DRAUGHTSMAN CIVIL

NSQF LEVEL - 5

1st Semester

TRADE THEORY

SECTOR: Construction

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, an autonomous body under the Directorate General of Training (DGT), Ministry of Skill Development & Entrepreneurship is entrusted with developing producing and disseminating Instructional Media Packages (IMPs) required for ITIs and other related institutions.

The institute has now come up with instructional material to suit the revised curriculum for **Draughtsman Civil 1st Semester Trade Theory NSQF Level - 5 in Construction Sector under Semester Pattern.** The NSQF Level - 5 Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 5 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 5 the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

ASHEESH SHARMA
Joint Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi (NSQF LEVEL - 5) under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

R. P. DHINGRA
EXECUTIVE DIRECTOR

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ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Theory)** for the trade of **Draughtsman Civil** (NSQF LEVEL - 5) under **Construction** Sector for ITIs.

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NIMI records its appreciation for the Data Entry, CAD, DTP operators for their excellent and devoted services in the process of development of this Instructional Material.

INTRODUCTION

Trade Theory

The manual of trade theory consists of theoretical information for the first semester course of the Draughtsman Civil under NSQF - Level 5. The contents are sequenced according to the practical exercise contained in the manual on trade practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The trade theory has to be taught and learnt along with the corresponding exercise contained in the manual of the trade practical. The indications about the corresponding practical exercises are given sheet of this manual.

It will be preferable to teach/learn trade theory connected to each exercise at least one class before performing the related skill in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not the purpose of self-learning and should be considered as supplementary to class room instruction.

Trade Practical

The trade practical manual is intended to be used in practical workshop /Hall. It consists of a series of practical exercises to be completed by the trainees during the first semester course of **Draughtsman Civil** under **NSQF Level - 5** Syllabus, which is supplemented and supported by instructions / informatics to assist in performing the exercises. These exercises are designed to ensure that all the skills in prescribed syllabus are covered.

Module 1 - Safety

Module 2 - Basic Engineering Drawing

Module 3 - Masonry

Module 4 - Foundation

Module 5 - Temporary Structure

Module 6 - Treatment for Building

Module 7 - Arches and Lintels

The skill training in the shop floor is planned through a series of practical exercise centered around some practical object. However, there are few instances where the individual exercise does not from a part of project.

ASSESSABLE / LEARNING OUTCOME

On completion of this book you shall be able to

- **Recognize comply with safe working practices, environment regulation and house capering.**
- **Draw in freehand sketches of hand tools used in civil work.**
- **Draw plane figure Applying drawing instruments with proper layout and the method of folding drawing sheets.**
- **Construct plain scale, comparative scale, diagonal scale and vernier scale.**
- **Draw orthographic projections of different objects with the proper lines, lettering and dimensioning.**
- **Draw Isometric/ oblique/ perspective views of different solid/ hollow/ cut section with proper lines lettering and dimensioning.**
- **Draw component parts of a single storied residential building with suitable symbols and scales.**
- **Draw different types of stone and brick masonry.**
- **Draw different types of shallow and deep foundation.**
- **Draw different types of shoring scaffolding under pinning, frame work, and timbering.**
- **Draw different types of damp proofing in different position.**
- **Drawing of different types of arches and lintels in the chajja.**

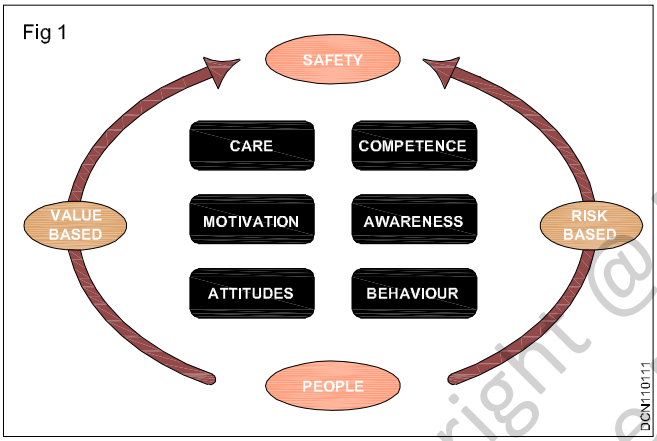
Occupational safety and health

Objectives: At the end of this lesson you shall be able to
- **define occupational safety and health**
- **state the importance of safety and health at workplace**
- **state the role of employer, trade union & employee for health & safety program.**

Occupational Safety and Health (OSH) is an area concerned with protecting the safety, health and welfare of people engaged in co-workers, family members, employees, customers, and many others who might be affected by the workspace environment.

Workspace safety : Owner/Occupier of industries have to comply with legal directions to take care for the safety, health and welfare of their employees. Equally the workers have moral responsibilities to follow all safety norms and healthy on the shop- floor (Fig 1).

Fig 1



Occupational health : Health at work is also called occupational health. It is concerned with enabling an individual to undertake their day to day work fully knowing the health hazards they are exposed to and preventing them at the workspace.

Good safety and helath practices can also reduce employee injury and illness related costs, including medical care, sick leave and disability benefit costs. (Fig 2)

Fig 2

The joint ILO/WHO committee on occupational health (1995) main focus in occupational health is on three different objectives.

i The maintenance and promotion of workers health and working capacity.

ii The improvement of working environment and work to become conductive to safety and health.

iii Development of work organization and working cultures in a direction which supports health and safety at work and in doing so also promotes a positive social climate and smooth operation and may enhance productivity of the undertakings.

Employment and working conditions in the formal or informal economy embrace other important determinants, including working hours, salary, workspace policies concerning maternity leave, health promotion and protection provisions etc.

The health of the workers has several determinants, including risk factors at the workspace leading to accidents, musculoskeletal diseases, respiratory diseases, hearing loss, circulatory diseases, stress related disorders and communicable diseases and others.

Creating safe and healthy working conditions is a challenge to all industries, as the new technologies and new patterns of work are fast growing. The challenges, changes resulting new risks and disorders are many. When safety and health measures are not followed or fail, accidents, injuries, diseases and even deaths may occur.

Victims of workspace injuries and occupational diseases have to be compensated properly. Prevention actions at workspace are needed so that similar cases will be prevented. The industries and the working population and their families including the dependent population will benefit from the good practice of occupational safety and health.

Safety problems in work settings range from immediate threats like toxic substances and grievous bodily injuries to subtle progressive dangers such as repetitive motion injuries, high noise levels, and air quality. In general, workplace hazards can be categorized into three groups:

1 **Chemical hazards,** in which the body absorbs toxins.

2 **Ergonomic hazards,** in which the body is strained or injured, often over an extended period, because of the nature (design) of the task, its frequency, or intensity.

3 **Physical hazards,** in which the worker is exposed to harmful elements or physical dangers, such as heat or moving parts.

In the modern context, corporate management increasingly has viewed industrial safety measures as an investment - one that may save money in the long run by way of reducing disability pay, improving productivity and

avoiding lawsuits.

Prevention is better than cure :

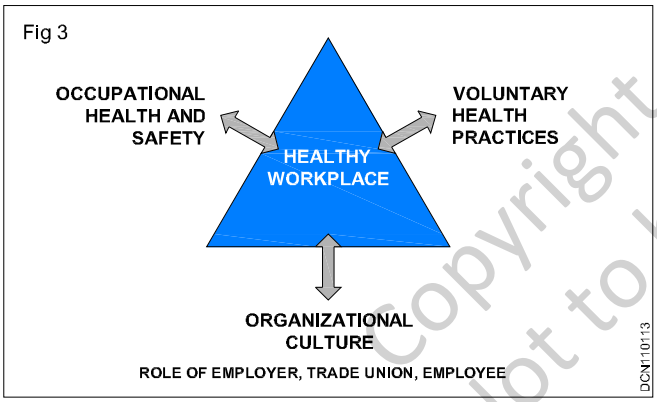
No place of work can always be completely safe all the time and whilst some work places present greater risks than others. Industry nowhere is immune to the possibility of an accident. Hence all industries should develop the ability to carry out risk assessment processes and to take all precautionary steps to ensure the safety of the workforce. It is a group collective effort that includes each and every member of the workforce. Employers should always ensure they do the following.

- Provide adequate control of the health and safety risks.
- Consult with employees on matters affecting their health and safety.
- Provide and maintain safe plant and equipment.
- Ensure safe handing and use of substances.
- Provide information, instruction, supervision and training so that employees are competent to carry out their role.
- Review and revise all these policies regularly.

Health and Safety programmes

For all of the reasons (Fig 3), it is crucial that employers, workers and unions are committed to health and safety, addressing the following areas.

Fig 3



- Workplace hazards are controlled - at the source whenever possible ;
- Records of any exposure are maintained for many years.
- Both workers and employers are informed about health and safety risks in the workplace.
- Establish an active and effective health and safety committee that includes both workers and management.
- To observe that the workers' health and safety efforts are ongoing.

Effective workplace health and safety programmes can help to save the lives of workers by reducing hazards and their consequences. Health and safety programmes also have positive effects on both worker morale and productivity, which are important benefits. At the same time, effective programmes can save employers a great deal of money.

Healthy workplace, hazard free work environment, zero accident work-life can help to save the lives of workers by reducing hazards and diseases. Effective programmes can also have positive effects on both worker morale and productivity. All put together enhance the human values at work and prosperity of the nation.

1 Occupational health and safety encompasses the social, mental and physical well-being of workers in all occupations.

2 Poor working conditions have the potential to affect a worker's health and safety.

3 Unhealthy or unsafe working conditions can be found anywhere, whether the workplace is indoor or outdoor.

4 Poor working conditions can affect the environment workers live in. This means that workers, their families, other people in the community, and the physical environment around the workplace, can all be at risk from exposure to workplace hazards.

5 Employers have a moral and often legal responsibility to protect workers.

6 Work-related accidents and diseases are common in all parts of the world and often have many direct and indirect negative consequences for workers and their families. A single accident or illness can mean enormous financial loss to both worker and employers.

7 Effective workplace health and safety programmes can help to save the lives of workers by reducing hazards and their consequences.

8 Effective programmes can also have positive effects on both worker morale and productivity, and can save employers a great deal of money.

Occupational hazard

Objectives: At the end of this lesson you shall be able to
- **explain various occupational hazard**
- **state occupational hygiene**
- **describe occupational disease disorders and its prevention.**

All jobs, primarily provides many economic and other benefits, But equally there are a wide varieties of workplace dangers and hazards, which are risky to the health and safety of people at work.

Basic hazards

Employers have a responsibility to protect workers against health and safety hazards at work. Workers have the right to know about potential hazards and to refuse work that they believe is dangerous. Workers also have a

responsibility to work safely with hazardous materials. Health and Safety hazards exist in every workplace. Some are easily identified and corrected, while others create extremely dangerous situations that could be a threat to your life or long-term health. The best way to protect oneself is to learn to recognize and prevent hazards in the workplaces.

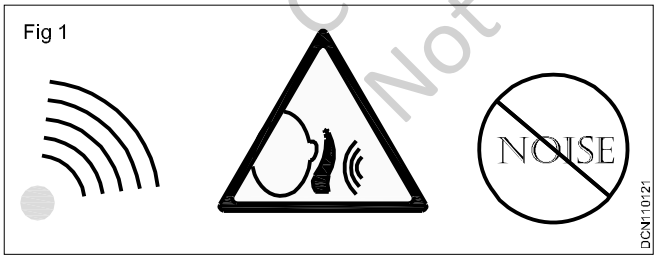
Physical hazards are the most common hazards and are present in most workplace at some point of time. Examples include; live electrical cords, unguarded machinery, exposed moving parts, constant load noise, vibrations, working from ladders, scaffolding or heights, spills, tripping hazards. Physical hazards are a common source of injuries in many industries. Noise and vibration, Electricity, Heat, Ventilation, Illumination, Pressure, Radiation etc.

- **Ventilation** and air circulation have major say on the health and working comfort of the worker. There must be good ventilation, a supply of fresh, clean air drawn from outside is required. It must be uncontaminated and circulated around the workspace. Closed of confined spaces also present a work hazard, which has limited openings for entry and exit and unfavorable natural ventilation, and which is not intended for continuous employee occupancy.

Spaces of this kind can include storage tanks, ship compartments, sewers, and pipelines. Asphyxiation is another potential work hazard in certain situations. Confined spaces can pose a hazard not just to workers, but also to people who try to rescue them.

- **Noise and Vibration :** Noise and vibration are both fluctuations in the pressure of air (or other media) which affect the human body. Vibrations that are detected by the human ear are classified as sound. We use the term 'noise to indicate unwanted sound. Noise and vibration can harm workers when they occur at high levels, or continue for a long time. (Fig 1)

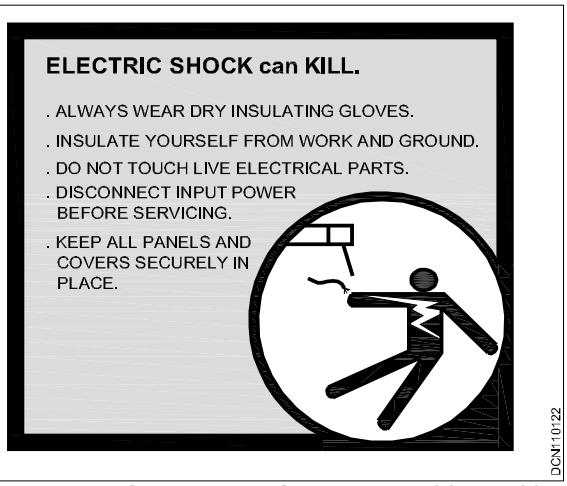
Fig 1



- **Electricity** poses a danger to many workers. Electrical injuries caused by contact with electric energy can be divided into four types
- fatal electrocution,
- electric shock,
- burns,
- falls .

Wires and electrical equipment pose safety threats in the workspace. When employees mishandle electrical equipment and wires, they are taking risks. (Fig 2)

Fig 2



- **Temperature (Heat Stress) :** A reasonable working temperature, for strenuous work, local heating or cooling where a comfortable temperature is to be maintained which is safe and does not give off dangerous or offensive fumes, Thermal clothing and rest facilities where necessary (for example, for 'hot work' or work in cold storage areas). Sufficient space in workrooms etc. are under the legislation for implementation by the owner of the factories.
- **Illumination (lighting) :** Good light lighting is essential for productivity Natural light is preferred where possible. Glare and flickering should be avoided.

HEAT EXHAUSTION/HEAT STROKE & TREATMENT

- **NORMAL BODY CORE TEMPERATURE - 37˚C**
- **HEAT EXHAUSTION - 38˚C - 40˚C**
- **HEAT STROKE 41˚C AND HIGHER**

SIGNS AND SYMPTOMS

HEAT EXHAUSTION	HEAT STROKE
• RESTLESS	• REDUCED LEVEL OF CONCIOUSNESS
• WEAK	• IRRITABLE
• DIZZY	• MUSCULAR PAIN
• RAPID PULSE	• RAPID PULSE
• LOW BLOOD PRESSURE	• HIGH BLOOD PRESSURE
• NAUSEA	• NAUSEA
• VOMITTING	• VOMITTING
• MENTAL STATUS - NORMAL	• MENTAL STATUS - CONFUSED
• BEHAVIOR - NORMAL	• BEHAVIOUR - ERRATIC
	• HOT, DAY, RED SKIN
	• DEATH

TREATMENT

• LAY PERSON DOWN & ELEVATE LEGS	• MOVE PERSON TO COOL VENTILATED AREA
• ENSURE NORMAL BREATHING	• CHECK FOR BREATHING, PULSE & CIRCULATION
• IF THIRSTY GIVE WATER TO DRINK	• IF POSSIBLE COVER THE PERSON WITH ICE PACKS OR COLD WATER TO REDUCE THE BODY TEMPERATURE
• REPORT INCIDENT TO SUPERVISOR	• GIVE WATER TO DRINK
	• MONITOR VITAL SIGNS
	• GET PERSON TO HOSPITAL
	• REPORT INCIDENT TO SUPERVISOR

Chemical hazards are present when you are exposed to any chemical preparation (solid, liquid or gas) in the workplace. Examples include: cleaning products and solvents, vapours and fumes, carbon monoxide or other gases, gasoline or other flammable materials. Chemicals hazards are the major causes of concern. Many chemicals are used not on generic names but on brands. The chemicals have biological effects on the human body if digested, inhaled or if direct skin contact with the chemicals, injuries occurs.

Accidents involving chemical spills, exposure and inhalation can lead to burns, blindness, rashes and other ailments. Most of them cause acute poisoning when taken orally, eye-skin irritation, Respiratory injuries etc. Long term effects of chemicals on blood, nerve, bones, kidneys, livers etc., my lead to serious diseases/disorders. The only way is to understand their chemical nature and handle them very carefully.

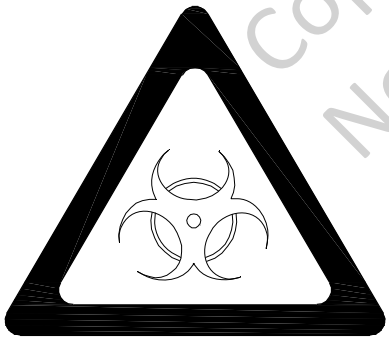
CHEMICAL POISONING

Poison : An agent or substances which may cause structural damage or functional disorders when introduced into the body by :

- **Ingestion**
- **Inhalation**
- **Absorption or**
- **Injection**

Biological hazards (Fig 3) come for working with people, animals or infectious plant material. Examples include; blood or other bodily fluids, bacteria and viruses, insect bites, animal and bird droppings. Biological hazards are due agent like bacteria, virus, fungi, mold, blood-borne pathogens etc., are main agents to cause various illness. (Fig 4)

Fig 3



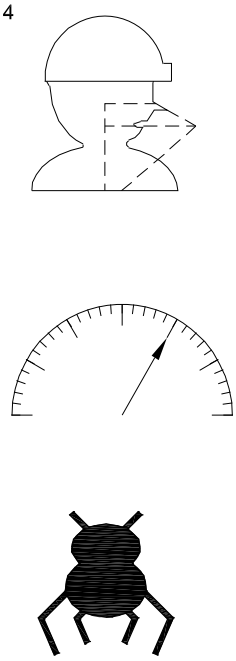
BIOLOGICAL HAZARD

DCN110123

Ergonomic hazards (Fig 5)

Ergonomic hazards occur when the type of work you do, your body position and/or your working conditions put a strain on your body. They are difficult to identify because you don't immediately recognize the harm they are doing to your health. Examples include : poor lighting, improperly adjusted workstations and chairs, frequent lifting, repetitive or awkward movements. Musculo Skeletal Disorders (MSDs) affect the muscles, nerves and tendons. Work related MSDs are one of the leading causes injury and illness.

Fig 4



BIOLOGICAL HAZARD

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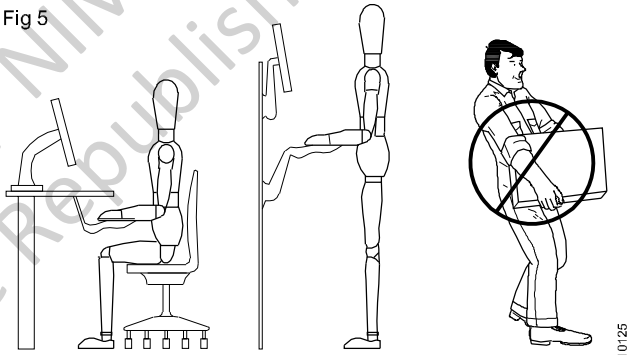
Fig 5



ERGONOMIC HAZARDS

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Workers in many different industries and occupations can be exposed to risk factors at work, such as lifting heavy items, bending, reaching overhead, pushing and pulling heavy loads, working in awkward body postures and performing the same or similar tasks repetitively. Exposure to these known risk factors for MSDs increases a worker's risk of injury.

Mechanical hazards are factor arise out of varieties of machines in industries including manufacturing, mining, construction and agriculture. They are dangerous to the worker when operated without training and experience. Operating machines can be risky business, especially large, dangerous machines. When employees don't know how to properly use machinery or equipment, they risk such injuries as broken bones, amputated limbs and crushed fingers. Many machines involve moving parts, sharp edges, hot surfaces and other hazards with the potential to crush, burn, cut, shear, stab or otherwise strike or wound workers if used unsafely.

Various safety measures exists to minimize these hazards, lockout-tagout procedures for machine maintenance and

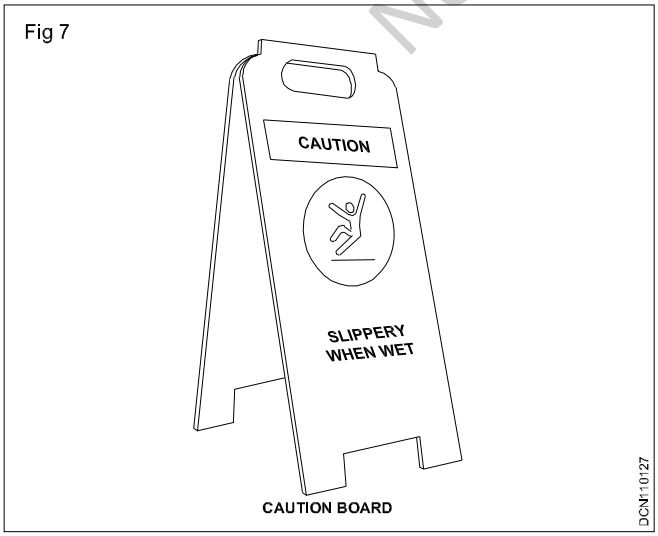
roll over protection systems for vehicles. Machines are also often involved indirectly in worker deaths and injuries, such as in cases in which a worker slips and falls, possibly upon a sharp or pointed object. Safeguarding machinery decreases accidents and keeps employees who use the machine safer.

Falls (Fig 6) are a common cause of occupational injuries and fatalities, especially in construction, extraction, transportation, healthcare, and building cleaning and maintenance. Slips and falls to be the leading cause of workplace injuries and fatalities. From slippery surfaces to un-railed staircases, the possibility of slipping, tripping or falling on the job is a workplace safety hazard. Broken bones, fractures, sprained wrists and twisted ankles constitute some of the physical injuries caused by falling accidents.

Fig 6

Falls in the workplace is effectively prevented by putting caution signs around slippery surfaces (Fig 7), having rails on every staircase and making sure that wires on the floor are covered to avoid tripping. They are perhaps unavoidable in certain industries, such as construction and mining, but over time people have developed safety methods and procedures to manage the risks of physical danger in the workplace. Employment of children may pose special problems.

Fig 7



Psychosocial hazards : psychosocial hazards are related to the way work is designed, organized and managed, as well as the economic and social contexts of work and are associated with psychiatric, psychological and/or physical injury or illness. Linked to psychosocial risks are issues such as occupational stress and workplace violence which are becoming a major challenge to occupational health and safety.

Workplace inspections prevent hazards

Regular workplace inspections are another important factor in preventing injuries and illnesses. By critically examining all aspects of the workplace, inspections identify and record hazards that must be addressed and corrected.

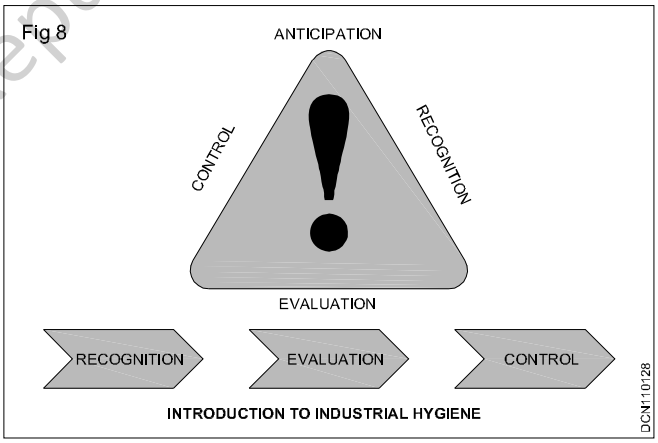
A workplace inspection should include

- Listening to the concerns of workers and supervisors.
- Gaining further understanding of jobs and tasks.
- Identifying existing and potential hazards.
- Determining underlying causes of hazards.
- Monitoring hazard controls (Personal protective equipment, engineering controls, policies, procedures)
- Recommending corrective action.

Occupational hygiene

Occupational hygiene (Industrial hygiene) (Fig 8) is the discipline of anticipating, recognizing, evaluating and controlling health hazards in the working environment with the objective of protecting worker health and well-being and safeguarding the community at large.

Fig 8



Occupational hygiene uses science and engineering to prevent ill health caused by the environment in which people work. It helps employers and employees to understand the risks and improve working conditions and working practices. (Fig 9)

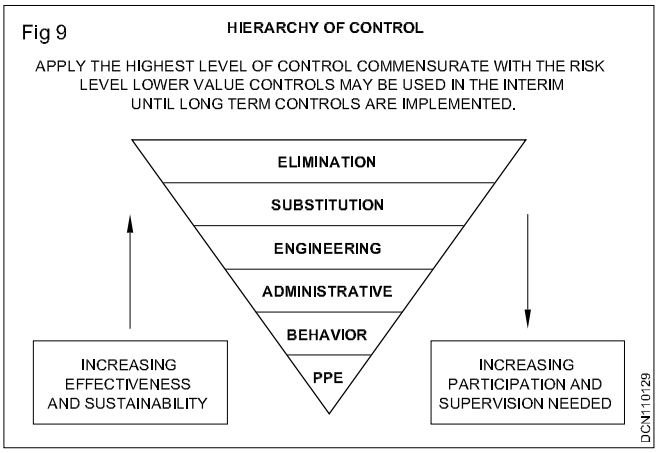
Occupational disease/Disorders & its prevention

Occupational disease, illness incurred because of the conditions or environment of employment. Unlike with accidents, some time usually elapses between exposure to the cause and development of symptoms. In some instances, symptoms may not become evident for may years and hence the relationship between work and disease is ignored.

Among the environmental causes of occupational disease are subjection to extremes of temperature leading to

heatstroke, air contaminants of dust, gas, fumes causing diseases of the respiratory tract, skin, or muscles and joints or changes in atmospheric pressure causing decompression sickness, excessive noise causing hearing loss, exposure to infrared or ultraviolet radiation or to radioactive substances. The widespread use of X rays, radium and materials essential to the production of nuclear power has led to an special awareness of the dangers of radiation sickness. Hence careful checking of equipment and the proper protection of all personnel are now mandatory.

Fig 9



In addition there are industries in which metal dusts, chemical substances, and unusual exposure to infective substances constitute occupational hazards. The most common of the dust and fiber inspired disorders are the lung diseases caused by silica, beryllium, bauxite and iron ore to which miners, granite workers and many others are exposed causing pneumoconiosis and those caused by asbestos is cancer - mesothelioma, Fumes, Smoke and Toxic liquids from a great number of chemicals are other occupational dangers. Carbon monoxide, Carbon tetrachloride, Chlorine, Creosote, Cyanides, Dinitrobenzene, Mercury, Lead Phosphorus and nitrous chloride are but a few of the substances that on entering through the skin, respiratory tract or digestive tract cause serious and often fatal illness.

Occupational hazards also are presented by infective sources. Persons who come into contact with infected animals in a living or deceased state are in danger of acquiring such diseases as anthrax. Doctors, Nurses and other hospital personnel are prime targets for the tuberculosis bacillus and for many other infectious organisms.

Fire safety

Objectives: At the end of this lesson you shall be able to
- **state different type of fire**
- **state the differemt types of fire extinguishers and their basic function.**

Fire safety : Fire is the most common serious hazard that one faces in a typical chemistry laboratory. While proper procedure and training can minimize the chances of an accidental fire, you must still be prepared to deal with a fire emergency should it occur.

Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent which can be discharged to extinguish a fire.

There are two main types of fire extinguishers :

- Stored pressure
- Cartridge-operated.

In stored pressure units, the expellant is stored in the same chamber as the firefighting agent itself. Depending on the agent used, different propellants are used. With dry chemical extinguishers, nitrogen is typically used, water and foam extinguishers typically use air. Stored pressure fire extinguishers are the most common type.

Carbon-dioxide extinguishers contain the expellant gas in a separate cartridge that is punctured prior to discharge, exposing the propellant to the extinguishing agent. This type is not as common, used primarily in areas such as industrial facilities, where they receive higher-than-average use. They have the advantage of simple and prompt recharge, allowing an operator to discharge the extinguisher, recharge it and return to the fire in a reasonable amount of time. Unlike stored pressure types, these extinguishers use compressed carbon dioxide instead of nitrogen, although nitrogen cartridges are used on low temperature (-60 rated) models.

Cartridge operated extinguishers are available in dry chemical and dry powder and in water, wetting agent, foam, dry chemical (classes ABC and B.C.) and dry powder (class D) types in the rest of the world.

Class A : This is suitable for cloth, wood, rubber, paper, various plastics, and regular combustible fires. It is usually filled with 2 ½ gallons (9.46 litres) of pressurized water.

Class A fire extinguishers are designed to put out fires that have started from household items that are made out of materials that will quickly ignite. These materials include paper products and furniture made from wood. The Type A fire extinguisher contains water. The number on the canister represents how much water it contains. If there is a No. 1, the extinguisher will have a little more than I gallon of water. The higher the number, the more water it contains. The letter A stands for ash. A fire that burns from household items will leave ashes.

Class B : This is suitable for grease, gasoline or oil-based fire is usually filled with a dry chemical. Extinguishers smaller than 6lbs (2.72kg) are not recommended.

Fig 1

A : Green Triangle		**Ordinary solid combustibles**		**A for "Ash"**
B : Red Square and gases		**Flammable liquids**		**B for "Barrel"**
C : Blue Circle		**Energized electrical equipment**		**C for "Current"**
D : Yellow Decagon (Star)		**Combustible metals**		**D for "Dynamite"**
K : Black Hexagon		**Oils and fats**		**K for "kitchen"**

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Class B fire extinguishers are used to put out fires that have started from highly flammable liquids. These liquids include any type of lacquer or oil-based paint products, paint thinners and lacquer thinners, oils and gasoline. According to the phoenix fire department, the letter B represents a barrel. Most of these chemicals are transported in a barrel-like container. The number on the extinguisher represents how many square feet it will cover. A 3 would represent 3 square feet, which is not a very large area. A larger fire could not be extinguished with this extinguisher.

Class C : This is suitable for electrical fires caused by appliances, tools and other plugged in gear. It can contain either halon or CO_2. Halon expensive and depletes the ozone layer and its use is restricted.

Class C : fire extinguishers are used to put out fires that have started from an electrical source. The source could be from appliances, lighting or your electrical system. This extinguisher uses carbon dioxide to put out the fire. Carbon dioxide will basically remove the oxygen from the air around the fire. Carbon dioxide is also used in some Type B extinguishers.

Class D : This is used for water-reactive metals such as burning magnesium and will be located in factories using such metals. It comes in the form of a powder that must cover the material to extinguish it.

Class D : Class D extinguishers are used to put out fires on metals that are capable of burning. These types of metals are found in the manufacturing industry only. This extinguisher uses a dry powder to put out the fire. You will not likely ever have a need for this type of extinguisher unless you work with titanium, sodium or magnesium.

Class K : This contains a special purpose wet chemical agent for use in kitchen fires and deep fryers to stop fires started by vegetable oils, animal fats, or other fats started in cooking appliances.

Class K : Many people have not heard of the Type K fire extinguisher. This extinguisher can be found in large kitchens. Many restaurants use large deep fryers full of cooking oils to deep fry foods. The typical Type B extinguisher would not be sufficient to put out a grease fire of this magnitude.

Fire fighting methods

Starvation/Blanketing	- Elimination of fuel
Smothering	- Limitation of oxygen
Cooling	- Removal of temperature

Accident & Safety

Objectives: At the end of this lesson you shall be able to
- **state the base principle for protective equipment**
- **state the accident prevention technique**
- **describe the controls of accidents & safety measures.**

Basic Principles for Protective Equipment (PPE)

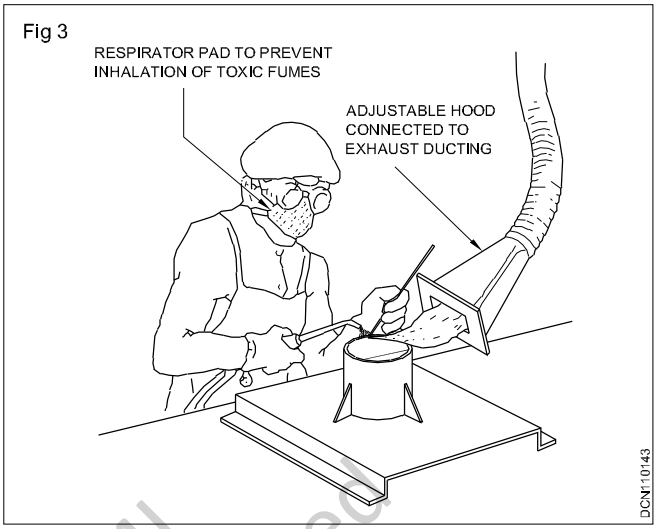
Personal protective equipment, commonly referred to as "PPE", is a equipment worn to minimize exposure to serious workplace injuries and illnesses. (Fig 1) These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators or coveralls, vests and full body suits. (Fig 2 & Fig 3)

Fig 1

Fig 2

Use of personal protective equipment : All personal protective equipment should be of safe design and construction, and should be maintained in a clean and reliable fashion. It should fit well and be comfortable to wear, encouraging worker use. If the personal protective equipment does not fit properly, it can make the difference between being safely covered or dangerously exposed. When engineering, work practice and administrative controls are not feasible or do not provide sufficient protection, employers must provide personal protective equipment to their workers and ensure its proper use. Employers are also required to train each worker required to use personal protective equipment to know:

Fig 3



- When it is necessary?
- What kind is necessary?
- How to properly put it on, adjust, wear and take if off.
- The limitations of the equipment
- Proper care, maintenance, useful life and disposal of the equipment.

If PPE is to be used, a PPE program should be implemented. This program should address the hazards present; the selection, maintenance and use of PPE; the training of employees and monitoring of the program to ensure its ongoing effectiveness.

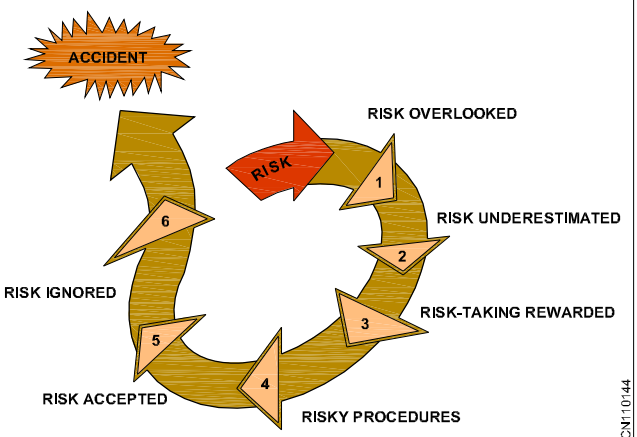
Accident prevention techniques-control of accidents and safety measures

Accident are unplanned, undesired event, not necessarily resulting in an injury or illness, but damaging property and/or interrupting the activity in process. Accident happen at all jobs. There are certain accidents that are common to a job. All employees should be trained and reminded how to do their job correctly to prevent unnecessary injuries while at work. An accident can occur when a machine malfunction or a person isn't paying attention to the work they are suppose to be doing. Even a small accident can cause major problems for an employee and their employer. The best practice to avoid all types of accidents is to teach and promote a safe and happy workplace. (Fig 4)

Accidents can happen anytime at any place they are more likely to happen when a person is participating in an unsafe act. That is why it is important to follow all safety rules and guidelines while working. If a taking a few more minutes to do the job safe is worth saving your life.

Overexertion in the workplace is a serious issue. Prevent damage to your back, knees and arms is very important. Train all employees on how to prevent overexertion by following safety rules and guidelines while completing workplace task.

Fig 4

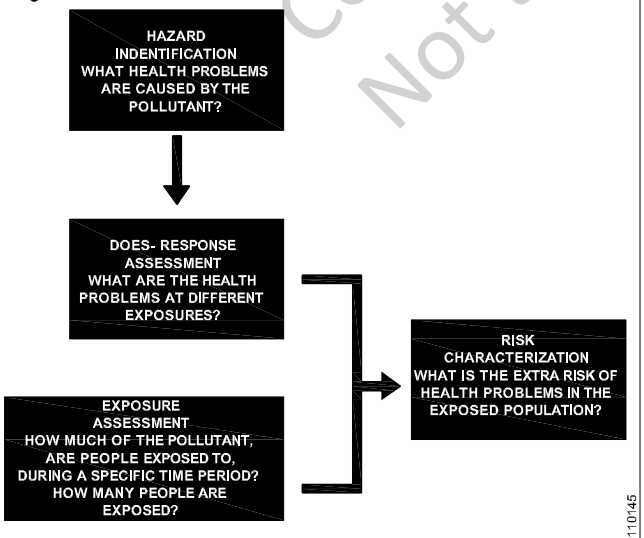


Control of accidents are done by reducing exposure to a hazards through engineering, work practices, administration or protective equipment.

Responsibilities

At department level the supervisors are made to instruct their employees regarding the requirements of this program, effectively enforce compliance of this program's procedures, including the use of disciplinary action, for any violations or deviations from the procedures outlined in this program; assure that the equipment required for compliance with this program is in proper working order, inspected and tested as required, and made available for use to their employees, promptly investigate and report all on-the-job accidents or job related health problems. (Fig 5)

Fig 5

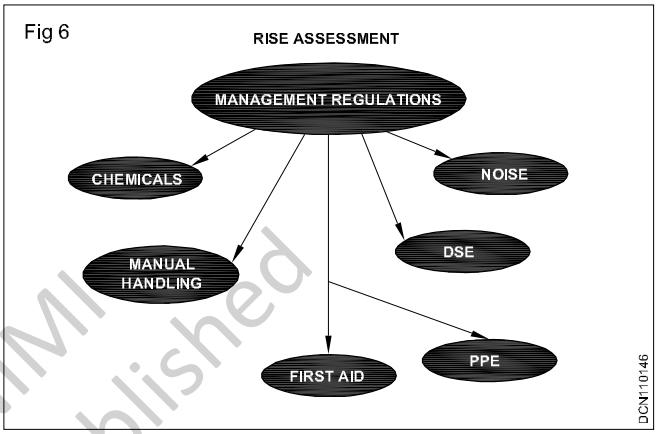


THE 4 STEP RISK ASSESSMENT PROCESS

Recognizing and controlling hazards

Engineering controls minimize employee exposure by either reducing or removing the hazard at the source or isolating the worker from the hazard. Engineering controls include eliminating toxic chemical and substituting non-toxic chemicals, enclosing work processes or confining work operations, and the installation of general and local ventilation systems. Work practice controls alter the manner in which a task is performed. Some fundamental and easily implemented work practice, controls include changing existing work practices to follow proper procedures that minimize exposures. While operating production and control equipment, inspecting and maintaining process and control equipment on a regular basis, implementing good housekeeping procedures, providing good supervision and mandating that eating, drinking, smoking, chewing tobacco or gum, and applying cosmetics in regulated areas be prohibited.

Fig 6



Administrative controls, include controlling employees' exposure by scheduling production and tasks, or both, in ways the minimize exposure levels. (Fig 6) For example, the employer might schedule operations with the highest exposure potential during periods when the fewest employees are present. When effective work practices or engineering controls are not feasible or while such controls are being instituted, appropriate personal protective equipment must be used. Examples of personal protective equipment are gloves, safety goggles, helmets, safety shoes, protective clothing and respirators. To be effective, personal protective equipment must be individually selected, properly fitted and periodically refitted, consciously and properly worn, regularly maintained and replaced, as necessary.

The employees have to comply with the procedures of this program, consult with their supervisor, when they have questions regarding the safety and health conditions of their workplace, report any accidents or job related injuries or illnesses to their supervisor and seek prompt medical treatment, if necessary.

Employees are responsible for exercising appropriate care and good judgment in preventing injuries and illnesses, adhering to all safety and health rules, policies and procedures and reporting all unsafe conditions, malfunctioning or unsafe equipment, work related accidents, injuries and illnesses, and unsafe work practices to their immediate supervisor. If that is not feasible, a report should be made to the head of their department, the plant operations safety officer, or a member of the work safe/be well committee.

First Aid

Objectives: At the end of this lesson you shall be able to
- **explain how to take care of injured & sick persons at workplaces**
- **explain how to provide first aid & transportation to sick person**
- **state ABC of first aid**
- **state how to report an emergency.**

Purpose of First Aid

- To sustain life
- To prevent suffering
- To prevent secondary complications
- To promote speedy recovery
- To prepare for further medical treatment.

Each separate work site or shop should have a fully stocked first aid kit available for injuries or emergencies. First aid kits will be regularly inspected to insure they are adequately stocked with consumables and equipment. All first aid kits should conform to the most recent guidelines for first aid kits.

For temporary work sites, first aid kits may be stored in gang boxes, on vehicles, or other similar locations, as long as easy access for all workers at the temporary site is maintained, each worker knows where the first aid kit is located, and the kit is maintained in accordance with.

In situations where workers are injured beyond the need for general first aid, medical treatment will be provided in accordance with the plant workplace health and medical treatment program. At anytime a potential life threating injury has been incurred, workers will contact local emergency response services immediately, by the quickest means available.

Workers receiving medical treatment or surveillance examinations may be supplied with copies of the written opinions of the examining physicians as required by regulation, or recommended by the physician. Medical records for employees must be kept strictly confidential with access restricted to information directly related to work activities. Generally, medical records will be kept in the control of the examining physician/staff of the first-aid centre.

In emergency situations, such as fires, criminal, terrorist or civil disturbances, situations involving spills of, releases of, or exposure to hazardous materials (e.g. Chemical, Biological, Radiological), situations of severe weather, such as storms, tornadoes, blizzards, etc., or the loss of utility services, such as electricity, water, heat etc., workers should take appropriate actions to safeguard their lives, the lives of building occupants, and if possible the property of the university. Workers are to contact the appropriate agency as outlined.

First aid is defined as the immediate care and support given to an acutely injured or ill person, primarily to save life, prevent further deterioration or injury, plan to shift the victims to safer places, provide best possible comfort and finally help them to reach the medical centre/hospital through all available means. It is an immediate life-saving procedure using all resources available within reach.

Imparting knowledge and skill through institutional teaching at younger age group in schools, colleges, entry point at industry level is now given much importance. Inculcating such habits at early age, helps to build good healthcare habits among people.

ASSESSING THE SICK OR INjURED

PRIMARY SURVEY

- Is an initial rapid assessment of a casualty to establish and treat conditions that are an immediate threat to life.

DANGER
RESPONSE
AIRWAY
BREATHING
CIRCULATION

DR ABC

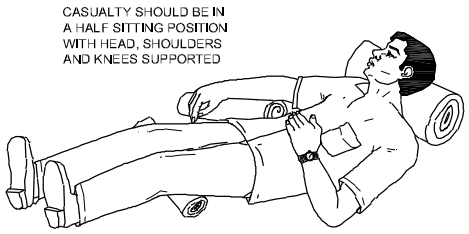
First-aid procedure often consists of a range of simple and basic life saving techniques that an individual performs with proper training and knowledge.

The key aims of first aid can be summarized in three key points :

- **Preserve life :** If the patient was breathing, a first aider would normally place them in the recovery position, with the patient leant over on their side, which also has the effect of clearing the tongue from the pharynx. It also avoids a common cause of death in unconscious patients, which is choking on regurgitated stomach contents. The airway can also become blocked through a foreign object becoming lodged in the pharynx or larynx, commonly called choking. The first aider will be taught to deal with this through a combination of 'back slaps' and 'abdominal thrusts'. Once the airway has been opened, the first aider would assess to see if the patient is breathing.
- **Prevent further harm :** also sometimes called prevent the condition from worsening, or danger of further injury, this covers both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleed becoming dangerous. Victim should be in half

sitting position with head, shoulder & neck support. (Fig 1)

Fig 1



- **Promote recovery :** First aid also involves trying to start the recovery process from the illness or injury, and in some cases might involve completing a treatment, such as in the case of applying a plaster to a small wound.

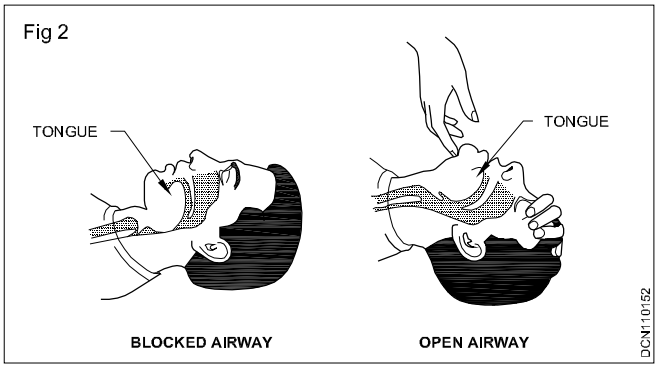
Training : Basic principles, such as knowing to use an adhesive bandage or applying direct pressure on a bleed, are often acquired passively through life experiences. However, to provide effective, life-saving first aid interventions requires instruction and practical training. This is especially true where it relates to potentially fatal illnesses and injuries, such as those that require Cardio Pulmonary Resuscitation (CPR), these procedures may be invasive and carry a risk of further injury to the patient and the provider. As with any training, it is more useful if it occurs before actual emergency, and in many countries, emergency ambulance dispatchers may give basic first aid instructions over the phone while the ambulance is on the way.

Training is generally provided by attending a course, typically leading to certification. Due to regular changes in procedures and protocols, based on updated clinical knowledge, and to maintain skill, attendance at regular refresher courses or re-certification is often necessary. First aid training is often available through community organizations such as the red cross and St. John ambulance.

ABC or First-aid : ABC stands for Airway, Breathing and Circulation

Airway : Attention must first be brought to the airway to ensure it is clear. Obstruction (choking) is a life-threatening emergency. (Fig 2)

Fig 2



Breathing : Breathing if stops, the victim may die soon. Hence means of providing support for breathing is an important next step. There are several methods practiced in first-aid.

Circulation : Blood circulation is vital to keep person alive. The first aiders now trained to go straight to chest compressions through CPR methods. (Fig 3 & Fig 4)

Fig 3

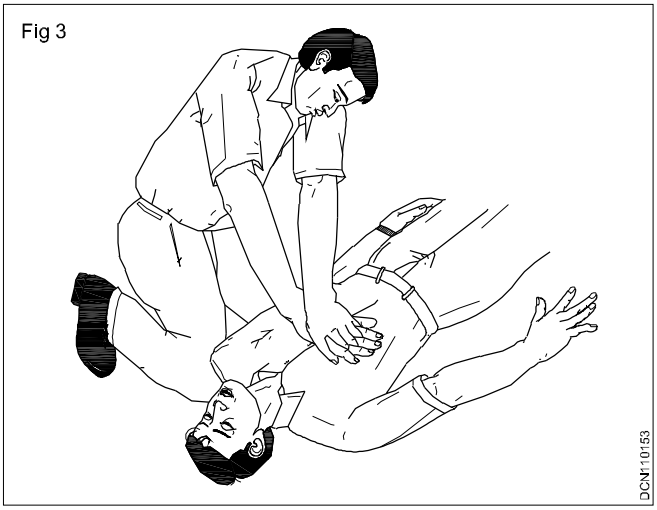


Fig 4

When providing first aid one needs to follow some rule. There are certain basic norms in teaching and training students in the approach and administration of first-aid to sick and injured. (Fig 5)

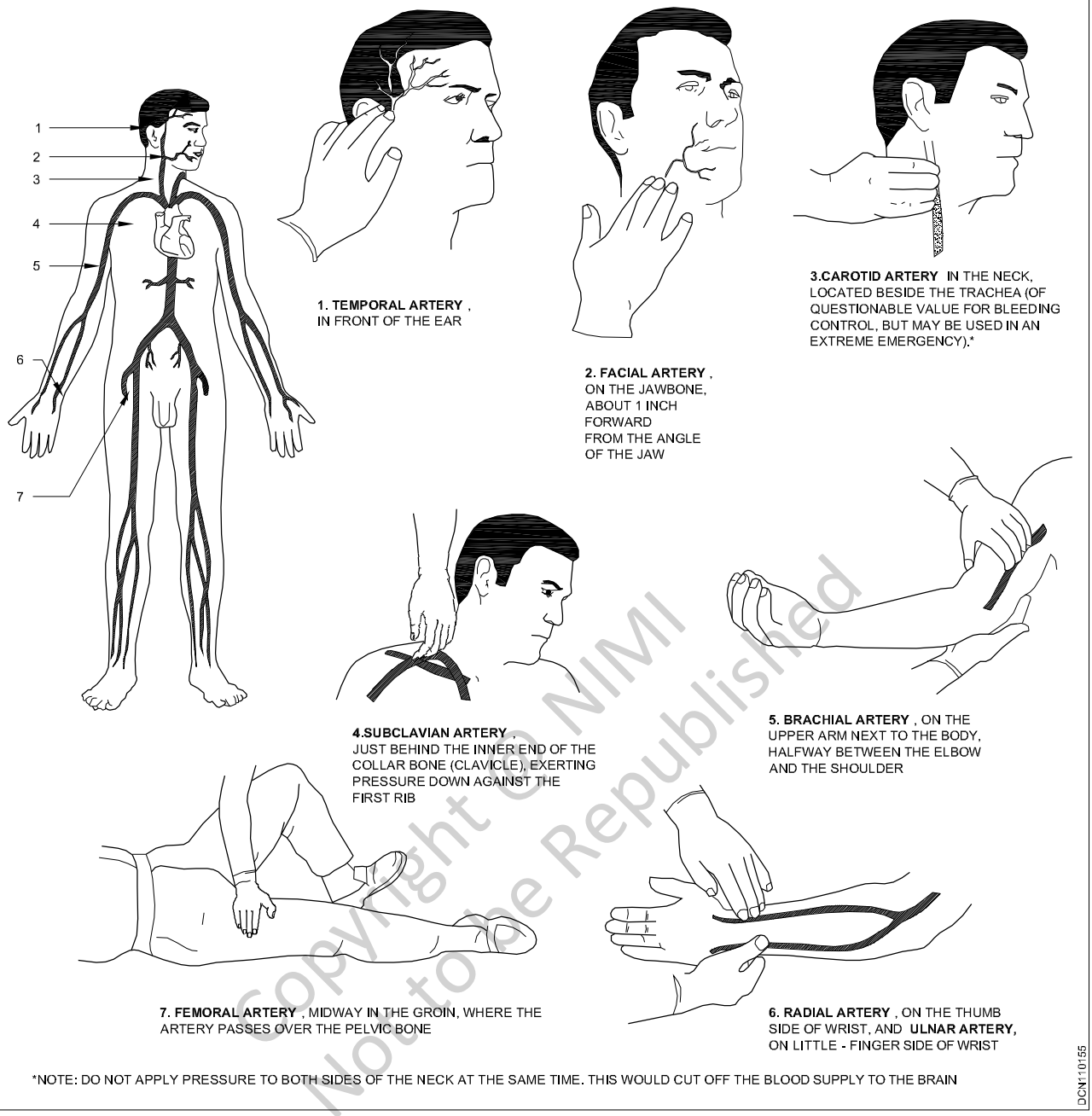
Not to get panic : Panic is one emotion that can make the situation more worse. People often make mistake because they get panic. Panic clouds thinking and causes mistakes. First-aider need calm and collective approach. if the first-aider himself is in a state of fear and panic gross mistakes may result. It's far easier to help the suffering, when they know what they are doing, even if unprepared to encounter a situation. Emotional approach and response always lead to wrong doing and may cloud one to do wrong procedures. Hence be calm and focus on the given situation. Quick and confident approach can lessen the effect of injury.

Call medical emergencies : If the situation demands, quickly call for medical assistance. Prompt approach may save the life.

Surroundings play vital role : Different surrounding require different approach. Hence first-aider should study the surrounding carefully. In other words, one need to make sure that they are safe and are not in any danger as it would be of no help that the first aider himself get injured.

Do no harm : Most often, enthusiastically practiced First-Aid Viz. administering water when the victim is unconscious, wiping clotted blood (which acts as plug to reduce bleeding), correcting fractures, mishandling injured

Fig 5



parts etc., would leads to more complication. Patients often die due to wrong FIRST-AID methods, who may otherwise easily survive. Do not move the injured person unless the situation demands. It is best to make him lie wherever he is because if the patient has back, head or neck injury, moving him would cause more harm.

This does not mean do nothing. It mean to make sure that to do something the care givers feel confident through training would make matters safe. If the first-aider is not confident of correct handling it is better not to intervene of do it. Hence moving a trauma victim, especially an unconscious one, need very careful assessment. Removals of an embedded objects (like a knife, nail) from the wound may precipitate more harm (e.g., increased bleeding). Always it is better to call for help.

Reassurance : Reassure the victim by speaking encouragingly with him.

Stop the bleeding : If the victim is bleeding, try to stop the bleeding by applying pressure over the injured part.

Golden Hours : India have best of technology made available in hospitals to treat devastating medical problems viz. head injury, multiple trauma, heart attack, strokes etc, but patients often do poorly because they don't gain access to that technology in time. The risk of dying from these conditions, is greatest in the first 30 minutes, often instantly. This period is referred to as golden period. By the time the patient reach hospitals, they would have passed that critical period. First-aid care come handy to save lives. It helps to get to the nearest emergency room as quickly as possible through safe handling and

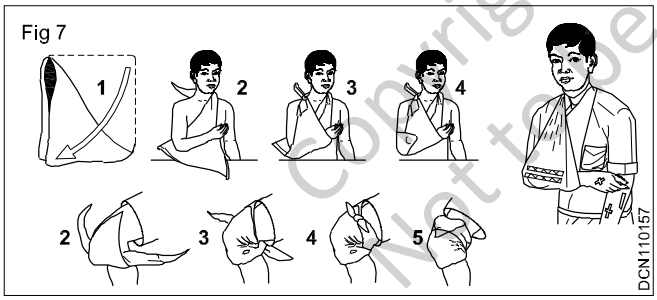
transportation. The shorter that time, the more likely the best treatment applied. (Fig 6)

Fig 6

Maintain the hygiene : Most importantly, first-aider need to wash hands and dry before giving any first aid treatment to the patient or wear gloves in order to prevent infection.

Cleaning and Dressing (Fig 7) : Always clean the wound thoroughly before applying the bandage. Lightly wash the wound with clean water.

Fig 7



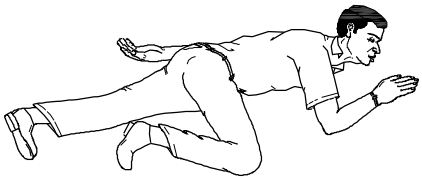
Not to use local medications on cuts or open wounds. They are more irritating to tissue than it is helpful. Simple dry cleaning or with water and some kind of bandage are best.

Stay with the victim until help arrives : Try to be a calming presence for the victim until assistance can arrive.

Unconsciousness

Loss of consciousness may threaten life if the person is on his back and the tongue has dropped to the back of the throat, blocking the airway. Make certain that the person is breathing before looking for the cause of unconsciousness. If the injuries permit, place the casualty in the recovery position with the neck extended.(Fig 8) Never give anything by mouth to an unconscious casualty. Unconscious also referred as **coma,** is a serious life threatening condition, when a person lie totally senseless and do not respond to calls, external stimulus. But the basic heart, breathing, blood circulation may be still intact, or they may also be failing if unattended it may lead to death.

Fig 8



The condition arises due to interruption of normal brain activity. The causes are too many.

- Shock (Cardiogenic, Neurogenic)
- Head injury (Concussion, Compression)
- Asphyxia (Obstruction to air passage)
- Extremes of Body temperature (Heat, Cold)
- Cardiac Arrest (Heart attack)
- Stroke (Cerbro-vasular accident)
- Blood loss (Haemorrhage)
- Dehydration (Diarrohoea & vomiting)
- Diabetes (Low or high sugar)
- Blood pressure (Very low or vey high)
- Over dose of alcohol, drugs
- Poisoning (Gas, pesticides, bites)
- Epileptic Fits (Fits)
- Hysteria (Emotional, Psychological)

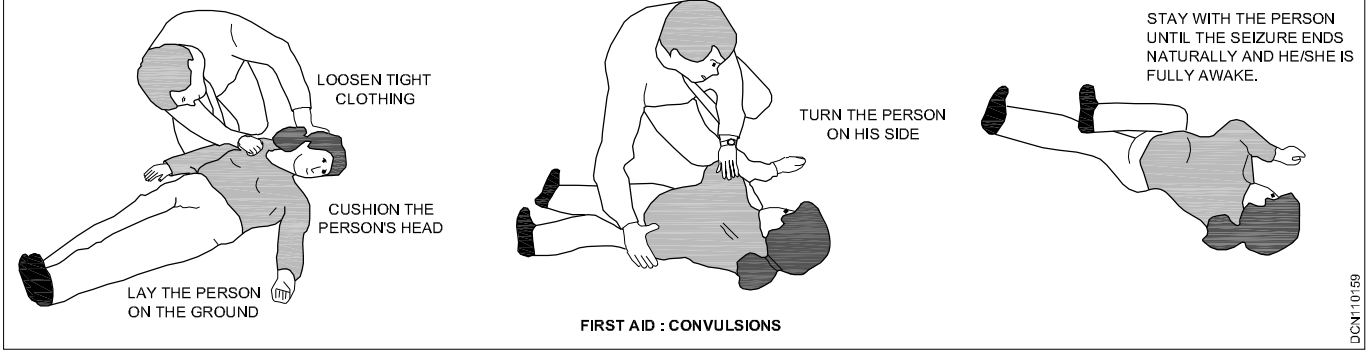
The following symptoms may occur after a person has been unconscious : (Fig 9)

- Confusion
- Drowsiness
- Headache
- Inability to speak or move parts of his or her body (see stroke symptoms)
- Light headedness
- Loss of bowel or bladder control (incontinence)
- Rapid heartbeat (Palpitations)
- Stupor

First aid

- Call emergency number.
- Check the person's airway, breathing and pulse frequently. If necessary, begin rescue breathing and CPR.
- If the person is breathing and lying on the back, and after ruling out spinal injury, carefully roll the person onto the side, preferably left side. Bend the top leg so

Fig 9

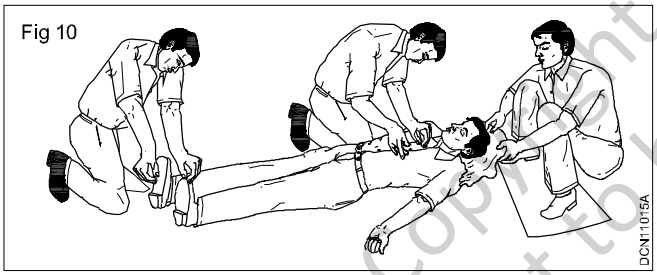


FIRST AID : CONVULSIONS

both hip and knee are at right angles. Gently tilt the head back to keep the airway open. If breathing or pulse stops at any time, roll the person on to his back and begin CPR.

- If there is a spinal injury, the victims position may have to be carefully assessed. If the person vomits, roll the entire body at one time to the side. Support the neck and back to keep the head and body in the same position while you roll.
- Keep the person warm until medical help arrives.
- If you see a person fainting, try to prevent a fall. Lay the person flat on the floor and raise the level of feet above and support.
- If fainting is likely due to low blood sugar, give the person something sweet to eat or drink when they become conscious. (Fig 10)

Fig 10



Do Not

- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

First-aid box

Small, medium and large dressings : These are sterile pads with bandages attached that can be used to control heavy bleeding and cover minor wounds. Triangular bandages - These are an extremely versatile piece of equipment. Folded into a pad, they can be used as a cold compress or as padding around a painful area. They can provide cover for burns or large scrapes and support broken bones.

Adhesive bandage (for small wounds), **Non-adhesive sterile dressings (various sizes), safety tape, adhesive tape and hypoallergenic tape.** Dressing can be cut to size and used to cover scrapes, burns and small wounds.

Gauze swabs : For use with water to clean wounds.

Ace bandages, compression bandages, tubular bandage : For use in providing support to sprains and strains.

Disposable gloves : For use in managing body fluids.

Blunt-ended scissors : tweezers.

Transport safety : Use one of the most safer methods.

CPR (Cardio-Pulmonary Resuscitation) : CPR can be life sustaining. If one is trained in CPR and the person is suffering from choking or finds difficulty in breathing, immediately begin CPR. However, if one is not trained in CPR, do not attempt as you can cause further injury. But most people do it wrong. This is a difficult procedure to do in a crowded area. Also there are many studies to suggest that no survival advantage when bystanders deliver breaths to victims compared to when they only do chest compressions. Second, it is very difficult to carry right maneuver in wrong places. But CPR, if carefully done by highly skilled first-aiders is a bridge that keeps vital organs oxygenated until medical team arrives.

Declaring death : It is not correct to declare the victim's death at the accident site. It has to be done by qualified medical doctors.

How to report an emergency?

Reporting an emergency is one of those things that seems simple enough, until actually when put to sue in emergency situations. A sense of shock prevail at the accident sites. Large crowd gather around only with inquisitive nature, but not to extend helping hands to the victims. This is common in road side injuries. No passer-by would like to get involved to assist the victims. Hence first-aid management is often very difficult to attend to the injured persons. The first-aiders need to adapt multi-task strategy to control the crowd around, communicate to the rescue team, call ambulance etc., all to be done simultaneously. The mobile phones helps to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- A crime, especially one that is currently in progress. If you're reporting a crime, give a physical description of the person committing the crime.
- A fire, if you're reporting a fire, describe how the fire started and where exactly it is located. If someone has already been injured or is missing, report that as well.
- A life-threatening medical emergency that requires immediate attention. If you're reporting a medical emergency, explain how the incident occurred and what symptoms the person currently displays.
- A car crash - Location, serious nature of injuries, vehicle's details and registration, number of people involved etc.

Call emergency services : The emergency number varies - 100 for Police & Fire, 108 for Ambulance.

Report your location : The first thing the emergency dispatcher will ask is where you are located, so the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information.

Give the dispatcher your phone number : This information is also imperative for the dispatcher to have, so he or she is able to call back if necessary.

Describe the nature of the emergency : Speak in a calm, clear voice and tell the dispatcher why you are calling. Give the most important details first, then answer the dispatcher's follow-up questions as best you can.

Do not hang up the phone until you are instructed to do so. Then follow the instructions you were given.

How to do basic first aid?

Basic first aid refers to the initial process of assessing and addressing the needs of someone who has been injured or is in physiological distress due to choking, a heart attack, allergic reactions, drugs or other medical emergencies. Basic first aid allows one to quickly determine a person's physical condition and the correct course of treatment.

Important guideline for first-aiders

Evaluate the situation (Are there things that might put the first-aider at risk)? When faced with accidents like fire, toxic, smoke, gases, an unstable building, live electrical wires or other dangerous scenario, the first-aider should be very careful not to rush into a situation, which may prove to be fatal.

Remember A-B-Cs : The ABCs of first aid refer to the three critical things the first-aiders need to look for.

- Airway - Does the person have an unobstructed airway?
- Breathing - Is the person breathing?
- Circulation - Does the person show a pulse at major pulse point (Wrist, carotid artery, groin)

Avoid moving the victim : Avoid moving the victim unless they are in immediate danger. Moving a victim will often make injuries worse, especially in the case of spinal cord injuries.

Call emergency services : Call for help or tell someone else to call for help as soon as possible. if alone in at the accident scene, try to establish breathing before calling for help, and do not leave the victim alone unattended.

Determine responsiveness : If a person is unconscious, try to rouse them by gently shaking and speaking to them.

If the person remains unresponsive, carefully roll them onto the side (recovery position) and open his airway.

- Keep head and neck aligned.
- Carefully roll them onto their back while holding his head.
- Open the airway by lifting the chin.

Look, listen and feel for signs of breathing : Look for the victim's chest to rise and fall, listen for sounds of breathing.

If the victim is not breathing, see the section below.

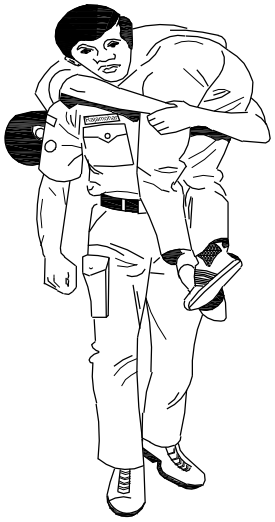
- If the victim is breathing, but unconscious, roll them onto their side, keeping the head and neck aligned with the body. This will help drain the mouth and prevent the tongue or vomit from blocking the airway.

Check the victim's circulation : Look at the victim's color and check their pulse (the carotid artery is a good option; it is located on either side of the neck, below the jawbone). if the victim does not have a pulse, start CPR.

Treat bleeding, shock and other problems as needed: After establishing that the victim is breathing and has a pulse, next priority should be, to control any bleeding. Particularly in the case of trauma, preventing shock is the priority. Some of the ways are mentioned in Fig 11, 12, 13 & 14 how to handle victims.

- **Stop bleeding :** Control of bleeding is one of the most important things to save a trauma victim. Use direct pressure on a wound before trying any other method of managing bleeding.
- **Treat shock :** Shock, a loss of blood flow to the body, frequently follows physical and occasionally psychological trauma. A person in shock will frequently have ice cold skin, be agitated or have an altered mental status, and have pale color to the skin around the face and lips. Untreated, shock can be fatal. Anyone who has suffered a severe injury or life-threatening situation is at risk for shock.
- **Choking victim :** Choking can cause death or permanent brain damage within minutes.

Fig 11



FIRE-MAN LIFT METHOD

DCN11015B

Fig 12

FORE AND AFT METHOD

DCN11015C

Fig 13

HAND SEAT METHOD

DCN11015D

Fig 14

HUMAN-CRUTCH METHODS

DCN11015E

- **Treat a burn :** Treat first and second degree burns by immersing or flushing with cool water. Don't use creams, butter or other ointments, and do not pop blisters. Third degree burns should be covered with a damp cloth. Remove clothing and jewellery from the burn, but do not try to remove charred clothing that is stuck to burns.
- **Treat a concussion :** If the victim has suffered a blow to the head, look for signs of concussion. Common symptoms are; loss of consciousness following the injury, disorientation or memory impairment, vertigo, nausea and lethargy.
- **Treat a spinal injury victim :** If a spinal injury is suspected, it is especially critical, not move the victim's head, neck or back unless they are in immediate danger.

Basic provisions for OSH

Objectives: At the end of this lesson you shall be able to
- **state the basic provisions of safely, health, welfare under legislation of India.**

India has legislation on occupational health and safety for over 50 years. A safe and health work environment is the basic right of every worker. The constitutional provision for occupational safety and health under the Article 24 - No child below the age of fourteen years shall be employed to work in any factory or mine or engaged in other hazardous employment.

Article 39 (e & f) - The state shall in particular direct its policy towards securing.

e that the health and strength of workers, men and women, and the tender age of children are not abused and that citizens are not forced by economic necessity to enter vocations unsuited to their age and strength.

f That children are given opportunities and facilities to develop in healthy manner and in conditions of freedom and dignity and that childhood and youth are protected against exploitation and against moral and material abandonment.

Article 42 - The state shall make provision for securing just and human conditions of work and maternity relief.

National policy

Safety and health occupies a very significant position in India's constitution which prohibits employment of children under 14 in factories, mines and in hazardous occupations. Policy aims to protect the health and strength of all workers. It prevents employment in occupations unsuitable for the age and strength of the workers. It is the policy of the state to make provisions for securing just and humane conditions of work. The constitution provides a broad framework under which policies and programmes for occupational health and safety could be established.

National Legislation

Legislation provides an essential foundation for safety. To be meaningful and effective legislation should be reviewed and updated regularly as scientific knowledge develops.

The most important legislation cover occupational safety, health and welfare are :

- The Factories Act 1948. amended 1954, 1970, 1976, 1987.
- The Mines Act, 1952.
- The dock workers (safety, health and welfare) Act, 1986.
- The plantation labour Act, 1951.
- The Explosives Act, 1984.
- The Petroleum Act, 1934.
- The Insecticide Act, 1968.
- The Indian Boilers Act, 1923.
- The Indian Electricity Act, 1910.
- The Dangerous Machines (Regulations) Act, 1983.
- The Indian Atomic Energy Act, 1962.
- The Radiological Protection Rules, 1971.
- The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.

Environment

Objectives: At the end of this lesson you shall be able to
- **state the meaning and definition of environment**
- **list out and explain the components of environment**
- **explain atmosphere and its composition**
- **state the relationship between society and environment**
- **state the factors responsible for destruction and natural disasters.**

Environment Education is a process which makes the world community conscious about the problem of the environment. By this way we may understand the problem and find its solution and may also protect future problems.

Environmental Education (EE) can be linked with three main components

- Education about the environment (Knowledge).
- Education for the environment (Values, attitudes & positive actions).
- Education through the environment (A resource).

Meaning and definition of environment

In general, the word **environment** refers the cover of our surroundings, which includes our earth, soil, water and the atmosphere situated on it. The environment is the important system which covers all the living and non-living system. So it is necessary every layman and literate person to know its meaning.

The word environment is composed of two words- **'environ'** and **'ment'** their meaning is 'to surround' or 'to enwrap', which gives the meaning of sense of situation of the surroundings or cover.

The dictionary meaning of the environment is the "particular surroundings in which living and non-living things exist".

In universal encyclopedia, it is defined as "Environment is the sum of all those condition, systems and influences which influence the development life and death of organisms and their species. On **5th June** every year **world environment** day is celebrated.

Some eminent scholars defined the environment as follows:-

According to **E.J.Ross,** "Environment is an external force which influences us"

According to **Dr. D.H. Davis,** "In relation to man environment means all those physical forms spread all around man on land by which he is influenced continuously.

According to **Kovits,** "Environment is the sum of all those external conditions which influences the development cycle of the organisms on the surface of the earth.

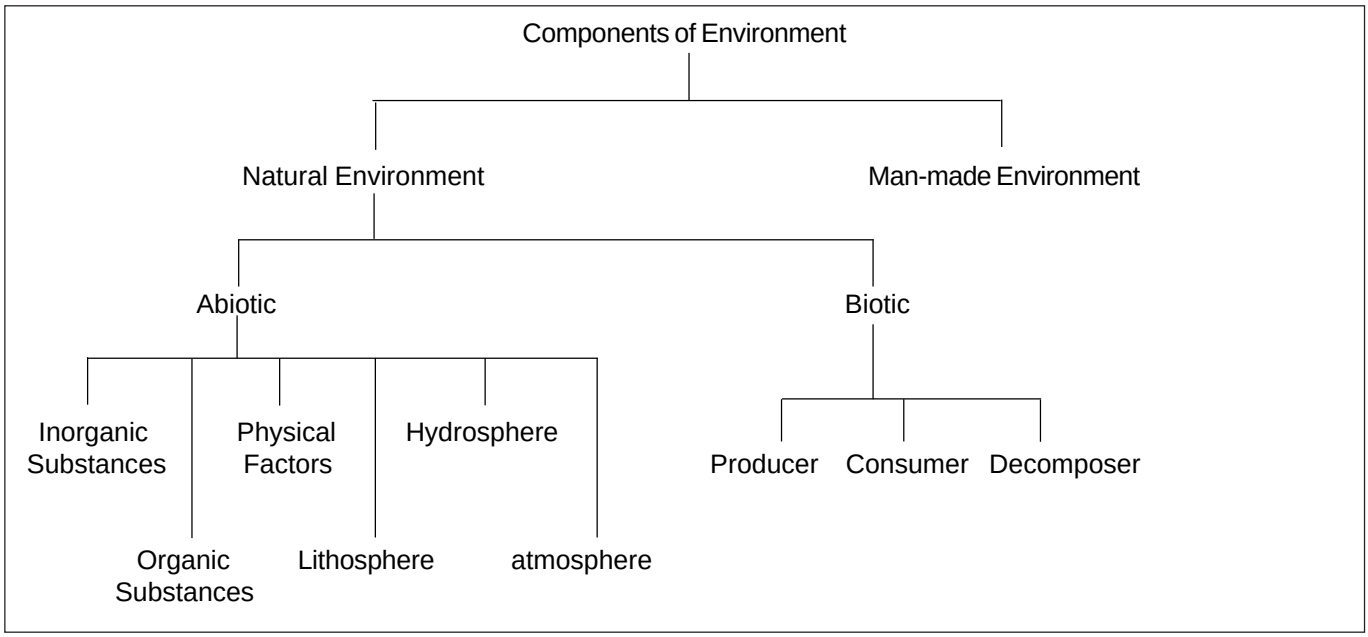
Components of Environment

The components of environment can be classified as shown in the flow diagram.

Land, water, air, soil etc are important inanimate (or) abiotic components. Man, animal, plants and other organisms are biotic components.

Natural Environment

The natural environment is the environment, which comes into existence without interference of man.



Billion years ago earth had surroundings which were not suitable for the existence of any kind of life. Then a mass of gaseous-chemical with hot temperature in which the organisms cannot exist. Due to the process of action and reaction of these chemicals after millions of years, the suitable condition of environment came to exist.

Many components together co-ordinated to form a natural environment which helps in substance of life. The natural environment components can be classified into two

1 Abiotic components

2 Biotic components

1 Abiotic components

These components are not living but can support other living organisms. When these components became unbalanced and they cause for total to the living organisms. Some kinds of such organisms are given below:

i) **Inorganic substances :** The elements which are taken up by the plants with the help of sunlight and converted into food. The examples of such inorganic elements are like nitrogen, calcium, phosphorus, hydrogen, carbon di-oxide and oxygen.

ii) **Organic substances :** The substances which are taken in the form of inorganic materials from the food source and are again sent back to the environment after decomposition by decomposers. E.g. Carbohydrates, proteins, fats etc.

iii) **Physical factors :** These factors have direct effect on living organisms, which are climatic conditions like temperature, rainfall, wind, humidity, soil and light energy which is used by the plants for the preparation of food.

iv) **Lithosphere :** The outermost layer of the earth (i.e.) soil or land.

v) **Hydrosphere :** Part of the earth having water resources like oceans, rivers, ponds and lakes.

vi) **Atmosphere :** It is a cover around the earth composed by variety of gases which protects the living organisms from various harmful cosmic radiations.

2 Biotic components of environment

The area in which the life is possible is called as biosphere. All living organism in the biosphere depends upon one another and these organisms exist in the biosphere forming the following community.

i) **Producers :** The green plants presents on earth surface which producers their own food only once by the process of photosynthesis in sunlight, water and carbon dioxide forms food for other organisms. E.g. Sugar, carbohydrates etc.

ii) **Consumer :** This organisms directly (or) indirectly depends upon the green plants for the source of food. E.g. All animals including man.

iii) **Decomposers :** These are micro organisms which decompose the complex compounds in the dead organic matter of plants and animals and again recycle the elements into the environment. E.g. Bacteria's and fungi.

Man-made environment

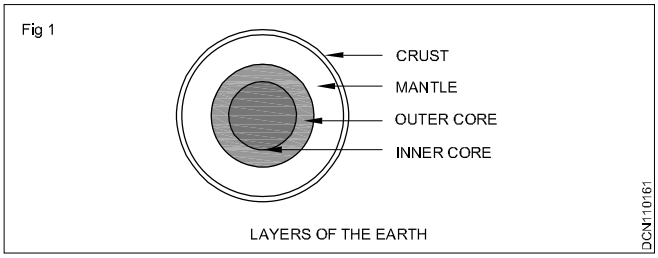
The man is the highest of all creatures on this earth, who has started modifying the environment according to his own needs and its consequences which he faces every day. The recent developments in the under developed countries lead to more critical conditions.

The conditions of the villages are worse because there is no sewerage and sanitation system. The competition in the villagers for the increase in production of agricultural products leads to more and more use which ultimately spoils the environment and alter the composition of natural products.

Atmosphere

The earth is a dynamic planet. It is constantly undergoing changes inside and outside of the earth.

Just like onion, the earth is made up of several concentric layers with one inside (Fig 1)



The uppermost layer over the earth's surface is called the 'crust'. It is the thinnest of all the layers and is about 35km on the continental masses and only 5km on the ocean floors. The main mineral constituents of the continental mass are the **'silica and alumina',** called as **'sial'.** The oceanic crust mainly consists of silica and magnesium, called as **'sima'.**

Just beneath the crust is the mantle which extends upto a depth of **2900km** below the crust.

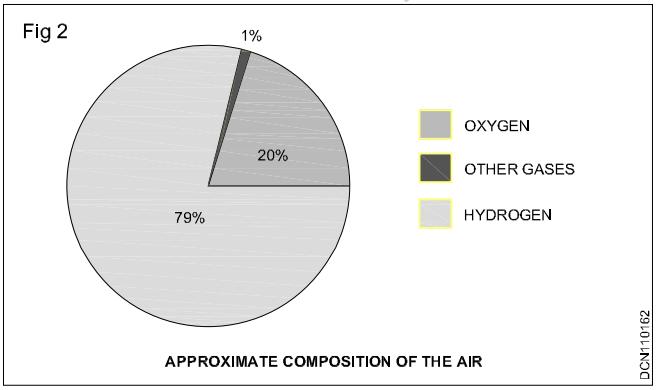
The innermost layer is the **core** with a radius of about 350km. It is made up of nickel and iron and is called **'nife'.** The central core has very high temperature and pressure.

The earth is surrounded by a huge blanket of air called **atmosphere.** All living things on this earth depend on the atmosphere for their survival. It provides the air to breathe and protects from the harmful effects of the sun's rays. It is the mass of air that has made the temperature on the earth liveable.

Atmosphere & its composition

The atmosphere is a thin layer of gases which stays above the earth due to the force of gravitation. It's air is colourless, odourless and tasteless.

The air is actually a mixture of many gases. Nitrogen and oxygen are two major gases of the atmosphere. Carbon dioxide (CO_2), Helium, Ozone, Organ and hydrogen are found in lesser quantities. Apart from these gases, tiny dust particles are also present in the air. The pie chart (Fig 2) shows the percentage of gases in the atmosphere.



Nitrogen is the most plentiful gas in the air. The plants need nitrogen for their survival. But they cannot take nitrogen directly from the air. Bacteria in the soil and roots of same plants take nitrogen from the air and change its form that plants can use it.

Oxygen (O_2) is the second most plentiful gas in the air. Humans and animals take oxygen from the air to breathe.

Green plants produce oxygen during photosynthesis. So oxygen content in the air remains constant.

Carbon dioxide (CO_2) to make their food and release oxygen. Humans or animals release carbon dioxide. The amount of carbon dioxide released by human (or) animals equal to the amount used by the plant make perfect balance.

This balance is upset by burning fuels (coal and oil). They add billions of tons of carbon dioxide into the atmosphere each year. This increased volume of carbon dioxide is affecting the earth's weather and climate.

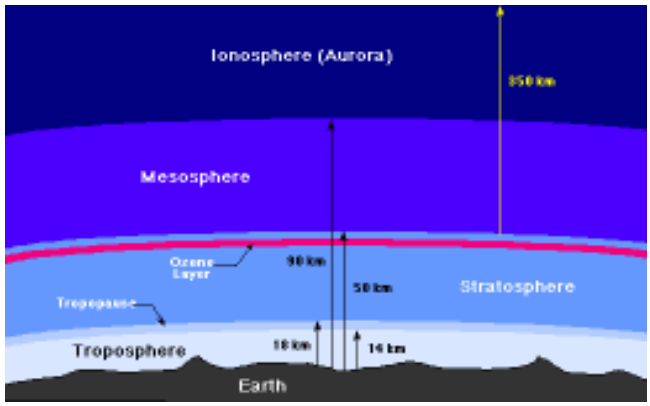
Atmospheric gases

The quantities of various gases.

Sl. No	Name of the gases	Percentage
1	Nitrogen	78.03%
2	Oxygen	20.99%
3	Argon	0.94%
4	Carbon dioxide	0.03%
5	Hydrogen	0.01%
6	Helium	0.0005%
7	Neon	0.0018%
8	Cryptal	0.0001%
9	Zeon	0.000009%
10	Ozone	0.000001%

Structure of the atmosphere

The atmosphere is divided into five layers starting from the earth's surface (Fig 3)



- **Troposphere (0 - 18kms) :** This layer is the most important layer of the atmosphere. The air breath exists here. All the weather like rainfall, fog and hailstorm occur in this layer.

- **Stratosphere (18 - 50kms) :** Above the troposphere lies the stratosphere. It is free from clouds and making continuous most ideal for flying Aeroplanes. It contains a layer of ozone gas, and it protects from the harmful effect of the sun rays.
- **Mesosphere (50 - 85kms) :** It is the third layer of the stratosphere. Temperature drops to about -95˚C.
- **Thermosphere(85 - 500kms) :** In this layer, the temperature rises very rapidly with increasing height. Ionosphere is a part of this layer. It helps in radio transmission.
- **Exosphere(500 - 1600kms) :** The upper most layer of the atmosphere is called as **exosphere.** It is very thin air. Temperature is very high due to direct solar radiation. Light gases like helium and hydrogen float into the space from here.

Relationship between the society and environment

Technological development was an important need of man in the ancient period but after that it became his habit because the facilities received from technology in the initial stage (or) in under developed storage ultra modern technology has affected environment more.

Nature controls pity mistakes of man, concerned with the environment by a self regulatory process and keep live environment in balance.

But continuous changes have attained such proportion that even the self regularly capacity of the nature has not been able to keep lie environmental balance. Due to this environmental problem have come into the force.

In ancient period the man used to collect his food in the form of fruits and roots and took shelter in the caves. This activity did not have any bad effect on the environment because his necessities were limited. When the man learnt to produce fire from the stone, then with the first invention in the field of technology was recognised. For cooking food, the man started making tools for cutting wood. It was the second stage of the advancement of technology in which he used his intellect according to his need.

In order to satisfy the needs for food, the man started propagation of plants which were good for his health. He recognised these plants, the fruits, leaves, stem and roots which were useful to him. The availability of resources at one place lead to increase the population, so people started migrating from one place to another. They cut down the forests for converting them into agricultural land. From this period onwards the process for a continuous change in the man and environment relation started.

For satisfying his economic needs man has developed science and technology to a great extent. To make the resources available in the increasing of population, ultra modern technology was developed. To satisfy his curiosity, the ambitions, man has started moving in the direction of achieving **'victory over nature'.** A change in this outlook has also occurred. He has changed into a **'technology man'.** Aspiring for an ownership over nature, he has started using the natural resources excessively.

The following physical changes for economic and industrial development

- New agriculture practice was adopted for more production crops to use hybrid seeds, and improved methods of irrigation to be adopted
- Use of machines in agriculture, chemical fertilizer are increased.
- Dams were made on the rivers; cannels were dug for irrigation and supply the storage of water.
- Roads and bridges were constructed.
- Construction of underground land and atmospheric explosions under nuclear programmes.

Environment problems created by man

Man has created problems with the nature and the environment which have become danger. Some of them are :

1 Depletion of ozone layer

Many gases are present in the atmosphere. In the upper portion of the stratosphere nearly 25km thick layer of **ozone gas,** known as **ozonosphere** which acts as a safety shield for the living things. Oxygen gas is converted into ozone gas and it forms a thick layer in the atmosphere. **Ozone layer** absorbs the sun rays and protects the flora present on the earth.

Scientist discovered the causes of depletion of ozone gas as follows.

- Man made Chloro - Fluro - Carbon (CFC)
- Excess of nitric oxide (NO) in the atmosphere
- Radiations from the nuclear centres.
- Gases released by explosion of atomic bombs.
- Chlorine gas related in volcano eruptions
- Polar cyclones.

What is CFC?

Chloro Fluro Carbons (CFC) constitute a family of manmade chemical compound. It was invented in the 1930's. They are non toxic and harmless to handle. CFCs are extremely stable and non-flammable. This stability gives them a long life span in the atmosphere allowing its transport to the stratosphere. In stratosphere, ultra violet radiation releases chlorine from the rest of the molecule. A single chlorine atom can destroy thousands of molecules of ozone

The scientist discovered a hole of 40km diameter, in the ozone layer above the South Pole. This ozone layer is affected by **polar cyclones.**

2 Green house effect

It occurs due to increase of the percentage of carbon dioxide in the atmosphere. It absorbs the solar rays and

energy of the sun due to which the temperature on the earth increases and natures balance gets disturbed. Our vehicles and industries are continuously increasing the amount of carbon dioxide in the atmosphere.

Solution to environment problems

By the **"Environment education"** only the environment pollution can be protected. Through the medium of education only human ideology and point of view can be changed. New sources of energy should be encouraged such as **solar energy, wind energy, biogas** and the use of **biodiesel in vehicles.** Such technology must be developed by which the natural sources and resources are used to the minimum and our environment and earth remains clean.

Personal and family responsibility about the environment

Man and his family can play important role in it. Their responsibilities are listed as below

- Educate awareness to prevent increasing of population
- Avoid wastage of water unnecessarily.
- Bio gas and solar cooker should be used in the place of wood as fuel.
- Cutting of trees should be prevented and the planted trees should be protected. Tree plantation on public places should be our goal.
- Insecticides and chemical fertilizers should be used in a limited quantity.
- In order to avoid noise pollution. Volume of T.V. and radio should be kept low.
- Control the use of petrol to vehicles should be used only for external essential tables.
- During festivals instead of electric lights the lamps and candles should be used. Now a days, instead of using filament lamps, CFL (Compact & Florescent Lamp) can be used.
- The domestic waste should not be thrown around. Use dustbin for such purpose.
- Use cloth bags instead of polythene bags.

Natural Disasters

Earth Quakes : The movement of lithosphere plates causes changes on the surface of the earth. When the lithospheric plates move, the surface of the earth vibrates. This vibrations can travel all round the earth. These vibrations are called as **'earth quake'.** It makes greatest damages of the buildings and environment.

The earth quake is measured with a machine called a **'seismograph'.** The magnitude of the earth quake is measured on the **'Richter scale'.**

Effect of destruction caused by earth quakes may be minimized by constructing earth quake resist building and construction project not to be undertaken in the sensitive area.

An earth quake of 2.0 richly or less	little effect
An earth quake of 5.0 falling	Course damage from things
An earth quake more than 6.0	very strong.

Volcano : It is a vent (opening) in the certain crust through which molten materials erupts and suddenly come out. It causes for mass disaster over the surface of earth. A volcano is a long narrow depression in the earth crust through which molten lava, ash and gases materials erupt. Tilt meter is one such instrument that can be implemented for volcanic activity.

Floods : Rivers can carry water according to their capacity only. Due to sudden essential rains and melting of ice the level of rivers suddenly increased. This water breaches the banks of the rivers and spread over the surrounding areas, is called as **'flood'.**

Due to the construction of roads, houses and commercial buildings, the area for flow of water and absorption in the earth reduced on maximum. The dams constructed for preventing the floods and due to digging of rivers undertaken.

Landslides : The process of sliding of the rocks and the soil downwards in the mountains due to the force of gravitation is called as **landslide.** The sudden sliding of rocks and the soil is dangerous. It is difficult to control landslide but its rate can be reduced by proper drainage of surface and ground water.and reducing erosion

Cyclones : Cyclones are a normal occurrence in coastal areas of torrid zone. Cyclones are produced in Torrid zone due to high temperature and humidity. In Atlantic Ocean they are named as **'hurricanes'** In Caribbean and northern eastern Pacific Ocean an **'Typhcon'** and in India occur as they are named as **"hilly willies or tropical cyclones.**

Storms : Storms are caused due to atmospheric depression in geographical area. Heavy storms brings severe calamity to the residential areas as well as in the agricultural fields.

Tsunami : 'Tsunami' is a Japanese word meaning 'harbour waves'. A Tsunami is a wave train or a series of waves generated in a body of water by an impulsive disturbance that vertically displaces the water column. Tsunami is generated when sea floor (Tectonic plates) abruptly crash and vertically displaces the overlying water. **Tectonic earth quakes** are associated with earth crustal deformation.

When these earthquakes occurs beneath the sea, the water above the deformed area is displaced from its equilibrium position. When layer of sea floor is elevated or subsided, Tsunami's are created.

A massive tsunami of 9.0 magnititude struck Indonesia, Southern Thailand, India (Andaman and Nicobar Islands, ECR(East Coast Road) of Tamil Nadu. Srilanka, Andhra, Kerala and Pondichery on **26th December 2004** and killing over 1,50,000 people and other damages.

Eco-system

Objectives: At the end of this lesson you shall be able to

- **state the concept of eco-system**
- **state the components of eco-system**
- **state the factors responsible for environmental degradation**
- **state the meaning of environmental hazards, disasters & its types.**

Concept of Eco-System

In 1935, **A.G. Tansley** defined the eco-system as a physical system in which **biotic** and **abiotic** components are included and the balance between them is rather constant. The term **'Eco'** means environment and **"system"** means internal process and a complex process of interdependence.

The accumulation of components of active abiotic environment in plants and animals is through the mean of interaction by which improvements, changes and development of the eco-system continues to happen. .

"Eco-system is a system involving the interaction between a community of living organisms in a particular area and it's non-living environment."

Components of Eco-system

They are broadly grouped into Abiotic and Biotic components

1 **Abiotic (Nonliving) components:** The abiotic component can be grouped into following three categories:-

i) **Physical factors :** Sun light, temperature, rainfall, humidity and pressure. They sustain and limit the growth of organisms in an ecosystem.

ii) **Inorganic substances :** Carbon dioxide, nitrogen, oxygen, phosphorus, sulphur, water, rock, soil and other minerals.

iii) **Organic compounds :** Carbohydrates, proteins, lipids and humus substances. They are the building blocks of living systems and therefore, make a link between the biotic and abiotic components.

2 Biotic (Living) components

i) **Producers :** The green plants manufacture food for the entire eco-system through the process of photosynthesis. Green plants are called **autotrophs,** as they absorb water and nutrients from the soil,

ii) **Consumers :** They are called heterotrophs and they consume food synthesized by the autotrophs. Based on food preferences they can be grouped into three broad categories.

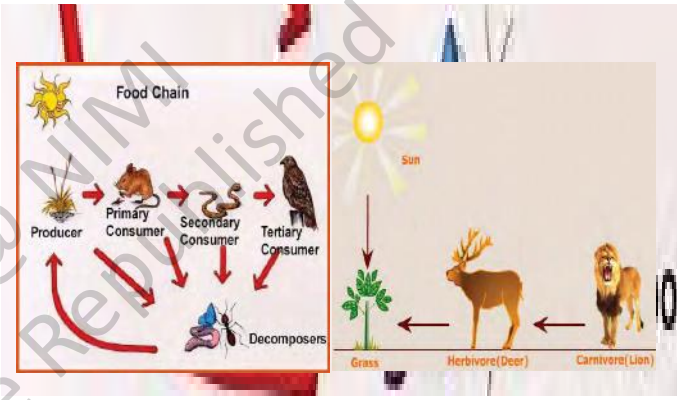
- Herbivores (e.g. cow, deer and rabbit etc.) feed directly on plants.
- Carnivores are animals which eat other animals (eg. lion, cat, dog etc.)
- Omnivores feed upon both plants and animals e.g. human, bears and crows

iii) Decomposers

They are also called **saprotrophs.** These are mostly bacteria and fungi that feed on dead decomposed and the dead organic matter of plants and animals by secreting enzymes outside their body on the decaying matter. They play a very important role in recycling of nutrients. They are also called **detrivores** or **detritus feeders.**

Food Chain

"Transfer of food energy from the plants through a series of organisms is referred as "food chain" (Fig 1) If one species in food chain gets affected or becomes extinct, then the species in the subsequent tropical level is also affected.

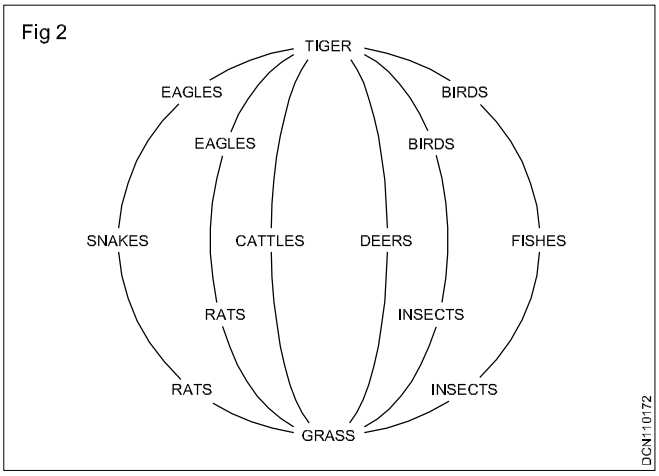


Food Web

"The interlocking pattern of various food chain in an eco-system is known as food web".

In food web, many food chains are interconnected where different types of organism are connected at different tropical level. If one species gets affected, it does not affect other tropical levels so seriously as there are number of options available at each tropic level. (Fig 2)

Fig 2



Environmental degradation

The meaning of environmental degradation is the decline in the quality of the whole environment which is due to the contrary changes caused by the activities of man which has a bad effect on the whole bio community and the human society.

The cause of degradation of the air of the environment can be pollution, natural hazards and calamities. The natural activities may produce crisis and calamity, suddenly (ie) earth quake, flood etc. and may be caused by the human activities (ie) by breaking of the dam, explosion by nuclear bombs etc.

The environment pollution due to the activities of man occur slowly as increase in population or population explosion, urbanization, industrialization, development of the means of transport, establishment of factories are polluting the environment gradually and continuously.

The environment degradation has a direct effect on the ecology by which the balance of the ecology gets disturbed because it causes decline in the quality of the eco-system.

The imbalance in ecology is an indicator of degradation of the environment.

Causes of environmental degradation

The basic causes of the degradation of environment are as follows.

i) **Natural process :** Tremors, earthquake, storms, floods, forest fire, draught and excessive rains etc.The man has no control over these because these processes occur all of a sudden.

ii) **Human activities :** These activities can be controlled. These have a slow and continuous effect of the following causes.

- The development of modern technology.
- Increase in population and its explosion.
- Move pressure by excessive use of natural resources.
- Industrial development and opening of factories.
- Housing problem due to urbanisation and pollution problem.
- Excessive development of economic tasks by man.
- Use of chemical fertilizers and insecticides in the agricultures.

Environmental hazards and disaster

'Environmental Hazard' may be stated as those extreme events caused by natural process (or mains activities which exceeds the tolerance magnitude within or beyond certain time limits, make adjustment difficult, result in losses of property and lives. The seriousness of environmental disaster can be estimated by the loss of life and property of the human society. The decline in the quality of the environment (or) the factors leading to its destruction are called **hazards** or **disasters.**

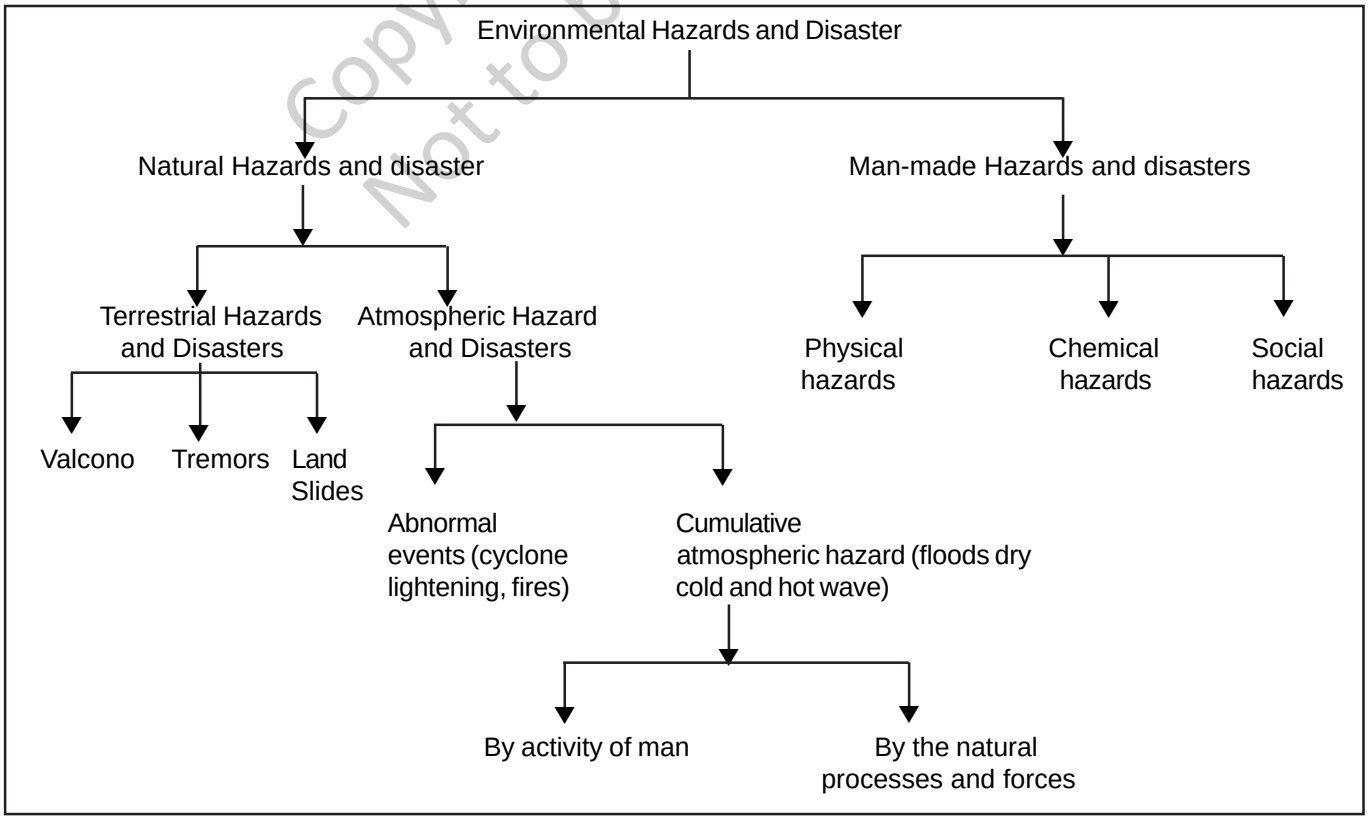
When due to physical process the hazards and disaster happen all of sudden and the human life.

Based on the casual factors, they are also divided into two subgroups

1 Natural hazards

2 Man induced hazards.

Types of environmental Hazards and Disaster



I Natural hazards : These are caused by natural factors. These can be divided into three groups ;

- **Terrestrial hazards :** arises on the surface of the earth (ie) tremors, earthquakes, volcanoes and forest fires etc.
- **Atmospheric hazards :** due to imbalance in the environment (ie) excessive rains, storms, cyclones, typhoon etc.
- **Cumulative atmospheric hazards :** The human activities have immediate effect such as forest fires, demolishing maintains, release of poisonous gases from the factories, nuclear explosion etc. The rivers get flooded due to breach in Dam losts of life, property, the crops and houses are destroyed.

II Man induced hazards and disasters

The environment degradation is also made by the activities of human. The hazards and the damages done by the man cannot be compensated. Man made hazards and disasters by their nature can be spontaneous or deliberate.

They have been divided into three groups

- **Physical hazards :** Tremors, landslides, soil erosion.
- **Chemical hazards :** Release of toxic gases from the tanks in the factories, gases produced by the factories air pollution by vehicles, nuclear experiments, sinking of oil ships in the sea or catching of fire by them.
- **Social hazards :** Increase is population or population explosion, decline of religions valves, giving importance to economic valves, use of nuclear power in war.

Pollution and pollutants

Objectives: At the end of this lesson you shall be able to
- **define the meaning of pollution**
- **list out various kinds of environmental pollution**
- **define the meaning of pollutant**
- **state various type of hazardous waste management**
- **list out the causes of indoor environment pollution and suggestion to keep the environment safe.**

The quality of the environment has declined due to environmental pollution. In industrial and technological progress of man, the chemical and nuclear energy, poisonous gases and other industrial workers have polluted the environment by which the quality for the environment is affected.

Pollution

An undesirable change in the quality of physical, chemical and biotic substances, air, water and soil is called **pollution.** This change is harmful for the health and life of living things. The pollution brings a change in some aspect of the biosphere in a direct or an indirect manner, which leaves a bad effect on the living beings and the humans.

There are mainly two kinds of pollutions. They are

1 Physical pollution

A decline in physical elements of the environment caused by man's activities is called as **physical pollution.** It can be divided into three sub parts

- Air pollution occurs when gases, dust particles, fumes (or smoke) or odour are introduced into the atmosphere in a way that makes it harmful to humans, animals and plant.
- Air pollution can result from both human and natural actions. Natural events that pollute the air include forest fires, volcanic eruptions, wind erosion, pollen dispersal, evaporation of organic compounds and natural radioactivity.

Human activities that result in air pollution include:

- **Emissions from industries and manufacturing activities :** Chimneys of manufacturing plant with lots of smoke and fumes coming out of it. Waste incinerators, Manufacturing industries and power plants emit high levels of carbon monoxide, organic compounds, and chemicals into the air. Petroleum refineries also release lots of hydrocarbons into the air.
- **Burning Fossil Fuels :** Cars, heavy duty trucks, trains, shipping vessels and airplanes all burn lots of fossil fuels to work. Fumes from car exhaust contain dangerous gases such as carbon monoxide, oxides of nitrogen, hydrocarbons and particulates. On their own, they cause great harm to people who breath them. Additionally, they react with environmental gases to create further toxic gases.
- **Household and Farming Chemicals :** Crop dusting, fumigating homes, household cleaning products or painting supplies, over the counter insect/pest killers, fertilizer dust emit harmful chemicals into the air and cause pollution. In many case, when we use these chemicals at home or offices with no or little ventilation, we may fall ill if we breathe them.

Air pollution prevention, monitoring and solution.

Solution efforts on pollution are always a big problem. This is why prevention and interventions are always a better way of controlling air pollution. These prevention methods can either come from government (laws) or by individual actions. In many big cities, monitoring equipment has been installed at many points in the city. Authorities read them regularly to check the quality of air.

- **Government (or community) level prevention**

Governments throughout the world have already taken action against air pollution by introducing green energy. Some governments are investing in wind energy and solar energy, as well as other renewable energy, to minimize burning of fossil fuels, which cause heavy air pollution.

Governments are also forcing companies to be more responsible with their manufacturing activities.

Car manufacturing companies are also building more energy efficient cars, which pollute less than before.

- **Individual Level Prevention**

- Encourage your family to use the bus, train or bike when commuting. If we all do this, there will be less cars on road and less fumes.
- Use energy (light, water, boiler, kettle and fire woods) wisely. This is because lots of fossil fuels are burned to generate electricity, and so if we can cut down the use, we will also cut down the amount of pollution we create.
- Recycle and re-use things. This will minimize the dependence of producing new things. Remember manufacturing industries create a lot of pollution, so if we can re-use things like shopping plastic bags, clothing, paper and bottles, it can help.

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater), very often by human activities. Water pollution is very harmful to humans, animals and water life. The effects can be catastrophic, depending on the kind of chemicals, concentrations of the pollutants and where there are polluted. The effects of water pollution are varied and depend on what chemicals are dumped and in which locations.

Many water bodies near urban areas (cities and towns) are highly polluted. This is the result of both garbage dumped by individuals and dangerous chemicals legally or illegally dumped by manufacturing industries, health centres, schools and market places. Some of the effects of water pollution are:

- **Death of aquatic (water) animals**

The main problem caused by water pollution is that it kills life that depends on these water bodies. Dead fish, crabs, birds and sea gulls, dolphins, and many other animals often wind up on beaches, killed by pollutants in their habitat (living environment).

- **Disruption of food-chains**

Pollution disrupts the natural food chain as well. Pollutants such as lead and cadmium are eaten by tiny animals. Later, these animals are consumed by fish and shellfish, and the food chain continues to be disrupted at all higher levels.

- **Diseases**

Eventually, humans are affected by this process as well. People can get diseases such as hepatitis by eating seafood that has been poisoned. In many poor nations, there is always outbreak of cholera and diseases as a result of poor drinking water treatment from contaminated waters.

- **Destruction of ecosystems**

Ecosystems (the interaction of living things in a place, depending on each other for life) can be severely changed or destroyed by water pollution. Many areas are now being affected by careless human pollution, and this pollution is coming back to hurt humans in many ways.

Prevention of water pollution

Dealing with water pollution is something that everyone (including governments and local councils) needs to get involved with. Here are a few things we can do:

- Never throw rubbish away any where. Always look for the correct waste bin.
- Use water wisely. Do not keep the tap running when not in use.
- Do not throw chemicals, oils, paints and medicines down the sink drain, or the toilet.
- Buy more environmentally safe cleaning liquids for use at home and other public places. They are less dangerous to the environment.
- If you use chemicals and pesticides for your gardens and farms, be mindful not to overuse pesticides and fertilizers. This will reduce runoffs of the chemical into nearby water sources.
- If you live close to a water body, try to plant lots of trees and flowers around your home, so that when it rains, chemicals from your home does not easily drain into the water.

Land pollution is the deterioration (destruction) of the earth's land surfaces, often directly or indirectly as a result of man's activities and their misuse of land resources.

2 Social pollution

Accumulated happenings or crises have a country effect on the social aspects is called social pollution. It can be divided into three subgroups

- Population explosion (or) growth
- Social backwardness
- Economic pollution - poverty

Pollutant

The substance, which causes a decline in the quality of environment or produces pollution in the environment is called as a pollutant. It includes any solid, liquid or gaseous substance, which by its presence (or) excess in the environment is harmful effect on the living beings and man.

Pollutants are residues of the substance which are to be thrown away after use. Water or rivers get polluted by the wastes of the cities and sewage thrown into them.

Some pollutants of the environment are the cause to pollute the air, water and the solid and bring a decline in their quality.

Some of the main pollutants are given below

- Collected substances - dust, smoke, tar etc.
- Gases - Carbon dioxide, Nitrogen and sulphur dioxide.
- Solid wastes - which we thrown away after use
- Radioactive substances
- Noise - excessive noise of the vehicles
- Complex chemicals - ether, benzene, acid etc.
- Metals
- Fluorides
- Photo chemical oxides.
- Agricultural chemical substances

From the above examples the pollutants are broadly categorised into three types

- In the form of solid substances (or) matter
- In the form of liquid substances
- In the form of gases

According to the nature, pollutants can be classified into Non-degradable pollutants and Bio - degradable pollutants.

1 Non -degradable pollutants

Those pollutants which cannot be broken down into simpler, harmless substances in nature, are called non-biodegradable pollutants. DDT, plastics, polythene, bags, insecticides, pesticides, mercury, lead, arsenic, metal articles like aluminium cans, synthetic fibres, glass objects, iron products and silver foils are non-biodegradable pollutants. (Table1)

Table 1

Sl. No.	Pollutant	Effect of human health
1	**Air pollution**	
	• Carbon monoxide	• Headache, hear stress
	• Lead	• Mental and physical improvement
	Water pollution	
	• Sewage pollutant	• Jaundice, cholera, typhoid
	• Methyl mercury	• Affects nerves system, lips and tongue deadness
	• Excess nitrate in drinking water	• Blue body syndrome
	Radioactive pollution	• Cancer, lung, breast, spot skin, genetic disorder
	Noise pollution	• Stress related diseases, eardrum may be damaged
	Ozone depletion	• Cataract, skin diseases, affecting immune system.

2 Bio-degradable pollutants

Hazardous waste

The waste that contains highly toxic and hazardous materials that injurious to all living things and environment are called as hazardous and toxic work.

Hazardous waste management

Following activities are to be followed for hazardous waste management. (Table 2)

Table 2

Sl. No.	Source	Type of hazardous waste
1	Chemical Industries	Acids solvent base
2	Workshop (mechanical)	Metal paints, lead for lead acid battery
3	Leather Industries	Solvent, acid bases
4	Paper industry	Waste - inks, solvents
5	Construction	Waste paints - inflammable
6	Metal Industries	Paint waste, sludges (containing heavy metals)
7	Electronic industries	Solvents, plating and slumping solutions
8	Nuclear power plants	Spent fuel, solvents, radio -active waste

- Reduce waste generation and choose less toxic materials. In Industries, manufacturing process can be altered to eliminate (or) reduce waste production.

- Recycle the solvent and acid to minimize the waste generation.
- Reuse the solvent and acids.

Handling methods of hazardous waste

The safest method to avoid hazardous waste problem is to cut down production of waste in the source itself. The methods of disposal of hazardous wastes are :

- **Physical process :** From this method, main aim is the volume reduction by Sedimentation, Absorption, Aeration, Osmosis, Ion exchange etc.
- **Chemical treatment :** In this method, chemicals are added to connect the hazardous waste into non-hazardous waste. This is suitable to the waste having corrosive and reactive proportion, and its aim to neutralize pH
- **Biological treatment :** This process is generally followed in municipal/corporation waste treatment plant. This process can be used, when the sludge contains high concentration of organic and low concentration of toxic substances.
- **Waste incineration :** This process is suitable if the waste is not subjected to complete decomposition and the waste is combusted for complete destruction.
- **OFF-site disposal :** The residue from thermal process or the untreated sludge have to be disposed in an environment, so that the soil and the ground water do not contaminate.

Indoor environment

Home or a house is such a place where family members live. Every person expects that the place should be pollution free so that he can live their conveniently.The increase in the technology and new domestic machineries and equipment is polluting the indoor environment.

A house has many such materials and appliances which cause pollutions inhouse environment and it affects out health badly but most of the people amongst us are ignorant of this environment.

Causes of the pollution of Indoor environment

There are many things in the house which cause a decline in the quality of the environment. The causes are follows

- Mica, plywood, new wood, varnish and chemical substances are harmful.
- Construction materials such as clay, lime, wood, cement, iron, concrete, plastic paints etc.
- Varnish, paints and fevicol etc. chemical substance used in making furniture's are poisonous and release poisonous gases in the indoor environment.
- The articles made of polythene and plastic has increased greatly, which pollute the air inside the soil.
- When chlorinated water is boiled it releases chlorine which leads pollution
- The kitchen is an important place in house. Where one or the other fuel is used for cooking food such as kerosene oil, petroleum gas etc. In the villages cow dung cakes and wood are burnt which produce harmful gases and smoke, mixer, indoor and juice and other application used in the kitchen also produce noise pollution.
- Many types of enjoyments are used at home which cause environmental pollution. CFC damages the ozone layer of the atmosphere due to which harmful and UV rays from the space and the sum come to the earth.
- Liquid waste water from bathing, working clothes and utensils, detergents, phenyls, disinfectant, geysers, heated up water etc. when chlorinated water is heated up, it forms chloroform which leads to suffocation and death.
- During technological advertisements various home gadgets also increase in number like. Cooler, heater, blower, refrigerator, washing machines, oven, air containers, VCRs computers, Fax, perfumes release CFCs which deplete the ozone layer of the atmosphere which reflects back to harmful radiations (UV) coming from the outer sphere and sun.

Today the science has given many things of comfort and luxury to man but they leave bad effect on health.

Suggestion for keeping the Indoor environmental safe

For keeping the indoor environment clean and pure following are the suggestion.

- While constructing a house it should be kept in mind that the house is spacious airy and well lighted.
- Methanol used in the construction should be of good quality.
- Materials of chemical composition must be avoided for the construction of houses.
- Synthetic and non-bio gradable materials should be avoided.
- Kitchen and bathrooms especially be airy and open.
- Waste from houses should be properly utilized.
- The sewage should not be sent to ground water by digging well.
- The electric appliances should be used in accordance with the introduction given on them.
- Proper disposal of excreting products.
- Traditional fuels should be avoided.
- Use of solar energy should be encouraged in houses.
- Elastic light appliance should not be installed in the house more than necessary.
- Excessive brightness should be avoided.
- The volume of various sources of entertainment like Television, tape recorder, stereo etc. should be kept in the house.

- Reduce the use of A.C. coolers, heaters etc. at home.
- The home should be well cleaned properly to avoid dust.
- The use of fragrant substances should be reduced.

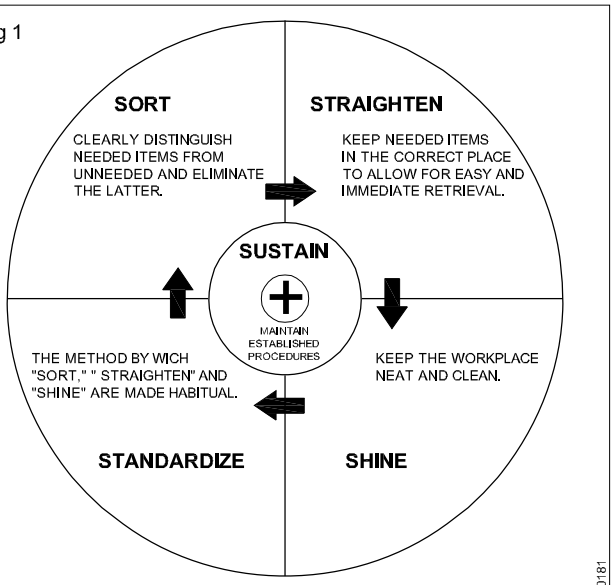
5S Concept

5S is a Japanese methodology for worksplace organization. In Japanese it stands for seiri (SORT), seition (SET), seiso (SHINE), seiketsu (STANDARDIZE), and shitsuke (SUSTAIN).

The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order. The list describes how to organize a work space for efficiency and effectiveness by identifying and stroing the items used, maintaining the area and items, and sustaining the new order.

5S Wheel

Fig 1



5S WHEEL

The Benefits of the 5S system

- Increases in productivity
- Increases in quality
- Reduction in cost

Conservation of energy

Objectives: At the end of this lesson you shall be able to
- **define energy and law of conservation of energy**
- **list out and state the difference forms of energy resources**
- **state the importance of conservation of energy**
- **explain the three R's (Reduce, Reuse and Recycle)**
- **state about right attitude towards environment.**

Energy : Energy is defined as capacity to do work. All humans, animal and plant life depend upon energy.

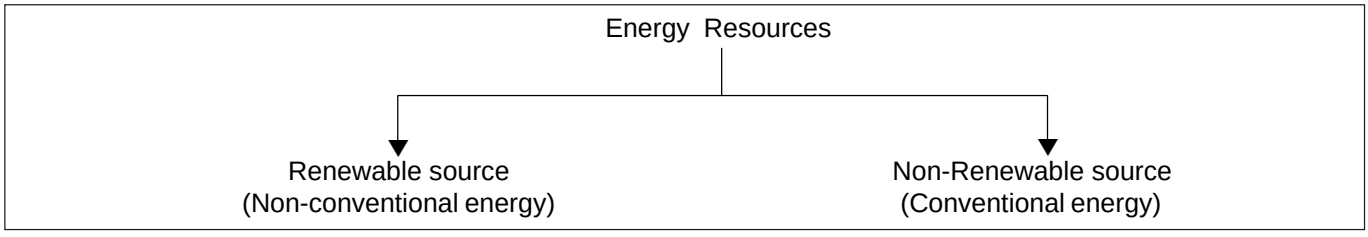
The **law of conservation of energy** states that the energy can neither be created nor destroyed but can be transformed from one form to another, the total energy remain conserved. Energy provides the force to hold structures together, tear them apart and move them from one place to another.

No energy transformation in the present is efficient. The fossil fuel, as it is generally called is expected to exhaust in another 200 years. The energy supply side needs heavy investments and import.

Renewable (Non-Conventional) Energy Source

Renewable energy resources are natural resources which can be regenerated continuously and are inexhaustible. They can be used again and again in an endless manner. Examples are Wood, Solar energy, wind energy, hydropower, tidal energy, geothermal energy etc. These energy resources are pollution free and do not need any fuel and also does not produce any waste.

Solar Energy - The energy that we get directly from the sun is called **solar energy.** Some important solar energy harvesting devices are :



- **Solar (Photovoltaic) cell :** Used in calculator, electronic watches, street lamps, water pumps etc.
- **Solar heat collectors :** Used in cold places where houses are kept in hot condition using solar heat collectors.
- **Solar water heater:**

Wind Energy : The energy recovered from the force of the wind is called **wind energy.** It is available easily in many off-shore, on-shore and remote areas.

Tidal Energy : Energy produced by tides due to gravitational forces of sun and moon is called **tidal energy.** As sea water is inexhaustible, it is completely independent of uncertainity of rain fall.

Geo-thermal energy : The energy harnessed from the high temperature present inside the earth is called **geo-thermal energy.** It is effectively and efficiently used for direct uses such as hot water bath, resorts, aquaculture, green house.

Biomass Energy : Energy produced by organic matter like plants and animals are called **Biomass Energy.** Examples of biomass are wood, crop residues, seeds, cattle dung, sewage, agricultural wastes etc.. Biogas and bio fuel are examples of biomass energy.

Merits of Renewable resources

- Unlimited supply
- Provides energy security
- Fits into sustainable development concept
- Reliable
- decentralized energy production

Non-Renewable (Conventional) Energy Source

Non-Renewable energy resources are natural resources which cannot be regenerated once they are exhausted.. They cannot be used again. Examples are Oil, Coal, petroleum, natural gas, nuclear fuels etc..

Coal : It gives extreme heat, this energy source cannot be renewed. It is used in power houses, factories, industries and fairness.

Petroleum: It includes petrol, diesel, mobil oil and mineral oils which are used in motor vehicles, furnaces and power houses. From the modern technology, it is hoped that 3000 million ton petroleum from the earth and another 1000 million ton from the sea can be obtained.

LPG (Liquified Petroleum Gas) : The petroleum gas obtained during cracking and fractional distillation, can easily be converted into liquid under high pressure as LPG.

Natural gas : Natural gas is formed by the decomposition of dead animal and plants, that are buried under lake and ocean under high pressure and temperature. It is found above the oil in oil well.

Conservational of energy

"Saving of energy is the production of energy" it means that the energy is very essential. In developing country like India, possible effort should be made to serve more and more energy.

The demand for electric energy is increasing at the rate of 10 percent every year. But it is not possible to increase its production at this rate. The consumption of energy is increased by 12.8 percent per year.The production of energy according to the consumption is not possible. So the only selection is that by saving energy, conserve more energy.**14th December** is celebrated as **world energy conservation day.**

Some examples of conservation of electric energy is given below:

Electric motor : Electric motors are strong means of spending energy. By applying modern technologies the expenditure of electric energy can be minimized. So it is essential the strong and quality motors must be used.

Pump : In these pumps, energy is spent through diesel engines and electric motors. Due to diesel engine the popularity of motor pump has increased and it is convenient too. By maintaining the quality diesel engine, more work can be done with less expenditure of energy.

Arrangement of light : The lights are needed in houses and industries. 17.4 percent of the total electricity is consumed for light. This consumption in future would be still more because even now the faculty of electricity is not available to the all population. Excessive use of electricity should be avoided because it is exhaustible source.

Since resources are being exhausted, it is the duty of every individual on this earth to conserve resources in such a way that they must be available for future generation also. Due to advancement and population growth, the present world is facing lot of crises on natural resources.

Measures recommended for conservation of natural resources:

- Switch off lights, fans and other appliances when not in use.
- Use solar cooker for cooking food on sunny day.
- Dry clothes in sunlight instead of driers.
- Grow more trees near the house and get a cool breeze and shade. It will cut off your electricity charges on ACand coolers.
- Use pressure cooker for cooking.
- Ride bicycle or just walk instead of using car or scooter.
- Use minimum water for all domestic purpose.
- Check for water leaks in pipe and repair immediately.
- Plant more trees and protect them.
- Minimise the use of papers and fuel wood.
- Grassing and fishing must be controlled.

The three R's: Reduce, Reuse and Recycle (Fig 1)

Fig 1

CAD - CONNECT THE FIG - MAKE IT CIRCLE SHAPE

These three R's (ie) Reduce, Reuse and Recycle are used to help to cut down on the amount of waste which are thrown out away. They conserve the natural resources, land fill space and energy. They save land and money

communities must use to dispose of waste in land fills. All must help to active this goal and save natural resources, energy and money by following the three R's.

Reduce

The best way to manage waste is not to produce it. This can be done by shopping carefully and being aware of few guidelines.

- Buy products in bulk, larger, economic size products or ones in concentrated form use less packaging and usually cost less per ounce.
- Avoid over - packaged goals, especially ones packed with several materials such as foil, paper and plastic.
- Avoid disposable goods, such as paper plates, cups, napkins, razors and lighters.
- Buy durable goods - ones that are well - built or that carry good warranties. They will last longer save money in the long run and same landfill space.
- At work, make two -sided photcopies whenever possible
- Maintain central files rather than using several files for individuals.
- Use electronic mail or main bulletin boards.
- Remove your name from the mailing lists of materials you no longer want to receive.
- Use a dish cloth instead of paper towels.

Reuse

It makes economic and environmental sense to reuse products and it takes creativity.

Reuse products in different ways :

- Use a coffee can to pack a lunch, use plastic mirowave dinner trays as picnic dishes.
- Sell old clothes, appliances, toys and furniture in garage sales or ads or donate them to charities.
- Use reasonable containers rather than plastic wrap.
- Use a ceramic coffee mug instead of paper cup.
- Reuse grocery bags or bring your own cloth bags to the store.
- Do not take a bag from the store unless you need one.

Recycle

The process of changing the waste materials into new products to present waste of potentially useful materials is called as 'recycling'. Recycling is a series of steps that takes a used material and processes, remanufactures and sells it as a new product.

- Begin recycling at home and at work
- Buy products made from recycled materials. Look for the recycling symbol (or) ask store managers or salesman. The recycling symbol means one of two things either the product is made of recycled material or the item can be recycled.
- Many plastic containers have a recycling symbol with a numbered code the identifications means what type of plastic resin it is made from.
- Check collection centres and curb side pickup services to see what they accept, and begin collecting those materials. It includes, metal lens, newspapers, paper products, glass, plastics and oil.
- Consider purchasing recycled materials at work, when purchasing materials for office supply, office equipment (or) manufacturing.
- Speak to store managers and ask for products and packaging that help cut down on waste, such as recycled products and products that are not over packaged.
- Buy products made from material collected recycling.
- Use recycled paper letterhead, copier paper and newsletter.

Right attitude towards environment

Having the right attitude towards environment will help us to improve our efficiency. Creating space in our offices and homes complements the space need in our minds will become clear thinking and focused.

In our home environments are important to help us make the most of ourselves professional. An environment used to be created at home for time to unwind and regroup.

Organising your workspace

- Our work place to be organised most effectively & professionally. Make some time to restore the working space so that it reflects a mind that is calm, focussed and in control with a well managed space where you will have higher productivity.
- Get into the habit of filling things in the correct place.

Create a productive, professional ambiance

- Plants and lights in office space are for promoting calm and productivity. Plants also keep the air oxygenated which will help your thinking process.
- Ensure the plants are healthy. Having dead and dying plants around will drain your energy.
- If your office is dark and gloomy with natural light, you can create the sanction of light and space - glass top desks may be more space enhancing than a dark and dusty oak.
- Make your office ooze with charm, images having clients here with you.
- Having this right attitude to your working environment, treating with care and respect will help the same attitude to your work.

Home is your sanctuary

- Getting a good night's sleep is essential for ensuring that your daily productivity is high.

- Never take your work into the bed room with you. Leave your electronics in another room.
- Create some space away from your laptop and your phone.
- Invert in a comfortable seating area and spend time reading a book.
- By having good night you will be able to function at your maximum potential.

Global warming - Ozone depletion layer

Objectives: At the end of this lesson you shall be able to
- **state the meaning of global warming**
- **state the meaning of green house & its effects**
- **state how to control the green house effect**
- **state ozone gas**
- **state the causes, effects and preventive measures of ozone layer depletion**
- **state acid rain and its effects.**

Global Warming

Increase in average temperature of the earth surface due to green house effect is called as **global warming.** It also refers to the increase in average temperature of the air and sea at earth's surface.

In 1987 **Jean Baptiste Joseph Fourier** a French scientist and mathematician coined the **"Green House Effect"** for trapping of heat in the atmosphere by certain gases.

There are some gases in the earth atmosphere that absorb some of the outgoing long wave radiation or heat energy. These includes Carbon dioxide (CO_2), methane (CH_4), Nitrogen Oxide (NO), Chlora Floro Carbon (CFC), Water vapour.

Effect of Global Warming

- Rising global temperature causes to raise sea level.
- Melting of glaciers, snow mountains and polar ice caps are the important resultant of global warming which leads to increase the sea level.
- The change in rainfall pattern.
- Fresh water bodies will be contaminated with the salty water of sea.
- Migration of human population takes place.
- Forest vegetation will not be able to adapt in the changing pattern of temperature and rainfall.

Meaning of Green House

In the cold countries of the world, houses which is natural that the temperature inside remains higher than outside which will not affect the growth of vegetarian. These type of houses of green glasses are called as "green house".

Carbon dioxide(CO_2) prevents the conversion of solar energy and the solar rays. It acts as a blanket in which the sun rays can enter the heat radiation emitted by the earth cannot go outside.

Now a days, the amount of carbon dioxide is increasing day by day due to Human beings activities such as industrialization and destruction of forest. The increasing of earth's temperature also affects the green house.

Green House Gases (GHG)

The major green house gases are

- Water vapour - causes about 36%-70% of the green house effect.
- Carbon dioxide (CO_2) which causes 9-26%.
- Methane (CH_4) causes 4-9% and ozone (O_3).

