SILIGURI INSTITUTE OF TECHNOLOGY

CIVIL ENGINEERING

PAPER DESCRIPTION : BIOLOGY LAB

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Semester __3RD_________ Year _____2ND________

Sl no	Name of the experiments
1	Isolation of Genomic DNA from bacterial cell.
2	Study of mineral crystal in plants
3	Isolation of plasmid DNA from bacterial cell.
4	Comparison of stomatal index in plants
5	Construction of ecological pyramids of population size in an eco system.
6	Data analysis using biostatistics tools
7	Determination of importance value index in of a species in a plant community.

ISOLATION OF GENOMIC DNA FROM GRAM POSITIVE BACTERIA

Aim- To isolate bacterial genomic DNA.

Principle-DNA, deoxyribonucleic acid, is the molecule of life. Every living organism has DNA in each cell of the organism and each molecule of DNA carries the blueprint for that organism. The DNA molecule is also responsible for heredity, passing on genetic information from parents to child. DNA molecules are large strands or chains of small molecules known as nucleic acids, which are localized in the nucleus of a cell. DNA isolation is a process of purification of DNA of sample using a combination of physical and chemical method. The gram positive bacterial cell wall I composed of a thick peptidoglycanelayer. For the rupture of the cell membrane different types of reagents are used. In the first step NaCl: EDTA solution as a cofactor is used for several times. NaCl increase osmotic pressure inside the cell and EDTA chelates Mg2+ ions from the cell which is needed for activation of DNAse enzyme which cleaves the DNA, so prevent the activation of DNaseenzyme. The peptidoglycane is composed of N-acetyl glucosamine (NAG) and N- acetyl muramic acid (NAM) which are linked by β1-4 glycoidic bond. To break this linkage lysozyme is used. This will rupture the cell membrane completely.Addition of SDS as a detergent or surfactant also helps in cell lysis. Proteinase k degrades the protein molecule by cleaving the proteins at peptide bond adjacent to the carbonylic group at the aliphatic and aromatic amino acid. The saturated phenol: chloroform (1:1) is used to remove the protein completely by altering the hydrophobicity of proteins. 0.8ml volume of isopropanol and three molar sodium acetate is used to precipitate the DNA. The isolation of genomic DNA is usually done to study the morphological structure of DNA of bacteria.

Requirements- 1. 24hrs old gram positive bacterial culture.

2. Eppendrof tubes

3. Different volumes of conical flasks.

4. Micropipettes and tips

5. Double distilled water.

6. Discarding beakers.

Reagents- NaCl: EDTA solution, SDS(Sodium dodecyl sulfate), Proteinae K, Phenol: chloroform(1:1), Tris- saturated phenol , Lysozyme, Isopropanol, Sodium acetate, 70% ethanol, 1X TAE buffer, Agarose gel, Gel electrophoresis apparatus.

Procedure-1.10ml nutrient brith was inoculated with a single colony of the target organism and grown over night at 37ºC.

2.Bcterial cell harvested at 8000rpm for 5min at 4ºC(pellete collected)

3.Pellete washed thrice with 1ml NaCl : EDTA solution.

4.Pellete homogenously mixed and centrifuged at 8000rpm for 5min.

5.Pelleteresuspended in 10 µl of NaCl : EDTA solution and freshly prepared lysozyme (100µl) added and mixed.

6. Incubated at 37ºC for 1hr in intermediated shaking.

7. Volume of mixture was made 500 µl by adding NaCl:EDTA solution.

8. 50 µl of 10% SDS / pinch of SDS added followed by 10 µl ProteinaseK (20gm/ml).

9. Content were mixed thoroughly and incubated at 55ºC for 1hr or till the solution become clear.

10. Afterincubation, equal volume of Tris- saturated phenol added.

11. Resultant mixture was centrifuged at 10,000rpm for 10mins at 4ºC.

12.Aqueous phase taken in another fresh eppendrof and equal volume of phenol: chloroform was added.

13. Centrifuge at 10,000rpm for 10mins at 4ºC.

14. Aqueous phase taken and DNA is precipitate out with 0.8 volume isopropanol and 0.3 volume of three molar sodium acetate.

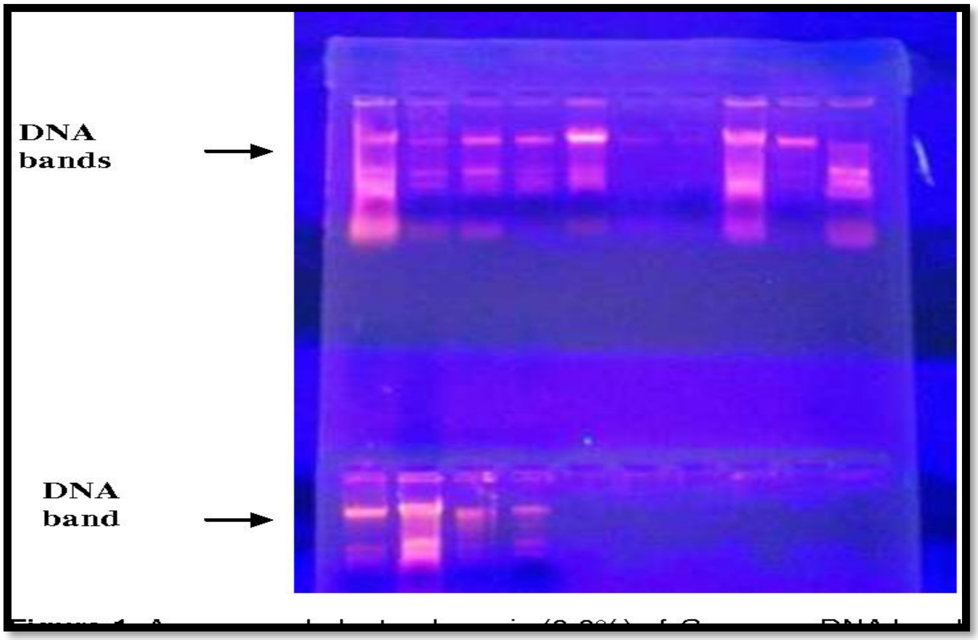
15. Centrifuge at 10,000rpm for 10mins at 4ºC.

16. Supernatant discarded and pellet washed with 70%ethanol(1ml).

17. Centrifuged at 10,000 rpm for 10mins at 4ºC.

18. Discard the alcohol and air dried the microfuge tube and add 20 µl of TAE buffer or sterile double distilled water .

19. The DNA is checked in 1X TAE buffer in 1% agarose gel.



<u>Fig- Gram positive genomic DNA bands on UV illuminaton</u>

<u>Observation-</u> After isolation of bacterial DNA the DNA was seen by using agarose gel electrophoresis apparatus and then visualized in a UV illumination.

<u>Result-</u>On illumination of agarose gel into a U.V illuminator, Orange colored DNA bands were seen.

This coloration is due to the EtBr that bound to the DNA molecule and gave visible effect on UV illumination.

STUDY OF MINERAL CRYSTALS IN PLANTS

Aim- To study structure and types of mineral crystals in plants.

Principle-Mineral formation in plants is common .In the biomineralization process, calcium is the predominant cation in most organisms, and calcium-bearing minerals comprise about 50 % of known biominerals. The most abundant minerals formed by plants are silica, calcium carbonate and calcium oxalate. Calcium is an essential plant nutrient, which performs many fundamental functions in cellular metabolism, and the divalent cation of calcium is a counter-cation for inorganic and organic anions in the vacuole. The calcium concentration of plants varies between 1 and >50 mg g^{-1} dry mass (DM) depending on the species, growing conditions and plant organ.Crystal formation is usually associated with membranes, chambers, or inclusions found within the cell vacuole(s). Tubules, modified plastids and enlarged nuclei also have been reported in crystal idioblasts. The Ca oxalate crystals consist of either the monohydrate whewellite form, or the dihydrateweddellite form.Although the shape, size and number of crystals show variations among taxa, they have been classified into five main groups based on their morphology: as prism, druses, styloids, raphides and crystal sand .Various physical, chemical and biological parameters such as light, temperature, pH, ion concentration and herbivory may affect the location, size and other properties of crystals in plants.

Many functions have been attributed to calcium oxalate crystals in plants such as participating in calcium homeostasis, storage of calcium ,removal of excess oxalate, metal detoxification, tissue support, light gathering and reflection ,and protection against insects and foraging animals. Calcium oxalate crystals protect plants against herbivores by their association with irritating chemicals or with proteolytic toxins. Mechanical effect of needle like crystals which puncture the foraging animals is also important part of the plant defence.

Requirements-1. Leaves of *Hypericumperforatum* L. (Hypericaceae)

2. A double-edged razor blade.

3.2·5 % (v/v) glutaraldehyde.

4.phosphate-buffered saline.

5.Ethanol series (50, 70, 90, 100 %, v/v).

6.Glycol methacrylate.

7.Glass knives.

8.0·05 % (w/v) toluidine blue O in benzoate

9. Bright field microscope.

Process-

1. Fresh, healthy and intact mature phyllodes were cut into small segments (about 3–5 mm long) using a double-edged razor blade.
2. Then segments were fixed in 2·5 % (v/v) glutaraldehyde in phosphate-buffered saline at pH 7·4.
3. After that segments are dehydrated in an ethanol series (50, 70, 90, 100 %, v/v), then infiltrated and embedded with glycol methacrylate .
4. Cross-sections of embedded samples were cut at a thickness of 2 μm with dry glass knives.
5. Sections were stained with 0·05 % (w/v) toluidine blue O in benzoate buffer at pH 4·4.
6. The stained sections were photographed.

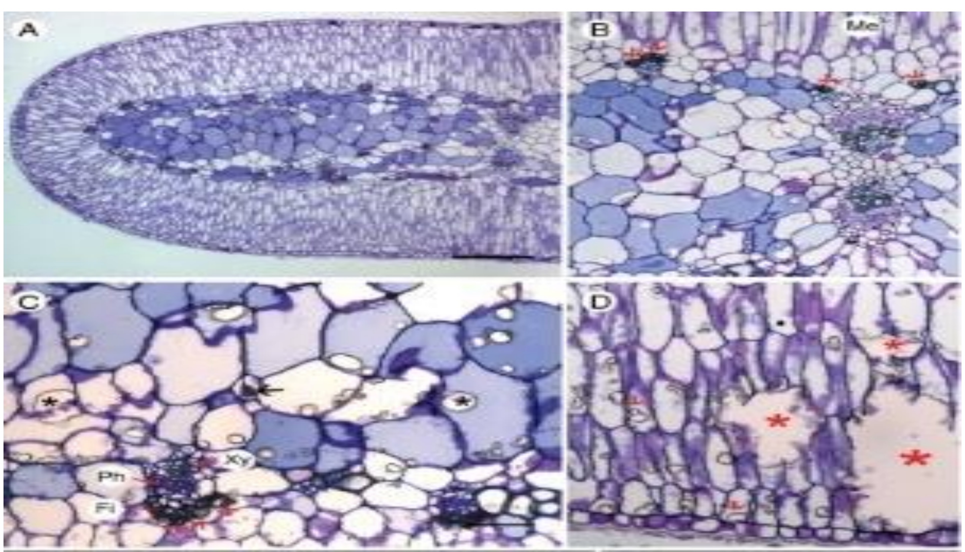


Fig-Optical microscope images of cross-sections of an *Hypericumperforatum* phyllode.

Observation-

(A) A view of half of a cross-section stained with toluidine blue.
(B) Dark-stained prismatic calcium oxalate crystals (red arrows) in cells associated with phloem fibre cells and unstained calcium sulfate crystals in mesophyll and parenchyma cells.
(C) A few prismatic calcium oxalate crystals (red arrows) associated with phloem fibre cells, a calcium oxalate druse (black arrow) and many calcium sulfate crystals (black asterisks) in parenchyma cells.
(D) Calcium sulfate crystals in mesophyll cells (red arrows) and occupying more than one cell (red asterisks).

Result-Both calcium oxalate and calcium sulfate crystals were found in almost all studied tissues in phyllodes. The crystals were of various morphologies, including prisms, raphides, styloids, druses, crystal sand and clusters. Calcium sulfate · magnesium oxalate crystals, which are possibly mixtures of calcium sulfate, calcium oxalate, magnesium oxalate and silica, were also abundant in mesophyll and parenchyma cells in phyllodes.Formation of most of the crystals was biologically induced, but the exact factors that induce formation of the crystals require further investigation.

Conclusion-Crystals in higher plant families may occur in a single tissue or in multiple tissues of an individual species. Distribution of crystals within the plant is highly variable among species and there are no generalities about the locations where crystals can be formed. Crystals are commonly found in members of all three subfamilies of the family Leguminosae, and certain members of the family contain leaf crystals which have distinct shapes and very specific patterns of distribution). It is generally accepted that the morphologies and precise locations of crystals are under strict genetic control, and that a particular species will form only a certain crystal type or subset of crystal morphologies .

Determination of Importance Value index of a species in a plant community

Importance Value is a measure of how dominant a species is in a given forest area. It is a standard tool used by foresters to inventory a forest. Foresters generally do not inventory a forest by counting all the trees, but by locating points in the forest and sampling a specified area around those points. Three kinds of data are collected:

1. Relative frequency, the percent of inventory points occupied by species A as a percent of the occurence of all species. If species A is found in 5 out of 8 sample points, its relative frequency is 62.5%

2. Relative density, the number of individuals per area as a percent of the number of individuals of all species.
3. Relative basal area. the total basal area of Species A as a percent of the total basal area of all species. Basal area is the sum of the cross sectional area of all the trees of species A, measured at 4.5 ft. above ground. The forester actually measures diameter and then converts that number to basal area.

Each of these values is expressed as a percent, and ranges from 0 to 100.

The Importance Value is the sum of these three measures, and can range from 0 to 300.

Sampling technique

Random sampling using Quadrats as described by Bryant *et,al* (2005) was employed to assess tree species composition in a forest area. An area of one hectare (10,000m2) was sub-divided into ten (10) plots 10m×100m each using machetes, ranging poles, compass, and red flagging tape. Five plots were selected at random and five quadrats of 10m x 20m were laid in each sample plot, giving a total of 25 plots for the entire area of study. From each plot, tree species were counted, recorded and separated into different families.

Data collection and Analysis

Data collection included identification of tree species and classification into families. Diameters at breast height (≥10cm dbh), and tree total height were also measured for all trees in each quadrat. Trees identified were listed and classified. Diameters at breast height and other data generated from this study were used to calculate the Basal Area, Frequency, Relative Frequency, Relative Density, Relative Dominance and Importance Value Index (IVI) using:

$$Frequency = \frac{\text{No. of quadrats in which species occurred X 100}}{\text{Total no. of quadrats studied}}$$

$$\text{Relative Frequency (R. F)} = \frac{\text{Frequency of occurrence of species X 100}}{\text{Total frequency of occurrence of all species}}$$

$$\text{Relative Density (R. Den)} = \frac{\text{No .of individuals of the species X 100}}{\text{Total no .of individuals in all species}}$$

$$\text{Relative Dominance (R. D)} = \frac{\text{Total basal area of a species X 100}}{\text{Total basal area of all species}}$$

$$\text{Basal area} = \frac{\pi D^2}{4} \text{ where D = dbh}$$

$$\text{Important Value Index (IVI)} = \text{R. D + R. F + R. D}$$

Result & discussion-

Table shows the DBH(Diameters at breast height) results of the tree species. The values were used to estimate the Importance Value Index (IVI) - Species dominance.

Tree species	*No. of stems*	*Mean DBH (cm)*	*Basal area (m²)*	*Frequency*	*Relative density*	*Relative dominance*	*Relative frequency*	*Importance Value Index (IVI)*

Conclusion -

Tree assessment is the process of collecting information about the extent and conditions of the vegetation within a specific area. Quantitative assessment of the tree species was carried out using sampling of plot with Quadrats. Measurements of tree height were used to classify tree species into different structures. Families and tree species were also identified. The diversity of tree species is unevenly distributed in the study area. Different tree species with different families were distributed heterogeneously with diverse height and sizes forming different storeys.

Reliable information on the status and trends of Forest resources helps give decision makers the prospect necessary for orientation of forest policies and programs. Thus, tree assessment and structure in forest area serves as a valuable tool that will enable conservators and managers of forest to quantify tree species composition as well as providing information on structure which are essential for forest management and tree utilization.

Isolation of plasmid DNA and its separation by Gel electrophoresis.

Aim- To isolate the plasmid DNA from the given bacterial culture by alkaline lysis method.

Principle- A plasmid is a small, circular, double-stranded DNA molecule that is distinct from a cell's chromosomal DNA. Plasmids naturally exist in bacterial cells, and they also occur in some eukaryotes. Often, the genes carried in plasmids provide bacteria with genetic advantages, such as antibiotic resistance. Plasmids have a wide range of lengths, from roughly one thousand DNA base pairs to hundreds of thousands of base pairs. When a bacterium divides, all of the plasmids contained within the cell are copied such that each daughter cell receives a copy of each plasmid. Bacteria can also transfer plasmids to one another through a process called conjugation.

The first stage for this experiment is to grow the selected bacterial colonies in a small volume (3-5ml) of LB broth containing the selection antibiotic. The bacteria are pelleted and resuspended in a resuspension buffer. This buffer is often a basic pH Tris buffer, which helps to denature DNA, and EDTA (ethylenediaminetetraacetic acid) that binds divalent cations destabilizing the membrane and inhibiting DNases (enzymes that degrade DNA). In addition, RNases are also added to degrade the released RNA. Next, the bacteria are lysed with strong alkali (Sodium Hydroxide (NaOH)) and detergent (Sodium Dodecyl Sulfate (SDS)). The SDS detergent solubilizes the phospholipids and proteins of the cell membrane resulting in cell lysis and the release of the cells contents. The high concentration of sodium hydroxide denatures the genomic and plasmid DNA, as well as cellular proteins. The cellular DNA becomes linearized and the strands are separated, where as the plasmid DNA is circular and remains topologically constrained (the two strands, although denatured remain together). Finally, a neutralization buffer of potassium acetate is added to neutralize the strong alkaline conditions. The addition of potassium acetate results in a high salt concentration that leads to the formation of a white precipitate that consists of SDS, lipids and proteins. In addition, the neutralization of the solution allows the renaturation of DNA. The large chromosomal DNA is captured in the precipitate, where as the small plasmid DNA remains in solution. The precipitate and chromosomal DNA is removed by centrifugation. Following centrifugation, the soluble plasmid DNA can be purified from the solution by various techniques. The most common is to precipitate the DNA with alcohol (ethanol or isopropanol) or high salt (ammonium acetate, lithium chloride, sodium chloride or sodium acetate). Another method is to bind the DNA to a solid support, such as glass fibers or silica. At high salt concentration and neutral or low pH, DNA molecules have a high binding affinity for these supports, allowing for the easy capture and subsequent elution of the DNA.

Requirements-

- **Preparation of LB Broth**

1. Transfer the entire contents of the 2 bottles of LB Broth to a sterile 200-250ml culture flask.

2. Rehydrate the ampicillin by transferring 250µl sterile water to the vial of ampicillin. Dissolve the ampicillin by inverting the tube several times.

3. Using aseptic techniques, transfer 60µl ampicillin to the LB broth and swirl to mix.

- **Prepare Bacterial Stocks**-

1. Add 0.8ml LB broth to the E.C. Plasmid 1 Agar stab and incubate at 37ºC for 30minutes.

2. Vigorously shake or vortex for 1-2 minutes, then transfer 0.5ml LB broth from the agar stab to the 200-250ml culture flask containing LB Broth with ampicillin.

3. Incubate the vial at 37ºC with shaking overnight.

- **Miscellaneous-**

1. Prepare the DNA wash solution. Label a 15ml tube with "DNA Wash". Transfer 10.5ml Precipitation Solution and 4.5ml ultra pure water to the labeled tube. Invert 5-6 times to mix.

2. Prior to commencement of the experiment, place the bottle of Precipitation Solution in a freezer. Ice-cold Precipitation Solution is needed for the optimal precipitation of plasmid DNA.

- **Visualization of Purified Plasmids-**
  In order to visualize the purified plasmids products, an agarose gel will need to be run.

- 8 Centrifuge tubes (1.5ml)
- 1 bottle Cell Suspension Solution (shared with class)
- 1 bottle Lysis Buffer (shared with class)
- 1 bottle Neutralization Buffer (shared with class)
- 1 bottle Precipitation Solution (shared with class)
- 1 tube DNA Wash (shared with class)
- 1 vial TE buffer (shared with class).

Procedure-

1. Each student labels two 1.5ml Centrifuge tubes with his or her name.

2. Transfer 1.5ml overnight culture into labeled 1.5ml centrifuge tube.

3. Centrifuge at high speed for 3-5 minutes to pellet bacteria. Pour off the supernatant.

4. Add 200µl Cell Suspension Solution and mix the contents by flicking the tube or pipetting several times. This solution contains Tris (pH 7.5), and EDTA (ethylenediaminetetraacetic acid). The basic pH helps to denature the DNA and the metal ion chelator, EDTA, stabilizes the cell membrane by binding the divalent cations of Mg^{2+} and Ca^{2+}. RNase can also be added at this stage to degrade the RNA when the cells are lysed.

5. Incubate the vial on ice for 15 minutes.

6. Add 200µl Lysis Buffer and mix the contents by gently inverting the tube 4-5 times.This solution contains sodium hydroxide and SDS (sodium dodecyl sulfate). The sodium hydroxide denatures the plasmid and chromosomal DNA into single strands. SDS, an ionic (charged) detergent dissolves the phospholipids in the membrane causing lysis and release of the bacteria contents, including the DNA, into the solution.

7. Add 200µl Neutralization Buffer and mix the contents by inverting the tube 4-5 times. This is a potassium acetate solution. The potassium acetate causes the precipitation of a SDS-protein complex as a white precipitate, consisting of SDS, lipids and proteins. In addition, the potassium acetate neutralizes the solution allowing the renaturation of the DNA. The large chromosomal DNA is captured in the precipitate, whereas the small plasmid DNA remains in solution.

8. The tube is then centrifuged for 10 minutes at high speed (>5,000xg).

9. Transfer the clear liquid, or supernatant, to a fresh labeled 1.5ml tube. This can be stored for up to a week at 4°C.

10. Alcohol Precipitation: To precipitate the plasmid DNA, add 480µl (0.8 volumes) Precipitation Solution (isopropanol) to the supernatants from step 9. Ethanol can be used instead of isopropanol and should be used at 2.5 volumes.

11. Mix the tubes by inverting 5 times. Place the tubes at -20°C for 10 minutes.

12. To pellet the plasmid DNA centrifuge at full speed for 15 minutes.

13. After centrifugation, examine the tubes for a small white pellet of plasmid DNA. Pour off the supernatants.

14. Add 300µl DNA Wash (70% isopropanol) to the pellets to wash away any excess salt. Centrifuge the tubes at full speed for 5 minutes.

15. Carefully remove the supernatants with a pipette and leave the tubes open on your bench to allow all residual alcohol to evaporate.

16. Once all alcohol has evaporated, add 50µl TE buffer to the pellets. Wait 2 minutes then vortex to resuspend the DNA. This is your purified plasmid DNA.

17. The DNA can be run on an agarose gel to visualize the DNA or can be subjected to restriction digestion analysis and then agarose electrophoresis to check the plasmids.

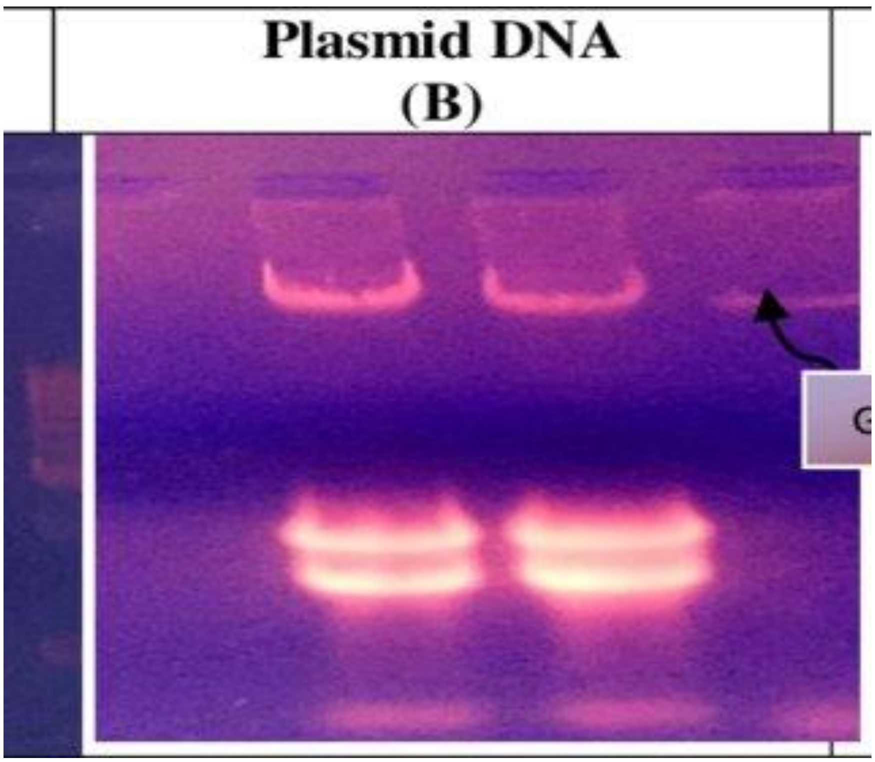


Fig-Plasmid DNA bands on UV illuminator.

Observation- After gel electrophoresis, the el was observed in UV immuninator.

Result- Plasmid DNA bands were observed. The coloration is due to ethidium bromide that bound to the DNA molecule and gave visible effect on UV illumination.

Determination of diversity indices in Plant community

Introduction

Species diversity is a characteristic unique to the community level of organization. The concept of diversity, however, can be applied at three different levels of organization. Alpha diversity, the most widely used and important concept of diversity, refers to the diversity of species within a given habitat. Beta diversity, in contrast, describes the degree of change in species from one habitat to another. Gamma diversity, finally, relates to the total regional species diversity that results from the number of habitats present, the diversity of species within each, and the degree of turnover of species between habitats (i.e, how similar or different are the species compositions of the habitats). In this exercise we shall confine our attention to alpha diversity. Species diversity, as most ecologists use the concept, combines two distinct aspects of the species composition of communities: number of species and equitability of their abundance. These aspects of diversity can be described separately, by indices of species LSC 322 — Fundamentals of Ecology Lab richness or of equitability of abundance, or they may be considered together, by indices of heterogeneity. Many indices of richness, equitability, and heterogeneity have been proposed. These indices vary widely in their mathematical basis, and often behave quite differently as sample size increases. None of the commonly used indices is independent of sample size, so that most comparisons of diversity indices require samples of equal size.

Sampling Techniques

In order to study species diversity, one must first tally the species and the numbers of individuals for each species in a community. It is usually cost prohibitive to count every organism in an ecosystem, even if one limits the study to one species. What is typically used by community ecologists is a sampling technique. A sampling technique is a method that collects a sample of the population being studied. The sampling technique is considered unbiased if the probability of an organism being sampled is roughly equivalent to its frequency in the environment. Obtaining an unbiased sample is one of the crucial goals in designing a good scientific study. One technique for sampling plant diversity is the use of a belt transect. A transect is a line of specified length, placed in an ecosystem. For a belt transect, the researcher marks the transect, and then records all of the organisms of interest that are located within a predetermined distance of the transect line. For example, a transect of fifty meters in length, where all plants that grow within one meter of either side of the transect line are counted, would sample 100 m2. The length and width of the belt transect can be designated by the researcher, and are usually set with respect to the natural densities of the plants being studied. For example, a one meter long by 10 cm wide belt transect would be far too small to adequately sample desert woody plants, while a 1 km by 10 m belt transect would be too large to completely count small plants such as grasses. The number of transect plots is quite important. Each individual belt transect is considered a single sample. The probability of detecting a difference in community structure, if it exists, increases with increasing sample size. The placement of the transects is also important. In order to avoid bias, placement within the area of study is often done by some random method. A common method to randomly place transects involves the use of a baseline. This technique starts by placing a baseline of fixed length (often twice the transect length) in the center of the study area. A random number generator is then used to pick points on the baseline from which transects will be sampled, perpendicular to the baseline. For our study, the baseline will be placed along the edge of a wash and run parallel to the wash (thus, it may not be a straight line). The transects will then extend from the baseline into the wash and into the flats. Your Excel Statistical Analysis workbook includes a random number generator. You will need to enter the minimum and maximum values (we recommend a minimum of no less than 10 and a maximum of around 30). (Another technique that you may find useful for your independent project is a plot sample or quadrat. A quadrat is simply a square that is placed in an ecosystem and all plants inside the square are recorded. Similar to the belt transect, the size of the plot is designated by the researcher with respect to the natural densities of the species being studied. Whether you use a belt transect or a plot sample will depend on the question that you are testing and the size and shape of areas of interest and whether transects are feasible. Circular plots can also be used. Placement of quadrats must also be done to avoid any bias. If the plot size is small enough, random techniques such as throwing a marker behind oneself and using where it lands as the corner of the plot can be used. With larger plot sizes, a random location can be generated by imposing a grid over a map of the study area. A random number generator is then used to determine in which grid space the plot will be placed. Alternatively, separate random numbers can be used to generate both distance and compass direction to the next plot location.)

Species Richness

Species richness refers simply to the number of species in a given area of habitat or in a sample of given size. A number of mathematical indices of species richness, some tending to be independent of sample size, have been suggested (Pielou 1977). These indices, however, assume specific patterns of frequency of common to rare species, and are not accurate if these assumptions are not met. Rarely can a particular pattern be assumed with confidence, so that most ecologists prefer simply to use the number of observed species itself as the index of species richness. The number of species can be determined either for a unit area of habitat or for a sample of a certain number of individuals. When number of species is related to area of habitat, the value is best considered to be species density. Species density varies widely with the productivity and favorability of the habitat, and is important to consider, for example, in the selection of areas for preservation of biotic diversity. Differences in species density can be tested using the standard t-test that we have used previously.

Shannon-Wiener Index-

Interest in diversity indices and concern for the environmental impacts of pollution developed at about the same time, and diversity indices were quickly introduced into analyses of environmental quality. The observation that mature communities of stable environments typically show high species diversity, and those of disturbed or stressed situations are less diverse, led some investigators to use low species diversity as indicators of environmental stress (Godfrey 1978). Indices of heterogeneity and Lab 8 — Plant Diversity Page 3 equitability remain in general use. The most important is the Shannon-Wiener Index (Peet 1974, Pielou 1977), and we will apply this in this exercise. This index is the most widely used index of heterogeneity (i.e., it combines both species richness and species equitability). It describes the average degree of uncertainty of predicting the species of an individual picked at random from the community. This uncertainty increases both as the number of species increases and as the individuals are distributed more and more equitably among the species already present. This index, H' can be calculated from the proportion of individuals of each species (pi = number of individuals of species i/total number of individuals) by the expression

$$H' = -\sum p_i \ln p_i$$

The Shannon-Weiner index varies from a value of 0 for communities with only a single species to high values for communities having many species, each with a few individuals. The null hypothesis that two Shannon-Weiner diversity indices come from communities equal in diversity can be tested by a specialized version of the t-test. Alternatively, we can collect multiple samples (transects or quadrats) from each community and calculate means and standard deviations of the Shannon-Weiner diversity indices of each sample and compare the communities using a standard Student's t-test. This is the approach taken on the Excel analysis worksheet for this lab.

Procedure

Laboratory for the field portion will meet at the any Park. Students will work in groups of 3-4 and use the lab period to collect data on the plant densities using transect. You will be expected to present your data in summary form and test it statistically. An Excel spreadsheet specifically for this lab will be available to help you with the diversity indices.

Determination of stomatal index

BACKGROUND:

Stoma (plural-stomata) is a minute epidermal opening covered by two kidney shaped guard cells in dicot leav cells, in turn, are surrounded by epidermal (subsidiary) cells. Stomata perform the functions of gaseou transpiration in plants. The nature of the stomata, as well as, the stomatal index and stomatal number are impo characteristics of dicot leaves.

Stomatal number is defined as the average number of stomata per sq mm of epidermis of the leaf. The ac stomata per sq mm may vary for the leaves of the same plant grown in different environment or under d conditions. It is, however shown that the ratio of the number of stomata to the total number of epidermal cell of epidermis is fairly constant for any age of the plant and under different climatic conditions.

Stomatal index is the percentage which the number of stomata form to the total number of epidermal cells, e counted as one cell. Stomatal index can be calculated by using the following equation:

Stomatal Index = S x 100/E+S

Where, S= Number of stomata per unit area

E= Number of epidermal cells in the same unit area.

Whilst stomatal number varies considerably with the age of the leaf and due to changes in environmental con index is relatively constant and therefore, of diagnostic significance for a given species. It is employed for th of allied or closely related to species of same genus in air dried, as well as fresh conditions.

Timmerman (1927) and Rowson (1943) were amongst the first few to investigate leaf drugs for stomatal numb index.

REQUIREMENTS :

Compound microscope

Camera lucida

Drawing board

Micro slides

Cover glasses

Forceps

Spirit lamp

Small watch

glass Blade

Cello tape

Drawing sheet

Dark coloured pencil with sharp lead

Chloral hydrate solution

PROCEDURE :

1. Preparation of lamina Take a mature leaf. If the leaf is small, the whole leaf may be taken and if the leaf is large, cut 5 mm square middle portion between the lamina and midrib. Fresh leaf 1. Sometimes the epidermis can be easily peeled off in thick leaves by breaking it into pieces by sheering the epidermis and treat with chloral hydrate.

2. Cut a number of 5mm pieces from the middle portion between the lamina and midrib.

3. Boil with chloral hydrate in a test tube placed in a water bath. The epidermis separates out. Car epidermis on a slide with the help of a brush along with 1-2 drops of chloral hydrate; cool and then place.

OR

4. Prepare an imprint of the epidermis: Take a little piece of gelatin gel (50%) with the help of a needle. S slide, place a fresh leaf and slightly press the leaf. Invert the slide and cool it under a water tap till the Then the leaf is removed. This leaves an imprint of the stomata and epidermal cells on the gel.

5. Trace the epidermal cells and stomata with the help of camera lucida.

Dry leaf

1. Heat the leaf with chloral hydrate in a test tube on a water bath for 30 min.

2. Cut the leaf into two pieces, observe under the microscope to see whether the stomata are present on one.

3. Place the cleared leaf with the veins facing down. Then the upper epidermis will be visible.

4. Place the other half with veins facing upwards. Then the lower epidermis will be visible.

5. Add two drops of glycerin and place a cover glass.

6. Label the slides as “upper” and “lower” and trace the epide

If the leaf is too thick and dark, separate the epidermis are given below.

1. Clear the leaf with chloral hydrate as given in step no.1. cut the leaf into two halves.

2. Place one half with the upper surface facing downwards.

3. Carefully scrape off the upper tissue, with the edge of a razor blade, without disturbing upper epidermis brush dipped in chloral hydrate solution.

4. The layer of cells remaining on the upper epidermis. Turn the layer upside to trace the cells.

5. Repeat the procedure with the second half, this time placing the lower surface facing downwards, pro step no. 3. And 4.

6. Usually herbs and small shrubs have stomata on both surfaces. In tree species, stomata are present on th More stomata are present on the lower surface in dorsiventral leaf, almost the same number in isobilatera

Tracing of cells

1. Draw a square of about 8-10 cm square on a drawing sheet or any unit area. 2. Place the prepared slide on the stage of the microscope.

