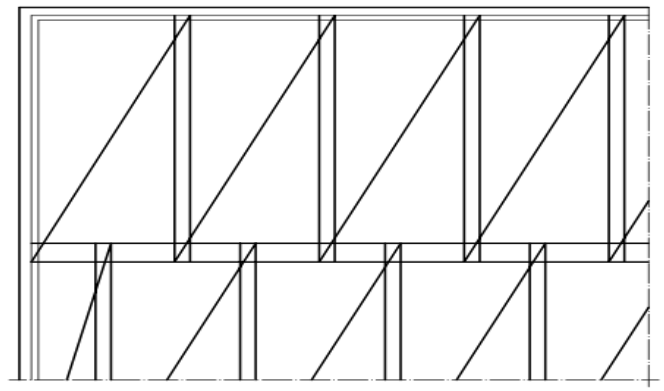
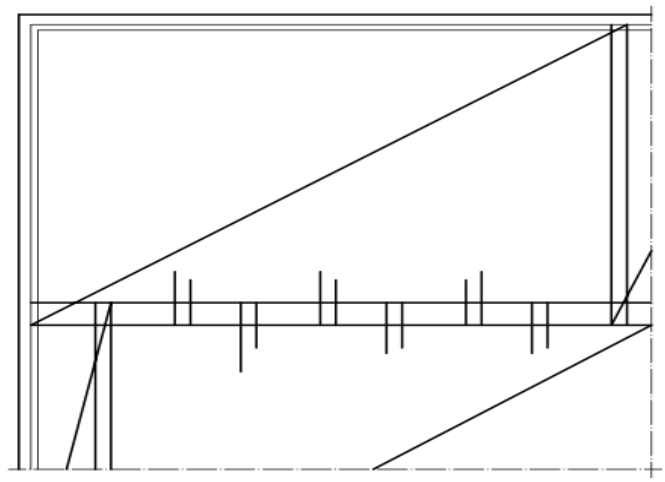
Table 3: Representation and drawing conventions of concrete reinforcements without pre stressing

No.	Description	Representation
1	**Views** a) General representation of bar by a continuous extra-wide line b) Bent reinforcement bar 1) representation as a polygonal continuous line or 2) representation as a continuous line made up of straight lines and arcs c) Bundle of bars drawn using a single line, with end markings indicating number of bars in bundle EXAMPLE Bundle of three identical bars.	

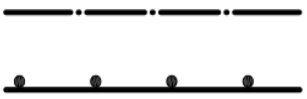
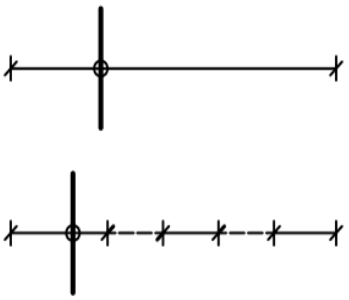
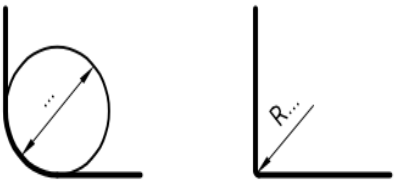
2	**Section of bar** a) section of single reinforcement bar b) bundle of two reinforcement bars c) bundle of three reinforcement bars	
3	**Bar with hook anchoring** a) elevation of bar terminating in a 90° bend b) elevation of bar terminating in a bend between 90° and 180° c) elevation of bar terminating in a 180° bend	
4	Straight bars lying in a row or a plane to indicate the ends of the bars, showing corresponding bar marks using narrow line	
5	**End anchorage with plates** a) elevation or plan view b) section or end view	

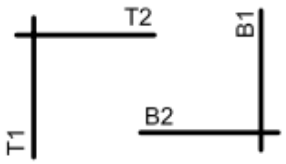
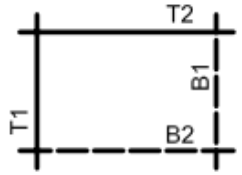
No.	Description	Representation
6	Bar bent at a right angle away from viewer	
7	Bar bent at a right angle towards viewer	
8	**Overlapping stack of reinforcement bars** a) *without* marking bar ends by a slash and bar marks b) *with* marking bar ends by a slash and bar marks	
9	**Bars joined by mechanical couplers — general representation** a) tension coupler b) compression coupler	
10	Welded fabric, top view (If required, an oblique stroke crossing the diagonal line may be used to indicate the direction of the main reinforcement, as shown here.)	

11	**Welded fabric, identical sheets in a row** a) with representation of single sheets b) condensed representation Overlapping length shall be given on the drawing	

No.	Description	Representation
12	**Top view of layer containing identical sheets** a) with representation of single sheets	
	b) condensed representation with indication of overlapping Overlapping length shall be given on the drawing	

No.	Description	Representation

13	**Welded fabric, section** a) simplified representation by a long dashed dotted extra-wide line b) conventional representation	
14	**Set of identical bars** a) each set of identical bars indicated by one scaled-drawn reinforcement bar and a line terminated by oblique lines to mark extreme bars (circle connects "set line" with correct bar) b) identical bars placed in groups.	
15	Bars with a specification of the diameter or radius of mandrel, if differing from the minimum diameter or radius of the mandrel NOTE A radius is indicated by the additional letter R.	

No.	Description	Representation
16	**Location of layers of reinforcement on plan drawings** where B is the bottom layer; T is the top layer; 1 is the layer nearest the concrete face; 2 is the second layer from the concrete face. NOTE B and T are used for the English language; equivalent letters for other languages are possible. a) bottom and top layers shown on separate plans b) bottom and top layers shown on the same plan (The bottom layer shall be indicated by a dashed extra-wide line.)	 

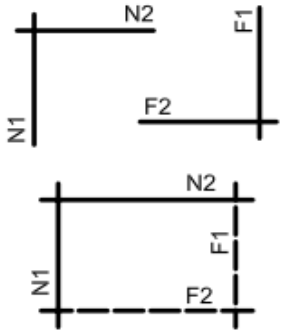
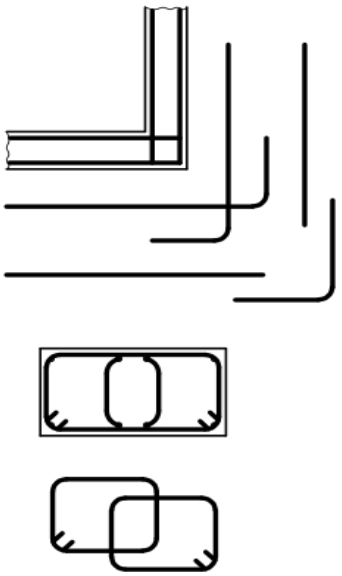
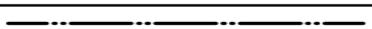
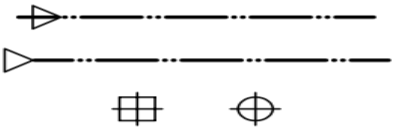
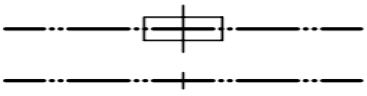
No.	Description	Representation
17	**Location of layers of reinforcement on elevation drawings** where N is the near face F is the far face 1 is the layer nearest the concrete face 2 is the second layer from the concrete face NOTE N and F are used for the English language; equivalent letters for other languages are possible. a) near-face and far-face reinforcement shown on separate elevations b) near-face and far-face reinforcement shown on the same elevation (The far face layer shall be indicated by a dashed extra-wide line.)	
18	If the arrangement of the reinforcement is not represented unambiguously by the section, an additional detailed representation of the reinforcement may be given outside of the section. NOTE For the representation of the bends, see No. 1.	

Table 4: General representation and drawing conventions of pre stressed concrete reinforcements

No.	Description	Representation
1	Prestressing bar or cable (tendon) by long dashed double-dotted extra-wide line	
2	Section of post-tensioned reinforcement in pipes or conduits	
3	Section of prestressed reinforcement with immediate bond	
4	**Anchorage** a) anchorage at tensioning end b) fixed anchorage c) end view of anchorage	
5	**Coupling** a) movable splice b) fixed splice	

- **Marking:** Items of information concerning reinforcing bars shall be written on the drawing in the longitudinal direction of the bars or along reference lines indicating the bars in question. Items of information for welded fabric shall be written along the diagonal line. The sheet mark shall be indicated together with the number of sheets. For every bar mark, details concerning reinforcement bars shall be given on the drawing in accordance with Table 5.

Table 5: Bar mark, details concerning reinforcement bars

Indication	Example
Alphanumerical bar mark (surrounded by, for example, a circle or an oval)	③[a]
Number of bars	19
Bar diameter, in millimetres	Ø20
Spacing, in millimetres	200
Position in the component or construction part (optional)	T
Shape code of reinforcement bar (optional)	13

[a] *Indication for the example: 19 Ø20—200—T—13 or 19 Ø20—200. See Figure 31*

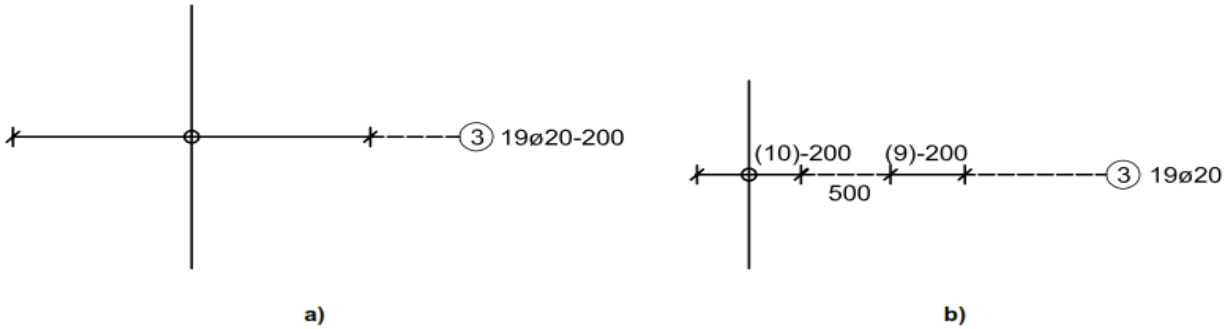
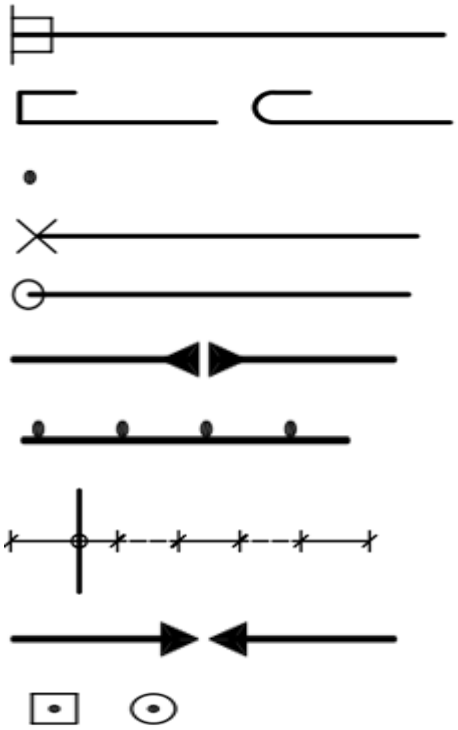


Figure 31: Examples of bar markings (without options)

Self-Check -2	Written Test

Directions: Much the descriptions from column A with their representation from column B. Use the spaces provided. (3 pts each)

A	B
_____1. Section of single reinforcement bar _____ 2. Elevation or plan view _____ 3. Bar bent at right angle towards view _____ 4. Tension couple _____ 5. Compression couple _____ 6. Identical bars placed in groups _____ 7. Elevation of bar terminating in a 180^{o} _____8. Conventional representation	

Note: **Satisfactory rating - 12 points** **Unsatisfactory - below 12 points**

Score = _____

Rating: _____

Information Sheet-3	Selecting formwork components

3.1 Selecting formwork components

Formwork can be made out of a large variety of materials:

- The material most commonly being used to date is timber. However, due to the depleting forest reserves and increasing cost of timber the use of alternate materials such as plywood and steel has become prominent.
- More recently, materials such as plastics and fiberglass are also being used for pre-fabricating formwork.
- The type of material to be used depends on the nature of construction as well as availability and cost of material.
- The constraints on the project such as overall cost, time of completion also play a major role in the use of a particular material for formwork.

Timber forms: Timber is required for practically all jobs of formwork. The timber brings used for formwork must satisfy the following requirements:

- It should be durable and treatable
- It should have sufficient strength characteristics
- It should be light weight and well-seasoned without warping,
- It should hold nails well.

Advantages of using timber forms:

- It is economical for small construction jobs
- It is design flexible and easy to erect
- It has good thermal insulation which makes it useful to be used in colder regions
- It can easily be made into any shape or size

Figure 32: Timber formwork

- **Plywood forms (in combination with timber):**
  - ✓ Concrete shuttering plywood, is preservative treated and especially suited for use in concrete shuttering and formwork.
  - ✓ The plywood is built up of odd number of layers with grain of adjacent layers perpendicular to each other.
  - ✓ Plywood is used extensively for formwork for concrete, especially for sheathing, decking and form linings.
  - ✓ There are two types of plywood - internal and exterior.
  - ✓ The interior type is bonded with water resistant glue and exterior type is bonded with water proof glue.
- **Hardboard forms:**
  - ✓ Hardboard is a board material manufactured of wood fiber, which is then refined or partly refined to form a panel having a density range of approximately 50 to 80 pounds per cubic foot.
  - ✓ Hardboards are standard / non-tempered or tempered.

- ✓ The tempered one being used for formwork. Tempered hardboard is solid or perforated hardboard panels impregnated with resin under high pressure to make them stronger and more resistant to moisture and abrasion.
- ✓ The boards available in large sheets have a hard, smooth surface that produces a concrete whose surface is relatively free of blemishes and joint marks.
- ✓ The thin sheets can be bent to small radii, which is an advantage when casting concrete members with curved surfaces.

- **Aluminum forms**
  - ✓ Forms made from aluminum are in many respects similar to those made of steel.
  - ✓ However, because of their lower density, aluminum forms are lighter than steel forms, and this is their primary advantage when compared to steel.
  - ✓ As the strength of aluminum in handling, tension and compression is less than the strength of steel, it is necessary to use large sections.
  - ✓ The formwork turns out to be economical if large numbers of reuses are made in construction.
  - ✓ The major disadvantage of aluminum forms is that no changes can be made once the formwork is fabricated.
- **Plastics**: These forms have become increasingly popular for casting unique shapes and patterns being designed in concrete because of the excellent finish obtained requiring minimum or no surface treatment and repairs. Different types of plastic forms are available like glass reinforced plastic, fiber reinforced plastic and thermoplastics etc. Fiberglass-reinforced plastic is the most common and has several advantages such as:
  - ✓ The material allows greater freedom of design
  - ✓ Unusual textures and designs can be molded into the form
  - ✓ It allows the contractor to pour structural and finished concrete simultaneously
  - ✓ Because sections can be joined on the job site in such a way so as to eliminate joints, there is no size limitation. If carefully handled, a number of reuses are possible making it highly Economical
  - ✓ It is lightweight and easily stripped

The disadvantage of using plastic forms is that it does not lend itself to field fabrication Hence, the design and planning of this form must be carefully carried out.

Also, care must take not to damage the plastic by the heat applied for accelerated curing of the concrete. Trough and waffle units in fiberglass are used in construction of large floor areas and multistoried office buildings.

Figure 33: Plastic form work

- **Steel formwork:** Mostly used in large construction projects or in situations where large number of re-uses of the same shuttering is possible. Suitable for circular or curved shaped structures such as tanks, columns, chimneys. Etc. & for structures like sewer tunnel and retaining wall.

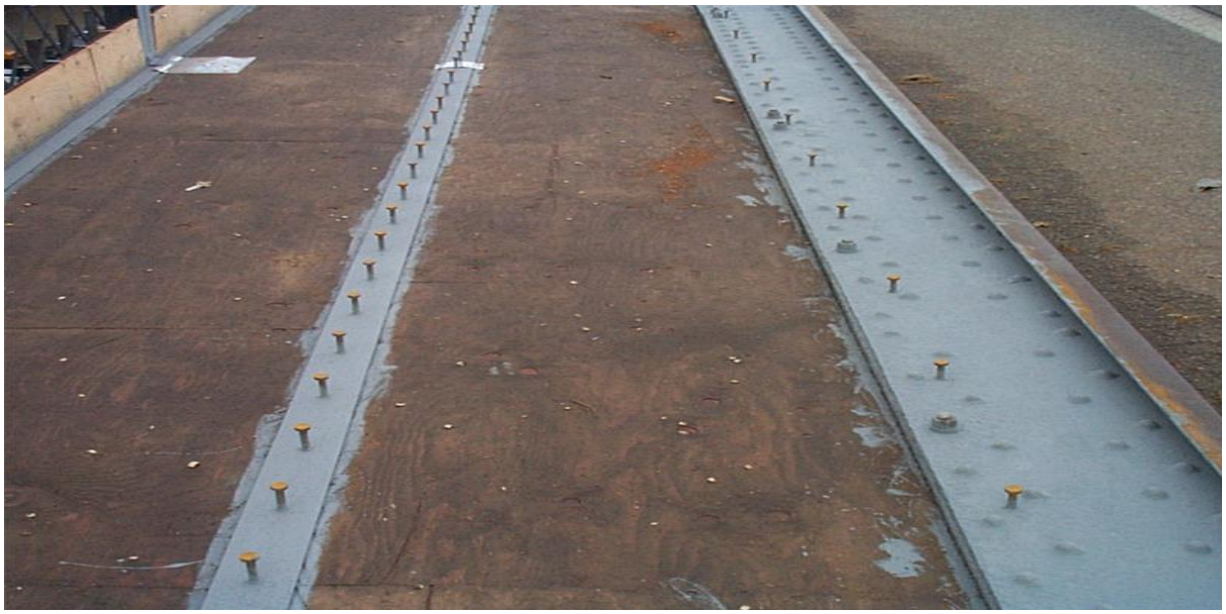


Figure 34: Steel form work

Advantages of steel formwork over timber form:

- Strong, durable & have longer life
- Reuses can be assumed to vary from 100 to 120 wares timber varies from 10 to 12.
- Steel can be installed & dismantled with greater ease & speed resulting in saving in labor cost.
- Excellent quality of exposed concrete surface obtained. Thus, saving in the cost of finishing the conc. surface
- No danger of formwork absorbing water from the conc. & hence minimizing honeycombing

3.2 Formwork types (by shape)

Considering shapes, formwork types can be classified as:

- Column Formwork
- Beam Formwork
- Slab Formwork
- Wall Formwork

- **Column formwork:** - is made usually with either timber or metal panels. The principle is to create an enclosed box with frames at the exact size of the column and fix it tightly on the kicker left from base or at the last stage of column concreting. The box is held in position by steel column clamps or bolted yokes and supported by timber studs or props.

Figure 35: Column formwork

- **Beam Formwork:** Beam formwork consists of open through section and because it is not closed at the top requires more supporting framework to restrain the sides. The supports need to be maintained to the soffit and also provide lateral support to the sides. In timber this is done by the use of a head tree across the top of a vertical member. Metal panels are used with corner pieces, but timber head trees are needed for vertical support.

Figure 36: Beam formwork

- **Slab Formwork:** Floors require a large area of formwork to be provided usually front beam to beam. Timber floor formwork consists of timber boards or plywood sheets supported on a frame work and resting on a series of timber joists. Again, timber and metal props can be used for vertical supports. Metal panels can be used and bolted or clipped together and held in place by a system of metal beams or a tabular scaffold system. Adjustable props need for leveling purposes.

Figure 37: Slab formwork

- **Wall Formwork:** Wall formwork is a simpler than for other concrete units as the actual forces against it is less, most of the load being carried vertically downwards. The panels at both sides are held in position by ties. Ties are also used as spacer, arranging wall thickness. Wall support systems are usually sloping props at satisfactory intervals.

Figure 38: Wall formwork

Self-Check -3	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. Which type of formwork cannot be changed once the formwork is fabricated?
   A. Steel formwork
   B. Aluminum forms
   C. Timber forms
   D. Hardboard forms
2. Which one of the following are not the advantages of using timber forms?
   A. It can easily be made into any shape or size
   B. It has good thermal insulation
   C. It is design flexible and easy to erect
   D. It is not flexible
3. Which material of formwork allows greater freedom of design?
   A. Timber form
   B. Plastic form
   C. Aluminum
   D. Steel form

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

1. _____

2. _____

3. _____

Information Sheet-4	Selecting Fixing/Fasteners for Consistent

4.1. Definition

Fasteners are tie bolts shall be positioned such that those left in the concrete do not project into the concrete cover. Tie bolts shall be removed without causing damage to the concrete surface. Where the concrete surface is to be later treated, tie bolt cores shall be loosened but left in place until after the surface treatment is applied. Filling of tie bolt holes shall be with a material which matches the surface color. Filling shall be recessed 5 mm below the concrete surface to give a neat appearance.

Concrete fastening is more than a science. It's closer to a craft. Like stone masonry, bricklaying and concrete placing, there are also many variables in working with concrete fasteners. First are the fasteners themselves. Each type has their designed application or purpose. Then, there are the many tools involved in attaching fasteners. Finally, combining the proper concrete fasteners and tools to meet the specific type of concrete materials can amount to an art form.

It's best to start by knowing your options. First, you have to be familiar with what materials you're bonding and what their characteristics are. Then, you're in a better position to identify what specific fastener suits your purpose. Only after establishing a baseline can you pick up the right tools and make a successful fastening that supports the weight and lasts a long time.

Here are some concrete and concrete fastener basics.

- **Concrete:** Concrete and cement are two different things. Concrete is a blend of water, crushed stone and cement powder that hardens into a building product. Portland cement is the dry powder component. It's not a brand name, but it's a vital part that causes a chemical reaction called hydration that turns a wet mix into a rock-hard substance.
- **Concrete strength:** When selecting concrete fasteners, it's crucial to be aware that not all concrete has the same strength. Concrete is a predictable substance

that takes exactly 28 days to become structurally sound. During that period, concrete is called “green.” Concrete then ages for 50 more years before becoming “aged” or inert.

- **Concrete compression:** Concrete mixes vary in compressive strength. You can calculate this figure by considering the ratio of cement powder to aggregate. As a rule of thumb, the more Portland powder there is in a mix, the higher or greater its compressive strength will be. Most ready-mix concrete blends range between 2,500 and 3,200 psi after the 28-day curing period.
- **Concrete load:** This figure refers to the weight or load of the piece you intend to attach to a concrete structure. For instance, you might be securing some stairs or patio lights to an Allan wall. You’ll need to calculate the load and determine if your concrete compressive strength will hold it. Then, you can select the right concrete fastener size to work with the primary material and the attachment.
- **Concrete load types:** It’s also essential to factor concrete load types when you choose concrete fasteners. There are five load categories. Static load is a consistent gravitational force that doesn’t move. Dynamic loads happen when things move or vibrate. Impact loads occur when objects collide. Tensile loads happen when forces try pulling a fastener from its anchor, and shear loads occur when forces slice across the face between a fastener and its bonded surfaces.
- **Concrete thickness:** Concrete products are three-dimensional objects. They have height, width and length. You can view all three of these dimensions as thickness, depending on where you’re trying to attach an object to them. Thickness is highly important to fastener selection. A fastener must be suitable to the minimum thickness of the primary concrete material to achieve sufficient holding power.
- **Concrete materials:** In America, builders use four main concrete types. The first is cast-in-place concrete poured in one mass. Second are concrete masonry units or block. These are individual components that stack together. Third are bricks. These are lighter-duty concrete pieces that don’t lend themselves well to drilling and installing fasteners. Fourth is concrete mortar. Builders mix wet mortar and allow it to dry, bonding blocks or bricks together. If you’re planning on attaching fasteners to bricks, make sure you tap into the mortar and not the brick material.

Here are the main concrete fastener materials to choose from.

- **Standard steel:** Untreated standard steel fasteners are somewhat rare. That's because concrete material reactions from rust, chemical erosion and electrolysis quick break down standard steel, causing it to fail.
- **Hot-dipped galvanized steel:** As a step up from standard steel, galvanized steel has good rust and electrolysis resistance, but the galvanizing process compromises some strength.
- **Stainless steel:** A good choice in outdoor and wet conditions, stainless steel has chromium and nickel additive, making it impervious to corrosion and other damaging forces.
- **Lead:** Many medium and heavy-duty screw and wedge anchors use lead cores with steel screw or bolt inserts. Lead resists all common threats from concrete chemicals and reactions.
- **Zinc:** Like lead, zinc has excellent properties for resisting corrosion, chemical reaction and electrolysis threats found in concrete products. Fastener manufacturers usually use zinc for plating screws, bolts, rods and wedge inserts, rather than manufacturing the entire fastener from zinc.
- **Plastic:** For light-duty applications, plastic inserts are a popular part of a concrete fastener solution. Plastic won't rust, rot or break down from concrete reactions. However, plastic's weakness best suits it as sleeves set into concrete that receive simple screws.

4.2. Types of Fastener

- **Removable: -**This type permits the parts to be readily disconnected without damaging the fastener, e.g. nut and bolt.
- **Semi-permanent: -**For this type, the parts can be disconnected, but some damage usually occurs to the fastener, e.g. cotter, pin
- **Permanent: -**When this type of fastener is used, the parts will never be disassembled.

4.3. Fastener application

- Primary function
- Appearance
- Number of fasteners

- Operating conditions
- Frequency of disassembly
- Adjustability
- Types of materials
- Consequences of failure

Self-Check -4	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. Which one of the following is removable fastener?

A. Nut
B. Welding
C. Pin
D. Rivets

2. A popular part of a concrete fastener solution is:

A. Zinc
B. Lead
C. Plastic
D. Stainless steel

3. In which types of fastener, the parts will never be disassembled?

A. Removable
B. Semi-permanent
C. Permanent
D. All

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

1. _____
2. _____
3. _____

Operation Sheet 1	Procedures of Determining Location of Steel Reinforcement and Formwork

Steps:

Step 1: Wear PPE

Step 2: Prepare tools and materials

Step 3: Determine the location of steel reinforcement and formwork based on the drawing

Step 4: Select the reinforcement and stirrups

Step 5: Measure the reinforcement bar and form work to locate

Operation Sheet -2	Checking reinforcement against drawing

Procedures for checking reinforcement against drawing:

Step 1: Check the cutting and placing of the reinforcement.

Step 2: Check main and transverse reinforcement are placed in position

Step 3: Check reinforcement placed in position are according to center to center distance of the working drawing.

Step 4: Check the capes are tied together firmly with tie wire.

Step 5: Checks the axes of the structures are in their correct position using string and mason square.

Step 6: Finally checks the stability of the capes and proper covers are provided.

Operation Sheet -3	Selecting formwork components or materials

Procedures for Selecting formwork components or materials:

Step 1: Identify materials with respect to sagging under load.

Step 2: Check the prevention against loss of concrete.

Step 3: Check against uniformity texture.

Step 4: Check against minimal damage.

Step 5: Select materials.

Operation Sheet -4	Selecting and using Fixing/fasteners

Procedures for Selecting and using Fixing/fasteners:

Step 1: Wear appropriate PPE

Step 2: Clean the working area

Step 3: Prepare the materials and tools used to tie reinforcement bar

Step 4: Select the reinforcement and stirrups

Step 5: Measure the reinforcement bar

Step 6: Cut the reinforcement with respect to specification

Step 7: Bend the reinforcement with respect to drawing

Step 8: Lay the reinforcement bar

Step 9: Tie the reinforcement with respect to drawing

Step 10: Finish the work

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hours.

Task 1: Determine location of steel reinforcement and formwork

Task 2: Check reinforcement against drawing

Task 3: Select formwork components or materials

Task 4: Select and using Fixing/fasteners

Instruction Sheet	Learning Guide 62: Set Out for Concrete Work

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Setting string lines
- Checking concrete grades
- Identifying and preventing services

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Set string lines accurately from existing pegs
- Check grades to ensure correct fall
- Identify services and protected to prevent damage

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1, Sheet 2, and Sheet 3” **in page 2, 10, and 16**respectively.
4. Accomplish the “Self-check 1, Self-check 2, and Self- check 3” -” **in page 9, 15, and 21**respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3”**in page 22**
6. Do the “LAP test” **in page 23**

Information Sheet-1	Setting String Lines

1.1. Setting out string lines

Setting out is a fairly quick exercise in the scale of things, but obviously it has to be done with great care. A few of the things that I will be mentioning below might sound like I am writing a how to for dummies.

First checks, before you start.

- Assuming that the relevant permits to construct have been obtained.
- You should have an accurate block plan, with the lengths and angles of all the boundaries marked on it.
- Use it to check every fence line. You may have to buy or hire a long tape measure for this.
- Every time that I have built on a boundary line (not a fence, but a proper building) I have had a certified surveyor to do a check.
- First off tidy up the site, remove all trees that are in the way. We all love trees on our blocks, but don't try to save ones that are just too close to the new structure. They are an absolute pain to work around with scaffold etc. and they usually have to go in the end anyway.
- On the drawing there is always one point and one line, or two reference lines that cross one another, given to start the set out.
- Usually they are referenced to a couple of boundary lines, or an existing building.
- Go around with a few steel pegs and bang them in near enough at the corners of the proposed slab.
- From them mark out roughly the area of the job.

Somewhere on your drawings or in the structure specifications there will be a clause that says something to the effect that you should strip the area of the work plus an extra 1m all around, of all topsoil and deleterious materials to a min. depth of 150. before starting to place the compacted approved fill. This means get rid of all

vegetable matter, grass tree roots etc. Get a machine in to clean up and remove top soil.

First layout

- Go around again and put in pegs for the corners more accurately this time.
- At this stage your pegs can be short wooden things that you can tap a nail in, steel rods, even screwdrivers or just besser blocks placed on the ground.
- Anything that will give you the positions of the corners.
- As you do this do checks for square. (See section on squaring below).
- At this stage, if the job is small and you getting machinery in for excavation work, you may put string lines between the pegs, and mark out the lines of trenches, or pier holes with lime.
- You could then get the excavation work done first, before going on to the next stage.

Profiles, batter boards or hurdles.

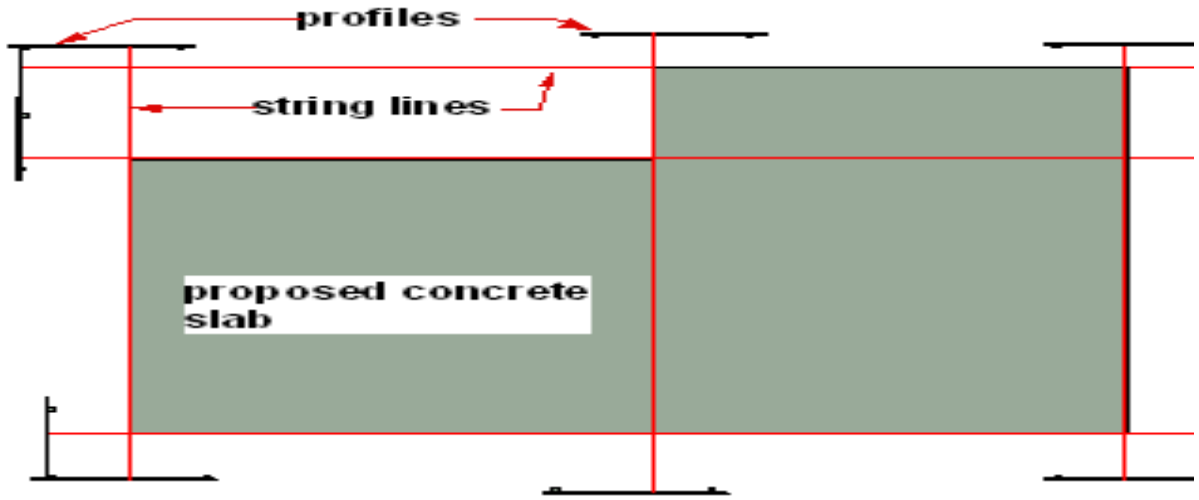


Figure 39: Setting out - A plan of a concrete slab is showing the profile positions.

- **Profiles** consist of pegs, stakes or pickets, driven into the ground, with cross piece of timber attached to them. Like formwork they are only temporary and as such they don't always look too neat, made up of all sorts of odds and ends and yet they have to contain quite a lot of information, even on a simple house extension.

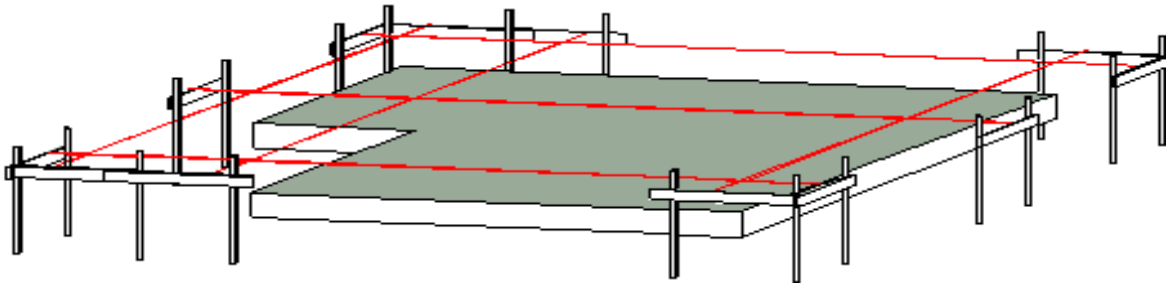


Figure 40: Setting out - A 3D view showing the use of profiles on the above slab.

They are used to transform the original pegs in the ground to something that is a semi-permanent but accurate reference of the important sizes, measurements and offsets etc for a particular stage of a job. In the case above, when the concrete slab is poured the profiles can then be removed, because further measurements can be made from the actual concrete.

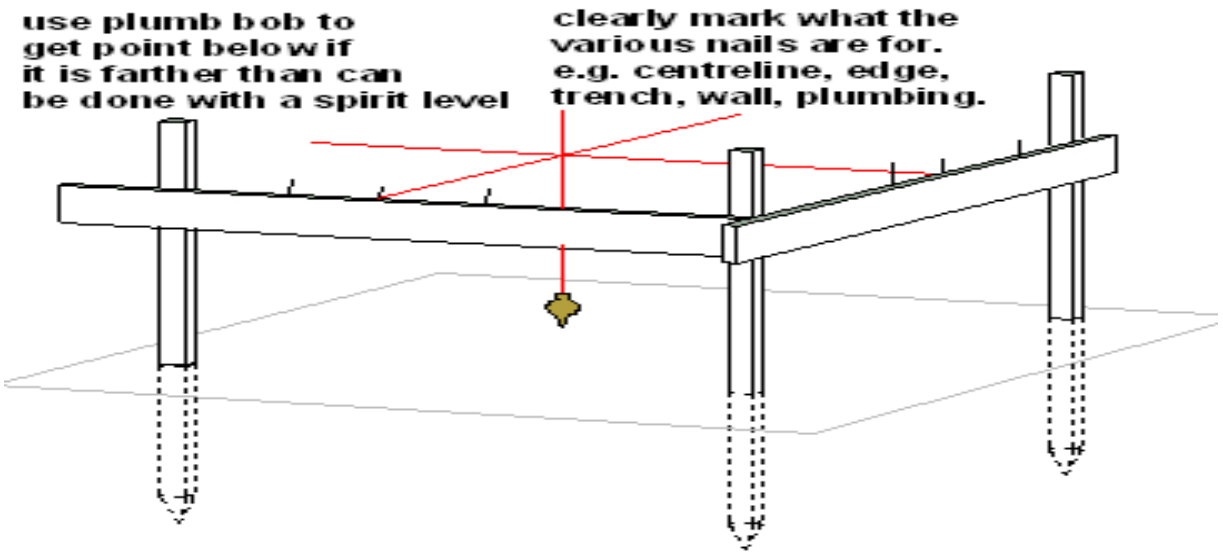


Figure 41: Setting out - A hurdle or profile used for setting out.

In most cases the guy on the job, say the plumber setting a floor waste or the carpenter fixing the perimeter formwork, will use a spirit level to plumb down from the string line to his job.

Many times, in sloping ground or when working in an excavation where it is hard to use a level, then the plumb bob can be very effective. I have used it in basement type situations where I simply hang the plumb line off the profile lines. I use a tie wire hook through a slip knotted loop to adjust the length of the plumb line.

A lot more convenient than straight edges and spirit levels.

- **Getting it square:** Far easier to get it right in the setting out, right in the concrete (check the formwork before the pour) and right when laying out the internal walls.

We mainly work with rectangles in concrete work. A rectangle has the following attributes which help us in setting out work.

- **Each of the four angles is 90 degrees** or square as we call it. Great, this means that if we have a base line side set up, and then gets a second line set up off it at the right spot, at 90 degrees to the first we have two of our side done.
- **The opposite sides are parallel**, that is, they are the same distance apart. That is it! Measure the correct length from one end of the first side and the **same length** from the other end and we have our third side fixed. Do the same again and we have our fourth side. That could be it - finished.
- **The diagonals are equal lengths.** That is the length from one set of opposite corners is the same or equal to the length from the other set. This means that if we have got a touch out with either of the first two steps (as you do:-), we have an excellent way of checking our set out.

Diagonal measures work well when they are at a reasonable angle. When the rectangle is long and narrow then the angle is flatter this way is a less reliable way of checking.