The effects of green house and change in climate

Due to green house effect, the following changes takes place in the climate

- Vegetarian and animals are badly affected by it.
- Rains are greatly increased.
- If a effects the eco systems balance.
- By increasing of carbon dioxide, the production will increase but the quality of crops is reduced.
- The soil would be less fertile.
- In the cold area, the winter season would become short, and it would be less cold.
- Due to industrialization and destruction of forest, produces impregrenable gases, which results into hot soil.
- The plants would have less amount of nitrogen in them. It is more affected by the insecticides.
- Due to the continuous, increasing of temp of earth, the ocean became warm and the level of the sea water will increase.
- Health of men will be badly affected, due to that the number of diseases will increase (ex. Malaria, respiratory and skin disease).
- The energy sources also will be affected badly.
- Due to scarcity of water the generation of electricity will decrease.

Methods to control line Green House Effect

In 1979, the world environment committee decided that it is very essential to reduce or control the amount of carbon dioxide in the atmosphere.

After 13 years, the earth conference on environment and development was held in 1992 in Riodega-Neiro (Brazil), by 182 countries participants made serious deliberation as given below

- Decreasing the quantity of carbon dioxide in the atmosphere
- Management of forests
- Change of technology
- Bio diversity
- Sustained development
- Financial management to save the world from pollution
- The alternative bio-sources instead of petroleum products should be used.

Climate change is a change which can be related to the activities of man directly or indirectly, which changes the components of global environment and which can be seen in the natural period of time.

Mainly the climate changes can be seen by the total stock of available green house gases in the environment and not by the release of green house gases annually.

Melting of the polar ice

The depletion of ozone is increasing, the temperature of earth's surface is also increasing day by day. Due to the effect of increasing temperature the ice on the poles of the earth has started melting rapidly, then the water level of the sea is rising. By melting of the ice of the poles an imbalance in the eco-system is increasing which is very harmful.

It is essential to control the gases CFC, methane, Nitrous oxide etc. released by industries which harms the ozone layer, and 'melting' ice of the poles destroying animals and vegetation.

Rise in sea water

Due to increase in the temperature of the surface of the earth, the ice on the polar region is rapidly melting, as a result water level of the sea is upto 6cm and by the 21st century level of sea water will rise upto 65cm. So, rise in temperature should be stopped otherwise animals and plants will be affected greatly.

Kyoto conference 1977

In the atmosphere, the carbon-di-oxide is increasing and its temperature is also continuously increasing, causes dangers. So an international conference on climate was held in Dec. 1977 in the city of Kyoto in Japan. 160 countries delegates participated and made a historical agreement for prevention of change in climate due to increase in temperature of the environment of the earth.

The main goal of this conference on climate change was to control the main causes of climate change and trying quality improvement in the world environment from the angle of hygiene and health.

According to this agreement various countries agreed or reducing green house gases.

European organisation - 86%, America - 7%, Japan 6%.

A provision was made in the agreement that the defaulter would be fired and the amount of fine would be voluntarily deposited in the development fund.

Ozone gas

'Ozone' word is originated from Greek word **'Ozo'.** 'Ozo' means **'smell or odour".** This gas was first discovered by a dutch scientist **"Van Marum"**. It has a peculiar odour". Due to this odour only, it is called **ozone gas.** Sun light produces this gas. The oxygen in the atmosphere becomes active in sunlight and changes into ozone gas.

In the environment, this gas is present in a very small quantity. Ozone (O_3) contains 3 atoms of oxygen. This combination of 3 atom of oxygen present in the lower atmosphere is harmful for the human beings, but 'its' presence in the upper atmosphere is very beneficial and essential. This gas is produced itself. When the sun rays strike the upper layer of the atmosphere, then due to high energy radiation, some part of it is converted into ozone. The oxygen gas is converted into ozone by action of electricity clouds, lightening.

At a height of 20-30 km from the surface of the earth in the area of stratosphere of the atmosphere one layer is found. This layer or cover is called as **'ozone gas'.**

This gas acts as a protector of the environment. The part where the ozone gas is found is called as **ozone sphere.**

Ozone Layer Depletion

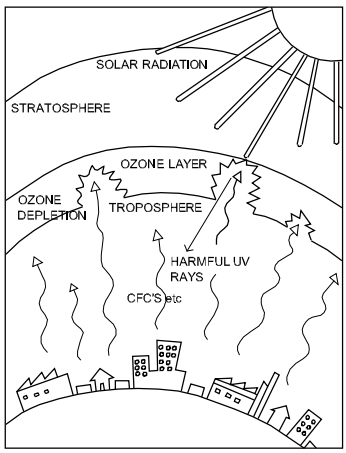
The reduction in the thickness of ozone layer in spring is called as **ozone hole.** This hole is declining in the northern hemisphere on an average rate of **4.1% annually since 1997.**

Causes of the depletion of ozone layer

The reasons for depletion of ozone layer are

- Due to the production of the compound **'Chloro Flouro Carbon'** (CFC) the ozone gas is depleting. When it reaches the stratosphere it attacks the ozone layer and reduces it. (Fig 1)

Fig 1



- The ozone gas layer is affected by polar cyclones.

- The chlorine gas produced by eruption of volcanoes also leaves a bad effect on ozone layer, and it is converted into carbon monoxide.
- Due to excessive amount of Nitrogen oxide in the atmosphere, it affects the ozone layer.
- Radioactive radiation from the nuclear centres has also badly affected the ozone layer.

Effects of ozone depletion

- It produces green house effect and the climate is also changed.
- Ozone depletion results in low production of crops.
- It causes damage to the organs of living things.
- Ultra violet rays harm the plants.
- It causes to spread the skin cancer diseases.
- It increases the smoke in the cities.
- It raises the possibilities of acid rains in the urban areas..
- It increases the temperature of the environment.
- It affects the mental health of man.
- It increases the temperature of atmosphere which has a bad effects on the vegetation.
- The UV rays reaching the earth are harmful to the pregnant women and the infants children also.

Preventive measures for ozone layer depletion

In 1989 limited nations environment and development conference, serious deliberation move alone to put a ban an Chloro Fluro Carbon in a fixed period of time.

- The main cause of formation of ozone hole was the use of Chloro Fluro Carbon (CFC) which is used in refrigerator industry. It harms the ozone layer therefore it should be banned all over the world
- Smoke emitted by the aeroplane should be controlled
- Nuclear explosive strictly banned.
- Use eco-friendly household cleaning products
- Efforts to be made for controlling the smoke emitted by transport vehicles, and in factories.

The ozone layer above India is fortunately completely protected. Because the thickness of ozone layer above the land area of India is 3 times as compared to other countries which are hinge holes in ozone layer.

Acid rain and its effects

When the quantity of acids in the raining water is more than the average, then such rain is called as 'Acid rain'.

or

When the PH of rain water or snow is less than 5.7, it is called as **acid rain.**

or

It is the precipitation of diluted acid from the atmosphere on the earth.

There are two types of depositions of acids in acid rain, they are

- Dry deposition
- Wet deposition

In dry deposition, particles of acid gases like 'NO_2, SO_2' and acid aerosols fall on the earth along with rain. It helps in making acid by dissolving in water in the soil.

In wet deposition, along with acid, water falls on the earth in the form of rain, fog or snow.

Composition of acid rain

Acid rain contains

- Sulphuric acid (H_2SO_4) ' 60% - 70%
- Nitric acid (HNO_3) ' 30% -40%

Nitric acid is formed by dissolving of nitrogen peroxide (NO_2) in water. It is produced in the factories, vehicles, nitrogenous fertilizers factories by the burning of fossil fuel. Sulphuric acid is formed by dissolving sulphur dioxide gas in water. It is produced in volcanoes (67%) and factories (23%).

Due to presence of acid in the rain water, PH values falls. The average PH of rainwater is between 5-6 and 6-5.

The acid rains are the result of the activities if man and the negligence of the industrial units.

The bad effects of acid rain

- By the use of water pollutant with acid rain, man and other living beings are badly affected and the man becomes victims to many types of diseases.
- This rain reduces the lustre of the metals too.
- It decreases the reproduction process of the fishes.
- Wide leaves of the vegetation are harmed by it.
- The nutrients in the soil are badly affected by this rain, ,especially the amount of iron is reduced.
- Water of the rivers, natural resources like wells and ponds gets polluted with acid rain waters. By drinking this water, both man and animals are badly affected.
- It may also causes corrosion in many buildings bridges, monuments, fencing etc.
- With the excessive acid rain, visibility is reduced.
- It decolorizes the leaf pigments.
- It causes irritation in the eyes and skin of human beings.
- Mosquitoes, flies and water insects multiply in this rain.

Familiarisation and information about the institute and trade

Objectives: At the end of this lesson you shall be able to
- **state the general training system**
- **state the information about the trade**
- **state the rules and regulation of the institute and trade.**

Training system

General

The Directorate General of Training (DGT) under Ministry of Skill Develpment & Entrepreneurship offers range of vocational training courses catering to the need of different sectors of economy labour market. The vocational training programmes are delivered under aegis of National Council of Vocatinal Training (NCVT). Craftsman Training Scheme (CTS) and Apprenticeship Training Scheme (ATS) are two pioneer programmes of NCVT for propagating vocational training.

Draughtsman Civil trade under CTS is one of the popular courses delivered nationwide through network of ITIs. The course is of two years (04 semester) duration. It mainly consists of Domain area and Core area. In the Domain area-trade theory and practical impart professional skills and knowledge; while core area imparts workshop calculation and science, Engineering Drawing, and Employability Skills impart requisite core skills & knowledge and life skills. After passing out the training programme, the trainee is being awarded National Trade Certificate (NTC) by NCVT which are recognized worldwide.

Candidates broadly need to demonstrate that they are able to :

- Read & interpret technical parameters /documentation, plan and organize work processes, identfy necessary materials and tools.
- Perform work with due consideration to safety rules, Govt. Bye laws and environmental protection stipulations.
- Apply professional knowledge, core skills & employability skills while performing the work
- Check the work as per sketches and rectify erros
- Document the technical parameters related to the work undertaken.

About the trade

What do draftsman do?

Draftsmen, also called drafters, perform some of the same tasks as architects and often work with architects. Draftsmen, like architects, prepare CAD drawings. However, drafting can be applied to many other areas besides construction and architecture. Drafting can be used to create drawings of circuitry or mechanical designs. A draftsman's CAD drawings include technical details and specifications such as materials, dimensions and procedures. In addition to using CAD, draftsmen also use calculators, tables and technical handbooks.

The type of work a draftsman does depends on his or her area of expertise. For example, drafters produce drawings for new construction projects. They may specialize in residential or commercial buildings or in the type of material used, such as steel, timber or reinforced concrete. Civil drafters prepare drawings for use in major civil engineering projects, such as highway and bridge construction, sewage systems and flood control projects.

Draftsmen are responsible for creating technical drawings that accurately represent design ideas. Draftsmen use hand drawing and computer - aided drafting methods to generate precise drawings that meet given specifications and are used by manufacturers, builders and engineers.

Plan and organize assigned work and detect & resolve issues during execution. Demonstrate possible solutions and agree tasks with in the team. Communicate with required clarity and understand technical English. Sensitive to environment, self-learning and productivity.

Job duties and tasks for "civil drafter"

1 Produce drawings using computer assisted drafting systems (CAD) or drafting machines or by hand using compasses, dividers, protractors, triangles and other drafting devices.

2 Draft plans and detailed drawings for structures, installations, and construction projects such as highways, sewage disposal systems, and dikes, working from sketches or notes.

3 Draw maps, diagrams, and profiles, using cross-sections and surveys, to represent elevations, topographical contours, subsurface formations and structures.

This course is meant for the candidates who aspire to;

1 Use and maintain in good condition -drawing instruments, slide rule, survey instrument, autolevel, digital theodolite, total station, GPS, computer & drafting software, plotter & printer etc.

2 Plan and draw of residential buildings from given data.

3 Prepare working drawings of all types of buildings from line sketches in CAD.

4 Planning, drawing, estimating, and costing of civil work. Drawing plans by using CAD. Making of 3D models of

civil work. Giving setting out of site, supervision of civil work etc.

5 Prepare proposals for drainages and water supply for a given building including preparation of detailed drawings.

6 Plot the longitudinal section and cross - section for a proposed road and calculate the earth work and materials for road work.

7 Draw the parts of R.C.C structures and steel sections. Prepare working drawing of R.C.C structures from the given field data.

8 Draw from sketches or specifications various types and cross - section of roads culverts, bridges, Railways & irrigation structures in CAD.

9 Carry out the surveying by using latest equipments (Auto level, Digital theodolite, total station, GPS).

N.C.O Code No. 3118.20 Draughtsman, Civil

Prepare drawings of buildings, stores, highways, dams, culverts, etc. from sketches, notes or data for purposes of construction or alternations. Takes instructions form Civil Engineer studies sketches and calculates dimensions from notes or data. Draws to given scale different elevations, plan, sectional views etc. of desired construction using drawing instruments. Draws detailed drawings of specific portions as required. Indicates types of materials to be used, artistic and structural features, etc. in drawing as nenessary. may do tracing and blue printing. May reduce or enlarge drawings. May prepare or check estimate schedules for cost of materials and labour. May prepare tender schedules and draft agreements. May work as draughtsman Archtectural.

N.C.O. Code No.3118.50 Draughtsman, Structural : Prepares drawings of bridges, steel structures, roof tresses etc. from sketches, designs of data for purposes of construction, alteration orrepairs. Stuides sketches, data, notes etc. and receives instructions from Structural or Mechanical Engineers, regarding details and types of drawings to be made. Calculates dimensions as necessary from available notes, data etc and by application of standard formulae. Draws to scale detail, assembly and arrangement drawings showing sectional plan and other views as directed and prints (writes) necessary instructions regarding materials to be used, limits, assembly etc. to clearly indicate all aspects of structure to be manufactured. May prepare estimate and operation schedules for labour and material costs. May prepare tender schedule and draft agreements. May prepare tables showing requirements of bars, their numbers, sizes and shapes. May trace and make blue prints.

N.C.O Code No.3118.60 Draughtsman, topographical: Sketches topographical drawings to scale in different colours using blue print prepared from field plane tables. Carries out independently projection of small scale map to predetermined size, incorporating featues covered in survey, producing total geographical effect by hill shading, giving contours, profile, cross sections, authorized symbols, etc. Uses grid tables, projection table compasses, pantograph, planimeter, etc.

Options for employment are

Employment opportunities for trainee from this trade as draftsman, surveyor and land surveyor shall be available in Central & State Governmnet Departments.

Private sector opportunities shall be as Draftsman, Construction Supervisor with Architect, Civil Engineer, and Civil Contractor, Builders.

Options for Self- Employment are

The Trainee shall be able to independently undertake planning, drawing, estimation & costing and supervision of civil construction work. He can set up his own office for above work and also to supply Civil Construction materials.

Rules and regulation of the institute and trade

- The trainees who are all got admission in I.T.I has to follow same general rates stiuplated by the institution, and those are given below
- The trainees who are all got admission in I.T.I has to follow same general rates stipulated by the institution, and those are given below
- He should try to earn good room from the institution
- The trainees should attend the institution to the correction in punctuality should be maintained.
- He should be very sincere and faithfull not only to this instructor but also other instructors and staff the institute.
- He should attend were proper formal dress as specified by the institute.
- He should not wear loose clothes and this may be the cause for accident while crossing in shops floor.
- He should have good attitude and behave with good manner to all the staff members his fellow students and to this senior students.
- He should take part in the activities of the institute.
- He should maintain discipline of the class room and the institution.
- He should not spoil the environment of institute.

Note : The above rules and regulation are also compulsory for the Girl trainees to adhere

Overview of the subject to be taught in each semester

Objective: At the end of this lesson you shall be able to
- **state the subject to be learned in each semester.**

Overview of the subject to be taught for each semester

During the two years duration, a candidate is trained on subject viz. Professional Skill, Professional Knowledge, Workshop Science & Calculation and Employability Skills. In addition to this, a candidate is entrusted to undertake project work and Extra Curricular Activities to build up confidence. The practical skills are imparted in simple to complex manner & simultaneously theory subject is taught in the same fashion to apply cognitive knowledge while executing tasks. The practical part starts with simple geometrical drawing and finally ends with preparing sanction plan of Residential / Public building; drawing of roads, bridges, railway tracts, dams and Estimation and costing of civil works at the end of the course.

The broad components covered under Professional Skill subject are as below.

Job area after completion of training

After completion of this training trainees maybe able to earn their livelihood. Environment of I.T.I is differs from the schools education. In I.T.I we concentrate more time in practical training i.e he has to obtain good skill in the trade in which he trained. Hence we can say I.T.I.s are institutions which lay the carpet for self job opportunity and differ job opportunity in public sector and private sector.

There are so many departments in public sector and private sector which provides the job opportunity for the trade of Draughtsman Civil .

The name of some public sectors are given below.

- Central public works department
- Central archetech department
- Military Engineering service
- National High ways department
- Central geological department
- Survey of India
- Railways
- State P.W.D.
- Nagar palkas
- Private building construction companies

Now Government of India passed an order in parliament those are all trained in particular group of trades such as D'man Civil, D'man Mechanic and Mechanic shop group of trades, they can join in 2nd year of diploma courses in the respective states.

Subject to be taught in the trade of D'man Civil for each semester

Ist Semester

- Occupational safety and health
- First Aid and introduction of PPF
- 5S concept
- Power failure, fire alarm
- Use of drawing instruments and equipment, their care and maintenance
- Layout of drawing sheets and following of different size of drawing sheets.
- Plane and solid geometrical figures
- Simple problems on projection of points, lines surfaces and solids.
- Drawing of sketches from modles (Plan, sections and elevation)
- Conventional signs and symbolism drawing
- Read and use of plains, diagonal, comparative, diagonal, vernier and scale of chords.
- Arrangement of bricks in different types of bonds in building and in foundation
- To have to knowledge to prevent the structure from the dampress
- Various types of arches and lintels

IInd Semester

- Chain surveying and preparation of site plan
- Observe the bearings of lines
- Traverse survey using compass
- Longitudinal and cross - sections for the given route using auto level.
- Calculation of reduced levels of various points.
- Preparation of contour map
- Traverse survey using theodolite
- Topographical map using theodolite and level
- Different type of doors and windows
- Different type of carpentry joints
- Electrical wiring system drawing
- Different ground floors
- Different types of roofs with all details
- Upper floors - General principles of construction
- Truss and stair cases.

IIIrd Semester

- Draw plan, section and elevation of a residential building (single story / and double story) with the help of sketches and line diagram.
- Practice an CAD- Explain method of giving commands -Explain drawing area setup - explain drawing and settings.
- Principles of planning local building by laws with ISI standards.
- Perspective them of building
- Inking - Lerroy set printing of letters- tracing- practice of blue prinks.
- Create objects on 3D modeling and concept of CAD.
- Preparing detailed drawing of reinforced bars -*dincating shape of band, hook, details of cranks and development length.
- Draw details of R.C.C stair
- Preparation of bar bending schedule
- Draw reinforcement details of T-beam, inverted beam and cantilever
- Draw reinforcement details of R.C.C retaining wall
- Preparation of the reinforcement details of column with footing and contagious columns
- Draw the details of framed structures and portal frame.
- Draw the different types of steel sections.
- Draw the different types of rivets and bolts.
- Elevation and section of girders
- Draw roof trusses and standings
- Preparing the detailed drawing of various pipe joints
- Preparing the detailed drawing of the different types of sanitary fittings arrangements of man holes - details of septic tanks in plumbing system of new technology.
- Draw the details of R.C.c water tanks

4th Semester

- Draw the cross - sectional view of different types of roads showing component / parts.
- Draw the detailed longitudinal section of road showing its gradient.
- Typical plan showing curve.
- Details of different types of culverts and bridge.
- Draw the typical cross- section of rail sections, railway tracks in cutting and reimbursement
- Draw the detailed drawing of dam, barrages and weir.
- Draw the detailed sectional view of distributaries and head regulators.
- Preparing detailed drawing of different types of cross drainage works.
- Draw the schematic diagram of different structures of hydro electric project.
- Preparing the detailed estimate of a building - quantity of items required, rate analysis etc.
- Preparing the detailed estimate by using software.
- Transverse survey using total station.
- Use of GPS and application in survey work.

Engineering Drawing

Objectives: At the end of this lesson you shall be able to
- **state the importance of engineering drawing**
- **state the areas of civil engineering drawing.**

Introduction

The communication of ideas through the graphical language is probably the oldest form of communication among human. Engineering graphics is the study that required special equipment to form the images.

Engineering Drawing

Drawing drawn by a person, having knolwedge about engineering aspect for the engineering purpose is an engineering drawing. It is the universal graphic language of engineers, spoken, read and written in its own way. Every language has its own rules of grammer.

Engineering drawing also has its grammer in the theory of projections, its idioms in conventional practice, its punctuations in the types of lines, its abbreviations, symbols and its descriptions in the constructions.The shape of objects are established by different lines and size description are by symbols lettering and dimensioning.

In Civil Engineering, this is concerned with structural works. It is very broad with many subspecialties, including structural, geotechnical, water resource and transportation engineering. Structural engineers are concerned with the safe design and construction of structures.

These can range from small warehouses to skyscrapers and from highway overpasses to large bridges and can include dams of all sizes. Geotechnical and soil mechanics engineers evaluate the capacity of rocks and soils to bear heavy structures.

Water resource engineers handle water collection, distribution, and purification, including the building of dams, flood control, and irrigation. Transportation engineers design highway and public transportation systems.

Geometrical Drawing

It is the foundation of all engineering drawing. It is the art of representation of geometrical objects on a drawing sheet, which is difficult to learn or teach without the good aids. Accuracy, neatness and legibility are of great importance in engineering drawing.

Plane geometrical Drawing

It is the art of representation of objects having two dimensions, i.e. length and breadth such as, square, rectangle, etc. on a drawing sheet.

Solid Geometrical Drawing

It is the art of representation of objects having three dimensions, i.e. length and breadth and height such as, cube, cylinder, etc. on a drawing sheet.

Can computer graphics replace the drafting board? If the necessary hardware and software are available, much time can be saved, by using the computer to construct geometrical figures, drawing etc. however, the computer cannot replace the drafting board and equipments as a learning tool.

The learning process is accomplished through traditional construction methods, may then only easily accomplished by the use of computer.

The skill of manual drafting is still in great demand and will continue to be, however, because computer drafting is not suitable for all phases of design.

For example, for designing certain types of custom-made architecture and in remodeling one-of-a-kind developments manual draughtsman are still in demand for their abilities and extensive experience.

List of drawing instruments, equipments and materials to be used during training

Objectives: At the end of this lesson you shall be able to
- **state instruments, equipments and materials**
- **list out instrument, equipments and materials**
- **state the standard as per 962-1987**
- **to use different drawing instruments, equipments and materials**
- **follow Precautions in the use of instruments, equipments and materials.**

Introduction

Engineering Drawing is the language of engineers, the accuracy and neatness of the engineering Drawing depends on the quality of the instruments, equipments and material used. Hence, preference should be given to standard instruments and equipments and draughtsman should be able to use different drawing instruments.

List of instruments

- Drawing board
- Tee-square or Mini Drafter
- Set-square

- Scale
- Protractor
- French curves
- Stencil
- Drawing instruments box

List of equipments

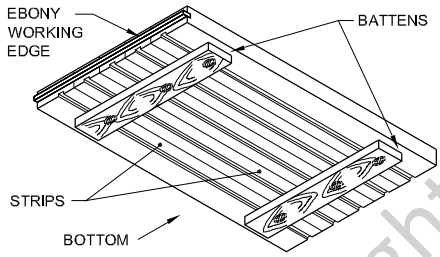
- Drafting machine
- Computer for Auto CAD. (Monitor UPS, CPU, key board, mouse, etc.)
- Plotter/Printer

List of materials

- Drawing papers
- Drawing pencils
- Rubber/ Eraser
- Drawing papers fasteners (Drawing pins, Cello tape)
- Tracing paper or tracing film

Drawing board (Fig 1)

Fig 1



The standard size should be as per IS: 1444-1963/1977 of Bureau of Indian Standards.

Sl. No.	Designation	Drawing Boards Sizes in mm (L x W x T)	Drawing sheets to be used with designation
1	B0	1500 x 1000 x 25	A0
2	B1	1000 x 700 x 25	A1
3	B2	700 x 500 x 15	A2
4	B3	500 x 350 x 15	A3

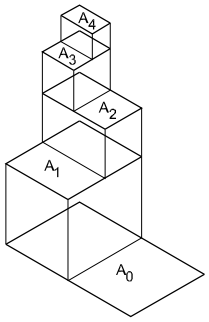
The following precaution may be taken in handling the drawing boards:

- Always keep an extra sheet on the top surface of the drawing board.
- Do not keep anything on the top flat surface of the drawing board.
- Take sufficient care in up keeping the straightness of the ebony edge.

Drawing papers: (Fig 2)

The standard size as per Bureau of Indian standard (B.I.S)

Fig 2



Designation	Trimmed size (mm)	Untrimmed size (mm)
A0	841 x 1189	880 x 1230
A1	594 x 841	625 x 880
A2	420 x 594	450 x 625
A3	297 x 420	330 x 450
A4	210 x 297	240 x 330
A5	148 x 210	165 x 240

1 The size of the drawing sheets to be used depends on the size of the object to be drawn and the scale to be used.

2 The length of the drawing sheet can be horizontal or vertical while drawing.

3 A2 size of drawing sheet is most convenient for drawing purposes in the class room.

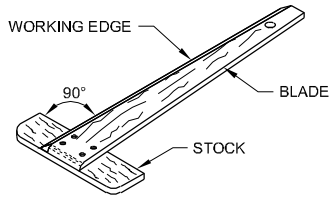
4 The width to length ratio of drawing sheet is $L : \sqrt{2}$

5 Area of A0 drawing sheet is 1.00 square metre.

T-square (Fig 3)

Fig 3

(a)



It consists of two parts, a long strip called blade and a short strip called head or stock. The blade is fitted with an ebony or plastic piece on its upper edge to form a working edge.

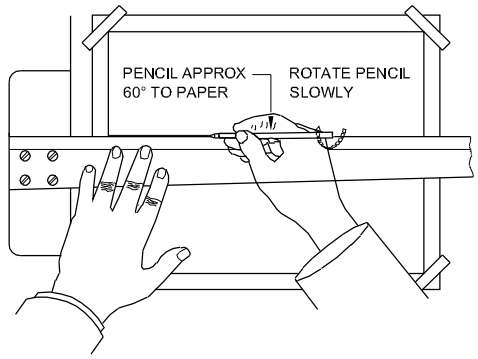
The following precautions may be taken in handling the T-square: (Fig 4)

1 When not in use, T-square should be left flat on the drawing board or suspended from the hole at the end of the blade.

2 Clean the blade with moist cloth to remove lead particles.

3 Do not use T-square as a hammer to drive in the drawing pins etc.

Fig 4



4 Do not use the ebony edge as a straight edge for cutting paper with knife.

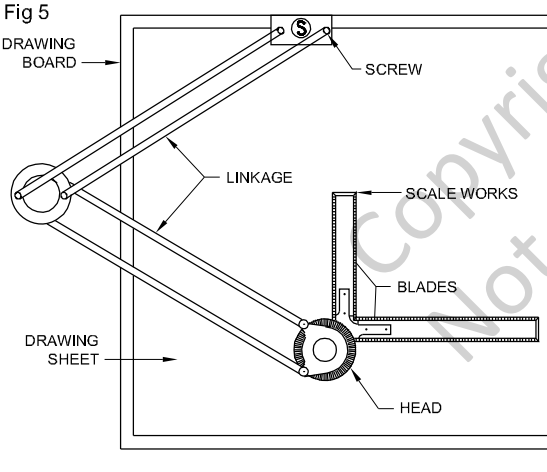
5 Ensure that the screw heads are tight.

T-square is used to draw only horizontal lines. Do not use lower edge of the T-square to draw horizontal lines. While drawing horizontal lines, the pencil should be slightly inclined towards the right. Vertical and inclined lines are drawn with the help of set squares.

Mini drafter(Fig 5)

It is a simple and small shaped instrument of the drafting machine. Now-a-days these are mostly used by the engineering students. All the working functions of T-Square, Set-Square, Protractor, Scales and their merits are co-ordinated in a Mini-Drafter.

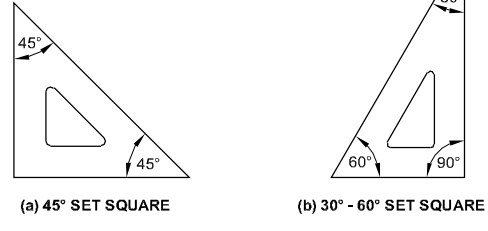
Fig 5



MINI DRAFTER

Set-square (Fig 6 and Fig 7)

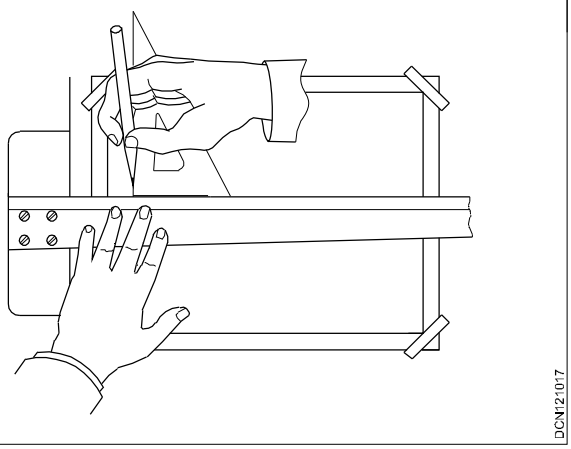
Fig 6



(a) 45° SET SQUARE (b) 30° - 60° SET SQUARE

It is made of transparent celluloid plastic in triangular shape They are available in two types, 30^0-60^0 and 45^0-45^0.

Fig 7



Engineer's scales (Table)

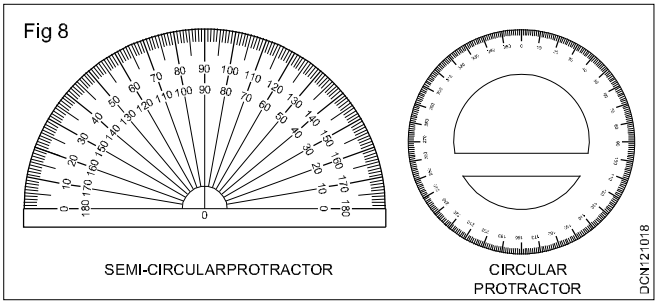
It is used to make full size, reduced size or enlarged size drawings conveniently, depending upon the size of the object and that of the drawing sheet. They are made of cardboard, plastic and as recommended by Bureau of Indian Standards, are available in set of eight scales. They are designated from M1 to M8.

Table

Designation	Description	Scales
M1	Full size	1:1
	50 cm to a metre	1:2
M2	40 cm to a metre	1:2.5
	20 cm to a metre	1:5
M3	10 cm to a metre	1:10
	05 cm to a metre	1:20
M4	02 cm to a metre	1:50
	01 cm to a metre	1:100
M5	5 mm to a metre	1:200
	2 mm to a metre	1:500
M6	3.3 mm to a metre	1:300
	1.66 mm to a metre	1:600
M7	2.5 mm to a metre	1:400
	1.25 mm to a metre	1:800
M8	1 mm to a metre	1:1000
	1.5 mm to a metre	1:2000

Protractor: (Fig 8)

Fig 8



It is made of transparent celluloid plastic, available in semi circle or circle.

Compass (Fig 9)

It is used for drawing circles both in pencil and in ink. It consists of two legs hinged at one end. One leg is attached with a steel needle by means of a screw while the other leg is provided with a socket to accommodate interchangeable attachments.

Dividers (Fig 10)

Dividers are similar to the compass and are made in square, flat and round forms. They are used for:

1 Dividing curved or straight lines into any number of equal parts.

2 Transferring dimensions from one part of the drawing to another part.

3 Setting dimensions form the scale to the drawings.

Fig 9 a

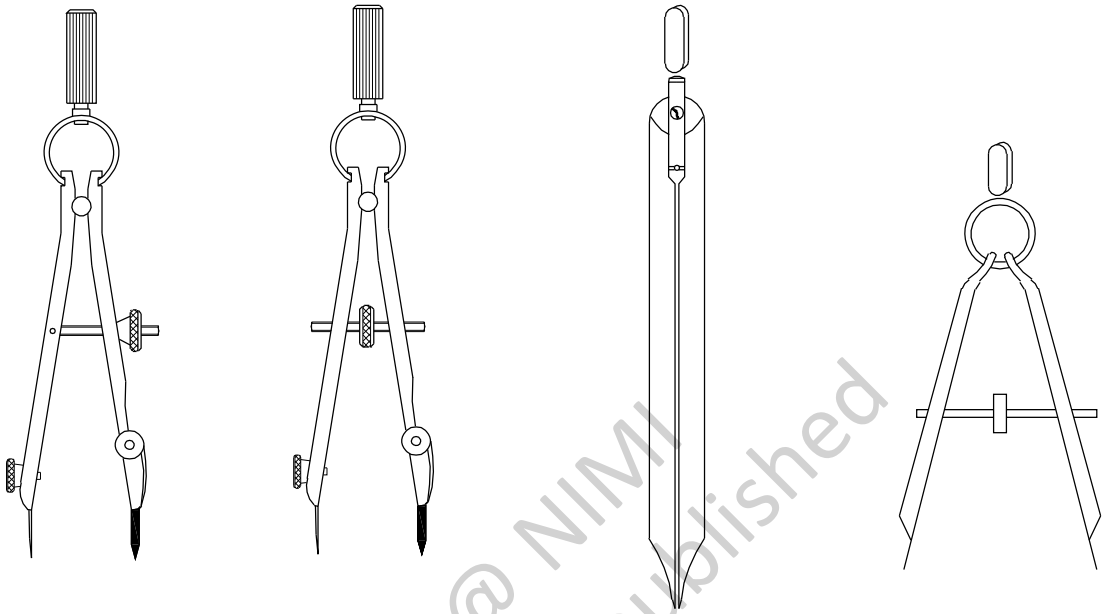
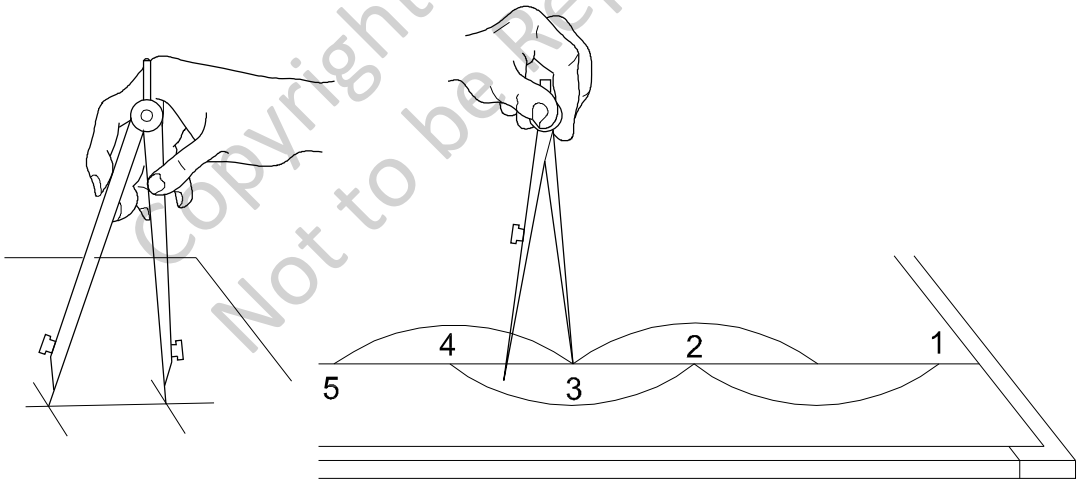


Fig 9 b



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Drawing pencils (Fig 11)

These are in many grades. The grade HB denotes medium soft. The grade H denotes the degree of hardness in an increasing order. Similarly, grade B indicates the degree of softness in an increasing order.

The lead of the wood pencil may be sharpened in the following ways

1 Cylindrical

2 Conical

3 Wedge (Chisel edge)

4 Bevel

Mechanical clutch pencil is very common in use. This is very simple, easy to use, requires no sharpening time and even cheaper in long run. Hence, this type of pencil is preferred by professional draughtsman. Students using these types of pencils will save a lot of time.

1 Only a sharp pencil can make quality drawing and hence, sharpen the pencil as and when it is necessary.

2 Sharpen the pencil only where there is no grade mark.

3 In a compass H pencil sharpened to bevel point, having its wedge shaped side slopping outside, is used.

Fig 10

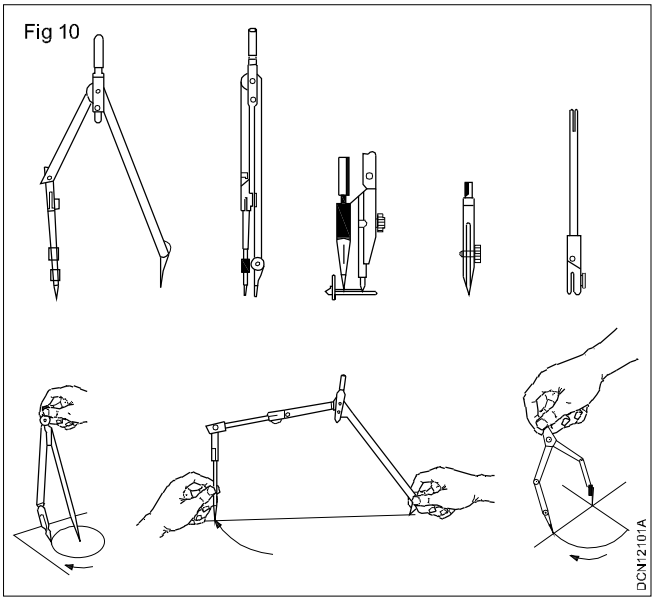
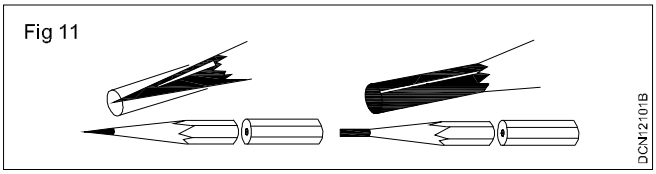


Fig 11



4 As a general guide, use:

I HB pencil for sketching

II H for outlines, visible lines, finishing, dimensioning, lettering, arrows etc.

III 2H for construction lines, dimension lines, centre lines, section lines **etc.**

Eraser

Soft pencil erasers are ideal for erasing pencil marks. This eraser will not destroy the surface of the paper and hence drawing can be re-penciled.

Fastener: (Fig 12)

Following materials are used to fix the drawing sheet on the drawing board.

- Thumb pins
- Cello tapes
- Fold back gap spring clips.

Template

Templates are available for drawing circles, arcs, ellipses, triangles, squares and other polygons. Also, symbols used by various engineering faculties, such as architectural, mechanical, electrical, chemical etc. are now available in the form of templates.

Stencils

Stencil is a thin flat piece of celluloid used to write letters and numerals. This helps the draftsmen to write neatly and uniformly and at a faster rate.

French curves (Fig 13)

A French curve is a curved ruler used for drawing irregular curves that are neither circles nor circular arcs. It is made of wood, plastic or transparent celluloid. There are different forms and sizes of French curves.

Fig 12

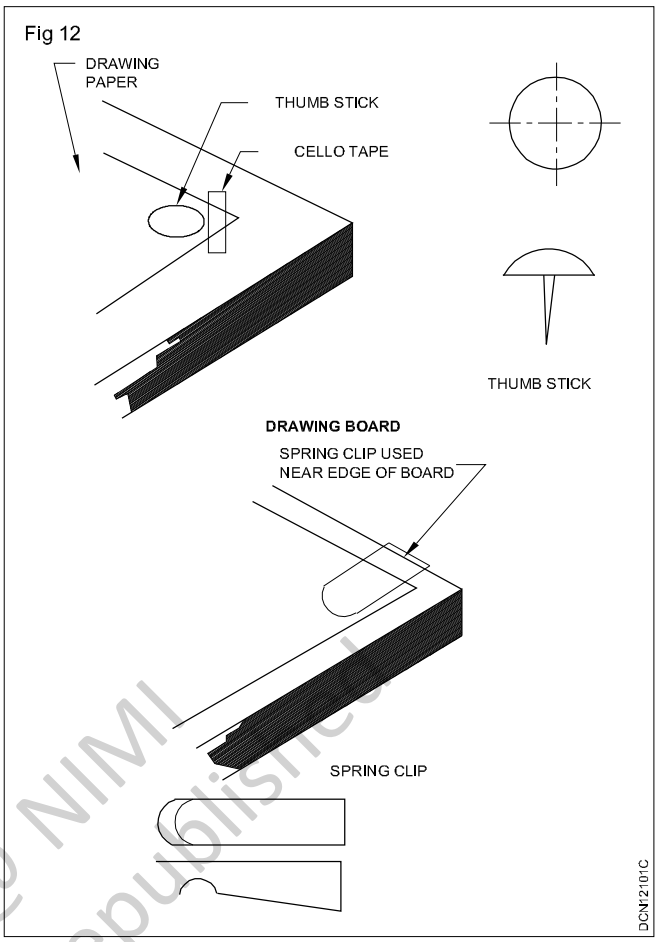
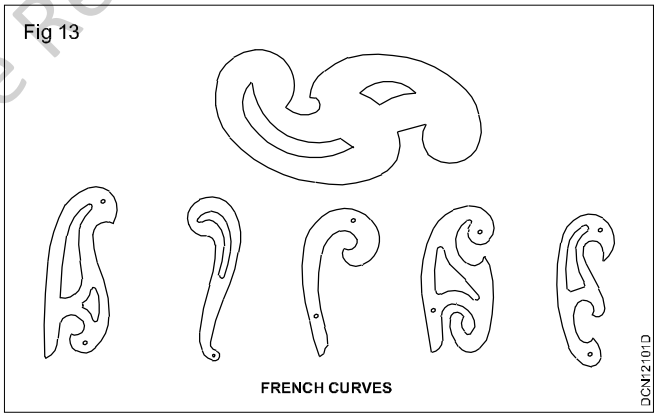


Fig 13



Flexible curve

Flexible curve is made out of materials having flexibility. It is made of lead bar enclosed in rubber and can be bent into any shape to form a curve. It helps to draw smooth curve passing through any given points. Flexible curves of various sizes are now available in the market.

Selection

- HB- For free hand works
- H- For making drawing and lettering
- 2H- for drawing construction lines, dimensions lines, section lines and centre lines.
- 3H, 4H- For drawing minute details

- B- For shading

Precautions in the use of instruments:

Following precautions should be taken while doing the drawing works,

1 The lower edge opposite to the working edge of the Tee-Square should not be used for drawing horizontal lines.

2 T- Square should not be used as hammer to drive to drawing board pins.

3 Measuring scales should not be used as hammer to drive to drawing pins.

4 Drawing sheets should never be cut by blade or knife with the T-Square blade as the guide.

5 All the instruments and drawing sheet etc. Should be throughly dusted off and cleaned before starting the work.

6 No end of the pencil should be kept in mouth.

7 No oiling should be done to the joints of the instruments; otherwise, oil will give stains or spots on the drawing sheets.

8 Only required instruments should be kept on the drawing board. All extra instruments should be kept away in drawer.

9 Divider should not be used as pincer.

10 Soaking paper should not be used for drying the ink.

11 After completing the work all the instruments should be properly cleaned.

Conclusions

One should practice handling and using drawing instruments before attempting complex drawing problems. Developing correct drawing habits will enable to make continuous improvement in the quality of drawings. Each drawing will offer an opportunity for practice. Later on, good form in the use of instruments will become a natural habit.

Layout of drawing sheet

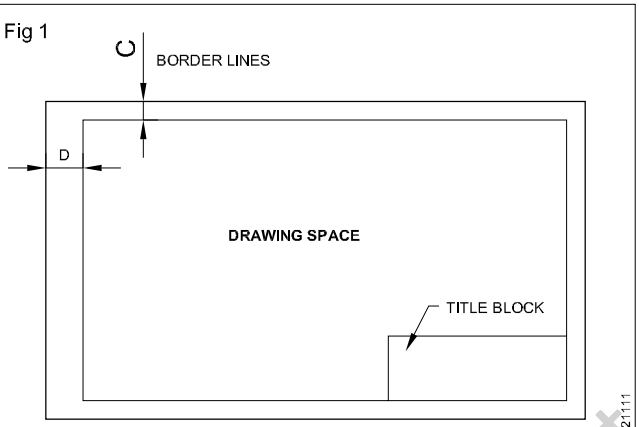
Objectives: At the end of this lesson you shall be able to
- **state the system of layout of drawing sheet**
- **list the different layout for designated drawing sheet**
- **explain the title block.**

Introduction

The details of layout showing frame with border lines, title block and margins around the frame as per Bureau of Indian Standards (B.I.S.) IS: 10711-1983 specifies the sizes and layout of drawing sheets.

Layout of drawing sheet (Fig.1)

Fig 1



LAYOUT OF DRAWING SHEET

After fixing drawing sheet on the drawing board, draw

- Border lines
- Title block

Border lines

All drawing requires a border. The standard line thickness of the border is 0.60 mm. The top, right and bottom margin should be 10mm and the left margin should be 20mm. This applies for all sheets sizes (A0, A1, A2, and A3). Notice that the left margins in larger to allow space for binding a drawing sheet. The title block place at right hand bottom of the sheet except A4 drawing sheet.

Borderline width : 0.60 mm

Top margin : 10 mm

Right margin : 10 mm

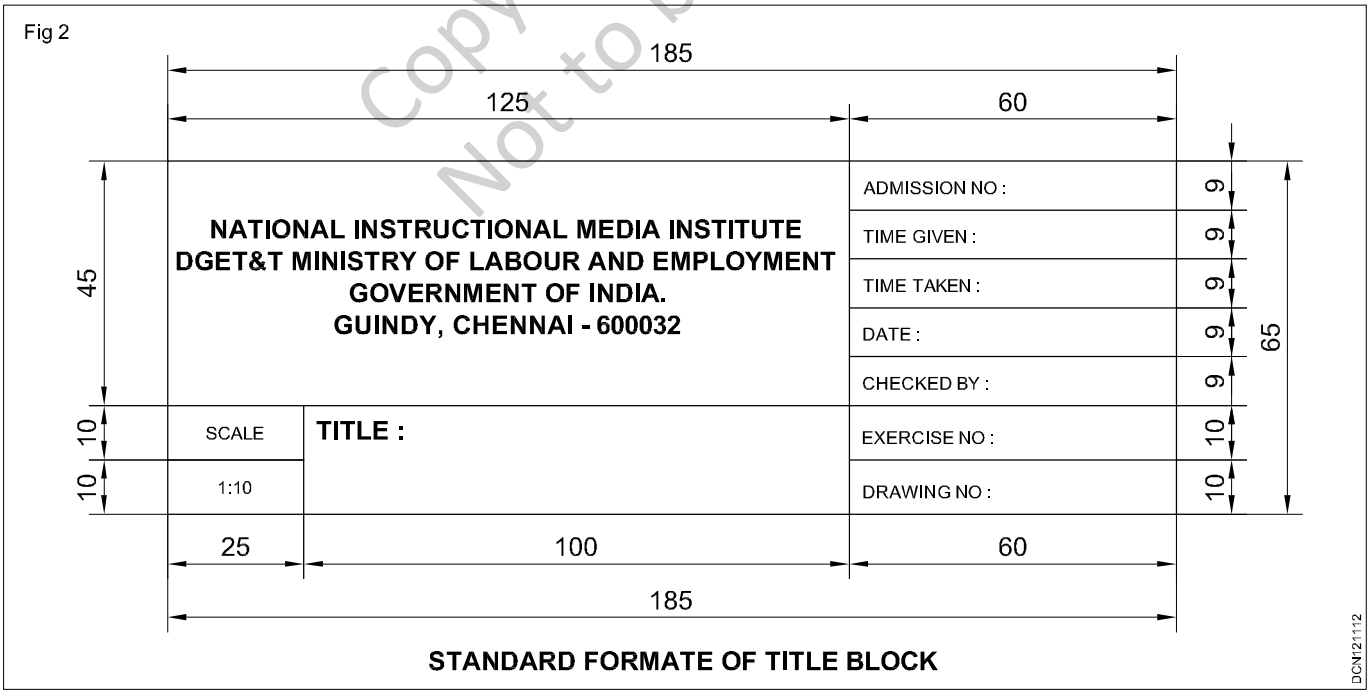
Bottom margin : 10 mm

Left margin : 20 mm

Title Block: (Fig.2)

A rectangular of 185 mm x 65 mm is draw at the bottom of the right-hand side on drawing sheets of all sizes, to furnish the details, namely name of the firm/institute, name of the Draughtsman /trainee, Roll number, title of the Drawing, scale of drawing and checked by architect/ engineer/trainer.

Fig 2

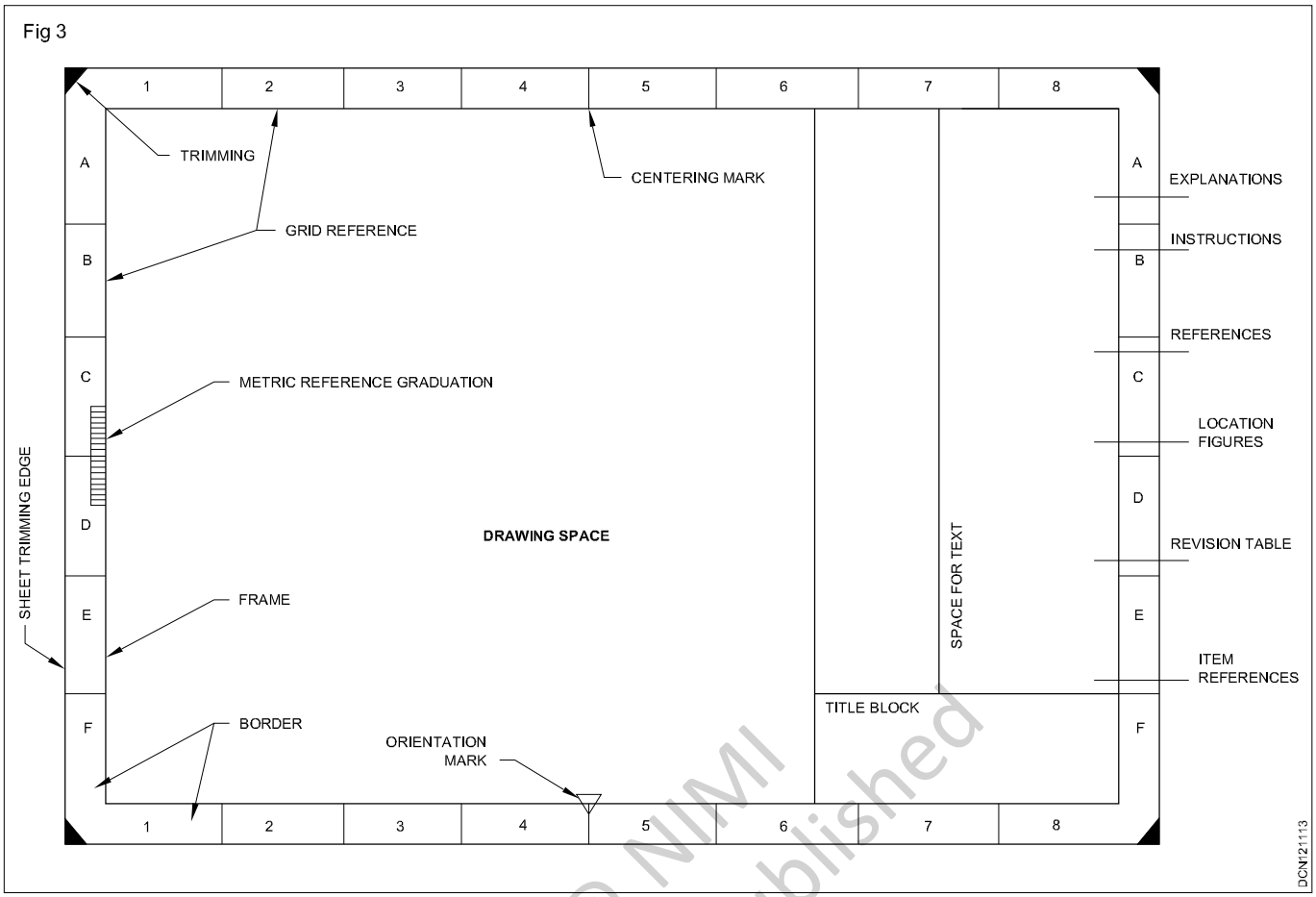


STANDARD FORMATE OF TITLE BLOCK

Spacing Drawing: (Fig.3)

When only one figure is to be drawn on a sheet it should be drawn in the centre of the working space. For more than one figure, the space should be planned and divided into suitable bocks.

Fig 3



Folding of drawing sheets

Objectives: At the end of this lesson, you shall be able to,
- **state the purpose of folding a drawing sheet**
- **explain the method of folding for drawing sheet.**

Introduction

After the completion of the drawing, the drawing should be folded properly according to IS: 11664-1986 recommended by Bureau of Indian Standards, and filed neatly for submission or for future revision / reference. All the maps and plans are folded to final size for convenience of record in office files.

The following proceduredure shall be adopted (Fig.1)

a) Always fold vertically first,

b) Fold horizontally next

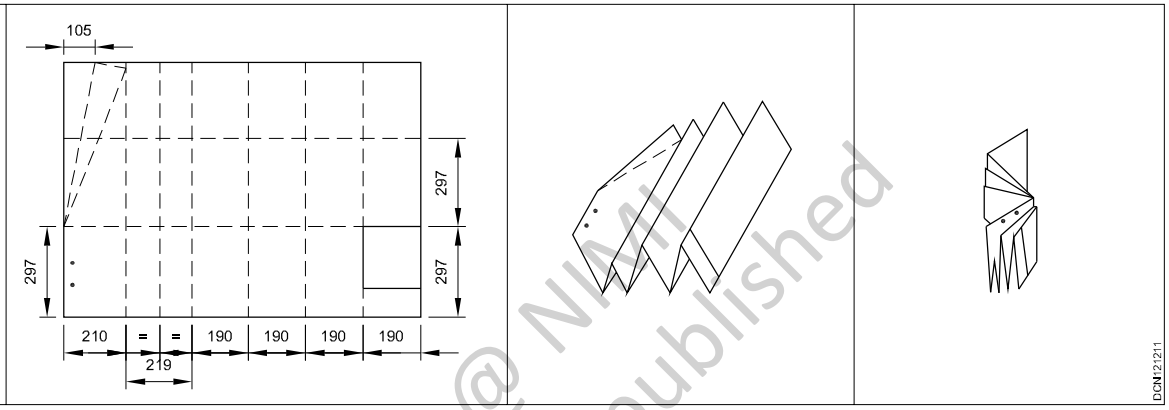
c) Folded drawing to be size of file, and

d) It can see that the Title block of all the folded prints appears in topmost position for easy reference.

Fig 1

A0

841 X 1189



Free hand technical sketching of tools in civil work

Objectives: At the end of this lesson you shall be able to
- **state the importance of technical sketching**
- **state the types of sketches**
- **explain the methods of sketching pictorial views**
- **explain the various methods adopted in sketching**
- **multi-views of the object/civil working tools.**

Importance of technical sketching: The importance of free hand sketching of machine parts and components in engineering field cannot be over estimated. Free hand technical sketching is a drawing drawn with/without the use of any drawing instruments and drawn not to scale.

The presentation of the views should be in good proportion to the extent possibility and by visual identification. Free hand technical sketching helps the designer in reflecting his thoughts and recording his ideas. Most original ideas and thoughts are expressed first through the medium of free hand sketching. For verbal explanation free hand sketching plays a very important role.

Free hand sketching contains all necessary details such as shape and size description.

The Fig 1 shows a chuck key which records the importance of free hand sketching.

Fig 1a shows the `object' for layman's easy understanding and Fig 1b gives a free hand sketch for easy production with necessary dimensions.

The perfection and proficiency in free hand technical sketching can be obtained only by more practice.

Fig 1a

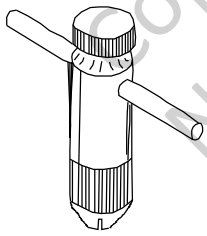
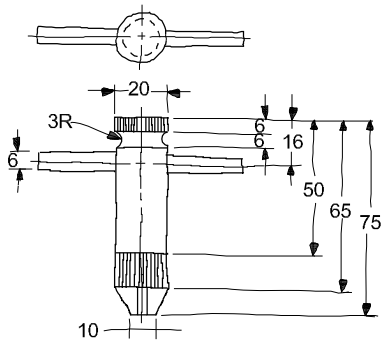


Fig 1b

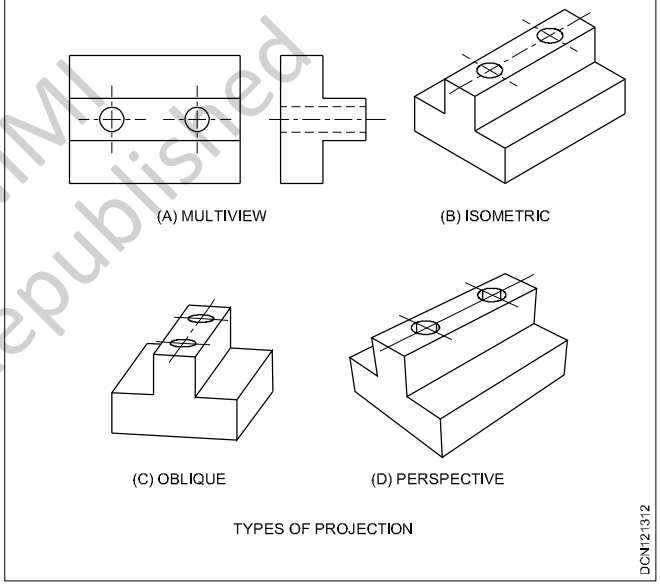


Note: The sketching materials are already explained in earlier lesson of module 1.

Type of sketches

In technical sketching the sketches are prepared from three dimensional objects. The form of the sketch determines approximately to any one of the following standard types of projections. (Fig 2)

Fig 2



– Multi-view
– Isometric
– Oblique
– Perspective

In multi-view (2A) the object is explained by its required views, which has been already discussed in earlier lesson. For ready reference find enclosed the comparative statement of two kinds of projection methods of representation in Fig 3.

The object may be shown in a single view by isometric (Fig 2B), oblique (Fig 2C) and by perspective (Fig 2D) projections.

Scale: Sketches, generally are made not to scale. In technical sketching object should be sketched in proportion to the nearest possible size.

Grid (Cross-section) paper provides a ready scale that may be employed to help in sketching to correct proportions.

The size of the sketch depends on the complexity of the object and the size of the paper.

Small objects can be sketched to an enlarged view to show the necessary details clearly.

Technique of Lines: The main difference between an instrumental technical bearing of a machine part/component and a free hand technical sketching lies in the character of technique of lines.

A good and perfect free hand line should not be rigidly straight or perfectly uniform as lines drawn with instruments. The quality of free hand sketch depends in its freedom and variety, whereas drawings done by using instruments lie in exact uniformity. (Fig 4)

Fig 4

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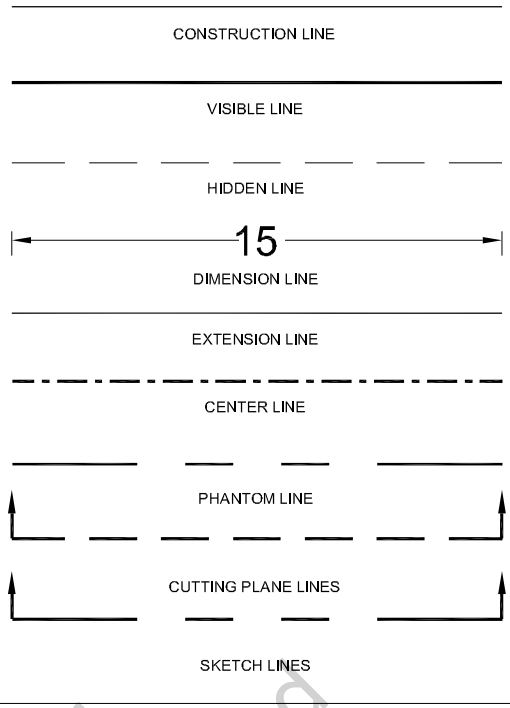
Conventional lines drawn by using instruments are shown in earlier lessons and the corresponding free hand sketches are shown in Fig 5. The free hand construction line is very light rough line in which some strokes may overlap. In free hand technical sketching you should maintain a sharp contrast between the line thickness. In free hand technical sketching, sketch visible lines heavy so the outline will show out clearly, and make hidden lines, centre lines, dimension lines and extension lines thin.

Fig 5



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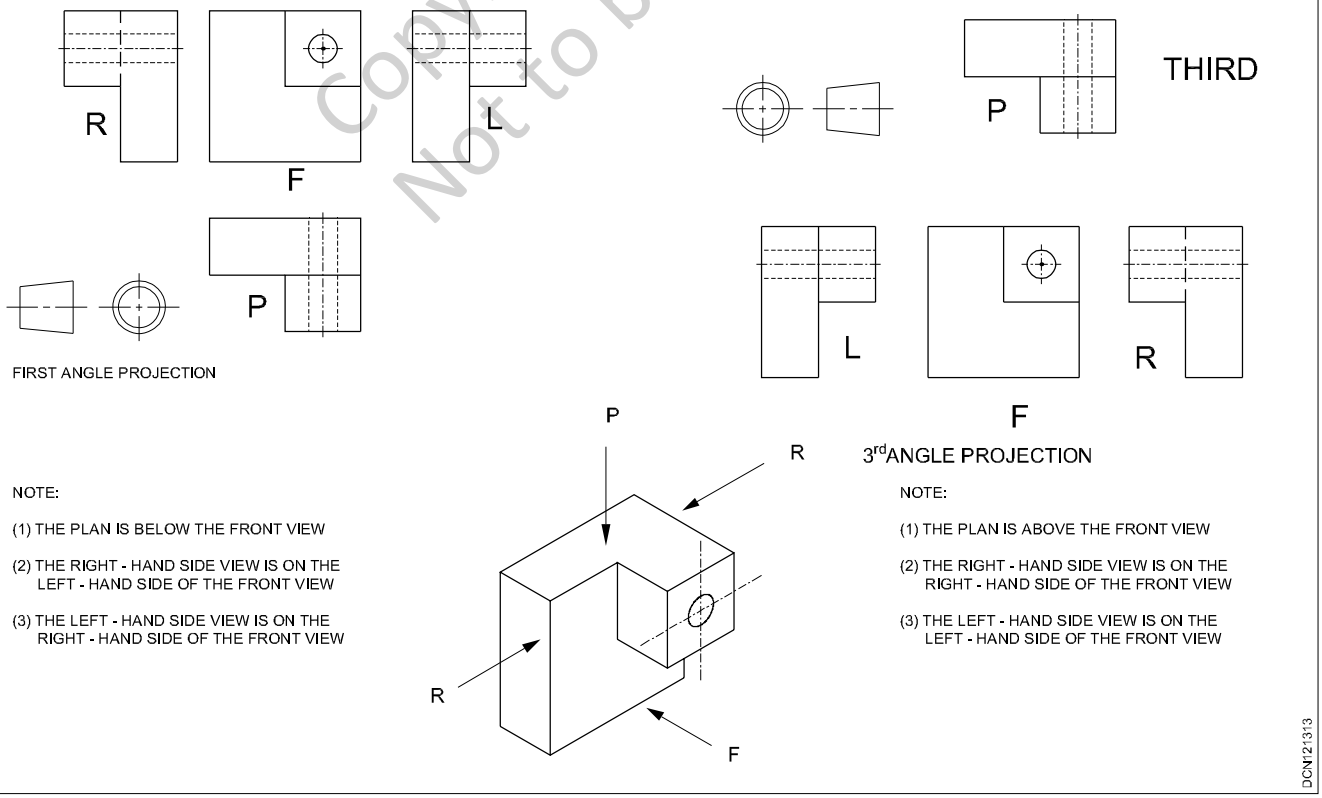
Pictorial sketching: There are several simple methods of preparing pictorial sketching which will be more helpfull in learning of principles of multi-view projection. The method of drawing pictorial views is explained in this module in Exercise 4 & 5.

Fig 3



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Isometric sketching

– To make an isometric sketch from an actual object/ component hold the object/component in hand and tilt towards you as shown in Fig 6A.

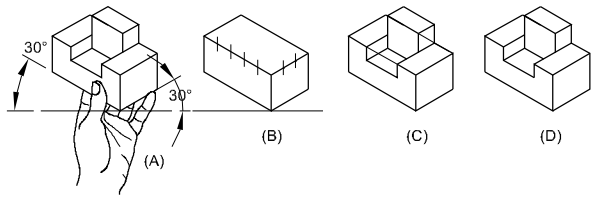
– In this position, the front corner will be vertical and in the other two receding bottom edges will be inclined about 30° to the horizontal.

– Sketch the enclosing box lightly as shown in Fig 6B.

– Block the recess and projecting block. (Fig 6C)

– Erase all construction lines with soft eraser. (Fig 6D)

Fig 6



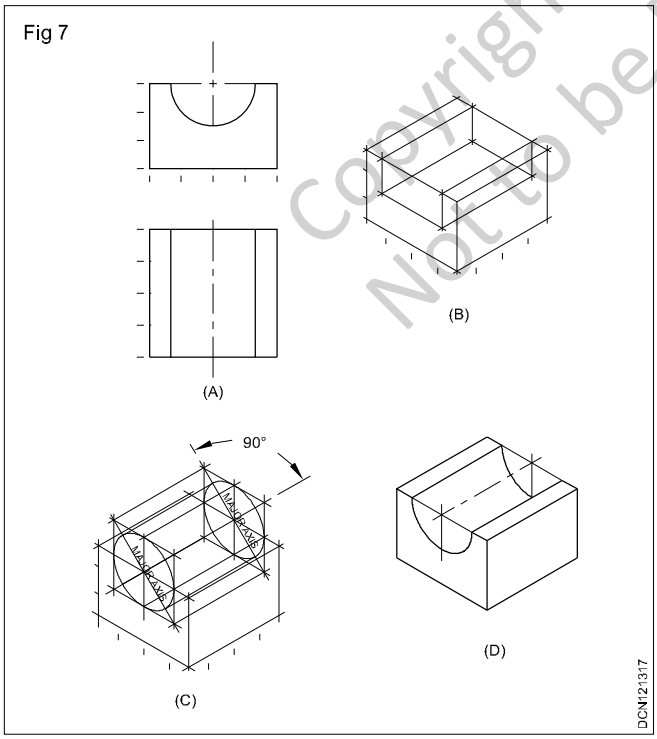
– Sketching an isometric view of a block when two views are given. (Fig 7A)

– Block the given object, including the rectangular space for semi-cylinder. (Fig 7B)

– Block in the box enclosing the full cylinder lightly as shown in Fig 7C.

– Remove all construction lines and dark the all final lines showing only the lower half of the cylinder. (Fig 7D)

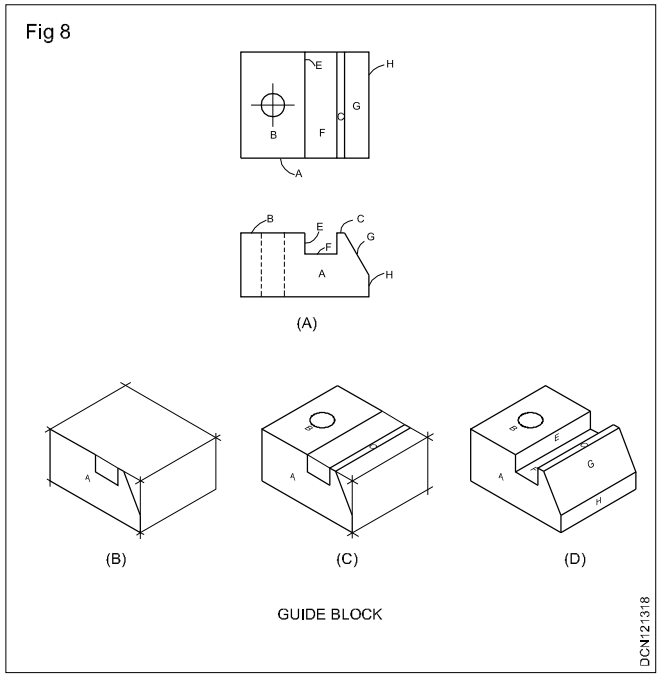
Fig 7



Sketching on isometric paper: Two views (plan and elevation) of a object are shown in Fig 8.

By using a isometric paper which gives perfect visual effect of the object.

Fig 8



By counting off the isometric grid spaces equal to the squares on the corresponding given views sketch the enclosing box and also the surface A. (Fig 8B)

Sketch the other surfaces B,C,E etc to complete the isometric views. (Fig 8C & 8D)

Oblique sketching: The another method of pictorial sketching. Fig 9 shows the method of sketching oblique view.

– Hold the object in your hand as shown in Fig 9A.

– Sketch the front view of the object as shown in Fig 9B.

– Sketch the receding lines parallel to each other and at any convenient angle.

The receding lines may be equal to the original length of the object or half of the original length.

If the length is full i.e equals to original length, the sketch is a Cavelier sketch. If half size, the sketch is a cabinet sketch. Sketch the receding lines equals to the full length of the object. (Fig 9C) Fig 9D shows the completed view of the object in Oblique view.

Oblique sketching in cross-section paper: Fig 10 explains that the given two views for a bearing bracket, an oblique view is sketched on a cross-section paper.

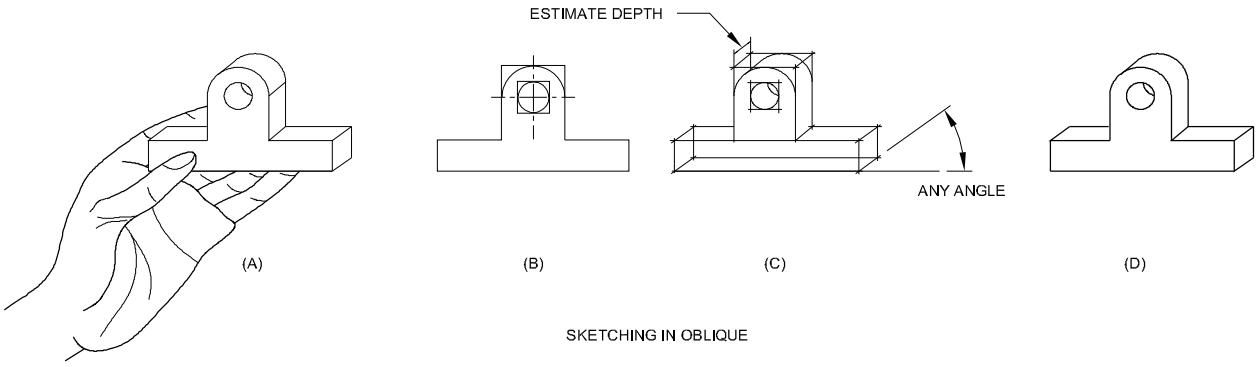
– In this methodthe dimensions are determined by counting the squares.

– The receding lines are drawn at 45° diagonally through the squares.

To sketch in a reduced scale, sketch the receding lines diagonally through half as many squares as ghe given numbers shown at Fig 10A.

Fig 10B, 10C, & 10D are steps or sequence of procedures in developing a oblique view of an object object on a cross-section paper.

Fig 9



SKETCHING IN OBLIQUE

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Fig 10

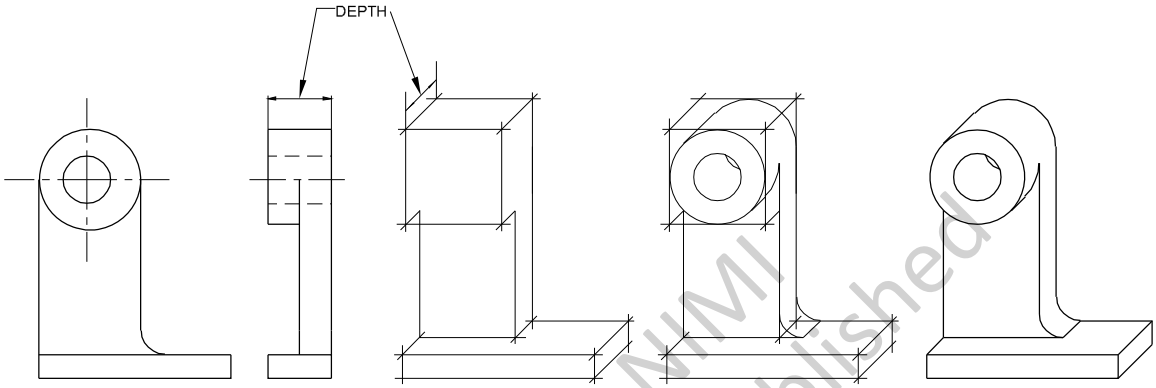

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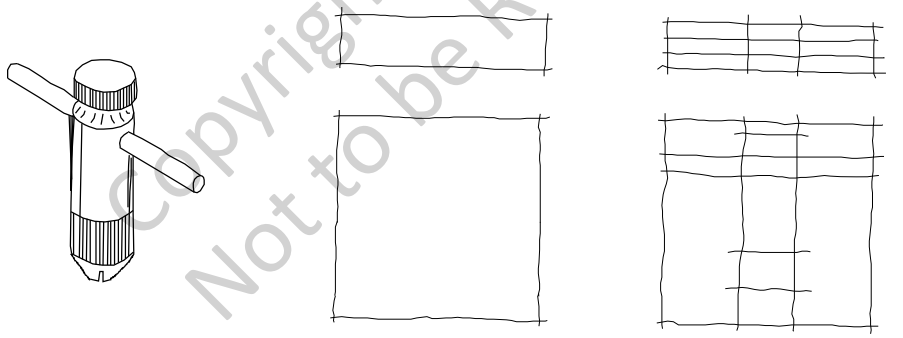
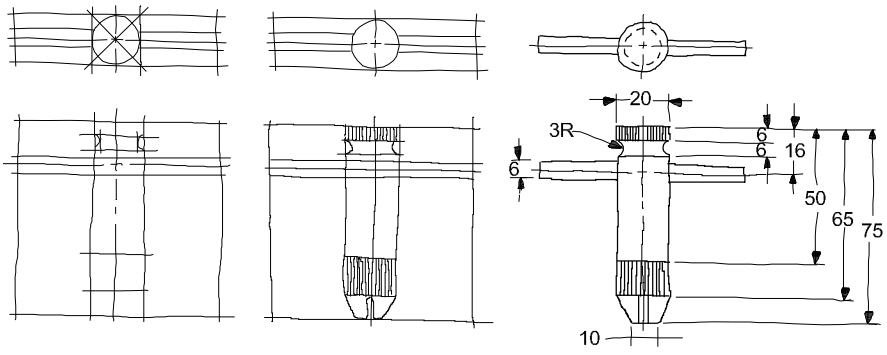
Fig 11





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Sketching multi-views of object: In sketching multi-views of the object the following steps are most important in this endevour.

– Visualisation of the object
– Determination of the views (whether 1st andle or 3rd angle)
– Determination of the size of the sketch.
– Location of centre lines
– Allocation of dimensions with proper dimension lines an arrow heads.
– Blocking the main outlines
– Writing titles and any other notes/details with dates
– Checking the drawings.

Before making a free hand technical sketch of a machine part/component the following points is to bear in the mind.

– Before a graphic idea can be developed it is essential that the mental image of it to be defiinite and clear.
– When making fee hand multi-views sketches, it has to begin by blocking the overall size of each view by using very light lines.
– Establish the length, height and width of each view.
– Locate the centre line of the cylindrical features.
– Locate the centres for arcs and circular parts.
– Circular parts and arcs are sketched first followed by horizontal and vertical lines.
– Additional separate views may be sketched rather than complicating views with added lines.
– A machine component can be represented right side up in its natural working position.
– If symmetrical about an axis mostly one half may be sketched.
– Choose a correct scale for the sketch, so that enough space is provided to show all details.
– The rules and methods are same as applicable to multi-views drawn by using instruments.
– Fig 11 shows a model of free hand sketch for the reference.

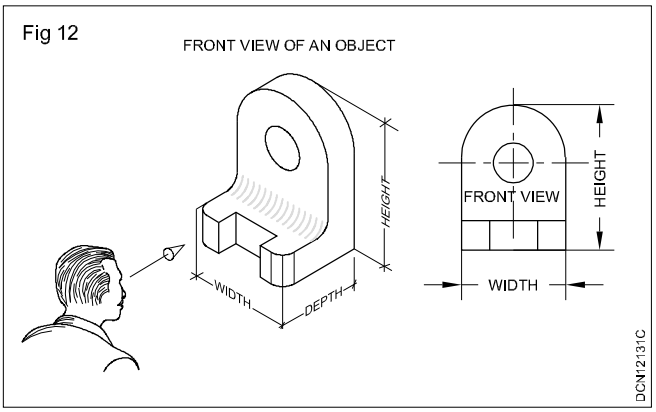
Views of objects: A pictorial representation of a drawing or a photograph representation shows an object as it appears to the observer, but not as it is. Hence such a representation cannot describe the object fully and also it does not show the exact shapes and sizes of the several parts.

In industry for the purpose of production, a complete clear description of the shape and size of an object to be made is essential, to sketch certain objects that to be manufactured as intended by the designer. So to provide such information perfectly and correctly a number of views and arranged in multi-views method of projection. In this method each view supplies a certain definite information.

When the view is projected in the direction perpendicular to a principle face or side of the object.

In Fig 12 the observer looks perpendicularly to the face of the object and obtains true shape and size of that side. This has shown in Figure. It is known that an object has three principle dimensions such as height, width and depth.

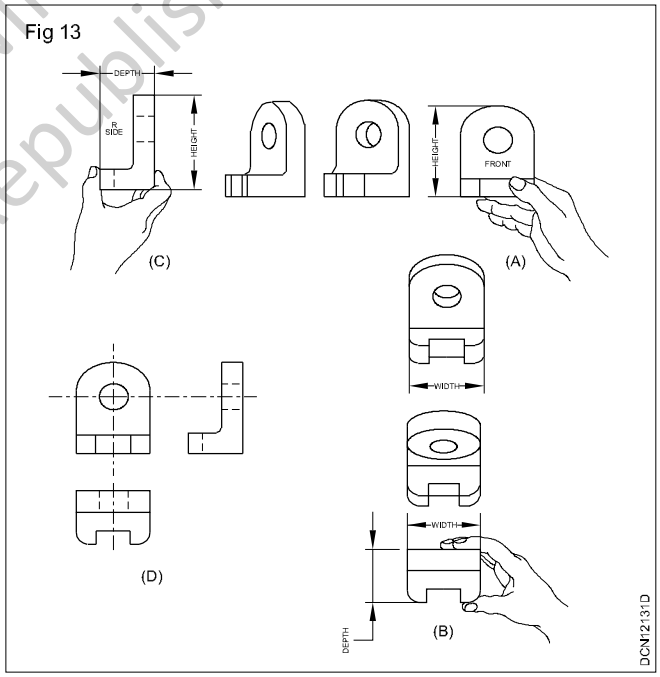
Fig 12



Note: In any one view of a three dimensional object can show only two dimensions, the third dimensions will be seen in an adjacent view.

To get the additional views, the object is revolved as shown in Fig 13.

Fig 13



Any object can be visualised from six mutually perpendicular directions as shown in Fig 14 and the arrangement of the views shown in Figure. The method of obtaining the views of the objects is discussed in earlier lessons.

Choice of views: It is more important that drawing of the object for use of production should have only such of those views needed for a clear and complete shape description of the object. Fig 15 has three distinctive features that need to be shown on the sketch/drawing and also shows the sketch of six views. The required distinctive features are rounded top hole, seen from front.

– Rectangular notch and rounded corners seen from the top.

Fig 14

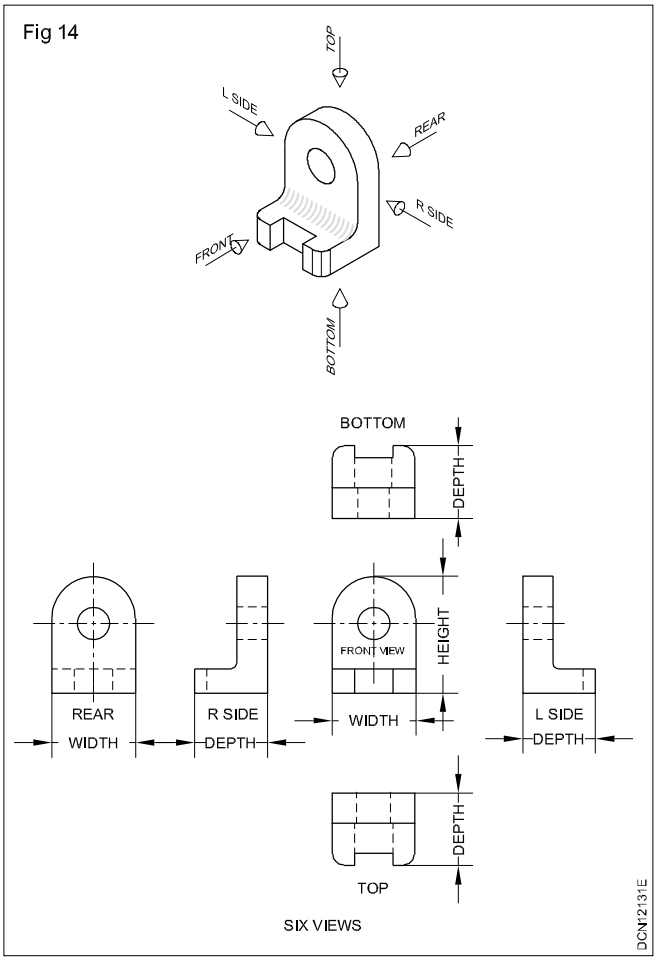
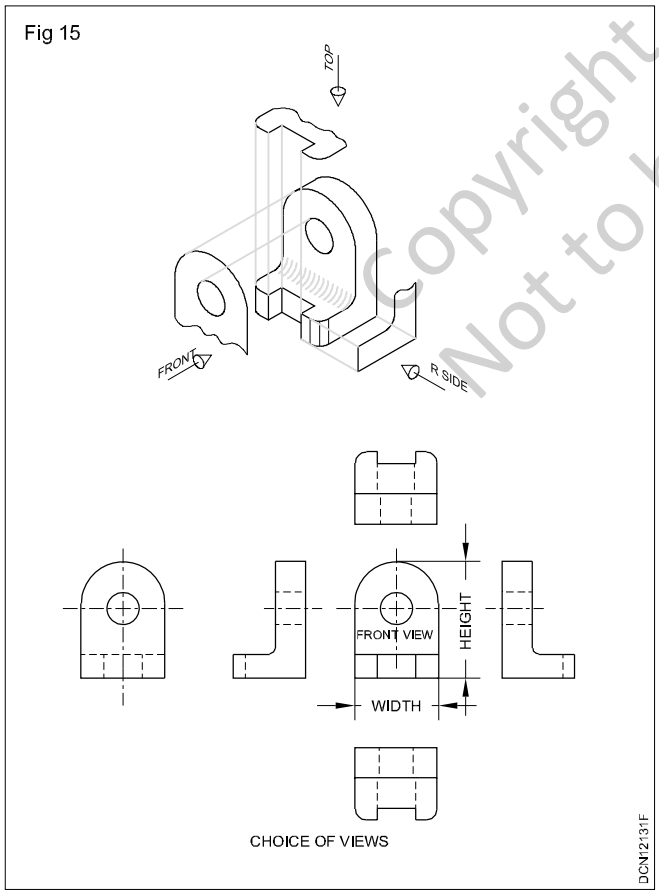


Fig 15

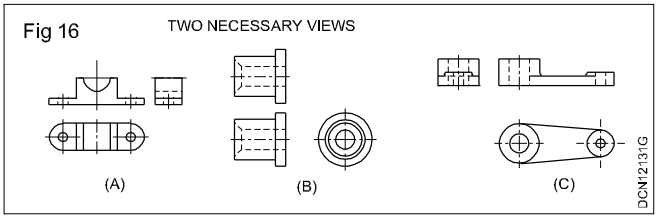


– Right angle with filleted corner, seen from the side.

The above features can be shown in three views by eliminating the unnecessary views which has shown in Fig 15.

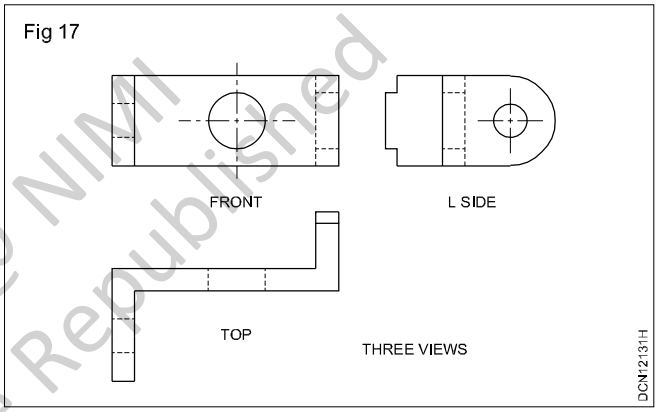
In same cases two views will be sufficient to furnish the features of the object. Fig 16A,B,C are the some examples for such cases.

Fig 16



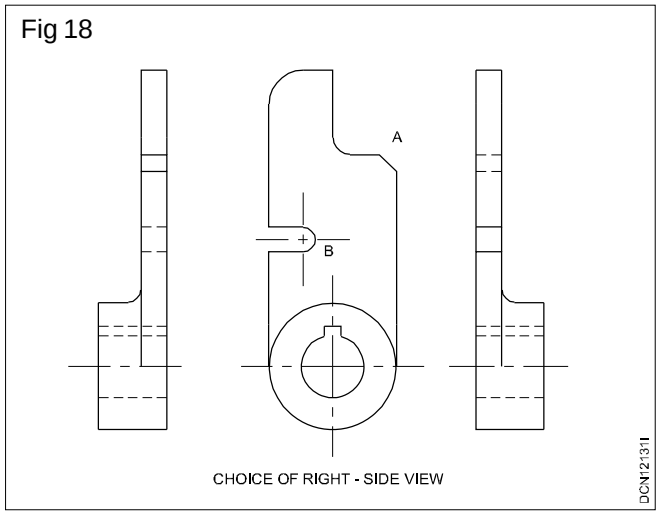
In some cases three views are compulsary. For example Fig 17 shows the three views of a bracket. In this case if the top view is omitted, providing the front and side view alone, it is difficult to understand the two views or visualise the object, because the characteristic `Z' shape of the top view is omitted and also the corners A & B are squares and not filleted. Hence in this example three views are necessary.

Fig 17



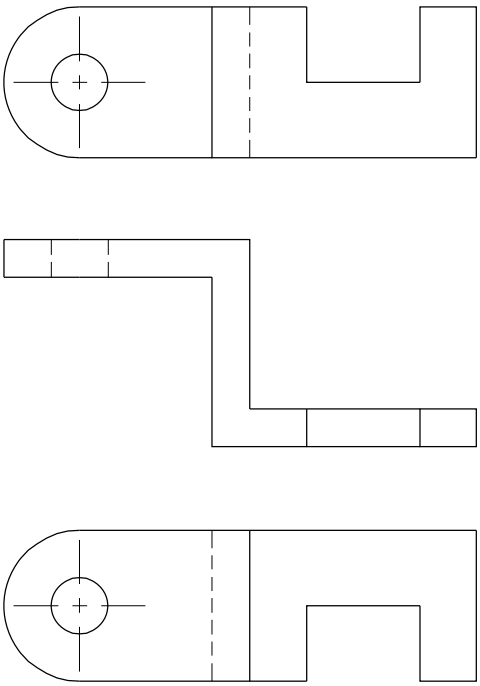
Similarly, it can be choosen the choose of side view on top view shown in Figs 18,19 & 20.

Fig 18



One view drawings: Often single view with a note or lettered symbols is so sufficient to explain the features of the object. Fig 21A one view of the slim, adding a note indicating the thickness is sufficient to explain the features. At Fig 21B one view of a stepped turning piece shown with a threaded portion at the end with additional notes, is sufficient to explain the features of the object.

Fig 19



CHOICE OF TOP VIEW

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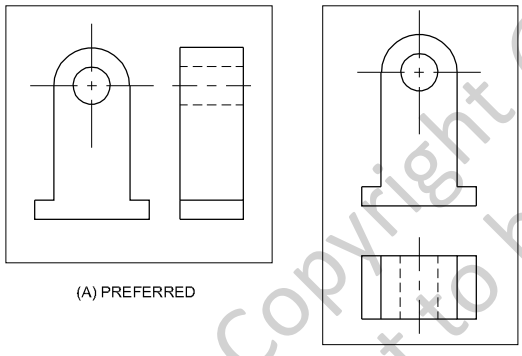
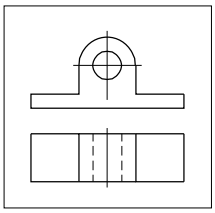
Fig 20

CHOICE OF VIEWS TO FIT PAPER

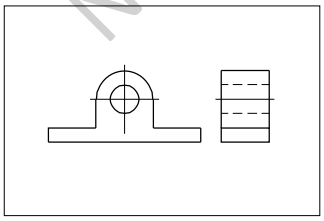


(A) PREFERRED

(B) POOR



(C) PREFERRED

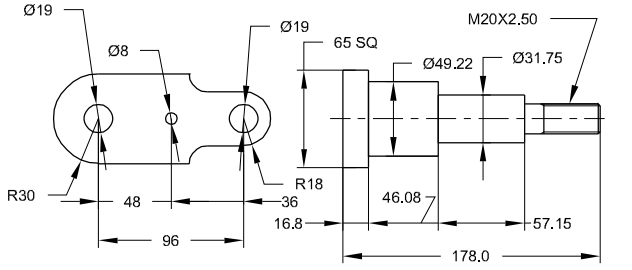


(D) POOR

DCN12131K

Fig 21

ONE - VIEW DRAWINGS



(A) MATL : 0.25 BRASS

(B) STOCK : 65 SQ CRS

DCN12131L

Hidden lines: Correct and incorrect method in sketching/ drawing hidden lines are shown in Fig 22.

The following rules can be adopted for the drawing of hidden lines.

– Leave a gap wherever a hidden line dash forms a continuation of a visible line. (Fig 22A)

– A hidden line should intersect to form `L' or `T' corners. (Fig 22B)

– A hidden line preferably should jump a visible line. (Fig 22C)

– Parallel hidden lines should be staggered. (Fig 22D)

– When two or three hidden lines meet at a point, the dashes should join. (Fig 22E)

– For showing the counter sunk hole. (Fig 22F)

– Correct and incorrect methods of hidden arcs. (Fig 22G & H)

Centre lines: Centre lines are used to indicate arcs of symmetrical objects or features. Fig 23 shows the typical applications of the centre lines in various features.

Meaning of lines: A hidden line or a visible line has the following meanings

– Intersection of two surfaces

– Edge view of a surface

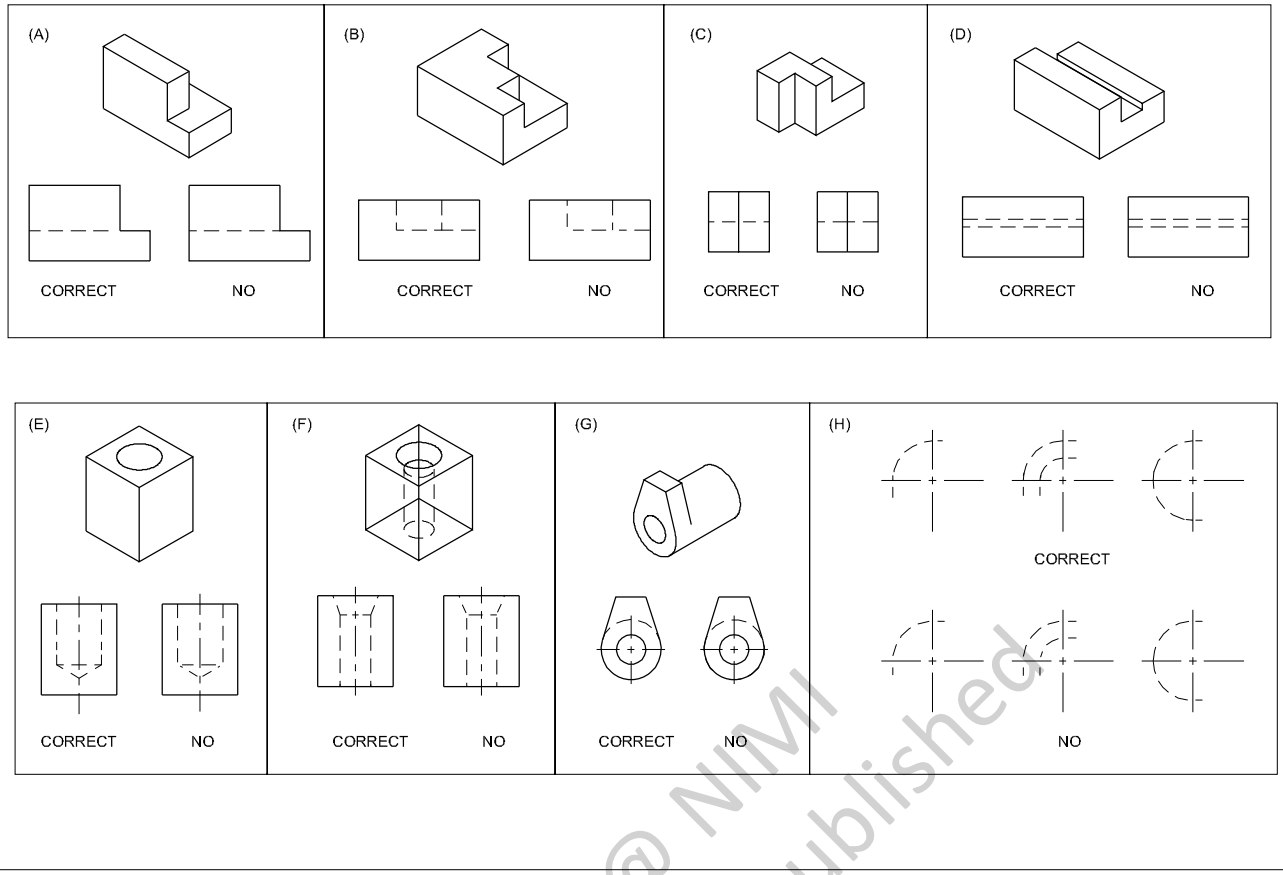
– Contour view of a curved surface. (Fig 24)

Procedure line: Hidden lines, centre lines and visible lines often coincide with each other and it is needed for draughtsman to know which line should be shown. Fig 25 explains the same. A visible line is always precedence over (corners up) a centre line or hidden line A & B of Fig 25. A hidden line is always takes precedence over a centre line ab at c of Fig 25.

Note that at A and C of 25 the centre line are shown, but separated from the view by a short gap.

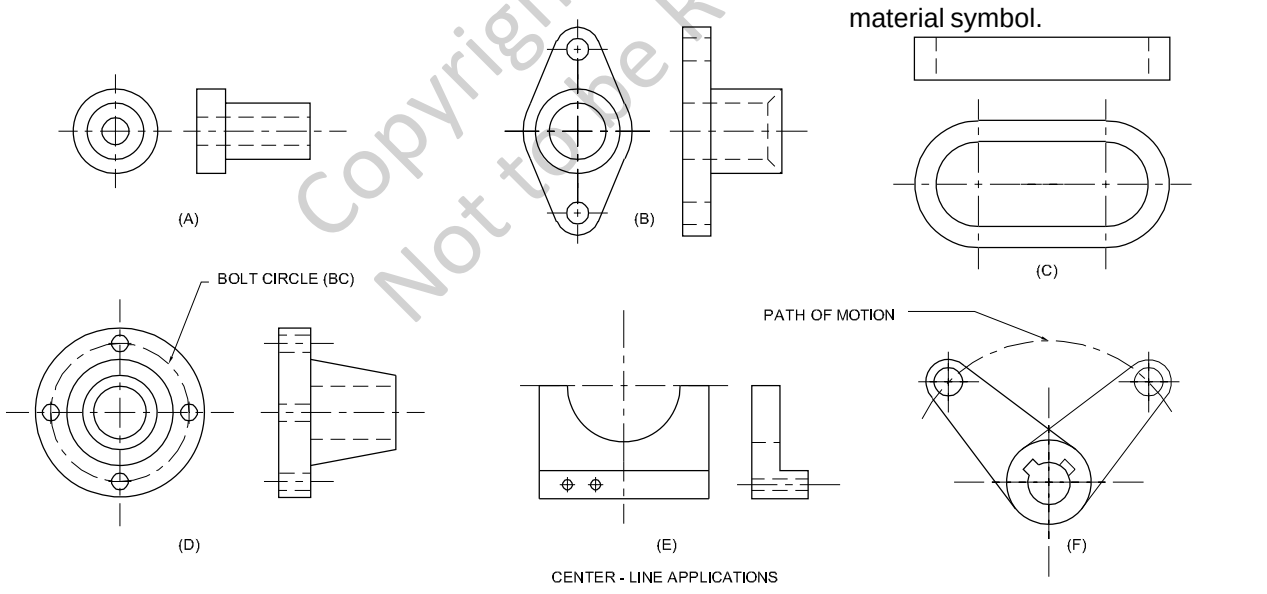
Fig 22

HIDDEN - LINE PRACTICES



DCN12131M

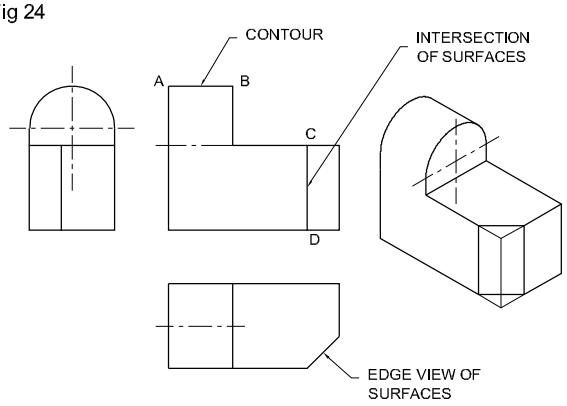
Fig 23



CENTER - LINE APPLICATIONS

DCN12131N

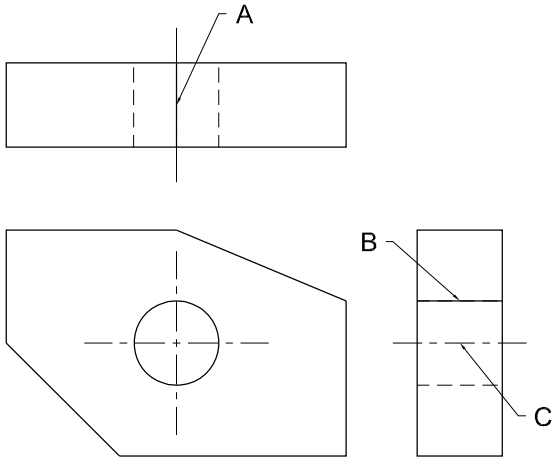
Fig 24



MEANING OF LINES

DCN121310

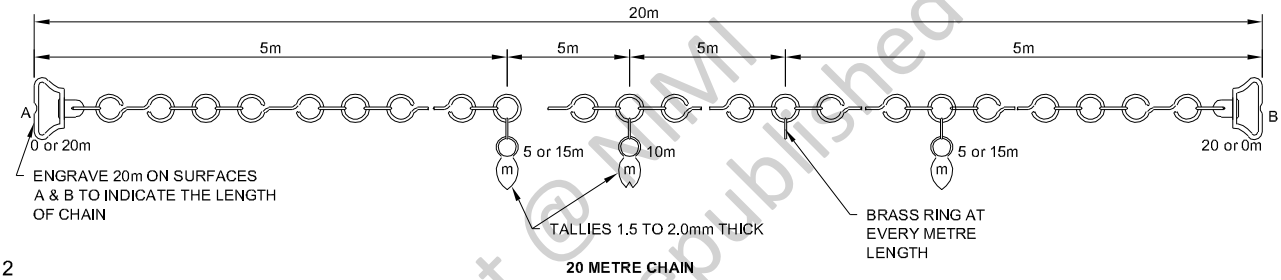
Fig 25



PRECEDENCE OF LINES

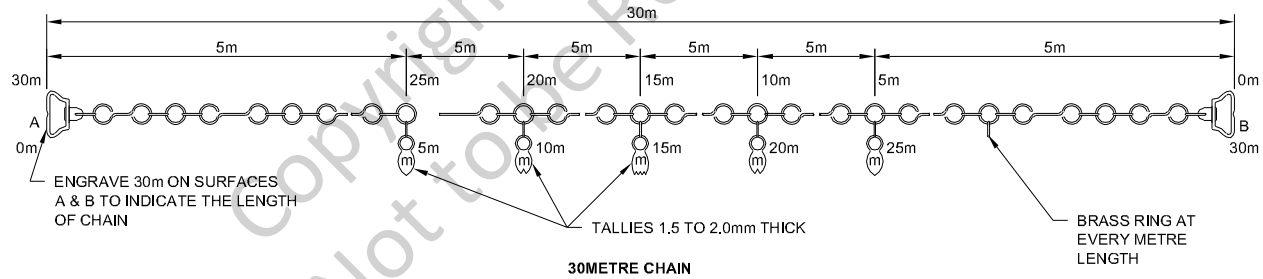
DCN121311P

Fig 1



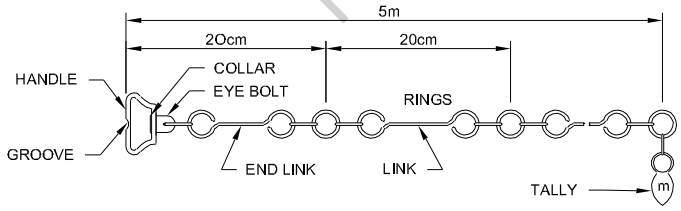
20 METRE CHAIN

Fig 2



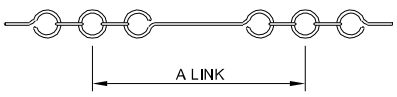
30METRE CHAIN

Fig 3



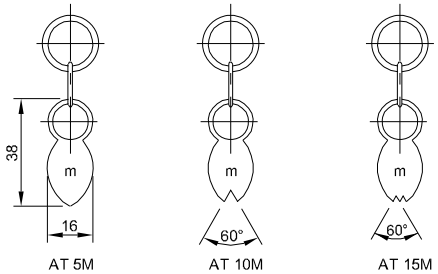
DETAILS OF A METRIC CHAIN

Fig 4



A LINK OF A CHAIN

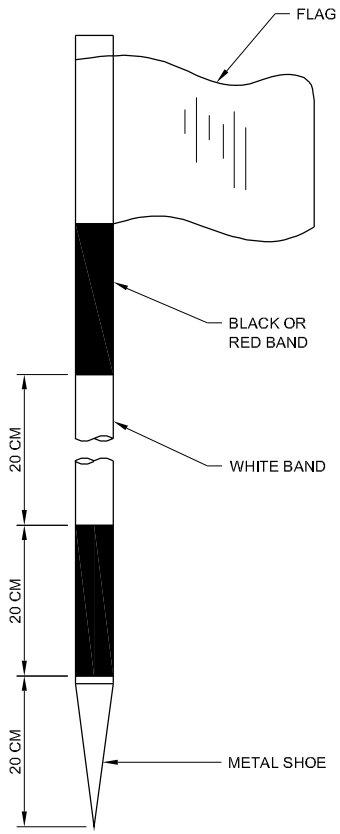
Fig 5



SHAPE OF TALLIES IN 30m METRIC CHAIN

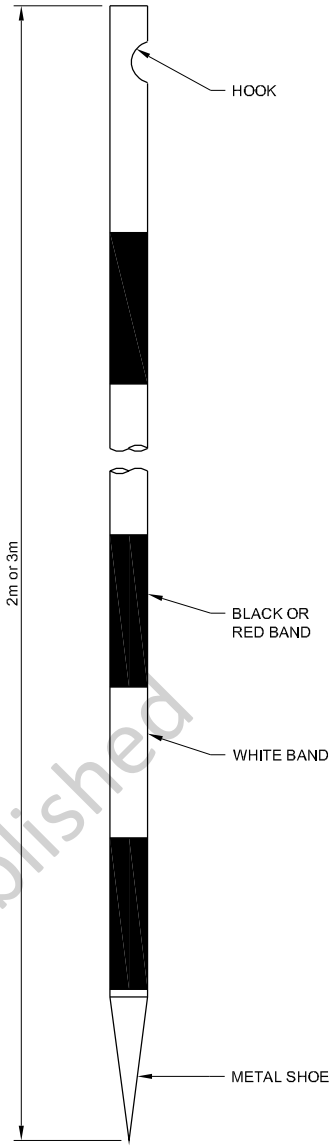
DCN121321

Fig 6



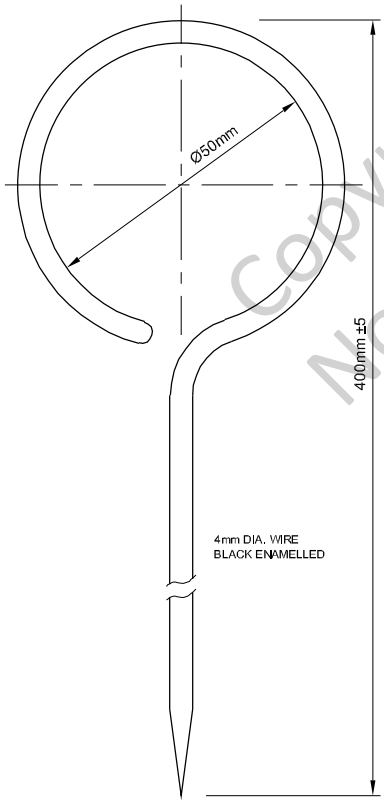
RANGING ROD

Fig 7



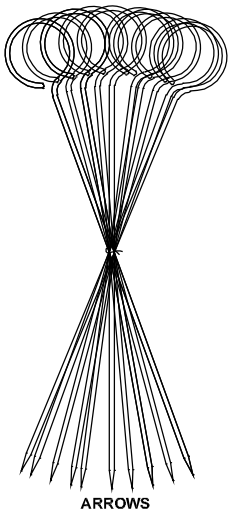
OFFSET ROD

Fig 8



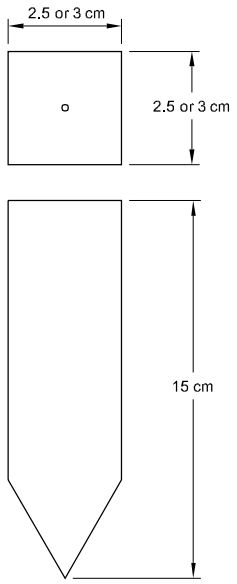
ARROW

Fig 9



ARROWS

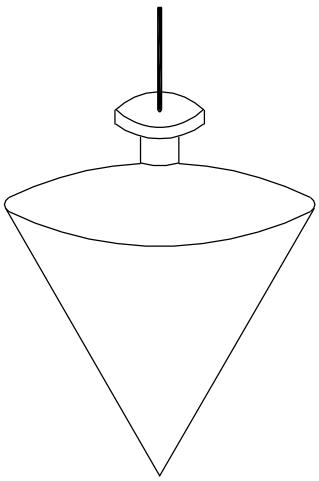
Fig 10



WOODEN PEG

DCN12132A

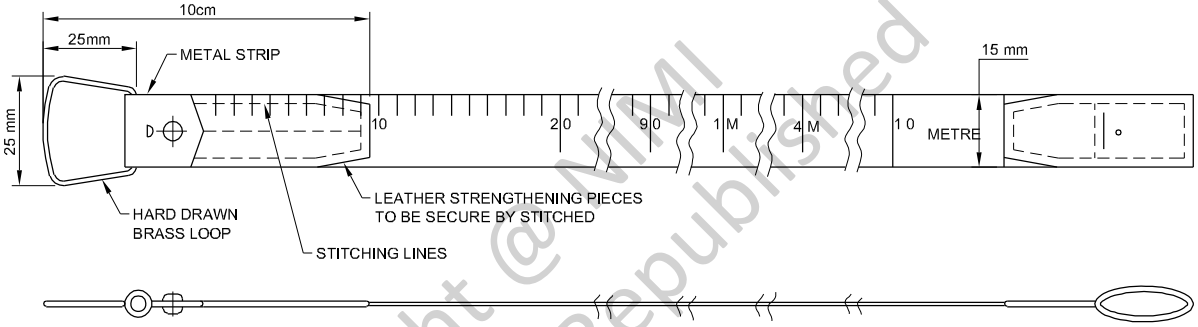
Fig 11



PLUMB BOB

DCN12132B

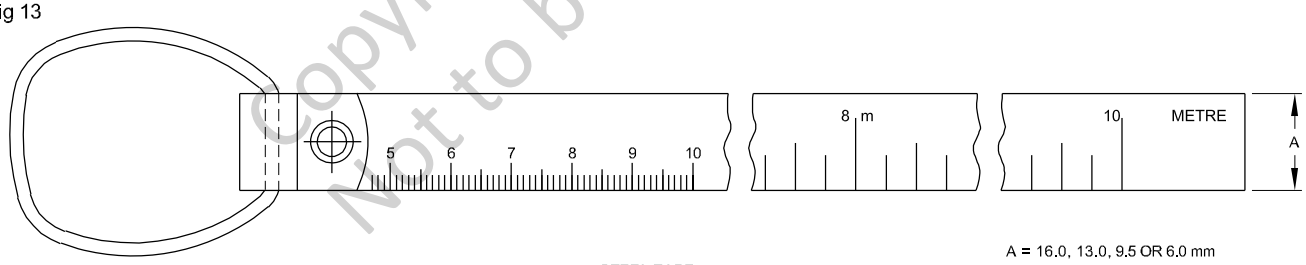
Fig 12



METALLIC TAPE

DCN12132C

Fig 13

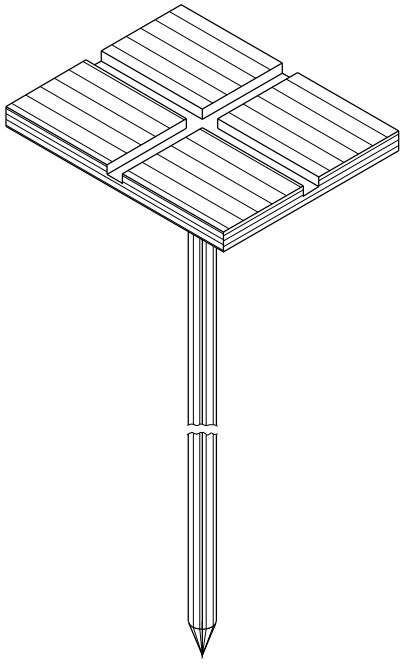


A = 16.0, 13.0, 9.5 OR 6.0 mm

STEEL TAPE

DCN12132D

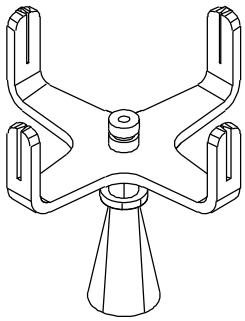
Fig 14



WOODEN CROSS STAFF

DCN12132E

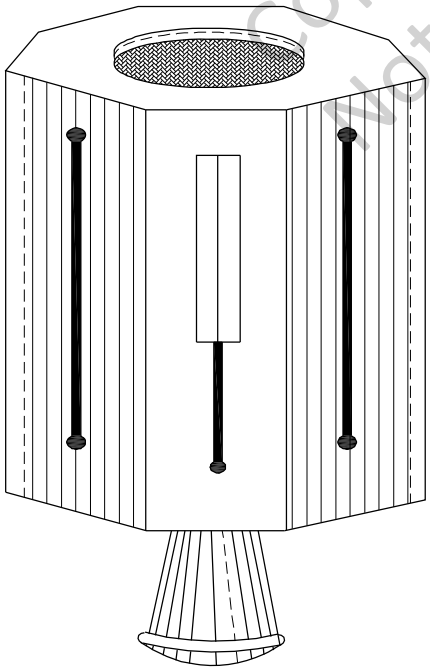
Fig 15



METAL ARM CROSS-STAFF

DCN12132F

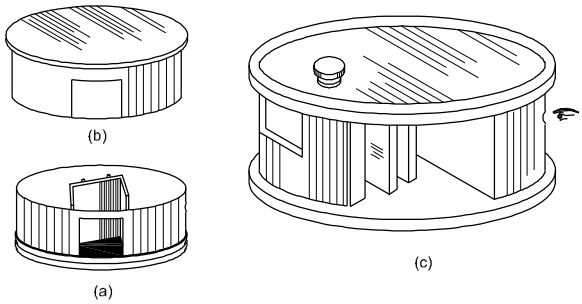
Fig 16



FRENCH CROSS-STAFF

DCN12132G

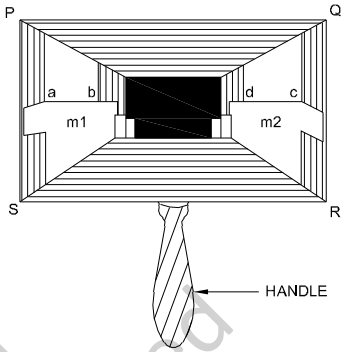
Fig 17



ROUND OR CYLINDERICAL OPTICAL SQUARE

DCN12132H

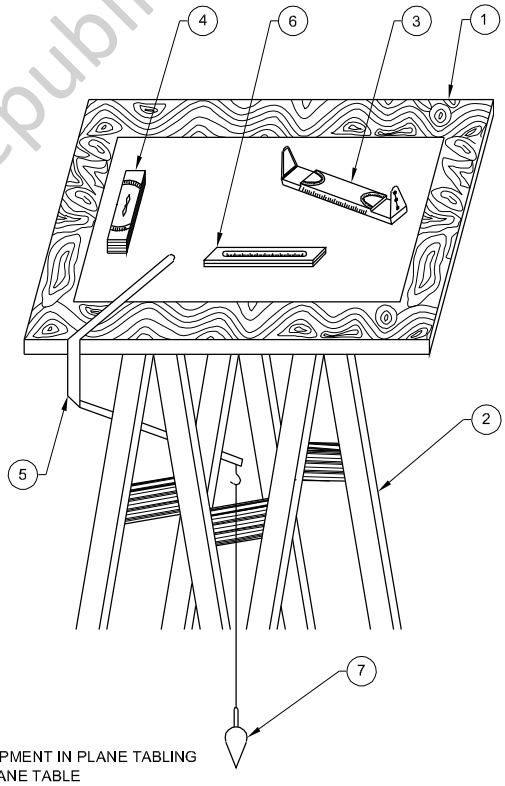
Fig18



INDIAN OPTICAL SQUARE

DCN12132I

Fig 19

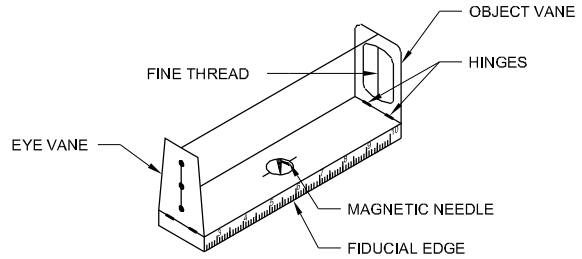


EQUIPMENT IN PLANE TABLING
1. PLANE TABLE
2. TRIPOD STAND
3. ALIDADE
4. TROUGH COMPASS
5. U-FRAME
6. SPIRIT LEVEL
7. PLUMB-BOB

PLANE TABLE

DCN12132J

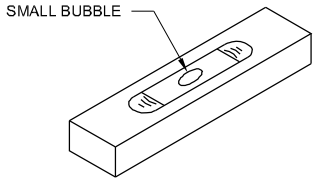
Fig 20



A PLAIN ALIDADE

DCN121132K

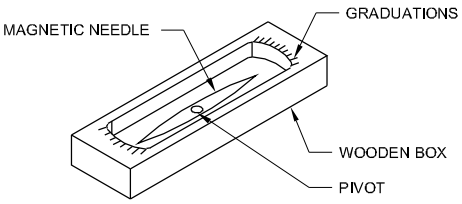
Fig 21



SPIRIT LEVEL

DCN121132L

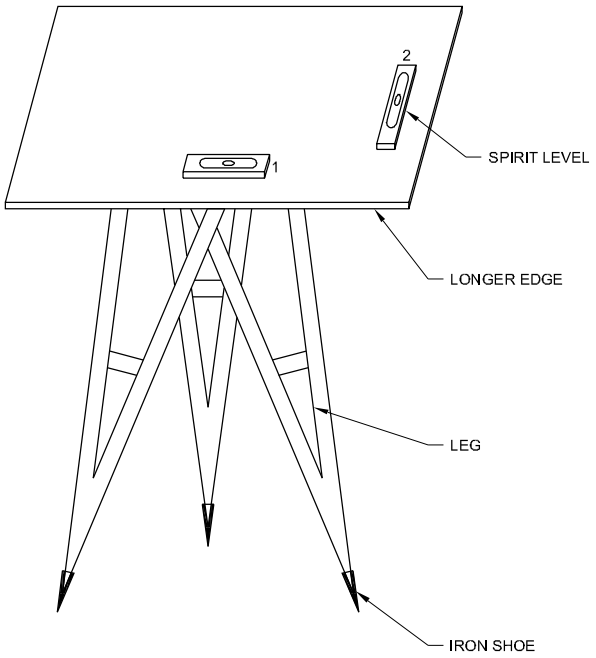
Fig 22



TROUGH COMPASS

DCN121132M

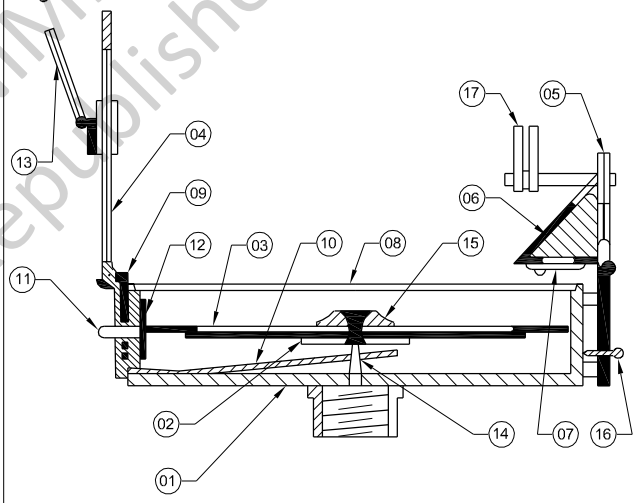
Fig 23



LEVELLING THE PLANE TABLE

DCN121132N

Fig 24

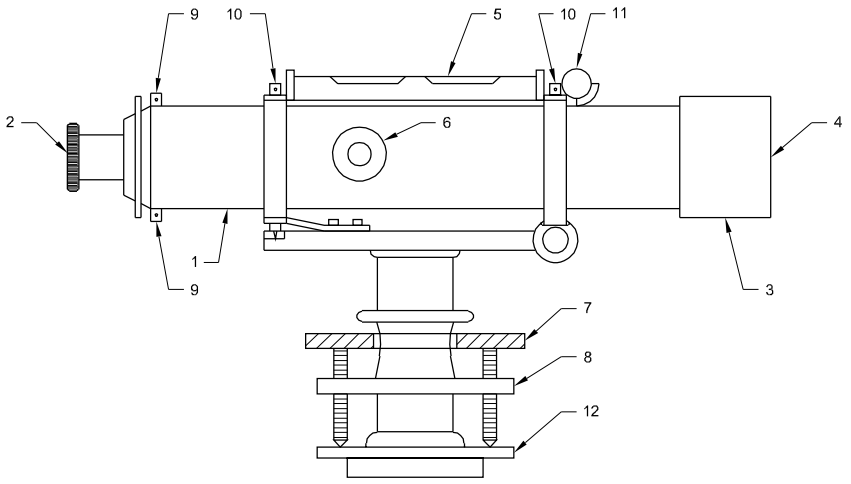


01. BOX
02. NEEDLE
03. GRADUATED RING
04. OBJECT VANE
05. EYE VANE
06. PRISM
07. PRISM CAP
08. GLASS COVER
09. LIFTING PIN
10. LIFTING LEVER
11. BRAKE PIN
12. SPRING BRAKE
13. MIRROR
14. PIVOT
15. AGATE CAP
16. FOCUSING STUD
17. SUN GLASS

THE PRISMATIC COMPASS

DCN121132O

Fig 25

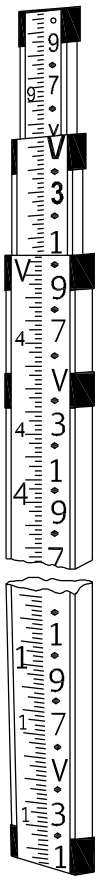


1. TELESCOPE
2. EYE-PIECE
3. RAY SHADE
4. OBJECTIVE END
5. LONGITUDINAL BUBBLE
6. FOCUSING SCREWS
7. FOOT SCREWS
8. UPPER PARALLEL PLATE (TRIBRACH)
9. DIAPHRAGM ADJUSTING SCREWS
10. BUBBLE TUBE ADJUSTING SCREWS
11. TRANSVERSE BUBBLE TUBE
12. FOOT PLATE (TRIVET STAGE)

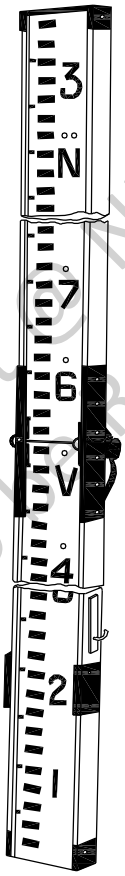
DCN12132P

DUMPY LEVEL

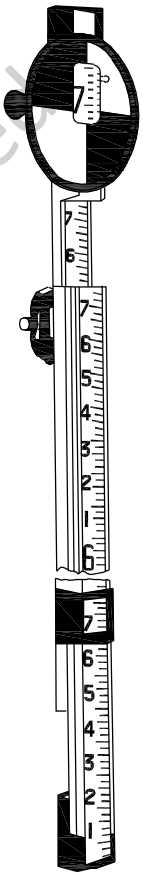
Fig 26



TELESCOPIC STAFF



FOLDING STAFF



TARGET STAFF

DCN12132Q

Symbols for architectural & building drawings (IS 962 - 1989)

Objectives: At the end of this lesson you shall be able to
- **identify the symbols for building plan- bath kitchen.**

Symbols for building plan- bath kitchen

Building plan- bath kitchen- ready made symbols for building plan

Ready -made symbols for building plan

It is a fast and easy building plan software for creating great - looking office layout and commercial floor plans. It includes thousands of ready-made graphics that you simply stamp to create your drawing, including appliances, bath kitchen, building core, cabinets, electrical and telecom, furniture, garden accessories, wall shell and structure, cubicles, office accessories, office equipment, office furniture, planting, wall, door and window.

Home floor- bath kitchen

Free download building plan software and view all examples

Home plan & floor plan

Home plan - used for kitchen and bathroom design, architectural and construction documents, space plans, remodeling and planning additions.

Floor plan - used for commercial building design, space plans, architectural layout, construction documents, structural diagrams and facility planning.

More kitchen and bathroom symbols

The new version of symbols includes more kitchen and bathroom symbols for drawing floor plans.