3. Focus epidermal cells and the stomata first with 10×10 and later focus with 10×40 or 10×20.

4. With the help of camera lucida, trace the stomata and the epidermal cells in the square.

5. Trace epidermal cells and the stomata outside the square to completion on two adjacent sides o counting purpose.

6. Number the complete epidermal cells and the stomata within the square.

7. Then continue numbering the cells that are more than half on two adjacent sides.

Calculation:

.... Stomatal index = no. of stomata x 100

No. of stomata + epidermal cells

About 10 readings or count of 400 cells are taken to determine the average stomatal index

CONSTRUCT ECOLOGICAL PYRAMIDS OF POPULATION SIZES IN AN ECOSYSTEM

INTRODUCTION :

After several decades of war devastated wildlife populations, park scientists and conservation managers are now working to restore the ecosystem and the wildlife that depend on it. Lion researcher Paola Bouley and her team use motion-detecting trail cameras to learn more about lions. Lions are not the only animals that are captured on these cameras. National Park is home to wildebeests, elephants, zebras, and many other types of animals. These photos can provide valuable information for science and conservation in park, such as the quantity and type of animals within ecosystems. Scientists often depict this information in ecological pyramids, which are diagrams that show the relationships between trophic levels and the position of species among trophic levels. Trophic levels are the levels of a food chain where the organisms at higher positions eat those directly below them. The bottom level is producers (usually plants), which are eaten by primary consumers, followed by secondary consumers, and so on. Ecological pyramids can represent a variety of relationships, such as the numbers of organisms (numbers pyramid), energy flow (energy pyramid), or biomass of organisms (biomass pyramid). A biomass pyramid is constructed by calculating the total mass, or weight, of all living organisms within each trophic level in an ecosystem. In this activity, you will be an ecologist studying the structure of the trophic levels in different vegetation types in park. Using the trail camera photos, you will identify and make observations about the species present in this ecosystem. Then you will create a biomass pyramid showing the relationships among trophic levels within your vegetation type and compare it with other vegetation types.

<u>PROCEDURES AND QUESTIONS</u>:

Follow the instructions below and complete the tasks in the spaces provided.

Part 1: Meet the Organisms the first step in building an ecological pyramid understands the species and their interactions with one another in an ecosystem. The steps below will familiarize you with the vegetation type you were assigned and the species within it that will become the basis for your pyramid. 1. Log in or register for an account on WildCam park, With your partner, spend 10 minutes observing and identifying species in photos. As you work, record the name of the species and any relevant observations or questions you have about the species you are identifying.

<u>Observations</u>

What do you notice (body size, quantities, animal type)?

Now you will gather information about the species you observed to create a biomass pyramid in order to answer the following questions:

1) How does biomass differ between trophic levels within your vegetation type? 2) How does the structure of the biomass pyramids differ across vegetation types? 3) What do these patterns suggest about the stability of the trophic structures in park

Part 2: Make a Prediction

When making predictions about the biomass pyramid, you may use the WildCam field guide,for additional information about the species in your vegetation type.

2. Based on the animals you saw on WildCam, which species do you think will be at each trophic level for your assigned vegetation type? Why? (Note: you may not have tertiary consumers and you may have multiple species at each trophic level. All of the species in your photos should be listed.)

Species name Trophic level prediction (producer, primary consumer, secondary consumer, tertiary consumer)

Reason/rationale

3. Predict which trophic level will have the most biomass, based on your observations about each species for each trophic level: Trophic level Species list Estimated proportion of biomass (out of 100%) Producers It won't be possible to record the species of the producers. Simply estimate the proportion of the biomass you think they make up. Primary consumer

Secondary consumer

Tertiary consumer

4. Use your predictions in questions 2 and 3 to draw a biomass pyramid. Beginning with the producer level at the bottom, draw a horizontal bar for each trophic level. The width of the bars should match the proportion of biomass that you estimated in question 3. Label the trophic levels and, at each level, list the species you observed and your predicted percent biomass.

Part 3: Formulate a Plan Now that you have a better understanding of what a biomass pyramid represents, you will work with your group or partner to develop a plan for building a biomass pyramid. Trail camera images do not provide enough information for you to estimate the biomass of the producer level. For now, you will focus on the consumer levels, and you will learn how to estimate producer biomass in part 5.

5. Circle the data in the example spreadsheet below that would be useful for calculating the biomass of each trophic level within your assigned vegetation type. The time period of your study will be the dry season, so this will be the variable that you use to filter the data set.

6. With your group/partner, brainstorm and list the additional information you will need to calculate the biomass of each trophic level within your assigned vegetation type.

7. Debrief with your classmates and instructor about the data that you need to build your biomass pyramid, make any necessary modifications, and describe your plan for gathering and analyzing the data to build your pyramid.

Discussion-

LABORATORY INSTRUCTION MANUAL

Computer Aided Civil Engineering Drawing LAB

(CE (ES) -392)

DEPARTMENT OF CIVIL ENGINEERING
SILIGURI INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

NAME: ____GROUP: _____________

ROLL NO.__________________

LIST OF EXPERIMENTS

EXPERIMENT NO	EXPERIMENT NAME
CE(ES)-392/1	Building with load bearing walls including details of doors & windows
CE(ES)-392/2	Taking standard drawings of a typical two storied building including all MEP joinery, rebars, finishing and other details and writing out a description of the facility in about 500-700 words.
CE(ES)-392/3	RCC framed structures
CE(ES)-392/4	Reinforcement drawings for typical slabs, beams, columns and spread footings
CE(ES)-392/5	Industrial buildings – North light roof structures - Trusses
CE(ES)-392/6	Perspective view of one and two storey buildings

MODULE -1

ITRODUCTION TO AUTOCAD

INTRODUCTION

AutoCAD is a drafting package for use in CAD. There are several drafting packages like Cad key, DIAD, CADAM, Draftsman Delight etc. AutoCAD is a one of the popular CAD packages. It is a general purpose computer aided design (CAD) and drafting software package for desktop computers and workstations. AutoCAD's, features are easy to use pull down menus, dialog boxes and icon menus to guide the construction process. Using a mouse, we can draw geometrical entities of any
complexity and then layer, rotate, copy, mirror, fillet, chamfer, move, stretch, scale,
firm them.

AutoCAD can be used to create a drawing using two modes.

I. Command mode.
II. Menu mode

In **Command mode**, the user has to type various commands on keyboard. The software responds with appropriate prompts to help the user to input the necessary information.

In **Menu mode**, the use of software is through a menu which is located on the right side of the screen or top of the screen. The menu can be selected using the cursor control key on keyboard or mouse. Use of mouse may be found easy. Menu selection can be performed through icons. AutoCAD provides icons for a limited number of commands. Icons enable quick selection of menu.

BENEFITS OF AUTOCAD

The following are the advantages of using CAD.
• Improved engineering productivity
• Reduced engineering personnel requirement
• Drawing modifications are easier to make
• Improved accuracy of design
• Better communication

FUNCTION KEYS

Sl.No.	KEY	FUNCTION
1	F1	Displays HELP
2	F2	Toggles between the text and the graphic screen
3	F3	Snap on & off
4	F4	Puts the Tablet (an input device) on & off
5	F5	Top, right and left views of isometric drawings
6	F6	Coordinates on & off
7	F7	Grid on & off
8	F8	Ortho on & off
9	F9	Snap mode on & off
10	F10	Polar option on & off
11	F11	Object snap Tracking on & off
12	Enter	With no command typed, it repeats the previous commands
13	Esc	To cancel the current command
14	Space Bar	At the end of command is equivalent to an Enter action
15	Delete	Deletes a character or selected objects
16	Ctrl +J	Opens a file
17	Ctrl +N	Opens a New file
18	Ctrl +O	Opens a Old file
19	Ctrl +S	Saves a drawing file
20	Ctrl +T	Displays Draw pull down menu
21	Ctrl +C	Copies the drawing
22	Ctrl +V	Pastes the drawing
23	Ctrl +L	Ortho ON/ OFF

AutoCAD Coordinates System

There is only 3 AutoCAD coordinates system you should know. Absolute coordinates, Relative coordinates and Polar coordinates.

Absolute Coordinates

All input points specify in your drawing using standard Cartesian coordinates x and y. Using absolute coordinate, points entered by typing x,y [Enter]

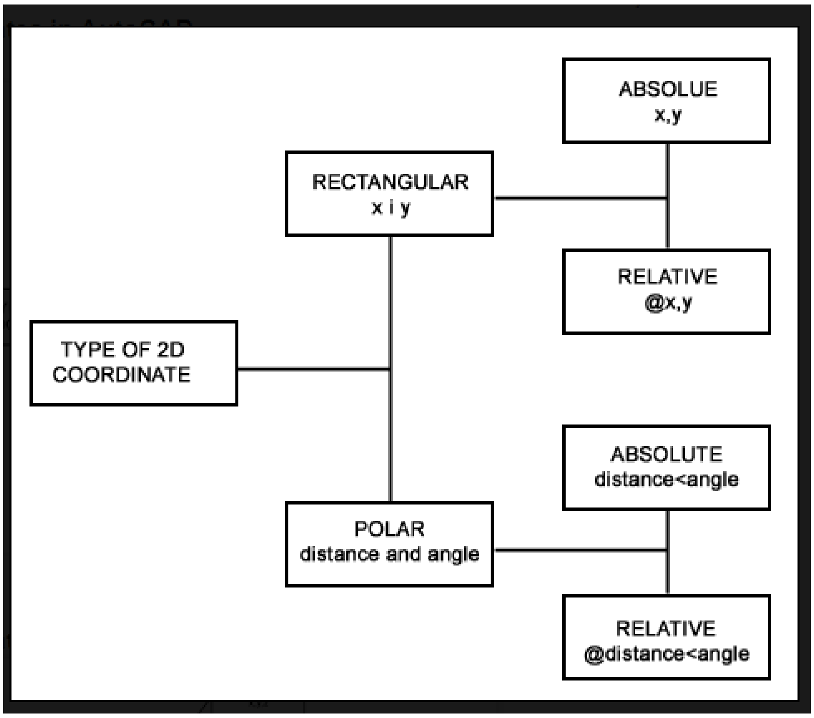
Relative Coordinates

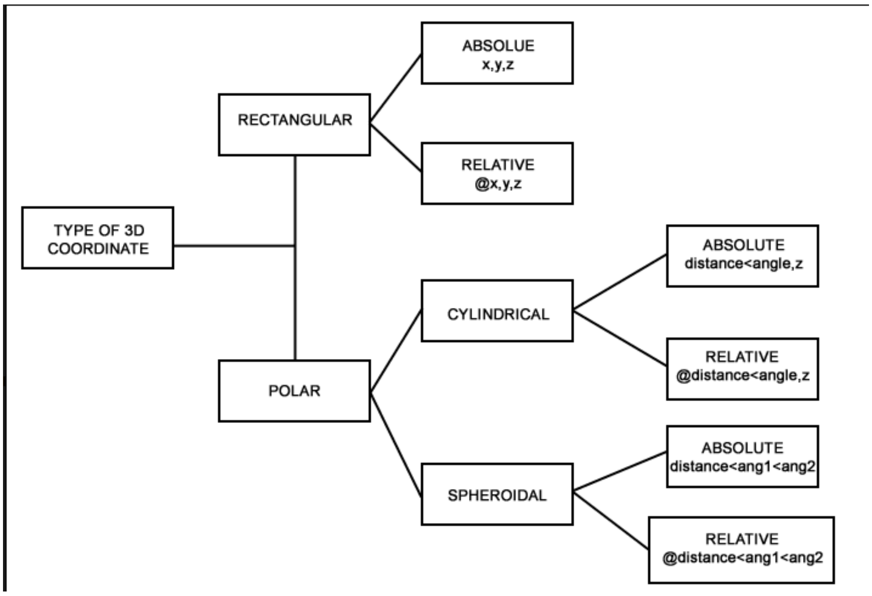
After first points entered, your next points can be entered by specifying the next coordinate compare/relative from the first points. The relative coordinate started with symbol "@" tell AutoCAD it was a relative coordinates. Using relative coordinate, points entered by typing @x,y [Enter]

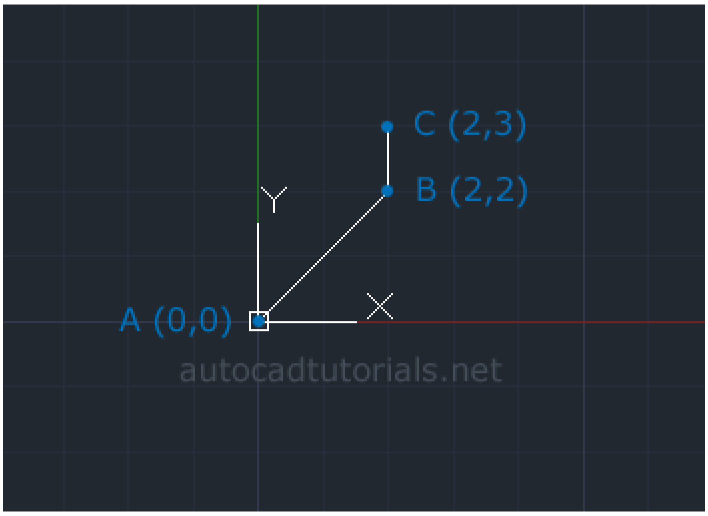
Polar Coordinates

Polar coordinates used when you need to draw the next points at specify angle. Polar coordinates system in AutoCAD specifies distance length at which angle. Using polar coordinate, points entered by typing @distance<angle [Enter]

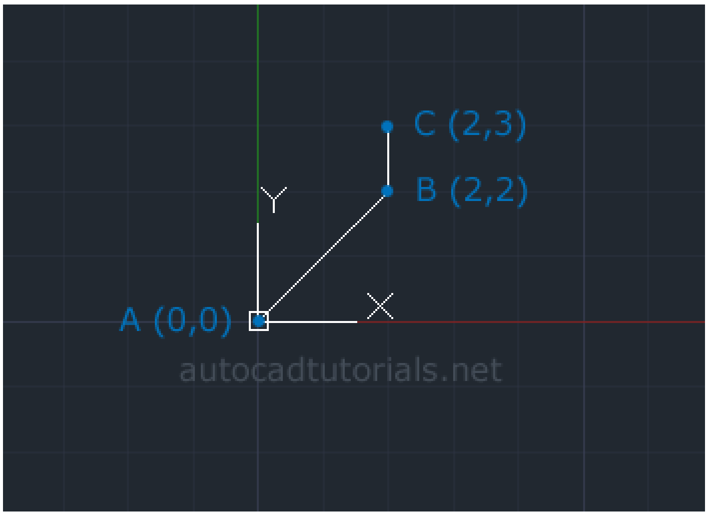
Example of AutoCAD coordinates usage;





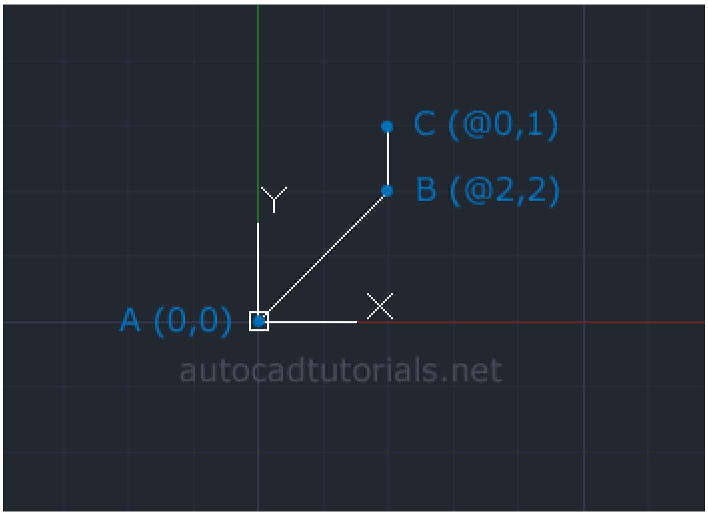


Absolute coordinates



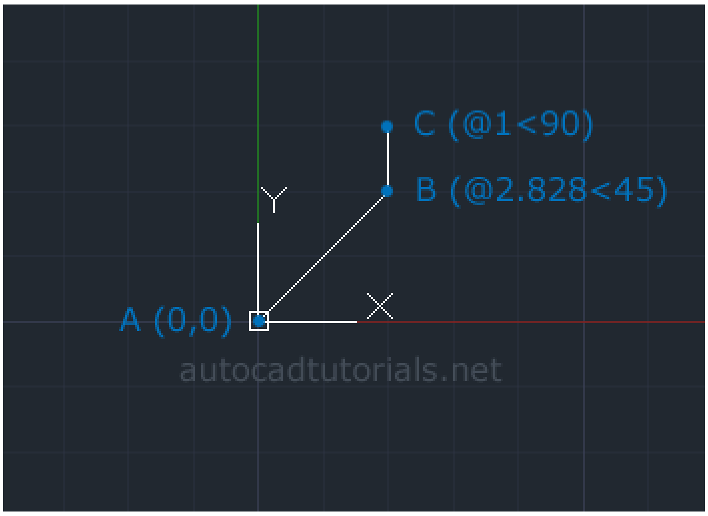
Enter LINE command: L [Enter]
Start line at point A: 0,0 [Enter]
End first line at point B: 2,2 [Enter]
End of second line at point C: 2,3 [Enter]

Relative coordinates



Enter LINE command: L [Enter]
Start line at point A: 0,0 [Enter]
End first line at point B: @2,2 [Enter]
End of second line at point C: @0,1 [Enter]

Polar coordinates



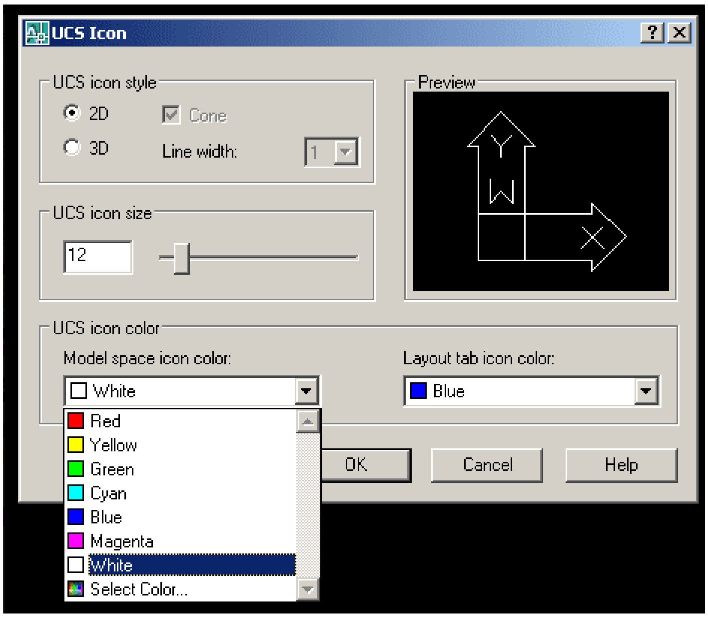
Enter LINE command: L [Enter]
Start line at point A: 0,0 [Enter]
End first line at point B: @2.828<45 [Enter]
End of second line at point C: @1<90 [Enter]

INITIAL SETTINGS IN AUTOCAD

Initial Settings and Layout UCS Icons In AutoCAD

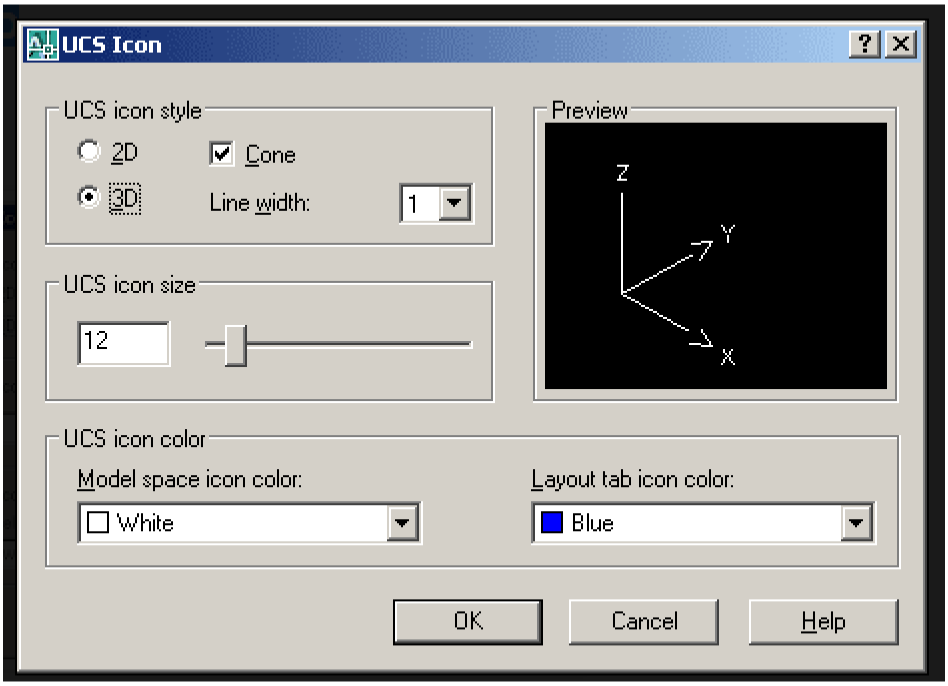
After running **AutoCAD**, You can start to change some settings. Besides STARTUP settings at startup can be defined as follows:

2D UCS icon in AutoCAD



In any respect we draw the line 2D or 3D and can be adjusted accordingly and display the UCS icon on your desktop. View => Display => UCS Icon => Properties

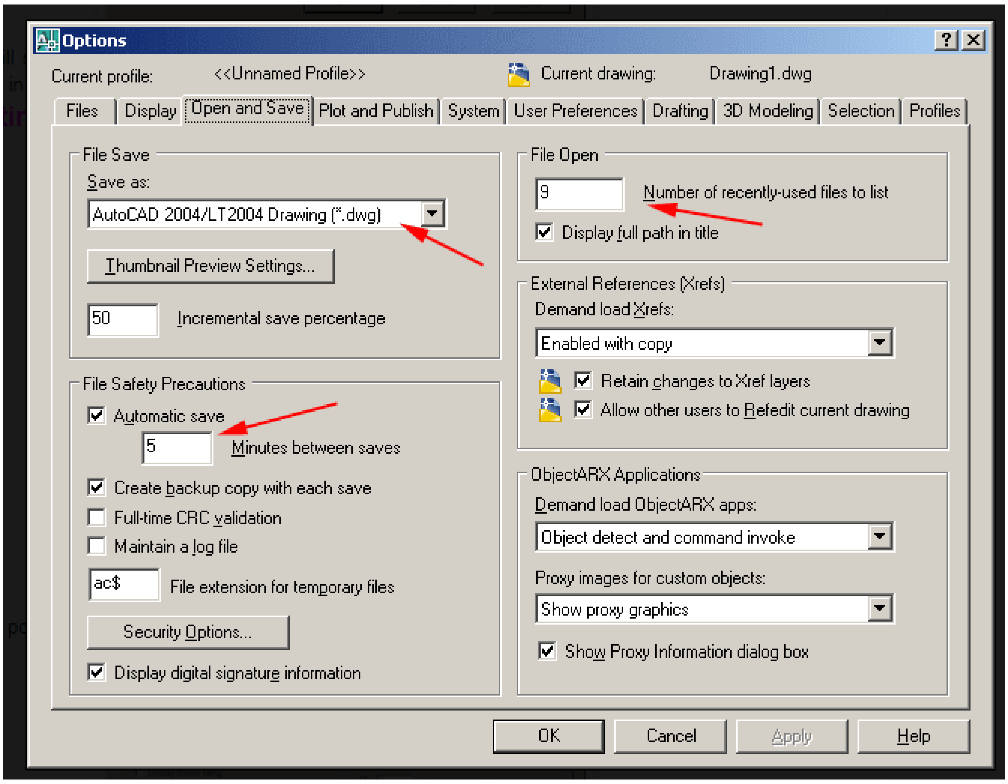
3D UCS icon in AutoCAD



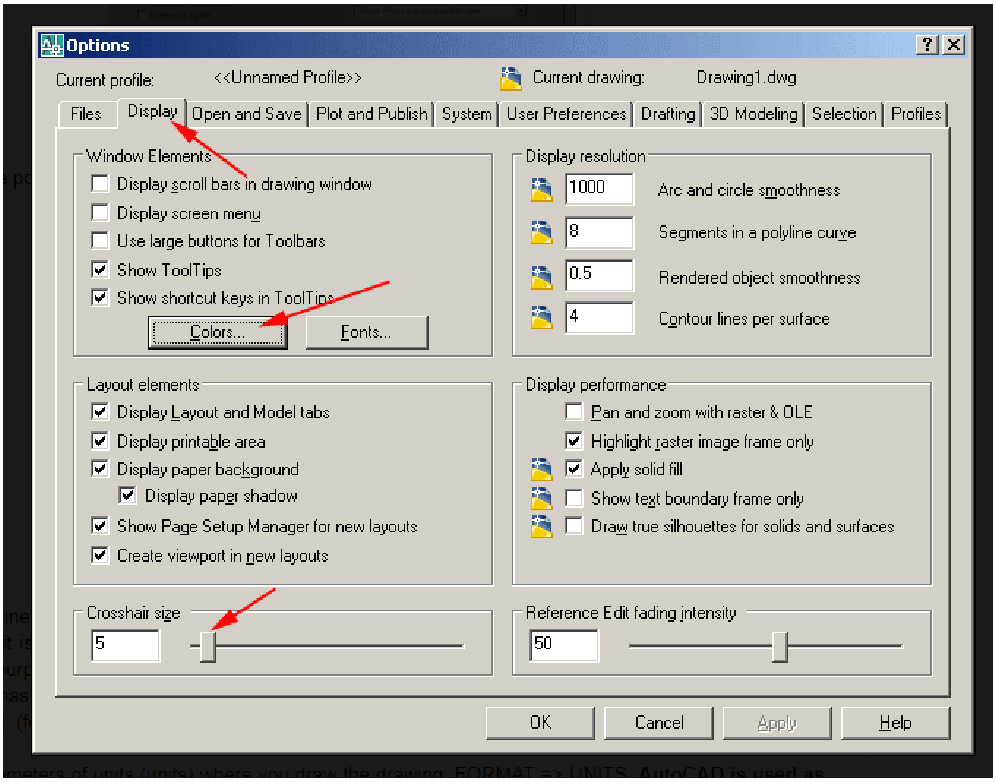
In what format will save the finished drawing (an older version of Autocad)? How often will create AutoCAD *. BAK file (backup) in case of problems with the computer and power supply.

Options settings in AutoCAD

Tools => Options

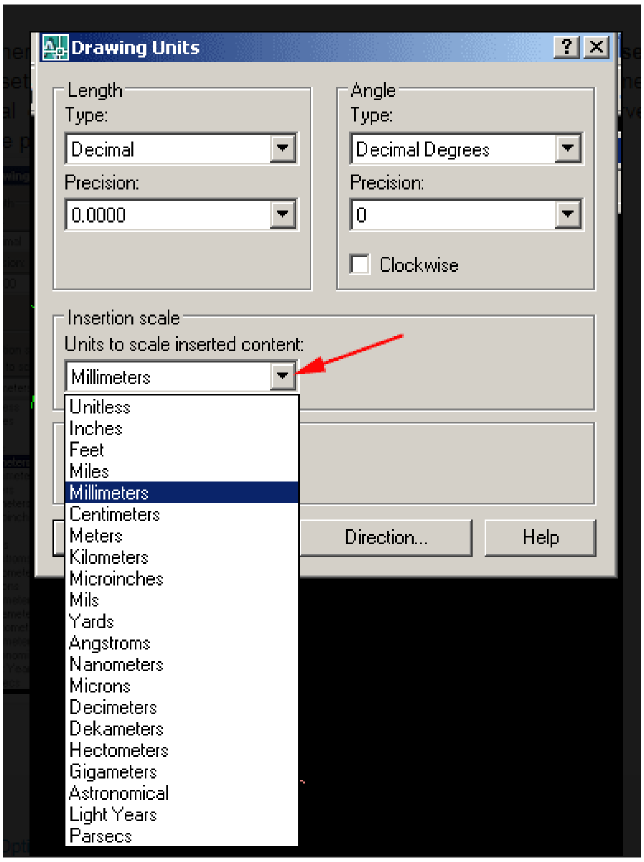


What size mouse pointer will be? What color is your desktop? etc etc...



The size of the line for the mouse pointer (**Crosshair size**) should not be changed unless you're dealing with surveying, then it is advisable to set it at 100%. Why? I have no idea as I saw that surveyors work ;-), and probably has a purpose that can see a certain point in the line of the cursor while drawing lines and the like. In this dialog box has more settings you can change, but it leaves you to explore. Yet this is the only web for education BASIS. (for the beginner)

Also set the parameters of units (units) where you draw the drawing. FORMAT => UNITS. **AutoCAD is used as a measuring parameter "UNITS"** and setting the settings. I choose whether to be millimeters, centimeters, meters, kilometers, etc. ... In mechanical engineering using millimeters, centimeters and building surveying meters. So this is important because of the plotting (printing on paper) and scale that is set to end.



Drawing Aids

Drawing aids is, in a way, what Draft and 2D CAD is all about, to be able to draw accurately and with ease.Accurately here means with precision. When you draw shapes, lines, arcs, anything, you are not limited to the accuracy of how well you can point with the mouse or see what you are drawing on the screen. Instead when you draw e.g. a line from point to point, you pick the point on something that is already defined in the drawing, say the end point of another line, the crossing of two lines or from a grid. Or you define it by constraints, saying that the line is to be a tangent to a circle and passing through a point. Precisely, perfectly.

Snap Cursor

Whenever you are drawing, the cursor turns into a cross hair. In addition to this cross hair that moves as you move the mouse, there is a Snap Cursorthat tracks the point that would/will be entered if you click with the mouse. This snap cursor gives clear visual indication of what the cross hair cursor is snapping to.

Grids

A Grid is a rectangular array of points that are spaced at equal distance from each other. When you snap to a Grid the nearest grid point is picked. This makes it easy to draw things to conform to some, well, grid. Any number of grids can be defined, but only one of them can be active at any time. Grids have names and colors to distinguish them on the screen and lists.

The Active grid is displayed, and can be changed with, the Select Grid -drop down menu on the top toolbar.

LIST OF COMMANDS

DRAW COMMANDS

DRAW COMMANDS SHORTCUT USE		
Line	L	To draw straight line
Circle	C	To draw circle
Ellipse	El	To draw ellipse
Arc	a	To draw a portion of a circle
Rectangle	Rec	To draw a rectangle
Polygon	Pol	To draw a regular polygon of no. of sides
Polyline	Pl	To draw continuous line
Donut	Do	To draw solid circle
Mline	Ml	To draw no. of parallel lines
Xline	Xl	To draw straight line of infinite length
Ray		To draw straight line of infinite length
Hatch	H	To section the object
Boundary Hatch	bh	To section the object
Text	Dtext	To write text in single line
Mtext	t	To write text in a paragraph

EDIT COMMANDS

Erase	E	Erase a single entity or a group of entities
Oops		Retrieve objects erased inadvertently
Move	M	Move objects to a new location
Copy	Co	Makes no. of copies of an entity to a new location
Array	ar	Make multiple copies of an object
Change	Ch	Changes the properties of the object
Break	br	Break an existing object into pieces
Mirror	mi	Create mirror images of existing objects
Explode	X	Explode a polyline into its component entities
Rotate	ro	Rotate an existing object through a specified angle
Chamfer	c	Chamfer corners of objects
Fillet	f	Provide radius on corners of objects
Stretch	s	Move parts by stretching the objects connected to it
Offset	o	To draw parallel lines or curves
Undo	u	Undo a specified number of commands
Trim	tr	Trim portions of entities

DIMENSIONING COMMANDS

Dimlinear	dimlin	To create linear dimensions, i.e vertical, horizontal and
		inclined dimensions
Dimaligned	dimali	To create an aligned linear dimension
Dimradius	dimrad	To create radial dimensions for circles and arcs
Dimdiameter	dimdi a	To create diameter dimensions for circles and arcs
Dimangular	diman g	To create angular dimensions
Dimbaseline	dimb ase	To create parallel dimensioning
Dimcontinue	dimco	To create progressive dimensioning

	nt	
Dimordinate	**dimor d**	**To create ordinate point dimensioning.**
Leader	**lead**	**To create a leader line to connect it with any object so**
		that the required annotation can be added.

HATCHING COMMANDS

In many drawings, the area must be filled with some pattern. Different filling patterns make it possible to distinguish between different parts or components of an object. Also, the material, the object is made of can be indicated by the filling pattern. Filling the objects with a pattern is known as Hatching. This Hatching process can be accomplished by using the **HATCH** or **BHATCH** command.

HATCHING COMMANDS USE

Hatching To hatch a region enclosed within a boundary by picking a point inside the boundary

Hatch To fill the specified hatch boundary with a non associative hatch

Layer :

1. LAYER COMMANDLAYER COMMAND This command's shortcut is LA (Enter). In this command we can give the different color for the different type of object and different type of style also. We can edit the object of the different type from the current layer window. This command allows you to create the different type of object. When we using the layer command then open a layer window. There are many types of sub tool to modifying the object.

2. This is the window of layer where's we can change the object line type, line weight, color and give the description of the object.

3. NEW PROPERTY FILTERNEW PROPERTY FILTER In this property, from which current layer we have done work, we can save and hide that layer. We cannot modify layer in this property.

4. NEW GROUP FILTERNEW GROUP FILTER In this option we can save and maintain the layer from which layer we have done our work.

5. LAYER STATES MANAGERLAYER STATES MANAGER In this option we can save the layer for recovery, from which layer we have done work. If we have done our work from many layer then we can save our layer in this option, and we are recover in this.

6. NEW LAYER (Alt + N)NEW LAYER (Alt + N) From this option we can make a new layer according to our work and we can give the name of layer.

7. NEW LAYER VP FROZEN INNEW LAYER VP FROZEN IN ALL VIEWPORTSALL VIEWPORTS This option is work as a new layer option. In this option we can freeze the layer.

8. DELETE LAYER (Alt + D)DELETE LAYER (Alt + D) From this option we can delete the layer which is not usable.

9. SET CURRENT LAYER (Alt + C)SET CURRENT LAYER (Alt + C) From this option we can set the layer which is we want to use in drawing.

10. ON /OFF In this option we can hide or unhide the object.

11. FREEZE / UNFREEZE In this layer we can hide and leave the object. This layer is never freeze current layer.

12. LOCK / UNLOCK In this layer we can lock the layer which we want to lock. If we are locking the layer then we cannot done any work of object which is made by that layer.

13. COLOR In this layer we can give the different color of different object.

14. LINETYPE In this layer we can change the line type of object.

15. LINEWEIGHT In this layer we can change the line width of object.

16. From Menu Bar Format – Layer Tool There are many tools of layer such as.

17. MAKE OBJECT'S LAYER CURRENTMAKE OBJECT'S LAYER CURRENT From this tool we can change the object layer in to the current layer.

18. LAYER PREVIOUSLAYER PREVIOUS From this tool we can set the current layer to previous layer which layer is active first from the current layer.

19. LAYER MATCH From this tool we can match any object layer to any object layer.

20. CHANGE TO CURRENT LAYER From this tool we can convert the any layer of object in the current layer.

21. COPY OBJECTS TO NEW LAYER From this tool we can copy the layer object and we can change the layer of copy object.

22. LAYER ISOLATE From this tool we can highlight the layer object which was we selected.

23. THAW From this tool we can unfreeze of all layer.

24. BYLAYER In this option we can maintain the color from current layer only.

25. BYBLOCK From this option, in running with current layer we can make the content through any color. We maintain the by block through property option

BLOCK:-

1. Draw the objects that you want in the block.
2. Choose Home tab> Block panel> Create to start the BLOCK command. The Block Definition dialog box opens.
3. Type a name in the Name text box. The name can have spaces.
4. You need to specify a base point. That's the point at which you'll insert the block. In the Base Point section, click Pick Point. Be sure to use an object snap for accuracy! You'll immediately be returned to the dialog box.
5. In the Objects section, click the Select Objects button. Select the objects and press Enter to return to the dialog box. **Tip:** You can select the objects before using the command and they'll show up in the dialog box.
6. Just below, choose Retain, Convert to Block, or Delete. These options control what happens after you create the block.