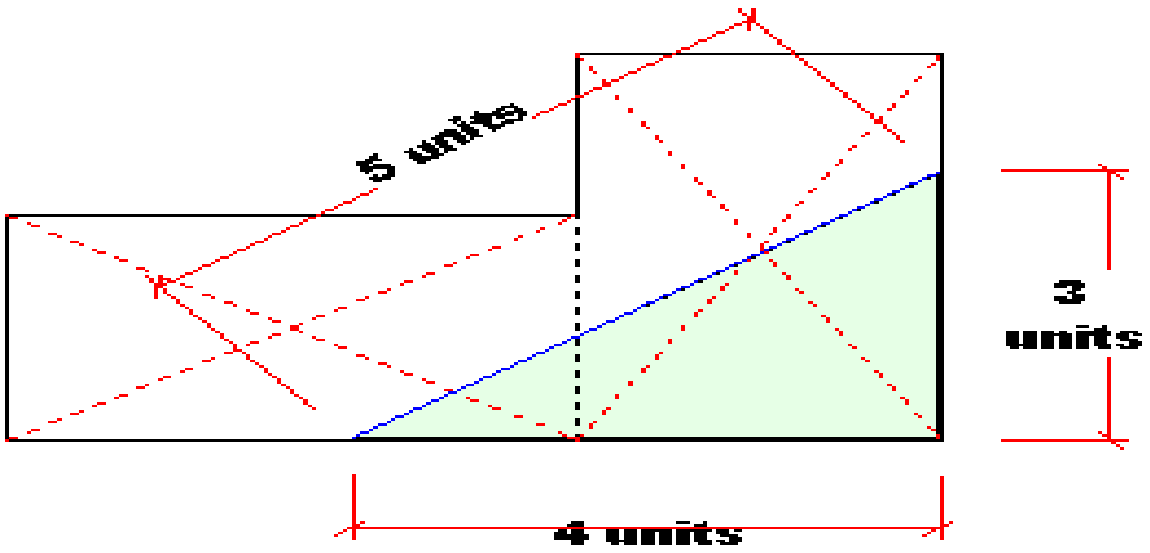
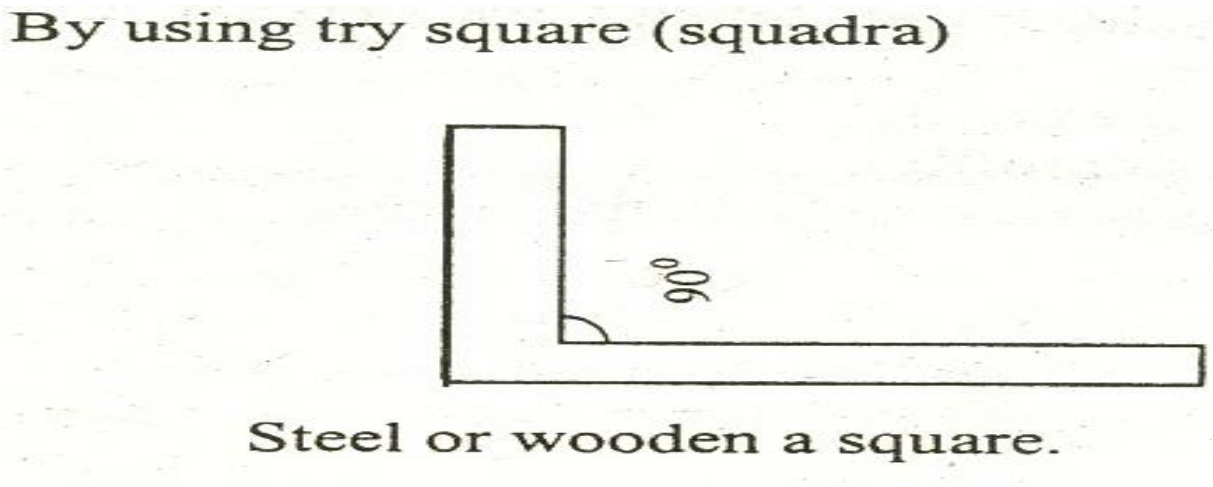


Figure 42: Setting out - Using a 3,4,5 triangle

In our setting out of the rectangles in the sketch you can clearly see that each rectangle could be also seen as two triangles.

- There is a unique triangle that is often used to demonstrate this principle, 3,4,5. ((3x3=9) +(4x4=16) 9+15=25, so does 5x5=25)
- So, any triangle in this ratio, will have a 90-degree corner opposite the long side.
- Ratio is the key word.
- The units don't matter as long as the ratio is the same.
- 3,4,5 miles, or 3,4,5 centimeters, the right angle is still there.
- Builder's square method
- Set out the front line in the usual manner with pegs or marks at the required distance.
- Place the builder's square so that front line touch one side if the square right through its length.
- Stretch a line from the peg so that it is parallel to second side of the square and establish the third peg. A corner of angle 90 degree is thus obtained.
- with the aid of a tape measure mark out the length and breadth of the proposed building.
- Transferring the builder's square to the remaining corners and repeating the above operations; a simple rectangular building can be set out.
- After establishing the four corner pegs, profiles (separate or continuous) may be erected in the same way.



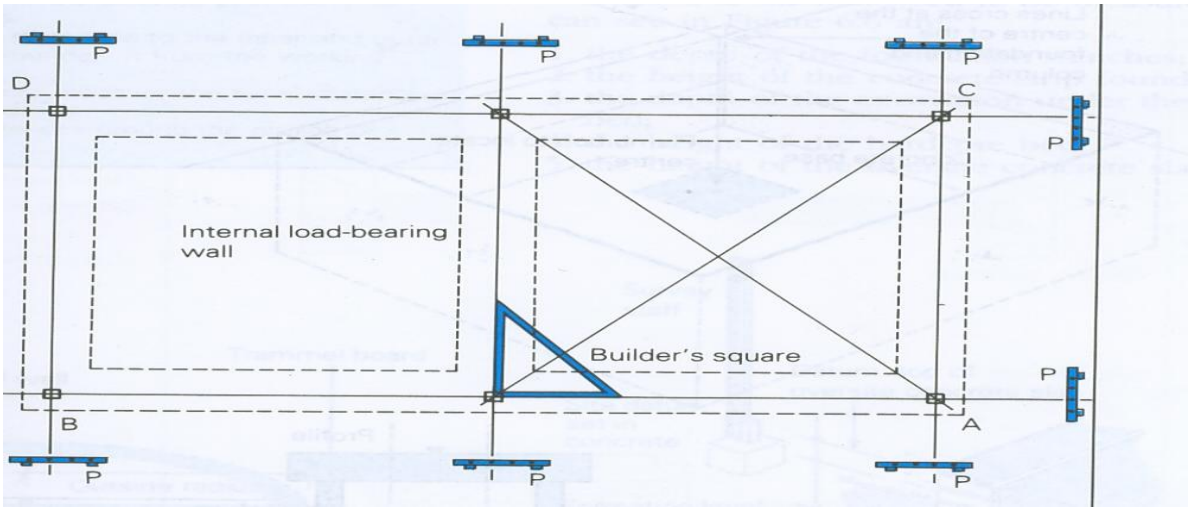


Figure 43: Builders square.

- **The Site Square Method/Leveling Instruments/:** When a right angle is to be set out, the corner of the angle and one side of the corner are always known. One has only to find the second side. The square solves the problem in a very simple, quick and reliable way.

✓ Setting out of the front or building line in the usual manner, with pegs or marks at the required distances.

Peg 1 **Peg 2**

✓ Set up the tripod at peg 2 so that the datum rod is directly over the peg or mark, which represents the corner point. Mark sure that the pegs are firm on the ground.

✓ Release the spike screw and extend the spike so that it sits firmly on the nail or mark. Tighten the screw.

✓ Before mounting the instrument in to the tripod head, ensure that the locoing screw is tightened. Screw on the site square. Release the locking screw. By rotating the site square, point the lower telescope along the front or building line. Tight the locking screws.

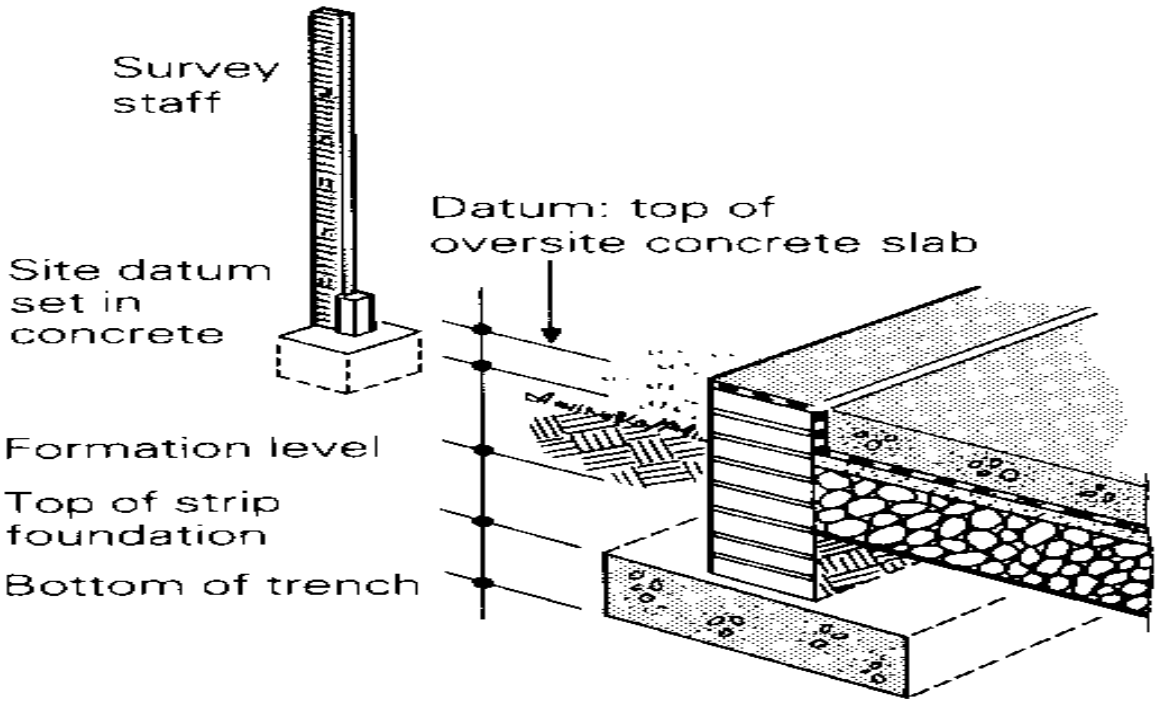


Figure 44: Setting out with leveling instrument.

Self-Check -1	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided:

1. One of the following is true for rectangular setting out of concrete. (2 pts)
   C. The diagonals are equal lengths
   D. The opposite sides are parallel
   E. Each of the four angles is 90
   F. degrees G. All
2. Which setting out method used when the corner of the angle and one side of the corner

are always known? (2 pts)

   A. Builder's square method
   B. The Site Square Method
   C. 3,4,5 triangle method
   D. Leveling Instruments
3. Which one of the following should be done before starting setting out? (2 pts)
   A. You should have an accurate block plan
   B. Mark out roughly the area of the job
   C. Go around with a few steel pegs
   D. Put in pegs for the corners more accurately

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

1. _____

2. _____

3. _____

Information Sheet-2	Checking Concrete Grades

2.1. Definition

During your site visit you will have determined the natural incline or slope of the ground on the site. You will also have confirmed the depth of the authority connection point. This information will assist you in calculating the required depth and slope of the drain trenches to ensure you achieve the minimum grade of the drain to maintain the self-cleaning effect of the system.

Grade or gradient is the term used to describe slope. In plumbing work the grade is the slope at which sanitary drainage pipes are to be laid in trenches. Grade may be expressed as a percentage or ratio. For example, a grade of 2.00% is the same as a ratio of 1 in 50. This means over a distance of 50 m the trench or pipe will slope down, or fall, 1 m from the horizontal.

2.2. Concrete working base

Concrete working bases, where specified, shall comprise concrete strength grade N20, laid over the footprint of the structure or sub grade and screened to the required levels. Minimum thickness of the base shall be 50mm.Where required to support a membrane, the base shall have a wood float finish with a surface tolerance of plus or minus 5 mm from the correct plane and plus or minus 5 mm from a 2 m straight edge. Notwithstanding the above requirements, the finish shall be compatible with the proposed membrane and not contain any sharp projections or edges.

A base for the film shall be prepared according to base type, as follows:

- **Graded stone base:** Blind with sufficient sand to create a smooth surface free from hard projections. The sand shall be wetted just before laying the underlay.
- **Concrete working base:** Remove loose material and any projections above the plane surface.

The film shall be installed by lying over the base. Joints shall be lapped not less than 200 mm, and laps shall face away from the direction of concrete pour. Laps shall be sealed with adhesive tape not inferior to double sided butyl adhesive tape. The film shall be similarly sealed around unavoidable penetrations such as service pipes and the like. The underlay shall be taken up vertical faces as far as the damp proof course where applicable, and fixed at the top by tape sealing. Vertical or inclined surfaces shall only have vertical laps. Any punctures or tears shall be patched and scaled before pouring concrete.

2.3. Check Grades to Ensure Correct Fall

The most important step in placing concrete is planning. Always plan every step before any concrete is delivered. Proper planning avoids delays, wastage, segregation and problems which develop from these. To eliminate problems of Delay, Segregation and wastage, the following should be taken before any concrete is placed.

A. Measurement: - Measure and stake out the area to be concreted and consider how thick the slab must be. The thickness will depend on the weight the concrete must carry (driveway carries the weight of a car and needs to be thicker than a garden path).

B. Finishing level: - Once the thickness of concrete has been established, work out where the concrete will finish. Concrete cannot finish too high against steps or the external house wall and should not cover any part of weep holes in the wall. The finishing level shows how much digging or excavation must be done. Pavements must grade away from buildings and boundaries.

C. Excavation: -The ground should be excavated as deep as is required by the finishing levels. Any roots or grass must be dug out until there is firm soil to place on. Always dig the hole wider than needed to allow for the formwork. Try to keep the edges and corners square.

D. Sub grade: -The soil a concrete pavement or floor rests on is called the sub grade. If the soil is soft or varies in softness, a layer of crushed rock should be used.

If there are only a few poor areas these can be dug out, refilled and compacted. It is important that the soil evenly supports the concrete. Many later problems can be avoided by properly preparing the sub grade. Formwork gives concrete its shape. Formwork must be properly braced so it is strong.

2.4. Tools and equipment used in grading

Profile Board: -A profile board is designed in such a way that it can be attached to a ranging rod. It has a screw mechanism that enables the profile board to slide up and down on the ranging rod and be fixed at any desired point simply by tightening the screw. A long-lasting profile board is the one made from thin steel plate (40 cm x 10 cm) welded to a short length of metal tubing that can slide up and down and can be clamped to the metal rod. Alternatively, wooden profile boards can be attached to a hard wood rod and fixed with a clamp.

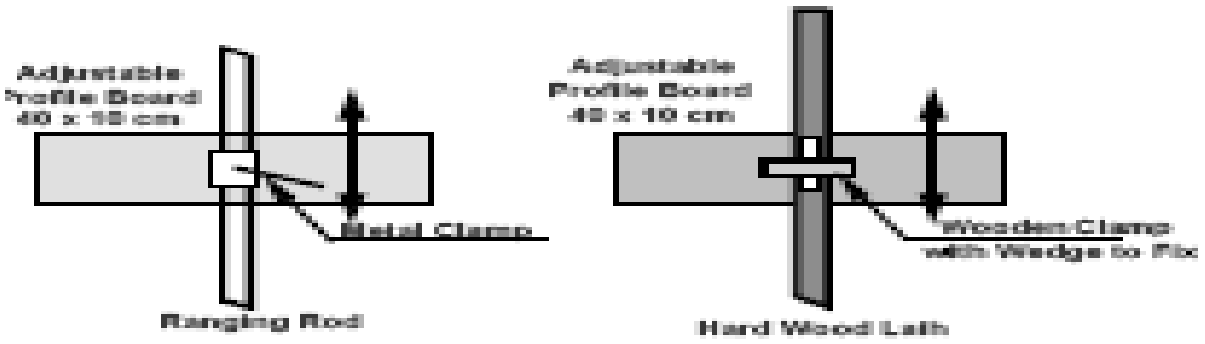


Figure 45: Profile board

Spirit level: - It is used to control the horizontal and vertical alignment of wall surface and edges. The length is at least 80 to 120cm long. It is made of metal, synthetic material or wood. It has two measuring bubbles: one is located at mid length and is used to check horizontal positions. While the second one, at the end, and is used to check vertical position. This tool requires always to be handled with care and needs

to be checked from time to time weather it is still working accurate or not. The longer the spirit level the more accurate the measurement will be.

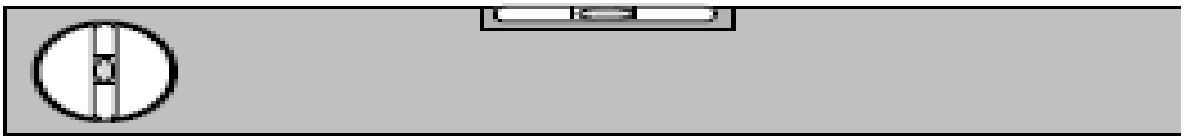


Figure 46: Sprit level

Line Level: -A line level is a small spirit level of about 80 - 120 mm length. It has a hook on each end of the level which is used for hooking the level onto a smooth line. The level is used together with a line, ranging rods (or profile boards) and a tape measure. The line level requires two people to operate.

The line level can be used to:

- to transfer levels
- to check existing gradients
- to set out gradients

Always check:

- that the line is smooth or of nylon keep the line tight,
- level is in the middle between the two ranging rods,
- Check the accuracy of the level regularly.

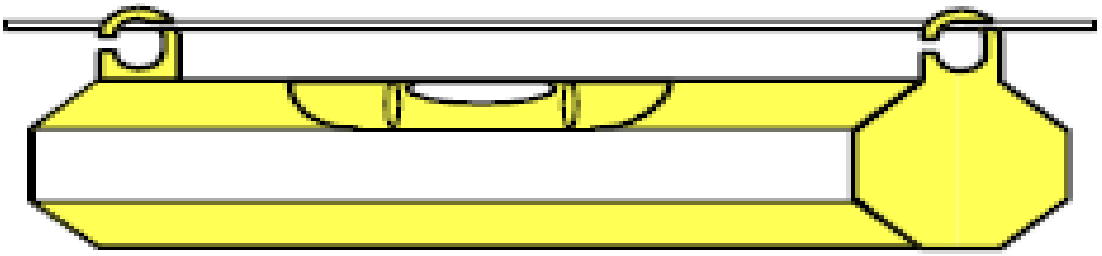


Figure 47: Line level

Figure 48: Using line level

Measuring tape: Tape is used to measure dimensions of building parts and distances in site. It is manufactured from steel, plastic or fiber in lengths of 1m, 2m, 3m, 5m, 30m, etc. and 50m. In using tapes for measurements, the two points should be aligned perfectly. In addition, when long horizontal measurements are needed, care should be taken to avoid sag on the tape meters.

Self-Check -2	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. The most important step in placing concrete is:

A. Measuring

B. Excavation

C. Planning

D. Finishing

2. The equipment which is attached to a ranging rod for grading in concrete work is:

A. Line Level

B. Profile Board

C. Spirit level

D. Measuring tape

3. One of the following should not be taken before any concrete is placed.

A. Concrete compaction

B. Excavation

C. Measurement

D. Sub grade

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

1. _____

2. _____

3. _____

Information Sheet-3	Identifying and preventing services

3.1. Identifying and Preventing Services

The prevention of damage to buried facilities will have a positive impact on worker safety, public safety, protection of the environment and preservation of the integrity of the underground infrastructure that provides goods and services essential to today's society.

Utility network structures (electricity, gas, telecommunications, water, etc.) are an important part of the economic health of a country. City developments are integrating multiple communication technologies (ICT) and Internet of things (IoT) to manage their assets.

Several specific safety initiatives were introduced to ensure worker safety, such as:

- **De-energising**: High-risk electrical services were de-energised, where possible, during work on sites using methods including rerouting of the power supply to remove the risk of exposure while surrounding areas could receive power supply.
- **Electronic detection of utilities**: Global Positioning System backpacks were developed enabling the latest survey data to be used onsite. This technology was coupled with electronic wands and pot-holing to locate underground utilities. Accurate location of utilities lowered the risk of accidentally striking underground utility services during excavation.
- **Service identification**: Colour coded conduits were used to identify the type of service, location and depth to ensure hazard awareness. This highlighted services in key areas to reduce the risk of striking utilities.
- **Permit to excavate**: These permits were developed by engineers and safety personnel. Each work crew was required to be in possession of a current permit before undertaking any excavation. The permits not only covered location but detailed who was responsible for managing the works. Safety coordinators ensured that all excavation work complied with the conditions of the permit to excavate and that permits were clearly understood by work crews. Safety

coordinators were authorised to stop work if any aspect of the permit to excavate was not adhered to. Coordinators highlighted the importance of communicating safety messages between crews.

- **Non-destructive digging**: Surface pegs detailing depth, type of service and position were used to identify the location of services to avoid digging in those areas. Spray paint was also used to mark the service location. Water blasting, hand digging and toothless buckets were used during excavation to prevent damage to underground utilities.
- **Safety awareness reinforcement**: Banners, posters, stickers and signage were used extensively to reinforce procedures and identify hazards involved with underground utilities. For example, banners were hung at bridges near sites, showing messages such as 'Must have a permit to excavate' or the warning 'Power live'. Variable message boards, intended for users of the completed road, were utilised onsite to convey reminders of potential hazards.To keep vital services operating, repair and modernization programs need to undertake vast amounts of street works, and excavate holes to reach the buried utilities. Undertaking any excavation will inevitably bring site workers in close proximity to underground utilities. Consideration should be given to knowing the exact location of all buried utilities before and during any excavation process.
- **Safe working practices:** Over half of all utility strikes are to electrical cables, with a majority caused by mini diggers, air powered tools and metal hand tools. A large number of utility strikes occur when teams do not follow safe working practices, nor consult with utility plans or even use associated detection equipment.

Infrastructure, especially utilities, must be maintained or repaired continuously. The main challenge for this change does not know the accurate position of the utilities. Without knowing the accurate position of utilities, we can't plan them. This brings the need of detecting and mapping utilities. The quality of detection and the maps is very important – if the location of the utility is wrongly detected, or if the utility cannot be detected, this can lead to hazardous accidents and damages. In order to protect people and assets, the quality of detection and mapping must be ensured.

To improve the quality of utility data and reduce the risk of a utility strike, a number of government standards have been developed:

- Desktop utility records to collate existing utility records
- Site reconnaissance to validate existing records
- Geophysical survey to detect underground utilities
- Verify the location of utilities during excavation

3.2. Underground utility color codes

Underground utility color codes are used to differentiate and identify underground utilities to protect it from potential damage during excavation. There are different types of utilities and in order to tell them apart, either colored lines or flags, or sometimes both are used. These lines/flags help mark the location and indicate the type of utility that is buried underground. Utility systems are buried underground due to the nature of their function, as well as convenience and aesthetics.

Excavators are required to check and locate these lines before any digging takes place. Before any excavation work can begin, they are liable to contact the concerned companies and organizations to notify them about the proposed excavation activity so that the existing underground utilities can be determined and marked.

How are underground utility color codes mapped?

Different section and location methods are used due to the fact that utilities are made of different types of materials. For metal pipes and similar cables, electromagnetic equipment with a transmitter and receiver is used. For plastics and concrete, radio location and ground penetrating radars are used. Utilities such as petroleum products are permanently marked using posts and bollards due to the nature of their content. There are maps to locate these utilities but certain equipment is required in order to have a precise and accurate location.

A specific type of spray paint, which is often a fluorescent color, is used to mark lines. For flags, a type of logo representing the company or municipal utility is used to identify the ownership of the lines.

Flags are also used as a sort of advertisement by companies installing lines for irrigation purposes for lawns and garden. In which case, the head of sprinklers are usually marked so that landscapers will leave the head open to avoid damage from tractors, construction equipment used for digging holes and fencepost.

The United Kingdom uses a color code similar to the US for marking underground utilities like water, gas, electric, telephone and cables. The system is based on convention with no written standard. Contractors will paint different colors onto the pavement to mark areas with underground utilities by using the color code.

The National Color Coding System for underground utilities is:

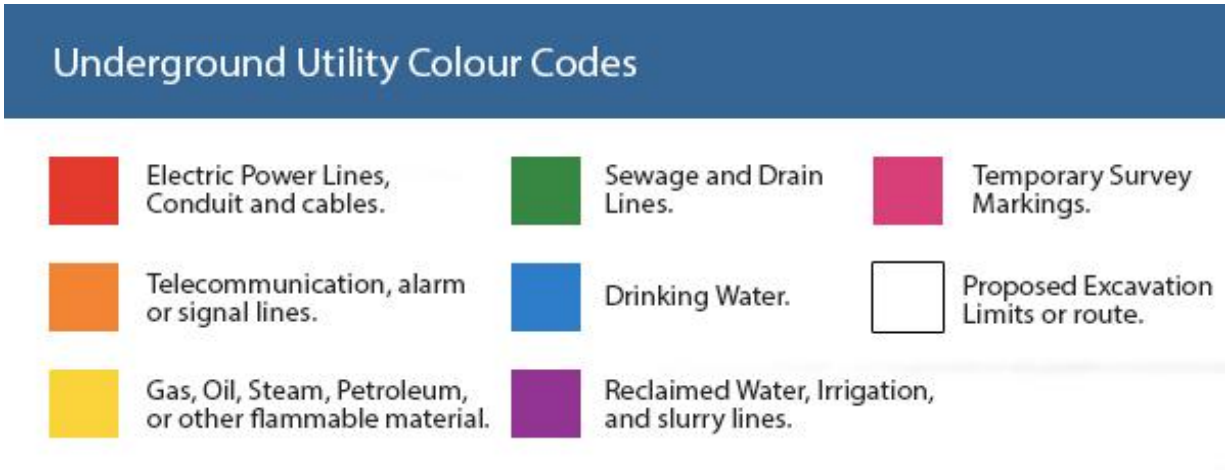


Figure 49: Underground Utility Codes

Red – Electric power lines, conduit and cables.

Orange – Telecommunication, alarm or signal lines.

Yellow – Gas, oil, steam, petroleum, or other flammable material.

Green – Sewage and drain lines.

Blue – Drinking water.

Purple – Reclaimed water, irrigation, and slurry lines.

Pink – Temporary survey markings, unknown/unidentified facilities.

White – Proposed excavation limits or route.

Self-Check -3	Written Test

Directions: Match the colors in Column B with representing underground utilities in column A. Use the spaces provided. (3 pts each)

A	B
____1. Proposed excavation limits or route ____2. Temporary survey markings, unknown/unidentified facilities ____3. Reclaimed water, irrigation, and slurry lines ____4. Drinking water ____5. Sewage and drain lines ____6. Gas, oil, steam, petroleum, or other flammable material ____7. Telecommunication, alarm or signal lines. ____8. Electric power lines, conduit and cables.	Orange Red Yellow Blue Green Pink White Purple

Note: **Satisfactory rating - 12 points** **Unsatisfactory - below 12 points**

Score = _____

Rating: _____

Operation Sheet 1	Setting string lines

Instruction for setting out string line:

Step 1: Wear PPE

Step 2: Select tools the materials and used to measure reinforcement bar

Step 3: Clean the working area

Step 4: Setting string lines by using appropriate method

Step 5: Check each corner of the area

Operation Sheet -2	Checking concrete grades

Procedures for Checking concrete grading:

Step 1. Wear appropriate PPE.

Step 2: Select tools and materials

Step 3: Clean the area

Step 4: Measure the area

Step 5: Excavate the area

Step 5: Sub grade the area

Step 6: Checks grades of the area by using appropriate tools and equipments.

Step 6: Finally clean tools and equipments.

Operation Sheet -3	Identifying and preventing services

Procedures for identifying and preventing services:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Identify services from concrete working area by using appropriate tools/equipment

Step 4: Mark service with marking materials

Step 5: Prevent services from damage with different preventing methods

Step 6: Check services are well prevented

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hours.

Task 1: Set out string lines

Task 2: Check concrete grades

Task 3: Identify and prevent services

Instruction Sheet	Learning Guide 63: Construct and fit reinforcement

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Cutting and bending reinforcing fabric and bars
- Tying/fixing of fabric and bars
- Attaching stiffening rods to panels
- Locating and placing reinforcement materials
- Locating and securing Cast-ins

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Cut and bend reinforcing fabric and bars as required to project drawings and specifications
- Tie/fix fabric and bars to configuration from project drawings and specifications
- Attach stiffening rods to panels as required to facilitate handling
- Locate reinforcement material in formwork and placed on bar chairs/spacers as determined from drawings, noting clearance from formwork
- Locate and secure cast-ins are

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1, Sheet 2,Sheet 3, Sheet 4 and Sheet 5” in page 2, 8, 15, 17, and 21respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3, Self-check 4 and Self-check 5” -” in page 7, 14, 16, 20 and 22respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2,Operation Sheet 3, Operation Sheet 4 and Operation Sheet 5 ” in page 23 and 24
6. Do the “LAP test” in page 25

Information Sheet-1	Cutting and bending reinforcing fabric and bars

1.1 Reinforcing fabric and bars

While concrete performs well under compression, it does not tolerate tension well. To improve the tensile strength, steel bars are added to the concrete in places where tensile stress is expected to occur - such as in beams and slabs.

Consequently, the load bearing capacity of this composite material called Reinforced Cement Concrete (RCC) is substantially better as compared to when concrete or steel members are used in isolation. With reinforcement steel firmly embedded into the concrete, it can be used to build load-bearing structures such as columns, beams and slabs.

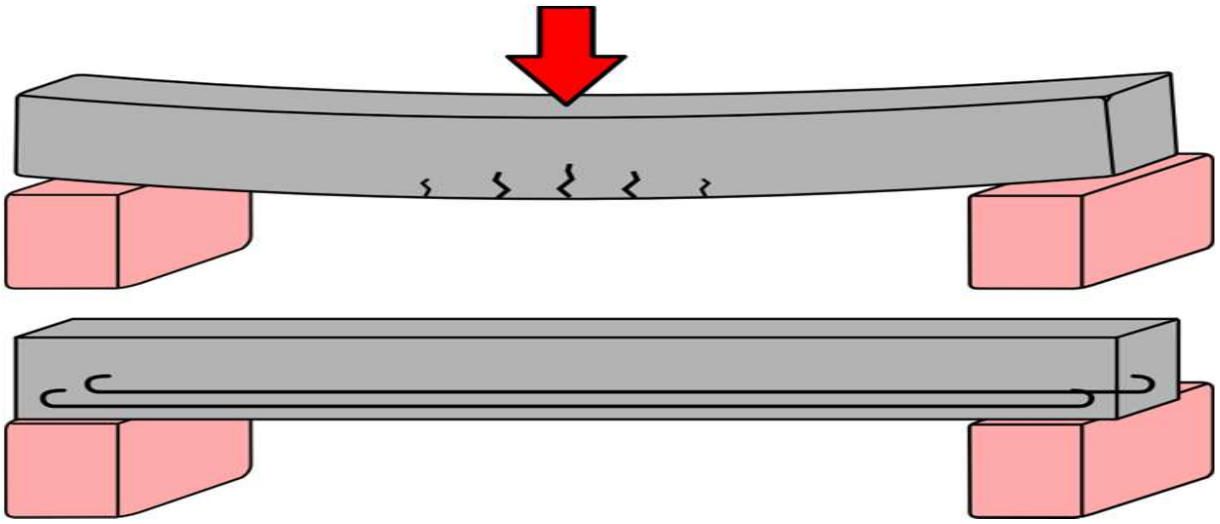


Figure 50: Load bearing capacity of concrete

There are two main categories and purposes of reinforcement steel. The main bars are meant to take most of the tension stresses, while the distribution reinforcement serves the purpose of spreading the load and keeping the main reinforcement in position when pouring concrete.

The main reinforcement bars are placed in the area where tension occurs. It should be adequately covered with concrete with minimum 20 to 25 mm for slabs, 25 to 30 mm for beams on all sides and 40 mm for columns to avoid any corrosion of the reinforcement.

If steel bars need to be extended, some of the critical points to be remembered are:

- The lap length should be greater than 50 times the diameter of the bars used.
- Lapping should not be done close to joints or any other critical areas of the structure.
- All the laps should not be concentrated in a single area or straight line as the lap may create a point of vulnerability within the structure.

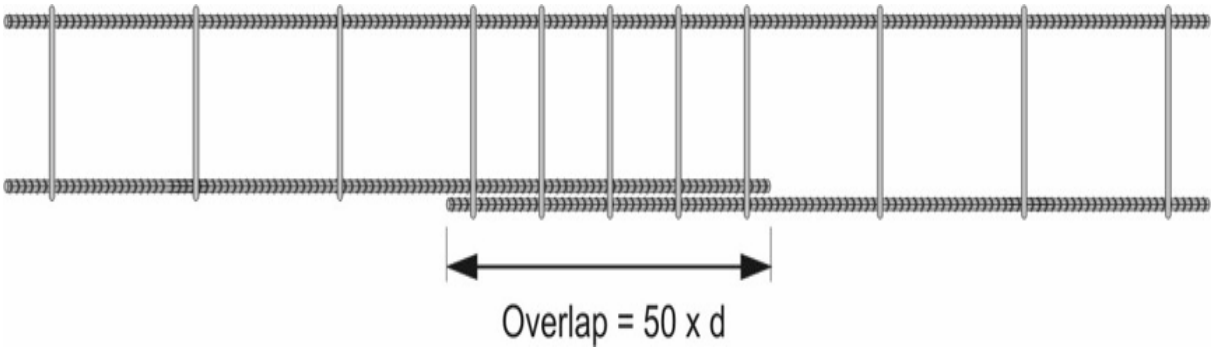


Figure 51: Steel bars extending

1.2 Cutting and bending reinforcement steel bars

Structural designs invariably provide what is known as bar bending schedule. This is prepared in a standard manner and gives details of type, quantity and location of all bars, it is also customary to give the total length of the bar and details of bending.
A useful exercise before commencing cutting is to arrange the listed order, which is often dictated by location, and to put the bars in length order, and then by first cutting the longest bars, waste can be reduced.

The reinforcement bars are cut and bent on site. This requires some skill and the appropriate tools. The reinforcement bar bending schedule describes what type of bars to prepare in terms of size, shape and numbers of each type.

The stirrup is the outer frame that holds the load bearing bars in the correct position. These are prepared on site using 10mm diameter bars. The exact length of the bars for stirrups needs to be carefully calculated based on the dimensions of the column or beam. The re-bars have to be covered all round with at least 25mm to 30mm concrete. The stirrups therefore need to be cut and bent to allow for sufficient coverage. Make sure the end bend is minimum 50mm.

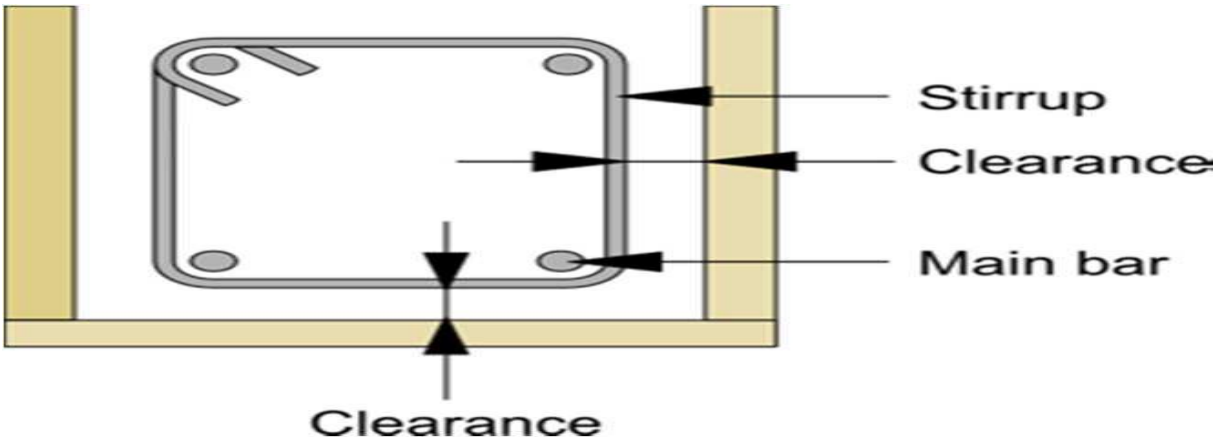


Figure 52: Bending stirrups

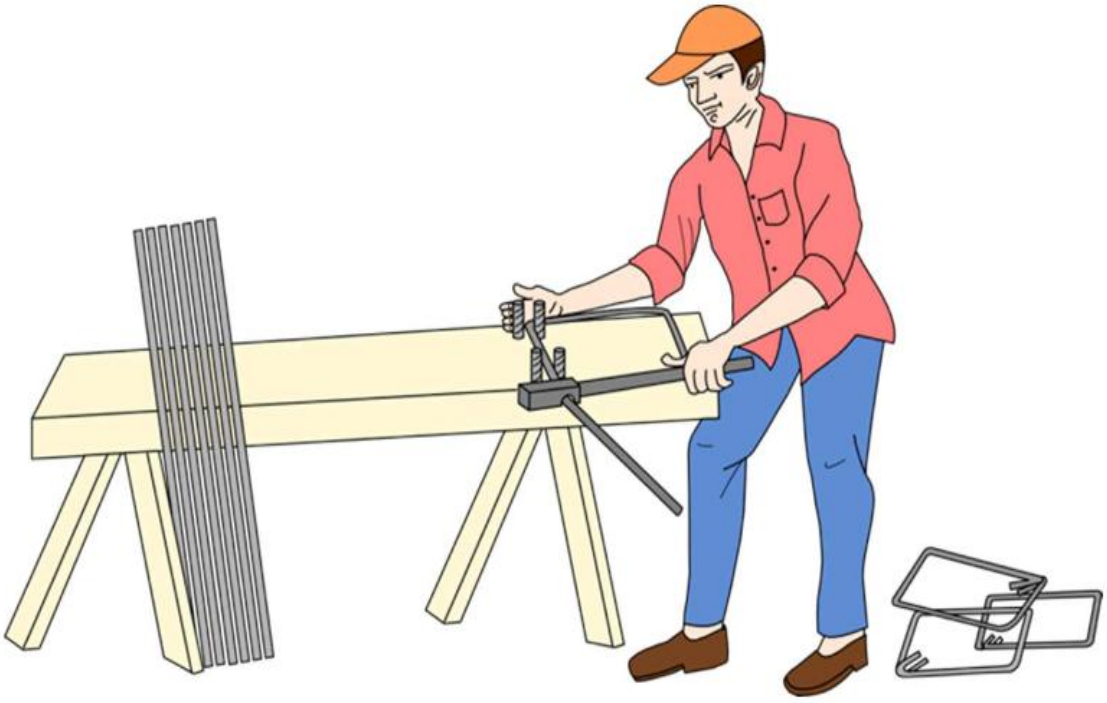


Figure 53: Cutting and bending reinforcement bars

Rebar thickness is an important factor to consider when attempting to cut a piece of rebar; this is because tools that may be used cutting for a small-diameter piece of rebar may not be appropriate for use when cutting a large-diameter piece of rebar.