Fig 1

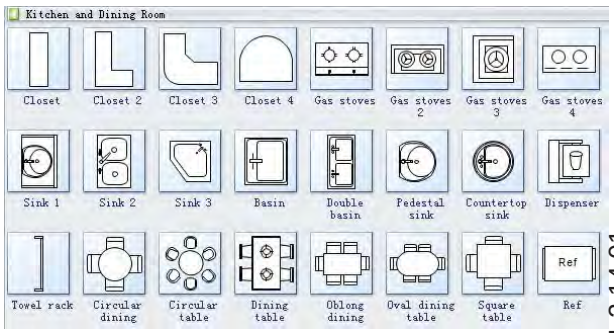


Fig 1.2.14.01

Fig 2

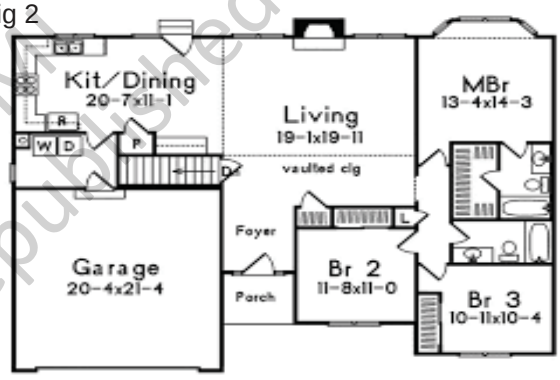


Fig 1.2.14.02

Fig 3

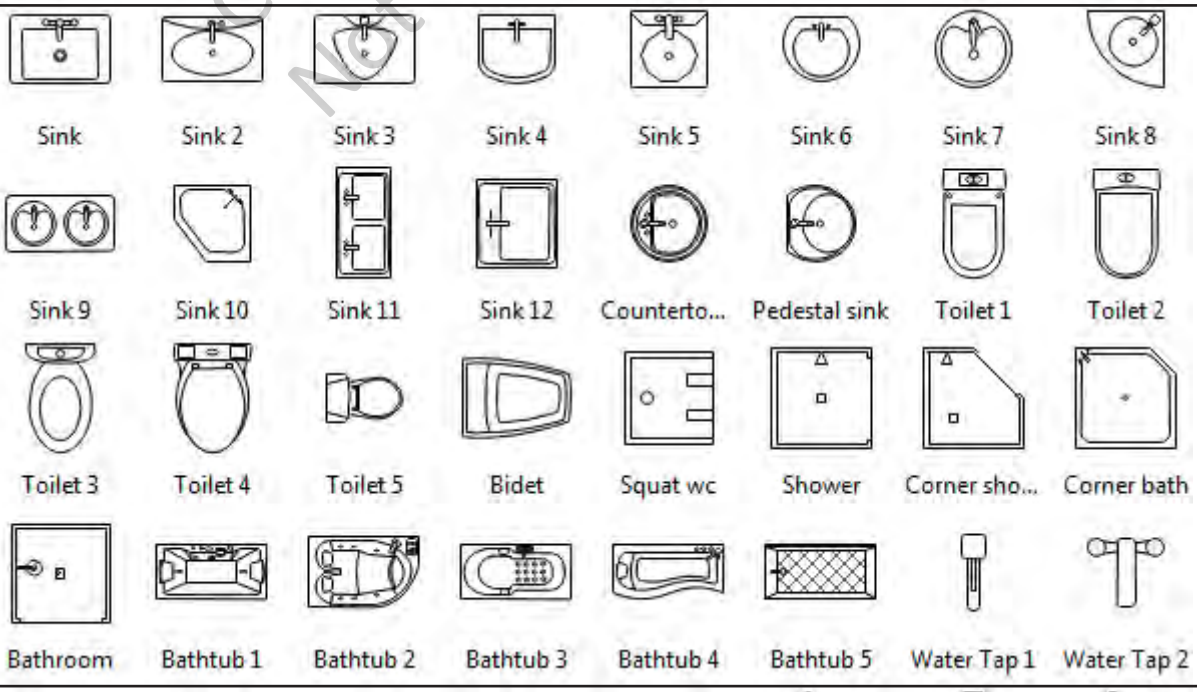


Fig 1.2.14.03

How to use appliances symbols for building plan

One of the obligatory documents that is included to design project of home, appartment, office center, or any other premise is the plan of arrangement of different appliances and home appliances. Creation the plan of such kind lets you to preplan the location of appliances, to make sure in convenience of their location and to envisage all nuances. Well though-out plan helps to avoid mistakes and future reworks, especially in relation to be location of major and large appliances. Concept draw PRO software extended with floor plans solution offers the perfect set of drawing tools, samples, examples, templates and ready-to-use vector objects that let you easily develop best layouts for your rooms, kitchen, bathroom, laundry etc. Ready-made symbols of appliances included to the appliances library are ideal and even indispensible for designing professional building plans and appliances layouts for homes, commercial and office premises. When designing your plans, you can make several variants and choose the best solution.

Fig 4

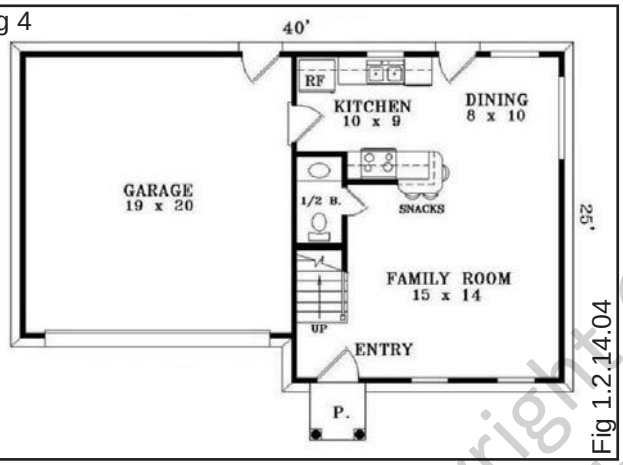
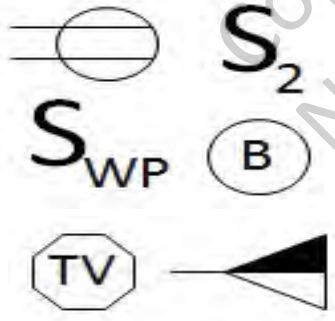


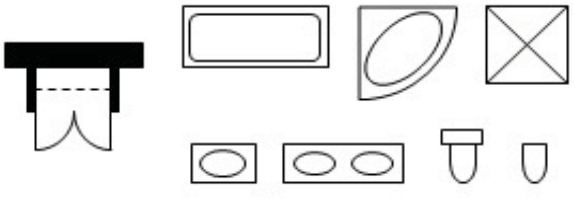
Fig 1.2.14.04

Fig 5



Blueprint Symbols

Fig 6

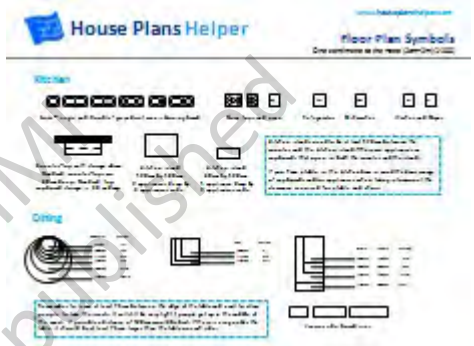


Floor plan symbols

Fig 7

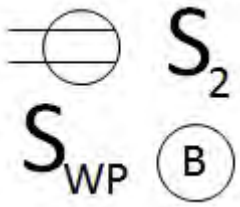
Free blueprint symbols

Fig 8



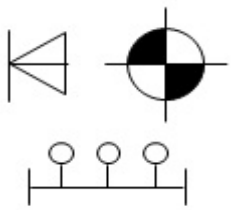
Free floor plan symbols

Fig 9



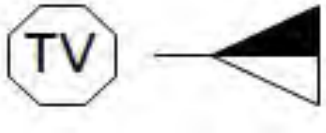
Electric symbols

Fig 10



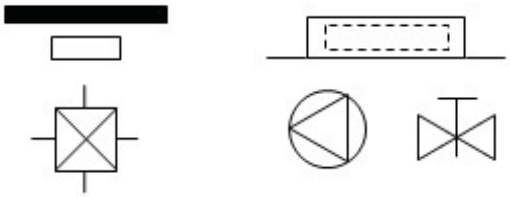
Lighting symbols

Fig 11



Data / Comms / TV symbols

Fig 12



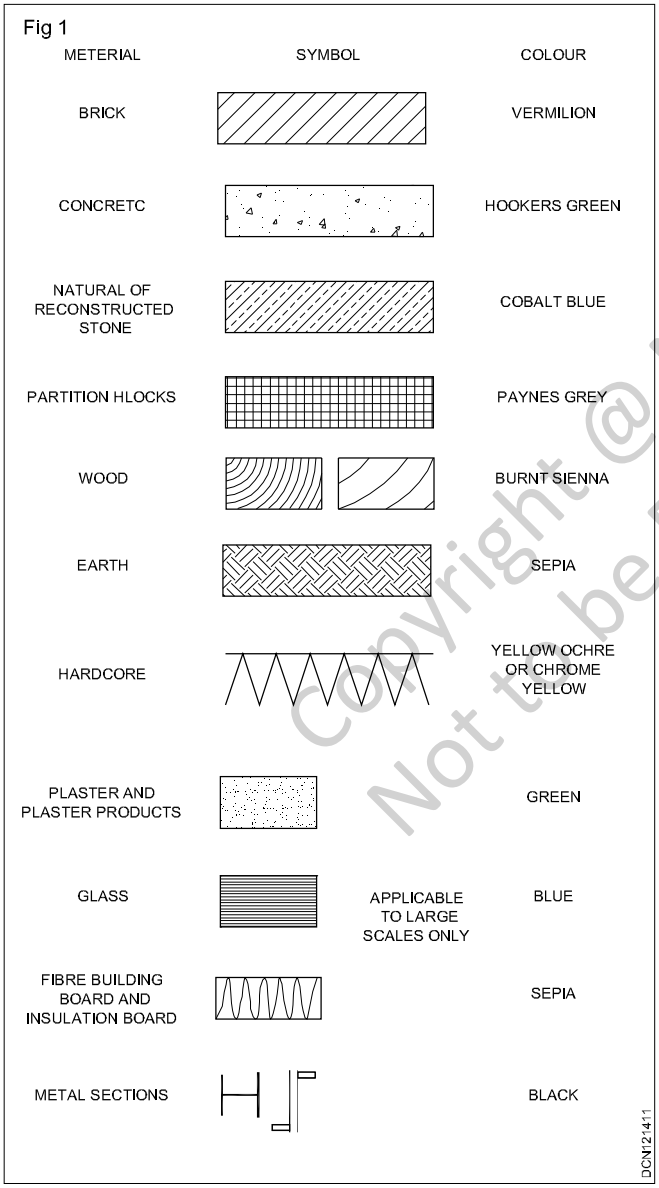
HVAC symbols

Plumbing symbols

Hatching pattern can be used as a means to broadly indicate the material of the part /object to differentiate difference material is sectional views BIS laid out standards ((IS:11663) on conventional representations of the materials and the some are given below.

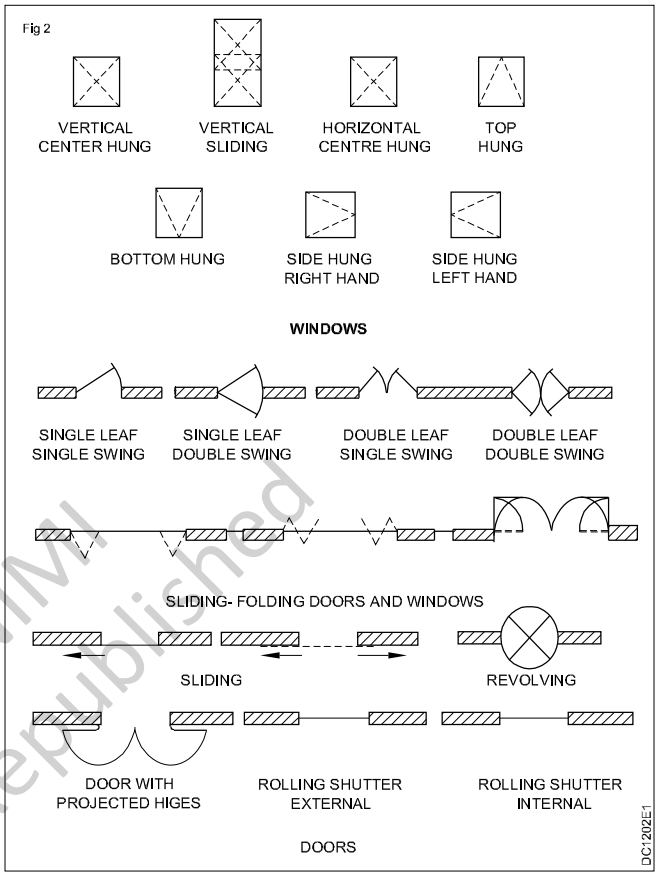
Material Symbol

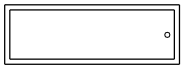
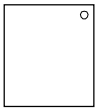
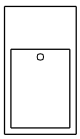
Fig 1



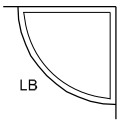
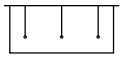
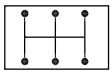
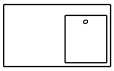
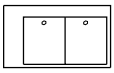
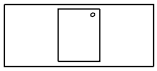
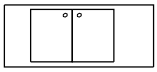
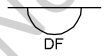
Symbols for doors & windows

- Layout on drawing area for showing signs and symbols of doors and windows.
- Illustrate signs and symbols of different types of doors and windows.
- Name the illustration drawn.

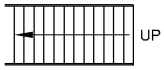
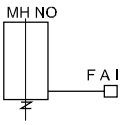
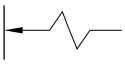
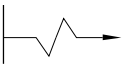
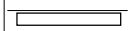
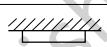


NAME	SYMBOL	NAME	SYMBOL
BATH		SHOWER TRAY	
BIDET		WASH BASIN	

SYMBOLS FOR SANITARY INSTALLATIONS-CONTD

NAME	SYMBOL	NAME	SYMBOL
CORNER LAVATORY BASIN		CLEANER'S SINK	
TROUGH LAVATORY, WALL TYPE		LAUNDRY SINK	
TROUGH LAVATORY, ISLAND TYPE		WC	
CIROULAR WASHING FOUNTAIN		URINAL BOWL	
SINGLE SINK, LEFT HAND DRAINER		URINALSTALLS	
DOUBLE SINK, LEFT HAND DRAINER		INDUSTRIAL WASHING TROUGH	
SINGLE SINK, WITH DOUBLE DRAIN BOARD		PEDESTAL DRINKING FOUNTAIN	
DOUBLE SINK, WITH DOUBLE DRAIN BOARD		DRINKING FOUNTAIN, WALL TYPE	
		FLOOR TRAP	

SYMBOLS FOR SANITARY INSTALLATIONS

NAME	SYMBOL	NAME	SYMBOL
MANHOLE OR INSPECTION CHAMBER		STAIR	
COLD WATER CISTERN		COOKER	
INTERCEPTING TRAP AND FRESH AIR INLET		REFRIGERATOR	
VENT INLET		WASH BOILER, 'G'GAS,'B'ELECTRIC	
VENT OUTLET		WASHING MACHINE, WRINGE TYPE	
RAIN-WATER OUTLET		WASHING MACHINE, AUTOMATIC	
RADIATOR		CENTRIFUGAL DRYER	
UNIT HEATER		CABINET DRYER	
CONVECTOR		RACK DRYER	
SURFACE PANEL, WALL TYPE		LAUNDRY TRAY, SINGLE	
SURFACE PANEL, WALL TYPE		LAUNDRY TRAY, DOUBLE	
EMBEDDED PANEL IN CAST-IN CEILING		IRONING MACHINE	
EMBEDDED PANEL IN SUSPENDED CEILING		BUILT-IN IRONING BOARD	
EMBEDDED PANEL IN CAST-IN FLOOR		SURFACING IRONING BOARD	
UNIT HEATER		BED	
TOWEL RAIL			

FITMENT SYMBOLS

DCN121413

SL. NO.	OBJECT	CONVENTIONAL SIGN	COLOUR
1.	CHAIN LINE		CRIMSON LAKE
2.	TRIANGULATION STATION	A	CRIMSON LAKE
3.	TRAVERSE STATION	A	CRIMSON LAKE
4.	BENCH MARK	OR B.M. 10.000	CRIMSON LAKE
5.	BUILDING (PUCCA)		CRIMSON LAKE
6.	BUILDING (KATCHA)		BURNT UMBER
7.	TEMPLE, CHURCH, MOSQUE		CRIMSON LAKE
8.	WALL & GATE		CRIMSON LAKE
9.	BOUNDARY WITH PILLARS		CRIMSON LAKE
10.	DAM		CRIMSON LAKE
11.	CITY OR TOWN		BUILDINGS - CRIMSON LAKE ROADS - BURNT SIENNA
12.	CEMETRY		BLACK
13.	RIVER		PRUSSIAN BLUE
14.	CANAL OR STREAM (PERENNIAL)		PRUSSIAN BLUE
15.	CANAL OR STREAM (NON-PERENNIAL)		EDGES - BLACK
16.	CANAL WITH LOCK		PRUSSIAN BLUE
17.	LAKE OR POND		PRUSSIAN BLUE
18.	WELL		PRUSSIAN BLUE
19.	DRAIN (KATCHA)		PRUSSIAN BLUE
20.	DRAIN (PUCCA)		DRAIN - PRUSSIAN BLUE DIRECTION - CRIMSON LAKE
21.	WIRE FENCING		BLACK
22.	WOOD FENCING		YELLOW
23.	PIPE RAILING		BLACK
24.	BOUNDARIES		BLACK
25.	HEDGE		HEDGE GREEN
26.	TREE	OR	HEDGE GREEN

SL. NO.	OBJECT	CONVENTIONAL SIGN	COLOUR
27.	JUNGLE		HEDGE GREEN
28.	ORCHARD		HEDGE GREEN
29.	CULTIVATED LAND		DRAINS - PRUSSIAN BLUE CULTIVATION - GREEN
30.	BARREN LAND		BLACK
31.	ROUGH PASTURE		BLACK
32.	MARSH OR SWAMP		BLACK
33.	SAND HILL		BLACK
34.	EMBANKMENT		BLACK
35.	CUTTING		BLACK
36.	FOOTH-PATH		BURNT UMBER
37.	VILLAGE CART-TRACK		BURNT UMBER
38.	UNMETALLED ROAD		BURNT SIENNA
39.	METALLED ROAD		BURNT SIENNA
40.	RAILWAY SINGLE LINE	OR	BLACK
41.	RAILWAY DOUBLE LINE		BLACK
42.	ROAD BRIDGE		BURNT SIENNA
43.	RAILWAY BRIDGE		BLACK
44.	ROAD & RAIL LEVEL CROSSING		RAIL - BLACK ROAD - BURNT SIENNA
45.	TELEPHONE OR TELEGRAPH LINE		BLACK
46.	ELECTRIC LINE		BLACK
47.	NORTH DIRECTION	N	BLACK
48.	DEMARCATED PROPERTY BOUNDARY		
49.	UNDEMARCATED PROPERTY BOUNDARY		
50.	CULVERT		
51.	ELECTRIC LINE		

DCN12414

Electrical symbols

- Layout on drawing area for showing signs and symbols of electrical points.
- Illustrate signs and symbols of different types of electrical points.
- Name the illustration drawn.

NAME	SYMBOL	NAME	SYMBOL
RELAY (AT 'N', INSERT THE NUMBER OF WAYS)		AERIAL	
SYNCHRONOUS CLOCK OUTLET		CEILING FAN	
IMPULSE CLOCK OUTLET		BRACKET FAN	
MASTER CLOCK		EXHAUST FAN	
FIRE ALARM PUSH		FAN REGULATOR	
AUTOMATIC CONTACT		COOKER CONTROL UNIT	
BELL CONNECTED TO FIRE ALARM		EARTH POINT	
FIRE ALARM INDICATOR (AT 'N' INSERT NUMBER OF WAYS)		SURGE DIVERTER	
AMPLIFIER		PILOT OR CORRIDOR LAMP	
CONTROL BOARD		INDICATOR (BUZZER MAY BE ADDED, IF REQUIRED)	
MICROPHONE OUTLET		RELAY	
LOUDSPEAKER OUTLET		RESET POSITION	
RECEIVER OUTLET		HORN OR HOOTER	
		SIREN	

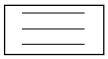
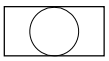
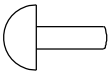
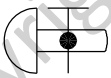
THIS GENERAL SYMBOL IS APPLICABLE TO ANY SYSTEM BY THE ADDITION OFAN IDENTIFYING SYMBOL (APPROPRIATE TO A PARTICULAR SYSTEM) IN THE UPPER HALF.FOR EXAMPLE,BELL SYSTEM RELAY.

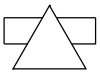
WHERE ITEMS OF OPERATIONS ARE COMBINED, THE SYMBOLS MAY BE COMBINED, FOR EXAMPLE,INDICATOR AND BELL.

DCN'21415

NAME	SYMBOL	NAME	SYMBOL
MAIN FUSE- BOARD WITHOUT SWITCHES,LIGHTING		COUNTER WEIGHT PENDANT	 C W
MAIN FUSE-BOARD WITH SWITCHES,LIGHTING		ROD PENDANT	 R
MAIN FUSE- BOARD WITHOUT SWITCHES,POWER		CHAIN PENDANT	 C
MAIN FUSE-BOARD WITH SWITCHES,POWER		LIGHT BRACKET	
LIGHT PLUGS		BATTEN LAMPHOLDER	 BH
POWER PLUG		WATER-LIGHT LIGHT FITTING	 W T
DISTRIBUTION FUSE-BOARD WITH OUT SWITCHES, LIGHTING		BULK-HEAD FITTING	
DISTRIBUTION FUSE-BOARD WITH SWITCHES, LIGHTING		POWER FACTOR CAPACITOR (WHEN INSTALLED REMOTE FROM THE LAMP UNIT)	
DISTRIBUTION FUSE-BOARD WITHOUT SWITCHES, POWER		FLUORESCENT LIGHT (SIGLE)	
DISTRIBUTION FUSE-BOARD WITH SWITCHES, POWER		FLUORESCENT LIGHT (DOUBLE)	
MAIN SWITCHES, LIGHTING		LIGHTING OUTLET CONNECTION TO AN EMERGENCY SYSTEM	
MAIN SWITCHES,POWER	P	CHOKE (WHEN INSTALLED REMOVE FROM THE LAMP UNIT)	
METER		ONE-WAY SWITCH	
SINGLE LIGHT PENDANT		TWO-WAY SWITCH	
PENDANT SWITCH	P	INTERMEDIATE SWITCH	
		PULL SWITCH	

DCN'21415

NAME	SYMBOL
SOCKET-OUTLET,2 PIN 5 AMP	
SOCKET-OUTLET,3 PIN 5 AMP	
SOCKET-OUTLET AND SWITCHCOMBINED, 2 PIN 5 AMP	
SOCKET-OUTLET AND SWITCH COMBINED, 3 PIN 5 AMP	
SOCKET-OUTLET,2 PIN 15 AMP	
SOCKET-OUTLET,3 PIN 15 AMP	
SOCKET-OUTLET AND SWITCH COMBINED, 2 PIN 15 AMP	
SOCKET-OUTLET AND SWITCH COMBINED, 3 PIN 15 AMP	
CONVECTION HEATER	
ELECTRIC UNIT HEATER	
IMMERSION HEATER	
THERMOSTAT	
IMMERSION HEATER WITH INCORPORATED THERMOSTAT	

NAME	SYMBOL
SELF-CONTAINED ELECTRIC WATER HEATER	
HUMIDISTAT	
BELL PUSH	
BELL	
BUZZER	
INDICATOR (AT 'N' INSCRT NUMBER OF WAYS)	
TELEPHONE INSTRUMENT POINT PUBLIC SERVICE	
TELEPHONE INSTRUMENT POINT INTERNAL	
TELEPHONE CABLE DISTRIBUTION BOARD PUBLIC SERVICE	
TELEPHONE CABLE DISTRIBUTION BOARD INTERNAL	
TELEPHONE PRIVATE EXCHANGE PUBLIC SERVICE	
TELEPHONE PRIVATE EXCHANGE OR INTERNAL	

DCN121416

Line conventions

Objectives: At the end of this lesson you shall be able to
- **state the types of line**
- **explain the application of different types of lines.**

Introduction

The lines on engineering drawing differ in character and thickness to be read easily and to convey different appropriate messages to the trained eye.

Types of lines

Line	Description	General applications see figure and other relevant figure
A	Continuous thick	A1 Visible outlines A2 Visible edges
B	Continuous thin(straight or curved)	B1 Imaginary lines of intersection B2 Dimension lines B3 Projection lines or extension line B4 Leader lines B5 Hatching B6 Outline of revolved sections in place B7 Short centre lines B8 Thread lines B9 Diagonal line
C	Continuous thin free hand	C1 Limits of partial or interrupted views & sections, if the limit is not a chain thin
C		D1 Line (see figure)
D	Continus thin (Straight) with zig-zags	
E	Dashed thick	E1 Hidden outlines E2 Hidden edges
F	Dashed thin	F1 Hidden outlines F2 Hidden edges
G	Chain thin	G1 Centre lines G2 Lines of symmetry G3 Trajectors
H	Chain thin, thick at ends & changes of direction	H1 Cutting planes
J	Chain thick	J1 Indication of lines or surfaces to which a special requirement applies
K	Chain thin double dashed	K1 Outlines of adacent parts K2 Alternative and extreme positions of movable parts K3 Centroidal lines K4 Initial outlines prior to forming K5 Parts situated in front of the cutting plane.

Lettering

Objectives: At the end of this lesson you shall be able to
- **state the lettering style**
- **designate the letters and numerals as per IS:962-1989.**

Introduction

1 An engineering drawing not only shows the shape of an object but also describes the size and other specifications necessary for its construction in the form of dimensions and notes.

2 Writing of titles, sub-titles, dimensions, scale and style, if it is in poor lettering, will spoil the appearance of an otherwise acceptable drawing.

3 'Practice makes a man perfect', Practice accompanied by continuous efforts would certainly improve the lettering skill and style

4 B.I. Standards (Bureau of Indian Standards) IS: 962-1989 (lettering for technical drawings) adopted from ISO: 3098/1-1974(E).

The essential features of lettering on engineering drawings are:

1 Legibility

2 Uniformity

3 Rapidity of execution

4 Suitability for micro filming, photographic, re-production, Xeroxing, ammonia printing, etc.

Since time is more important, the lettering should be in plain and simple style so that it can be done in freehand with speed. Single stroke letters satisfy the above requirements.

Recommended sizes of letters and numerals

(Table - 6.01)

Items	Size Height in mm
Drawing number in title block and letters denoting cutting plane section	10,12
Title of drawing	6,8
Sub-title and heading	3,4,5,6
Notes, such as legends, schedules,materials list, dimensioning	3,4,5

Letters and numerals are designated by their heights. However, actual sizes used depend upon the size of the drawing and the purpose for which it is intended.

The standard height for most lettering is 3 mm. For longer drawings a height of 5 mm to 6 mm is recommended. For special notes and title block information uniform lengths of 4 mm, 6 mm and 8 mm can be used.

Uniformity, size and spacing:

1 Lettering must appear neat and pleasing, like, uniformity in height, inclination, spacing and strength of line essential for good lettering. The lettering must be accurate, sharp, dark and easy to read.

2 Horizontal guidelines determine horizontal alignment, lettering height. It determines the spacing between lines of lettering.

3 Vertical guidelines serve to keep the verticality. It keeps proper inclination of freehand characters uniform.

4 In any drawing, only one kind of lettering style must be used. Lower case (small) letters are not generally used, except as symbols.

Dimensioning

Objectives: At the end of this lesson you shall be able to
- **to define Dimensioning.**
- **to dimension the drawings the drawings as per Indian Standard Specification.**

Introduction

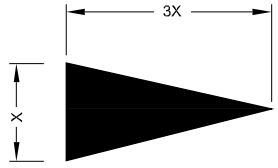
1 Dimensioning plays a predominant role in engineering drawing. It expresses the quantity, adds value and signifies relation to the parts of the diagram. This information is very vital. Without dimension, the meaning of the drawing is lost.

2 Dimensioning is provided in every part of the drawing to provide enough of details, to avoid misconception, confusion, leaving to chance and doubts etc.

3 Dimensioning must be clear and appear only once.

Arrow heads: (Fig 1)

Fig 1



Arrowheads are marked at both ends of the dimension lines. The size of the arrowheads should be proportionate to the size of the drawing.

Fig 2

Oblique strike and origing indication

1 Where space is insufficient for arrowheads, oblique's stroke or dot may be used.

2 Oblique stroke is drawn as a short line inclined at 45 Degree. The origin indication is drawn as a small open circle of about 3mm Diameter.

Leader line is a line referring to a feature like dimension object and outline it continuous thin line.

1 If the leader line ends with in outline of an object, it should have a dot at the end.

2 It should have an arrowhead if it ends on the outline of an object.

3 It should terminate without dot or arrowhead if it ends on a dimension line.

Dimensioning method(IS: 11669-1986)

Method-1: (Fig 2 and Fig 3) (Aligned system)

1 The dimensions lines are drawn parallel to the object lines.

2 The dimensions values are placed above the dimensions lines and not by breaking the dimensions lines.

Fig 2

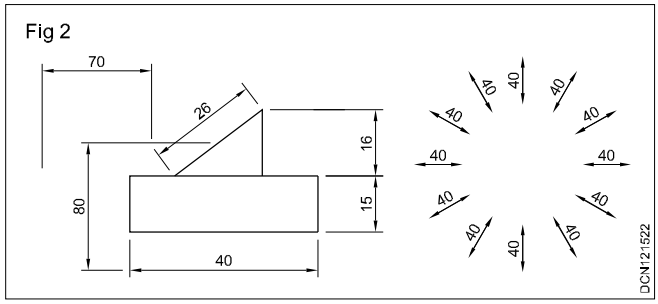
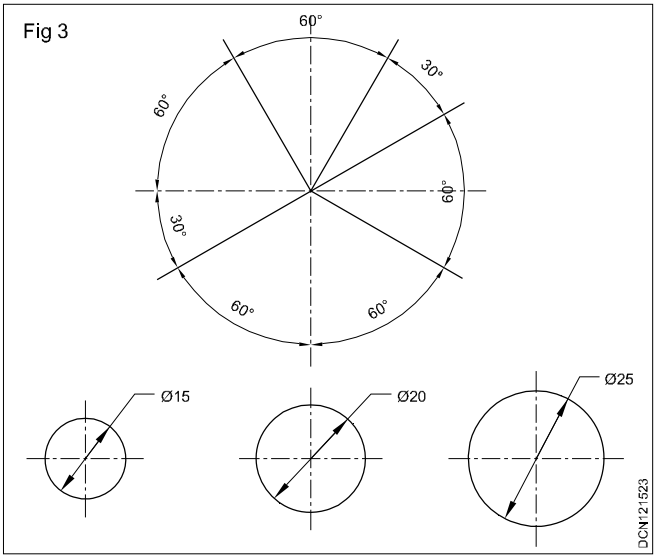


Fig 3



3 The dimensions values are placed near the middle and clear of the dimensions lines.

4 All dimensions are so placed that they can be read from the bottom or the right hand edge of the drawing sheet.

Method-2: (Fig 4) (Undirectional system)

1 The dimensions lines are drawn parallel to the object lines.

2 The horizontal lines are dimensioned as in method-1

3 Vertical and inclined lines are dimensioned by writing the dimensions value in the gap left in the middle of the dimensions lines.

4 All dimensions are so placed that they can be read from the bottom of the drawing sheet.

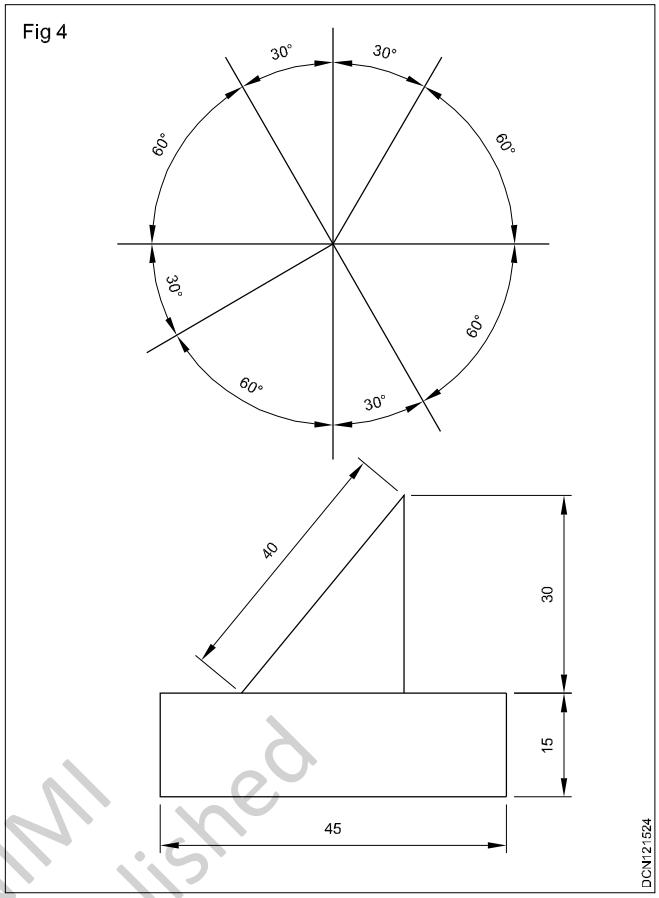
On any one drawing, use only one method of placing the dimensions.

Unit of dimensioning

1 The recommended unit of dimensioning is millimeters. There is no need to add the symbol for the unit e.g. a dimension value 40 means 40mm but a foot-note like "all dimensions in mm" is written in a prominent places.

2 When the dimension is less than 1, a zero should be placed before the decimal point such as 0.75.

Fig 4



Procedure to mark dimensions: (Fig 5 and Fig 6)

1 Draw dimensions line parallel to the object line to be dimensioned at about 8 to 10mm from it.

2 Draw projection lines perpendiculars' to the object line. Where necessary, they may be drawn obliquely but parallel to each other.

3 Mark arrowheads at both end is of the dimensions line as per method-1 or method-2

Fig 5

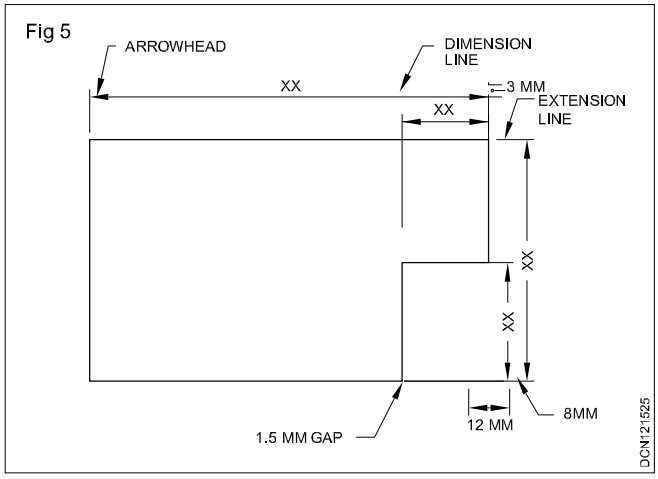
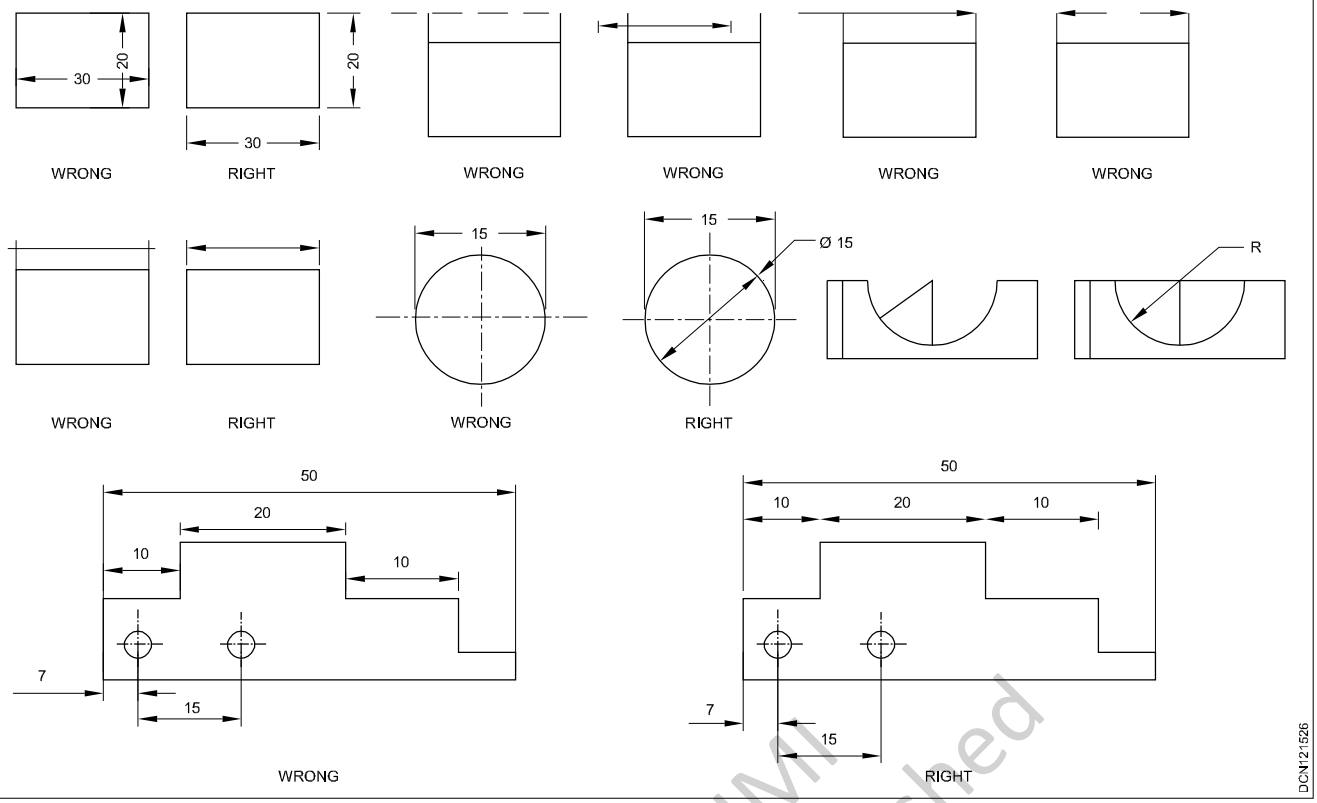


Fig 6



Plane Geometrical construction

Objectives: At the end of this lesson you shall be able to
- **define the terms of most commonly used geometrical shapes.**

Introduction

Geometry is the shape of the object represented as views, how the object will look when it is viewed from various angles, such as front, top, side, etc. Preparation of engineering drawings involves a numbers of geometrical constructions, which are mostly based on plane geometry. Knowledge of various geometrical shapes and their terms are essential, hence, it is necessary to study geometrical constructions.

Important geometrical terms

Triangles

Equilateral, Isosceles and Scalene. (A scalene triangle has three unequal sides).

Quadrilaterals

1 **square-** All sides equal and all angles right angles.

2 **Rectangle or oblong-** Opposite sides equal and all angles right angle.

3 **Rhombus-** All sides equal, but angles are not right angles.

4 **Rhomboid**- Opposite sides equal and parallel, but angles are not right angles.

5 **Trapezoid**- Only two sides parallel.

6 **Trapezium**- No sides parallel, but may have two of its sides equal. When two of the sides are equal, it is called a trapezium or kite.

Polygons:

Regular and irregular; when all sides are equal, it is a regular polygon, otherwise irregular.

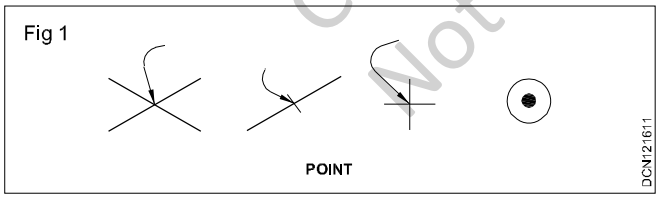
Pentagon- 5 sides; Hexagon- 6 sides; Heptagon- 7 sides; Octagon- 8 sides; Nonagon- 9 sides; Decagon- 10 sides;

Types of Lines and Angles

Objectives: At the end of this lesson you shall be able to
- **define points and lines**
- **state the classification of lines**
- **state the different types of angles**
- **explain the method of measuring angles.**

A point represents a location in space, having no width or height. It is represented by drawing intersection of lines or a dot. (Fig 1)

Fig 1



Line is the path of a point when it moves. It has no thickness and are of two types:

– Straight line

– Curved line

Straight line: It is the path of a point when it is moving in a particular direction. It has only length and no width. (Fig 2) Also a straight line is the shortest distance between two points. Straight line, depending on its orientation are classified as Horizontal, Vertical and Inclined or Oblique line.

Horizontal line (Fig 2)**:** Horizontal lines are those which are parallel to a horizontal plane. Example of horizontal plane is the surface of a still water. (Fig 3)

Fig 2

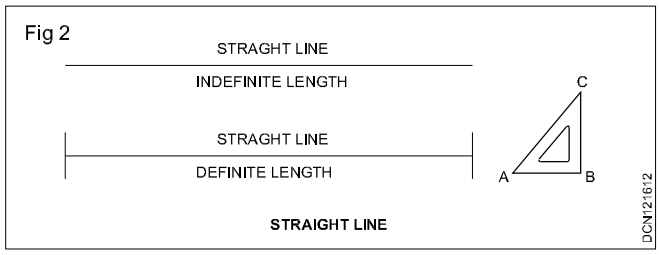
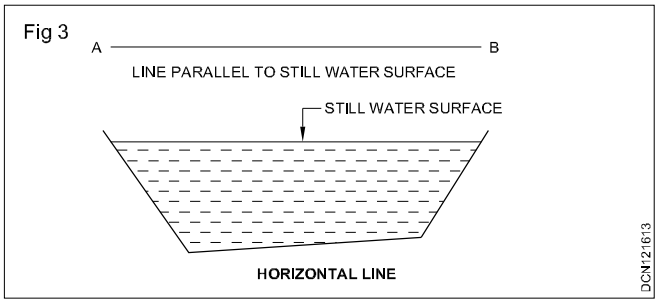


Fig 3



Vertical line (Fig 4a)**:** Lines which are perpendicular to horizontal lines are called vertical lines. It can be treated as a line along the plumb line of the plumb bob or parallel to a plumb line. (Fig 4b)

Inclined line or Oblique line: A straight line which is neither horizontal nor vertical is called an inclined line. (Fig 5)

Fig 4

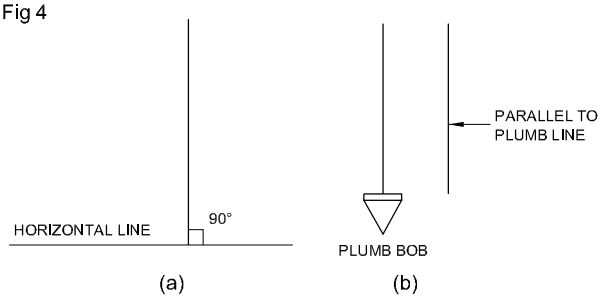
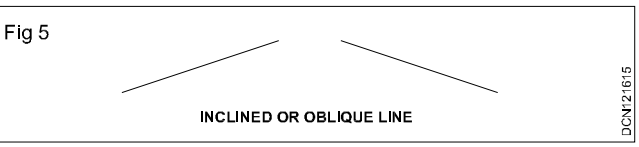
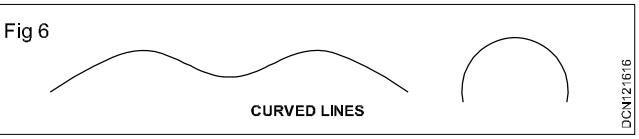


Fig 5



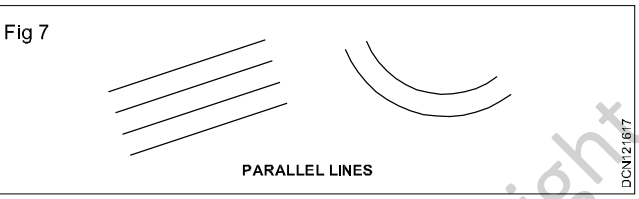
Curved line: It is the path of a point which always changes its direction. Examples of curved lines are shown in Fig 6.

Fig 6



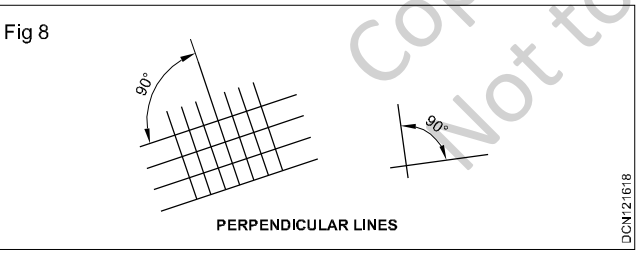
Parallel lines: They are the lines with same distance between them. They may be straight lines or curved lines. Parallel lines do not meet when extended. (Fig 7)

Fig 7



Perpendicular lines: When two lines meet at 90°, the two lines are said to be perpendicular to each other. One of this line is called as reference line. (Fig 8)

Fig 8



Angles: Angle is the inclination between two straight lines meeting at a point or meet when extended. AB and BC are two straight lines meeting at B. The inclination between them is called an angle. The angle is expressed in degrees or radians.

Concept of a degree: When the circumference of a circle is divided into 360 equal parts and radial lines are drawn through these points, the inclination between the two adjascent radial lines is defined as one degree. Thus a circle is said to contain 360°. (Fig 9)

Acute angle: If an angle which is less than 90° is called an acute angle. (Fig 10)

Right angle: Angle between a reference line and a perpendicular line is called right angle. (Fig 11)

Fig 9

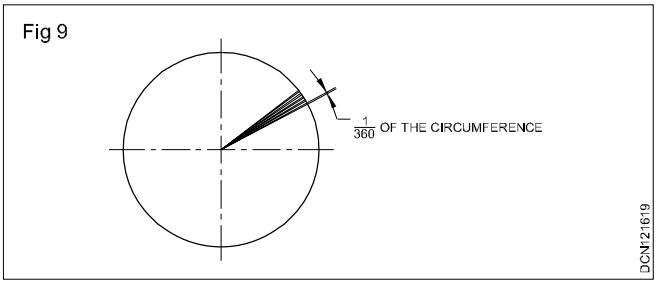


Fig 10

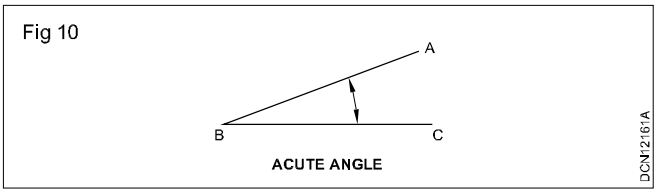
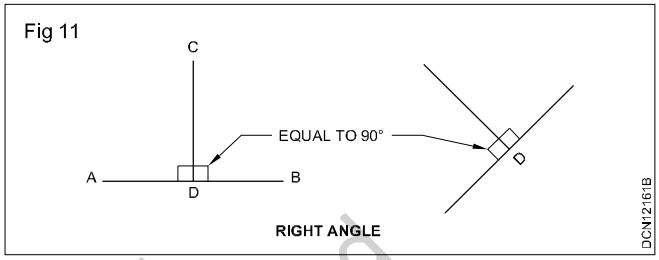
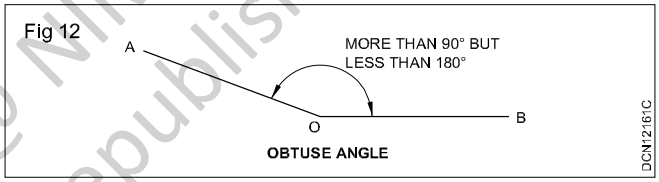


Fig 11



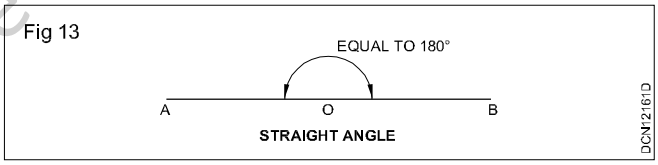
Obtuse angle: This refer to an angle between 90° and 180°. (Fig 12)

Fig 12



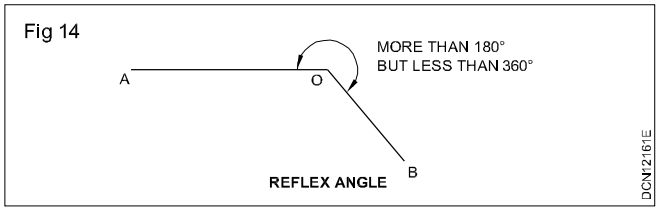
Straight angle: This refers to an angle of 180°. This is also called as the angle of a straight line. (Fig 13)

Fig 13



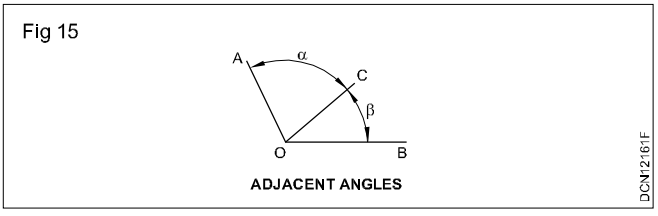
Reflex angle: It is the angle which is more than 180°. (Fig 14)

Fig 14



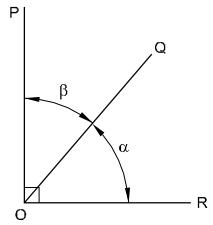
Adjacent angles: These are the angles lying on either side of a line. (Fig 15)

Fig 15



Complementary angles: When the sum of the two angles is equal to 90°, angle POQ + angle QOR = 90° angle POQ and angle QOR are complementary angles to each other. (Fig 16)

Fig 16



COMPLEMENTARY ANGLES

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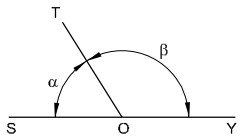
Supplementary angle: When the sum of the two adjacent angles is equal to 180°, example angle SOT + angle TOY = 180°, angle SOT and angle TOY are supplementary angles to each other. (Fig 17)

Protractor: Protractor is an instrument for measuring angles. It is semi-circular or circular in shapes and is made of flat celluloid sheet. The details of graduation in a semi-circular protractor is shown in figure 18.

Fig 17



SUPPLEMENTARY ANGLES

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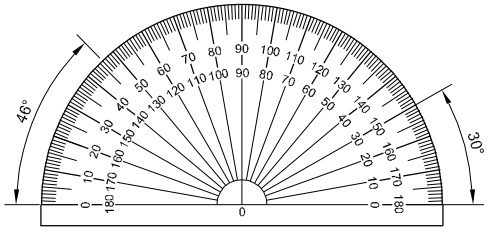
Fig 18



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The angles can be set or measured from both sides, aligning the reference line and point `0' with the corner point of the angle.

Figure 18 shows how to read or set the angle. Protractor can also be used to divide a circle or drawing sectors.

Triangles and their types

Objectives: At the end of this lesson you shall be able to
- **define triangles**
- **name the different types of triangles and state their properties.**

Triangle is a closed plane figure having three sides and three angles. The sum of the three angles always equals to 180°.

To define a triangle, we need to have a minimum of three measurements as follows:

– 3 sides or

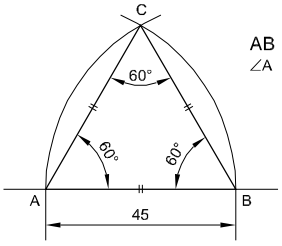
– 2 sides and one angle or

– 2 angles and one side

Types of triangles

– **Equilateral triangle** is a triangle having all the three sides equal. Also all the three angles are equal (60°) (Fig 1)

Fig 1



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– **Isosceles triangle** has two of its sides equal. The angles opposite to the two equal sides are also equal. (Fig 2)

– **Scalene triangle** has all the three sides unequal in lengths. All the three angles are also unequal. (Fig 3)

Fig 2

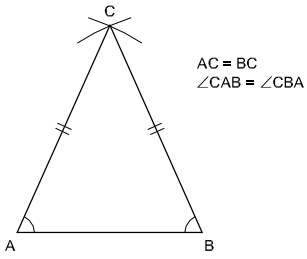

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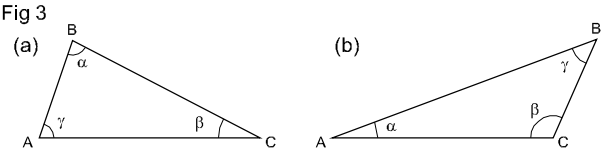
Fig 3



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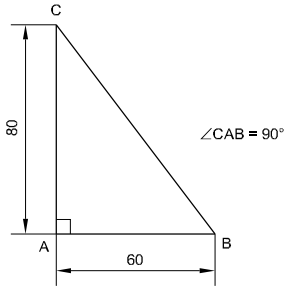
– **Right angled triangle** is one in which one of the angles is equal to 90° (Right angle). The side opposite to right angle is called hypotenuse. (Fig 4)

Fig 4



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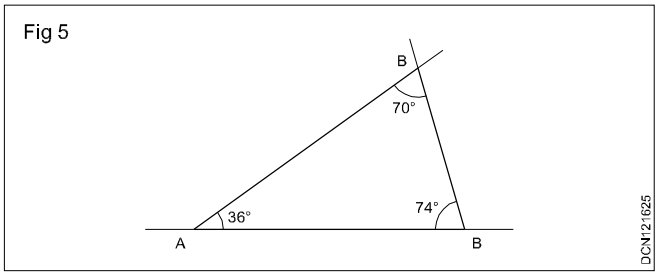
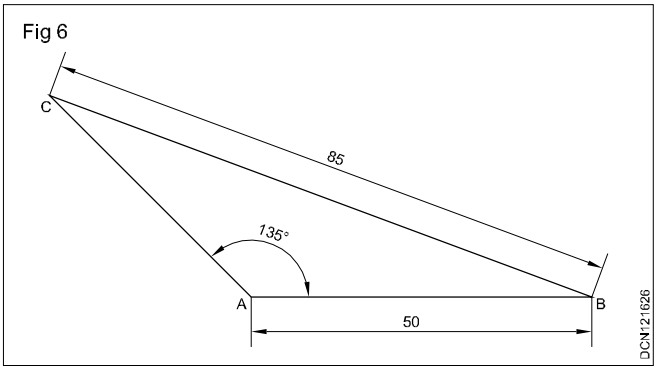
– **Acute angled triangle** is one in which all the three angles are less than 90°. (Fig 5)

Fig 5



– **Obtuse angled triangle** has one of the angles more than 90°. (Fig 6)

Fig 6



The sum of the three angles in any triangle is equal to 180°.

The sum of any two sides is more than the third side.

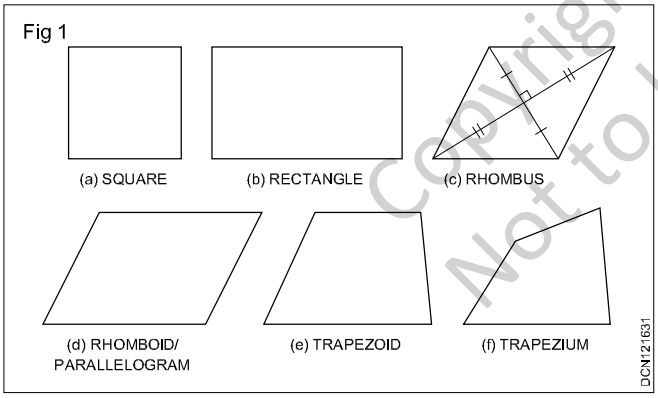
Quadrilaterals and their properties

Objectives: At the end of this lesson you shall be able to
- **define a quadrilateral**
- **name the quadrilaterals**
- **state the properties of quadrilaterals.**

Quadrilateral is a plane figure bounded by four sides and four angles. Sum of the four angles in a quadrilateral is of interior angles is equal to 360°. The side joining opposite corners is called diagonal. To construct a quadrilateral out of four sides, four angles and two diagonals a minimum of five dimensions are required of which two must be sides. Quadrilaterals are also referred as Trapezoid.

Types of quadrilaterals. (Fig 1)

Fig 1



– Square
– Rectangle
– Rhombus
– Rhomboid/Parallelogram
– Trapezoid
– Trapezium

Square : In a square all the four sides are equal and its four angles are right angles. The two diagonals are equal and perpendicular to each other.

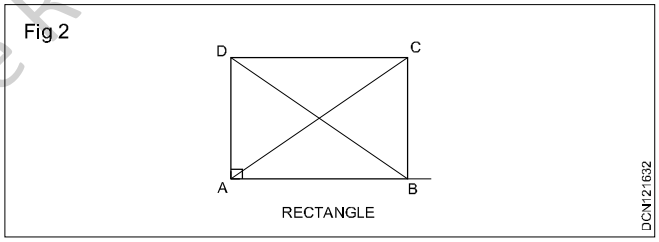
To construct a square we need to know (a) length of the side or (b) length of the diagonal.

Rectangle (Fig 2)**:** In a rectangle, opposite sides are equal and parallel and all four angles are right angles.

To construct a rectangle we need to know the length (a) two adjacent sides or (b) diagonal and one side.

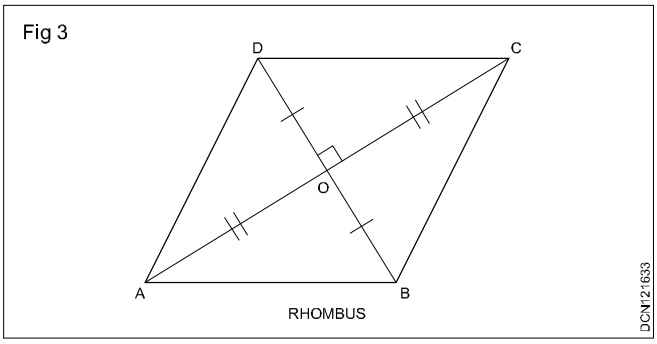
Fig 2 shows a rectangle ABCD. Sides AB = DC and BC = AD. Diagonals AC and BD are equal, bisect but not at right angles.

Fig 2



Rhombus (Fig 3)**:** In rhombus all the four sides are equal, but only the opposite angles are equal. ABCD is the rhombus where AB = BC = CD = AD.

Fig 3



Angle ABC = Angle ADC and Angle BAD = Angle BCD.

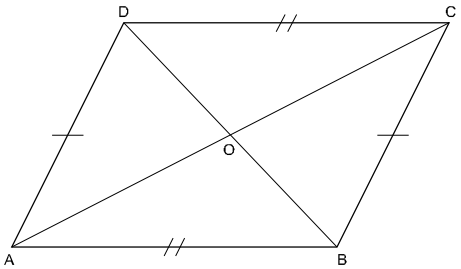
Diagonals AC and BD are not equal but bisecting at right angles.

AO = OC and BO = OD.

To construct a rhombus we need to know (a) two diagonals (b) one diagonal and an opposite angle or (c) one side and its adjacent angle.

Rhomboid/Parallelogram (Fig 4)**:** In a parallelogram opposite sides are equal and parallel. Opposite angles are also equal. Diagonals are not equal but bisect each other.

Fig 4



RHOMBOID / PARALLELOGRAM

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Parallelogram is also known as rhomboid. To construct a parallelogram we need (a) two adjacent sides and angle between them or (b) one side, diagonal, and angle between them or (c) two adjacent sides and perpendicular distance between the opposite sides.

In the parallelogram ABCD, AB = DC; AD = BC

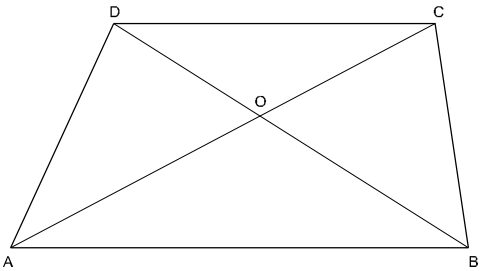
Angle DAB = angle DCB, angle ABC = angle ADC

Sides AB,CD and AD, BC are parallel.

Diagonals AC and BD are not equal but bisect at 0.

Trapezoid (Fig 5)**:** It is a quadrilateral, all the four sides are different and only two sides are parallel, all the four angles are different. The diagonals do not bisect at right angles.

Fig 5



TRAPEZOID

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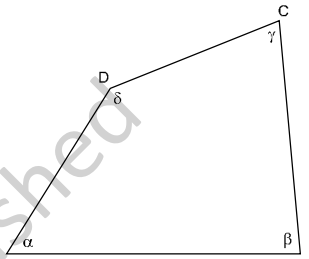
ABCD is a trapezoid, sides AB and DC are parallel but not equal.

Diagonals AC and BD and AO = OC need not be equal.

Sides AD and BC may sometimes equal.

Trapezium (Fig 6)**:** It is a plane figure of 4 sides, and any two sides equals to each other.

Fig 6



TRAPEZIUM

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Polygon and their properties

Objectives: At the end of this lesson you shall be able to

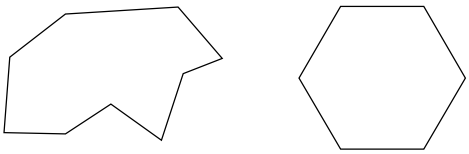
- **define a polygon**
- **name the polygon in terms of the number of sides**
- **state the properties of polygon.**

Polygon is a plane figure bounded by many (usually five or more) straight lines. When all the sides and included angles are equal, it is called as a regular polygon.

Names of polygons: Polygons are named in terms of their number of sides as given below: (Fig 2)

Name	No. of sides
Pentagon	Five sides
Hexagon	Six sides
Heptagon	Seven sides
Octagon	Eight sides
Nonagon	Nine sides
Decagon	Ten sides
Undecagon	Eleven sides
Dadecagon	Twelve sides

Fig 1



IRREGULAR POLYGON REGULAR POLYGON

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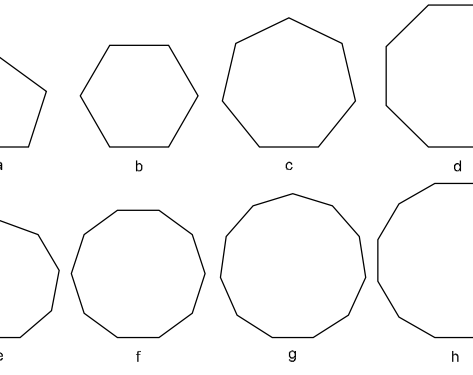
Fig 2



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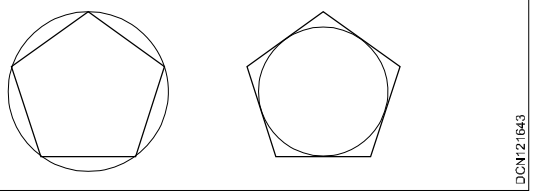
Properties of polygon

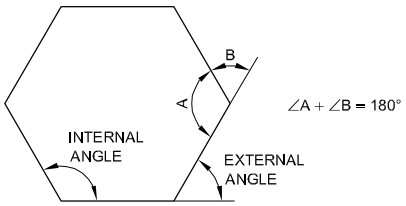
- All corners of a regular polygon lie on the circle. The sides of a regular polygon will be tangential to the circle drawn in side. (Fig 3)

Fig 3



- The sum of the interior angles of a polygon is equal to (2 x n - 4) x rt angle, where n is the number of sides.
- The sum of exterior angles of a polygon is equal to 360°.
- The sum of the interior angle and the corresponding external angle is 180°. (Fig 4)

Fig 4



Circles

Objectives: At the end of this lesson you shall be able to
- **state what is a circle**
- **name its elements**
- **state the function of a compass**
- **explain concentric and eccentric circles.**

Circle: Circle is a plane figure bound by a curve, formed by the locus of a point which moves so that it is always at a fixed distance from a stationery point the "Centre".

Radius: The distance from the centre to any point on the circle is called the "Radius".

Diameter: The length of a straight line between two points on the curve, passing through the centre is called the "Diameter", D: Dia or d. It is twice the radius.

Circumference: It is the linear length of the entire curve, equal to πD

Arc: A part of the circle between any two points on the circumference or periphery is called an 'Arc'.

Chord: A straight line joining the ends of an arc is called the chord. (Longest chord of the circle is the diameter)

Segment: A part of the circle or area bound by the arc and chord is the segment of the circle.

Sector: It is the part of a circle bounded by two radii (plural of radius) meeting at an angle and an arc.

Quadrant: Part of a circle with radii making 90° with each other is a quadrant (one fourth of the circle).

Half of the circle is called as semi-circle.

Tangent of a circle is a straight line just touching the circle at a point. It does not cut or pass through the circle when extended. The point where the tangent touches the circle is called the "point of tangency". The angle between the line joining the centre to the point of tangency and the tangent is always 90°.

Fig 1 shows all the above elements.

Concentric circles: When two or more circles (drawn) having common centre, they are called concentric circles. Ball bearing is the best example of concentric circles. (Fig 2)

Fig 1

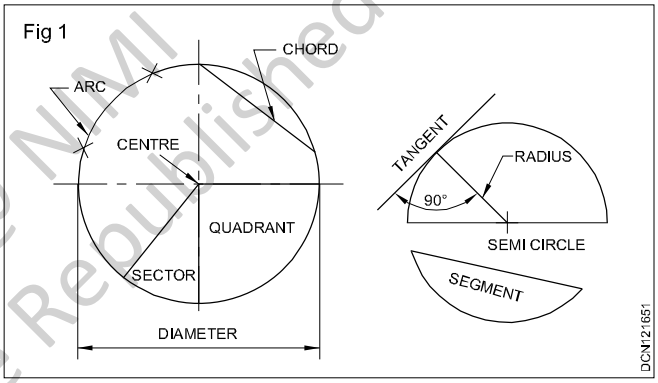
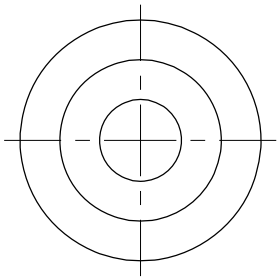
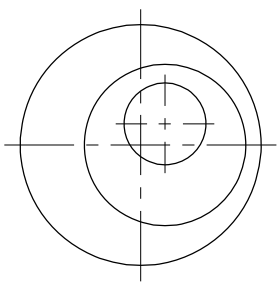


Fig 2



Eccentric circles: Circles within a circle but with different centres are called eccentric circles. (Fig 3)

Fig 3



Types of scales

Objectives: At the end of this lesson you shall be able to
- **state the necessity of scales**
- **explain representative fraction (RF)**
- **list the types of scales**
- **explain plain, comparative scales, scale of chords, diagonal scale and vernier scale.**

Inroduction

Engineering drawings are rarely drawn to the same size of the object. In the preparation of drawings of a building, it is not practically possible to make the drawing to the same size of the building. Here, the drawing is prepared to the reduced size and it is called reduced scale drawing.

Thus, the drawings prepared proportionately to the smaller or larger size than the actual size, are said to be made to a scale. Scale of a drawing may be defined as the ratio of linear dimension of the same object. Scales used in engineering practice are available in sets of 8 or 12 scales. Same times the required scale will not be available. Then, it is necessary to construct a new scale.

Therefore, a convenient scale is always chosen to prepare the drawings of big as well as small object in proportionately smaller or larger sizes. So the scales are used to prepare a drawing at a full size, reduced size or enlarged size.

Representative fraction

Representative fraction may be defined as the ratio of the distance between any two points of the object on a drawing to the actual distance between the same points of the object and it is abbreviated as R.F.

Mathematically,

R.F= distance on drawing/Distance on object

Reducing scale

An actual length of 5m of a room is represented by 25 mm length on drawing. Then,

R.F= distance on drawing/Distance on object

= 25mm/5m

= $25/5 \times 100 \times 10$

= 1/200

Scale of drawing is 1:200

Enlarging scale

An actual length of a typical terminal strip of 10mm is represented by 50mm length on drawing. Then,

R.F. = Distance on drawings / Distance on object

= 50mm/10mm

= 5/1

Scale of drawing is 5:1.

Full scale

An actual length of an electrical switch board of length 30 mm, is represented by a 30mm length on drawing. Then,

R.F.= Distance on drawing/Distance on object

= 30mm/30mm

= 1/1

Scale of drawing is 1:1.

Scales used to scale drawn large parts in engineering drawings and architecture:

1:40 1:100

1:50 1:150

1:65 1:200

1:80

Typical scales for site plan. Units in m.

1:500 1:5000

1:1000 1:10000

1:2000 1:20000

Scales used in surveys. Units in m.

1:50000 1:200000

1:100000 1:50000

Scale used in maps. Units in m.

1:1000000

Recommended scales

Scales recommended for use on engineering drawings are given below-

Full Scale	Reduced scale	Enlarged Scale
1:1	1:2	10:1
	1:2.5	5:1
	1:5	2:1
	1:10	
	1:20	
	1:50	
	1:100	
	1:200	

Civil Engineers and Architects generally use reduced scales while Mechanical and Electrical Engineers use both reduced and enlarged scales according to the need of the problems.

Metric measurements

Table 11.1

10 millimeters (mm)	1 centimeter (cm)
10 centimeters (cm)	1 decimeter (dm)
10 decimeters (dm)	1 meter (m)
10 meters (m)	1 decameter (dam)
10 decameters (dam)	1 hectometer (hm)
10 hectometers (hm)	1 kilometer (km)

Types of scales

- Plain scale
- Diagonal scale
- Vernier scale
- Comparative scale
- Scale of chords (for angles)

To construct a scale the following information is essential

RF of the scale

- Units which it must represent example mm, cm, m, ft inches etc.
- the maximum length it must show
- Minimum length of the scale = RF x the maximum length required to be measured.

Plain scales (Fig 1)**:** Scales are drawn in the form of rectangle, of length 15 cm (can be upto 30 cm) and width 5 mm. It is divided into suitable number of parts. The first part of the line is sub-divided into smaller units as required.

Every scale should have the following salient features:

- The zero of the scale is placed at the end of the first division from left side.
- From zero, mark further divisions are numbered towards right.
- Sub-divisions are marked in the first division from zero to left side.
- Names of units of main divisions and sub divisions should be stated/printed below or at the end of the divisions.
- Indicate the `RF' of the scale.

Example of construction of a plain scale to measure metres and decimetres. RF = $\frac{1}{50}$ and to measure upto 8 metres. Minimum standard length of scale = 15 cm.

The length of the scale = RF x maximum length to be measured = $\frac{1}{50} \times 8 \times 100 \text{ CM} = 16 \text{ CM}.$

Length of 16 cm is divided into 8 equal parts or major divisions each representing one metre. If each major division is divided into 10 sub-divisions each sub-division will represents one decimetre.

A distance of 6.7 m will be shown as in the Fig 1.

Comparative scales (Fig 2)**:** Comparative scale is a graphical device to compare or convert one variable into another. It compares two similar units in different systems. For example meters, yards, kilometers, miles, temperature in degrees, centigrades and Fahrenheit etc.

Fig 2 shows the construction of a comparative scale to convert Fahrenheit (F) into Celsius (Centigrade-C) and Celsius into Fahrenheit.

- The line AB (15 cm) is divided equally into 10 equal parts.
- Division on the top side of the scale is divided into 10

Fig 1

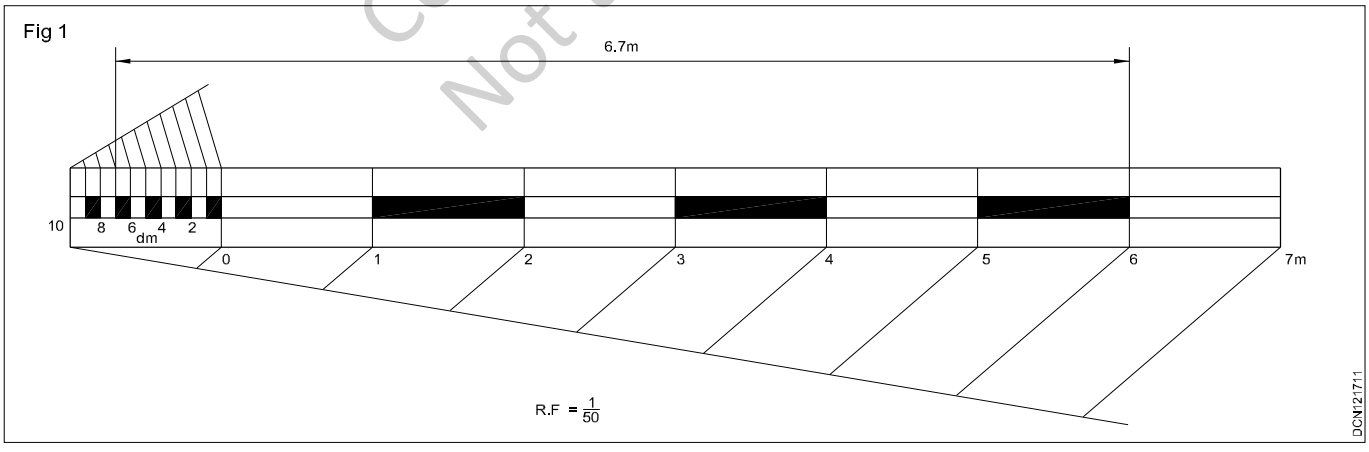
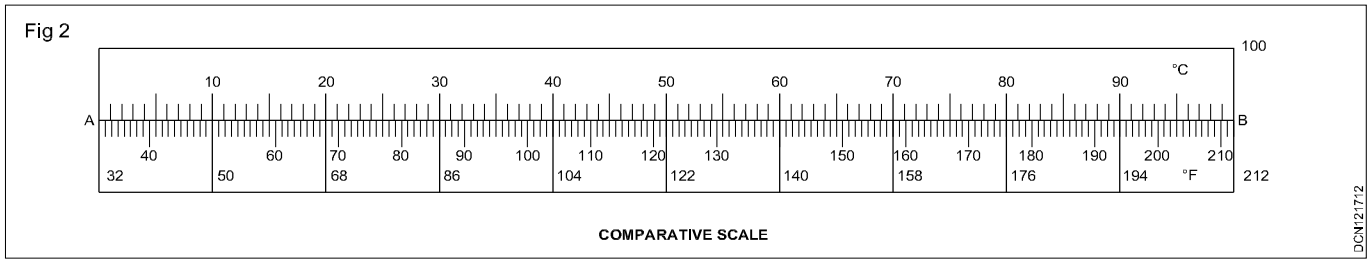


Fig 2



equal sub-divisions. Each sub-division is representing 1°C.

- Division on the bottom side of the scale is divided into 18 equal sub-divisions. Each sub-division is called 1°F.
- Datum of 'F' side scale is starting with 32°F instead of 0.
- Conversion from °C to F or vice-versa can be found out directly from the scale.

  10°C equivalent reading of F scale = 50°F

  25°C equivalent reading of F scale = 77°F

For the verification of the conversion using the scale use the following formulae.

$C = (F - 32) \times \frac{5}{9}$

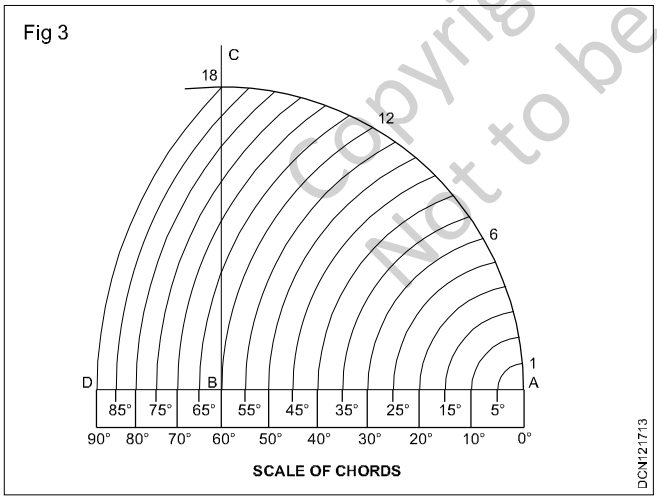
$F = (C \times \frac{9}{5}) + 32$

Scale of chords (Fig 3)**:** It is different from conventional linear scales. It is used to construct angles in the absence of a protractor, so called as a scale to measure or set angles or degrees. There is no rigid length of scale, so any convenient length can be taken to construct it.

Fig 3 shows the method of constructing the scale of chords.

- Draw a quadrant ABC and extend AB.
- A as centre, AC as radius, draw an arc CD.
- AD is the chord of arc AC.
- Divide the arc AC into 18 equal parts and each part is 5°.

Fig 3



– A as centre, draw arcs with radius. A1, A2, A3.....A18 to intersect line DA and mark them 5°, 10°.....90°.

Diagonal scale: Plain scales cannot be used for taking smaller measurement. The distance between the consecutive divisions on a plain scale, at best can only be 0.5 mm. In other words, the smallest measurement that can be taken. Using a plain scale of RF 1:1 is 0.5 mm. If the RF of a plain scale is 1:5, the smallest measurement such a scale can take is 2.5 mm (0.5 mm x 5).

To overcome this limitation two different types of scales are employed. They are

- Diagonal scale
- Vernier scale

Principle of diagonal scale: Diagonal scale relies on a "diagonal" to divide a small distance into further equal parts.

Principle of diagonal scale is based on the principle of similar triangles.

***Example*:** A small distance AB is to be divided into 10 equal parts using diagonal scale.

AB is the line to be divided into 10 equal parts.

Diagonal scale is shown in the Figure 4.

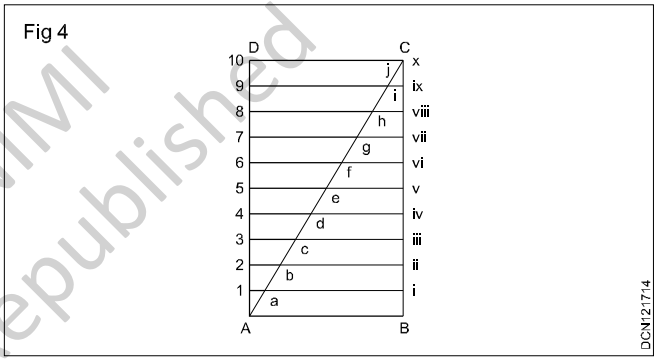
Side AD is the line to be divided into 10 equal parts 1 to 10. Parallel lines are drawn to AB from points 1,2.....10.

Join one of the diagonal AC.

Join parallel line cuts the diagonal at a,b.....j.

Distance 1 - a is $\frac{1^{th}}{10}$ of AB = 0.1 AB

Fig 4



Distance 2 - b is $\frac{2^{th}}{10}$ of AB = 0.2 AB

Distance a - i is $\frac{9^{th}}{10}$ of AB = 0.9 AB

Distance b - ii is $\frac{8^{th}}{10}$ of AB = 0.8 AB

If AB is 1 mm then 1 - a will be 0.1 mm and 2 - b will be 0.2 mm.

Similarly a - i will be 0.9 mm and c - iii will be 0.7 mm.

Parallel lines on both sides of the diagonal can be considered for measurement.

Vernier scale (Fig 5)**:** As stated earlier vernier scales are yet another means of dividing a small dimension into a number of equal parts so as to facilitate taking smaller measurements than is possible by plain scales.

Vernier scale consists of two parts - secondary scale or vernier scale (VS) and primary scale or main scale (MS).

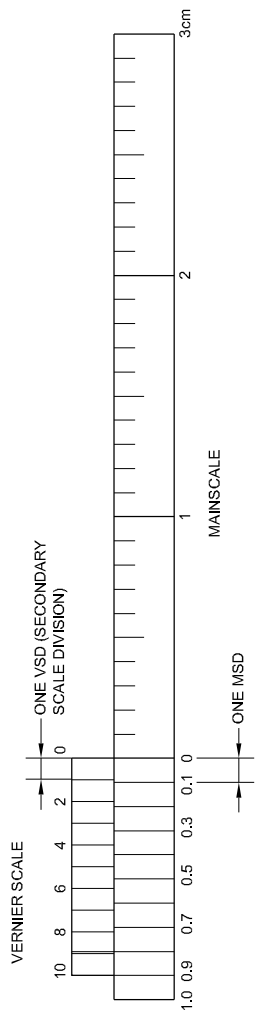
The smallest measurement that can be taken on the main scale is called main scale division (MSD).

Least count of the vernier scale is the fraction of the main scale division upto which the measurement can be taken.

To arrive at the fraction of MSD, imaginarily MSD is divided into a number of equal parts (n)

$$n = \frac{\text{MSD}}{\text{Fractional part of msd}}$$

Fig 5



VERNIER SCALE LENGTH = 9 DIVISIONS OF MSD
LEAST COUNT = ONE MSD – ONE VSD

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The length of the secondary scale depend upon the MSD and number of divisions (n) we have decided to make.

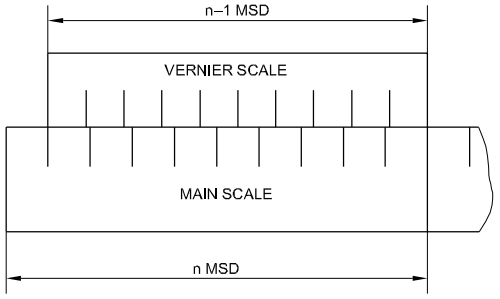
If one MSD is to be divided into 'n' parts, the length of the secondary scale (vernier) will be equal to the length of either (n-1) or (n + 1) parts of MSD.

Length of the secondary scale is divided into 'n' equal parts.

Thereby one secondary scale (vernier) division is equal to $\frac{(n-)MDC}{N}$ OR $\frac{(n+1)MSD}{N}$ as the case may be.

Direct or forward reading: Vernier scale is the scale constructed having n - 1 numbers of MSD as the secondary scale (vernier) length. (Fig 6)

Fig 6



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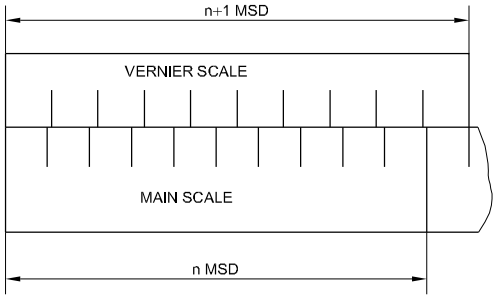
Retrograde or backward reading: Vernier scale is the scale having n + 1 numbers of MSD as the secondary scale (vernier) length. (Fig 7)

Fig 7



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According to Direct reading vernier

1 Main scale division - 1 Secondary scale division (vernier) $= \frac{1}{n}$ MSD

1 cm - $\frac{9}{10}$ $= \frac{1}{10}$ CM

According to backward reading vernier

1 Secondary division (vernier) - 1 Main scale division $= \frac{1}{n}$ MSD

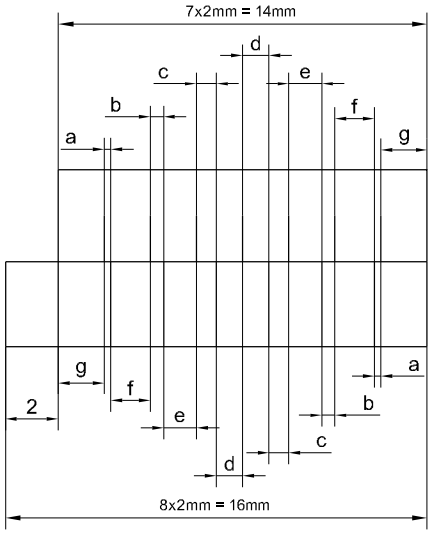
1.1 cm - 1.0 cm $= \frac{1}{10}$ CM

MSD is the least count of the vernier scale

Example on direct reading vernier scale (Fig 8)**:** Construct a directing reading scale with one MSD = 2 mm, Least count = 0.25 mm.

First find the number of equal parts MSD (n)

Fig 8



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$$n = \frac{MSD}{\text{least cound}} = \frac{2\,mm}{0.25mm} = 8$$

Length of secondary scale (vernier) is equal to 'n - 1' number of MSDs. 7 divisions of MSDs are taken and the length is equally divided into 8 parts on secondary scale (vernier)

1 secondary scale division = $\frac{7 \times 2mm}{8} = 1\frac{3}{4}mm$

The difference of one MSD and one secondary scale The difference of one MSD and one secondary scale division (vernier) will be

$2mm - 1\frac{3}{4}mm = \frac{1}{4}mm = 0.25mm$

It means that the scale can measure upto $\frac{1}{4}$ mm (0.25 mm).

In the figure, the fraction of the MSD is shown as the distance between the lines of VSD and MSD and they are marked as a,b,c.....g.

Figure 9 shows a retrograde vernier scale with same least 0.25 mm (1/4 mm) and one MSD = 2 mm.

Length of secondary (vernier) scale is n + 1 number of MSDs.

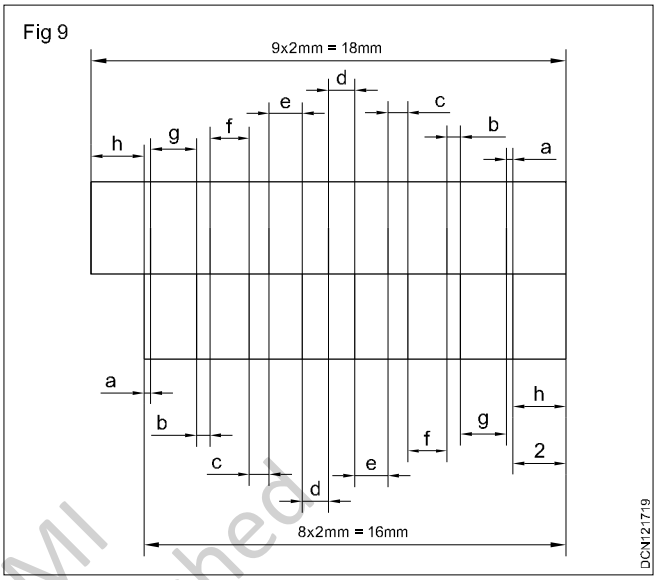
9 MSDs are equally divided into 8 parts on secondary (vernier) scale.

1 secondary (vernier) division = $= \frac{9 \times 2mm}{8} = 2\frac{1}{4}mm$

1 VSD - 1 MSD = least count

Least count = 0.25 mm

Fig 9



Properties of materials

Objectives: At the end of this lesson you shall be able to
- **classify MATERIALS**
- **state the properties of materials**
- **explain the properties of building materials.**

Introduction

The engineering material plays a vital role in our national economy.

This lesson deals with the study of Materials in respect of,

1 sources, composition, properties,

2 manufacturing methods and testing

3 utility in the various fields,

4 modern techniques for handling and using to materialize economical and safer

Classification

Materials may be classified as follows,

A. 1 Civil MATERIALS

building stones, clay products, lime, cement, concrete, mortar, timber, etc.

2 Electrical MATERIALS

copper, aluminum, iron and steel…..conductors,

Silicon, germanium, etc……semiconductors

Asbestos, mica, varnishes, air, etc……insulators Bakelite, Iron, nickel, cobalt, etc……..magnetic materials

3 Mechanical MATERIALS

Cast iron, steel, lubricating materials, etc..

B. Metals

Iron, aluminum, copper, zinc, etc…

And further… ferrous metals (cast iron, wrought iron and steel) and alloy (silicon steel, high speed steel, spring steel, etc.) and non-ferrous metals (copper, aluminum, zinc, etc.) and alloy (brass, bronze, duralumin, etc.)

C 1 Metals and alloy, (steels, copper, aluminum, brass, bronze, invar, super alloys, etc.)

2 Ceramics, (silica, soda lime glass, concrete, cement, ferrites, garnets, etc.)

3 Organic polymers, (plastics, p.v.c, polythene; fibres; terylene, nylon, cotton; natural and synthetic rubbers, leather, etc.)

Properties of materials.

1 Physical properties

2 Mechanical properties

3 Electrical properties

4 Magnetic properties and chemical properties

Properties of building materials

The properties of various building Materials(have to be ascertained for purposes of specifying them for particular use, classifying them and testing them for acceptance) may be classified into following categories:

1 Mechanical properties, (e.g. elasticity, plasticity, hardness, strength, etc.)

2 Chemical properties, (e.g. chemical composition, acidity, alkalinity, corrosion, etc.)

3 Electrical properties, (e.g. resistivity, conductivity, dielectric strength, etc.)

4 Optical properties, (e.g. light transmission, colour, reflectivity, refractive index, etc.)

5 Thermal properties, (e.g. specific heat, thermal conductivity, thermal expansion, etc)

Physical properties

Depending on the type of materials, these include a number of properties like;

1 **Specific gravity:** It is the ratio of the weight of material per unit volume (not including air holes and pores) to the weight of an equal volume of water under its standard conditions. It is used to calculate the density and porosity of materials.

2 **Density:** It is defined as the mass of a material per unit of its volume.

3 **Bulk density or unit weight:** The mass per unit volume of a material in its natural state.

4 **Porosity:** The degree by which the volume of a material is occupied by pores is indicated by the term porosity. The strength, bulk density, durability, thermal conductivity, etc. of a material depend on its porosity.

5 **Water absorption:** The water absorption of a material is its ability to absorb and retain water. This property is important in the case of stones, bricks, etc.

6 **Hygroscopicity:** It is the property of a material to absorb water vapour from air, as in the case of salt, sugar, etc., timber, is a hygroscopicity material.

7 **Permeability:** It is the capacity of a material to permit water to pass through it under pressure. It is important in the case of soils.

8 **Fire resistance:** It is the ability of a material to resist the action of high temperature without losing its load-bearing capacity.

9 **Durability:** Durability is the resistance of a material to destruction by natural agencies.

Building stones

Objectives: At the end of this lesson you shall be able to
- **define rock and building stone**
- **explain the characteristics of good building stones**
- **classify the rocks**
- **identify type of stones available in India**
- **explain testing of stone.**

Introduction

Stones are obtained from rocks, which may be classified according to geological, physical, chemical and practical classifications. A particular building stone may be selected depending on the requirements of the structure to be built.

Definition:

The soldified definite portion of earth's surface has not definite chemical composition and shape is called rock.

The quarried pieces of rock which is using for engineering purpose are called stone.

Characteristics of a good stone

To find the suitability of stones under different conditions, the following characteristics should be considered.

Appearance and colour: Have the ability to receive good polish, a pleasing colour and be free from cracks and spots.

WEIGHT: A heavy stone possesses more compactness and less porosity.

Porosity and absorption: If it present in greater extent it makes the unsuitable for building construction.

Fineness of grain: Fine grained stone are suitable for molding works.

Compactness: Compact stone can with stand the effects of external agencies effectively.Durability of stone is decided by their compactness or density of composition.

Resistance to fire: Should have homogeneous composition and be free from calcium carbonate or oxide of iron.

Electrical resistance: The stone must be non-absorbent like slate.

Hardness and toughness: To resist wear and tear, the stone must be adequately hard and tough. Hardness may be tested by scratching with a pen knife and toughness tested by hammer.

Strength: The crushing strength of stone should be greater them 100N/mm2. All igneous rocks have around 100N/mm2and same of the metamorphic rocks also satisfy this requirement. Sedimentary rock has a low strength.

Specific gravity: For docks, harbors, gravity dams etc stones should have a high specify gravity, not less 2.6.The more specify gravity; more will be the weight of the stone for a given volume.

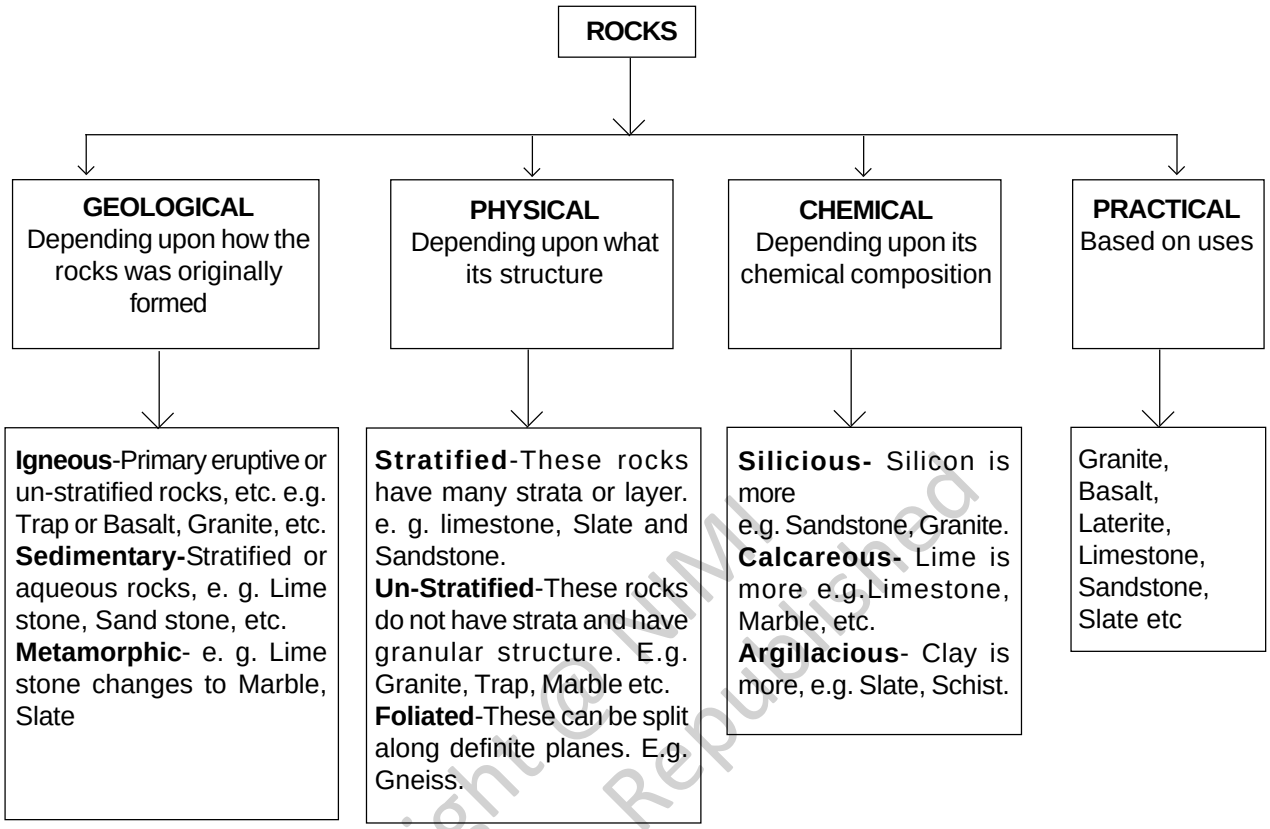
Durability: A stone is more durable, if it is compact, homogeneous and free from any Materials affected, also have negligible water absorption.

Dressing: Stone should possess uniform texture and softness if it is to hard, finish will be poor and dressing uneconomical

Cost: An important consideration in the selection of building stone.

Seasoning: Stone must be free from quarry sap, after quarrying and dressing, stone should be left for a period of 6-12 months for proper seasoning.

Classification of rocks



Types of Rocks

Rocks may be classifed in the following three ways:

1.Geological 2.Physical 3.Chemical

GEOLOGICAL CLASSIFICATION

Based on their origin of formation stones are classifed into three main groups- igneous, sedimentary and metamorphoric rocks.

Igneous rocks: These rocks are formed by cooling and solidifying of the rock masses from their molten magmatic condition of the material of the earth. Generally igneous rocks are strong and durable. Granite, trap and basalt are the rocks belonging to this category, Granites are formed by slow cooling of the lava under thick cover on the top. Hence they have crystalline surface. The cooling of lava at the top surface of earth results into non-crystalline and glassy texture. Trap and basalt belong to this category.

Sedimentary rocks : Due to weathering action of water, wind and frost exisitng rocks disintegrates. The disintegrated material is carried by wind and water, the water being most powerful medium. Flowing water deposits its suspended Materials at some points of obstacles to its flow. These depositied layers of Materials get consolidated under pressure and by heat. Chemical agents also contribute to the cementing of the deposits. The rocks thus formed are more uniform, fine grained and compact in their nature.

They represent a bedded or startified structure in general. Sand stones, lime stones, mud stones etc. belongs to this class of rock.

Metamorphic rocks: previously formed igneous and sedimentary rocks under go changes due to metamorphic action of pressure and interanl heat. For example due to metamorphic action grainte becomes gneiss, trap and basalt changes to schist and laterite, lime stone changes to marble, sand stone becomes quartizite and mud stone becomes slate.

Physical Classification

Based on the structure, the rocks may be classified as:

1. Stratified rocks 2. Unstratified rocks

Stratified rocks : These rocks are having layered structure. They posses planes of stratification or cleavage. They can be easily split along these planes. Sand stones, slate etc. are the examples of this class of stones.

Unstratified rocks: These rocks are not stratified. They possess crystalline and compact grains. They cannot be

split in to thin slab. Granite, trap, marble etc, are the examples of this type of rocks.

Foliated Rocks : These rocks have a tendency to split along a definite direction only. The direction need not be parallel to each other as in case of stratified rocks.

Chemical classification

On the basis of their chemical composition engineers prefer to classify rocks as:

Silicious rocks, Argillaceous rocks and Calcareous rocks

Silicious rocks : The main content of these rocks is silica. They are hard and durable. Examples of such rocks are granite,, traps and quartzines etc.

Argillaceous rocks: The main constituent of these rocks is argil i.e., clay. These stones are hard and durable but they are brittle. They cannot withstand shock. Slates and laterites are examples of this type of rocks.

Calcareous rocks: The main constituent of these rocks is calcium carbonate. Limestone is a calcareous rock of sedimentary origin while marble is a calcareous rock of metamorphic origin.

Testing of stones

To determine the suitability of stone for its use in engineering works the following tests are performed:

1 Hardness test
2 Crushing test
3 Impact test
4 Fire resistance test
5 Attrition test
6 Acid test
7 Water absorption test
8 Smith's test
9 Crystallization test
10 Microscopic test
11 Freezing and thawing test.

1 **Hardness:** To determine the hardness of stone
2 **Crushing test :** To determine the maximum load at which stone crushes or fails while loading.
3 **Impact test:** To determine the toughness of a stone.
4 **Fireresistance test:** Determine the presence of calcium carbonate which will produce fire
5 **Attrition test:** To determine the rate of wear of stones
6 Acid test: To determine the action of acid on the stone
7 **Water absorbption test :** To find out the % of water absorbtion of test stone.
8 **Smith's test :** Indicate the presence of earthly matter
9 **Crystallization test :** To determine the durability or weathering quality
10 **Microscopic test:** To study the mineral constituents, grain size etc.
11 **Freezing and thawing test:** To determine the behavior of stone under freezing

Table

COMMON BUILDING STONES OF INDIA

STONES	ROCKS	CHARACTERISTICS	USES	PLACES
Basalt and Trap	Igneous	Hard and tough; difficult to work Its sp. gravity is 3 and compressive strength varies from 1530 to 1890 kg/cm^2. Its weight varies from 1800 to 2900 kg/m^3	Road metal, for rubble masonry, foundation work, etc.	Maharashtra, Bihar, Gujarat, Bengal. And M.P.
Chalk	Sedimentary	Pure white limestone soft and easy to from powder.	In preparing glazier's putty: as colouring material in manufacture of Portland cement.	Maharashtra, Bihar, Gujarat, Bengal. Punjab, Rajasthan, M.P, Andaman- Island U.P.& H.P.
Gneiss	Metamorphic	Splits into thin slabs easy to work .Its sp. Gravity is 2.69 and compressive strength is 2100kg/cm^2.	Street paving, rough stone masonry work, etc.	Madras, Mysore, Bihar, A.P, Maharashtra, Bengal, Kerala, Gujarat

STONES	ROCKS	CHARACTERISTICS	USES	PLACES
Granite	Igneous	Hard, durable and available in different colours, highly resistant to natural forces, can take nice polish. Its Sp. gravity Varies from 2.6 to 2.7 and compressive strength varies from 770 to 1300 kg/cm^2. Its weight is about 2600 to 2700 kg/m^3.	Steps, sills, facing walls work bridge piers, columns, road metal, ballast, etc. It is unsuitable for carving.	Kashmir, Madras, Punjab, Rajasthan, U.P, M.P, Mysore, Assam, Bengal, Bihar, Orissa, Kerala, & Gujarat.
Kankar	Sedimentary	Impure limestone	Road metal, manufacture of hydraulic lime, etc.	North & central India.
	Metamorphic	Porous and spongy structure, easily quarried in blocks. Contains high percentage of Oxide of iron; available in different colours. Its compressive strength various from 18 to 32 kg/cm^2.	Building stone, road metal, rough stone, masonry work. etc.	Bihar, Orissa, Mysore, M.P., Maharashtra, Kerala, A.P., & Madras.
Lime Stone	Sedimentary	Consist of carbonate of lime easy to work Its Sp. gravity various from 2.00 to 2.75 and compressive strength is 550 kg/cm^2.	Floors steps , walls, road metal, manufacture of lime in blast furnace etc.	Maharashtra, Bihar, Gujarat, Bengal. Punjab, Rajasthan, M.P, Andaman- Island U.P.& H.P.
Marble	Metamorphic	Can take nice polish and available in different coloures. Its Sp. gravity is 2.65 and compressive strength is 720 kg/cm^2. and carved.	Flooring, facing work, Columns, steps, ornamental works etc. It can take nice polise lt can easily be shown	Maharashtra, Gujarat, Rajasthan, M.P, Mysore, U.P and A.P.
Moorum	Metamorphic	Decomposed laterite, deep brown or red in colours.	Blindage for metal roads,for fancy paths and garden walls .	Bihar, Orissa, Mysore, M.P, Mah., Kerala, A.P., & Madras
Quartzite	Metamorphic	Hard, brittle, crystalline, and compact, difficult to work and dress.	Retaining wall, road metal, concrete, aggregate, pitching, rubble masonry,facing building etc.	Madras, Punjab, U.P, Mysore, Bengal, Gujarat. Rajasthan, A.P.
Sand stone	Sedimentary	Consists of quartz and other minerals, easy to work &dress and available in different colours. It is Sp.gravity various from 2.65 to 2.95 and compressive strength is 650 kg/cm^2. Its weight is about 2000 to 2200 kg/ cm^3.	Steps, facing work columns, flooring walls, road metal,ornamental work etc .	Maharashtra, Bihar, Gujarat, Bengal, Punjab, Rajasthan, M.P, Andaman Island, U.P, H.P, A.P, Kashmir, Madras .
Slate	Metamorphic	Black colour and splits along natural bedding planes, non-absorbent. Its Sp. gravity is 2.89 and compressive strength varies from 75 to 207 N/mm^2.	Roofing work, sills, damp proof courses, etc.	U.P., M.P., Bihar, Madras, Mysore and Rajasthan.

Quarrying (building stones)

Objectives: At the end of this lesson you shall be able to
- **define quarrying**
- **state quarry location**
- **explain methods of quarrying**
- **list out the explosives used in blasting.**

Introduction

Good stones are obtained by quarrying from solid rocks formation and not from loose boulders. Boulders are weathered blocks of stones are not fit for important constructions. The term quarry refers to the places exposed to air like a stone outcrop from which we extract the building stone (by digging or blasting). On the other hand, the term mine refer to the places where we extract mineral resources like coal, precious stones, etc.

Definition: The art of extracting stone from the rock beds is called quarrying.

Quarry location

It is required to be carefully paid attention to before starting the quarry

1 examination of rocks surface

2 layout

3 men and machine

4 removed the top surface

5 structural stability

Methods of quarrying

The different types of methods of quarrying are the following.

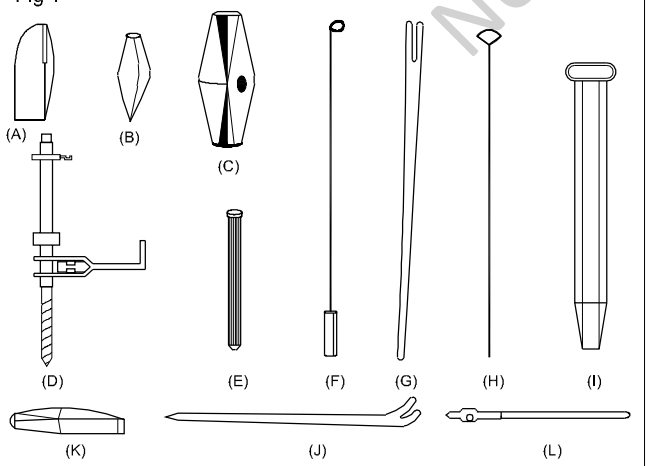
1 Quarrying by hand tools.

2 Quarrying by use of channelling machine.

3 Quarrying by blasting.

1 Quarrying by hand tools:

Fig 1



TOOLS FOR QUARRYING STONES

It is very old method and still used for soft stones occurring in large or small blocks. With the help of suitable instruments such as pickaxes, hammers, shovels, chisels, scraping spoon, priming needle, dipper, and steel, pin.

The following are the methods used:

1 By digging and excavating

2 By Heating

3 By wedging

2. Quarrying by use of a channelling machine:

1 Use a channeling machine, driven by steam, compressed air or electricity.

2 Machine can cut 50 to 75 mm width channels up to 24 m. in length and240 to 370 cm in depth.

3 First, cut channels of sufficient depth.

4 Horizontal holes are then driven beneath the block from the exposed face.

5 Wedges are then driven into the horizontal holes, when the block will break loose.

6 The block is lifted from its bed, to be cut into the slabs of required sizes.

3. Quarrying by blasting with explosives:

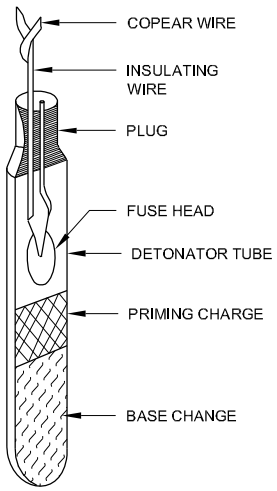
1 The explosives are used to convert rocks in to small pieces of stone.

2 The operation of blasting constitutes the boring or drilling of holes,

3 Charging them with some suitable explosive

4 Then firing the charge.

Fig 2



ELECTRICAL DETONATOR

5 This method is adopted for quarrying hard stones, having no fissures or cracks.

Explosives in blasting:

1 In the process of blasting, following factors are considered to avoid the occurrence of serious accidents:

2 Failure of explosion

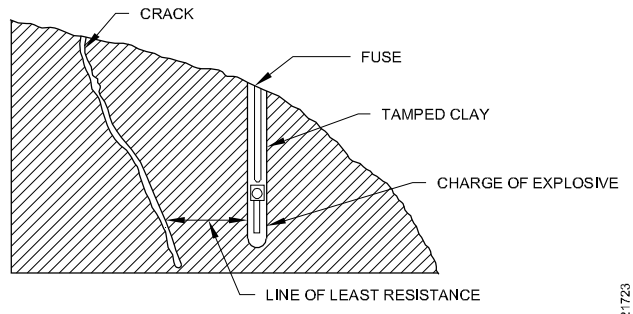
3 Line of least resistance (line along which the explosion of the powder will find least opposition to its vent to the atmosphere)

4 Needle and tamper

5 Notice of blasting

6 Retreat to a distance

Fig 3



TAMPED AND CHARGED BLAST HOLE

7 Seepage of water

8 Skilled supervision

Table 3.1

Sl. No	Name of Explosive	Composition	Remarks
1	Blasting gelatine.	It consists of 93% of nitro-glycerine and cotton 7% of gun cotton.	It has high explosive powder about 50% more than that of dynamite.
2	Codite.	It is prepared from gelatinized combination of nitro-glycerine and nitro-cellulose.	It is powerful explosive and it does not produce smoke. It can be used under water.
3	Gelignite	It consists of 65% blasting gelatine and 35% of absorbing powder.	It is more convenient than dynamite. It is a powerful explosive and can be used under water.
4	Gun-cotton	Clean cotton is saturated in a cool mixture of nitric acid (HNO_3) and sulphuric acid (H_2SO_4). It is pressed in to blocks or sticks while it is wet	It is as strong as dynamite. But its shat tering power is less. If it decomposes with rise of temperature. It is genarly transported and stored in moist condi tions.
5	Liquid oxygen	It is oxygen in liquid state.	It is stored in special containers. It is comparatively cheaper. It is used for blasting on a large scale, mining for operations, for blasting under water etc.
6	Rock-a-rock	It consists of 79% of potassium chlorate ($KClO_3$) and 21% of nitro-benzol .	Its action under water is more effective. It is used in U.S.A.
7	Dynamite	75% nitrogly cerine mixed with 25% sandy earth to form a thick paste.	Quick action, more powerful than blast ing power and six times powerful used under water and damp situation.
8	Blasting power	65% potassiun nitrate 20% sulphur	Slow action, cheaper. 15% charcoal

Precautions to be taken while blasting

1 It should be done at fixed hours made known to the public.

2 Before actual firing, siren should give timely warning to workmen and others to retire to safety.

3 Danger flag (red) should be displayed at a distance about 200 m around the area of explosion. And no person should allow entering in the danger zone other than the firing man.

4 All fuses should cut to proper lengths before inserting them into the holes.

5 For making a hole in cartridges to take detonates, only hard wooden pegs should be used.

6 Cartridges should preferably be handled with rubber or polythene gloves on.

Dressing of stones (building stones)

Objectives: At the end of this lesson you shall be able to
- **define dressing**
- **state purposes of dressing**
- **explain varieties of finishes**
- **list out the artificial stones**
- **explain natural bed of stone.**

Definition

The stone after being quarried are to be cut into suitable size and with suitable surface. This process is known as the dressing of stone and it is carried out for following purpose.

1 To get the desired appearance from stone work to make the transport from quarry easy and economical.

2 To suit to the requirement of stone masonry.

3 To take advantage of local men near who are trained for such type of work.

Following are the varieties of finishes obtained by the dressing of stone:-

1 Axed finished

2 Boosted as droved finish

3 Chisel -draughted margins

4 Circular finish

5 Dragged as combed finish

6 Furrowed finish

7 Moulded finish

8 Hammer-dressed finish

9 Plain finish

10 Polished finished

11 Punched machine

12 Reticulated finish

13 Rubbed finished

14 Tooled finished

15 Shackling finished

16 Self-faced or rock faced or quarry faced finish

17 Sunk finish

Artificial stones

It is also known as cast stones or reconstructed stones. Since it is difficult to obtain durable natural stones at a moderate cost in many localities, many processes have been invented for the manufacture of artificial stone.

Varieties of artificial stones

1 Cement concrete blocks.

2 Ransom's patent stone,

3 Artificial marble,

4 Terrazzo

5 Mosaic tiles,

Fig 1 a.

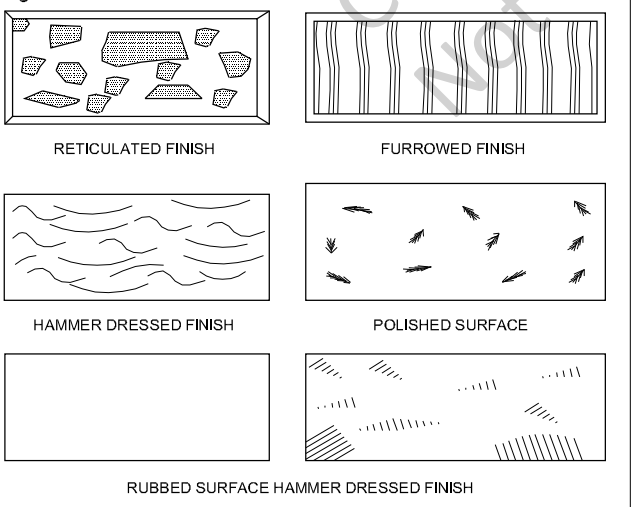


Fig 1 b.

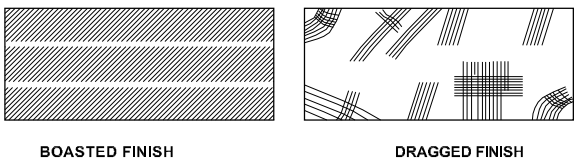
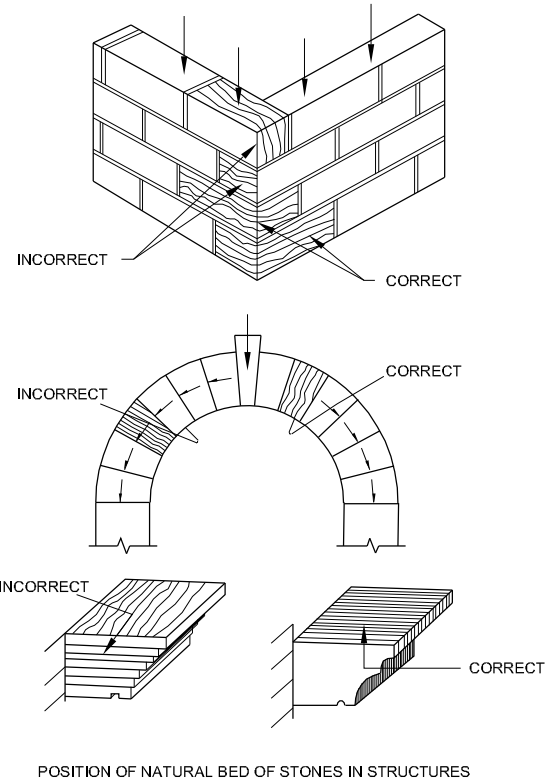


Fig 2



6 Reconstructed stone,

7 Bituminous stone

Natural bed of stone

1 It is the original position occupied by the sedimentary (stratified) rocks from which the stone is obtained. It is also known as the plane of cleavage.

2 These rocks have a distinct plane of division along which stones can easily be split and it thus indicates the layer is divided into numerous thin layers or laminations, whose planes are parallel to the plane of the main strata.

3 Thus, stone quarried from such rocks should be placed in a stone masonry; in such a manner that the direction of load or pressure is at right angles to its laminations.

4 Such an arrangement gives maximum strength to the stone work.

With respect to natural bed, the stones are placed in different situations as follows:

1 Arches

The bedding plane is kept at right angles to the resultant line of thrust, from consideration of the stability of the arch.

2 Cornices, string courses, etc.

The natural bed should be placed vertically and perpendicular to the face otherwise the layers of overhanging portions being horizontal will drop of.

3 Column or a wall

In this, the load line is vertical; the stones should be placed with the planes of bedding radial, so that, thrust acts normal to the bedding plane.

Clay products (bricks)

Objectives: At the end of this lesson you shall be able to
- **define clay products**
- **compare stone and brick**
- **explain composition of brick earth**
- **describe the method of manufacturing of bricks**
- **explain the qualities of good bricks**
- **classify the bricks**
- **state testing of bricks**
- **list out the special bricks.**

Introduction

The clay occurs plenty in nature, when it is made wet with water possesses a high degree of tenacity and plasticity it can be moulded in designed shape and they dried and burnt.The clay products which are employed in building industry are bricks, ceramic products (tiles, refractory bricks, terra-cotta, porcelain, earthen-wares and stone-wares). Burning of moulded clay products makes them sufficiently strong for use as construction materials.

Bricks: Moulded clay in rectangular block of uniform size, shape as per standard, which is dried and burned for the purposes of masonry work, is called brick.

Comparision of stone and brick

S.No.	Stone	Brick
1	It is heavier than brick	It is lighter than stone.
2	It is obtained from rock	It is made from clay.
3	Free from clay holes and flaws.	Free from lumps, flaws and cracks.
4	Hard and tough	Hard and sound
5	It absorbs heat more than a brick.	It absorbs less heat comparatively.
6	Water absorption <5%	Water absorption <16%
7	It is uniform in colour and can be Shaped to the desired size.	Uniform in colour, shape and size.
8	It has high durability.	It is durability is less than that of stone.
9	Suitable for industrial area as it is acid and smoke proof.	Acid and smoke resistance is good but Less than that of stone.
10	Dressing, transporting costly.	Overall cost of manufacturing is less.
11	Labour cost for laying is more.	Labour cost is less

Brick earth:(IS: 2117-1975)

A good brick earth should be such that it can be easily moulded and dried without cracking and wrapping. In order to determine the suitability of the brick earth, the necessary field tests are carried out, e.g. consistency test, test for moulding properties and test for deformation and shrinkages on burning.

Requirements of good brick earth:-

1 It must have proper proportions of sand, silt and clay.

2 It must be homogeneous.

3 It should have sufficient plasticity.

4 It must be free from lumps of lime or kankar.

5 It must be free from earth containing alkaline salts, kankar.

6 It must be free from pebbles, grits and lumps of earth.

7 It must not contain vegetable and organic matter.

8 It should not mix with salty water.

Composition of brick earth

1 Alumina (or) clay = 20-30% by weight

2 Silica or Sand = 35-50%by weight

3 Silt = 20-25% by weight

4 i. Iron oxide

ii. Magnesia

iii. Lime (CaO)

iv. Sodium potash = 1.2% by weight

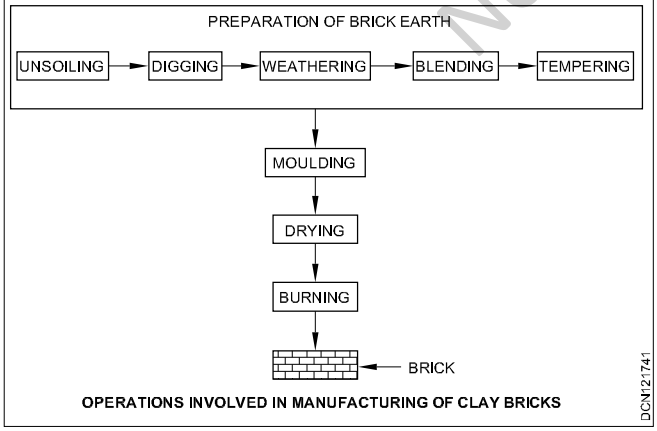
Total water- soluble material not more than 1%.

Lime + magnesia not more than 1% for alluvial soil

Not more than 15 for others.

Manufacturing of clay bricks (IS: 2117-1975)

Fig 1



OPERATIONS INVOLVED IN MANUFACTURING OF CLAY BRICKS

The process of manufacture can be described the following steps:

Selection of site, (selection and un-soiling)

Prepartion of clay, (digging & cleaning, weathering)& blending and tempering

Preparation of clay: The clay for bricks is prepared in the following order

i unsoiling

ii digging

iii cleaning

iv weathering

v blending

vi tempering

Unsoiling: The top layer of soil about 20cm in depth is taken out and thrown away. The clay in top soil is full of impurities and hence, it is to be rejected for the purpose of preparing bricks.

Digging : The clay is then dug out from the ground. It is spread on the levelled ground just a little deeper than the general level of ground. The height of heaps of clay is about 60cm to 120cm

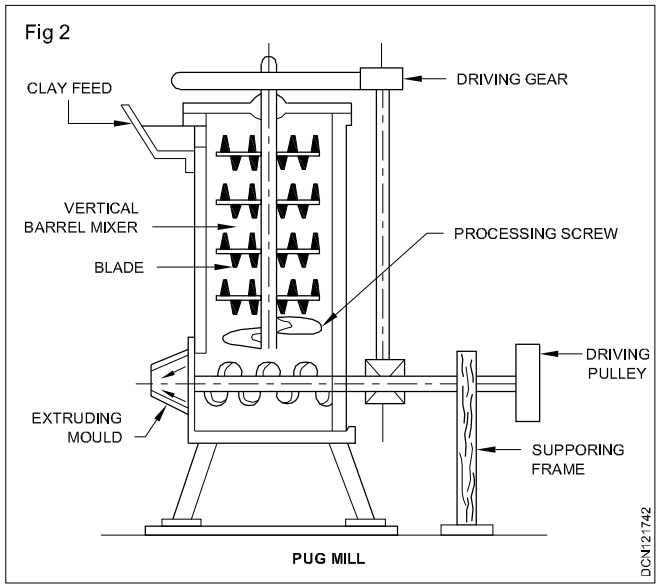
Cleaning: The clay as obtained in the process of digging, should be cleaned of stones, pebbles, vegetables matter, etc. If these particles are in excess the clay is to be washed and screened. Such a process naturally will prove to be troublesome and expensive. The lumps of clay should be converted into powder form in the earth crushing roller.

Weathering: The clay is then exposed to atmosphere for softening or mellowing the period of exposure varies from few weeks to full for a large project the clay is dug out just before the monsoon is allowed to weather throughout the monsoon.

Blending: The clay is made loose and any ingredient to be added to it, is spread out at its top. The blending indicates intimate or hormonious mixing. It is carried out by taking small portion of every time and by turning it up and in vertical direction. Blending makes clay fit for next stage of tempering.

Tempering: In the process of tempering, the clay is brouhght to a proper degree of hardness and it is made fit for the next operation . The water in required quanity is

Fig 2



PUG MILL

mass of clay added to clay and whole mass is kneaded or pressed under the feet of men or the tempering should be done exhaustively to obtain homogeneous uniform character.

Moulding : The clay which is prepared as above is then sent for the next operation of moulding. Following are the two ways of moulding:

Bricks

1 Hand moulding

2 Machine moulding

Hand moulding : In hand moulding the bricks are mould by hand ie manually. It is adoped where man power is cheap and is readilly available for the manufacturing process of brick on a small scale. The moulds are rectangular boxes which a open at top and bottom. They may be of wood or steel.

Ground moulded bricks : The ground is first made level and fine sand is sprinkled over it. The mould is dipped in water and placed over the ground the lump of tempered clay is taken and it is dashed in the mould. the clay is pressed or forced in a mould in such a way that it fills all the corners of mould. The extra or surplus clay is removed either by wooden strike or metal strike or frame with wire . A strike is a piece of wood or metal with sharp edge. It is to be dipped in water every time. The mould is then lifted up and raw brick is left on the ground. The mould is dipped in water and it is placed just near the previous brick to prepare another brick. The process is repated till the ground is covered with raw bricks. A brick moulder can mould about 750 bricks per day with working period of 8 hours. When such bricks become sufficiently dry, they are carried and placed in the drying sheds.

Table moulded bricks: The process of moulding these bricks is just similar as above. But in this case the moulder stands near a table of size about 2m X 1m. The clay mould water pots stock bard strkies and pallet boards are placed for the further process of drying. However the efficiency of moulder decreases gradully because of standing at the same place for long duration. The cost of brick moulding also increases when table moulding is adopted.

Machine moulding : The moulding may also be achieved by machines. It proves to be economical when bricks in large quantity are to be manufactured at the same pot in a short time. It is also helpful for moulding hard and strong clay. These machine are broadly classfied in two categories:

1 Plastic clay machines

2 Dry clay machines

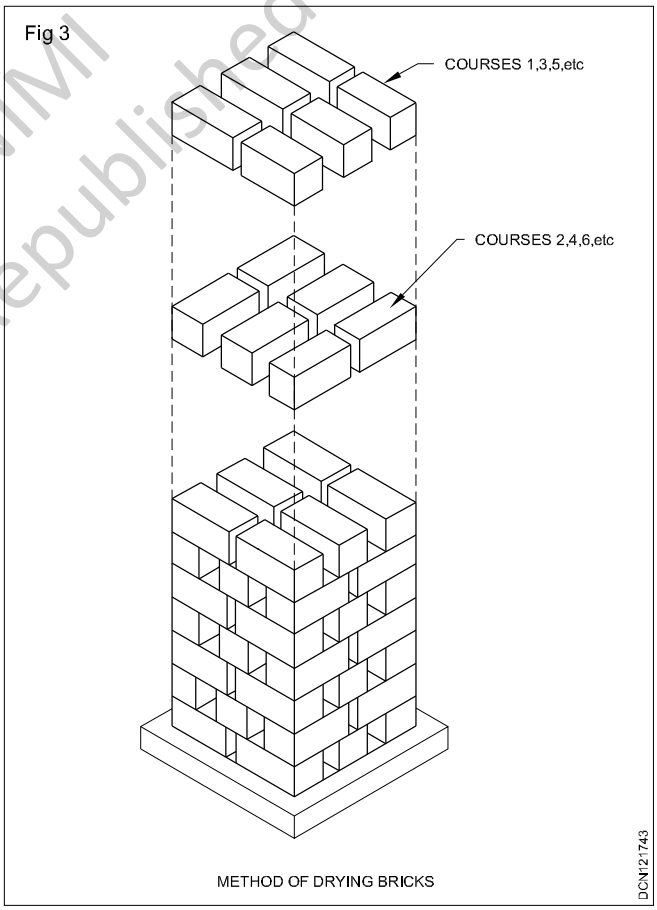
Plastic clay machines: Such machines contain a rectangular opening of size equal to length and width of a brick. The pugged clay is placed in the machine and as it comes out through the opening it is cut into strips by wires fixed in frames. The arrangements is made in such a way that strips of thickness equal to that of the brick are obtained. As the bricks are cut by wire, they are also known as wire cut bricks.

Dry clay machines: In these machines, the strong clay is first converted into powder form. A small quantity of water is then added to form a stiff plastic paste. Such paste is placed in mould and pressed by machine to form hard and well shaped bricks. These bricks are known as pressed bricks and they do not practically require drying. They can be sent directly for the process of buring.

The wire cut and pressed bricks have regular shape, sharp edges and corners. They have smooth external surface.They are heavier and stronger than ordinary hand moulded bricks. They carry distinct frogs and exhibit uniform dense texture.

Drying : The damp bricks, if burns are likely to be cracked and distorted. Hence the moulded bricks are dried before they are taken for the next operation of buring. For drying the bricks are laid longitudinally in stacks of width equal to two bricks. A stack consists of eight or ten tiers. The bricks are laid along and across the stock in alternate layers. All bricks are placed on edge. The bricks should be allowed to dry till they become leather hard or bone-dry with moisture content of about 2 per cent or so (Fig 3).

Fig 3



METHOD OF DRYING BRICKS

The important facts to be remembered in connections with drying of bricks are as follows:

Artificial drying : The bricks are generally dried by natural process. But when bricks are to be rapidly dired on a large scale, the artificial drying may be adopted. In such a case, the moulded bricks are allowed to pass through special dryers which are in the form of tunnels or hot channels or floors. Such dryers are heated with the help of special furnances or by hot flue gases. The tunnel

dryers are more economical than hot floor dryers and they may be either periodic or continous.

In the former case, the bricks are filled, dried and emptied in rotation. In the latter case, the loading of bricks is done at one end and they are taken out at the other end. The temperature is usually less than 120^0C and the process of drying of brikcs takes about 1 to 3 days depending upon the temperature maintained in the dryer, quality of clay product etc.

Circulation of Air: The bricks in stacks should be arranged in such a way that sufficient air space is left between them for free circulation of air.

Drying yard: For the drying purposes, special drying yards should be prepared. It should be slightly on a higher level and it is desirable to cover it with sand. Such an arrangement would prevent the accumulation of rain water.

Period for drying: The time required by moulded bricks to dry depends on prevailing weather conditions.Usually it takes about 3 to 10 days for bricks to become dry.

Screens: It is to be seen that bricks are not directly exposed to wind or sun for drying. Suitable screens, if necessary may be provided to avoid such situations.

Burning : This is a very important operation in the manufacturing of bricks. It imparts hardness and strength to bricks and makes them dense and durable. The bricks should be burnt properly. If bricks are overburnt, they will be brittle and hence break easily, if they are underburnt, they will be soft and hence, cannot carry loads.