7. In the Behavior section, you can make a block Annotative, force it to scale uniformly and choose whether to allow exploding.
8. In the Settings area, choose the block unit. You can choose Unitless but if you choose a unit, AutoCAD will try to scale the block appropriately when you insert it into another drawing. You can also add a hyperlink if you want.
9. Finally, you can add a description in the Description box. A description is helpful in the DesignCenter, when you want to insert the block from another drawing.
10. Click OK to complete the box. If you chose Delete, the objects disappear. You can use the OOPS command to bring them back.

Next time, I'll cover the process of inserting a block.

CREATING TEXT

Command Use

Text The TEXT command lets you write test on a drawing. AutoCAD provides a number of fonts, by applying a style to the font, you may stretch, compress or mirror the text.

Text alignment

m The main text alignment modes are left, center and right. You can align a text using a combination of modes; eg. Top / Middle / Base line / Bottom.
Mtext To create multiple line of text width varying height, Rotation, Justification and fonts.

FILE MANAGEMENT

New
To create a new drawing file. Directly control + N can also be pressed to get a new drawing file.

Open
To open existing drawing file which is already saved? Directly Ctrl + O can also be pressed.

Qsave
If the current drawing has a name, by virtue of either opening an existing or saving it at least once already, the Qsave command saves the drawing by the same name. If the drawing has been saved drawing As dialog box appears, enabling you to enter a name for the drawing file.

Save As
The save command opens the save drawing as dialog box. If the drawing has been named, you can enter a name for the drawing file in this dialog box. If the drawing already has a name, you can accept the current drawing name or enter a different one. It saves the current drawing under the specified name and then sets that drawing to be current.

Save
The save command can only be invoked by entering save at the command prompt. The save option on the file menu or the standard tool bar is Qsave. It opens the save drawing as dialog box from which you can accept the name of the current drawing or enter a new drawing file menu.

Quit
When the most recent drawing is saved, the computer quits out of AUTO CAD. Otherwise drawing modifications dialog box is displayed. So you can save it before you quit AUTOCAD.

CONTROLLING THE DRAWING DISPLAY

AutoCAD provides many ways to display views of your drawing. As you edit your drawing, you can control the drawing display to move quickly to different areas of your drawing while you track the overall effect of your changes. You can ZOOM to change magnification or PAN to reposition the view in the graphics area.

Zoom

To increase or decrease the apparent size of object in the current view port.

Pan
To move the drawing to a new location.

Vports It displays several views at one time by splitting the screen into several tiled view ports.

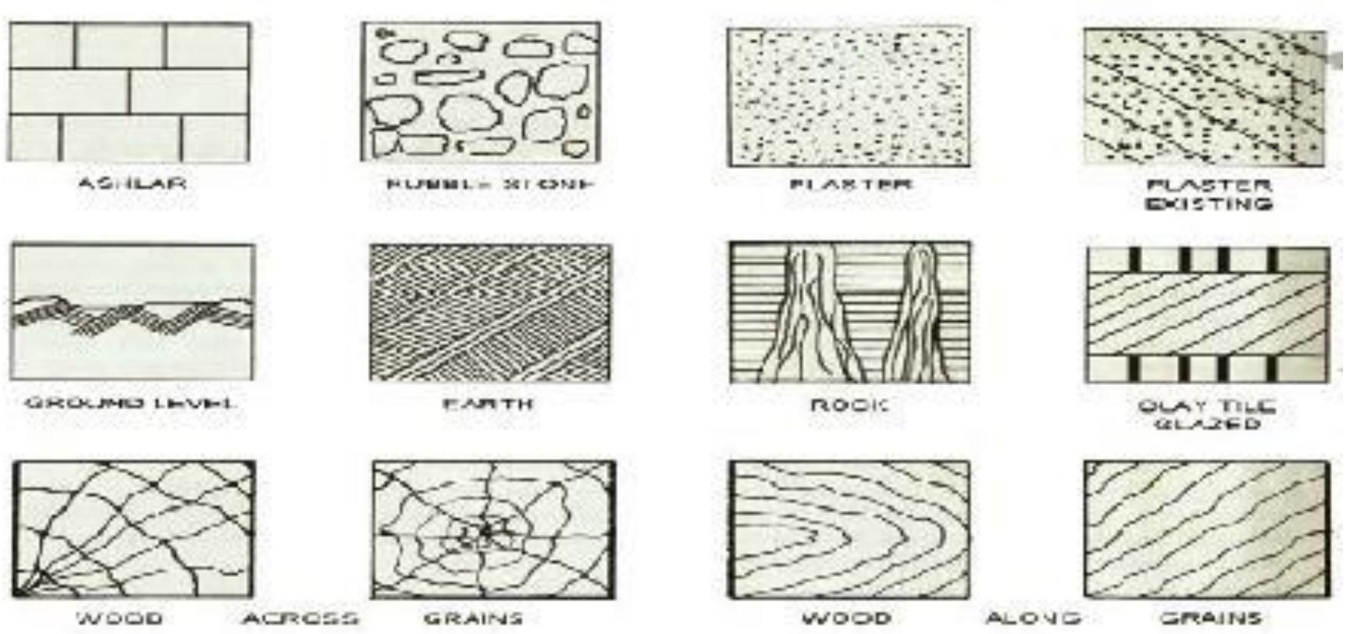
Redraw To refresh the display of all view port.

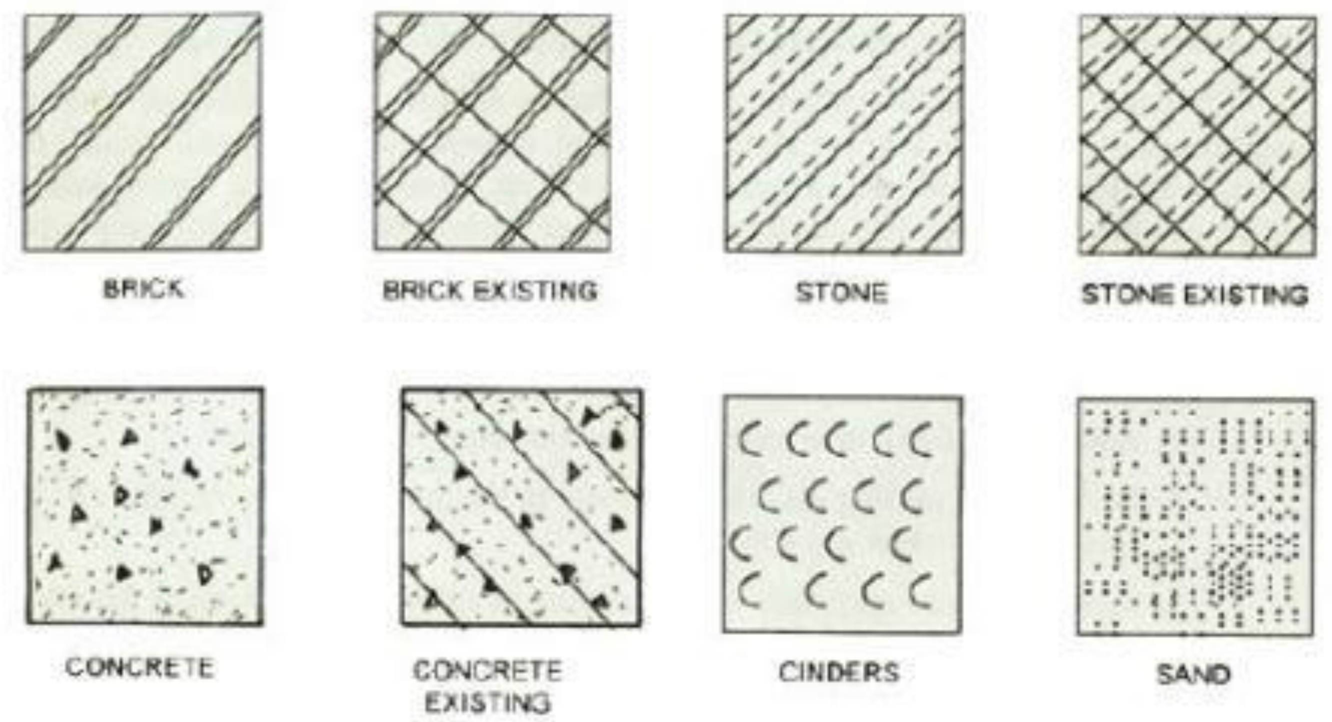
Regen To regenerates the drawing and refreshes all view port.

MODULE -2

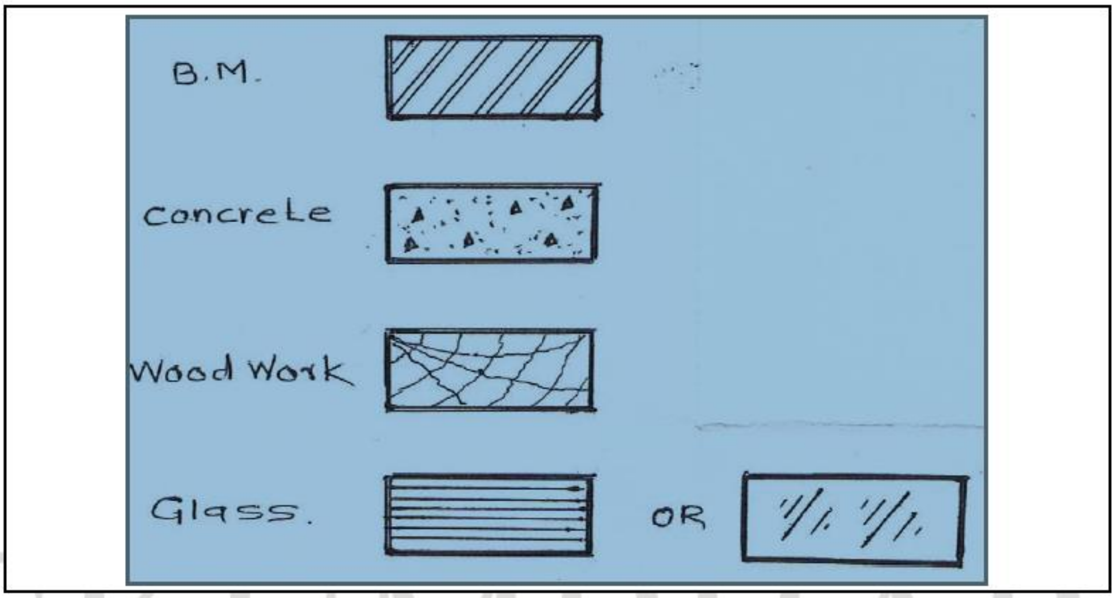
SYMBOLS AND SIGN CONVENTIONS

The conventional signs for civil engineering materials as shown:

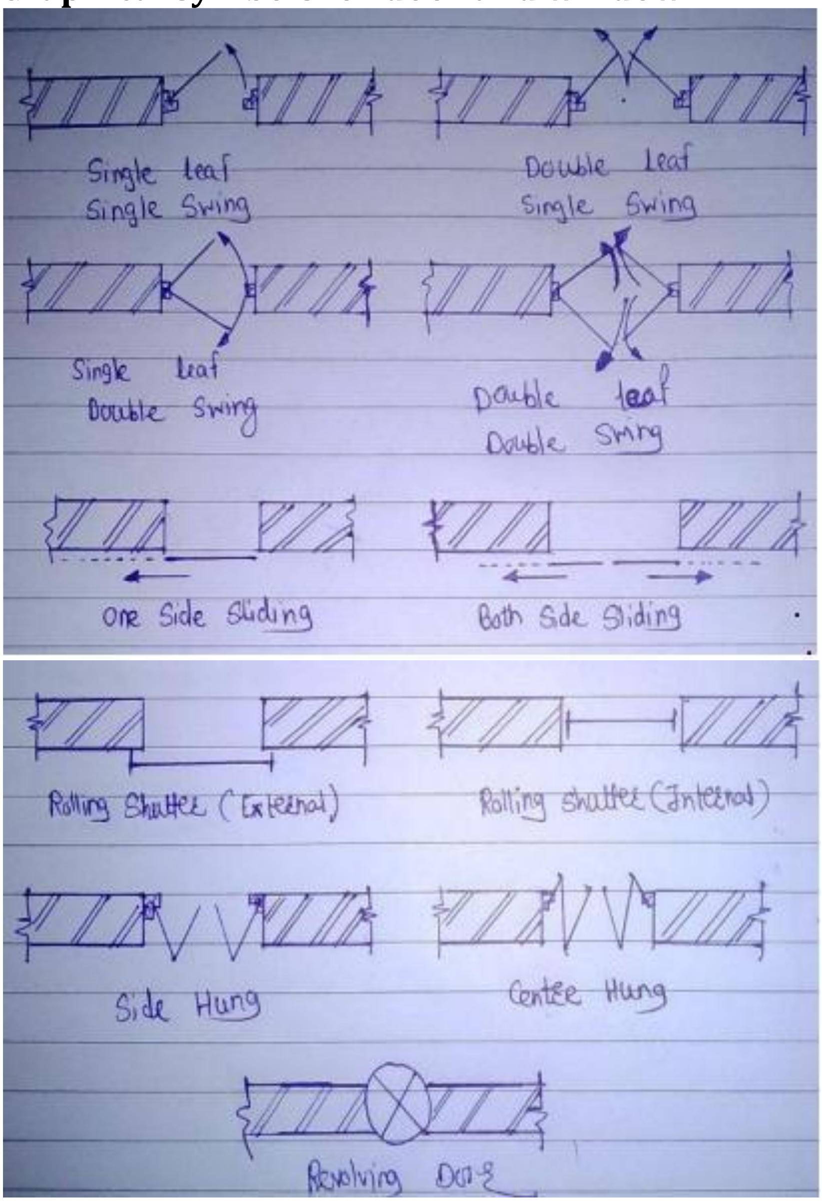




Graphical symbols for Brick Masonry, Concrete, Wood work and Glass:



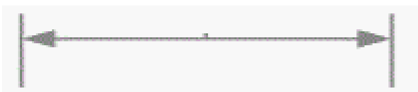
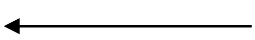
Graphical symbols for door and window:



Various abbreviations used in drawing of any plan are given below:

S. No.	Abbre viations	Full Form	S. No.	Abbre viations	Full Form
1	BBM	Burnt Brick Masonry	2	CM	Cement Mortar
3	DPC	Damp Proof Course	4	UCRM	Uncoursed rubble Masonry
5	CR	Coursed Masonry	6	D	Door
7	W	Window	8	V	Ventilators
9	WC	Water Closet	10	FSI	Floor Space Index
11	FAR	Floor area ratio	12	CCTW	Country cut teak wood
13	TW	Teak Wood	14	MH	Man Hole
15	NT	Nahani Trap	16	GT	Gully Trap
17	GI	Galvanized Iron	18	CI	Cast Iron
19	RCC	Reinforced Cement Concrete	20	AC	Asbestos Cement
21	PCC	Plain Cement Concrete	22	IC	Inspection Chember
23	CC	Cement Concrete		GL	Ground Level
25	PL	Plinth Level	26	CL	Ceiling Level
27	LL	Lintel Level	28	SL	Sill Level

Types of lines used in drawing - visible lines, centre line, hidden line, section line, dimension line, extension line, pointers, arrow head or dots:

S.No.	Type of Line	Symbol	Necessity
1	Visible Outline		These lines should be outstanding in appearance. These lines are used to show wall thickness, plot boundary, proposed structure etc. Thickness may be 0.6mm to1.3mm.
2	Center Line	Thickness 0.2mm to 0.3mm. 	These lines are used to show centre. e.g. Center line of column, centre line of wall or window etc. Alternate long and short dashes are used in proportion of 6:1 or 4:1.
3	Section Line	Thickness 0.6mm to 1.0 mm. 	It is cutting plane on which a section has been taken. It should be indicated by a thick long dash and two short dashes alternately and evenly spaced and lettered at ends.
4	Dimension Line		These lines are used to show dimensions of structure. Thin full line is used in contrast with heavier visible outlines to show dimension. Thickness 0.2mm to 0.3mm.
5	Extension Line		Light and thin lines are drawn from the extremities of feature to which dimensions has to be given. It should not touch the feature.
6	Hidden Line	Thickness 0.4mm to 0.5mm 	These lines are used to show interior or hidden portions e.g. slab projection, chajja projection, loft, truss etc. It consists of small dashes evenly spaced.
7	Pointer Line		When space is insufficient to write a note or dimension near the feature, pointer lines are

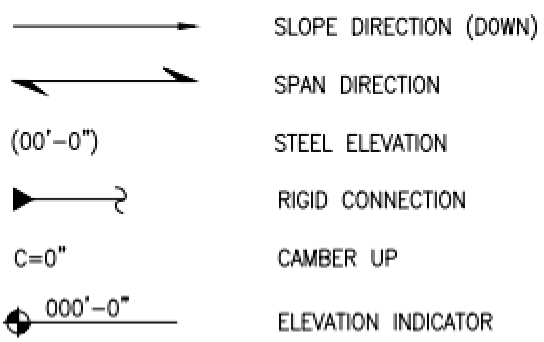
			drawn from the note or dimension to show where it applies.
8	Break Line		Short break lines are free hand drawn. To show continuity of the object, long break line or short break line is used.

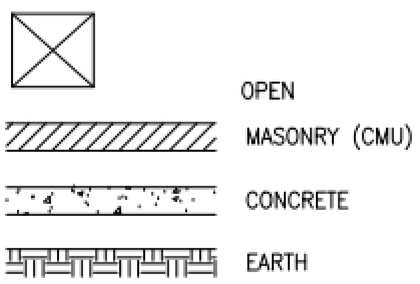
Different Types of scale- Monumental, Intimate, criteria for Proper Selection of scale for various types of drawing:

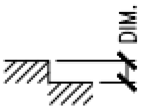
For proportionate and accommodate drawings of structure of various sizes in standard size of sheet, following types of scales are used.

S.No.	Scale	Use
1	1: 200 or 1: 100 or 1: 50	For submission and working drawing
2	1: 20 or 1: 10	For large scale drawings like door and window details.
3	1: 5 or 1: 2 or 1: 1	For enlarge details.

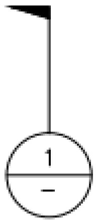
SYMBOLS AND LEGENDS OF STRUCTURAL DRAWING:-



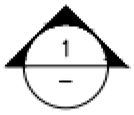




CHANGE (STEP) IN ELEVATION INDICATOR



SECTION CUT

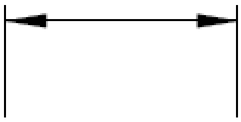


ELEVATION REFERENCE

NORTH INDICATOR

REVISION

SYMBOLS AND ABBREVIATIONS FOR CONCRETE (as per ACI)

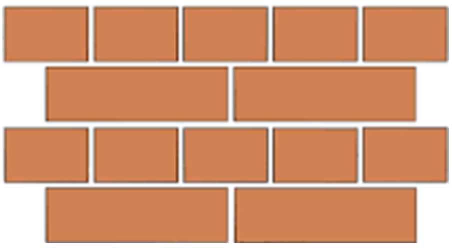
#	TO INDICATE SIZE OF DEFORMED BAR
∅	PLAIN ROUNDS, AS SPIRALS
@ or AT	SPACING CENTER TO CENTER
	DIRECTION IN WHICH BARS EXTEND
	LIMITS OF AREA COVERED BY BARS

MODULE 3:-

- In brick masonry, there are many techniques to stack bricks. These different arrangements are known as bricks bonds. Each bond has its own characteristics. Following are the commonly used bricks bonds. Some of the different types of brick bonds are,
    1. English bond
    2. Flemish bond
    3. Stretching bond,
    4. Heading bond,
    5. Garden wall bond,
    6. Facing bond,
    7. Raking bond,
    8. Dutch bond,
    9. English cross-bond,
    10. Zigzag bond,
    11. Silver lock's bond.
    12. Rat trap bond 13.Dearne's Bond
    13.

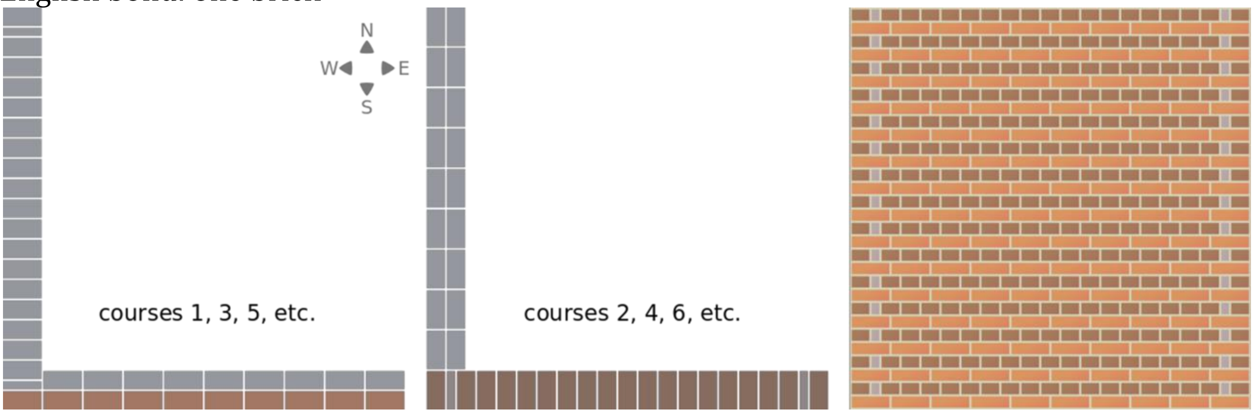
English bond:

- Consists of alternate course of headers and stretches.
- In this English bond arrangement, vertical joints in the header courses come over each other and the vertical joints in the stretcher course are also in the same line.
- For the breaking of vertical joints in the successive course it is essential to place queen closer, after the first header in each heading course.
- The following additional points should be noted in English bond construction:

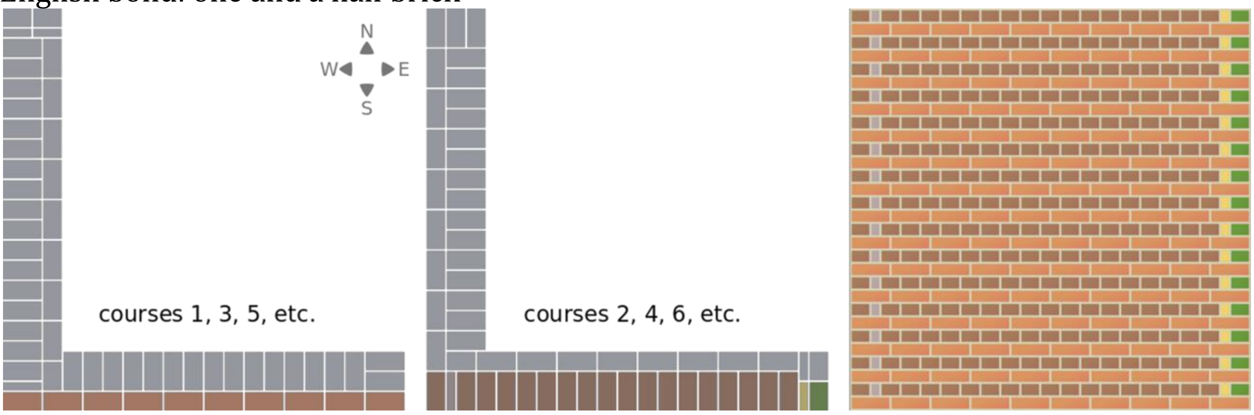


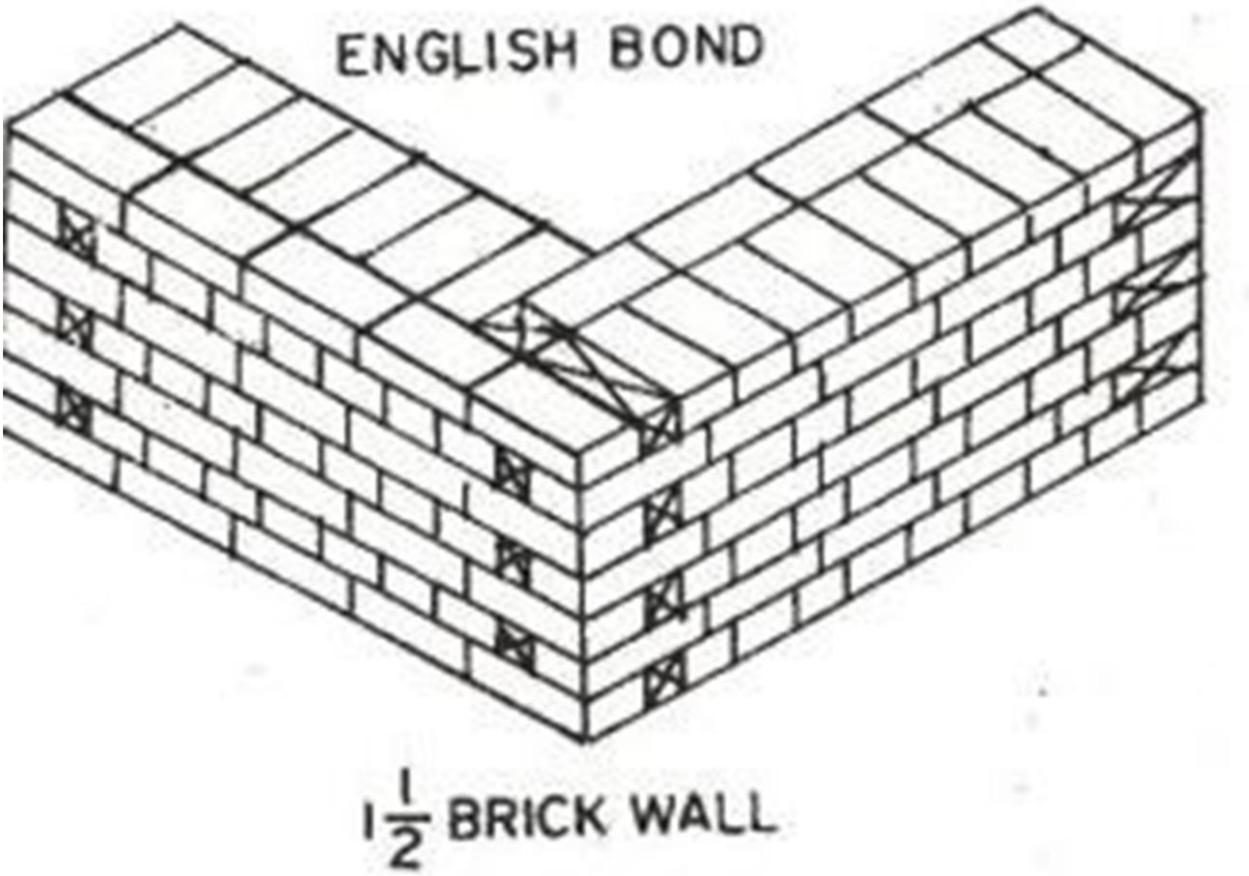
1. In English bond, a heading course should never start with a queen closer as it is liable to get displaced in this position.
2. In the stretcher course, the stretchers should have a minimum lap of 1/4th their length over the headers.
3. Walls having their thickness equal to an even number of half
   Bricks, i.e., one brick thick wail, 2 brick thick wall, 3 brick thick wall and so on, present
   The same appearance on both the faces, i .e. a course consisting of headers on front
   Face will show headers on the back face also.
4. In walls having their thickness equal to an odd number of half brick, i.e. 1½ brick thick walls or 2½ brick thick walls and so on, the same course will show stretchers on one face and headers on the other
5. In thick walls the middle portion is entirely filled with header to prevent the formation of vertical joints in the body of the wall.
6. Since the number of vertical joints in the header course is twice the number of joints in the stretcher course, the joints in the header course are made thinner than those in the stretcher course.

English bond: one brick



English bond: one and a half brick



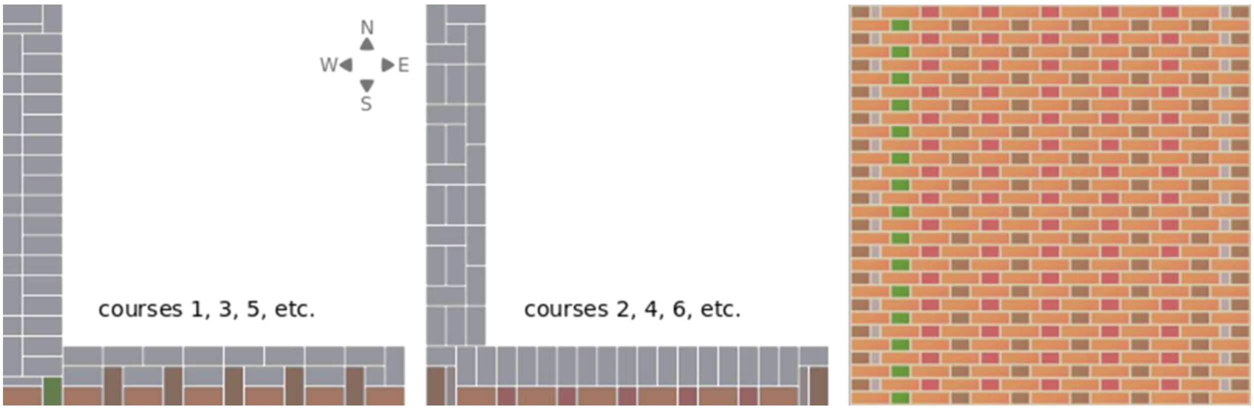


Flemish bond:

- Each course consists of alternate headers and stretchers.
- The alternate headers of each course are centered over the stretchers in the course below.
- Every alternate course starts with a header at the corner.
- For the breaking of vertical joints in the successive courses, closers are inserted in alternate courses next to the quoin header.
- In walls having their thickness equal to odd number of half bricks, bats are essentially used to achieve the bond.
- Flemish bond is further divided into two different types namely,
    1. Single Flemish bond,
    2. Double Flemish bond.

Single Flemish Bond.

- This bond is a combination of English bond and Flemish bond.
- In this work the facing of the wall consists of Flemish bond and the backing consists of English bond in each course.
- This type of bonding cannot be adopted in walls less than one and a half brick in thickness.
- This bond is adopted to present the attractive appearance of Flemish bond with an effort to ensure full strength in the brick work.

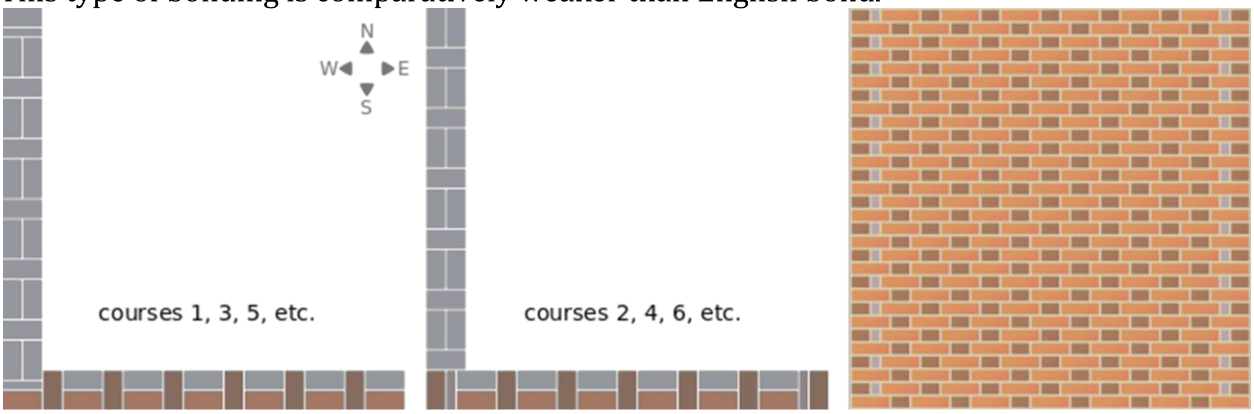


Single Flemish bond: one and half brick

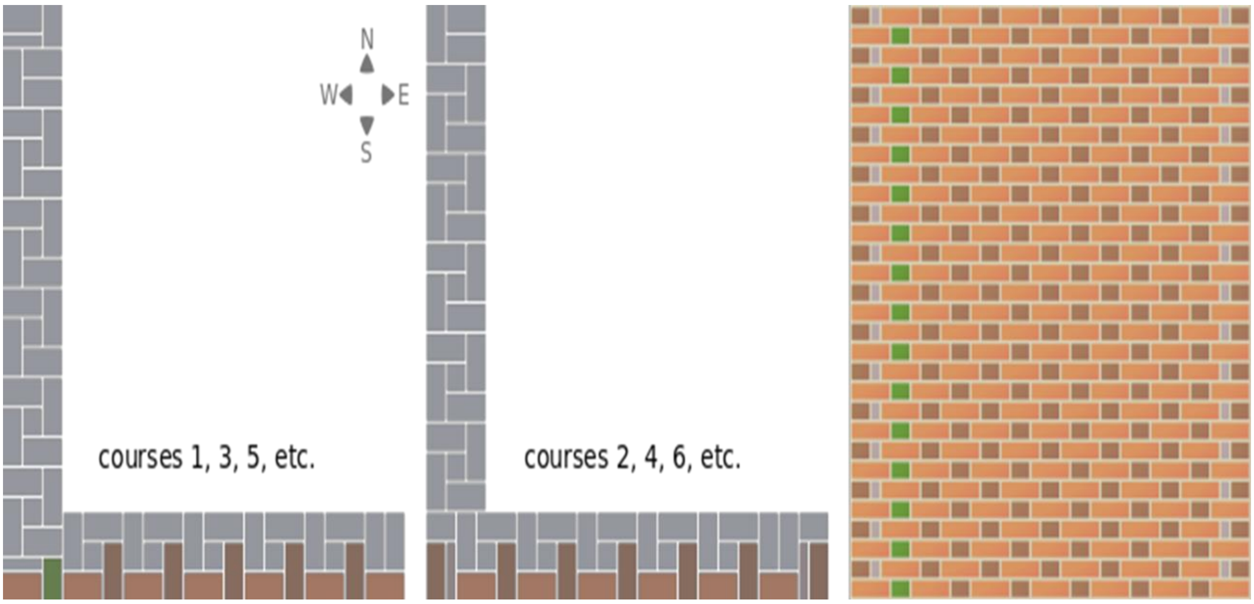
Double Flemish bond.

- In Double Flemish Bond, each course presents the same appearance both in the front and back elevations.
- Every course consists of headers and stretchers laid alternately.
- This type of bond is best suited from considerations of economy and appearance.
- It enables the one brick wall to have flush and uniform faces on both the sides.

This type of bonding is comparatively weaker than English bond.



Double Flemish bond: one brick



Double Flemish bond: one and a half brick

MODULE 4:-

Basic principles of planning are:

1. Aspect 2. Prospect
3. Privacy 4. Roominess
5. Grouping 6. Circulation
7. Flexibility 8. Sanitation
9. Elegance 10. Economy
11. Furniture requirement

1. Aspect:

It is the proper placement of different rooms of the building so that the occupants can enjoy the gift of nature such as sun shine, breeze, and view of the landscape at different hours of the day. If these are cheerful, people living in their midst contented and happy. Hence, building must be designed to suit with all its varying aspects.