- **Manual Cutting Tools:** Many smaller-diameter rebar sizes are similar in diameter to common steel and brass bolts. Some hand tools, such as hacksaws and bolt cutters, may be used to cut smaller-diameter rebar sizes. However, a bolt cutter may not be large enough to accommodate medium- and large-diameter pieces of rebar; similarly, it would take a long time and great physical effort to cut a larger-diameter piece of rebar with a hacksaw.
- **Powered Cutting Tools:** A powered cutting tool, such as a handheld rotary tool, chop saw, electric rebar cutting tool or angle grinder may be used to cut rebar. A handheld rotary tool with a metal-cutting accessory can cut cleanly through a small-diameter piece of rebar, whereas a chop saw with a carbide blade may be used to cut larger-diameter pieces with ease. Angle grinders and electric rebar cutting tools are the most versatile of these tools in that both tools are capable of cutting small-, medium- and large-diameter pieces while remaining portable.
- **Torches:** Plasma and oxyacetylene torches may also be used to cut rebar; however, since these torches operate by melting metal, the cut edges will not be as straight as a cut made by a mechanical or electromechanical tool. Using a torch to cut rebar can be time-consuming and may not be cost-effective when compared to using a mechanical or electromechanical tool to complete the task.

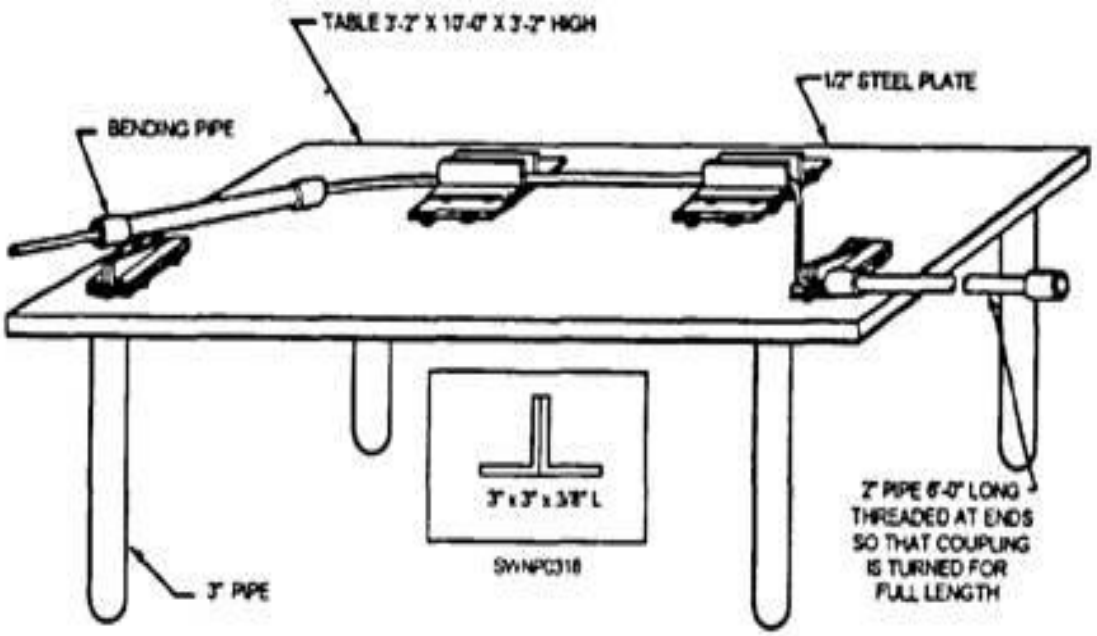


Figure 55: Bar-bending table.

1.4 How to cut and bend rebar

Rebar can be bent and cut to fit the needs of any concrete project. Although it comes in lengths of 20 feet, it can be reduced or bent to form various angles. However, there are various tools and techniques available for you to use when cutting or bending rebar. The do-it-yourselfer with little or no experience with rebar can bend and cut it successfully.

Instructions

- Cut the rebar by placing it on a metal chop saw. You can rent the saw from most any tool rental store. It resembles a miter saw and can make very accurate cuts. Place the saw on a solid surface and slide the rebar onto the base of the saw. Mark the desired cut length, start the saw motor and pull the saw head down onto the rebar.
- Cut the rebar with a reciprocating saw if you do not have a chop saw. Fit the reciprocating saw with a 6-inch metal cutting blade. Place the rebar on a wooden 2-by-4 block or other surface in order to raise it off the ground. Measure and mark the rebar to the desired length. Have a helper hold the rebar tightly while you cut into the metal surface.

- Cut rebar with a circular saw fitted with a masonry blade. As with the reciprocating saw, place the rebar on a 2-by-4 or other blocking material, measure the rebar and cut into the metal with the surface. Wear safety goggles when cutting with a circular saw.
- Bend the rebar with a conduit bender, which can be rented or purchased at most tool rental stores. Measure and mark the rebar and place it into the conduit bender. Pull the bender to bend the rebar to various angles, including 30-, 45- and 90-degree angles.

Self-Check -1	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. Why steel bars are added to the concrete?
   A. To spread the load
   B. To improve the tensile strength
   C. To make it durable D. All

2. Which bar cutting tool is time-consuming and may not be cost-effective when compared to complete the task?
   A. Powered Cutting Tools
   B. Manual Cutting Tools
   C. Torches D. Hack saw

3. The outer frame that holds the load bearing bars in the correct position during bar bending is:
   A. Stirrup C. Bar bending table
   B. Main bar D. Torches
   C.

4. Important factor to consider when attempting to cut a piece of rebar is:
   A. Type of bar C. Length of bar
   B. Thickness of bar D. Age of bar
   C.

5. One of the following tools is manual bar butting tools.
   A. Angle grinder C. Bolt cutters
   B. Handheld rotary tool D. Chop saw

Note: **Satisfactory rating – 5 points** **Unsatisfactory - below 5 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

1. _____

2. _____

3. _____

4. _____

5. _____

Information Sheet-2	Tying/Fixing of Fabric and Bars

2.1 Tying/fixing of fabric and bars

Once the reinforcement steel bars have been cut and bent to the right shape, they are ready to be installed in the formworks. For columns, beams and lintels the reinforcement can be tied together to the correct shape and length before the formworks installed. They can actually be assembled on the ground ready for installation once the formwork is complete.

The reinforcement plan describes which main bars and stirrups (distribution bars) to use, where they are to be placed and the distance between them. The main bars are always inside while the stirrups are fixed outside with regular spacing.

The stirrups can have different shapes, but should be ‘closed’ as shown in the drawing. It is important that the stirrups have the correct size to allow for adequate concrete cover (25mm to 30mm forbears and columns in housing).
The stirrups are tied onto the main bars using binding wire.

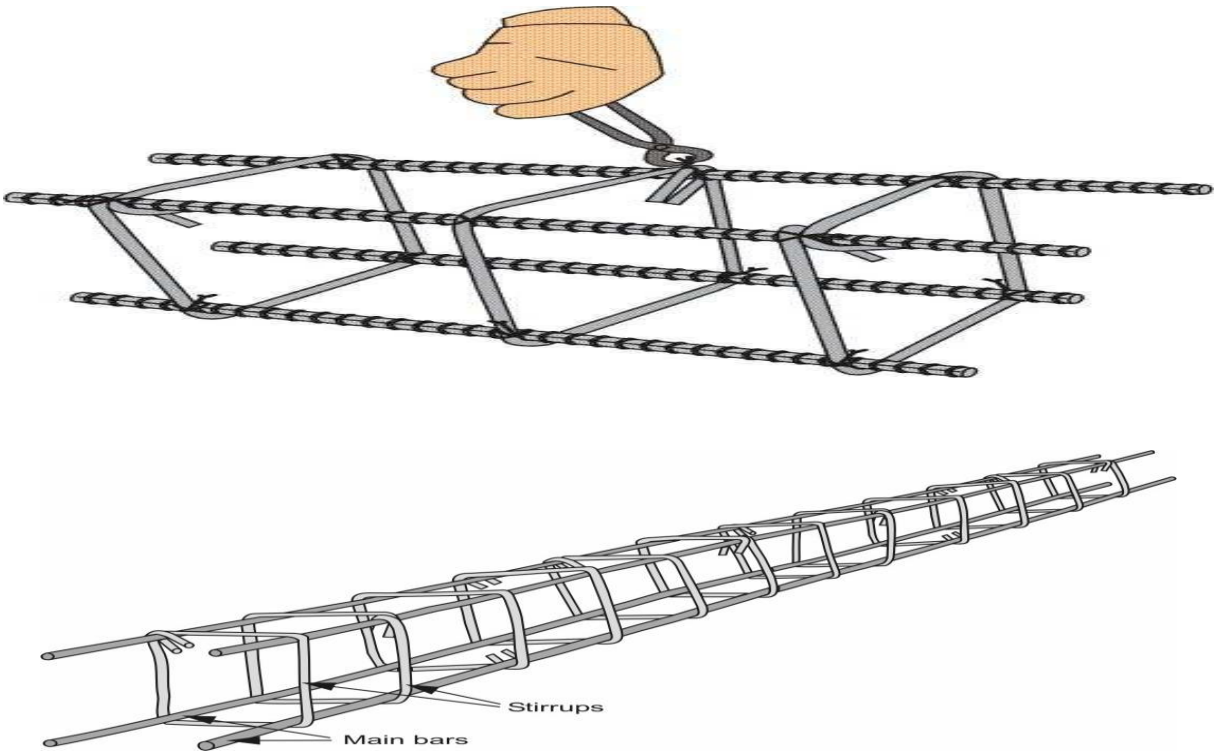


Figure 56: Bar tying

For slabs the reinforcement bars are usually arranged and tied together when the formwork has-been completed. The main bars are at the bottom, while the distribution bars are laid and fixed on top of them.

Figure 57: Tying reinforcement bars

2.2 Steps for tying reinforcement bars

- **Plan the project.** Planning the actual fabrication and placement, as well as the schedule of the work is your first task.
- **Purchase the rebar.** For simple projects like typical building foundations and slab reinforcement, you can most likely buy the necessary rebar from a building supply center or home improvement warehouse.
- **Consult your reinforcing placement drawings/plan.** For simpler projects, your building plans should provide spacing requirements and bar sizes. Use these documents to determine where and what rebar is needed in individual locations.
- **Choose the method you will use to *tie* the rebar.** Most times, rebar is tied with annealed steel wire, either bought in four-pound bulk rolls, or if using a *bag tie* spinner, in bundles of precut wire pieces with loops formed on both ends.
- **Prepare the area where the concrete is to be placed.**

- **Decide whether the concrete forms will be installed prior to placing your rebar**. For concrete slabs, the subgrade (ground underneath the slab) is often pre-treated for termites, and a moisture barrier or damp proofing is installed before the mat is tied.
- ***Shake out* the rebar.** This involves removing individual bars, stirrups, and dowels from their respective bundles according to the placement drawing counts. An example would be a slab measuring 12 feet by 12 feet with rebars at 8-inch centers in one direction, and 12-inch centers the other.
- **Tie your rebar.** This is the primary focus of this article. Tying the bars so that they remain in their correct respective positions is critical to achieve the desired strength of the completed concrete structure.

a. Place each rebar in its respective position according to the layout described in the previous steps.

b. Select the appropriate type of tie you will use. Here are some of them, with a simplified description of how they are made:

- ✓ **Figure 59 ties.** These are made by pulling the wire around the rear (from the rod buster) bar, diagonally across the front bar, back around the rear bar, diagonally in the opposite direction across the front bar, and then twisting back around the beginning wire.
- ✓ **Saddle ties.** Similar to the figure 8 tie, you begin by passing the wire feeding from your reel behind the rear bar, then across the front bar staying parallel to the bar. You then pass it behind the rear bar again, back around the front bar on the opposite side. You now twist the ends together, cut the feed wire, and bend the cut ends back.
- ✓ **Combinations of figure 59 and saddle ties** with additional *wraps* around vertical rebars can be used to increase the hold of the tie so bars cannot slip downward when weight is applied to them or the plastic concrete is dropped into the form.

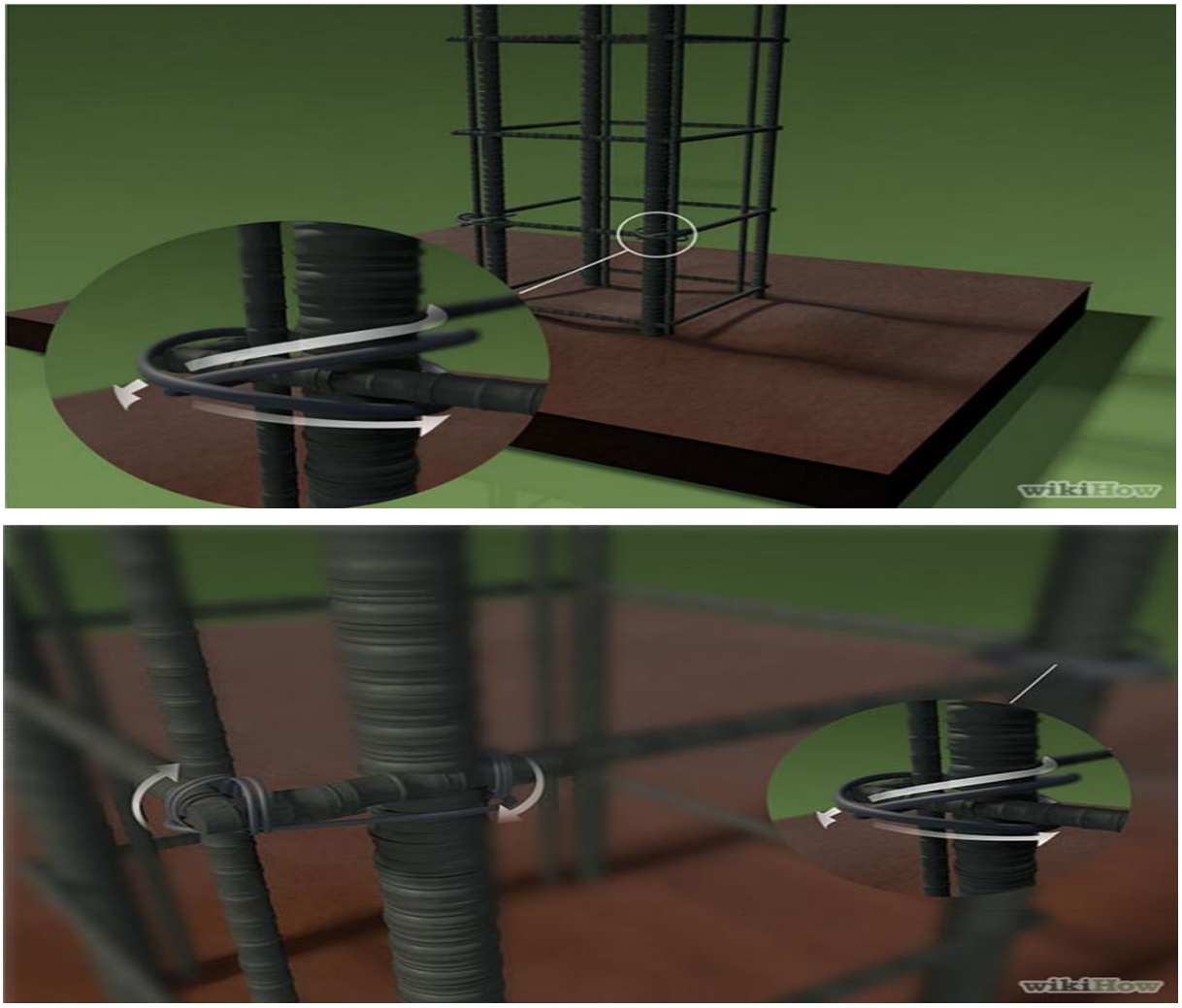


Figure 59: Types of ties

c. **Use your pliers for tying these ties efficiently.** For all the above-mentioned ties, you pull the feeding end from the wire reel with your non-dominant (hereafter regarded as left, please reverse for right-handed persons) hand. Grip the end of the wire with your pliers in your right hand, and *poke*, or push it behind the rebar described in the first step of your chosen tie. Bend or angle the end toward the place you will be grabbing the end in the next step of the tie, then reach from that side, grip it again with the pliers, pull it toward the next place you will route it to, pulling enough slack wire to complete the tie.

Figure 60: Pliers for tying of reinforcement bar

d. **Tie all the bars required in their correct positions.** Check your plans to make sure each component of the reinforcement is in place. Often, in structural concrete reinforcement, you will find several elements that interface together in addition to the basic rebar mat discussed so far.

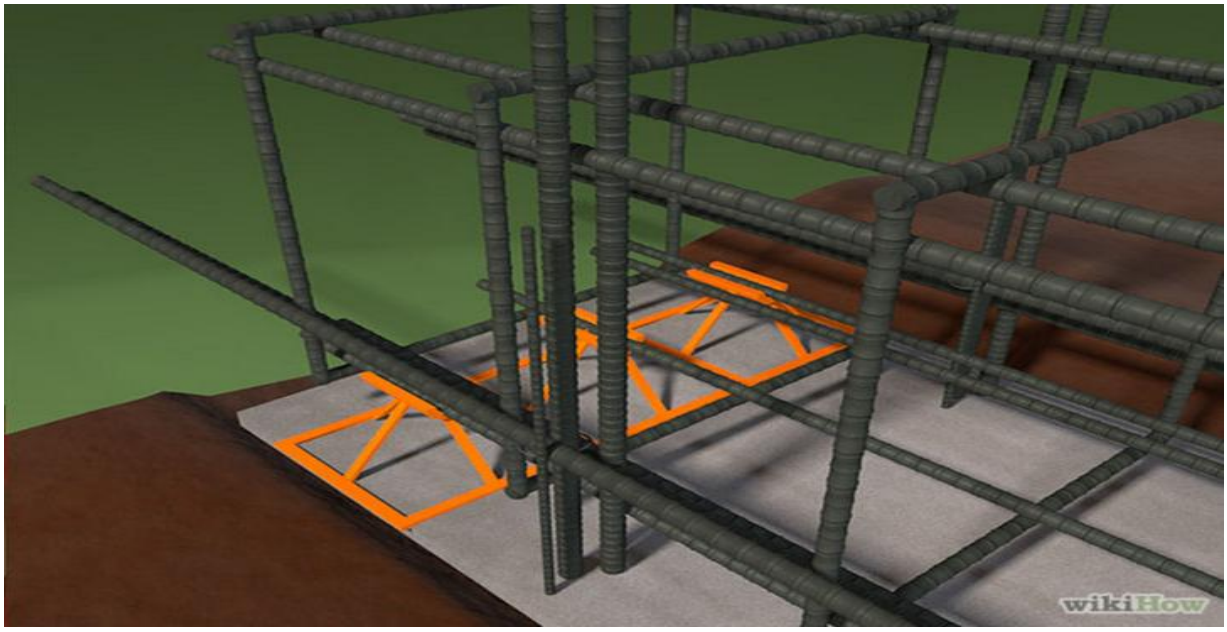


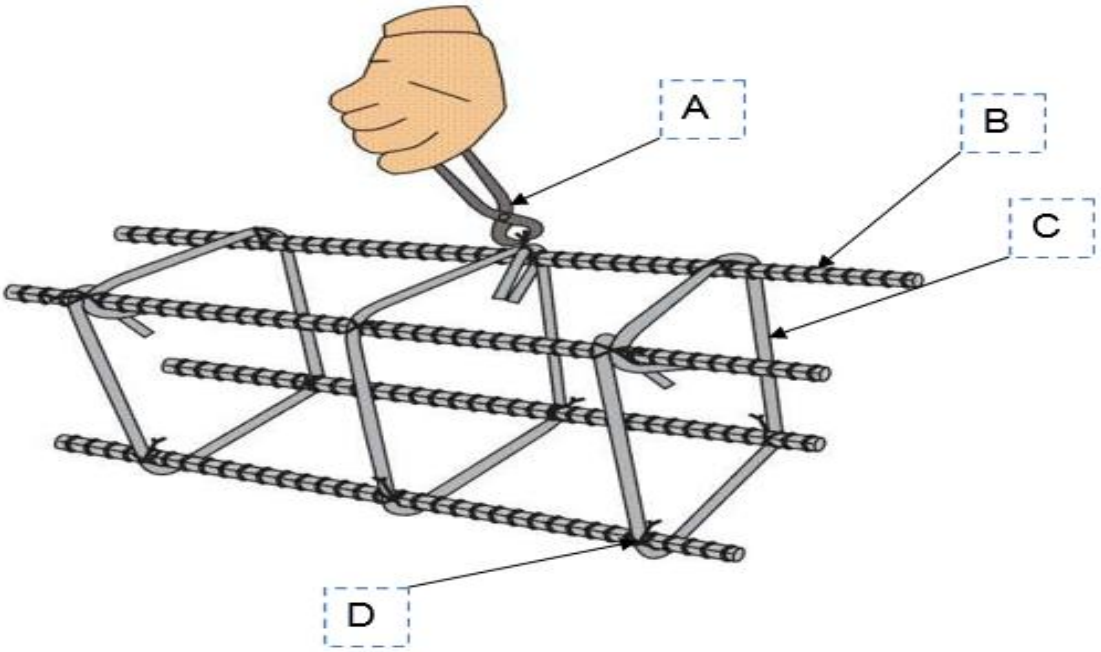
Figure 61: Tie bars in their correct positions

- **Chair or support your rebar.** Once the mat or cage is assembled, you must hold it in position so the concrete will cover it completely. Rebar chairs or concrete brick are often used for this purpose.

- **Observe the rebar configuration while the concrete is placed.** If shifting occurs, support the rebars with a handled tool like a shovel wedged so that you can achieve sufficient leverage to hold its position, or alter the direction of flowing concrete so force is applied in the opposite direction.
- **Cap or otherwise protect any exposed bars while working near them.** Rebar that is sheared, or mechanically cut has very sharp surfaces at the location of these cuts. Construction workers have suffered serious injuries and have also been killed when they have fallen on projecting rebar dowels.

Self-Check -2	Written Test

Directions: From the figure bellow much the names with letters label at the figure and write the letter on the space provided: (3 pts each)



_____1. Main bar

_____2. Stirrup

_____3. Tying player

_____4. Binding wire

Note: **Satisfactory rating –6 points** **Unsatisfactory - below 6 points**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-3	Attaching Stiffening Rods to Panels

3.1 Stiffening rods to panels

A structurally efficient rod-stiffened panel incorporating pre pressing benefits is provided, the pre stress provided by pultruded rod which is already in the system. The pultruded rods being retained in either tension or compression stresses apply pre stressing via interfacial behavior. The new system improves the efficiency of structural composites by tailoring the stress system within structure to fully utilize the structural potential of various components, and to avoid premature local failures within composite structures. A method for producing a pre stressed rod stiffened composite structure is also provided.

Multipurpose concrete form panels are constructed using cross stiffener members for resistance to deflection under load. Each of the cross-stiffener members is formed of a base strip of metal with a pair of parallel ribs of hat section extending there from and joined to opposite side rails of the form panel. Rail stiffener strips are fastened to the side rails on alternate sides of the rail for added rigidity. Bores for connecting pins extend through the side rails to join the panels side by side to form a wall or, using a corner form, to form a column. Bores through the side rails are positioned between the cross-stiffener members and between the ribs in each pair of ribs for joining the side rails together with continuity of the cross-stiffener members for maximum dispersal of stress. Holes for wall ties extend through the face of the form panel and between the ribs in each pair of ribs. Fasteners for the ends of the wall ties engage the pairs of ribs to disperse localized stress.

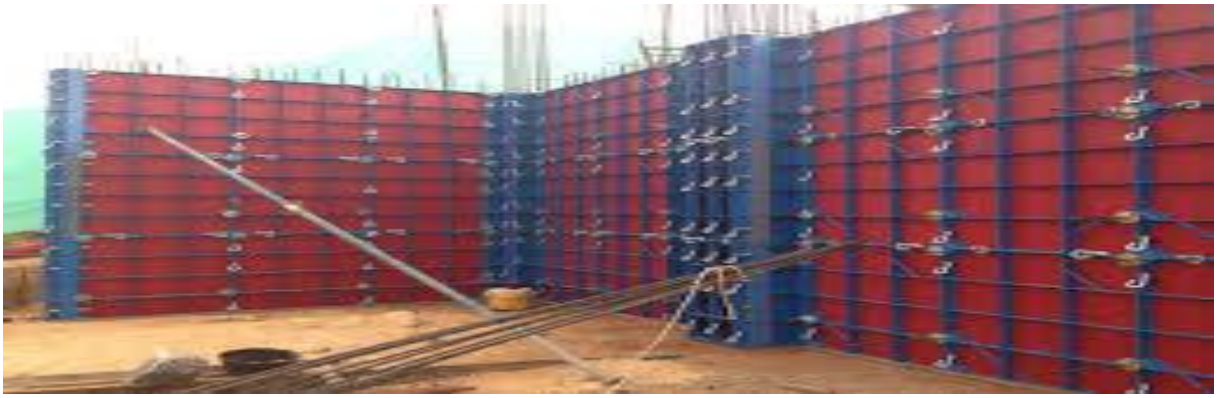


Figure 62: Stiffening rods to panels

Self-Check -3	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. Stiffening rods to concrete panels used to resist deflection under load.

   A. True B. False

2. One of the following is not the purpose of stiffening rods to concrete panels:

   A. Avoid premature local failures within composite structures
   B. Resistance to deflection under load
   C. Improves the efficiency of structural composites
   D. Add extra load to structural composites

3. Why we attaching stiffening rods to concrete panels?

   A. Avoid premature local failures within composite structures
   B. Improves the efficiency of structural composites
   C. Resistance to deflection under load
   D. Retained either tension or compression stresses E. All

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Information Sheet-4	Locating and Placing Reinforcement Materials

4.1. Placing reinforcement bars

Reinforcing bar placing drawings are the instructions from the engineers to the contractors on how to build the structure to resist the anticipated loads. They provide the details and placing instructions so that the ironworkers can set the reinforcing bars into place at the jobsite.

Placing drawings are used to show where the reinforcing bars to be placed. Sometimes the structural and placing drawings are very specific about exactly where reinforcing bar is placed. The ironworkers need to figure out how those reinforcing bars relate to the overall dimensions of the structure.

The amount of concrete cover over the reinforcing bar is very important. If it's constructed properly, the concrete protects the reinforcing bar from corrosion. Bar supports are used to hold the reinforcing bars in place to attain the proper depth of cover. Types of bar supports range from as simple as plain concrete blocks to all-plastic chairs, to wire bar supports.

4.1.1 Placing reinforcement bars for columns and beams

There are the procedures that should be followed when reinforcement bars placed in columns and beams:

- Prepare a stand or a table for assembling the reinforcement bars.
- Check the exact size and shape of the reinforcement bars with the bending schedule.
- Start with two main bars by laying them parallel to each other. Slip in and distribute the necessary number of stirrups. Confirm the quantity of stirrups required by checking the distance required between them.
- Distribute the stirrups along the two main bars with uniform spaces as indicated in the reinforcement plan. Fix the stirrups with binding wire to the two main bars.

- Slip in the remaining main bars and tie them to the stirrups. Make sure the stirrups are tied to the main bars in a right angle.
- The assembled reinforcement can now be placed into the correct position in the form works, i.e. for a column, beam orlintel.
- Once the reinforcement has been placed, fix spacer blocks of the required thickness to avoid the bars from touching the formwork, thereby ensuring that the bars will be fully covered by concrete.

Figure 63: Reinforcement bars placed in columns and beams

4.1.2 Placing reinforcement bars in slabs

Procedures for reinforcement bar placing in slabs:

- Refer to the reinforcement plan for which bars to use (size, shape and quantity).
- Also confirm the required spacing between the main bars as well as the distribution bars.
- Mark with a chalk on the ground or shuttering for the slab the exact position for each main bar. Place the main bars where you have marked. Ensure again that the bars are exactly parallel and with the same distance from each other.
- Also mark where the distribution bars are to be laid (perpendicular to the main bars and on top of them). The slab reinforcement now looks like a big mesh.

- Bind all distribution bars to the main bars using binding wire. Make sure all knots are firmly tied.
- When all the bars have been tied together, the entire mesh needs to be raised and placed on top of spacer blocks.
- For slabs where also an upper reinforcement mesh is required, the same placing and binding arrangements are applied as for the lower one. Instead of spacer blocks, the upper mesh is fixed to chairs in order to lift it to the required height.

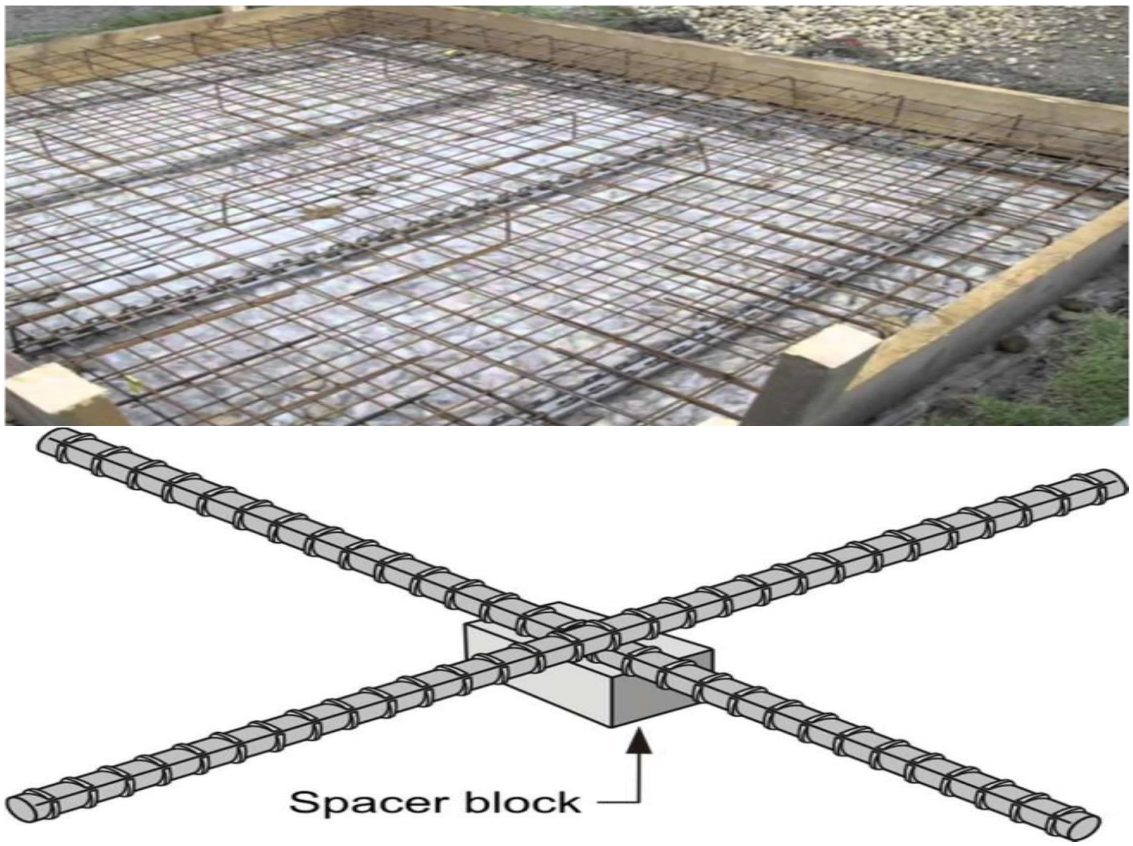


Figure 64: Placing reinforcement in slabs

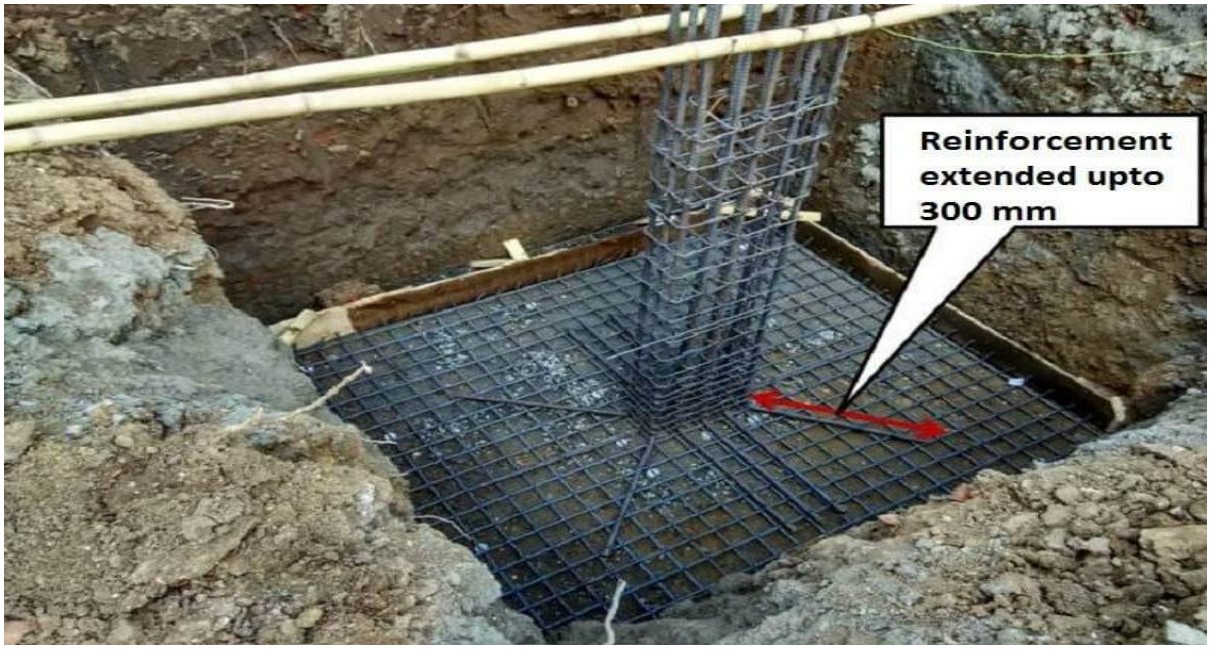


Figure 65: Placing reinforcement in footing

Self-Check -4	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (3 pts each)

1. Reinforcing bar placing drawings used to:
   A. As instructions from the engineers to the contractors
   B. Show where the reinforcing bars to be placed
   C. Provide details and placing instructions D. All

2. What is the main function of **spacer blocks** in reinforcement placing?
   A. Avoid failures formwork
   B. Support the formwork
   C. Avoid the bars from touching the formwork
   D. Improves the efficiency of structural composites

3. Why we avoid the bars from touching the formwork?
   A. To prevent damage
   B. To cover bars fully by concrete
   C. Avoid failures formwork D. To make formwork clean

4. What is the main purpose of covering bars fully by concrete?
   A. To protect corrosion C. To add additional load
   B. To avoid personal contact D. To prevent formwork

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____
Rating: _____

1. _____
2. _____
3. _____
4. _____

Information Sheet-5	Locating and securing Cast-ins

5.1 Cast-in-place concrete

Cast-in-place concrete, also known as poured-in-place, is a concreting technique which is undertaken in situ or in the concrete component's finished position. Cast-in-place concrete is the preferred choice for concrete slabs and foundations, as well as components such as beams, columns, walls, roofs, and so on.

The concrete is typically transported to site in an unhardened state, often using a ready mixed concrete truck. A chute extends from the back of the truck to place the concrete either in the required location or into a dumper or pump.

An alternative concreting technique is precast concrete which is prepared, cast and cured off-site, usually in a controlled factory environment, using reusable moulds. While cast-in-place concrete can allow for greater flexibility and adaptability, it can be difficult to control the mix particularly if weather conditions are not favorable. Cast-in-place concrete will also require a strength test and time for curing, which makes it slower to construct than precast concrete. However, there are fewer joints in the structural system not as much handling equipment is required.