When the temperature of dull red heat, about 650^0C is attained, the organic matter contained in the brick is oxidized and also the water of crystallization in driven away. But heating of bricks is done beyond this limit for the following purposes:

(i) If bricks are cooled after attaining the temperature of about 650^0C, the bricks formed will absorb moisture from the air and get rehydrated.

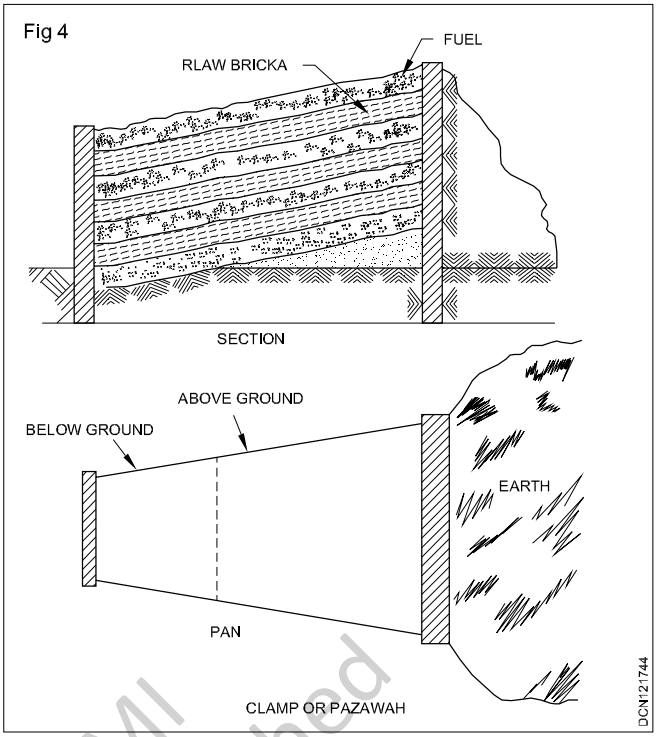
(ii) The reactions between the mineral constituents of clay are achieve at higher temperature and these reactions are necessary to give new properties such as strength hardness, less moisture absorption.etc. to the bricks

When the temperatrue of about 1100^0C is reached, the particles of two important constituents of brick clay, namely alumina and sand bind themselves together resulting in the increases of strength and density of bricks. Further heating is not desirable and if the temperatrue is raised beyond 1100^0C a great amount of fusible glassy mass is formed and the bricks are said to be vitrified. The bricks begin to loose their shape beyond a certain limit of vitrification.

The burning of bricks, is done either in clamps or in kilns the clamps are temporary structures and they are adopted to manufacture bricks on a small scale to serve a local demand or a specific purpose. The kilns are permanent structure and they are adopted to manufacture bricks on a large scale.

Clamps : A typical clamp is shown in fig 4 following procedure is adopted in its construcion.

Fig 4



A piece of ground is selected its shape in plan is generally trapezoidal. The floor of clamp is prepared in such a way that short end is slightly in the excavation and wider end is raised at an angle of about 15^0 from ground level.

The brick wall in mud is construced on the short end and a layer of fuel is laid on the prepared floor. The fuel may consists of grass, cow dung, litter, husks of rice or ground nuts, etc. The thickness of this layer is about 70 cm to 80cm. The wood or coal dust may also be used as fuel.

A layer consisting of 4 or 5 courses of raw bricks, is then put up. The bricks are laid on edges with small spaces between them for the circulation of air.

A second layer of fuel is then placed and over it another layer of raw bricks is put up. Thus alternate layers of fuel and raw bricks are formed. The thickness of fuel layer gradually decreases as the height of clamp increases.

The total height of a clamp is about 3m to 4m . When nearly one-third height is reached the lower portion of the clamp is ignited. The object for such an action is to burn the bricks in lower part when the constvection of upper part of clamp is in progress.

When clamp is completely constructed it is plastered with mud on sides and top and filled with earth to prevent the escape of heat. If there is any sudden and violent outbursts of fire, it is put down by throwing earth or ashes.

The clamp is allowed to burn for a period of about one to two months.

It is then allowed to cool for more or less the same period as buring

The burnt bricks are then taken out from the clamp.

Advantages of clamp buring

The advantages of clamp burning are as follows:

The burning and cooling of bricks are gradual in clamps. Hence the bricks produced are tough and strong.

The buring of bricks by clamp proves to be cheap and Economical no skilled labour and supervision are required for the construciton and working of clamps.

The clamp is liable to damage/affected from high wind or rain.

There is consisderable saving of fuel.

Disadvantage of clamp burning

Following are the disadvantags of clamp buring

The bricksa are not of regular shape. This may be due to settlements of bricks when fuel near bottom is burnt and turned to ashes

It is very slow process

It is not possible to regulate fire in a clamp once it starts burning and the bricks are liable to uneven buring

The quality of bricks is not uniform. The bricks near the bottom are overburnt and those near sides and top are underburnt

Kilns: A kiln is large oven which is used to burn brick. The kilns which are used in the manufacture of bricks are of the following two types

Intermittent kilns

Continuous kilns

Intermittent kilns : These kilns are intermittent in operation which means that they are loaded, fired, cooled and unloaded. Such kilns may be either rectangular or circular in plan. They may be overgound or underground. They are classified in two ways:

Intermittent up draught kilns

Intermittent down-draught kilns

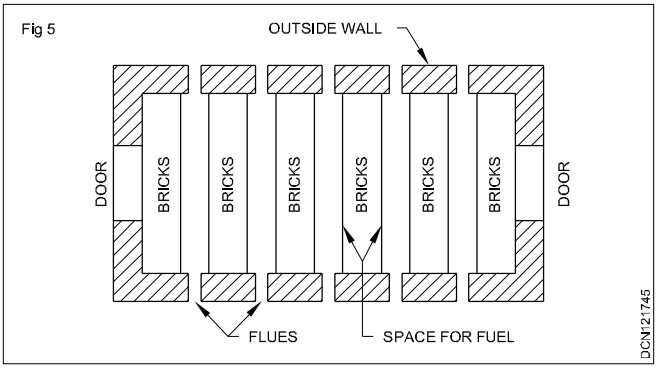
Intermittent up draught kilns : These kilns are in the form of rectangular structures with thick outside walls. The wide doors are provided at each end for loading and unloading of kilns. The flues are channels or passages which are provided to carry flames or hot gases through the body of kiln. A temporary roof may be installed of any light material. Such roof gives protection to raw bricks from rain while they are being placed in position. This roof is to be removed when the kiln is fired. Fig-5 shows the plan of a typical intermittent up-draught kiln. The working of the kiln is as follows:

The raw bricks are laid in rows of thickness equal to 2 to 3 bricks and of height equal to 6 to 8 bricks. A space of about 2 bricks is left between adjacent rows. This space is utilized for placing fuel.

The fuels are filled with brushwood which takes up a fire easily. The interior portion is then filled with fuel of bigger size.

An arch like opening is formed by projecting 4 to 5

Fig 5



rows of bricks. The projection of each row is about 30mm to 40mm.

The loading of kiln with raw bricks is then carried out.The top course is finished with flat bricks . Other courses are formed by placing bricks-on-edge.

The end doors are built up with dry bricks and are covered with mud or clay.

The kiln is then fired. The fire can be regulated by opening or closing the iron sheet doors of the fire holes and by controlling the supply of fuel. The progress of burning at any instant can be seen through these holes. For the first three days, the firing is kept slow by proper manipulation of flues. The strong fire is maintained for a period of 48 to 60 hours. The draught rises in the upwards direction from bottom of kiln and brings about the buring of bricks.

The kiln is allowed to cool down gradually for at least 7days and the brikcs are taken out.

The procedure is then repeated for the next buring of bricks.

The bricks manufactured by the intermittent up-draught kilns are better than those prepared by clamps. But such kilns have the following disadvantags

The quality of burnt bricks is not uniform. The bricks near, bottom are overburnt and those near top are underburnt.

The supply of bricks is not continous

There is wastage of fuel heat as kiln is to be cooled down every time after burning.

Intermittent down-draught kilns: These kilns are rectangular or circular in shape. They are provided with permanent walls and closed light roof. The floor of the kiln through flues. The working of this kiln is more or less similar to the up-draught kiln. But it is so arranged in this kiln that hot gases are carried through vertical flues up to level of roof and they are then released. These hot gases move downward by the chimney draught and in doing so, they burn the bricks.

Following advantages are claimed for intermittent down-draught kilns:

The bricks are evenly burnt

The performances of this kiln is better than that of up-draught kiln.

There is close control of heat and hence, such kilns are

useful for burning structural clay tiles, terra-cotta, etc.

Continuous kilns: These kilns are continous in operation. This means that loading, firing, cooling and uploading are carried out simultaneously in these kilns. There are various types of the continuous kilns. Following three varieties of continous kilns will be discussed:

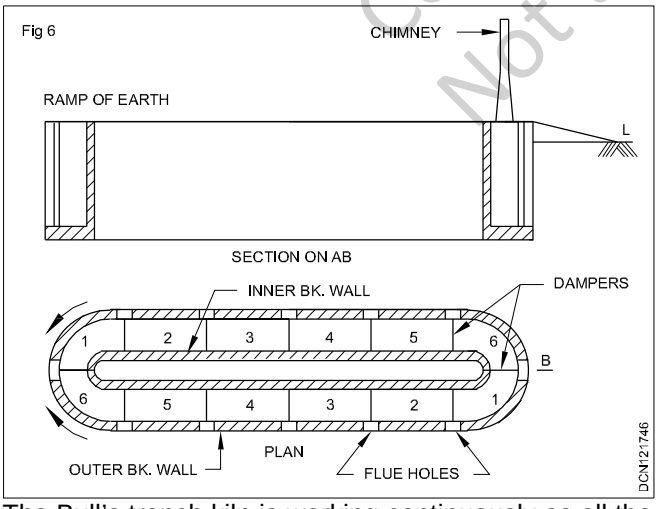
Bull's trench kiln

Hoffman's kiln

Tunnel kiln

Bull's trench kiln: This kiln may be of rectangular circular or oval shape in plan. Fig 6 shows a typical bulls kiln of oval shape in plan. As the name suggest the kiln is constructed in a trench excavated in ground. In latter case, the ramps of earth should be provided on outside walls. The outer and innner walls are to be constructed of bricks. The opening are generally provided in the outer walls to act as flue holes. The dampers are in the form of iron plates and they are used to divide the kilns in suitable sections as shown in fig 6. This is most widely used kiln in India and it gives continuously supply of bricks.

The bricks are arranged in sections. They are arranged in such a way that the flues are formed. The fuel is placed in flues and it is ignited through flue holes after covering top surfaces with earth and ashes to prevent the escape of heat. The flue holes are provided in sufficient number on top to inset fuel holes when buring is in progress. Usually two movable iron chimneys are employed to from draught. These chimneys are placed in advance of section being fired. Hence the hot gases leaving the chimneys warm up the bricks in next section. Each section requires about one day to burn. When a section has been burnt, the flue holes are closed and it is allowed to cool down gradually. The fire is advanced to next section and chimneys are moved forward as shown by arrows in Fig 6.



The Bull's trench kiln is working continuously as all the operations-loading, buring cooling and uploading are carried out simultaneously Fig 6 shows Bull's kiln with two sets of sections. Two pairs of chimneys and two gangs of workers will be required to operated this kiln. A tentative arrangements for different sections may be as follows:

Section 1 - Loading

Section 2 - Empty

Section 3 - Unloading

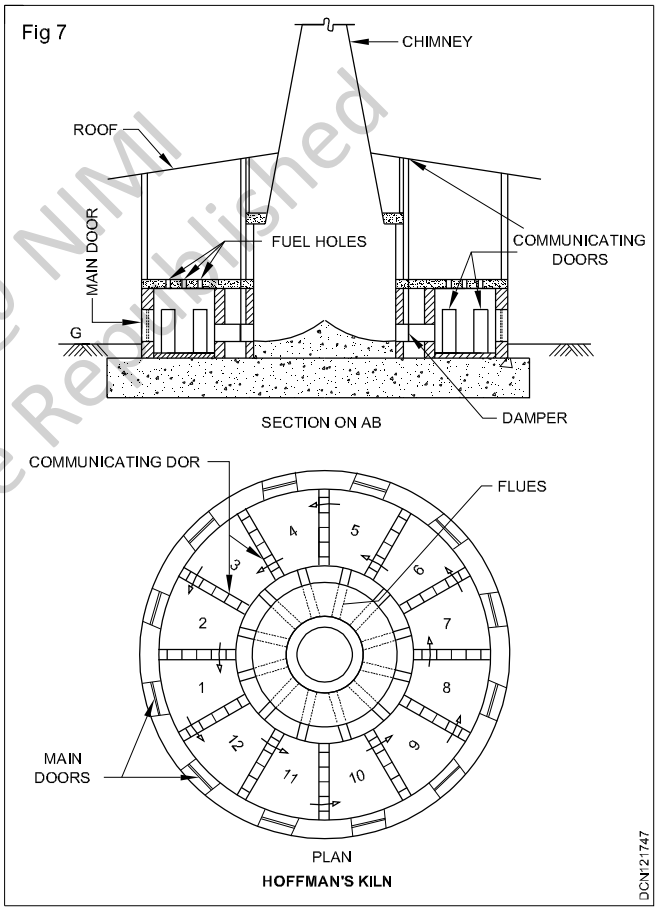
Section 4 - Cooling

Section 5 - Burning

Section 6 - Heating

Hoffman's kiln: This kiln is constructed overground and hence, it is sometimes known as flame kiln. Its shape is circular in plan and it is divided into a number of compartments or chambers. As a permanent roof is provided the kiln can even function during rainy season. Fig 7 shows plan and section of Hoffman's kiln with 12 chambers. Each chamber is provided with following:

- a maindoor for loading and unloading of bricks
- communicating doors which would act as flues in open conditions.



a radial flue connected with a central chimney and fuel holes with covers to drop fuel, which may be in the form of powdered coal, into burning chambers.

The main doors are closed by dry bricks and covered with mud, when required. For communications doors and radial flues, the dampers are provided to shut or open them. In the normal conditions, only one radial flue is connected to chimney to establish a draught.

In this type of kiln each chamber performs various functions in succession, namely loading drying burning cooling and unloading. As an illustration 12 chambers

shown in Fig 7 may be functioning as follows:

Chamber 1	-	loading
Chamber 2 to 5	-	drying and pre-heating
Chamber 6 and 7	-	Burning
Chamber 8 and 11	-	Cooling
Chamber 12	-	Unloading

With the above arrangements the circulation of the flue gas will be shown by arrows in fig 7 The cool air enters through chambers 1 and 12 as their main doors are open. After crossing the cooling chambers 8 to 11, it enters the burning section in a heated condition. It then moves to chambers 2 to 5 to dry and pre-heat the raw bricks. The damper of chamber 2 is in open condition and hence, it escapes into atmosphere through chimney.

The initial cost of installing this kiln is high: but it possesses the following advantages:

- The bricks are burnt uniformly equally and evenly. Hence the high percentage of good quality bricks can be produced
- It is possible to regulate heat inside the chambers through fuel holes.
- The supply of bricks is continous and regular because of the fact that the top of kiln is closed and it can be made to work during the entire year.
- There is considerable saving in fuel due to pre-heating of raw bricks by flue gas. Thus the hot gases are fully utilized in drying and pre-heating the raw bricks.
- There is no air pollution in the locality because the exhaust gases to not contain black smoke or coal dust particles.

Qualities of good bricks

The good brick which are to be used for construction of important engineering structure should possess the following qualities

1 Size and shape
2 Color
3 Structural
4 Hardness
5 Soundness
6 Porosity
7 Strength
8 Resistance of fire
9 Efflorescence
10 Durability

Example

1 Colour: - Uniform copper red colour.
2 Shape: - Rectangular 19 x 9 x 9 cm Standard.
3 Sound: - Sound proof, clear ringing sound when struck with each other.
4 Absorption:- It should not<20% for I Class <22% for II Class When socked in cold water for 24hrs
5 Toughness: - Should not be break when dropped from an height of 1 meter.
6 Crushing Strength: - 3-5 N/mm square. Minimum.
7 Specific gravity - 2-2.6

Classification of brick:-

The brick can broadly be dividing into two categories as following:

1 Unburnt bricks: These brick are dried with the help of sun heat only.

2 Burnt bricks: These brick are burnt clamp or kiln. They are classified into the following the four categories:-

1 **1ST Class bricks:** R.B. work, following, as blast R.C. work arches etc.
2 **2nd Class brick:** Un-important situation and for internal walls.
3 **3rd Class brick:** Temporary building
4 **4th Class brick:** Foundation and Floor etc.

Testing of bricks: Indian standards, IS: 3495-1992, 'Method of test for burnt clay bricks, Part 1 to 4' gives details of the tests, as follows:

Class designation IS:3102-1071 according to their compressive strength (N/ mm²)	**Sampling size**	**Lot size**	**Test to be made**
10	20 bricks	50,000 or more	1 com.strength 2 waterabsorption 3 efflorescence 4 dimensional test 5 hardness 6 soundness
7.5 to 3.5	20 bricks	100,00 or more	Test at the discretion of the engineer in charge.

The tests to be made on bricks, as given above, are as follows

1 **Absorption test:** To know about the amount of water absorbed of brick.

2 **Crushing strenght test:** To know about the compressive strength in brick

3 **Effloresence test:** To know about the presence of soluble salt in the brick.

4 **Hardness test:** To know the hardness of brick by figure nail.

5 **Shape and size:** To know the standard size and shape of brick.

6 **Soundness:** To know about the strength of soundness.

7. **Structure:** To know about the any hole, lumps in the brick.

Special bricks: (Fig 8)

These bricks differ from the commonly used building bricks with respect to their shape, specification and special purpose for they are made.

1 Specially shaped bricks

2 Heavy duty bricks

3 Perforated bricks

4 Burnt clay hollow bricks

5 Sand lime bricks

6 Sewer bricks

7 Acid resistant bricks

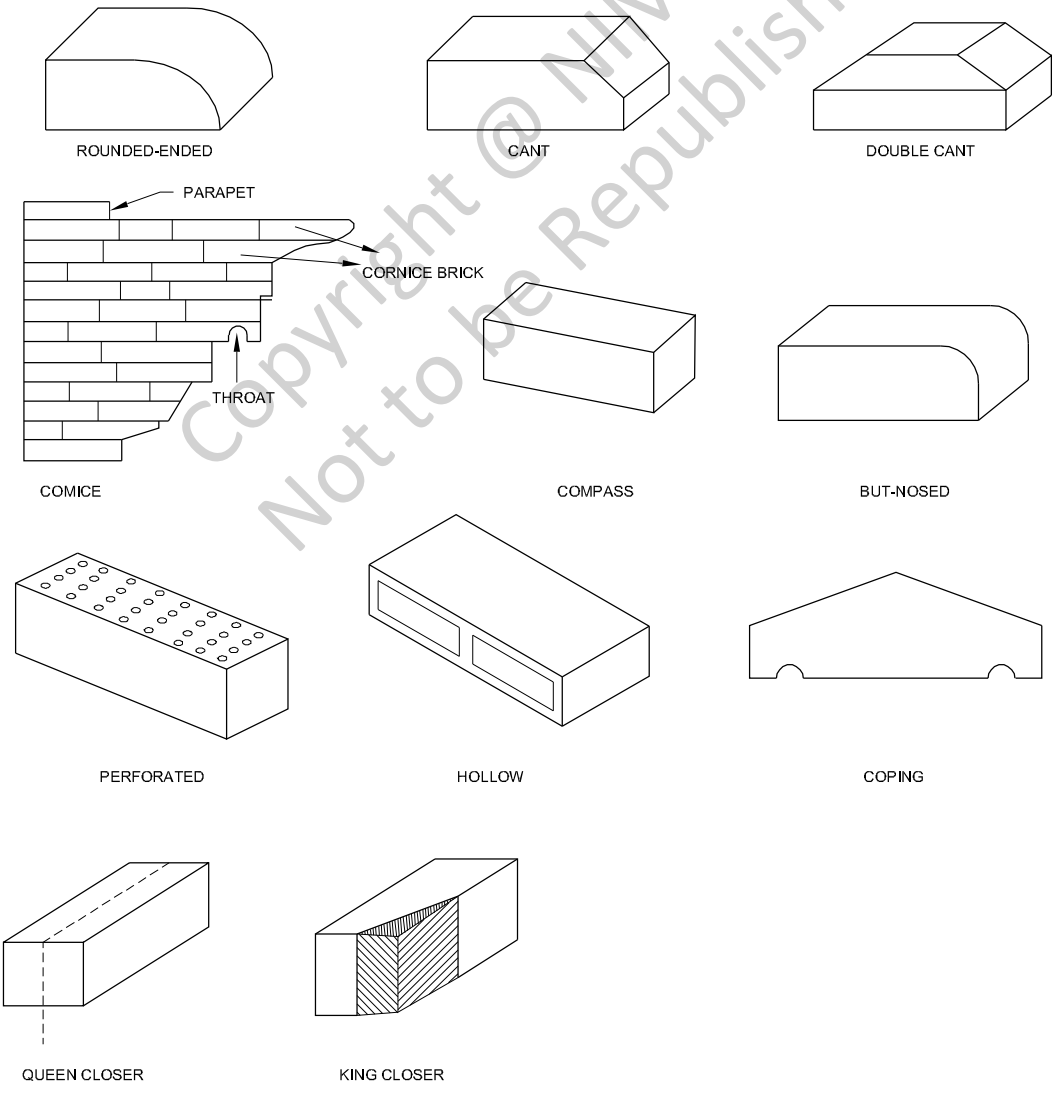
Hollow bricks

Hollow bricks are made from clay and formed with cavities which module their weight.

These bricks are used 20 mm to 25 mm thick wall. They are suitable for partition wall.

The cavity reduces the transmission of sound and hoot. The hollow bricks are machine pressed and formed cavity in the brick (Fig 8)

Fig 8



Lime

Objectives: At the end of this lesson you shall be able to
- **define lime**
- **classify lime**
- **state properties of lime**
- **describe uses of lime**
- **compare fat and hydraulic lime**
- **explain tests for lime**
- **list out the precautions in handling lime.**

Introduction

lime is produced from calcium carbonates in the form of limestone, seashells, coral, kankar, etc. quicklime is not a stable product. If it left exposed to air, it absorbs carbon dioxide from air and revert back to carbonate. Hence, quick lime should be slaked to calcium hydroxide (Hydrated or slaked lime) as early as possible to make the material stable.

Definition

A powder obtained by heating limestone, is called lime.

Classification

IS: 712-1973, classifies lime as follows:

Class a: eminently hydraulic lime, which can be used for structural works, such as arches, domes, etc.

Class b: semi-hydraulic lime which can be used for constructing masonry.

Class c: fat lime that can be used for finishing coat in plastering, white washing, etc. or used for masonry mortar with addition of pozzolanic material.

Class d: magnesium or dolomite lime is used for finishing coat in plastering and whitewashing.

Class e: Kankar lime produced by burning lime nodules (found in soils like black cotton soils contain silica) is hydraulic. It can be used for masonry mortar.

Class f: Siliceous dolomite lime is used generally for undercoat and finishing coat of plaster.

Notes:

1 Carbide lime is a by-product of manufacturing of acetylene. It can be used for mortar for plaster work, but generally it is not recommended for whitewashing un less procured fresh in the form of a paste before it dries up or is treated properly.

2 Lime containing more than30percentage impurities like clay is called poor limes.

Properties of lime

1 Easily workable.

2 Possesses good plasticity.

3 Stiffens early.

4 Provides strength to the masonry.

5 Offers good resistance to moisture.

6 An excellent cement and adheres to the masonry units perfectly

7 Lime masonry proves durable due to low shrinkage in drying.

Uses of lime

1 It is used as a matrix for concrete.

2 It is used as a binding material in mortars for stoneware and also in bedding and joining brickwork of low strength.

3 It is used for plastering walls, ceilings, etc.

4 It is employed for white washing and as a base coat for distempers.

5 It is used for knotting of timber work before painting.

6 It is used for production of artificial stone, lime - sand bricks, foam-silicate products, etc.

7 When mixed with Portland cement, the lime-cement mortar attains such valuable properties, that it replaces the costly cement plaster and serves as a plasticizer.

8 It is used as a flux in the manufacture of steel.

9 Eminently hydraulic lime can be used for masonry work below ground level.

10 It is used in the manufacture of paints.

11 It is used for stabilizing the soils.

12 It is employed for creating good sanitary conditions in foul, damp and filthy places.

Tests for lime: It can be classifies into two types- laboratory test and field test.

Laboratory tests for building lime: Indian standards specify ten laboratory tests for lime in IS: 6932-1973 'Methods of test for building lime'.

Field tests for building lime: IS: 6924-1974, gives a number of field tests for building lime, as follows:

1 Visual examination: class C lime should be pure white in colour.

2 Hydrochloric acid test: The purpose of this test is to assess the classification and calcium-carbonate content of lime.

3 Ball test: the purpose of this test is to assess the classification.

Comparison between fan lime and hydraulic limes:

S.No.	Item	Fat Lime	Hydraulic lime
1	Composition	It is obtained from comparatively pure carbonate of lime containing only 5% of clayey impurities.	It is obtained from lime stones containing to the extent of about 5 to 30 % and some amount of ferrous oxide.
2	Slaking action	It slakes vigorously. Its volume is increased to about 2 to 2 1/2 times the volume of quick lime. The slaking is accompained by sound and heat.	It slakes slowly. Its volume a slightly increased. The slaking is not accompanied by sound or heat.
3	Setting action	It sets slowly in presence of air. It absorbs carbon dioxide from atmosphere and forms atmosphere and forms calcium carbonate.	It sets under water. It combines with water and forms crystals of hydrated tri-calcium silicate.
4	Hydraulicity	It does not possess hydraulic property.	It possesses hydraulic property.
5	Colour	It is perfectly white in colour.	Its colour is not so white as fat lime.
6	Strength	It is not very strong. Hence, it cannot be used where strength is required.	It is strong and can therefore be adopted where strength is required.
7	Uses	It is used for plastering, white washing, etc. and for preparing mortar with sand or surkhi.	It is used for preparing mortar for thick walls, damp places, etc. extreme care is required to prepare mortar of this lime for plaster work.

4 **Impurity test:** the purpose of this test is to assess the quality of lime.

5 **Plasticity test:** the purpose of this test is to assess the plasticity of lime

6 **Workability test:** the purpose of this test is to assess the workability of lime.

Precautions in handling lime:

1 Contact with water: the quick lime should not be allowed to come in contact with water before slaking.

2 Facilities for workers: goggles for eyes and respirators for nose and throat protection, rubber gloves, gum boots, skin protecting cream or oil and there should be provision of adequate quantity of water.

3 Fire hazard: all suitable measures should be taken to avoid chances of any fire hazard.

Cement

Objectives: At the end of this lesson you shall be able to
- **define cement**
- **state the properties of cement**
- **explain uses of cement**
- **compare cement and lime**
- **state manufacturing of cement**
- **explain the flow diagram of the wet process of cement manufacturing**
- **describe types of cement**
- **state cement water proofer**
- **state Admixtures**
- **explain test for cement**

Introduction

cement is the most important material in building construction. This is obtained by heating a mixture of lime and clay. Cement may be prescribed as a material with adhesive and cohesive properties which must be capable of bonding mineral fragments into a compact whole. Cement may be classified as: (i) Natural Cement, (ii) Artificial Cement.

Definition

Material obtained by burning mixture of calcareous and argillaceous Materials with a small quantity of gypsum at a very high temperature and pulverized into very fine powder, known as Cement.

Properties of cement

Good cement possesses the following properties:

1 Provides strength to masonry.

2 Stiffens or hardens early.

3 Possesses good plasticity.

4 An excellent building material.

5 Easily workable.

6 Good moisture-resistant.

Uses of cement:

1 Cement mortar for masonry works, plaster, pointing, etc.

2 Concrete for laying floors, roofs and constructing lintels, beams, weather sheds, stairs, pillars, etc.

3 Construction of important engineering structures such as, bridges, culverts, dams, tunnels, storage reservoirs, light houses, docks, etc.

4 Construction of water tanks, wells, tennis courts, septic tanks, lamp posts, roads, telephone cabins, etc.

5 Making joints for drains, pipes, etc.

6 Manufacture of precast pipes, piles, garden seats, artistically design urns, flower pots, etc., dustbins, fencing posts, etc.

7 Preparation of foundations, watertight floors, footpaths, etc. The comparision between cement and lime is shown in Table - A

Manufacture of portland cement: (Fig 1 and Fig 2)

There are two processes employed,

1 Wet process- this process is generally used if the raw Materials available are soft e.g. chalk and clay.

Burning: The burning is carried out in a rotary kilin as shown in fig 1. A rotary klin is formed of steel tubes. Its diameter varies form 250 cm to 300cm. Its length varies from 90m ti 120m. It is laid at a gradien of about 1 in 25 to 1 in 30. The klin is supported at intervals by columns of massonry or concrete. The refractory lining is provided on the inside surface or rotary klin. It is so arranged that the klin rotates at about one to three revolutions per minute about its longitudinal axis.

The corrected slurry is injected at the upper end of klin. Fig 1 shows the rotary klin for the wet process. The hot gases or flames are forced through the lower end of kiln. The portion of the kiln near its upper end is known as dry zone and in this zone, the water of slurry is evaporated. As the slurry gradually descends, there is rise in temperatrue and in the next sectin of kiln, the carbon dioxide from slurry is evaporated. The small lumps, known as nodules, are formed at this stage . These nodules then gradually roll down passing through zones of risinhg temperatrue and ultimately reach to the burning zone, where temperature is about 1400^0C to 1500^0C. In burning zone, the calcined product is formed and nodules are converted into small hard dark greenish blue balls which are known as clinkers.

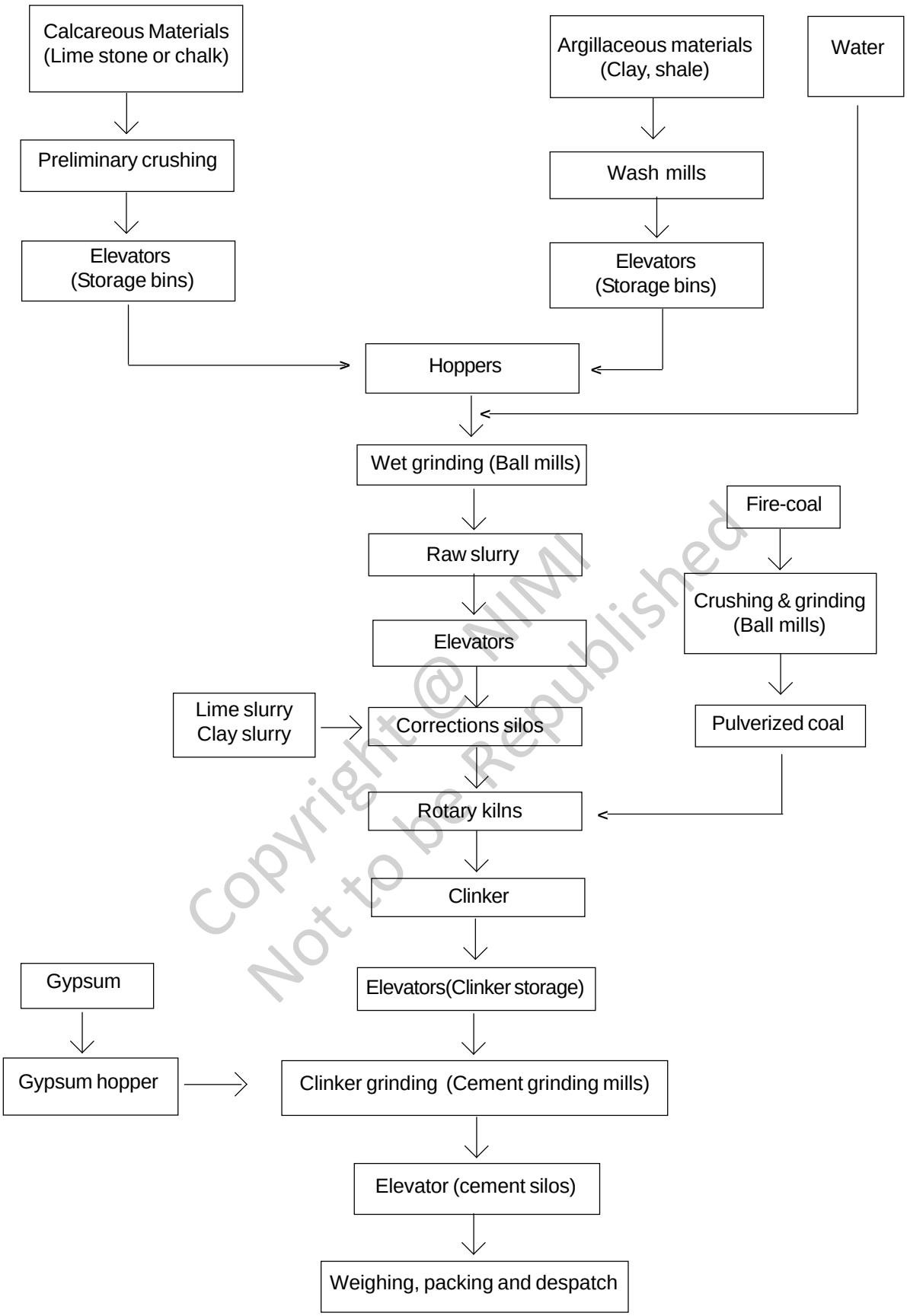
In the modern technology of dry process, the coal brought from the coal fields is pulverised in vertical coal mill and it is stored in silos. It is pumped with required quantity of air through the burners. The preheated raw Materials roll down the kiln and get heated to such an extent that the carbon dioxide is driven off with combusion gases. The material is then heated to temperature of nearly 1400^0C to 1500^0C when it gets fused together. The fused product is known as clinkers or raw cement.

Table - A

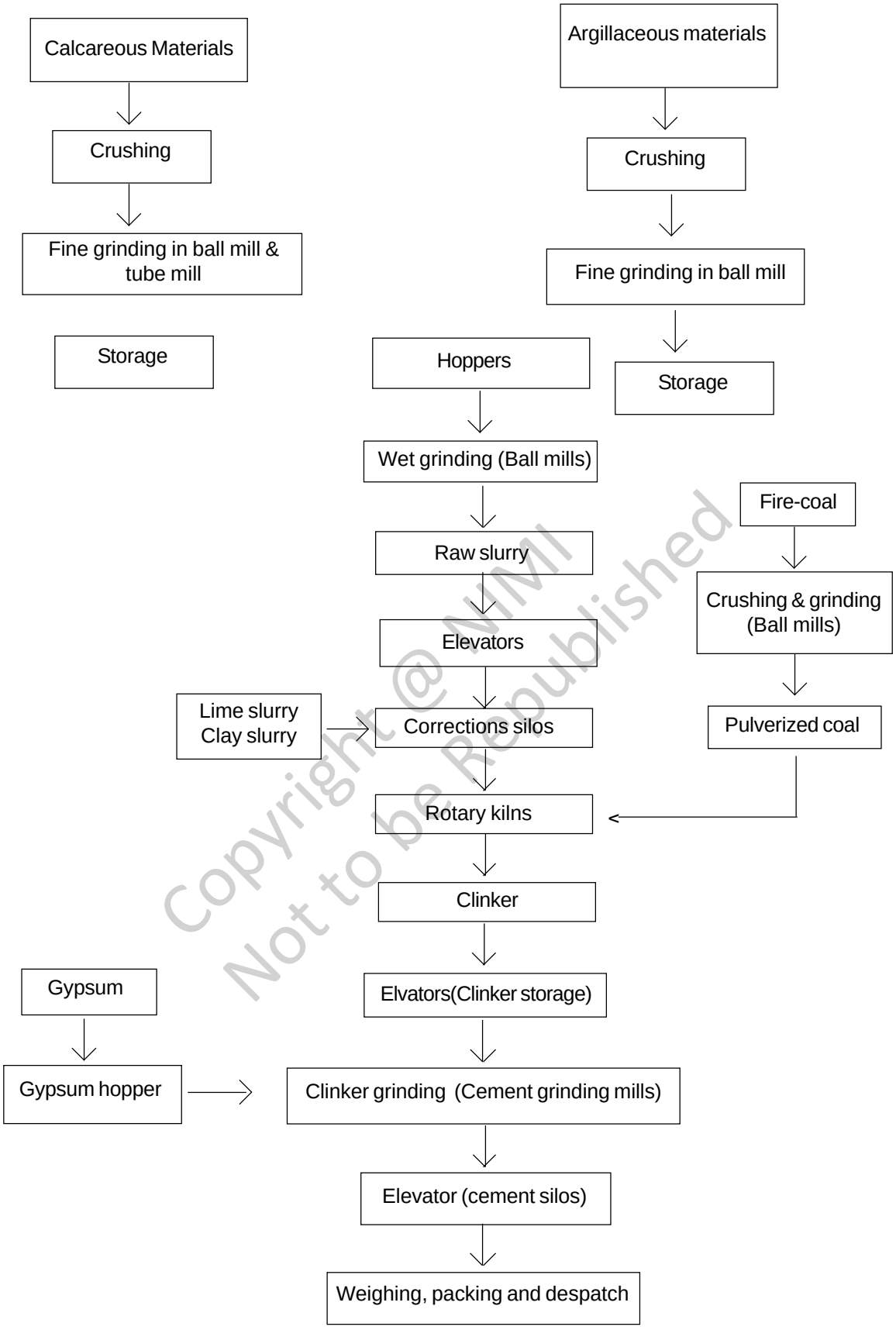
Comparison between cement and lime

S.No.	Aspects	Cement	Lime
1	Colour	Greenish grey.	White or grayish.
2	Slaking	Does not slake when wetted with water	Slakes when wetted with water
3	Setting	Sets rapidly when mixed with water	Sets slowly when mixed with water
4	Strength	Artificial cement possesses more strength	Possesses less strength.
5	Suitability	Can be used for important and heavy engineering structures	Cannot be used for important and heavy engineering structures.

FLOW DIAGRAM FOR WET PROCESS



FLOW DIAGRAM OF DRY PROCESS



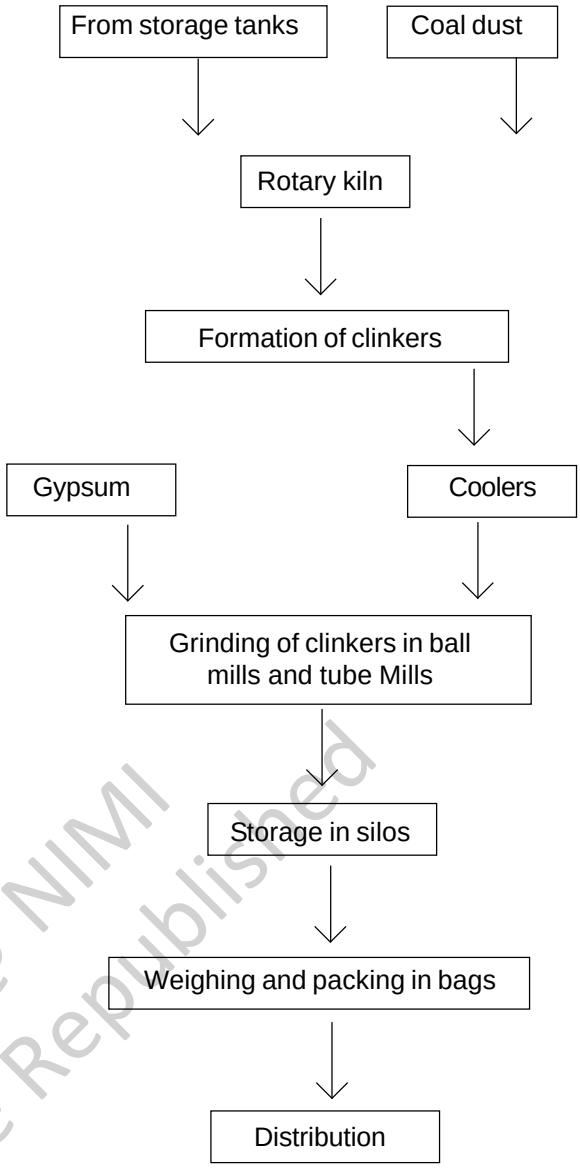
The size of clinkers varies from 3mm to 20mm and they are very hot when they come out of buring zone of kiln. The clinker temperature at the outlet of kilnis nearly 1000^0C to 1500^0C when it gets fused together. The fused product is known as clinkers or raw cement.

The size of clinkers varies from 3mm to 20mm adn they are very hot when they come out of buring zone of kiln. The clinker temperature at the outlet of kin is nearly 1000^0C. A rotary kiln of small size is provided to cool down the hot clinkers. It is laid in opposite direction as shown in Fig 1 and the cooled clinkers having temperature of about 95^0C are collected in containers of suitable sizes.

Grinding : The clinkers as obtianed from the rotary kiln are finely ground in ball mills and tube mills. During grinding a small quantity about 3 to 4 percent of gypsum is added. The gypsum controls the initial setting time of cement. If gypsum is not added,the cement would set as soon as water is added. The gypsum acts as a retarder and it delays the setting action of cement. It thus permits cement to be mixed with the aggregate and tobe placed in position.

The grinding of clinkers in modern plants is carried out in the cement mill which contains chromium steel balls of various sizes. These balls roll within the mill and grind the mixture which is collected in a hopper and taken in the bucket elevator for storage in silos. The cement from silos is fed to the packer machines. Most of the modern plants have electric packing plant having provision plan to account for the weights of empty bags of different types and to ensure a 50kg net weight of cement bag within $\pm$200g[3] limit . Each bag of cement contains 50kg or about 0.035m[3] of cement. These bags are automatically discharged from the packer to the conveyoyur belts to different loading area. They are carefully stored in a dry place Fig 1 shows the flow diagram of buring and grinding operations.

Flow diagram of burning and grinding operations of cement



Packing of cement : The packing of cement is mostly done in our country in conventional jute or gunny bags. These bags have proved to be satifactory containers as their shape and size make them convenient to handle. If the properly handled, they may make three to five trips form the factory to the cement users. However the main drawbacks of such type of packing are as follows:

At every point of handling some portion of cement contained in jute bag is wasted.

Even after emptying the cement bag, small quantity of cement remains in the bag and it is thus not possible to take advantage of the full contents of the bag.

Such type of packing leads to the air pollution.

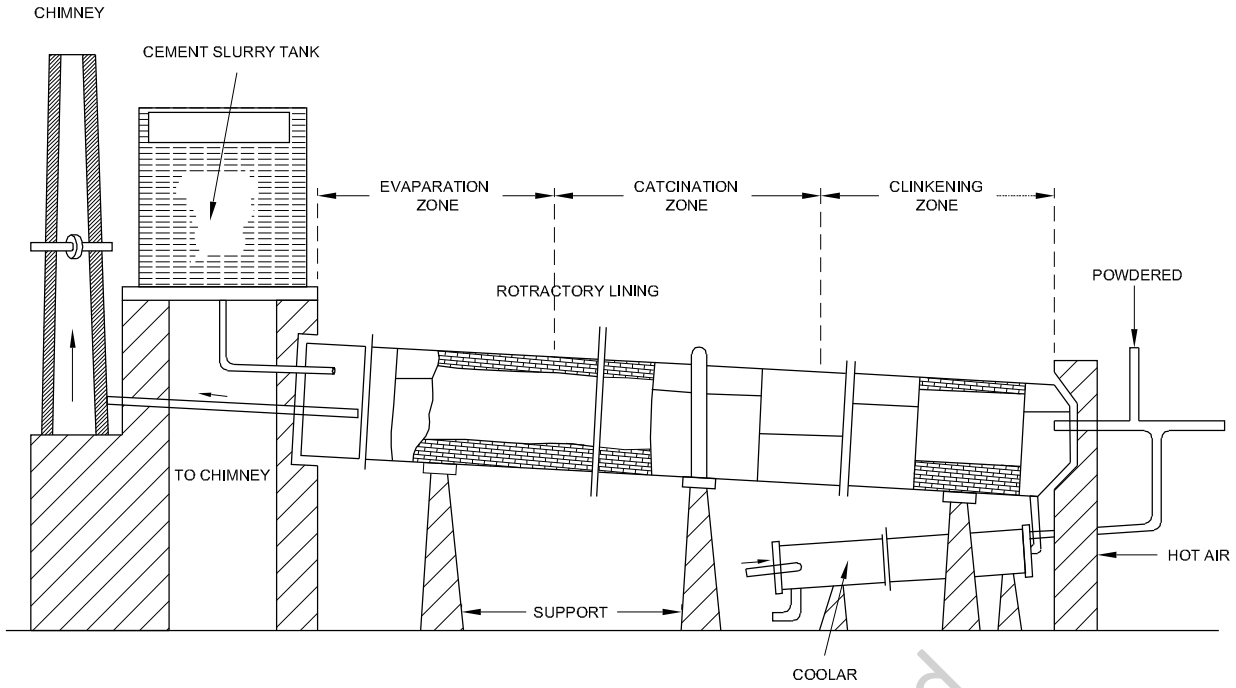
The handling of jute bags proves harmful to the healthy of labourer also as he inhales a considerable amount of cement particles during the transport of such bags.

The quality of cement is affected due to entry of moisture from the atmosphere.

Dry process : this is usually employed where the raw materials are hard such as cement rock or blast furnace slag. adopted in most of the cement industries, due to-

- For dry process the heat required per kg of clinker produced is less.
- The blending of dry powders has now perfected and the wet process which requires much higher consumption of power can be replaced with confidence.
- The application of modern technology has made the production of cement by dry process more economical and of superior quality.
- Both the processes involve the following steps:
- Collection of raw materials.
- Crushing, grinding and mixing of raw materials.
- Burning.
- Grinding of clinker.(Fig 2)

Fig 1



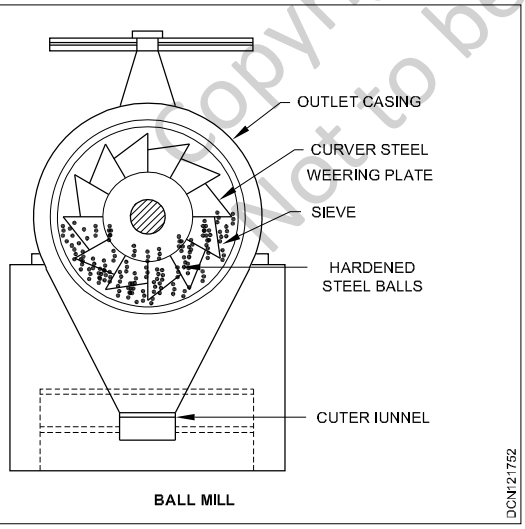
ROTART KILN

Ball mill (Fig 2)

TYPES OF CEMENT

Cement is specified by its grade (compressive strength of 1:3 cement mortars as cubes of 50 cm² areas (7.06 cm) in 28 days for defining strength) thus, Grade-33 cement (C-33) means cement with standard mortar cube strength of 33 N/ mm² in 28 days. Only the grade of the cement is marked on the bags of 50 kg.,

Fig 2



BALL MILL

The following are the IS specifications:

1. Ordinary Portland cement (OPC) in 3 grades,

a) Grade 33 - IS: 269-1989 designated as C-33,

b) Grade 43 - IS: 269-1989 designated as C-43,

c) Grade 53 - IS: 269-1989 designated as C-53

2. Portland pozzolana cement (PPC) (a mixture of OPC and Pozzolana)

a) IS: 1489 (Part-I)-1991 (fly ash -based)

b) IS: 1489 (Part-II)-1991 (calcined clay-based)

3 Sulphate-resisting cement-IS: 12330-1988

4 Portland slag cement-IS:455-1989 (PSC)

5 Low- heat cement-IS: 12600-1989

6 Rapid-hardening cement-IS:8041-1990

7 Concrete sleeper-grade cement-IS: T40-1985

8 Coloured cement-white cement-IS: 8042-1989

9 Oil well cement-IS: 8229-1986

10 Hydrophobic cement-IS: 8043-1991

11 Masonry cement-IS: 3466-1988

12 High-alumina cement-IS: 6452-1989

13 Super-sulphated cement-IS: 6909-1990

14 Expansive cement

15 Quick setting cement

CEMENT WATER PROOFERS

The water proofers are required for all water retaining structures especially for:

i) Swimming pools

ii) Basements

iii) Hospitals

iv) Refrigeration rooms

v) Cold storages

vi) Water supply and sewage works

vii) Exterior plaster

viii) Bath rooms and kitchens

ix) Reservoir

These water proofers render mortar or concrete water tight either by filling the pores physically or reacting chemically. The water proofer may be in powder, paste or liquid form. The amount to be added must be in accordance with the instructions of the manufactures; generally the following proportions are used:

" 2 to 5 %.....when in powder form

" 1part paste and 10 parts water…when in paste form

" 1 litre liquid and 15 litres water….when in liquid form

ADD MIXTURES

These are the Materials which are added in cement mortar or concrete to improve upon their quality. The admixtures serve the following purposes:

1 Improve the workability

2 Retard setting action of the mortar and concrete.

3 Increase the bond strength between reinforcement and concrete.

4 Improve the water proofing properties of the cement mortar or concrete.

5 Reduce shrinkage during setting of mortar or concrete.

6 Reduce bleeding and segregating effect of concrete.

TESTS FOR CEMENT

The properties of concrete or mortar largely depend upon the quality of cement used. The quality of cement can be tested in the laboratory by the following tests based on Indian Standard Specification (IS: 269-1958):

1 Fineness-To know the fineness of grinding.

2 Compressive strength-Cement cubes are prepared and tested after 3,7 and 28 days of curing.

3 Consistency-to know the quantity of water to be added for testing the cement for setting time, soundness and compressive strength. Vicat apparatus is used for this test.

4 Setting times-To know the initial and final setting times. Vicat apparatus is used for this purpose.

5 Soundness -To find out the presence of free lime. Le chatelier apparatus is used for this purpose.

Field tests may be carried out to ascertain roughly the quality of cement:

1 Colour-Greenish grey

2 Presence of lumps, -Pressed between the thumb and fore finger it should be powdered.

3 Rubbing-When rubbed between the fingers it should feel smooth.

4 When a hand full of cement thrown into a bucket of water it floats.

5 One should feel cold when a hand is insert in to a bag of cement.

Grades of cement

The bureau of Indian Standards has classified in three different grades

i 33 grads

ii 43 grade

iii 53 grade

The grade number indicates the compressive strength of cement sand mortar in N/mm^2 at 28 days

Properties of cement

- Provides strength to masonry
- Stiffens or hardens early
- Possesses good plasticity
- An excellent building material
- Easily workable
- Good moisture resistant

S.No.	Types	Features	Uses
1	Ordinary portland cement	General concrete structures	Medium rate of strength developed less resistance to chemcial attack
2	Acid resistant cement	Acid resistant heat resistant coating of installation of chemical industry	It cannot resist the action of water well
3	Rapid hardening portland cement	Rapid strength is developed	Curing period short, burnt at high temperature
4	Blast furnance cement	Mass concrete structure	Initial setting time not less than 30 minutes, final setting time 10 Hrs
5	Expading cement	Construction of water retaining structures repairing the damaged concrete structures	

S.No.	Types	Features	Uses
6	Coloured cement	Finishing of floors, external surface artificial marble, stair tread	By adding 5 to 15% of suitable colouring pigment before the cement is finally ground.
7	High alumina cement	For works in chemical plant and furnaces	It is completely resistant to the action of surface
8	Hydrophobic cement	Frost resistant and water resistant	Initial stage the gain in strength is less
9	Modified portland cement	Heavy construction of heavy abutment, large piers, retaining wall etc	Less heat of hydration
10	Extra rapid hardening cement	Suitable for cold weathering concrete	Qty of calcium chloride should not exceed 3 percentage
11	Sulphate resisting portland cement	Used at places where sulphate action is severe.	

Port land - pozzolana cement (IS:1489)

- This cement is made either by intergrading port land cement clinker and pozzolana or by uniformly blending port land cement and fine prozzolana.
- The pozzolana cement contain varies from 10 to 25% by weight of cement.
- Pozzolana does not possess cementing value themselves but any how the property of combining with the lime which possess cementing property.
- It free lime is removed, the pozzolana concrete have a greatly resistance to chemical agencies and also resist the sea work better than ordinary cement.
- Pozzolana cement is popularly used in the construction of dam.
- Pozzolana cement manufactured in burnt clay or shade or fly ash.

The following table shows the compressive strengths reduces by ordinary portioned cement and port land pozzolana cement.

Table

Compressive strength of port land pozzolana cement and ordinary port land cement

Age in days	Compressive strength	
	Ordinary port land cement	**Port land Pozzolana cement**
1	77 Kg/cm^2 - 8 N/mm^2	77 Kg/Cm^2 - 8 N/mm^2
3	192 Kg/cm^2 - 19 N/mm^2	165 Kg/cm^2 - 16 N/mm^2
7	256 Kg/cm^2 - 26 N/mm^2	247 Kg/cm2 - 25 N/mm^2
14	310 Kg/cm^2 - 31 N /mm^2	301 Kg/cm^2 - 30 N /mm^2
15	375 Kg/cm^2 - 38 N /mm^2	375 Kg/cm^2 - 38 N /mm^2

Projection

Objectives: At the end of this lesson you shall be able to
- **define projection**
- **classify projection**s
- **state the types of pictorial projection.**

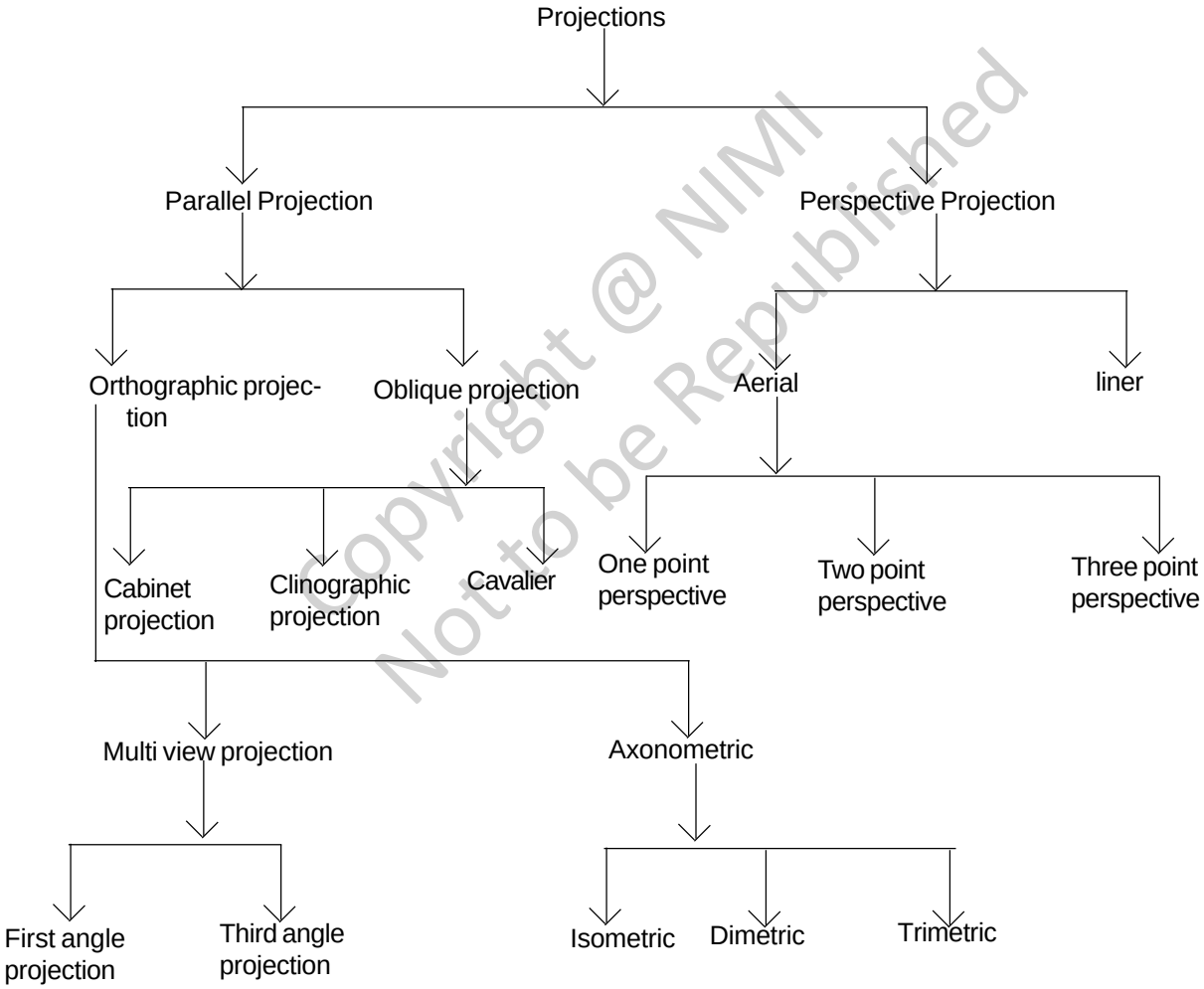
Introduction

As object, have three dimensions like length, width and height/ thickness. The shapes and sizes of three-dimensional objects have to be represented on a sheet of drawing paper, which has only two-dimensional planes.

For obtaining the image of an object, various points on the contour of an object, are thrown forward on to a plane by means of straight lines or visual rays.

The figure formed by joining various points thus obtained on the plane, is the image of the object and is called Projection.

Classification of projections



Pictorial projection

It is used for easy understanding of the drawing and visualizing the object for the persons without technical knowledge. These drawings create three dimensional effect and they reveal the shape of an object, approximately, when an observer, views the object.

But for orthographic projection, persons without technical knowledge cannot understand easily, hence, trainee shall develop the ability to convert orthographic views into pictorial views.

Isometric projection

Isometric projection is a type of pictorial projection in which the three dimensions of solid are not only shown in one

view but their actual sizes can be measured directly from it. In isometric projection, there are three principle axes such as height axis, length axis and width axis. Three axis of the object are equally inclined 120^0 to each other and the three dimensions length, height and width are equally fore-shortened by using an isometric scale.

Important points for isometric drawings

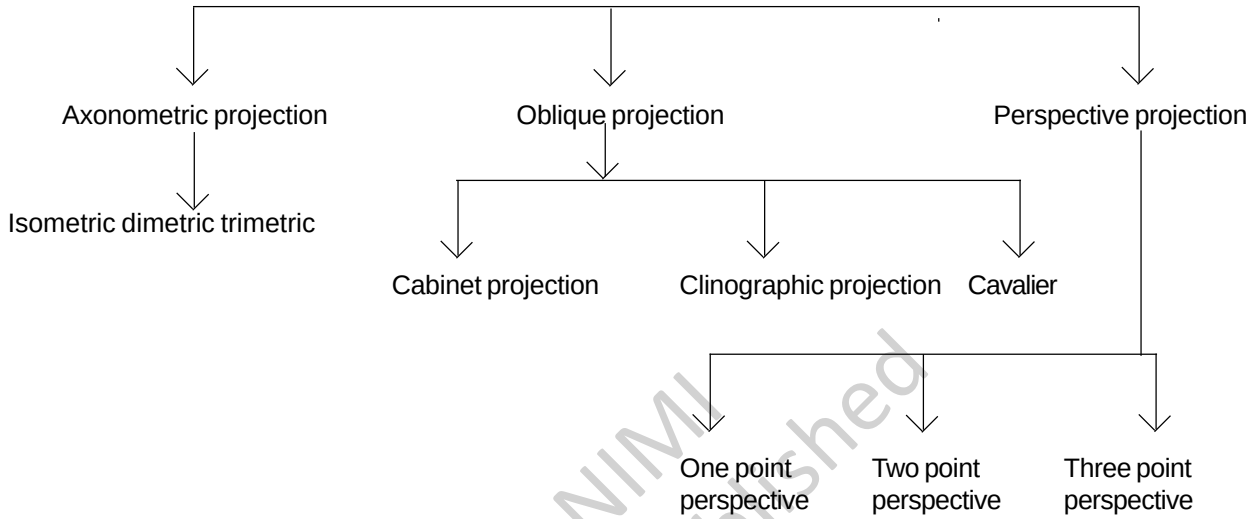
1 In isometric view, the two sides are inclined at 30^0 to the height axis.

2 The length may be drawn on the right or left depending on the side view of the orthographic projection of the object.

3 Hidden features are not to be shown in isometric views.

4 Vertical lines will be drawn vertical, while horizontal line will be drawn at a angle 30^0 to horizontal.

Types of pictorial drawings



Difference between Isometric view and projection

Isometric View	Isometric projection
Draw to actual scale	Draw to isometric scale.
When lines are drawn parallel to isometric axes, the true lengths are laid off.	When lines are drawn parallel to isometric axes, the lengths are foreshort -ened to 0.82 times the actual lengths.

Oblique projection

Pictorial projections are becoming more popular due to use of a computer in a modern drawing, dimensional object on the projection plane by one view only. This type of drawing is useful for marking an assembly of an object and provides directly a production drawing (working drawing) of the object for the manufacturing purpose.

Definition

When an observer looks towards an object from infinity the line of sight (projectors) will be parallel to each other and inclined to the plane of projection.

Types of the oblique projection

1 Cavalier projection.

2 Cabinet projection.

1 The oblique projection is based on scales by which the receding lines are drawn.

2 When the receding lines are drawn to full size scale and the projection inclined at an angle of $30^0, 45^0, 60^0$ to the plane of projection. Such oblique projection is known as cavalier projection.The inclined lines in an oblique projection are called receding lines.

3 If the receding lines are drawn to half size scale such oblique projection is known as the cabinet projection.

The difference between the Oblique and Isometric Projections

Sl.No.	Oblique Projection	Isometric Projection
1	Projectors from an object are parallel to each other and incline to the plane of projection.	Projector from an object are parallel to each other and perpendicular to the plane of the picture.
2	The object is placed in such a way that one of its prominent faces remains parallel to the Plane of projection.	The rest on one of its Faces. The object is kept in such way that its three mutual perpendicular edges (axes)make equal angles with the plane of the Projection. The object stands on one of its Corners.

Sl.No.	Oblique Projection	Isometric Projection
3	The object is drawn with the actual Dimensions.	The object is drawn with the reduced (About 82%) dimensions.
4	The faces of object which are perpendicular to the plane of the projection will be Distorted in the shape and size.	All the faces of the object distorted in the Shape and size.
5	The choice of position of the object.	The choice of position of the object is not possible.

Orthographic projection

If the projections from the object are perpendicular to the projection plan, then such a projection of the object is known as Orthographic Projection. A thorough knowledge of the principles of pictorial projection is required for converting pictorial views into orthographic views.

General Procedure

1 Determine the overall dimensions of the given object for the required orthographic views.

2 Draw rectangles for the views using suitable scale. It is also required to keep sufficient space between the views and from border lines.

3 Draw centre lines for circles and arcs.

4 Draw circles and arcs of circles first, next draw straight lines for the main shapes of the object.

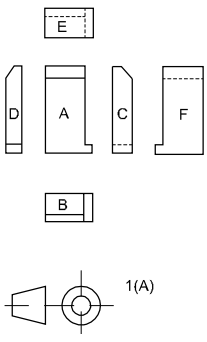
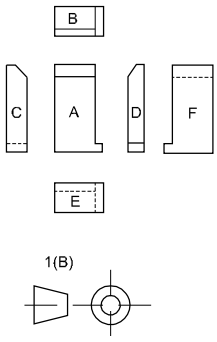
5 And finally draw straight lines and small curves for the minor details of the object.

Points to be considered for converting a pictorial view in to orthographic views

- Dimensions which are parallel to the direction of viewing will not be seen. Edges which are parallel to the direction of viewing are seen as points. Surfaces which are parallel to it are seen as lines.
- The visible edges and the intersection if the surfaces are shown by object lines. But the hidden edges are shown by dotted lines.
- The centre linens of the symmetrical parts like whole cylinder etc. should be clearly shown.

System of orthographic projection

Orthographic views can be obtained by two methods:

First Angle projection	Third angle projection
Arrangement of views in first Angle projection.	Arrangement of views in Third Angle Projection.
With reference to the front view the other arranged as follows:	With reference to the front view the other arranged as follows:
	
The view from above is placed underneath	The view from above is placed above.
The view from below is placed above.	The view from below is placed underneath
The view from the left is placed on the right.	The view from the right is placed on the right.
The view from the right is placed on the left.	The view from the left is placed on the left.
The view from the rear may be placed on the left or on the right as may be found convenient .	The view from the rear may be placed on the left or on the right as may be found convenient .
The distinctive symbol of this projection is Fig 1a	The distinctive symbol of this projection is Fig 1b

- When a hole or a cylindrical part in seen as a circle draw two centre lines intersecting each Other at right angles at its centre line for its axis.
- When a centre line coincides with a visible edge it is drawn as a dotted line.
- When a hidden edge coincides with a visible edge, it is drawn an object line (visible out line)

First angle projection

- When the object is placed in 1st quadrant such that it is between the projection plane and the observer, the projection so obtained is called first angle projections.

Third angle projection

- In this case, the object is placed in the 3rd quadrant and the planes of projections are in between the object and the observer.

Basic principles

- Depending upon the relative position of the object, the picture plane and the station point, the following situation may arise:
- If the picture plane is in between the object and the station point, a normal perspective is obtained.
- If the object is in between the picture plane and the station point, a larger perspective is obtained.
- If the station point is in between the object and the picture plane, the perspective is reversed.

Projection of points and lines

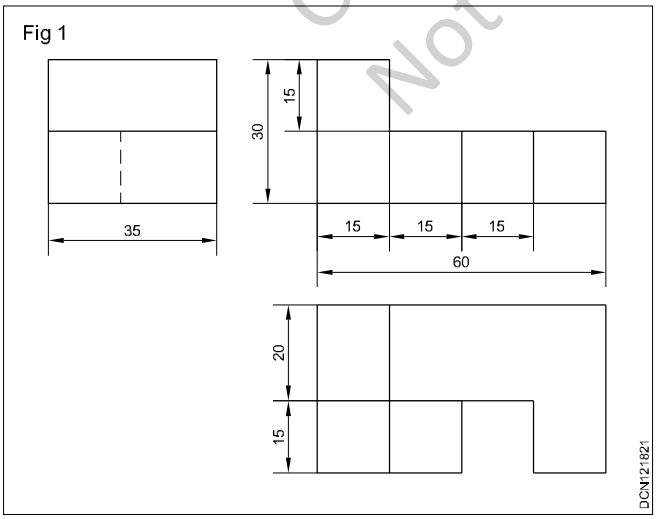
Objectives: At the end of this lesson you shall be able to
- **explain the four dihedral angles**
- **state the meaning of orthographic projection**
- **explain terms plan and elevation as applied toorthographic views**
- **state the relative position of views in first and third angle projection**
- **state the projection of lines of different orientation.**

Graphics are preferred by engineer's and craftsman to communicate their ideas. When graphics are used for communication it is called graphical language. Those who donot have the knowledge of this language are professionally illiterate.

The saying that "A picture is worth a thousand words" is very much relevant in technical work.

An engineering drawing conveys many different types of information of which the most important thing is the shape of the object. Fig 1 shows a sample drawing. In this drawing the shape of the part is represented by three views.

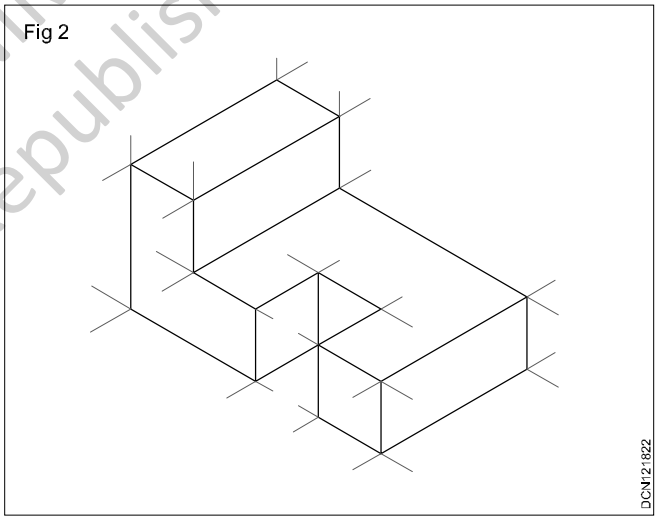
Fig 1



For an untrained person it will be very difficult to conceive the shape of the object from the above drawing.

But in Fig 2, the same object is shown pictorially in a different ways and the shape is easily understood even by a layman.

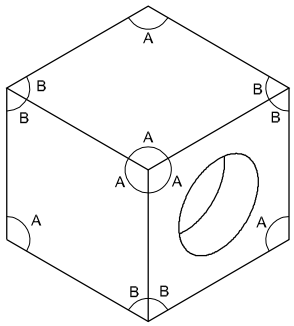
Fig 2



From Fig 1 & 2, it is clear that there are different ways of describing the shape of a part on a paper. Figure 1 is called as Multiview drawing or Orthographic drawing and the method adopted in figure 2 is called pictorial drawing. The different views in a multiview drawing are called as 'Orthographic views' or Orthographic projections.

To describe the shape of a part in engineering drawings, multiview or orthographic view method is preferred as only Orthographic view can convey the true shape of the object. Whereas in pictorial drawing through this shape is easily understood and it is distorted. To emphasise this point, see Fig 3, wherein a cube with a circular hole is represented pictorially. We know that all corners of the cube are of 90°. But in the pictorial drawing in Fig 3, the same 90° is represented at some places by acute angles and at some other places by obtuse angles.

Fig 3



A - OBTUSE ANGLES
B - ACUTE ANGLES

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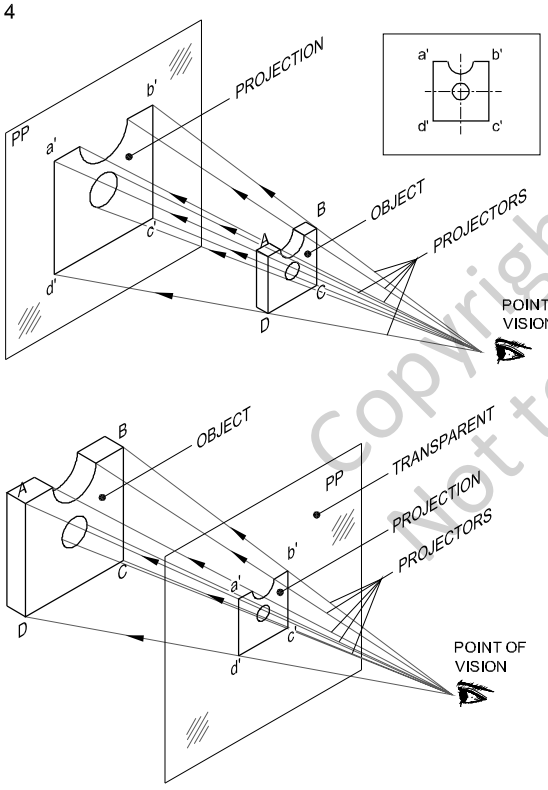
Projection: Projection is commonly used term in draughtsmans vocabulary. In the context of engineering drawing, projectors means image and it is comparable to the image formed on the retina of the eyes. (Projection can also be compared to the image of the object on the screen, where the film is projected (by the cinema projector) by the light rays.

Projection or images can also be formed inbetween the eyes and the object by keeping a transparent plane. (Fig 4)

Fig 4



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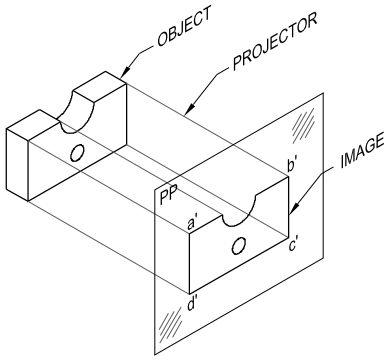
In this figure 4 the rays from the object converge to the eyes and this image (Projection) is smaller than the object. However if the rays are parallel as in the case of rays coming from the sun, the image (Projection) will be of the same size as that of the objects. Such a projection is called orthographic projection. The parallel lines/rays drawn from the object are called projectors and the plane on which image is formed is called plane of projection. In orthographic projection, the projectors are perpendicular to the plane of projection. (Fig 5)

Fig 5



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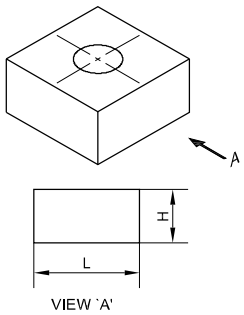
Orthographic projection: The term orthographic is projection derived from the words. Ortho means straight or at right angles and graphic means written or drawn. The projection comes from the Old Latin words PRO means forward and Jacene means to throw. The orthographic projection literally means "Throw to forward", "drawn at right angles" to the planes of projection.

An orthographic system of projection is the method of representing the exact shape and size of a three dimensional object on a drawing sheet or any other plain surface such as drawing board.

A single orthographic view of an object will show only two of its three dimensions. The view in figure 6 shows only the length and height of the object only.

Fig 6



VIEW 'A'

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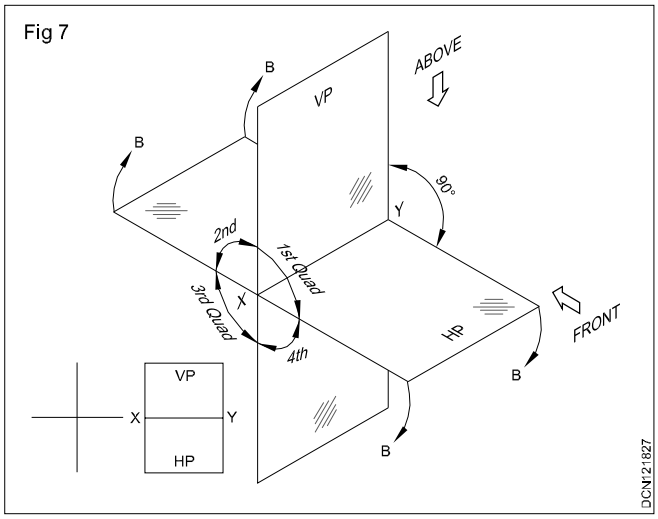
Therefore, it becomes necessary to have an additional view to show the missing dimensions (width). Therefore, we have to make two views to represent the three dimensions of an object.

The two views thus required are to be obtained on two different planes which are mutually perpendicular (one HP and one VP) with the object remaining in the same position. The projection or the view obtained on the horizontal plane is called the top view or plan and the view obtained on the vertical plane is called elevation.

First angle and third angle projection: One vertical plane (VP) and one horizontal plane (HP) intersect at right angles to each other. (Fig 7)

All the four quadrants have one HP and one VP formation. As per convention in mathematics, the quadrants are numbered as 1st, 2nd, 3rd and 4th. These four quadrants are called four dihedral angles, namely 1st angle, 2nd angle, 3rd angle and 4th angle.

Fig 7



To draw two views of an object, we assume that the object is placed in any one of the quadrant/angles, 1st angle & 3rd angle Fig 8a, 9a and its plan and elevation projected to the respective planes. Now tomake it possible to draw the two views (Plane & elevation) in one plane i.e the plane of the drawing paper, the horizontal plane is assumed to be unfolded in clockwise direction through 90° Fig 8b & 9b. We proceed this way, when the views are made. When the object is placed in the 2nd or fourth quadrant the plan and elevation will get super imposed (one up on the other) Fig 10a & b. Due to this reason the 2nd and 4th angle are not used for making engineering drawings as the three dimensions cannot be easily identified. Hence for representing the three dimension of the object, we assume the object is placed either in 1st angle or in 3rd angle. (Fig 11 & 12)

Fig 8

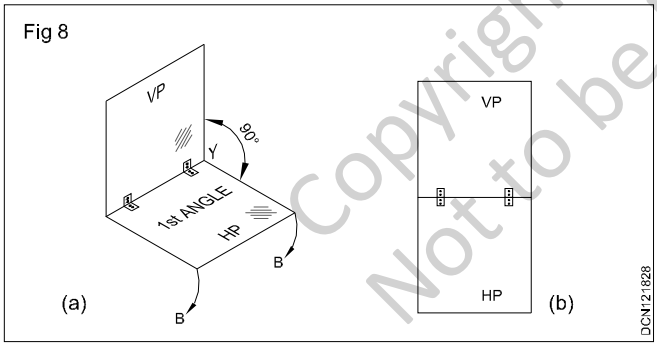
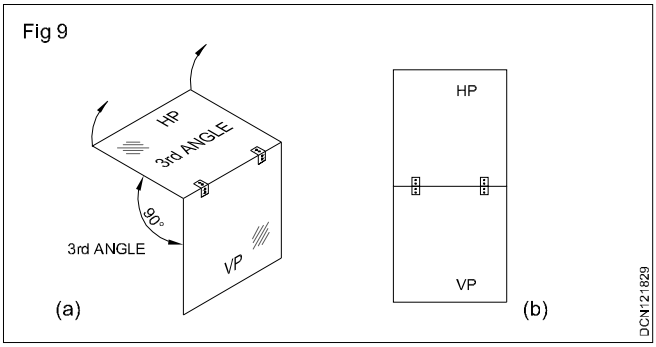


Fig 9



The placement of plan and elevation when the horizontal plane is unfolded will be different in these two systems. It may be observed in Fig 13 that in the first angle projection plan (top views) will be directly below the elevation, whereas in 3rd angle projection plan lies directly above the elevation. (Fig 14)

Fig 10

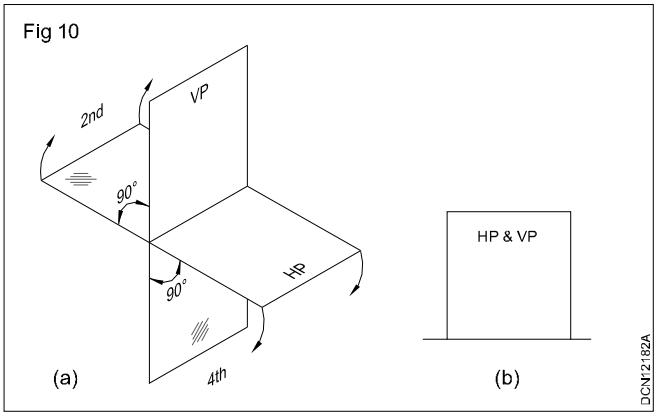


Fig 11

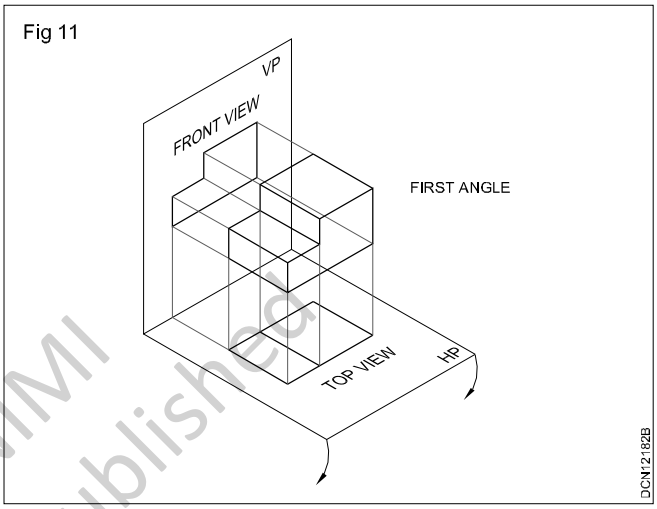


Fig 12

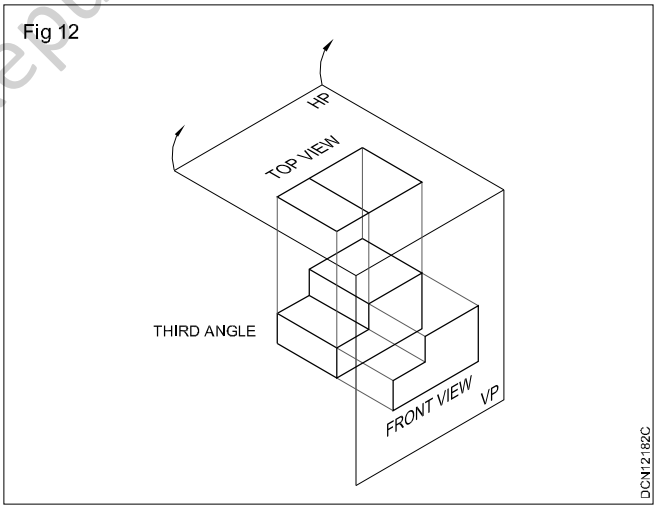
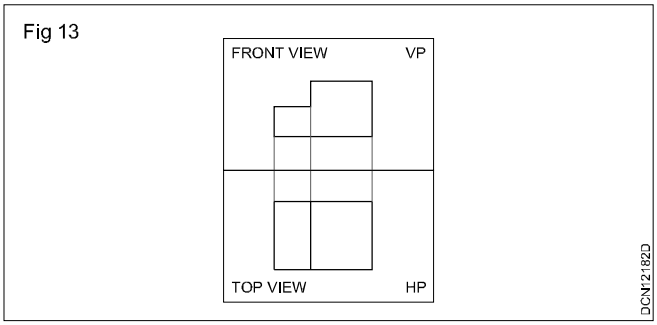
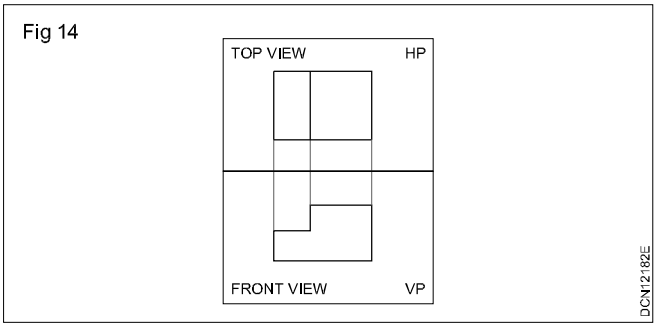


Fig 13



Views can be drawn in any one of these two methods. However Indian STandard (BIS) has recommended the first angle method to be used in our country.



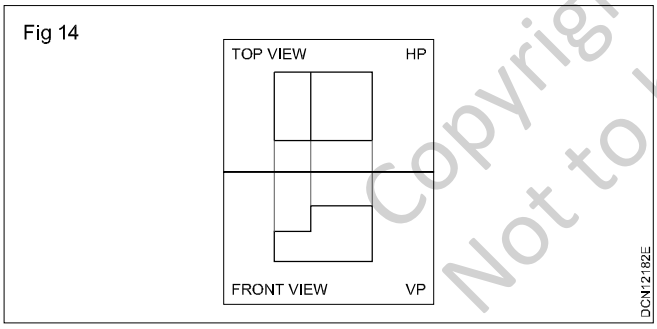
Orthographic views are drawn, based on the principle of projection. To acquire sound knowledge to make orthographic views, one has to study solid geometry which deals extensively with principle of projections. Remember that the purpose of studying solid geometry is to have clear in sight of principle of projection which is the basis of describing the shapes of solid objects on a plain paper.

Solids are made of planes and planes are made of lines and lines and made of points. Hence the solid geometry will be dealt in the order of points, lines, planes and solids.

Projection of a point: The projection of a point no matter where it is placed relative to the plane of projection will always be a point.

Figures 15 to 18 shows the projection of a point which is at a distance of 'h' and 'd' respectively from HP and VP respectively, where it is placed in 1st, 2nd, 3rd and 4th quadrant. Here, F and T are the directions of the views for projections to VP and HP.

The projectors of a point when it is placed in 1st quadrant is shown in Fig 15.



At Fig 15 (i, ii, iii), the two planes forming the quadrant are in horizontal and vertical position whereas at Fig 16, the two plans lie on the same plane. (After rotating the HP clockwise).

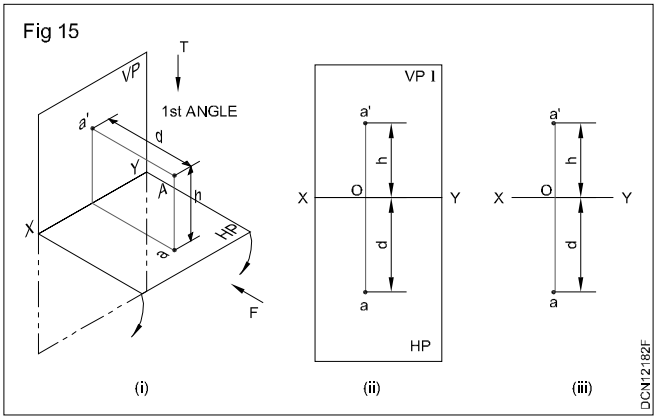
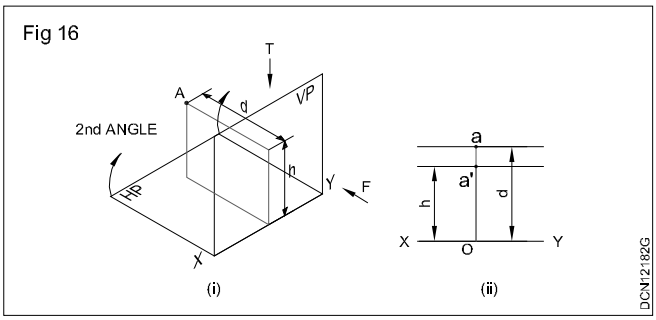


Figure 17 shows the projection of the point only as it is customary not to show the planes of projection.



The projector of the point on VP is marked as c' and the projection point on HP is marked as c. The distance 'h' and 'd' are also shown in these figures.

Marking conventions in Orthographic projections: In all the examples in plane and solid geometry the following conventions are practiced.

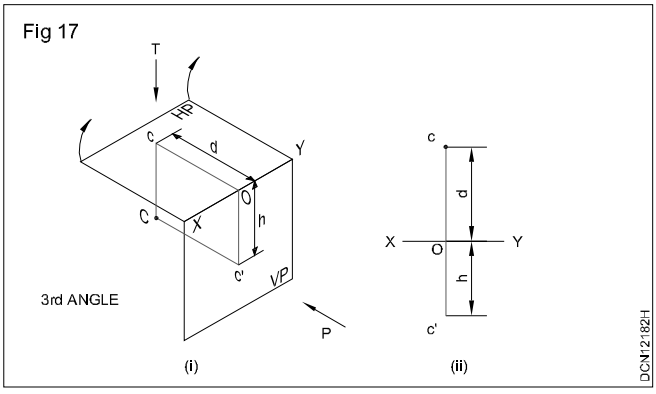
– The intersection line of VP and HP is marked as XY.

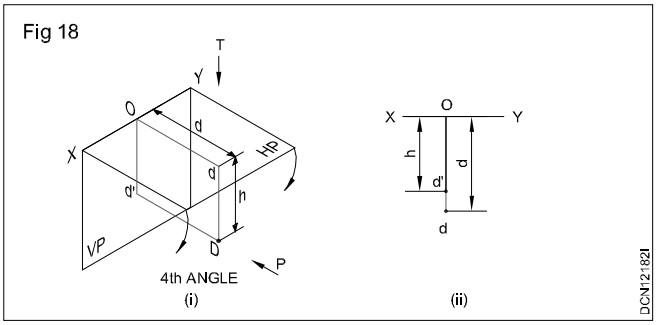
– The point to be projected is marked by capital letters and its projections are marked with corresponding small letters.

Example

In figure 15 point to be projected is marked 'A' and its projections are marked as 'a' in HP, a' and a" in VPI and VPII. In this figure VPII is not shown. Hence a" will not be seen. It may be noted that the distance a'. 0 is equal to the distance 'h' of the point from HP. Also the distance a0 is equal to the distances 'd' of the point from the vertical plane.

Projection of the points when it is placed 2nd, 3rd and 4th quadrant is shown in a similar way at i & ii in figures 16,17 & 18.

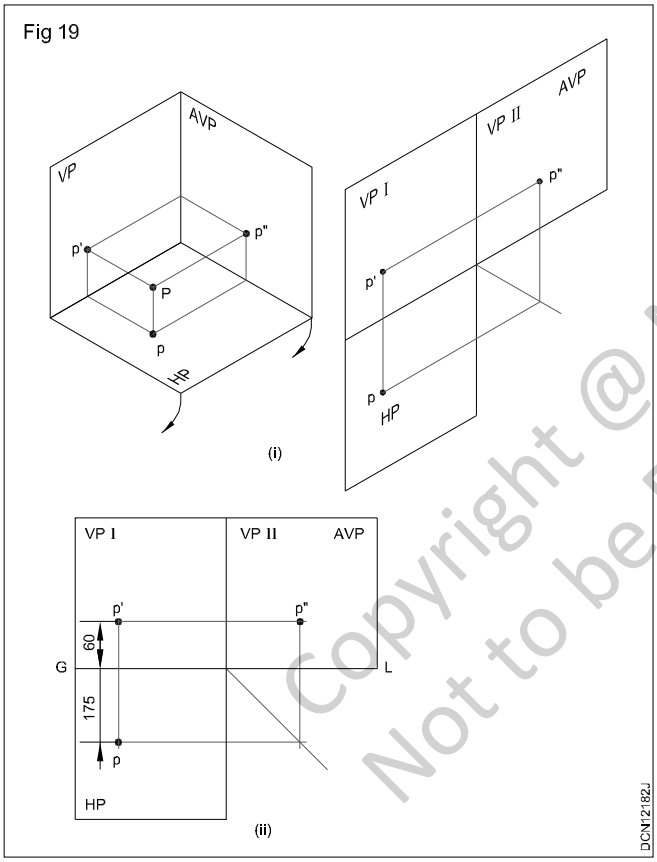




Projection on a third plane: In our study of making orthographic views, so far we had considered projection only on two mutually perpendicular (one HP and one VP) planes. Sometimes it will be necessary to have projection on additional planes also.

Figure 19 & 20 shows one more plane added to the two planes forming the first angle and third angle (first quadrant and third quadrant) and the projection of a point 'P' on all these planes. The added plane is marked as VPII. VP II and HP are rotated to lie in the same plane (Fig 19 & 20) as VPI. We know that the projection on HP is called as plan or top view and the projection on VPI is the front elevation. The third view on VPII is called side elevations while VPI and HP are called as principle planes, the additional vertical plane (VPII) is called as auxiliary vertical plane. The principle projection of a point as it is applied to a solid part is shown in Fig 21 i & ii.

Fig 19



Projection of a line: A straight line connects two points. In otherwords the line has a start point and one end point.

By projecting start point and end point as discussed earlier and joining them we get the projections of a line. However the following points should be noted as guidelines.

– If a line is parallel to the plane of projection, the projection will be of the same length as that of the line. (Fig 22)

– If a line is perpendicular to the plane of projection, it will be a point.

Fig 20

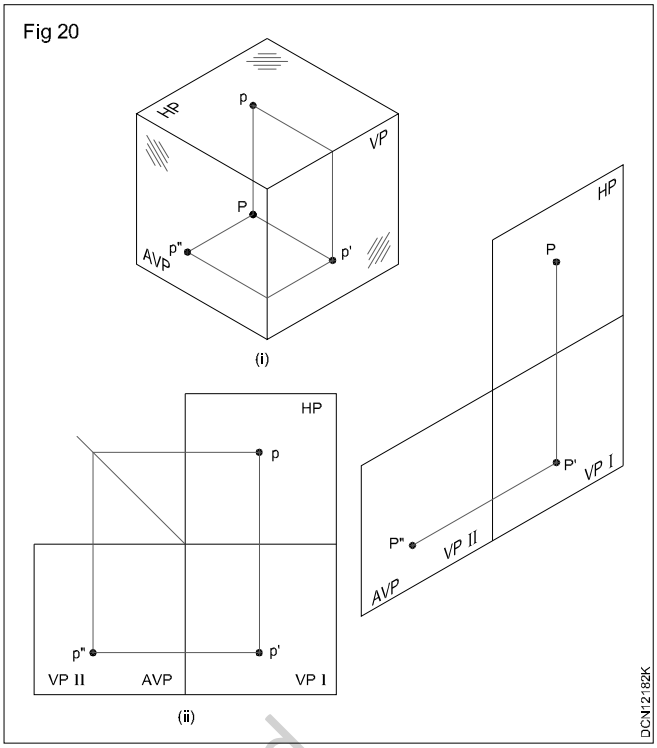
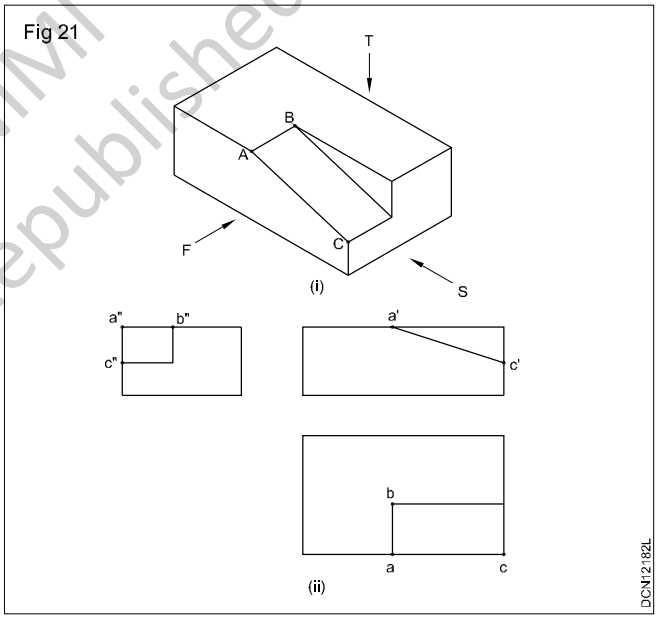
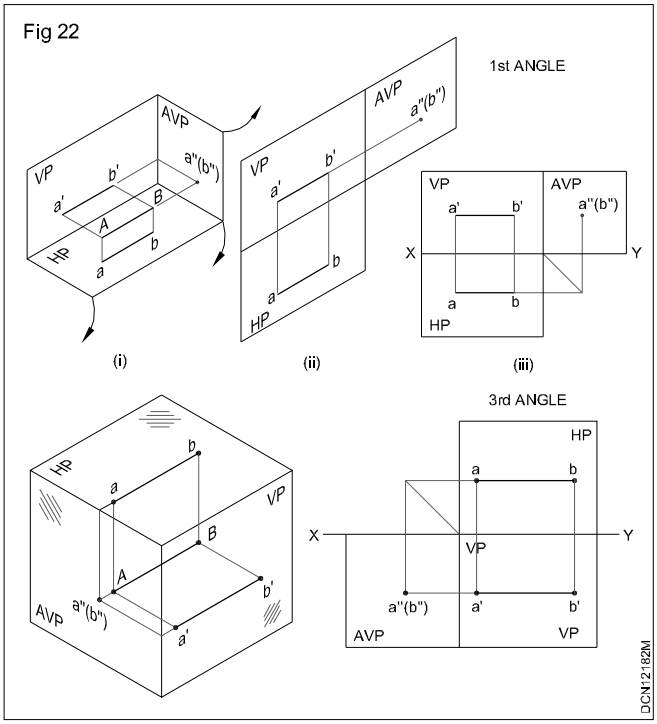


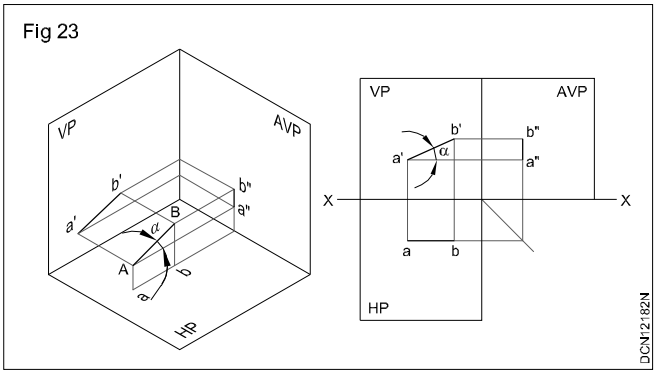
Fig 21

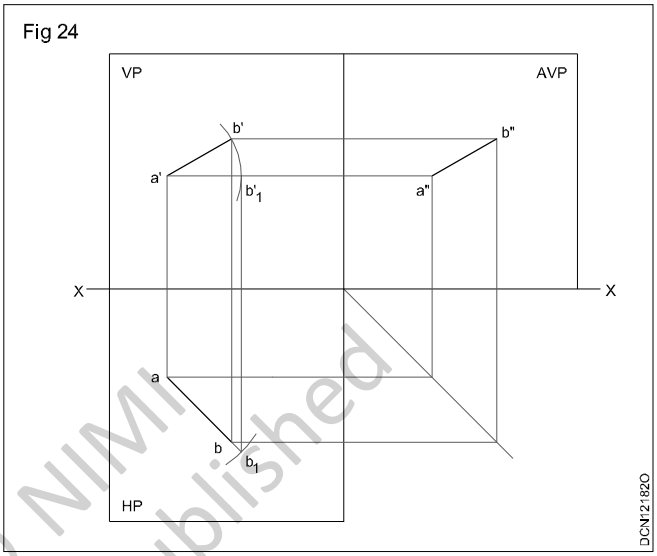


– If a line is inclined to the plane of projection, its projection is smaller in than the actual length of the line. (Fig 23)

– If the line is inclined to all the true planes i.e plane of projection (HP, VPI and VPII) its projections will be of in smaller than the actual length of the line in all the three planes. (Fig 24)







Projection of plane figures

Objectives: At the end of this lesson you shall be able to

- **distinguish between a two dimensional and a three dimensional figure**
- **identify the type of surfaces the object is composed of**
- **explain as to how the projection of a given surface will be on the different planes of projection**
- **state the meaning of the term true shape and the condition to obtain true shape and the views.**

Two dimensional and three dimensional figures: We know that solid object are enveloped by surfaces while solids are classified as three dimensional surfaces and implies volume and two dimension implies area.

When we draw orthographic views to represent solids in effect, we are drawing the projection of the solids.

Types of surfaces (Fig 1)**:** Surfaces may be flat or curved. Flat surfaces are also referred as planes. (Plain surfaces) Flat surfaces, depending on their orientation, may be vertical, horizontal or inclined. Fig 1 shows a solid and it has flat surfaces and curved surfaces. Flat surfaces are marked as F_1,F_2 etc.

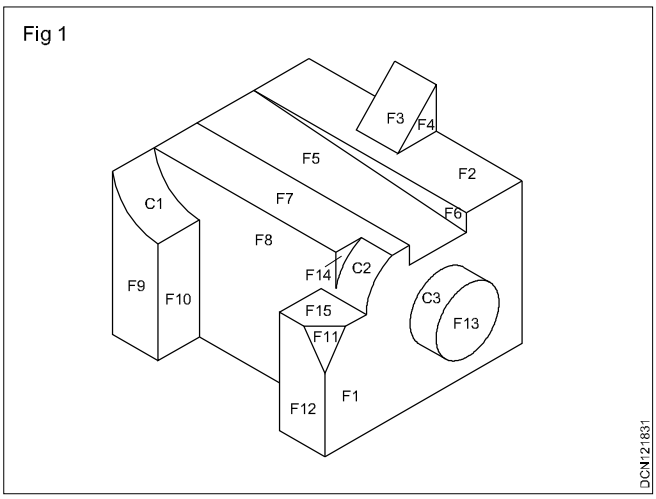
Surfaces F_1,F_4,F_6,F_8,F_9,F_{10},F_{12},F_{13} and F_{14} are vertical surfaces.

F_2, F_7 and F_{15} are the horizontal surfaces.

C_1,C_2 and C_3 are the curved surfaces.

F_3, F_5 and F_{11} are inclined or oblique surfaces or their combination.

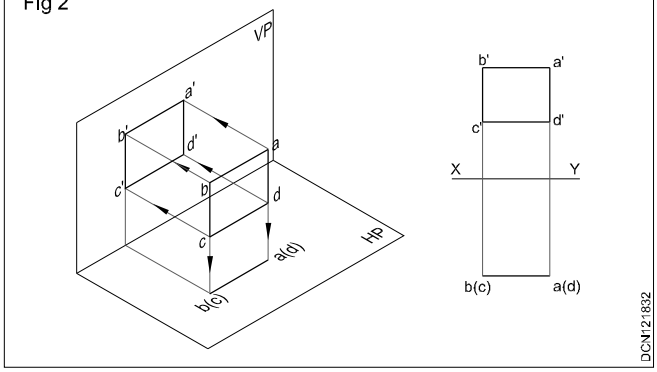
For example in F_3 is rectangular while F_{13} is circular. But surface F_1 is a combination of several plane figure.



Projection of Flat surfaces: While drawing the projection of surfaces (plane figures) the following points should be noted.

If the surface is parallel to the plane of projection, the resulting projection will be the true shape of the surface. (Fig 2)

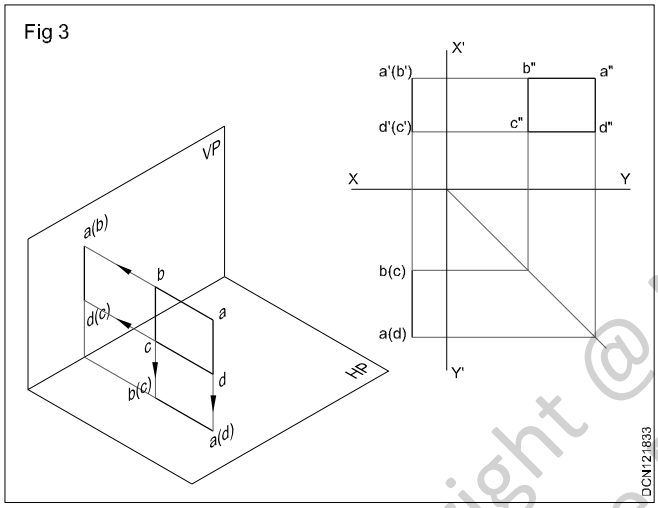
Fig 2



True shape: When the projection of a surface is identical to the surface projected, the projection is said to be of true shape.

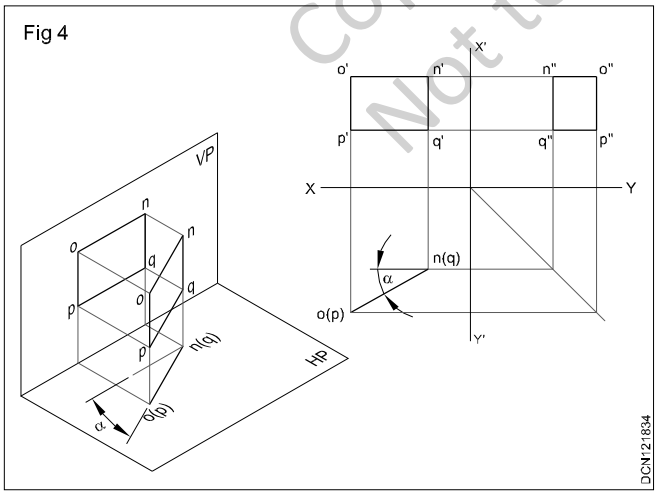
When the surface is perpendicular to the plane of projection, the resulting projection will be a straight line. (Fig 3)

Fig 3



If the surface is inclined to the plane of projection, its projection will not have the true dimensions. They are fore shortened. (Fig 4)

Fig 4



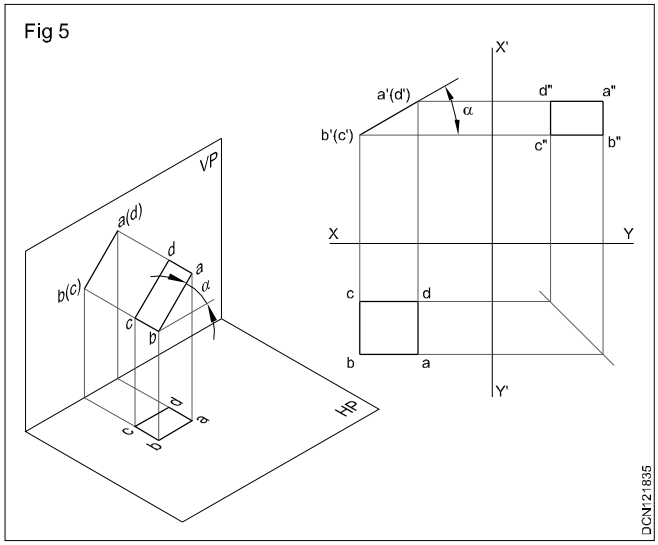
Foreshortened view: Where the projection of a surface is not identical tot he surface projected, the projection is said to be foreshortened.

In figure 4, the length pq or the length on is of true length in plan, but in front elevation and in side view same is foreshortened in a different way according to the inclination of the surface to the plane of projection.

If a surface is inclined to a vertical plane, the angle of inclination will be seen on HP and vice-versa. (Fig 4)

If a surface is inclined to horizontal plane the angle of inclination will be seen on VP and vice-versa. (Fig 5)

Fig 5

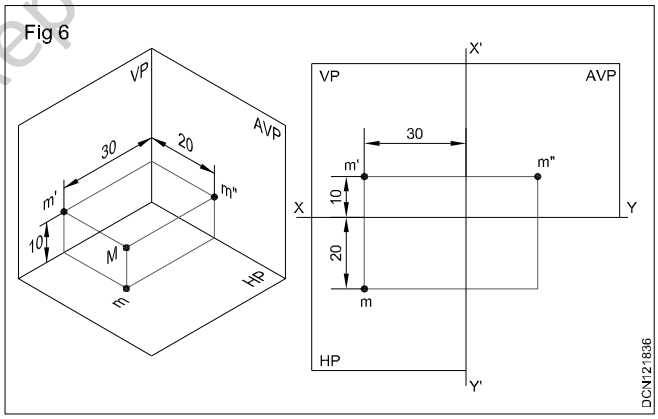


Guidelines to be followed: The intersection (folding lines) between HP and VP is marked as XY whereas the intersection between VP and AVP is marked as X'Y'.

In exercises/problems wherein the distances of the object (point, line, surface) from HP, VP and AVP are not given a convenient distances may be assumed and followed.

Terminology of views/projections: (Fig 6)

Fig 6



- The view projected on HP is termed as plan or top view.
- The view projected on VP is termed as elevation or front elevation or front view.
- The view projected on AVP is termed as side view or end view or side elevation or end elevation.

The distance from XY to a point in the plan and to the corresponding point in the side view from X_1Y_1 is equal to the distance from VP.

The distance from XY to point in the front elevation and to the corresponding point in the side view from XY is equal to the distance of the point from HP.

The distance from X_1Y_1 to a point in the front elevation and the corresponding point in the plan from X_1Y_1 is equal to the distance of the point from AVP.

The above three statements may be summerised as follows:

the distance of a point from one plane will not reflect in the projection on that plane, but it will be reflected in the projections of other planes.

This can be observed in the figure shown.

Point M is 10 mm from HP, 20 mm from VP and 30 mm from AVP.

In the figure B, the projections of point M in the three planes and distances from XY and X,Y, are marked.

Point M is really 10 mm from HP, but the distance of 10 mm is not reflected in HP. Similarly 20 mm is not reflected in VP and 30 mm is not reflected in AVP.

Distance of 10 mm from HP is reflected in front and side views.

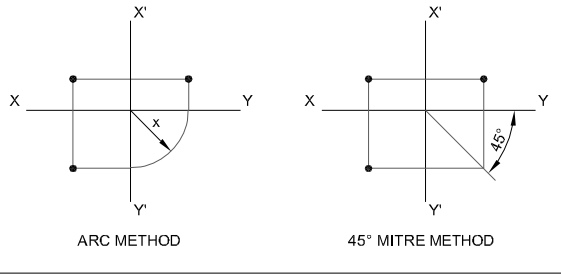
Distance 20 mm from VP is reflected in plan and side view.

Distance 30 mm from AVP is reflected in plan and front view.

If we know the projection of point in two planes, its projection to third plane can be obtained by projecting from the given/known two views and transfering distances.

For example, if you draw the front view and side view of a point (Fig 7), plan can be completed by drawing projection from the front view and side view. Transfer of distances from two views to third view may be done either by arc method or by 45° mitre line method.

Fig 7



Following standard conventional markings are to be followed for points, lines and surfaces on plan, front view and side views.

Plan	Final	just an alphabet	(a)
	1st stage		(a1)
	2nd stage		(a2)
Elevation	Final	alphabet with	(a')
	1st stage	a dash	(a1')
	2nd stage		(a2')
Side elevation	Final	alphabet with	(a")
	1st stage	two dash	(a1")
	2nd stage		(a2")

Geometrical solids

Objectives: At the end of this lesson you shall be able to
- **define various geometrical solids**
- **define solids of revolutions**
- **state the method of drawing the three views of solids in different position**
- **auxiliary view**
- **sectional views.**

Solids: Solids are the objects which have definite shape, size and occupies certain space. They have three dimensions viz., length, breadth or width and height. According to their shapes. They are classified into two groups.

– Polyhedra

– Solid of revolution

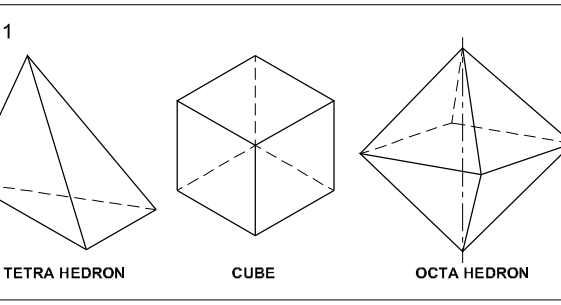
Polyhedra: are solids having (poly-many) more than thre flat surfaces called faces. The ends of surfaces meeting with each other are called edges. When the faces are identical to each other, they are called `Regular Polyhedra'. Depending on the number and shape of faces regular polyhedrons are named. Of the many regular polyhedrons three are defined below:

Tetrahedron: A solid having four equilateral triangular faces solid having least number of flat surfaces.

Cube or Hexahedron: A solid having six regular square faces.

Octahedron: A solid having eight equilateral triangular faces. (see Fig 1)

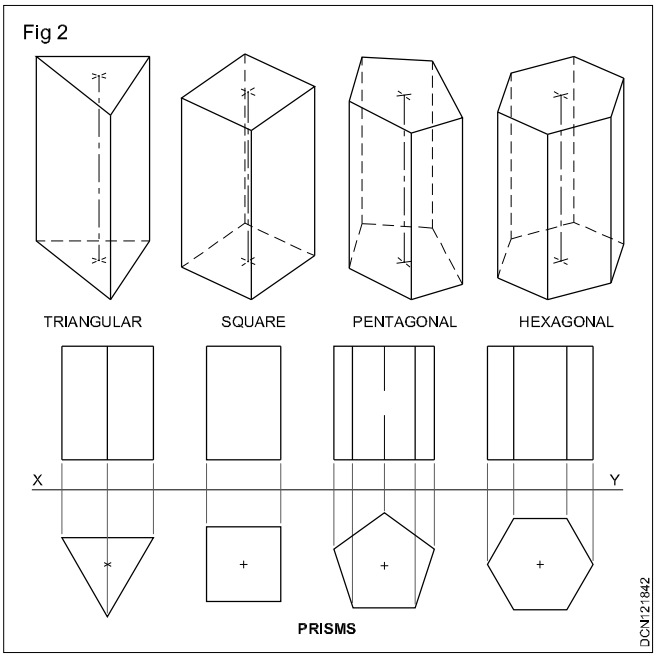
Fig 1



When solids are not composed of identical surfaces, such polyhedrons are either Prisms or Pyramids.

Prism: Prism is `Polyhedron' having two identical end faces. The top and bottom base surfaces are joined by parallelograms or rectangular surfaces. Imaginary line joining the centre of the end faces is called the axis. The axis is right angles to the end faces. Prisms are in general designated according to the shape of the end faces. Eg. Square, rectangular, triangular, hexagonal, pentagonal, octoganal (Prisms) etc. Prisms are right or oblique, the

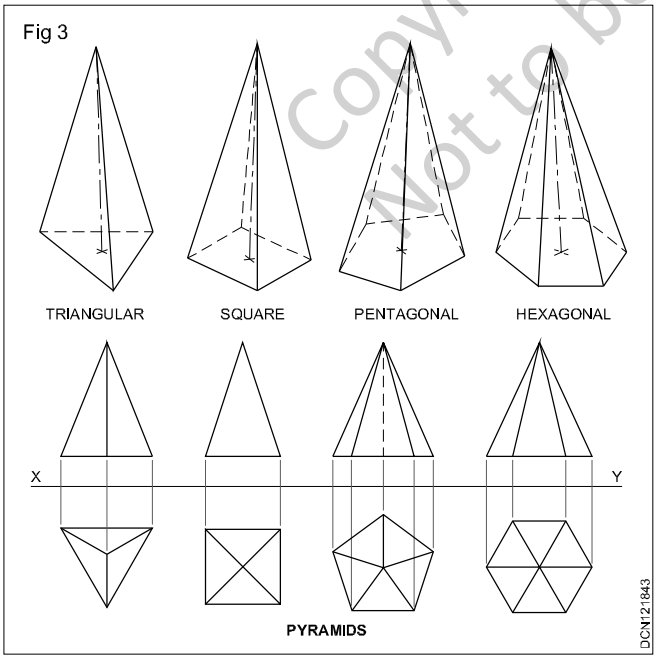
axis of regular prisms is at right angles to the face. Whereas in oblique prisms the axis is inclined to the end face. (Fig 2)



Pyramids: Pyramids are polyhedra solids having a base surface whose shape may be triangular, square or polygon and as many slant triangular faces as there are sides in the base. All the slant triangular faces join at a common point called APEX.

Similar to prisms, pyramids also are known by the shape of their base viz triangular, square, rectangular, pentagonal, hexagonal etc. The imaginary line joining the centre of the base to the apex is called the AXIS.

Fig 3 shows some pyramids and their views.



Solids of revolution: When a plane figure revolves about an axis a solid is generated.

Example

The solid shown in the Fig 4 is formed by the revolution is formed by the revolution of the plane (Fig 4a) ABC about the axis AB.

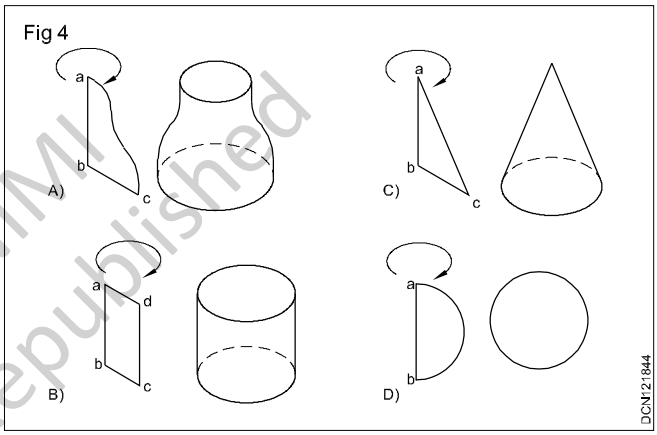
Geometrical solids like cylinder, cone and sphere are solids of revolutions.

Cylinder: When a rectangle rotates about one of its sides a cylinder is generated.

Cylinder has two flat circular faces and a curved surface. (Fig 4b)

Cone: When a right angled triangle revolves about one of its side formign the right angle, a cone is generated. Cone forming has a circular face and a slant curve surface. (Fig 4c)

Sphere: When a semi-circle revolves about its diameter a sphere is generated. A sphere has no flat surface. (Fig 4d)

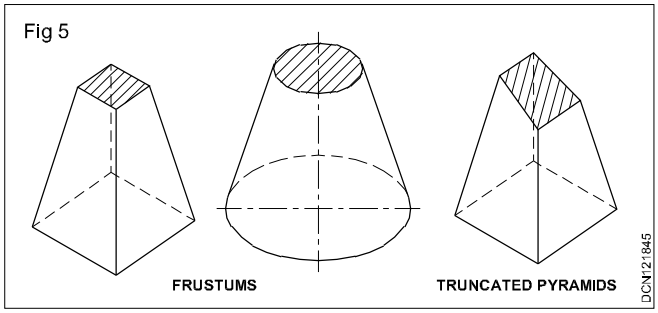


The term solids of revolution is a mathematical concept and a physical requirement in geometry.

Frustums: When the pyramids or cone are cut parallel to the base and top of remaining the pyramid or cone is removed, the parts are called frustums.

If the cutting plane is at an angle to the axis/base, of the pyramids or cone they are called "Truncated pyramids or cones".

Fig 5 shows frustums and truncated pyramids.



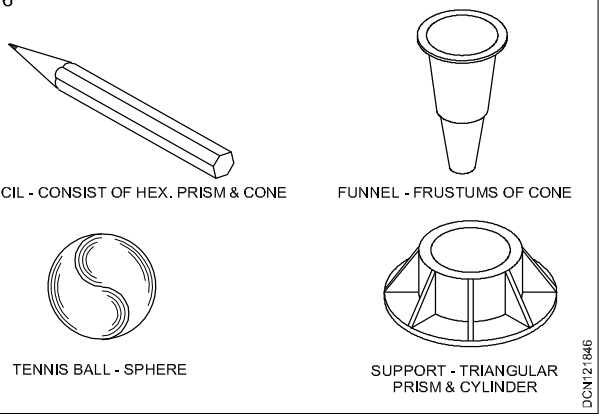
All items we use are solids. Their shapes may confirm to individual geometrical solids like prisms, cones or other combination.

Figure 6 shows some such items.

Views of solids: When dealing with projection of plane figures earlier was stated that solids are enveloped by

planes and therefore drawing the views of solids would actually mean drawing the views of planes the solids aer composed of.

Fig 6



The faces of solids which are parallel to the planes of projection will be seen in true shape in the respective planes. When planes are not parallel to the plane of projection the views will have a disorted look.

Figures 7,8,9,10,11,12 & 13 indicate the plan, elevation and end view of some solids for the position defined against each.

Fig 7

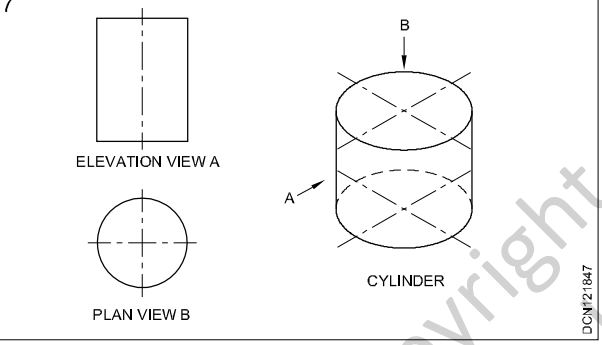


Fig 8

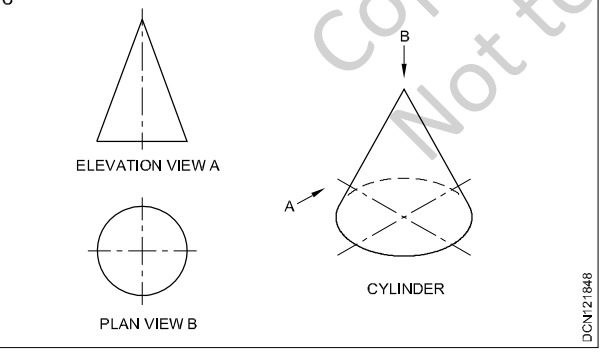


Fig 9

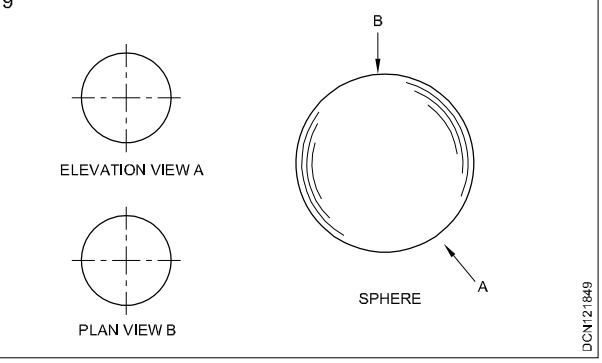


Fig 10

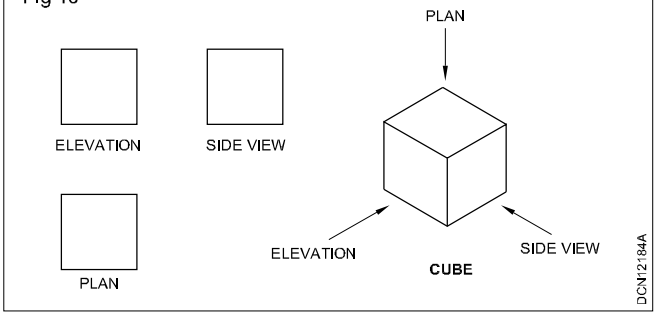


Fig 11

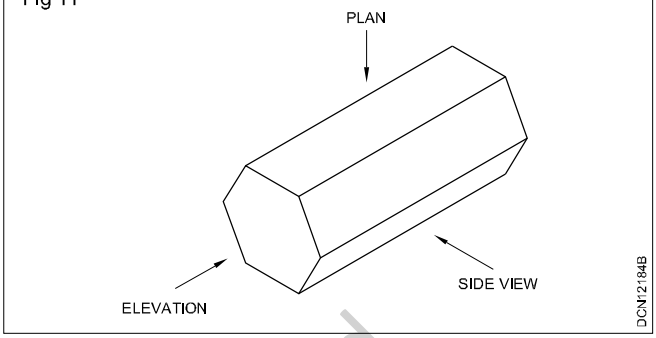


Fig 12

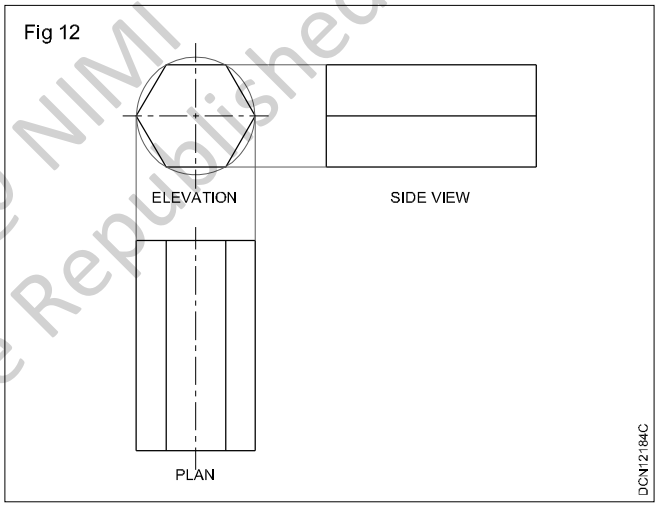
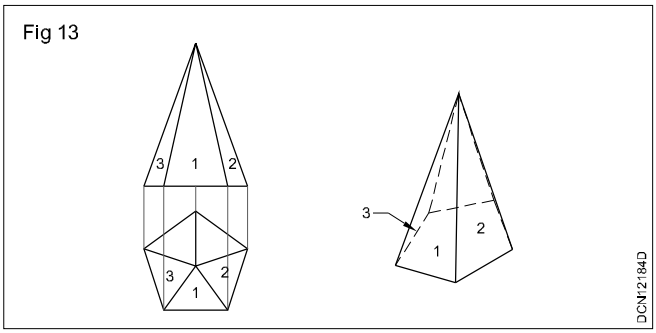


Fig 13



While drawing the views of solids all the edges of solids may not be visible in the views concerned. For example in the figure shown the edge will not be visible in the front view. Such edges ae referred as hidden or invisible edges. All visible edges in a view are drawn usually thick lines. But, invisible edges are drawn using dotted lines of medium thickness. (The thickness of dotted lines is inbetween thickness of thick lines and construction lines) Dotted lines are short dashes.

In some cases it is required to show the axis of solids. Axis is represented by another type of line called centre line.

Centre lines are thin lines consisting of alternating, alternat long and short dashes. (Figs 14,15 & 16)

Fig 14

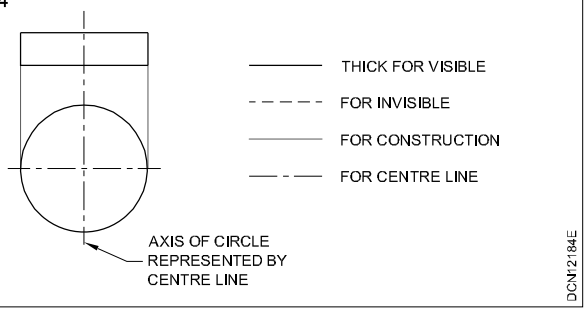


Fig 15

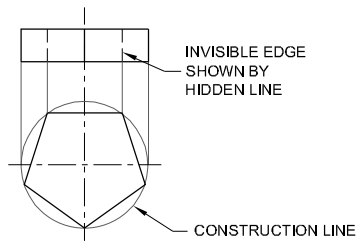
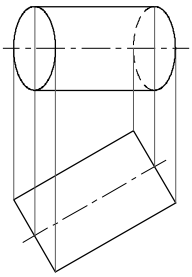


Fig 16



Pictorial projection

Objectives: At the end of this lesson you shall be able to

- **state the importance of pictorial projection**
- **list the kinds of pictorial projection**
- **describe the types of axonometric projections**
- **state what is isometric projection**
- **differentiate between isometric projection and isometric view.**

Knowledge gained so far in solid geometry will enable you to describe the shape of an object by drawing its orthographic views. Such as front view, side view, plan etc. Since all the three dimensions/faces of the object are not visible in any one single view, the shape cannot be conveived just by looking at it. To understand the shape from such views one has to analyse the views and think in 3 dimension.