Aspect not only provides comfort but it is important from hygienic point of view. By careful disposition of doors and windows in external walls, it is possible to admit sun's rays and air into any desired room. The general appearance of the building largely depends upon the disposition doors and windows in the external walls, however aspects does not mean appearance.

Aspects depends upon the direction of the sun, light, air , rain. A room receiving light and air from particular direction is said to have aspect of that direction.

The kitchen should have eastern aspect so that morning sun refreshes and purifies air and kitchen would remain cool and clean in later part of the day. From the point of view of sunlight, living room used for group discussion should southern or south east aspect. Here in winter since the sun is towards south, sun rays enter the room, while in summer direct rays from north are prevented to enter. Similarly, bed room should have west or south west aspect since cool breeze is available in summer whereas wind from north in winter cannot enter the rooms. North aspect is very good for study room, reading room, workshop, classroom, stores and stair because there will not be direct sun from north but only diffused and evenly distributed light will available.

2. Prospect:

Prospect refers to the view as seen of the outside from the windows in general and doors in external walls. It is determined by the view as desired from certain rooms of the building such as view of garden, beautiful scene, a nearby hill etc. Prospect includes taking full advantage of beauties of nature in the landscape by revealing to the occupants certain pleasant features and at the same time concealing some undesirable views in given outlook. Prospect depends upon the surroundings of the building.

Aspect & Prospect are both primary consideration of building planning and both demand disposition of doors and windows. It will be seen that sometimes aspect and prospect considerations may be at variance with each other as such they should be skillfully disposed.

Prospect can also be accomplished by providing projecting windows since such windows not only provide pleasant features but also help in concealing undesirable views.

Window locations are also helpful to keep a watch on the plot i.e. the main entrance gate as well as back side.

3. Privacy: Privacy is one of the most important considerations in the planning of buildings of all types in general and residential buildings in particular.

Privacy is of two types:

(i) Privacy of all parts of a building with reference to the surrounding building, streets & by-ways. This can be achieved by growing plants, trees & also by keeping windows high enough with respect to roads or ground near by.

(ii) Privacy of one room from another i.e. bed-room, kitchen, bath-room etc. This can be attained by carefully positioning of doors & openings of shutter. The shutters should open in such a way that a person entering the room should get the minimum view.
For maximum privacy such as in bed-room single shutters are better than double shutters.
Privacy can be achieved by means of small corridor or lobby. Partition, screens or curtains also help to provide the requisite privacy use of frosted glass for windows provide more privacy than plain glass. Louvers for shutters provide not only privacy but also ventilation.

Internal Privacy:

i) In internal Privacy, the direct view inside any room from any other room or passage, lobby is prevented.
ii) Internal privacy plays an important role in circulation of inside the building.

Examples:

i) All doors should not be placed in one line, placing of single shutter doors offer more privacy than double shutter doors.
ii) By proper furniture arrangement.
iii) Use of screens at the doors of W.C. and Bath etc.
iv) Use of partitions.

External Privacy:

i) In External Privacy, the direct view of the building from surrounding buildings is obstructed.
ii) Also privacy from noise and pollution from the road.

Examples:

i) Sufficiently kept sill height will not disturb external privacy.
ii) Verandah is to be planned in the front side to maintain external privacy.
iii) Further raising sill height of W.C. and bathroom also maintains the external privacy.
iv) Built a compound wall on plot boundary.
v) Plant the trees near building.

4. Roominess

It refers to the effect achieved by making the best of small portions of room by deriving maximum benefit from minimum dimensions. It appears to be simple at first but really difficult to achieve. It is opposite of crampedness & taxes the brain of the engineer. The feeling of space that is whether it is less, more or adequate depends up on the shape or proportions of length, width & height. A rectangular room is relatively felt bigger than a square room of the same area. It is also found more convenient from utility point of view see fig. (a) & (b). For a rectangular room the length to width ratio should be between 1:2:1 & 1:5:1. A ratio 2:1 or more will cause "tunnel" effect & create bad feeling which should be avoided.
Colour is also responsible for creating the effect of space. Light colours create the effect of more space than the dark colours. Hence a combination of light & dark colours used on different walls of the same room will create the sense of more space.

5. Grouping

Grouping means arrangement of various rooms in the layout in such a fashion that all the rooms are placed with reference to their functions & in due proximity with each other. The building consists of units
or rooms in general. Each room or unit has to perform certain function or functions & there is also some sort of sequence in between them. Proper grouping should have smooth change over rather than abrupt one. Bad grouping lacks in privacy also.
Generally people like to sit in the verandah as such living room should naturally be next to it. Dining room must be close to the kitchen. At the same time, the kitchen should be away from the drawing or living room otherwise the bad smell & smoke will cause nuisance for the occupants. Sanitary arrangements should be adjacent to the bed-room but away from the kitchen, dining room. There should be an independent access to sanitary units.

6. Circulation

Circulation is the access or the internal movement or thoroughfare provided. Circulation is of two types. One is the horizontal circulation & the other is vertical circulation. If the movement is for the same floor & may be from one room to another or within the room itself, then it is called horizontal circulation. The horizontal circulation can be achieved by providing passages, corridors, lobbies, verandahs & halls. It should be straight, short, sufficiently lighted & well ventilated to provide comfort, convenience, efficiency & safety. Desirable horizontal circulation has short, straight & independent passages. It helps to provide privacy of the room. Vertical circulation is the movement from one floor to another floor. It can be achieved by means of stairs, lifts & escalators. These should be easily accessible from entrance, various rooms without intruding privacy. They should also be properly lighted & ventilated. Stairs should be sufficiently wide with strong balusters or parapets & handrails on both the sides. All the sanitary services & staircases must have an independent access from every room through a lobby. It should be airy & well lit.

7. Furniture requirements

The requirements of furniture depend on the type of buildings, the number of persons using the room & function of the room. Therefore the requirement of furniture their sizes etc. is an important consideration because the furniture will decide the size of the room. To make best use of the available space in the room, minimum furniture should be provided. The room does not look pleasing, attractive if it is overloaded in spite of good selected furniture. So at the time of planning the proper position of furniture such as sofas, chairs, tables, television, wall unit in living room, beds, easy chairs, cupboards, almirah, dressing table in bedroom; dining table with chairs in dining room, racks, fridge in kitchen etc. is to be decided with proper circulation & roominess.

Here are some important hints to be borne in mind, while arranging the furniture:

- Furniture should satisfy the functional purpose as well as decorative purpose.
- Furniture should be proportional to the size of the room.
- The arrangement of furniture should well balance.
- Furniture should be arranged parallel or perpendicular to the wall but never at an angle.
- Minimum clearance for movement or circulation should be provided.
- Traffic lanes should be clear of obstacles.
- Too many furniture pieces should be avoided in the room to avoid a crowded & suffocated look.
- Furniture arrangement should depict harmony or unity & rhythm.
- Furniture should provide maximum utility.

8. Flexibility

Flexibility means planning a room in such a way that even though a room originally planned to satisfy a particular purpose, it should also serve other desired purposes when required in future. Space has maximum value now a day, so economy of space is an important factor. Space or lack of space is a problem for all. The answer is not to finding more space but to make maximum use of available space. This is particularly important for designing the houses where economy is major consideration. So we should be careful to see that even the smallest room should serve big role. One should be flexible over the use of rooms. The requirements go on changing as the family expands in future. Hence, planning is to be done in a manner that the rooms like living room can be easily converted into a guest room. Dining can be provided in the kitchen, in that case it may be useful as kitchen-cum-dining room. If there is a separate dining room, it may be used as study room.

9. Sanitation

Sanitation includes provision of sufficient light, ventilation, cleanliness and sanitary convenience in following way.

(i) Lighting: The object of lighting is to promote the work or any activity to be carried in the building under safety conditions, and pleasant environment which are helpful to create interest, economy, and a sense of well being. Lighting is of two types. One is natural and other is artificial.

Natural lighting: The sun is the main source of natural light. Sunlight illuminates and also destroys bacteria and disease germs, since it contains ultra violet rays. The blue sky over our head is also the source of day-light and brightness. The intensity of light is affected by clouds, dust, smoke and gases. Hence, planning is to be making to get the required natural light.

Artificial lighting: - Artificial lighting is mainly required at night & replace or supplement the natural illumination. Igneous & imaginative lighting technique can bring life cheerfulness, comfort & a style in a moderately decorated room. Proper illumination increases cheerfulness & efficiency of the workers in a factory or office by reducing fatigue. Glare should be avoided as far as possible because it not only distracts but also disables the vision.

(ii) Ventilation: - It may be defined as a system of supplying of fresh air from outside by natural or mechanical devices & removing of air vitiated by respiration, bacteria & unpleasant odors from the rooms in order to maintain comfortable conditions. Lack of movement of air produces a feeling of discomfort, increases temperature, humidity. Ventilation may be natural or artificial.

(iii) Cleanliness: - It is the responsibility of the occupant to maintain the building clean & neat. However precaution should be taken to provide facilities for cleaning & prevention of dust accumulation. The dust is harmful to health. It allows the growth of bacteria & decreases to spread. So dust should be prevented to accumulate on mounding, skirting, ceramics & corners by giving proper shape for easy cleaving. The interior wall should be perfectly plane & their meeting lines at the corners should be rounded off for easy cleaning. The floor should be on non-absorbent type & smooth. Also proper slope should be given for easy cleaning & washing.

(iv) Sanitary Conveniences:- This includes the provision of bath-rooms, water-closets, lavatories, latrines, urinals to remove unhygienic matter away from the living place. Dust bins should also be provided to collect the garbage & to carry away from the living place. The walls of the bathrooms & water closet should be provided with dadoes so that they can be cleaned regularly. The flooring & side walls should be treated with water-proofing compound before fixing the glazed tiles for floor & dadoes.

10. Elegance

Elegance means beauty & grace. This effect is produced by greater purity & delicacy of ornamental enrichment of construction. Elegance is related to the appearance of the building i.e. elevation, which can be made attractive, impressive & pleasing. This elegance in a building can be achieved in three ways. Firstly, it can be achieved by

the treatment of walls, the proportions of openings in the form of doors & windows, relation of one storey to another etc. Secondly it can be achieved by the treatment of exterior of a building which is aesthetically significant as a whole, such as the effect of a pitched or flat roof or a dome, the rhythm of projection & recessions etc. Thirdly it can be achieved by the treatment of the interior, the arrangement of rooms, a graceful stair-case etc. The first of the above three ways is two dimensional, whereas second & third are three dimensional.

11. Economy

Economy is not the principle of planning but rather a factor on which the planning can be based. No general rules can be made to achieve economy since the ways & means to attain it are different in different situation. Economy can be achieved by keeping the minimum dimensions of the rooms, doors, windows; simple design for windows, plain tiles as well as fixtures & fastening. The height of the building can be kept to a minimum of 3 m. for a residential building. Porches, lobbies can be avoided. If the land cost is high, multistoried building can be constructed to save the cost for foundation & roof. A building designed for a good strength, utility & safety will certainly prove to be costly in the beginning but may prove to be cheaper in the long run as it saves the cost of maintenance in future. It should be remembered that a building or house is immovable property & built with one's life saving, to last for many years to come. One should not therefore, adopt false economy by erecting a weak building.

ORIENTATION OF BUILDING USING ASPECT AND PROSPECT:

S. No.	Unit	Aspect	Remark
1	Kitchen or Kitchen cum dining	E/NE/SE	Morning sun should enter
2	Bed room	W/SW/NW	Evening sun should come to remove dampness and germs. Sun rays in evening are cool in nature so bed room becomes pleasant till its time of use. Good breeze comes from west.
3	Living room	SE/NE	For all the time of day, good sunlight should come.
4	Study room	N	This room should be well lighted.
5	Store room	N	This room should be well lighted.
6	verandah	N/S	This room should be well lighted.
7	WC and Bath	-	Must be located near kitchen and bed.

Space requirement and norms for minimum dimension of different units in the residential buildings:

S.No.	Room Name	Minimum Size
1	Living room	9.5 sqm (mini 2.4 m wide)
2	Bedroom	9.5 sqm (mini 2.4 m wide)
3	Kitchen	4.5 sqm (mini 1.8 m wide)
4	Kitchen cum store	5.5. sqm

5	Kitchen cum dining	9.5 sqm
6	bath	1.8 sqm (General size 1.5m X 1.2m)
7	W.C.	1.1 sqm (General size 1.1m X 1m)
8	Combined WC and bath	2.8 sqm (mini 1.2 m wide)
9	Stair case	Width: min. 1m FOR RESIDENTIAL Rise: 150 mm Trade: 250 mm Width of landing = width of stair Head room : 2.2 m
10	verandah	Width of verandah = 1.2 m

Important bye-laws:
(I) Building & Control Lines
(II) Open Space Requirements
(III) Built-up Area
(IV) Floor Space Index (F.S.I.) or Floor Area Ratio (F.A.R.)
(V) Height of Building
Plinth height: - Plinth height should be more than 300mm.
Generally it is taken from 450mm to 750mm.

For garages plinth height is 150mm.

Ceiling height:-
1. for habitable rooms: 2.75m
F.S.I.:- F.S.I. means floor space index. It is defined as the ratio of total built-up area (total area of all floors) to the area of the plot. It is also called as floor area ratio (F.A.R.) it regulates population density and overcrowding in dwelling units.
Floor area: - This is the usable covered area of the building at any floor level. Floor area is calculated by deducting area of walls from plinth area.
Built up area: - It is the area covered by all floors of the building. It covers everything under roof but excludes balconies, staircases etc. It includes floor area of all rooms plus wall thickness.
Carpet area: - This is the floor area of the usable rooms at any floor. (Actually where carpet can be laid.) Carpet area can be calculated from floor area deducting sanitary accommodation, kitchen, pantries, verandah, corridors, passages, stores etc.

Floor Space Index (F.S.I.) or Floor Area Ratio (F.A.R.)
Floor space index is defined as a ratio of total built-up area of all floors to the plot area.

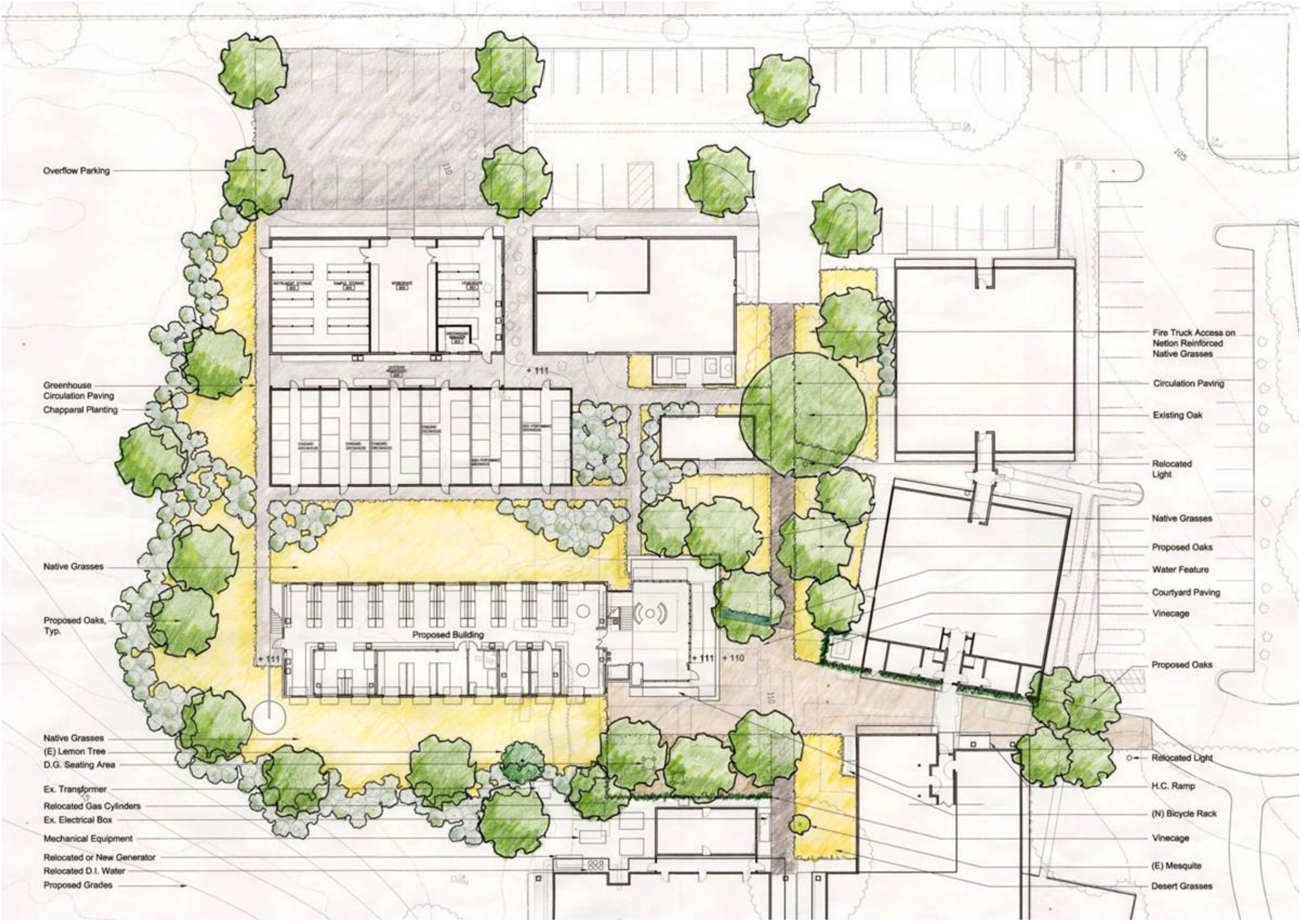
Total built-up area of all floors
FSI= ---------------------------------
Area of Plot

Plinth Area = Carpet area + Wall thickness of all units + Area which is excluded in calculation of carpet area.

TYPES OF DRAWING:-

Site Plan

This type of drawing is concerned with one or more buildings which are within the same area and shows these buildings within their own **site** (or plot) boundary. The site plan allows the builder to mark out the site before digging trenches for foundations and drains. The scale is normally **1:200** for domestic buildings.



Site plans may include:

 Boundaries of the plot

The position (dimensions) of the building within the plot access paths

Drainage information for the removal of waste: pipe runs, manholes and the location of the main sewer

Contour lines to indicate the direction and gradient of sloping ground

Existing trees and the positions of any new trees that is required

A north direction arrow

The scale of the drawing

Floor Plan

Drawings provide a "bird's-eye view" of the different floor levels of your project. They show scaled dimensions of the project, and include rooms, spaces, walls, partitions, doors, windows, fixtures and other features.

For renovation and alteration projects, the drawings must clearly distinguish between existing, new, and demolished or removed construction.

Walls and partitions must be shown at an appropriate width for the scale used. Single line wall and partition drawings are not acceptable.

ELEVATION:

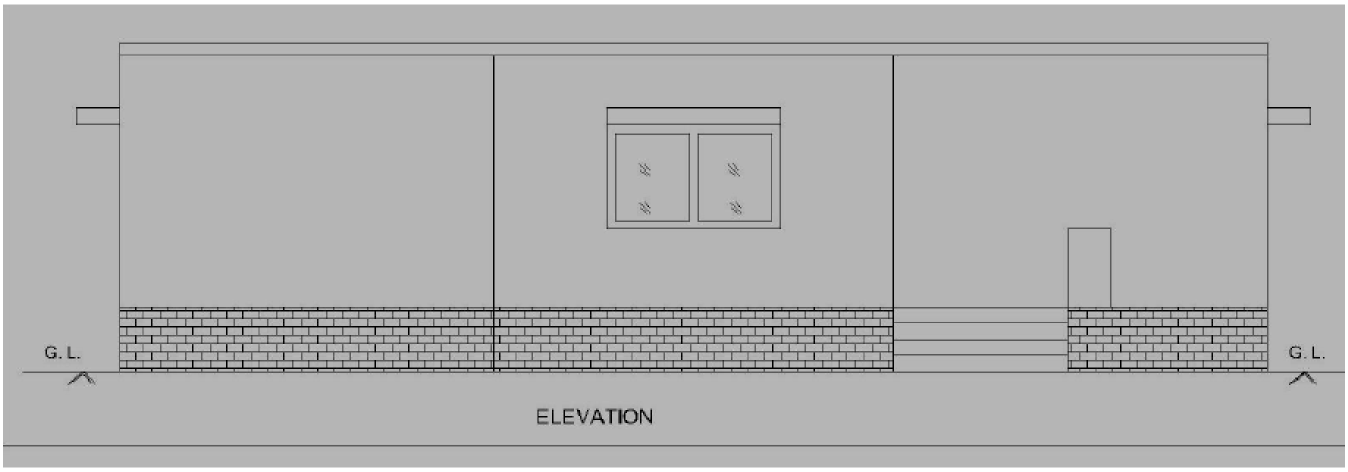
Elevation or front view is the outward view of a completed building along any side of the building. When a building is seen by standing in front of it, the view that can be viewed is known as front elevation.

Similarly backside view is called rear elevation or from any side of it which is known as side elevation.

Building Elevation Drawings show the exterior views of the building, for each building face. The drawings show height relationships and exterior finish information. A Building Elevation Drawing is required for each building face.

For most renovation or alteration projects, Building Elevations Drawings would not be required. If the project involves substantial alterations to the building exterior, Building Elevation Drawings will be required.

Typical Elevation:



Section:

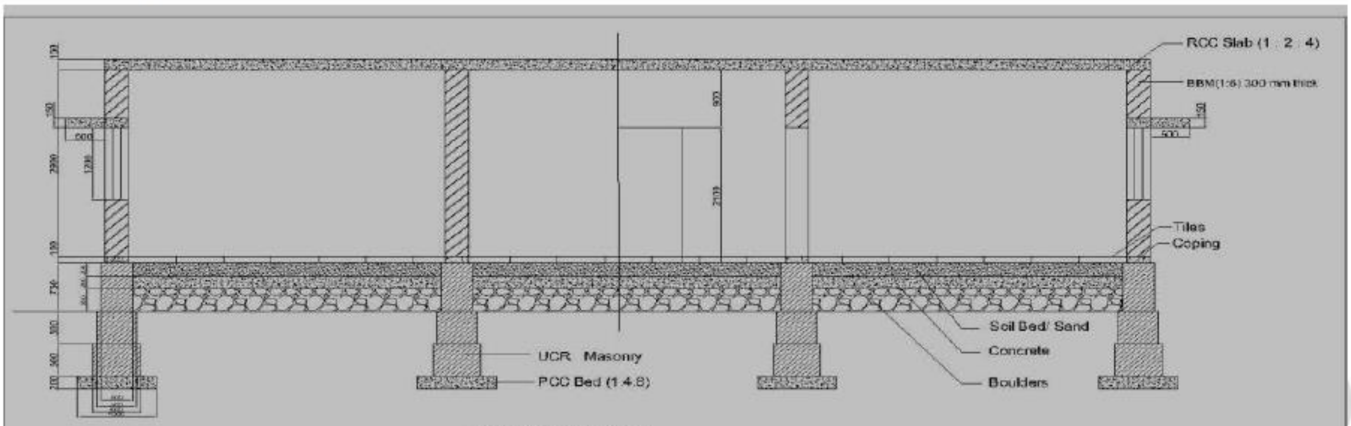
Section is also known as vertical section and sectional elevation or cross section. It is imagined that a finished buildings is cut vertically along a line so that the building is separated into two portions along the imagined vertical plane right from top of the building to the lowest part of foundation. The view that can be seen while travelling along this imaginary vertical plane when looking towards left is drawn to the same scale as that adopted for the plan.

The line, which is drawn on the plan to indicate the section, is called sectional line and represented by A-B or X-X. The arrow heads shall be marked to indicate the way in which the sectional view is to be drawn. In some cases offset is given to indicate the necessary details, but the offset is only to shift the vertical plane from one position to another position as shown below.

The necessity of the section is to indicate all the vertical dimensions like, foundation details, basement, details of flooring, height of super structure, sizes of doors, windows, almairahs, cupboards, other openings, thickness of roofing, width and depth of parapet wall, lintels, sunshades, portico and other details. All these details are required to calculate the quantities of items of work and to execute the process of construction.

Building Section Drawings show a view at an imaginary line cut through the building vertically, indicating the buildings structural and construction elements. The Building Section Drawings expose and identify the construction elements of the roof, walls, partitions, floors, ceilings, and foundations. For most renovation or alteration projects, Building or Wall Sections would not be required. If the project involves alterations to the roof, floor, walls, or foundations components of the building, appropriate Building or Wall Sections (showing the proposed alterations) will be required.

Typical Section Plan:



SECTION ALONG AB

MODULE 5

PERSPECTIVE VIEW:

Definition:

Perspective is a Latin word meaning „look through". It is a three dimensional view as a person sees or a camera captures a picture. It is representation of an object as it appears to the observer. It is illusion which is different from actual form of object. It is useful to architects, engineers, designers, public and artists. It is used for advertisement and printing brochures.

Types of perspective:

a) Based on position of object with respect to picture plane :-

I) parallel perspective

II) oblique perspective

b) Based on No of Vanishing point :-

I) One point perspective

II) Two point perspective

III)Three point perspective

Terms used in perspective drawing:

1) Picture Plane: It is an imaginary, transparent vertical plane erected between the object and the observer, very near to, or touching or cutting one corner of the object.

2) Vanishing points: The vanishing points on a line are the points where the perspective of all straight lines except those parallel to the picture plan appears to terminate. **OR**

2) Vanishing points: The vanishing points on a line are the points in which a system of parallel line of the object inclined to picture plane appear to converge.

Principal used in prospective drawing:-

1) The lines appear to be shorter than their actual length, and his effect increase, as the distance of the object increase.

2) The picture of all points and lines on the picture play coincides with the points and lines themselves. 3) Perspective of all the parallel lines which are also parallel to the picture plane .not parallel to the picture plane, converge to a point

OR

Perspective drawing is figure formed on a picture plane when visual rays from eye to the object cut the picture plane.

Size and shape of perspective view depends on position of picture plane, eye level, station point and vanishing points.

When object is nearer to the observer or camera, it forms larger angle at eye or lens hence form larger images and if object is farther, it subtends smaller angle so forms smaller image.

In addition to length and breadth perspective view creates illusion of height/depth.

For human eye, parallel lines seen converged. E.g. railway track.

EXPERIMENT NO. CE (ES) 392/ 1

Name: Building with load bearing walls including details of doors and windows

AIM:
To draw Building Plan.

Procedure:

List of commands to be used:

DRAW Command: UNIT, LINE, PLINE, X LINE, RECTANGLE, ARC

Edit commands:

Command: **OFFSET, TRIM, EXTEND, COPY, MOVE, ERASE, ROTATE**

For TEXT matters:

Command: **DTEXT, MTEXT**

For Layer:
Command: LAYER PROPERTIES

For Dimensioning:
Command: DSTYLE, DIMENSIONING, LEADER

For Block: Command: BLOCK, INSERT

For Hatching: HATCH

SCHEDULE FOR OPENINGS:

SL.NO.	ITEM	SYMBOL	SIZE	DESCRIPTION	REMARK
1.	Door	D	standard		External/Internal
2.	Window	W	standard		External/Internal

EXPERIMENT NO. CE (ES) 392/ 2

Name: Taking standard drawings of a typical two storied building including all MEP joinery, rebars, finishing and other details and writing out a description of the facility in about 500-700 words.

AIM:
To draw Building Plan .Elevation, Section

Procedure:

List of commands to be used:

DRAW Command: UNIT, LINE, PLINE, X LINE, RECTANGLE, ARC

Edit commands:

Command: **OFFSET, TRIM, EXTEND, COPY, MOVE, ERASE, ROTATE**

For TEXT matters:

Command: **DTEXT, MTEXT**

For Layer:
Command: LAYER PROPERTIES

For Dimensioning:
Command: DSTYLE, DIMENSIONING, LEADER

For Block: Command: BLOCK, INSERT

For Hatching: HATCH

EXPERIMENT NO. CE (ES) 392/ 3

Name: **RCC framed structures**

AIM:
To draw Column Layout Plan .Beam Layout Plan

Procedure:

List of commands to be used:

DRAW Command: UNIT, LINE , PLINE, X LINE, RECTANGLE, ARC

Edit commands:

Command: **OFFSET, TRIM, EXTEND, COPY, MOVE, ERASE, ROTATE**

For TEXT matters:

Command: **DTEXT, MTEXT**

For Layer:
Command: LAYER PROPERTIES

For Dimensioning:
Command: DSTYLE, DIMENSIONING, LEADER

For Block: Command: BLOCK, INSERT

For Hatching: HATCH

EXPERIMENT NO. CE (ES) 392/ 4

Name: Reinforcement drawings for typical slabs, beams, columns and spread footing

CE 392/ 4a
Name: Preparation of detailed drawing of RCC Slab

AIM:
To draw RCC Slab using AUTOCAD commands.

Procedure:

List of commands to be used:

DRAW Command: UNIT, LINE, PLINE, X LINE, RECTANGLE, ARC

Edit commands:

Command: **OFFSET, TRIM, EXTEND, COPY, MOVE, ERASE, ROTATE**

For TEXT matters:

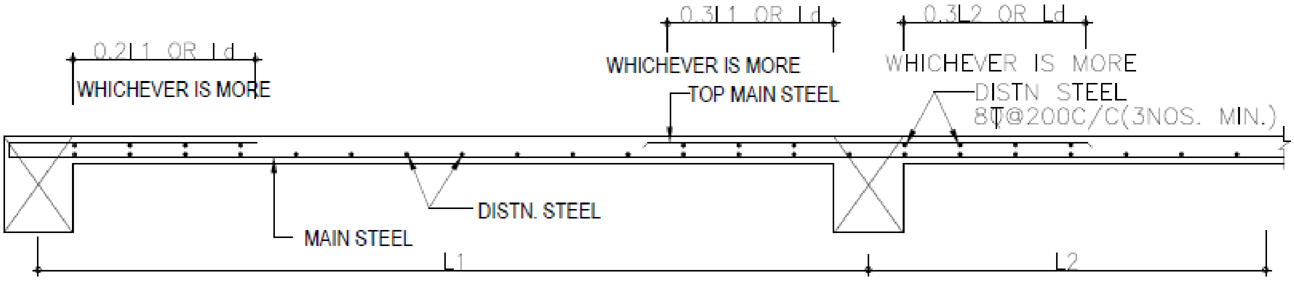
Command: **DTEXT, MTEXT**

For Layer:
Command: LAYER PROPERTIES

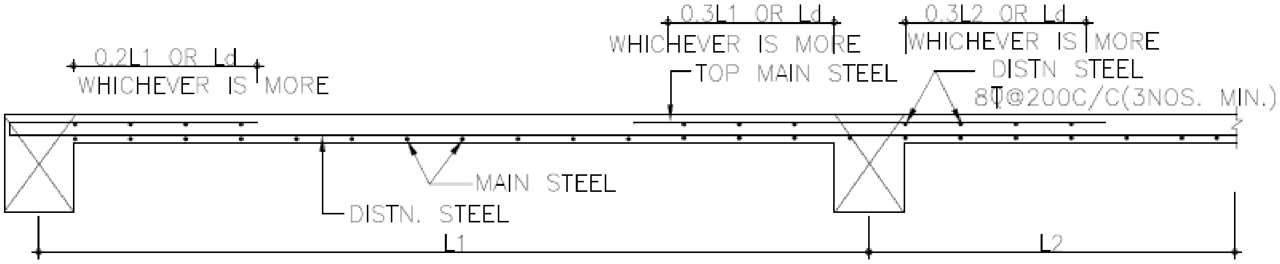
For Dimensioning:
Command: DSTYLE, DIMENSIONING, LEADER

For Block: Command: BLOCK, INSERT

For Hatching: HATCH



TYP. SEC. OF SLAB ALONG SHORTER DIRECTION



TYP. SEC. OF SLAB ALONG LONGER DIRECTION

CE 392/ 43b
Name: Preparation of detailed drawing of RCC Beam

AIM:
To draw RCC Beam using AUTOCAD commands.

Procedure:

List of commands to be used:

DRAW Command: UNIT, LINE, PLINE, X LINE, RECTANGLE, ARC

Edit commands:

Command: **OFFSET, TRIM, EXTEND, COPY, MOVE, ERASE, ROTATE**

For TEXT matters:

Command: **DTEXT, MTEXT**

For Layer:
Command: LAYER PROPERTIES

For Dimensioning:
Command: DSTYLE, DIMENSIONING, LEADER

For Block: Command: BLOCK, INSERT

For Hatching: HATCH

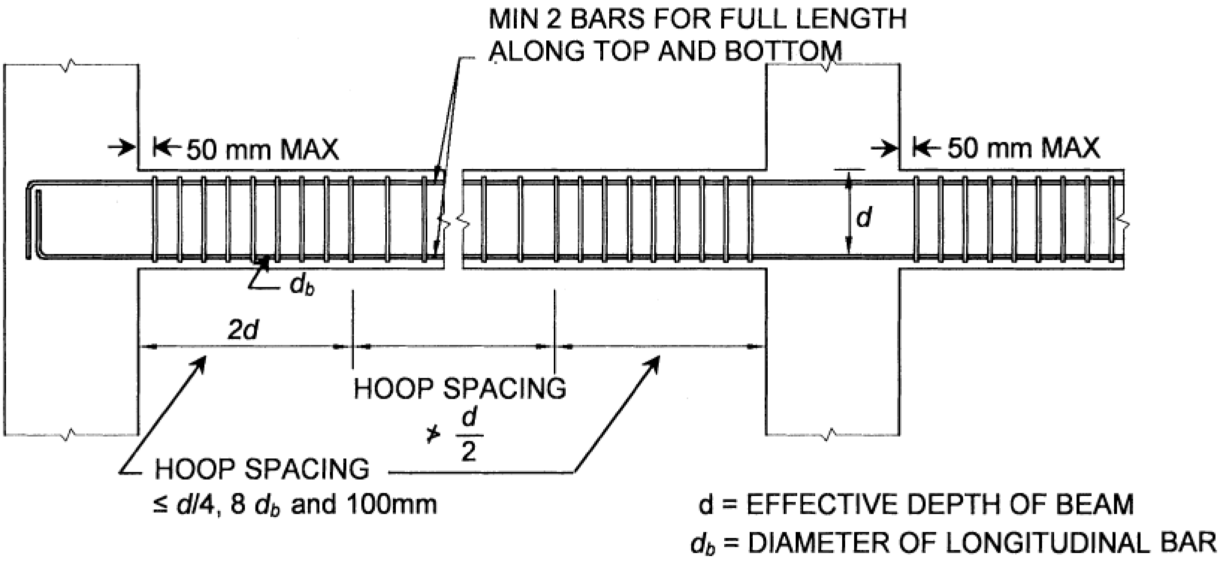


FIG. 6 DETAILS OF TRANSVERSE REINFORCEMENT IN BEAMS

CE 392/ 4C

Name: Preparation of detailed drawing of RCC Column

AIM:

To draw RCC Column using AUTOCAD commands.