Self-Check -5	Written Test

Directions: Say True if the statement is correct and false if the statement is incorrect. (2 pts each)

1. While cast-in-place, concrete can allow for greater flexibility and adaptability.
2. Cast-in-place concrete undertaken in situ or in the concrete component's starting position.
3. Cast-in-place concrete requires a strength test and time for curing, which makes it faster to construct than precast concrete.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answers

1. _____
   _____
   _____
2. _____
   _____
   _____
3. _____
   _____
   _____
   _____

Operation Sheet 1	Cutting and bending reinforcing fabric and bars

Techniques for cutting and bending reinforcing fabric and bars:

Step 1: Wear PPE

Step 2: Select tools and materials for bar bending

Step 3: Select the type of bar with appropriate thickness

Step 4: Clean bar bending and cutting table

Step 5: Measure the bar as required size

Step 6: Cut and bend bars as required

Step 7: Check the size of cut and bet bar

Operation Sheet -2	Tying/fixing of fabric and bars

Procedures for tying/fixing of fabric and bars:

Step 1: Wear appropriate PPE.

Step 2: Select tools and materials

Step 3: Prepare the tying/fixing of fabric and bars

Step 4: Locate the place where fabric and bars tied/ fixed

Step 5: Place and the fabric and bars in the appropriate place

Step 6: Tie the fixed fabric and bars with appropriate tying materials

Step 7: Checks fabric and bars wither properly ties/fixes or not

Step 8: Finally clean tools and equipments.

Operation Sheet -3	Attaching stiffening rods to panels

Procedures for identifying and preventing services:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare stiffening rods

Step 4: Select the panels which will be attached with stiffening rods

Step 5: Attach stiffening rods with panel

Step 6: Check the attachment

Step 7: Clean tools and materials

Operation Sheet -4	Locating and placing reinforcement materials

Procedures for identifying and preventing services:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare reinforcement materials

Step 4: Identify the place where reinforcing materials placed

Step 5: Place reinforcement materials

Step 6: Check the appropriate placement of reinforcement materials

Step 7: Clean tools and materials

Operation Sheet -5	Locating and securing Cast-ins

Procedures for identifying and preventing services:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare Cast in concrete

Step 4: Locate/ identify the place

Step 5: Cast in concrete

Step 6: Prevent/protect it from unfavorable weather

Step 7: Clean tools and materials

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 6 hours.

Task 1: Cut and be reinforcing fabric and bars

Task 2: Tie/fix of fabric and bars

Task 3: Attach stiffening rods to panels

Task 4: Locate and place reinforcement materials

Task 5: Locate and secure Cast-ins

Instruction Sheet	Learning Guide 64: Erect formwork

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Understanding concepts of Formwork
- Clearing preparing work area for safe erection
- Setting out the Formwork
- Assembling/erecting and bracing formwork
- Positioning expansion joint
- Positioning dowel joints
- Removing debris, sawdust and other waste material
- Applying release agents

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Clear work area and prepare surface for safe erection of formwork
- Set out formwork to requirements of drawings and specifications
- Assemble/erect formwork and brace to specifications
- Position expansion joints to specification and to relevant standards.
- Position dowel joints to specification
- Debris, sawdust and other waste material are removed from formwork
- Release agent is applied to manufacturers' specifications

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2,Sheet 3, Sheet 4,Sheet 5, Sheet 6, Sheet7 and Sheet 8" in page 3, 12, 15, 19, 24,32, 42 and46respectively.

4. Accomplish the “Self-check 1, Self-check 2, Self-check 3, Self-check 4, Self-check 5, Self-check 6, Self-check 7 and Self- check 8” -” in page 11, 14, 18, 23, 31, 41, 45and 48respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2,Operation Sheet 3, Operation Sheet 4, Operation Sheet 5, Operation Sheet 6 and Operation Sheet 7”in page 49, 50 and 51
6. Do the “LAP test” in page 52

Information Sheet-1	Understanding Concepts of Formwork

1.1. Concepts of formwork

Formwork is a die or a mould including all supporting structures, used to shape and support the concrete until it attains sufficient strength to carry its own weight. It should be capable of carrying all imposed dead and live loads apart from its own weight. The term ‘formwork’ includes the actual material contact with the concrete, known as form face, and all the necessary associated supporting structure.

Formwork has been in use since the beginning of concrete construction. New materials such as steel, plastics and fiberglass are used in formwork. Greater attention is being given to the design, fabrication, erection and dismantling of formwork.

Formwork Terminologies

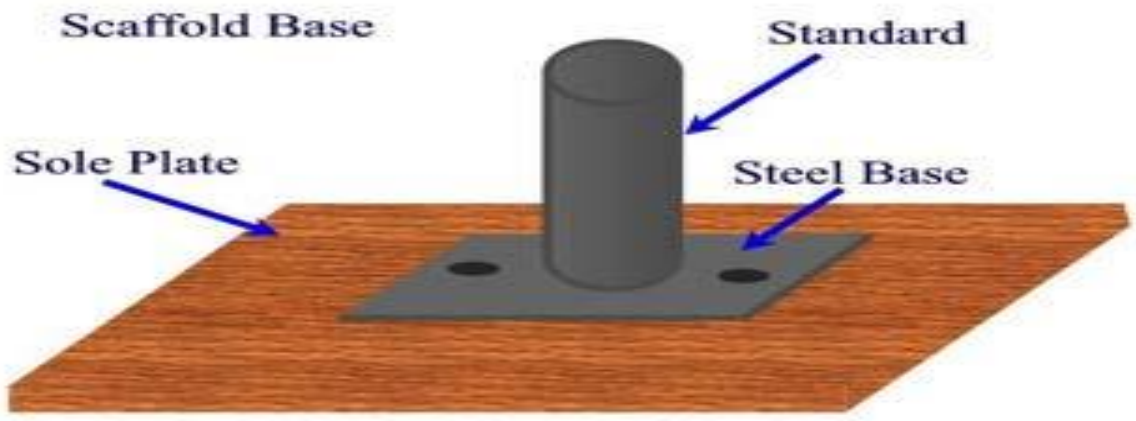


Figure 66: Parts of formwork

- **Sole plate:** A Sole Plate is a horizontal piece of timber or other rigid material, beneath a short pop or jack to distribute the load from the member above.

Figure 67: Sole plate of formwork

- **Stiffening piece:** Raking members frequently 100x75, placed on top of the riser boards, used in conjunction with cleats to prevent the rise boards, used in conjunction with cleats to prevent the riser board bending or bulging along their lengths.

Figure 68: Stiffening piece

- **Carriage piece:** A Carriage piece is similar to a joist in concrete stair formwork situations; these can be seen sitting on the bearers supporting the decking of the stair soffit.

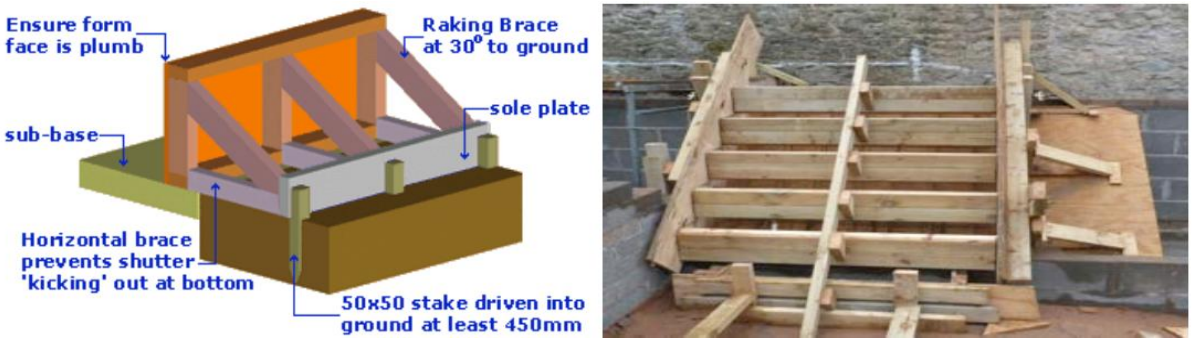


Figure 69: Carriage piece

- **Brace:** A horizontal or raking member resisting a compressive or tensile stress in a bracing system. In the image above on the right, the cleats and the braces can be easily seen.

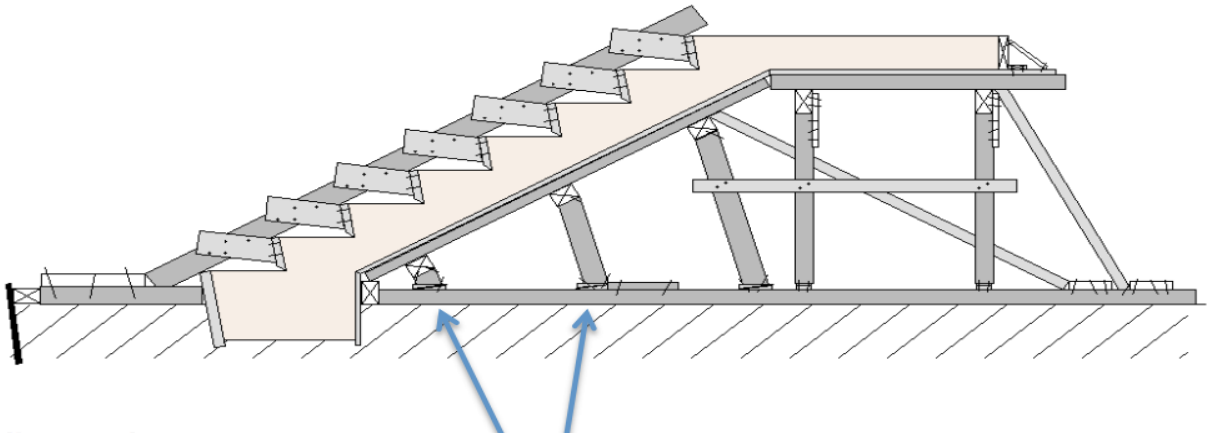
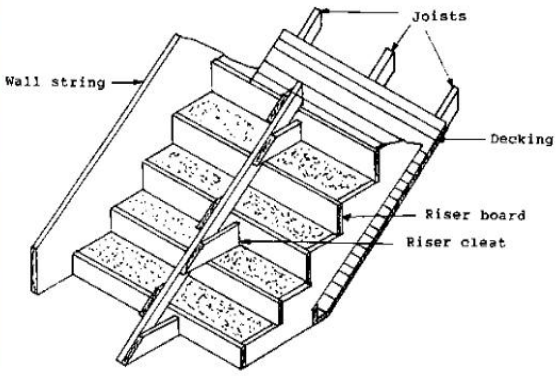


Figure 70: Brace

- **Folding wedges:** Wedges used in pairs to tighten, loosen raise or lower props or other members. Example seen in the image above. They are used to aid in the release of forms after concrete has set.



1.6 Folding wedges

- **Riser board:** The board that forms the vertical face of a step, seen above between the wall and side stringer.

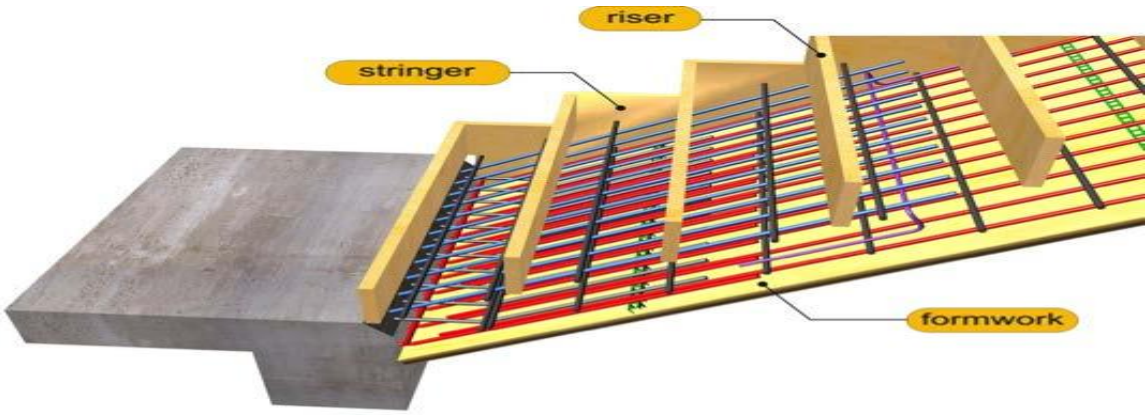


Figure 71: Riser board

- **Cleat:** A timber member nailed across a number of boards to hold them together. A block fixed to a minimum member to provide a bearing or resist a thrust.

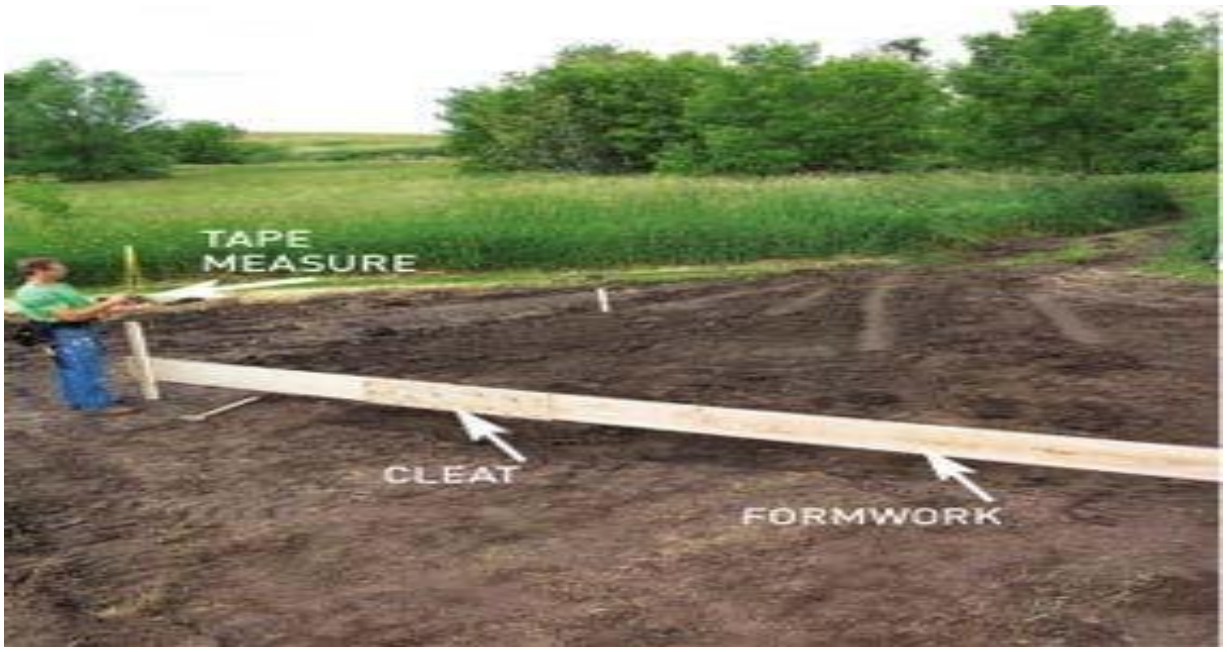


Figure 72: Cleat

- **Wall string:** A raking member fixed to the wall above the ends of the riser boards, where the stairs are constructed against an existing wall and to which cleats are fixed which then hold in position the ends of the rise boards.

Figure 73: Wall string

Outer string: A raking member of formally or boards cleared together, placed on edge and set at right angles to the raking decking to resist the lateral thrust of the wet concrete, and to take cleats which position the riser boards.

Figure 74: Outer string

In order to successfully carry out its function, formwork must achieve a balance of following requirements:

- **Containment:** formwork must be capable of shaping and supporting the fluid concrete until it cures.
- **Strength:** formwork must be capable of safely withstanding without distortion or danger the dead weight of the fluid concrete is placed on it, labour weight, equipment weight and any environmental loadings.
- **Resistance to leakage:** all joints in form work must be either close fitting of covered with form tape to make them grout tight. If grout leakage occurs the concrete Will leak at that point. Leakages cause honeycombing of the surface.
- **Accuracy:** formwork must be accurately set out so that the resulting concrete product is in a right place and is of correct shape and dimensions.

- **Ease of handling:** form panels and units should be designed so that their maximum size does not exceed that which can be easily handled by hand or mechanical means. In addition, all formwork must also be designed and constructed to include facilities for adjustments, leveling, easing and striking without damage to the form work or concrete.
- **Finish and reuse potential:** the form face material must be selected to be capable of consistently imparting the desired concrete finish (smooth, textured, featured or exposed aggregate etc.) At the same time, it should also achieve the required number of reuses.
- **Access for concrete:** any formwork arrangement must be providing access for placing of the concrete. The extent of this provision will be dependent on the ease of carrying out the concrete operations.
- **Economy:** all the formwork is very expensive. On average about 35% of the total cost of any finished concrete unit or element can be attributed to its formwork; of this just over 40% can be taken for material for formwork and 60% for labour. The formwork designer must therefore not only consider the maximum number of times that any form can be reused, but also produce a design that will minimize the time taken for erection and striking.

1.2 Construction of formwork

The following are constructions of formwork:

- **Propping and centering:** The props used for centering may be of steel, timber post or bellies. Pillars made up of brick masonry in mud mortar are also sometimes used as props.
- **Shuttering:** can be made up of timber planks or it may be in the form of panel unit made either by fixing ply wood to timber frames or by welding steel plates to angle framing.
- **Provision of camber:** Certain amount of deflection in structure is unavoidable. It is therefore desirable to give an upward camber in the horizontal member of conc. Structure to counteract the effect of deflection.

- **Surface treatment:** Before laying concrete, the formwork should be cleaned of all rubbish particularly the sawdust savings & chippings etc. and treated with release agent like raw linseed oil or soft soap solution as to prevent the concrete getting struck to the formwork.
- **Order and method of removing formwork:** Shuttering forming vertical faces of walls, beams & column sides should be removed first. Shuttering forming soffit to slab should be removed next. Shuttering forming soffit to beams, girders or other heavily loaded member should be removed in the end.

As according to the nature of work, the Reinforced Cement Concrete may be cast-in-situ or pre-cast that comprises of the operations - formwork, reinforcement and concreting. The formwork is a sort of temporary construction, which conforms to the shape, lines and dimensions as shown on the plan.

A good formwork should satisfy the following requirements:

- **Erection and Release:** It should be designed and constructed in such a manner that the forms can be removed in desired sequence without damaging the surface of concrete or disturbing other sections or causing collapse of the formwork systems. The connections joining various components of the formwork should be capable of being easily removed while formwork stripping.
- **Ease of Inspection:** The scheme of false work should facilitate adequate and safe access to all areas for inspection. Care should be taken to see that no piece is keyed into the concrete
- **Shape and size:** It should be erected such that the shape and dimensions of the concrete structures are conforming to the drawings, the specifications and tolerances. Chamfers, beveled edges and moldings if specified, should be provided in the forms.
- **Finish:** It should be hard enough so as to not to get damaged due to operations of reinforcement fixing, pouring and vibrating of concrete and removal of forms. The materials of formwork should depend upon the final finished surface required.
- **Reuse:** It should be designed and planned to permit maximum reuses, reducing the cost of concrete work. While avoiding un-safe or poor practices, adequate

planning should be done right from initial stages to develop a viable re-use plan, utilizing member sections and sizes that will involve minimum material cutting, wastage and minimum assembly.

- **Rest on firm base:** The formwork should rest on firm base to handle easily using available equipment or manpower and to provide easy and safe access for concrete handling and placing.

Figure 75: Construction of canal formwork

Self-Check -1	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. _____is a supporting structure, used to shape and support the concrete until it attains sufficient strength to carry its own weight.
   A. Reinforcement C. Formwork
   B. RCC D. Stirrup
2. Which one of the following included in constructions of formwork?
   A. Bar bending Bar cutting
   B. Shuttering Locating bar
3. Which requirements should be satisfied for good formwork?
   A. Erection and Release C. Shape and size
   B. Rest on firm base D. Reuse E. All
4. What is the main purpose of formwork surface treatment?
   A. Prevent concrete struck to the formwork
   B. Stuck concrete to the formwork
   C. Make the formwork strong
   D. Increase concrete durability

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

Rating: _____

1. _____

2. _____

3. _____

4. _____

Information Sheet-2	Clearing preparing work area for safe erection

2.1 Site clearing for formwork erection

Scrape off the top soil with grass roots in it, then level and compact the sub-soil which has been uncovered. Sloping sites will need to be cut and filled where the slab is to be placed. Most soil can be used for fill. Clay fill is not recommended. If the site is clay, cut material should be removed and granular filling (coarse sand or gravel) used to fill the low side of the site. The formwork must be well staked in place and thick enough so as not to bend under the load of fresh concrete placed against it. Formwork must be rigid.

Prepare the Ground:

- Hammer wooden pegs into the ground to mark out the area you want to concrete.
- Use wooden pegs about 25mm square and long enough to be rigid when driven into the ground.
- Stretch a strong string or twine between the pegs.
- Cut pegs off at length of timber.
- Decide how high you want the concrete in relation to the ground around it.
- Remove turf or loose soil from the marked-out area.
- If the ground is soft - spread sand or ashes to make a better base.
- Fill any holes or uneven ground with stones, broken bricks or clean fill. (Final leveling is best done with sand after you've put in the formwork).
- When the whole area is flat, compact it by rolling, walking or driving over it and hosing lightly. The more it settles - the better the foundation for the concrete

Cleaning site is much safer for the workmen than a dirty one and also used to construct the building components without problems (injuries). The preliminary site works for a construction project usually begin after the site facilities are set up.

Cleaning the site means.

- Removed all vegetation such as bushes and scrub
- The roots of trees and bushes must be dug out and cleaned away.

- Unwanted topsoil also removed.

The site (working area) needs to be clear of rocks and boulders in the area where the building will be set out. It they are too large, and then the boulders or rocks must be broken into smaller pieces and taken away.

Cleaning the site can be done by a combination of manual and mechanical methods. Suitable arrangements for the safe disposal of waste materials must be provided. If possible, waste materials should be collected and disposed their source area. Where this procedure is impossible, these materials should be stared in a safe way (area) until they can be disposed of. Accumulation of waste should not be allowed where it will interfere with the operation of the machine or with the safety of the workmen. Cleaning tools are very essential to remove loose particles, dusts, grasses, etc before and after using the tools and also from the formwork sheathing material. Some of these cleaning tools are: -

- Fiber brush
- Brooms
- Cleaning machine
- Single bag dust extractor
- Small extractor

Self-Check -2	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. The formwork must not bend under the load of fresh concrete placed against it.

   A. True B. False

2. Formwork must not be rigid.

   A. True B. False

3. Cleaning site is much safer for the workmen than a dirty one.

   A. True B. False

4. Accumulation of waste allowed where it will interfere with the operation of the machine or with the safety of the workmen.

   A. True B. False

5. Cleaning the site can be done by a combination of manual and mechanical methods.

   A. True B. False

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

Rating: _____

1. _____

2. _____

3. _____

4. _____

5. _____

Information Sheet-3	Setting Out the Formwork

3.1 Setting out formwork

Setting out lines should continue through openings, external corners etc., by a minimum of 150mm. This makes it easier to fix the formwork in position prior to concreting. It is very important that the reference points and the setting out points are protected against accidental movement or damage.

Transferring of reference points from the level below requires to be done quite accurately. Incorrect reference points give incorrect deviations therefore creating unnecessary work for the formwork erection. It is suggested a theodolite be used for transferring the points through openings provided in the slab.

A study of the deviation and kicker level survey should confirm what, if any, corrective action is required. If the kicker requires adjustment for level, loosen the holding - in bolt by turning anti-clockwise, adjust kicker to the required position and retighten the bolt. Once the vertical formwork is fixed in position, the external corners should be checked for plumpness. This will determine if further action is required to control the deviation. In addition to the kicker levels, the formwork can be pulled by using bottle screws and chain blocks. If the formwork requires to be pushed adjustable props can be used.

To avoid accidents always set elements down in such a way that they are structurally stable (guy, brace, anchor) this includes placing them down safely on the ground.

Figure 76: Setting out formwork

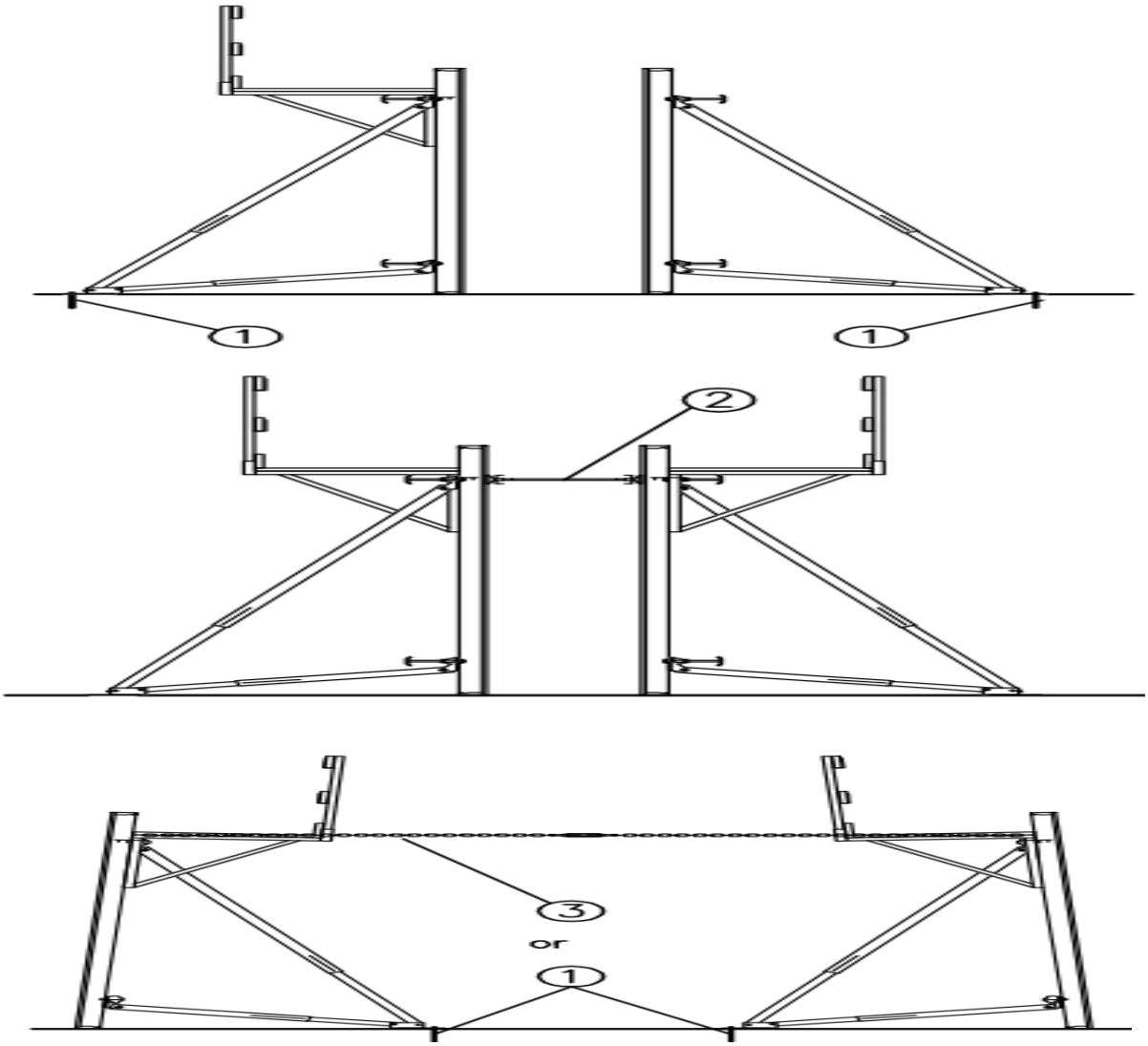


Figure 77: Double -faced formwork system

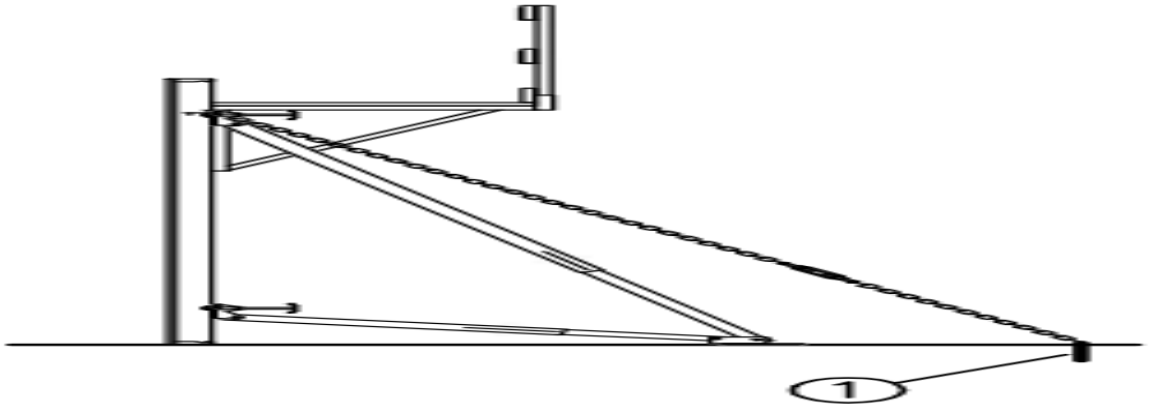


Figure 78: Single faced formwork system

Note: 1. Anchor bolt

2. Tie rod (to resist tension and compression)

3. Tie (to resist tension)

Self-Check -3	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. What is the purpose of setting out formwork?
   A. Protected against accidental movement or damage
   B. Fix the place of formwork
   C. To do quite accurate work
   D. All

2. Which one of the following materials is **not** used in setting formwork?
   A. Tie (to resist tension)
   B. Tie rod (to resist tension and compression)
   C. Anchor bolt
   D. Stirrup

3. If the formwork requires to be pushed adjustable props can be used.
   A. True B. False

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Information Sheet-4	Assembling/erecting and Bracing Formwork

4.1 Assembling/erecting and bracing formwork

Propping formwork: Collapses of formwork have been mostly attributable to incorrect propping system. This can be due to inadequate quality of propping material or improper application. It is preferable that wooden props are not used. Steel props are safer and their load carrying capacity is more predictable than that of wooden props. It is very important that steel props are also correctly used and props having defects not used in the supporting system.

The following essential tips are required to be followed at site

- Defective props should not be used. Props must be properly inspected piece by piece prior to erection. Steel tube props having a bend or crease, extensive surface corrosion, bent or damaged head and /or pin and /or base plate should not be used.
- Correct setting up of props is vital. The load carrying capacity of adjustable steel props is considerably reduced if they are erected out of plumb and/or if the load applied is eccentric. This is also applicable to plain tubular props or wooden props. No props should be more than 1 in 40 out of plumb.
- Bracings should be provided in both directions and securely clamped.
- Props at ends must be checked for verticality in each row and the rest can be inspected by visual inspection. Runners supported by props should not be off center. Maximum of 25 mm off center can be permitted.
- Props should have a firm bearing. Spreaders must be used if the supporting sub grade or base is weak in taking bearing pressures. Spreaders will not be required if bearing is directly on concrete.

4.1.1 Erecting formwork

Formwork is a temporary structural arrangement which is removed as soon as concrete is capable of taking adequate load. It is therefore to be designed in an

engineering manner so that it can withstand the pressures and loads occurring during the concreting operations and also after, till such time concrete has achieved reasonably good strength.

Each erection job is specific to its requirements and therefore will have its own individual problems. Some general tips, which may help to avoid serious problems, are given below:

- All fixtures, fittings and fastenings must be in the right place and each panel to avoid mistakes.
- All tie bolts or wall ties must be removed.
- Formwork must be cleaned and checked to ensure that nothing has fallen within.
- Avoid drilling holes or cutting standard panels.
- Any make up or fill-in pieces or closure panels should marry with the main formwork. They should be so designed that they can be easily fixed and stripped without causing any damage to themselves and the neighboring panels.
- Holes made in the formwork on site should be neat so that plugging is easier. Timber formwork must be drilled from the face to avoid splintering.
- Make sure, that while fixing the upper lift panels, the lower edge of the panel is tightly fixed against the hardened concrete of the previous lift.
- Foamed plastic strip at the panel edges, stop ends and construction joints are fixed to prevent grout leakage.
- Make sure that inserts, blocking out pieces, boxes and battens are securely fixed.
- Ensure that dirt, wooden shavings, tie wire clippings, nails etc. from the formwork are removed prior to commencement of concreting.
- Ensure that proper walkways, working platforms and approaches are available for free and safe movement of work force. Guardrails must be provided to ensure safety.
- Sloping or horizontal top forms are subjected to uplift pressure from freshly placed concrete and therefore need to be firmly restrained.
- Large prefabricated formwork panels must be provided with a spreader or lifting beam to prevent damage or distortion.

Figure 79: Erecting formwork

4.1.2 Erecting formwork frames

Formwork frames should be erected in a progressive manner to ensure both the installers safety and the stability of the overall structure. Braces should be attached to the frames as soon as practical. As erecting the frames continues, designated access ways should be indicated by using bunting or by other means.

The risk of a fall can exist on edges of formwork frames during their erection. In this situation it is necessary to install edge protection on the frames as they are erected. Provided the side bracing or other edge protection is installed progressively and as soon as enough material has been raised up, other control measures to prevent a fall occurring do not have to be provided. Many conventional formwork frames consist of diagonal braces that cross in the middle. While these braces are not considered to be suitable edge protection for a completed formwork deck, they may provide reasonable fall protection during frame erection. This is only the case where braces are installed in a progressive manner as soon as the braces are handed up to a person.

As the height of formwork frames increase, there is a greater need to provide lateral stability to the frames. Check whether framing is carried out in accordance with on-site design documentation and manufacturers' instructions. People erecting formwork must be trained to erect formwork using safe methods.

The risk of internal falls while erecting frames can be controlled by fully decking each lift of the formwork decks and any false decks provided. This involves:

- Positioning a full deck of scaffolding planks or other suitable decking at each lift
- Positioning decking on the next lift while standing on a fully decked platform
- Leaving each lift fully decked in place until it is dismantled.

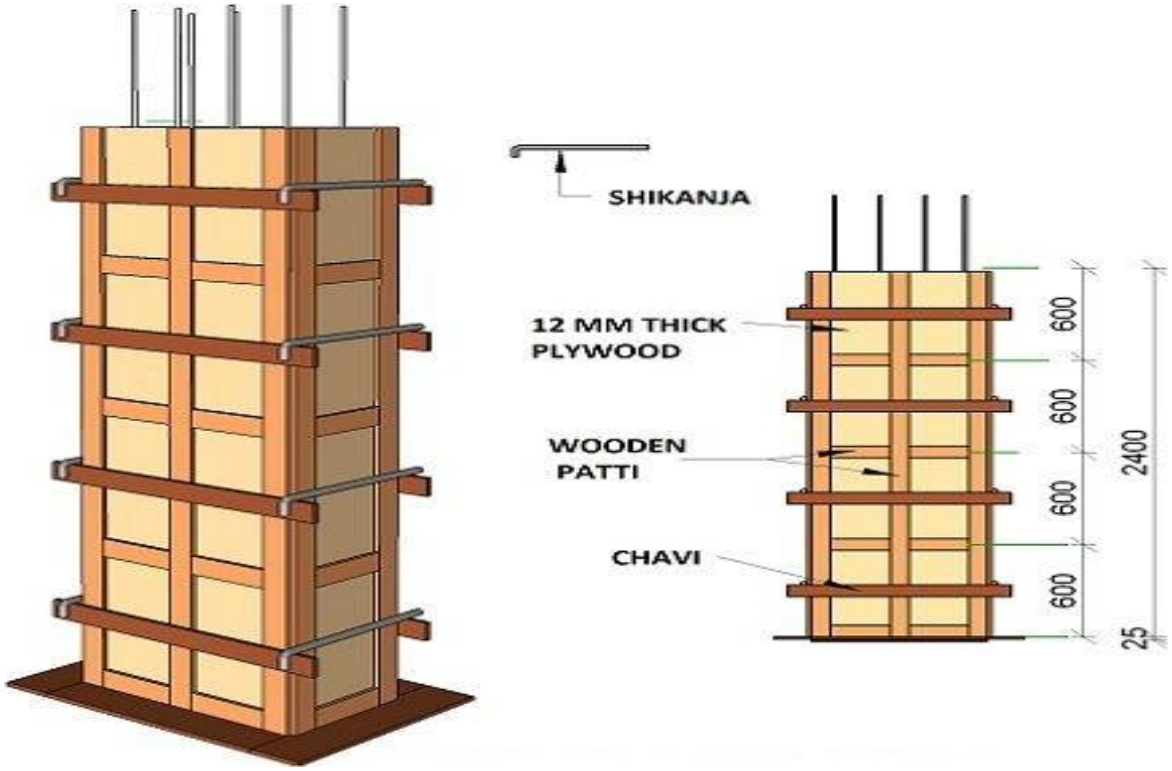


Figure 80: Erecting formwork frames

Self-Check -4	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. One of the following statements is correct.
   A. Collapses of formwork mostly caused by incorrect propping system.
   B. It is preferable that wooden props are used
   C. Wooden props are safer than steel props
   D. Defective props should be used

2. Which one of the following is essential requirement to be followed at site?
   A. Props should have a firm bearing
   B. Bracings should not be provided in both directions
   C. Correct setting up of props is not vital
   D. Defective props should not be used

3. Which may help to avoid serious problems in erecting formwork?
   A. All tie bolts or wall ties must be removed
   B. Formwork must be cleaned and checked
   C. Avoid drilling holes or cutting standard panels
   D. Holes made in the formwork on site should be neat
   E. All

4. The purpose of form of frame is:
   A. To make strong formwork
   B. Prevent risk of a fall on edges of formwork
   C. To support the formwork
   D. None

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

Rating: _____

1. _____

2. _____

3. _____

4. _____

Information Sheet-5	Positioning expansion joint

5.1 Introduction to concrete joints

Concrete joints are used to compensate when concrete expands or shrinks with changes in temperature. Concrete joints are normally used to prevent cracks when the concrete shrinks by creating forming, tooling, sawing, and placing joint formers. The pre-planned cracks will provide a better finish concrete product and will be formed in specific locations where those cracks could be monitored. Sometimes because of the material and width or span of the concrete joints are required to improve the performance of the material and allow the materials to expand/contract or move without damaging other structures.