Pictorial projection: It is possible to show all the 3 faces/ dimensions of an object in one view itself. Such orthographic views are called pictorial drawings or pictorial projections. To get the pictorial drawing the object (say a cube) has to stand on one corner such that 3 of its mutually perpendicular faces are inclined to the plane of projection. (Fig 1)

Fig 1

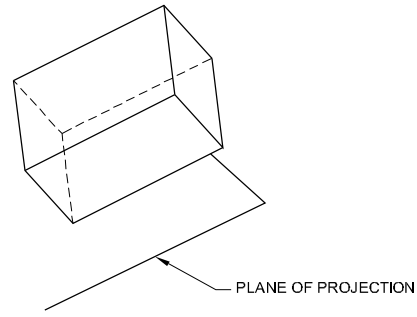
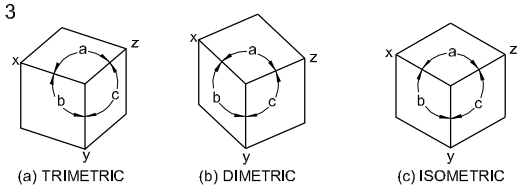


Fig 2 shows the front view, plan and side view of a rectangular prism positions in the manner stated above. Here notice that two of the views (Plan and side view) lock like solids, the reason being that in each of these two views we can see the three faces of the prism. So in this example both the plan and side view are pictorial views in its own right.

Depending on the angle of inclination of the faces with the plane of projection, pictorial projection are classified as Timetric, Dimetric or Isometric.

In trimetric projection (Fig 3a) the three faces make unequal angles with the plane of projection whereas in dimetric (Fig 3b) projection 2 faces make equal angles. In isometric projection all the three faces make equal angles. (Fig 3c)

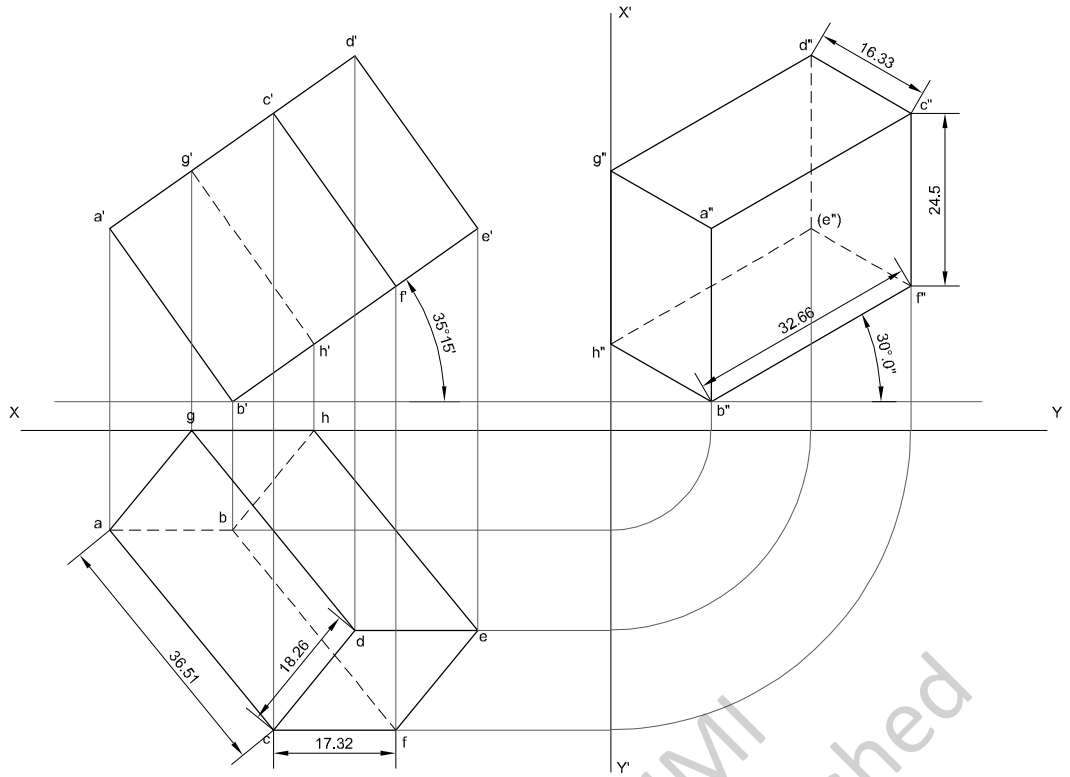
Fig 3



The projections - trimetric dimetric and isometric projection are generally grouped in one heading called "Axanometric" projection.

In the three types (trimetric, dimetric and isometric) of pictorial projections mentioned above, because the faces of the object are not parallel to the plane of projection the views will not show the true size and shape of the object. The shapes are distorted and lengths of edges are fore shortened. Referring to Fig 2 it may be seen that the true

Fig 2



dimensions of the prims is 40 x 30 x 20. But in the front view these dimension measure 32.66 x 24.5 x 16.33 and in plane this corresponding measurements are 36.51 x 17.32 x 18.26. The reason for different lengths in front view and plane is that individual faces make different angles to their respective plane of projection.

Pictorial projections will enable even a common man to understand the shape quickly, even though these pictorial views have a distorted look. In any case, these views are very useful for describign the shapes.

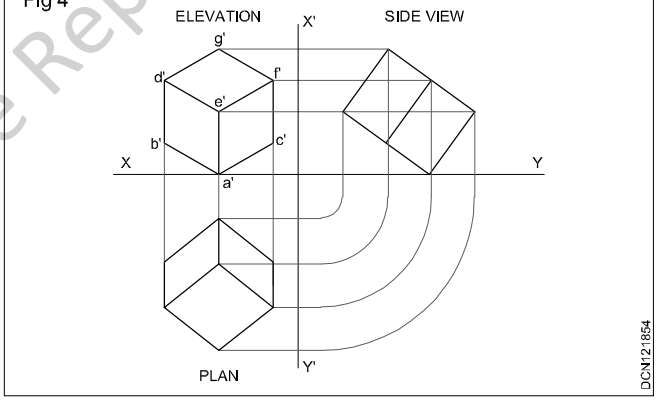
Out of the three types of axanometric projections, isometric views are preferred due to an advantage and hence it is dealt in move detail.

Isometric projection: In an isometric projection the three mutually perpendicular faces make the equal angles with the plane of projection The term isometric is derived from the Greek word ISO means equal and metra means measurement.

The projection of a cube, the three faces which make equal angles with vertical plane is shown in Fig 4. Here the front view is the isometric projection. Notice that the a'b', a'e', c'f', e'f', c'd', d'g', g'f', b'd', a'c' which represent the various edges of the cube are of equal lengths meaning that all have the same amount foreshortening. Because of this reason isometric projection will give a more natural appearance than trimetric and dimetric and this is extra advantage of isometric projection.

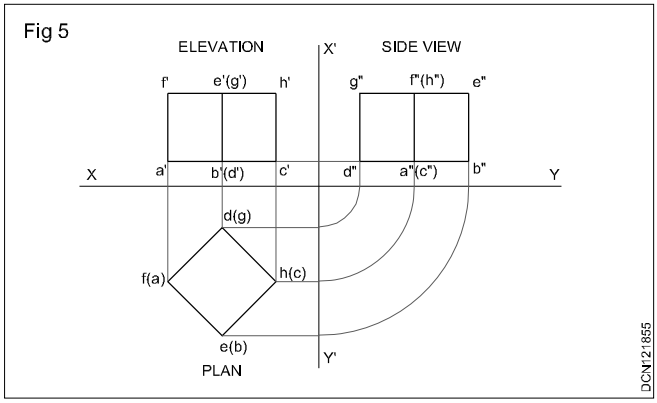
Isometric projection - Method of construction: We can make the isometric projection of any object using the principle of orthographic projection. But the method is best understood by constructing the isometric projection of cube or rectangular prism. The position required for isometric projection may be brought about as follows.

Fig 4



Place the cube on HP such that two of its mutually perpendicular faces make 45° will VP (the plan and side view elevation in the position will be as in Fig 5).

Fig 5



Next tilt the cube towares you with the corner b on HP. Tilt the solid diagonal DE will be at right angles to VP. Now the 3 mutually perpendicular faces will make angles (35°16') with HP. The three views of the cube in this position are shown in Fig 6. Now the elevation will be the isometric projection. To obtain this proceed as follows:

– First reproduce the side view in Fig 5. Such that DE is parallel to XY line.

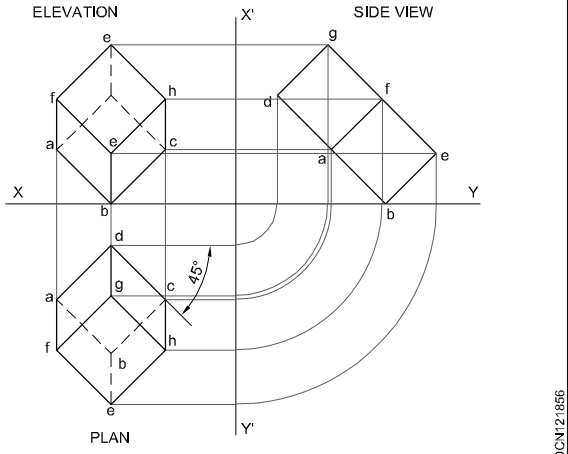
– Project from the above side view and the plan in Fig 5 shall be reproduced in Fig 6.

– Draw the elevation

Note : In figure 6, a plan for the tilted position is also drawn. But this is not an isometric projection. Actually it is a dimetric projection.

It may be observed from the above construction that the isometric projection gives 3d (3 dimensional) effect as we are able to show the length, breadth and thickness in the same view. however, making isometric projections this way is complicated and time consuming. Therefore, simpler method have been deviced to make pictorial drawing that are identical isometric projection and these methods are discussed below.

Fig 6



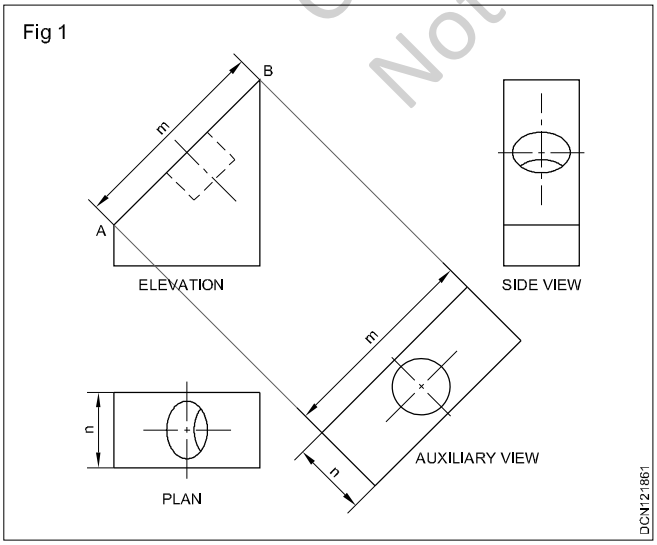
Auxiliary views

Objectives: At the end of this lesson you shall be able to
- **explain the concept of an auxiliary view**
- **state and explain auxiliary front and top views.**

In our lesson on projection of solids it was seen that projection of surfaces which are not parallel to the plane of projection will not show the true shape of the surfaces. In other words when there are inclined surfaces in solids their true shape cannot be shown in plan and elevation. In such cases, true shapes are shown by projecting the inclined surface to a plane parallel to the inclined surface. Such planes are called auxiliary planes, the views projected on auxiliary planes are called auxiliary views.

Figure 1 shows the views of a simple solid having an inclined rectangular surface with a blind hole, axis of which is perpendicular to the inclined surface.

Fig 1

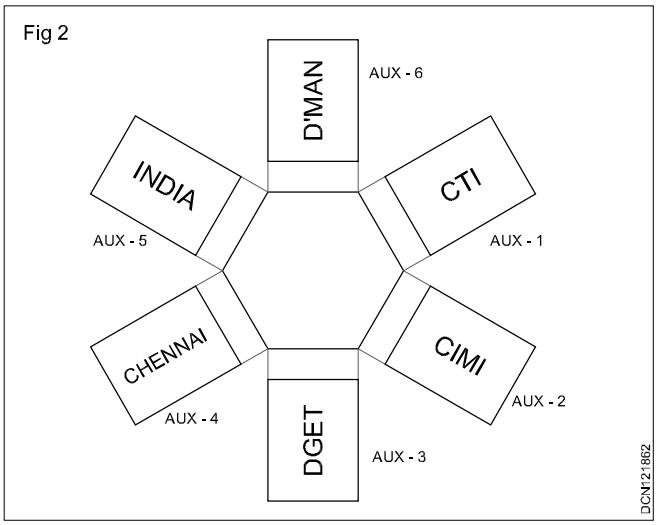


The length and breadth of the inclined surface are m and n.

It may be seen that neither the plan, elevation nor the side view reveal the true shape of the inclined surface and the cylindrical hole. Therefore, in order to show the true shape a new plane, auxiliary plane, parallel to AB (inclined surface) is created and the surface is projected on that plane. Notice that the projected view (auxiliary view) shows the true shape of the inclined surface and hole in it.

There can be any number of auxiliary views depending upon the shape of the component. For example, to reveal the treu shape of the details of surfaces of an hexagonal prism we may draw six auxiliary views as shown. (Fig 2)

Fig 2

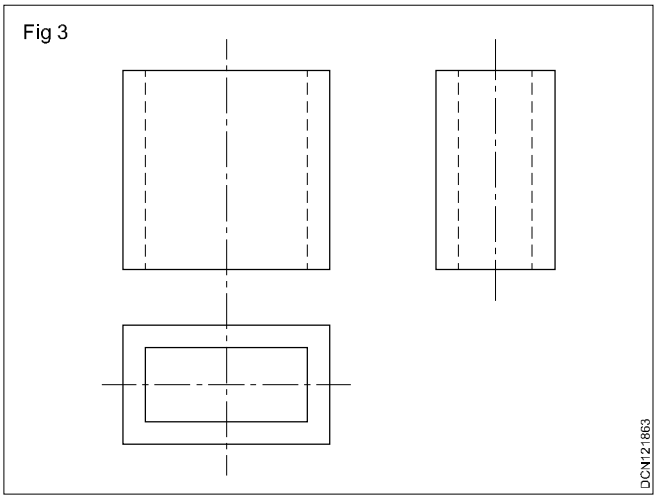


When auxiliary views are drawn we do not make the full view of the object on the auxiliary plane, but only details required to show the true shape is made.

In the normal Orthographic views (plan, elevation and side view), the internal details, their features and relative positions which cannot be seen are shown by dotted lines.

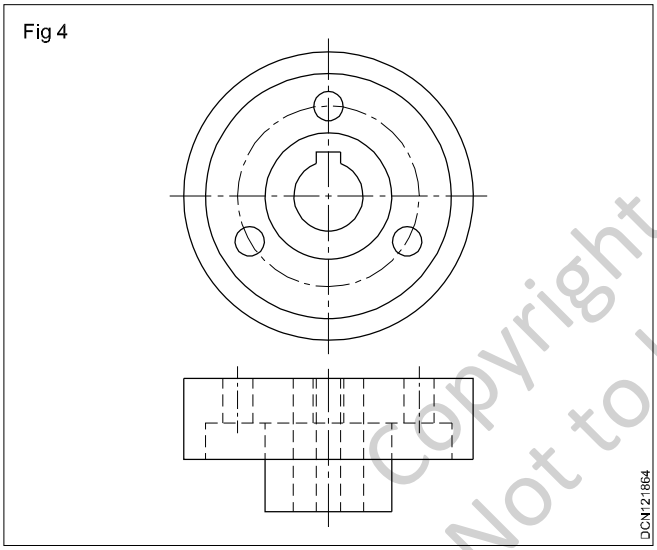
For example in the object shown in figure 3 the hole is invisible in the elevation and side view. Hence it is represented by dotted lines.

Fig 3



When there are too many dotted lines in a drawing (Fig 4) it is difficult to conceive the details of the object. In such a cases, details can be shown clearly and reading of drawing can be made easier by resorting to what are known as "Sectional views".

Fig 4



Sectional views: For obtaining sectional views an object is assumed to be cut by an imaginary plane called cutting plane. The part between the cutting plane and the observer is assumed as removed to reveal the internal details. Then the projection of part left out is projected/drawn as usual and the view thus made is the sectional view. (see Fig 5)

To distinguish a sectional view the surface formed when it is cut by the cutting plane is "hatched". (Fig 6)

Hatching means filling the surface with equi-distant parallel lines.

If the surfaces of a prism or pyramid cut at an angle, the true shape of the surface cut is available in auxiliary view. The auxiliary view surface is to be drawn with hatched lines. Reference: Procedure of Ex.No.7.1.1 to 7.1.5 - Trade Practical Book.

Note: Application of sectional views are dealt in more detail in future lesson.

Fig 5

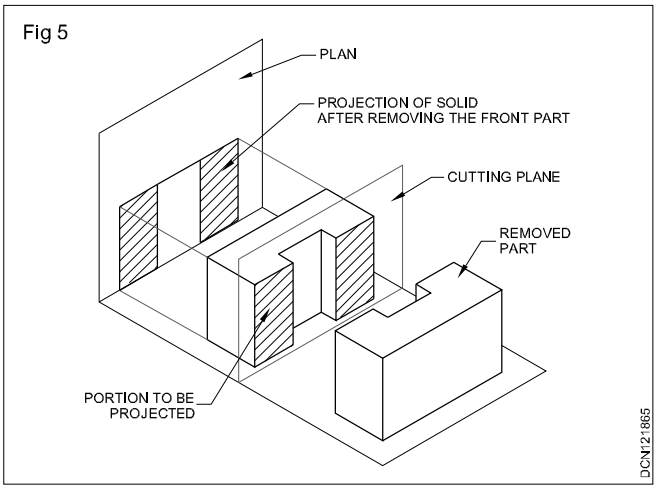
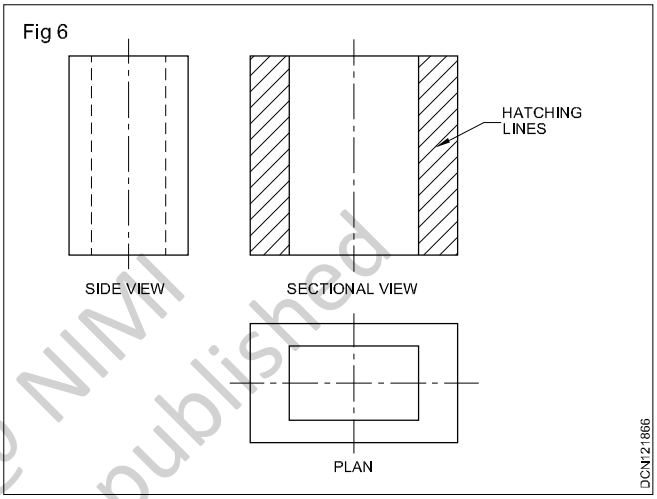


Fig 6



In order to avoid projectors crossing the views, auxiliary views are sometime drawn in 3rd angle projection even though the other views are in first angle projection.

All the views in Fig 1 is drawn in 1st angle projection. But auxiliary view can be shifted above the elevation.

Note: In figure 6, a plan for the tilted position is also drawn. But this is not an isometric projection. Actually it is a dimetric projection.

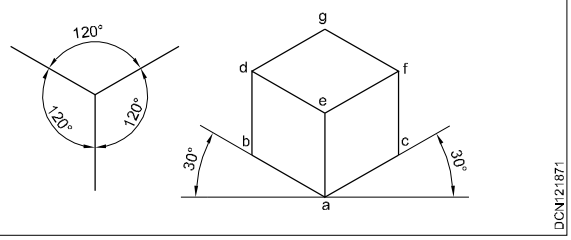
It may be observed from the above construction that the isometric projection gives 3d (3 dimensional) effect as we are able to show the length, breadth and thickness in the same view. However, making isometric projections this way is complicated and time consuming. Therefore, simpler method have been deviced to make pictorial drawing that are identical isometric projection and these methods are discussed below.

Simpler method of isometric projection: On analysing the isometric projection in Fig 6, it will be seen that three mutually perpendicular edges of the cube are at an angle of 120° to each other. These three lines which represent the mutually perpendicular edges are called isometric axes. (Fig 7)

So to draw the isometric projection say of a cube, we firstdraw the three mutually perpendicular edges as in figure and set other lengths. Since of the lengths are foreshortened in isometric projections we must use an "isometric scale" to find out the foreshortened lengths.

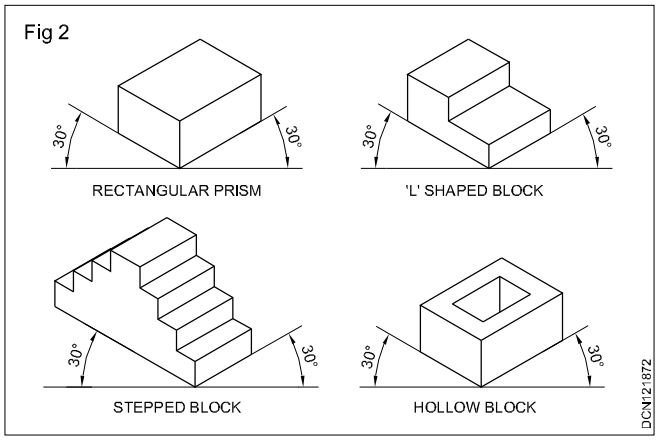
Thereafter, other edges are drawn parallel to the respective isometric axes to complete the figure.

Fig 1



Instead of drawing the isometric axes, first we can also start from the point `a' .(Fig 7) At this point also 3 mutually perpendicular edges meet. While two of these edges make 30° to the horizontal, the other edge is vertical. (90° to horizontal) After drawing the two 30° lines one vertical line the parallel lines are drawn to complete the cube. Few other objects drawn this way are shown in Fig 8. The length of each edge of corner will be less than the true dimensions and it can be determined by using an isometric scale.

Fig 2



Isometric projection

Objectives: At the end of this lesson you shall be able to

- **state the method of isometric projection**
- **explain isometric scale**
- **explain box method of isometric view**
- **explain off set method of isometric view.**

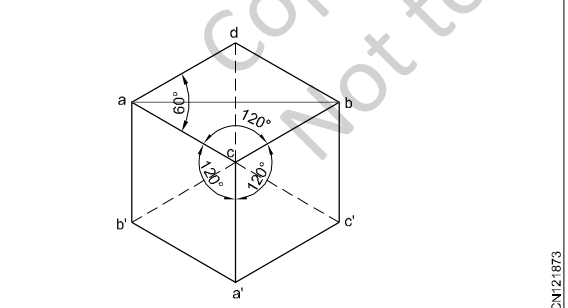
Isometric scales are used to get the foreshortened lengths required for isometric projection.

Before constructing an isometric scale, you must understand is the relationship between the true length of an edge and the length of the same in isometric projection.

To determine the relationship between the true length and corresponding length in isometric projection, proceed as follows:

Consider the isometric projection of a cube. (Fig 1)

Fig 3



Separately draw the top face of the cube adbc and join the longer diagonal ab. (Fig 2)

Note that the diagonal ab is of same length both in the isometric view of the face and the true face. Assume the top true face of teh cube as afbc.

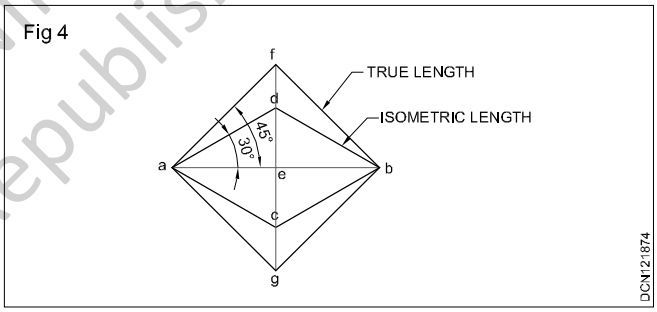
Now superimpose the true top face afbg keeping the diagonal ab common. (Fig 2)

$\angle FAE = 45°$ and $\angle DAE = 30°$

x $AE = AF \times Cos45°$ and $AD = AE \div Cos30° = AF \times$

$$\frac{\text{Isometric length}}{\text{True length}} = \frac{AD}{AF}$$

Fig 4



$$\frac{AD}{AF} = \frac{AF \times Cos45°}{AF \times Cos30°} = \frac{Cos45°}{Cos30°}$$

$$\frac{AD}{AF} = \frac{AF \times Cos45°}{AF \times Cos30°} = \frac{Cos45°}{Cos30°} = 0.8165$$

AD = 0.82 AF. This means that the length of a line in isometric projection is 0.82 times of it true length. While drawing an object in isometric projection, the dimensions on or parallel to isometric axes are reduced to this proportion. To make things easier we can construct a scale to the above ratio. Such a scale is called as isometric scale.

Procedure to construct

Isometric scale (Fig 3)

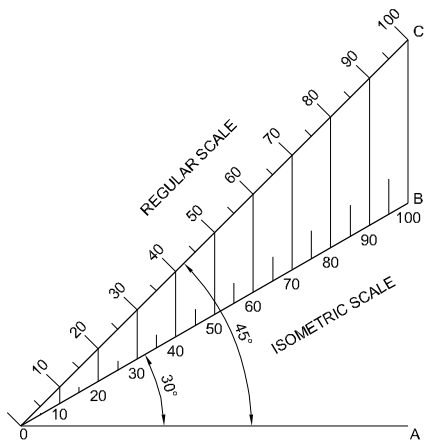
– Draw a horizontal line OA.

– Draw lines OB and OC making 30° and 45° with OA respectively.

– Mark 5 mm, 10 mm, 15 mm upto 100 mm on line OC.

– From the marked points on the regular scale OC, draw perpendiculars to OA meeting at OB.

Fig 5

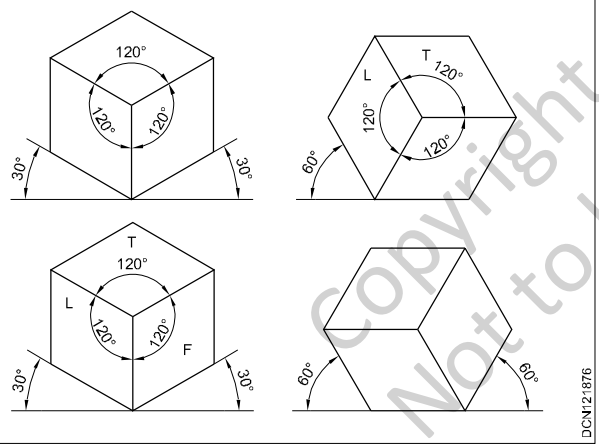


– Print the corresponding values on the line OB resulting in the isometric scale.

Orientation of isometric axes: While the isometric axes make 120° to each other they may have different orientation as shown in Fig 4. Each of the orientation show3 of the 6 faces (left, right, top, bottom, front and rear) are shown in different combinations.

Isometric view and Isometric projection: A drawing is made with true lengths (dimensions) is called isometric view or isometric drawing. Whereas the same drawing made with isometric lengths is termed as isometric projection. (Fig 5)

Fig 6



Isometric and non-isometric lines: Fig 6 shows the isometric view of a shaped block. Here all lines except AB, BC and DE are parallel to isometric axis. Lines such as then which are parallel to isometric axes are called isometric lines whereas such as lines AB, BC and DE which are not parallel to isometric axes are called non-isometric lines.

The length of non-isometric lines will not follow the scale used for isometric lines. To proove this point consider the non-isometric lines AB or BC. The true length of both AB and BC is 5 cm while BC will be longer. Because of this reason non-isometric lines are drawn first by locating their starting and end points on isometric lines.

To locate the end points and to draw the non-isometric lines two methods are employed. They are

– Box method

Fig 7

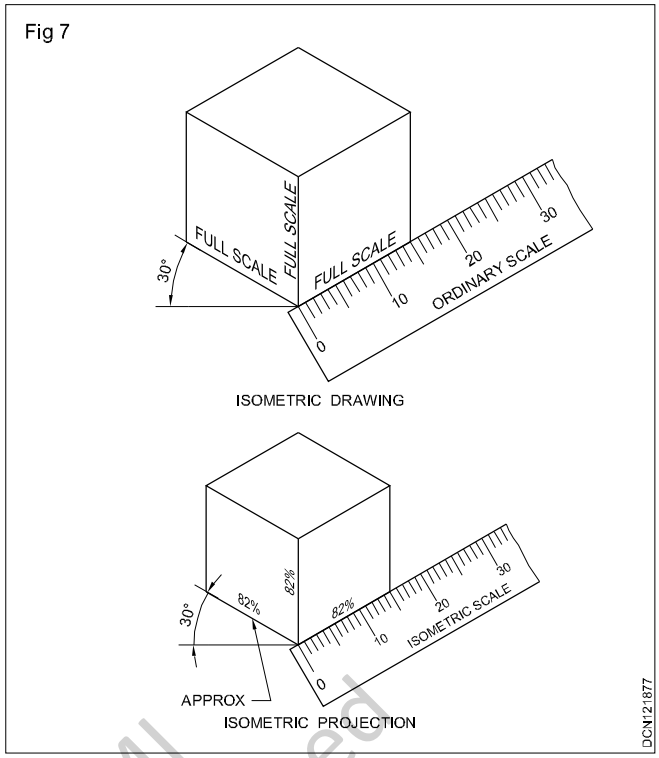
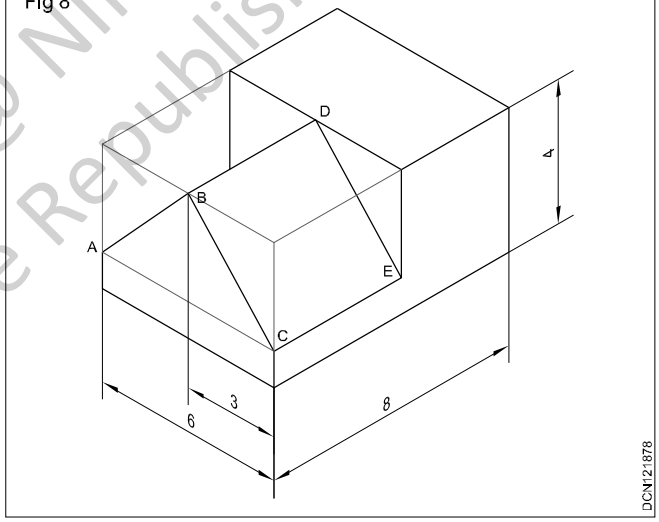


Fig 8



– Off-set method

Box method: The object is assumed to be inside a rectangular box. Starting and end points are located and marked. By joining the points isometric view is drawn.

Off-set method: This method is most suited for the objects consisting of number of planes at a number of different angles.

These methods are not only useful for isometric views involving non-isometric lines but also for the isometric views involving isometric lines.

Box method of drawing a pyramid

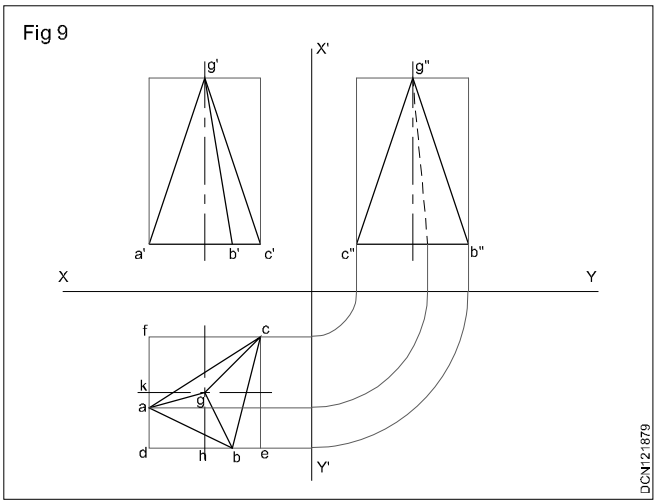
Example

Draw an isometric view for the triangular pyramid shown in

Fig 7 using a box method.

– Construct a rectangular box to the overall size of the pyramid (Fig 8a)

– Mark the distances ad and be from the plan of Fig 7 in



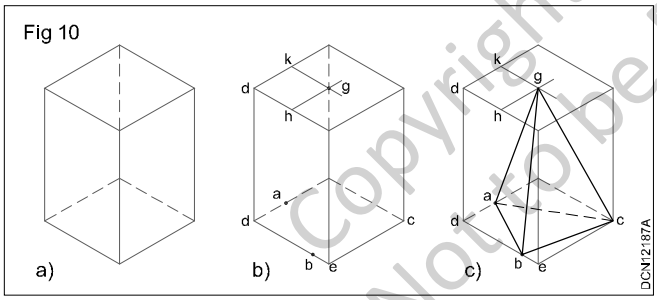
the base of the box.

– Mark the distances kg and dh on the top face of box. (Fig 8a)

– Join the points AB, BC, CA, AG, BG and CG and complete the isometric view of the pyramid in box method. (Fig 8b)

Off-set method of drawing a pyramid

Example



Same triangular pyramid (Fig 7) is considered for drawing isometric view using offset method.

– Draw an isometric square/rectangle considering the corners of the base of the pyramid. (Fig 9a)

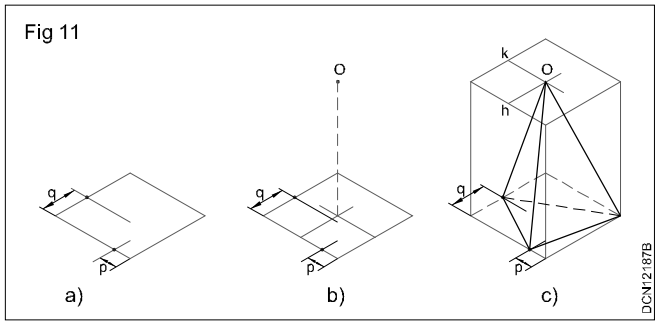
– Locate the corners 1,2 & 3 with help of offsets P and Q.

– Locate the projection of the vertex O_1 on the base by offsets x and y and draw the vertical centre line O_1O to the height of the pyramid. (Fig 9b)

– Join 1-2, 2-3, 1-3, 0-1, 0-2, 0-3 and complete the isometric view of the pyramid. (Fig 9c)

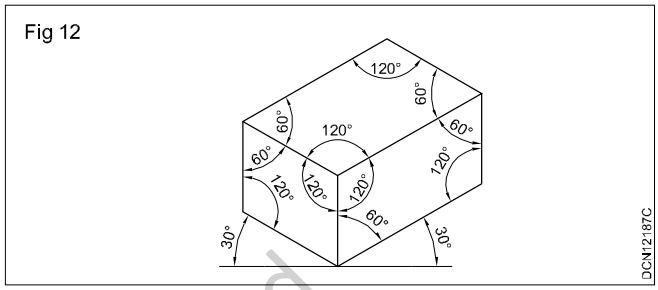
Angles in isometric projection: The angles of inclined surfaces will not have true value in the isometric projection, but will be more in some cases and less in other cases.

For example, in the isometric view of prism shown in Fig 10 the true value of all the angles is 90°. But in isometric projection the angles are 60° in some cases and 120° in



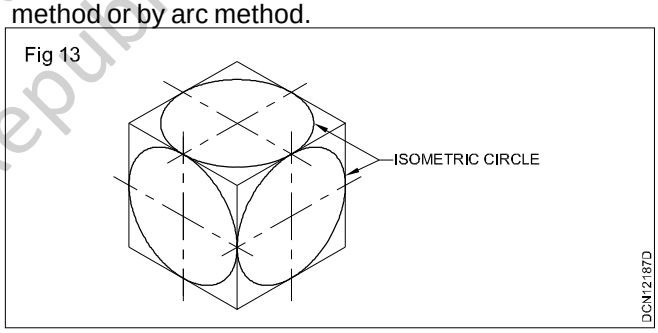
others.

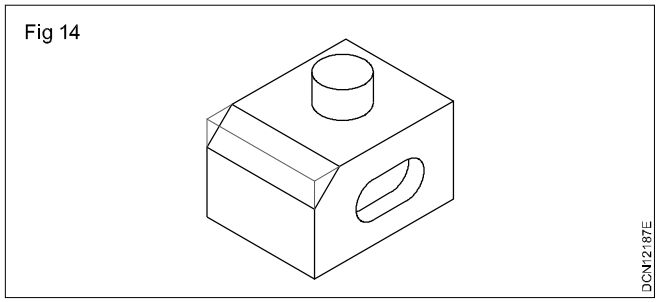
Isometric circles: The term isometric circle refers to the shape of circle in isometric view. An isometric circle will



be elliptical in shape as shown in Fig 11 while drawing isometric view of cylindrical features isometric circles will have to be used. (Fig12)

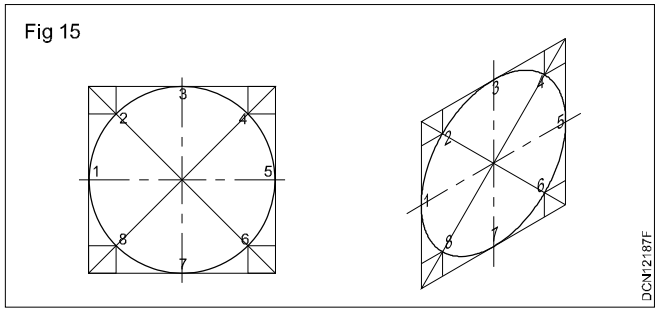
An isometric circle can be drawn either be plotting/offset method or by arc method.





Plotting method (Fig 13)

– Draw a square of side equal to the dia of circle and inscribe the circle.



– Divide the circle into any number of equal parts and mark points such as 1,2,3,4,5,6,7,8 on the circle.

– Through the points 1,2,3 etc draw lines parallel to the both the axis of cylinder.

– Draw isometric view of the square.

– Mark points corresponding to 1,2,3....8 with isometric view of the square as points 1',2',3'....8'.

– Join these points with a smooth curve to for an ellipse.

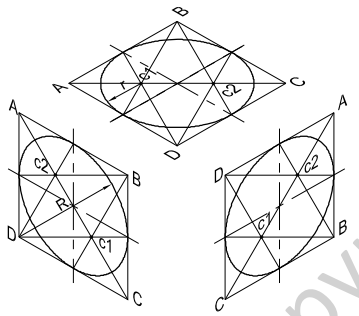
Note: The orientation of the isometric circle will depend upon the plane on which the circular feature exists.

Arc method: Isometric circles drawn by offset method is the ideal method of making isometric circles as the ellipse obtained this way is geometrically true. But by free hand we cannot get a clear line.

Fig 14 shows the construction of isometric circle in 3 different orientation by arc method. Four arcs are to be drawn and the centres an C_1, C_2, B & D. While centre B and D are the corner of the rhombus C_1 and C_2 are intersection points of the longer diagonal with lines from points B or D to the mid point of the side of the rhombus.

Note: The arc method gives a clean ellipse, but this ellipse drawn this way will slightly deviate from true ellipse. It

Fig 16



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does not matter for our purpose.

The isometric circles can also be drawn using templates which can be bought from stationary shops.

Isometric views profiles: The profile MN of the block shown in Fig 15 is irregular in nature. The isometric views of such lines may be drawn by offset method described earlier. The points 1,2,3 and 4 lie on the profile. Lines A-1, B-2, C-3, D-4 are isometric lines and their length are same both in Fig 15 & Fig 16. After getting the points 1,2,3 & 4, they joined by smooth curve.

Note: In offset method more the number of points, better will be the accuracy of the curve.

Isometric projection of sphere: The Orthographic view of a sphere seen from any direction is a circle of diameter equal to the diameter of the sphere. Hence, the isometric projection of a sphere is also a circle of the same diameter.

The front view and the top view of a sphere resting on flat surface are shown in Fig 17a.

O as its centre, D is the diameter and P is the point of contact with the surface.

Fig 17

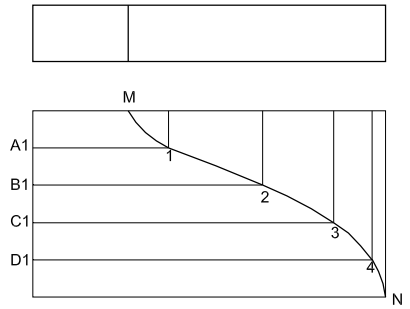

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Fig 18

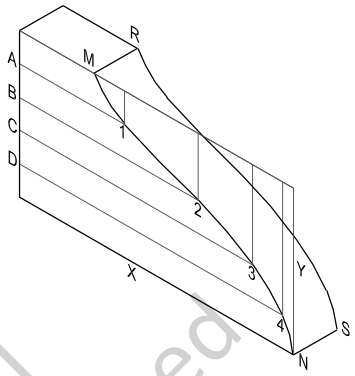

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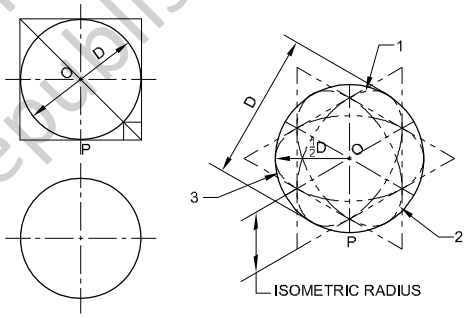
Fig 19



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Assume a vertical section the centre of the sphere. Its shape will be a circle of diameter D. The isometric projection of this circle are ellipses 1 & 2 Fig 17(b) drawn in two different vertical positions around the same centre O. The major axis in each case is equal to D. The distance of the point P from the centre O is equal to the isometric radius of the sphere.

Again, assume a horizontal section through the centre of the sphere.

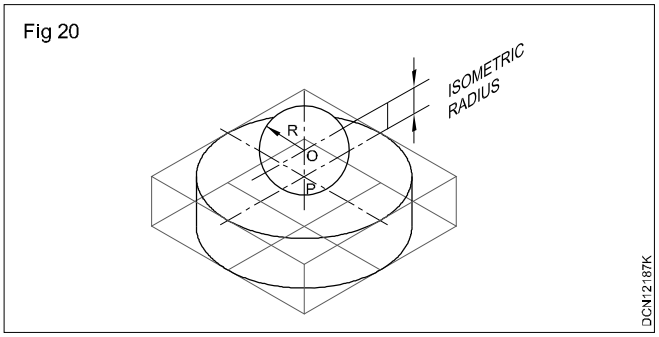
The isometric projection of this circle is shown by the ellipse 3, drawn in a horizontal position around the same centre O. In all the three cases 1,2 & 3 the outermost points on the ellipse from the centre O is equal to 1/2 D.

Thus, it can be seen that in an isometric projection, the distances of all the points on the surface of a sphere from its centre are equal to the radius of the sphere. Hence, the isometric projection of a sphere is a circle whose diameter is equal to the true diameter of the sphere.

Also the distance of the centre of the sphere from its point of contact with the flat surface is equal to the isometric radius OP of the sphere.

It is therefore of the utmost importance to note that isometric scale must invariably be used while drawing isometric projection of solids in conjunction with spheres or having spherical parts.

Fig 20



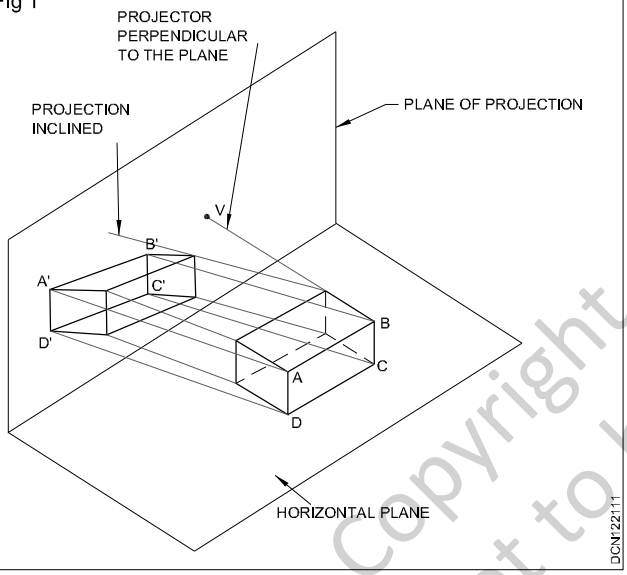
Oblique projection

Objectives: At the end of this lesson you shall be able to
- **state what is an oblique view**
- **compare oblique view with isometric view**
- **identify the different types of oblique views**
- **explain various angle used for drawing oblique views**
- **list the hints on positioning and drawing oblique views.**

Oblique projections are yet another type of pictorial projections, they differ from isometric projections in two ways.

– In oblique projections, projections are oblique (inclined) to the plane of projection. whereas in isometric projections projectors are perpendicular to the plane of projection. (Fig 1)

Fig 1

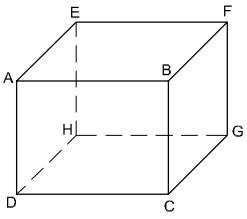


– In an oblique projection one of the principal faces of the object is kept parallel to the plane of projection, but in isometric, none of the faces of the object is parallel to the plane of projection.

Even though one of face of the object is positioned parallel to the picture plane, we still get a pictorial view and the projections are inclined to both HP and VP.

Because one of the principle faces of the object is parallel to the plane of projection. In the oblique projection, the projection of this face and faces parallel to it will appear in true size and shape. In the oblique projection of a prism is shown in Fig 2, the faces ABCD and EFGH are parallel to the plane of projection and they appear to be true in size and shape. The other four faces which are perpendicular to the plane of projection do not appear in true shape. (all these four faces are seen as parallelogram) However the vertical edges of these faces are parallel to the plane of projection and hence the projection of these edges will measure to their true lengths.

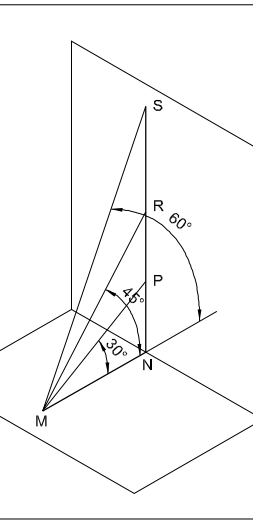
Fig 2



Projection of edges such as AE, DH, BF and CG which are perpendicular to the plane of projection will measure differently depending on the angle of inclination of the projectors. If the inclination of the projectors is 45° the projections of these edges measure to their true lengths. If the angle is less than 45° the projection of such perpendicular edges will measure less than the true length, if the angle of inclination of the projectors is greater than 45°. Projection of such perpendicular edges will measure more than the true length.

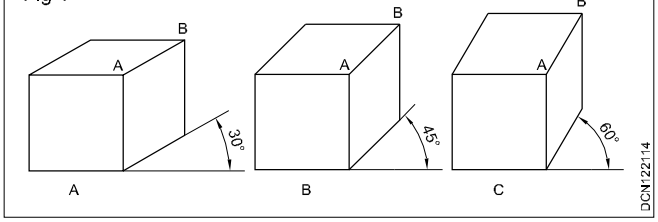
In the Fig 3, a line MN is drawn perpendicular to the plane of projection. NP, NR and NS are its projection when the projectors are 30°, 45° & 60° respectively. NR is equal to MN, NP is less than MN and NS is greater than MN.

Fig 3



Figures 4a,b and c shows the oblique views of a square prism when the angle of the projectors are 30°, 45° & 60°. Because of the variation of the length of edges (AB) which are perpendicular to the plan of projection the views give a rather distorted picture of the prism. This is a disadvantage of oblique projections over isometric projections.

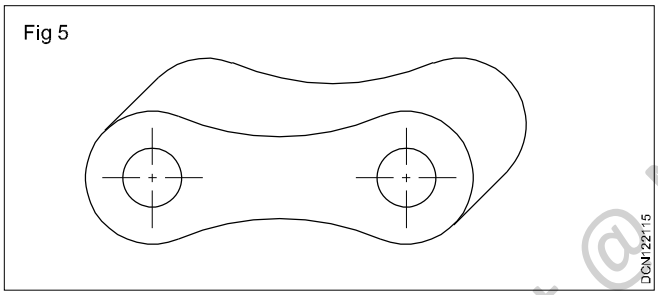
Fig 4



Oblique projections nevertheless have an unique advantage what we want to make pictorial drawings of object having curved features. For making isometric views of a curved feature we have first to draw their orthographic views in order to find out the offsets of points lying on the curve. But this difficult procedure is not necessary in the case of oblique views.

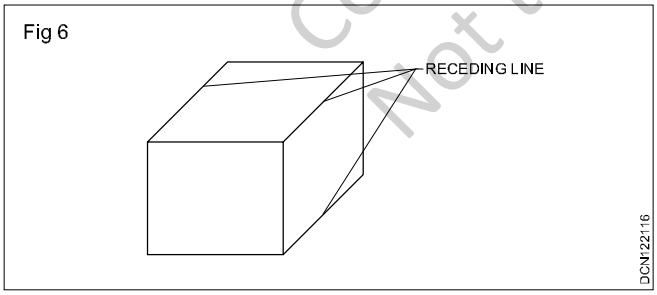
For example the component shown in Fig 5 has several curved features. While drawing oblique view of this component the curved features are drawn to true shape using compass. This is relatively easier method in comparison to the drawing of the same component in isometric view.

Fig 5



Inclination of projectors: While projectors can have any angle of inclination, usually oblique views are drawn to either 45° or 30°. The inclined lines in the oblique drawings are called receding lines (Fig 6) and they are more commonly drawn to 45°. The scale of lines along receding may be 1:1 (true lengths) or 1:2 (half of the true length).

Fig 6



Oblique drawing drawn to 1:1 (Fig 7) are called as cavalier projections and those drawn to 1:2 (Fig 8) are called as cabinet projections. These two terms are of academic interest only and mostly we refer these views as oblique projections/drawings only.

In comparisn a cabinet projection will look less distorted than a cavalier projection.

Procedure for drawing oblique views: The procedure for creating oblique drawing is very much similar to that for drawing isometric views. To make isometric view we start from drawing three isometric axes at the desired orientation. In oblique drawing also we start by drawing three axes at the desired orientation. But here two of the axes are perpendicular to each other while the third axis (receding axis). Make 45° or 30° to the horizontal. The orientation of the axes may be any one of the four possibilities given in the figure 9.

Fig 7

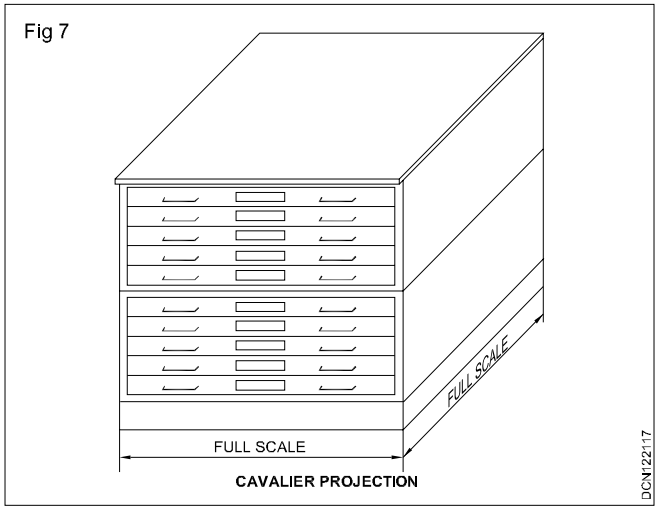


Fig 8

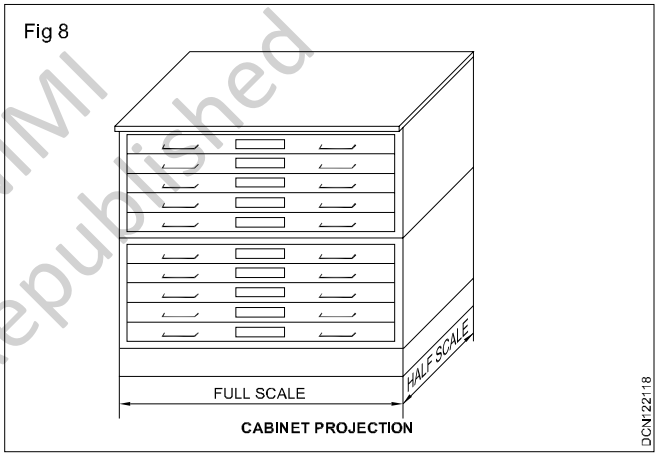
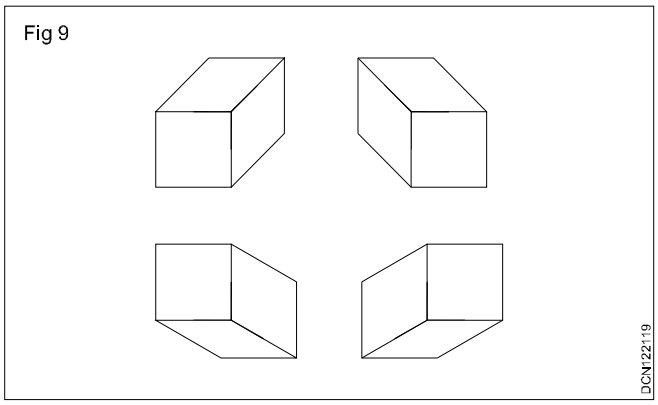


Fig 9

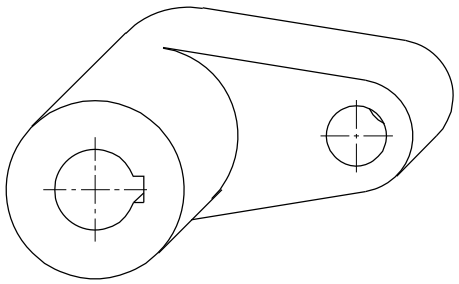


Object positioning in oblique drawing: Remember to position the object in such a way as to make best use of the advantage offered by oblique projection. The face that has the maximum curved details should be placed parallel to the plane of projection. See example in Fig 10.

Another point to note is as far as possible, place the longest dimension parallel to the plane of projection. (Fig 11 a & b)

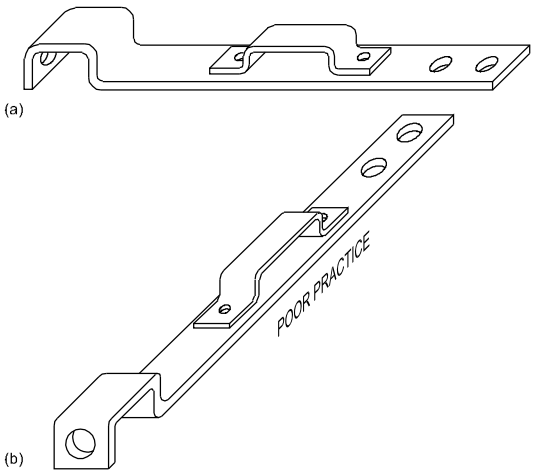
Few examples of oblique drawings are shown in Fig 12.

Fig 10



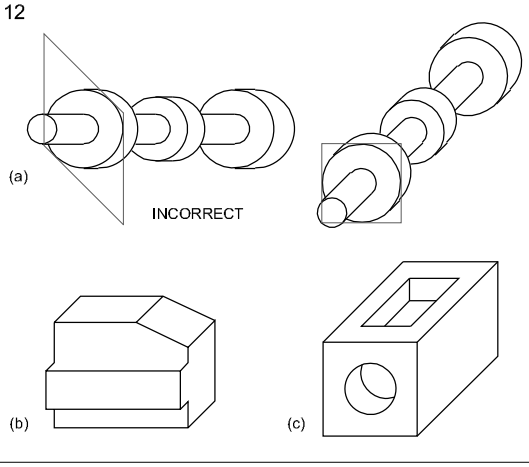
DCN12211A

Fig 11



DCN12211B

Fig 12



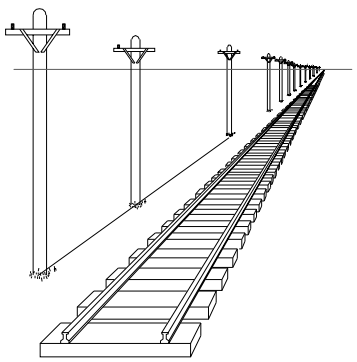
DCN12211C

Perspective views

Objectives: At the end of this lesson you shall be able to
- **explain perspective projection**
- **explain various terms used in perspective projection**
- **differentiate between the three types of perspective views.**

Perspective projection: Perspective projections are pictorial views that look more like a photograph or rather it is a pictorial view similar to how an object looks like when it is viewed by the human eye. The basic characteristic of a perspective view is that parallel feature look tapered or converging as the distance from the feature increases from the observer's eye. (Fig 1) whereas in axonometric and oblique projections the projectors are parallel to each other. (Fig 2)

Fig 1



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For producing a perspective view/projection, you should be familiar with the following terminologies. (Fig 3)

Ground plane (GP)**:** It is the horizontal plane on which the object is assumed as resting on which the observer stands.

Station point (SP)**:** It is the point where the observer's eye is located while viewing the object.

Picture plane (PP)**:** It is the (imaginary) vertical plane, resting between the station point and the objects being viewed. This is the plane (surface) on which the perspective view is formed.

Ground line (GL)**:** It is the line of intersection of the picture plane with ground plane.

Horizon plane (HP)**:** It is an imaginary plane, at the level of the eye i.e. station point. It is a horizontal plane above the ground plane and at right angle to the picture plane.

Auxiliary ground plane (AGP)**:** This plane is placed above the normal HP and the object. The view from top view (TV) of the object and of the perspective elements are projected on this plane.

Horizontal line (HL)**:** It is the line of intersection of horizontal, plane and the picture plane.

Fig 2

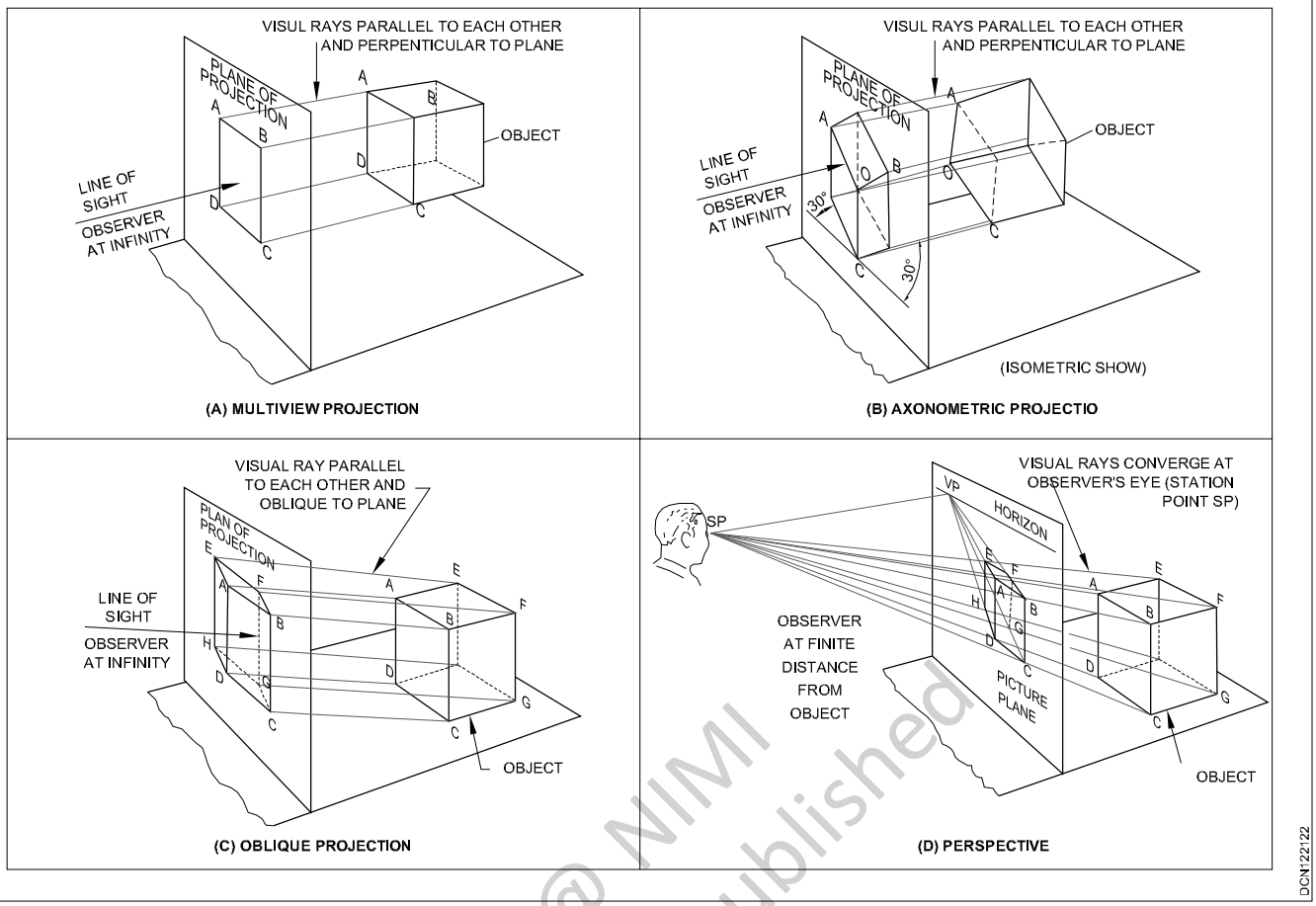
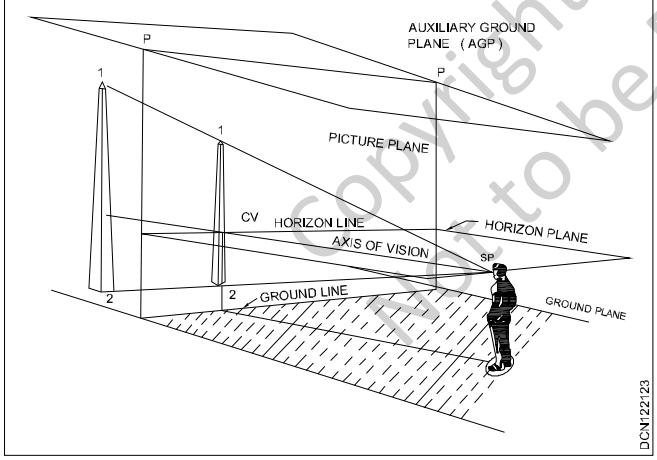


Fig 3



Axis of vision or perpendicular axis (PA)**:** It is the line drawn through the station point perpendicular to the picture plane.

Centre of vision (CV)**:** It is the point on the picture plane where at which the perpendicular axis passes through the picture plane.

Central plane (CP)**:** It is the imaginary vertical plane, which passes through the station point and the centre of vision. It is perpendicular to the picture plane as well ground plane.

Position of station point: Station point is the viewing point and its location should be where the object can be viewed to the best advantage.

The appearance of the finished perspective drawing depends very much on the position of the station point and hence considerable care must be exercised in selecting its location. The following points may serve as guidelines for selecting the location of the station point.

– the distance from the picture plane to the station point shall be atleast twice the maximum dimension (width, height or depth) of the object.

– visual rays from the station point to the outermost boundaries of the object shall be within a cone having an angle of not more than 30°.

– the station point should be offset slightly to one side and should be located above or below the exact centre of object if the object is small.

– when making perspective of tall objects such as buildings the station point shall in at the eye level of the viewer who is standing on the ground.

– The location of the station point shall be fixed so that the angle between the visual rays from the station point and the outermost boundaries of the object is approximately 30°. (Fig 5) If this angle is very wide, the picturisation may not be good.

Position of object

– The object is assumed to be placed on the ground plane. (GP)

– The object is placed either with one principal face parallel or at an angle to the picture plane.

– If kept at an angle the value of the angle shall be 30° for objects like rectangular prism. (Fig 4)

Fig 4

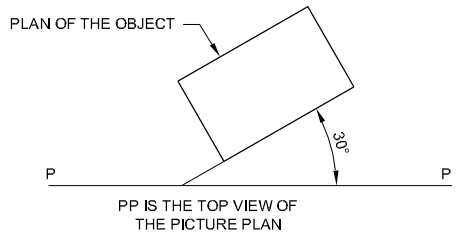
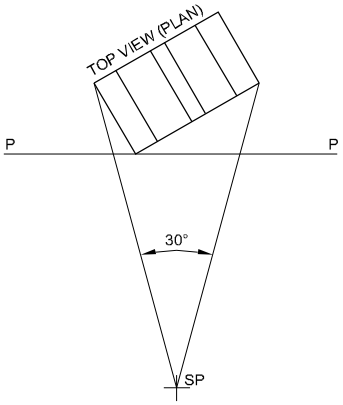


Fig 5



The position of the picture plane with reference to the object determines the size of the perspective view. When the object is placed behind the picture plane, the view is reduced as it is moving towards the picture plane, the view increases. When the object is placed in front of the picture plane, the view is bigger than the object. If the object is on the picture plane, the height of the view is same as the object.

Vanishing point (VP)**:** It is a common knowledge that parallel features like the one shown in Fig 6 appears to meet at a point in infinity and this point is termed as "Vanishing point".

In practice, the point at which the visual ray from the eye (station point - SP) to that infinetely distant vanishing point pierces the picture plane is referred to as the vanishing point.

Note that the vanishing point will be at the same height as that of station point and will lie on the horizon line (HL).

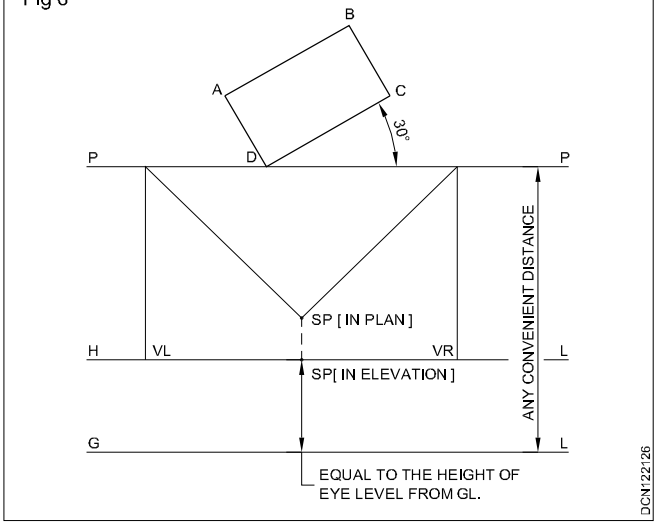
Procedure for determination of vanishing point

– Draw three parallel lines PP, HL and GL to represent picture plane (PP), Horizon plane (HP) and Ground plane (GP).

Note: In figure 6 the plane of the paper is the picture plane. The auxiliary GP (AGP) is rotated to bring it in plane with the picture plane. so the AGP extends above and below the line PP which also is the top view of the picture plane. The lines HL and GL are the elevations (front view) of horizon plane and ground plane respectively.

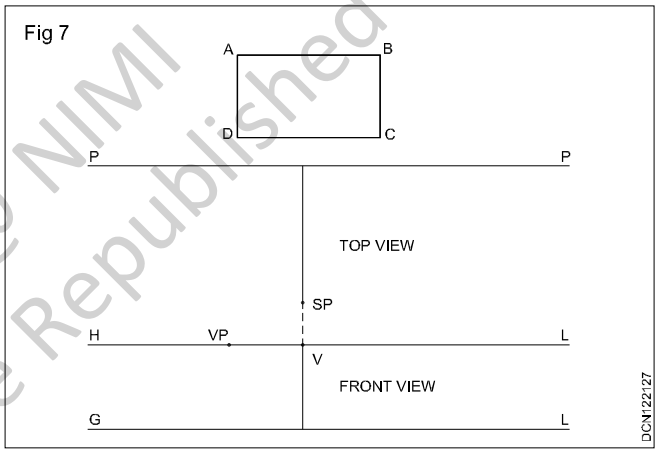
The distance between PP and GL may be decided as per our convenience. The distance between GL and HL will be equal to the height of station point. (eye level)

Fig 6



– Draw the plan of the object in the desired/defined positions. The plan will be above the line PP as the object is behind the picture plane or touching the picture plane. (In Fig 7 the plan of a rectangular prism is drawn)

Fig 7



– Mark the top view of the SP. This will be below the line PP. The picture plane is inbetween the SP and the object (rectangular prism).

– Draw the line from SP parallel to DC meeting PP at R.

– Draw the line from SP parallel to AD meeting PP at L.

– Project R and L vertically down to meet HP at VR and VL.

Now VR and VL an vanishing points at right and left of the object and they are at the same height as the height of SP.

Instead of placing the rectangular prism at an angle as in previous Fig. If it is placed such that one of its principle face is parallel to the picture plane there will be only one vanishing point as against two in the previous case. Because the lines AB and CD and parallel to the picture plane this set of lines will not have any vanishing point. The only vanishing point will be for the lines AD and BC which are perpendicular to the PP.

To obtain this vanishing point draw a line from station point (SP) parallel to AD (Perpendicular to PP), mark the point V and extend the line down to HL. The intersecting point on HL is the vanishing point V. This point incidentally

coincides with the front view of station point and centre of vision.

Methods of drawing perspective views: Basically there are two methods for constructing perspective drawings. They are:

– Vanishing point method

– Visual ray method

Depending on the position of the object relative to the picture plane vanishing point method is further classified as

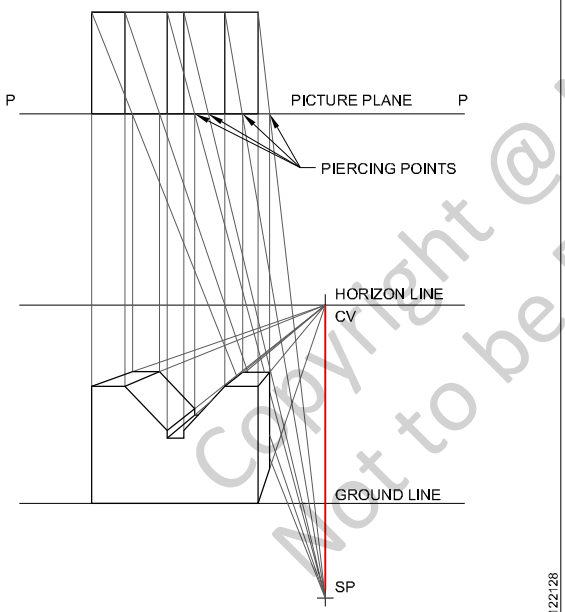
– One point perspective

– Two point perspective

– Three point perspective

One point perspective (Fig 8 & 9)**:** In this method the bottom face of the object is parallel to the ground and one of its vertical faces is parallel to the picture plane. One point perspectives are also called as parallel perspective. Fig 8 & 9 are examples of parallel perspective. Notice that there is only one vanishing point in both the examples and it coincides with centre of vision (V).

Fig 8



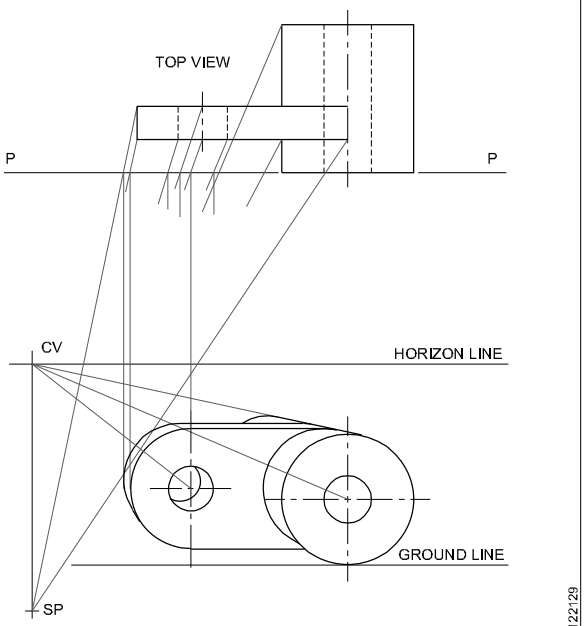
PARALLEL PERSPECTIVE

One point perspective has the similar advantage as oblique drawings in the sence that we can draw curved features parallel to the picture plane and draw the circular features using compass.

Two point perspective (Fig 10)**:** Also called as angular perspective. In this method of construction the vertical faces of the object are at an angle to the picture plane while the bottom face to parallel to the ground plane. As these are two sets of parallel edges, two vanishing points are required for this construction. Examples of two point/ angular perspective are shown in figures.

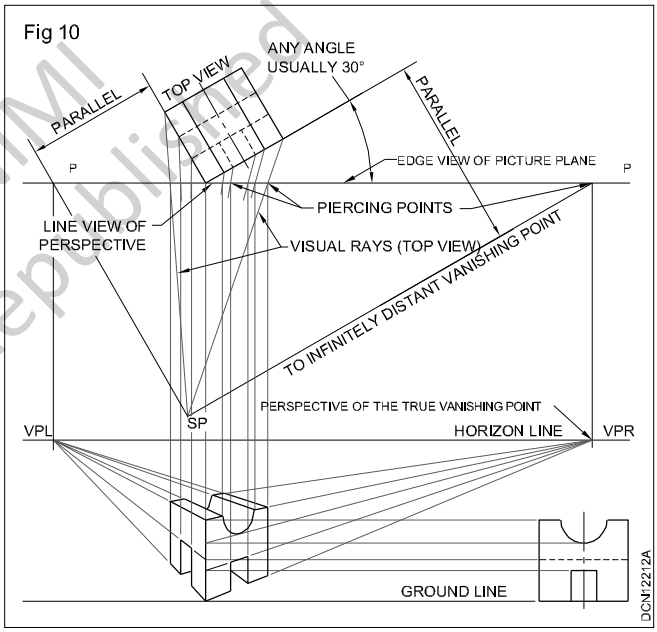
Three point perspective: In this type of perspective all the three prime faces are inclined to the picture plane. The object is placed in a similar fashion as in axonometric projection.

Fig 9



CIRCLE IN PARALLEL PERSPECTIVE

Fig 10



For such position of the object three vanishing points are required for making the perspective. This method is used only very rarely and hence it is not dealt in detail.

Visual ray method: Using this we can make a perspective drawing by projecting from the plan and elevation of the object. (Fig 11)

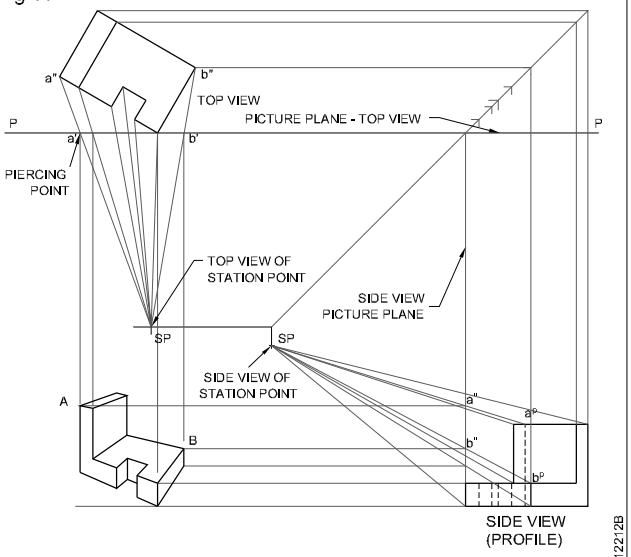
In figure the object is placed such that vertical faces are inclined to picture plane (This corresponds to the position for angular perspective). The side view for this position is drawn on the ground line. Now projectors are drawn from top view and side view for obtaining the perspective of the block.

The most generally used method for creating a perspective is two point method. (Angular perspective)

General procedure for making perspective drawing: The general steps for making perspective drawings are given below in the order of sequence. While reading these

steps reference may be made to figures.

Fig 11



PERSPECTIVE DRAWING - ORTHOGRAPHIC METHOD

To make a perspective drawing

– Draw the top view (edge fo the picture plane)

– Orient the object relative to the picture plane so that the object will appear to advantage, and draw the top view of the object.

– Select a station point that will best show the shape of the object.

– Draw the horizon and ground line.

– Find the top view of the vanishing points for the principal horizontal edges by drawing lines parallel to the edges, through the station point, and to the picture plane.

– Project from the top views of the vanishing points to the horizon line, thus locating the vanishing points for the perspective.

– Draw the visual rays from the station point to the corners of the object in the top view, locating the piercing point of each ray with the picture plane.

– Start the picture, building from the ground up and from the nearest corner to the more distant ones.

Reference

Detailed procedure for each of the methods of making perspective drawing is given in the relevant section of the exercise book.

Note: Pictorial drawing of the perspective type are more difficult to make in comparison to Axanometric and oblique drawings. Therefore it is not a method of preference to make pictorial views of machines and component. However it is very popular among architech as they can create photographic like picture of the finished building etc even before the construction begins.

Admixtures of concrete and application

Objectives: At the end of this lesson you shall be able to
- **state the classification of admixture by function**
- **uses of concrete admixture.**

Admixtures are those ingredients in concrete other than portland cement, water, and aggregates that are added to the mixture immediately before or during mixing (Fig 1) Admixtures can be classified by function as follows:

Fig 1

Liquid admixtures, from left to right : antiwashout admixture, shrinkage reducer, water reducer, foaming agent, corrosion inhibitor, and air-entraining admixture. (69795)

1 Air-entraining admixtures

2 Water - reducing admixtures

3 Plasticizers

4 Retarding admixtures

5 Hydration- control admixtures

6 Accelerating admixtures

7 Corrosion inhibitors

8 Shrinkage reducers

9 Alkali-silica reactivity inhibitors

10 Coloring admixtures

11 Miscellaneous admixtures such as workability, bonding, dampproofing, permeability reducing, grouting, gas-forming, antiwashout, foaming, and pumping admixtures.

Table 1 provides a much more extensive classification of admixtures.

Concrete should be workable, finishable, strong, durable, watertight, and wear resistant. These qualities can often be obtained easily and economically by the sleection of suitable materials rather than by resorting to admixtures (except air-entraining admixtures when needed).

The major reasons for using admixtures are:

1 To reduce the cost of concrete construction.

2 To achieve certain properties in concrete more effectively than by other means.

3 To maintain the quality of concrete during the stages of mixing, transporting, placing and curing in adverse weather conditions.

4 To onvercome certain emergencies during concreting operations.

Despite these consideratin, it should be borne in mind that no admixture of any type or amount can be considered a substitute for good concreting pratice.

The effectiveness of an admixture depends upon factors such as type, brand, and amount of cementing materials; water content; aggregate shape, gradation, and proportion; mixing time; slump; and temperature of the concrete.

Admixtures being considered for use in concrete should meet applicable specifications as presented in Table .1 Trial mixtures should be made with the admixture and the job materials at temperatures and humiddities anticipated on the job. In this way the compatibility of the admixture with other admixtures and job materials, as well as the effect of the admixture on the properties of the fresh and hardened concrete, can be observed. The amount of admixture recommended by the manufacturer or the optimum amount determined by laboratory tests should be used.

Table 1

Concrete admixtures by classification

Type of admixture	Desired effect	Material
Accelerators (ASTM C 494 and AASHTO M 194, Type C)	Accelerate setting and early - strength development	Calcium chloride (ASTM D and AASHTO M 144) Triethanolamine, sodium thiocyanate, calcium nitrite, calcium nitrate
Air detrainers	Decrease air content	Tributyl phosphate, dibutyl phthalate, octyl alcohol, water-insoluble esters of carbonic and boric acid, silicones.
Air-entraining admixtures (ASTM C 260 and AASHTO M 154)	Improve durability in freeze-thaw, decier, sulfate, and alkalireactive environments improve workability	Salts of wood resins (Vinsol resin), some synthetic detergents, salts of sulfonated lignin, salts of petroleum acids, salts of proteinaceous material, fatty and resinous acids and their salts, alkylbenzene sulfonates, salts of sulfonated hydrocarbons
Alkali-aggregate reactivity inhibitors	Reduce alkali-aggregate reactivity expansion	Barium salts, lithium nitrate, lithium carbonate, lithium hydroxide
Antiwashout admixtures	Cohesive concrete for underwater placements	Cellulose, acrylic polymer
Bonding admixtures	Increase bond strength	Polyvinyl chloride, polyvinyl acetate, acrylics, butadiene-styrene copolymers
Coloring admixtures (ASTM C 979)	Colored concrete	Midified carbon black, iron oxide, phthalocyanine, under, chromium oxide, titanium oxide, cobalt blue
Corrosion inhibitors	Reduce steel corrosion activity in a chloride -laden environment	Calcium nitrite, sodium nitrite, sodium benzoate, certain phosphates or fluosilicates, fluoaluminates, ester amines
Dampproofing admixtures	Retard moisture penetration into dry concrete	Soaps of calcium or ammonium stearate or oleate Butyl stearate, Petroleum products
Foaming agents	Produce lightweight, foamed concrete with low density	Cationic and anionic surfactants, Hydrolized protein
Fungicides, germicides and	Inhibit or control bacterial and fungal growth	Polyhalogenated phenols, Dieldrin emulsions, Copper compounds
Gas formers	Cause expansion before setting	Alumimum powder
Grouting admixtures	Adjust grout properties for specific Accelerators applications	See Air- entraining admixtures, Accelerators, Retarders, and water reducers
Hydration control admixtures	Suspend and reactivate cement hydration with stabilizer and activator	Carboxylic acids, Phosphorus- containing organic acid salts
Permeability reducers	Decrease permeability	Latex, Calcium stearate

Type of admixture	Desired effect	Material
Pumping aids	Improve pumpability	Organic and synthetic polymers, Organic flocculents, Organic emulsions of paraffin, coal tar, asphalt, acrylics, Bentonite and pyrogenic silicas, Hydrated lime (ASTM C 141)
Retarders (ASTM C 494 and AASHTO M194, Type B)	Retard setting time	Lignin, Borax, Sugars, Tartaric acid and salts
Shrinkage reducers	Reduce drying shrinkage	Polyoxyalkylene alkyl ether, Propylene glycol
Superplasticizers* (ASTM C 1017, Type 1)	Increase flowability of concrete Reudce water-cement ratio	Sulfonated mealmine formaldehyde condensates, Sulfonated naphthalene formaldehyde condensates, Lignosulfonates, Polycarboxylates
Superplasticizer* and retarder (ASTM C 1017, Type 2)	Increase flowability with retarded set Reduce water- cement ratio	See superplasticizers and also water reducers
Water reducer (ASTM C 494 and AASHTO M 194, Type A)	Reduce water content at least 5%	Lignosulfonates, Hydroxylated carboxylic acids, Carbothydrates, (Also tend to retard set so accelerator is often added)
Water reducer and accelerator (ASTM C 494 and AASTHO M 194 Type E)	Reduce water content (minimum 5%) and accelerate set	See water reducer, Type A (accelerator is added)
Water reducer and retarder (ASTM C 494 and AASHTO M 194, Type D)	Reduce water content (minimum 5%) and retard set	See water reducer, Type A (retarder is added)
Water reducer - high range (ASTM C 494 and AASHTO M 194, Type F)	Reduce water content (minimum 12%)	See superplasticizers
Water reducer-high range- and retarder (ASTM C 494 and AASHTO M 194, Type G)	Reduce water content (minimum 12%) and retard set	See superplasticizers and also water reducers
Water reducer - mid range	Reduce water content (between 6 and 12%) without retarding	Lignosulfonates, Polycarboxylates

* Superplasticizers are also referred to as high range water reducers or plasticizers. These admixtures often meet both ASTM C 494 (AASHTO M 194) and ASTM C 1017 specifications.

1 Air - entraining admixtures

Air-entraining admixtures are used to purposely introduce and stablize microscopic air bubbles in concrete. Air-entrainment will dramatically improve the durability of concrete exposed to cycles of freezing and thawing (Fig 2) Entrained air greatly improves concrete's resistance to surface scaling caused by chemical deicers (Fig 3) Furthermore, the workability of fresh concrete is improved significantly and segregation and bleeding are reduced or eliminated.

Fig 2

Frost damage (crumbling) at joints of a pavement (top),frost induced cracking near joints (bottom), and enlarged view of cracks

Fig 3

Scaled concrete surface resulting from tack of air entrainment, use of deicers, and poor finishing and curing practices

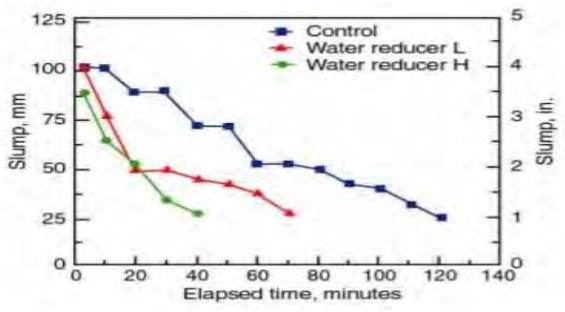
Air-entrained concrete contains minute air bubbles that are distributed uniformly throughtout the cement paste. Intrained air can be produced in concrete by use of an air-entraining cement, by introduction of an air-entraining admixture, or by a combination of both methods. An air-entraining cement is a portland cement with an air-entraining addition interground with the clinker during manufacture. An air-entraining admixture, on the other hand, is added directly to the concrete materials either before or during mixing.

The primary ingredients used in air-entraining admixtures are listed in Table 1. Specifications and methods of testing air - entraining admixtures are given in ASTM C 260 and C 233 (AASHTO M 154 and T 157). Air-entraining additions for use in the manufacture of air-entraining cements must meet requirements of ASTM C 226. Applicable requirements for air-entraining cements are given in ASTM C 150 and AASHTO M 85.

2 Water - reducing admixtures

Water- reducing admixtures are used to reduce the quantity of mixing water required to produce concrete of a certain slump, reduce water - cement ratio, reduce cement content, or increase slump. Typical water reducers reduce the water content by approximately 5% to 10%. Adding a water - reducing admixture to concrete without reducing the water content can produce a mixture with a higher slump. The rate of slump loss, however, is not reduced and in most cases is increased. (Fig 4). Rapid slump loss results in reduced workability and less time to place concrete.

Fig 4

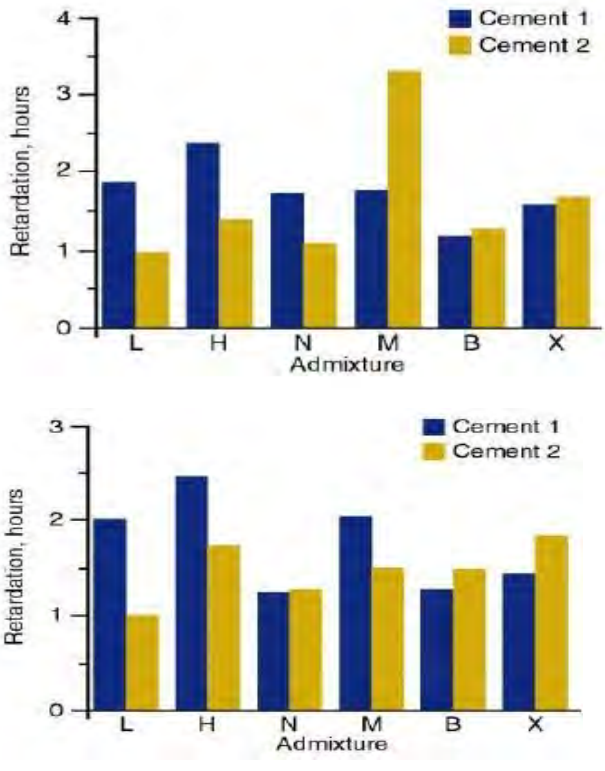


Slump loss at 23°C (73°F) in concrets containing conventional water reducers (ASTM C 494 and AASHTO M 194 Type D) compared with a control mixture

An increase in strength is generally obtained with water-reducing admixtures as the water - cement ratio is reduced. For concretes of equal cement content, air content, and slump, the 28 day strength of a water-reduced concrete containing a water reducer can be 10% to 25% greater than concrete without the admixture. Despite reduction in water content, water- reducing admixtures may cause increases in drying shrinkage. Usually the effect of the water reducer on drying shrinkage is small compared to other more significant factors that cause shrinkage cracks in concrete. Using a water reducer to reduce the cement and water content of a concrete mixture- while maintaining a constant water - cement ratio- can result in equal or reduced compressive strength and can increase slump loss by a factor of two or more.

Water reducers decrease, increase, or have no effect on bleeding, depending on the chemical composition of the admixture. A reduction of bleeding can result in finishing difficulties on flat surfaces when rapid drying conditions are present. Water reducers can be modified to give varying degrees of retardation while others do not significantly affect the setting time. ASTM C 494 (AASHTO M 194) Type A water reducers can have little effect on setting, while Type D admixtures provide water reduction with retrardation, and Type E admixtures provide water reduction with accelerated setting. Type D water-reducing admixtures usually retard the setting time of concrete by one to three hours (Fig 5). Some water - reducing admixtures may also entrain some air in concrete. Lignin-based admixtures can increase air contents by 1 to 2 percentage points. Concretes with water reducers generally have good air retention (Table 2)

Fig 5



Retardation of set in cement- reduced mixtures relative to control mixture. Concretes L and H contain conventional water reducer, concretes N, M, B and X contain high - range water reducer

The effectiveness of water reducers can concrete is a function of their chemical composition, concrete temperature, cement composition and fineness, cement condent, and the presence of other admixtures. The classifications and components of water reducers are listed in Table 1 for more information on the effects of water reducers on concrete properties.

Mid- range water reducing admixtures

Mid-range water reducers were first introduced in 1984. These admixtures provide significant water reduction (between 6 and 12%) for concretes with slumps of 125 to 200 mm (5 to 8 in.) without the retardation associated with high dosages of conventional (normal) water reducers. Normal water reducers are intended for concretes with slumps of 100 to 125 mm (4 to 5 in.) Mid -range water reducers can be used to reduce stickiness and improve finishability, pumpability, and placeability of concretes containing silica fume and other supplementary cementing materials. Some can also entrain air and be used in low slump concretes.

High-range water reducing admixtures

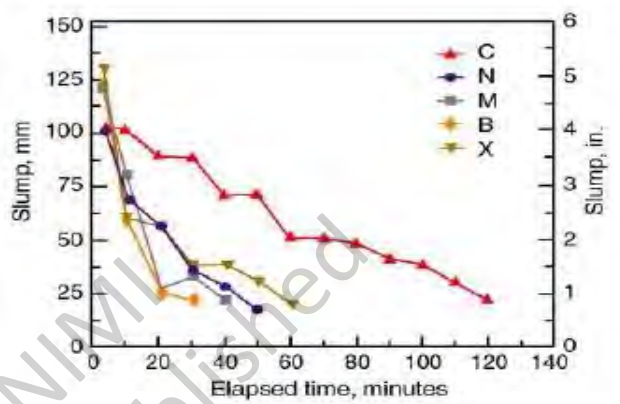
High- range water reducers, ASTM C 494 (AASHTO M 194) Types F (water reducing) and G (water reducing and retarding), can be used to impart properties induced by regular water reducers, only much more efficiently. They can greatly reduce water demand and cement contents and make low water-cement ratio, high -strength concrete with normal or enhanced workability. A water reduction of 12% to 30% can be obtained through the use of these admixtures. The reduced water content and water- cement ratio can produce concretes with (1) ultimate compressive strengths in excess of 70 MPa (10,000 psi), (2) increased early strength gain, (3) reduced chloride-ion penetration, and (4) other beneficial properties associated with low waer -cement ratio concrete (Fig 6).

Fig 6

Low water to cement ratio concrete with low chloride permeability - easily made with high-range water reducers- is ideal for bridge decks.

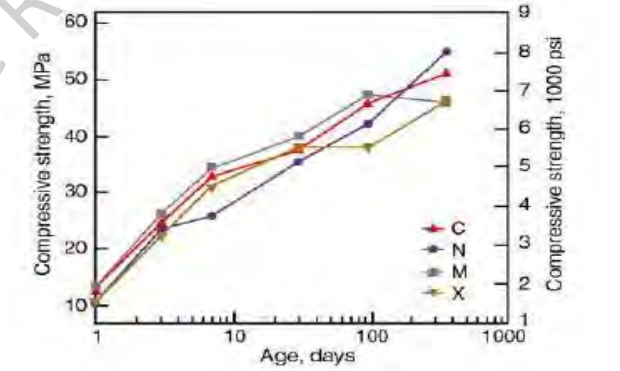
High- range water reducers are generally more effective than regular water - reducing admixtures in producing workable concrete. A significant reduction of bleeding can result with large reductions of water content; this can result in finishing difficulties on flat surfaces, when rapid drying conditions are present. Some of these admixtures can cause signficant slump loss (Fig 7). Significant retardation is also possible, but can aggravate plastic shrinkage cracking without proper protection and curing (Fig 5). Drying shrinkage, chloride permeability, air retention (Table 2), and strength development of concretes with high - range water reducers are comparable to concretes without them when compared at constant water - cement ratios (reduced cement and water contents) Fig.8.

Fig 7



Slump loss at 23°C (73°F) in mixtures containing high- range water reducers (N, M, B and X) compared with control mixture (C)

Fig 8



Compressive strength development in cement - reduced concretes; controls mixture (C) and concretes containing high- range water reducers (N, M, and X)

Concretes with high-range water reducers can have larger entrained air voids and higher void- spacing factors than normal air-entrained concrete. This would generally indicate a reduced resistance to freezing and thawing; however, laboratory tests have shown that concrets with a moderate slump using high- range water reducers have good freeze-thaw durability, even with slightly higher void- spacing factors. This may be the result of lower water-cement ratios often associated with these concretes.

When the same chemicals used for high -range water reducers are used to make flowing concrete, they are often called plasticizers or superplasticizers (see discussion below).

3 Plasticizers for flowing concrete

Plasticizers, often called superplasticizers, are essentially high - range water reducers meeting ASTM C 1017; these admixtures are added to concrete with a low-to-normal slump and water- cement ratio to make high - slump flowing concrete (Fig 9). Flowing concrete is a highly fluid but workable concrete that can be placed with little or no vibration or compaction while still remaining essentially free of excessive bleeding or segregation. Following are a few of the applications where flowing concrete is used; (1) thin-section placements (Fig 10), (2) areas of closely spaced and congested reinforcing steel, (3) tremie pipe (underwater) placements, (4) pumped concrete to reduce pump pressure, thereby increasing lift and distance capacity, (5) areas where conventional consolidation methods are impractical or can not be used, and (6) for reducing handling costs. The addition of a plasticizer to a 75 mm (3 in.) slump concrete can easily produce a concrete with a 230 mm (9 in.) slump. Flowing concrete is defined by ASTM C 1017 as a concrete having a slump greater than 190 mm (7 1/2 in.) yet maintaining cohesive properties.

Table 2

Loss of air from cement reduced concrete mixtures

Mixture	Initial air content, %*	Final air content %*	Percent air retained	Rate of air loss, %/ minute
C Control	5.4	3.0	56	0.020
L Water	7.0	4.7	67	0.038
H reducer	6.2	4.6	74	0.040
N	6.8	4.8	71	0.040
M High -range	6.4	3.8	59	0.065
B Water	6.8	5.6	82	0.048
X Reducer	6.6	5.0	76	0.027

* Represents air content measured after addition of admixture

* Represents air content taken at point where slump falls below 25 mm (1 in.)

Fig 9

Flowable concrete with a high slump (top) is easily placed (middle) even in areas of heavy reinforcing steel congestion (bottom)

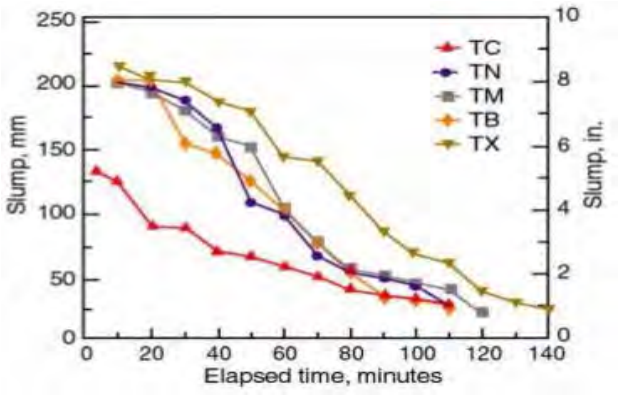
Fig 10

Plasticized, flowing concrete is easily placed in thin sections such as this bonded overlay that is not much thicker than 1 1/2 diameters of a quarter.

ASTM C 1017 has provisions for two types of admixtures; Type -1 plasticizing, and Type 2- plasticizing and retarding/ Plasticizers are generally more effective than regular or mid -range water- reducing admixtures in producing flowing concrete. The effect of certain plasticizers in increasing workability or making flowing concrete is short - lived, 30 to 60 minutes; this period is followed by a rapid loss is workability or slump loss (Fig 11). High temperatures can also aggravate slump loss. Due to their propensity for slump loss, these admixtures are some times added to the concrete mixer at the jobsite. They are available in liquid and powder form. Extended-slump-life plasticizers added at the batch plant help reduce slump-loss problems. Setting time may be accelerated or retarded based on the admixture's chemistry, dosage rate, and interaction with other admixtures and cementing materials in the concrete mixture. Some plasticizers can retard final set by one to almost four hours (Fig 12). Strength development of

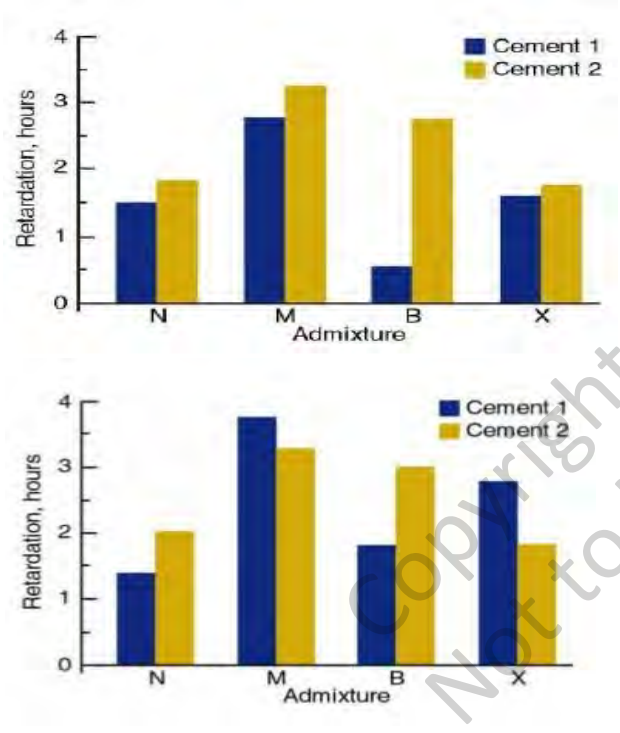
flowing concrete is comparable to normal concrete. (Fig 13)

Fig 11



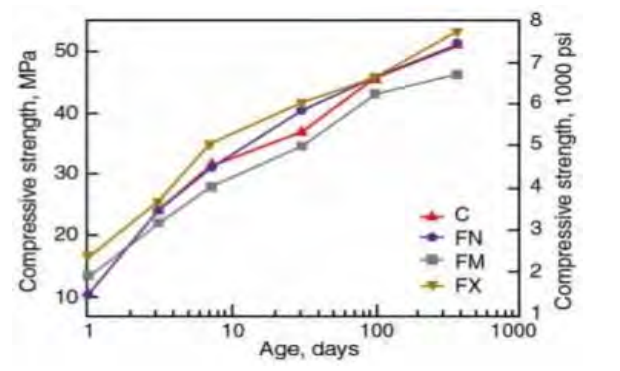
Slump loss at 32°C (90°F) in flowing concretes (TN, TM, TB and TX) compared with control mixture (TC)

Fig 12



Retardation of set in flowing concrete with plasticizers (N, M, B and X) relative to control mixture

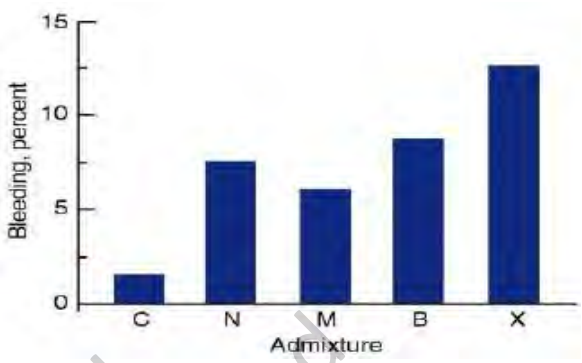
Fig 13



Compressive strength development in flowing concretes. C is the control mixture. Mixtures FN, FM and FX contain plasticizers

While it was previously noted that flowing concretes are essentially free of excessive bleeding, tests have shown that some plasticized concretes bleed more than control concretes of equal waer-cement ration (Fig 14); but plasticized concretes bleed significantly less than control concretes of equally high slump and higher water content. High - slump, low-water-content, plasticized concrete has less drying shrinkage than a high - slump, high - water-content conventional concrete, however this concrete has similar or higher drying shrinkage than conventional low-slump, low water- content concrete.

Fig 14



Bleeding of flowing concretes with plasticizers (N, M, B and X) compared to control (C)

The effectiveness of the plasticizer is increased with an increasing amount of cement and fines in the concrete.

Plasticized flowing concrete can have larger entrained air voids and greater void- spacing factors than conventional concrete. Air loss can also be significant. Some research has indicated poor frost- and deicer-scaling resistance for some flowing concretes when exposed to a continuously moist environment without the benefit of a drying period. However, field performance of flowing concretes with low water to portland cement ratios has been good in most frost environments.

Table 1 lists the primary components and specifications for plasticizing (superplasticizer) admixtures.

4 Retarding admixtures

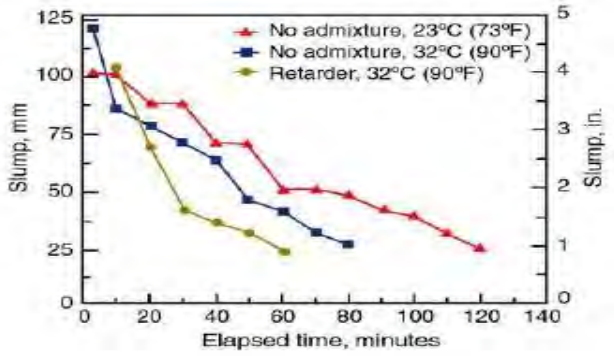
Retarding admixturs are used to delay the rate of setting on concrete. High temperatures of fresh concrete (30°C (86°F) are often the cause of an increased rate of hardening that makes placing and finishing difficult. One of the most practical methods of counteracting this effect is to reduce the temperature of the concrete by cooling the mixing water and / or the aggregates. Retarders do not decrease the initial temperature of concrete. The bleeding rate and bleeding capacity of concrete is increased with retarders.

Retarding admixtures are useful in extending the setting time of concrete, but they are often also used in attempts to decrease slump loss and extend workability, especially prior to placement at elevated temperatures. The fallacy of this approach is shown in Fig 15, where the addition of a retarder resulted in an increased rate of slump loss compared to the control mixtures.

Retarders are sometimes used to : (1) offset the accelerating effect of hot weather on the setting of concrete; (2) delay

the initial set of concrete or grout when difficult or unusual conditions of placement occur, such as placing concrete in large piers and foundations, cementing oil wells, or pumping grout or concrete over considerable distances; or (3) delay the set for special finishing techniques, such as an exposed aggregate surface.

Fig 15



Slump loss at various temperatures for conventional concretes prepared with and without set- retarding admixture

The amount of water reduction for an ASTM C 494 (AASHTO M 194) Type B retarding admixture is normally less than that obtained with a Type A water reducer. Type D admixtures are designated to provide both water reduction and retardation.

In general, some reduction in strength at early ages (one to three days) accompanies the use of retarders. The effects of these materials on the other properties. Therefore, acceptance tests of retarders should be made with actual job materials under anticipated job conditions. The classifications and components of retarders are listed in Table 1.

5 Hydration - control admixtures

Hydration controlling admixtures became available in the late 1980s. They consist of a two part chemical system; (1) a stabilizer or retarder that essentially stops the hydration of cementing materials, and (2) an activator that reestablishes normal hydration and setting when added to the stabilized concrete. The stabilizer can suspend hydration for 72 hours and the activator is added to the mixture jost before the concrete is used. These admixtures make it possible to reuse concrete is used. These admixtures make it possible to reuse concrete returned in a ready-mix truck by suspending setting overnight. The admixture is also useful in maintaining concrete in a stabilizhed non -hardened state during long hauls. The concrete is reactived when it arrives at the project. This admixture presently does not have a standard specification.

6 Accelerating admixtures

An accelerating admixture is used to accelerate the rate of hydration (setting) and strength development of concrete at an early age. The strength development of concrete can also be accelerated by other methods : (1) using Type III or Type HE high- early strength cement, (2) lowering the water- cement ratio by adding 60 to 120 kg/m^3 (100 to 200 lb/yd^3) of additional cement to the concrete, (3) using a water reducer, or (4) curing at higher temperatures. Accelerators are designated as Type C admixtures under ASTM C 494 (AASHTO M 194).

Calcium chloride ($CaCl_2$) is the chemical most commonly used in accelerating admixtures, especially for non-reinforced concrete. It should conform to the requirements of ASTM D 98 (AASHTO M 144) and should be sampled and tested in accordance with ASTM D 345.

The widespread use of calcium chloride as an accelerating admixtures has provided much data and experience on the effect of this chemical on the properties of concrete. Besides accelerating strength gain, calcium chloride causes an increase in drying shrinkage, potential reinforcement corrosion, discoloration (a darkening of concrete), and an increase in the potential for scaling.

Calcium chloride is not an antifreeze agent. When used in allowable amounts, it will not reduce the freezing point of concrete by more than a few degrees. Attempts to protect concrete from freezing by this method are foolhardy. Instead, proven reliable precautions should be taken during cold weather, Cold- Weather concreting).

When used, calcium chloride should be added to the concrete mixture in solution form as part of the mixing water. If added to the concrete in dry flake form, all of the dry particles may not be completely dissolved during mixing. Undissolved lumps in the mix can cause popouts or dark spots in hardened concrete.

The amount of calcium chloride added to concrete should be no nore than is necessary to produce the desired result and in no case exceed 2% by mass of cementing material. When calculating the chloride content of commercially available calcium chloride, it can be assumed that.

1 Regular flake contains a minimum of 77% $CaCl_2$.

2 Concentrated flake, pellet, or granular forms contain a minimum of 94% $CaCl_2$.

An overdose can result in placement problems and can be detrimental to concrete. It may cause; rapid stiffening, a large increase in drying shrinkage, corrosion of reinforcement, and loss of strength at later ages.

Applications where calcium chloride should be used with caution.

1 Concrete subjected to steam curing

2 Concrete containing mebedded dissimilar metals, especially if electrically connected to steel reinforcement.

3 Concrete slabs supported on permanent galvanized steel forms.

4 Colored concrete.

Calcium chloride or admixtures containing soluble chlorides should not be used in the following.

1 Construction of parking garages

2 Prestressed concrete because of possible steel corrosion hazards.

3 Concrete containing embedded aluminum (for example, conduit) since serious corrosion of the aluminum can result, especially if the alumnium is in contact with embedded steel and the concrete is in a humid environment.

4 Concrete containing aggregates that, under standard test conditions, have been shown to be potentially deleteriously reactive.

5 Concrete exposed to soil or water containing sulfates

6 Floor slabs intended to receive dry-shake metallic finishes.

7 Hot weather generally

8 Massive concrete placements.

The maximum chloride-ion content for corrosion protection of prestressed and reinforced concrete as recommended by the ACI 318 building code is presented in Table -3. Resistance to the corrosion of embedded steel is further improved with an increase in the depth of concrete cover over reinforcing steel, and a lower water - cement ratio. Stark (1989) demonstrated that concretes made with 1% $CaCl_2$- $2H_2O$ by mass of cement developed active steel corrosion when stored continuously in fog. When 2% $CaCl_2$ - $2H_2O$ was used, active corrosion was detected in concrete stored in a fog room at 100% relative humidity. Risk of corrosion was greatly reduced at lower relative humidities (50%) demonstrates how to calculate the chloride content of freshconcrete and compare it with recommended limits.

Table 3

Maximum chloride - ion content for corrosion protection on reinforcement

Type of member	Maximum water soluble chloride-ion (Cl) in concrete percent by mass of cement
Prestressed concrete	0.06
Reinforced concrete exposed to chloride in service	0.15
Reinforced concrete that will be dry or protected from mositure in service	1.00
Other reinforced concrete construction	0.30

* Requirements from ACI 318 tested per ASTM C 1218.

Several nonchloride, noncorrosive accelerators are available for use in concrete where chlorides are not recommended (Table 1). However, some nonchloride accelerators are not as effective as calcium chloride. Certain nonchloride accelerators accelerators are specially formulated for use in cold weather applications with ambient temperatures down to 7°C (20°F).

7 Corrosion inhibitors

Corrosion inhibitors are used in concrete for parking structures, marine structures, and bridges where chloride salts are present. The chlorides can cause corrosion of steel reinforcement in concrete (Fig 16). Ferrous oxide and ferric oxide form on the surface of reinforcing steel in concrete. Ferrous oxide, though stable in concrete's alkaline environment, reacts with chlorides to form complexes that move away from the steel to form rust. The chloride ions continue to attack the steel until the passivating oxide layer is destroyed. Corrosion-inhibiting admixtures chemically arrest the corrosion reaction.

Fig 16

The damage to this concrete parking structure resulted from chloride- induced corrosion of steel reinforcement

Commercially available corrosion inhibitors include; calcium nitrite, sodium nitrite, dimethly ethanolamine, amines, phosphates, and ester amines. Anodic inhibitors, such as nitrites, block the corrosion reaction of the chloride-ions by chemically reinforcing and stabilizing the passive protective film on the steel; this ferric oxide film is created by the high pH environment in concrete. The nitrite-ions cause the ferric oxide to become more stable. In effect, the chloride-ions are prevented from penetrating the passive film and making contact with the steel.

A certain amount of nitrite can stop corrosion up to some level of chloride-ion. Therefore, increased chloride levels require increased levels of nitrite to stop corrosion.

Cathodic inhibitors react with the steel surface to interfere with the reduction of oxygen. The reduction of oxygen is the principal cathodic reaction in alkaline environments.

8 Shrinkage - reducing admixtures

Shrinkage-reducing admixtures, introduced in the 1980s, have potential uses in bridge decks, critical floor slabs, and buildings where cracks and curling must be minimized for durability or aesthetic reaons (Fig 17). Propylene glycol and polyoxyalkylene alkyl ether have been used as shrinkage reducers. Drying shrinkage reductions of between 25% and 50% have been demonstrated in laboratory tests. These admixtures have negligible effects on slump and air loss, but can delay setting. They are generally compatible with other admixtures.

9 Chemical admixtures to reduce alkali-aggregate reactivity (asr inhibitors)

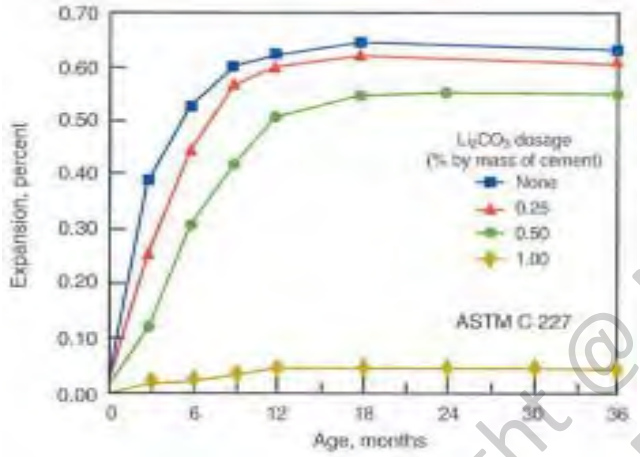
Chemical admixtures to control alkali-silica reactivity (alkali-aggregate expansion) were introduced in the 1990s (Fig 18). Lithium nitrate, lithium carbonate, lithium hydroxide, lithium alumnium silicate (decrepitated

spodumene), and barium salts have shown reduction of alkali-silica reaction (ASR) in laboratory tests. Some of these materials have potential for use as an additive to cement. There is little long-term field experience available on the effectiveness of these materials.

Fig 17

Shrinkage cracks, such as shown on this bridge deck, can be reduced with the use of good concreting practices and shrinkage reducing admixtures

Fig 18



Expansion of specimens made with lithium carbonate admixture

10 Coloring admixtures (Pigments)

Natural and synthetic materials are used to color concrete for aesthetic and safety reaons. (Fig 19). Red concrete is used around buried electrical orgas lines as a warning to anyone near these facilities. Yellow concrete safety curbs are used in paving applications. Generally, the amount of pigments used in concrete should not exceed 10% by weight of the cement. Pigments used in amounts less than 6% generally do not affect concrete properties.

Fig 19

Red and blue pigments were used to color this terrazzo floor.

Unmodified carbon black substantially reduces air content. Most carbon black for coloring concrete contains an admixture to offset this effect on air. Before a coloring admixture is used on a project, it should be tested for color fastness in sunlgiht and autoclaving, chemical stability in cement, and effects on concrete properties. Calcium chloride should not be used with pigments to avoid color distortions. Pigments should conform to ASTM C 979.

11 Dampproofing admixtures

The passage of water through concrete can usually be tracted tobe existence of cracks or areas of incomplete consolidation. Sound, dense concrete made with a water-cement ratio of less than 0.50 by mass will be watertight if it is properly placed and cured.

Admixtures known as dampproofing agents include certain soaps, stearates, and petroleum products. They may, but generally do not reduce the permeability of concretes that have low cement contents, high water-cement ratios, or a deficiency of fines in the aggregate. Their use in well - proportioned mixes, may increase the mixing water required and actually result in increased rather than reduced permeability.

Dampproofing admixtures are sometimes used to reduce the transmission of moisture through concrete that is in contact with water or damp earth. Many so-called dampproofers are not effective, especially when used in concretes that are in contact with water under pressure.

Permeability - reducing admixtures

Permeability- reducing admixtures reduce the rate at which water under pressure is transmitted through concrete. One of the best methods of decreasing permeability in concrete is to increase the moistcuring period and reduce the water- cement ratio to less than 0.5. Most admixtures that reduce water -cement ratio consequently reduce permeability.

Some supplementary cementing materials, especially silica fume, reduce permeability through the hydration and pozzolanic - reaction process. Other admixtures that act to block the capillaries in concrete have been shown to be effective in reducing concrete corrosion in chemically aggressive environments. Such admixtues, designed for use in high- cement content/ low -water- cement ratio concretes, contain aliphatic fatty acid and an aqueous emulsion of polymeric and aromatic globules.

Pumping aids

Pumping aids are added to concrete mixtures to improve pumpability. Pumping aids cannot cure all unpumpable concrete problems; they are best used to make marginally pumpable concrete more pumpable. These admixtuers increase viscosity or cohesion in concrete to reduce dewatering of the paste while under pressure from the pump.

Some pumping aids may increase water demand, reduce compressive strength, cause air entrainment, or retard setting time. These side effects can be corrected by adjusting the mix propertions or adding another admixture to offset the side effect.

A partial list of materials used in pumping aids is given in Table 1. Some admixtures that serve other primary purposes but also improve pumpability are air-entraining agents, and some water-reducing and retarding admixtures.

Bonding admixtures and bonding agents

Bonding admixtures are usually water emulsions of organic materials including rubber, polyvinyl chloride, polyvinyl acetate, acrylics, styrene butadiene copolymers, and other polymers. They are added to portland cement mixtures to increase the bond strength between old and new concrete. Flexural strength and resistance to chloride-on ingress are also improved. They are added in proportions equivalent to 5% to 20% by mass of the cementing materials; the actual quantity depending on job conditions and type of admixture used. Some bonding admixtures may increase the air content of mixtures. Nonreemulsi□able types are resistant to water, better suited to exterior application, and use in places where moisture is present.

The ultimate result obtained with a bonding admixture will be only as good as the surface to which the concrete is applied. The surface must be dry, clean, sound free of dirt, dust, pain, and grese, and at the proper temperature. Organic or polymer modi□ed concretes are acceptable for patching and thin-bonded overlayment, particularly where feather-edged patches are desired.

Bonding agents should not be confused with bonding admixtures. Admixtures are an ingredient in the concrete; bonding agents are applied to existing concrete surfaces immediately before the new concrete is placed. Bonding agents help “glue” the existing and the new materials together. Bonding agents are often used in restoration and repair work; they consist of portland cement or latex-modi□ed portland cement grout or polymers such as expoxy resins. or latex.

Grouting admixtures

Portland cement grouts are used for a varity of purposes: to stabilize foundations, set machine bases, □ll cracks and joints in concrete work, cement oil well, □ll cores of masonry walls, grout prestressing tendons and anchor bolts, and □ll the voids in preplaced aggregate concrete. To alter the properties of grout for speci□c applications, various air-entraining admixtures, accelerators, retarders, and nonshrink admixtues are often used.

Gas - forming admixtures

Aluminum powder and other gas- forming materails are sometimes added to concrete and grout in very small quantities to cause a slight expansion of the mixture prior to hardening. This may be of bene□t where the complete grouting of a con□ned space is essential, such as under machine bases or in post-tensioning ducts of prestressed concrete. These materials are also used in larger quantities to produce autoclaved celluar concretes. The amount of expansion that occurs is dependent upon the amount of gas-forming material used, the temperature of the fresh mixture, the alkali contnet of the cement, and other variable. Where the amount of expansion is critical, careful control of mixtures and temperatures must be exercised. Gas-forming agents will not overcome shrinkage after hardening caused by drying or carbonation.

Air detrainers

Air- detraining admixtures reduce the air content in concrete. They are when the air content cannot be reduced by adjusting the mix proportions or by changing the dosage of the air-entraining agent and other admixtures. However, air -detrainers are rarely used and their e□ectiveness and dosage rate should be established on trial mixes prior to use on actual job mixes. Materials used in air-detraining agents are listed in Table 1.

Fungicidal, germicidal, and insecticidal admixtures

Bacteria and fungal growth on or in hardened concrete may be partially controlled through the use of fungicidal, germicidal, and insecticidal admixtures. The most e□ective materials are polyhalogenated phenols, dieldrin emulsions, and copper compounds. The e□ectiveness of these materials is generally temporary, and in high dosages they may reduce the compressive strength of concrete.

Antiwashout admixtures

Antiwashout admixtures increase the cohesiveness of concrete to a level that allows limited exposure to water with little loss of cement. This allows placement of concrete in water and under water without the use of tremies. The admixtures increase the viscosity of water in the mixture resulting in a mix with increased thixotropy and resistance to segregation. They usually consist of water soluble cellulose ether or acrylic polymers.

Compatibility of admixtuers and cementitious materials

Fresh concrete problems of varying severity are encountered due to cement admixture incompatibility and incompatibility between admixtures. Incompatibility between supplementary cementing materials and admixtures or cements can also occur. Slump loss, air loss, early sti□ening, and other factors a□ecting fresh concrete properties can result from incompatibilities. While these problems primarily a□ect the plastic-state performance of concrete, long-term hardened concrete performance may also be adversely a□ected. For example, early sti□ening can cause di□culties with consolidation of concrete, therefore compromising strength.

Reliable test methods are not available to adequately address incompatibility issues due to variations in materials, mixing equipment, mixing time, and environmental factors. Tests run in a laboratory do not re□ect the conditions experienced by concrete in the □eld. When incompatibility is discovered in the □eld, a common solution is to simply change admixtures or cementing materials.

Storing and dispensing chemical admixtures

Liquid admixtuers can be stored in barrels or bulk tankers. Powdered admixtuers can be placed in special storage bins and some are available in premeasured plastic bags. Admixtures added to a truck mixer at athe jobsite are often in plastic jugs or bags. Powdered admixtures, such as certain plasticizers, or a barrel of admixture may be stored at the project site.

Dispenser tanks at concrete plants should be properly labeled for specific admixtures to avoid contamination and avoid dosing the wrong admixture. Most liquid chemical admixtures should not be allowed to freeze; therefore, they should be stored in heated environments. Consult the admixture manufacturer for proper storage temperatures. Powdered admixtures are usually less sensitive to temperature restrictions, but may be sensitive to moisture.

Liquid chemical admixtuers are usually dispensed individually in the batch water by volumetric means (Fig 20). Liquid and powdered admixtures can be measured by mass, but powdered admixtures should not be measured by volume. Care should be taken to not combine certain admixtures prior to their dispensing into the batch as some combinations may neutralize the desired effect of the admixtures. Consult the admixture manufacturer concerning compatible admixture combinations or perform laboratory tests to document performance.

List of common concrete admixtures (Additives)

Fig 20

Liquid admixture dispenser at a ready mix plant provides accurate volumetric measurement of admixtures.

Admixtures are added to concrete batch immediately before or during mixing concrete. Concrete admixtures can improve concrete quality, manageability, acceleration or retardation of setting time among other properties that could be altered to get specific results. Many, not to say all, concrete mixes today contain one or more concrete admixtures that will help your pouring process driving odwn cost while increasing productivity, The cost of these admixtures will vary depending on the quantity and type of admixture being used. All of this will be added to the cubic yard/meter cost of concrete.

Concrete admixtures : Set - retarding

Set retarding concrete admixtures are used to delay the chemical reaction that takes place when the concrete starts the setting process. These types of concrete admixtures are commonly used to reduce the effect of high temperatures that could produce a faster initial setting of concrete. Set retarding admixtures are used in concrete pavement construction, allowing more time for finishing concrete pavements, reducing additional costs to place a new concrete batch plant on the job site and helps eliminate cold joints in concrete. Retarders can also be used to resist cracking due to form deflection that can occur when horizontal slabs are placed in sections. Most retarders also function as water reducers and may entrain some air in concrete.

Fig 21

Concrete admixtures, hisham ibrahim / getty images

Concrete admixtures : Air - entrainment

Air entrained concrete can increase the freeze-thaw durability of concrete. This type of admixture produce a more workable concrete than non-entrained concrete while reducing bleeding and segregation of fresh concrete. Improved resistance of concrete to severe frost action of freeze/thaw cycles. Other benefits from this admixture are:

- High resistance to cycles of wetting and drying
- High degree of workability
- High degree of durability

The entrained air bubbles act as a physical buffer against the cracking caused by the stresses due to water volume augmentation in freezing temperatuers. Air entrainers admixtures are compatible with almost all the concrete admixtures. Typically for every one percent of entrained air, compressive strength will be reduced by about five percent.

Fig 22

Concrete admixtures, hisham ibrahim / getty images

Water - reducing concrete admixtures

Water-reducing admixtures are chemical products that when added to concrete can create a desired slump at a lower water- cement ratio than what it is normally desinged. Water- reducing admixtures are used to obtain specific

concrete strength using lower cement content. Lower cement contents result in lower CO2 emissions and energy usage per volume of concrete produced. With this type of admixture, concrete properties are improved and help place concrete under difficult conditions. Water reducers have been used primarily in bridge decks, low-slump concrete overlays, and patching concrete. Recent advancements in admixture technology have led to the development of mid - range water reducers.

Fig 23

Water reducing admixture. Lester lefkowitz / getty images

Concrete admixtures : Accelerating

Accelerating concrete admixtures are used to increase the rate of concrete strength development or to reduce concrete setting time. Calcium chloride could be named as the most common accelerator component; however, it could promote corrosion activity of steel reinforcement. Nonetheless, concrete best practices such as proper consolidation, adequate cover and proper concrete mix design could prevent these corrosion issues. Accelerating admixtures are especially use ful for modifying the properties of concrete in cold weather.

Fig 24

Accelerating admixture : Natalie Fobes / Getty images

Concrete admixtures : Shrinkage reducing

Shrinkage reducing concrete admixtures are added to concrete during initial mixing. This type of admixture could reduce early and long-term drying shrinkage. Shrinkage reducing admixtures can be used in situations where shrinkage cracking could lead to durability problems or where large numbers of shrinkage joints are undesirable for economic or technical reasons. Shrinkage reducing admixtures can, in some cases, reduce strength development both at early and lather ages.

Fig 25

Justin Sullivan / Getty images

Concrete admixtures : Superplasticizers

The main purpose of using superplasticizers is to produce flowing concrete with a high slump in the range of seven to nine niches to be used in heavily reinforced structure and in placements where adequate consolidation by vibration cannot be readily achieved. The other major application is the production of high -strength concrete at w/c's ranging from 0.03 to 0.04. It has been found that for most types of cement, superplasticizer improves the workability of concrete. One problem associated with using a high range water reducer in concrete is slump loss. High workability concrete containing superplasticizer can be made with a high freeze- thaw resistance, but air content must be increased relative to concrete without superplasticizer.

Fig 26

Banks photos / getty images

Concrete admixtures : Corrosion - inhibiting

Corrosion - inhibiting admixtures fall into the specialty admixture category and are used to slow corrosion of reinforcing steel in concrete. Corrosion inhibitors can significantly reduce maintenance costs of reinforced concrete structures throughout a typical service life of 30-40 years. Other specialty admixtures include shrinkage-reducing admixtures and alkali-silica reactivity inhibitors. Corrosion - inhibiting admixtures have little effect on strength at later ages but may accelerate early strength development. Calcium nitrite based corrosion inhibitors do accelerate the setting times of concretes over a range of curing temperatures unless they are formulated with a set retarder to offset the accelerating effect.

Fig 27

Frank cezus / Getty images

Fig 28

Are you following the right steps when pouring concrete in winter?

Fig 29

The basics for mixing concrete

Fig 30

Tips and recommendations for placing concrete in hot weather

Fig 31

Are you using the right cement when curing concrete during winter?