Procedure:

List of commands to be used:

DRAW Command: UNIT, LINE, PLINE, X LINE, RECTANGLE, ARC

Edit commands:

Command: **OFFSET, TRIM, EXTEND, COPY, MOVE, ERASE, ROTATE**

For TEXT matters:

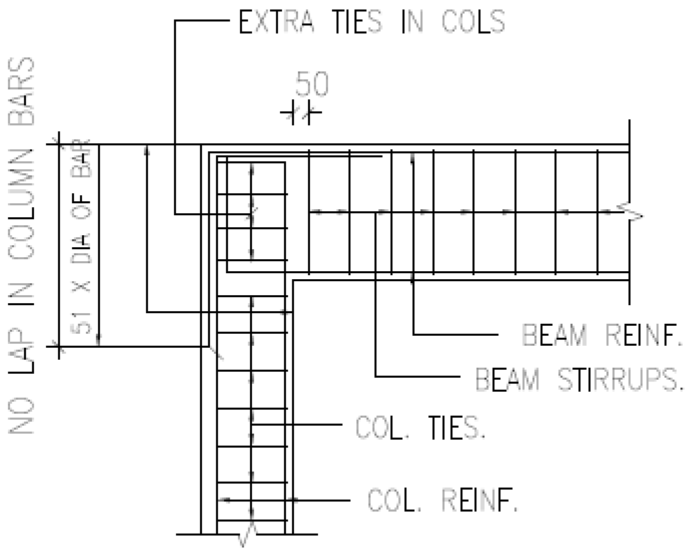
Command: **DTEXT, MTEXT**

For Layer:
Command: LAYER PROPERTIES

For Dimensioning:
Command: DSTYLE, DIMENSIONING, LEADER

For Block: Command: BLOCK, INSERT

For Hatching: HATCH



TYP. DETAILS OF BEAM-COLUNMN
JUNCTION AT EXTERIOR COLUMN

CE 392/ 4d
Name: Preparation of detailed drawing of Spread footing

AIM:
To draw Footing Design using AUTOCAD commands.

Procedure:

List of commands to be used:

DRAW Command: UNIT, LINE, PLINE, X LINE, RECTANGLE, ARC

Edit commands:

Command: **OFFSET, TRIM, EXTEND, COPY, MOVE, ERASE, ROTATE**

For TEXT matters:

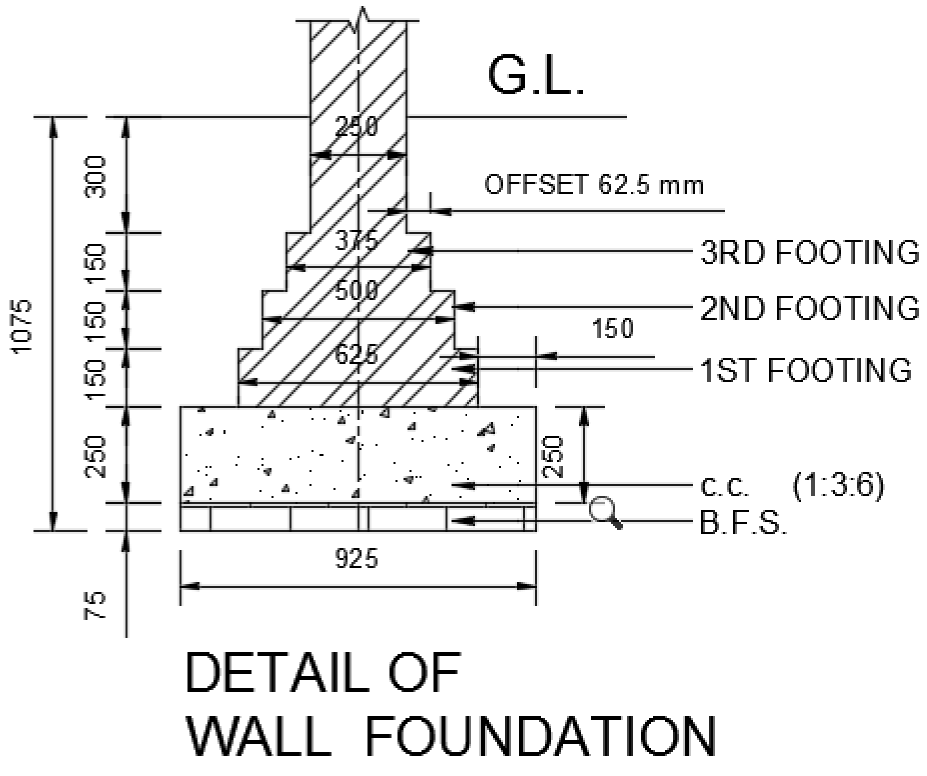
Command: **DTEXT, MTEXT**

For Layer:
Command: LAYER PROPERTIES

For Dimensioning:
Command: DSTYLE, DIMENSIONING, LEADER

For Block: Command: BLOCK, INSERT

For Hatching: HATCH



CE 392/5

Name: Preparation of detailed Industrial buildings – North light roof structures - Trusses

AIM:

To draw Industrial North light roof truss using AUTOCAD commands.

Procedure:

List of commands to be used:

DRAW Command: UNIT, LINE, PLINE, X LINE, RECTANGLE, ARC

Edit commands:

Command: **OFFSET, TRIM, EXTEND, COPY, MOVE, ERASE, ROTATE**

For TEXT matters:

Command: **DTEXT, MTEXT**

For Layer:
Command: LAYER PROPERTIES

For Dimensioning:
Command: DSTYLE, DIMENSIONING, LEADER

For Block: Command: BLOCK, INSERT

For Hatching: HATCH

LABORATORY INSTRUCTION MANUAL

COMPUTER APPLICATION IN CIVIL ENGINEERING

(CE (PC) -597)

DEPARTMENT OF CIVIL ENGINEERING
SILIGURI INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

NAME: ____GROUP: _____________

ROLL NO.__________________

LIST OF EXPERIMENTS

MODULE NO	EXPERIMENT NAME
CE(PC)-597/1	Introduction: Concept of problem-solving using computer, use of programming language and software for problem solving; Identification of various design and analysis problems in different fields of Civil Engineering to be solved using computers; Procedure, formulae and data related to the analysis and design of such problems
CE(PC)-597/2	Use of spreadsheets: Learning spreadsheets like MS Excel, matrix analysis, use of Goal Seek and Solver, Optimization Tools; Plotting. Applications to problems involving tabular data, CE estimation, surveying, and design problems.
CE(PC)-597/3	Programming Languages: Learning at least one language: Fortran 2003/2008/2018, C++11/C++14, Python 3, VBA 7.0; Computing platforms like Matlab/Scilab/MathCAD; Solving analysis and design problems in areas like surveying, hydraulics, structural analysis, RCC design, soil mechanics and foundation, transportation, water resources, etc.
CE(PC)-597/4	Use of Software: Familiarity with widely used Civil Engineering software like STAAD Pro, HECRAS, HEC-HMS, SWMM, Mx Roads, etc.; Solving at least two such analysis/design problems

MODULE-1 CE (PC) 597/2

Use of spreadsheets: Learning spreadsheets like MS Excel

Applications to problems involving tabular data, CE estimation, surveying, and design problems

LOAD CALCULATION OF A BUILDING

FLOOR LOAD CALCULATION:

Dead load calculation:

Reference IS code: 875(PART 1)-1987

Unit weight of RCC	=	25	KN/m^3
Slab thickness	=	0.15	mm
1.Weight of slab:Unit weight of Rcc x length x breadth x thickness	=	3.75	KN
Unit weight of plaster	=	24	KN/m^3
Thickness of plaster	=	0.01	m
2.Weight of plaster Unit weight of plaster x length x breadth x thickness	=	0.24	KN/m^2
Floor Finish load		1	KN/m^2
Total dead load	=	4.99	KN/m^2
Imposed load	=	3	KN/m^2

Reference IS code: 875(PART 2)-1987

Total load on floor	=	**7.99**	KN/m^2

ROOF LOAD CALCULATION:

Refer to IS 875(PART 1)-1987

Dead load calculation:

Unit weight of RCC	=	25	KN/m^3

Slab thickness	=	0.13	m
1.Self weight on slab			
Unit weight of RCC x length x breadth x thickness	=	3.25	KN/m^2
Unit weight of plaster	=	24	KN/m^3
Thickness of plaster	=	0.01	m
2.Weight of plaster			
Unit weight of plaster x length x breadth x thickness	=	0.24	KN/m^2
Roof finish load		1	KN/m^2
Total dead load	=	4.49	KN/m^2
Imposed load	=	2	KN/m^2
Reference IS code: 875(PART 2)-1987			
Total floor load	=	**6.49**	KN/m^2

MEMBER LOAD CALCULATION:

Refer to IS 875(PART 1)-1987			
Unit weight of brick	=	19.2	KN/m^3
Thickness of wall	=	0.25	mm
For ground floor:unit weight of brick x height x thickness	=	17.5	KN/m
For first floor:unit weight of brick x height x thickness	=	15	KN/m
For second floor:unit weight of brick x height x thickness	=	15	KN/m
For third floor:unit weight of brick x height x thickness	=	15	KN/m
For fourth floor:unit weight of brick x height x thickness	=	15	KN/m
For roof:unit weight of brick x height x thickness	=	4.5	KN/m

MODULE-1 CE (PC) 597/4

INTRODUCTION TO STAAD PRO

INTRODUCTION:

The STAAD.Pro Graphical user interface (GUl) is normally used to create all input specifications and all output reports and displays. These structural modeling and analysis input specifications are stored in text file with extension".STD". The objective of this is to familiarize the user with the basic principles involved in the implementation of the various analysis/design facilities offered by the STAAD engine. STAAD pro means Structural Analysis and Design Program.

INPUT GENERATION:

The GUI communicates with the STAAD analysis engine through the STD input file. That input file is a text file consisting of a series of commands which are executed sequentially. The commands contain either instructions or data pertaining to analysis and design. The STAAD input file can be created through a text editor or the GUl modeIing facility.

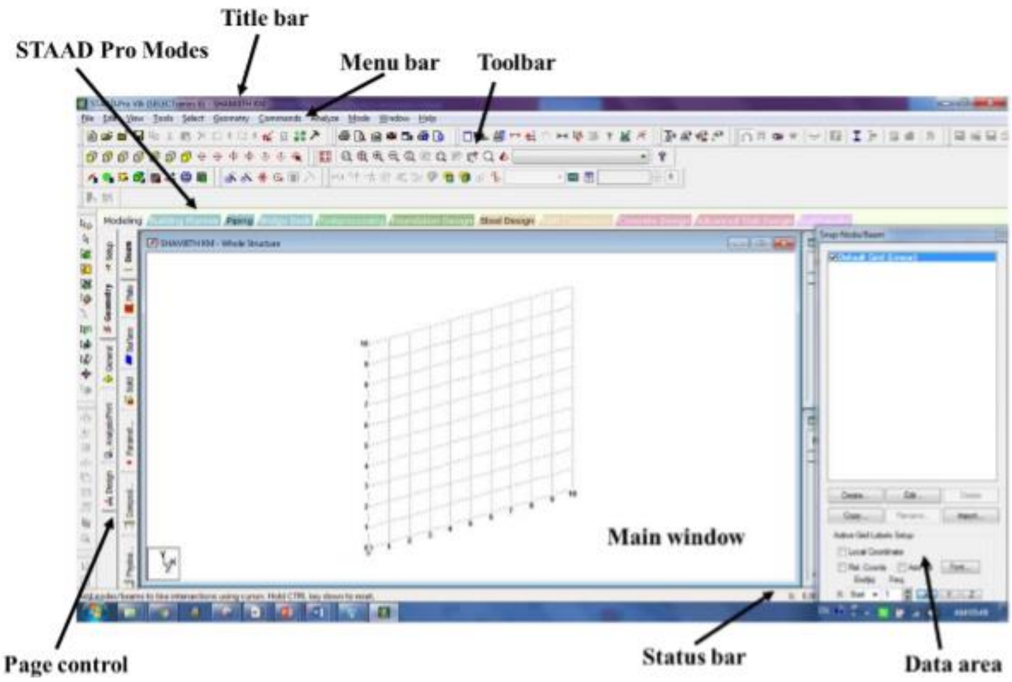
TYPES OF STRUCTURES

1. Statically determinate - When the equations of statistics are enough to determine all the forces acting on the structures, in the structures, then, the structures are known as statistically determinate structures. 2. Statically indeterminate structures - When the equations of statistical equilibrium are not sufficient to determine all forces acting on the structure and in the structures, then the structures are known as Statistically Indeterminate Structures. The equations of consistent deformations are added to the equations of equilibrium in order to analyse the Statistically Indeterminate Structures.

STAAD Pro provides 4 different structure types

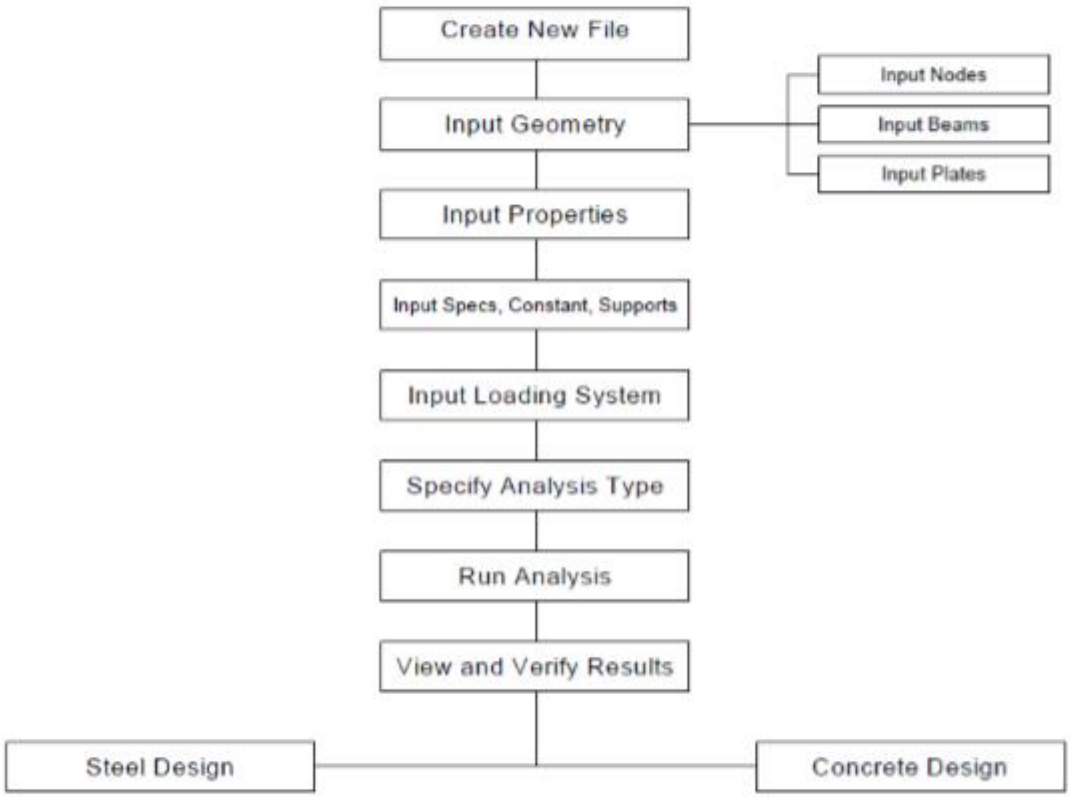
Type of Structure	Details
Space	3D framed structure with loads applied in any plane (The most general).
Plane	2D structure framed in the X-Y plane with loads in the same plane
Floor	2D or 3D structure having no horizontal (global X or Z) movement of the structure (FX, FZ & MY, are restrained at every joint)
Truss	Any structure consists of truss members only, which can have only axial member forces and no bending in the members Columns can also be modelled with the floor in a FLOOR structure as long as the structure has no horizontal loading. If there is any horizontal load, it must be analysed as a SPACE structure

GUI (GRAPHICAL USER INTERFACE)INTERFACE OF STAAD.PRO



GRAPHICAL USER INTERFACE

STAAD Pro METHEDOLOGY



WHAT ARE NODES, BEAMS, AND PLATES? CAD LAB (CE 693)

Node	Stiffed joint with 6 reactions. It is located at each end of Beam, and each corner of Plate. Nodes considered the essence of the Geometry of any structure in STAAD.Pro. Each Node will hold the following information: ⍰ Node Number. ⍰ Node Coordinate in XYZ space
Beam	Any member in the structure. It can be beam, column, bracing member, or truss member. Each Beam will hold the following information: • Beam Number. The Node numbers at its ends.
Plate	a thin shell with multi-nodded shape Starting from 3 nodes, and more. It can be anything of slab, wall, or raft foundation. Each Plate will hold the following information: • Plate Number. • Node Numbers at each corner of it.

PROCEDURE:

1) STARTING THE PROGRAM

1. Start STAAD.Pro by double clicking on the icon

UNIT SYSTLEMS:

The user is allowed to input data and request output in almost all commonly used engineering unit systems including MKS, SI and FPS. in input file, the user may change units as many times as required.

STRUCTURE GEOMETRY:

A structure is an assembly of individual components such as beams, columns, slabs, plates etc. In STAAD, frame elements and plate elements may be used to model the structural components. Typically modeling of the structure geometry consists of two steps.

*Identification and description of joints or nodes

*Modeling of members or elements through specification of connectivity Between joints.

COORDINATE SYSTEMS:

STAAD uses two types of coordinate system to define the structures geometry and loading patterns. The Global coordinate system is an arbitrary coordinate system in space which is utilized to specify the overall geometry and loading pattern of the structure. A Local coordinate system is associated with each member and is utilizes in member end force output or local load specification.

a) Conventional Cartesian coordinate System: This coordinate system is at rectangular coordinate system (X, Y,Z) which follows the orthogonal right hand rule. This coordinate system may be used to define the joint location and loading directions.

b) Cylindrical coordinate system: ln this coordinate system, the X and Y coordinates of the conventional Cartesian system are replaced by R (radius) and ϕ (angle in degree). The Z coordinate is identical to Z coordinate of the Cartesian system and its positive direction is determined by right hand rule.

MEMBER INCIDENCES SPECIFICATION:

This set of commands is used to specify members by defining connectivity between joints. Repeat and Repeat all commands are available to facilitate generation of repetitive patterns. The member/element incidences must be defined such that the model developed represent one single structure only, not two or more separate structures. STAAD is capable of detecting multiple structures automatically.

MEMBER PROPERTIES:

The following types of member property specification are available in STAAD.

a) Prismatic property specification

1. The following prismatic properties are required for analysis are AX - cross sectional area, IX -Torsional constant, IY - moment of inertia about Y axis and IZ - moment of inertia about Z axis.

2. Standard steel shapes from "built in section library. A

3. User created steel tables.

4. Tapered sections.

5. Through assign command.

6. Curved specification.

* This feature of the program allows the user to specify section names of standard steel shapes manufactured in different countries.

* The user can provide a customized steel table with designated names and proper corresponding properties. The programs can the find member properties from those tables. Member selection may also be performed with the program selected members from the provided tables only.

* Properties of tapered I sections and several types of tapered tubes may be provided through the member property specification.

* If one wishes to avoid the trouble of defining a specific section name, but instead wants to leave itto the program to assign a section name by itself, the assign command is available. The section types that may be assigned include Beam, Column, Channel, Angle and Double angle.

* Member can be defined as being curved. Tapered sections are not permitted. The

cross section should be uniform throughout the length.

MEMBER RELEASE:

STAAD allows releases for-both members and elements. One or both ends of members can be released. Members are assumed to be rigidly framed into joints in accordance with the structural type specified. When this full rigidity is not applicable, individual force components at either end of the member can be set to zero with member release statements. By specifying release components, individual degrees of freedom are removed from the analysis. Release components given in the local coordinate system for each member. The Partial moment release is also allowed.

TRUSS/TENSIONI/COMPRESSION:

lt is used only for members. For analyses which involve members that carry axial loads only, i.e., truss member, there are two methods for specifying this condition. When all the members in the structure are truss member then the type of structure is declared as Truss and whereas, when only some of the members are truss member. The member truss command can be used where those members will be identified separately.

MEMBER OFFSET:

Some members of a structure may not be concurrent with the incident joint thereby creating offsets. This offset distance is specified in terms of global or local coordinate system (i..e., X,Y, & Z - distances from the incident joint).

MATERIAL CONSTANTS:

The material constants are Modulus of Elasticity (E), Weight density (DEN), Poisson's ratio (POISS), Coefficient of thermal expansion (ALPHA), Composite Damping Ratio and Beta angle (BETA) or Coordinates for any reference point(REF).

SUPPORTS:

STAAD allows specifications of supports that are parallel as well as inclined to global axes. Support are specified as pinned, fixed or fixed with different releases (known as fixed but). A pinned support has restraints against all translational movement and none against rotational movement. ln other words, a pinned support will have reactions for all forces but will resist no moments. A fixed support has restraints against all directions of movement. The restraints of a fixed but support can be released in any desired direction. Translational and rotational spring can also specify.

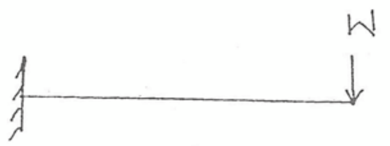
MASTER/SLAVE JOINTS:

The master/slave option is provided to enable the user to model rigid links in the structural system. The facility can be used to model special structural element like a rigid floor diaphragm. Several slave joints maybe provided which will be assigned same displacements as the master joint. The user is also allowed the flexibility to choose the specific degrees of freedom for which the displacement constraints will be imposed on the slaved joints. If all degrees of A freedom (FX, FY, FZ, MX, MY, and MZ) are provided as constraints, the joints will be assumed to be rigidly connected.

LOADS:

Loads: in structure can be specified as joint load, member load. STAAD can also generate the self weight of the structure and use it as uniformly distributed member loads in analysis. Any fraction of this self weight can also be applied in any desired direction.

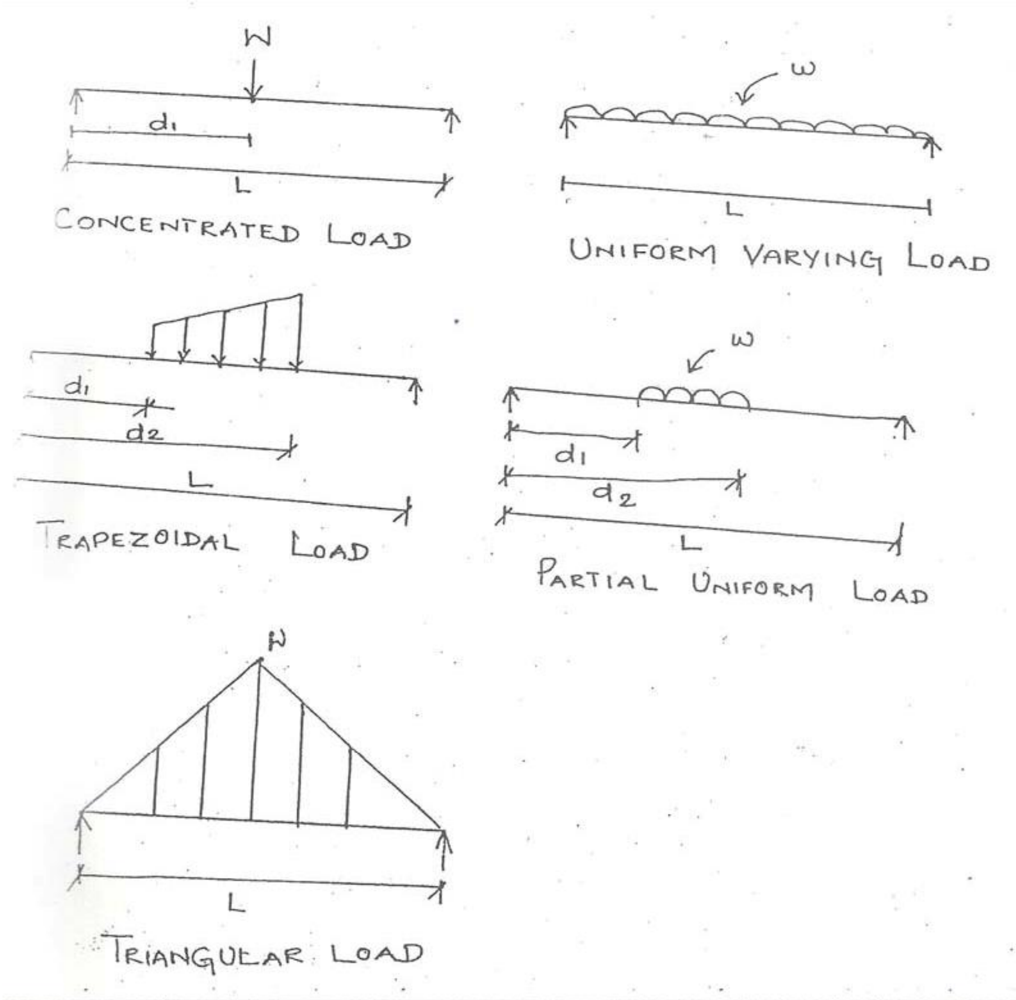
1. Joint load: Joint loads, both forces and moments, may be applied to any free joint of a structure. These loads act in the global coordinate system of the structure. Positive forces act in positive coordinate direction. Any member of loads may be applied on single joint, in which case the loads will be additive on that joint.



JOINT LOAD

2. Member load: Three types of member loads may be applied directly to a member of a structure. These loads are uniformly distributed loads, concentrated loads and linear varying loads (trapezoidal). Uniform loads act on the full or partial length of the member. Concentrated loads act at any intermediate, specified point. Linearly varying

loads over the full length or the member.Trapezoidal linearly varying loads act over the full or partial length of a member. Trapezoidal load are converted into a uniform load and several concentrated loads.



3. Wind load generation: The STAAD wind load generator is capable of calculating wind loads on joints of a structure from user specified wind intensities and exposure factors. Different wind intensities may specified for height zones of structure. Opening in the structure may be modeling exposure factors. An exposure factor is associated with each joint of the structure and is defined as fraction of the influence area on which the wind load acts. Built in algorithms automatically calculate the exposed area based on the areas bounded by members, then calculates the wind loads from the intensity and exposure input and distributes the loads as lateral joint loads.

STAAD PRO

FEATURES:
1. It is based on Finite Element Method (FEM).
2. It is used to analyse 2D (Plane) structures.
3. It is used to analyse 3D (Space) structures.
4. It is used to design RCC structures.
5. It is used to design Steel structures.
6. It is used to design Timber structures.
7. It is used to design Plastic structures.
8. Earthquake analysis can be done using Staad Pro.
9. Wind load analysis can be done using Staad pro.
10. It has built in Codes.
11. Automatic Load calculation can be done using Staad Pro.
12. It is 100% accurate and flexible.

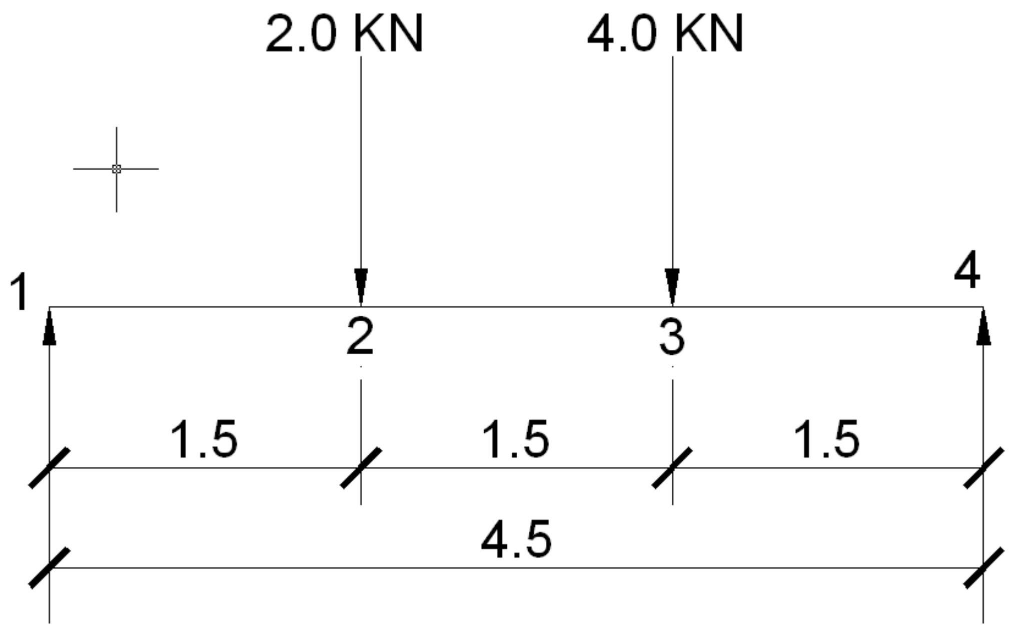
Steps in Staad Pro :
1.Creation of Structure.
2.Member Properties.
3.Suuport conditions.
4. Loadings
5. Analysis type
6. Post Analysis Print.
7.Design.
8. Analysis.
9. View output Results.

Sign conventions:
Axial Loads:
Compression +ve
Tension -ve
Bending Moments:
Tension at top (Hogging) +ve
Tension at bottom (Sagging) -ve
Shear Force:
Parallel and in the direction of Local Y axis +ve

Design of Individual members:
1. Beams : MZ, FY
2. Columns : FX,MY,MZ
3. Footings : FX, FY, MX, MZ.
Support Conditions:
For design We can take following condition:
1. Isolated Footings on Rock : Fixed case.
2. Isolated Footings on Firm soil (say SBC >25t/m2)

3. Isolated Footings on soft soil : Hinged case.
4. Footings on raft or Pile foundation: Fixed condition.

PROBLEM NO.1:



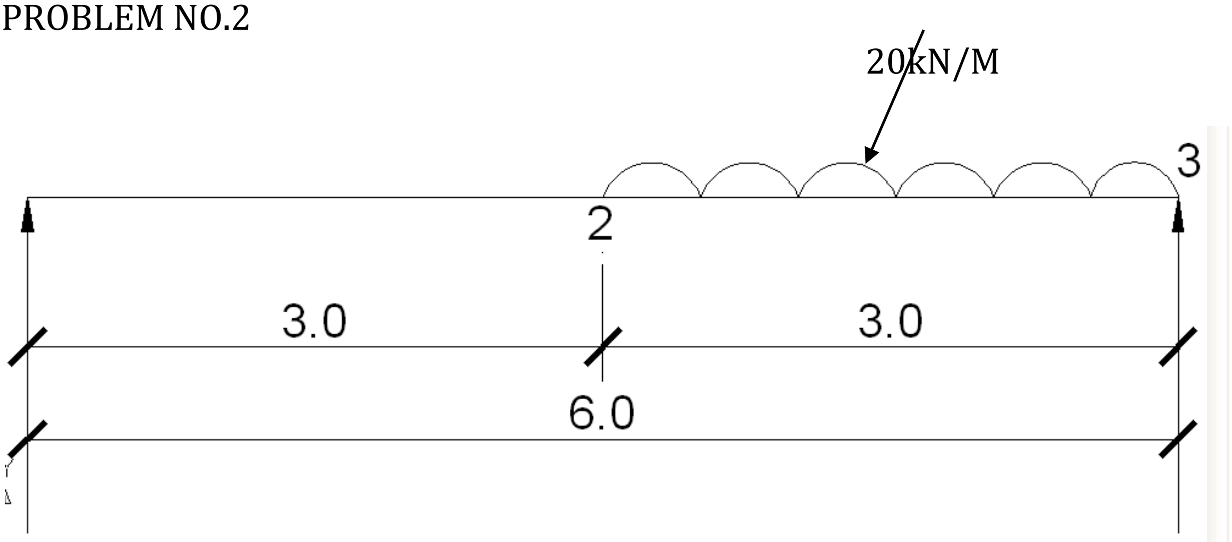
5. STEP 1 (Creation of Geometry):
6. New Project → Select Plane → Length =meters; Force=KN;
7. File Name=Plane 1 → Next
8. Select ⊙ Open Structure Wizard → Finish.
9. Change to Frame Models from Truss models → Select Continuous beam and double click on it.
10. Length=4.5m ••• Click
11. No. of bays (Span) =1
12. Apply → Transfer model → Click yes → OK→ Go to Front view icon (first view)

13. STPE 2 (Member Properties):
14. Select the member → From Main menu → Commands → Member Property → Prismatic → Rectangular YD=0.4 ZD=0.23 → Assign → Close.
15. De select the member.

16. STEP 3 (Supports):
17. Change to Node cursor (joint) and select the nodes (joints).

18. (If more than one node use CTRL key and select the nodes) → From Main menu → Commands → Support specification → Pinned → Assign → Close → De select the nodes and change to beam cursor.
19. STEP 4 (Loading):
20. From Main menu → Commands → Loading → Primary Load → Load case 1 → Add → Close → Select Load case 1 → Add → Self Wt → Factor -1→Add →Member Load → Concentrated Force → P1=2KN ; d1=1.5 ; d2= 0 → Add
21. P2=4.0 KN; d1=3.0; d2= 0 → Add → Close
22. Select the Load self wt →Assign to selected beam→ Assign→OK.
23. Select the Load P1=2KN and its member – Assign to selected beam → Assign → OK.
24. Select the Load P2=4.0KN and its member → assign to selected beam →
25. Assign → OK→ Close.
26. STEP 5(Analysis):
27. From Main menu → Commands – Analysis → Perform Analysis → ⦿ No print → OK.
28. STEP 6 (Post Analysis Print):
29. From Main Menu → Commands → Post Analysis Print → Support Reactions →
30. ⦿ To view → OK.
31. STEP 7(Design) :
32. From Main menu → Commands → Design → Concrete Design → Current code=IS 456 → From Main menu → Tools → Set current input unit
33. Length =mm; Force = N → OK.
34. → Select the member → Define parameters
35. ELY =0.85 → Assign
36. ELZ =0.85 → Assign
37. FC =20 → Assign
38. FYMAIN= 415 → Assign
39. FYSEC =415 → Assign
40. MAXMAIN =16 → Assign
41. MAXSEC =8 → Assign
42. MINMAIN =12 → Assign
43. MINSEC =8 – Assign → Close.
44. De select all members and select beam member only → Commands (Concrete Design) → Design beam → Assign → Close → Take off → Assign → Close.
45. Note: Save the File and Run the Program.
46. STEP 8 (Analysis):
47. From Main Menu → ` Analysis → Run Analysis → Run Analysis → Done.
48. Select the member and double click on it → Shear bending → Close.

PROBLEM NO.2



STEP 1 (Creation of Geometry):
New Project → Select Plane → Length =meters; Force=Kg;
File Name=Plane 2 → Next →
Select ⦿ Open Structure Wizard → Finish.
Change to Frame Models from Truss models → Select Continuous beam and double click on it.
Length=6m [...] Click
No. of bays (Span) =1
Apply → Transfer model → Click Yes → OK → Go to Front view icon (first view)
STPE 2 (Member Properties):
Select the member → From Main menu → Commands → Member Property → Prismatic → Rectangular YD=0.4 ZD=0.23 → Assign → Close.
De select the member.

STEP 3 (Supports):
Change to Node cursor (joint) and select the nodes (joints).
(If more than one node use CTRL key and select the nodes) → From Main menu → Commands → Support specification → Pinned → Assign → Close → De select the nodes and change to beam cursor.

STEP 4 (Loading):
From Main menu → Commands → Loading → Primary Load → Load case 1 → Add → Close → Select Load case 1 → Add → Self Wt → Factor -1→Add →Member Load → Uniform Force → F=20 ; d1=3.0 ; d2= 0 → Add → Close.
Select the Load and its member → Assign to selected beam → Assign → OK.
→ Close.