5.1.1 Concrete contraction joints

Intended to create a weakened area in the concrete and regulate where cracks will occur, normally in a straight line. Contraction joints should be placed to produce panels that are as square as possible and never exceed a length to width ratio of 1 1/2 to 1. Joints are commonly spaced at distances equal to 24 to 30 times the slab thickness.

Joint spacing that is greater than 15 feet requires the use of load transfer devices. Contraction joints may be tooled into the concrete surface at the time of placement. Joints may also be sawed into the hardened concrete surface. It is important to understand that the longer sawing is delayed, the higher the potential for cracks to establish themselves before sawing is complete.

5.1.2 Concrete expansion joints

Concrete expansion joints are used to separate slabs and concrete from other parts of the structure. Expansion joints allow independent movement between adjoining

structural members, minimizing cracking when such movements are restrained. It allows for thermal expansion and contraction without inducing stress into the system.

Construction joints are used in circumstances where two consecutive placements of concrete meet. Construction joints are normally placed at the end of the day or be placed when concrete pour has been stopped for longer than the initial setting time of concrete. Construction joints should be designed and specified by a structural engineer. You can also achieve bond and continue reinforcement through a construction joint. If enough PCC is available at the end of the day, the construction joint can be placed at a planned transverse contraction joint.

All concrete, once placed, will contract slightly during the curing process; this is the primary cause of small surface cracks that appear during the curing process. When set, concrete will expand and/or contract slightly with ambient temperature. It is therefore advisable to incorporate some form of movement joint within larger slabs, particularly those 6m x 6m in plan or larger.

Any concrete structure that is going to require numerous movement joints, is best designed by a civil or structural engineer. Movement joints are also useful when laying concrete within an area bounded by walls or buildings, or when an object such as a manhole cover has to be incorporated within the slab, as they allow the concrete to expand and/or contract without transferring pressure onto the other structures, causing cracks within the concrete slab, or the wall, cover, etc.

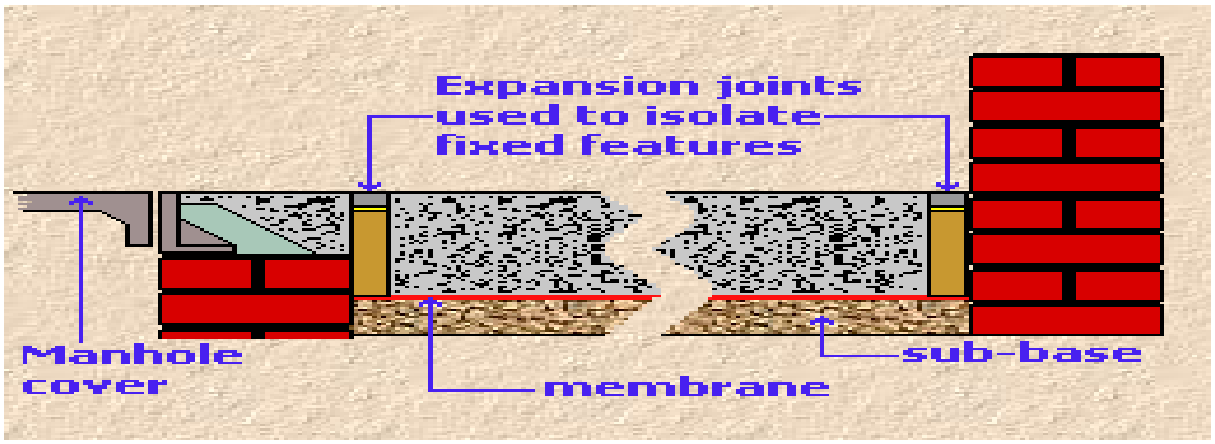


Figure 81: Movement joints

5.2 Placing of construction joints

The following recommended tips should be observed:

- Maximum Joint Spacing should be 24 to 36 times the thickness of the slab.
- Joints should be spaced about 10 feet and a maximum of 15 feet.
- When using joint groove for contraction joints, the joint should be a minimum depth of ¼ thickness of the slab.
- Saw-cut joints should be done within 4 to 12 hours after the concrete has been finished.
- Keyed joints are not recommended for industrial floors.
- Dry-cut joints should be made between 1 to 4 hours after completion of finishing.
- The pre-molded joint filler should be used to separate slabs from building walls or footings. Place 2 inches of sand over the top of a footing to prevent bond to the footing.
- If the slab contains wire mesh, it is recommended to discontinue the mesh across contraction joints.
- Joint spacing should also be chosen, so that concrete sections are approximately square.
- It is recommended to have concrete joints along column lines, either sawed or keyed.
- Metal dowels should be used in slabs that carry heavy loads.
- Plan exact locations of all joints, including the timing of saw cutting.
- Use isolation joints between slabs and columns, walls and footings and where curbs or sidewalks meet other concrete structures.
- Materials used on concrete joints must be flexible enough to absorb or deform as needed and then being able to restore back to their original state.
- Always look for materials that are permeable, and that can bond to the concrete.

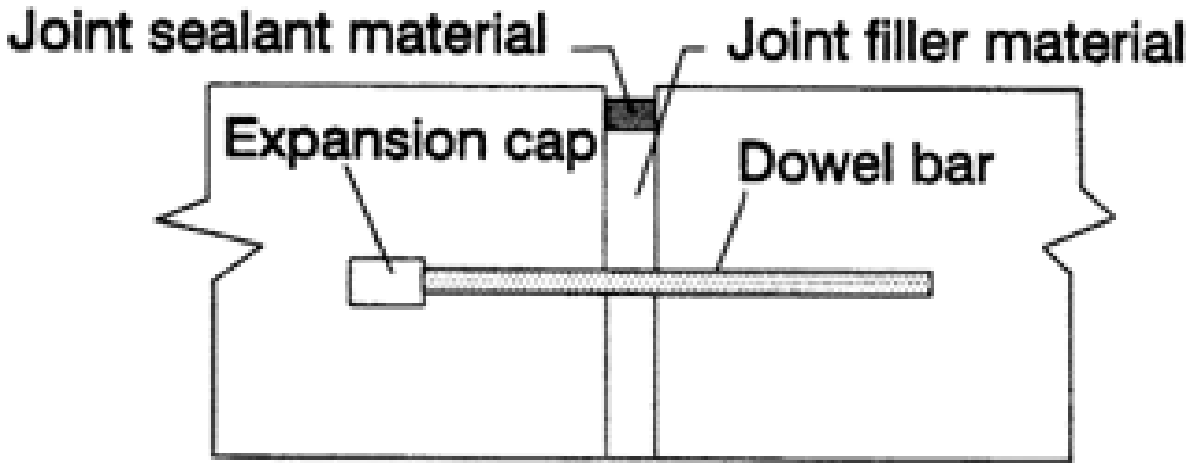


Figure 82: Expansion joint in concrete

Spacing

The usual recommendation is for some form of movement joint to be created in a non-reinforced slab at a separation of approximately 30 times the slab thickness. So, for a 100mm thick slab, there should be some for of joint every 100m × 30 = 3000mm = every 3.0-3.6m and, in a 150mm slab, 150 × 30 = 4500mm = 4.5-5.4m. Naturally, there is some leeway with these calculations, and joints can be positioned to coincide with band courses or to be 'centered' within a slab for aesthetic reasons.

5.3 Types of Joint

Different joints are used for differing purposes:

- **Expansion joints** - allow expansion and contraction of a concrete slab without generating potentially damaging forces within the slab itself or the surrounding structures. Expansion joints are usually a complete 'gap' between adjacent bays, ie, there is a definite break in the concrete and any reinforcing steel that may be present. Where adjacent bays are 'tied' together by means of dowel bars, these dowels are sleeved in one of the bays to allow expansion to take place without generating stresses within the slab.
- **Contraction joints** **-** also known as 'shrinkage joints', this type of joint allows only for contraction or shrinkage of the slab, as can be anticipated during the curing process.

- **Crack control joints -** as some wit once remarked, "There are only two types of concrete; that which has cracked, and that which is about to crack." Crack control joints are a partially-formed contraction joint that aims to ensure that when the concrete does crack, it cracks in a predictable manner at a precise location.
- **Construction joints** Although this type of joint is not a true movement joint, it is a commonly formed joint in concrete construction and so is included here for completeness. Construction joints can be horizontal or vertical and are formed when placement of the concrete is interrupted for some reason. It may be the end of a day's work or it may be that some other work needs to be completed before resuming the placement, but the result is the same - a 'surface' is formed as the placed concrete cures, and then fresh, plastic concrete is poured against this 'surface' as some later point in time.

5.4 Materials for Concrete Joints

There are numerous different materials used in forming joints in concrete slabs, but the most common are...

Flexible board: A fibrous, compressible, flexible board, such as 'Flex cell', It is cheap and readily available from Builders' merchants in pre-cut strips of the required depth, expressly for creating expansion joints. It is typically 12mm, 20mm or 25mm thick and the right thickness for the joint should be chosen. No joint should be wider than 30mm.

Figure 83: Sealed movement joint

Dowels: 400-600mm long, 20-32mm in diameter and manufactured from Grade 250 steel.

Sealants: There are three main types: -

- hot poured, usually bituminous in origin. Not as widely used nowadays as they once were.
- cold applied - often a two-part polysulphide mix incorporating resin and curing agent such as Colpor 200 or Thioflex. Usually applied via a mastic gun and smoothed with a putty knife. The most commonly used joint sealant.
- pre-formed elastomeric - expensive and, in trade parlance, a "right bastard" to work with. Need to be squeezed and inserted into a scrupulously clean and well-lubricated, perfectly formed joint.

Figure 84: Sealed movement joint

Fiberboard or 'compressible filler' joints are usually quite scruffy looking, and the soft nature of the material, which allows it to absorb expansion and contraction of the adjacent slabs, also means it will abrade and deteriorate relatively quickly. Accordingly, on projects where the finished look is important, such as the polished concrete job shown opposite, the fiberboard will often be chopped out to a depth of 30mm or so and the joint topped with a flexible sealant.

Figure 88: Fiberboard joint in polished concrete slab

The sealant is supplied in containers of various sizes, to suit the job in hand, with different sealants being used for different projects. Builders' Merchants will advise on the most appropriate sealant for a given project, if none is specified.

Before applying the sealant, the joint should be thoroughly cleaned to remove any laitance, dust or other deleterious matter. Grit blasting is the preferred method of cleaning a joint prior to sealing but a blast of very carefully aimed compressed air will usually works just as well on new joints.

Sealant tends to bond better to a dry joint and ought to be kept free from traffic for the first 24 hours. A temporary cover may be placed over the joint to prevent accidental trafficking.

Self-Check -5	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. Concrete joints used to:
   A. Compensate when concrete expands
   B. Prevent shrinks with changes in temperature
   C. Support formwork D. A and B
2. The type of joints used to separate slabs and concrete from other parts of the structures:
   A. Crack control joints C. Construction joints
   B. Concrete contraction joints D. Concrete Expansion Joints
3. 'Shrinkage joints' also known as:
   A. Expansion joints C. Construction joints
   B. Crack control joints D. Contraction joints
4. When load transfer devices require in concrete joints?
   A. Joint spacing that is greater than 15 feet
   B. Joint spacing that is greater than 10 feet
   C. Joint spacing that is less than 15 feet
   D. Joint spacing that is less than 10 feet

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

Rating: _____

1. _____

2. _____

3. _____

4. _____

Information Sheet-6	Positioning Dowel Joints

6.1 Dowelled joints

Where a large area is being covered with concrete, the slab is normally divided into a number of bays and adjacent bays are tied to each other by means of dowels, short lengths of steel bar embedded half in one bay and half in its neighbor. In alternate bay construction, the dowels are positioned in the first bay and left protruding, to be concreted over when the second bay is poured. In continuous run concreting (CRCR), a highly mechanized form of concreting normally only used on the very largest projects such a major roads and runways, the dowels are auto-inserted into the concrete as it is laid and a joint wet-formed or cut as required.

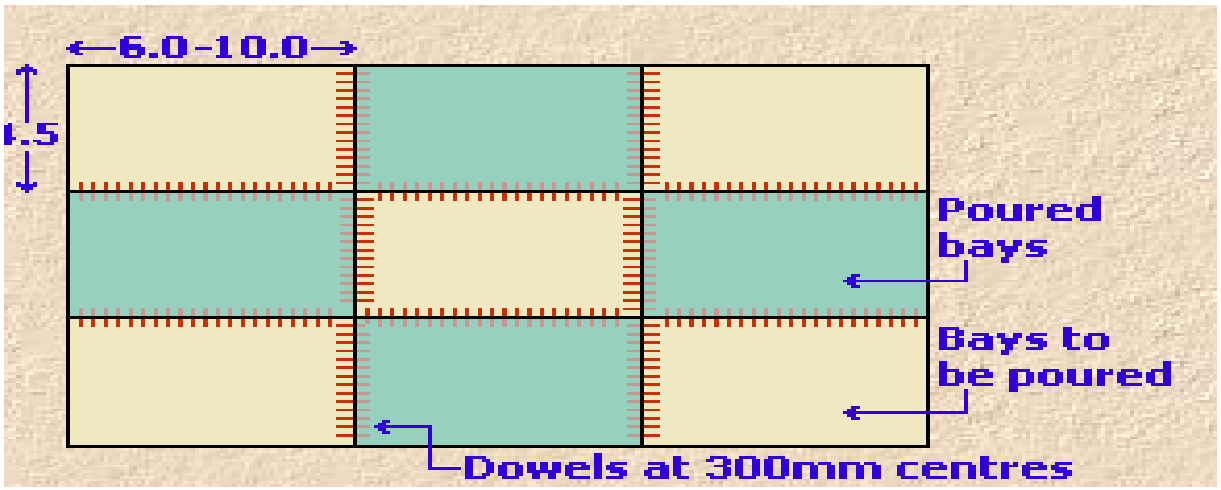


Figure 89: Alternate bay construction

The dowels should be 600mm long and manufactured from mild steel (Grade 250). In expansion joints, the dowels are 25mm diameter at 300mm centers, but for contraction joints, the dowels may be slightly shorter, 400mm in length and 20mm diameter, again at 300mm centers.

It is essential that the dowels are aligned to be level with the plane of the slab and parallel to each other to avoid the creation of stresses within the slab when movement occurs.

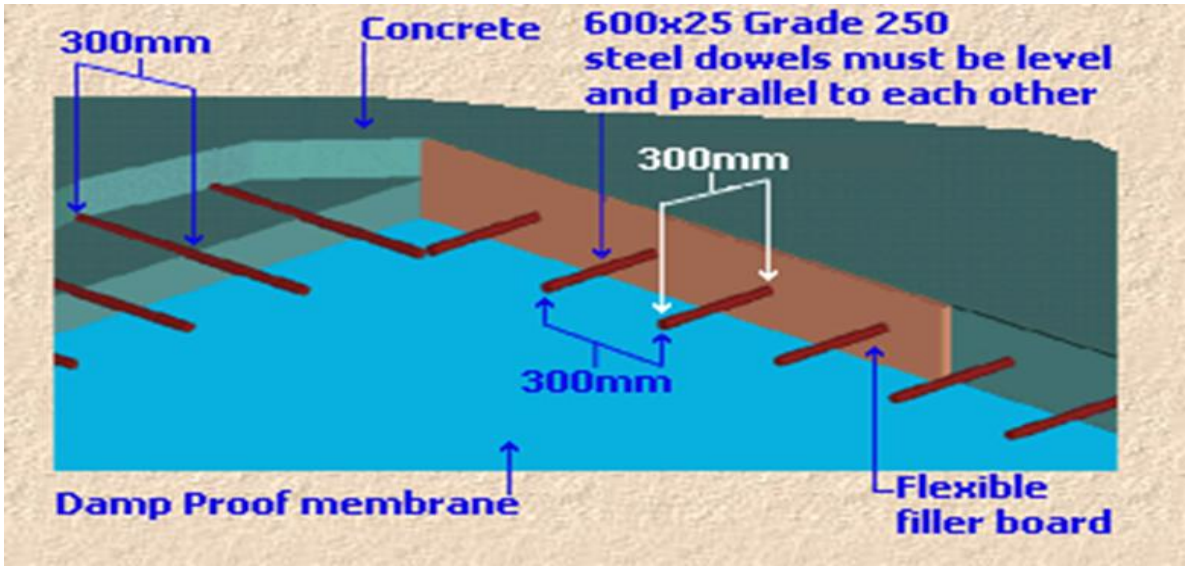


Figure 90: Dowel joints

6.1.1Dowelled expansion joints

Expansion Joints consist of a flexible piece of compressible board, such as 'Flex cell', topped with a waterproof sealant and sandwiched between adjacent bays or between the concrete slab and another fixed object. For a dowelled expansion joint, the dowel should be de-bonded to half-length to prevent it 'sticking' to the concrete and thereby limiting free movement. In heavy duty applications, such as roadways, the de-bonded half is sleeved and capped, or sheathed in plastic film, to ensure free movement. Provision must be made to support the dowels and maintain their accurate alignment while the first bay hardens.

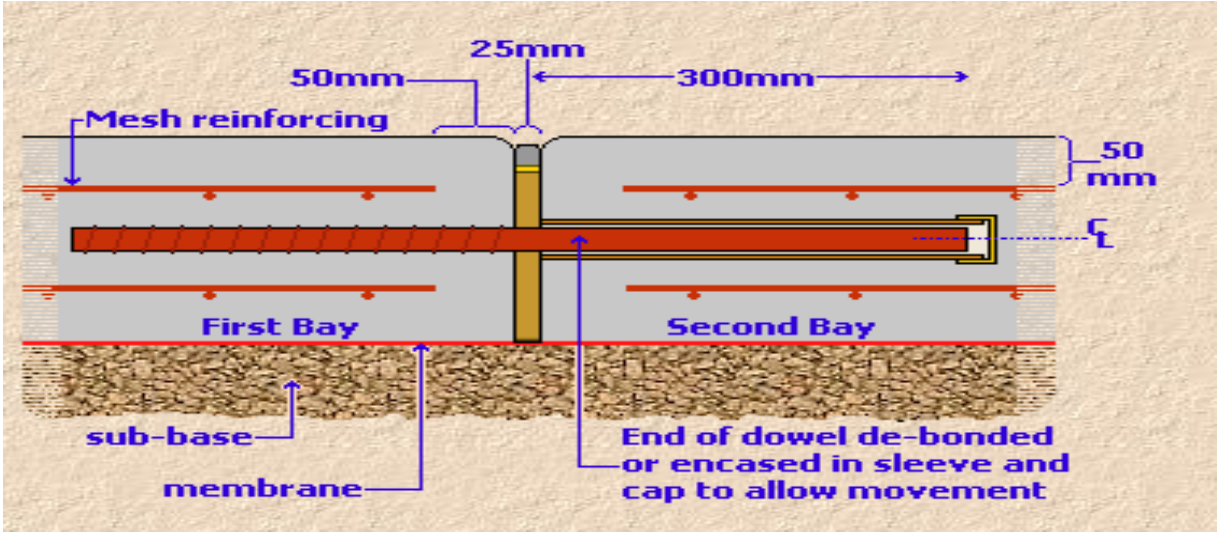


Figure 91: Dowelled expansion joints

The flexible board will need to be drilled to accommodate the dowels and the edges of the expansion joint should be arise to prevent spalling. Once the second bay has hardened, the expansion joint can be sealed with a suitable sealant to prevent ingress of water, salts or detritus.

6.1.2Dowelled Contraction Joints

With dowelled contraction joints, again the dowels are de-bonded to one half. In some cases, the sleeving will extend into the first bay so that when the completed joint is formed, the steel dowel is fully insulated from any water or salts that may find their way in to the joint.

The shutter has a temporary former attached at the top edge to create a gap that will eventually accommodate the joint sealant. The edge of the concrete is arisen to prevent spalling.

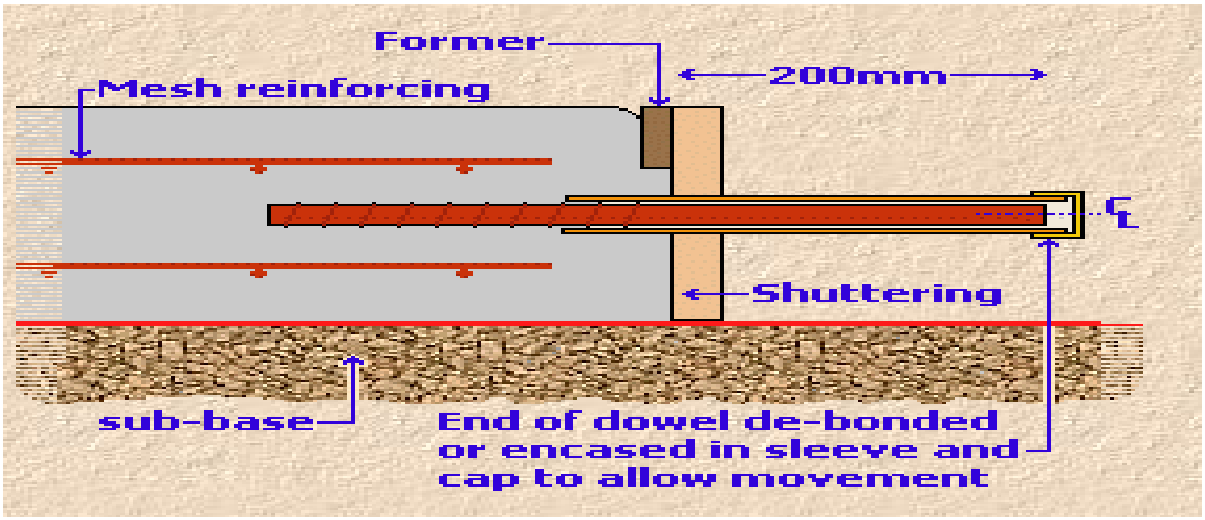


Figure 92: Dowelled contraction joints

Once the first bay has hardened sufficiently and the former and shuttering has been removed, the second bay can be poured. The tight joint between the adjacent bays generates a high degree of interlock between the aggregates. After a period of hardening has been allowed for the second bay, the joint can be sealed with the appropriate sealant.

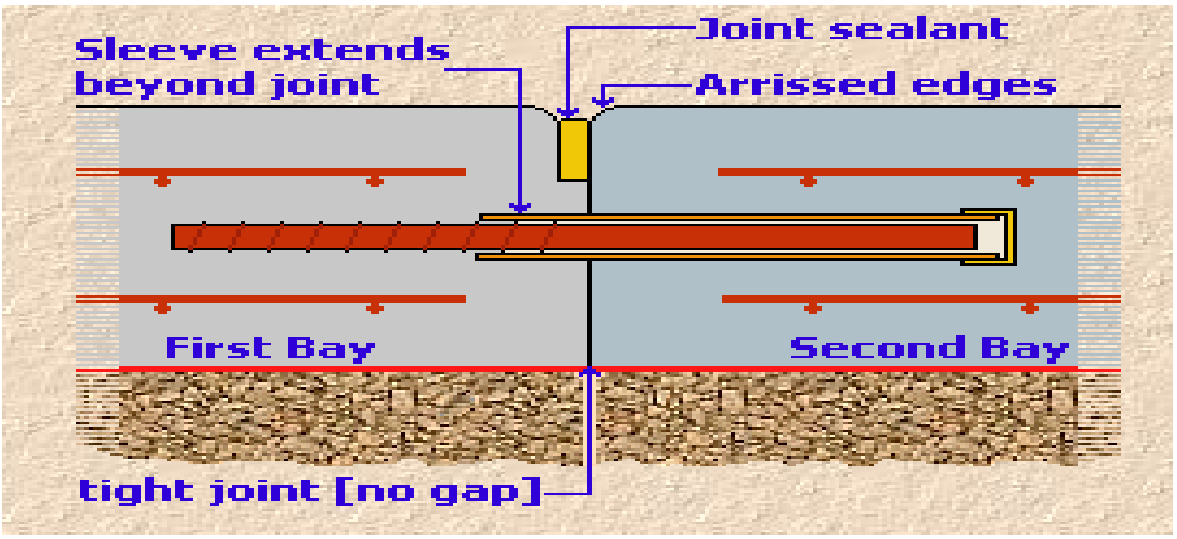


Figure 93: Sealed joints

6.1.3Dowelled control joints

Dowelled control joints (dummy joints) are most commonly used on highway and airport runway constructions, where continuous run concrete trains are used and the dowels can be automatically inserted.

A crack inducer at the base of the concrete slab may be incorporated and a 'starter' joint created by sawing at a critical point during the curing process or insertion of a wet-former when the concrete is placed.

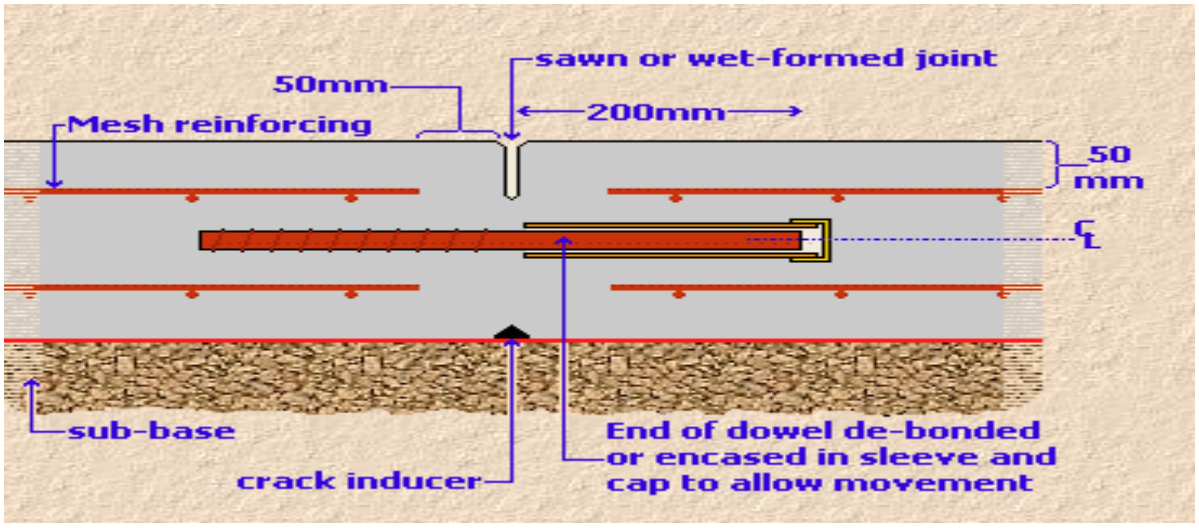


Figure 94: Dowelled control joints

6.2Non-dowelled Joints

Non-dowelled joints tend only to be found in light-use applications, such as residential paths, patios and driveways. There is a good argument for all joints to be dowelled unless there are extenuating circumstances, but site practice and tradition tends to follow the simplest, cheapest option when left to its own devices.

6.2.1 Expansion joints

Non-dowelled expansion joints are not particularly common between two new concrete bays, but they are occasionally encountered as the joint between a new

concrete slab and another fixed feature, such as a wall, as the wall (or other feature) is not capable of being dowelled.

This series of 3 diagrams illustrates the formation of an expansion joint between two new slabs, but the same principles apply for constructing an expansion joint between a wall and a slab.

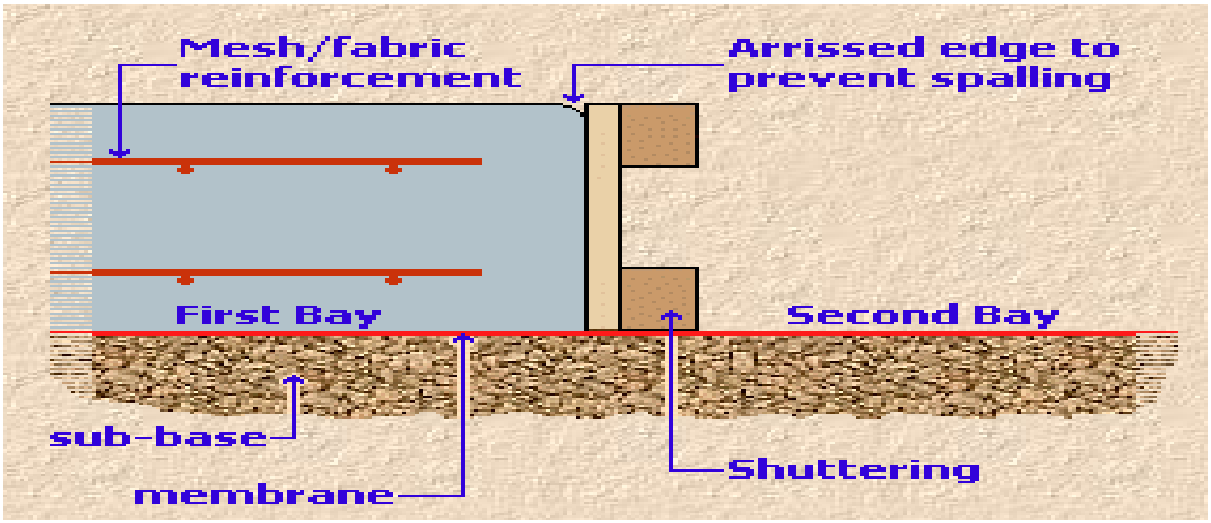


Figure 95: Non-dowelled expansion joints

The flexible strips should be placed vertically against a solid edge, such as a wall or to the face of an already cast concrete slab and are typically set 30mm below the finished surface level of the concrete to accommodate the sealant and a bond-breaker, if one is specified. A temporary filler strip may be positioned on top of the flexi-board to keep the joint free of concrete during placement. This temporary filler strip is removed once the concrete has hardened to reveal the required gap for the sealant.

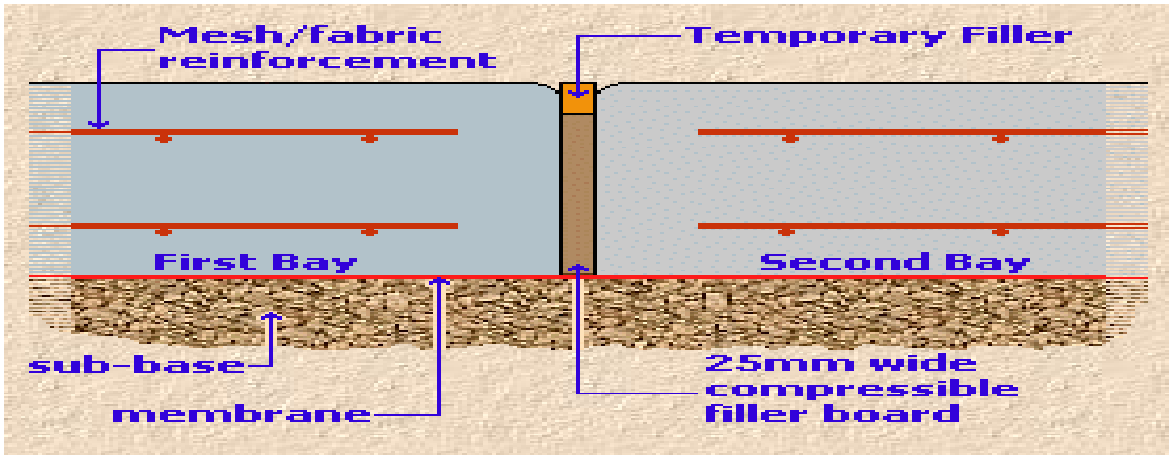


Figure 96: Sealed non dowelled expansion joints

The top of the joint should be sealed with an appropriate sealant which is left slightly lower than the top of the joint. When sealing an expansion joint between a slab and a wall, a cold-pour sealant applied via a mastic gun is the easiest option.

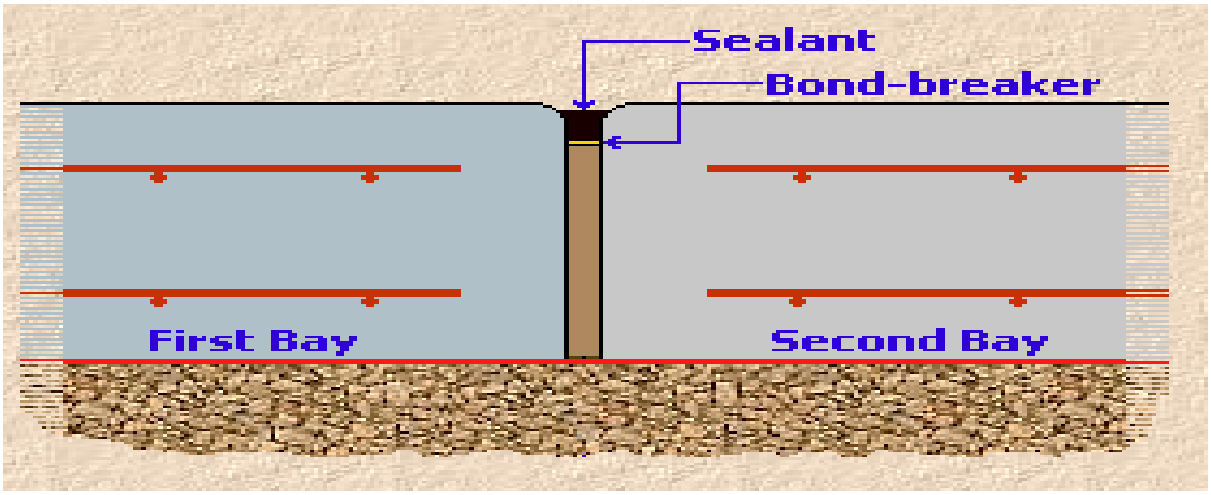


Figure 97: Cold-pour sealant

6.2.2Contraction Joints

Contraction joints are the simplest of joints in that they are basically a break in the concrete and the reinforcement created to allow the natural shrinkage of concrete (because of curing and/or temperature change) to take place without generating crack-inducing tensile forces within the slab.

They are formed by embedding a 25×25mm timber or plastic joint-former into the still wet concrete, then removing it once hardening has taken place, and filling the void with a suitable sealant.

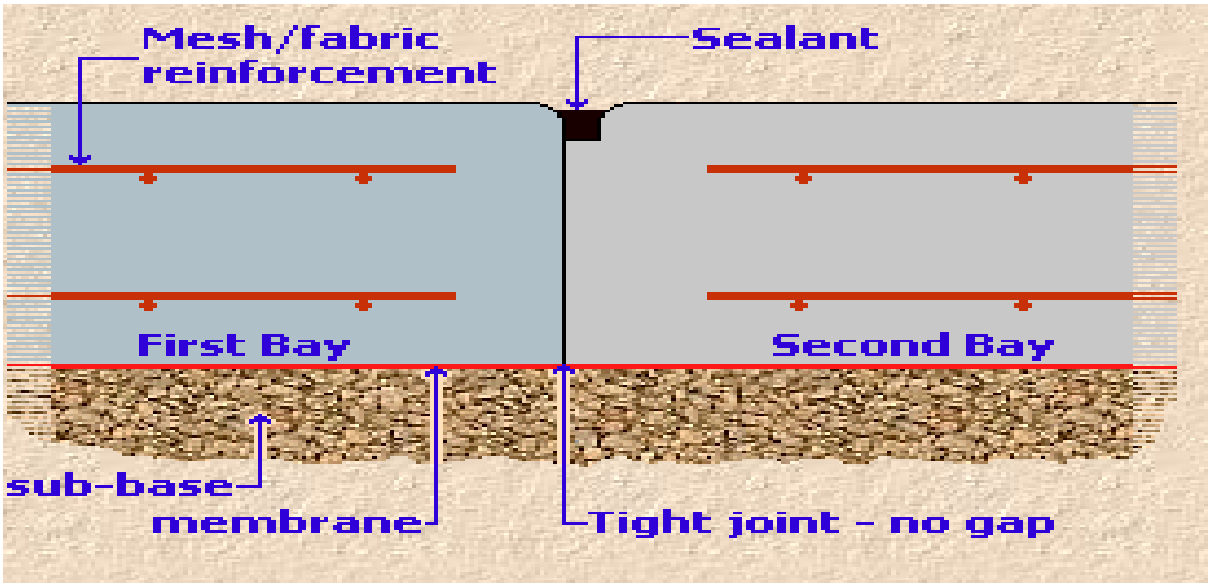


Figure 98: Contraction Joints

6.2.3 Crack Control Joints (Dummy Joints)

This type of joint is most commonly encountered on Pattern Imprinted Concrete paving, particularly residential driveways and patios. For creation during construction, the control joints may be pre-formed using a timber strip and/or a Grooving Trowel. The inclusion of a crack inducer will help ensure cracking takes place in exactly the right place. Depending on the type of joint required, additional work may be necessary once the concrete has cured. If a timber or other temporary former has been used to create the wet-formed joint, it should be removed and the joint sealed with a suitable sealant, usually a polysulphide such as Thioflex.