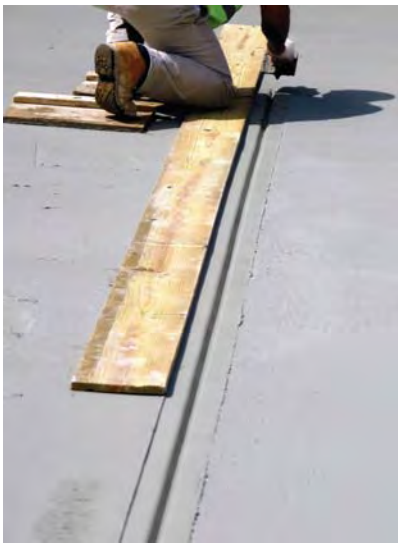
Fig 32

Prevent cold - weather damage following these masonry tips

Fig 33

Uses, Benefits and drawbacks of fkly ash in construction

Fig 34



Contraction, expansion and construction are all concrete joints

Fig 35

A new admixture is capable of minimizing concrete shrinkage

Fig 36

How to solve curling, cracking, scaling and more concrete problems

Fig 37

Want a concrete with no cracks and no joints? this might be for you

Fig 38

Use and applications of autoclaved aerated concrete (AAC)

Fig 39

Self- compacting or consolidating concrete has many advantages

Sand

Objectives: At the end of this lesson you shall be able to
- **define sand**
- **state the characteristics of sand**
- **state the type of sand**
- **state uses of sand.**

Sand

- Sand particles consists of small grains of silica.
- Sand is formed by decomposition of sand stone due to various effects of weather. Decording to the material sources sand is obtained. Artificial sand is prepared by crushing stones and gravel to powder.

Characteristics of good sand

1 Sand should be clean and free from coatings of clay and silt.

2 Sand should be free from salt

3 Sand should be coarse, angular, hard and sharp grows

4 Sand should not contain organic matter.

5 It should be strong and durable

6 It should be chemically inert.

7 Sand should pass through 40.75 mm sieve and entirely retained on is sieve of 75 micron

Types of sand

There are three types of sand

1 Pit sand

2 River sand

3 Sea sand

1 Pit sand

- Pit sand is found as deposits in soil
- It is obtained by forming pits into soils.
- Sand is excavated from a depth of about 1 m to 2 m from the ground level.
- Pit sand consists of sharp, angular grains and also free from salts.
- For preparing mortar, clean the pit sand free from organic matter.

2 River sand

- River sand is obtained from bed of rivers
- River sand consists of fine round grains
- Colour of sand is almost white.
- River sand is available in clean condition
- This sand is used for purposes

3 Sea sand

- This sand is obtained from sea shore.
- Sea sand consists fine rounded grains like river sand
- The colour of sea sand is light brown.
- Sea sand contains salts.
- The salts absorb moisture from the atmosphere and causes dampross, efflorescence and disintegration of work.
- Sea sand retorts the setting action of cement
- Due to above reason, to avoid the use of sea sand for engineering works.

Classification of sand according to the size of grains

1 Fine sand

2 Coarse sand

3 Gravelly sand

1 Fine sand

- Sand passing through a sieve with clear opening of 1.5875 mm is known as fine sand. This sand is used for plastering.

2 Coarse sand

- Sand passing through a sieve with clear opening of 3.175 mm is known as coarse sand. This sand is used for masonry work.

3 Gravelly sand

- Sand passing through a sieve with clear opening of 7.62 mm is known as gravelly sand. This sand is used for concrete work.

Bulking of sand

- The presence of moisture is sand increases the volume of sand is called bulking of said.

Uses of sand

- Sand is used as binding materials to make the mortar economical.
- It is used for making mortar and concrete
- Sand helps in early setting of mortar
- Sand increases the density of mortar
- Sand is used to fill the basement.

Clay products (Tiles)

Objectives: At the end of this lesson you shall be able to
- **define ceramic**
- **state clay for ceramic**
- **explain technical terms of ceramic products**
- **classify and describe the tiles.**

Introduction

Ceramic means the technology and the art of making objects with clay and similar Materials by treating with fire. Clay products, refractories and glass come under this. As tiles in various forms are the principal ceramic products used in building.

Clay for ceramic:

The special ceramic product requires its own type of special clay, even though ordinary earthenware's can be made from many types of ordinary clay. Fine white clay is required to manufacture porcelain articles. Refractory clay, which is special heat-resisting clay, is necessary for making refractories for chimney and ovens.

Technical terms:

1 **Earthenware:** Ordinary cooking pots and pans usually used in village come under this.

2 **Stoneware:** It is a product of refractory clay. Stoneware jars are very popular. Earthenware and stoneware together is called pottery.

3 **Porcelain:** Dinner plates, tea cups and saucers come under this category.

4 **Terracotta:** It is a hard brownish, unglazed vitrified ceramic material used for architectural ornamentation.

5 **Faience:** It is a city in Italy. It is earthenware or pottery to which heavy glazing has been applied and fired. It differs from porcelain. Faience has a porous shell and porcelain a solid shell.

6 **Glazing:** The provision of a transparent or opaque glass like coating is called glazing. It improves the appearance, provides a smooth surface and protects the surface from atmospheric as well as chemical action.

7 **Tiles:** It is a thin slab of baked clay of different shapes and sizes. Terrazzo tiles made of concrete and rubber tiles made of rubber to be used on floors and clay tiles to be used on roofs and floors.

Classification of tiles:

1 Common clay tiles for floors

2 Clay tiles for terraces

3 Clay tiles for ceiling

4 Glazed tiles for floors and walls

5 Vitrified tiles

6 Common clay roof tiles

7 Country roof tiles

(Encaustic tiles are the tiles initially painted with colours and the colours get fixed to the tiles with heat)

Clay floor tiles:

There are generally salt glazed to give a good appearance. Floors made of these tiles, unlike cement floors, are more suitable for walking barefooted.

Clay terracing tiles: These tiles are to be made according to IS: 2690-1964.

Clay ceiling tiles:

(IS: 1464-1959) these tiles are usually placed on reepers, over these ceiling tiles, Mangalore tiles are laid. They are generally given a floor pattern decoration on the exposed faces.

Glazed ceramic tiles:

These tiles were exclusively used as wall tiles for bathrooms in hospitals etc. large size with thick glazing are being used for flooring in offices, airports, etc.

Fully-vitrified tiles:

These tiles bridge the gap between ordinary ceramic tiles and marble floors. These tiles are especially used in kitchen floors as ordinary ceramic tiles are brittle and the full of any heavy object is liable to chip the ceramic tiles.

Porcelain tiles:

These are available in many forms as plain, coloured and also with decorative patterns and sizes. They are rather expensive compared to the traditional floors.

Common clay roof tiles:

There are many types of clay roof tiles. They are mostly used for covering sloped roofs, e.g.,

1 Mangalore pattern roofing tiles(Fig 1)

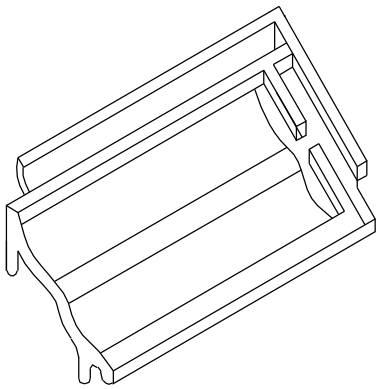
2 Half round country tiles (Spanish tiles)(Fig 2)

3 Allahabad tiles (Italian tiles)(Fig 3)

Mangalore pattern roofing tiles(Fig.1)

(IS: 654-1972) These are available in various shape and dimensions. They overlap on the tile below and also lock with the adjacent tile.

Fig 1



MANGALORE TILE

DCN122011

Clay half round country tiles (spanish tiles)(Fig.2,3)

These are laid in pairs as under tiles and over tiles. These tiles are also sometimes placed over A.C. or G.I. sheets.

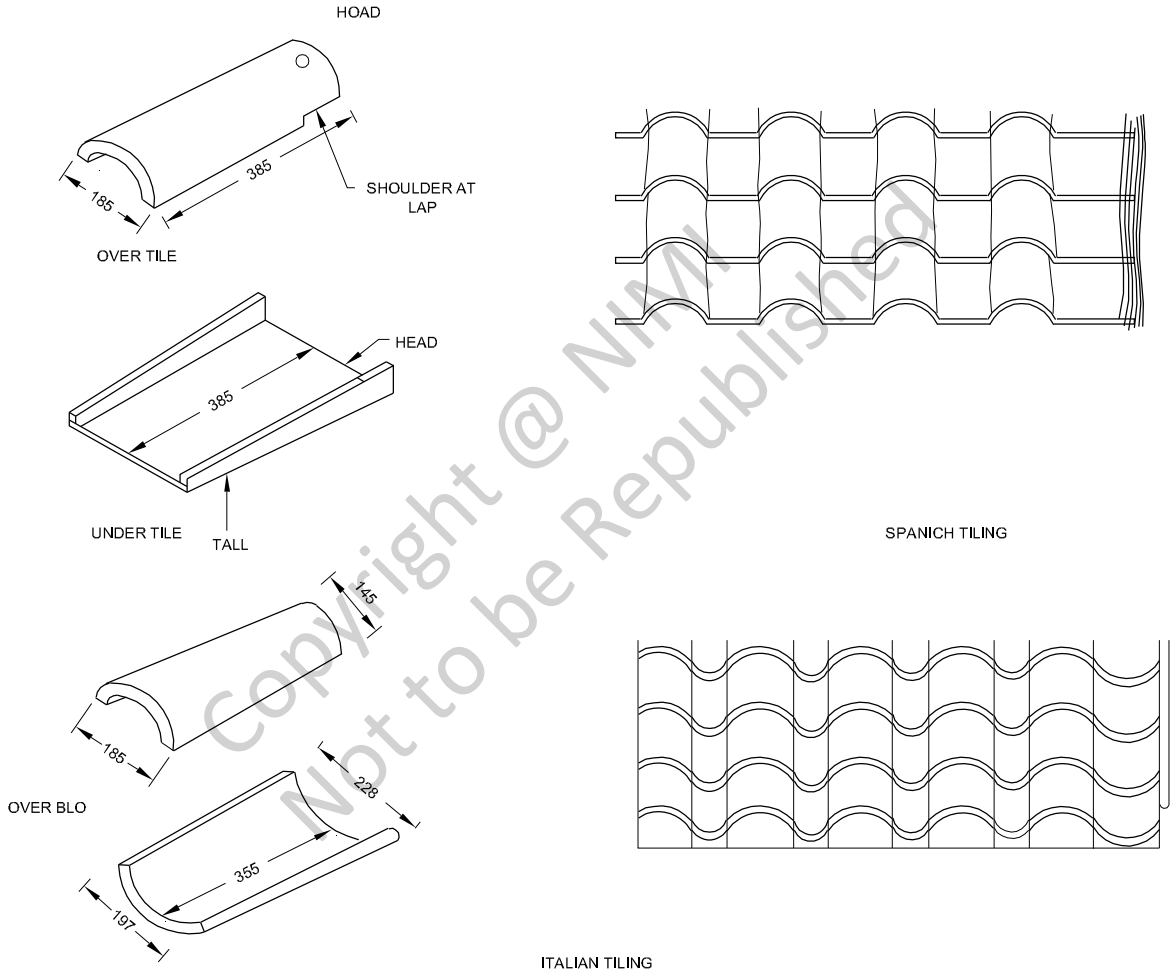
Allahabad tiles (italian tiles): (Fig.4)

These are two types-the bottom and top tiles. The bottom tiles are flat, tapered with upturned flanges at the sides. The over tiles are half round and tapered.

Terra - cotta

The terra means earth and cotta means baked. Hence terrra-cotta means baked earth. It is thus a type of earthenware or porous pottery made from local clays and glazed with glazes contianing galena.It is soft enough to be scratched by a knife.

Fig 2



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Varities of terra-cotta

The terra-cotta articles are of the following two types:

Porous terra-cotta **Polished terra cotta**

Porous terra cotta : To prepare porous terra-cotta, the saw dust or ground cork is added in clay before the stage of moulding. When articles from such clay are burnt in a kiln, the organic particles are brunt and they have leave pores in the articles. The porous terra-cotta is a fire-proof and a sound-proof material. It can be chiselled, sawn and nailed easily with nails, screws, etc. It is light in weight, but it is structurally weak.

Polished terra-cotta

This is also known as fine terra-cotta or faience. To obtian this variety of terra-cotta, the article are burnt at a lower temperatrue of about 650^{0}C. This first buring is known as biscuiting. The articles brought to biscuit stage are removed from kiln and are allowed to cool down.

They are then coated with glazing compound and burnt again in the kiln at a temperature of about 1200^{0}C .The faience is svailable in a variety of colours and it indicates superior quality of terra-cotta.It is used for ornamental purposes and in industrial areas since it is ordinarily unaffected by the adverse atmospheric conditions.

Advantages of terra-cotta

Following are the advantages of terra-cotta

It is strong and durable material

It is available in different colours

It is cheaper than ordinay finely dressed stones

It is easily cleaned

It is easily moulded in desired shapes

It is fire-proof and can, therefore, be conveniently used with R.C.C work.

It is light in weight

It is not affected by atmospheric agencies and acids and is capable of withstanding weathering actions better than most kinds of stone.

Disadvantages of terra-cotta

Following are the disadvantages of terra-cotta:

It can not be fixed during the progress of work. But it is to be fixed when the work is in final stage of completion.

It is twisted due to unequal shrikage in drying and burning.

Uses of terra-cotta

Following are the uses of terra-cotta:

The hollow terra-cotta blocks are used for various ornamental purposes such as facing work, arches, cornices, casing for coloumns,etc.

It is adopted for all sorts of ornamental work

It is used as a decorative material in place of stones for ornamental parts of buildings such as cornices, string courses, sills, copings, bases of pillars, fire places etc.

Earthenware: The term earthenware is used to indicate wares or articles prepared from clay which is burnt at low temperatrue and cooled down slowly. The clay is mixed with required quantity of sand, crushed pottery, etc.

The addition of such Materials prevents the shrinkage during drying and burning. The earthenwares are generally soft and porous. When glazed, the earthenwares become impervious to water and they are not affected by acids or atmospheric agences. The terra-cotta is a kind of earthenware.

The earthenware is used for making ordinary drain pipes, electrical cable, conduits, partition blocks etc.

Stoneware

The term stoneware is used to indicate wares or articles prepared for refractory clays which are mixed with stone and crushed pottery. Such a mixture is then burnt at a high temperature and cooled down slowly.

The stoneware is more compact and dense than earthenware.When glazed, the stoneware become impervious to water and they are not affected by acids or atmospheric agences. The sound stonewares give clear ringing sound when struck with each other.

The stoneware are strong impervious durable and assistant to corrosive fuluids and they resemble fire bricks. The stoneware can be kept clean easily and hence, they have become very popular as sanitary articles such as wash basins sewer pipes, glazed tiles, water closets, gully traps etc. They are also used as jars to store chemicals

Porcelain

The term poreclain is used to indicate fine earthenware which is white thin an semi-transparent. Since the colour of porcelain is white, it is also referred to as whiteware.

The clay of sufficent purity and possessing high degree of tenacity and plasticity is used in preparing porcelain. It is hard, brittle and non-porous. It is prepared from clay, felspar.

Refractories

The term refractories is used to indicate substances that are able to resist high temperature. The desired properties of refactories are as follows:

It must possess excellent resistance to rapid changed in temperature i.e. thermal shocks

Its dimensional stability i.e. resistance to change in volume at high temperature should be excellent.

It should be able to withstand abrasion and rough usage and should give reasonably long life without cracking or spalling.

It should be strong i.e. it must be capable of resisting compressive crushing and tensile forces in hot or cold conditions.

It should not fall into pieces at high temperatures

Its melting point should be high.

Its thermal conductivity should be suitable for the purpose for which it is to be used.

Classification of refractory materials

The refractory Materials are classified in the following two ways

i according to chemical properties and

ii according to resistance to temperature

According to chemical properties

The refractory Materials are divided into the following three categories as per their chemical properties , acidic, basic and neutral.

According to resistance to temperature

The refractory Materials are divided into the following two categories as per their capacity to resist temperature.

low quality and high quality

The low quality refractory Materials are used in the manufacture of fire-bricks, as lining material for furnances, etc. The melting point of such Materials is more than 1580^0C.

The high quality refractory Materials containing pure clay are pure oxides of alumina, magnesia, etc. or nitrides or carbides. Those metals which melt at a temperature of about 1600^{0}C can be used as metal refractories. Such metals are molyblendum, tungsten, zirconium etc. These metals and their alloys are used as refractory materials.

The term cermet (cer from ceramics and met from metals) is used to indicate the refractory Materials containing a combination of clay and metal. The usual percentages are 80% clay and 20% metal. The usual metals employed for cermets are aluminium, chromium, cobalt, iron, etc. The cermets are widely used where shocks due to sudden changes of temperature are to be resisted.

The high quality refractory Materials are stable even at high temperature and they are used in the construction of modern aeroplanes such as rockets, jets, etc. These Materialsare composed of either pure clay or metals or combination of clay and metals.

High Voltage Porcelain

Sl.No.	Name	Properties	Uses
1	Carbon and graphite	Its is a refractory material of high quality. But it is oxidized at high temperature	It is used for making electrodes and in the construction of atomic reactor rockets.
2	Carbon brick	It is prepared from powder coke and tar. It can resist high temeprature	It is used as lining material for electric furnance
3	Cordierite porcelain	It contains 22% alumina, 35% clay and 43% silicate of magnesia. It is available in porous, partly porous and glassy form	It is used for electric furnance, refractory bricks, etc.
4	Steatic porcelain	It contains 70 to 90% silicate of magnesia. etc.	It is used as electrical insulator for high intensity electric current, vacuum tubes,
5	Zircon porcelain	It contains 45 to 60% zircon, 15 to 30% clay and 15 to 30% silicate of zircon. Its dielectric constant at high temperature is good	It is used in the manufacture of spark plugs.

Acidic refractory materials

Sl.No.	Name	Properties	Uses
1	Fire - clay	Its important constituents are alumina and silica.	It is used for manufacture of firebricks, crucibles, lining material for furnances, hollow tiles, etc.
2	Quartzite	It is a metamorphic stone. It is hard, brittle, crystalline and compact. Its metling point varies from 1650^{0}C to 1720^{0}C	It is used as lining material for electric furnance
3	Silica	It is available in the form of sand with some impurities from river bed. It melts at 1730^{0}C	It is used for preparing sillica bricks, coke oven and lining for glass furnance.

Basic refractory materials

Sl.No.	Name	Properties	Uses
1	Dolomite	It is carbonate of lime and magnesium. Its melting point varies from 2300^{0}C to 2600^{0}C	It is used for making refractory bricks
2	Magnesia	It is available in crystalline form. It melts at 2800^{0}C	It is used for preparing magnesia bricks

Neutral refractory materials

Sl.No.	Name	Properties	Uses
1	Bauxite	It is mixed with clay and finely ground. Its melting point is 1200^{0}C. It is an amosphous substance with dirty-white, brown or reddish-brown colour.	It is used for preparing fire-bricks containing more percentage of silica.
2	Carbon	It is available in three forms-amorphous carbon, graphite and diamond. Its melting point is 3500^{0}C	It is used as activated carbon, absorbent, catalyst, etc. It is also used as lining material for furnaces.
3	Chromite	It is the oxide of iron and chromium. Its melting point is 2180^{0}C	It is the most powerful neutral refractory material.
4	Forsterite	It does not spall easily and it maintains well its volume at high temperature. Its melting point is 1890^{0}C	It is widely used in the furnance for melting copper.

Mortar & concrete

Objectives: At the end of this lesson you shall be able to
- **define mortar**
- **describe ingredients of mortar**
- **state the functions of mortar**
- **explain properties of good mortar**
- **List out the uses of mortar.**
- **State the types of mortar**
- **State preparation of mortar**
- **List out the tests for mortar**
- **Select the mortars for different engineering works.**

Inroduction

For construction of buildings, nowadays, we mostly use cement mortar and cement plasters. A large amount of cement is consumed for these works. The total consumption is about 3 bags per square metre of plinth area in residential buildings and about 4 bags per square metre of plinth area in office buildings of this a major part is used for making mortar and plasters.

Definition

A paste formed by the addition of water to a mixture composed of an aggregate such as sand and a matrix or binding material like lime or cement is called mortar.

Ingredients of mortar:

1 Binding or cementing materials…..such as cement or lime

2 Fine aggregates……..such as sand, surkhi, ashes, cinder, etc.

3 Water……should be free from oils, acids, alklies and other inorganic impurities.

Functions of mortar

- It's binds together stones or bricks properly.
- In any concrete, it holds coarse aggregates together.
- In stone masonry and brick masonry, it fills up empty joints; a thin liquid mortar used for such purposes is termed as grout.
- It provides a durable / weather resisting layer between different course of masonry in the structure.
- It forms a homogeneous mass of the structure so that it may resist all the loads coming over it and transfer the same uniformly to its foundation.
- It does pointing or plastering to the structure.

Properties of a good mortar

- It should be capable of developing good adhesion with the building units.
- It should be easily workable
- It should be cheap.
- It should be durable
- It should be capable of resisting penetration of rain water
- It should be capable of developing the design stresses.
- It should be durable and should not affect the durability of other materials.
- The joints formed by mortar should not develop cracks and they should be able to maintain their appearance for quite a long period.

Uses of mortar

1 To bind the building units such as bricks, stones, etc. into a solid mass.

2 To carry out pointing and plaster work on exposed surfaces of masonry.

3 It is employed for moulding purposes.

4 It is used to form joints of pipes.

5 It is used to improve general appearance of structure.

6 It is used to hide open joints of a masonry work.

7 It is used as a matrix in concrete.

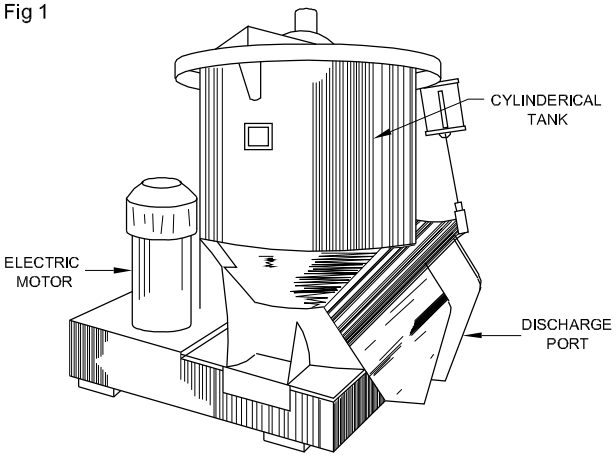
Preparation of mortar(Fig 1)

It may prepare by Hand mixing or Machine mixing. When a small quantity of mortar required, hand mixing method is adopted. When large quantity of mortar is required continuously at a fast rate, it is prepared by mixing of the ingredients in mechanical mixtures.

In order to test the quantity of mortar, the following tests are usually conducted:

1. Adhesiveness to building units test.
2. Crushing strength test.

Fig 1



TURBULENT MORTAR MIXER

3. Tensile strength test.
4. Setting time test

SELECTION OF MORTARS FOR DIFFERENT ENGINEERING WORKS

S. No.	Nature of Work	Mortar - Type and Composition
1	Thick joints in stone masonry	Hydraulic time sand mortar (1:2:3)
2	Stone masonry in foundations and superstructure of ordinary buildings.	1:2 fat lime surkhi mortar or 1 part lime, 1 part surkhi and 1 part sand.
3	Brickwork in arches, plastering inside of walls. mortar (1:2) or lime, surkhi and sand. (1:1:1)mortar.	1:5 to 1:6 cement mortar, or lime surkhi
4	Reinforced brickwork.	1:3 cement mortar.
5	Mass concrete in foundations, paving tiles, cavity walls, plastering of ceiling and external plastering work etc., where good finish is required.	1:4 cement sand mortar or 1:2 to 3hydraulic lime mortar.
6	Massive work below ground level especially in water logged areas.	1:3 cement sand mortar or 1:3 lime (eminently hydraulic) sand mortar.
7	Massive works, dams, retaining walls, damp proofing, flooring, etc. where very high finish is required.	1:3 cement sand mortar.
8	Pointing work	1:1 to 1:2 cement sand mortar.
9	General R.C.C. works such as slabs, beams and columns cement concrete flooring etc	1:2 cement sand mortar.
10	Damp proof course and cement concrete roads.	1:2 cement sand mortar.
11	R.C.C tanks and other retaining structures etc.	1:1½ cement sand mortar.
12	Highly stressed numbers of structure	1:1 cement sand mortar.
13	Laying fire-bricks.	Fire- resisting, mortar consisting of 1 part of luminous cement to 2 parts of finely crushed of fire-bricks.

Substitute for sand

In place of sand attain materila such as stones screenings burned clay or sunkhi ashes from coal, coke dust it may be used to prepaie mortor, The steps screenings are obtained by screening crushed stones. They are sharp and impart more strength to the mortor. They are generally used in big construction projects like concrete dams, bridges etc. Where sand in high quantities is not available where the place of work they should used the stone dust. The surkhi is the popular substitute for sand. It is obtained by finally grinding burned clay it is clean and face from any impurities. It gives strength and improves hydraulic property of mortor. Mortar with surkhi should not be used for external plaster or pointing work etc it disintegrates under the action of air and humididty.

Classification of mortars

The mortars are classified on the basis of the following

Bulk density

Kind of binding material

Nature of application

Special mortar

Bulk density : According to the bulk density of mortor in dry state there are two ways of mortor.

1 Heavy mortor 2 light weight mortor

The mortor having bulk density of 15KN/MM^3 or more are known as heavy mortor. If it is less than 15kn/mm^3 known as light weight mortor.

Kinds of binding materials

According to the kind of binding material mortars are classified into following five categories.

Lime mortar

Surkhi mortar

Cement mortar

Gauged mortar

Gypsum mortar

Lime mortar

In these type lime fat lime or hydraulic lime is used in binding material. The lime should be slaked before use. This mortar is not suitable for water logged areas or in damp situation. The proportion of lime to sand by volume is about 1:2 as so. It is durable and hardens slowly. It is generally used for lightly loaded above ground parts of building.

Surkhi mortar

In this type of mortar using fully surkhi instead of sand or half surkhi instead of lime. The powder of surkhi should be fine enough to pass BIS No.9.

The residure should not exceed more than 10% by weight. Surkhi mortor is used for ordinary masonry work of all kinds of foundations and super structure. But is cannot be used for plastering or pointing. Since surkahi is likely to desintegrate after some time.

Cement mortar

In this type of mortor the cement is used as binding material. Depending upon the strength required and important of work the proportion of cement to sand by volume varies from 1:2 to 1:6 the sand only can be used to form cement mortar. The proportion should be determine with due regard to the specified durability and working condition. The cement mortar is used where a mortar required such as underground constructions water saturated soils etc.

Gauged mortar

To improve the quality of lime mortar and to achieve only strength the cement is sometimes added to it.This process is known as gauging. It makes mortar economical, strong and dense. The usual proportion of cement to lime by volume is about 1:6 - 1:8 . This mortar is also known as composite mortar or lime cement mortar.

Gypsum mortar

These mortar are prepared from gypsum as binding material.

Properties of good mortar

It should be capable of developing good whole vision with the building units such as bricks.

It should be capable of developing the designed stresses

It should be capable of resisting penetration of rain water.

It should be cheap

It should be durable and easily workable

It should not effect the durability Materials with which it comes into contact

It should set quickly so that speed in construction may be achieved

It should not develop crakcs and to maintian these apperances for a long period.

Preparation of mortar

For preparing mortar water is added to a intimate mixture of binding material and sand. The water to be used for the purpose should be fit for drinking.

Preparation of different mortars

Lime mortar

The time mortar is prepared within by pounding or grinding. For preparing small quantities the pounding is adopted. And for large quantities or a continuous supply grinding is adopted. The following are the objects of pounding or grinding.

To crush the particles of unslaked lime if any so as to and ensure slaking

To make and intimate mixtue of whole mass so that no gains of sand are without a film of binding material

Pounding

In this method the pits are formed in hand ground with lining of bricks or stones at there side and bottom. The pits are 180cm long 40 cm wide at bottom and 500m wide at topand 50cm deep. The dry mixture is then placed in pits. Small quantity of water is added and 4-5 persons with heavy mortar wooden poundans or beaten as work on mortar. They turn mortar up and down and required quantity of water is added at intervels. When desired consistency is achieved the mortar from pits is taken out.

Grinding

In the method grinding mills are used to prepare mortar. This grinding mills are either bullock driven or power driven.

Surkhi mortar

The mix of fat time and surkhi or fat lime surkhi and sand is decided and it is converted into a good paste by grinding in a mortar mill or pounding

Cement mortar

It does not require pounding or grinding. The cement and sand are mixed in required proportion in dry state twice or thrice on water tight platform and the water is then added and the ingrediants are again throughly mixed.

Gauged mortar

The lime mortar is prepared as per about and the required quantity of cement is then added and the ingredient are throughly turn up and down to cause intimate mixing.

Uses of mortor

To bind the building units such as bricks, stones etc into a solid mass.

To carryout pointing and plastering on on expossed surface of masonary

To form a bedding layer for building units

To form joins of pipes

To improve the general apperance of structures

To prepares moulds for coping, corbels, cornice etc

To servcie as martix to hold coarse aggregates.

To hide the open joints of brick work and stone work

To fill up the cracks detected in the structures during maintenance process etc.

Precautions in using mortar

Following precautions to be taken while making use of mortar

Consumption of mortar

After prepartion the mortar should be consumed as only as possible the lime mortar should be consumed within 30 minutes after adding water. Therefore it is advisable to prepare cement mortar of 1 bag of cement at a time. The gauged mortar should be used with 2 hrs of the addition of cement.

Staking of building units

The presence of water in mortar is essential to cause its salting action of mortar. Hence the building units should be soaked in water before mortar is applied this precaution is not taken, the water of mortar will be absorbed by the building units and the mortar will become weak.

Sprinkling of water

The water may be sprinkling for about 7-10 days.

To avoid rapid drying of mortar the exposed surfaces are some times correct to give protection against sun.

Workability

The excess mortar from joints should be neatly taken of by a travel. The mortar should not contain excess water and it should be as stiff as can be conveniently used.

Selection of mortar

Depending upon the nature of civil engineering work suitable type of mortar should be selected.

Plain cement concrete

Objectives: At the end of this lesson you shall be able to
- **define concrete**
- **state the proportioning of concrete**
- **describe the advantages of concrete**
- **state the disadvantages of concrete**
- **list out the uses of concrete.**

Introduction

Cement concrete is a major building material used in modern building constructions. It is used in all parts of a building like, foundations, superstructure and roofs. It is prepared at site by hand mixing or machine mixing, it is now available as a factory made product known as' Ready Mixed Concrete (RMC)'.

Deinition:

Concrete is a mixture obtained by mixing a binder (cement or lime), aggregate (fine and coarse) and water in certain proportions.

Proportioning concrete:

The process of selection of relative proportions of cement, sand, coarse aggregate and water, so as to obtain a concrete of desired quality is known as the proportioning concrete.

There are different methods of proportioning concrete:

a Arbitrary method

b Fineness modulus method

c Minimum voids method

d Maximum density method

e Water-cement ratio method

The concrete as per BIS: 456:1978 is designed in several grades, M10, M15, M20, M25, M30, M35 and M40. The letter M refers to the mix and the number indicates the specified compressive strength of that mix at 28 days expressed in N /mm^2.

GRADE	PROPORTION	GRADE	PROPORTION	GRADE	PROPORTION
M5	1:5:10	M10	1:3:6	M20	1:1½:3
M7.5	1:4:8	M15	1:2:4	M25	1:1:2

Advantage of concrete

High compressive strength

Corrosive and weathering effect minimized

Economical

Durable

Fire resistant

Very little maintenance

Molded to any shape

Can be sprayed and filled in cracks

Strong in compression

When reinforcement is added it is good in compression and tension also.

Ingredients of concrete

Cement

Sand or fire aggregate

Course aggregate

Water

Admixtures (in case of special conditions)

Properties of cement concrete

Properties of cement may be considered through two states

Fresh state

Hardened state

Fresh state

Workability

Hardened state

Permeability of concrete

Permeability of concrete depends on cement content grading aggreagate quality of water, mixing compaction and curing of concrete.

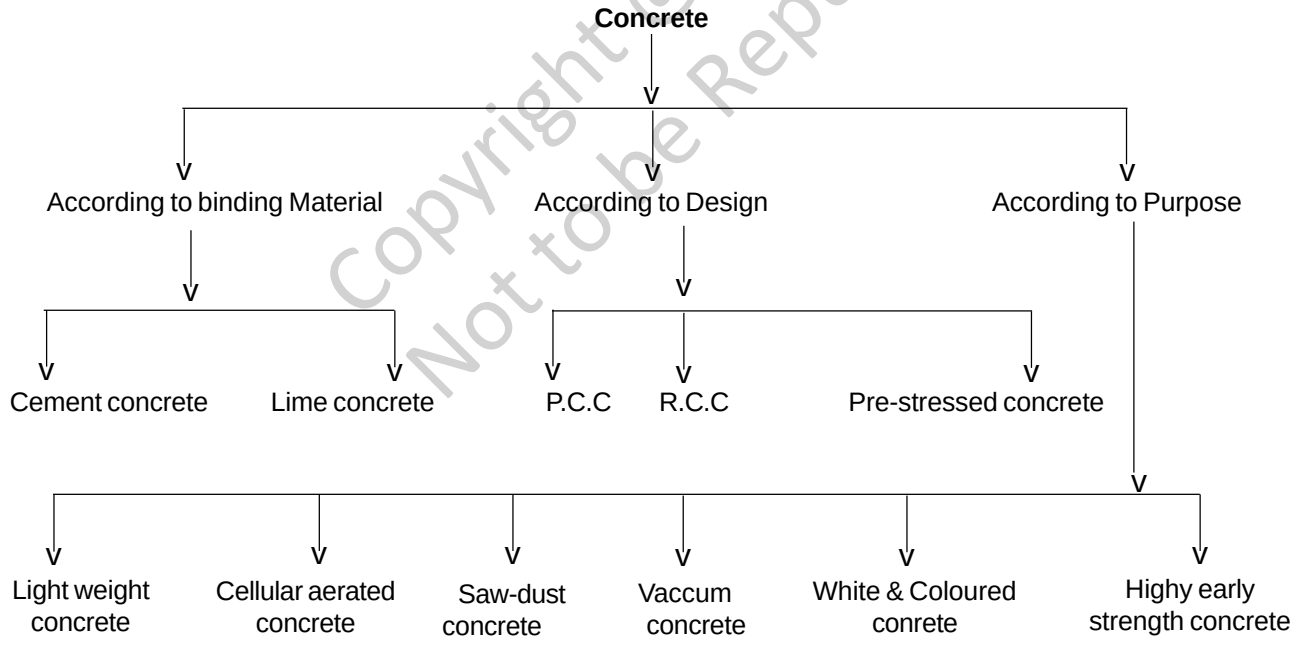
Durability of concrete

High compressive strength

Free from corrosion

Hardness increase with age

Economical



Recommended mixes of concrete

S.No.	Proportion of concrete mix	Maximum size of aggregate	Maximum size of aggregate
1	1:1:2	12 to 20mm	Heavily loaded R.C.C column and R.C.C. arches of long span
2	1:2:2	12 to 20mm	Heavily loaded R.C.C column and R.C.C. arches of long span

S.No.	Proportion of concrete mix	Maximum size of aggregate	Maximum size of aggregate
3	1:2:2	12 to 20mm	Small precast memebrs of croncrete such as poles for fencing Long piles water tight construction
4	$1:1^{1/2}:3$	20 mm	Water retaining structures, piles, precast product etc.
5	1:2:3 or 1:2/3:31/3	20 mm	Water tank, concrete deposited under water, bridge constrution and sewers. For all general RCC work in building
6	1:2:1/2:3 1/2	25 mm	Foot path and road work
7	1:2:4	40 mm	For all general RCC work in building such as stair, beam, column etc
8	1:3:6	50 mm	Mass concrete work in culvert, retaining wall etc.
9	1:4.:8 or 1:5:10 or 1:6:12	60 mm	Mass concrete work for heavy wall foundation footing etc

Recommended mixes of concrete

S.No.	Proportion of concrete mix	Maximum size of aggregate	Maximum size of aggregate
Grade of concrete	M10	1:3:6	Compressive strength 10N / mm2
	M15	1:2:4	Compressive strength 15N / mm2
	M20	1:1:5:3	Compressive strength 20N / mm2
	M25	1:1:2	Compressive strength 25N / mm2

Grade of concrete	Total quantity of dry aggregates by mass per 50kg of cement to be taken as the sum of individual masses of fine and coarse aggregate Maximum (Kg)	Proportion of fine aggregate to coarse aggregate (by mass)	Quantity of water per 50kg of cement mix-litres
M5	800	Generally 1:2 but subject to an upper limit of 1:1:5 and lower limit of 2.5	60
M 7.5	675		45
M 10	480		34
M 15	390		32
M 20	250		30

Grading of concrete

In order to obtain concrete of denser quality the fine and coarse aggregate are properly graded

- gradation of fine aggregates as determined by sieve analysis
- gradation of aggregates effects on workability uniform and finishing quality of concrete
- grading of fine aggregate is expressed in terms of BIS test sieve nos 480,240,120,60,30 and 15

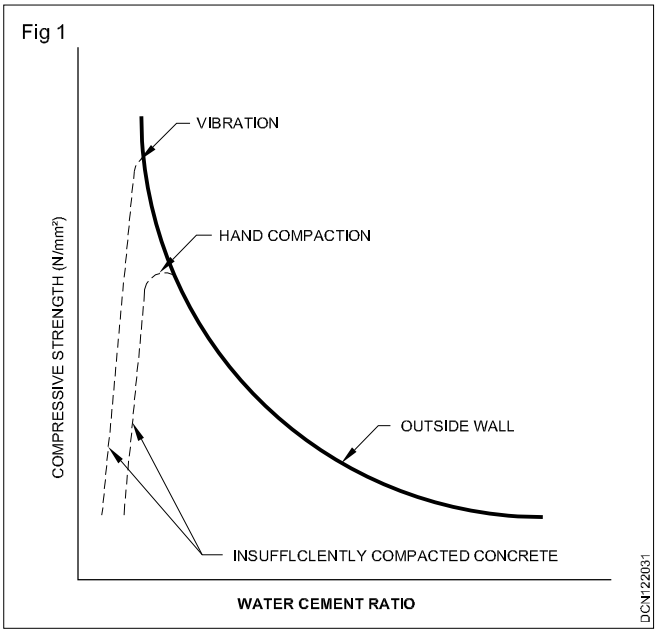
Water cement ratio

It is the ratio of water to cement and is expressed as the ratio of weight or volume of water to the weight of the cement to the concrete mixture.

Workability

The term workability is used to describe ease on difficulty in which concrete is handled, transported and placed between the forms with minimum less homogeneity workability some easily determine by slump test.

Fig 1



Recommended slumps of concrete

S.No	Type of concrete	Slump (mm)
1	Concrete for road construction	20 to 40
2	Concrete for top of kerb, parapet, slabs, walls, etc.	40 to 50
3	Concrete for canal lining	70 to 80
4	Concrete for arch and side wall of tunnel	90 to 100
5	Normal R.C.C work	80 to 150
6	Mass concrete	25 to 50
7	Concrete to be vibrated	10 to 25

Classification of concrete mixture

S.No	Slump	Nature of concrete mix
1	No slump	Stiff and extra stiff mix
2	From 10mm to 30 mm	Poorly mobile mix
3	From 40 to 150 mm	Mobile mix
4	Over 150 mm	Cat mix

Mixing the material of concrete

The process of rolling, folding and spreading of particles is known as mixing of concrete

Mixing of ingredients

To impart uniform colour

Distribute various sizes of particles uniformly and evenly

To spread evenly the binding material over every particles of aggregate.

To impart required consistency to concrete

Ingredients of concrete are mixed by following methods

Hand mixing

Machince mixing

Hand mixing

- Ingredients are measured and mixed in dry state
- Mixed on a water tight platform so as not to avoid loss of water
- Water is then added in correct concrete quantity and wet mixing is done
- Mix throughly till the concrete becomes uniform in colour and consistency
- It is preferred to add about 8 to 10 percent extra cement considering lesser efficiency of hand mixing.

Machine mixing

Mixing the ingredients by a machine

Ensures a better and more uniform concrete

Ensure thorough mixing

Cement consumption less than hand mixing

Transportation and placing of concrete

Transportation is the transporting the concrete and placing the concrete on the form work with suitable equipments or machines. The important precautions should take care

No chance of water should be added the concrete during its transportation

No segregation of aggregate

Precautions in placing of concrete

Clean the form work properly

Desirable to deposit the concrete as near as practible to its final position

Large quantity of concrete should not be deposited at a time

Concrete should be dropped vertically from a reasonable height.

Concrete should be deposited horizotal layers of 150 mm

As far possible concrete should be placed in single thickness

Concrete should thoroughly worked around the reinforcement

Concrete should be placed on the form work as soon as possible.

During placing it should be seen that all edges and corners of concrete surface remains unbroken

Placing of concrete should be carried out without obstruction of construction joint

Consolidation of concrete

"Consolidation or compaction is the process which expels entrapped air from freshly placed concrete and packs the aggregate particles together so all to increase the density of concrete".

Purpose of consolidation

Eliminate air bubbles

To give maximum density to concrete

Presence of 50% of voids reduces 30% strength of concrete

Methods of consolidation

Hand consolidation

For unimportant works

By ramming

By tamping

By rodding

Vibrator

These are mechnical devices. There are four types

Internal vibrator

Surface vibrator

Form vibrator

Vibrator table

Curing of concrete

It is the process of keeping the set concrete damp for some days in order to enable the concrete gain more strength

For Portland cement 7 to 14 days

Period of curring depends atmospheric condition and type of cement

Methods of curing

By ponding : Employed for flat surface

By using wet sacks/sprinling water frequently : Coloumns and similar members, sloping element

By stem : Used for precast concrete

Alternating current : Current is passing through freshly laid concrete for 24 hrs.

By sealing curing compound in the concrete surface:

By chemical water : Sprinkled over surface

EFFECTS OF IMPROPER CURING

Durability decreased

Compressive and structural strength decreased

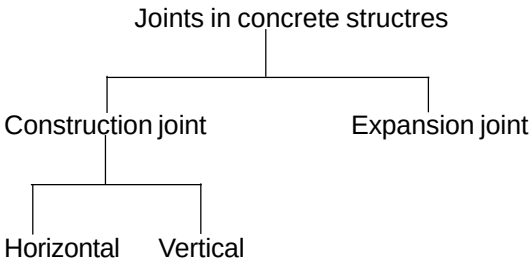
Weathering resistance decreased

Resistance to atmospheric chemicals and chlorides decreased

Shrinkage cracks are formed

Thermal cracks are formed

Joints in concrete structures



Construction joint

When construction is stopped at the end of a day or other reasons when large concrete is done.

Inclined or curved member right angle to the axis

Expansion or contraction joint

Concrete structures length exceed 12m

Joint filler elastic material compressible, rigid

Dowels, keys-transfer load

Quality control of concrete

The process of keeping the specification provided according to the design concept. Field organisation are of three types:

Field organisation (3 types)

1 Grades of concrete
   Inspectin of form work
   Reinforcement
   Insulation of all embedded parts
2 Control over concrete material
   Batch
   Mixing
3 Placing
   Compacting
   Related operations

Highest possible density is obtained by

Air bubble should be eliminated

Cement particle should be smallest size

Compact fully

Cured sufficiently

Cubical particles of aggregate should be used.

Water cement ratio should be kept low

Advantages of quality control

Improved utilization of scarce resources

Minimise failures

Lower the cost of construction

Structre becomes durable

Admixtures

When an agent is inter ground with cement as an additive or is added to gauge water as admixture during the manufacture of concrete. They consist chiefly

- accelerate or which retard hydration or setting of cement
- to increase workability
- for water proofing
- Colouring agents
- Air entraining agents

Accelerators

Addition of calcium chloride 2% by weight of cement

To acquire strength soon

Retardors

a. Retard setting
b. Used in tropical places
c. Pumping of concrete
d. Oil well construction

The commonly used retarders are

a Plaster of paris
b. Gypsum
c. Milk powder
d. Ammonium chloride

Water proofers

To be impervious to water under pressure

Resist absorption of water

Underwater concreting

It may be required in case of deep foundation and marine works.

The placing of concrete under water is usually confined to plain concrete construction because loss of cement and segregation of concrete.

Methods of underwater concrete

By tremie: Tremie is the name given to a steel pipe of 150mm to 300mm dia and sufficiently long to reach the bed of water.

By ship of bottom opening bucket: In this method cubical hinged bottom bucket or cylindrical bucket equipped with a rolling gate of a ship is used for concreting under water.

Placing in Bags : The method is only suited for placing the concrete in rather shallow water

Prepacked concrete: Prepacked aggregates are packed in position and cement mortar of required proportions are grouted in it.

Under water concreting : Any concreting operation done at a temperature below 5^0C

Effects of cold weather concrete

Settting time is delayed-retard the development of strength

Early freezing of concrete results loss of properties of concrete

Stresses due to temperature differential occurs

Hot weather concreting : Any operation of concreting done to atmospheric temperture above 40^0C.

Effects of hot weather concrete

Accelerating setting

Reduction in setting

Increased tendency to cracking

Rapid evaporation during curing

Difficulty in controlling the air content

Guniting

The guniting is the most effective process of repairing concrete work which has damaged due to inferior work

Used for providing impervious layer

A mixture of cement and sand (1:3) in a cement gun is used to deposit with a pressure of 20-30N/cm^2

General precautions in cement concrete

Cement should be fresh

Aggregates should be well graded

Free from clay, silt, dirt

Water should free from harmful chemicals and foreign materials

While preparing rigid impervious of water tight platform should be used

Ingredients should be measured correctly

Care taken to avoid bleeding and segregation

Formwork should be cleaned and moister with water

Before concreting shuttering and centering should be checked

Laid concrete should be tamped thoroughly

Suitable expansion and contraction joints should be provided

Concrete should be laid within 30 minute

Defects in concrete

1 Cracks

Cracks in concrete may occur due to the following causes:

Excess water

Early loses of water

Alkali aggregate reaction

Corrosion of steel

Freezing of water

2 Crazing

Results from difference in shrinkage between the surface and the interior

3 Sulphate deterioration

Caused by the soil containing sulphates or sulphate water

4 Efflorescence

Apperance of fluffy white patches on the structure caused by poorly washed aggregates

Salty water used in making concrete

5 Seggregation

Separation of course aggregate from fine aggregate

Separation of paste from course aggregate

Causes of segregation are as follows

Drops concrete from heights

Badly design mixes

Concrete comes over long distances - pumping, belt conveyour

Over vibration

6 Bleeding

Flow of mixing water within or emergence to the surface

From freshly placed concrete

Usually due to excess vibration imparted to concrete

7 Laitance

Cement and water slurry coming on top and setting on the surface

Special type of concrete

Concrete as a structural material has to fulfill different function depending on the situation

Low density concrete is using for partition wall cladding etc.

High density concrete is used for radiation shielding in

Radiation shielding in nuclear contained structures

Following are the various special types of concrete.

1 Light weight concrete

Densities as low as 400kg/m3 compared to 2400kg/m3 of ordinary concrete

2 Cellular concrete

Gas or air bubbles are introduced into the plastic-cement mortar mix to produce a material with a cellular structure.

3 No- fines concrete

This type is composed of cement course aggregate and water only

4 Heavy weight concrete

Using high density aggregate produced from magnetic and hematite (ironore) density of concrete varying from 3400 to 4000 kg/m^3

5 Ready mixed concrete

Mixed at a central batching plant and delivered at the site by suitable transport vehicle

6 Vacuum concrete

This consists of withdrawing some of the excess water and air not required for hydration of the cement by means of vacuum subsequent to placing of concrete

7 Resin concrete

Concrete can be made tougher and stronger by admixing extra resins like araldite cpirex etc.

8 Ferro cement concrete

May be considered as a type of thin reinforced concrete construction where cement mortar-matrix is reinforcement with many layers of continous and relatively small diameter wire-meshes. While the mortar provides the mass, the wire-mesh imparts tensile strenth and ductility to the material

9 Pre stressed concrete

It is the concrete in which high compressive stresses are artifically induced before its use. In reinforced concrete members, the prestress is commonly introduced by tensioning the steel reinforcement

10 Gap graded concrete

Provided the specific surface of the aggregate (C.A. and FA) is kept constant, it has been found that a wide difference in grading affect the workability. Not necessary to continous grading in order to obtain a minimum of air voids.

11 Colored concrete

The concrete can be made coloured by addition of suitable coloring pigments to the extent of about 8 to 10% of the weight of cement

Colored concrete is used for manufacture of items for public welfare ornamental finishes in buildings preparing park lanes, separating lines of traffic of road surface, underground pedestrain crosssings etc.

12 Polymer concrete

It is highly impermeable and resistant to attack by acid alkalies and other chemicals

Addition of polymers improvement in compressive strenth fatigue resistance, impact resistance, toughness and durability

13 Sulphur impregenated concrete

It consists of a mixture of sulphur coarse aggregate and fine aggregate there being no cement and water.

14 Fibre reinforced conrete

Addition of small diameter small length randomly distributed fibres to increase tensile strength of P.C.C

Fibres suitable for reinforcing concrete have been produced from steel, glass and organic polymers.

Timber and wood products

Objectives: At the end of this lesson you shall be able to
- **define timber**
- **classify trees**
- **explain and indicate the parts of structure of trees**
- **describe the process of seasoning**
- **list out the qualities and uses of timber**
- **explain wood based products.**

Introduction

Wood used for structural purposes is known as timber. There is a lot of demand for primary species of timber like, teak, deodhar, sissco, sal, etc.

In order to enhance and economize the utilization of wood, many wood-based products have been developed in a big way like veneers, plywood, hard board, particle board, etc.

Definition

The products of wood from felled trees suitable for construction purposes are called Timber.

Classification of trees

According to their manner of growth, the tree may be divided into two main classes;

i) Exogenous tree, (a) Conifer or evergreen trees,(soft wood) (b) Deciduous or broad-leaf trees.(hard wood) e.g. Deodar, chir, Kail, shishum, teak, etc.

ii) Endogenous trees. e.g. canes, bamboos, palms, etc.

Structure and growth of tree (Fig 1)

Basically, a tree consists of the following three parts; (i) Trunk, (ii) crown, (iii) roots.

The trunk supports the crown and supplies water and nutrients from the roots to the leaves through branches and from the leaves back to the roots.

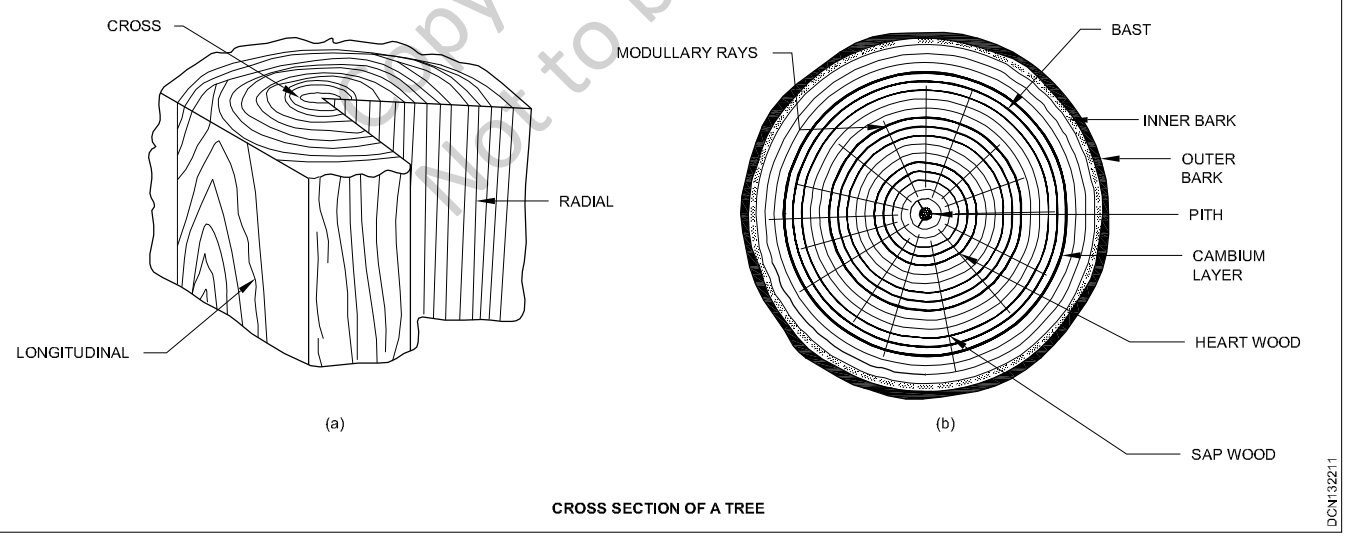
The roots are meant to implant the trees in the soil, to absorb moisture and the mineral substances it contains and to supply them to the trunk

Seasoning of timber

When a tree is newly felled it contains about 50% or more of its own dry weight as water. The water is in the form of sap and moisture.

It is the process of drying timber or removing moisture or sap, present in a freshly felled timber, under more or less controlled conditions.

Fig 1



CROSS SECTION OF A TREE

Object of seasoning of timber

To allow timber to burn readily if used as fuel

To decrease the weight of timber and there by to lower the cost of transport and handling

To impart hardness stiffness strength and electrical resistance to timber.

To maintain the shape and size of the components of the timber articels

To make timber easily workable and to facilitate operations during conversion

To make timber fit for receiving treatment of paints preservatives, varnishes etc.

To make timber safe from the attack of funges and insects.

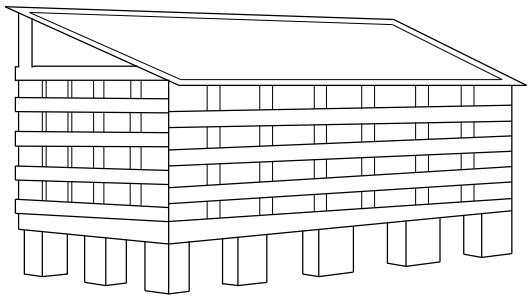
Seasoning can be broadly divided into the following two catagories

1 Natural seasoning

2 Artificial seasoning

Natural seasoning : In this method done by stacking timber with space between them for free circulation of air they should be kept clean off the ground and protect from sun and rain. The timber should be turned frequently if possible. It takes 2-4 years, then timber is ready for use in carpentary or joinerys (Fig 2).

Fig 2



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SHED FOR AIR SEASONING OF TIMBER

Aritificial seasoning

Various method of artificial seasoning are

Boiling

Chemical seasoning

Electrical seasoning

Water seasoning

Kiln seasoning

Boiling

In this method timber is immersed in water and water is then boiled for about 3-4 hrs .Timber is then taken out and dried very slowly. Inplace of boiling water timber may be exposed to the action of hot steam.

Chemical seasoning

This method is also known as salt seasoning. In this method the timber is immersed in a solution of suitable salt. It is then takenout and seasoned in the ordinary way.

Electrical seasoning

In this method high frequency alternating current is used for seasoning. Green timber offers less resistance to the flow of current. The resistance increase as the wood dries internally which also the production of heat.

Water seasoning

In this method following procedure is also adopted

The timber is cut into pieces of suitable sizes

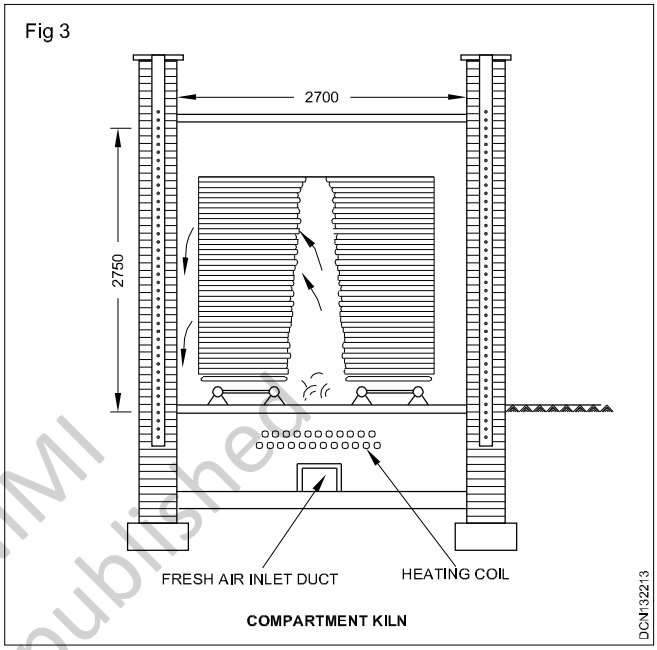
This pieces are immersed wholly in water preferably in running water of stream. The care should be taken to see that timber is not partially immersed

The timber is taken out after a period of about 3-4 weeks During this period the sap contained in timber is washed away by water

The timber is taken out of water and allowed to dry under shed having free circulation of air.

Kiln seasoning (Fig 3)

Fig 3



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COMPARTMENT KILN

Kiln seasoning is carried out in an airtight chamber or oven. The process of seasoning is as follows:

The timber is arranged inside the chamber such that space are left for free circulation of air.

The air which is fully saturated with moisture and which is heated to a temperature of about 35^0C-38^0C is then forced inside the chamber by suitable arrangements

This forced air is allowed to circulate round the timber pieces. As air is fully saturated with moisture the evopratoin from the surfaces of timber pieces is prevented. The heat gradually reaches inside the timber pieces

The relative humidity is now gradually received

The temperature is then raised and maintained till the desired degree of moisture content is attained.

Depending upon the mode of construction and operation, the kilns are of two type namely

Stationery kilns

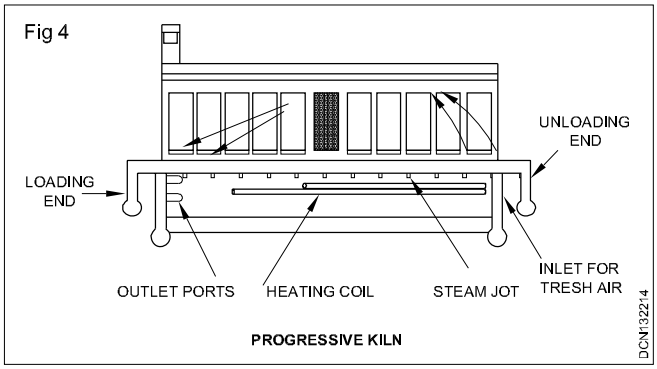
Progressive kiln (Fig 4)

Uses of Timbers

a. It is used for door and window frames, shutters of doors and windows, roofing materials, etc.

b. It is used for form work of cement concrete, centering of an arch, scaffolding, etc.

c. It is used for making furniture, agricultural instrument etc.



Defects in timber

Natural defects occurs in all kinds of timber depending upon the climate condition and soil upon which they grow.

Following are the common natural defects in timber.

1 Heart shake & Ring shakes

2 Star shakes

3 Cup shakes

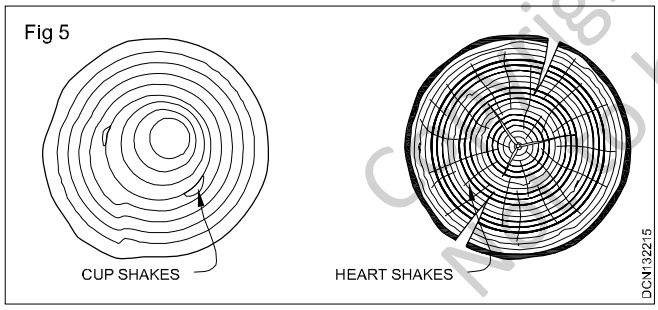
4 Radial shakes

5 Knots

6 Druxiness.

Cup shakes (Fig 5a)

These are caused by the rupture of tissues in a circular direction. It is a curved cracks and it separate partially one annual ring from the other. It developes due to non-niform growth on due to excessive bending of growing tree during cyclonic weather. It covers only a potion of ring. It maynot be harmful.



Heart shakes (Fig 5b)

These cracks occur in a cetre of a tree and they extend from pith to sapwood in the direction of medullary rays This crakcs occur due to shrinkage of interior part of the tree which is approaching maturity it divide tree the cross section into two to four parts

Ring shakes (Fig 6a)

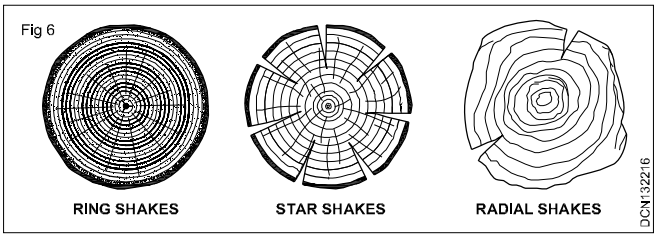
When cup shakes cover the entire ring they are known as the ring shakes.

Star shakes (Fig 6b)

These are crakcs which extends from bark towards sap wood. They are wider on the outside and narrow on the inside ends. They are formed due to the extreme heat or severe frost during the growth of tree.

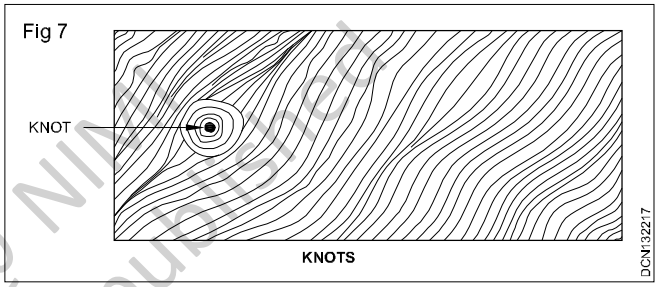
Radial shakes(Fig 6c)

They are similar to star shakes but they are fine and numerous. They occur when tree is exposed to seasoning after being felled down. They run for a short distance from bark towards the centre. Then follow direction of annual ring and ultimately run towards the pith.



Knots (Fig 7)

These are the bases of branches which are broken or cut off from the tree. The portion from which the branch is removed ultimately results in the formation of dark hard rings known as the knots. As continuity of wood fibres is broken by knots they form a source of weakness.



The classification of knots on basis of size

Pin knot : Size diameter upto 6.5mm

Small knot : Size diamter between 6.5 and 20mm

Medium knot : Size diameter between 20mm and 40mm

Large knot : Size diameter greater than 40mm

Classification of knots on basis of their form and quality

Dead knot	Decayed knot	Live knot
Loose knot	Round knot	Tight knot

Druxiness

This defects is indicated by white decayed spots in a healthy wood. They are formed by the access of fungi.

Further the defects occuring in the timber are grouped into the folloiwng five divisions

Defects due to conversion

Defects due to funges

Defects due to insects

Defects due to natural forms

Defects due to seasoning

Defects due to natural causes

The main natural causes for defects in timber.

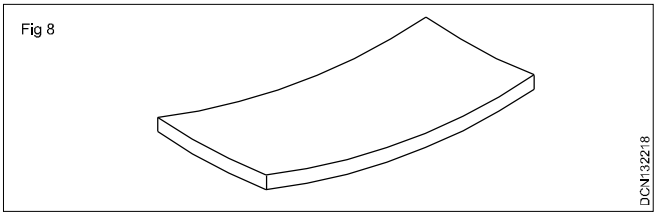
Abnormal growth **Rupture tissues**

Defects due to seasoning

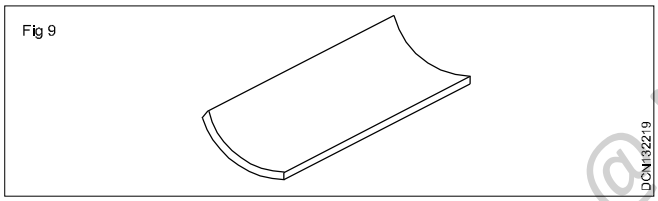
Following defects occur in the seasoning of wood

Bow	Cup
Case-hardening	Check
Split	Collapse
Honey combing	Radial shakes
Twist	Warp

Bow : This defects is indicated by the curvature formed in the direction of length of timber as shown in figure (Fig 8)



Cup : This defect is indicated by the curvature formed in the transverse direction of timber as shown in fig (Fig 9)



Case- hardening

The exposed surface of timber dries very rapidly. It there fore shrinks and is under compression. The interior surface which has not completely dried is under tension. This defect is known as case hardening.

Check - A check is crake which separates fibres of wood. It does not extent from one end to the other.

Split

When a check extends from one end to the other is known as split.

Collapse

Due to uneven shrinakge the wood sometimes flattens during drying. This is known as the collapse.

Honey - combing

Due to status developed during the various radial and circular cracks develop in the interior portion of timber. The defect so developed is known as the honey-combing.

Radial shakes

Radial shakes are explained earlier.

Twist

When a piece of timber has spirally distorted along its length. It is known as twist.

Warp

When a piece of timber has twisted out of shape it is said to have warped.

Factors of Quality of good timber

1 Environmental conditions of the locality.

2 Maturity of the tree.

3 Method of seasoning.

4 Nature of the soil

5 Process of preservation and

6 Time of felling

Qualitites of good timber

Following are the qualities of good timber

Appearance

A freshly cut surface of timber should exhibit hard and shining apperance.

Colour

The colour of timber should preferably dark. The light colour usually indicate timber with low strength

Defects

A timber should be free from serious defects such as dead knots, flaws, shakes etc.

Durability

A good timber should be durable. It should be capable of resisting the action of fungi insects, chemical, physical agencies and mechanical agencies.

Market forms of timber

The timber is converted into suitable commercial size.

Following are various forms in which the timber is available in the market

Batten

This is a timber piece whose breadth and thickness do not exceed 50mm.

Baulk

It is a roughly squarred timber piece and it is obtained by removing barks and sapwood. One of the cross- sectional dimension exceeds 50mm while the other exceeds 200mm

Board

It is a plank i.e. a timber piece with parallel sides. Its thickness is less than 50mm and width exceeds 150mm

Deal

It is a piece of soft wood Its thickness varies from 50mm -100mm and its width does not exceed 230mm.

End

This is a small piece of batten, deal, scantling etc.

Log

It is trunk of the tree obtained after removal of branches.

Plank

It is a timber piece with parallel sides.Its thickness is less than 50mm and its width exceeds 50mm.

Pole

It is sound long log of wood. Its diameter does not exceed 200mm. It is also known as Spar.

Quartering

It is a square piece of timber the length of side being 50mm - 150mm.

Scantling

It is a timber piece whose breadth and thickness exceed 50mm but are less than 200mm in length. These are the pieces of miscellaneous size of timber sawn out of a log.

Wood Products

Following are the industrial form of timber

Veneers

Ply woods

Fibre boards

Impreg timbers

Compreg timbers

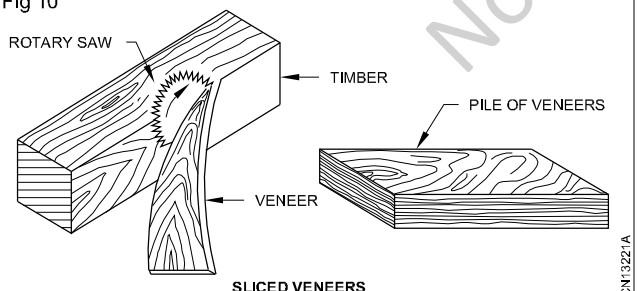
Laminated board

Veneers (Fig 10)

There are the thin sheets of wood of superior quality. The thickness of wood varies from 0.4mm to 6mm or more. They are obtianed by rotating a log wood against a sharp knife of rotary cutter or saw.

Indian timber which are suitable for veneers, teak,rosewood,mahogony etc.

Fig 10



Ply wood

Ply woods boards which are prepared from thin layers of wood or veneers 3 or more veneers are one above and they are held in position by applications of suitable adhessives while being glued the pressure may be appliyed on veneers. The ply woods are used various purposes such as ceiling, doors, furniture partitions etc.

Fibre boards

These are rigid or reconstructed wood boards and they are also known as pressed wood. The thickness varies from 3mm-12mm They are available in length varying 3m -4.5m and its width varying from 1.2m-1.8m.

Depending upon their form and composition the fibre boards are classified as insulating boards, laminated boards, medium hard boards, hard boards and super hard boards. They are also available under various trade name such as Euraka, Indianite, Masonite etc.

Impreg timbers

The timber which is fully or partially covered with resin is known as the impreg timber. The usual resin phenol formaldehyde which is soluable in water. The veneers of thin strips of woods are taken and they are immersed in resin .

The resin fills space between wood cell and by chemical reaction a consolidate mass developed. It is then cured at a temperature of about 150°C-160°C. It is available under trade names are Formica, Sunglass, Sunmica etc.

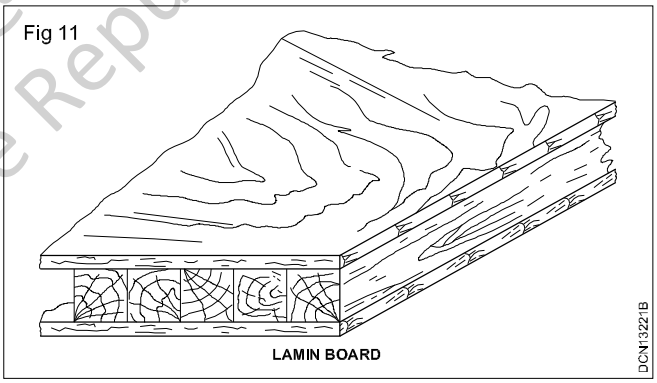
Compreg timbers

The process of preparing compreg timbers is same as that of impreg timbers except that curing is carried out under pressure. The strength and durability of compreg timbers are more as compared to the impreg timber.

Laminated board

The laminated boards are light, strong and do not split or crack easily as shown in (Fig 11)

Fig 11



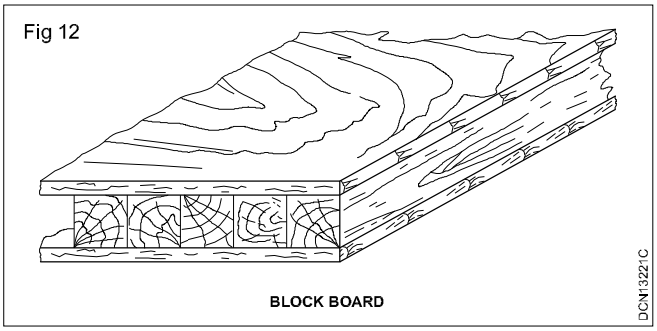
Uses

They are used for walls, ceilings, partitions and packing cases.

Block board:- (Fig.12)

In this case core consists of smaller timber block upto 25mm in width. These blocks are cemented edge to edge and on each face plies upto 3mm thickness are glued.

Fig 12

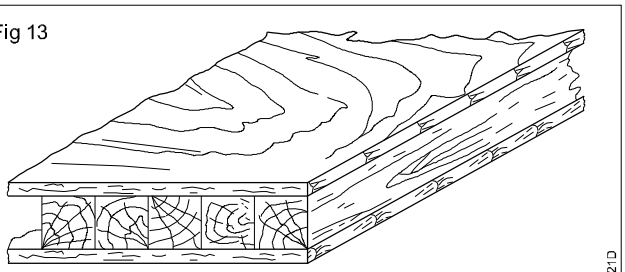


Uses

Block-board are extensively used for construction of railway carriages, bus bodies, marine, river crafts and for furniture making, partitions, paneling, prefabricated houses.

Batten board (Fig 13)

Fig 13



BATTEN BOARD

Batten boards are light and strong

Uses

These boards are used for door panels, table, tops etc.

For internal finish, wall panelling, floor , flush doors

Fire sound insulation in large commercial buildings and cinema houses.

For suspended ceilings and dado.

Making partitions and finishing cover to furniture.

Hard board

These boards are hard pressed and hence are more compact, strong durable.

They impart internal appearance and finish to a structure

They are least affected by change in temperature and humidity of surroundings

Indian Timber Trees	
Iron wood	Jack
Mahagony	Mango
Mulbery	Oak
Pine	Red colour
Rose wood and black wood	Sal
Sandal	Tamarind
Teak	Toon
Bamboo	Benteak

Mahagony

Its colour is shining reddish brown. It takes a good polish It is easy to work. It is durable under water. Its weight after seasoning is about 7200 N/mm^3

Sandal

Its colour is white or red. It give out pleasent smell. Its weight after seasoning is about 9300N/m3. It is found in Assam, Nagpur and Bengal.

Bamboo

It is an endogeneous tree it is flexible strong and durable. It is found in most of the part of the country

Benteak

It is strong and take up a smooth surface.Its weight after seasoning at 12% moisture content is 6750 N/m3. It is found in Kerala, Madras and Maharashtra.

Teak

Its colour is deep yellow to dark brown it is moderatly hard. It is durable and fire resistant. It can be easily seasoned and worked. It takes up a good polish. It is not attacked by white ants and dry rot. It most valuable timber tree of the world. Its weight after seasoning at 20% moisture content is about 6250N/m3. It is found in central India and southern India. It is used for house construction Railway carriages, flooring, furnitures etc.

Fire proof reinforced plastic (FRP)

Objectives: At the end of this lesson you shall be able to
- **explain FRP fires**
- **explain regarding the smoke and the amount of smoke generated.**

FRP fire resistance : Fiberglass reinforced plastic and fires

No one wants to have a fire in their building or business, but what if you do? How will materials made from fiber glass reinforced plastic react? What about FRP fire resistance? With new regulations and code requirements regulating smoke toxicity, like those in New York City, the amount of smoke created in a fire is also smoething a lot of builders are keeping in mind these days. So.

What do you need to know about FRP and fires?

While the fiberglass reinforcements used in corrosion resistant laminates will not burn, most thermoset resins used as the matrix for “FRP” laminates will support combustion. Even the “fire retardant” resins will burn vigorously when fire is supported by an outside source. The rate of flame spread is somewhat lower for these fire retardant resins. Fire retardant thermoset resins typically contain halogens or bromine molecules. When combustion occurs, these additives suppress or smother the flame and the laminate becomes self-extinguishing.

What about smoke?

When the more common thermoset resins (polyesters, epoxies, vinyl ester, etc), used for fiberglass reinforced plastic composites burn, large amount of heavy, black, dense smoke can be generated. The carbon chains in these resins contribute to that smoke. There is no difference in the density of the smoke generated between a non-fire retardant resin and a fire retardant resin. The only difference is that the amount of smoke may be less when fire retardant resins are used, and the fire is not supported by an external source.

Although some facilities can experience more damage from the smoke rather than the actual fire, such as in electronics plant, for most facilities the fire itself and the damage it can cause, is of far greater concern that smoke. As one plant engineer of a major chemical plant told us one time. "When we have a fire in a chemical plant, we are allowed to have smoke" In those cases of typically wide-open spaces, or facilities with low occupancy, the smoke generated is the least of the problems when a chemical plant or refinery catches on fire.

How much smoke will be generated?

ASTM E-84 test results for polyesters, vinyl ester, and epoxies typically yield smoke generation values in excess of "750". It can be said unequivocally that if FRP composite pipe and FRP ductwork is exposed to a "raging fire", there will be a lot of smoke generated. The ASTM test can only provide a hint of how much smoke.

Inquiries to all of the major manufacturers of resin system used for corrosion resistant applications have solicited written responses that they have no, and know of no, polyester and vinyl ester thermoset resin systems that will generate, by themselves, smoke generation values under 350. If you are going to be specifying flame spread and smoke generation levels, we recommend that you consult with either a knowledgeable fabricator, or one of the resin manufacturers.

Medium density fire board (MDF)

Objectives: At the end of this lesson you shall be able to

- **define physical properties of MDF**
- **state the types of MDF and the comparison with natural wood**
- **state advantages and disadvantages of MDF**
- **state the application and safety concerns of MDF**
- **explain veneered MDF.**

Physical properties

Over time, the term MDF has become a generic name for any dry process fibre board. MDF is typically made up of 82% wood fibre, 9% urea - formaldehyde resin glue, 8% water and 1% paraffin wax and the density is typically between 500 kg/m^1 (31 lb/ft^3) and 1,000 kg/m^3 (62 lb/ft^3). The range of density and classification as light, standard, or high density board is a misonorner and confusing. The density of the board, when evaluated in relation to the density of the fibre that goes into making the panel, is important. A thick MDF panel at a density of 700-720 kg/m^3 may be considered as high density in the case of softwood fibre panels, whereas a panel of the same density made of hard wood fibres is not regarded as so. The evolution of the various types of MDF has been driven by differing need for specific applications.

Types

There are different kinds of MDF (sometimes labeled by colour)

- Ultralight MDF plate (ULDF)
- Moisture resistant is typically green
- Fire retardant MDF is typically red or blue

Although similar manufacturing processes are used in making all types of fibreboard, MDF has a typical density of 600-800 kg/m^3 or 0.002-0.029 lb/in^3, in contrast to particle board (160-450 kg/m^3) and to high density fibreboard (600-1,450 kg/m^3).

Comparison with natural woods

MDF does not contain knots or rings, making it more uniform than natural woods during cutting and in service. However, MDF is not entirely isotropic, since the fibres are pressed tightly together through the sheet. Typical MDF has a hard, flat, smooth surface that makes it ideal for veneering, as there is no underlying grain to telegraph through the thin veneer as with plywood. A so called "Premium" MDF is available that features more uniform density throughout the thickness of the panel.

MDF may be glued, doweled or laminated. Typical fasteners are T-nuts and pan-head machine screws. Smooth - shank nails do not hold well, and neither do fine-pitch screws, especially in the edge. Special screws are available with a coarse thread pitch, but sheet-metal screws also work well. Like natural wood, MDF may split when woodscrews are installed without pilot holes.

Benefits

- Is an excellent substrate for veneers.
- Some varieties are less expensive than many natural woods
- Isotropic (its properties are the same in all directions as a result of no grain), so no tendency to split.
- Consistent in strength and size
- Shapes well.
- Stable dimensions (won't expand or contract like wood)
- Easy to finish (i.e. paint)

Drawbacks

- Denser than plywood or chipboard (the resins are heavy)
- Low grade MDF may swell and break when saturated with water.
- May warp or expand if not sealed.
- May release formaldehyde, which is a known human carcinogen and may cause allergy, eye and lung irritation when cutting and sanding.
- Dulls blades more quickly than many woods. Use of tungsten carbide edges cutting tools is almost mandatory, as high speed steel dulls too quickly.
- Though it does not have a grain in the plane of the board, it does have one into the board., Screwing into the edge of a borad will generally cause it to split in a fashion similar to delaminating.
- Subject to significant shrinkage in low humidity environments.
- Trim (e.g baseboards) comes pre-primed, but this is insufficient for fine finish painting. Painting with latex paints is difficult due to rapid water absorption. Most finishes appear uneven and nail holes tend to pucker.

Applications

Fig 1

Loudspeaker enclosure being constructed out of MDF

MDF is often used in school projects because of its flexibility. Slatwall Panels made from MDF are used in the shop fitting industry. MDF is primarily used for internal use applications due to its poor moisture resistance it is available in raw form with fine sanded surface or with decorative overlay.

MDF is also usable for furniture such as cabinets, because of its strong surface.

Safety concerns

When MDF is cut, a large quantity of dust particles are released into the air. It's important a respirator is worn and that the mateiral is cut in a controlled and ventilated environment. It's a good partice to seal the exposed edges to limit the emissions from the binders contained in this material.

Formaldehyde resins are commonly used to bind together the fibres in MDF, and testing has testing has consistently revealed that MDF products emit free formaldehyde and other volatile organic compounds that pose health risks at concentrations considered unsafe, for at least several months after manufacture. Urea-formaldehyde is always being slowly released from the edges and surfce of MDF. When painting, it is a good idea to coat all sides of the finished piece in order to seal in the free formaldehyde. Wax and oil finishes may be used as finishes but they are less effective at sealing in the free formaldehyde.

Whether these constant emissions of formaldehyde reach harmful levels in real -world environments is not yet fully determined. The primary concern is for the industries using formaldehyde. As far back as 1987, the U.S EPA classified it as a "probable human carcinogen" and, after more studies, the WHO International Agency for Research on Cancer (IARC), in 1995, also classified it as a "probable human carcinogen". Further information and evaluation of all known data led the IARC to reclassify formaldehyde as a "known human carcinogen" associated with nasal sinus cancer and nasopharyngeal cancer, and possibly with leukaemia in June 2004.

Veneered MDF

Veneered MDF provides many of the advantages of MDF with a decorative wood veneer surfce layer. In modern construction, spurred by high costs of hardwoods, manufacturers have been adopting this approach to achieve a high quality finishing wrap covering over a standard MDF board. One common type uses oak veneer. Making veneered MDF is a complex procedure, which involves talking an extremely thin slice of hardwood (approx 1-2 mm thick) and then through high pressure and stretching methods wrapping them around the profiled MDF boards. This is only possible with very simple profiles because otherwise when the thin wood layer has dried out, it will break at the point of bends and angles.

Tar, bitumen, asphalt

Objectives: At the end of this lesson you shall be able to
- **state tar in type and uses**
- **state bitumen and forms of bitumen**
- **state asphalt and is type.**

Tar

Tar is a dark back liquid with high viscosity.

Tar is classified into the following three types

1 Coal tar

2 Mineral tar

3 Wood tar

1 Coal tar

Coal tar is prepared by heating coal in closed iron vessels. The escaping gases and allowed to pass through tube which are not cool by circulation of water. Coal tar gets deposited in these tubes.

Coal tar is used for making macadam roads, preserving timber etc.

2 Mineral tar

Mineral tar is obtained by distilling bituminous Sholes

3 Wood tar

This tar is obtained by distillation of pines and similar other resinous trees. It posses strong preservative property.

2 Bitumen

Bitumen is the binding material which is present in asphalt. it is also called as mineral tar. It is obtained by partial distillation of crude petroleum. It is chemically a hydro - carbon. It is insoluble in water. It is completely dissolves in carbon disulphide.

- Bitumen is black or brown in colour.
- It is obtained solid or semi-solid state.

Forms of bitumen

i Bitumen emulsion

It is liquid product containing bitumen to a great extent is an aqueous medium.

ii Blown bitumen

It is a special type of bitumen which is obtained by passing air under pressure at a high temperature. This bitumen used as roofing and damp - proofing felts in the manufacturer of pipe asphalts and joint fillers and also or heat insulating materials

iii Cut -back bitumen

It is obtained by fluxing asphaltic bitumen in pressure of same suitable liquid distillates of coal tar or petroleum.

iv Plastic bitumen

It consists of bitumen, thinner, and suitably inert filler. It is used for filling cracks in masonry structures, for stopping leakages.

v Straight run bitumen.

When the bitumen is being distilled to a definite viscosity or penetration without further treatment, it is known as straight run bitumen.

Asphalt

Asphalt is a mechanical mixture of inert mineral matter like alumina, lime, silica, etc.

Classification of asphalt

Asphalt is classified into two

1 Natural asphalt

2 Residual asphalt

1 Natural asphalt

Natural asphalt is further subdivided into two groups

i Lake asphalt

ii Rock asphalt

i Late asphalt

- Lake asphalt is obtained from lakes at Trinidad and Bermudez (South America)
- It contains about 40 to 70% of pure bitumen. 30% water content. The rest is impurities it is refined and impurities are removed.
- This refined lake asphalt is used for road and pavement construction.

ii) Rock asphalt

Rock asphalt is obtained from rocks at Switzerland, France. It contain about 10 to 15% of pure bitumen. The rest consists of calamitous materials.

It is used to put on the road surface and also used for roofing sheet, paving file etc.

2 Residual asphalt

- This is also known as artificial asphalt
- It is obtained by the fractional distillation of crude petroleum oils with an asphaltic base. This solid substance is the residual asphalt.

Forms of asphalt

1 Asphaltic cement

- It is prepared by blowing air through melted asphalt at high temperature.
- It is highly resistant to varying climatic conditions.
- It is used for flooring, roofing, water-proofing and filler in expansion joints in concrete.

2 Asphaltic emulsion

Asphaltic emulsion is produced by mixing asphalt with 50 to 60% water in presence of 1% of emulsifying agent.

After the evaporation of water, the emulsion breaths and form a water proofing layer. This can be applied in cold condition.

3 Cut - back asphalt

Cut - back asphalt is a liquid asphalt. This is prepared by dissolving asphalt in a volatile solvent. This asphalt can be applied at normal temperature in cold condition. This asphalt is used to prepare bituminous points for repairing roofs etc.

4 Mastic asphalt

Mastic asphalt is produced by heating asphalt with sand and mineral fillers. It is a void less impermeable mass. This asphalt may either be in solid or semi-solid state. This asphalt is used as a damp proofing material and water proofing.

Properties of asphalt

1 It is a water proof material
2 It is non-inflammable
3 It is not affected by acids
4 It is reasonably elastic
5 It is good insulator of electricity and sound

Uses of asphalt

1 Asphalt is used as damp proof course
2 It is used basement of the building
3 It is used preparing points
4 It is used as construction of road metal and pavement.

Protective Material - Paints & Varnishes

Objectives: At the end of this lesson you shall be able to
- **define timber**
- **classify trees**
- **explain and indicate the parts of structure of trees**
- **describe the process of seasoning**
- **list out the qualities and uses of timber**
- **explain wood based products.**

Protective Material

Introduction

One of the broadly classfication of building Materials is protective materials. Protective of a structure is a main necessity. Apperance is also main factor. Final finishings are required for all surfaces such as walls, ceilings, wood works, metal works etc.

Definition

The Materials are used for the protective the surface of structure are known as protective materials.

Types of Materials used

Paint

Varnish

Distemper

White wash

Colour wash

Termite proof materials

Paint

The paint are coating of fluid material and they are applied over the surface of timber and metal.

Characteristics of an ideal paint

It should posses good spreading power

It should be fairly cheap and economical

It can easily and freely applied

It should dry in reasonable time

Colour should last for a long time

It should hard and durable

Ingredients of oil borne paints

A base

A vehicle or carrier

Drier

Colouring pigment

A solvent

Base

A base is a solid substance is a fine state of division and it forms the bulk of paint. It determine character of paint and it imparts durability to painted surface.

Commonly used bases are

White lead	Red lead	Zinc white
Oxide of iron	Titanium white	Aluminium white
Lithophone	Antimony white	

Vehicle or carrier

Vehicle are liquid substance which hold the ingredients of a paint in a liquid suspension.Vehicles employed are

Linseed oil Poppy oil Tung oil Nut oil

Driers

These are substance accelerate the process of drying. Drier absorb oxygen from air and transfer it to linseed oil which gets hardened. Some of the driers

a)Litharge b)Red lead c)Sulphate of Manganese

Colouring pigments

Colouring pigments gives desired colour besides the base.

Pigments are Graphite lamp black

Indigo Pressian blue

Umber

Chrome green

Copper sulphate

Solvent

The function of solvent is to make the paint thin so that it can easily applied on the surface. It helps the paint to penerate through the porous surface. The most commonly used solvents is spirit ot turpentine.

Types of paint

Aluminium - Gas tank, hot water pipes , radiater oil tank

Anti corrosive paint - An corroisive metal - iron

Asbestos paint - Acidic gases and steam

Bituminous paint - Iron work under water

Cellulose paint- Surface contact with high cold and heat

Cement paint- Plastered surface

Colloidal paint - Walls

Emulsion paint - Wood, metal, plastered surface

Enamel paint- Wall surface, wood, metal

Graphite paint- Iron surface contact with ammonia, clorine sulphar gas etc, mines and under ground railway

Inodorous paint

Luminous paint - Dials of watch

Oil paint - Redecorate the surface

Plastic paint- Show room auditorium

Varnish

The term varnish in used to indicate the solution of resinous substance prepard either in alcohal, oil or turpentine.

Characteristics

It should not shrink or show cracks after drying

The protecting film develped by varnish should be tough , hard and durable

It should dry rapidly

It should not fade

Ingredients

Resins or resinous substance

Driers

Solvents

Resins- Copal, lac or shellac and rosin amber mastic gum, dammar etc.

Driers - Litharge, white copper and lead acetate

Solvent - boiled oil, spirit of wine, turpentine wood naphta

Types of varnish

Depending upon solvent varnishes are :

Oil varnish

Spirit varnish

Turpentine varnish

Water varnish

Distemper

The main ingredients are whiting or chalk and water and glue or casein. It provides a smooth to plastered surface. They are available in market under different trade names and varity of colours. They are cheaper than paint and varnish.

White wash

It contains fresh lime, water, and gum lime is toxic for germs. It reflects light and increase brightness of surface. It is used interior wall and ceilling.

Colour wash

It prepared by adding colouring pigment to white wash.Applied on outer wall and inner wall.

Termite proof materials

Termite are white ants found in abundance in tropical and subtropical countries. They are very fast in eating wood, cellulosic and non-cellulosic materials. The treatment which is given to prevent or control the growth of termites in a building is known as termite proofing.

Type of Termites

Dry Wood termites - in humid coastal regin.

Subterranean termites - in connection with soil.

Metal and alloys

Objectives: At the end of this lesson you shall be able to
- **state Types of steel reinforcement.**
- **describe steel for pre-stressed concrete**
- **identify the types of rolled steel sections.**

Metals and Alloys

Introduction

Metals are employed for various engineering purposes such as structural members, roofing materials, damp proof course, pipes, tanks, doors, windows etc.

Definition

The substance which are extracted from ores through various refining method are called metals

Classification of metals

Metals are classified into two

Ferrous metals

Non ferrous metals

Ferrous metals

Main element of ferrous metals iron, the iron ores are compound of iron with non-metallic elements and certain impurities such as carbon, manganese, phosphorous, silicon and sulphur. Important varities of iron ore are Haematite, limonite, magnetite pyrite and siderite.

Non-ferrous metals

The metal which do not contain iron ores as main constituent are called non ferrous metals.

Types of ferrous metals

- Pig iron
- Cast iron
- Wrought iron

- Steel

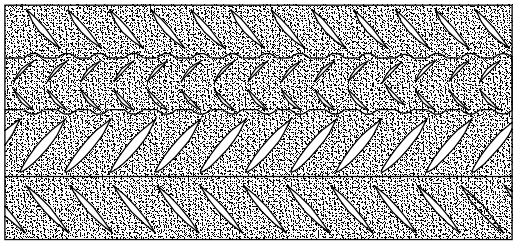
TYPES OF STEEL REINFORCEMENT:

Steel rods used for reinforcement concrete work should be of specified tensile strength, and they should develop good bond strengths with concrete. There are different types of steel, like, mild steel, tor-steel, TMT bars, etc.; and one should be able to identify them by sight. Steel rods of different diameters are used for R.C. work. In order to identify the sizes easily, only standard sizes should be used in building units. The following types of bars are commonly used in reinforced concrete construction.

1 Hot rolled bars, there are four types, (i) Hot rolled plain round mild steel bars (MS bars); (ii) Hot rolled ribbed mild steel bars (generally not recommended for use);(iii) Hot rolled high strength deformed bars (bars like Tistrong bars by Tisco) also called as HYSD bars (high strength got by micro alloying).(Fig 1)

2 Hot rolled cold twisted deformed bars like Tor steel (CTD) bars (high strength got by cold twisting) (Fig 2)

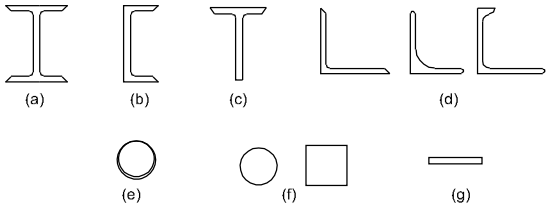
Fig 1



HIGH YIELD STRENGTH DEFERMED BARS

DCN132311

Fig 2



ROLLED STRUCTURAL SHAPES

DCN132312

Market forms of Steel

SNo.	Form of Steel	Types	Uses
1	Angle section	Equal angle section unequal angle section	Structural steel work
2	Channel section	Junior channel (ISJC) Medium channel(ISMC)	Structural member
3	Corrugated sheets	G.I. Sheets	Roof covering
4	Expanded sheets		Reinforcing concrete in foundations, roads, floors, bidges lathing material partions
5	Flat bars	Width 10mm to 400mm and thickness 3mm to 40mm	Steel grill works
6	I Sections	Junior beams (ISJB) Light beams (ISLB)medium beams (ISMB)wide flange beams (ISWB)Heavy beams (ISHB)	Suitable for beams lintels, columns etc
7	Plates	Thickness 5mm to 50mm	Structural steel work
8	Ribbed torsteel	Dia 6mm to 50mm	Reinforcement in concrete structure
9	Round bars	Dia 5mm to 250mm	Reinforcement in concrete structures and for steel grill work
10	Square bars	Side 5mm to 250mm	Construction of steel grill work
11	T Sections		Steel roof truss and for built up section
12	Miscellaneous section	Acute angle sections, Obtuse angle sections, rail section, trough section, Z section	Structural steel work.

3 Thermo-mechanically Treated (TMT) bars (high strength got by controlled cooling)

4 Cold drawn steel wire fabric (welded wire fabric)

Types of non ferrous metals

Following are the right non-ferrous metals which are sued in engineering field are

- Aluminium
- Cobalt
- Copper
- Lead
- Manganese
- Nickel
- Tin
- Zinc

Alloys

Definition

Alloys is an intimate mixture of two or more metals

Process of making alloys

- The more infusible metal melted fast in fire clay crucible
- The other metals then added subsequently in order to their infusibility.
- The contents are continuously stirred to form a homogeneous mass
- The molten mixture is cast in suitable moulds and allowed to cool.
- The product obtained is called alloy
- The metal which is present in the alloy in largest proportion is called base material and the other metals are called alloying elements.

Important Alloys

Duralumin : This is the important alloy of aluminium

Aluminium	- 94%
Copper	- 4%
Manganese	- 0.5 %
Magnessium	- 0.5 %
Silicon	- 0.5%
Iron	- 0.5%

Brass : This is an alloy of copper and zinc

Copper	- 60%
Zinc	- 40%

Bronze : This is an alloy of copper and tin

Bell metal	Copper	- 82%
	tin	- 18%
Gun metal	Copper	- 88%
	Tin	- 10%
	Zinc	- 2%

Dow metal

Magnesium	- 88%
Aluminium	- 12%
Manganese	- 0.1%

Nickel silver or german silver

Copper	- 50 to 80%
Tin	- 10 to 30%
Zinc	- 20 to 30%

Steel Alloys

Chrome - molybdenum steel

Chrome - nickel stainless steel

Chrome - nickel steel

Chromium steel

Chromium - vanadium steel

Cobalt steel

Copper steel

Manganese steel

Molybdenum steel

Nickel - chromium- molybdenum steel

Nickel steel

Tungsten steel

Vanadium steel

Nickel -molybdenum steel

Plastics

Objectives: At the end of this lesson you shall be able to

- **explain briefly the history of plastic**
- **state the composition of plastic**
- **define polymerization**
- **state the classification of pasties and explain**
- **state the moulding compounds of plastic and fabrication process involved in the fabrication of plastics**
- **explain properties of plastics**
- **state the use of plastics**
- **pvc pies and pipes of other materials and advantages of PVC pipes.**

Brief history of plastic

Plastic is one of the recent engineering material which is available in the market all over the world. After the long research by the scientists the birth of plastic in industry took place in the 19th century.

The development of plastic industry may be grouped into three stages.

1 The main objective of the first stage of development was mainly to initiate or copy the natural plastics. In 1865 camphor and alcohol mixed with nitro-cellulose, and the result of the product is known as parasite, which is the name of the scientist. This is used for gear wheels, dory knobs etc.

2 The second stage is comprised in first twenty years or so of this century. In this stage the plastic industry scientifically scrutinized and local foundation for further

scientific development in this field. In 1909 Dr.L.Bakeland invented a product named as Bakelite which was found to be strong and hard material.

3 The final stage includes present trend and its main aim was improving the old plastic and producing new varieties of plastics. In 1924 the scientist pollats prepared a produce from urea and formaldehyde. It was transparent like glass, and it was un breakable. The same was produced in different attractive colours.

Composition : Plastic is organic substance and it consists of natural or synthetic benders or without moulding compounds. In general plastics are compounds of carbon with other elements like hydrogen, nitrogen of carbon and oxygen.

The finished product of plastic is rigid and stable at normal temperature, plastics are organic substances and they can flam when required heat and pressure are applied at the same stage of manufacture.

Polymerization : The substance containing of one primary chemical are known as monomers or monoliths. They are synthesized to form polymers by the process known as polymerization. The properties like strength, rigidity, elasticity are unproved by polymerization.

The following are the two methods of polymerization.

1 Addition polymerization

2 Condensation polymerization.

1 Addition polymerization

In this method, different molecules join together, and the molecular weight of the resulting polymer is equal to the some of the molecular weight of the reacting molecular. This process involves three stages.

i Beginning of the process

ii Expansion of the chain

iii End process

The polymers obtained in this method are polyethylene, polypropylene, polyvinylchloride, polystyrene, polyarcylates etc.

2 Condensation polymerization

In this method, low molecular substances are removed from high molecular substances formed from a large number of identical or different molecular. The reaction proceeds with an evolution of ammonia, hydrogen chloride and similar other low molecular substances.

The polymers obtained by this method are phenol formaldehyde, carbonate, melamide*, melamine formaldehyde etc.

Classification of plastics

They are classified according to their:

1 Behaviour with respect to heating

2 Structure and

3 Physical and mechanical properties

1 Behaviour with respect to heating

According to this classification plastics are divided into two groups.

1 Thermo plastic

2 Thermo setting

1 Thermo- plastic

The thermo plaster or heat non - convertible group is the general term applied to plastics which become soft when heated and hard when cooled. The process of softening and hardening may be repeated for an indefinite time, provided the temperature during heat is not so high as to cause chemical decomposition. So it is possible to shape and reshape these plastics by means by heat and temperature. The advantage of this variety plastics is that the scrap obtained from old and worn-out articles can be effectively used again.

2 Thermo setting

The thermo setting or heat convertible group is the term applied to plastics which be come rigid when moulded at a suitable temperature and pressure. When they are heated in temperature ranging 127° to 177°C, It sets permanently and further application of heat does not alter their from or soften. But at 343°C charring occurs. This charring is a peculiar characteristic of organic substances.

The thermo setting plastics are soluble in alcohol and in certain organic solvents, when they are in thermo plastic stage. This property is used for making paints and varnishes.

The thermo plastics are durable strong and hard. They are available in many beautiful colours. They are mainly applied in engineering application plastics.

2 Structure : As per classification, plastics are divided into two groups.

1 Homogeneous plastic

2 Heterogeneous plastic

1 Homogeneous plastic

The plastics of this group contains carbon atoms and they exhibits homogeneous structure.

2 Heterogeneous plastic

In this plastic it contains carbon and oxygen, nitrogen and other elements and they exhibit Heterogeneous structure.

3 Physical and mechanical properties

According to this, plastics are divided into four groups.

i Rigid plastics

ii Semi- rigid plastics

iii Soft plastics

iv Elastomers

i Rigid plastics

These plastics possess a high modulus of elasticity and they retain their slope under exterior stresses applied at normal or moderately increased temperature.

ii Semi-rigid plastics

These plastics have a medium modulus of elasticity and the elongation under pressure completely disappears when pressure is removed.

iii Soft plastics

These plastics have a lam modulus of elasticity and the elongation under pressure disappears sonly when the pressure is removed.

iv Elastomers

These plastics are of soft and elastic materials having low modulus of elasticity. The deformation is in tension and the deformation disappears rapidly at room temperature.

Resins

The plastics are grouped in to two groups, based on their behaviour according to heating, resins or benders are also broadly divided into the following groups.

1 Thermo plastic resins

2 Thermo setting resins

1 Thermo plastic resins

i Alkyd

These resins are made from glycerin and ophthalmic anhydride. The cool slowly and possess electricity properties. They are used for preparing this felons of plastics.

ii Celluloses

These are derived from various cellulose compounds like cellulose acetate, cellulose nitrate etc. Plastics made from this are like glass. They are tough, strong and posses electrical properties. Possible to obtain all types of colours.

iii Coumarone - indene

These resins are soft in very small temperature. They are brittle and used for floor tiles, rubber manufacture etc.

iv Methyl methocrylate

This is known as acrylic. It is derived from coal petroleum and water. It transmits ultra-violet waves of light. It can be acts, sawn or turned it acts as good electrical insulator. Plastics prepared from this are used for safety glass, artificial jewels, roof lights, lightening fittings, bath and sink units etc.

v Styrene

This is the product form ethylene which is made from petroleum . It is light an weight and transmits ultra- violet waves of light. It possess very high electric resistance. It is used as emulators at radio frequencies in wireless and television industry.

vi Vinyl

It is prepared by passing acetylene gas through acetic acid or dry hydrogen chloride. It is used for wire and cable for coatings polyethylene is a vinyl resin which is tough and flexible and used for cable causing.

2 Thermo setting resins

i Casein

Casein is a phosphor protein and is derived by the precipitation of milk with acids. If has bright attractive appearance but not strong. It is used for buckles, buttons, etc.

ii Melamine -formaldehyde

It is obtained from calcium carbide, melamine when reacted with formaldehyde, forms this resin. It possess excellent resistance to electrical arcs. It is used for electrical insulators, glass reinforced plastics etc.

iii Phenol formaldehyde

Phenol is a carbolic acid it is extracted resin prepared from this lightly resistant to heat. It possess both mechanical and electrical properties. It is used for paints, varnishes, preparation of laminated products, electrical fitting, w.c. seats etc.

iv Phenol farfuraldehyde

Farfuraldehyde vapours when reacted with phenol, from resin. It is darie colour and resists very high temperature.

v Urea formaldehyde

Urea is prepared from calcium cyanamide or a mixture of liquid carbon dioxide and liquid ammonia. Urea reacted with formaldehyde produce this resin. It is not easily attached by dilute acids and alkalies oil, chemicals, water etc. Plastics made from this resin are unidely* used for making adhesives for wood, lighting fixtures, like lamps, reflectors etc.

To give desired finished plastic articles, certain moulding compounds are to added to plastics. Following are the such moulding compounds.

1 Catalysts

2 Fillers

3 Hardeners

4 Lubricants

5 Pigments

6 Plasticizers

7 Solvents

In plastic fabrication following are the process involved in the fabrication of plastic articles.

1 Blowing

2 Calendaring

3 Casting

4 Laminating

5 Moulding (compression moulding - extrusion moulding)

Properties of plastics

1 **Appearance :** Some plastics are completing transparent in appearance.

2 **Chemical resistance :**Plastics are great resistance to moisture, chemicals and solvents. Many plastics are found to be corrosion resistance and hence they are used to convey chemicals.

3 **Dimensional stability :**This property of plastic is very satisfactory with that of other common engineering materials.

4 **Ductility :** It is lacks in ductility and may fail with out warning.

5 **Durability :** Plastic and are quite durable. It possess sufficient surface hardness.

6 **Electric insulation :** Plastics are for superior to ordinary electric insulators

7 **Finishing :** Any surface treatment can be given to plastics. It is easy to have technical control during manufacture. It results to man production with uniformity of surface finish.

8 **Fire -resistance :** Plastics are organic in nature and hence all plastics re combustible. Cellulose acetate burns slowly. Polyvinyl chloride plastics are non - inflammable. Phenol formaldehyde and urea formaldehyde resist fire and they are used as fire - proofing materials.

9 **Fixing :** Plastics can be fixed easily in position and they can be bolted, clamps, drilled, glued, threaded simply push fitted in position.

10 **Humidity :** The properties of plastics are governed to same extent by humidity, plastics which do not contain water attracting groups like polyvinyl chloride plastics offer great resistance to moisture.

11 **Maintenance :** It is easy to maintain plastic surfaces and they do not require any protective coat of paints.

12 **Melting point :** Most of plastics have low melting point and some of plastics have 50°C. In general it can be said that the co-efficient of thermal expansion of plastics is ten times than that of steel.

13 **Optical property :** Several types of plastics are transparent and translucent .

14 **Sound absorption :** This material has absorption coefficient of about 0.67

15 **Strength :** Plastics are reasonably strong. Plastic members can be used as tensile members.

16 **Thermal property :** The thermal conductivity of plastics is low and it can be compared with wood. Foamed or expanded plastics are among the loading thermal insulators.

17 **Weather resistance :** Only limited varieties of plastics can be exposed to weather.

18 **Weight :** Plastics, whether thermoplastic or thermo setting have low specific gravity, the a usage being 1.30 to 1.40. The light weight of plastic reduces the transport cost and easy to fixing .

Uses of plastics

The typical uses of plastics in building are summarized as follows.

1 Bath and sack writs

2 Cistern ball floats

3 Corrugated and plain sheets

4 Decorative laminated and mouldings

5 Electrical conduits

6 Films for water proofing, damp - proofing and concrete curring

7 Electrical insulators

8 Floor files

9 Foams for thermal insulation

10 Joint less flooring

11 Lighting fixtures

12 Over heads water tanks

13 Paints and varnishes

14 Pipes to corry cold water

15 Roof lights

16 Safety glass

17 Wall tiles

18 Water resistant adhesives etc

The advantages of PVC pipes

1 They have good insulating properties and hence the water passing through this is not affected by the out side temperature.

2 The have no problems of incrustation .

3 They permit high smooth and undionanished flam of water.

4 They possess high Hazen Williams constant.

5 They prove to be economical as compared to other pipe conventional materials.

6 They provide resistance to a variety of chemicals.

Disadvantages of PVC pipes

1 They are liable to creep phenomena, when installed above ground level.

2 They can not be used in high temperature.

3 They do not have same strength as cost iron or galvanized iron pipes.

4 They possess higher co-efficient of expansion.

Precautions to be taken in the design and installation of PVC pipes.

1 The design of PVC pipes should accommodate adequate provisions of air vents etc.

2 The fittings such as tees, elbows, caps etc used in PVC piping system fit well with the pipes.

3 After installation the PVC pipes should be tested.

4 The turbulent flow of water through PVC pipes should be avoided.

5 The trances for laying PVC pipes should be as narrow as possible.

6 They are available in different colours. It is advisable to avoid red and black colours.

7 Should be used freely to eliminate external stresses

8 They should not be used at places likely to be heavy loading.

9 The should not be bent too much.

- The properties of various types of plastics make them suitable for wide range of engineering applications. The development of plastic industry is very recent and have much scope for research.
- Most of plastics possess low heat resistance
- Plastics are not very low
- Plastics exhibits high creep
- Plastics have high co-efficient of thermal expansion
- It varies from 25×10^{-6} to 120×10^{-6} as compared to 10×10^{-6} of steel.

Sequence of construction of a building

Objectives: At the end of this lesson you shall be able to
- **parts of a building**
- **list the sequence of construction**
- **explain the levels of different parts of building**
- **draw and indicate the parts.**

Introduction

A Building consist of sub-structure and superstructure. Foundation, Plinth, walls, floors and roofs are the main structural components of the building. Each of these components is an essential part of a building and requires due consideration in design and construction for their functional performance.

Parts of a building

The sectional view of a building shows all constructional details from the foundation level to the top of roof such as total height and different levels i.e. depth of foundation, plinth level ground floor level, thickness of wall, window sill level, floor to ceiling height, window / door height, chajja level, roof top level, parapet level and coping.

The sequence is listed form foundation

1 Foundation
2 Plinth
3 Plinth course
4 Sill
5 Door & window
6 Lintel
7 Floors
8 Roof
9 Parapet
10 Coping

1 Foundation

It is the lowest artificially prepared part, below the surface of the surrounding ground, which is in direct contact with sub-starter and transmits, all the loads to the sub-soil.

2 Plinth

It is the middle of the structure, above the surface of the surrounding ground up to the surface of the floor, immediately above the ground.

3 Plinth course

It is top most course at plinth level which is finished flush with the surface of ground floor.

4 Sill

It is the horizontal member comprising concrete, stone or wood to give support to the vertical members of wooden window. It helps in shedding rain water from face of wall.

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4 Sill

It is the horizontal member comprising concrete, stone or wood to give support to the vertical members of wooden window. It helps in shedding rain water from face of wall.

5 Door & window

Door is a frame work of wood, steel, glass. The purpose of door to give access to the users of the structure and free movement into and outside the structure. The door provide a good ventilation. Windows are constructed for providing light and ventilation in the building.

6 Lintel

A horizontal member of stone, wood, brick, steel, rein forced brick, R.C.C etc above the opening to support the masonry or load above, it is called lintel.

7 Floors

Floors are horizontal elements of a building structure which divide the building into different levels for the purpose of creating more accommodation.

8 Roof

A root is the uppermost part of a building which is supported on structural members and covered with a roofing material. The main function of a roof is to enclose the building and to protect the same from the damaging effects of weather such as rains, wind, snow etc.

9 Parapet

It is the wall built around a flat roof which acts as a protective wall for the users of the terrace. In case of pitched roof, the parapet wall is used to conceal to gutter at coves level.

10 Coping

The coping is covering of bricks or stones which is placed on the exposed top of on external wall to prevent seepage of water through joints of top most course in a wall.

Parts of a building (Fig 1)

Buildings: Building is not only a "SHELTER" but:

1 Energy saving

2 Efficiency improving

3 Environment friendly

4 Users friendly

5 Building can be defined as the three dimensional shape or form in the space, resting on the earth, secured to the earth by foundation for stability.

Different stages in the life of building

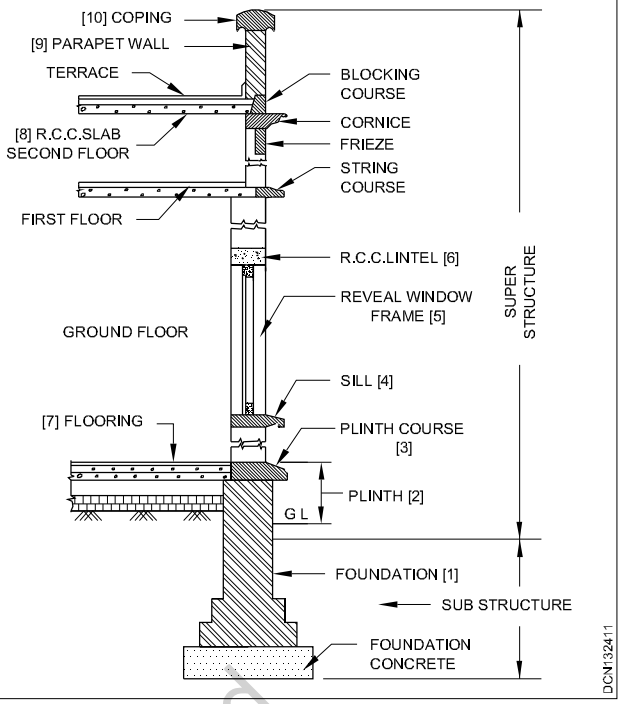
Planning: Decides the initial form

Designing: Decides the final form

Drawing: Tool to convert requirements into reality.

Construction: Conversion of two dimensional drawing into three dimensional structure. It is engineering in action, hence needs Construction Management.

Fig 1



Occupation: Environment Design Evaluation is essential after occupation to assess achievements in Planning, Designing and Construction by observing behavior of user and by obtaining user's views.

Maintenance and preservation: Preparation of maintenance programme to maintain livability throughout the life of the building by observing effect of Sun, Rain, Wind, and Human Behavior on building materials and construction.

Masonry

Objectives: At the end of this lesson you shall be able to
- **define masonry**
- **identify the components of masonry**
- **explain the materials required for masonry**
- **list out the classification of masonry.**

INTRODUCTION

The term masonry is used to indicate the art of building the structures either in stone or brick or combination of materials such as stones, bricks, tiles, concrete block etc. Even though new principles of construction and new materials are adopted in the construction process, masonry has got highest importance in the building industry. Masonry is normally used for the construction of foundation, walls, pillars and other structural components of buildings.

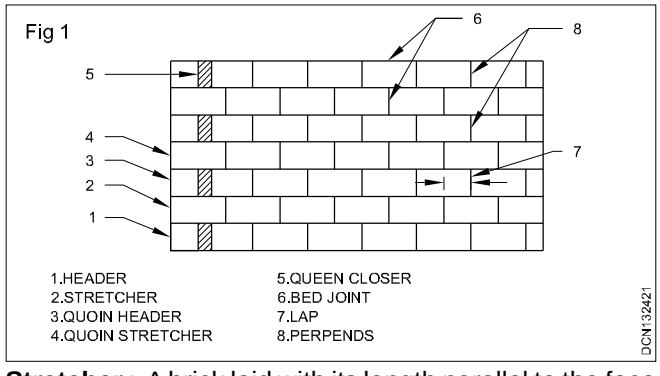
MASONRY

Masonry is the art of binding building blocks (stone, brick, or other building blocks) with binding material or an assemblage of masonry units properly bonded together with mortar.

COMPONENTS OF MASONRY

Technical Terms:

Fig 1



Stretcher : A brick laid with its length parallel to the face of the wall

Header : A brick laid with its breadth or width parallel to the face of wall

Bed : The lower surface of the brick when laid flat

Bed joint : The horizontal layer of mortar up on which the bricks are laid

Perpends : The vertical joints separating the bricks in either length or cross direction.

Lap : The horizontal distance between the vertical joints in successive course.

Closer : A piece of brick which is used to close up the bond at the end of brick courses.

Queen closer : Cutting the brick longitudinally in two equal parts

MATERIALS REQUIRED FOR A MASONRY

MASONRY UNITS

Masonry units shall confirm to accepted standards. Masonry units may be of the following types :

a Common burnt clay bricks

b Stones (in regular sized units)

c Sand lime bricks and

d Concrete blocks

MORTAR

Where specified for normal masonry and in all cases for load bearing masonry walls, mortar shall be sampled and tested for flow and water retention .

CLASSIFICTION OF MASONRY

The masonry is generally classified as follows.

1 Stone masonry

2 Brick masonry

3 Hollow block concrete masonry

4 Reinforced masonry and

5 Composite masonry

Stone Masonry

Objectives: At the end of this lesson you shall be able to
- **define stone masonry**
- **state the general principles of construction of stone masonry**
- **describe the five types of ashlar masonry**
- **explain types of stone masonry joints.**

Introduction

In ancient times most of the building construction was done in stone masonry. Stones are available in large quantity but not in all parts of India. Stones are used for the construction of walls ,pillars, lintels, arches footings etc.' of the building. Most common types of stones available in India for stone masonry are granite, sand stone, limestone, marbles, slates etc., Usually lime and cement mortar are used in the stone masonry.

Definition

The art of building the structures with stone is called stone masonry.

General princiles of contruction of stone masonry

- Stones shall be hard, tough, compact and durable.
- Stone should be laid on their natural bed.
- Proper bond should be maintained.
- Masonry should be raised uniformly otherwise too things or recesses or steps should be provided.
- The hearting of masonry should be properly filled with stones and spalls or snicks with mortar.
- Vertical faces should be checked with plumb rule.
- The masonry should not be subjected to tensile stress.
- When construction is to be done over old surface it should be well cleaned and wetted before starting the work.
- The stones should be wetted before used to avoid absorption of water from mortar.
- The exposed joints should be pointed.
- The entire masonry should cure for two weeks.
- Through stones should be used at every 1.5m height.

Materials required for stone masonry

1 Stone

2 Mortar

1 Stone: Stones should be hard, durable, tough and free from any defect. **Eg** : Basalt, Granite, Laterite, Marble, Quartzite Sandstone, Slate.

2 Mortar: Mortar is used to keep the stones in position. Selection of mortar depends on strength required load coming and resistance desired for weathering agencies. **Eg**: Lime mortar, Cement mortar, Lime cement mortar, Cement lime mortar.

Rubble Masonry

In the rubble masonry the blocks of stones used are either undressed or rough dressed. The strength obtained from

1 Quality of mortar

2 Using of through stone in certain intervals

3 Filling up mortar thoroughly between the facing.

Ashlar Masonry

In ashlar masonry regular stones of square or rectangular shape with accurate bed joints are used.

CLASSIFICATION OF STONE MASONRY

Stone Masonry

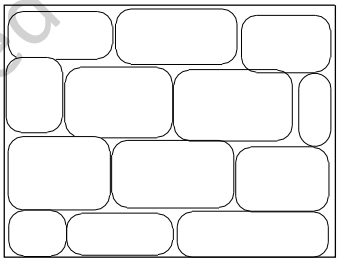
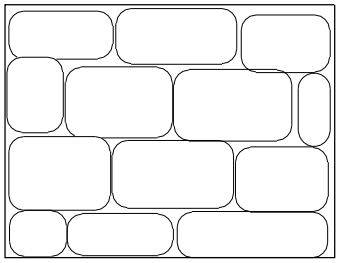
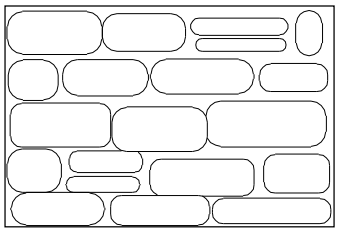
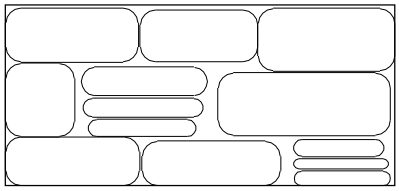
Rubble Masonry

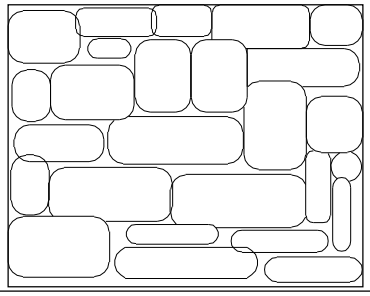
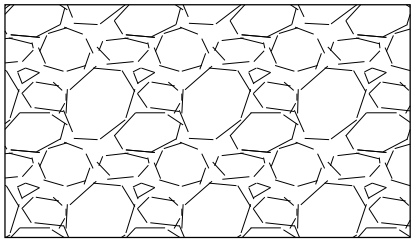
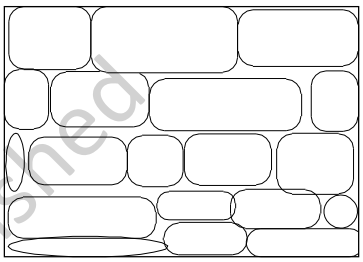
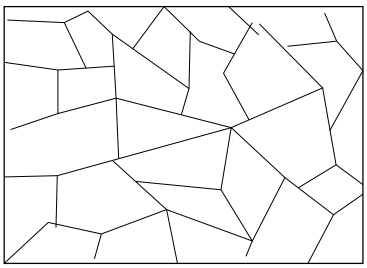
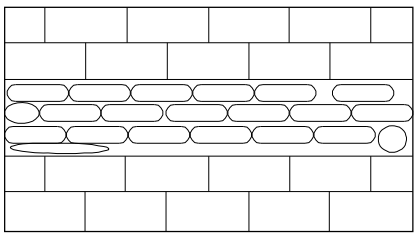
1 Coursed Rubble
2 Uncoursed Rubble
3 Random Rubble
4 Dry Rubble
5 Polygonal Rubble
6 Flint Rubble Course

Ashlar Masonry

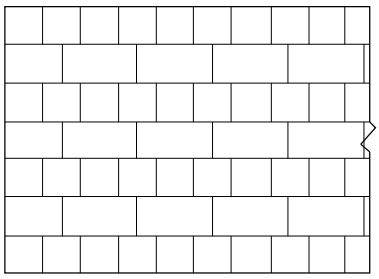
1 Ashlar Fine
2 Ashlar Rough Tooled
3 Ashlar Rock or Quarry Faced
4 Ashlar Chamfered
5 Ashlar Block in course masonry

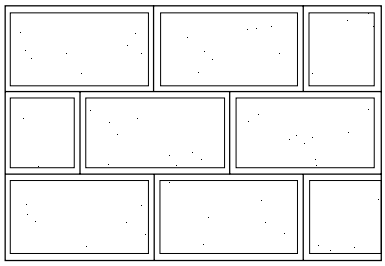
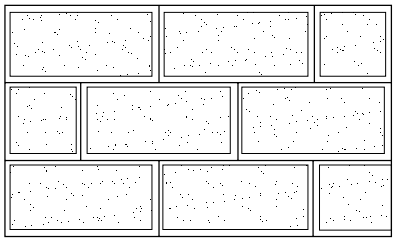
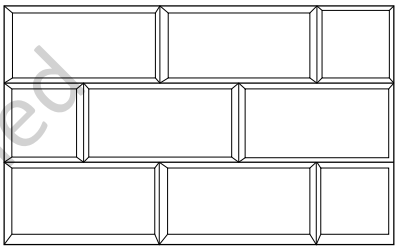
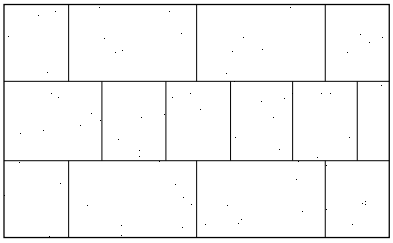
RUBBLE MASONRY

Sl No	Name of masonry	Description	Figure
1	Coursed rubble masonry	Heights of stones vary from 50mm to 200mm. Stones inparticular course are of equal heights. Used for public buildings, residential buildings etc.,	
1a	Coursed rubble (1st sort)	Face stones are hammer dressed, bushings do not project more than 40mm, mortar joint does not exceed 10mm.	
1b	Coursed rubble (2nd sort)	Stones are of different heights, two stones are to be used to make up the height of one course mortar joint 12mm.	
1c	Coursed rubble (3rd sort)	Minimum height 50mm,only three stones are to be used to make up the height of one course, mortar joint is 16mm.	

Sl No	Name of masonry	Description	Figure
2	Un coursed rubble masonry	Stones are used as they are available from the quarry, course is not regularly, and the thickness of mortar joint is 12mm. This masonry is used in compound wall, go downs, garages etc.,	
3	Random rubble masonry	The stones are irregular size and shape but arranged so as to have good appearance, so more skill is required. Mortar joint does not exceed 6mm. Used for residential building, compound wall etc.,	
4	Dry rubble masonry	Similar in construction to the coursed rubble masonry3rd sort except that no mortar is used. It require more skill in construction Used for compound wall ,pitching on bridge approaches ,retaining wall etc.	
5	Polygonal Rubble Masonry	Stones are hammer dressed. Stones are selected for face work are dressed in a irregular polygonal shape. More skill required for the construction. Used for face work.	
6	Flint Rubble Masonry	Stones used are flint which is irregularly shaped nodules of silica. Face arrangements may be coursed or uncoursed. Strength is increased by introducing lacing course.Used at place where flints are available readily	

ASHLAR MASONRY

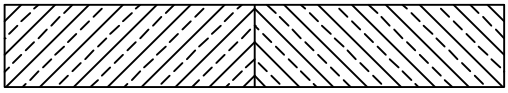
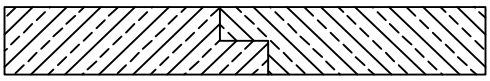
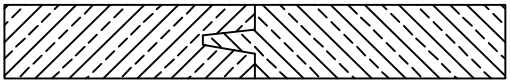
Sl no	Name of masonry	Description	Figure
1	Ashlar Fine	The beds, sides ,and faces are finely chisel dressed. The stones are arranged in proper bond. Thickness of mortar joints does not exceed 3mm.It gives smooth appearance ,but it is very costly. Used for superior work.	

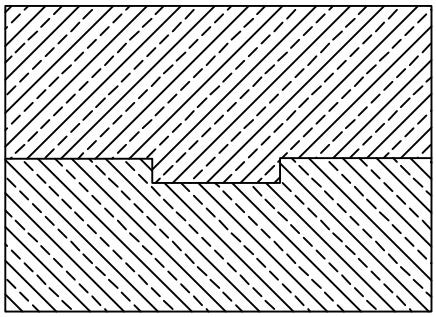
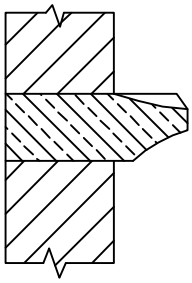
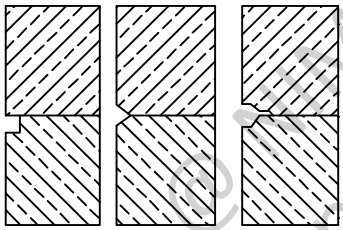
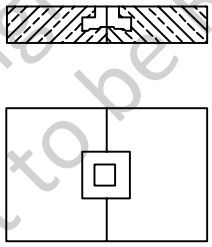
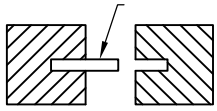
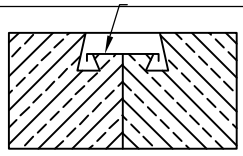
Sl no	Name of masonry	Description	Figure
2	Ashlar rough tooled (Bastard ashlar)	Beds and sides are finely chisel dressed. Faces made rough.Thickness of mortar joints does not exceed 6mm. A strip is provided around the perimeter. Used only for exposed surface.	
3	Ashlar rock or quarry faced	All the faces and sides except exposed face is left as received from quarry. Only bushings are removed. A strip is provided around the perimeter.	
4	Ashlar chamferred	A strip is provided 25mm wide, it is chamfered or beveled at an angle of 45° using chisel . Another strip 12mm wide remaining exposed face of the stone. Remaining part just like received from quarry. It gives neat appearance.	
5	Ashlar block in course masonry	It occupies a position between the rubble masonry and ashlar masonry. Faces are hammer dressed. Thickness mortar joint does not exceed 6mm. It is used for retaining walls, sea walls, railway stations, temples bridges etc.,	

JOINTS IN STONE MASONRY

In order to increase the length, breadth, thickness of stone in masonry or to secure the stones firmly with each other, joints are required.