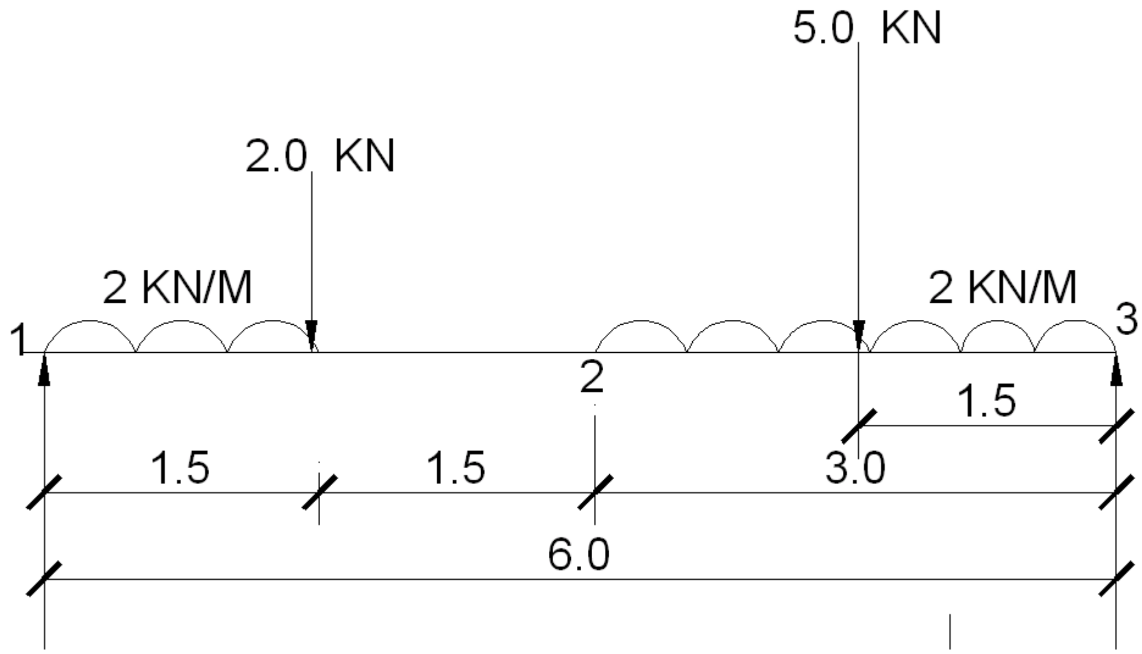
STEP 5(Analysis):
From Main menu → Command – Analysis → Perform Analysis → No print –OK.

STEP 6 (Post Analysis Print): From Main Menu → Commands → Post Analysis Print → Support Reactions →
⦿ To view → OK.

STEP 7(Design) :
From Main menu → Commands → Design → Concrete Design → Current code=IS 456 → From Main menu → Tools → Set current input unit.
Length =mm; Force = N → OK.
Select the members → Define parameters
ELY =0.85 → Assign
ELZ =0.85 → Assign
FC =20 → Assign
FYMAIN= 415 → Assign
FYSEC =415 → Assign
MAXMAIN =16 → Assign
MAXSEC =8 → Assign
MINMAIN =12 → Assign
MINSEC =8 – Assign → Close →
De select all members and select beams only → Commands (Concrete Design) → Design beam → Assign → Close → Take off → Assign → Close.
Note: Save the File and Run the Program.

STEP 8 (Analysis):
From Main Menu → ` Analysis → Run Analysis → Run Analysis → Done.
Select the member and double click on it → Shear bending → Close.

PROBLEM NO.3.



STEP 1 (Creation of Geometry):
New Project → Select Plane → Length =meters; Force=KN;
File Name=Plane 3 → Next
Select ⦿ Open Structure Wizard → Finish.
Change to Frame Models from Truss models → Select Continuous beam and double click on it.
Length=6m [...] Click
No. of bays (Span) =1
Apply → Transfer model → Click yes → OK → Go to Front view icon (first view)

STPE 2 (Member Properties):
Select the member → From Main menu → Commands → Member Property → Prismatic → Rectangular YD=0.4 ZD=0.23 → Assign → Close.
De select the member.

STEP 3 (Supports):
Change to Node cursor (joint) and select the nodes (joints).
(If more than one node use CTRL key and select the nodes) → From Main menu → Commands → Support specification → Pinned → Assign → Close → De select the nodes and change to beam cursor.

STEP 4 (Loading):
From Main menu → Commands → Loading → Primary Load → Load case 1 → Add → Close → Select Load case 1 → Add → Self Wt → Factor -1→ Add → Member Load → Concentrated Force → P1=2KN ; d1=1.5 ; d2= 0 → Add
P2=5 KN; d1=4.5 ; d2= 0 → Add
Select Load case 1 self Wt→Assign to selected beam→ Assign→OK.
Select the Load P1=2KN and its member → Assign to selected beam → Assign → OK.
Select the load P2=5KN and its member →Assign to selected beam→ Assign→OK.
Select the Load case 1 → Add → Member Load → Uniform Force → F=2KN/m; d1=0; d2=1.50 →Add
F=2KN/m ; d1= 3; d2= 0 →Add
→Select the uniform load and its member → assign to selected beam →
Assign → OK→ Close.

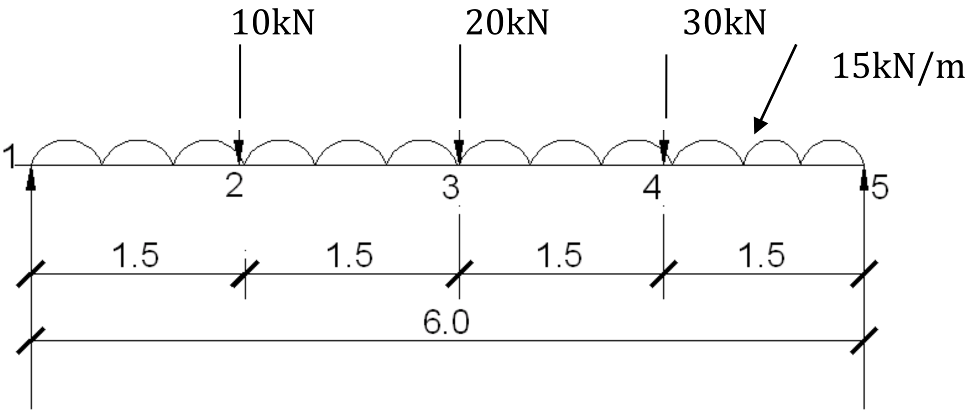
STEP 5(Analysis):
From Main menu → Commands → Analysis → Perform Analysis →
⦿ No print → OK.

STEP 6 (Post Analysis Print):
From Main Menu → Commands → Post Analysis Print → Support Reactions →
⦿ To view → OK.

STEP 7(Design) :
From Main menu → Commands → Design → Concrete Design → Current code=IS 456 → From Main menu → Tools → Set current input unit
Length =mm; Force = N → OK.
→Select the member → Define parameters
ELY =0.85 → Assign
ELZ =0.85 → Assign
FC =20 → Assign
FYMAIN= 415 → Assign
FYSEC =415 → Assign
MAXMAIN =16 → Assign
MAXSEC =8 → Assign
MINMAIN =12 → Assign
MINSEC =8 – Assign → Close.
De select all members and select beam only → Commands (Concrete Design) → Design beam → Assign → Close → Take off → Assign → Close.
Note: Save the File and Run the Program.

STEP 8 (Analysis):
From Main Menu → ` Analysis → Run Analysis → Run Analysis → Done.
Select the member and double click on it → Shear bending → Close.

PROBLEM NO.4:



STEP 1 (Creation of Geometry):

New Project → Select Plane → Length =meters; Force=KN;

File Name=Plane 4 → Next

Select ⊙ Open Structure Wizard → Finish.

Change to Frame Models from Truss models → Select Continuous beam and double click on it.

Length=6m [...] Click

No. of bays (Span) =1

Apply → Transfer model → Click yes → OK → Go to Front view icon (first view)

STPE 2 (Member Properties):

Select the member → From Main menu → Commands → Member Property → Prismatic → Rectangular YD=0.5 ZD=0.23 → Assign → Close.

De select the member.

STEP 3 (Supports):

Change to Node cursor (joint) and select the nodes (joints).

(If more than one node use CTRL key and select the nodes) → From Main menu → Commands → Support specification → Pinned → Assign → Close → De select the nodes and change to beam cursor.

STEP 4 (Loading):

From Main menu → Commands → Loading → Primary Load → Load case 1 → Add → close → Select Load case 1 → Add → Member Load → Uniform Force → UDL=15kN/m ; d1=0 ; d2= 0 → Add→ Member load →Concentrated forces →P1=10kN; d1=1.50; d2=0 → Add → Member load → Concentrated force → P2=20kN; d1=3.0 ; d2= 0 → Add → Member load → Concentrated forces → P3=30kN; d1=4.5; d2=0 → Add → Close → Select the UDL P1 =15kN and select the member → Assign to selected beam → Assign → Select the Load P2=20kN and select the member → Assign selected member(beam) → Assign → Select the Load P3=30kN and select the member → Assign → OK→ Close.

STEP 5 (Analysis):

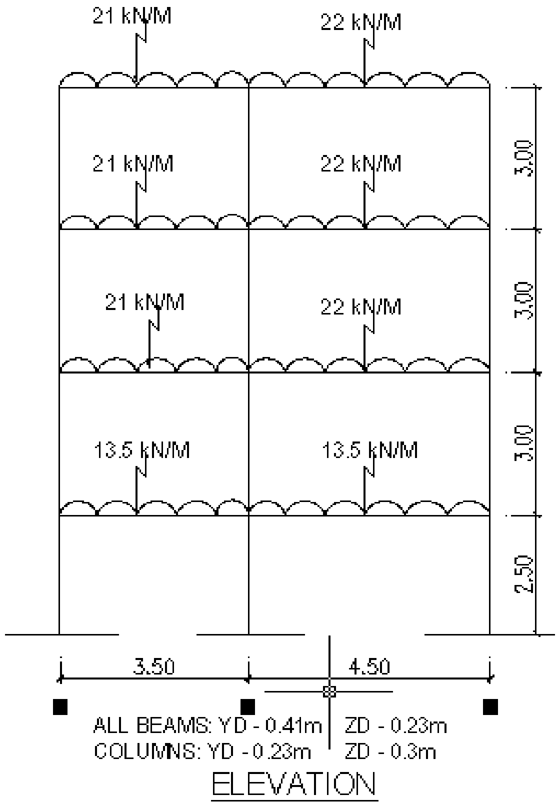
From Main menu → Command → Analysis → Perform Analysis → ⊙No print –OK.

STEP 6 (Post Analysis Print):
From Main Menu → Commands → Post Analysis Print → Support Reactions →
⊙ To view → OK.

STEP 7 (Design) :
From Main menu → Commands → Design → Concrete Design → Current code=IS 456
→ From Main menu → Tools → Set current input unit
Length =mm; Force = N → OK.
Select the member → Define parameters
ELY =0.85 → Assign
ELZ =0.85 → Assign
FC =20 → Assign
FYMAIN= 415 → Assign
FYSEC =415 → Assign
MAXMAIN =16 → Assign
MAXSEC =8 → Assign
MINMAIN =12 → Assign
MINSEC =8 – Assign → Close.
De select all members and select beam only → Commands (Concrete Design) → Design beam → Assign → Close → Take off → Assign → Close.
Note: Save the File and Run the Program.

STEP 8 (Analysis):
From Main Menu → ` Analysis → Run Analysis → Run Analysis → Done.
Select the member and double click on it → Shear bending → Close.

PROBLEM NO.5 PORTAL FRAME (2D)



STEP 1 (Creation of Geometry):
New Project → Select Plane → Length =meters; Force=KN;
File Name=RCC Frame 1 → Next
Select ⦿ Open Structure Wizard → Finish.
Change to Frame Models from Truss models → Select Bay Frame and double click on it.
Length (Along X Direction)= 8.0m.
No. of bays (Span) =2 Click [...]
Bay No.1 =3.5 Bay No.2=4.50
Height (Along Y Direction) =11.5m.
No. of bays (Span) =4 Click [...]
Bay No.1 =2.50 ; Bay No.2=3.0 ; Bay No.3=3.0 ; Bay Np.4=3.0
→ Apply → Transfer model → Click yes → OK→ Go to Front view icon (first view)

STPE 2 (Member Properties):
To select the member (Beam along X axis)
From Main menu →Select→ Beam parallel to X axis→
Main menu→Commands → Member Property→Prismatic→Rectangular
YD=0.41 ZD=0.23→Assign →Close→ Deselect the member→ Main menu→
select→Select beam parallelto Y axis (Column) → From Main
menu→Commands→Member Property→Prismatic→Rectangular YD=0.23 ZD=0.30
(In column always horizontal width is YD and perpendicular width is ZD).
→Assign→Close.
To confirm whether any missing property

Main menu→ Select→ Missing attributes→ Missing Property→ No entity missing→ Property is found→ Ok.
De select the member.

STEP 3 (Supports):
Change to Node cursor (joint) and select the nodes (joints) by windowing at the bottom of frame.
(You can also select one node then use CTRL key if more than one node and select the nodes) →
From Main menu → Click Front view icon→
Commands → Support specification → Fixed → Assign → Close →
De select the nodes and change to beam cursor.

STEP 4 (Loading):
From Main menu → Commands → Loading → Primary Load → Load case 1=Dead(load) → Add → Close →Select Load case1→Add
Self weight(dead load) Factor=--1 Direction ⦿ Y (Beams and columns) →
Member Load→Uniform Force→W=--21 d1=- d2=-→Add Member Load→Uniform force W=-22 d1=- d2=- →Add Member load→ Uniform force W=-13.5→Add→Close.
Select the uniform force W=-21→ select top left three members→ Assign to selected beam→Assign→Yes→Select uniform force Floor load (Dead load of slab) Pressure=-->3.5(self weight of slab= 2.50 + Floor finish=1.0)
Define Y range Mini=5.50 (2.50+3.0); Max=14.50
Define X range Mini=0; Max=7.01 (3.05+3.96)
Define Z range Mini=0; Max =10.36 (2.74+3.96+3.66) → Add→ Member load (wall loads) → Uniform force W1=--12 (9" wall load→ Add→
W1=-6 (41/2" wall load) → Add→ Close → Assign 9" wall load to external beams and 41/2" wall load to internal beams in top view→ Select load case 2(live load) → Add→ Floor load (Live load on slab) → Pressure=-2 (Live load)
Define Y range Mini=5.50 Max =14.50
Define X range Mini=0 Max=7.01
Define Z range Mini=0 Max=10.36→ Add→ Close→
Main menu→ command→Loading→ Load combination→ Load comb 3 Default=1.50

Available load		
Load case 1	>	
Load case 2	>>	
	<	
	<<	

Add →Close.
From Main menu → Command→Loading→ Load List(selecting design loads) →Load list.

Available load		Load list
Load case 1 Load case 2 ✓Load comb 3	> >> < <<	Load comb 3

→ Ok→ Close.

STEP 5(Analysis):
From Main menu → Commands – Analysis → Perform Analysis →
⦿ No print → OK.

STEP 6 (Post Analysis Print):
From Main Menu → Commands → Post Analysis Print → Support Reactions →
⦿ To view → OK.

STEP 7(Design):
From Main menu → Commands → Design → Concrete Design → Current code=IS 456
→ From Main menu → Tools → Set current input unit
Length =mm; Force = N → OK.
→ Select the members(Beams & Columns) → Define parameters
ELY =0.85 → Assign
ELZ =0.85 → Assign
FC =20 → Assign
FYMAIN= 415 → Assign
FYSEC =415 → Assign
MAXMAIN =16 → Assign
MAXSEC =8 → Assign
MINMAIN =12 → Assign
MINSEC =8 – Assign → Close.
De select all members and select beams only → Commands (Concrete Design) → Design beam → Assign → Close → De select all beams and select columns only → Commands (Concrete Design) → Design column → Assign → Take off → Assign → Close.
Note: Save the File and Run the Program.
STEP 8 (Analysis):
From Main Menu → ` Analysis → Run Analysis → Run Analysis → Done.
STEP 9 (Viewing Results)
Select the member and double click on it → Shear bending → Close.

Siliguri Institute of Technology

Civil Engineering Department

<u>Concrete Technology Lab Manual CE(PC)494</u>

LIST OF EXPERIMENT

EXPERMENT NO.	EXPERIMENT NAME
CE(PC)494/1	FINENESS MODULUS OF FINE AGGREGATE
CE(PC)494/2	FINENESS MODULUS OF COARSE AGGREGATE
CE(PC)494/3	BULKING OF SAND
CE(PC)494/4	SPECIFIC GRAVITY VOID RATIO POROSITY AND BULK DENSITY OF COARSE AND FINE AGGREGATE
CE(PC)494/5	FINENESS OF CEMENT
CE(PC)494/6	NORMAL CONSISTENCY OF CEMENT
CE(PC)494/7	INITIAL AND FINAL SETTING TIME OF CEMENT
CE(PC)494/8	SPECIFIC GRAVITY OF CEMENT
CE(PC)494/9	SOUNDNESS TEST OF CEMENT
CE(PC)494/10	COMPRESSIVE STRENGTH OF CEMENT
CE(PC)494/11	SLUMP TEST OF CONCRETE
CE(PC)494/12	COMPACTION FACTOR TEST FOR CONCRETE
CE(PC)494/13	VEE-BEE TEST
CE(PC)494/14	COMPRESSIVE STRENGTH OF CONCRETE
CE(PC)494/15	FLEXURAL STRENGTH OF CONCRETE

EXPERIMENT NO. 1
FINENESS MODULUS OF FINE AGGREGATE

AIM

To determine the fineness modulus of the given fine aggregate and to draw the grading curves for the given fine aggregate.

APPARATUS

1. B.I.S test sieves 4.75mm, 2.36mm, 1.18mm, 600micron, 300micron, 150micron, 75micron and pan.
2. Balance to weight (up to 1gm accuracy)

INTRODUCTION

A sieve analysis (or gradation test) is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called gradation) of a granular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is stopped by each sieve as a fraction of the whole mass.

The size distribution is often of critical importance to the way the material performs in use. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, soil, a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method. Being such a simple technique of particle sizing, it is probably the most common.

DIAGRAM

PROCEDURE

1. Take 500gms of fine aggregate B.I.S. test sieves 4.75mm, 2.36mm, 1.18mm, 600micron, 300micron, 150 micron and pan.
2. Weigh the residue on each of the sieves as explained below. First sieve 500gm of fine aggregate through 4.75mm sieve and weigh the residue.
3. The balance of the fine aggregate is sieved through 2.36mm sieve. The residue is weighed.
4. Repeat the above procedure by using other available sieves in order.
5. After tabulating the results compute % of material retained on each of the sieves.
6. Then calculate the cumulative % of material retained on each sieve and plot connecting log of apertures of sieves and % of passing.
7. Compute the fineness modulus of the given aggregate as the sum of the cumulative percentages retained on each sieve divided by 100

OBSERVATION TABLE

SL.NO.	B.I.S Sieve Size	Weight retained	Cumulative weight retained	Cumulative % of weight retained	Cumulative % passing
1	4.75mm				
2	2.36mm				

3	**1.18mm**				
4	**600**				
5	**300**				
6	**150**				
7	**75**				
8	**pan**				

$$\text{Fineness Modulus of Fine Aggregate} = \frac{\text{Cumulative \% of weight retained}}{100}$$

RESULT

The Fineness Modulus of given Fineness Aggregate is =

VIVA QUESTIONS

1. **Fine Aggregates should pass through which IS sieve?**
Answer: 4.75mm IS sieve is the aggregate size deciding sieve. Anything retained on sieve is coarse aggregate and the ones that pass through sieve are fine aggregates.
2. **What is the fineness modulus value of fine sand?**
Answer: Based on fineness of sand, there are very fine sand, fine sand, medium sand, coarse sand and very coarse sand. Fine sand has fineness modulus between 2.2-2.6.
3. **What is a receiver in a sieve analyser?**
Answer: At the base of all the sieve sets, round pan is placed to collect the particles finer than the last sieve size. It is called the receiver.
4. **For how long is the mechanical vibrator shaked?**
Answer: As per IS code 2720 Part 4. Mechanical vibrator is switched on and allowed to vibrate for 15-20 minutes. It ensures proper grading of particles.
5. **The aggregate sample for the sieve analysis is placed on:**
Answer: Largest sieve

EXPERIMENT NO.2
FINENESS MODULUS OF COARSE AGGREGATE

AIM

To determine the fineness modulus of the given coarse aggregate and to draw the grading curves for the given coarse aggregate.

APPARATUS

1. B.I.S test sieves 80mm, 63mm, 40mm, 20mm, 16mm, 12.5mm, 10mm, 4.75mm and pan.
2. Balance to weight (up to 1gm accuracy)

INTRODUCTION

A sieve analysis (or gradation test) is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called gradation) of a granular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is stopped by each sieve as a fraction of the whole mass.

The size distribution is often of critical importance to the way the material performs in use. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, soil, a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method. Being such a simple technique of particle sizing, it is probably the most common.

DIAGRAM

PROCEDURE

1. Take 5000gms of coarse aggregate B.I.S. test sieves 80mm, 63mm, 40mm, 20mm, 16mm, 12.5mm, 10mm, 4.75mm and pan.
2. Weigh the residue on each of the sieves as explained below. First sieve 5000gm of fine aggregate through 80mm sieve and weigh the residue.
3. The balance of the coarse aggregate is sieved through 63mm sieve. The residue is weighed.
4. Repeat the above procedure by using other available sieves in order.
5. After tabulating the results compute % of material retained on each of the sieves.
6. Then calculate the cumulative % of material retained on each sieve and plot connecting log of apertures of sieves and % of passing.
7. Compute the fineness modulus of the given aggregate as the sum of the cumulative percentages retained on each sieve divided by 100.

OBSERVATION TABLE

SL.NO.	B.I.S Sieve Size	Weight retained	Cumulative weight retained	Cumulative % weight retained	Cumulative % passing
1	80 mm				
2	63 mm				

3	**40 mm**				
4	**20 mm**				
5	**16 mm**				
6	**12.5 mm**				
7	**10 mm**				
8	**4.75 mm**				
9	**PAN**				

$$\text{Fineness Modulus of Coarse Aggregate} = \frac{\text{Cumulative \% of weight retained}}{100}$$

RESULT

The Fineness Modulus of given Coarse Aggregate is =

PRECAUTIONS

1. The sample should be taken quartering.
2. The sieving must be done carefully to prevent the spilling of aggregate.

VIVA QUESTIONS

1. The sieve sets for coarse aggregate ranges from:

Answer: 80-4.75mm, according to IS 565, the sieve sets are 80mm, 40mm, 20mm, 10mm, 4.75mm for coarse aggregates.

2. What is fineness modulus of aggregate?

Answer: Fineness modulus is an empirical factor obtained by adding the cumulative percentages of aggregate retained on each of the standard sieves ranging from 80 mm to 150 micron and dividing this sum by 100.

3. Flaky particles have:

Answer: Flaky particles have a small thickness compared to the dimensions of other parameters that is width and length.

4. The fineness modulus of an aggregate is roughly proportional to

Answer: average size of particles in the aggregate

5. What is the fineness modulus value of fine and coarse aggregate?

Answer: Fine aggregates range from a FM of 2.00 to 4.00, and coarse aggregates smaller than 38.1 mm range from 6.50 to 8.00.

EXPERIMENT NO. 3
BULKING OF SAND

AIM

To determine the percentage of bulking.

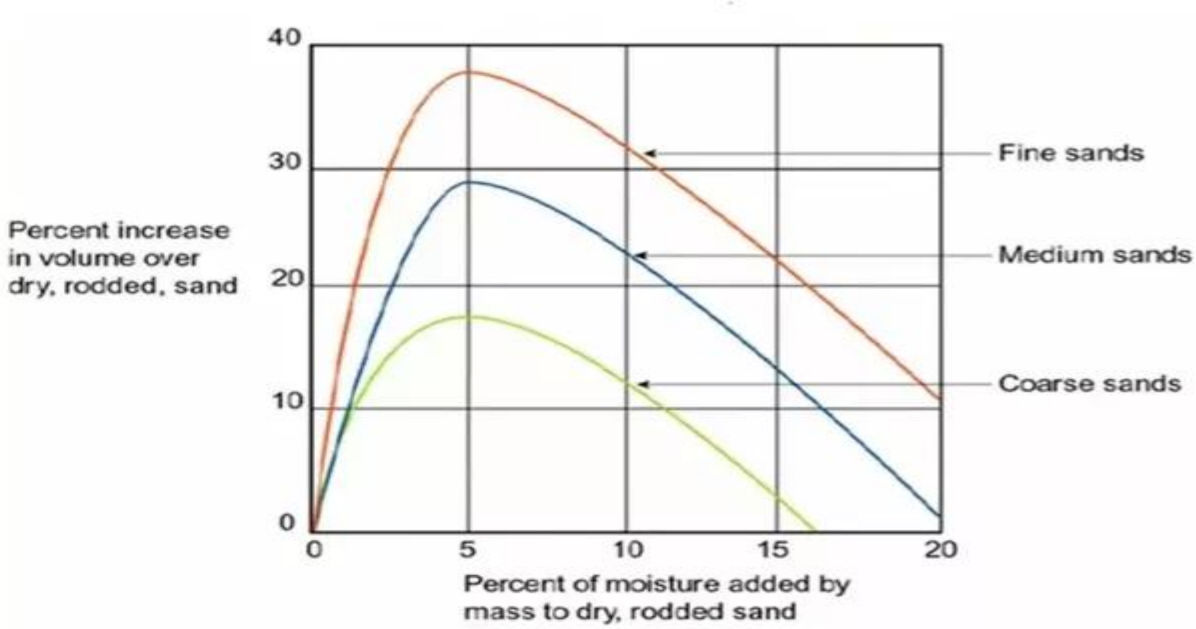
APPARATUS

1. Graduated glass cylinder
2. Measuring jar
3. Pan
4. B.I.S sieve 600micron

INTRODUCTION

The free moisture content in the fine aggregate results in bulking of volume. Free moisture in both coarse and fine aggregate affects quality of concrete in more than one way. Due to the bulking, fine aggregate shows completely unrealistic volume and the resulting concrete is likely to be under sanded and hash. It will also affect the yield of concrete for given cement content.

DIAGRAM



PROCEDURE

1. Take a known quantity of sand 500 grams in the cylinder. Note down the height H_1 in cm of the sand layer.
2. Add 1% of water to it and mix it thoroughly.
3. Fill the sand in the cylinder and note down the height H_2 in cm of the sand layer.
4. Take out the sand and add another 1% of water. Hence now total amount of water added in 2%.
5. Repeat the same procedure (step 2 to 4) for this and other readings.
6. Calculate the bulking of sand.

GRAPH

Draw a graph by taking moisture content in % in X – axis and bulking percent in Y - axis.

It can be seen from the curve that the bulking increases with the increase in moisture content up to a certain limit and beyond that the further increase in the moisture contents results in decreases in the volume. At a moisture content representing saturation point, the fine aggregate shows no bulking.

OBSERVATION TABLE

SL.NO	Percentage of water	Initial Height (H_1)	Final Height (H_2)	Percentage of bulking (H_2-H_1)/H_1X100

RESULTS

The maximum bulking of the given sand is _____ at ________ % of moisture content.

PRECAUTIONS

1. While mixing water with sand grains, mixing should be thorough and uniform.
2. The sample should not be compressed while being filled in jar.
3. The sample must be slowly and gradually poured into measuring jar from its top.
4. Increase in volume of sand due to bulking should be measured accurately.

VIVA QUESTIONS

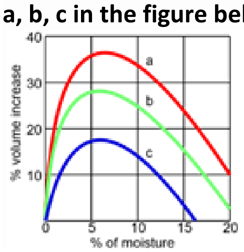
1. **What is the meaning of bulking of sand?**

Answer: Increase in volume of sand due to moisture absorption

2. **How is bulking related to moisture content?**

Answer: The volume i.e. bulking increases as sand absorbs moisture. At about 6- 10%, the film starts breaking and the volume reduces. If sand absorbs further moisture, no bulking takes place.

3. **a, b, c in the figure below in order are:**



Answer: fine, medium, coarse grained sand

4. **By how much percentage does the volume increase when moisture content is 5-10%?**

Answer: 20-40%

5. **Sand does not show any bulking when:**

Answer: A completely saturated sand has no void space left to absorb any more water and undergo bulking.

EXPERIMENT NO.4
SPECIFIC GRAVITY VOID RATIO POROSITY AND BULK DENSITY OF COARSE AND FINE AGGREGATES

(IS 2386 PART III-1963)

AIM

To determine the specific gravity, void ratio, porosity and bulk density of given coarse and fine aggregates.

APPARATUS

10 Kg capacity balance with weights, cylindrical containers of 1 litre and 5 litre capacities, measuring jar of 1000ml capacity.

INTRODUCTION

The specific gravity of an aggregate is generally required for calculations in connection with cement concrete design work for determination of moisture content and for the calculations of volume yield of concrete. The specific gravity also gives information on the quality and properties of aggregate. The specific gravity of an aggregate is considered to be a measure of strength of quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values.

The bulk density of an aggregate is used for judging its quality by comparison with normal density for that type of aggregate. It is required for converting proportions by weight into proportions by volume and is used in calculating the percentage of voices in the aggregate.

1. **Specific gravity** is the weight of aggregate relative to the weight of equal volume of water.
2. **Void ratio** is the ratio of volume of voids to the volume of solids in an aggregate.
3. **Percentage of voids or porosity** is the ratio of volume of voids to the total volume of a sample of an aggregate.
4. **Bulk density** or unit weight is the weight of material per unit volume.

DIAGRAM

PROCEDURE

Coarse aggregate

1. Find the weight of the empty container W1.
2. Take coarse aggregate in the container up to approximately half of the container and find out the weight W2.
3. Fill the container with water upto the level of the coarse aggregates so that all void space inside the aggregate is filled with water. Find its weight W3.
4. Fill the container with water after emptying it from mix of coarse aggregate and water.
5. Water should be upto the mark, upto which coarse aggregate is filled. Find its weight W4
6. Repeat the same process for another trail by taking the aggregate upto the full of the container and by filling the water up to same point.

OBSERVATIONS TABLE

S.No			Trail 1	Trail 2
1)	Weight of empty container	W1		
2)	Weight of container with material	W2		
3)	Weight of container + material + water	W3		
4)	Weight of container + water	W4		

i) Void ratio = Vol. of Voids / Vol of Solids
=W3 - W1 / ((W4 - W1)-(W3-W2))

ii) Porosity = Vol. of Voids / Total Vol. of aggregate *100 = W3 - W2 / (W4 - W1) * 100

iii) Specific gravity = (W2 - W1) / ((W4 - W1) - (W3 - W2))

iv) Bulk density = (W2 - W1) / (W4 - W1)

Fine aggregate:
Void Ratio and porosity

1. Take 150 ml of dry sand (v1 ml) in clean measuring jar of 1000 ml capacity.
2. Add a measured quantity of 100 ml clean water to the above sample (v2 ml) i.e. v2=100 ml
3. Shake the jar thoroughly till all air bubbles are expelled.
4. Now note the readings against the top surface of water in the jar (V3 ml)

Void ratio = v1 + v2 - v3 / v3 - v2
Porosity = v1 + v2 - v3 / v1

Specific gravity of fine aggregates:

1. Weigh the empty measuring jar of 1000 ml capacity = W1
2. Take the weight of empty measuring jar with 150 ml of sand
   Empty jar + sand =W2
3. Take the weight of empty measuring jar with 150 ml of sand and 100 ml of water
   Empty jar + sand + water = W3
4. Remove the mix of sand and water from bottle and fill it with water up to volume V3 then weigh it.

Empty jar + water = W4 Specific gravity = Weight of solids / Volume of Solids

=W2 - W1 / ((W4 - W1) - (W3 - W2))

RESULT

1) Specific gravity of course aggregate.
2) Void ratio of course aggregate.
3) Porosity of coarse aggregate.
4) Bulk density of course aggregate.
5) Specific gravity of fine aggregate.
6) Void ratio of the given fine aggregate.
7) Porosity of the given time aggregate.

PRECAUTIONS

While filling the container with water in determining void ratio and porosity of coarse aggregate care should be taken that water should not be in excess of the level of course aggregate.

VIVA QUESTIONS

1. **What is specific gravity?**

   Answer: Specific gravity is the weight of aggregate relative to the weight of equal volume of water.
2. **What is bulk density?**

   Answer: Bulk density or unit weight is the weight of material per unit volume.
3. **What is void ratio?**

   Answer: Void ratio is the ratio of volume of voids to the volume of solids in an aggregate.
4. **What is porosity?**

   Answer: **porosity** is the ratio of volume of voids to the total volume of a sample of a aggregate.
5. **What are the apparatus needed to determine the specific gravity of aggregate?**

   Answer: 10 Kg capacity balance with weights, cylindrical containers of 1 litre and 5 litre capacities, measuring jar of 1000ml capacity.

EXPERIMENT NO. 5
FINENESS OF CEMENT

(IS: 269-1989 and IS: 4031-1988)

AIM

To determine the fineness of the given sample of cement by sieving.

APPARATUS

IS-90 micron sieve conforming to IS: 460-1965, Standard Balance, Weights and Brush.

INTRODUCTION

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers greater surface area for hydration and hence the faster and greater the development of strength. Increase in fineness of cement is also found to increase shrinkage of concrete. Fineness of cement is tested either by sieving or by determination of specific surface by air-permeability apparatus. Specific surface is the total surface area of all the particles in one gram of cement.

DIAGRAM

PROCEDURE

1. Weigh accurately 100 gm of cement and place it on a standard 90 micron IS sieve.
2. Break down any air-set lumps in the cement sample with fingers.
3. Continuously sieve the sample giving circular and vertical motion for a period of 15 minutes.
4. Weigh the residue left on the sieve. As per IS code the percentage residue should not exceed 10%.

OBSERVATION TABLE

S. No.	Weight of sample taken(g)	Weight of residue(g)	Fineness (%)

Average fineness of cement=

RESULT

Fineness of given sample of cement =

PRECAUTIONS

Air set lumps in the cement sample are to be crushed using fingers and not to be pressed with the sieve. Sieving shall be done holding the sieve in both hands and with gentle wrist motion. More or less continuous rotation of the sieve shall be carried throughout sieving.

VIVA QUESTIONS

1. **What is fineness of cement?**

Answer: Fineness of cement is property of cement that indicates particle size of cement and specific surface area and indirectly effect heat of hydration. If fineness is more then heat of hydration should be more.

2. **What is the average particle size of cement?**

Answer: Approximately 95% of cement particles are smaller than 45 microns and the average particle size is 15 microns.

3. **Who invented Portland cement and in which year?**

Answer: Joseph Aspdin patented Portland cement in 1824. William Aspdin, his son is regarded as inventor of modern Portland cement due to his developments in 1840s.

4. **Why is natural cement used very limitedly?**

Answer: Natural cement sets very quickly after addition of water and hence it is not quite workable. Artificial cement is preferred over this.

5. **What are the main ingredients of Portland cement?**

Answer: lime and silica.

EXPERIMENT NO. 6
NORMAL CONSISTENCY OF CEMENT

(IS: 269-1989 and IS: 4031-1988 (Part4))

AIM

To determine the quantity of water required to produce a cement paste of standard consistency.

INTRODUCTION

The standard consistency of a cement paste is defined as that consistency which will permit the vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the vicat mould. For finding out initial setting time, final setting time, soundness of cement, it is necessary to fix the quantity of water to be mixed in cement in each case. This experiment is intended to find out the quantity of water to be mixed for a given cement to give a cement paste of normal consistency and can be done with the help of vicat apparatus.

DIAGRAM

PROCEDURE

1. Prepare a paste of weighed quantity of cement (300 grams) with a weighed quantity of potable or distilled water, starting with 26% water of 300g of cement.
2. Take care that the time of gauging is not less than 3 minutes, not more than 5 minutes and the gauging shall be completed before setting occurs.
3. The gauging time shall be counted from the time of adding the water to the dry cement.
4. Fill the vicat mould with the paste, the mould resting upon a non-porous plate.
5. After completely filling the mould, trim off the surface of the paste, making it in level with the top of the mould. The mould may slightly be shaken to expel the air.
6. Place the test block with the mould, together with the non porous resting plate, under the rod bearing the plunger (10 mm diameter),lower the plunger gently to touch the surface of the test block and quickly release, allowing it to penetrate into the paste.
7. This operation shall be carried out immediately after filling the mould.
8. Prepare trial paste with varying percentages of water and test as described above until the amount of water necessary for making the standard consistency as defined above is obtained.
9. Express the amount of water as a percentage by weight of the dry cement.