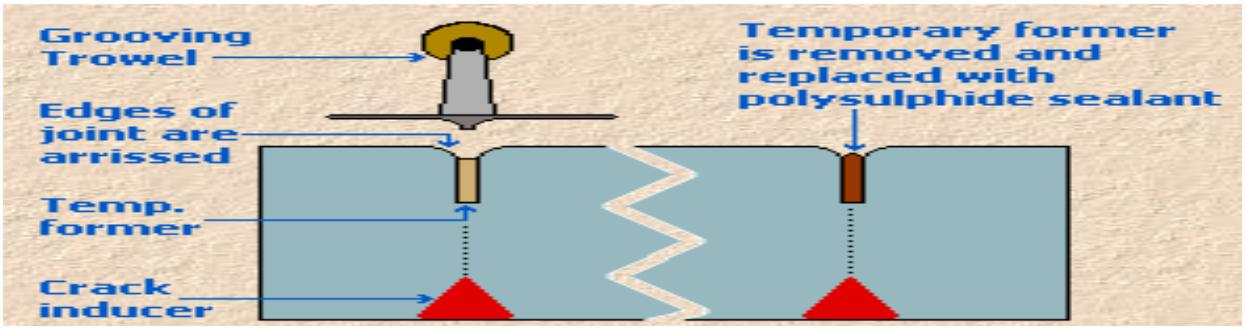


Figure 99: Wet-formed crack control joint

Sawn joints are normally cut a week or more after sealing, so that the concrete will have had a reasonable amount of time to cure and avoid 'spalling' at the cut edges, and for the sealant to protect the surface from the concrete dust. On no account should concrete dust be allowed to rest on the surface for any length of time as it will set and could damage the surface when forcibly removed.

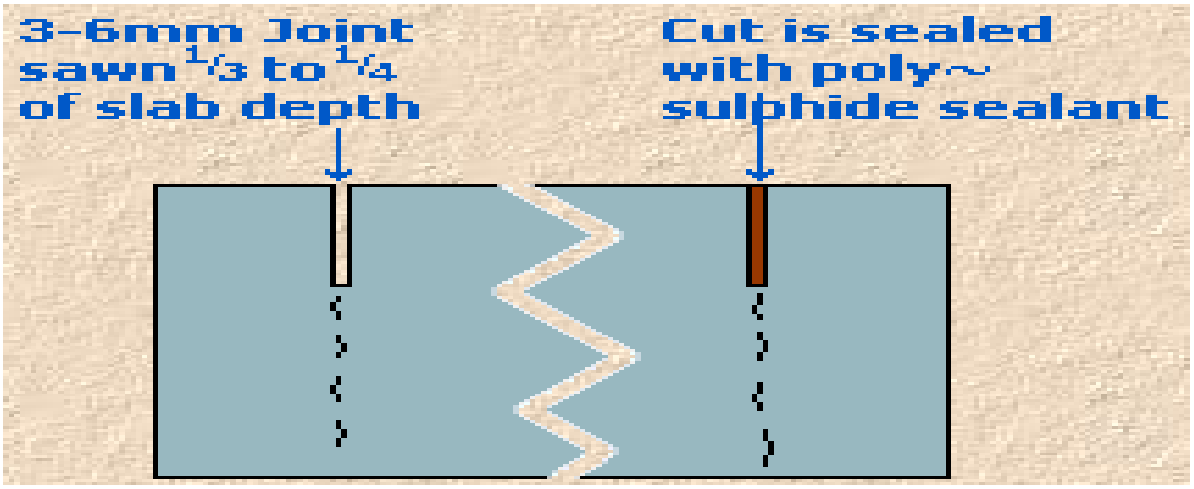


Figure 100: Sawn crack control joint

Self-Check -6	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. The joints that used to tie adjacent bays of a slab to each other is:
   A. Non-dowelled expansion
   B. Non-dowelled Joints
   C. Dowelled Joints
   D. Sealed non dowelled expansion joints
2. The simplest of joints in that they are basically a break in the concrete and the reinforcement created to allow the natural shrinkage of concrete is:
   A. Crack Control Joints
   B. Expansion Joints
   C. Contraction Joints
   D. Dowelled Joints
3. Joint between a new concrete slab and another fixed feature is known as:
   A. Contraction Joints
   B. Non-dowelled expansion
   C. Dowelled Joints
   D. Crack Control Joints (Dummy Joints)

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Information Sheet-7	Removing debris, sawdust and other waste material

6.1 Cleaning formwork

Before laying concrete, the formwork should be cleaned of all rubbish particularly the sawdust shavings and chippings etc. All surfaces of timber shuttering that are to come in contact with concrete should be well wetted with water to prevent the chances of dry shuttering timber absorbing water from the concrete that may cause warping, swelling and distortion to timber besides resulting in defect of honeycombing in concrete. Similarly, steel forms that have been exposed to hot weather should be cooled by watering before laying concrete.

Any surplus is to be removed from those areas in contact with the concrete immediately after striking. Following this, the release agent can be applied. For cleaning, only tools may be used which do not damage the form lining and any other system parts. The use of sandblasting equipment, angle grinders, wire brushes and pointed tools lead to damage.

Thorough cleaning by air hose and surface wetting of the formwork before concreting is essential. Lack of bond between concrete and formwork should be ensured by applying suitable ‘release agent’.
In addition, all surfaces of shuttering which are to come in contact with concrete should be given a good coating of raw linseed oil or soft soap solution or any other material so as to prevent the adhesion of to formwork and thus facilitate easy removal. It is, however, important to note that the coating should not come in contact with reinforcement. The selected coating should be impermeable and should neither get flaky on exposure to weather nor stain the surface of concrete.

6.1.1 Sealing of edges and holes

At the production plant, coated plywood is protected with a coat of varnish along all four edges to protect it against moisture. You should restore this protection again after sawing or drilling.

- Use sharp, suitable tools when working on the formwork panels.
- Seal unprotected edges and drill holes at least once with edge protective paint.

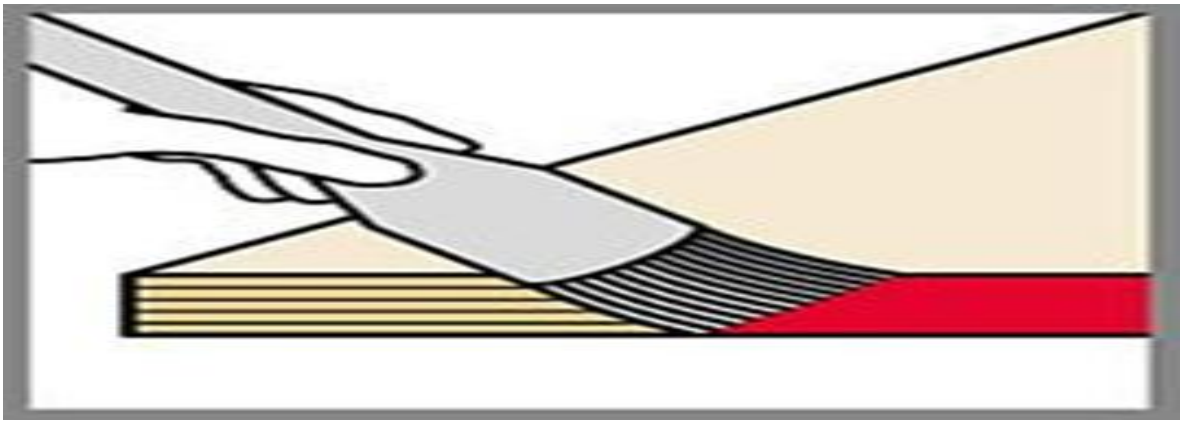


Figure 101: Sealing of edges and holes of formwork

6.1.2 Lubricate before use

Treat the formwork panels regularly with a suitable release agent. Apply a thin and even film of release agent and smoothen it. Excess amount has to be removed with a cloth or a wiping mop. You can achieve the best results with high-quality concrete release agents.

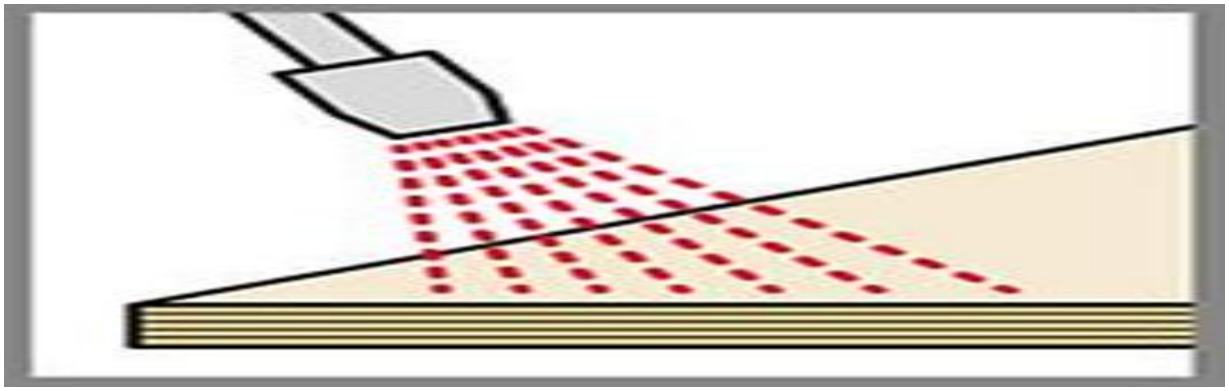


Figure 102: Lubricate before use

- Use suitable fasteners for the retaining of recess units and built-in parts to reduce the damage to the form lining.
- Avoid walking on the form lining surface. Soil on the sole of the shoes might lead to scratches on the form lining, and this might show on the concrete surface.
- Spacers for reinforcement should be used with large supports. This helps to avoid indentations on the form lining in case of loads.

Self-Check -7	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. Why all surfaces of timber shuttering that are to come in contact with concrete should be wetted with water?
   A. To prevent abortion of water from concrete
   B. To make it strong
   C. To avoid the direct contact of water
   D. To cure concrete
2. Coating of formwork surface with raw linseed oil or soft soap solution or any other material is used:
   A. To contact reinforcement bar
   B. Make formwork strong
   C. For easy removal formwork
   D. All
3. Which one of the following is true?
   A. Excess amount of release agent applied to formwork
   B. Spacers for reinforcement should not be used with large supports
   C. Walk on the form lining surface
   D. Apply a thin and even film of release agent and smoothen i

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Information Sheet-8	Applying Release Agents

8.1 Release Agents

Before lying concrete, the formwork should be cleaned of all rubbish particularly the sawdust shavings and chippings etc. All surfaces of timber shuttering that are to come in contact with concrete should be well wetted with water to prevent the chances of dry shuttering timber absorbing water from the concrete that may cause warping, swelling and distortion to timber besides resulting in defect of honeycombing in concrete. Similarly, steel forms that have been exposed to hot weather should be cooled by watering before laying concrete.

In addition, all surfaces of shuttering which are to come in contact with concrete should be given a good coating of raw linseed oil or soft soap solution or any other material so as to prevent the adhesion of to formwork and thus facilitate easy removal. It is, however, important to note that the coating should not come in contact with reinforcement. The selected coating should be impermeable and should neither get flaky on exposure to weather nor stain the surface of concrete.

8.2 formwork coatings and releasing agents

Formwork in contact with concrete may be treated with a coating or releasing agent of approved composition. The type of coating and its composition depends upon the type of shuttering material used and its surface, which would be in contact with concrete. Coating and release agent should

- Provide a clean easy release or strike without damage to either the concrete face or the form,
- Contribute to the production of blemish free concrete surface,
- Have no adverse effect upon either the form or concrete,
- Be easy to apply evenly at the recommended coverage, and
- Not inhibit adhesive of any finish applied to the formed surface.

Shuttering should be coated with suitable form release agents for easy stripping, before each used. The form release agents are temporary coatings consisting of fatty acids, which react with the alkali in cement and leave behind soap like substance on the contact surface. This helps release of the form. These may be oils, emulsified wax, oil phase demolsions with water globules, petroleum-based products, catalyzed polyurethane form, etc.

Careful consideration should be given to the choices of release agent taking account of the type of surface to which it is to be applied, the conditions under which it is to be used, the type of concrete, the quality of finish, the area of form and the ease of application.

Note: The conventional use of waste oil as release agent should not be encouraged since it does not contain fatty acids.

Releasing agents: The main purpose of treating formwork with a release agent is to make it easy to strike and release the formwork away from the concrete face. It is often observed that burnt transformer oil and other cheap oils are used as release agents. They can cause severe stains and also result in inefficient removal of formwork from the concrete surface. It is therefore extremely important to select the right type of release agent. Some commonly used release agents are a follow:

- **Neat oils with surfactants:** They can be used on steel, timber or ply faces of the formwork.
- **Mould cream emulsions:** The most general-purpose release agent used on all types of form faces.
- **Chemical release agents:** Recommended for all high-quality form finished concrete works.

As unused and untreated plywood and timber surfaces have a tendency to absorb the coating of the release agent, the surfaces should be given a primary coat of

release agent 36 hours before being used and a secondary coat of release agent should be applied just before using it for the first time.

It is important to apply the right amount of release agent in the form of a thin film. Application can be made uniformly either by brush, roller or best of all by spraying. Too thick or too much application of release agent can stain the concrete while too less release agent can cause difficulty in striking of the formwork. In case excess mould oil is put on the formwork surface, by mistake, then the excess amount can be wiped off using clean rag.

Self-Check -8	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. Steel forms that have been exposed to hot weather should be cooled by watering before laying concrete

   A. True B. False

2. The main purpose of treating formwork with a release agent is to prevent absorption of water from concrete.

   A. True B. False

3. A primary coat of release agent 36 hours before being used and a secondary coat of release agent should be applied just before using it for the first time.

   A. True B. False

4. Which one of the following is **not** true about coating and using release agents?

   A. Contribute to the production of blemish free concrete surface

   B. Have no adverse effect upon either the form or concrete

   C. Be easy to apply evenly at the recommended coverage

   D. Inhibit adhesive of any finish applied to the formed surface

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

Rating: _____

1. _____

2. _____

3. _____

4. _____

Operation Sheet 1	Clearing preparing work area for safe erection

Techniques for clearing preparing work area for safe erection:

Step 1: Wear PPE

Step 2: Select tools and materials for bar bending

Step 3: Select the area to be clear

Step 4: Prepare the area for safe erection

Step 5: Check the area either suitable for erecting or not

Step 6: Clean tools and materials

Operation Sheet -2	Setting out the Formwork

Procedures for setting out the formwork:

Step 1: Wear appropriate PPE.

Step 2: Select tools and materials

Step 3: Prepare materials for setting out

Step 4: Measure different dimensions

Step 6: Mark the lay out in the area

Step 7: Checks setting out

Step 8: Finally clean tools and equipments.

Operation Sheet -3	Assembling/erecting and bracing formwork

Procedures for assembling/erecting and bracing formwork:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare formwork with required dimension

Step 4: Erect the required formwork

Step 5: Bracing formwork

Step 6: Check the erecting formwork

Step 7: Clean tools and materials

Operation Sheet -4	Positioning expansion joint

Procedures for positioning expansion joint:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare jointing materials

Step 4: Identify expansion areas

Step 5: Place expansion joints

Step 6: Check the appropriate placement of joints

Step 7: Clean tools and materials

Operation Sheet -5	Positioning dowel joints

Procedures for positioning dowel joints:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare jointing materials

Step 4: Identify dowels that will be joined

Step 5: Place dowel joints on the identified dowels

Step 6: Check the appropriate placement of joints

Step 7: Clean tools and materials

Operation Sheet -6	Removing debris, sawdust and other waste material

Procedures for removing debris, sawdust and other waste material:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare the formwork to cleaned

Step 4: Clean the formwork

Step 5: Check all debris, sawdust and other waste material removed from formwork

Step 6: Clean tools and materials

Operation Sheet -7	Applying release agents

Procedures for applying release agents:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare formwork for applying release agent

Step 4: Apply a primary release agent to formwork 36hrs before use

Step 5: Apply a secondary release agent before use

Step 6: Check the formwork either well coated or not

Step 7: Clean tools and materials

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 8 hours.

Task 1: Clear and prepare work area for safe erection

Task 2: Set out the Formwork

Task 3: Assemble/erect and brace formwork

Task 4: Position expansion joint

Task 5: Position dowel joints

Task 6: Remove debris, sawdust and other waste material

Task 7: Apply release agents

Instruction Sheet	Learning Guide 65: Carry Out Concrete Work

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Placing concrete to specified levels and grades
- Concrete compacting method
- Concrete screening, finishing and curing
- Covering and protecting concrete surface

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Place concrete correctly to specified levels and grades
- Compact concrete to specification using immersion vibrator or other specified method
- Apply screen, finish and curing concrete process to specifications
- Cover and protect concrete surface adequately.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1, Sheet 2,Sheet 3, and Sheet 4” **in page 2, 24, 28 and 36** respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3, and Self- check 4” -” **in page 22, 27, 35 and 41** respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2,Operation Sheet 3 and Operation Sheet 4”**in page 42 and 43**
6. Do the “LAP test” **in page 44**

Information Sheet-1	Placing Concrete to Specified Levels and Grades

1.1 Concrete construction terminology

Accelerators: Admixtures that decrease the setting time by increasing the rate of hydration.

Admixture: A material other than water, aggregates, or cement that is used as an ingredient of concrete or mortar to control setting and early hardening, workability, or to provide additional cementing properties.

Aggregate: Inert solid bodies such as crushed rock, sand, gravel.

Binder: Hardened cement paste.

Bleed: To have water seep to the surface of the cement paste due to settling.

Calcinations: Decomposition due to the loss of bound water and carbon dioxide.

Cement: Finely powdered mixtures of inorganic compounds which when combined with water harden with hydration.

Cement paste: Cement plus water. When the mass has reacted with water and developed strength it is called hardened cement paste.

Clay: Type of soil consisting of very fine particles.

Compression: Forces acting inwardly on a body.

Concrete: A hard compact building material formed when a mixture of cement, sand, gravel, and water undergoes hydration.

Cure: To keep concrete moist during initial hardening.

Deformation: The process of changing the dimensions of a structure by applying a force.

Dormancy period: Time period that concrete retains it workability.

Elasticity: The ability of a material to return to its original shape after being stretched.

Forms: Holders in which concrete is placed to harden.

Gypsum: Calcium sulfate dehydrate, $CaSO_4 \cdot 2H_2O$ added to cement to regulate setting.

Hydration: The reaction of cement with water to form a chemical compound.

Limestone: Mineral rock of calcium carbonate.

Mortar: Cement paste mixed with sand.

Pozzolan cement: Volcanic rock powdered and used in making hydraulic cement.

Porosity: The amount of empty space in concrete.

Portland cement: cement consisting predominantly of calcium silicates which reacts with water to form a hard mass.

Retardants: Admixtures that increase the setting time by slowing down hydration.

Set: Transformation of cement paste or concrete from a fluid-like consistency to a stiff mass.

Slump test: Test used to determine workability.

Tension: The stress resulting from elongation.

Workability: How easily fresh concrete can be placed and consolidated in forms.

1.2 Concrete characteristics and properties

Performance of concrete is evaluated from mechanical properties which include shrinkage and creep, compressive strength, tensile strength, flexural strength, and modulus of elasticity. But compressive strength of concrete is the most important characteristic and it is generally assumed that an improvement in concrete compressive strength will improve its mechanical properties; however, in case of concrete in which cement is partially replaced by mineral admixtures, all mechanical properties are not directly associated with compressive strength and the effects of the same amount of different mineral admixtures on the mechanical properties of hardened concrete are not same. This difference of the effects of different minerals on the mechanical properties is as follows.

Properties of concrete are influenced by many factors mainly due to mix proportion of cement, sand, aggregates and water. Ratio of these materials controls the various concrete properties which are discussed below.

- Grades (M20, M25, M30 etc.)
- Compressive strength
- Characteristic Strength
- Tensile strength

- Durability
- Creep
- Shrinkage
- Unit weight
- Modular Ratio
- Poisson's ratio

- **Grades of concrete:** Concrete is known by its grade which is designated as M15, M20 etc. in which letter M refers to concrete mix and number 15, 20 denotes the specified compressive strength (f_{ck}) of 150mm cube at 28 days, expressed in N/mm^2.Thus, concrete is known by its compressive strength. M20 and M25 are the most common grades of concrete, and higher grades of concrete should be used for severe, very severe and extreme environments.
- **Compressive strength of concrete**: Like load, the strength of the concrete is also a quality which varies considerably for the same concrete mix. Therefore, a single representative value, known as characteristic strength is used.
- **Characteristic strength of concrete:** It is defined as the value of the strength below which not more than 5% of the test results are expected to fall (i.e. there is 95% probability of achieving this value only 5% of not achieving the same)
- **Design strength (fd) and partial safety factor for material strength:** The strength to be taken for the purpose of design is known is known as design strength and is given byDesign strength (fd) = characteristic strength/ partial safety factor for material strength.The value of partial safety factor depends upon the type of material and upon the type of limit state. According to IS code, partial safety factor is taken as 1.5 for concrete and 1.15 for steel. Design strength of concrete in member = 0.45fck
- **Tensile strength of concrete:** The estimate of flexural tensile strength or the modulus of rupture or the cracking strength of concrete from cube compressive strength is obtained by the relations fcr = 0.7 fck N/mm^2. The tensile strength of concrete in direct tension is obtained experimentally by split cylinder. It varies between 1/8 to 1/12 of cube compressive strength
- **Creep in concrete:** Creep is defined as the plastic deformation under sustained load. Creep strain depends primarily on the duration of sustained

loading. According to the code, the value of the ultimate creep coefficient is taken as 1.6 at 28 days of loading.

- **Shrinkage of Concrete:** The property of diminishing in volume during the process of drying and hardening is termed Shrinkage. It depends mainly on the duration of exposure. If this strain is prevented, it produces tensile stress in the concrete and hence concrete develops cracks.
- **Modular ratio:** Short term modular ratio is the modulus of elasticity of steel to the modulus of elasticity of concrete.

Short term modular ratio = E_s / E_c

Es = modulus of elasticity of steel (2 x 10 5 N/mm^2)

Ec = modulus of elasticity of concrete (5000 x SQRT (f_{ck}) N/mm^2)

As the modulus of elasticity of concrete changes with time, age at loading etc the modular ratio also changes accordingly. Taking into account the effects of creep and shrinkage partially IS code gives the following expression for the long-term modular ratio.

Long term modular ratio (m) = 280/ ($3f_{cbc}$)

Where, f_{cbc} = permissible compressive stress due to bending in concrete in N/mm^2.

Poisson's ratio: Poisson's ratio varies between 0.1 for high strength concrete and 0.2 for weak mixes. It is normally taken as 0.15 for strength design and 0.2 for serviceability criteria.

- **Durability of concrete:** Durability of concrete is its ability to resist its disintegration and decay. One of the chief characteristics influencing durability of concrete is its permeability to increase of water and other potentially deleterious materials. The desired low permeability in concrete is achieved by having adequate cement, sufficient low water/cement ratio, by ensuring full compaction of concrete and by adequate curing.
- **Unit weight of concrete:** The unit weight of concrete depends on percentage of reinforcement, type of aggregate, amount of voids and varies from 23 to 26 kN/m^2. The unit weight of plain and reinforced concrete as specified by IS:456 are 24 and 25 KN/m^3 respectively.

1.3 Principles of concrete

1.3.1 Mixing Concrete

Thorough mixing is essential in order to obtain a homogeneous mixture of all the ingredients and achieving a suitable workability. The equipment and applied work methods need to be able to effectively mix concrete containing the specified size aggregate, obtaining a uniform mixture with the required workability within an acceptable water cement ratio.

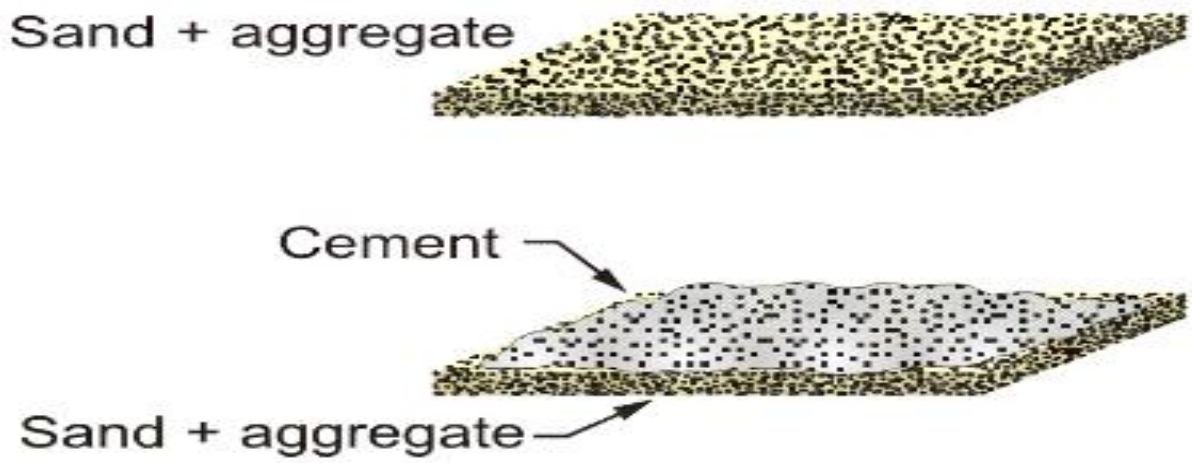


Figure 103: mixing concrete materials

a. Hand mixing

When mixing is carried out by hand it requires a suitable surface (metal sheets, boards or lean concrete slab) to ensure that the mix is not contaminated with soil. The surf ace should be level to prevent water or fluid material from running off the mixing area. The space needs to be sufficiently large to allow for the required size of batches to be mixed without spilling into surrounding areas.

A careful balance of cement to water is therefore required when preparing the mix. Water-cement ratios in the range between 0.4 and 0.6 provide a good workability without compromising the strength of the concrete. Hand-mixed and hand-placed

concrete requires more water to achieve sufficient workability (water/cement ratio between 0.5 and0.65).

Rule of the thumb for hand mixing: between 20 liters and maximum 25 liters of water per bag of cement.

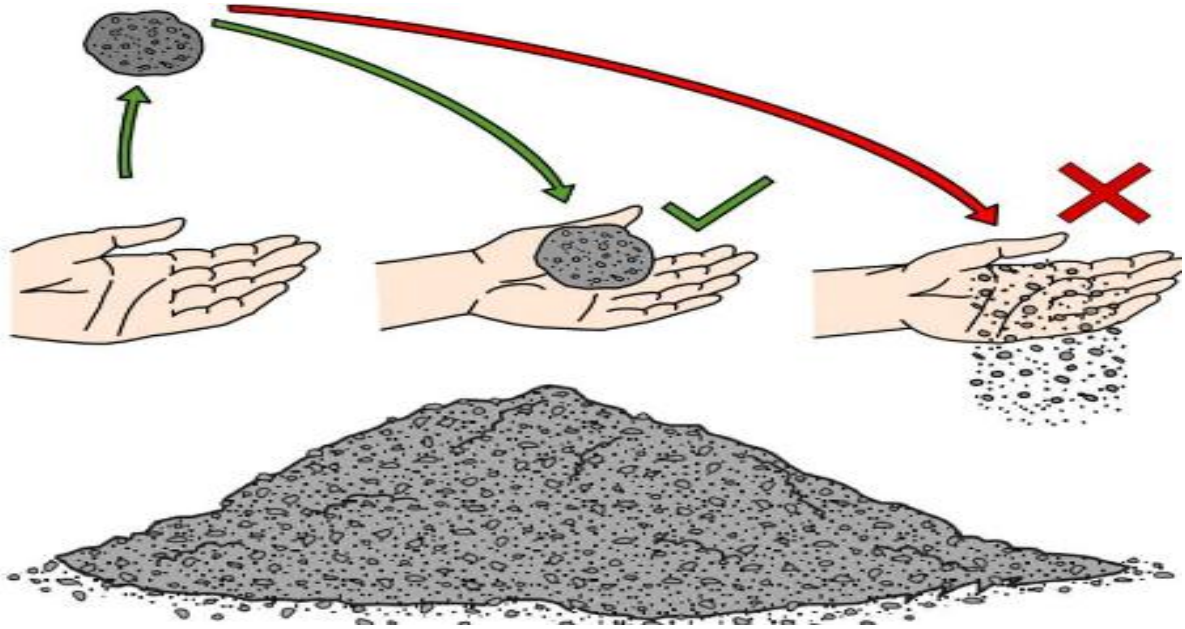


Figure 104: Laddu test for water cement ration

The Laddu test is a common hands-on procedure to find out whether the water cement ratio is correct. Form a ball of ready mixed concrete in your hand, knead it well, throw it up about 60cmand catch it again. If the mixture retains the form of a ball, then the water-cement ratio is acceptable. The water-cement ratio is not correct if the ball disintegrates when you catch it. When pouring concrete for columns you may need slightly more water in order to ensure that concrete reaches all corners in the tight space inside the formwork, to avoid honeycombs.

Figure 105: Hand mixing

b. Mechanical mixing

There exist a large number of different types and sizes of concrete mixers. The most commonly found type on construction sites is the tilting drum mixer. Depending on their size, these mixers can be manually driven or powered by electrical or diesel /petrol engines. The drum on the mixers can be positioned at different angles for charging, mixing and discharging. The drum rotates on an inclined axis when mixing to avoid the mix falling out of the drum. When the mix is ready the drum can be tilted in order to discharge the concrete. Mechanical mixing produces a more homogeneous and better mix. The concrete mixer should never be filled completely.

Figure 106: Mechanical mixing

Mixing Ratio: In mix design the concrete prepositions are designed to have an average strength corresponding to the value specified using scientific design methods. This concrete should have adequate workability for conditions prevailing on the work in question, and can be properly compacted with the means available.

In nominal mix method, it is not practicable to use controlled concrete. Nominal mix method may be used for grades of concrete up to C-20. In proportioning nominal mix, the quantity of cement can be determined by weight. The quantity of fine and coarse aggregate may be determined by volume, though there should also preferably be determined by weight. If the fine aggregate is moist and volume batching is adopted, allowance should be made for bulking. The most commonly med batching boxes size in a country are 50 cm x 40 cm x 20 cm and 50 cm x 40 cm x 18 cm. Even though 6 grades of concrete are mentioned below, only 5 of them are suitable for nominal mix, since on this concrete no strict control through supervision is done. These five grades of concrete are C-5, C-7, C-10, C-15, and C-20. The table below gives mix ratio for nominal mix concretes.

Figure 107: Batching box

Table 6: Classes of concrete and their purpose

Type of concrete	Class of Concrete	Mixture (cement : sand : gravel)	Purpose
Lean Concrete	C10	1 : 4 : 8	Culvert beds, fills
Mass Concrete	C15	1 : 3 : 6	Non-reinforced structures
Structural Concrete	C25	1 : 2 : 4	Culvert pipes,lightly reinforced structures
	C30	1 : 1.5 : 3	Heavily reinforced structures

Calculating Quantity of Materials: An estimate is probable cost of a building before construction. This estimate should not be far away from the actual cost of the building after completion of the project. it is done by mathematical calculation based on working trainings. First of all, the quantity of the work is calculated based on standard unit of measurement for each work. This unit of measurement can be pieces (No), meter linear, meter square and meter cube.

The unit of measurement for concrete is meter cube for thick surfaces such as ground floor slab. The data given below can be used to calculated materials required for making concrete, the materials needed depends on the grade of concrete as given on the data. General formula for calculating material list of concrete

Basic data

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

Density of Sand - - - - 1840 kg. /m^3

Density of Stone Aggregate - - - - 2250 kg/m^3

Density of Lime - - - - 1900 kg/m^3

Density of Cement Mortar - - - - 2300 kg/m^3

Density of Compo Mortar - - - - 1200 kg/m^3

Density of Tracheae - - - - 2600 kg/m^3

Assume 30% Shrinkage and 5% wastage.

1) Concrete Mix = **1:3:6**

Let volume of concrete = Zm^3

$$then\ \ a)\ Cement = \frac{1}{10} \times Zm^3 \times 1400 kg/m^3 \times 1.30\ shrinkage \times 1.05\ wastage$$

$$= 191 kg\ Z$$

$$= 0.41 m^3\ Z$$

$$b)\ Sand = \frac{3}{10} \times Zm^3 \times' 1840\ kg/m^3 \times 1.30\ shrinkage \times 1.05\ Wastage$$

$$= 754\ kg\ Z$$

$$= 0.41\ m^3$$

$$c)\ Aggregate = \frac{6}{10} \times Zm^3 \times 2250\ kg/m^3 \times 1.30\ Shrinkage \times 1.05\ Wastage$$

$$= 1843 kg \times Zm^3$$

$$= 0.82 \times Zm^3$$

Material list Calculation:

Concrete

Assuming 30% Shrinkage and 5% Wastage

For: Mechanical mix, Water/ Cement = 0.4-0.5

Hand mix, Water/ Cement = 0.4-0.65

Note: Hand mix shall only be allowed for class II concrete, and shall not be allowed for Concrete of Class c-20 **above.**

Table 7: Types of concrete and their material required

Item	Type of work	Material required to produce 1m^3 Concrete
1	Concrete c-7 Mechanical mix Mix ratio 1:4:8	Cement = 150 kgs (3 bags) Sand = 773 kgs (0.42 m^3) Gravel = 1890 kgs (0.84 m^3) Water = 60 liters
2	Concrete c-15 Mechanical mix Mix ratio 1:3:6	Cement = 200 kgs (4 bags) Sand = 754 kgs (0.41 m^3) Gravel = 1843 kgs (0.82 m^3) Water = 80 liters

3	Concrete c-20 Mechanical mix Mix ratio 1:2:4	Cement = 275 kgs (5.5 bags) Sand = 718 kgs (0.39 m^3) Gravel = 1755 kgs (0.78 m^3) Water = 110 liters
4	Concrete c-30 Mechanical mix Mix ratio 1:2:3	Cement = 325 kgs (6.5 bags) Sand = 837 kgs (0.45 m^3) Gravel = 1536 kgs (0.68 m^3) Water = 130 liters
6	Concrete c-15 Mechanical mix Mix ratio 1:2:5:6	Cement = 202 kgs (4.04 bags) Sand = 661 kgs (0.36 m^3) Gravel = 1940 kgs (0.82 m^3) Water = 121 liters

Methods of Mix:

Among the various methods of mix properties, the following will be dissolved here after.

a) Trial method of proportioning.

b) Arbitrary methods of proportioning.

c) ACI method of mix design.

A) Trial Method of Proportioning:

This method is based on abrasion law, i.e., the strength of concrete depends up on the net ratio of the mixing water to the cement.

Steps: -

1. Select W/C ratio from strength - W/C curve
2. Measure the cement (about 3kg for Lab. trial) and the corresponding area of water.
3. Mix by hand in a pan to form paste.
4. Make the aggregate surface saturated dry condition (SSD) & measure known quantities from each of aggregate say "M"kg of fine aggregate and "N" kg of coarse aggregate.
5. The aggregate are mixed with intermittent mixing until it brought to the desired consistency.

The coarse aggregate is the 1st aggregate to be added.

Then the sand is added continuously till enough mortar is produced to fill the space between pieces of coarse aggregate.

6. When the batch is satisfactory the remaining aggregate in the containers are weight and by the difference the amount used in the batch is computed.

7. Then the cubes should be prepared from the mix for 7 day & 28 days compression test.

Examples:

Given: Compressive strength of 25 MpaPlastic consistency

Required: Design the mix calculate the quantities per one bag of cement.

Solution:

1. W/C: 0.62

2. Cement: 3kg

Water =3 x 0.62 = 1.86 kg.

3. Mix (form a paste).

4. Suppose 10kg of sand and 12kg of Coarse Aggregate are available.

5. Suppose 4 kg sand and 3 kg of Coarse Aggregate are left in the container

C. A. 12 - 3 = 9kg

F. A. 10 - 4 = 6kg

6. Proportions

C: FA: CA

3: 6: 9 = 1: 2: 3 by wt.

The quantities per one bag of cement.

50: 100: 150

B) Arbitrary Proportions

The arbitrary proportions have been established by experience, but this method of proportioning doesn't secure concrete of certain strength because the mount of W/C ratio is not defined.

In Arbitrary proportioning strength is rapidly contributed by varying each content.

Such as - rich mix **1:1:2**and Lean mix **1:3:6**

Example: 2

Given a concrete mix in which the proportions of cement to fine aggregate to coarse aggregate are 1: 2: 3 by wt. and using a W/C of 0.60 by wt.

Calculate:

a) The yield (The amount of concrete per one bag of cement)

b) The cement factors (cement content in bags per one-meter cube of concrete)

c) The materials per cubic meter of concrete.

Given data:

S.p.gr of cement = 3.15

S.p.gr pf FA = 2.65

S.P.gr CA = 2.65

Solution: wt. proportions per sack are**50:100:150**

The volume of one bag batch

Solid volume

- Absolute volume of cement=50/3.15*1000=15.87litert
- Volume of water = 50 x 0.6 = 30 liters
- Absolute volume of FA =100/2.65*1000=37.74liter
- Absolute volume CA = 150/2.65*1000=56.6liter

a) Yield = 140.21 liter = 0.144m^3.

b) Cement factor = 1/0.1404 = **7.14 bags**

c) Materials per cubic meter of concrete.