TYPES OF JOINTS IN STONE MASONRY

NO	TYPE OF JOINTS	FIGURE	USES
1	Butt joint		Most common joint used in ordinary works .
2	Rebated joint or Lapped joint		Used arch work, coping of gable tops.
3	Tongued and grooved joint or joggled joint		Joint require more labour make expensive . Used only in some portions of ashlar masonry.

NO	TYPE OF JOINTS	FIGURE	USES
4	Tabled joint		This joint prevent lateral movement. Used in structures like sea wall where lateral pressure is more.
5	Saddled or rusticated joint		Used to protect the joint of cornice.
6	Rusticated joint		These joints are used for plinth, quoin, outer wall of lower storey.
7	Plugged joint		This used for coping cornice etc.
8	Dowelled joint		In some end portions of ashlar masonry at places where joggled joint is needed we can use this joint.
9	Cramped joint		It prevent the tendency of stone joint to pull apart. This joint is used instead of dowel joint

Brick masonry

objectives : At the end of this lesson you shall be able to,

- **define brick masonry & bond**
- **state the general principles of bonding in brick masonry**
- **explain special bricks used in brick masonry**
- **explain the types of bonds used in brick masonry**
- **describe types of brick masonry**
- **points to be observed while supervising the brickwork**
- **differentiate brick masonry & stone masonry**

Introduction

The techniques of laying various types of bricks, together with the different kinds of mortar used in the construction of thick walls, all require a different craft operation.

In dry weather all bricks must be well soaked in water before use and the top of old wall should be wetted before the comencement of work. The soaking and wetting is done to remove dust and prevent the bricks absorbing too much water from the mortar.

Definition

An art of builidng which the structure with bricks bonded with mortar is called brick masnory. A bond is an arrangement of bricks in layers by which no continuous vertical joints.

Principles of Bonding

1 The amount of lap should be minimum of ¼ th brick along the length of the wall and ½ brick across the thickness of wall.(Ref. components of masonry)

2 The brick should be uniform size to get uniform lap

3 The structure should be used in facing

4 Hearting should carry out with headers only.

5 Use of brickbats should avoid as far as possible.

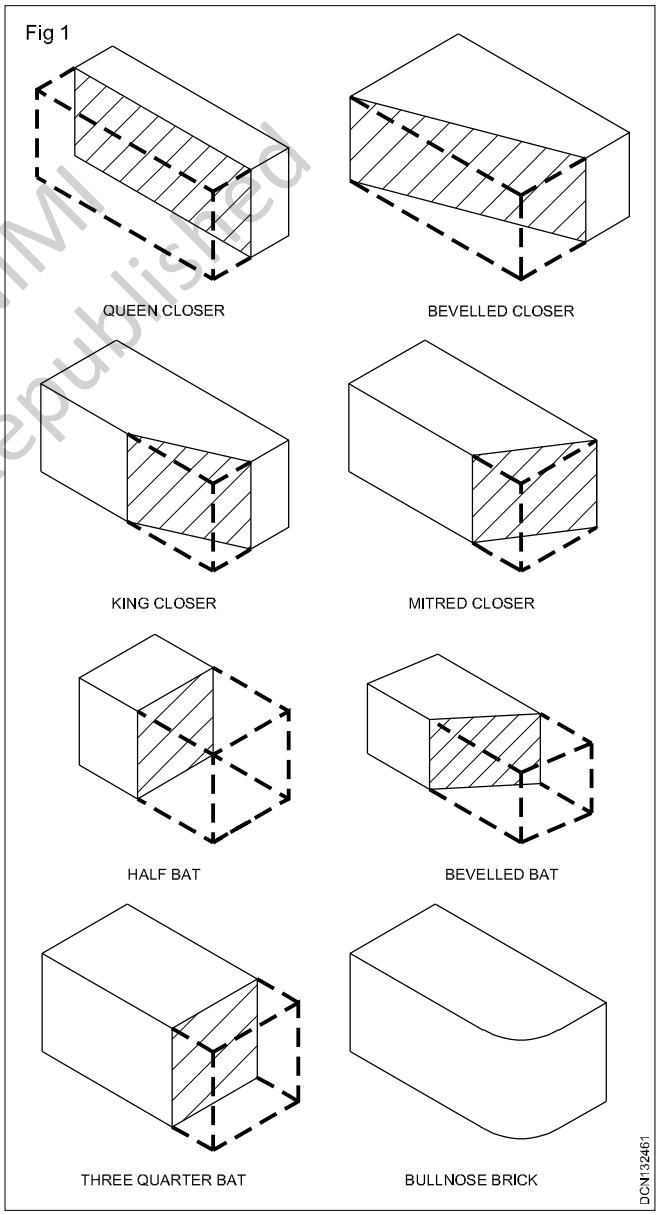
6 The vertical joints in alternate courses should be along it perpend.

Special bricks

Closer - A piece of brick which is used to close up the bond at the end of brick courses.

- **Queen closer** : Cutting the brick longitudinally in two equal parts(Fia 1a).
- **King closer**: Cutting a triangular portion of the brick such that half a header and half a stretcher are ob tained on the adjoining cut face (Fia 1b).
- **Bevelled closer:** Cutting a triangular portion of half the width but of full length(Fia 1c).
- **Mitred closer**:- Cutting a triangular portion of the brick through its width an angle of 45° to 60° with the length of the brick(Fia 1d).
- **Half Bat** : The portion made by cutting the standard brick across their length,i.e,quarter bat,half bat, three quarter bat (Fig 1 e).
- **Bullnose** :A brick moulded with a rounded angle (Fia f).
- **Cow nose**: A brick moulded with a double bull nose on end.
- **Bevelled Bat :**The portion cut 3/4 of length of brick one side and 1/2 of the length on other side.(Fig 1g)

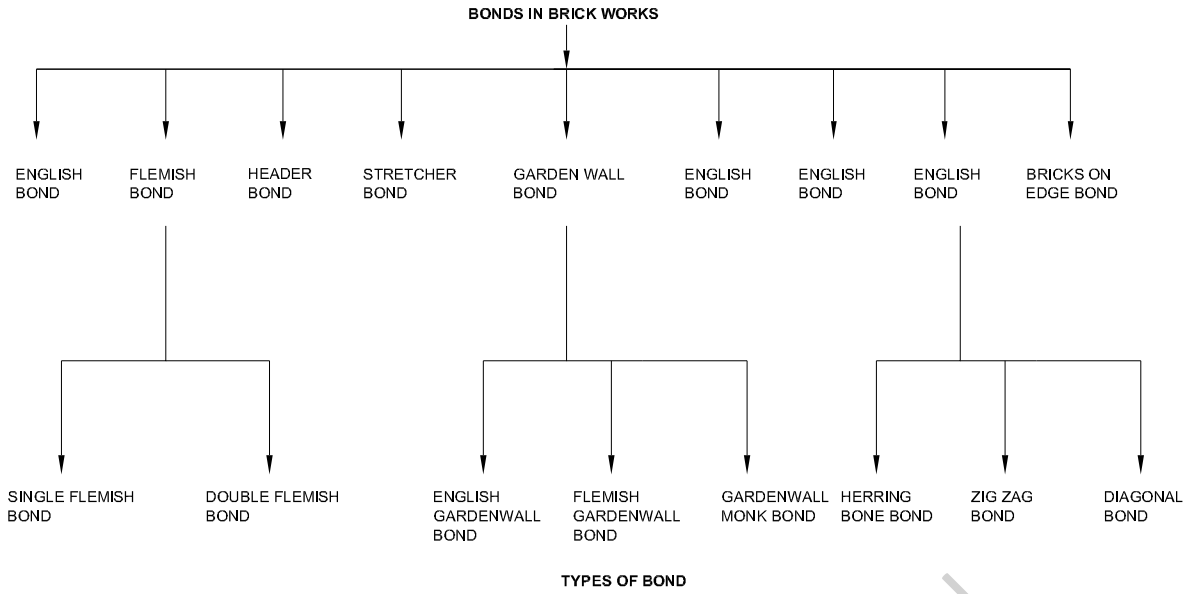
Fig 1

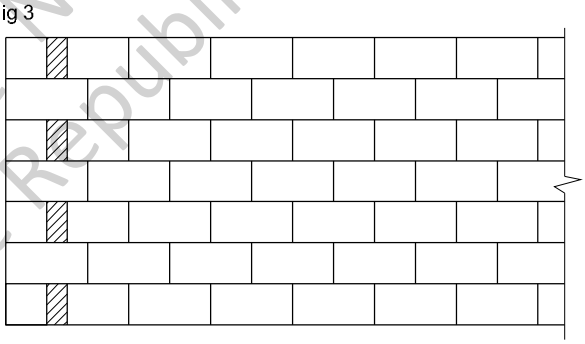
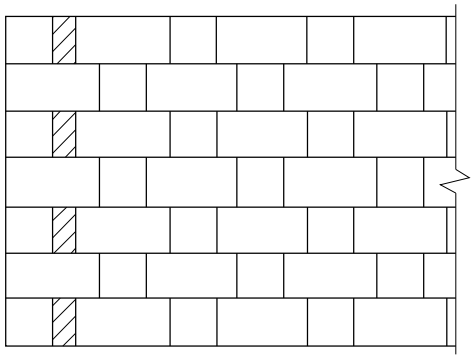


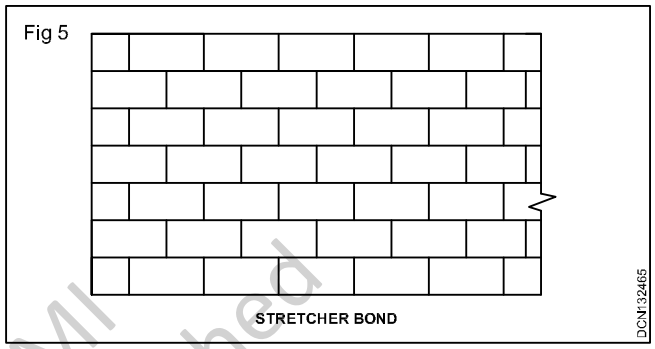
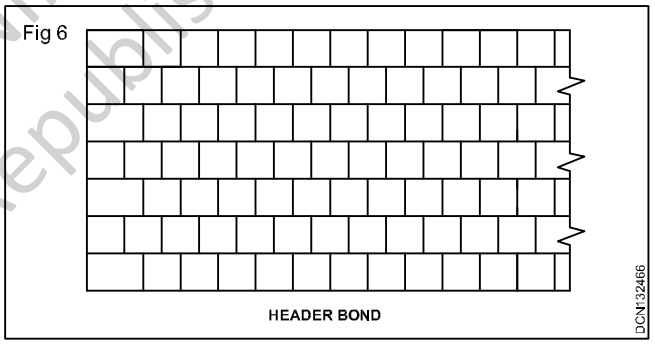
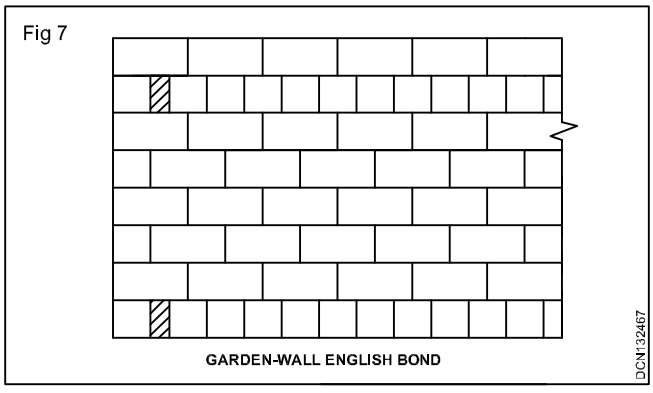
Types of Bond

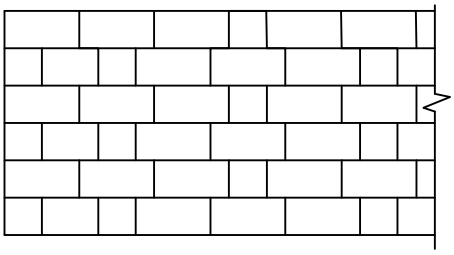
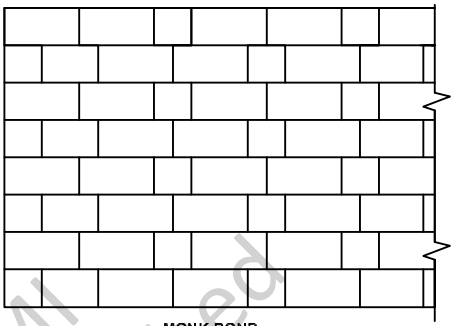
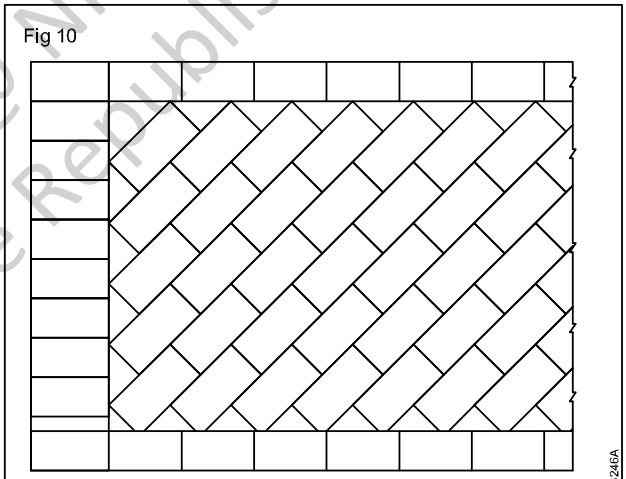
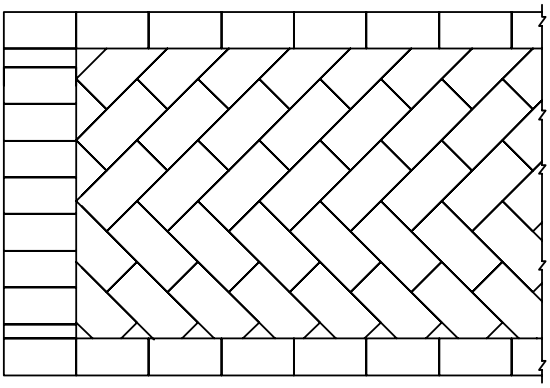
Bonds in brick works

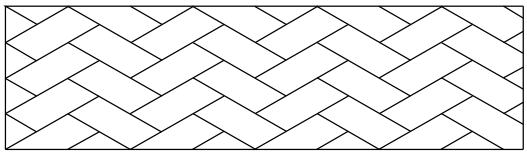
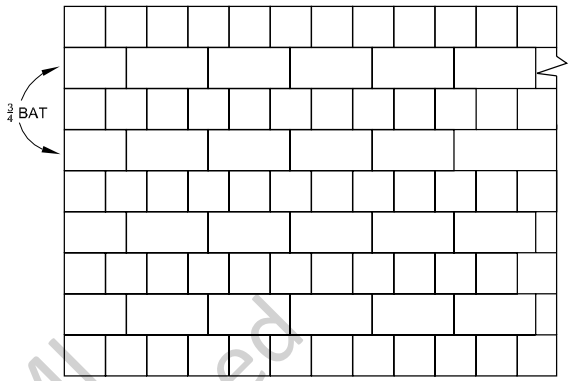
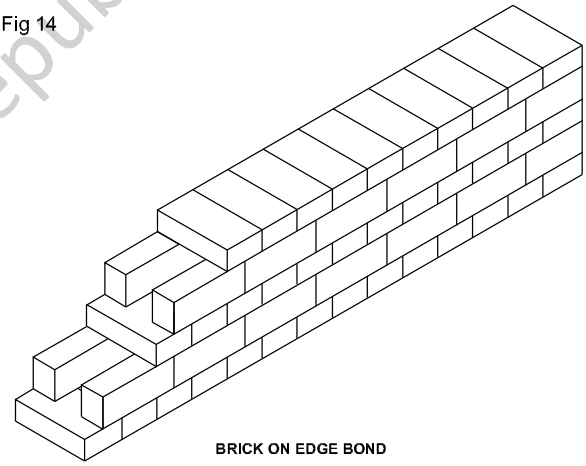
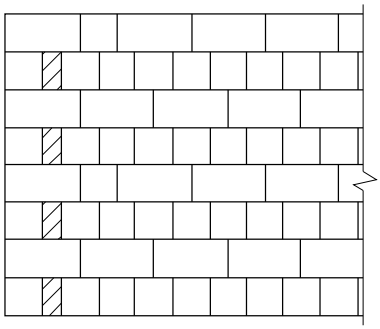
Fig 2

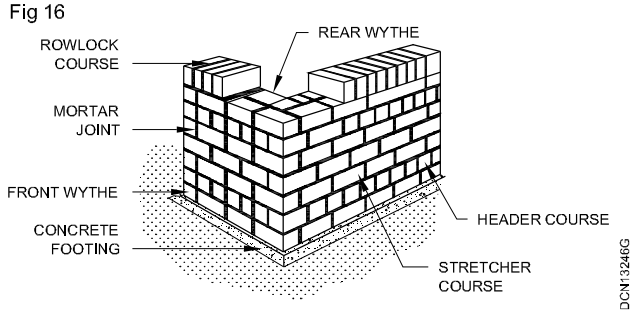
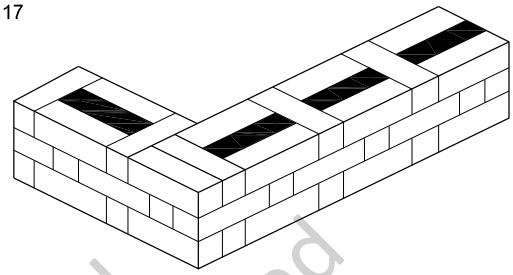


Name of bond	Features and uses	Figure
English bond	Alternate courses consists of headers and stretchers (Fig 3). Queen closer put next to the quoin header to get lap. Each alternate headers centrally supported on stretchers. Continuous vertical joints are not formed excepted stopped ends. Header course should never start with a queen closer. Queen closers are not required in tretcher course. Minimum lap should be ¼ th brick. 1,2,3...thick wall same look on both faces Multiple of half thick wall not in same look in facing and backing.	Fig 3  ENGLISH BOND DCN132463
Flemish bond	In every course headers and stretchers are placed alternatively.(Fig 4) A queen closer is put next to the quoin header. Every header is centrally supported over a stretcher below it. In thin board short continuous vertical joints are formed. Brickbats are to be used in the un even multiple of half brick.	Fig 4  FLEMISH BOND DCN132464

Name of bond	Features and uses	Figure
a) Single flemish bond b) Double flemish bond	a) The facing elevation is Flemish bond but backing and hearting are of English bond b) The headers and stretchers are placed alternatively in facing as well as backing. Uses:- 1. For structural work or load bearing walls 2. Having pleasing appearance.	
Stretcher bond	1. All the bricks are arranged in stretcher course. (Fig 5) 2. It does not develop proper internal bond	Fig 5  STRETCHER BOND DCN132465
Header bond	1. All the bricks are arranged in header course. (Fig 6) 2. Overlap is kept equal to half brick width achieved by using ¾ bats. Uses : For circular wall For circular manhole	Fig 6  HEADER BOND DCN132466
Garden wall a) English garden wall bond	1. One header course is provide to two or five stretcher course. 2.Quoin headers are placed in alternate bond course and queen closer is placed next to the quoin header in header course to develop lap 3. The wall is one brick wall thick and the bond height is 2m (Fig 7). 4. It may be constructed in English or Flemish bond. Uses:-The bond is used for Garden walls and compound wall.	Fig 7  GARDEN-WALL ENGLISH BOND DCN132467

Name of bond	Features and uses	Figure
b) Flemish garden wall bond	1. Each course contain one header to three or five stretcher 2. A ¾ th bat is placed next to the quoin header.	Fig 8  GARDEN-WALL FLEMISH BOND DCN1:32468
c) monk bond	3. A header is placed centrally over each middle stretcher. 1. Each course contain one header to two stretchers 2. The header rest on the joint between two headers. 3. A 3/4Th bat is placed next to the quoin header.	Fig 9  MONK BOND DCN1:32469
6. Raking bond a) Diagonal bond	1. Courses are inclined 2. Inclination should be in opposite direction in alternate courses. 3. Brick are laid at 45° Bricks are laid longitudinally, Usefull for 2-4 brick thick.(Fig 10)	Fig 10  PLAN SHOWING ARRANGEMENT OF BRICK IN DIAGONAL BOND DCN1:3246A
b) Herring bone bond	Brick are laid at 45° from the centre in both the direction, Useful for ornamental finish.(Fig 11)	Fig 11  HERRING BONE BOND DCN1:3246B

Name of bond	Features and uses	Figure
c) Zig-zag bond	Bricks are laid at 45° in zig-zag fashion and used for flooring (Fig 12)	Fig 12  ZIG-ZAG BOND DCN13246C
Dutch bond	1. Alternate courses of headers and stretchers. (Fig 13) 2.The quoin of stretcher course is ¾ bat. 3. A header is introduced next to the ¾ bat in every alternate stretcher course. Uses:- Corner of wall can be strengthened.	Fig 13  DUTCH BOND DCN13246D
Brick on edge bond	1. Bricks are laid as headers and stretchers in alternate courses.(Fig 14) 2. Headers are laid on bed and stretchers are laid on edge. 3. Continuous cavity is formed. Uses:- Used for garden wall, compound wall, partition wallet.	Fig 14  BRICK ON EDGE BOND DCN13246E
English cross bond	1.Alternate courses are of headers and stretchers. (Fig 15) 2. The queen closers are placed next to the quoin header. 3. A header is introduced next to the quoin stretcher. Uses:- This bond adds the beauty of wall	Fig 15  ENGLISH CROSS BOND DCN13246F

Name of bond	Features and uses	Figure
Facing bond	1. A header course is placed after several stretcher course.(Fig 16) Uses:- Used when facing and backing brick are varying size.	Fig 16 
Rat trap bond	1. Locally made bricks having thick ness less than 10cm are used. (Fig 17) 2. all the bricks are laid on edge. 3. Alternate headers and stretchers are used in same course. 4. A cavity is formed inside the course. 5. It is strong ,sound and heat proof.	Fig 17 

Comparision of English bond with Flemish bond

Features	English Bond	Flemish Bond
Arrangement of brick	a. Headers and stretchers are laid in alternate courses b. Each alternate header is centrally supported over a stetcher	a. Headers and stretchers are laid alternatively in each course. b. Every header is centrally supported over a stetcherbelow it.
Strenth	Strongest type of bond	Weakest bond for all walls
Appearance	Provides rough appearance	Provides good appearance
Skill	Requires less skill	Requires more skill
Material cost	Costly, brick bats are not used	Economical, as brick bats are used.
Mortar	More mortar required	More mortar required for additional joints.

Bonds at connections

The walls in different directions are united together at certain places, which are called connections.

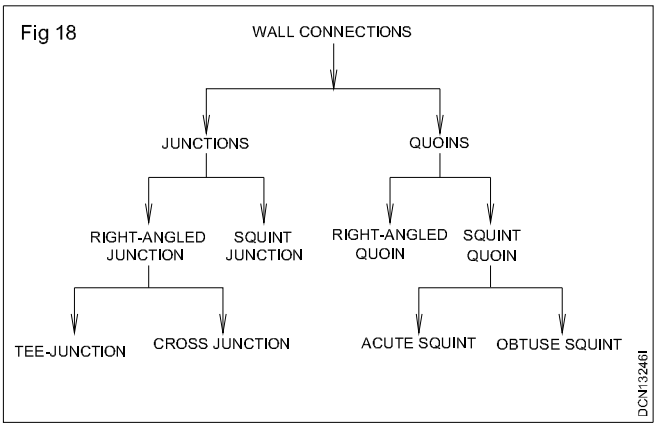
Requirements to be satisfied by bond at connections are:-

1 Vertical joints should not be continuous.

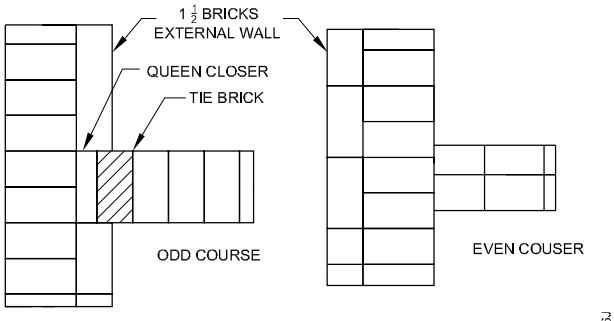
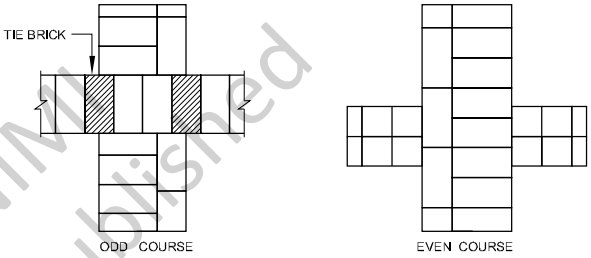
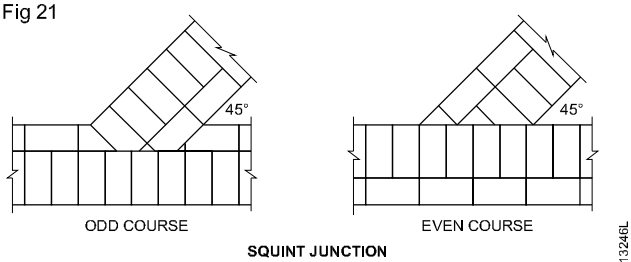
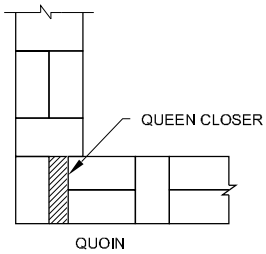
2 Broken bricks to be used minimum.

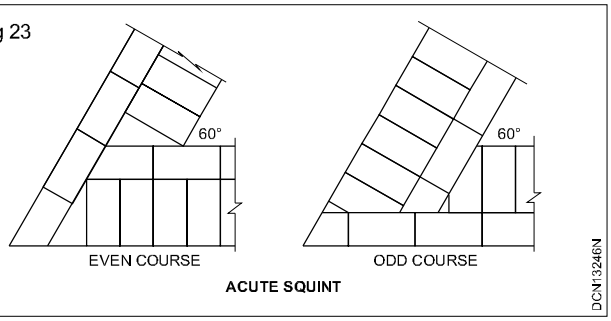
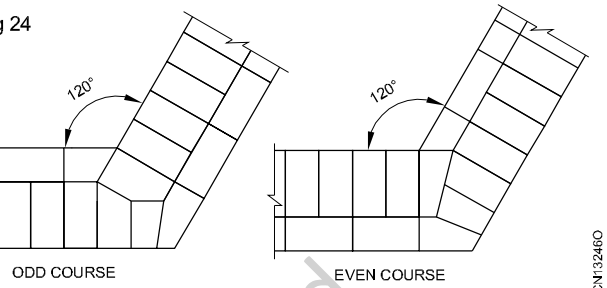
3 Connection should be strong enough to resist differential settlement.

Fig 18



Forms of connections

Forms of connections	Features	Figure
1. Junction a) Right angled junction	Two walls meet each other at right angles (Fig 19)	Fig 19  PLANS OF ALTERNATE COURSES T - JUNCTION DCN13246J
a.i) Tee Junction	Forms the shape of letter 'T'. Header courses of courses of cross wall enters the stretcher course of main wall. Alternate courses simply abutting the main wall.	
a.ii) Cross junction	Two walls cross each other. Alternate courses simply abutting the main wall. Other alternate courses are provided with the bricks in the form of key headers to create necessary lap. (Fig 20)	Fig 20  CROSS JUNCTION DCN13246K
b) Squint junction	Two walls meet each, other then a right angle. Not common in use (Fig 21)	Fig 21  SQUINT JUNCTION DCN13246L
2 Quoins	Connection formed when a wall takes turn (Fig 22)	Fig 22  ONE BRICK WALL DCN13246M

Forms of connections	Features	Figure
2.a) Right angled quoin 2. b) Squnit quoin	Wall take a turn and makes a right quoin (square quoin) angle. No vertical continuous joints are formed. (Fig 23) Walls takes a turn and make other than a right angle. Enclosed angle on the side of the	Fig 23 
2. b i) Acute squint quoin 2. bii) Obtuse squint quoin	Wall is less than a right angle Enclosed angle on the side of the wall should between 90^0 to 180^0 (Fig 24)	Fig 24 

Defects in brick masonry

Following are the causes of defects in a brick masonry work.

1 Corrosion of embedded fixtures.

2 Crystallization of salts from bricks

3 Shrinkage on drying

4 Sulphate attack

5 Freezing of water

Types of brick masonry

The brickwork is classified according to the quality of mortar, quality of brick, and thickness of mortar joint are as follows.

Types of brickwork	Pecularities
1. Brickwork in mud mortar	a. Intimately mixed sand and clay -mud- is used to fill joints. b. Mortar thickness 12mm c. Used for cheapest construction of height up to 4m
2. Brickwork in CM or LM I class	a. Cement mortar or lime mortar is used . b. Bricks are table moulded of standard shape c. The surface and edges are sharp, square and straight. d. Mortar joint doesn't exceed 10mm
3. Brickwork in CM or LM II class	a. Cement mortar or lime mortar is used. b. Bricks are ground moulded of standard shape and burnt in kilns. c. Thickness of mortar joint is 12mm
4. Brickwork in CM or LM III class	a. Cement mortar or lime mortar is used. b. Bricks are ground moulded of standard shape and burnt in clamps. c. Thickness of mortar joint is 12mm

Points to be observed while supervising the brick work

Following points are to be carefully attended to while supervising the brickwork:

1 The bricks to be used should confirm with the requirements of the specification of the work.

2 The bricks should be saturated with water so as to prevent absorption of moisture from the mortar. This is effectively done by providing a tank at the site of work and by immersing the bricks for a period of at least 2 hours before the bricks are actually placed in position.

3 The bricks should be properly laid on their beds. The mortar should completely cover the bed as well as the sides of bricks. The bricks should be laid with the frog uppermost.

4 The brickwork should be carried out in proper bond.

5 The brickwork should complete with the requirements of the specifications for the work.

6 The mortar to be used for the work should be of quality and of proportion as specified.

7 As far as possible, the brickwork should be raised uniformly. But when this is not possible or when a cross wall is intended to be inserted after sometime, the steps or toothings should be provided.

8 In the brickwork, the brickbats should not be used except as closers. All the brickbats of size less than half- brick should be rejected and not allowed to be used in the construction.

9 The single scaffolding should be adopted to carry out the brickwork at a higher level. The required headers are taken out to create supports for the scaffolding and they should be inserted when the scaffolding is removed.

10 The brickwork should be carried out as per line and level. The vertical faces should be checked by means of a plumb bob and the inclined surfaces, if any should be checked by means of wooden templates.

11 After construction, if cement martor is used the brick work should be cured for a period of about two to three weeks, if lime mortar is used and for a period of about one to two weeks.

Difference between stone masonry and brick masonry

Stone Masonry	Brick Masonry
1. Stones are natural material obtained from quarries.	1. Bricks are artificial material.
2. Dressing of stone is important.	2. Dressing not required only rectangular blocks using
3. Bonding is fair but strength is more	3. Bonding is good. But strength is less.
4. Required skill labour.	4. Less skilled labour
5. Lifting and laying is heavy	5. convenient in lifting and laying.
6. More quantity of mortar need	6. Less quantity of mortar need.
7. Mortar joints are irregular	7. Mortar joints are uniform.
8. Plastering is not required	8. Plastering is required.
9. Fire resistance less	9. Fire resistance more.
10. Wall thickness more than 300 mm	10. 100 mm, 200 mm wall easily constructed.
11. Ornamental work costly	11. Cheap and easy construct ornamental works.

Reinforced masonry

Objectives : At the end of this lesson you shall be able to,
- **explain reinforced masonry**
- **describe the features of reinforced masonry walls & columns**
- **explain reinforced masonry lintel & slabs**
- **prepare freehand sketches of reinforced masonry for walls & columns.**

Introduction

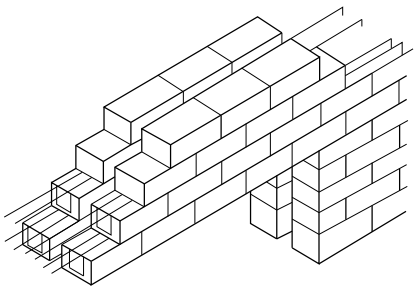
Brickwork strengthened by expanded metal, steel-wire mesh, hoop iron, or thin rods embedded in the bed joints .Reinforced masonry is also essentially a wall material. Of course, beams and slabs have been built in reinforced masonry, but with the exception of deep wall beams, it is hard to justify them in comparison with reinforced concrete ones. Reinforced masonry does not require shuttering and expensive element of concrete. The real advantage of reinforced masonry lies in walls subject to bending perpendicular to the wall plane. It combines flexibility of form with good finish and frequently a large cost saving compared with reinforced concrete. Reinforced masonry is thus a cheap, durable, fireproof, easy to construct and in most cases it results in the increase of floor space due to adoption of brickwork of lesser thickness. The reinforced masonry has been used with advantage under the following circumstances.

1 Retaining walls up to 6 m height can be constructed using various types of brick walls and filled hollow blocks, with a drained granular fill. (fig.1)

2 Reinforced masonry can be used for cantilevering vertically in boundary walls or tall sheds where the walls cannot be restrained at the top.

3 It can also be used in horizontally spanning cladding where it is not possible to prove stability in wind due to arching.

Fig 1



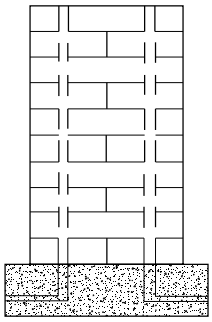
DCN132471

Reinforced masonry walls: (Fig 2)

Iron bars or expanded metal mesh is generally provided at every third or fourth course. Before starting the next course the steel fabric is spread flat on the cement mortar and pressed evenly.

Flat bars of section about 25mmX2mm may be used as hoop iron reinforcement for walls. They are hooked at corners and junctions and usually dipped in tar and sanded immediately so as to increase their resistance against rusting. Generally, one strip is provided for every thickness of half brick. Reinforcement in vertical directions may be provided by using special bricks or blocks. Mild steel bars (6 mm diameter) can also be used as longitudinal reinforcement in walls.

Fig 2

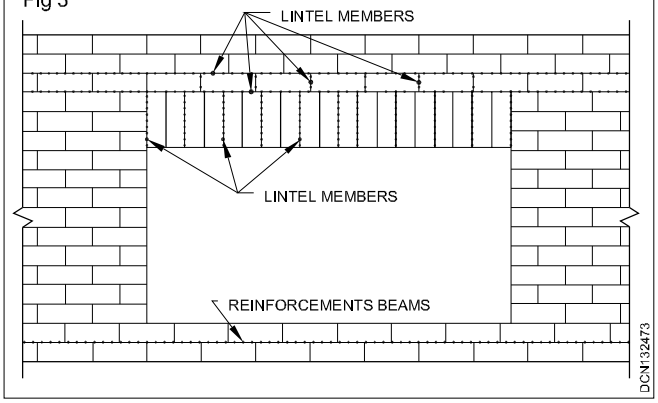


DCN132472

Masonry units used in reinforced masonry (Fig 3)

The properties of masonry units used for reinforced masonry work should complete with the requirements of relevant European standards (EN 771-1-6). Masonry units are classified into the following types: solid, perforated unit, hollow unit, cellular unit, horizontally perforated unit.

Fig 3



DCN132473

Masonry reinforced columns (Fig 4)

The reinforced columns are provided with steel plates of about 6 mm thickness at every fourth course. Vertically reinforcement bars are placed between special type of blocks used for the columns. The steel bars are fixed in the foundation concrete block.

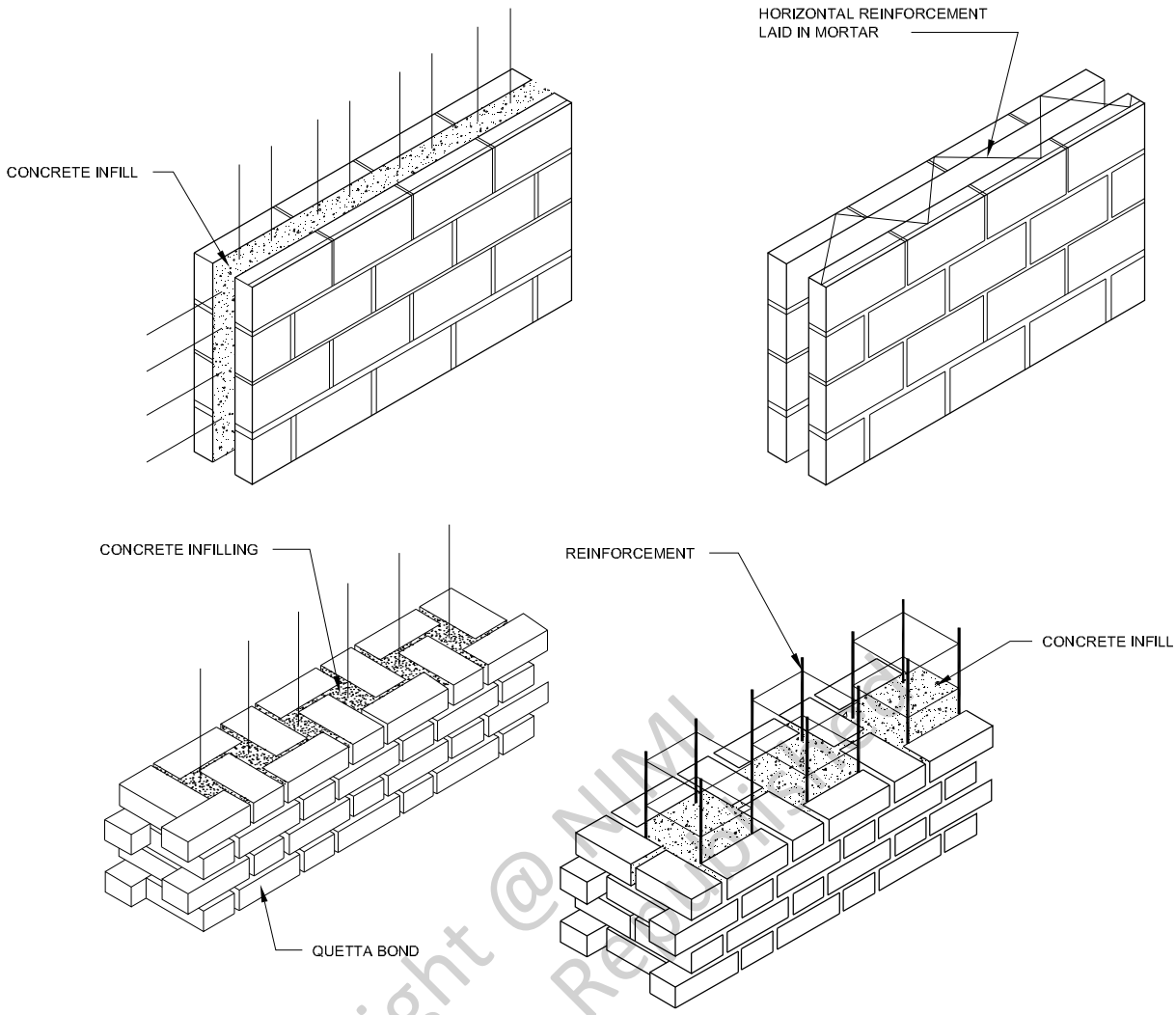
Reinforced masonry lintes: (Fig 5)

In case of brick lintels reinforcement in the form of 6 to12 mm diameter bars is provided longitudinally in between in between the vertical joints. Vertical stirrups of 6 mm diameter are provided at every third vertical joint to take up the vertical shear.

Reinforced masonry slab

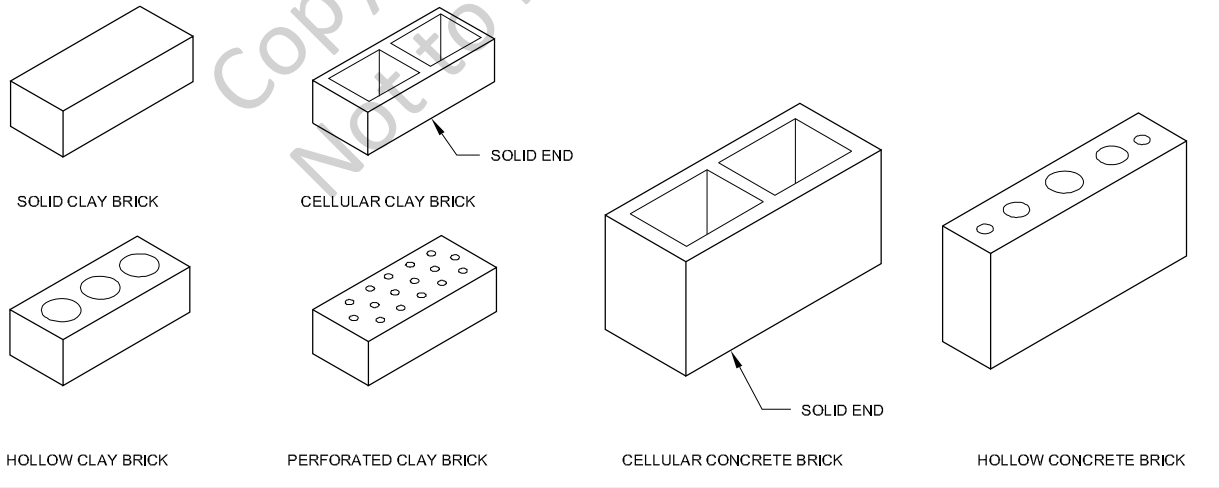
For the construction of masonry slab, the centering in the form of a platform of wooden planks supported on beams is erected at the required level. The centering is covered with well-beaten earth and fine sand is sprinkled over it. Reinforcement is placed in positions and the bricks are laid in one or two courses. Reinforcement should be properly embedded in mortar. Joints should be properly filled with mortar. The slab is kept wet for a period of two to four weeks for proper curing. After 28 days the centering is removed and top and bottom surfaces of slab are suitable finished

Fig 4



REINFORCED MASONARY WALLS

Fig 5



Composite masonry

Objectives : At the end of this lesson you shall be able to,
- **explain composite masonry**
- **list out the measures adopted for composite masonry**
- **explain usual combinations to obtain composite masonry.**

Introduction

When facing and backing of walls are constructed using different types of materials, the construction so obtained is known as composite masonry. The composite masonry reduces the overall cost of construction. This also makes the structure more durable by providing materials of better quality and good workmanship in the facing so as to minimize the effects of atmospheric influcences on the wall.

Measures adopted for composite masonry

This type of construction results in a large number of mortar joints in the inside than at the outside of the wall. This may lead to unequal settlement. The following measures must be adopted to prevent the unequal settlement.

1 Use large number of tough stones.

2 Provide metal cramps, dowels, lead plugs, etc, between facing and backing of the wall.

3 Provide the hearting portions in rich cement mortar.

4 Carry up the facing and backing portions of the wall simultaneously

The usual combinations adopted to obtain composite masonry can be listed as below:

Facing of ashlars and backing of rubble masonry or brickwork figure.

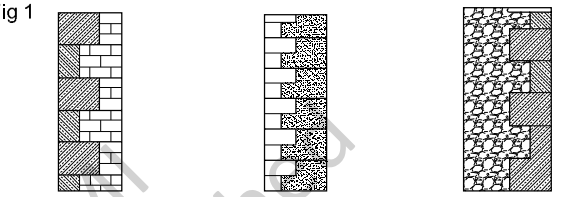
1 Facing of stone slabs and backing of concrete.

2 Facing of brickwork and backing of ashlar masonry.

3 Facing of brickwork and backing of concrete, and

4 Facing of brickwork and backing of hollow concrete blocks.

Fig 1

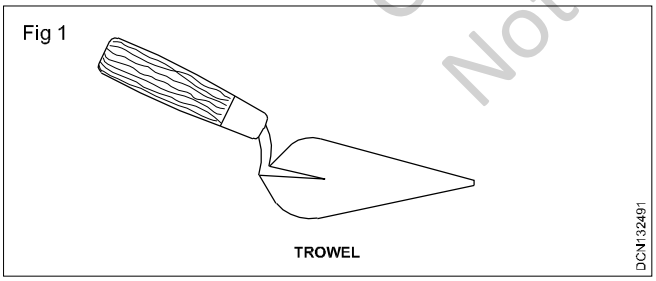


Tools and equipments used in brick masonry

Objectives: At the end of this lesson you shall be able to
- **state the various tools and equipment used in brick work.**

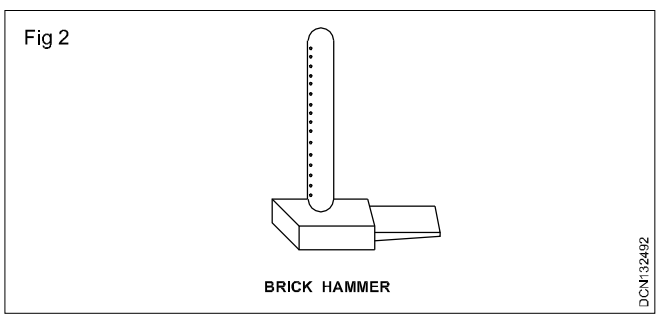
1 Trowel : It consists of a blade and shank in to which a wood handle is fixed. It is used for lifting and spreading mortar on to a wall cutting the brick and forming joints (Fig 1)

Fig 1



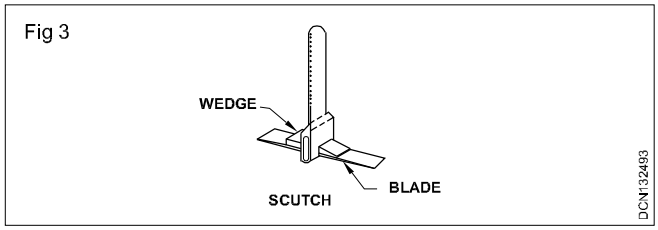
2 Brick hammer : This hammer is used for cutting the bricks to the required shape. One edge of hammer is sharp and the other is square. (Fig 2)

Fig 2



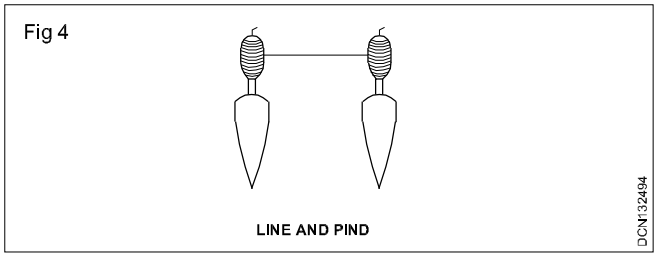
3 Scutch : It is used for cutting soft bricks and dressing the surface of the brick (Fig 3)

Fig 3



4 Line and pin : The line is wood round two pins. It is used to maintain the correct alignment of courses. (Fig 4)

Fig 4



5 Spirit level : Sprit level for getting horizontal surfaces. (Fig 5)

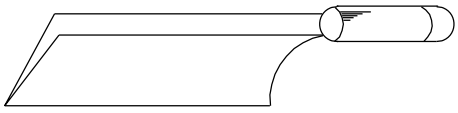
Fig 5

SPIRIT LEVEL

DCN132495

6 Brick axe : It is purpose is similar to brick hammer. (Fig 6)

Fig 6

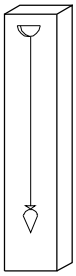


BRICK AXE

DCN132496

7 Plumb rule : Plumb rule is used to clock verticality of brick work or stone wall. (Fig 7)

Fig 7

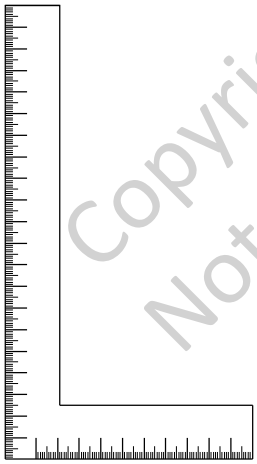


PLUMB RULE

DCN132497

8 Manson's square : It is made of steel or wood is used for checking right angle of the wall. (Fig 8)

Fig 8

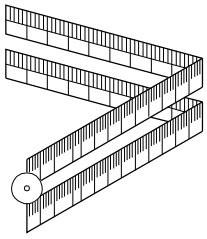


MASON'S SQUARE

DCN132498

9 Four folded foot rule : It is used for taking measurements (Fig 9)

Fig 9

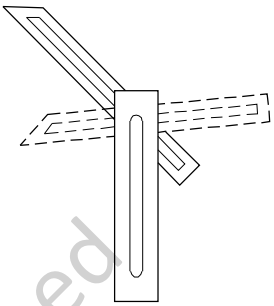


1-METER 4-FOLD RULE

DCN132499

10 Bevel : It is used for setting out angles (Fig 10)

Fig 10



BEVEL

DCN13249A

Strength of walls

Objectives: At the end of this lesson you shall be able to
- **explain strength and stability of walls**
- **state the related posts by category.**

Strength and stability - walls

The strength of the materials used in wall construction is determined by the strength of a material in resisting compressive and tensile stress and the way in which the materials are put together. The usual method of determing the compressive and tensile strength of a material is to subject samples of the material to tests to assess the ultimate compressive and tensile stress the material fails in compression and in tension.

From these tests the safe working strengths of materials in compression and in tension are set. The safe working strength of a material is considerably less than the ultimate

strength, to provide a safety factor against variations in the strength of materials and theri behaviour under stress. The characteristic working strengths of materials, to an extent, determine their use in the construction of buildings.

The traditional building materials timber, brick and stone have been in use since man first built permanent settlements, because of the ready availability of these natural materials and their particular strength characteristics. The moderate compressive and tensile strength of timber members has long been used to construct a frame of walls, floors and roofs for houses.

The compressive strength of well burned brick combined with the durability, fire resistance and appearance of the material commends it as a walling material for the more permanent buildings.

The sense of solidity and permanence and compressive strength of sound building stone made it the traditional walling material for many larger buildings.

Steel and concrete, which have been used in building since the industrial revolution, are used principally for their very considerable strength as the structural frame members of large buildings where the compressive strength of concrete, separately or in combination with steel, is used for both columns and beams.

In the majority of small buildings, such as houses, the compressive strength of brick and stone in rarely fully utilized because the functional requirements of stability and exclusion of weather dictate a thickness of wall in excess of that required for strength alone. To support the very must loads on the walls of small buildings the thinnest brick or stone wall would be quite adequate.

Related posts by category

Walls

- Rubble walling and random rubble - wall
- Dowels, Cramps - walls- stones.
- Weathering to cornices, cement joggle-stones-walls.
- Conice and parapet walls, saddle joint-walls-stones.
- Openings to stone walls - lintels.
- Stone masonry walls.
- Vapour barrier, vapour check, external insulation, resistance to the passage of sound.
- Solid walls, mechanical fixing, internal finish.
- Solid walls, adhesive fixing.
- Solid walls: Thermal insulation, internal insulation.
- Brick lintels - walls.
- Prestressed concrete lintels and composite and non-composite lintels - walls.
- Reinforcing rods and casting lintels - walls.
- Head of opening in solid walls and timber lintels.
- Bonding of bricks at rebated jambs - walls.
- Jambs of openings and rebated jambs - walls.
- Openings in solid walls.
- State and tile hanging - walls.
- External weathering to wall of brick and block and rendering.
- Resistance to weather - solid wall of brick.
- Solid walls.
- Cavity wall insulation : Partial fill, insulation materials, insulation thickness, total fill, thermal bridge.
- Resistance to the passage of heat - walls.
- Concrete lintels walls.

Strength of masonry

Objectives: At the end of this lesson you shall be able to
- **explain compressive strength of masonry**
- **explain application - advantages- disadvantages structural limitations of masonry**
- **describe veneer and dry set masonry.**

Verifying compressive strength of masonry

For masonry under construction, we need to determine compliance with the specified compressive strength of masonry. We have two options for accomplishing this. One is the unit strength method and the other is testing masonry prisms for compressive strength.

The unit strength method verifies the compressive strength of the individual materials and then uses tables to determine compressive strength of the assembly from that information. The MSJC specification in section 1.4B, compressive strength determination, is one source of tables for the unit strength method and the international building Code (IBC) is another. They are set up similarly. They have one table for clay masonry and one for concrete masonry and each give the compressive strength of the assembly based on the strength of the unit and the type of mortar. If the wall is grouted, then the grout simply has to comply with ASTM C476, specification for grout for masonry, or be the same strength as the specified strength of masonry, but not less than a minimum of 2,000 pounds per square inch (psi).

If you do not use tables, you need to know about constructing prisms to verify compliance with design compressive strength. These specimens are built at the job site. Methods for ths are outlined in ASTM C 1314, Standard test method for compressive strength of masonry prisms, which entails constructing the prisms, including grouting if applicable, and bag curing them.

Masonry prisms for compressive strength testing are constructed and then cured in plastic bags. Following initial curing, they are shipped to the lab in a rig to prevent damage during movement. (IMG15865)

Fig 1

The construction will be deemed acceptable or not acceptable based on the prism test results, so it's important to do the job right. Prisms are fabricated in moisture-tight-bags. Large black polyethylene bags, like heavy-duty trash bags, are common. units are mortared together, and the resulting prisms are left to cure for 24 to 48 hours. If the construction is to be solidly grouted, the prisms are grouted at this time. Following grouting, the bags are resealed and cured for an additional 48 hours or longer. Prisms are then strapped or clamped together to prevent damage during transport to the testing laboratory. Then they are further cured, removed from the bags two days prior to compressive strength testing, and tested in compression at an age of 28 days or another designated test age. This produced values for strength of masonry to determine whether or not the as-constructed wall meets the design requirements.

Resources

Standard test method for compressive strength of masonry prims, ASTM C1314-12.

Masonry

This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed. (April 2012) (Learn how and when to remove this template message)

Masonry is the building of structures from individual units, which are often laid in and bound together by mortar; the term masonry can also refer to the units themselves. The common materials of masonry construction are brick, building stone such as marble, granite, travertine, and lime stone, cast stone, concrete block, glass block, and cob. Masonry is generally a highly durable form of construction. However, the materials used, the quality of the mortar and workmanship, and the pattern in which the units are assembled can substaintially affect the durability of the overall masonry construction. A person who constructs masonry is called a mason or brick layer.

Fig 2

A mason laying mortar on top of a finished course of blocks, prior to placing the next course

Applications

Masonry is commonly used for walls and buildings. Brick and concrete block are the most common types of masonry in use in industrialized nations and may be either weight- bearing or a veneer. Concrete blocks, especially those with hollow cores, offer various possibilities in masonry construction. They generally provide great compressive strength, and are best suited to structures with light transverse loading when the cores remain unfilled. Filling some or all of the cores with concrete or concrete with steel reinforcement (typically rebar) offers much

greater tensile and laterial strength to structures.

Advantages

The use of material such as brick and stones can increase the thermal mass of a building and can protect the building from fire.

Masonry is non - combustible product.

Masonry walls are more resistant to projectiles, such as debris from hurricanes or tornadoes.

Disadvantages

Extreme weather, under certain circumstances, can degradation of masonry due to expansion and contractions forces associated with freeze - thaw cycles.

Masonry tends to be heavy and must be built upon a strong foundation, such as reinforced concrete, to avoid setting and cracking.

Other than concrete, masonry construction does not lend itself well to mechanization, and requires more skilled labor then stick-framing.

Masonry consists of loose components and has a low tolerance to oscillation as compared to other materials such as reinforced concrete, plastics, wood, or metals.

Structural limitations

Masonry has high compressive strength under vertical loads but has low tensile strength (against twisting or stretching) unless reinforced. The tensile strength of masonry walls can be increased by thickening the wall, or by building masonry piers (vertical columns or ribs) at intervals. Where practical, steel reinforcements such as windposts can be added.

Veneer masonry

A masonry veneer wall consists of masonry units, usually clay- based bricks, installed on one or both sides of a structurally independent wall usually constructed of wood or masonry. In this context the brick masonry is primarily decorative, not structural. The brick veneer is generally connected to the structural wall by brick ties (metal strips that are attached to the structural wall, as well as the mortar joints of the brick veneer). There is typically an air gap between the brick veneer and the structural wall. As clay- based brick is usually not completely water proof, the structural wall will often have a water- resistant surface (usually tar paper) and weep holes can be left at the base of the brick veneer to drain moisture that accumulates inside the air gap. Concrete blocks, real and cultured stones and veneer adobe are sometimes used in a very similar veneer fashion.

Most insulated buildings that utilize concrete block, brick, adope, stone, veneers or some combination there of feature interior insulation in the form of fiberglass batts between wooden wall studs or in the form of rigid insulation boards covered with plaster or drywall. In most climates this insulation in much more effective on the exterior of the wall, allowing the building interior to take advantage of the aforementioned thermal mass of the masonry. This technique does, however, require some sort of weather - resistant exterior surface over the insulation and consequently, is generally more expensive.

Dry set masonry

Fig 3

Dry set masonry supports a rusticlog bridge, where it provides a well - drained support for the log (which will increase its service life)

Dry stone

The strength of a masonry wall is not entirely dependent on the bond between the building material and the mortar; the friction between the interlocking blocks of masonry is often strong enough to provide a great deal of strength on its own. The blocks someties have grooves or other surface features added to enhance this interlocking, and some dry set masonry structures forgo mortar altogether.

Compressive strength of brick masonry

A wall or column carrying a compressive load behaves like any other strut, and its load bearing capacity depends on the compressive strength of the materials, the cross-sectional area and the geometrical properties as expressed by the slenderness ratio.

Fig 4

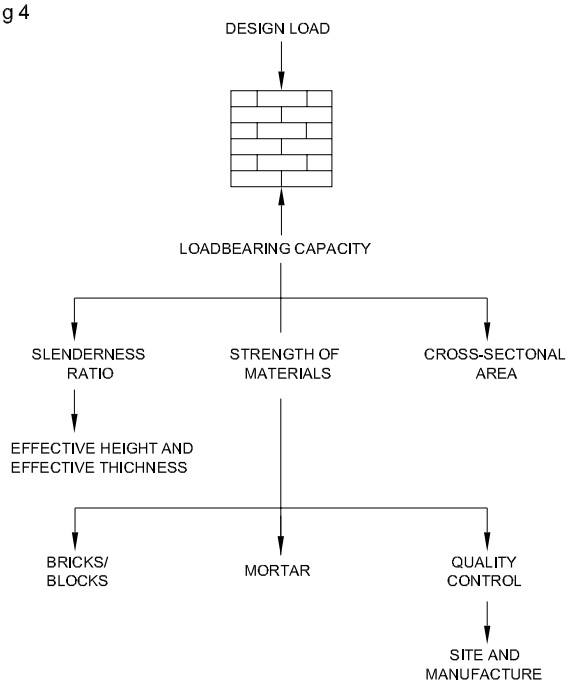
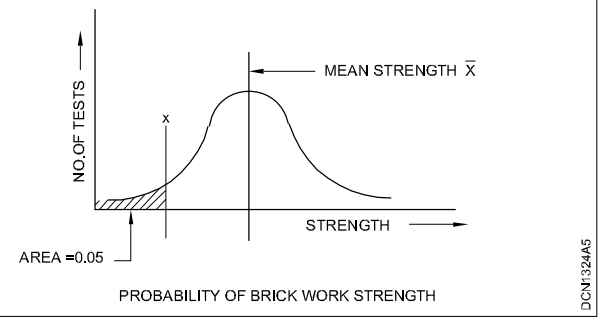


Fig 5



PROBABILITY OF BRICK WORK STRENGTH

The compressive strength of a wall depends on the strength of the units used, the bricks or blocks, and the mortar. The assessment of the combined strength of these elements will also be affected by the degree of quality control exercised in manufacture and construction. The slenderness ratio, in turn, depends upon the effective height (or length) and the effective thickness of the wall or column.

Fig 6

COMPRESSIVE STRENGTH OF UNIT (N/mm ^{2})

BRICKS	BLOCKS
5.0	2.8
10.0	3.5
15.0	5.0
20.0	7.0
27.0	10.0
35.0	15.0
50.0	20.0
70.0	35.0
100.0	

TYPICALLY AVAILABLE VALUES

TYPICAL STRUCTURAL UNITS

BLOCKS OF THESE STRENGTHS MAY NOT BE READILY AVAILABLE

DCN1324A6

Site exploration

Objectives : At the end of this lesson, you shall be able to,
- **define site exploration**
- **state the purposes of exploration**
- **explain preliminary investigation**
- **explain various method of site exploration**

Introduction

The knowledge of soil characteristics and the factors influencing their properties will help the investigation in the identification of individual soils encountered in soils exploration and in the selection of right type of foundation for the building.

Definition:

For designing a right type of foundation safely and economically, a designer must possess sufficient information about the physical properties and the arrangement of the underlying materials. The field and laboratory investigations required to get this essential information are known as soil/site exploration.

General inspection of site

It is desirable to visit the site of work and inspect the same carefully from the view point of foundation details. The nature and thickness of strata of soil may be estimated by studying the excavation details of near by construciton or by examining the open side of a near by well etc. The general inspection of site of work serves as a guide for determine the type of foundation to be adopted for the proposed work. It also helps in getting the following data

Purposes

Before starting the exploration work, the following data should be collected.

1 The nature, thickness and variation of soil strata in the region.

2 Procuring representative samples for assessing the physical properties of the soil strata encountered, which in turn, will help in the design and mode of construction of the proposed foundations.

3 The seasonal variation in ground water table and their possible effects on the soil strata met.

4 The strength and compressibility values of soil bed.

5 If necessary, the depth of underlying rock bed.

Preliminary Investigation

The following information regarding the proposed site should be collected.

1 The soil condition at different depths.

2 Location of water table and its seasonal variations.

3 The depth of rocks.

4 Behavior of soils at site, which can be known from the type of construction and conditions of the structure in the adjoining properties.

5 The general topographical features of site, viz, site on the top of hill, in a valley, on an abandoned lot, or reclaimed ground etc.

Methods of site exploration

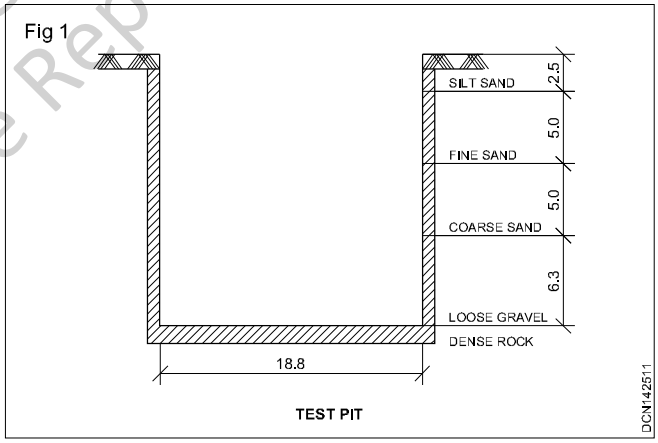
1 Open excavation (test pits)

1 This method is useful when hard soil is available within a maximum depth of 1.5m

2 A square pit, with side as about 1.50 m ,is excavated up to a depth at which sufficiently hard soil is avaiable

3 A sufficient number of test pits should be dug on the site to know the variation of the ground

Fig 1



Probing

1 Probing consists of driving either a hollow tube or a steel rod or an iron rod into the ground

2 This method is possible to examine the ground for a maximum depth of 3 m.

Auger boring

1 An auger may be of post-hole type or screw type or shell type

2 Auger is worked by applying leverage at the top the auger is driven into the ground and turned like a screw the auger is withdrawn and the material caught in the slit is inspected.

3 With the help of this method ,it is possible to inspect the ground for a depth of 6 m to 8 m.

Fig 2

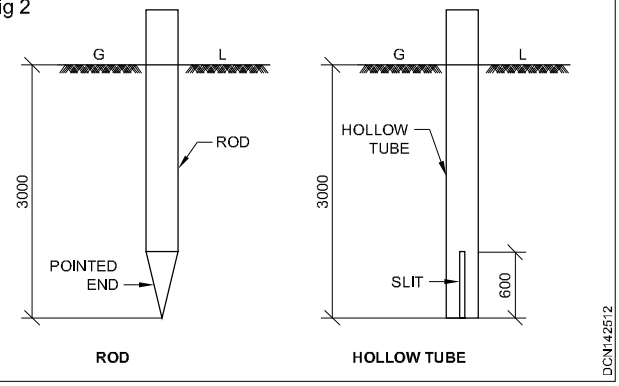


Fig 3

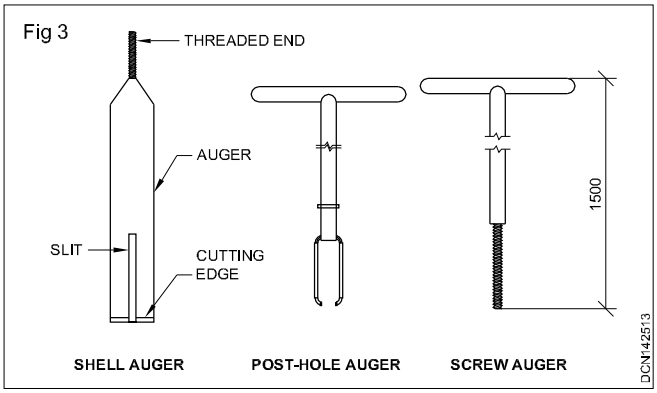
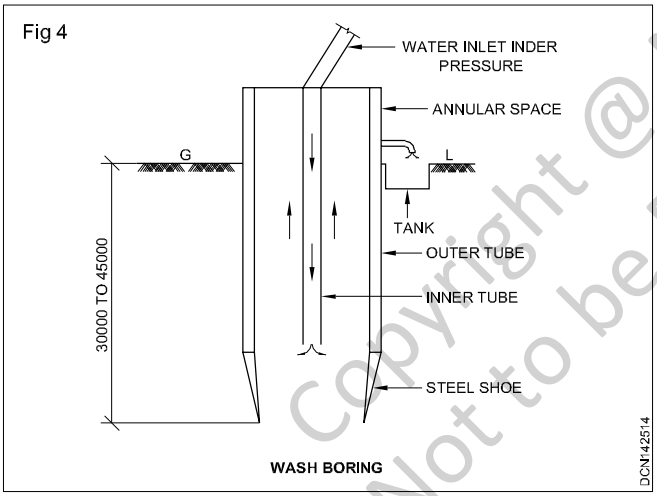


Fig 4



4 **Wash boring**

The wash boring is the term used to denote a method in which a casing is driven into the ground and the material inside the casing is washed out and brought to the surface for inspection.

5 Sub-Surface sounding

1 In this method, the resistance of the soil with depth is measured by means of a tool known as penetro-meter under static or dynamic loading.

2 This test is useful for :

i) Finding the depth of bed rock or stratum.

ii) Knowing the general exploration of erratic soil profiles and

iii) Testing cohesion less soils from which it is difficult to obtain the undisturbed samples.

6 Deep boring

1 It becomes essential to carry out deep boring for big important engineering structures such as dams.

2 The machines used for deep boring are as follows.

i) Percussion boring machine.

ii) Core or rotary drilling machine.

7 Geophysical method

1 This method is used when the exploration depth is substantial and the speed of investigation is of primary importance.The method is mainly adopted to as certain the depth at which useful minerals and oils are available.

2 The two most commonly adopted methods are as follows.

i) Electrical resistivity method.

ii) Seismic refraction method.

Bearing capacity of soil

Objectives : At the end of this lesson, you shall be able to,

- **define bearing capacity of soil**
- **explain safe bearing capacity of soil**
- **state ultimate bearing capacity of soil**
- **describe methods for determining the bearing capacity of soil**
- **explain methods of increasing bearing capacity of soil**
- **state the safe bearing capacity of various soil.**

Introduction

Bearing Capacity of soil is used to indicate the maximum load per unit area, which the soil will resist safely without displacement, the load of the structure.

Safe Bearing capacity of soil

It is the maximum pressure, which the soil can carry safely.

Ultimate Bearing capacity of soil

The gross pressure intensity at which the soil fails.

Safe Bearing capacity =

The basic requirement of any structural components of a building is that it should be strong enough to carry or support all possible type of loads

There are three types of load on the foundations

Design Loads

Dead load

Live load

Wind load

Dead load

This is the load of the material used for the various components of a builidng such as wall floor roof etc. All permanent loads are thus included in that load. Sometimes a dead load of 10kg/m2 of the floor area is allowed for construction of a partition wall.

The weight of common material are given below:

Sl.No.	Materials	Weight in kg/m2
1	Aluminium	2590
2	Bitumen	1440
3	Coal tar	1000
4	Clay (dry)	1440
5	Clay (damp)	1760
6	Earth (dry)	1410-1840
7	Earth (moist)	1600-2000
8	Sand	1540-1600
9	Sand(moist)	1760-2000
10	Alcohol	780
11	Ice	910
12	Nitric Acid(91%)	1540
13	Sulphuric Acid(87%)	1790
14	Vegetable oil	930
15	Water(fresh)	1000
16	Brick	1600-1920
17	Cement(ordinary)	1440
18	Chalk	2240
19	Glass	2400-2720
20	Lime stone	2400-2240
21	Sand stone	2240-2400
22	Steel	7850
23	Timber	650-720
24	Brick masonry	1920
25	Plain concrete	2300
26	Reinforced concrete	2400
27	Cast iron	7200
28	Copper	8590
29	Lead	11360
30	Marble	2700
31	Lime mortar	1740
32	Plaster cement	2080
33	Stone masonry	2500
34	Asbestos cement sheet	12-15.60
35	G.I Sheet(0.5mm thick)	5
36	G.I. Sheet(1.63mm)	13
37	Mangalore tiles	68

Live load

This is the movable load on the floor and hence it is variable. It is also sometimes known as super imposed load. It includes load of person standing on a floor, weight of material temporarily stored on a floor, weight of snow on a roof etc. For the purpose of dressing the live load is converted into equipement dead load. Super imposed load for floors of different types are as follows:

Sl.	Material	Load kg/m^2
1	Residential building, hospital room and ward and hotel, bed room etc	250
2	Office building, church,school building, art gallories,stairs in residential building retail shop and light garages	400
3	Assembly building, public building dance hall, theatre restaurants, gymnasium, stair in public builidng light workshop	500
4	Heavy workshop,printing press and factories	750
5	Work houses, book stall, sanitary stores and heavy garages	1000

Wind load

In case of tall building the effect of wind should be considered. The exposed sides and roofs of such building are subjected to wind pressure. And its affect is to reduce the pressure on the foundation on the wind ward side and to increase the pressure on the foundation on the lee-ward side.

The wind pressure will depend on the velocity of the ground. The relation between wind pressure and wind is generally expressed by the formula .

$P = 0.00750^2$

where p = wind pressure v = velocity of wind in km/hour

Bearing capacity of soil

A foundation should be designed to satisfy to essential conditions.

i) It must have some specified safety againce ultimate failure.

ii) The settlement under working load should not exceed the allowable limits for the super structure.

The bearing capacity of soil is defined as the maximum load per unit area which will resist safely without displacement.

The ultimate bearing capacity is defined as the maximum gross pressure at the base of the foundation at which the soil mass fails in shear. Gross pressure is the total pressure at the base of the foundation, due to the weight of the super structure, self weight of the foundation and weight of earth fill if any. The safe bearing capacity may be defined as ultimate bearing capacity divided by factor of safety.

$$\text{Safe bearing capacity} = = \frac{\text{Ultimate Bearing capacity}}{\text{Factor of safety}}$$

Factor of safety means only a number to be selected depends on how accurately soil conditions are known. Is generally 2-3 for stable building.

MAXIMUM SAFE BEARING CAPACITY OF VARIOUS SOIL

Sl No	Description of soil	M.S.B.C in Tone/m
1	Very soft, wet, pasty or muddy clay	5
2	Black cotton soil in dry condition	15
3	Soft clay	10
4	Moist clay and sand clay mixture	15
5	Medium clay	25
6	Compact clay nearly dry	45
7	Fine sand, loose and dry	10
8	Medium sand compact and clay	25
9	Compacts and prevented from spreading	45
10	Loose gravel	25
11	Compact gravel and moorum	45
12	Soft rock	45
13	Laminated rocks such as lime stone and sand stone	165
14	Hard rock without defects such as granite trap	330

Method for determining bearing capacity of soil

The bearing capacity of soil can be determined by any one of the following methods

- Analytical method
- Method of loading
- Method of dropping a weight

Analytical Methods

Rankine's gives an analytical method for determining the ultimate bearing capacity is,

$$Qf = r_0 \frac{(1+\sin\theta)^2}{(1-\sin\theta)^2}$$

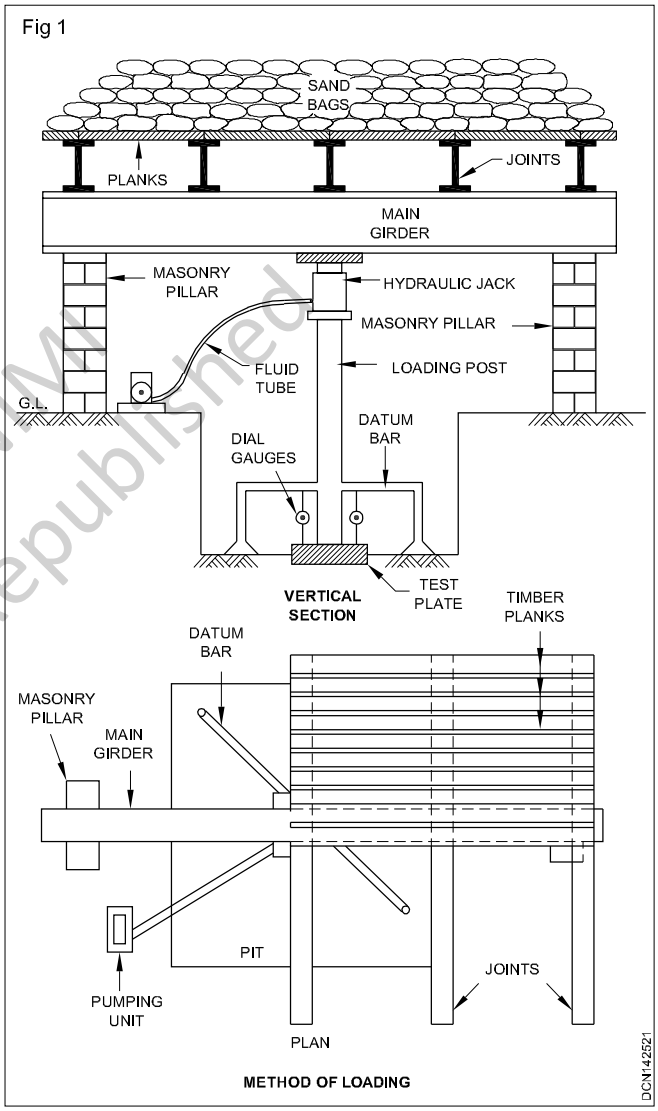
Where Qf = Ultimate bearing capacity

ro = density of soil at depth D

q = The angle of internal friction of soil.

Method of loading

Fig 1



This is a field test to determine the ultimate bearing capacity of soil and the probable settlement under a given loading. The test essentially consists in loading a rigid plate (usually of steel) at the foundation level.

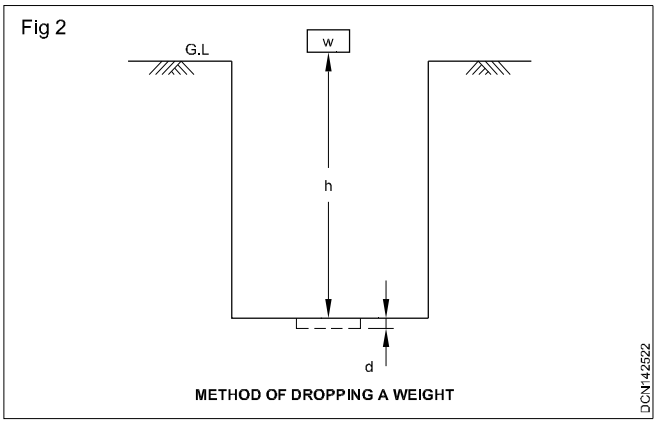
Determine the settlement, corresponding to each load increment. The ultimate bearing capacity is taken as load at which the plate, start sinking at a rapid rate.

The ultimate bearing capacity in tone/m

Method of dropping a weight

In this method a substance of known -weight is dropped

Method of dropping a weight



In this method a substance of known -weight is dropped from a known-height as shown in figure. The depth of impression made by the weight on the soil is noted.

Then the bearing capacity of soil is worked out as follow:

If, R= resistance of soil

w= Weight of the substance

h= height

d= depth of impression

Total energy = wh=Rxd

$$R = \frac{wh}{d}$$

ie, R= ultimate bearing capacity of soil

if A= Cross sectional area of the substance

$\frac{R}{A}$ = Resistance of soil per unit area.

$$\text{Bearing capacity} = \frac{R}{A}$$

$$\text{safe bearing capacity} = \frac{R}{AxF}$$

Where F= factor of safety.

The results obtained by this method are approximate and hence this method is used for minor engineering structure.

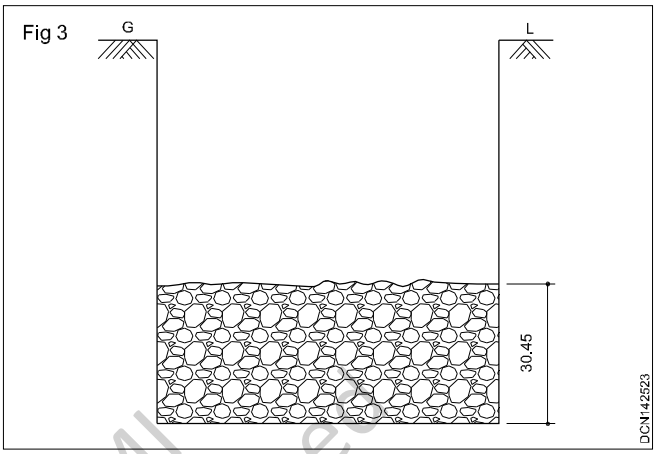
Method of improving bearing capacity

Increasing depth of foundation

It has been found that in granular soil the bearing capacity increase with the depth due to the confining weight of overlying material. It is not economical since the cost of construction increases with the increase in depth. This method is useful when bearing straturm is met at greater depth.

Compacting soil

In this method the width of foundation is increased by about 45cm or 50 and a layer of 30cm - 45cm of rubble is spread over the bottom of the foundation as shown in (Fig 3). This layer of rubble is well rammed. If the material is buried completely, another layer of depth about 15-25cm is laid and it is well rammed. At the end of this process, if the bearing capacity of soil is tested, it is found to have increased considerably. This increasing bearing capacity of soil may then be used for the design purpose.



Drainage of soil

It is a well known fact that the presence of water decreases bearing power of soil. This is because of less shearing strength of soil in presence of excess water. Drainage results in decrease in voids ratios and improvement of bearing power.

Confining the soil (sheet piling):-

The movement of soil under the action of load can be prevented by confining the ground by use of sheet piles. This will results in the increasing of bearing power of soil.

Grouting

Bore holes in sufficient number are driven in the ground the cement grout is then forced under pressure through these bore holes. The cracks or fissures of the rocks are these filled up, resulting in the increase of bearing power of soil.

Chemical Treatment

In this treatment certain chemicals are used in place of cement grout to solidify the soil. But as this process is costly it is adopted only in case of important building.

CAUSES OF FAILURE OF FOUNDATION AND MEASURES TO PREVENT SUCH FAILURE

The unequal settlement of sub soil may be due to

- Unequal distribution of load on foundation.
- Varying bearing power of subsoil.
- Eccentricity of the load

Due to unequal settlement of the subsoil, cracks are formed in the building. This failure can be prevented by

- Foundation should be rest on rock or hard moorum.
- Proper design of the base of footing. So that it can be resist cracking.
- Avoiding eccentric loading

Unequal settlement of masonry

Mortar joint may shrink and compress which may lead to unequal settlement of the masonry.

This failure can be prevented

- Using mortar of proper strength.
- Using thin mortar joint.
- The height of wall to be raised per day should be limited to 1m in lime mortar and 1.5m in cement mortar.
- Properly watering the masonry.

Withdrawal of moisture from the sub soil

This occurs at places where there is considerable variation in the height of water table. When water table falls the soil particles loose cohesion and hence, there is shrinkage of soil, resulting in the cracks to the building. To prevent such failure,drive piles upto the hard rocks.

Lateral pressure on the super structure

The thrust on a pitched roof or arch action, or wind action on the super structure causes wall to overturn.

To prevent such failure, provide a sufficient wide base and to design the foundation for the worst condition.

Horizontal movement of the earth

Very soft soil is liable to give away under the action of load, especially as places such as sloping ground, river banks etc. Hence in such cases it is desirable to construct retaining walls or to drive a sheet piles to prevent the escape of earth.

Transpiration of trees and shurbs

The roots of trees planted near a building may extent upto the foundataion level and may absorb the moisture. This effect is seen in the form of a depression on the ground, and it may lead to crack in the building. To prevent such failure.

- The foundation should be taken sufficiently deep at a minimum depth of 1m is required for this purpose.
- The trees should not be planted near the building with a distance of 8m.

Atmospheric action

Rain and sun are the main atmospheric agents to seriously effect the foundation of a building. Heavy rain or considerable variation in temperature or thrust action may damage the foundation. If the water remains stagnant near the foundation it will remain constantly damp resulting in the decrease in strength of footing or foundation wall. Hence it is always recommended to provide suitable wind protection along the external wall by

- Filling back the foundation trenches with good soil and compacting it.
- Providing a gentle ground slope away from the wall.
- Suitable underground drains should be provided to maintain water table at definite level.

Foundation

Objectives : At the end of this lesson, you shall be able to,

- **define foundation**
- **state types of foundation**
- **explain purpose of foundation**
- **explain various loads on foundation**
- **describe causes of failure of foundation and its remedies.**

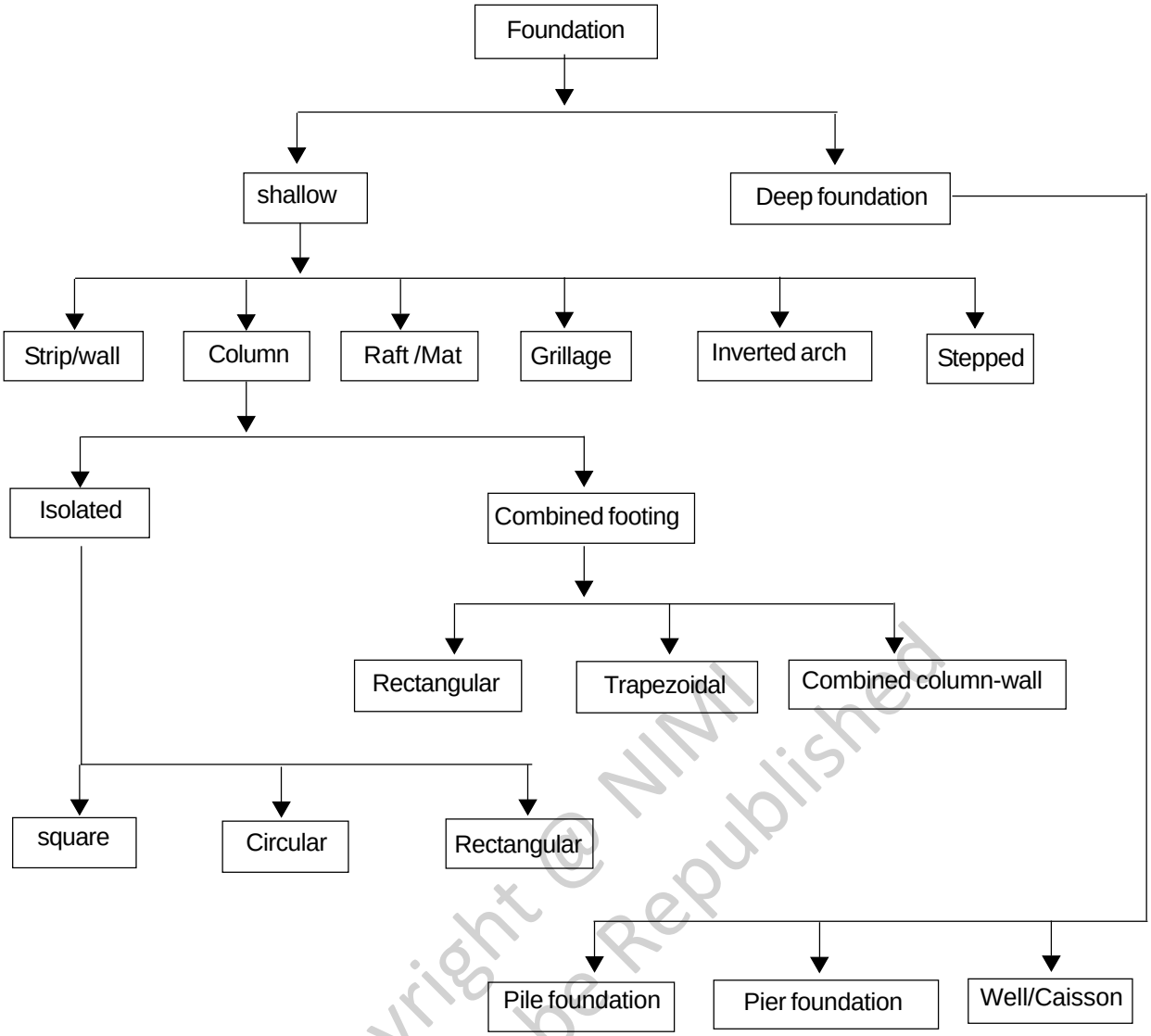
Introduction

Every structure consists of two parts, namely foundation and super structure. Foundation is the lowest part of a structure which transmits the weight of the structure, together with the effect of live loads and pressure, to the material on which the structure rests in such a manner that the underlying material is not stressed beyond its safe bearing capacity.

Definition

The lowest artificially prepared part of the structure, usually located below the ground level, which transmit the load of the superstructure to the ground is known as substructure or foundation.

Types of foundations



Types of loads

1 Dead load 2 Live load 3 Wind load 4 Snow load

Causes of failure of foundations and its remedies

Causes	Remedies
1 Unequal settlement of the subsoil	Foundation should rest on rigid strata. Design of foundations should be appropriate to the nature of subsoil.
2 Unequal settlement of the masonry	Using mortar of proper strength. Masonry work should be raised evenly. Proper Curing.
3 Withdrawal of moisture from the subsoil	Provide drive piles up to the hard rock.
4 Lateral pressure on the superstructure	Provide sufficient wide base.
5 Horizontal movement of the earth	Construct retaining walls to prevent the escape of earth.
6 Transpiration of trees and shrubs	Foundations should be sufficiently deep. Trees should not be planted near the building.
7 Atmospheric action	Provide suitable underground drains. Providing gentle ground slope away from the wall.

Shallow foundation

Objectives : At the end of this lesson you shall be able to,
- **define shallow foundation**
- **explain various types of shallow foundation**
- **describe setting out of building on ground.**

Introduction

It is possible to construct foundation of a building at a reasonable shallow depth, the foundations are termed as the shallow foundations.

Definition

The depth of foundation is equal or less than its width, is known as shallow foundation.

Setting out of building on ground

1 Clear the Site.

2 Prepare a plan of setting out on paper.

3 Centre lines of walls to be marked on plan

4 This is to be marked on ground.

5 Mark the centre lines of walls by stretching a string between wooden pegs.

6 Cross walls set by 3, 4,5 method.

7 Corners of building are laid and sides checked by measuring diagonals.

8 Entire width of foundation marked

9 For big projects reference pillars of brick may be constructed.

Shallow foundation

Foundation having its depth less than or equal is its width are known as shallow foundation. Since such foundation are constructed by open excavation.

Hence those foundation having its depth even greater than its width but are constructed by way of open excavation are also come under shallow foundation.

Design of shallow foundation

Following data are required before design of a foundation

a The total load to be transmitted by the wall or pier to the foundation bed.

b The results of trial pit and the corresponding bearing capacity of each strata of soil.

The design of foundation required the three terms,

a Width of foundation.

b Depth of foundation below ground level.

c Depth of concrete block below the masonry rooting.

Width of foundation

The width of foundation should be sufficient enough to bear the super imposed load per unit length on the foundation bed. The width of foundation is obtained by

i) Dividing the total load per unit length on foundation bed by safe bearing capacity of the soil.

$$\text{Thus, width of foundation} = \frac{w}{p}$$

Where, w = total load in tone/metre

p = safe bearing capacity of soil in tonne/m^2

ii) Width of foundation = 2 (T+J) Where,

T= thickness of wall above the plinth level.

J= the projection of concrete block on the either side of the lowermost masonry footing. which should be atleast 10cm-15cm.

Depth of foundation below ground level

This is generally determined by the rankine's formula. Which gives the maximum depth.

Depth of foundation below the ground level,

$$d = \frac{p}{w}\left[\frac{1-\sin\theta}{1-\sin\theta}\right]^2$$

Where p = total load on soil in kg/m^2

w = wt of soil in kg/m^3

θ = Angle of repose of the soil.

In order that all the shallow foundation should be taken to a minimum depth of 80cm below the natural ground level. Unless hard soil is available within 80cm.

Angle of repose

Angle of repose is the angle 95 the loose soil will make with the horizontal, if allowed to remain free in loose condition. The angle of repose of the soil varies with the type of earth.

Depth of concrete block

The depth of concrete block below the masonry footing is calculated by using the formula

$$d = \sqrt{\frac{3PJ^2}{m}}$$

Where, P = the load on soil in kg/m^2

J= The projection of concrete on either side of the lowermost masonry footing which should be at least 10-15cm.

m= modulus of rupture of concrete in kg/m

The depth of concrete block below the masonry footing is also determined by the formula

$$d = \frac{5}{6}T$$

Where T = thickness of wall above the plinth level.

TYPES OF SHALLOW FOUNDATION

A) Spread footing

The total load of the structure is transmitted to the base of the structure is spread out to a large area by spread footing.

a) Strip footing

Spread footing for a wall is known as strip footing.

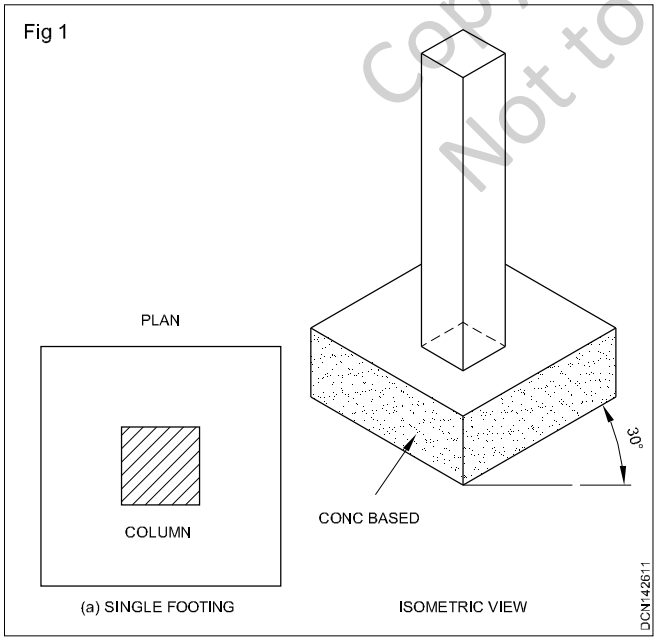
b) Pad footing

The spread footing for a single column is known as pad footing or isolated footing.

The spread footing may be of the following types

i) Single footing

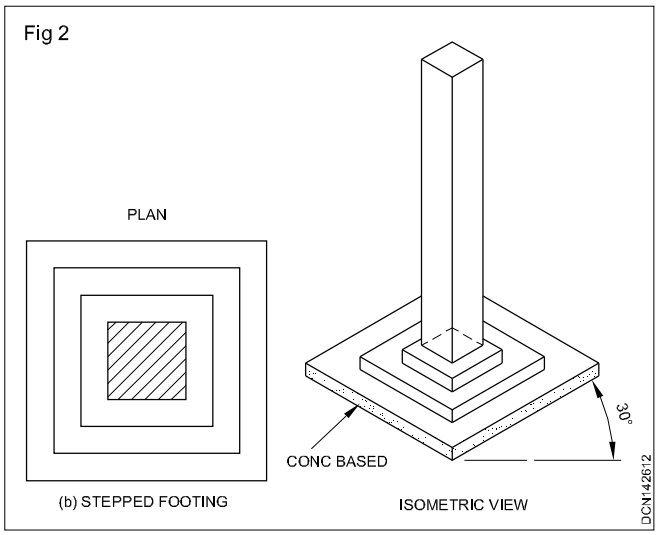
Fig 1 shows the single footing for a column in which the loaded area (bxb) of the column has been spread to the



size (BxB) through a single spread.

Stepped footing

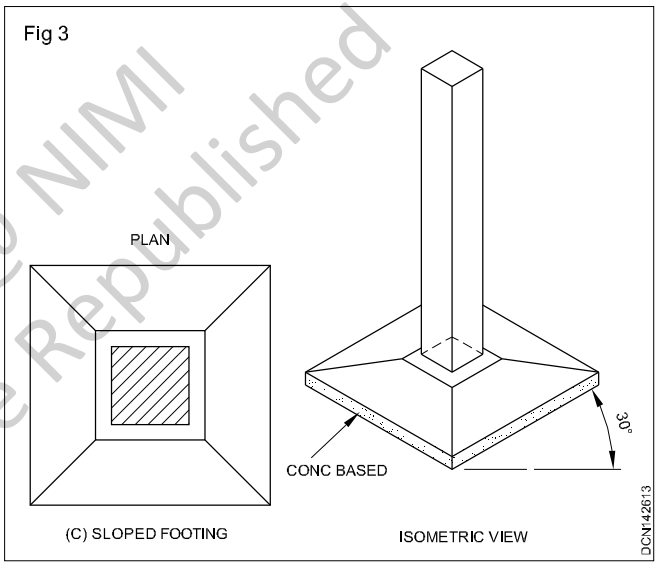
The Fig 2 shows the stepped footing for a heavily loaded



column which require greater spread. The base of the column is made of concrete.

iii) Sloped footing

Fig 3 shows the sloped footing made in concrete base of



non uniform thickness. Greater thickness at its bottom, smaller thickness at the top.

iv) Wall footing without step

Fig 4 shows the stepped footing for a wall consisting of concrete base without step.

v) Stepped footing for a wall

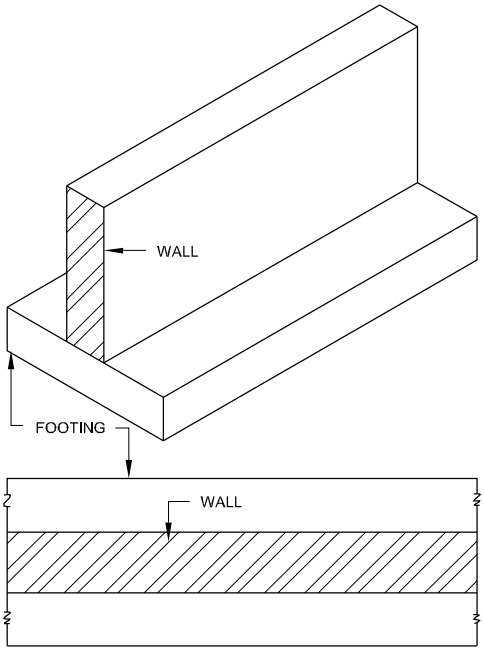
Fig 5 shows the masonry wall have stepped footing with a concrete base.

vi) Grillage foundation

A grillage foundation is a special type of isolated footing. Generally provided for heavily loaded steel stanchions or column, specially in those location where bearing capacity of soil is poor. The depth of foundation is limited from 1-1.5m. The load of the column or stanchion is distributed or spread to a very large area by means of layers of tiers of joist, each tier being placed at right angle to the next tier.

Grillage foundation are of two types:-

Fig 4



WALL FOOTING WITHOUT STEP

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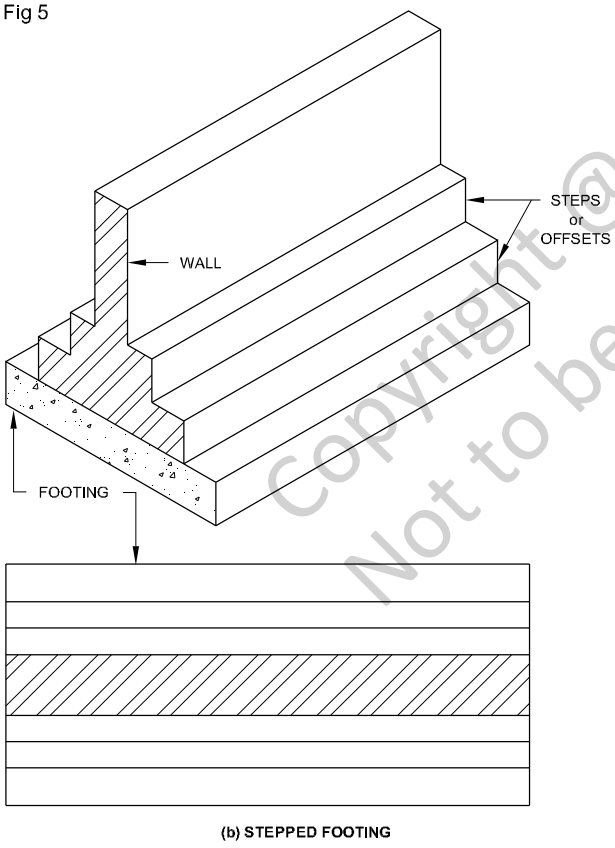
Fig 5



(b) STEPPED FOOTING

SPREAD FOOTINGS FOR WALLS

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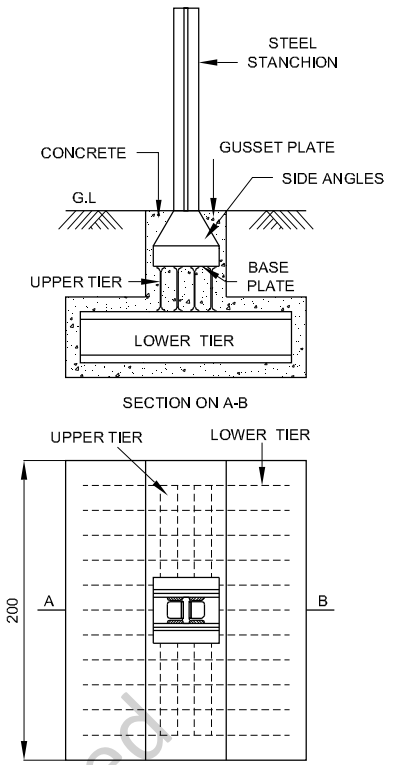
Steel grillage foundation

Timber grillage foundation.

Steel grillage foundation

Steel grillage foundation is constructed of steel beams, structurally known as rolled steel joist (RSJ) provided in two or more tiers. In case of double tier grillage (which is commonly provided) the top tier of grillage beams is laid at right angle to the Bottom tier. The joists or beams of

Fig 6



GRILLAGE FOUNDATION

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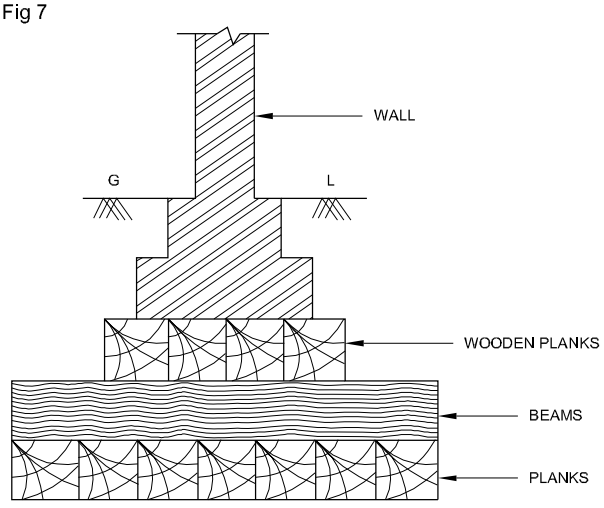
each tier are held in position by 20mm diameter pipe separators (tie rod 20mm diameter) as shown in Fig 6..

The grillage beams are embedded in concrete. Generally, the minimum clearance of 8cm is kept between the grillage beams. So that the concrete can be easily poured ,properly compacted. However the distance between the flanges should not exceed 30cm or 1 1/2 times the flange width. So that the filled concrete acts monolithically with the beams. It should prevent their corrosion. A minimum concrete cover of 10cm is kept on the outerside

Fig 7



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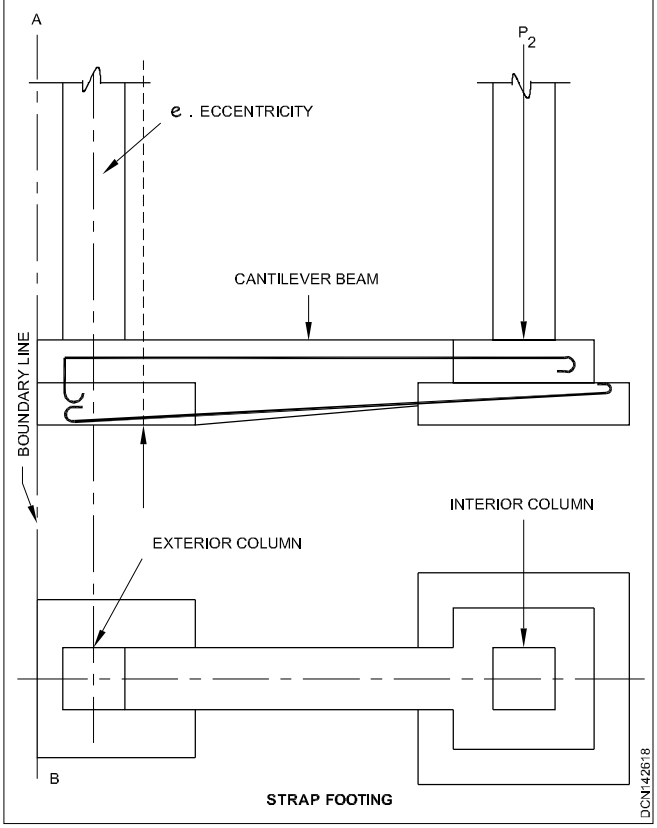
of the external beams as well as upper flanges of top tier.

Timber grillage foundation (Fig 7)

Temporary grillage foundation in the form of timber beams may be provided to timber columns, posts or walls etc. They can be design for supporting light building. In water

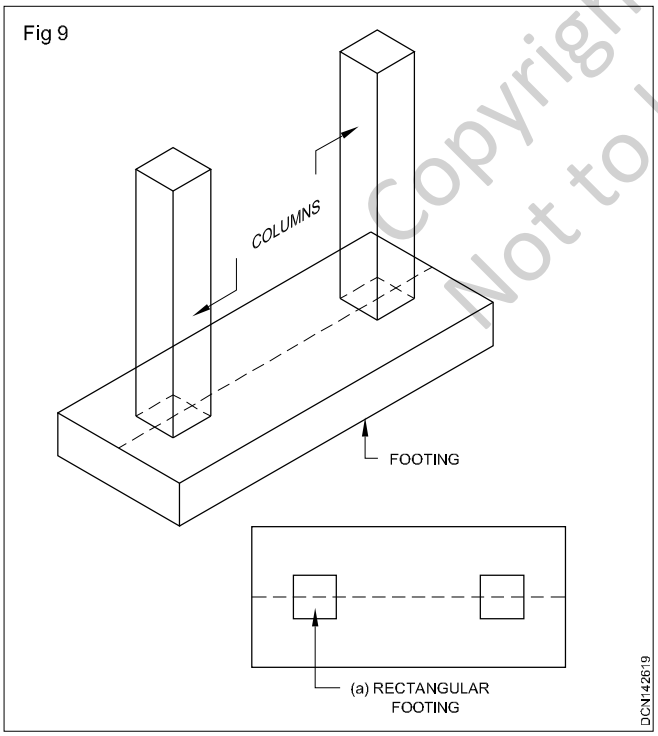
logged areas. The loading on the soil is limited is 5.5 tone/m. The grillage takes the form of a platform of wooden planks arranged in 2 layers at rectangle to each other.

Fig 8



The two layers of planks are separated by rectangular

Fig 9

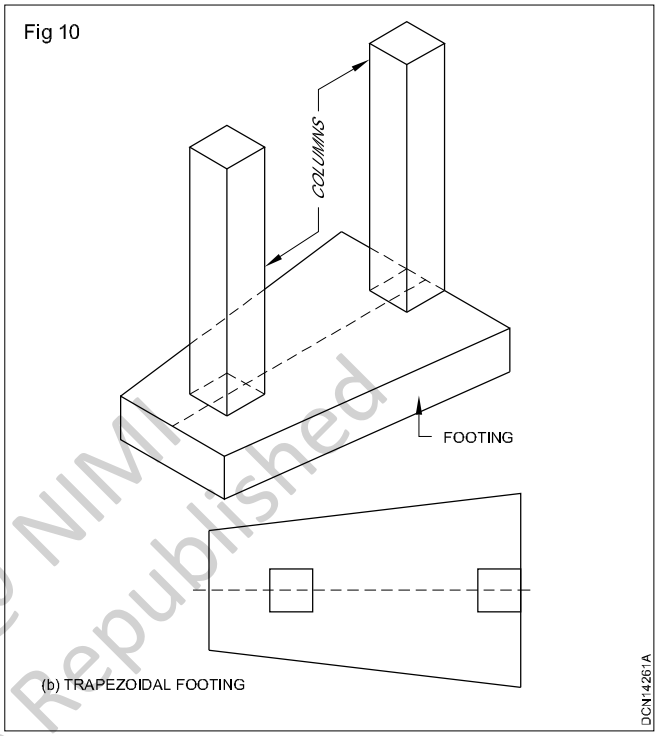


section of timber placed at centre to centre distance of about 3.5cm-40cm.

B) Strap footing or cantilever footing (Fig 8)

A strap footing comprises of two or more footings of individual columns, connected by a beam called a strap. When a column is near or right next to a property limit, its foundation cannot extended beyond the property line, and if the distance between this columns and the adjoining column is large, in that case strap footing may be provided. The strap beam connecting the spread footings of the two columns do not remain in contact with soil and does not transfer any pressure to the soil. The function of strap beam is to transfer the load of heavily loaded outer column to the inner column. In doing so the strap beam is subjected to bending moment and shear force and it

Fig 10



should be suitably designed to withstand these.

iii) Combined footing

RECTANGULAR FOOTING (Fig 9)

A spread footing which supports two columns is termed has combined footing. If the footing supports more than two columns it is known as continuous footing.

A combined footing is provided under the following circumstances

1) When the columns are very near to each other so that their footings overlap.
2) When the bearing capacity of soil is less requiring more area under individual footing.
3) When the end column is near a property line so that its footing spread in that direction.

A combined footing may be rectangular or trapezoidal in plan. The aim is to get uniform pressure distribution under the footing. For this the centre of gravity of the footing area should coincide with centre of gravity of the combined load of two columns. If the outer column, near the properly

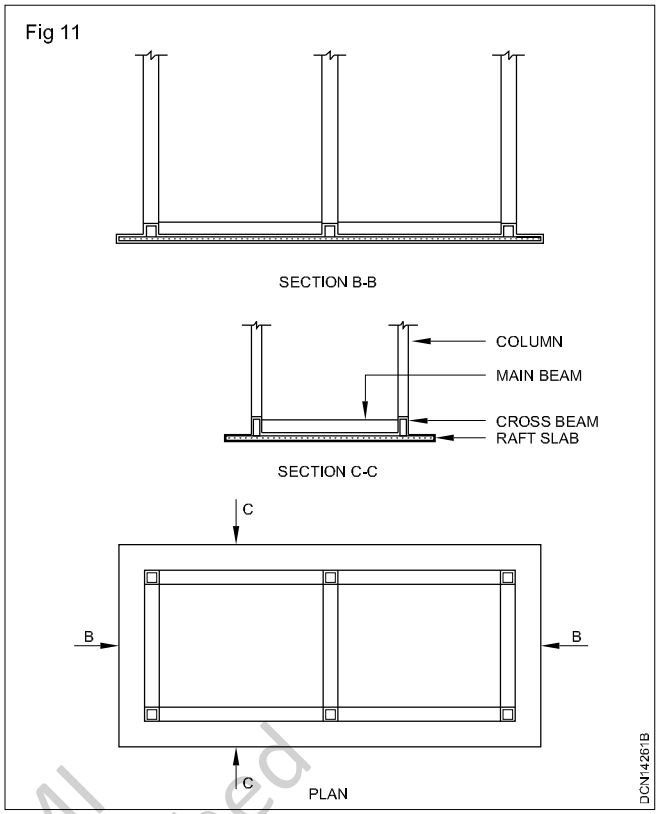
line carries heavier load, provision of trapezoidal column becomes essential to bring the c.g of the footing in line with the c.g of the two column loads. In other cases rectangular footing may be prefered.(Fig 10)

IV) Mat or raft foundation

Generally a raft or mat foundation is used when the bearing capacity of soil is very poor and when it is required to distribute heavy concentrated load over a large area. The raft foundation is useful where there is a possibility of unequal settlement to occur. The raft foundation consist of thick R.C.C slab covering whole area in the form of a mat. If the required area of footing exceeds half the total area of the structures, raft foundation is used. Raft foundation is also used for increasing the area of foundation to neutralise the hydrostatic uplifts.

v) Inverted arch foundation - The foundation which consist of inverted arches between the pier are known as inverted arch foundation. The rise of the arch is about 1/5th -1/10th of the span. The load transmitted to the soil through inverted arch. These are suitable for the construction of bridges, reservoirs, tanks etc. Now a days this type of foundation is rarely used in India.

Fig 11



Deep foundation

Objectives : At the end of this lesson, you shall be able to
- **define deep foundation**
- **state classification of deep foundation**
- **explain pile foundation**
- **identifies various types of piles**
- **describe pier foundation**
- **explain well foundation (caisson).**

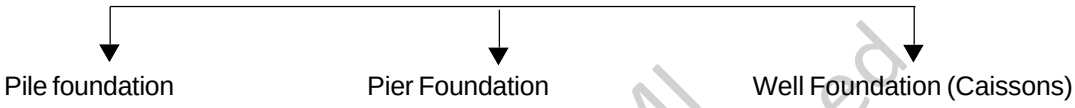
Introduction

This construction is adopted when the loose soil extends to a great depth. The load of the structure is transmitted by the piles to hard stratum below or it is resisted by the friction developed on the sides of piles.

Definition

The depth of foundation is greater than its width is called deep foundation.

Classification of deep Foundation



A Pile Foundation

Pile is a long vertical load transferring member which may be of timber, steel or concrete.

1 The loads are taken to a low level by means of columns in the soil.

2 It may be adopted where no firm bearing strata exists at reasonable depth and the loading is uneven

3 The pumping of subsoil water is too costly for keeping the foundation trench in dry condition.

4 This foundation is to be adopted for the structures in the area where canals ,deep drainage lines, etc. are to be constructed

Pile

Following are the situation in which a pile foundation is preferred:-

a When the load coming from the structure is very high and concentrated.

b When the other type of foundation cannot be provided due to heavy cost and site difficulties.

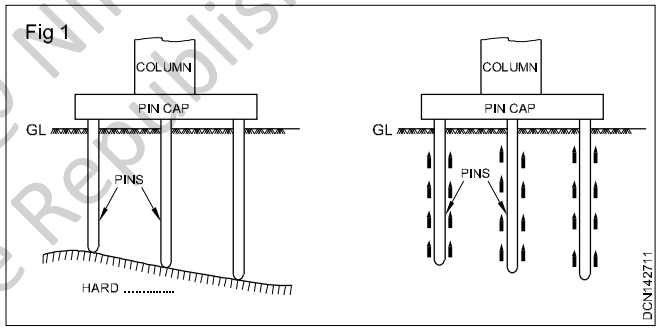
c When the water table is very near to the ground level and may defect the other type of foundation.

d When due to heavy inflow seepage, it is not possible to execute the trenches and keep them dry.

e Where there are chances of construction of irrigation canal in the near by area, which causes seepage of water in the foundation.

f When hard bearing strata is at a greater depth.

Fig 1

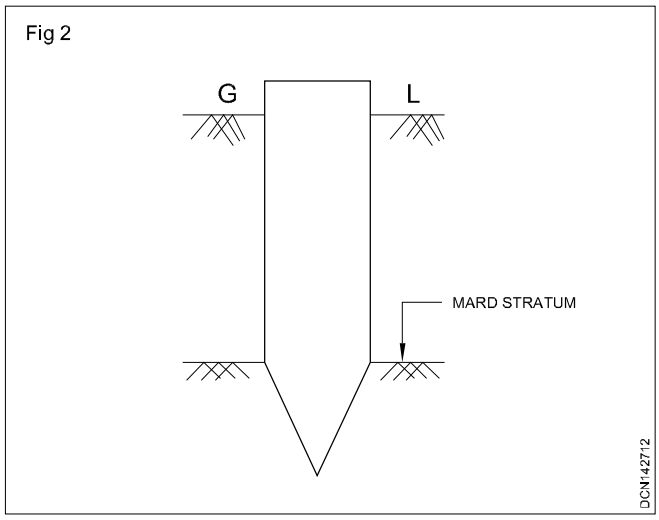


Classification of piles

(a) Classification according to foundation:-

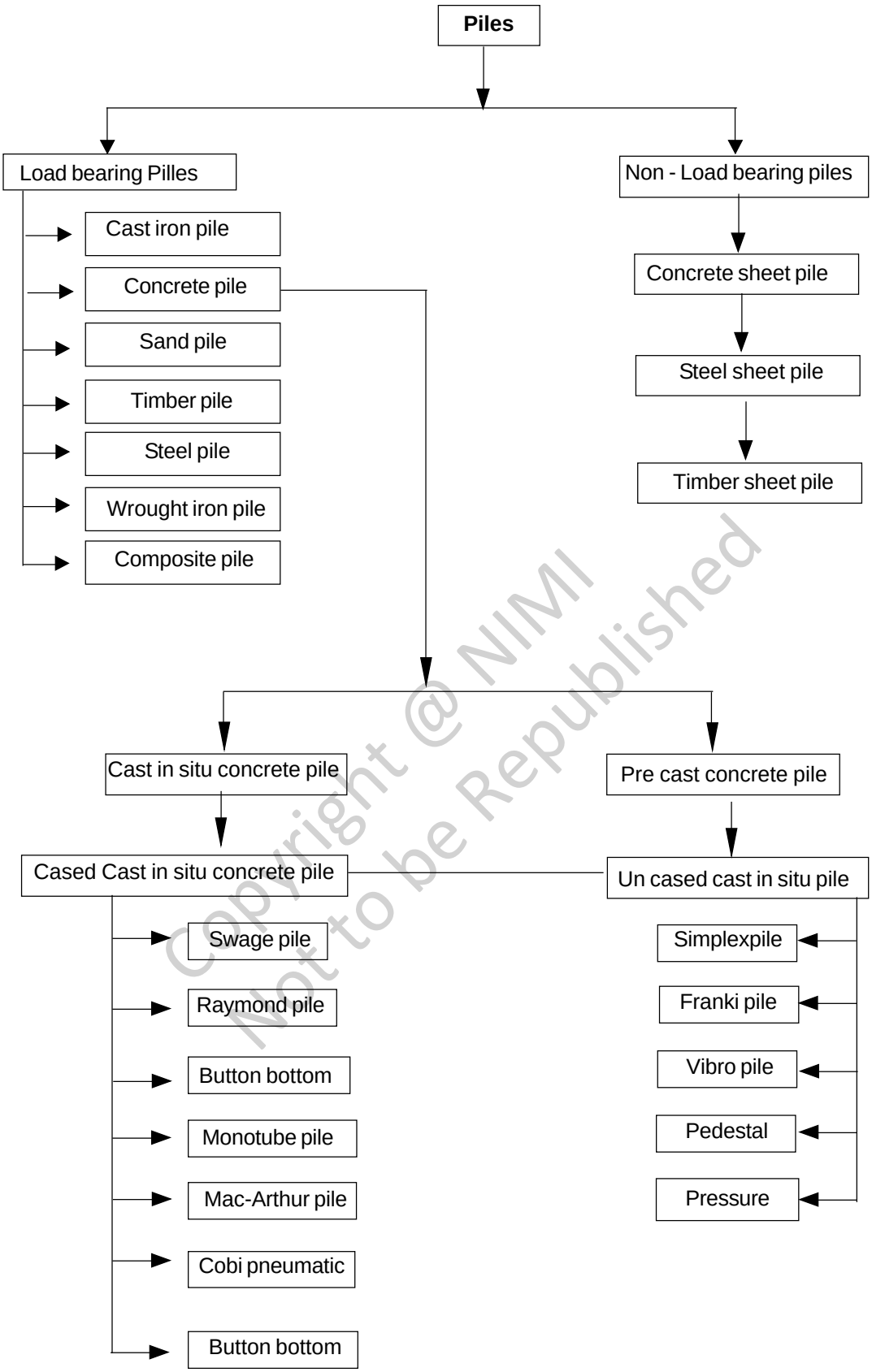
1 End bearing piles (Fig 2)

Fig 2



Piles whose lower end rest on hard rock (hard stratum) is known as end bearing piles. These piles are used to transfer heavy load through water or soft soil to a suitable hard stratum.

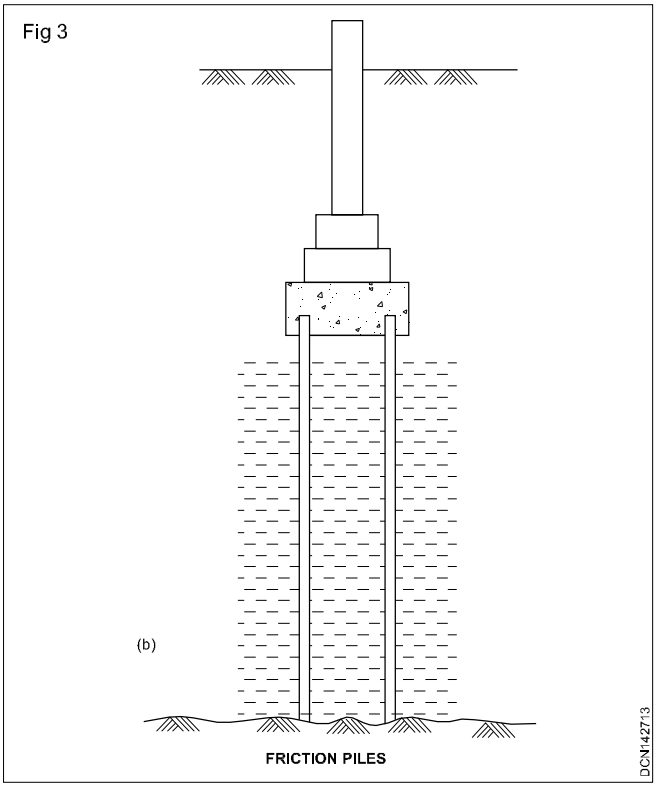
Types of pile



2 Friction piles (Fig 3)

The piles which support the structure load due to friction between the piles and surrounding soil are known as friction piles. Such piles are generally use in granular soil when the depth of hard strata is very great.

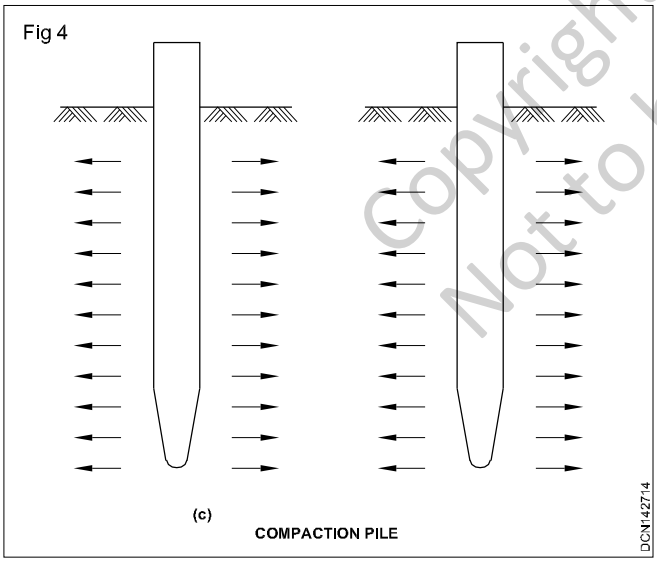
Fig 3



FRICTION PILES

3 Compaction piles (Fig 4)

Fig 4



COMPACTION PILE

Compaction piles are used to compact loose granular soil thus increasing their bearing capacity. The compaction piles themselves do not carry any load. Hence they may be made of weaker materials like timber, bamboo sticks etc. Sometimes they may be made of sand only. The pile tube driven to compact the soil, is gradually taken out and sand is filled in its place thus forming a sand pile.

4 Tension or uplift pile

The tension piles anchor down the structures subjected to uplifts due to hydrostatic pressure or due to overturning moment.

5 Anchor piles

These piles provide anchorage against the horizontal pull from sheet piling or other pulling force.

6 Sheet piles

The piles are differ from bearing pile and friction pile. In that they are rarely used to furnish vertical supports, but are used to retain the soil that is, liable to escape laterally when subjected to pressure or to enclose the area required for some foundation. And protect it from the action of running water or leakage.

7 Fender piles and dolphins

These piles are used to protect the concrete deck or other water front structures against impact from ship or other floating objects.

8 Batter piles

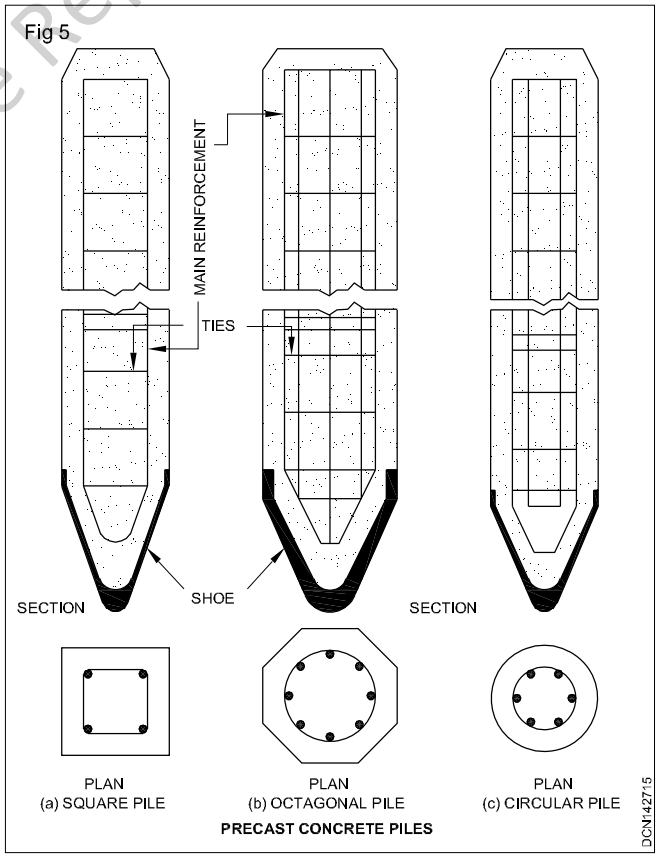
These piles are driven at an inclination to resist large horizontal or inclined forces.

b) Classification according to materials used

1) Concrete piles
2) Timber piles
3) Steel piles
4) Composite piles

1 Cement concrete piles (Fig 5)

Fig 5



PRECAST CONCRETE PILES

Cement concrete possess excellent compressive strength. R.C.C piles are becoming more popular and they are fast

replacing piles of other material. R.C.C piles are divided into two groups.

i Pre cast concrete piles (Fig 5)

Pre-cast concrete piles are those which are manufactured in a factory or at a place away from the construction site and then driven into the ground at the place required. They may be square and octagonal piles are cast in horizontal form. The round piles are cast in vertical forms. The size of the piles may be 30cm-50cm and the length may be much as 18m or moré.

The reinforcement may consist of longitudinal steel bars of 20-40 mm in diameter 4-8 No's with lateral ties of 5-10mm wires spaced at 10cm-30cm c/c from bottom to middle respectively. A concrete cover of atleast 50mm is provided as shown in figure. At the toe of the piles a steel shoe is generally provided. The steel shoe protect the toe and helps the pile in penetrating into the ground during the driving. Pre-casting piles are useful in carrying fairly heavy loads through soft materials to tinner strata.

Advantages of pre-cast concrete piles

a The position of reinforcement in pile is not disturbed from its original position.

b These piles can be driven under water. Concrete in the cast-in-site piles may not be set under water.

c It is possible to have a proper control over the composition and design of these piles as they are manufactured in a workshop.

d Any defect of casting such as hollows etc can be found out and repaired before driving the pile.

e Any number of piles can be manufactured at a convenient place and this may prove to be economical.

f These piles process high resistance to biological and chemical action of the ground.

g These piles, when driven are ready to take up the load. There is no wastage of time.

Disadvantages of pre-cast concrete piles

a These piles are heavy in weight and it is therefore difficult to transport, to handle and to drive them.

b Extra reinforcement is provided to resist the stresses during handling and driving operation. This fact makes the pile costly.

c If sufficient care is not taken, piles may break during transport or driving.

d The size and length of pile will depend on the available transport facilities.

ii) Cast-in-situ concrete pile

In this type of concrete piles a bore hole is dug into the ground by inserting a casing. This bore is then filled with concrete after placing reinforcement, if any. The casing may be kept in position or it may be withdrawn. The former piles are known as cased-cast-in-situ concrete piles and the latter is known as uncased-cast-in-situ concrete piles.