OBSERVATION TABLE

Sl. No.	Weight of cement taken in gms (a)	Weight of water taken in gms (b)	Plunger penetration (mm)	Time taken	Consistency of cement in % by weight b/a*100

RESULT

Normal Consistency for given sample of cement is=

PRECAUTIONS

Clean appliances shall be used for gauging. In filling the mould the operator hands and the blade of the gauging trowel shall alone be used. The temperature of cement, water and that of rest room, at the time when the above operations are being performed, shall be 27+2 C. For each repetition of the experiment fresh concrete is to be taken.

VIVA QUESTIONS

1. **What is the normal consistency of Ordinary Portland Cement?**

Answer: 30%

2. **What is a standard consistency?**

Answer: Standard consistency of cement paste may be defined as the consistency which permits the Vicat's plunger (10 mm, 40 to 50 mm in length) to penetrate to a point 5 mm to 7 mm from the bottom (or 35 mm to 33 mm from top) of Vicat mould.

3. **Why do we need Standard Consistency test?**

Answer: This test is performed to determine the quantity of water required to produce a cement paste of standard or normal consistency.

4. **Calculate standard consistency (%) when 100 ml of water is added in 1000 g of cement.**

Answer: Standard consistency (%) = (wt of water added/ wt of cement) *100= 100/1000*100 =10

5. **What is the depth the needle in Vicat apparatus should penetrate into the cement paste in consistency test?**

Answer: 33-35 mm from top of mould.

EXPERIMENT NO. 7
INITIAL AND FINAL SETTING TIME OF CEMENT

(IS: 269-1989 and IS: 4031-1988 part 5)

AIM

To determine the initial and final setting times for the given sample of cement.

APPARATUS

Vicat apparatus (conforming to IS: 5513-1976) with attachments, balance, weights, gauging trowel.

INTRODUCTION

In actual construction dealing with cement and concrete, certain time is required for mixing, transporting and placing. During this time cement paste, mortar or concrete should be in plastic condition. The time interval for which the cement products remain condition is known as setting time. Initial setting time is regarded as the time elapsed between the moment that the water is added to the cement to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain pressure. The constituents and fineness of cement is maintained in such a way that the concrete remains in plastic condition for certain minimum time. Once the concrete is placed in its final position, compacted and finished it should lose its plasticity in its earliest possible time so that it is least vulnerable to damages from external destructive agencies. The time should not be more than 10 hours which is referred to as final setting time. Initial setting time should not be less than 30 minutes.

DIAGRAM

PROCEDURE

Preparation of Test Block:

1. Prepare a neat cement paste by gauging 300 grams of cement with 0.85 times the water required to give a paste a standard consistency.
2. Potable or distilled water shall be used in preparing the paste.
3. The paste shall be gauged in the manner and under the conditions prescribed in determination of consistency of standard cement paste.
4. Start a stop-watch at the instant when water is added to the cement.
5. Fill the mould with the cement paste gauged as above the mould resting on a non-porous plate.
6. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould .The cement block thus prepared in the mould is the test block.

Determination of Initial Setting time:

1. Place the test blocks confined in the mould and rest it on the non-porous plate, under the rod bearing initial setting needle, lower the needle gently in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block.
2. In the beginning, the needle will completely pierce the test block.
3. Repeat the procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block to a point 5 to 7 mm measured from the bottom of the mould shall be initial setting time.

Determination of Final Setting time:

1. Replacement the needle of the Vicat apparatus by the needle with an annular attachment.
2. The cement shall be considered as finally set when, upon applying the needle gently to the makes an impression there on, while the attachment fails to do so.
3. The period elapsed between the time when water is added to the cement and the time at which the needle makes an impression on the surface of the block while the attachment fails to do so shall be the final setting time.

OBSERVATION TABLE

Time in minutes :	
Height in mm fails to penetrate :	

RESULT

Initial setting time for the given sample of cement=
Final setting time for the given sample of cement=

PRECAUTIONS

Clean appliances shall be used for gauging. All the apparatus shall be free from vibration during the test. The temperature of water and that of the rest room, at the time of gauging shall be 27±2ºC. Care should be taken to keep the needle straight.

VIVA QUESTIONS

1. What is the initial setting time for Ordinary Portland cement?
Answer: 30 minutes
2. What is the final setting time for Ordinary Portland cement?
Answer: 10 hours.
3. Which equipment is used to test setting time of cement?
Answer: Vicat apparatus.
4. What is the standardised temperature to conduct the setting time test?
Answer: 27±2ºC
5. When the cement paste is tested within the gauging time, what is the value of gauging time?
Answer: 3 to 5 minutes.

EXPERIMENT NO. 8
SPECIFIC GRAVITY OF CEMENT

(IS: 269-1989 and IS: 4031-1988)

AIM

To determine the specific gravity of given sample of hydraulic cement.

APPARATUS

Physical balance, specific gravity bottle of 50 ml capacity, clean kerosene.

INTRODUCTION

Specific gravity is defined as the ratio between weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of cement, kerosene is used with does not react with cement.

DIAGRAM

PROCEDURE

1. Clean and dry the specific gravity bottle and weigh it with stopper (W_1).
2. Fill the specific gravity bottle with cement sample at least half of the bottle weigh with stopper (W_2).

3. Fill the specific gravity bottle containing the cement, with kerosene (free of water) placing the stopper and weigh it (W_3).
4. While doing the above do not allow any air bubbles to remain in the specific gravity bottle.
5. After weighing the bottle, the bottle should be cleaned and dried again.
6. Then fill it with fresh kerosene and weigh it with stopper (W_4).
7. Remove the kerosene from the bottle and fill it with full of water and weigh it stopper (W4).
8. All the above weighing should be done at the room temperature of 27ºC±1ºC

OBSERVATION TABLE

Description of item	Trial 1	Trial 2	Trial 3
Weight of empty bottle W_1 g			
Weight of empty bottle + Cement W_2 g			
Weight of bottle + Cement + Kerosene W_3 g			
Weight of bottle + Full kerosene W_4 g			
Weight of bottle + Full water W_5 g			

CALCULATION

Specific gravity of kerosene S_k = (W4 – W1) / (W5 – W1)

Specific gravity of Cement S_c = $\dfrac{(W2 - W1) \times S_k}{(W4 - W1) - (W3 - W2)}$

RESULT

Average specific gravity of the given sample of cement =

PRECAUTION

1. Only kerosene which is free of water shall be used.
2. At time of weighing the temperature of the apparatus will not be allowed to exceed the specified temperature.
3. All air bubbles shall be eliminated in filling the apparatus and inserting the stopper.
4. Weighing shall be done quickly after filling the apparatus and shall be accurate to 0.1 mg.
5. Precautions shall be taken to prevent expansion and overflow of the contents resulting from the heat of the hand when wiping of the surface apparatus.

VIVA QUESTIONS

1. What are the apparatus needed to determine the specific gravity of cement?

Answer: Physical balance, specific gravity bottle of 50 ml capacity, clean kerosene etc.

2. What is meant by Specific Gravity?

Answer: Specific gravity is defined as the ratio between weight of a given volume of material and weight of an equal volume of water.

3. What is the dimension of specific gravity?

Answer: As Specific gravity is the ratio between weight of a given volume of material and weight of an equal volume of water, so it is dimensionless.

4. What is the standard room temperature for this test?

Answer: 27ºC±1ºC

5. What is the use of pycnometer?

Answer: Pycnometer is used to determine the water content and specific gravity.

EXPERIMENT NO. 9
SOUNDNESS OF CEMENT

(IS 269-1989 AND IS 4031-1988 PART 3)

AIM

To determine the soundness of given sample of cement by “Le Chatelier” method.

APPARATUS

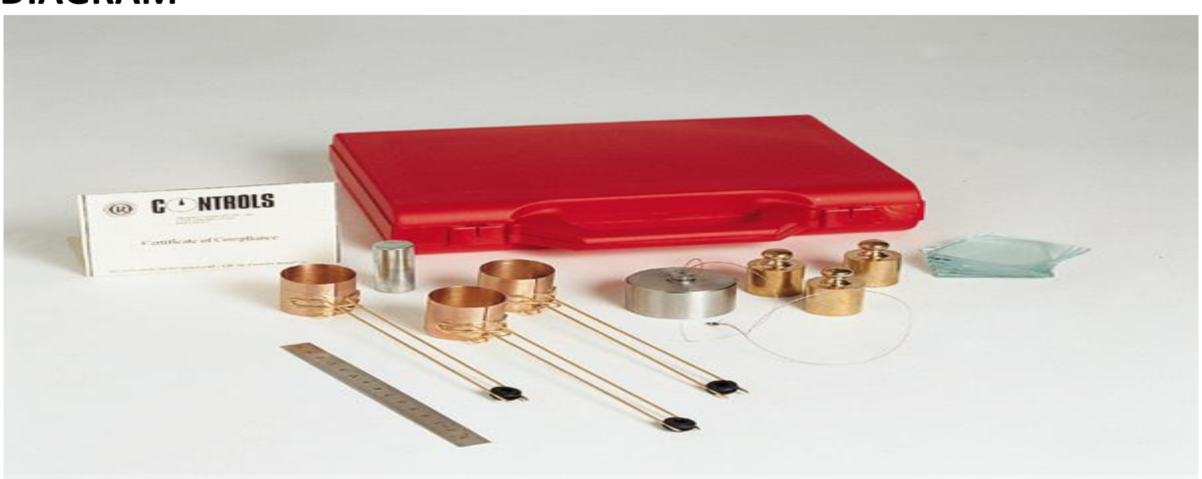
Le Chatelier apparatus conforming to IS 5514-1969, Balance, Weights, Water bath.

INTRODUCTION

It is essential that the cement concrete shall not undergo appreciable change in volume after setting. This is ensured by limiting the quantities of free lime, magnesia and sulphates in cement which are the causes of the change in volume known as unsoundness. Unsoundness in cement does not come to surface for a considerable period of time. This test is designed to accelerate the slaking process by the application of heat and discovering the defects in a short time. Unsoundness produces cracks, distortion and disintegration there by giving passage to water and atmospheric gases which may have injurious effect on concrete and reinforcement.

The apparatus for conducting the test consist of small split cylinder of spring brass or other suitable metal of 0.5 mm thickness forming a mould 30 mm internal diameter and 30 mm high. On either side of the split mould are attached to indicators with pointed ends, the distance from these ends to the centre of the cylinder being 165 mm. The mould should be kept in a good condition with the jaws not more than 50 mm apart.

DIAGRAM



PROCEDURE

1. Place the lightly oiled mould on a lightly oiled glass sheet and fill with it cement paste formed by gauging cement with 0.78 times the water required to give a paste of standard consistency.
2. The paste shall be gauged in the manner and under the condition prescribed in determination of consistency of standard cement paste, taking care to keep the edges of the mould gently together.
3. While this operation is being performed cover the mould with another piece of glass sheet and immediately submerge the whole assembly in water at a temperature of 27-2ºC and keep there for 24 hours.
4. Measure the distance separating the indicator points.
5. Submerged the mould again in water at the temperature prescribed above.
6. Bring the water to boiling, with the mould kept submerged for 25 to 30 minutes, and keep it boiling for three hours.
7. Remove the mould from the water allow it to cool and measure the distance between the indicator points.
8. The difference these two measurements represents the expansion the cement.
9. For good quality cement this expansion should not be more than 10 mm.

OBSERVATION TABLE

Initial distance between the indicator points in mm=

Final distance between the indicator points in mm=

Expansion in mm=Final length- Initial length=

RESULT

Expansion in mm

PRECAUTIONS

1. All the measurements should be done accurately.
2. Do not apply extra pressure while filling the moulds.
3. During boiling water level should not fall below the height of the mould.

VIVA QUESTIONS

1. **What is soundness?**

Answer: Soundness of cement is the property by virtue of which the cement does not undergo any appreciable expansion.

2. **Which apparatus we need to find soundness?**

Answer: This test is performed with the help of Le Chatelier apparatus as shown in figure. It consists of a brass mould of diameter 30 mm and height 30 mm.

3. **Why do we need to find soundness?**

Answer: Soundness Test on Cement. Soundness Test on cement is carried out to detect the presence of uncombined lime in cement.

4. **Le Chatelier apparatus consist of ___________**

Answer: Le Chatelier apparatus consist of brass mould with the diameter of 30mm and height of 30 mm.

5. **What is the maximum size of split?**

Answer: There is a split in mould and it does not exceed 0.50 mm. On either side of split, there are two indicators with pointed ends. The thickness of mould cylinder is 0.50 mm.

EXPERIMENT NO .10
COMPRESSIVE STRENGTH TEST OF CEMENT

(IS 269-1989,IS 8112-1989,IS 12269-1987, IS 4031 -1988 (part-4) & IS 4031-1988)

AIM

To determine the compressive strength of cement mortar cubes compacted by means of standard vibration machine.

APPARATUS

Vibration machine and cube mould to size 7.06 cms (conforming to IS: 4031-1988)

STANDARD STAND

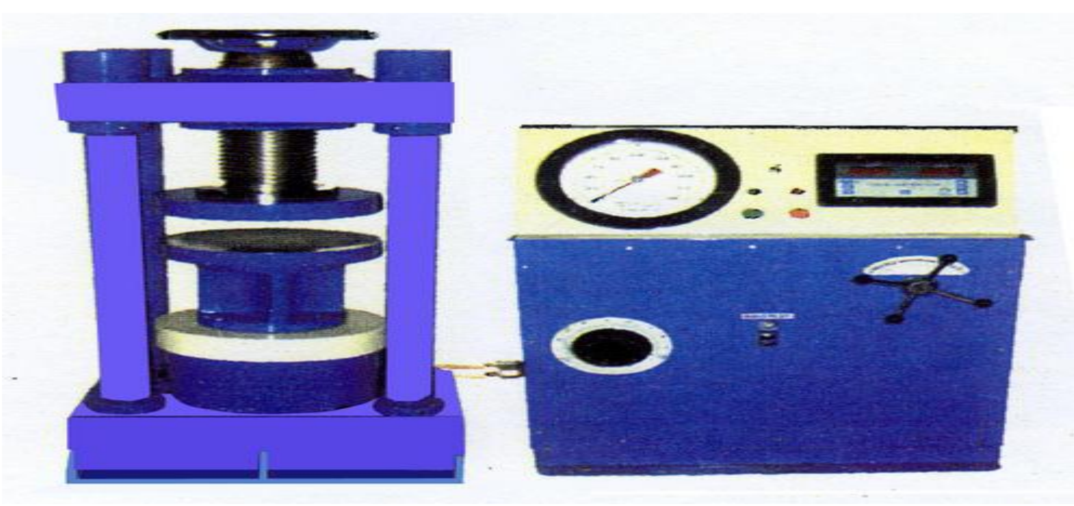
The standard sand to be used in the test shall conform to IS: 650-1991 or sand passing 100 per cent through 2 mm sieve and retained on 90 micron IS sieve.

2 mm to 1 mm	33.33 per cent
1 mm to 500 micron	33.33 per cent
500 micron to 90 micron	33.33 per cent

INTRODUCTION

The Compressive strength of cement mortars is determined in order to verify whether the cement conforms to IS specification and whether it will be able to develop the required compressive strength of concrete. The average compressive strength of at least three mortar cubes (area of the face 50 cm^2) composed of one part of cement and three parts of standard sand should satisfy IS code specification.

DIAGRAM



PROCEDURE

Mix proportion and mixing:

1. Clean appliances shall be used for mixing and the temperature of the water and that of test room at the time when the above operations are being performed shall be 27+2ºC
2. Place a container of mixture of cement and standard sand in the proportion of 1:3 by weight mix it dry, with a trowel with one minute and then with water until the mixture is uniform colour.
3. The quantity of water to be used shall be specified below.
4. In any element, it should not take more than 4 minutes to obtain uniform colour mix.
5. If it exceeds 4 minutes the mixture shall be rejected and the operation repeated with a fresh quantity of cement.
6. The material for each cube shall be mixed separately and the quantity of cement standard sand and water shall be as follows:

Cement	200 gms
Standard sand	600 gms
Water	(P/4 + 3.0) per cent of combined weight of cement and Sand, where p is the percentage of water required to produce a paste of standard consistency.

Moulding Specimens:

1. In assembling in the mould ready for use, cover the joints between the halves of the mould with a thin film of petroleum jelly and apply a similar coating of petroleum jelly between the contact surfaces of the bottom of the mould and its base plate in order to ensure that no water escapes during water.
2. Treat the interior faces of the mould with a thin coating of mould oil.
3. Place the assembled mould on the table of the vibration machine and firmly hold it is position by means of suitable clamps.
4. Securely attach a hopper of suitable size and shape at the top of the mould to facilitate filling and this hopper shall not be removed until completion of vibration period.
5. Immediately after mixing the mortar, place the mortar in the cube mould and rod with a rod.
6. The mortar shall be robbed 20 times in about 8 seconds to ensure elimination of entrained air and honeycombing.
7. Place the remaining quantity of mortar in the hopper of the cube mould and rod again as specified for the first layer and then compact the mortar by vibrations.
8. The period of vibration shall be two minutes at the specified speed of 12,000+400 vibrations per minute.
9. At the end of vibration remove the mould together with the base plate from the machine and finish the top surface of the cube in the mould by smoothing surface with the blade of a trowel.

Curing Specimen:

1. Keep the filled mould at a temperature of 27+2ºC in an atmosphere of at least 90% relative humidity for about 24 hours after completion of vibration.
2. At the end of the period remove them from the moulds.
3. Immediately submerge in clean fresh water and keep them under water for testing.
4. The water in which the cubes are submerged shall be renewed every 7 days and shall be maintained at a temperature of 27ºC±2ºC.
5. After they have been taken out and until they are tested the cubes shall not be allowed to become dry.

Testing:

1. Test three cubes for compressive strength at the periods mentioned under the relevant specification for different hydraulic cements, the periods being reckoned from the completion of vibration.
2. The compressive strength shall be the average of the strengths of three cubes for each period of curing.
3. The cubes shall be tested on their sides without any packing between the cube and the steel platens of the testing machine.
4. One of the platens shall be carried base and shall be self adjusting and the load shall be steadily and uniformly applied starting from zero at a rate of 350 kgs/cm^2 /min.

   The cubes are tested at the following periods

Ordinary Portland cement	3, 7 and 28 days
Rapid hardening Portland cement	1 and 3 days
Low heat Portland cement	3 and 7 days

OBSERVATION

Calculate the compressive strength from the crushing load and the average area over which the load is applied. Express the results in N/mm^2 to the nearest 0.05 mm^2.

Compressive strength in N/mm^2 =P/A=

Where P is the crushing load in N and A is the area in mm^2 (5000 mm^2)

RESULT

The average strength of given cement

at 3 days	N/mm^2
at 7 days	N/mm^2
at 28 days	N/mm^2

PRECAUTIONS

Inside the cube moulds should be oiled to prevent the mortar from adhering to the sides of the mould.

VIVA QUESTIONS

1. **What does grade 33 cement indicate?**

   Answer: Compressive strength of 33 N/mm^2

2. **Ordinary Portland cement (OPC) has been classified into how many grades?**

   Answer: There was only one grade of OPC before 1987 and was according to IS 269-1976. It was revised in 1991 and IS 1489-1991 included 3 grades namely, 33 grade, 43 grade and 53 grade.

3. **After how many days is strength of cement is tested and graded according to the result?**

Answer: Cement blocks are prepared to test their compressive strength. With proper curing and attaining strength, these can be tested. It requires 28 days to fully cure and attain strength of required grade, say 43 N/mm^2 for grade 43 OPC.

4. What is the size of a mortar cube?

Answer: Mortar Cube Moulds. As per IS 10080 - 1982; 4031 (Part - VI) - 1988. Size: **70.6mm** W x **70.6mm** L x **70.6mm** D Made of mild steel.

5. The compressive strength of an ordinary Portland cement (1 : 3 cement mortar cube) after 7 days test should not be less than

Answer: 17.5 N/mm^2

EXPERIMENT NO. 11
SLUMP TEST

AIM

To determine the workability of concrete by slump test.

MATERIALS REQUIRED

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Water

APPARATUS

1. Slump cone
2. Ramming rod
3. Balance
4. Measuring jar
5. Trowel
6. Tray

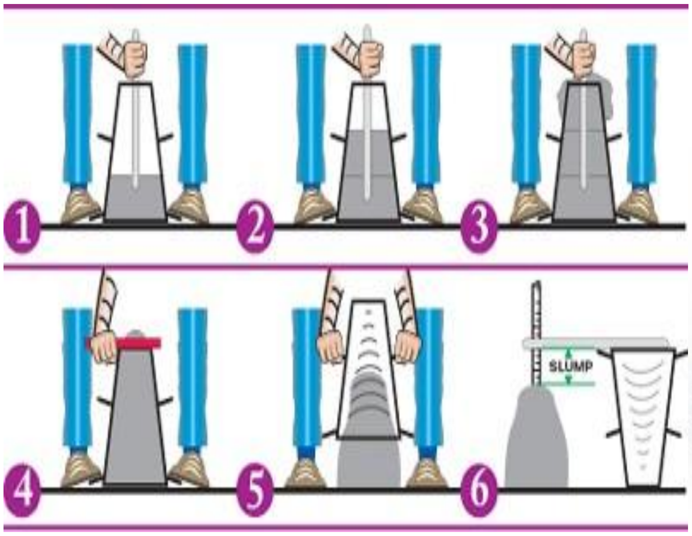
INTRODUCTION

Slump test is the commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site work. It is not a suitable method for very wet or very dry concrete.

Slump:

The subsidence of concrete after removal of cone is known as slump. The pattern of slump indicates the characteristic of concrete in addition to the slump value. If one half of the cone slides down, it is called shear slump. In case of a shear slump, the slump value is measured as the difference in height between the height of the mould and the average value of the subsidence.

DIAGRAM



PROCEDURE

1. Clean thoroughly the internal surface of the mould and free it from superfluous moisture.

2. Prepare the concrete with the required ingredients for particular water / cement ratio.

3. Place the mould on a smooth, horizontal, rigid and non – absorbent surface.

4. Fill the mould in four layers each approximately one – fourth of the height of the mould. Each layer is tamped 25 times by the tamping rod taking care to distribute the stroke evenly over the cross section.

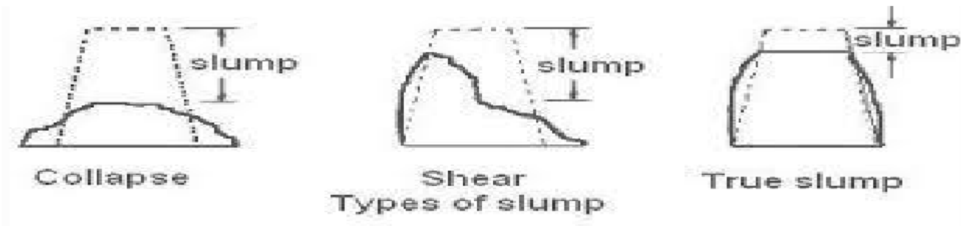
5. Strike off level concrete with a trowel and remove the mould from the concrete immediately by raising slowly and carefully in a vertical direction.

6. Measure the difference in level between the height of the mould and that of the height point of the subsided concrete. This height in 'mm' is taken "slump" of concrete.

7. Repeat the same procedure, (steps 3 – 6) by increasing the water cement ratio until the slump collapses.

OBSERVATION TABLE

Weight of cement =
Weight of sand =
Weight of coarse aggregate =
Water added in ml =



Sl.No.	W/C ratio	Water added in ml	Initial height ‘H_1’ mm	Final Height ‘H_2’ mm	Slump (H_1-H_2) mm

RESULT

The workability of concrete in terms of slump different water / cement ratio is found out and they are tabulated.

PRECAUTIONS

1. The strokes are to be uniformly applied through the entire area of concrete section.

2. The cone should be removed very slowly by lifting it upwards without disturbing the concrete.

3. During filling the mould must be firmly pressed against the base.

4. Vibration from nearly machinery might also increase subsidence; hence test should be made beyond the range of ground vibration.

VIVA QUESTIONS

1. How many types of tests are there to find workability?

Answer: There are 5 types of test to find the workability of a concrete i.e. slump test, compacting factor test, flow table test, vebe test, Kelly ball test.

2. What are the dimensions of a slump cone?

Answer: Slump cone (Height = 30 cm, Base dia = 20 cm, Top dia = 10 cm)

3. What are the types of slump in a slump test?

Answer: Three types namely True slump, Shear slump, Collapse slump

4. In how many layers concrete is tamped in slump test?

Answer: 4 layers.

5. What is the recommended slump in mass concrete?

Answer: 25 to 50 mm

EXPERIMENT NO.12
COMPACTION FACTOR TEST

AIM
To determine the workability of concrete by compaction factor test.

MATERIALS REQUIRED
1. Cement

2. Fine aggregate

3. Coarse aggregate

4. Water

APPARATUAS
1. Compaction factor apparatus

2. Ramming rod

3. Balance

4. Measuring jar

5. Trowel

6. Tray

INTRODUCTION
Compaction factor test is useful for concrete mixes of very low workability where as normally used concrete is to be compacted by vibration. It is one of the efficient tests for measuring the workability of concrete.

This test works on the principles of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height.

DIAGRAM

Compacting factor test Apparatus

PROCEDURE

1. Prepare the concrete using the ingredients in required amount. Note down the water / cement ratio.
2. Record the weight of empty cylinder. Let it be W gm.
3. Place the concrete in the upper hopper up to the brim.
4. Open the trap door so that the concrete falls into the lower hopper.
5. Open the trap door of the lower hopper and allow the concrete to fall into the cylinder.
6. Cut off the excess of concrete remaining above the top level of the cylinder with the help of plane blades supplied with the apparatus.
7. Wipe away outside of the cylinder cleanly and fill the concrete exactly up to the top level of the cylinder. Weight it to the nearest 10gms. Let it be W gm.
8. The cylinder is emptied and then refilled with the concrete from the same sample in layers approximately 5 cm deep.
9. Ram heavily the layers of concrete so as to obtain full compaction.
10. Carefully strike off with the top of the Cylinder and weight to the nearest 10gm. Let it be W gm.
11. Repeat the whole procedures (steps 1 to 9) for two more similar samples.

OBSERVATION TABLE

W 1 = Weight of the cylinder
W 2 = Weight of cylinder + concrete falling through standard height
W 3 = Weight of cylinder + fully compacted concrete
Compaction factor = Weight of partially compacted concrete
Weight of fully compacted concrete

Sl. No.	Description of item	Sample-I	Sample-II	Sample-III

RESULT:
Compaction factor of concrete is =

PRECAUTIONS
1. The top hopper must be filled gently.
2. The mix should not be pressed or compacted in the hopper.
3. If the concrete in the hopper does not fall through when the trap door is released, it should be freed by passing a metal rod. A single steady penetration will usually affect release.

VIVA QUESTIONS
1. What is the compaction factor for medium degree of workability?

Answer: .92
2. How to improve the workability of concrete?

Answer: Increasing the water cement ratio, helps in improving the workability of the concrete.
3. What is the compaction factor for low degree of workability?

Answer: The compaction factor for low degree of workability is .85 and .95 is the compaction for the high degree.
4. What is workability?

Answer: Concrete is said to be workable when it is easily placed and compacted homogeneously i.e. without bleeding or Segregation.
5. Why we do compaction factor test?

Answer: Compaction factor of fresh concrete is done to determine the workability of fresh concrete by compaction factor test as per IS: 1199 – 1959

EXPERIMENT NO.13
WORKABILITY OF CONCRETE–VEE BEE TEST

AIM:
To find workability of concrete by Vee-Bee consistency test in terms of Vee Bee Seconds.

APPARATUS:
Vee Bee consistometer, Stopwatch, Balance, Tray, Tamping rod, measuring jar, Weights and Trowels.

INTRODUCTION
The consistometer is used for determining the consistency of concrete by vibrating and transforming a concrete specimen from the shape of conical frustum into a cylinder.
The consistometer consists of a
1. A vibrator table, which vibrates a rate of 3000 vibrations / min.

2. A metal pot, which holds the specimen when the concrete is vibrated. It is secured to the vibrator table by bolts.

3. Slump cone of 300 mm high, 200 mm at the bottom and 100 mm at the top (Open both ends).

4. Swivel arm holder: A tube, which is fixed the rear of the base of the vibrator table. It has 4 positioning slots for swivel arm to position the metal cone over the slump cone or Perspex disc on the specimen or to position both of them away.

5. Swivel arms the Swivel moves freely inside the swivel arm holder. A metal rod and a guide sleeve are fixed to the swivel arm. The graduated metal rod passes through the guide sleeve.

6. Metal cone - this is in the form of a frustum of cone with open ends (funnel). This is fixed to the swivel arm

7. Graduated rod

8. Tamping rod. A metal rod of 16 mm x 60 cm. long with one end bullet ended.

DIAGRAM

PROCEDURE:

1. Position the metal cone over the slump cone. Place the concrete inside the slump cone in 4 layers each approximately 1/4 of the height. Strokes are applied by the rounded end of the tamping rod. Distribute the strokes in a uniform manner over the cross section.

2. After the top layer has been rodded, position the metal cone of the swivel arm away, and strike off the concrete, level with the top of the cone using a trowel so that the mould is exactly filled.

3. Remove any material spilled inside the metal pot or sticking on to the side of the slump filled.

4. Position the Perspex disc over the cone and note down the reading on the graduated rod (L1). After keeping the disc away, lift the slump cone vertically and remove.

5. Position the disc over the concrete. Note down the reading of the graduated rod (L2). The difference in the readings gives the slump in Centimetres.

6. Switch on the vibrator starting a stopwatch simultaneously. Allow the concrete to spread out in the pot. When the whole concrete surface uniformly adheres to the Perspex disc, stop the watch, simultaneously, switch off the vibrator. Note down the time in seconds. Also note the reading on the graduated rod (L3).

7. The consistency of the concrete is expressed in Vee-Bee degrees which are equal to the time in seconds.

8. Repeat the procedure of different W/C ratios viz.: 0.4, 0.5, 0.55, 0.6 & 0.65.

9. Draw a graph between slump in centimetres and Vee – Bee Degrees.

10. Knowing the dia of the disc and the height of the concrete after Vibration (30+ L1 – L3), the Volume of the concrete can be computed.

OBSERVATION TABLE

Sl No	W/C Ratio	Slump(mm)	Vee-Bee seconds

RESULTS

EXPERIMENT NO. 14
COMPRESSIVE STRENGTH OF CEMENT CONCRETE
(IS: 516-1959)

AIM
Determination of the compressive strength of cement concrete specimen.

APPARATUS
Testing machine, two steel bearing platens with hardened faces (As per IS: 516-1959).

INTRODUCTION
Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days, ages of 13 weeks and one year are recommended if tests at greater ages are required. Where it may be necessary to obtain the early strength, test may be made at the ages of 24 hours+1/2 hour and 12 hours +2 hours. The ages shall be calculated from the time of the addition of the water to the dry ingredients.

DIAGRAM

PROCEDURE

Specimens stored in water should be tested immediately on removal from water and while they are still in wet condition. Surface water and grit shall be wiped off the specimens and any projecting fines removed. Specimens where received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the nearest 0.2 mm and their shall be noted before testing.
Placing the specimen in the testing machine the bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimens which are to be in contact with the compression platens. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The axis of the specimen should be carefully aligned with the centre of thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platens of testing machine. As the spherically seated block is brought to bear on the specimen, that movable portion shall be rotated gently by hand so that uniform section may be obtained. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min. Until the resistance of the specimen to the increasing loads breaks down and no greater load can be sustained. The maximum load applied to the specimen shall be recorded and the appearance of the concrete and any usual features in the type of failure shall be noted.

CALCULATION

The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test, by the cross sectional area, calculated from the mean dimensions of section and shall be expressed to the nearest Kg/sq.cm. Average of three values shall be taken as the representative of the batch provided the individual variation is not more than + 15% of the average. Otherwise, repeat tests shall be made.
In case of cylinders, a correction factor according to the height to diameter ratio of specimen after capping shall be obtained from the curve shown in fig. 1 of IS: 516-1959. The product of this correction factor and the measured compressive strength shall be known as the corrected compressive strength, this being the equivalent strength of a cylinder having a height/diameter ratio of two. The equivalent cube strength of the concrete shall be determined by multiplying the corrected cylinder strength by 5/4.

REPORTING OF RESULTS:

The following information shall be included in the report on each test specimen:

a) Identification mark

b) Date of test

c) Age of specimen

d) Curing conditions including date of manufacture of specimen in the field

e) Weight of specimen

f) Dimensions of specimen

g) Compressive strength

h) Maximum load and

i) Appearance of fractured faces of concrete and type of fractures if these are unusual

RESULTS

Compressive strength of Concrete --------------.

VIVA QUESTIONS

1. What is the size of a concrete cube mould?

Answer: 150mm X 150mm

2. What is the strength of a M20 grade concrete at 7 days?

Answer: 7 days compressive strength is around 70% of the designed target strength; hence a grade 20 concrete should have a minimum of 14N/mm2 at 7 days. However this is only an approximation.

3. What is the strength of a M25 grade concrete at 28 days?

Answer: Compressive strength of concrete at 28 days should not be less than 100% of its characteristic compressive strength. M25 should achieve compressive strength more than or equal to 25MPa at 28 days.

4. Why do we test at 7, 14 & 28 days?

Answer: Concrete is a macro content with Sand, Cement, & Coarse aggregate as its micro-ingredient (Mix Ratio) and gains its 100% strength over time at the hardened state.
Take a look at the below table.

Days after Casting	Strength Gain
Day 1	16%
Day 3	40%
Day 7	65%
Day 14	90%
Day 28	99%

Concrete Strength Overtime
As you can see the concrete gains its strength rapidly till 7th & 14th Days. Then gradually increases from there. So we can't predict the strength until the concrete comes to that stable state.
Once it attains certain strength at 7 days, then we know (according to the table) only 9% of strength going to increase. So at sites, we do normally test concrete at this interval. If the concrete fails at 14 days, then we will reject that batching.

EXPERIMENT NO.15
FLEXTURE TEST ON HARDENED CONCRETE

AIM
To determine the strength of the concrete by using flexure test.

APPARATUS
Prism mould, compression testing machine.

INTRODUCTION
Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield.

DIAGRAM

PROCEDURE

1. Test specimens are stored in water at a temperature of **24oC to 30oC for 48 hours** before testing. They are tested immediately on removal from the water whilst they are still wet condition.

2. The dimension of each specimen should be noted before testing.

3. The bearing surface of the supporting and loading rollers is wiped and clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers.