Cement = 7.14 bags = 375 kg/m^3

Fine aggregate = 2 x 375 = 714 kg/m^3

Coarse aggregate = 3 x 375= 1077 kg/m^3

Water = 0.6 x 375= 2.15 kg/m^3.

Example: 3

Given: C: FA: CA= 1: 2: 3 by volume

W/C = 0.85 by volume.

Required. a) The yield

b) Cement factor

c) material per cubic meter of concrete

Take: Unit wt of FA = 1700 kg/m^3

Unit wt of CA = 1400 kg/m^3

Sp. gr of cement = 3.15

Sp.gr of FA & CA = 2.65

Volume of one bag (sack) of cement = 35 liter.

Solution:

If the proportions by volume per one bag of cement is;

35: 70: 105

The volume of one bag batch

- abs. volume of cement = 50/3.15 = 15.8 liter
- abs. vol. of $FA = {}^{W}\!/_{solid\,unit\,wt} = \frac{volume\,x\,unit\,wt\,FA}{solid\,unit\,wt}$

$$= \frac{70x1700}{2.65x1000} = 44.90lit$$

- abs. vol. of CA $\frac{105x1400}{2.65x100} = 55.47litre$
- Volume of water $= 0.85x35 = \underline{\underline{\frac{29.75litre}{145.99litre}}}$

a) Yield = 145.99 liter = 0.146 m^3.

b) Cement factor $= {}^{1}\!/_{0.146} = 6.85bags/m^3$

c) materials per m^3 of concrete.

Cement = 6.89 bags = 240 liter

FA= 2 x 240= 480 liter

CA = 3 x 240= 720 liter

Water = 0.85 x 240= 204 liter

ACI - method of mix Design:

Procedure

1. Data to be collected.
   - i) Fines modulus of selected FA.
   - ii) Unit wt. of dry roaded CA
   - iii) Sp.gr of CA and FA
   - iv) Absorption characteristics of both CA and FA
   - v) Sp.gr cement (3.15)
2. From the minimum strength specified estimate the average design strength (table 8.27)
3. Specify the minimum cement content (table 8.27)
4. Choice of clump (table 8.21 or table 8.28)

5. Determine the max. Size of CA.

6. Estimate mixing water, and air content (table 8.28)

7. Select W/C (table 8.23) based on strength or (table 8.24) based on requirement for Durability.

8. Calculate the cement content and compare with step 3 $\Rightarrow$ take whatever is larger.

9. Estimate the bulk volume of dry roaded as per unit volume of concrete (table 8.25)

10. Calculate wt. of CA. per m^3 of concrete

W_{CA} = bulk vol. x bulk density

11. Calculate the solid volume of CA in one m^3 of concrete

V_{CA}**:** W_{CA}/1000.sp.gr

12. Similarly the solid volume of cement/water and volume of air is calculated in one m^3.

13. Solid volume of sand is then calculated by subtracting from the data volume of concrete the solid volume of cement, CA, water & entraps air or if the **wt.** of concrete per unit volume is assumed or can be estimated from experience (table 8.26), the rigged wt. of FA is the difference between the **wt.** of fresh one and the total **wt.** of the other ingredients.

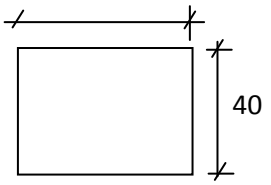
14. Adjustments for aggregate moisture.

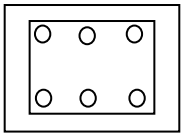
15. Trial batch adjustments. The calculated mix proportions should be checked by means of trial batch.

Maximum size of aggregate recommended for various types of construction.

Type of element	Dimensions of section (cm)			
	10-15	15-20	20-35	35-75
	Maximum size of aggregate (mm)			
Un reinforced or light reinforced foundations or slabs	25-40	40	40-50	50
Reinforced foundations or slab, un rein forced or lightly reinforced walls or columns.	20-25	25	25-40	40
Reinforced columns, beams, walls hollow block slabs	15-20	20-25	25-30	30

N.B: Maximum size should not be larger than **1/5** of minimum dimensions of section





or larger than 3/4 of minimum clear spacing b/n reinforcing bars.

Example: -

20cm square reinforced concrete columns have to be cast in the interior of a building. Reinforcement &ϕ 12 mm bars and nominal strength of concrete 200 kg/cm^2. Prepare a mix design assuming class of control good.

Solution:

Step - 1- Data

i) FM of sand = 2.4

ii) Dry roaded unit wt. C.A: 1600 kg/m^3

iii) Specific gravity of C.A.: 2.6and Specific gravity of F.A. = 2.65

iv) Absorption Capacity of C.A. = 0.56 and Free moisture in sand = 4%

v) Specific gravity of cement = 3.15

Step - 2- Minimum strength (For mix design)

Average strength = 1.2 x 200 = 240 kg/m^2.

Step - 3 - Minimum cement context (table 8.27) = 240 kg/m^3.

The space between two reinforcing bars = clear spacing

Step - 4 - $\frac{Choice\ of\ \ slump}{Lightly\ reinforced(row-2)}$ = 75 cm

Step - 5 - maximum size of Aggregate = 25

Step - 6 - Mixing water = 185 lit / m^3

air content = 10 lit/m^3

Step - 7 - W/C (8.23) = 0.64 based strength

Step - 8 - Cement content $= \frac{mixing water}{W/C} = 185/0.64 = 289\ kg/m^3$

Step - 9 - bulk volume of dry roaded C.A. per unit volume of concrete (8-25 = 0.71)

Step - 10 - Wt. of C.A. = 0.71 x 1600 = 1136 kg.

Step - 11 - Solid volume of C.A. = 1136/2.6 x 1000

Step - 12 - Solid volume of cement = 289/3.15 = 92.0 lit/m^3.

" " water = 185 lit/m^3

" " air = 10 lit/m^3.

= 724 lit/m^3.

Step - 13 - Solid volume of sand = 1000 - (437 + 92 + 185 + 10)

Based on volume = 276 lit/m^3.

Wt. of F.A. = 0.276 x 2.65 x 1000 = 732 kg/m^3.

	Volume (lit)	wt.**(kg)**
Air	10	-
Cement	92	289
Water	185	185
C.A.	437	1136
F.A.	276	732
	1000 lit	**2342 kg/m^3**

Or based on wt. **(8.26)**

The wt of concrete per unit volume = 2375 kg/m^3

Wt of F.A. = 2375 - (1136 + 289 + 181) = 765 kg/m^3

	wt (kg)	**Volume (lit)**
Air	0	10
Cement	289	92
Water	185	185
F.A.	765	289
C.A.	1136	437
	2375 lit	**1013 kg/m^3**

Step - 14- Adjustments for Aggregate moisture

- C.A. absorbs 0.5/100 x 1136 (wt. Of C.A.) = 5.68 kg of mixing water
- Sand supplies 9/100 x 732 (wt. Of. sand = 29.28 kg) of H_2o to the mixing water. Therefore, the estimated requirement for added water. Therefore, the estimated batch wt for cubic meter of concrete are

= 185 + 568 - 29.28 = **161.4** lit.

Step - 15 - Trial batch" a trial batch of 30 lit. Concrete is prepared for trial mix

Water = 0.03 x 161 = 4.83 kg

Cement = 0.03 x 289 = 8.67kg

C.A. = 0.03 x 1130 = 33.90 kg

F.A. = 0.03 x 761 = 22.83 kg

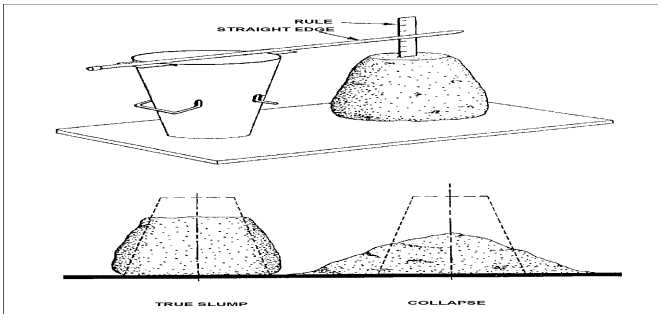
1.3.2 Conduct Concrete Testing

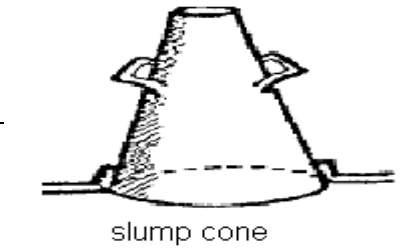
Slump Test

Except for drier mixes, this test is a measure of workability. It is the simplest method of ensuring that the consistency of the concrete does not alter throughout the job. The equipment required consists of a slump cone, a bullet - pointed 15 mm diameter steels rod 600 mm in length, a trowel, straight edge and rule.

The test is carried out in the following way: -

- Make sure the cone is clean and stand it on a smooth, hard surface, preferably a sheet of metal.
- Stand on the footrests and fill the cone in three layers, rodding each layer as required by the local Standard. (Usually 25 times)
- Overfill the cone and strike off the surplus.
- Clean round the base and lift the cone vertically, placing it upside down beside the resulting mound of concrete.
- Place the straight edge across the cone and measure down to the topmost point with the rule.
- This dimension is termed “the slump” and it should be reasonably constant throughout the job.
- To measure the slump, the rod is rested on the cone and the distance from the underside of the rod and the top of the concrete is measured. Collapse as shown in the adjacent figure, is caused by excess water in the mixture.





slump cone

Figure 109: measuring the slump

1.3.3 Transportation

Concrete needs to be transported from the place of its preparation to the place of its final deposition. Concrete may segregate if not handled carefully during transporting. Care should be taken so that the concrete is not subjected to stocks or vibrations during transit. Specially designed leak proof and loosed type containers should be used for transporting concrete so that the basic characteristic of fresh concrete are not charged during transit. Proper care during transporting concrete thus plays important role in achieving the designed quality of concrete.

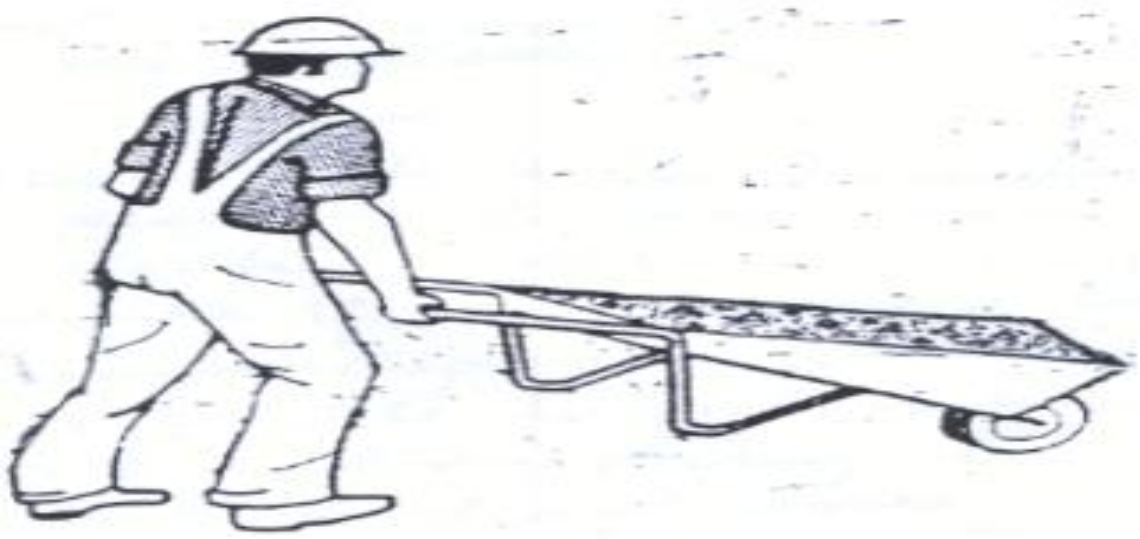


Figure 110: concrete transporting

1.3.4 Placing of concrete

When concrete is being actually deposited, the following precautions must be taken**:**

- Concrete should be placed as near as possible to the final position.
- In slat – construction, placing should start around the perimeter at one end with each batch dumped against previously placed concrete.
- Concrete should not be placed in separate piles, nor should it be deposited in a big pile and then moved horizontally into the final position.

- In walls, the first batches in each lift should be placed at litter end of the section, placing should then progress towards the center. This is also true of beams and girders.
- In general, concrete should be placed in a horizontal layer of uniform thickness, each layer being thoroughly compacted before next is placed. Layers may be 15 to 50 cm thick for reinforced members and 20 to 50 cm for man work. For road and airfield pavements, slabs up to 25 cm thickness can be laid in a single layer.
- To avoid cracking due to settlement, concrete in columns and walls should be allowed to stand for at least two hours and preferably overnight, before concrete is placed in slabs, beams or girder framing in to them.

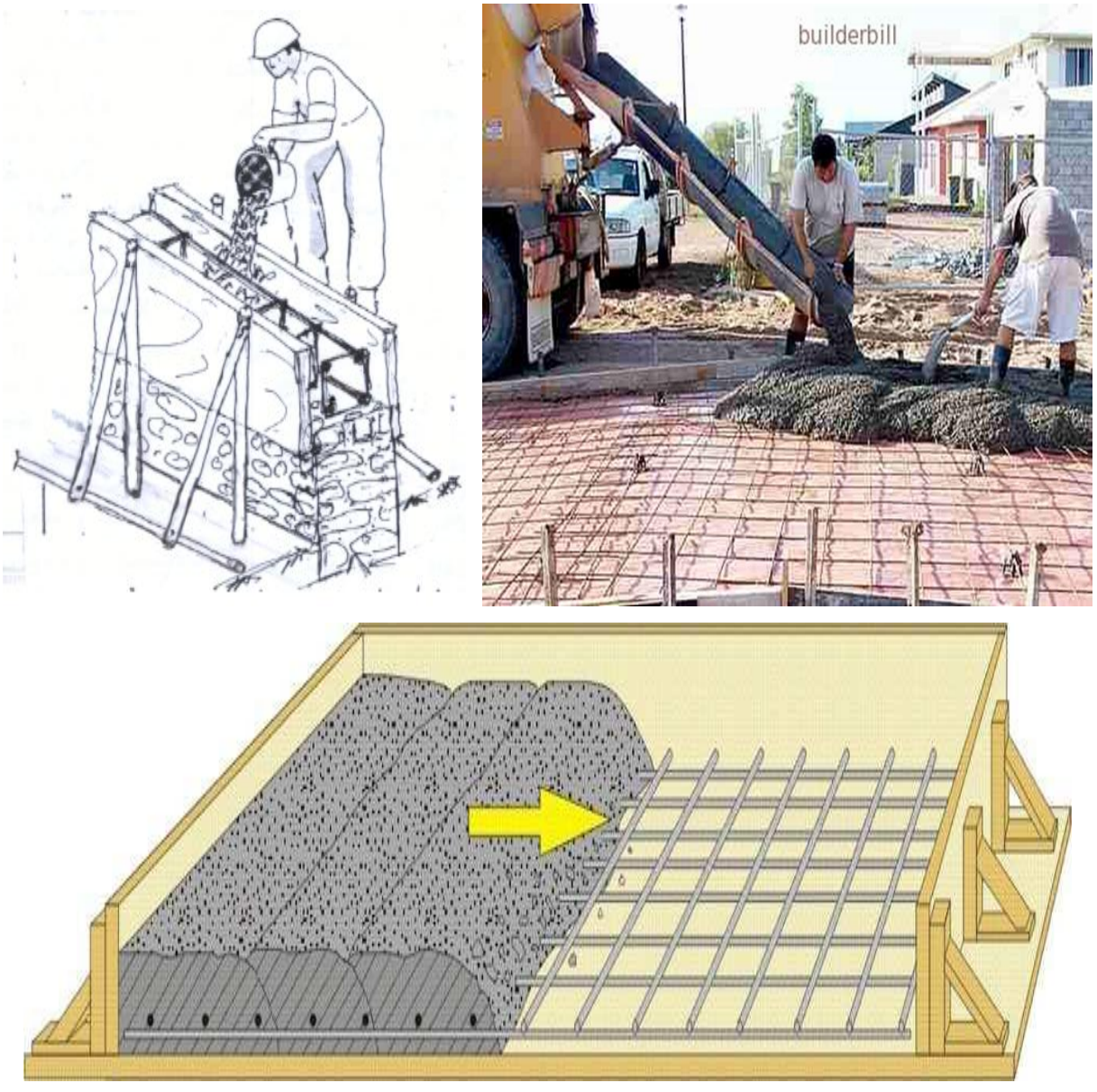


Figure 111: Concrete placing

Self-Check -1	Written Test

Directions I: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. The property of concrete which is defined as the plastic deformation under sustained load is:

   A. Durability of concrete
   B. Creep in concrete
   C. Tensile strength of concrete
   D. Compressive strength of concrete

2. Mass concrete (C15) which is used for non- reinforced structures has mixture ratio (cement: sand: gravel) of:

   A. 1: 4: 8
   B. 1: 2: 4
   C. 1: 3: 6
   D. 1: 1.5: 3

Directions II: Match the terms in column B with their meaning in column A and write the answer on the space provided.(2 pts each)

A.		B
____1. Decrease the setting time by increasing the rate of hydration	A	Workability
____2. Inert solid bodies	B	Slump test
____3. Finely powdered mixtures of inorganic compounds	C	Tension
____4. Cement plus water	D	Porosity
____5. Keep concrete moist during initial hardening	E	Elasticity
____6. Ability of a material to return to its original shape after being stretched	F	Concrete
____7. Reaction of cement with water	G	Cement
____8. Cement paste mixed with sand	H	Aggregate
____9. Amount of empty space in concrete	I	Accelerators
____10. Used to determine workability	J	Cement paste
	K	Mortar

____11. How easily fresh concrete can be placed and consolidated in forms ____12. The stress resulting from elongation		Hydration Admixture Binder

Note: **Satisfactory rating - 14 points** **Unsatisfactory - below 14 points**

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Answers

1._____

2. _____

Information Sheet-2	Concrete Compacting Method

2.1 Compacting of concrete

The process of compacting concrete essentially comprises the elimination of entrapped air and achieving maximum density. The importance of compaction should not be undermined. The strength of concrete is reduced by 30 percent of only 5 percent voids.

Compaction is a process of expelling the entrapped air. If we don't expel this air, it will result into honeycombing and reduced strength. It has been found from the experimental studies that 1% air in the concrete approximately reduces the strength by 6%.

- **Methods of Compaction:**

There are two methods of compaction as

A. Hand compaction

Reasonably workable and flow able concrete mixtures are consolidated by hand employing a rod. The bar should adequately reach the bottom of the form work and rode diameter need to compact concrete between reinforcement spacing and formworks.

The concrete is tamped by the rod tool repeatedly to consolidate it. Mixtures with low slump value could be consolidated by hand if super plasticizers are added to decrease slump and make the concrete workable.

Furthermore, tools such as spade is used to provide good surface appearance and hitting formwork sides make way to repel entrapped air out of the concrete. Mechanical consolidation is not recommended to use if the mixture is designed to compact by hand to avoid segregation.

Hand compaction is used for ordinary and unimportant structures. Workability should be decided in such a way that the chances of honeycombing should be minimum. The various methods of hand compaction are as given below.

- **Rodding:** It is a method of poking with 2m long, 16 mm dia rod at sharp corners and edges. The thickness of layers for rodding should be 15 to 20 cm.
- **Ramming** It is generally used for compaction on ground in plain concrete. It is not used either in RCC or on upper floors.
- **Tamping** It is a method in which the top surface is beaten by wooden cross beam of cross section 10 cm x 10 cm. both compaction and leveling are achieved simultaneously. It is mainly used for roof slabs and road pavements.

Figure 112: Concrete compacting by hand

B. Mechanical compaction

When the compaction is done manually it is called hand mixing and when it is done mechanically using vibrator it is called mechanical compaction.

Vibration is imparted to the concrete by mechanical means. It causes temporary liquefaction so that air bubbles come on to the top and expelled ultimately. Mechanical vibration can be of various types as given under.

- **Internal vibration:** It is most commonly used technique of concrete vibration. Vibration is achieved due to eccentric weights attached to the shaft. The needle diameter varies from 20 mm to 75 mm and its length varies from 25 cm to 90 cm. the frequency range adopted is normally 3500 to 5000 rpm. The correct and incorrect methods of vibration using internal vibration
- **External vibration:** This is adopted where internal vibration can't be used due to either thin sections or heavy reinforcement. External vibration is less effective

and it consumes more power as compared to the internal vibration. The form work also has to be made extra strong when external vibration is used.

- **Table vibration:** It is mainly used for laboratories where concrete is put on the table.
- **Platform vibration:** It is similar to table vibrators but these are generally used on a very large scale.
- **Surface vibration:** These are also called screed board vibrators. The action is similar to that of tamping. The vibrator is placed on screed board and vibration is given on the surface. It is mainly used for roof slabs, road pavements etc., but it is not effective beyond 15 cm depth.

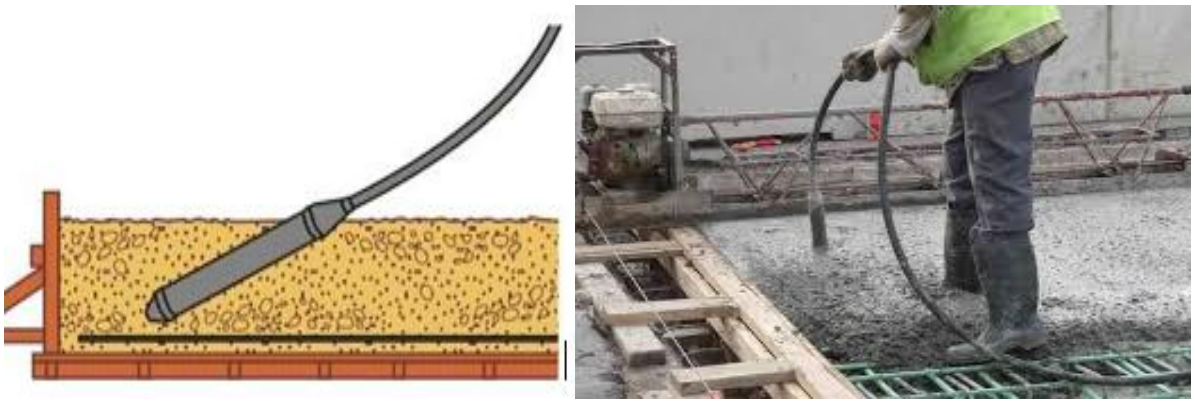


Figure 113: Mechanical methods of concrete compaction

For vibration in the reinforced concrete, a clear space of 7.5 cm must be available between the bars or group of bars for the vibrating needle to pass. The space between the bars of any group may be two thirds the maximum size of the coarse aggregate. The width of group of bars should not exceed 25 cm.

The vibrator needle should not be kept too close, nor too far away from the formwork. The most suitable distance is 10 cm to 20 cm. For high walls and columns, it should be remembered that it is not possible to penetrate the vibrating head more than three meters in the formwork. In such a case, the vibrating should be done by inserting the needle through a side opening into the formwork.

Self-Check -2	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. One of the following is hand concrete compaction method.
   A. Table vibration
   B. Platform vibration
   C. Surface vibration
   D. Rodding
2. Which mechanical method of compaction mainly used for laboratories?
   A. Table vibration
   B. External vibration
   C. Platform vibration
   D. Surface vibration
3. Compaction is a process of expelling the entrapped air
   A. True B. False
4. Which hand compaction method of concrete used for compaction on ground in plain concrete?
   A. Tamping
   B. Ramming
   C. Rodding
   D. Table vibration

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

Rating: _____

1. _____

2. _____

3. _____

4. _____

Information Sheet-3	Concrete Screening, Finishing and Curing

3.1 Concrete screening

Screening is the process in a concrete finishing performs by cutting off excess wet concrete to bring the top surface of a slab to the proper grade and smoothness. A power concrete screed has a gasoline motor attached which helps smooth and vibrate concrete as it is flattened.

Immediately after concrete has been placed in forms, concrete finishers utilize a screed to level out the concrete surface. Screeds often consist of long pieces of metal or wood that are pulled and pushed across the concrete surface to remove excess concrete and fill in gaps in the concrete surface.

If you want a smoother finish than the screened surface, use a wood float. "Floating" agitates the surface, compacts the material and brings enough mortar to the surface to fill the voids.

- Use the float with light pressure - tilted slightly upwards into the direction you are pushing it.
- After floating, round off the edges with an edging tool.

Figure 114: Concrete screening

3.2 Concrete finishing

Finishing is the operation of attaining a concrete surface of desired texture and pattern. Functional and decorative requirements determine the finish of a concrete surface.

"The floor finishes shall be laid depending upon the expected load and wear on the floor and the fact whether the topping is to be laid monolithic with the base or separately on a set and hardened base. In either case, special precautions are necessary to ensure a good bond between the topping and the base."

Finishing makes concrete more functional and aesthetic. Concrete that will be visible, such as driveways, highways, or patios, often needs finishing. Concrete's end use usually determines the final surface texture and patterns.

Finishing of concrete surface requires one, or many of the following operations:

- Level the surface
- Edge the concrete
- Joint the concrete
- Float the concrete
- Trowel the concrete
- Texture the concrete surface
- Cure the concrete

Never add cement or sprinkle water on concrete while finishing it.

The most basic type of concrete finish is a smooth surface created through the use of screeds and trowels. Immediately after concrete has been placed in forms, concrete finishers utilize a screed to level out the concrete surface. Screeds often consist of long pieces of metal or wood that are pulled and pushed across the concrete surface to remove excess concrete and fill in gaps in the concrete surface.

Allow all of the water to disappear before you do anything else. This can take 20 minutes or 4 hours depending on the temperature, humidity and how hard the wind is blowing. After the bleed water is all gone, you can get out your steel finishing trowel and put on the final touches

For a very smooth finish, use a steel trowel after the concrete has become quite stiff.

- Take care not to add excess water or fine material to the surface.
- Start toweling as soon as the "shiny water sheen" disappears, but while concrete still looks damp.
- Do final edging now.
- Do final hard toweling when the concrete is nearly hard.

3.2.1 Concrete finishing materials

i. Toweling or Floating

Once the concrete has been tooled with a screed, concrete finishers utilize trowels to smooth and fine-level the surface of the concrete. This can be accomplished through manual or mechanical means. To smooth concrete manually a hand trowel, which is typically composed of a flat steel blade with attached handle, is pushed and pulled across the concrete surface. Power trowels are available and are typically used on large commercial and industrial projects where using hand trowels is not feasible. Power trowels resemble large fans with the blades sitting directly against the concrete. These power trowels are available in both walk behind and riding versions.

ii. Edging

Edging of the concrete is conducted to provide rounded or beveled edges on the finished concrete as well as to create joints where needed in the surface to help minimize cracking. A specific edging tool is used to accomplish this task, and requires quite a bit of practice to master.

iii. Broom Finish

In order to make concrete surfaces slip resistant, a broom finish can be applied. This is done after placement, leveling, and troweling of concrete. Once a smooth surface has been created, a broom is dragged across the surface of the concrete to create small ridges that provide for traction control, particularly when the concrete surface is wet. Concrete surfaces without a broom finish tend to be slippery and dangerous when liquids are present on the surface.

3.2.2 Concrete textural finishing

Aside from broom finishing, there are several other means of creating textures on the surface of concrete, some of which are listed below.

b. Exposed Aggregate Finish

An exposed finish, once commonly found in sidewalks of old cities, is created by washing the top layer of concrete away, which exposes the edges of the natural stone aggregates that are mixed into the concrete. This provides an attractive and slip resistant finish.

In addition to the use of the normal concrete materials (cement, sand, gravel and water), other materials may be added into the mix to provide exposed finishes with unique looks. Examples are rose quartz, limestone, dark gray or black basalt, red or blue granite and even colored glass or seashells. The key with any of these additives is to avoid materials containing iron, which can stain the concrete. Also, it's important to provide a high-quality seal after concrete curing in order to protect the surface.

c. Salt Finish

A salt finish is a type of finish used mainly for swimming pool decks. Salt finishes are created by applying rock salt to the top of the wet concrete and then washing it away, which leaves small pits in the finished surface.

d. Stamped Concrete

A common method of texturing is to use concrete stamps. Concrete stamps are comprised of panels with inlaid designs, which are placed on concrete while it is still curing. Designs may consist of brick, stone or other decorative patterns to provide the desired look, sometimes mimicking other common building materials, but retaining the strength and durability of concrete. Once the forms are removed, the concrete surface may have color applied via staining, as described below.

3.2.3 Concrete Coloring

Concrete have color added to provide a look that fits with the architecture of the associated structure. This can be accomplished through mix-added pigments or post-cure staining, both of which are discussed below.

a. Pigments

Concrete coloring using pigments is a simple process, accomplished by adding the pigments directly to the concrete mix prior to pouring. Pigments are available in liquid form or in “mix-ready” dissolvable bags. In both cases, the pigments are placed in the mixer with the other concrete ingredients. The range of colors available is typically confined to “earthy” variants of browns and tans, although greens, blues and grays can also be purchased. It is important to keep pigmented concrete well sealed throughout its lifetime in order to prevent water infiltration, which may cause the pigment to fade.

b. Concrete Stain

The color of concrete can also be manipulated through the use of various staining products. One common method of staining concrete is through the use of acid. Similar to concrete pigments, the range colors is typically confined to non-bright, relatively subtle tones. Water-based (acrylic) staining provides for a much larger number of colors, including black and white. Stains can be applied to concrete of any age, though the colors are typically more vibrant if the stain is applied relatively soon

after the concrete has been placed. Application of stain is typically followed up with installation of a seal over the concrete to protect the surface.

c. Polished Concrete

Cured concrete, whether freshly-placed or well-aged, can be provided with a polished surface for a clean and glossy look, ease of maintenance and a surface that provides additional slip resistance over that of non-polished concrete.

The polishing process is typically accomplished using concrete floor grinders that are outfitted with diamond abrasives. The grade of the abrasives, from coarse to fine, will determine the final smoothness of the concrete surface at the completion of the polishing process. First, concrete is stripped of any existing sealer or coatings and any visible cracks are repaired. This is followed by the polishing process using the floor grinders mentioned above. Part way through the polishing process, chemical hardeners are often added to the concrete to provide future protection against water infiltration. Finer and finer abrasives are used until the desired surface finish is achieved. If desired, the final step involves application of a sealing product to protect the concrete from oil, chemicals, staining and moisture.

3.3 Curing

Curing is defined as "maintenance of a satisfactory moisture content and temperature in the concrete for a period of time immediately following placing and finishing so that the desired properties may develop." Early curing is critical when the concrete will be exposed to harsh weather conditions since it dramatically affects the permeability and durability of the concrete. In some instances, curing must be initiated even before the finishing operations are complete to provide the necessary concrete properties.

The following are advantages of curing the concrete:

- Concrete develops its strength when the water reacts with the cement.
- Prevent concrete from drying out too quickly otherwise a weak, poor quality surface may result.

- As soon as the surface is hard enough to resist marking, cover the concrete with plastic sheeting or waterproof building paper and secure well, especially on the edges. This will keep the moisture in.
- Another method is to spread a layer of hessian or sand over the surface and keep moistening it continuously.
- This process of keeping your concrete damp is known as "curing". Your concrete will continue to gain strength for at least one month provided curing is continued for that time.

Since the strength and durability properties of concrete are set by the chemical reactions of the various components during the hydration process, there are three key factors to proper curing.

- **Moisture -** Having sufficient moisture to ensure the hydration process continues
- **Temperature -** Maintaining a sufficient temperature (≥10°C) to ensure that the chemical reaction continues
- **Time -** Maintaining both the moisture and temperature requirements for a minimum period of time (3-7 days) to ensure that the durability properties fully develop. Curing needs to be initiated as soon as the finishing operations are complete and the surface will not be damaged by the curing operation.

  Other notes to keep in mind when curing concrete:
- Alternating cycles of wetting and drying during the curing process is extremely harmful to the concrete surface and may result in surface crazing and cracking. This should be avoided at all cost.
- A 28-day air drying period is recommended immediately following the 28-day curing period to provide the necessary freeze/thaw resistance for the concrete. Curing methods that result in fully saturated concrete, which will be exposed to freeze/thaw cycles once the curing period is over, may result in premature deterioration of the concrete (even if the concrete is properly air entrained.)
- Concrete with low water/cement ratios (≤0.40) may not have sufficient free moisture in the mix to allow for the use of "moisture loss prevention" curing methods. This situation should be reviewed prior to the start of the project.

Self-Check -3	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. When we use a steel trowel for a very smooth finish, which one of the following is true?
   A. Add excess water or fine material to the surface.
   B. Do final hard troweling when the concrete is nearly hard
   C. Start troweling when concrete becomes harden D. None

2. Maintenance of a satisfactory moisture content and temperature in the concrete for a period of time is:
   A. Concrete screening
   B. Concrete finishing
   C. Concrete curing
   D. Concrete compaction

3. Which one of the following is concrete textural finishing?
   A. Polished Concrete
   B. Stamped Concrete
   C. Concrete Stain
   D. Pigments

4. One of the following is not the advantages of curing the concrete.
   A. Concrete develops its strength when the water reacts with the cement
   B. Drying out concrete too quickly
   C. Curing is continued for one month to gain concrete strength
   D. Maintenance of a satisfactory moisture content and temperature

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

Score = _____

Rating: _____

1. _____

2. _____

3. _____

4. _____

Information Sheet-4	Covering and Protecting Concrete Surface

4.1 Covering and protecting concrete surface

While it is true that covering the curing concrete with plastic will keep it cleaner, there is a more essential purpose behind this practice. Remember, you mix water into concrete to activate the cement binding agent within. But the drying, or "curing" should be gradual, otherwise cracking may occur.

If the concrete is kept at around 50°F, protection can typically be removed after two days. If the concrete remains at 50°F, depending on what kind of cement is used and how much accelerator, you should wait a couple of weeks-better to wait 4 weeks-before actually putting it into service.

Covering fresh concrete with a plastic sheet has other benefits besides protecting it from rain. It can protect the new concrete from environmental cooling and heating fluctuations as it cures, and it helps resist uneven curing due to rapid moisture loss at the top. Leave it covered for 24 hours.

At specified curing temperatures, well-portioned concrete mixtures should attain this strength within 24 to 48 hours. Therefore, it is critical that newly placed concrete be protected from freezing for the first 24 to 48 hours or until the concrete attains a strength of approximately 500 psi.

Reinforcing bars and shuttering must be free of ice and snow. Cover and insulate the concrete where possible. If concrete has to be placed it should be organized so that it is done as quickly as possible. Frost blankets should be used to provide insulation and protection for exposed concrete surfaces.

Frozen ground will settle as it thaws, which leaves your concrete susceptible to cracking. In addition, when wet concrete is placed on a cold surface, the concrete will set more slowly. This, too, can create cracking in the concrete.

If the rain occurs when the concrete is fresh (about 2-4 hours after mixing), the surface should be protected from the rain. If the finishing process was recently completed, rainwater may not cause damage as long as it is not worked into the surface and the slab is left untouched.

In cold weather, plastic-clad concrete curing blankets are often used to protect the surface from snow and insulate the concrete from freezing. If the concrete is completely covered with plastic, no outside moisture can penetrate to contact the slab. ... Plastic not only repels water from above, but also from below.

Protecting concrete in cold weather is a continuous challenge for concrete contractors and site supervisors. Placing concrete in the cold weather condition requires special preparation and protection. All necessary precautions should be taken in order to alleviate the negative impacts of cold weather. Special curing and protection is required in most cases. In my previous article, we reviewed what is considered cold for concrete construction, and what should be done prior to placing concrete. In this article, I will review some of the widely used protection techniques and strategies and the challenges in protecting the concrete from extreme cold. But first, let's see what cold means for concrete:

The hydration of cement is a chemical reaction. Extremely low temperatures as well as freezing can significantly slow down the reactions, thus, affecting the strength growth. In fact, freezing temperatures within the first 24 hours (or when concrete is still in plastic state), can reduce the strength by more than 50%.