Advantages of cast-in-situ concrete piles

a Light weight shells are used in cast-in-situ concrete piles and these shells are easy to handle and to drive in the ground.

b No extra reinforcement is necessary to resist stresses developing during handling or driving operation only.

c There is no wastage of materials as the piles of required length is constructed.

d The pile are sound in construction as they are not driven into the ground by a hammer.

Disadvantages

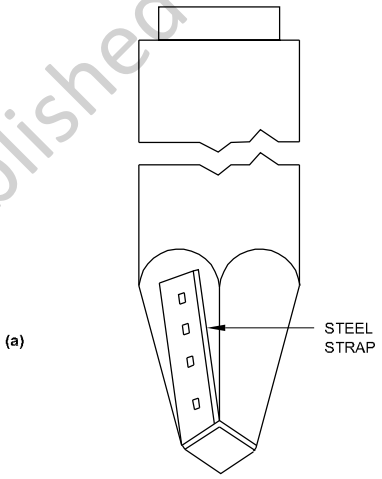
a It is difficult to maintain the reinforcement in correct position during construction of piles.

b These pile cannot be constructed under water.

c The dry ground may absorb, moisture from the wet concrete. The piles are then weakened.

2 Timber piles (Fig 6)

Fig 6



TIMBER PILES

The timber pile may be rectangular, circular, square. The size of timber varies from 30cm-5-cm. The length of the timber pile does not exceed 20times its top width otherwise it may fail by buckling. At the bottom a cast-iron shoe is provided and at the top, a steel plate is fixed. The timber pile should be properly treated so as to make them durable.

A timber pile is made of trunk of a tree. The wood to be used for timber pile should be free from knots. flaws and shakes and other defects. The common Indian timber which are used are babool, chir, jarul, poon,. Sal, teak.

Advantages of timber piles

a Where timber is available easily these piles prove to be economical in cost.

b These piles can be handled easily with little risk or danger of break.

c The length of the timber pile can be adjusted either by cutting or lengthening without must extra cost.

d Skilled supervision is not required in the construction of timber lile.

e These piles can be removed easily if necessary.

f These pile donot required heavy equipment for driving them into the ground.

Disadvantages

a These piles cannot be take heavy loads and are unsuitable for used as end bearing piles.

b A joint in the lengthened timber pile is a source of weakness.

c It becomes very difficult to drive these piles in the hard formation.

d Timber piles are generally used for temporary work.

3 Steel piles

Steel piles are used as load bearing piles in the different form.

i H-beam piles

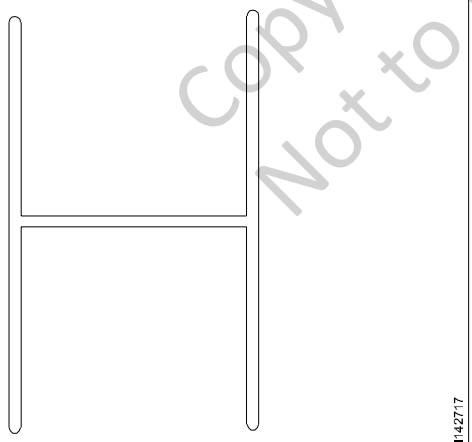
ii Box-piles

iii Tube-piles

i H-beam piles

Fig 6 shows the plan of an H-beam steel piles. These piles are usually of wide flange section and they are most common variety of steel piles in general use. They are found very much suitable especially for trested type structure in which the pile extent above ground level and work also as column for the structure. The driving of H-piles is very simple and energy from a piles hammer is effectively transmitted to the lower portion of the pile.

Fig 7



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ii) Box pile

Fig 8 shows the plan of box pile. Various type of patended box piles are available, the figure shows "Larssen-Box pile". A box is driven either with closed bottom or with open bottom. These piles are used when it is not possible to drive H-beam piles upto the hard strata.

iii) Tube piles

Fig 9 shows the plan of tube pile. In this type of steel piles, tubes or pipes of steel are driven into the ground. The pile may be driven either with open end or with closed end. Concrete is filled in side the tube piles. Because of circular cross section these piles are easily to handle and easy to drive.

Fig 8

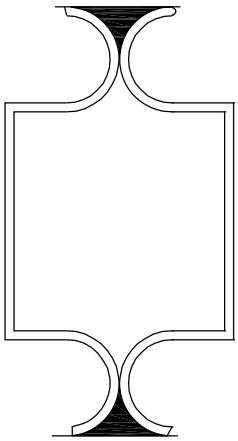

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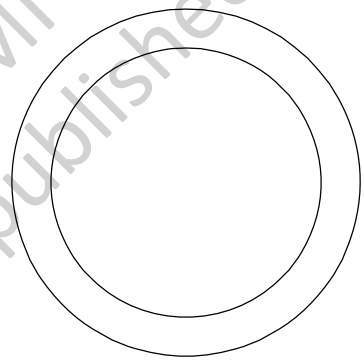
Fig 9



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Advantages of steel piles

a These piles withstand easily the stresses due to driving.

b These piles can be easily to lengthened by welding without any delay in driving operation.

c The extra length of these piles can be cut off easily.

d The bearing capacity of these pile is comparatively high. The allowable compressive stress on steel is taken as about 6-8 kg/mm^2

e These piles can be handled roughly without any serious damage.

Disadvantages

a Corrosion is the only drawback of steel pile.

4 Composite piles

Composite piles are those which are made of two portion of two different materials driven one above the other. Two common type of composite piles are :

a Timber and concrete pile

In the timber and concrete composite pile, timber portion

is use below the permanent or lowest water level, while concrete piles, usually cast-in-situ is formed above it. Due to this combination the advantages of both types are combined. Also the total cost of the pile is reduced.

b Steel and concrete composite pile

This type of composite pile is used where the required length of pile is greater than that available for the cast-in-situ type pile. The pile consist of steel pile attached to the lower end of concrete pile. This type of composite pile is used where satisfactory penetration of the pile into the rock is required for heavy loads.

Foundation for black cotton soil

Black cotton soil is a loose type of soil, and it considerably swells and shrinks by variation in moisture content. The variation in the volume of the soil is to the extent to the extend of 20%-30% of the original volume. During rainy season moisture penetrates into the soil the particles separate out, resulting in increase in the volume.

This increase in volume is known as swelling. During summer season, moisture moves out of the soil and consequently the soil shrinks, shrinkage cracks are formed on the ground surface. These shrinkage cracks are formed on the ground surface. These shrinkage cracks sometimes also known as tension cracks may 10-15cm wide,1/2-2m deep. Hence extreme care should be taken when foundation are to rest on this soil.

Following are the precautions to be taken in designing footings on black cotton soil:-

a For important structure the raft foundation should be adopted.

b The black cotton soil should be completely removed if possible and convenient.

c The black cotton soil should not be allowed to come in direct contact with the foundation masonry.

d The construction work should be carried out in dry season.

e The depth of foundation should extend beyond the depth of crack in black cotton soil.

Pile cap and pile shoe

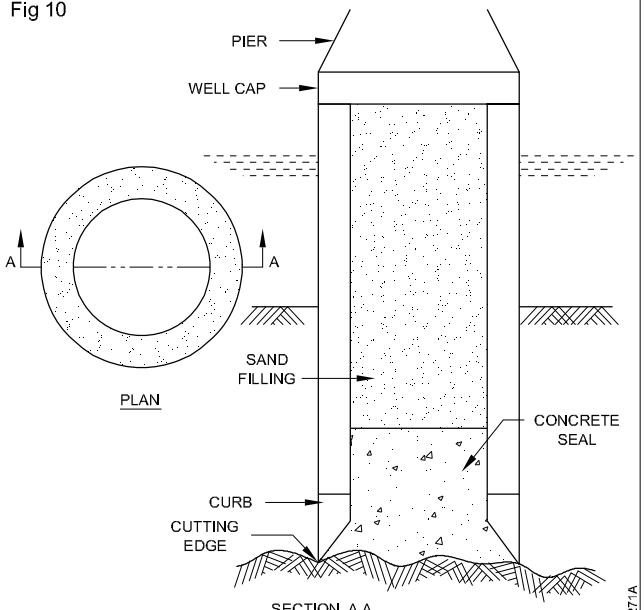
When the column or any other load carrying structural component is supported on more than one pile, the pile should be connected through a rigid pile cap, to distribute the load to individual pile, pile cap maintain the proper alignment of the pile. It is advisable to ensure that a pile projects atleast by about 10cm in the pile cap.

Pile shoes are provided at the tips to facilitate the process of driving through hard strata. Pile shoes are made from cast iron, steel or wrought iron. In case of steel piles it is necessary.

B Well foundation(caissons)

Well foundation is the convenient of securing a trust worthy foundation in deep sand or soft soil. It is also useful in moderate depth of water when foundation is to be taken in soft sandy soil, well are generally made of concrete or masonry. In masonry well vertical holding down bolt and iron plate or loop iron are provided to secure good bond.

Fig 10



CYLINDRICAL OPEN CAISSON (WELL FOUNDATION)

In order to prevent cracks during sinking operation. At the bottom of the well curb made of concrete, a steel or cast iron, cutting edge is attached. The position of well to be sank is first correctly marked on the ground and the curb is placed upon it. On the curb masonry ring is built to a hight of about 1.2m and allowed to drying.

Type of foundation in black cotton soil

Foundation in black cotton soil may be of the following types.

1 Strip or pad foundation

2 Pier foundation

3 Under-reamed pile foundation

1 Strip or pad foundation

For medium loads strip foundation (for walls) and pad foundation (columns) may be provided. These are two method of strip or pad foundation.

1st method

This method of constructing foundation on black cotton soil is adopted when the depth of black cotton soil is more and there are not chances for surface water to penetrate through the soil for more than 1m-1.5m.

The procedure is as follows

a The foundations trenches are excavated to a depth given by the equation.

d = maximum depth of crack+30cm

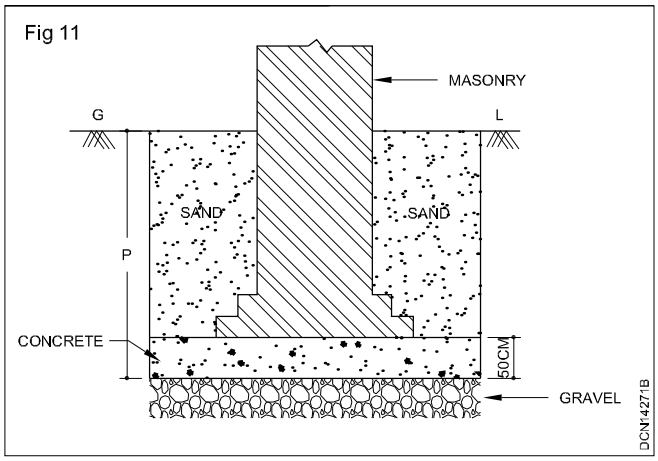
b The width of the trenches is kept such that the allowable bearing capacity of the soil does not exceed 15 tone/ m^2.

c Gravel is spread for the face width of the trench and well rammed.

d A layer of concrete of 50cm depth is laid on the gravel.

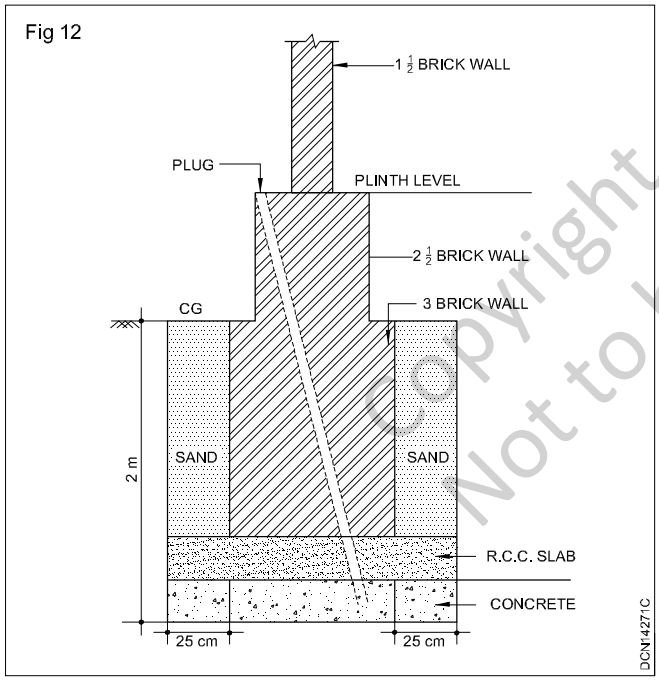
e The masonry work is started on the top of the foundation soil and it is carried out upto the plinth level.

f The side of the trenches are filled with sand as shown in fig 11.



II method

This method of constructing foundation on black cotton soil is adopted at places where there is heavy rain-fall and there are chances for surface water to reach a greater depth in the soil.



The procedure as follows

a The foundation trenches are excavated to a depth of 2m.

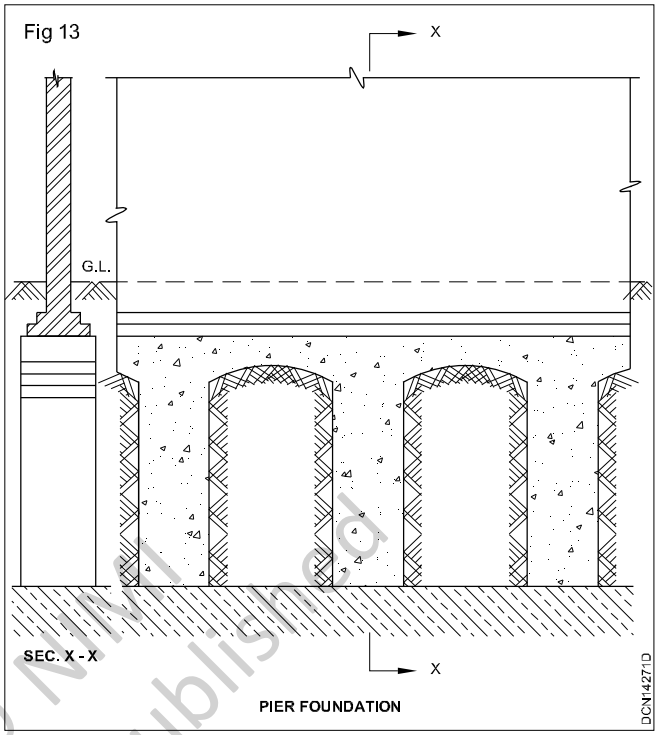
b The side portion of the trenches are filled with concrete having a section of 25cmx25xm as shown in fig 11 and the hollow space equal to 1st layer of masonry is filled with sand.

c 12cm-15cm thick R.C.C slab covering the face width of the trench is laid.

d The masonry work is started on the top of R.C.C slab and it is carried upto the plinth level.

e 80mm diameter pipes spread at 1.5cm centre to centre are placed through the masonry and R.C.C slab, as shown in figure. The pipes are brought upto plinth level and filled with sand. A plug is provided at the plinth level. These piles are inspected periodically if required.

2 Pier foundation (Fig 13)



When a heavy loaded building is situated in a sandy soil, black cotton soil or soft soil, over lying hard bed at reasonable depth pier foundation are sometimes used to transfer the load the building to the hard bed below. This method consist in sinking vertical shaft upto hard bed and filling them with concrete.

The diameter of the shaft and the centre to centre spacing depend upon the loading condition, the nature of soil and depth at which hard bed is situated. The diameter or horizontal dimension should be less than 1/12th its height. To prevent the side earth from falling in the side, the shaft is sometimes lined with timber. The timber lining is removed during the filling upthe shaft with concrete. The shaft are connected to each other by an arch or reinforced cement concrete or steel grillage cap.

3 Under reamed pile foundation

These piles are developed for serving as foundation for black cotton soil. An under reamed pile is a bored concrete pile having one or more bulbs in its lower portion. The bulbs or under-reams are formed by under reaming tools. The foundation will be anchored to the ground, and it would not move with the movement of the soil. The diameter of a under-reamed pile is about 3m-8m. The spacing of pile may vary from 2m-4m. The safe load for an under reamed pile varies from 20 to 40 tone (Fig 14).

The load carrying capacity of under reamed pile can be increased by adopting pile of large diameter or by extending the length of pile, or by making more bulb at the base. A single under-reamed pile has only one bulb at

the bottom. When the no.of bulbs at the base (2 or more) it is known as multi under-reamed piles. The vertical distance of bulbs varies from 1.25 to 1.50 times the diameter of the bulb. The under-reamed pile is selected by the consideration of pile length, stem diameter, bulb diameter, a no of bulbs. In black cotton soil the bulb of under-reamed piles, not only increase the load bearing capacity, but also provide anchorage against uplifts.

Fig 14

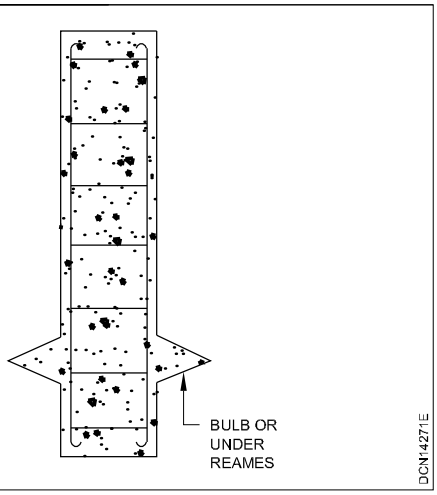
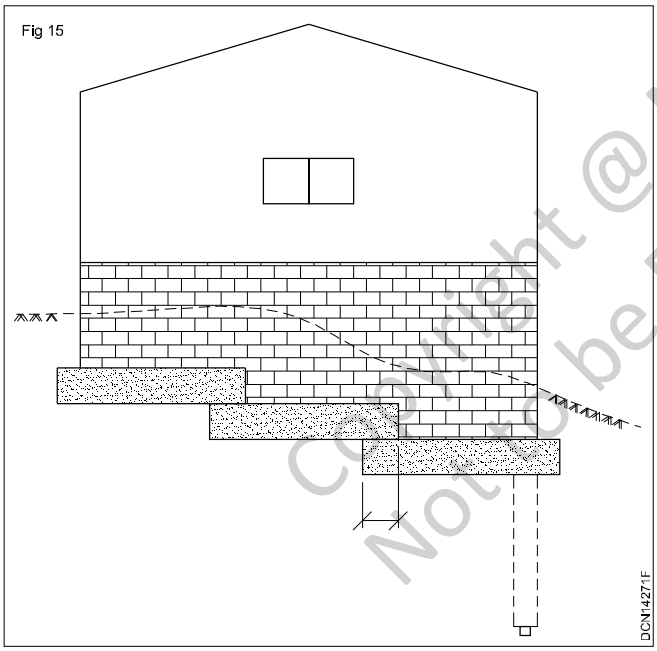


Fig 15



Stepped foundation on slopping ground

1 When the ground is sloping it becomes an-economical to provides foundation at same level along the length of the wall, in such cases stepped or benching foundation may be provided. The foundation trunch is excavated in the form of steps, if possible all the steps should be of equal depth and length. Overlap between two layer of foundation concrete should be atleast equal to the depth of foundation concrete. A minimum depth of 1m for soil and 60cm for rock should be provided between sloping surface and the lower edge of the footing.

COFFER DAM AND CAISSON

Coffer dam

Is defined as a temporary structure which is constructed so as to remove water and soil from an area and make it possible to carry out the construction work under reasonably dry condition.

Following are the uses of coffer dam

1 To facilitate the pile driving operation

2 To place grillage and raft foundation.

3 To construct foundation for pier and abutment of bridge, dams etc.

4 To provide working platform for the foundation of buildings when water is met with.

5 To provide space for carrying out the foundation work without disturbing or damaging the adjoining structure such as building, pipe line etc.

Caisson

It is defined as a structure which is sunk through ground or water to exclude the water and semifluid material during the process of excavation of foundation and which subsequently becomes an integral part of the sub-structure.

Following are the use of the caisson

1 To reach the hard bearing stratum for transferring the load coming on supports for bridge pier

2 To serve as an impervious core wall of earth dams. when place adjacent to it.

3 To provide on acces to a deep shaft or tunnel.

4 To provide an encloser below water level for installing machinery, pump etc.

The main difference between coffer dam and caisson is that the coffer dam is a temporary structure, while caisson forms the part of the permanent work.

Method of settingout of foundation trench

Setting out or ground tracing is the process of laying down the excavation lines and centre lines etc on the ground.

The process for setting out of foundation trenches as follows :-

1 From the site plan of the building one line which can be easily established on the ground is selected.

For example as per fig16 the point 'A' can be easily located on the ground and its co-ordinates are completely defined. With the help of point 'A' line 'AB' can be demarcated on the ground.

Thus line 'AB' will be the base line and from this base line the entired building can be traced out on the ground. It should be noted that the point 'A' and 'B' are on the centre line of the wall and hence it is essential to prepare the centre line plan of the building before starting this work.

2 Centre line wooden pegs are driven on the ground and they project about 25mm above the ground level. Nails are provided on the top of the pegs as shown in figure.

3 Two other pegs are driven at equal distance on either side of the centre line peg such that the distance between them becomes equal to the width of the foundation tranch as shown in figure 16.

4 With the help of these pegs the foundation plan can be completely traced on the ground. For this purpose strings are tied to respective pegs and lines are marked along these strings with the help of pick-axe or wing powder.

5 Along the centre line pegs brick pillars of size 20cm x 20cm are constructed about 2m away from centre. In some level upto plinth level height. The top surface of the piller is plastered and grooves showing centre lines are provided as shown in figure.

6 The masonry pillar should be preserved till the foundation work is completed.

7 The depth of excavation can be started.

8 The depth of excavation is check by fixing a strings along the grooves on the opposite pillars and holding boning rod. The length of the boning rod should be equal to the depth of foundation trenches.

Simple- Machine foundation

Objectives: At the end of this lesson you shall be able to
- **state the functions of a foundation bolt**
- **name the type of foundation bolts**
- **explain the specific application of the bolts.**

Machines are generally subjected to the vibration of forces. Due to this cause the machines are like to shift or move or dislocate from their positions. To over come this defaults the machines are fixed to the ground with the help of specific devices which are called as foundation bolts.

These bolts do not have a specific shape of head similar to hexagonal or square bolts. The length of the shank is according to the thickness of nut and the thickness of machine base. The odd shaped part of the bolt hold the machine firmly to the ground and preventing the machine, shift or move or dislocation from its positions.

Types (Fig 1 & 2)

Fig 1

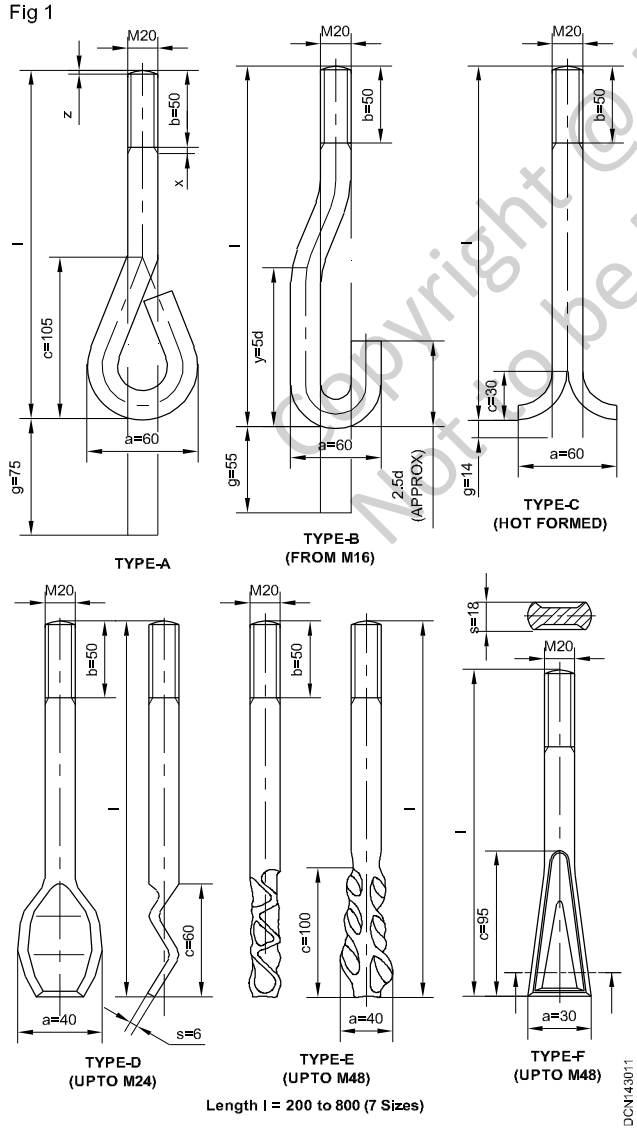
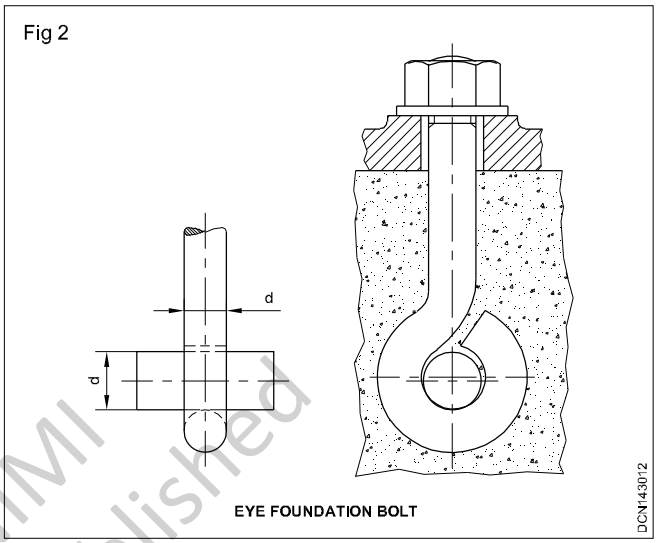


Fig 2



As per IS : 5624-1971 there core six types designated as type A, B, C, D, E & F figure 1 shows the same. These bolts are available in 13 dia sizes from M8 to M75, length 80mm to 320mm. These botls are designated by the shanks dia and length without nut . The ends tare formed by forging .

There are other non standard forms which are generally used are

- Eye foundation bolt
- Rag foundation bolt
- Lewis foundation bolt

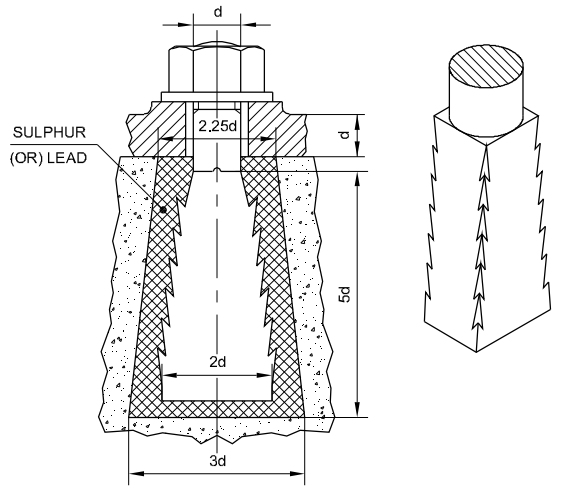
The position of the holes of machine base /feet marked on the ground. Pits are formed and foundation bolts are placed in position, with cross bars placed in bolt eyes. The position of eye bolt is checked and aligned. The thread and of the bolt protrude above the ground level. Cement eye foundation bolt (Fig 2) and rubble are mixed with water and pounced around the bolt. When it sets, the bolts are hold in aligned. After this, the machine is placed in position and nut are toughened on the bolts holding the machine firmly.

Rag bolt (Fig 3)

This is in the shape of a rectangular pyramid with round shanks are formed with rags or grooved, forming small projections. These are bolts are placed in the foundation cavity in position as done in previous case and then molten lead of sulphur is pound around with. When the molten lead or sulphur /lead solidified the bolts are held firmly. The machines are placed in position and nuts are fixed.

By melting the lead or during the sulphur the bolt can be removed.

Fig 3



RAG FOUNDATION BOLT

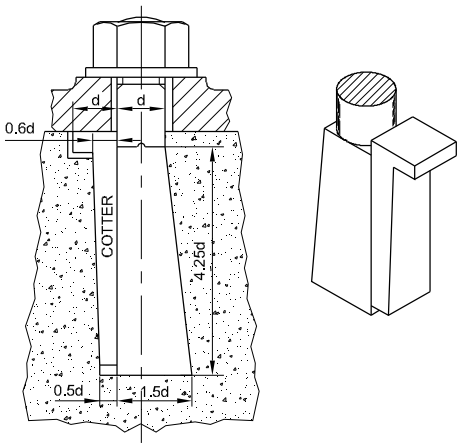
Lewis foundation bolt (Fig 4)

This is a rectangular shanks bolt with one side taper. AGIB headed key is placed on the other side of the taper and concrete is panned around it if is aligned. The foundation bolt can easily be with drawn by removing the gib headed key first and then the bolt.

Cotter foundation bolt (Fig 5)

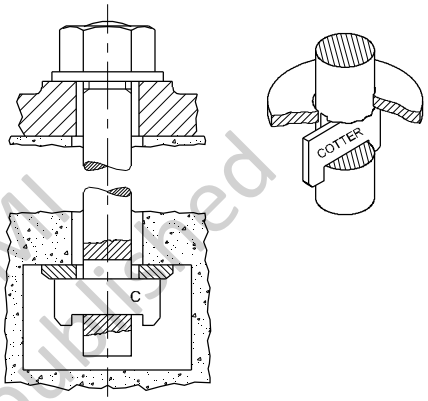
This type of bolt has a rectangular slot through which a double headed cotter is placed. A cast iron washer is rests above the cotter. Through the hand hole, connecting the cavity in the concrete and the bolt is pulled down and lifting the cotter. Now the cotter is placed in position.

Fig 4



LEWIS FOUNDATION BOLT

Fig 5



COTTER FOUNDATION BOLT

Shoring

Objectives : At the end of this lesson you shall be able to,
- **define shoring**
- **sketches and explain types of shores**
- **describe raking shore with its parts and functions**
- **follow important points while supervising the shoring work.**

Introduction

Structures which have become unsafe due to unequal settlement of foundations or due to removal of the adjacent building or due to any other reason. For safe structures, the shoring is required to prevent movements when certain additions and alterations are being carried out.

Circumstances

The shoring is required under following circumstances,

1 Adjacent structure is to be dismantled.

2 Cracks developed due to unequal settlement of foundation in a wall are to be required.

3 Defective walls of a building are to be dismantled and rebuilt and support is necessary to the floors or roofs connected to that wall.

4 Large openings are required to be made in the main walls of an existing building.

5 Walls of a building showing signs of bulging out or leaning outwards due to bad workmanship.

Materials: timber or steel tubes or in a combination of both.

Duration: no limit for the duration of shoring.

Requirements: loads coming on shoring are required to study separately and designed accordingly.

Approval: The shoring should be carried out as per prevailing rules and regulations of the authority and necessary approval should be obtained.

Types of shoring: Shores are classified, depending upon their supporting characteristics:.

1 Raking or Inclined shores.

2 Flying or Horizontal shores.

3 Dead or Vertical shores.

1 Raking or inclined shores: (see fig 1)

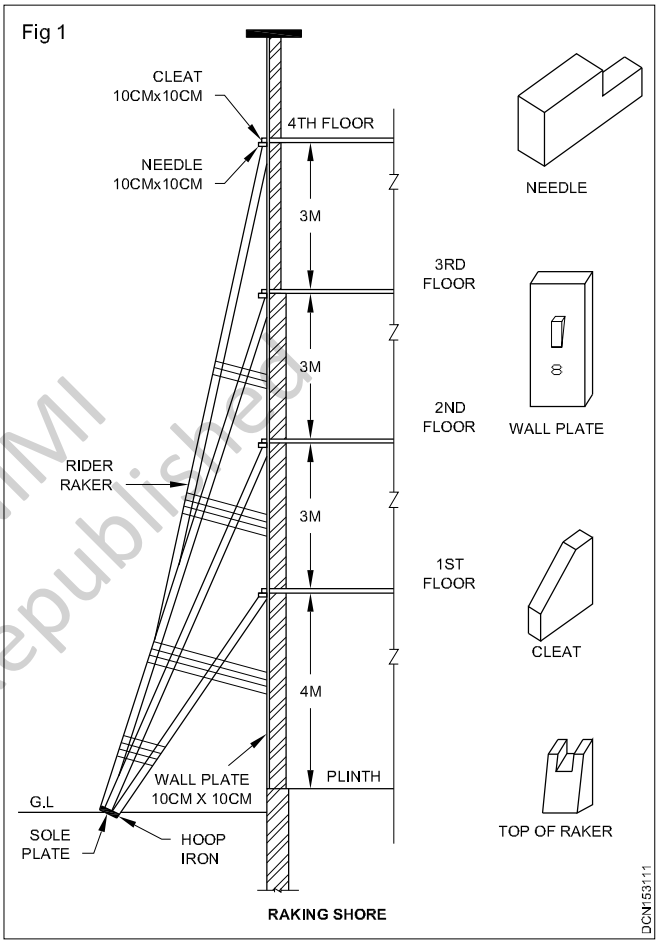
This is an inclined support provided to an unsafe existing structure externally is called Raking or Inclined Shores.

Component parts of a Raking

1 Wall Plate: - A wall plate is secured against the wall by means of square needles which penetrate in to the wall for a distance of about 15cm.

2 Needle: in turn, secured by cleats which are nailed to the wall plate?

Fig 1



3 Rakers: are interconnected by struts or braces or lacings. The feet of rakers are stiffened by similar braces or hoop iron and they are connected with the sole plate by means of iron dogs.

4 Braces :(Struts or lacings) these members are fixed diagonally on the standards.

5 Cleats: These are small blocks of wood, angle iron, or steel, to fixed raker and needle.

6 Sole Plate:-The bottom of the raker rest on sole plate

7 Hoop Iron:-The bottoms of rakers fixed hoop iron Dog, to avoid slip of rakers.

8 Straining Sill:-This horizontal tie beam between two inclined strut

Flying or Horizontal Shore (see figure): In this arrangement, the horizontal supports are given to the parallel walls, which have become unsafe due to the removal or collapse of the intermediate building

Shores are two Flying or Horizontal types,

1 Single flying shore

2 Double flying shore

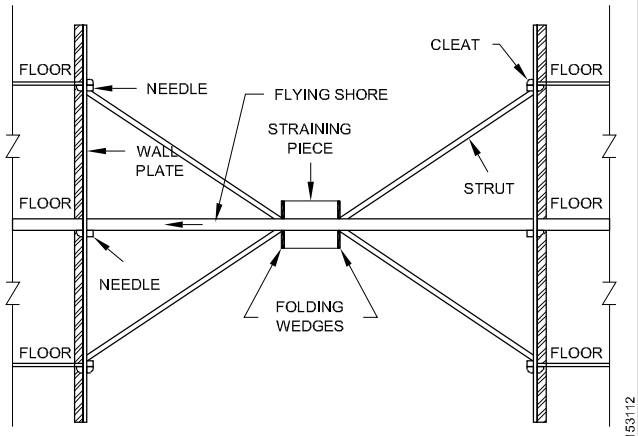
1 Single flying shore (see fig 2)

1 A single flying shore consists of wall plate, needles, cleats, struts, straining pieces, and folding wedges.

2 The flying shores should have a depth not less than one-third of the clear spans and width not less than one- fifth of its length.

3 This is suitable for a maximum distance of about 9m between the adjacent parallel walls.

Fig 2

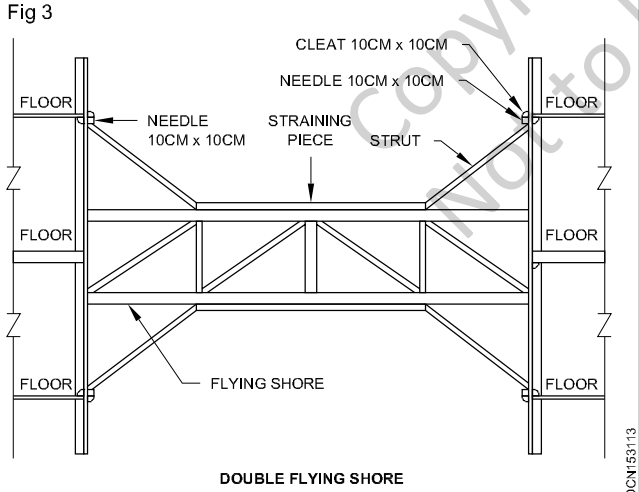


SINGLE FLYING SHORE

2 Double flying shore (see fig 3)

When the distance is between 9 m to 12 m, a compound or double flying shore is provided.

Fig 3

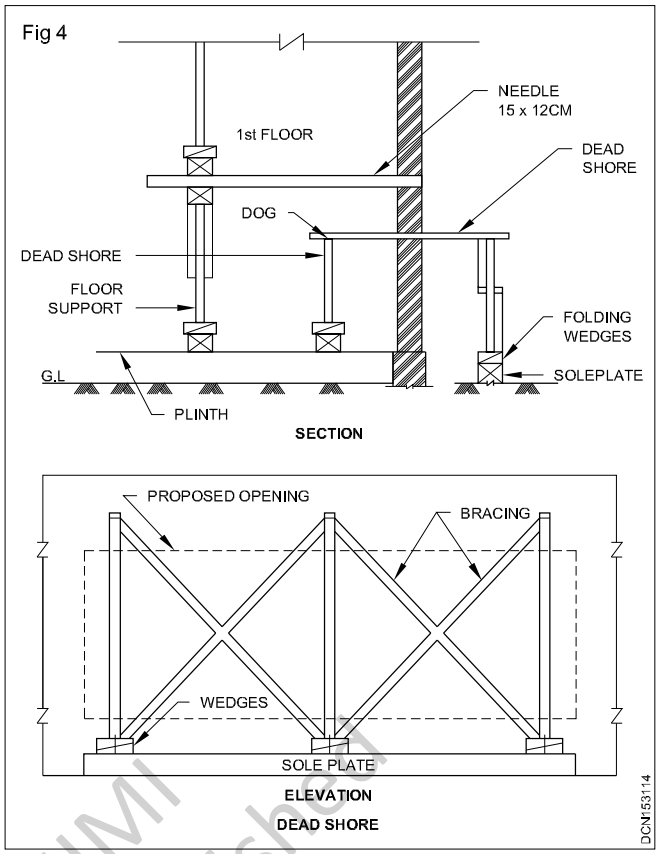


DOUBLE FLYING SHORE

3 Dead or vertical shores (see fig 4)

In this arrangement, the horizontal members, known as the needles are supported by vertical members known as the dead shores. The needles are driven at right angles to the wall through the holes made in the wall.

Fig 4



A dead shore is used under the following circumstances.

1 The lower part of the wall has become defective.

2 The foundations are to be deepened.

3 The lower part of the wall is to be rebuilt or reconstructed.

4 The large openings are to be made in the existing wall.

Important points for supervision the work of shore

1 Various It is possible to calculate the stresses in the members of a dead shore.

2 The needles are placed at a distance of about 1.50 m to 2 m and they are suitably braced. The folding wedges, sole plate, dogs and braces are used as shown figure.

3 The floors are suitably supported inside.

4 The openings above and near a dead shore are suitably strutted.

5 A raking shore may be provided as an additional safety especially in case of weak walls.

6 The shores should be removed at least after 7 days of construction of new work .This period is necessary for the new work to obtain the required strength.

7 The sequence of removal should be needles, strutting from openings, the floor strutting inside and raking shores. If any it is desirable to allow an interval of two days between each of these operations.

Scaffolding

Objectives : At the end of this lesson, you shall be able to,

- **define scaffolding**
- **identify required materials**
- **explain the purpose/uses of scaffolding**
- **state component parts of a scaffolding**
- **describe the types of scaffolding**
- **follow important points while supervision the scaffolding work.**

Introduction

In the normal activities of the building construction, it becomes necessary to have some type of temporary structure or support, so as to proceed with the work.These temporary arrangements take up the form of scaffolding , shoring, underpinning and formwork .

Definition

When the height above floor level exceeds about 1.50 m a temporary structure, usually of timber, is erected close to the work to provide a safe working platform for the workers and to provide a limited space for the storage of plant and building materials. This temporary framework is known as scaffolding.

Materials

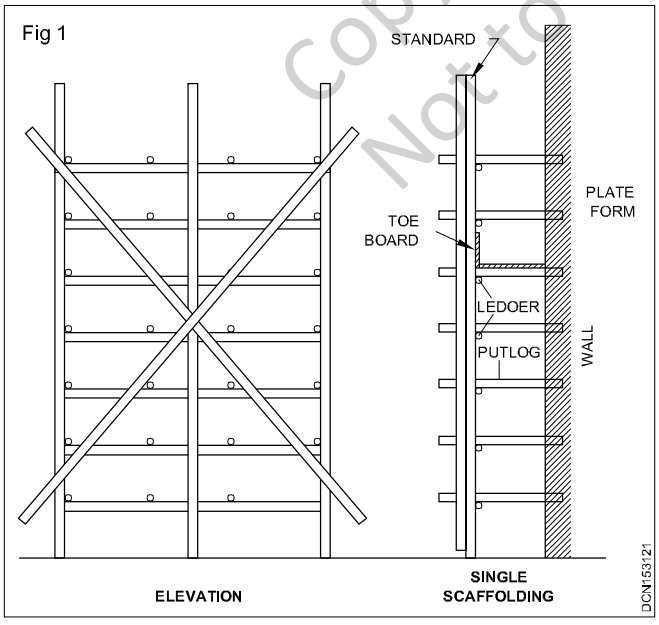
The scaffolding can be carried out either in Timber, bamboo, teak or steel tubes, G.I. pipe, Steel Square, or composite materials. The timber surfaces should be coated with a preservative so as to give protection against wet rot.

Purpose/uses

It is useful in construction, demolition, maintenance or repair works, etc.

Component parts of scaffolding

Fig 1



The Technical Term associated with the design and construction of scaffolding is defined below:

Standards: These are the vertical members of the framework and they are either supported on the ground or drums or embedded into the ground.

Ledgers: These are the horizontal members parallel to the wall.

Putlogs: These are the transverse pieces which are placed on the legders and which are supported on the wall at one end. They are at right angles to the wall.

Transoms: These are putlogs, but the both ends are supported on the ledgers.

Bridle: This is a piece which is used to bridge an opening in a wall and it supports one end of the putlogs at the opening.

Braces: These are the diagonal or cross pieces fixed on the standards.

Guard rail: This is a rail provided like a ledger at the working level.

Toe board: This is a board placed parallel to the ledgers and supported between the putlogs. It is provided to work as a protective measure on the working platform.

Raker: This is an inclined support.

The various members of a scaffold are secured by means of devices such as nails, bolts, rope, etc.

Types of scaffolding:

1 Single scaffolding or bricklayer's scaffolding.

2 Double scaffolding or mason's scaffolding.

3 Cantilever or needle scaffolding.

4 Suspended scaffolding.

5 Trestle scaffolding.

6 Steel scaffolding.

7 Patented scaffolding.

Single (putlog) scaffolding or bricklayer's scaffolding (See figure)

1 This is the most common type of scaffolding and is widely used in the construction of brickwork.

2 It consists of a single row of standards placed at a distance of about 1.2 m from the wall .

3 The distance between the successive standards is about 2 m to 2.50 m.

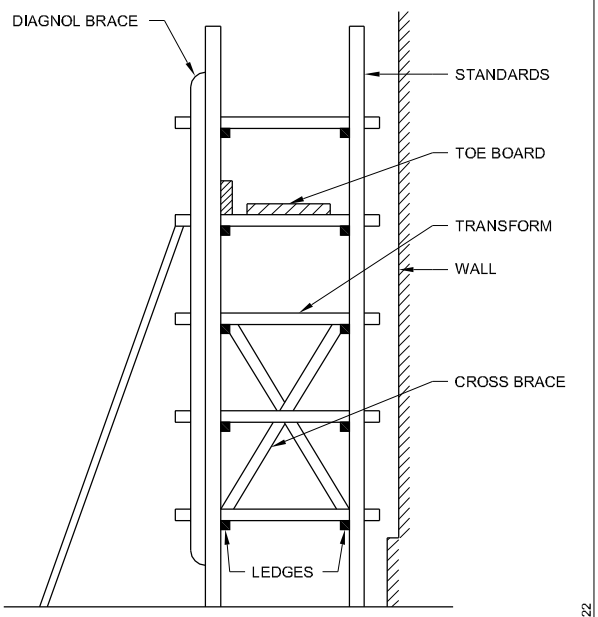
4 The ledgers are then fixed to the standards at a vertical distance of about 1.20 m to 1.80 m.

5 The putlogs, with one end on the ledger and the other end on the wall, are then placed at a horizontal distance of about 1.20 m to 1.80 m.

6 The braces, guard rail and toe board are fixed.

Double (Independent) scaffolding or mason's scaffolding. (See fig 2)

Fig 2



DOUBLE SCAFFOLDING

1 This scaffolding is stronger than single scaffolding and it is used in the construction of stonework.

2 The framework is similar to the single scaffolding except that two rows of standards are provided.

3 The distance between the face of the wall and the first row of standard is about 200mm to 300 mm and the distance between the two rows is about one meter.

4 The rakers and cross braces may be provided to make the scaffolding more strong as shown in figure.

5 This type is also sometimes known as Independent Scaffolding.

Cantilever/Needles scaffolding

The general framework, in this type of scaffolding, may be of single scaffolding type or of double scaffolding type. But the standards are supported by a series of needles or ties which are taken out at floor levels or through openings or through holes kept in the masonry.

It is useful under the following circumstances,

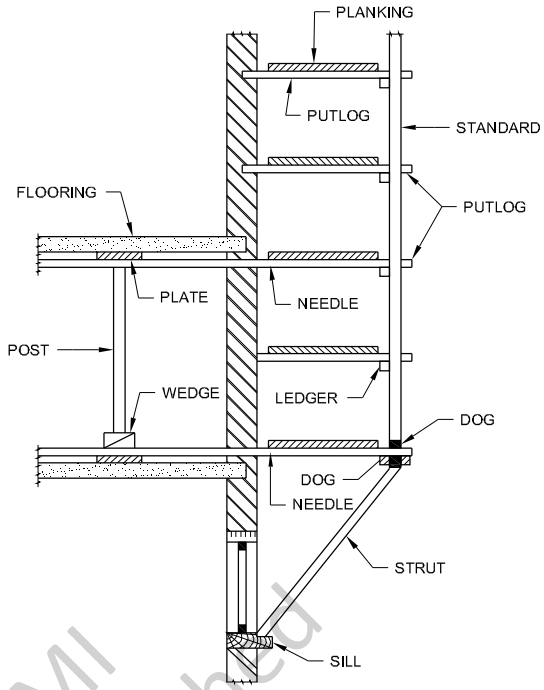
1 The proper hard ground is not available for the standards to rest.

2 It is desired to keep the road or pavement near the face of wall, clear of obstruction caused by the scaffolding.

3 The construction work is to be carried out for upper parts of a multi-storied building.

1 A Cantilever Scaffolding of Single Scaffolding Type (Fig 3)

Fig 3



CANTILEVER SCAFFOLDING

- The needles are supported at the floor levels and struted through projections such as sills, cornices, string courses, etc.
- The inner end of the needle projects sufficiently in side and is well strutted between the floors as shown in figure.

2 A Cantilever Scaffolding of Independent Type (Fig 4)

- The needles are passing through the openings and are strutted on the floors through the openings as shown figure.
- The suitable timber blocks should be interposed at the ends of struts on the floor levels.

Independent Type (See fig)

Suspended scaffolding:

1 This is a very light type of scaffolding and can be used only for the maintenance works such as painting, pointing, whitewashing, distempering, etc.

2 The working platform is suspended from the roofs by means of ropes, wires or chains and arrange ments are made such that the platform can be raised or lowered

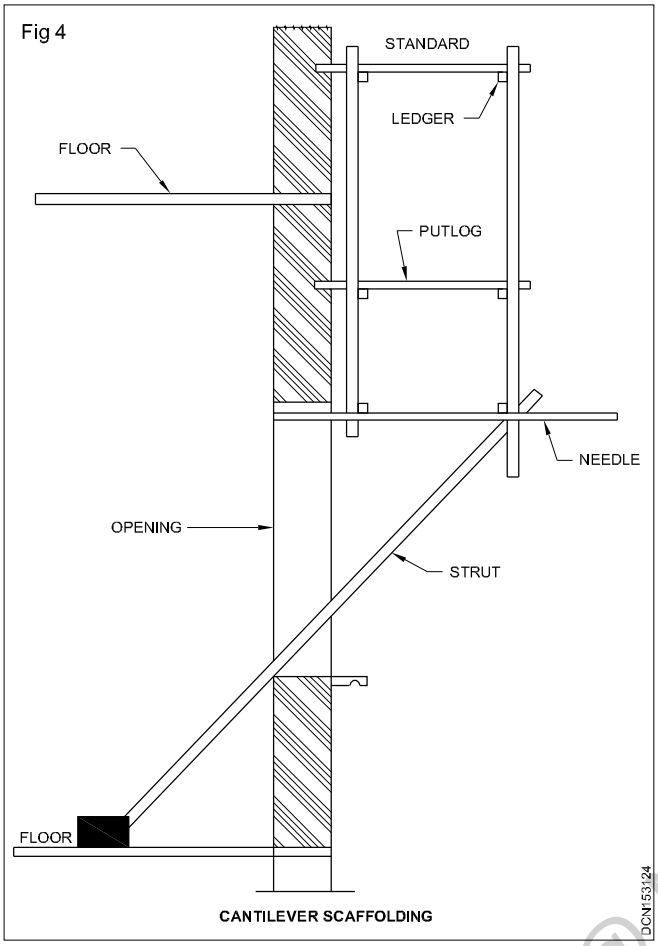
3 This type of scaffolding does not create any obstruction on the ground and

4 It is the most effective as it always provides the optimum level for working.

Trestle scaffolding

In this type scaffolding,

Fig 4



CANTILEVER SCAFFOLDING

1 The working platform is supported on movable contrivances such as ladders, tripods, etc., mounted on wheels.

2 It is useful for minor repairs or painting work inside the rooms and

3 The maximum height up to which this type of scaffolding can be adopted is about 5 m from the supporting surface.

Steel scaffolding

1 In place of timber, the steel tubes can be effectively used for the scaffolding work.

2 The diameter of the tubes is about 40 mm to 50 mm and the thickness is about 5 mm.

3 The tubes are available in standard lengths with special couplings and set-screws.

4 The advantages of steel scaffolding are manifold.

5 The scaffolding can be used up to any height;

6 It is strong and more durable;

7 It can be easily erected and dismantled;

8 It possesses high scrap value and it is resistant to fire.

9 The disadvantages are that the initial cost is high,

10 It requires skilled labour and

11 Also requires periodical painting.

Patented scaffolding

1 Now a days, the various patented scaffoldings made of steel, with special types of couplings and frames,

2 Usually the working platform is supported on a bracket which can be adjusted to any suitable height.

Important points for supervising the work of scaffolding

Following important points should be carefully attended to the scaffolding work;

1 Bedding of standards

If standards are not resting on the firm ground, the base-plates of suitable size should be provided at their bottom ends. Further, if required a timber sole plate may be provided on which all the base-plates rest.

2 Loading

The scaffolding should never be loaded heavily mainly because it is a temporary structure and in case of single scaffolding, one of the ends of putlogs rests on the green surface of the masonry.

3 Tying-In scaffold

It is necessary to tie back the scaffolding with the building at suitable levels. This can be achieved in different ways:

A vertical or horizontal tube, wedged by means of a reveal pin, may be provided in an opening and one of the ends of the putlogs may be coupled with this tube.

A tube may be provided across the opening inside the wall and one of the ends of the putlogs may be coupled with this tube.

4 The Rakers: Strutting from the ground level, may be provided.

5 Raising

As the work proceeds, the standards are suitably lengthened and fresh ledgers and putlogs are inserted. The working platforms are then shifted to new levels.

6 Finishing

After the scaffolding is removed, the holes of putlogs in the wall should be immediately filled up.

7 Spacing of standards

The loading on the scaffolding decides the spacing of standards. It is less for heavy loading and more for light loading .The maximum spacing is about 3 m.

8 Miscellaneous structure

The scaffolding of special types should be built for miscellaneous structure such as chimney's lowers domes etc.

Under pinning

Objectives : At the end of this lesson you shall be able to
- **define under pinning**
- **describe the situations demanding underpinning**
- **state the purposes**
- **follow the guide lines for supervise underpinning**
- **explain the methods of underpinning.**

Introduction

The placing of new foundation below an existing foundation or the process of strengthening the existing foundation is known as the underpinning of foundation.

Situations demanding underpinning

1 A building with deep foundations is to be constructed adjoining to an existing building.

2 The settlement of existing foundation has taken place.

3 The basement is to be provided to an existing building.

4 The existing foundations are to be depended so as to rest them on soil of higher bearing power.

Materials: used timber or steel etc.

Purpose/Uses: mainly to strengthening of existing foundation.

Important points to consider before underpinning

1 Shoring and strutting

The necessary shoring and strutting should be provided to the structure to make it safe for carrying out the process of underpinning.

2 Examination of structure

The structure should be carefully examined before underpinning is commenced and poor masonry work should be suitably rectified.

3 Repairs

It is necessary to carry out urgent repairs such as grouting of cracks, insertion of tie rods between walls, etc. before commencing underpinning.

4 Checking arrangement

The levels may be marked on the structure and the movement of structure during underpinning should be checked and recorded.

5 Expensive operation

The process of underpinning is an art rather than a science. Due to advance made in the science of soil mechanics, much guess-work in underpinning is eliminated. But still it remains an expensive operation.

6 Bearing plate

When R.S. joist is used as needle, the bearing plate is provided to avoid the crushing of masonry

Methods of underpinning:

Following are the methods of underpinning:

i- Pit method, ii- Pile method, iii- Miscellaneous methods.

Pit method (Fig 1)

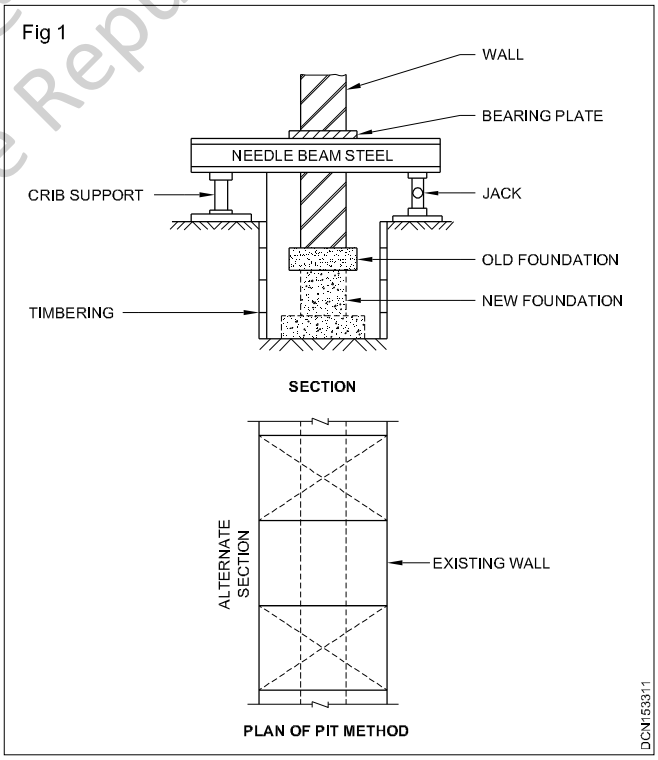
1 In this method the existing wall is divided into suitable sections of width about 1:20 m to 1:50 m.

2 The holes are then made in the existing wall.

3 The needles with bearing-plates are then inserted through these holes and supported on jacks.

4 The pit is excavated and the existing foundation is taken up to the required level.

Fig 1



Following precautions are necessary

1 One section should be excavated at a time.

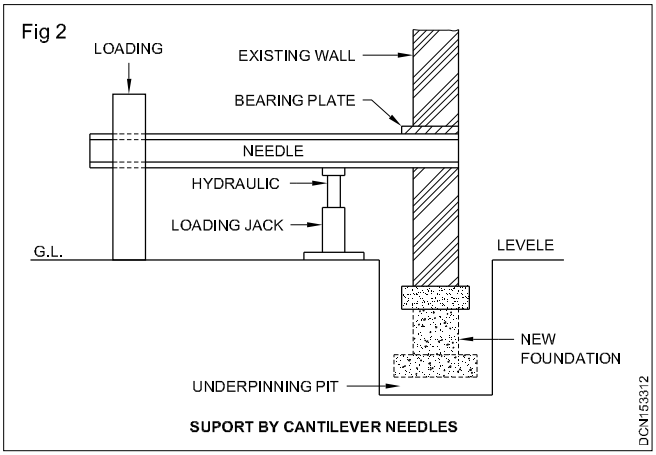
2 The alternate sections should be taken in succession.

3 If the length of wall is more, the underpinning is started from the middle and it is then extended in both the directions.

4 The proper timbering should be provided for the trench.

5 It is desirable to carry out the new foundation work in concrete.

6 If space to support needles on outside is not available, the cantilever needles, projecting inside and provided with fulcrums and loadings, may be adopted as shown in (Fig 2). A hydraulic jack is placed between the needles and fulcrum.



Pile method

1 In this method, the piles are driven along both the sides of the existing wall and

2 Then needles in the form of pile caps are provided through the existing wall as shown in fig.

3 Thus the existing wall is relieved of the loads coming on it.

4 This method is useful in clayey soils and for water-logged areas and for walls carrying heavy loads.

5 For structure and then brackets or cantilever needles are provided to carry the structure.

Miscellaneous methods

Following are some of the specialized underpinning methods which may sometimes be successfully adopted:

1 Cement grouting,

2 Chemical consolidation

3 Freezing ,

4 Vibroflotation.

1 Cement grouting

This method is used to restore slab or pavement which has settled. The operation is simple. The holes are drilled in the slab and the cement grout is forced under pressure through these holes. The pressure is maintained until the cement grout has set.

2 Chemical consolidation

In this method, the soil under the existing footing is consolidated by using chemicals.

The procedure for chemical consolidation is as follows

1 The perforated pipes are driven in an inclined direction.The inclination slopes are so adjusted that the entire area under the existing footing comes under the command of the inclined pipes.

2 When the pipes are being driven, the solution of sodium silicate in water is injected through the pipes.

3 The pipes are then withdrawn and during the withdrawal of pipes, the calcium or magnesium chloride is injected through the pipes.

4 The chemical reaction takes place between these two chemicals and the soil is consolidated.

5 This method is useful when the soil consists of sand or granular materials and the cost of consolidation depends on nature of soil, depth of consolidation, site of work, etc.

3 Freezing

1 In this method, the freezing pipes are driven below the existing footing and the soil is frozen.

2 This method is rarely adopted, mainly because of two reasons: (i) it is expensive and (ii) more time is required for the installation of freezing pipes.

4 Vibroflotation

1 In this method, the underpinning is carried out by vibrating the sand and

2 Thereby increasing its density which ultimately results in the increase of bearing capacity of soil.

3 This method is useful for granular or sandy soil and before the process of underpinning starts, the building or any of its structural components is shored carefully.

4 The vibrating equipment or soil to be compacted is to be isolated from the building and its shoring.

Formwork or shuttering

Objectives : At the end of this lesson you shall be able to,
- **definition of formwork.**
- **state requirements of formwork**
- **explain removable of formwork**
- **describe centering for various building components.**

Introduction

Temporary boarding or shuttering or sheeting created to hold concrete work for some days to allow the hardening and strengthening, of concrete is known as formwork (casing or shuttering).

Moulds: The term moulds is sometimes used to indicate formwork of relatively small units such as lintels, cornices.

Centering: For circular work such as arch, dome, etc. the term centering is generally used.

Materials: Materials used for formwork such as wooden, plywood, steel, combined wooden-steel etc.

Requirement of formwork:

1 It should be sufficiently strong to take the dead and live loads during construction.

2 It should be as water tight as possible.

3 It should be easily removable without damage to it.

4 Formwork gives a smooth level surface concreting.

Removal of formwork: (Stripping)

The operation of removing the formwork is commonly known as stripping.

Stripping time:

Formworks may be struck after expiry of following periods:

1 Walls, columns and vertical sides of beams- 24 to 48 hours as may be decided by the engineer-in-charge.

2 Slab soffits (props left under)- 3 days.

3 Beam soffits (props left under)- 7 days.

4 Removal of props to slabs:

i) Spanning up to 4.5 m- 7 days.

ii) Spanning over 4.5 m - 14 days.

5 Removal of props to beams and arches:

i) Spanning up to 6 m- 14 days

ii) Spanning over 6 m - 21 days.

Centering for square and circular columns

Shuttering for a column is probably the simplest.

It consists of the following main components:

1 Sheeting all round the column periphery,

2 Side yokes and end yokes,

3 Wedges and

4 Bolts with washers.

5 The side yokes and end yokes consist of two numbers each, and are suitably spaced along the height of the column.

6 The two-side yokes are comparatively of heavier section, and are connected together by two long bolts of 16 mm dia. Four wedges, one at each corner, are inserted between the bolts and the end yokes.

7 The sheathing is nailed to the yokes shuttering for octagonal and round columns.

Centring for beam and slab

1 The formwork for beam and slab floor.

2 The slab is continuous over a number of beams.

3 The slab is supported of 2.5 cm thick sheathing laid parallel to the main beams.

4 The sheathing is supported on wooden battens which are laid between may be propped at middle of the span through joints.

5 The side forms of the beam consist of 3 cm thick sheathing.

6 The bottom sheathing of the beam form may be 5 to 7 cm thick.

7 The ends of the battens are supported on the ledger which is fixed to the cleats throughout the length.

8 Cleats 10 cm X 2 cm to 3 cm are fixed to the side forms at the same spacing as that of battens, so that battens may be fixed to them.

9 The beam form is supported on a head tree.

10 The shore or post is connected to head tree through cleats.

11 At the bottom of share, two wedges of hard wood are provided over a sole piece.

Centering for concrete wall

1 Fix form for walls.

2 The boarding may be 4 to 5 cm thick for walls up to 3 to 4 m high.

3. The boards are fixed to 5 cm x 10 cm posts, spaced at about 0.8 m apart, known as studs or soldiers,

4. Horizontal waling of size 7.5 cm x 10 cm are fixed to the posts at suitable interval.

5. The whole assembly is then strutted using 7.5 cm x 10 cm struts.

6. The two shutters are kept apart equal to the thickness of the wall, by providing a 5 cm high concrete kicker at the bottom and by 2.5 cm x 5 cm spacers nailed to the posts.

Centering for arches:

1 A temporary structure (centering) is required to support brick, stone or concrete arches during their construction.

2 The upper surface of the centering corresponds to the shape of intrados of the arch.

3 The centering for arches consists of two parallel boards having their upper edges shaped to the required curvature.

4 The boards are connected through their curved length by mans of narrow wooden strip which are known as the laggings. These laggings are used to support the bricks or stones.

5 The centering is supported by props at each end.

6 The boards are prepared from two ribs whose thickness varies from 25 mm to 40 mm and whose width varies from 200 mm to 300 mm.

7 The struts and braces are provided to strengthen the

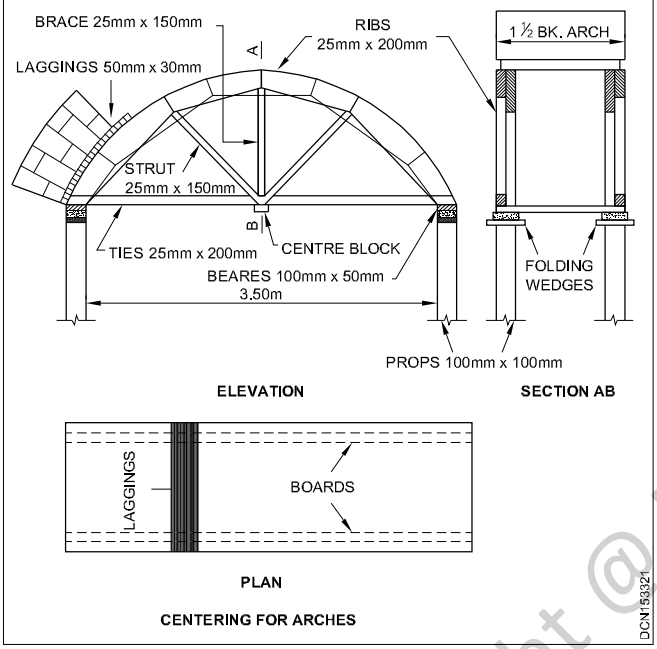
ribs to prevent them from spreading.

8 The ties are generally 25 mm to 50 mm thick and 200 mm to 250 mm wide.

9 The bearers support the ribs and a pair of folding wedges is provided at the top each drop to tighten or to loosen the centering.

Figure shows an arch centering for a span of 3.50 m and of width equal to 1½ brick thickness.Fig 1.

Fig 1



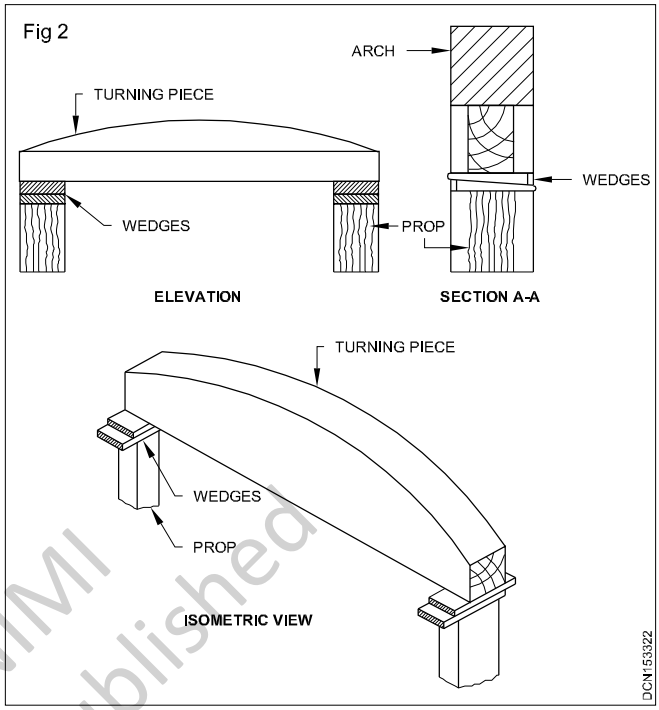
Following points should be noted in connection with the arch centering.

1 The length of laggings and the distance between the boards depend on the width of an arch. For rough and axed arches, the laggings are provided 20mm apart. But for gauged work, they are closely spaced.

2 The laggings should be kept 10 mm to 12 mm back from the face of arch work so that they will not form an obstruction to the line and plumb rule observed by the masons during construction.

3 A thick wooden plank can be used as centering for arch of thickness one-half brick. The plank is shaped to the curvature of the arch and it is supported on the props. Fig 2 shows the elevation, section and isometric view of centering with turning piece. The thick wooden plank with horizontal bottom and the upper surface shaped to the underside of the soffit is known as the center of turning piece. Its width is normally 100 mm and it is supported on vertical timber posts known as the props. The wooden wedges are provided to tighten or loosen the centering.

Fig 2



4 For small spans, the single ribs may be provided on side and laggings, bearers and folding wedges may be provided as usual.

5 The centering for arch should be removed after the arch has developed sufficient strength. For small spans, the removal of centering is done by slightly loosening the folding wedges. But when the span exceeds 7 m or so, a method known as the sand box method, is adopted to avoid shocks. A box is filled with sand and a hole is provided at the bottom of box. The hole is plugged to retain sand. The bottom of prop rests on a plate which is provided at the top surface of sand when it is desired to lower the centering, the plug is taken out and the sand is allowed to come out of the box. The prop is thus lowered gradually.

6 The construction of centering for an arch depends on the span of arch, rise or arch, form of arch curve and the materials of which arch is constructed .

Timbering of trenches

Objectives : At the end of this lesson you shall be able to,
- **definition of timbering of trenches.**
- **technical terms used for timbering**
- **method of timbering.**

Timbering of trenches

When the depth of trench is large, or when the sub-soil is loose, the sides of the trench may cave in. The problem can be solved by adopting a suitable method of timbering. Timbering of trenches, sometimes also known as shoring consists of providing timber planks or boards and struts to give temporary support to the sides of the trench.

Technical terms used for timbering

Following terms are used to denote the various members of the timbering

1 **Sheeting:** This is defined as the main plank which remains in contact with the sides of trench. The term sheathing is used to indicate vertical members of timbering which directly resist pressure from the side of a trench.

2 Ranger or wale: This is the name given to the piece of timber which transfers the load from the sheeting to the strut.

3 Strut: The piece of timber which maintains a fixed distance between the sheeting or between the walls is known as the strut.

4 Bracing: The diagonal piece of timber used to give rigidity to the framework is known as the bracing.

Methods of timbering

Following are the five methods of timbering:

1 Stay bracing

2 Box sheeting

3 Vertical sheeting

4 Runners

5 Sheet piling.

1 Stay bracing

1 This arrangement of preventing the slip of earth in foundation trenches is used when excavation is to be carried out in moderately firm ground and when the depth of excavation does not exceed 2 meter.

2 The vertical sheets or poling boards are placed opposite each other against the walls of the trench and they are held in position by one or two rows of struts.

3 The sheets are placed at an interval of 3 to 4 meter and generally, they extend to the full depth of the excavation.

4 The width of poling boards may be equal to 200 mm with thickness of about 40 mm to 50mm.

5 The struts may have size of 100 mm x 100 mm for trench up to 2 m width and 200 mm x 200 mm for trench exceeding 2 m in width.

2 Box sheeting

This arrangement of preventing the slip of earth in foundation trenches is used when excavation is to be carried out in loose soil and when the depth of excavation does not exceed 4 meters.

A box like structure is formed by providing sheeting, Wales, struts and bracings.

The arrangement is adopted for loose soil. In this arrangement, the vertical sheets are placed nearer or sometimes, touching each other as shown. The sheets are kept in position by longitudinal rows of Wales, usually two in number and then, the struts are provided across the Wales as shown.

The arrangement is adopted for very loose soil. In this arrangement, the sheets or planks are placed horizontally in plan and they are supported by Wales and struts as shown.

3 Vertical sheeting

For deep trenches up to about 10 meters in soft ground, the vertical sheeting is adopted.

The method is similar to box sheeting except that the work is carried out in stages and at each stage, an offset is provided. For each stage, vertical sheets, horizontal Wales, struts and braces are provided as usual. The offset is provided at a depth of 3 to 4 meters and its value varies from 300 m to 600 mm per stage.

Suitable movable working platform may be provided across the struts. This arrangement is very much suitable for laying sewers or water pipes at considerable depths.

4 Runners

In case of extremely loose and soft ground which requires immediate support as the excavation progresses, the arrangement, is adopted.

The runners which are long thick wooden sheets or planks are used in this arrangement. One end of a runner is made of iron shoe. The runners are driven by hammering about 300 mm in advance of the progress of the work. The Wales and struts are provided as usual.

5 Sheet piling

This arrangement of preventing the slip of earth in foundation trenches is adopted when-

a Large area is to be excavated for a depth greater than 10 meters or so;

b Soil to be excavated is soft or loose;

c Width of trench is also large; and

d Sub-soil water is present.

It should be noted that the sheet piles are designed to resist earth pressure only. The timber sheet piles can be used up to a depth of about 10 meters, depending upon the joints between them. The steel sheet piles are available in various sizes and patterns and can be used up to a depth of 30 meters.

The process consists of driving the sheet piles along the boundary of the area to be excavated. The sheet piles are driven slightly more than the depth of excavation. The work of excavation is then started and as soon as the excavation reaches a certain suitable depth, the vertical sheeting and struts are provided us usual, if required.

Damp proofing

Objectives : At the end of this lesson you shall be able to,

- **define damp proofing**
- **state the causes and effects of dampness**
- **describe the requirements of ideal damp proofing material**
- **state the materials used for damp proofing**
- **explain the methods of damp proofing**
- **explain the water proofing treatments for roofs.**

Introduction

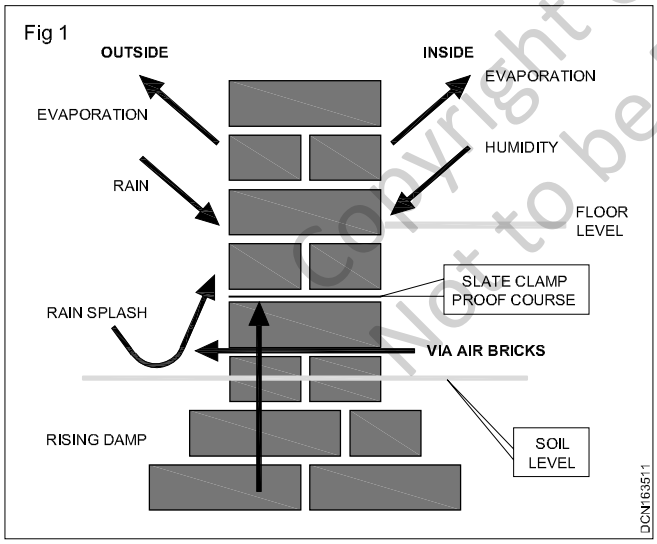
Dampness, is the unwanted and unauthorized accumulation of water in the building components. Continued presence of dampness in the building, deteriorates building components, spoils, the interior decoration and external appearance and affects the health and comfort of the occupants. Hence, in order to prevent the entry of damp into a building, the application of courses known as damp proofing courses, which are provided at various levels, at entry of damp into a building.

Definition

Treatments given to various places of building structure to keep walls, floors and basement dry, is called damp proofing.

Causes of dampness (Fig 1)

Fig 1



1 Rising moisture from ground
2 Condensation
3 Defective junctions between roof slab and parapet wall.
4 Defective roof covering of pitched roof
5 Faulty eaves and valley gutter.
6 Improper rain water pipe connections
7 Inadequate roof slope
8 Splashing of rain water
9 Unprotected tops of wall, parapet walls etc.

Effects of dampness

1 Metals used in the building corroded.
2 Unsighty patches formed
3 Decay of timber
4 Electrical deteriorated leakage of electricity and short circuiting.
5 Floor covering materials get damaged
6 Promotes the growth of termites.
7 Softening and crumbling of plaster
8 Gives rise to breading of mosquitoes, germs of dangerous diseases etc.
9 Wall decoration materials are damaged
10 Floorings get loosened
11 Cause efflorescence.

Requirements of an ideal damp proofing material

1 Durable
2 Remains steady and do not allow any movement it self.
3 Perfectly impervious
4 Capable of resisting the loads coming over it safely.
5 Flexible
6 Dimensionally stable
7 Reasonably cheap
8 Possible to carryout leak proof jointing work
9 Free from deliquescent salts like sulphates, chlorides and nitrates.

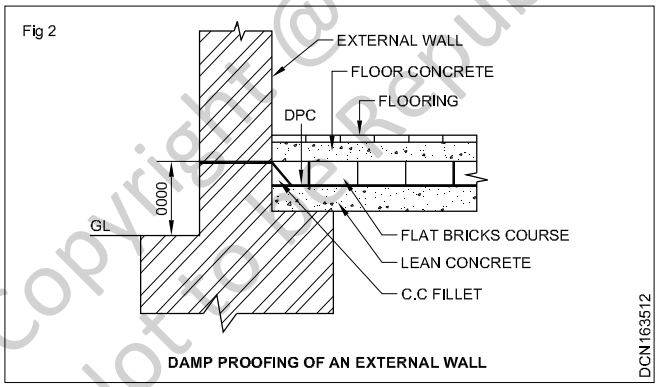
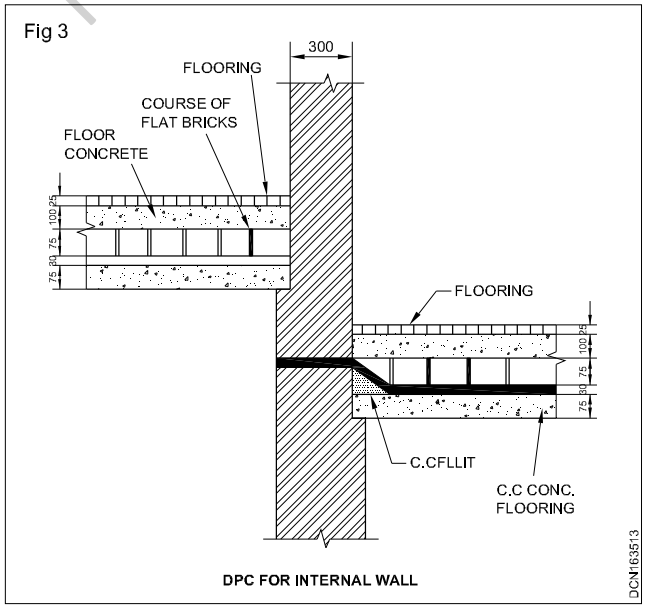
Materials for damp proofing

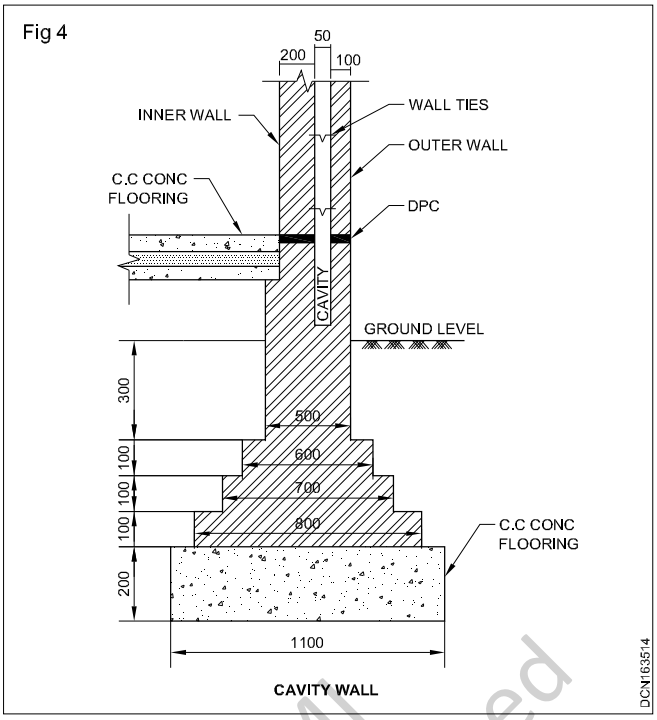
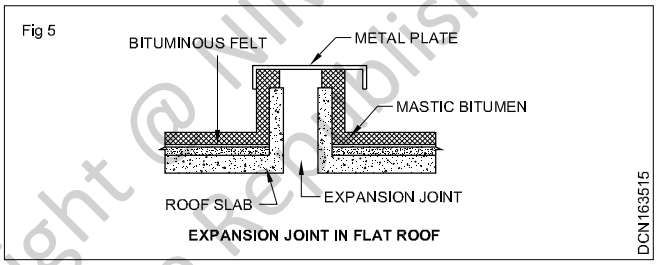
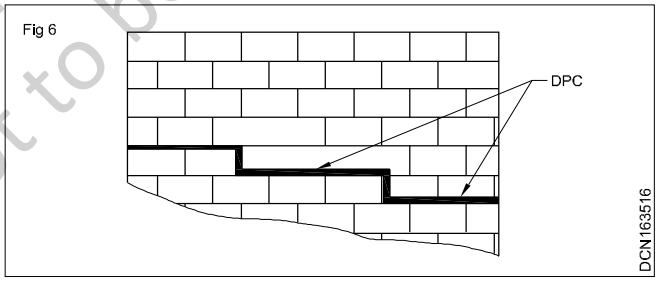
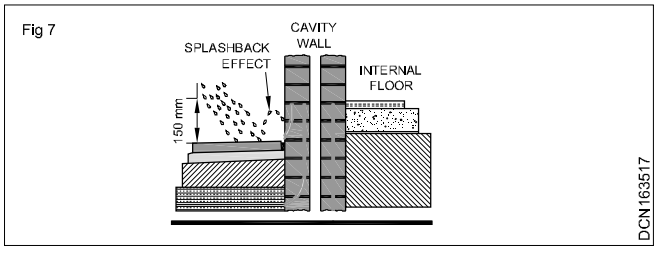
1 Bitumen
2 Mastic asphalt
3 Bituminous felt
4 Metal sheets (Lead, Copper, Aluminium)
5 Combination of sheets and felts
6 Stones
7 Bricks

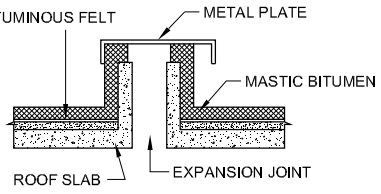
8 Mortar

9 Cement concrete

10 Plastic sheet.

Methods of damp proofing		
S.No	**Method**	**Description / Figure**
1	Integral treatment	Water proofing compounds or materials are added during the process of mixing the materials. Chalk, tale or filler's earth is used to fill the pores in concrete or mortar. Water proofing compounds such as Pudlo, Impermo etc. are used after diluting with water. Concrete is made water repellent by the use of soap solution, calcium and petroleum oil etc.
2	Surface treatment	Joints in brickwork or stone work are pointed or the surface is plastered. Paints, oils, waxes and soap solution are used for surface treatment. The cement paints act as vertical DPC.
3	Membrane damp proofing	This is done by providing a layer of water repellent materials between the source of dampness and part of the structure adjacent to it.
a (i)	Treatment to external walls	Fig 2  DAMP PROOFING OF AN EXTERNAL WALL
(ii)	Treatment to internal walls	Fig 3  DPC FOR INTERNAL WALL

S.No	Method	Description	Figure
b	Treatment to foundations against gravitational water		Fig 4  CAVITY WALL
c	Treatment to basements		Fig 5  EXPANSION JOINT IN FLAT ROOF
d	Treatment to sloping ground		Fig 6 
e	Treatment In pitched	1 In pitched roofs , the rain water gutters may be constructed in cement concrete and standard rain water fittings may be used. 2 The gutters lined with bituminous materials.	
4	Cavitywall construction	Cavity in between two walls prevents the moisture from reaching the inner wall Cavity wall prevent the entry of dampness	Fig 7 

S.No	Method	Description	Figure
5	Treatment to expansion and construction joints	The expansion joints and construction joints should be properly sealed by water proofing materials to obstruct the leakage of water.	Fig 8  EXPANSION JOINT IN FLAT ROOF
6	Guniting	Cement mortar consists of 1:3 is shot on the cleaned surface with the help of a cement gun, under a pressure of 2 to 3 kg/m2. Can be used over pipes, cisterns etc. for resisting water pressure	
7	Pressure grouting	Forcing cement grout, under pressure into cracks,voids,fissures etc. present in the structural components of the building or in the ground	

Water proofing treatment to flat roof

Flat roof must have to be provided with proper water proofing courses. Leakage of water through roof occur mainly due to stagnation of water at low area. To avoid this roof must have proper slope towards the outlets.

Following are the commonly adopted methods of water proofing treatments.

A Cement mortar plastering

1 The entire area of roof is cleaned with wire brush and all dirt is removed.

2 A neat cement wash is given to the surface and

3 20mm thick layer of cement mortar mixed with standard water proofing compound is laid and finished smooth.

B Tar felting

Hot bitumen is applied over the roof surface and tar felt is laid over it.

C Lime concrete terracing

1 It is most common in southern region of India.

2 They offer good resistance to solar radiation.

3 Lime concrete is made by mixing over burnt brick aggregate of size 25mm with lime mortar of 1:2mix.

4 First 10 cm thick lime concrete is laid, spread and rammed with wooden rammers.

5 Slope if required should be given in this layer.

6 Then entire surface is consolidated by beating.

D Lime concrete terracing with tiles

1 As explained above, proportion, method of laying, consolidation etc. is same.

2 At first a hot bitumen wash is given to the entire roof surface.

3 Then a layer of fine sand is spread immediately, when the bitumen is still hot.

4 Over this 10 cm thick lime concrete is spread and rammed with light rollers to get even thickness or the required slope.

5 Ramming is continued till 10 cm laid thickness will come down to 8 cm.

6 When lime concrete layer is still green, two courses of flat brick tiles are laid in cement mortar 1:3.

E Mud pushka terracing with tile paving

1 At first a layer of hot bitumen is spread over the entire roof surface.

2 The prepared mud pakka earth is spread to a thickness of 10 cm. and compacted to till the thickness reaches to 8cm.

3 Over this 25mm thick layer of mud mortar is laid and allowed to dry.

4 After drying up, a coat of gobi leaping is given.

5 Over this a layer of flat brick tiles is laid in mud mortar, and allowed to dry.

6 Joints are pointed with cement mortar 1:3.

7 Entire roof surface is covered with wet gunny bags.

8 After 12 hours brick terracing is cured by sprinkling of water.

Water proofing treatment for pitched roof

Usually the pitched roof has self draining property. The over laps should be as specified and size of gutters should be designed taking into consideration the average rainfall. The common methods adopted for water proofing are:

a Covering the entire roof surface with tar felt

b Covering the entire roof surface by lime mortar of proportion 1:1:2 (lime putty: surkhi: coarse sand)

Plastering

Objectives : At the end of this lesson you shall be able to,
- **to improve the appearace of the structure**
- **to give smooth surface**
- **to protect from atmosphere**
- **to cpm ceal the inferior materials and defective workmanship**
- **to protect from termites.**

Plastering

The method of applying mortar on the surface of masonry to protect the surface from atmospheric and to increase the beauty of the structure.

Requirements of good plaster

- it should adhere to the back ground
- it should hard and durable
- it should possess good workability
- it should be cheap and economical
- it should be possible to apply in all weather conditions

Types of mortar for plaster

- lime mortar
- cement mortar
- lime cement mortar
- water proof mortar

Method of plastering

- The mortar joints are raked to 20mm cleaned and well watered.
- A preliminary coat is applied to fill up the hollows
- Dots of 9mm to 10 mm thick are formed to make screeds at 2mm interval
- The first coat of plaster is applied, 9mm to 10mm thick
- The second coat of plaster is applied after about 6 hours with 2mm to 3mm thick
- If it is required a third coat also can be applied
- The completed work is allowed to rest for 24 hours and well watered for at least one week.

External finishes

Various types of external finished are given to the plastered surface to improve the appearance of the surface are

- Sand faced finish
- Pebble dash finish
- Rough cast finish
- Depeter finish
- Scrapped finish
- Textured finish

Fibrous plaster boards

It is combination of plaster canvas and lath united into structural mass in the form of pre-cast slabs or moulding. The fibrous plaster boards are available in different trade names in the market. These boards are used as final finishes to the surfaces.

Painting, Varnishing and Distempering

According to the nature of the surface and finishing required the surface are coated with paint, varnish, distemper or colour wash, etc. Painting is applied over surface of timber, metal or plasters, varnishing is applied over wooden surfaces and painted surfaces. Distempers are applied over plastered surfaces and white wash applied over distempered surfaces.

Special material for plastered surface

Material	Uses
Acoustic plaster	To make the room sound proof
Asbestos cement plaster	Beautiful marble like finish
Barium plaster	Used in X-ray rooms to protect the persons working
Granite silicon plaster	Quick setting highly elastic and used for superior work
Gypsum plaster	Fire resisting light in weight, not affected by bacteria, used for ornamental plaster, can be applied with ease and less wastage
Keene's cement	Used for skirting work, angles which gives glass like polish
Martin's cement	Internal finishing work

Painting

Objectives : At the end of this lesson you shall be able to,
- **protect surface from weathering effects**
- **prevent decay of timber and corrosion in metal**
- **gives good appearance to the surface**
- **provides smooth surface for easy cleaning.**

Methods of painting

- By brushes
- By spraying pistol
- By powder coating

Method of painting on different surfaces

Wood surfaces (new and repainting)

New woodwork

- Preparation of surfaces
- Knotting- Covering or killing of all knots in wood surfaces by red lead with glue or shellac with spirit or lime.
- Application of priming coat.
- Stopping - rubbing down of priming coat by pumice stone or glass paper or both
- Under coating second coat and successive coats are applied
- Finishing

Reprinting on old wood work

- Removal of old paint
  - With caustic soda
  - Mixture of soap, potash and quick lime
  - Washing soda and quick lime
- Cleaning of surfaces
- Under coating
- Finishing coat

Metal surfaces

New iron and steel surfaces

- Cleaning of surfaces removal rust, oil greease etc
- Treatment with phosphoric acid protects rusting
- Priming coat
- Under coating
- Finishing coating

Repainting old iron/steel

- Cleaning with soap water
- Removal of old paint by flaming cleaning
- Cleaning with caustic soda/slaked lime
- Priming coat
- Under coating
- Finishing coat

Galvanized iron

- To adhere paint, treatment with copper acetate or with another solution
- After 12 hours of this primer coat is applied
- Under coating
- Finsihing coat

Plastered Surfaces

Noted points are

Paint recommened for plastered surfces are cement paint, emulsion paint oil paint silicate paint etc

Surface is allowed to dry for 3 to 6 month to receive paint

Alkali resistant primer should be applied

Defects in plaster efflorescence should be removed

If necessary an antiseptic wash should be applied

Under coat and finishing coats are applied

Defects in Painting

Defects	Explanation
Blistering	Formation of bubbles on painted surfaces due to water vapour
Bloom	Formation of dull patches- due to bad ventilation
Fading	Gradual of colour - effect of sunlight
Flaking	Loose small portion - due to poor adhesion
Flashing	Glossy patches seen - bad workmanship, cheap paint
Grinning	Back ground is clearly seen - due to insufficient opacity
Running	Paint run back leave small area - due to too smooth
Sagging	When vertical and inclined surfaces are too thickly painted sagging occurs
Saponification	Formation of soap patches

Varnishing

Objectives : At the end of this lesson you shall be able to,
- **to brighten the appearance of natural grains in wood**
- **to render brilliancy to the painted surface**
- **to protect surface from atmospheric action.**

Application of varnish on wooden or painted surface is varnishing.

Process of Varnishing

Preparation of surface

The surface is smoothened by throughly rubbing it by sand paper or pumice stone.

Knotting

The process of covering or killing all knots in the wood work.

Stopping

Stopping is done by means of hot weak glue size so that the pores on the surfaces are filled up with boiled linseed oil.

Coats of varnishing

On the cleaned surface, two or more coats of varnish are applied .

Distempering

Objective : At the end of this lesson you shall be able to,
- **to create a smooth surface**

Application of distemper on plastered surface is known as distempering.

Process

Preparation on surface **:** Surface is thoroughly rubbed and cleaned.

Priming coat **:** It is applied and allowed to dry.

Coats of distemper **:** First coat is applied with a light tint and second coat is applied after heardening the first coat

White washing

Preparation of surface : The surface to be treated is well cleaned. The old loose white wash is removed and repairing plaster is carried out.

Application

The white wash is applied with jute brush. Three coats generally applied. Interior wall surface and ceilings are white washed.

Colouring washing

Colour wash is applied in the same fashion as white wash. This is prepared by adding the coloring pigment to the screened white wash. Exterior walls and interior walls are colour washed.

Termite proofing

Objectives: At the end of this lesson you shall be able to
- **define the term termite proofing**
- **state the types of termites**
- **explain the methods of anti termite treatment.**

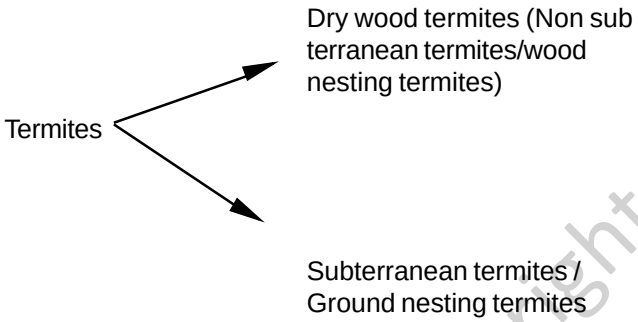
Introduction

The removal of termites from a building is not an easy task. The termites live in a colony and they are very fast in eating wood and other cellulosic materials as food. They damage materials of organic origin with cellulosic base, damage house hold articles like furniture, furnishings, clothing and stationary. Therefore it is necessary to adopt anti termite treatment in building.

Definition

The treatment which is given to a building to prevent or control the growth of termites is called termite proofing.

Types of termites



Methods of Anti-termite treatment

1 Preconstruction treatment

Here three operations involved.

a) Site preparation :- Remove stumps, roots, logs, waste wood etc. Detect termite mounds and destruct these by using insecticide solution. Chemicals for preparing solution are DDT, BHC, Aldrin, Heptachlor, Chlordane.

Chemical	Concentration by weight
DDT	5%
BHC	0.5%
Aldrin	0.25%
Heptachlor	0.25%
Chlordane	0.5%

Four litres of the above emulsion in water is required per cubic metre of volume of mound.

b) Soil treatment

The best method to protect the building to protect against termites is to apply a chemical treatment to the soil at the time of construction of the building. A complete chemical barrier is created.An insecticide solution consist of any one of the following chemicals in water solution.

Chemical	Concentration by weight
Aldrin	0.5%
Heptachlor	0.5%
Chlordane	1%

The emulsion should be applied evenly at the following stages.

Stage1-In foundation pits, to treat the bottom and sides upto a height of 30 cm.

Stage 2-Refill earth on both sides of the wall, for a width of 30cm and depth of 45cm approximately.

Stage 3-Before laying the floor ,entire levelled surface is to be treated at the rate of 5 litres of emulsion per square metre.

c) Structural Barriers:- These are concrete layer of 5cm-7.5cm thick or Metal sheets (Copper or G.I Sheets 0.8mm thick)

Post construction treatment

It is a maintenance treatment. Open earth around building and treat it with chemicals. In wood work or masonry work, bore holes and inject chemicals.

Fire protection

Objectives : At the end of this lesson you shall be able to,
- **define the term fire protection**
- **state the important considerations in fire protection**
- **explain the fire resistant construction.**

Introduction

Every building contains some materials which can either easily catch fire or which are impossible to fire..However, the architects and engineers should plan, design and construct the building in such a way that safety of the occupants may be ensured to the maximum possible extent.

Definition

It is defined as the protection of the occupants of the building, contents and structure of the building and adjacent buildings from the risks of fire and spread of fire.

Important considerations in fire protection:

1 It should be the objective of every engineer and arch tect while planning and designing the building that the structure offer sufficient resistance against fire so as to afford protection to the occupants, use of fire-resisting materials and construction techniques and providing quick and safe means of escape in the building.

2 All the structural elements such as floors, walls, columns, beams etc should be made of fire resisting materials

3 The construction of structural elements such as walls, floors, columns, lintels, arches etc

should be made in such a way that they should continue to function atleast for the time, which may be sufficient for occupants to escape safely in times of fire.

4 The building should be so planned or oriented that the elements of construction or building components can with stand fire for a given time depending upon the size and use of building, to isolate various compartments so as to minimize the spread of fire suitable separation is necessary to prevent fire, gases, and smoke from spreading rapidly through corridors, staircases ,shafts etc.

5 Adequate means of escape are provided for occupants to leave the building quickly and safely in terms of out break of fire.

6 In multi-storeyed office buildings suitable equipment for detecting, extinguishing and warning of fire should be installed in the niches.

Fire-resistant construction

National building code classifies the construction into four classes, namely type 1, type 2, type 3 and type 4 on the basis of fire-resistance offered by building components for 4-hours, 3- hours, 2-hours and 1-hour respectively. To achieve the objective of fire-resistance, due considerations should be made in design and construction of the structural members and use of combustible material should be avoided as far as possible in the construction

a) Walls and columns

b) Floor and roofs

c) Wall openings

d) Building fire escape elements (i.e.,) stair, staircase, corridors, entrances etc.

A Walls and columns:

1 The load-bearing non-load bearing walls should be plastered with fire resistive mortar.

2 Normally 20cm thick common wall is sufficient from fire resistance point of view.

3 Bricks should be preferred to stones if the construction is solid bearing wall.

4 For framed structures R.C.C. frames are preferred to those of steel frame.

5 Partition walls, should also be fire resistant materials.

6 Wooden partitions should be covered with metal lath and plaster.

7 Sufficient cover to R.C.C. members like beams or columns should be provided.

8 It has been recommended that a cover of atleast 5cm inside the main reinforcement of structural members, like columns, girders, trusses etc, 38mm for ordinary beam, long span slabs, arches etc, 25mm for partition walls, short spans should be provided.

9 Fire proofing treatments, which can possibly to concrete and steel column construction.

B) Floors and roofs

1 The floors and roofs should be made of fire-resisting material as they act as horizontal barriers to spread of heat and fire in vertical direction.

2 The floor such as concrete jack arch floor with steel joists embedded in concrete or hollow tiled ribbed floor, R.C.C. floor etc should be used as shown in figure.

C) Wall openings

1 The openings in the walls should be restricted to a minimum and they should be protected by suitable arrangements in case of fire.

2 Wireglass panels are preferred for windows.

3 Steel rolling shutters are becoming popular for door ways and window openings in garages, godowns, shops etc due to their ability in preventing the spread of fire

D) Building fire escape element

1 Staircases, corridors, Lobbies, entrances etc are the fire escape elements should be constructed out of fire-resistant materials and be well separated from the rest of the building.

2 Doors to the staircase, corridors and lifts should be made of fireproofing materials.

3 Staircase should be created next to the outerwalls and should be accessible from any floor in the direction of flow towards the exits from the building.

General measures of fire safety in building

In important buildings, in addition to the fire-resisting materials and adopting fire resistant construction, the following general measures of fire-safety have been recommended

i) Alarm system

ii) Fire extinguishing arrangements

iii) Escape routes for public buildings

Thermal insulation

Objectives : At the end of this lesson you shall be able to,

- **define thermal insulation**
- **state the advantages of thermal insulation**
- **state the thermal insulating materials**
- **explain the general methods of thermal insulation**
- **explain thermal insulation of roofs**
- **explain thermal insulation of exposed walls**
- **explain thermal insulation of exposed doors and windows.**

Introduction

When there is difference in temperature of inside of a building and outside atmosphere heat transfer takes place from areas of higher temperature to those of lower temperature. The aim of thermal insulation is to minimize the transfer of heat between outside and inside of the building.

Definition

The term thermal insulation is used to indicate the construction or provision by way of which transmission of heat from or in the room is retarded.

Advantages

1 Comfort-Thermal insulation keeps the room cool in summer and hot in winter.

2 Fuel saving-Since heat transfer is minimized due to thermal insulation,less fuel is required to maintain the desired temperature in the room.

3 Prevention of condensation-Use of thermal insulating materials inside a room results in prevention of condensation(moisture deposition) on interior walls and ceiling.

Thermal insulating materials

1 slab or block insulation.

2 blanket insulation.

3 loose fill insulation.

4 bat insulating materials.

5 Insulating boards.

General methods of thermal insulation

1 Heat insulation by orientation

- Orient the building with respect to the sun.
- During the day in summer minimum transfer of heat is desired.
- During winter maximum heating of rooms by solar heat is required.

2 Heat insulation by shading

- Shading of roof brings down the surface temperature.
- When the altitude angle of the sun is quite high ,during the period of peak heat gain this method is not effective.
- Raising the parapet walls can help only when the altitude angle of the sun is low.

3 Heat insulation by proper height of ceiling

- Provide a height of ceiling about 1 to 1.3 m above the occupants.

Thermal insulation of roofs

Heat gain through roofs may be reduced by adopting the following methods.

1 Heat insulating materials may be applied externally or internally to the roofs.

2 For flat roofs,external insulation may also be done by arranging asbestos cement sheets or corrugated galvenised iron sheets on bricks.

3 Shining and reflecting materials may be fixed on the top of the roof.

4 Roofs may be flooded with water in the form of sprays or otherwise.

5 Roofs may be white washed before on set of each summer

Thermal insulation of exposed walls

Heat insulation of the exposed walls may be achieved by the following ways

1 The thickness of the wall may be increased.

2 Cavity wall construction may be adopted, for external walls.

3 The wall may be constructed out of suitable heat insulating material.

4 Heat insulating material may be fixed on the inside or outside of the exposed wall.

5 Light coloured white wash or distember may be applied on the exposed side of the wall.

Thermal insulation of exposed doors and windows

Suitable methods should be adopted to reduce incidence of solar heat and heat transmission.

a) Reduction of incidence of solar heat:-This may be achieved by

1 External shading such as louvered shutters, sun breakers, etc.

2 Internal shading such as curtains and venetian blinds.

b) **Reduction of heat transmission**-This can be achieved by providing insulating glass or double glass with air space.

Arches

Objectives : At the end of this lesson you shall be able to,
- **define arch**
- **state the technical terms regarding the arch**
- **identify the components of arch**
- **classify the arches.**

Introduction

It is a geometrical shaped structure placed over an opening to transfer the load coming over it. It generally consist of small wedge shaped units which are joined together with mortar.

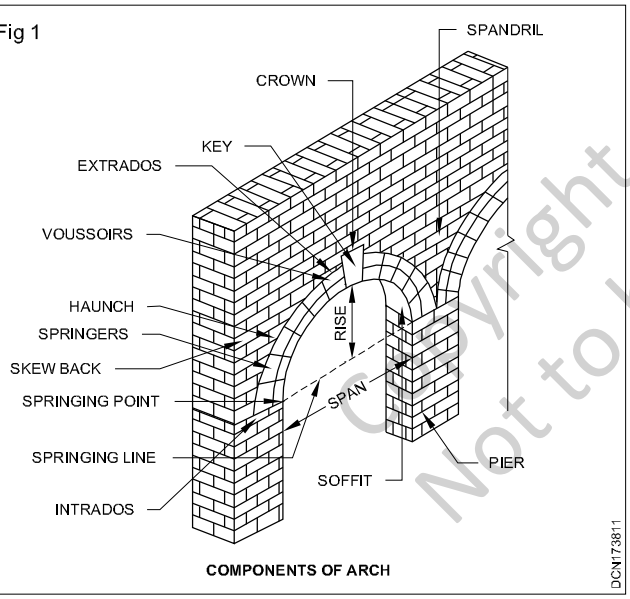
Arches made of steel and R.C.C is built in single units without the use of wedge shaped units and they are used for bridge construction.

Definition

An arch is a structure which is constructed to span across an opening.

Components of arch

Fig 1



COMPONENTS OF ARCH

Intrados : Inner curve of an arch.

Soffit : Inner surface of an arch.

Extrados : Outer curve of an arch

Voussoirs : Wedge shaped units of masonry

Crown : Highest part of extrados

Key : Wedge shaped unit fixed at the highest point of arch.

Spandril : Curved triangular space formed between extrados and the horizontal line through the crown.

Skew back : Inclined splayed surface on the abutment which is Prepared to receive the arch.

Springing point : Points from which the curve of the arch springs.

Springing line : It is an imaginary line joining the springing points.

Springers : The lowest voussoir immediately adjacent to the skewback.

Abutment : End support of an arch

Pier : An intermediate support of an arch

Arcade : Row of arches.

Haunch : Lower half of the arch.

Span : Clear horizontal distance between supports

Rise : Clear vertical distance between highest point on the intrados and the springing line.

Depth : Perpendicular distance between the intrados and extrados.

Thickness : Horizontal distance measured perpendicular to the front and back faces.

Classification of arches

Arches

According to shape	According to number of centers	According to materials used	According to workmanship
1. Flat arch	1. One centered arch	1. Brick arch	1. Rough arch
2. Segmental arch	2. Two centered arch	2. Stone arch	2. Rough cut
3. Semi-circular arch	3. Three centered arch	3. Concrete arch	3. Gauged arch
4. Bull's eye arch	4. Four centered arch	4. Purpose made	
5. Semi elliptical arch	5. Five centered arches		
6. Inverted arch			
7. Pointed arch			
8. Relieving arch			
9. Horse-shoe arch			
10.Stilted arch			
11.Venetian arch			
12.Florentine arch			
13.Ogee arch			
14.Tudor arch			
15.Drop arch.			

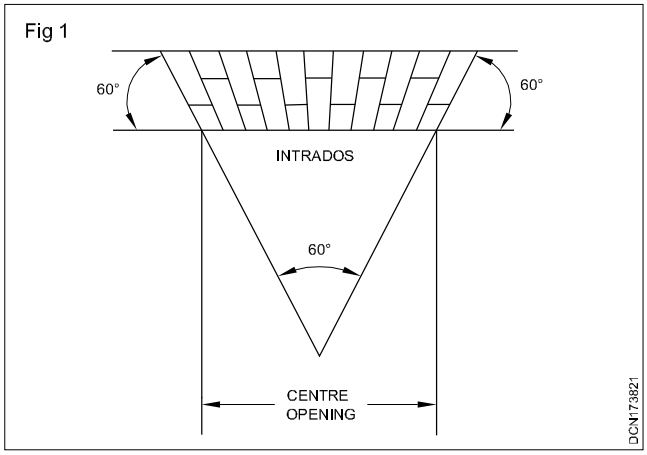
Arches according to shape

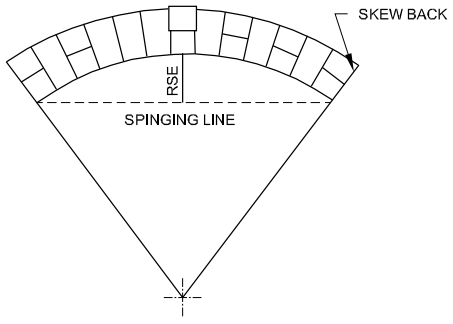
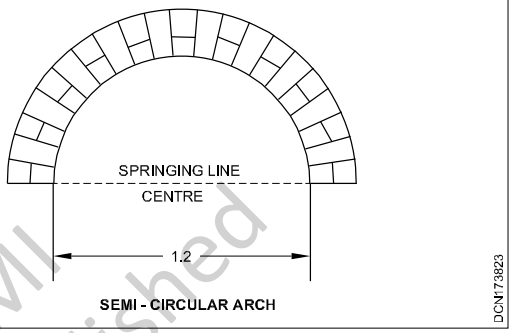
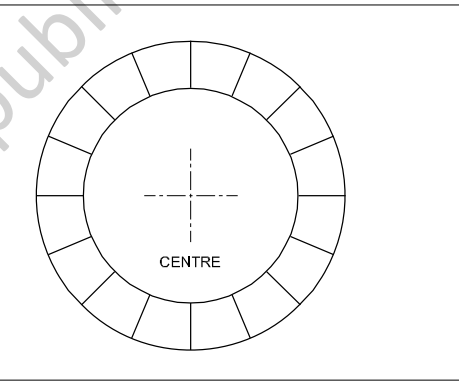
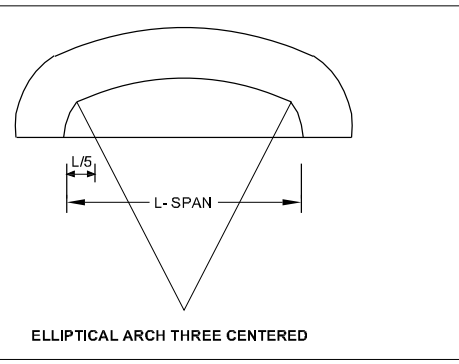
Objectives : At the end of this lesson you shall be able to,
- **classify arches according to shape**
- **state the technical terms regarding the arch**
- **classify the arches.**

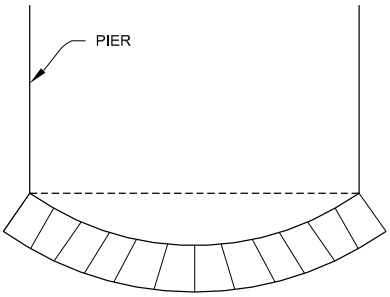
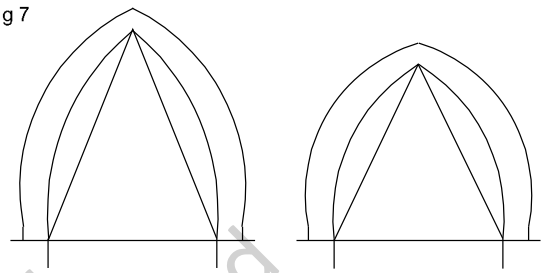
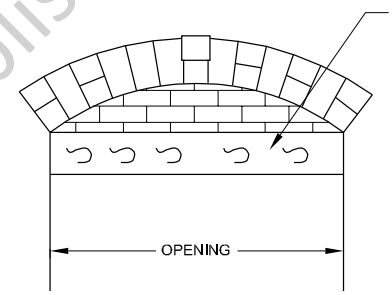
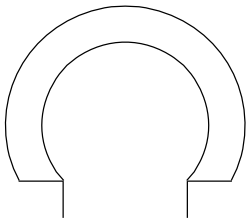
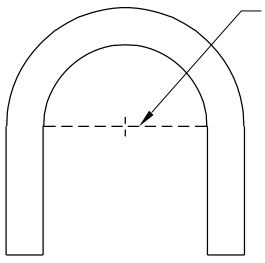
According to shape ,the arches are classified as follows.

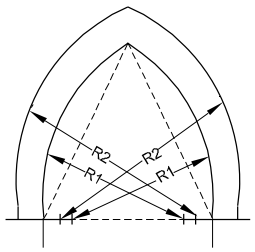
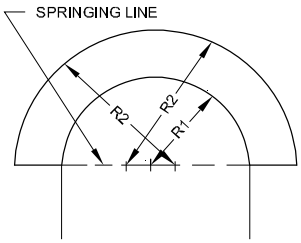
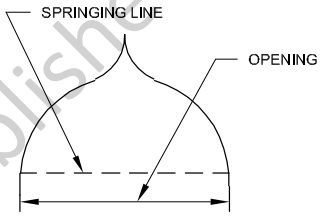
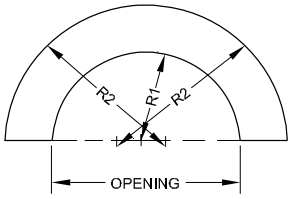
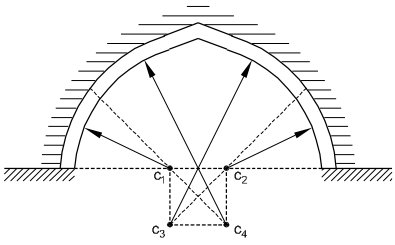
Classification of arches according to shapes

Classification of arches according to shapes

Name of arch	Features	Figure
1 Flat arch	• Shape flat and skewback forms 60 degree with horizontal. • Depth equal to course of masonry. • Slight rise of about 10mm to 15mm per metre length of masonry opening. • Max.span upto 1.5m • Used for light loading.	Fig 1 

Name of arch	Features	Figure
2 Segmental arch	• Centre of arch is below spring line. • Thrust transferred to the abutment in an inclined direction	Fig 2 
3 Semi-circular	• Centre of arch lies on the springing line • Skewback is horizontal. • Thrust transferred to the abutment in vertical direction.	Fig 3 
4 Bull's eye arch	• One centre only. • Used for circular windows	Fig 4 
5 Semi -elliptical	• More than one centre arch (Three or five)	Fig 5 

Name of arch	Features	Figure
6 Inverted arch	• Constructed between piers to increase the bearing power of soil. • Rise is 1/5 to 1/10 of span. • Built in ½ brick rings.	Fig 6  INVERTED ARCH DCN173826
7 Pointed arch	• Two curves meeting at the apex of a triangle. Two types are • Equilateral arch and • Lancet or isosceles arch.	Fig 7  LANCET OR ISOSCELES ARCH EQUILATERAL ARCH DCN173827
8 Relieving arch	• Constructed over a wooden joist or flat arch. • It relieves the joist or flat arch from carrying load.	Fig 8  RELIEVING ARCH DCN173828
9 Horse shoe arch	• Adopted from architectural considerations. • Shape include more than a semicircle.	Fig 9  HORSE - SHOE ARCH DCN173829
10.Stilted arch	• Semi circular portion attached at the top of two vertical por=tions. • Springing line passes through the top of vertical portions.	Fig 10  STILLED ARCH DCN17382A

Name of arch	Features	Figure
11 Venetian arch	• Depth at crown is more than that at the springing line. • Have four centres.	Fig 11  VENETIAN ARCH DCN17382B
12 Florentine arch	• Similar to venetian arch except that the intrados has a Semi circular shape.	Fig 12  FLORENTINE ARCH DCN17382C
13 Ogee arch	• Consist of three centres and with reverse (Ogee) curve.	Fig 13  OGEE ARCH DCN17382D
14 Drop arch	• Consist of two centres	Fig 14  DCN17382E
15 Tudor arch	• Consist of four centres. • This is a pointed arch of four centres.	Fig 15  DCN17382F

Arches according to number of centres

Objectives : At the end of this lesson you shall be able to,
- **classify arches according to number of centers**
- **sketch the various arches with number of centers**
- **state the features of arches according to the number of centers.**

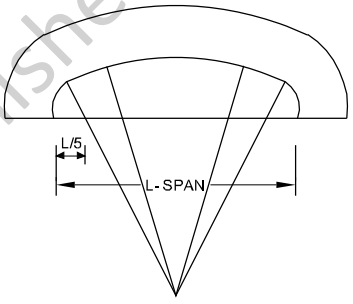
According to number of centers ,the arches are classified as follows

Classification of arches according to number of centres

Name of arch	Description	Example
1 one- centered arch	This type of arches have only one centre	Flat, Segmental, Circular, Horse shoe, Stilted, Etc.
2 Two- centered arch	This type of arches have two centers	Pointed arches ie, Equilateral pointed and isosceles pointed arch (Lancet and Drop).
3 Three-centered arch	This type of arches has three centers	Three centered semi-elliptical arch, Florentine arch, Ogee arch.
4 Four-centered arch	This type of arches has four centers	Venetian, Tudor.
5 Five-centered	This type of arches has five centers	Five centered semi elliptical arch.

We can make more types of arches with more number of centers.

Fig 1



FIVE CENTERED SEMI ELLIPTICAL ARCH

DCN173831

Arches according to material of construction & workmanship

Objectives : At the end of this lesson you shall be able to
- **classify arches according to material of construction & workmanship**
- **state the features of arches according to material of construction**
- **state the features of arches according to workmanship.**

ARCHES

- Stone arches
  - 1.Rubble arches
  - 2.Ashlar arches
- Brick arches
  - 1.Rough brick arches
  - 2.Axed or rough cut brick arch.
  - 3.Gauged brick arches and
  - 4.purpose made brick arches
- Concrete arches
  - 1.concrete block arches
  - 2. Monolithic arches

Classification of arches according to materials of construction

NAME	TYPE OF MATERIALS	DESCRIPTION
Stone arch	1 In ashlar masonry	• Constructed from wedge shaped units.
	2 In rubble masonry	• Stones should be laid with their natural bedding plane.

NAME	TYPE OF MATERIALS	DESCRIPTION
Brick arch	1 With ordinary bricks 2 With purpose made brick 3 With soft brick	• Weak and used for inferior work. • Span limited to 1m or so • Joints are made wedge shaped. • Not suitable for exposed brick work. • Good quality arch work. • Soft bricks are cut,sawn and rubbed to desired shape.
Concrete arch	1 With precast concrete blocks 2 Monolithic concrete	• Similar to stone arches in ashlar masonry. • Constructed from cast in -situ concrete and are suitable for long spans.

Classification of arch according to workmanship

Name	Description
1 Rough arch	• Using ordinary uncut bricks • Bricks are rectangular shape and mortar joints are wider at extrados than at the intrados. • Rough arch is used where appearance is secondary importance, the arch surface is plastered.
2 Axed or rough cut arch	• The bricks used are wedge shaped by means of an axe • The thickness of mortar joints varies 3 mm to 6 mm.
3 Gauged arch	• The bricks used are wedge shaped by means of a wire saw, the bricks are cut finely. • The mortar joints are 1.5mm to .75mm

Centering of arches

Objectives : At the end of this lesson you shall be able to,
- **define centering of arches**
- **identify the components of a timber centering**
- **state the features of centering**
- **explain removal of centering.**

Definition

It is the temporary structure which supports arch during construction or till it attains strength.

Centering of arch

- Timber centering is commonly used because it is simple to erect, dismantle & reuse.
- Narrow wooden strips known as 'LAGGING' supports the brick or stone of arch.
- Two parallel boards called 'RIBS'having their upper edge shaped to the curvature of arch to support Laggings.
- The struts & braces strengthen the rib.
- A horizontal ties provided at lower end of rib to prevent from spreading.
- The bearer support the rib.
- The whole centering is supported by props.
- A pair of folding wedges used to tighten or loosen the centering.
- The whole centering parts except props can be replaced

Removal centering

- The centering can be removed after attaining sufficient strength for arch .
- For small spans the removal is done by slightly loosening the wedges
- Spans exceeding 7m or so , bottom of the prop secured in sand box which is filled with sand having a plug.
- To lower the centering remove the plug and the prop lowered gradually.

Lintels with chajja

Objectives : At the end of this lesson you shall be able to,
- **define lintel**
- **explain bearing of lintel**
- **list out the materials used lintel**
- **classify the lintel according to material of construction.**

Introduction

A lintel can be a load bearing building component placed over an opening. The function of lintel is just the same as that of an arch or a beam. However the lintels are easy and simple in construction. Lintels are made from various materials. The lintels of RCC are widely used to span the openings for doors, windows etc. in a structure.

Definition

A Lintel is a structural horizontal member which is placed across an opening to support the portion of the structure above it.

Bearing of lintel

Bearing of lintel means the distance up to which it is inserted in the supporting wall. Bearing should be the minimum of the following three considerations.

1 150 mm or

2 The height of lintel or

3 1/10th to 1/12th span.

Materials for lintels

The common materials used in the construction of the lintel are as follows.

1 Wood or timber

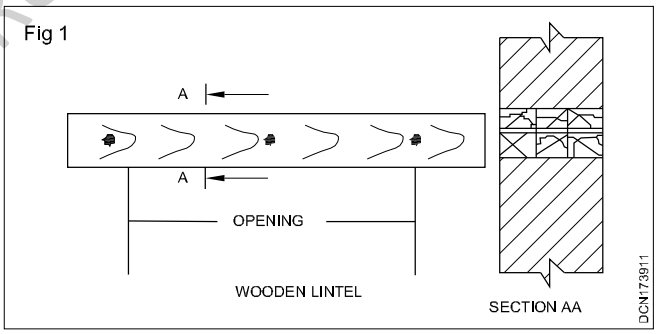
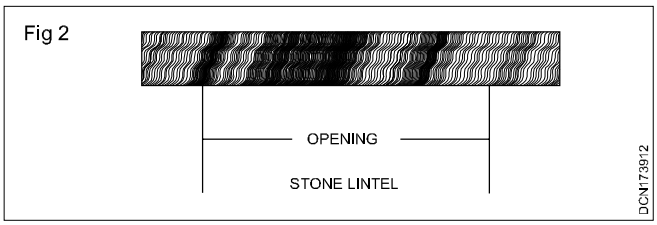
2 Stone

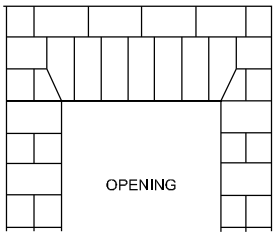
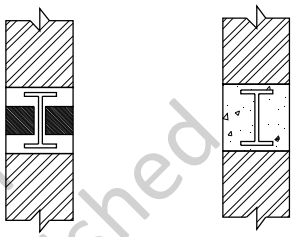
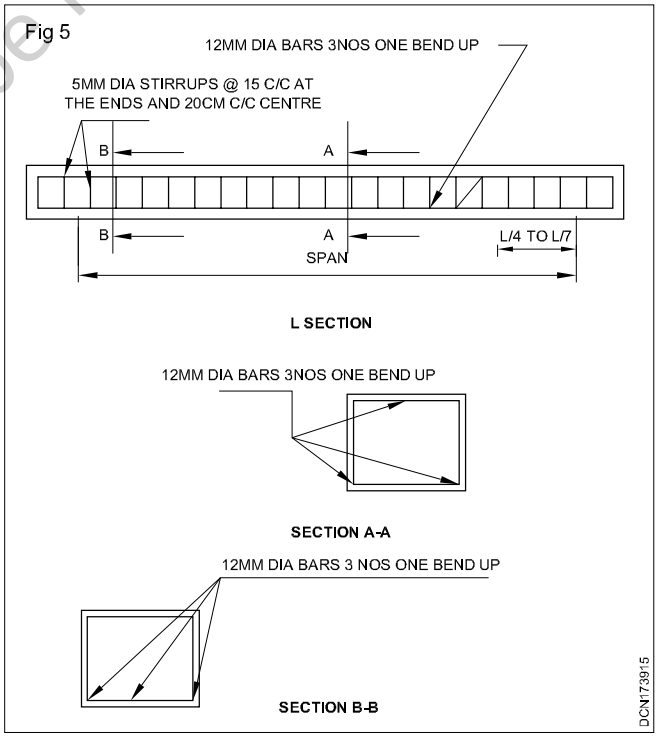
3 Brick

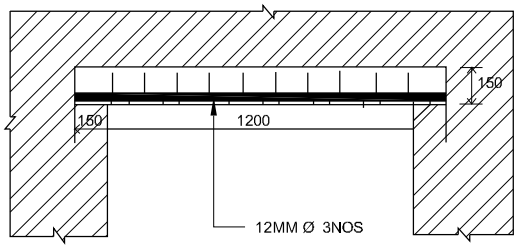
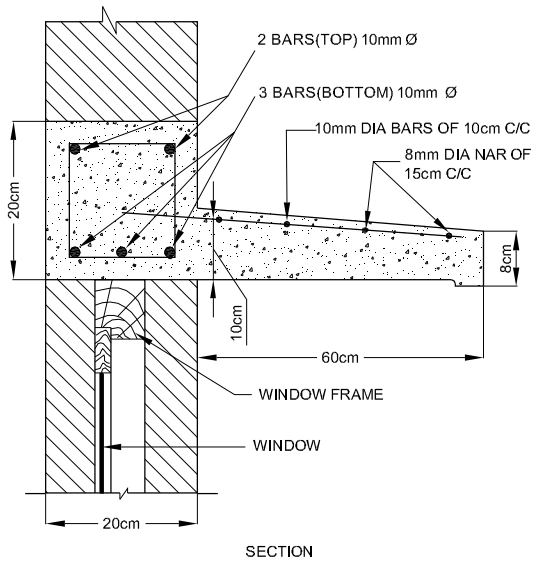
4 Steel

5 Reinforced cement concrete

Classification of lintels according to the material used

Name	Features	Figure
1 Wood or timber lintel.	A single piece of timber or built up sections of wood can be used as a lintel. • A bearing of about 15 cm to 20 cm should be provided. • The width of lintel should be equal to the opening • The depth of lintel should be about 1/12 to 1/8 of the span with a minimum value of 80 mm.	Fig 1 
2 Stone lintel	These lintels consists of slabs of stones which it placed across the openings. **Disadvantages of stone lintels** • Stone posses low tensile resistance. • It is difficult to obtain a good stone of required depth.	Fig 2 

Name	Features	Figure
3 Brick lintels	Brick lintels consist of bricks which are generally placed on edge. • bricks should be well burnt, copper coloured • free from cracks and with sharp and square edges. • this lintel have a depth equal to some multiple of brick courses. • Suitable up to a span of one metre and for greater spans reinforcement or steel angle may be provided.	Fig 3  DCN173913
4 Steel lintels	• steel lintels consist of steel angles or rolled steel joists. Steel angles are used for small spans and light loading. • Rolled steel joists are used for large spans and heavy loading. • Tube separator-may be provided to keep the joists in position. • R.S.J - The joists are embedded in concrete to protect steel from corrosion and fire.	Fig 4  DCN173914
5 Reinforced cement concrete a. Precast RCC	These lintels consists of reinforced cement concrete. The usual mix for concrete R.C.C lintel is 1:2:4 lintels lintels Properties of R.C.C lintels. • fire proof • durable • strong • economical • easy to construct • no relieving arches are necessary. The reinforcement provided depends on 1 span of lintel 2 width of opening 3 total load to be supported • Economical, Increase speed of construction • Allow sufficient time for curing before fixing.	Fig 5  DCN173915

Name	Features	Figure
b. Cast in situ RCC Lintel	• Centering is prepared reinforcement is placed and concreting is done.	Fig 6  REINFORCED BRICK LINTEL DCN173916
6 Reinforced Brick lintel	Brick lintel strengthened by the provision of mild steel. In this use first class bricks with high compressive strength. Dense cement mortar is used to embed the reinforcement. It is adopted or used in the following circumstances. • Brickwork has to bear tensile and shear stress • To increase the longitudinal bond • Brickwork supported on large settlement soil. • Brickwork is supported to act as a beam or lintel over opening • When brickwork is to resist lateral loads as in retaining walls • To carry heavy compressive load • In seismic areas	
7 R.C.C. lintel with chajja or canopy	• The number of main bars depends upon the load to be carried from the wall above and span of opening. • The diameter of the bar varies with the span and is adopted as follow • 6 mm ϕ bar span upto 1 m • 8 mm ϕ bar span 1 to 1.5m • 10 mm ϕ bar span 1.5 to 2 m • 12 mm ϕ bar span 2 to 3 m • The details of chajja projection or canopy is shown in Fig. 7	Fig 7  R.C.C LINTEL WITH CHAJJCH (OR) SUNSHADE DCN173917