Figure 115: Covering of concrete surface with blanket in cold weather

There are different methods to prevent moisture loss from concert in hot weather:

- **Curing Compounds**

✓ Form a membrane over the top surface of the concrete preventing moisture loss

✓ Must be applied at the manufacturer's suggested application rate

✓ Should be applied in two applications with the second being at the right angles to the first to ensure uniform coverage

✓ Should be applied as soon as the concrete surface is finished and when there is no free water on the surface

✓ Curing compounds can affect the "bond" of some floor coverings

✓ Confirm that this curing method is suitable for the final floor covering application

- **Plastic Sheeting**

✓ Ensure that the plastic sheeting covers 100% of the concrete surface and that it is adequately sealed at the edges to prevent moisture loss

✓ Select the appropriate colour (white, black, or clear) of the plastic based upon the ambient air conditions

✓ If uniform colour is a requirement for the project, ensure that the plastic is not placed directly on the concrete surface

✓ Ensure that plastic sheeting is not damaged by subsequent construction activities during the curing period

- **Leaving formwork in place**

✓ This system is most effective for vertical elements (walls, columns, beams, etc.). Care must be taken to also protect the top surface of the concrete appropriately

- ✓ "Breaking" or "releasing" the formwork dramatically reduces the effectiveness of this curing method since air flow is now possible between the concrete and the formwork
- ✓ If uniform colour is an issue, then a uniform curing time and temperature must also be maintained and form removal scheduled accordingly

To supply supplemental moisture to concrete, the following ways are used:

- **Water Ponding**

- ✓ Flooding of the concrete surface to provide both moisture and a uniform curing temperature
- ✓ Curing water should not be more than 12°C cooler than the concrete temperature to avoid the possibility of thermal cracking
- ✓ The water must cover the entire concrete surface

- **Water Sprinkling**

- ✓ Spraying water over the concrete surface. The entire surface must be wet for this method to be effective
- ✓ The concrete surface must have sufficient strength to avoid damaging the surface
- ✓ Excess water will run off the concrete and must be drained away
- ✓ This protection method can be adversely affected by high winds which prevent proper curing on the "upwind" side

- **Wet Burlap**

- ✓ Pre-soaked burlap is applied to the concrete surface and is covered with plastic to prevent moisture loss or water is reapplied as necessary to prevent the material from drying out
- ✓ Burlap should be rinsed prior to its first use to avoid possible staining
- ✓ Materials utilizing both geo textile fabric and plastic top coatings can be reused throughout the project

- **Wet Sand**

- ✓ Wet loose material such as sand can be used to cure concrete slabs and footings
- ✓ The sand thickness must be sufficient to prevent moisture loss at the concrete surface or the sand may be wetted throughout the curing period

Self-Check -4	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. The purpose of covering fresh concrete is:
   A. Keep it cleaner
   B. Protect concrete from environmental cooling and heating fluctuations
   C. Protecting it from rain
   D. It helps resist uneven curing due to rapid moisture loss at the top E. All
2. One of the following is used to protect concrete from cold weather.
   A. Water Sprinkling
   B. Water Ponding
   C. Wet Sand
   D. Leaving formwork in place E. Concrete curing blankets
3. Spraying water over the concrete surface to supply supplemental moisture to concrete is:
   A. Wet Burlap
   B. Water Ponding
   C. Water Sprinkling D. Wet Sand
4. Cover the entire concrete surface with water to supply moisture is:
   A. Curing Compounds
   B. Water Ponding
   C. Water Sprinkling
   D. Wet Sand E. Wet Burlap

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____
2. _____
3. _____
4. _____

Score = _____

Rating: _____

Operation Sheet 1	Placing concrete to specified levels and grades

1.1 Techniques for concrete mixing using hand method:

Step 1: Wear PPE

Step 2: Select tools and materials for bar bending

Step 3: Select and clean the area for mixing

Step 4: Add required amount of aggregate

Step 5: Add the prescribed amount of sand

Step 6: Add the required amount of cement

Step 7: Mix dry for appropriately

Step 8: Add the required amount of water slightly continue mixing until you get the required

Step 9: property of concrete

1.4 Techniques for placing concrete to specified levels and grades

Step 1: Wear PPE

Step 2: Select tools and materials for bar bending

Step 3: Make sure the concrete has the correct proportions and water content – with a consistency like curd-rice.

Step 4: Wet the shuttering with clean water just before pouring concrete.

Step 5: Pour concrete in layers that can be easily compacted

Operation Sheet -2	Concrete compacting method

Procedures for concrete compacting method:

Step 1: Wear appropriate PPE.

Step 2: Select tools and materials

Step 3: Prepare materials for compaction

Step 4: Pour and compact the concrete without any break until the entire job is completed.

Step 5: Use an iron rod to compact columns

Step 6: Also knock the shuttering lightly from the outside with a wooden hammer

Step 7: Then finish off with wooden dampers

Step 8: Finally clean tools and equipments.

Operation Sheet -3	Concrete screening, finishing and curing

Procedures for concrete screening, finishing and curing:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Compact and screening concrete with appropriate screening materials

Step 4: Finish the concrete after the water is totally disappear from concrete surface

Step 5: Cure the concrete by until the concrete achieves its strength

Step 6: Clean tools and materials

Operation Sheet -4	Covering and protecting concrete surface

Procedures for positioning expansion joint:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare covering materials based on the weather

Step 4: Properly cover the concrete surface and leave it until the concrete gets optimum strength

Step 5: Clean tools and materials

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hours.

Task 1: Place concrete to specified levels and grades

Task 2: Compact concrete

Task 3: Screen, finish and cure concrete

Task 4: Cover and protect concrete surface

Instruction Sheet	Learning Guide 66: Strip Formwork

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Removing edge boxing and braces
- De-nailing, cleaning and storing or stacking Timber components
- Cleaning, oiling and storing or stacking Steel components
- Discarding damaged formwork
- Cleaning screens

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Edge boxing and braces are removed sequentially
- Timber components are de-nailed, cleaned and stored or stacked
- Steel components are cleaned, oiled and stored or stacked
- Damaged formwork components are discarded after stripping
- Screens are safely cleaned before movement where applicable

Learning Instructions:

7. Read the specific objectives of this Learning Guide.
8. Follow the instructions described below 3 to 6.
9. Read the information written in the information “Sheet 1, Sheet 2,Sheet 3, Sheet 4 and Sheet 5” **in page 2, 9, 13, 15, and 17**respectively.
10. Accomplish the “Self-check 1, Self-check 2, Self-check 3, Self-check 4 and Self-check 5” -” **in page 8, 12, 14, 16and 20**respectively
11. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2,Operation Sheet 3, Operation Sheet 4 and Operation Sheet 5”**in page 21, 22 and 23**
12. Do the “LAP test” **in page 24**

Information Sheet-1	Removing edge boxing and braces

1.1 Removal of forms

Forms should not be removed until the concrete has sufficiently hardened in order that it can carry safely its own weight and any other live loads it is subjected to.

The supporting period (period between placing of concrete in forms and removal of forms) differ according to the type of cement used and the design of formwork. In general structures carrying construction loads, side timbers shall not be removed within 7 days and supporting timbers within 28 days of placing of concrete.

In no circumstances shall forms be stuck until the concrete reaches strength of at least twice the stress to which the concrete may be subjected at the time of striking. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions, and cured under conditions of temperature and moisture similar to those existing on the work. Where possible, the formwork should be left longer, as it would assist the curing.

All formworks should be removed without shock or vibration as this would damage the reinforced concrete. Before the soffit and struts are removed, the concrete surface should be exposed, where necessary in order to ascertain that the concrete has sufficiently hardened. Proper precautions should be taken to allow for the decrease in the rate of hardening that occurs with all elements in the cold weather.

The removal of concrete formwork also called as strike-off or stripping of formwork should be carried out only after the time when concrete has gained sufficient strength, at least twice the stress to which the concrete may be subjected to when the formworks are removed. It is also necessary to ensure the stability of the remaining formwork during formwork removal.

1.1.1Concrete formwork removal time

The rate of hardening of concrete or the concrete strength depends on temperature and affects the formwork removal time. For example, time required for removal of concrete in winter will be more than time required during summer.

Special attention is required for formwork removal of flexural members such as beams and slabs. As these members are subjected to self-load as well as live load even during construction, they may deflect if the strength gained is not sufficient to handle to loads.

To estimate the strength of concrete before formwork removal, the tests on concrete cubes or cylinders should be carried out. The concrete cubes or cylinders should be prepared from the same mix as that of the structural members and cured under same circumstances of temperature and moisture as that of structural member.

When it is ensured that the concrete in the structural members has gained sufficient strength to withstand the design load, only then formworks should be removed. If possible, the formworks should be left for longer time as it helps in curing.

Removal of formwork from concrete section should not make the structural element to:

- Collapse under self-load or under design load
- deflect the structural member excessively in short or the long term
- Physically damage the structural member when formwork is removed.

The following points must be kept in mind during formwork removal whether the structure will be prone to:

- freeze thaw damage
- cracks formation due to thermal contraction of concrete after formwork striking.

If there is a significant risk of any of the above damages, it is better to delay the removal time of formwork. If formwork has to remove for optimizing the concrete construction activities, then these structures must be insulated well to prevent such damages.

1.1.2Calculation of safe formwork striking times

Structural members are constructed based on designed load. But before a structure is complete and subjected to all loads assumed during structural design, the structural members are subjected to its self-weight and construction loads during construction process.

So, to proceed with construction activities at a quicker rate, it is essential to calculate the behavior of structure under is self-load and construction load. If this can be done and structural member is found to be safe, formwork can be stripped-off. If these calculations are not possible, then following formula can be used for calculation of safe formwork striking times:

Characteristic strength of cube of equal of maturity to the structure required at time of formwork removal

$$= \frac{\text{Dead load + construction load}}{\text{Total design load}} \times \text{grade of concrete}$$

This formula was given by Harrison (1995) which describes in detail the background of determination of formwork removal times. Other method to determine the strength of concrete structure is to conduct the non-destructive tests on structural member.

1.1.3Factors affecting concrete formwork striking times

The striking time of concrete formwork depends on the strength of structural member. The strength development of concrete member depends on:

- **Grade of concrete** – higher the grade of concrete, the rate of development of strength is higher and thus concrete achieves the strength in shorter time.
- **Grade of cement** – Higher cement grade makes the concrete achieve higher strength in shorter time.
- **Type of Cement** – Type of cement affects the strength development of concrete. For example, rapid hardening cement have higher strength gain in

shorter period than the Ordinary Portland Cement. Low heat cement takes more time to gain sufficient strength than OPC.

- **Temperature** – The higher temperature of concrete during placement makes it achieve higher strength in shorter times. During winter, the concrete strength gain time gets prolonged.
- A higher ambient temperature makes the concrete gain strength faster.
- Formwork helps the concrete to insulate it from surrounding, so longer the formwork remains with concrete, the less is the loss of heat of hydration and rate of strength gain is high.
- **Size of the concrete member** also affects the gain of concrete strength. Larger concrete section members gain strength in shorter time than smaller sections.
- **Accelerated curing** is also a method to increase the strength gain rate with the application of heat.

Generally following values of concrete strength is considered for removal of formwork for various types of concrete structural members.

Table 8: Strength of concrete vs. structural member type &span for formwork removal

Concrete Strength	**Structural member type and span**
2.5 N/mm^2	Lateral parts of the formwork for all structural members can be removed
70% of design strength	Interior parts of formwork of slabs and beams with a span of up to 6m can be removed
85% of design strength	Interior parts of formwork of slabs and beams with a span of more than 6m can be removed

Table 9: Formwork stripping time (When Ordinary Portland Cement is used):

Type of Formwork	**Formwork Removal Time**
Sides of Walls, Columns and Vertical faces of beam	24 hours to 48 hours (as per engineer's decision)
Slabs (props left under)	3 days
Beam soffits (props left under)	7 days
Removal of Props of Slabs:	

Slabs spanning up to 4.5m	14 days
Slabs spanning over 4.5m	14 days
Removal of props for beams and arches	
Span up to 6m	14 days
Span over 6m	21 days

During stripping of formwork, following points must be remembered:

- Formwork should not be removed until the concrete has developed sufficiently strength to support all loads placed upon it. The time required before formwork removal depends on the structural function of the member and the rate of strength gain of the concrete. The grade of concrete, type of cement, water/cement ratio, temperature during curing etc. influence the rate of strength gain of concrete.
- The formwork parts and connections should be arranged in a way that makes formwork removal easy and simple, prevents damage to concrete and formwork panels so that it can be reused without extensive repair.
- The formwork removal procedure should be supervised by the engineer to ensure that quality of hardened concrete in structural member, i.e. it should be free from or has minimum casting defects such as honeycombing, size and shape defects etc. These defects in concrete influence the strength and stability of structure. Thus, immediate repair works can be done or the members can be rejected.
- The separation of forms should not be done by forcing crowbars against the concrete. It may damage the hardened concrete. This should be achieved by using wooden wedges.
- Beam and joist bottoms should remain in place until final removal of all shoring under them are done.
- Joist forms should be designed and removed so that the shores may be removed temporarily to permit removal of joist forms but must be replaced at once. The shores and joists will be dismantled beginning from the middle of the member's span, continuing symmetrically up the supports.
- The approval from the engineer should be obtained for the sequence and pattern of formwork removal.

Figure 116: Concrete canal after removing formwork

Self-Check -1	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. One of the following is not true about concrete formwork removing:
   A. The separation of forms should be done by forcing
   B. All formworks should be removed without shock or vibration.
   C. Side timbers shall not be removed within 7 days.
   D. Forms should not be removed until the concrete has sufficiently hardened
2. Which one of the following factors affecting concrete formwork striking times?
   A. Temperature
   B. Type of Cement
   C. Grade of cement
   D. Grade of concrete
   E. All
3. Removal of formwork from concrete section should:
   A. Collapse the structure under self-load or under design load
   B. Physically damage the structural member
   C. Not be removed until the concrete has developed sufficiently strength
   D. Deflect the structural member excessively

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Information Sheet-2	De-nailing, cleaning and storing or stacking Timber components

2.1 De-nailing, cleaning and storing or stacking timber components

After the completion of concrete work, you should dismantle and remove all the components of formwork. If you use a timber formwork, you will: -

- Denial
- Clean, and
- Store in an appropriate place.

Formwork must be cleaned as soon as it is removed. Timber and ply forms should be cleaned with a stiff brush to remove dust and grout. A timber scraper should be used for stubborn bits of concrete or grout. Steel scrapers on ply or faced ply are not to be used.

i. Treatment

- Timber and untreated ply should be given a coat of release agent when it is required to be stored for a longer period.
- Steel form if required to be stored for a longer period will also need a light coat of oil to prevent rusting.
- If any repairs are necessary, they should be done immediately.
- Any depressions, splits and nail holes should be repaired with suitable material followed by light rubbing down.
- Unwanted holes should be over filled with suitable filler and then sanded down to a smooth surface.

ii. Clean after usage

- Clean the formwork panels directly after striking.
- Use only suitable cleaning tools to avoid damage (no high-pressure water cleaning).
- Repair scratches or holes with PERI repair discs.

- Filling is not recommended as the spackle will not permanently remain in the formwork panel.
- After using the formwork, proper storing until the next use has to be ensured.

Figure 117: Formwork cleaning

iii. Protect against weather influence

- Protect the formwork panels against contact with water and direct exposure to sunlight.
- Ensure good ventilation and cleanliness of the formwork panels.
- Store the panels on even ground to avoid deflection.
- Storing of other building materials, such as e.g. concrete steel, on the formwork panels is to be avoided.
- Stacks of panels must only be transported while secured with strap

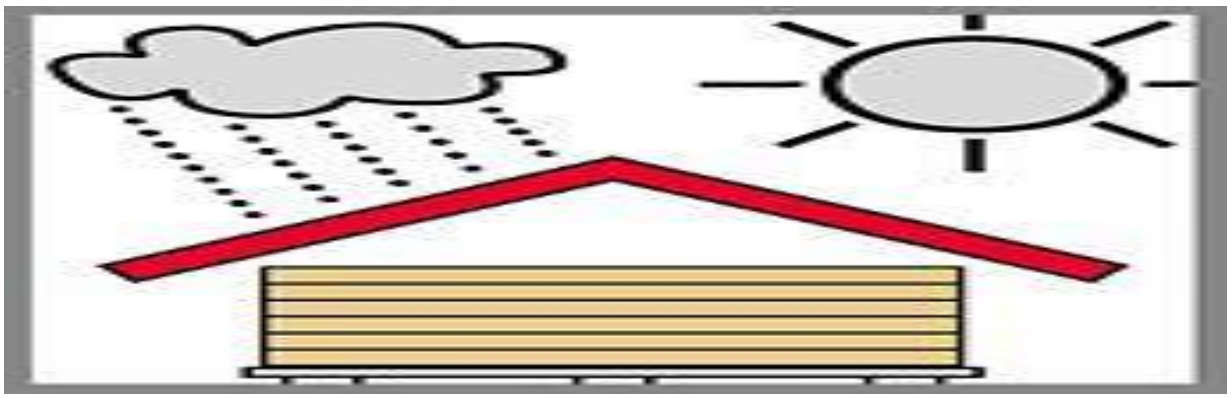


Figure 118: Protect formwork against weather

iv. Safe Storage

Storage of formwork is extremely important. Most of the formwork material deteriorates very fast if not repeatedly used and not preserved and stored properly. The main aim for good storage is to avoid doing any damage when formwork is not in use. If immediate re-use of formwork materials is not required, formwork must not be allowed to lie on site unprotected.

- Panels and plywood sheets after cleaning and oiling must be stored horizontally on a flat levelled base so that they lie flat without twisting and should be stacked face to face to protect the face.
- Large panels are best stored on edge in specially designed racks.
- Loose wailings, soldiers, struts etc., are best stored with their respective panels after numbering them so that they can be easily matched at a later stage.
- Small components such as bolts, clamps, keys, pins, wedges and ties should be kept in boxes.
- Props should be stacked off the ground to prevent them from deterioration due to contamination, mud and moisture.
- Fire extinguishers in working condition should always be made available in easily accessible areas.

  The storage area should be properly protected from rain and moisture. It should also be well ventilated and kept in a tidy condition so that it is easy to get any material required for re-use.

Self-Check -2	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. One of the following is not true about cleaning and treatment of after removed:
   A. Unwanted holes should be over filled with suitable filler
   B. Steel scrapers on ply or faced ply are used.
   C. Formwork must be cleaned as soon as it is removed.
   D. Timber and ply forms should be cleaned with a stiff brush.
2. Which one of the following used to protect formwork against weather influence?
   A. Cleaned with a stiff brush
   B. Repair scratches or holes
   C. Ensure good ventilation and cleanliness
   D. Clean the formwork panels directly after striking
3. Choose the one which is true about formwork storage.
   A. Fire extinguishers in working condition should always be made available
   B. Props should be stacked off the ground to prevent them
   C. Loose wailings, soldiers, struts etc., are best stored
   D. Must be stored horizontally on a flat levelled base after cleaning and oiling
   E. All

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Information Sheet-3	Cleaning, Oiling and Storing or Stacking Steel Components

3.1 Cleaning, oiling and storing or stacking Steel components

After the completion of concrete work, you should dismantle and remove all the components of formwork. If you use a steel formwork, you will: -

- Clean
- Oiling, and
- Store in appropriate place.

Provision must be made for the removal and storage large sections of formwork. A level storage area is required to store formwork after striking. They should be well cleaned before storing because the grout remaining on the forms become hard and stubborn. Then it is difficult to reuse. Metal panels need a light coating of oil before storage to prevent rust.

All forms need to be carefully stacked and stored. Panels of forms should be kept horizontal and face to face. The forms need to be carefully stacked and face to face. The forms and components should be clearly marked and kept together for easy identification on re-use. A tidy store reduces wastage, damage and losses.

Formwork, which is to be reused, should be carefully cleared and properly repaired between uses. Concrete or mortar film sticking to the form face or the joining surface should be completely removed after each use when not required for use; the formwork material should be properly stored. The component should be cleaned and painted periodically. Threaded parts should be oiled, greased after thorough clearing and removal of dirt or slurry. Free movement of the telescopic components should be ensured by periodic cleaning/oiling.

Self-Check -3	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. After the completion of concrete work, steel formwork should not be:
   A. Leaved in the site
   B. Clean
   C. Oiling
   D. Store in appropriate place
2. Which should be required to store steel formwork?
   A. level storage area
   B. Well cleaned before storing
   C. Need a light coating of oil before storage
   D. All
3. One of the following is **not** the advantage of tidy store for steel formwork.
   A. Reduce age of steel form
   B. Reduces wastage
   C. Reduce damage
   D. Reduce losses

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Information Sheet-4	Discarding Damaged Formwork

4.1 Discarding damaged formwork

Formwork materials must be handled carefully and accidental dropping must be avoided as possible. Used formwork panels should be inspected for damage before they are used again. Formwork highly affects the final appearance of the finished structure, so any defect must be checked first and repaired or removed; otherwise the formwork's defect will reflect on the finished surface of the concrete.

Various techniques have been proposed or used in the past in an effort to improve the quality and durability of concrete from panels and reduce formwork costs. Illustratively, oil have been applied to plywood concrete form panels as release agents to facilitate easy separation of the plywood form panels from the set concrete. However, even with the use of oil, or other release agent, the plywood panels can be typically only used for two or three concrete pours before they are damaged and must be discarded and replaced.

Damaged formwork components are safely discarded after stripping. Such formwork should not be thrown away in vain, after all, cost savings can save the company money, such forms are best used on some custom models, such as column and beam nodes by direct cutting the damaged parts and avoiding cracks. It depends on how the customer uses it, unless the forms can no longer be used

Self-Check -4	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. One of the following is true.
   A. Damaged formwork components are safely discarded after stripping
   B. Used formwork panels should be inspected for damage before they are used again
   C. Formwork materials must be handled carefully
   D. All
2. Why damaged formwork components are safely discarded after stripping?
   A. To make it cost effective
   B. To make it strong
   C. To remove the defect of concrete structure
   D. To use for other purposes
3. Damaged formwork components are used for other purposes.
   A. True B. False

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Information Sheet-5	Cleaning Screens

5.1 Cleaning formwork screens

Formwork is a vital part of building with concrete. Frames and facing material have to be regularly cleaned and checked for defects in order to prevent unwanted pores, blowholes and cavities from forming. This is where ultra-high-pressure water jet technology comes in: the water tools, pressure and flow can be adjusted according to how much residue must be cleaned off the formwork, saving you time and effort. This delivers excellent cleaning results without any damage to the formwork itself.

Concrete surfaces which satisfy demanding aesthetic requirements can only be produced using clean formwork. For this reason, all formwork must be regularly cleaned and repaired in order to deliver high-quality results.

Formwork construction systems primarily involve a combination of facing material and framework. The latter is normally made out of galvanized or painted steel to protect the edges of the embedded formwork from mechanical strain. Different aspects such as the texture or colour of the concrete surface will vary according to the facing material selected, with laminated wood being one particularly popular choice.

Formwork is removed once the concrete has set. This can rarely be achieved without some residue being left behind. Formwork is also often damaged through repeated use. When this formwork is re-used, all of the scratches, flaws, residue and individual screw holes will mark the new concrete surface. The frames of individual parts must also be intact in order for each facing structure to lie flat on top of the other. Otherwise cement ridges will form, which take a great deal of time to sand down.

Different methods can be used to remove concrete residue from formwork, ranging from manual or mechanical brush cleaning, to hammering off encrusted residue, to cleaning with ultra-high-pressure water jet devices. The latter has proven to be both gentler on materials and less time-consuming. The combination of water pressure, flow and water tools effectively remove even the most stubborn hard residues. This

method is particularly flexible, since it can be adapted to suit the formwork material properties and amount of residue build-up. You can clean facing materials and frames using this method provided you respect certain parameters: facing materials in laminated wood are very soft, which requires work at a lower pressure of maximum 500 bar to prevent damage to the facing. However, you can apply pressures of around 1,000 bar when working with steel formwork frames. You should avoid using blasting agents when carrying out wet cleaning in order to prevent damage to the frame's surface coating.

If formwork is not cleaned or treated with a separating agent for an extended period of time, it is almost impossible to re-use. In this case, the facing material has to be replaced. Regular cleaning is therefore particularly important when using formwork for longer projects. Many users neglect to do this because of time constraints – ultimately resulting in more time and effort spent on reworking the set concrete and more money spent on final cleaning and repairs. Facing materials should therefore be handled with care on construction sites.

As a general rule, only those tools which will not damage facing materials or frames should be used in the cleaning process. Ultra-high-pressure water jet technology cleans both components gently and effectively. It gives you repeated and cost-effective use of your facing materials and helps to produce a consistent cement design.

Figure 119: Screen cleaning

Advantages of cleaning formwork:

- Shorter working times
- No damage to surfaces from hammers, scrapers or sander attachments
- The value of the shuttering is maintained
- No costly post-treatment in the case of exposed concrete
- A positive image on the construction site

Checklist for cleaning and storage of formwork:

- Formwork as soon as it is removed cleaned with a stiff brush.
- Dust, dirt, stubborn bits of concrete or grout removed.
- Timber surface and uncoated ply coated with release agent before storing.
- Steel form coated lightly with oil to prevent corrosion.
- Damaged formwork sorted out and repaired before storage.
- Depressions nail holes repaired with suitable materials and lightly rubbed down to give smooth surface.
- Panels and plywood sheets stored on a horizontally leveled floor.
- Panels stored face to face to protect the surface.
- Storage area protected from rain and moisture and well ventilated.
- All formwork materials stacked off the ground.
- Loose wailing, soldiers (struts) etc. stored with respective panels after numbering for proper match when reused.
- Bolts, nuts, champs, pins, wedges, keys and ties stored in separate bins or boxes.

Self-Check -5	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. Why formwork must be regularly cleaned and repaired?
   A. To satisfy aesthetic requirements of concrete surfaces
   B. To make it attractive
   C. To make it strong
   D. All
2. One of the following is the advantage of Ultra-high-pressure water jet technology for formwork cleaning.
   A. Positive image on the construction site
   B. Costly post-treatment in the case of exposed concrete
   C. Damage to surfaces
   D. Longer working times
3. If formwork is not cleaned or treated with a separating agent for an extended period of time, it is almost impossible to re-use.
   A. False B. True

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Operation Sheet 1	Removing edge boxing and braces

Techniques for removing formwork:

Step 1: Wear PPE

Step 2: Select tools and materials for bar bending

Step 3: Allow the concrete to dry before removing the forms.

Step 4: Remove forms starting at the top of sloping slabs. Use a hammer to remove nails from the stakes holding the forms in place.

Step 5: Remove the stakes from the ground that support the forms with a stake puller to avoid damaging the stakes or the forms.

Step 6: Pull the forms away from the sides of the concrete slab using as little force as necessary.

Step 7: Remove forms on alternating sides of the slab to maintain the structural balance.

Step 8: Clean tools and equipments

Operation Sheet -2	De-nailing, cleaning and storing or stacking Timber components

Procedures for de-nailing cleaning and storing or stacking timber components:

Step 1: Wear appropriate PPE.

Step 2: Select tools and materials

Step 3: Denial the formwork

Step 4: Clean the formwork panels directly after striking by suitable cleaning tools to avoid damage

Step 5: Repair scratches or holes

Step 6: Clean storing areas

Step 7: Store proper until the next use has to be ensured

Operation Sheet -3	Cleaning, oiling and storing or stacking Steel components

Procedures for cleaning, oiling and storing or stacking steel components:

Step 1: Wear appropriate PPE.

Step 2: Select tools and materials

Step 3: Denial the formwork

Step 4: Clean the steel formwork panels directly after striking by suitable cleaning tools toavoid damage

Step 5: Repair scratches or holes

Step 6: Coating of oil before storage to prevent rust

Step 7: Clean storing areas

Step 8: Store proper until the next use has to be ensured

Operation Sheet -4	Discarding damaged formwork

Procedures for discarding damaged formwork:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Select damaged formwork

Step 4: Repair damaged formwork before storage

Step 5: Sort out damaged formwork which cannot be repaired and use for other purpose

Step 6: Clean tools and materials

Operation Sheet -5	Cleaning screens

Procedures for positioning expansion joint:

Step 1: Wear appropriate PPE

Step 2: Select tools and materials

Step 3: Prepare the formwork to be cleaned

Step 4: Clean the facing with high pressure and rotation cleaners

Step 5: Cleaning of all small parts

Step 6: Repair the damaged parts

Step 7: Check-up and assessment of every part of the formwork

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hours.

Task 1: Remove edge boxing and braces

Task 2: De-nail, clean and store or stack timber components

Task 3: Clean, oil and store or stack steel components

Task 4: Discard damaged formwork

Task 5: Clean screens

Instruction Sheet	Learning Guide 67: Clean up

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Clearing work area
- Maintaining plant, tools and equipment

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Clear work area and dispose materials of or recycled in accordance with project environmental management plan
- Clean, check, maintain plant, tools and equipment and store in accordance with manufacturers' recommendations and standard work practices

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1and Sheet 2" in page 2 and 11 respectively.
4. Accomplish the "Self-check 1and Self- check 2" -" in page 10 and 12 respectively
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1and Operation Sheet 2" in page 13
6. Do the "LAP test" in page 14

Information Sheet-1	Clearing work area

1.1 Managing construction waste

Construction waste consists of unwanted material produced directly or incidentally by the construction or industries. ... Much building waste is made up of materials such as bricks, concrete and wood damaged or unused for various reasons during construction.

Construction and demolition debris (C&DD) mean those materials resulting from the alteration, construction, destruction, rehabilitation, or repair of any manmade physical structure including houses, buildings, industrial or commercial facilities, and roadways.

C&DD includes structural and functional materials comprising the structure and surrounding site improvements, including:

- brick, concrete, and other masonry materials
- stone
- glass
- wall coverings
- drywall
- framing and finishing lumber
- roofing materials
- plumbing fixtures (toilets, sinks, water heaters, pipes)
- heating equipment (furnaces, duct work)
- electrical wiring and components containing no hazardous fluids or refrigerants
- insulation
- wall-to-wall carpeting
- asphaltic substances
- metal incidental to any of the above
- weathered railroad ties and weathered utility poles

Construction wastes can be classified into two categories:

- Hazardous Waste
- Non-Hazardous Waste

- **Hazardous Waste:** Waste exhibiting one or more of the following properties:
  - ✓ Flammability, Toxicity, Corrosivity, or Reactivity;
  - ✓ Require special handling, storage, use and disposal precautions.

Figure 120: Site hazardous wastes

- **Non-Hazardous Waste:** Waste that do not require special handling and disposal precautions. This includes:

✓ Project Office Non-Hazardous Waste;

✓ Construction Non-Hazardous Waste.

Project site non-Hazardous Waste Includes:

- Concrete Debris: Concrete chipping, concrete testing, backup concrete from mixers, demolition;
- Asphalt: Demolition of roads;
- Steel Scrap: Reinforcement bars, buckets and barrels, steel strips from packaging, steel pipes;
- Metal Scrap: Binding wire, HVAC duct sections, cable trays, aluminum sheets;
- Wood Scrap: Timber, plywood, formwork, crates, plates;
- Tile waste;
- Cardboard: Bituminous sheet rolls, packaging and storage boxes;
- Saw Dust from carpentry yard;
- Gypsum Board / partition board waste;
- Cement bags.
- Plastic: Polythene, pipes, warning mesh, safety cones, plastic buckets, tarpaulin;
- Paper: Laminated paper sheets (bitumen membranes), packaging.

1.2 Integrated Waste Management (IWM)

Integrated waste management requires:

- The waste producer to assess the potential for waste and put in place processes and procedures to eliminate and control the waste.
- The organization to establish targets and put all efforts in place to achieve these targets.
- The 5 R principles: Rethink, Repair, Reduce, Reuse, Recycle.

The following are elements of the Integrated Waste Management:

- Waste Planning;
- Waste Sorting;

- Waste Storage;
- 5 R Principles and examples of each;
- Waste Collection and Disposal;
- Reporting.

A. Planning stages

The following elements are considered, during the planning phase of establishing an Integrated Waste Management system:

- Consider types of waste that will be produced at the site and office;
- Estimate the volume of each type of waste;
- Research waste providers / facilities capable of handling these types of waste;
- Provide collection / sorting units capable of accommodating the estimated waste volumes;
- Ensure Employees are properly trained in order to separate the waste and achieve organizational targets;
- Plan for suitable collection and disposal of the collected waste;
- Produce reporting forms and procedures.

B. Waste sorting

During waste storing stage:

- Separate Hazardous and Non-Hazardous Waste.
- Separate all non-hazardous waste by type.
- Never mix any reusable / recyclable waste with food waste.
- Any material containing trace of food waste is non-recyclable. For example, a juice plastic bottle with juice still inside. Traces of food and drink have to be rinsed off.
- Components of one product might need further separation (e.g. water bottle).
- Do not know how to segregate? Simply Ask!
- Mixing waste for disposal makes it almost impossible to meet the organization's waste management targets. The temporary mixing of waste on sites should be avoided as it becomes difficult to separate at a later date.

Figure 121: Waste sorting

C. Waste storage

- Waste receptacles are to be provided within the project site and offices for collection by waste type.
- Waste storage areas must be of a suitable size to contain all the produced waste quantities.
- Cardboard boxes are made flat and collected in the store room.
- Each employee can keep a reuse box for paper at their desks.
- Employees should be required to utilize waste bins and keep them in good condition.
- Never mix waste.
- Do not leave waste in corridors to block movement.

Figure 122: Waste storage

D. 5 R Principles

Are strategies to manage waste and reduce the overall negative impacts to the environment.

- Rethink.
- Repair.
- Reduce.
- Reuse.
- Recycle.

Rethink:

- It requires commitment from each individual to rethink their behaviors and actions.
- If you care about giving your children a future at the same standard you live in now, think about the natural resources you are leaving them today.
- Think about eliminating the need to produce waste:

✓ For example, get your food in a reusable container;

✓ Or donate unneeded items rather than disposing them, surely someone needs them somewhere!

- Think about waste with lower environmental impacts.

✓ For example, paper cups rather than polystyrene cups.

Repair: Repairing electronics means less pollution going to the environment from discarded items. If repair is not possible, donate Electronic devices at e-waste locations.

Reduce:

Site teams shall reduce the waste produced through their activities:

- Reduce the amount of concrete backup to reduce the amount of wash out;
- Reduce the amount of steel reinforcement cutting onsite by ordering correct dimensions from supplier, where applicable;
- Request manufacturers to reduce the packaging of nonfragile materials;
- Reduce non-recyclable waste like polystyrene and glass;
- Separate recyclables and non-recyclables to reduce risk of non-recyclable waste.

Reuse:

Store reusable materials separately and label them as reusable. Some examples of reuse onsite:

- Wooden pallets for material storage and transport;
- Backup concrete to extend hard standing around site offices;
- Polythene and hessian cloth for concrete curing;
- Cardboard boxes for storage;
- Cut reinforcement for use with barricades and site marking.

Figure 123: Reuse wastes

Recycle:

Recycling means processing what is usually considered waste to become a new material.

- Recycling reduces:
- ✓ Pollution from extraction and manufacture of raw materials;
- ✓ Amount of waste going to landfill;
- ✓ Marine and environmental pollution.
- Recycling requires proper separation of waste according to type.
- Materials separated at source are then transferred to a licensed / authorized recycling facility.
- Consider take back recycling.

RECYCLABLE TIMBER AND WOOD

Figure 124: Recycle wastes

Self-Check -1	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. One of the following is hazardous waste in construction site:
   A. Steel Scrap
   B. Concrete Debris.
   C. Latex paint
   D. Tile waste
2. Processing a considered waste to become a new material is called -------.
   A. Rethink
   B. Recycle
   C. Repair
   D. Reuse
3. Elements of the integrated waste management which is used to separate hazardous and non-hazardous waste is:
   A. Recycle
   B. 5 R Principles
   C. Waste storage
   D. Waste sorting

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Information Sheet-2	Maintaining Plant, Tools And Equipment

2.1Cleaning and storing of tools and equipment

Concrete tools and equipment should be cleaned and properly stored for the next work. Cleaning the tools regularly is essential to their proper functioning.

Working with cement can be messy. If you have cement that has dried on your tools it can be difficult to remove, but with a little patience and elbow grease you can clean them up again.

Proper storage of tools &equipment

Importance of proper storage of tools and equipment:

- It is an important factor for safety and health as well as good business.
- Improves appearance of general-shop and construction areas.
- Reduces overall tool cost through maintenance.
- This also ensures that tools are in good repair at hand.
- Teaches workers principles of (tool) accountability.

Pointers to follow in storing tools and equipment:

- Have a designated place for each kind of tools.
- Label the storage cabinet or place correctly for immediate finding.
- Store them near the point of use.
- Wash and dry properly before storing.
- Store knives properly when not in use with sharp edge down.
- Put frequently used items in conveniently accessible locations.
- Gather and secure electrical cords to prevent entanglement or snagging.
- Cutting boards should be stored vertically to avoid moisture collection.
- Metal equipment can be stacked on one another after drying such as storage dishes and bowls.
- Make sure the areas where you are storing the equipment are clean, dry and not overcrowded.

Self-Check -2	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided. (2 pts each)

1. The purpose of cleaning tools and equipment is:
   A. To make ready for the next work
   B. To make it functional
   C. To elongate functional time
   D. To make a safe work environment
   E. All
2. The importance of proper storage of tools and equipment is
   A. Increase the overall tool cost through maintenance
   B. Ensure that tools are in good repair at hand
   C. Decrease lifespan of tools and equipment
   D. All
3. One of the following is pointers to follow in storing tools and equipment:
   A. Store them far from the point of use
   B. No need of label the storage cabinet or place correctly
   C. Have undesignated place for each kind of tools
   D. Wash and dry properly before storing

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____ Date: _____

Multiple Choice Questions

1. _____

2. _____

3. _____

Score = _____

Rating: _____

Operation Sheet 1	Clearing work area

Techniques for clearing work area:

Step 1: Wear PPE

Step 2: Select tools and materials for bar bending

Step 3: Identify types of waste (Hazardous, Non-hazardous).

Step 4: Sorting waste by their type.

Step 5: Reuse, recycle, dispose by the nature of waste

Step 6: Clean tools and equipments

Operation Sheet -2	Maintaining plant, tools and equipment

Procedures for how to clean dried cement on tools:

Step 1: Wear appropriate PPE.

Step 2: Select tools and materials

Step 3: Soak the tools in white vinegar. Vinegar will often dissolve a lot of the cement.

Step 4: Use a pressure washer to blast off more of the cement

Step 5: Scrape off small spots with a small, flexible putty knife

Step 6: Use a cement removal product

Step 7: Store proper until the next use has to be ensured

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hours.

Task 1: Clear work area

Task 2: Maintain plant, tools and equipment

Reference Materials

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