4. The specimen is then placed in the machine in such manner that the load is applied to the upper most surface as cast in the mould

5. The axis of specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surfaces of the specimen and rollers.

6. The load is applied without shock and increasing continuously at a rate of the specimen. The rate of loading is **4kN/min for the 15cm specimen and 18 kN /min** for the **10cm specimen.**

7. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded

RESULT

The strength of concrete is _________________**N/mm2**

Siliguri Institute of Technology

Civil Engineering Department

<u>Environment Engineering Lab. (CE(PC)595)</u>

ENVIRONMENT ENGINEERING LABORATORY (CE(PC)595)

DEPARTMENT OF CIVIL ENGINEERING

NAME: ____ GROUP: __________________

ROLL NO.________________________

ENVIRONMENT ENGINEERING LABORATORY

Code : CE(PC)595

LIST OF EXPERIMENT

EXPERMENT NO.	EXPERIMENT NAME
CE(PC)595/1	DETERMINATION OF TURBIDITY OF A GIVEN SAMPLE OF WATER
CE(PC)595/2	DETERMINATION OF ELECTRICAL CONDUCTIVITY OF A SAMPLE OF WATER
CE(PC)595/3	DITERMINATION OF TOTAL SOLID , SUSPENDED SOLID AND DISSOLVED SOLID OF A SAMPLE OF WATER
CE(PC)595/4	DETERMINATION OF PH OF A SAMPLE OF WATER
CE(PC)595/5	DETERMINATION OF ALKALINITY OF A SAMPLE OF WATER
CE(PC)595/6	DETERMINATION OF ACIDITY OF A SAMPLE OF WATER
CE(PC)595/7	DETERMINATION OF HARDNESS OF A SAMPLE OF WATER
CE(PC)595/8	DETERMINATIO OF IRON OF A SAMPLE OF WATER
CE(PC)595/9	DETERMINATION OF CONCENTRATION OF CHLORIDE OF A SAMPLE OF WATER
CE(PC)595/10	DETERMINATION OF OPTIMUN ALUM DOSE OF A SAMPLE OF WATER
CE(PC)595/11	DETERMINATION OF CHLORINE DEMEND OF A SAMPLE OF WATER
CE(PC)595/12	DETERMINATION OF DISSOLVED OXYGEN OF A SAMPLE OF WATER

CE(PC)595/13	DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND OF A SAMPLE OF WATER
CE(PC)595/14	DETERMINATION OF CHEMICAL OXYGEN DEMEND OF A SAMPLE OF WATER

DETERMINATION OF TURBIDITY (NTU).

AIM:

To determine the turbidity of the given samples

PRINCIPLE:

Turbidity can be measured either by its effects on the transmission of light which is termed as turbidimetry or its effects on the scattering of light which termed as Nephelometry. Turbidimetry can be used for sample with moderate turbidity and Nephelometer for sample with low turbidity. Higher the intensity of scattered light higher the turbidity.

APPARATUS:

1. Nephelometric Turbidimeter.
2. Cuvettes ti takes the samples for measurements.

REAGENTS:

- Solution (1) dissolves 1 g hydrazine sulphate in distilled water and dilute to 100 ml in volumetric flask.
- Solution (2) dissolve 10 g hexamine LR grade in distilled water and dilute to 100 ml in volumetric flask.
- In 100 ml volumetric flask, mix 12.5 ml solution (1) and 12.5 ml solution (2). Let them stand for 24 hrs at 250 dilute to mark and mix. The turbidity of the suspension is 1000 NTU.

PROCEDURE:

1. Switch on the instrument and keep it on for some time.
2. Select appropriate range depending upon the expected turbidity of the sample.
3. Set zero of the instrument with turbidity free water using a blank solution and adjust 000 with set zero knob.
4. Now in another test tube take standard suspension just prepared as above for 0-200 NTU solution as standard.
5. Take its measurements and set the display to the value of the standard suspension with the calibrate knob.

RESULT :

NAME: DETERMINATION OF SOLIDS: TOTAL SOLIDS, SUSPENDED SOLIDS AND DISSOLVED SOLIDS.

AIM:

To determine the total suspended solids, total dissolved solids and total solids of given sample.

PRINCIPLE:

Determination of total solids is made by evaporating and drying of a measured sample in an oven at 105°C for a period of 1 hour. Since water for potable use contains small amount of suspended matter, it is usual to filter a sample of water and determine solids in filtrate by the fore going method. The difference between total solids in unfiltered and filtered samples is taken as measure of the suspended solids is also classified as volatile or organic solids and fixed or inorganic solid.

APPARATUS:

1. Standard beaker
2. Conical Flask
3. Filter Paper.
4. Digital Balance.
5. Oven.
6. Evaporating Dish.

PROCEDURE:

SUSPENDED SOLIDS:

1. Take 25 ml of sample in beaker.
2. Note the weight of properly dried filter paper (W1).
3. Properly fold and place the filter paper on the Erlenmeyer flask.
4. Pour the sample through and filter it completely.
5. Transfer the filter paper to an oven at 105°C for one hour.
6. Note the weight of dried filter paper (W2).
7. The difference between the above two weight gives the suspended solids (W3).
   Total Suspended Solids = (W3 x 1000)/ml of sample taken.

DISSOLVED SOLIDS:

1. Filter a known quantity of water in filter paper.
2. Take the empty dish and clean it thoroughly, make it perfectly dry. Take the weight of the empty dish – W 1 gm.
3. Take a known quantity of the filtered water sample in the dish
4. Heat the dish till the entire liquid evaporate and the dry residues remain at the bottom.
5. Take the weight of dish after 20 minutes cooling and weigh it - W 2 gm.

Total Dissolved Solids = [(W2-W1) x 1000]/ ml of sample taken.

TOTAL SOLIDS:

Add suspended solids and dissolved solids which gives total solids.

RESULT:

1. Total Suspended Solids in the Sample=
2. Total Dissolved Solids in the sample=
3. Total solids in the sample=

NAME: pH METER - DETERMINATION OF pH OF SAMPLES

AIM:
To determine the pH (Hydrogen ion) in the given sample.

PRINCIPLE:
The pH is determined by measurement of the electromotive force of a cell comprising an indicator electrode (an electrode responsive to hydrogen ions such as glass electrode) immersed in the test solution and a reference electrode or a combined electrode. The contact between the test solution and the reference electrode is usually achieved by means of a liquid junction. The emf of this cell measured with pH meter. This is a high impedance electrometer calibrated in terms of pH.

APPARATUS:
1. pH meter
2. Standard buffer solution of known pH
3. Distilled water
4. Samples

REAGENTS:
Calibrate the electrode system against standard buffer solution of known pH. Buffer tablets having pH 4.0, 7.0, and 9.2 are available.

pH4, pH7, pH9.2 BUFFER SOLUTIONS:
Dissolve buffer tablet of pH4 in 10 ml of distilled water to get pH4 buffer solution. Similarly other buffer solutions can be prepared by dissolving corresponding buffer tablets.

PROCEDURE:
1. Switch on the instrument.
2. Wash probe and blot using tissue paper.
3. Check – Temp = 30o Switch the buttons to pH and stand by at the bottom.
4. Take Buffer pH - 4 and insert the probe. Press stand by to Read.
5. Adjust the Cal control to read 4. Wait for 1 min.
6. Press to stand by, wash probe and blot using tissue paper.
7. Take Buffer pH- 9.2 and insert the probe, press stand by to read.
8. After the Instrument shows 9.2, press to stand by, wash probe and using tissue paper.
9. Take one sample, insert the probe, press read, measure pH.
10. Press to stand by, wash probe and blot using tissue paper and repeat the same for other sample.
11. Finally, wash probe and blot using tissue paper, dip in distilled water.

NOTE:

pH = 7 indicates Neutral pH
pH < 7 indicates Acidic pH
pH > 7 indicates Alkaline pH

OBSERVATIONS AND CALCULATIONS:

Sl.No	Temp. of Sample (°C)	pH value	Remarks

RESULT:

pH of the taken sample is=……..

NAME: DETERMINATION OF ALKALINITY OF A GIVEN SAMPLE.

AIM:

To determine the amount of alkalinity present in the given sample

APPARATUS:

1. Burette with Burette stand and porcelain title
2. Pipettes with elongated tips
3. Conical flask
4. Measuring cylinders
5. Beakers
6. Dropper
7. Stirrer

REAGENTS:

1. Standard0.02N Sulphuric acid
2. Phenolphthalein indicator
3. Methyl orange indicator

REAGENT PREPARATION:

a) Std.acid of 0.02 N

Prepare 0.1N HCL solution by diluting 9ml of conc. HCL to 1 litre in distilled water. Standardize this with 0.1 N sodium carbonate solution .Prepare 0.02 N HCL solution by diluting 20 ml of 0.1 N HCL to 1 litre in distilled water.

(OR)

Place 7-ml conc.H2SO4 in a 250-ml jar and make up to the mark with carbondioxide free distilled water. Standardize it against 0.1N sodium carbonate solution using methyl orange as the indicator (End pt. is the appearance of faint orange color).This will give 1N standardize sulphuric acid.dilute 20ml of 1N standardize sulphuric acid to 1000ml in a volumetric flask with carbondioxide free distilled water to give 0.02N standard acid.1ml of exactly 0.02N acid =1.0 mg of CaCo3

(Either H2So4)

Sodium carbonate solution 0.1N

Dissolve 0.53 gm anyhydrous sodium carbonate in distilled water and make up to100ml.

B)Phenolphthalein indicator:

Add 1 gm of phenolphthalein in 200 ml distilled water and dissolve it. Add 0.02N sodium hydroxide solution dropwise until a faint pink color appears. (0.4 cm NaOH dissolved in 100ml distilled water gives 0.02N NaOH)

C) Methyl orange indicator:

Add 0.1gm of methyl orange in 200ml of distilled water. Heat until it gets dissolved and filters it.

PROCEDURE:

Phenolpthalein alkalinity(p)

1. Take 20ml of water sample in conical flask. (If the sample contains any chlorine. Dechlorine by the addition of 1 drop 0.1N sodium thiosulphate soln.)
2. Add 1 or 2 drops of phenolphthalein indication until the color becomes pink.
3. Titrate against std. acid till color just disappears.

Total alkalinity(t)

1. Add 1 or 2 drops of methyl orange indicator to the same solution in which phenolphthalein alkalinity has been determined. The color becomes yellowish.
2. Titrate against std. acid till the color changes to pale pink.
3. Repeat the titrate for concordant values

OBSERVATIONS AND CALCULATIONS:

Table -1: Determination of Phenolphthalein Alkalinity:

Sample No and source	Volume of Sample (mL)	Burette Reading (mL)		Volume of Sulphuric acid (mL)	Phenolphthalein Alkalinity (mg/L as CaCO3)
		Initial	Final		

Table – 2: Determination of Total Alkalinity:

Sample No and source	Volume of Sample (mL)	Burette Reading (mL)		Volume of Sulphuric acid (mL)	Total Alkalinity (mg/L as CaCO3)
		Initial	Final		

CALCULATION:

Phenolphthalein alkalinity (as CaCo3) mg/l= {Vol. of std. acid in ml x1000}/ Vol. of sample taken in ml
(For phenolphthalein end point)

Total alkalinity (as caCo3) mg/l= {Vol. of std. acid in ml x 1000}/vol. of sample taken in ml
(For methyl orange end pt.)

RESULT:

Hydroxyl alkalinity = mg/l
Carbonate alkalinity= mg/l
Bicarbonate alkalinity= mg/l
Total alkalinity = mg/l

NAME: DETERMINATION OF HARDNESS OF SAMPLES

AIM:

To determine the hardness of given sample by EDTA method.

PRINCIPLE:

EDTA and its sodium salt form a compound when added to a solution of certain metal cations. If a small amount of dye such as Eriochrome black T is added to an aqueous solution containing small calcium and magnesium ions at a pH of a 10±0.50 the solution become wine red. If EDTA is added then Ca and Mg will be complexed. When all these two ions are completed the solution will turn blue. This is the end point of titration. The higher the pH sharper the end point, however above pH 10, there is a danger of precipitation of Calcium Carbonate and Magnesium hydroxide. Hence, the pH is fixed at 10±0.50.

APPARATUS:

1. Burette.
2. Pipette
3. Conical flask.

REAGENTS:

EDTA solution 0.01 M.

PROCEDURE:

1. Take 20 ml well mixed sample in Erlenmeyer flask.
2. Add 1 to 2 ml buffer solution so as to bring the pH to 10±0.50.
3. Add 2 drops Eriochrome black T indicator solution. The solution changes in colour.
4. Titrate against standard EDTA till colour turns blue. Note down the volume (v).

OBSERVATIONS AND CALCULATIONS:

Sl. No.	Sample No.	Volume of sample (V)	Initial burette reading (ml)	Final burette reading (ml)	Volume of EDTA (ml)	Hardness(mg/l)

Hardness as $CaCO_3$= (v_1 x s x 1000)/v mg/l

Where v_1 = ml of titrant used

S = mg of $CaCO_3$ equivalent to 1 ml of EDTA solution = 1 mg $CaCO_3$

V = volume of sample.

RESULT:

Hardness as $CaCO_3$ =

NAME: Determination of Total Iron in Water.

AIM:

The purpose of this experiment is to determine the concentration of iron in an unknown sample.

APPARATUS:

1. Nessler tube
2. Measuring cylinder
3. Dropper

REAGENTS:

1. Hydrochloric acid
2. Potassium permanganate solution
3. Potassium thiocyanate solution
4. Standard iron solution

PROCEDURE:

1. Place 100 mL of the water sample in a Nessler.
2. Add 5 mL of dilute hydrochloric acid
3. Add two drops of potassium permanganate solution
4. Add 5 mL of potassium thiocyanate solution. The solution would turn brown if iron is present.
5. Compare the brown color formed with the standard prepared as follows:

a.Add 100 mL of distilled water in a Nessler tube

b.Add 5 mL of the dilute hydrochloric acid.

c.Add two drops of potassium permanganate solution.

d.Add 5 mL of potassium thiocyanate solution.

e.Add 0.2 mL at a time of the standard iron solution until the color of the standard and the sample match.

OBSERVATIONS AND CALCULATIONS:

Sample No	Source of Sample	Temperature of Sample (°C)	Total iron concentration (mg/l)

CALCULATION:

Total iron concentration of test sample (mg/L) =
[Standard iron solution added in distilled water (mL) x Conc. of standard iron solution(mg/L)] /mL of sample taken

RESULT:

Total iron concentration of the given sample=………mg/l.

NAME: DETERMINATION OF OPTIMUM DOSAGE OF ALUM (JARTESTAPPARATUS)

AIM:
To determine the optimum alum dosage of the given samples of water

PRINCIPLE:
Metal salts hydrolyse in presence of the natural alkalinity to form metal hydroxides. The multivalent actions can reduce the zeta- potential. The metal hydroxides are good adsorbents and hence remove the suspended particles by enmeshing them.

APPARATUS:
Jar Test Apparatus.

REAGENTS:
Standard Alum/ Ferrous/ Ferric salt solution: Prepare standard chemical solution such that 1l of solution contains 14.28 gm. of salt in the solution.

PROCEDURE:
1. Measure initial turbidity of the sample.
2. Measure 1 lit. of the water to be tested into a series of glass jars.
3. Attach to stirring device (Jar test apparatus).
4. Add progressive volumes of the chemical solution to each of the jars covering the range of chemical dosage expected of 0.25 ml, 0.5 ml, 0.75 ml, 1 ml, 1.25 ml, 1.25 ml.
5. Mix rapidly each sample for 1 minute @ 60 -80 rpm.
6. Reduce the speed to about 30 rpm and mix for 15 mins.
7. Allow the flocs to settle for 30 minutes.

OBSERVATIONS AND CALCULATIONS:
Initial turbidity of the sample:
Initial pH of the sample:

Jar no.	Coagulant dose added	Observation
	0.25	
	0.5	
	0.75	
	1	
	1.25	
	1.5	

RESULT:
Selected optimum dosage = x (say)ml/l
Strength of alum solution= 14.28 gm/l = 14.28 mg/ml
Optimum dosage, mg/l = 14.28 mg/ml X x ml/l

= 14.28 x mg/l.

NAME: Determination of available chlorine percentage in a given sample of bleaching powder.

AIM:
To determine the Available Chlorine in a Given Water Sample

APPARATUS:
1. Erlemeyer flask (250 mL)
2. Bottle
3. Beaker (250 mL)
4. Measuring cylinder
5. Dropper
6. Stirrer

REAGENTS:
1. Bleaching powder solution: Make a paste of 1 g. bleaching powder (CaCl, OCL, H2O) in minimum
2. water and dilute the paste with distilled water to a volume of 100 ml. Take care to see that the paste is transferred to the volumetric flask quantitatively.
3. 0.025N sodium Thisulphate: 6.25 g. Na2S2O3, 5H2O is dissolved in 1 liter of distilled water.
4. Glacial acetic acid.
5. Potassium iodide crystals.
6. 0.1 N potassium iodate solution: 812 mg dissolved in 250 ml. distilled water.
7. Starch indicator: 5 g soluble starch mixed with little water and ground in a pestle and mortar so as to prepare a paste. Paste is then transferred quantitatively to 1 liter of boiling water. Mixture is then allowed to settle overnight and the supernatant is used.

PROCEDURE:
1. Take 10 ml of bleaching powder solution in a conical flask and add to it KI crystals. Sufficient distilled water and approximately 2 ml of glacial acetic acid mix.
2. Titrate the sample till dark amber colored solution turns to pale straw color.
3. Add starch indicator and Mix.
4. Titrate till the blue colored starch iodide complex becomes colorless.
5. Prepare reagent blank using distilled water. Note the volume of thiosulphate required

CALCULATION:
1 ml of 1 N Thio = 35.45 mg Cl2
1 ml of 0.025 N Thio = 35.45 x 0.025
= 0.88625 or Say 0.89
ml of thio x 0.89 x 100
∴ Percent available= ----------- x (100 in bleaching chlorine ml of B. P. Solution Powder)

RESULT:

Available Chlorine in the given sample=………mg/l.

NAME: DETERMINATION OF DISSOLVED OXYGEN.

AIM:
To determine the amount of dissolved oxygen present in the given sample

PRINCIPLE:
Turbidity can be measured either by its effects on the transmission of light which is termed as turbidimetry or its effects on the scattering of light which termed as Nephelometry. Turbidimetry can be used for sample with moderate turbidity and Nephelometer for sample with low turbidity. Higher the intensity of scattered light higher the turbidity.

APPARATUS:
1. Burette
2. Pipettes
3. 300 ml glass stoppered BOD bottles
4. 500 ml conical flask
5. Pipette bulb
6. 250 ml gratuated cylinders
7. Wash bottle

REAGENTS:
1. Sodium hydroxide
2. Manganous sulphate
3. Potassium iodide
4. Sodium thiosulphate
5. Con.H2So4, starch

REAGENTS PREPARATION:
1. **Manganous sulphate**
   12gm of manganous sulphate is dissolved in 25ml of distilled water
2. **Alkaline-iodide solution**
   9gm of sodium hydroxide and 2.5 gm of potassium iodide are dissolved in 25ml of distilled water.
3. **Sodium thiosulphate solution(0.01N)**
   2.48gm of sodium thiosulphate is dissolved in 1litre of water
4. **Starch solution**
   Take 0.5gm of starch. Prepare paste with distilled water. Make 100ml with water and boil by stirring .cool it
5. **Pipette solution**

2ml of manganous sulphate solution and 2ml of alkaline iodide solution is added to the250ml of the sample taken in a reagent bottle. The bottle is stoppered and shaken thoroughly. When the precipitate formed is settled, 2ml of conc.HCL or conc.H2So4 is added and shaken thoroughly until the precipitate gets dissolved completely.

PROCEDURE:

1. Take two 300 ml glass stoppered BOD bottle and fill it with sample to be tested. Avoid any kind of bubbling and trapping of air bubbles. Remember no bubbles.
   or,
   Take the sample collected from the field. It should be collected in BOd bottle filled upto the rim.
2. Add 2 ml of manganese sulfate to the BOD bottle by inserting the calibrated pipette just below the surface of the liquid.
3. Add 2 ml of alkali- iodide - azide reagent in the same manner.
4. Squeeze the pipette sloely so no bubbles are introduced via the pipette (The pipette should be dipped inside the sample while adding the aqbove two reagents. If the reagent is added above the sample surface, you will introduce oxygen into the sample).
5. If oxygen is present, a brownish - orange cloud of precipitate or floc will appear.
6. Allow it to settle for sufficient time in order to react completely with oxygen.
7. Add 2 ml of concentrated sulfuric acid via a pipette held just above the surface of the surface.
8. Carefully stopper and invert several time to dissolve the floc.
9. At this point, the sample is fixed and can be stored for up to 8 hours if kept in a cool, dark place.
10. Rinse the burette with sodium thiosulphate and then fill it with sodium thiosulphate.Fix the burette to the stand.
11. Measure out 203 ml of the solution from the bottle and tranfer to an conical flask.
12. Titration needs to be started immediately after the transfer of the contents to conical flask.
13. Titrate it against sodium thiosulphate using starch as indicator. (Add 3-4 drops of starch indicator solution.)
14. End point of the titration is first disappearance of the blue colour to colourless.
15. Note down the volume of sodium thiosulphate solution added which gives the dissolved oxygen in 7.9 ml.
16. Repeat the titration for concordant values.

OBSERVATION AND CALCULATION:

Trial No.	Temp.	Volume of Sample (ml)	Burette Reading		Volume of Titrant (ml)	Dissolved Oxygen (mg/l)
			Initial	Final		

1						
2						
3						

Burette solution: Sodium Thiosulphate.
Pipette solution: Sample
Indicator: Starch
End point: Disappearance of blue colour.

Calculation:

1 ml of 0.025 N Na2S2O3 is equivalent to 0.2 mg of O2, since the volume of the sample is 200 ml.
1 ml of Sodium thiosulphate is equivalent to (0.2x 1000)/200 mg/l = 1 mg/l.

NOTE:

- For the calculation of DO the temperature at the time of measurment is 200C and the volume of sample taken is 200 ml.
- Sodium thiosulphate is taken in the burette.
- For the first titration the initial reading is 0 ml and the final reading is 7.8. The volume of sodium thiosulphate consumed to get the end point is 7.8 ml.
- For the second titration the initial reading is 0 ml and the final reading is 7.9. The volume of sodium thiosulphate cinsumed to get the end point 7.9 ml.
- For the second titration the initial reading is 0 ml and the final reading is 7.9. The volume of sodium thiosulphate cinsumed to get the end point 7.9 ml.
- For the second and third titration, we have achieved concordant value. So we can go for the calculations.

RESULT:

NAME: DETERMINATION OF CHEMICAL OXYGEN DEMAND (COD)

AIM:

To determine the Chemical Oxygen Demand (COD) in the given sample.

PRINCIPLE:

Most of the organic compounds was destroyed by adding a mixture of chromic and sulphuric acid. The purpose of running blank is to compensate for any error that may result because of the presence of extraneous organic matter in the reagents.

APPARATUS:

1. Reflux apparatus consisting of a flat bottom 250 to 500 ml capacity flask.
2. Burner or hot plate with temperature regulator.

REAGENTS:

1. Std 0.25 N Potassium di chromate Solution
2. Sulphuric acid – Silver sulphate reagent
3. Standard 0.1 N Ferrous Ammonium Sulphate
4. Ferroin Indicator

REAGENTS PREPARATION:

1. **Std 0.25 N Potassium di chromate Solution:**
   Dissolve 12.259 gm $K_2Cr_2O_7$ dried at 1030C for 24 hours in distilled water and dilute to 1000 ml. Add about 120 mg sulphamic acid take care of 6mg/l NO2-N.
2. **Sulphuric acid – Silver sulphate reagent:**
   Add 10 gm of Ag2 So4 to 1000 ml cone. H_2SO_4 and keep over night for dissolution.
3. **Standard 0.1 N Ferrous Ammonium Sulphate :**
   Dissolve 39 gm $Fe(NH_4)_2(SO_4)_2$ 6 H_2O in about 400 ml distilled water. Add 20 ml conc. H_2SO_4 and dilute to 1000 ml.
4. **Ferroin Indicator :**
   Dissolve 1.485 g of 2, 10 Phenanthroline monohydrate and 695 mg $FeSO_4$, 7 H_2O and dilute to 100 ml with distilled water.
5. **Mercuric Sulphate:**
   $HgSO_4$ crystals, analytical grade.

PROCEDURE:

1. Place 0.4 g $HgSO_4$ in a reflux flask.
2. Add 20 ml sample and mix well.
3. Add pumice stone or glass beads followed by 10 ml of standard $K_2Cr_2O_7$.
4. Add slowly 30 ml H_2SO_4 containing Ag_2SO_4 mixing thoroughly. This slow addition along with swirling prevents fatty acids to escape out due to high temperature.

5. Connect the flask to condenser: Mix the contents before heating.
6. Reflux for a minimum of 2 hours cool and then wash down the condenser with distilled water.
7. Dilute for minimum of 150 ml, cool and titrate excess $K_2Cr_2O_7$ with 0.1 N Ferr. Amn. Sulphate using ferroin indicator. Sharp colour change from blue green to wine indicates end point.
8. Reflux blank: in the same manner using distilled water instead of sample.
9. Caculate COD from the following formula:

COD mg/l= (a-b) xNx8000

Where, a = ml of Ferr. Amn. Sulphate for blank.

b= ml of Ferr. Amn. Sulphate for sample

N= Normality of Ferr. Amn. Sulphate.

OBSERVATION AND CALCULATION:

Sl.No.	Burette reading of Ferr. Amm. Sulphate			Remarks
	Initial Final difference	Initial Final difference	Initial Final difference	

RESULT:

COD of the given sample = ...mg/l.

NAME: DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND (BOD)

3 **AIM:**

To determine the Bio-Chemical Demand (BOD) of the given sample

APPARATUS:

1. BOD Incubator
2. Burette
3. Pipette
4. Measuring cylinders

REAGENTS:

1. Calcium Chloride
2. Magnesium Sulphate
3. Ferric Chloride
4. Di Potassium Hydrogen Phosphate
5. Potassium Di Hydrogen Phosphate
6. Di sodium Hydrogen Phosphate
7. Ammonium Chloride
8. Manganous Sulphate
9. Potassium hydroxide
10. Potassium iodide
11. Sodium Azide
12. Concentrated sulfuric acid
13. Starch indicator
14. Sodium thiosulphate
15. Distilled water

PROCEDURE:

1. Take four 300 ml glass stoppered BOD bottles (two for the sample and two for the blank)
2. Add 10 ml of the sample to each of the two BOD bottles and the fill the remaining quantity with the dilution water i.e. we have diluted the sample 30 times.
3. The remaining two BOD bottles are for blank, to these bottles add dilution water alone.
4. After the addition immediately place the glass stopper over the BOD bottles and note down the numbers of the bottle for identification.
5. Now preserve one blank solution bottle and one sample solution bottle in a BOD incubator at 20 0C for five days.
6. The other two bottles (one blank and one sample) needs to be analysed immediately.
7. Add 2 ml of manganese sulfate to the BOD bottle by inserting the calibrated pipette just below the surface of the liquid.
8. Add 2 ml of alkali-iodide-azide reagent in the same manner.

9. Allow it to settle for sufficient time in order to react completely with oxygen.
10. When this floc has settled to the bottom, shake the contents thoroughly by turning it upside down.
11. Add 2 ml of concentrated sulfuric acid via a pipette held just above the surface of the sample.
12. Carefully stopper and invert several times to dissolve the floc.
13. Titration needs to be started immediately after the transfer of the contents to Erlenmeyer flask.
14. Rinse the burette with sodium thiosulphate and then fill it with sodium thiosulphate. Fix the burette to the stand.
15. Measure out 203 ml of the solution from the bottles and transfer to an Erlenmeyer flask.
16. Titrate the solution with standard sodium thiosulphate solution untill the yellow colour of liberated iodine is almost faded out(pale yellow colour)
17. Add 1 ml starch solution and continue the titration untill the blue colour disappears to colourless.
18. Note down the volume of sodium thiosulphate solution added, which gives the D.O. in mg/l. Repeat the titration for concordent value.

OBSERVATION AND CALCULATION:

Trial No.	Day	Volume of Sample (ml)	Burette Reading		Volume of Titrant (ml)	Dissolved Oxygen (mg/l)
			Initial	Final		
Blank						
1						
2						
Blank						
1						
2						

RESULT:
BOD of the given sample = ...mg/l.

Siliguri Institute of Technology

Civil Engineering Department

Engineering Geology Laboratory Manual CE(ES)493

LIST OF EXPERIMENT

EXPERIMENT NO	EXPERIMENT NAME
CE(ES)493/1	Identification of minerals in hand specimen
CE(ES)493/2	Identification of igneous rocks in hand specimen
CE(ES)493/3	Identification ofsedimentary rocks in hand specimen
CE(ES)493/4	Identification of metamorphic rocks in hand specimen
CE(ES)493/5	Study of crystals with the help of crystal models
CE(ES)493/6	Study of geological structure with help of models
CE(ES)493/7	Interpretation of geologic maps :horizontal ,vertical ,inclined,uniclinal,folded and faulted structures
CE(ES)493/8	Microscopic study of rocks and minerals

EXPERIMENT NO. CE(ES)493/1

Name: Identification of minerals in Hand specimens

Mineral

A mineral may be defined as a natural, inorganic, homogenous, solid substance having a definite chemical composition and regular atomic structure.

Common methods of study for the identification of minerals

Method	Principle
X-ray analysis	Based on the study of atomic structure, distinctive for every mineral. Its limitation is expensive, time consuming.
Chemical analysis	Based on the study of chemical composition. Its limitation is expensive, time consuming and not suitable for minerals exhibiting polymorphism (two or more minerals exhibit different physical properties in spite of possessing the same chemical composition).
Optical study	Based on the net effect of chemical composition and atomic structure. Its limitation is expensive.
Study of physical properties	Based on the consistency in physical properties which are due to the definite chemical composition and regular atomic structure. Its limitation is liable for erroneous inference, sometimes.

LABORATORY STUDY

In laboratories minerals are identified preferably by the method of study of physical

properties. Advantages

O The unique advantage is that the minerals can be studied in the field itself.

It does not require any additional requirements, chemicals or equipment.

It involves no loss or wastage of minerals. Hence repetitive study is possible.

Immediate inference is possible.

It is the cheapest and simplest method.

The following are the physical properties identified in the laboratory

1. Form

The form represents the common mode of occurrence of a mineral in nature.

Form	Description	Example
Lamellar form	Mineral appears as thin separable layers.	Different varieties of Mica
Tabular form	Mineral appears as slabs of uniform thickness.	Feldspars, Gypsum
Fibrous form	Mineral appears to be made up of fine threads.	Asbestos
Pisolitic form	Mineral appears to be made up of small spherical grains.	Bauxite
Oolitic form	Similar to pisolitic form but rains are of still smaller size.	Lime stones

Rhombic form	Rhombic shape	Calcite

Bladed form	Mineral appears as cluster or as independent rectangular grains.	Kyanite
Granular form	Mineral appears to be made up of innumerable equidimensional grains of coarse or medium or fine size.	Chromite, Magnetite
Columnar form	Mineral appears as long slender prism.	Topaz
Prismatic form	As elongated	Apatite, quartz
Spongy form	Porous	Pyrolusite
Crystal form	Polyhedral, Geometrical shapes.	Garnets, Galena
Massive form	No definite shape for mineral.	Jasper, Graphite
Concretionary Form	Porous and appears due to accretion of small irregularly shaped masses.	Laterite
Nodular form	Irregularly shaped compact bodies with curved surfaces.	Flint

2. Colour

It is the usual body colour of mineral.

Name of the Mineral	Colour
Olivine	Olivine green
Biotite, Graphite, Magnetite	Black
Chlorite	Green
Garnet	Red
Kyanite	Blue
Amethyst	Violet
Quartz	Colourless, White, Green, Violet, Grey, Yellow, Pink etc
Feldspar	White, Grey, Shades of Red, Green, Dirty white, etc
Calcite	Colourless, white, shades of Red, Grey, Yellow, etc

3. Streak

The colour of the mineral powder is called the streak of a mineral. This is tested by rubbing the mineral on streak plate (An unglazed white porcelain plate).

Name of the Mineral	Body Colour	Streak
Hematite	Steel Grey	Cherry Red
Chromite	Black	Dark Brown
Magnetite	Black	Black
Graphite	Black	Black
Molybdenite	Black	Greenish Black

4. Lustre

Lustre is the nature of shining on the surface of the mineral.

Lustre	Description	Example
Metallic Lustre	It is the type of shining that appears on the surface of a metal.	Galena, Gold, Pyrite
Sub metallic Lustre	If the amount of shining is less when compared to metallic luster.	Hematite, Chromite, Magnetite
Vitreous Lustre	Shining like a glass sheet.	Quartz, Feldspar
Sub Vitreous Lustre	Less shining when compared to vitreous lustre.	Pyroxenes
Pearly Lustre	Shining like a pearl	Talc, Muscovite mica
Silky Lustre	Shining like silk	Asbestos
Resinous Lustre	Shining like a resin	Opal, Agate
Greasy Lustre	Shining like grease	Graphite
Adamantine Lustre	Shining like a diamond	Garnet, Diamond
Earthy or Dull Lustre	No Shining	Bauxite, Magnesite

5. Fracture

Fracture is the nature of the randomly broken surface of a mineral.

Fracture	Description	Example
Even fracture	If the broken surface is plain and smooth.	Magnesite, Chalk
Uneven fracture	If the broken surface is rough or irregular.	Hornblende, Bauxite
Hackly fracture	If the broken surface is very irregular like end of a broken stick.	Asbestos, Kyanite
Conchoidal fracture	If the broken surface is smooth and curved	Opal
Sub Conchoidal fracture	If the curved nature is less prominent.	Agate, Flint, Jasper

7. Cleavage

The definite direction or plane along which a mineral tends to break easily is called cleavage of that mineral. It occurs as innumerable parallel planes along which the mineral is equally weak. Such parallel planes of weakness are referred to as a set.

Cleavage	Example
One set of cleavage	Mica, Chlorite, Talc
Two sets of cleavages	Feldspars, Pyroxenes, Amphiboles
Three sets of cleavages	Calcite, Dolomite, Galena
Four sets of cleavages	Fluorite
Six sets of cleavages	Sphalerite
No cleavage	Quartz, Olivine, Garnet

7. Hardness

Hardness may be defined as the resistance offered by the mineral to abrasion or scratching. It is determined with the help pH Moh's scale of hardness which consists of ten reference minerals arranged in increasing order of hardness and numbered accordingly.

Name of the Mineral	Hardness
Talc	1
Gypsum	2
Calcite	3
Fluorite	4
Apatite	5
Feldspar	6
Quartz	7
Topaz	8
Corundum	9
Diamond	10

- **Specific gravity or Density**

Specific gravity or Density of minerals depends on their chemical composition and atomic structure.

Density	Range	Example
Low density	Specific gravity less than 2.5	Gypsum (2.3), Graphite (2-2.3)
Medium density	Specific gravity between 2.5 and 3.5	Quartz (2.7), Feldspar(2.5)
High density	Specific gravity greater than 3.5	Chromite (4.5- 4.8)

9. Degree of transparency

Degree of transparency is tested along the thin sharp edges of mineral keeping it against a powerful source of light. Depending upon the resistance offered by the minerals to the passage of light through them the transparency is classified.

Degree of Transparency	Example
Transparent	Thin layers of Muscovite, rock crystal
Translucent	Agate, Calcite
Opaque	Galena, Pyrite

10. Special properties

Some minerals exhibit unique characters which enable them to be identified easily.

Name of the Mineral	Special property
Talc	smooth touch or soapy feel
Graphite	Marks on a paper easily
Pyrolusite	Soils the fingers
Halite	Saline taste
Magnetite	Strongly attracted by any ordinary magnet
Chalk	Rough feeling of touch, adheres strongly to the tongue

Moh's Scale of Hardness

NAME OF MATERIAL	HARDNESS
Talc	1
Gypsum	2
Calcite	3
Fluorite	4
Apatite	5
Feldspar	6
Quartz	7
Topaz	8
Corundum	9
Diamond	10

EXPERIMENT NO. CE(ES)493/2

Name: Identification of Igneous rock in Hand specimens

Igneous rocks

These are characterized by vesicular structure, amygdaloidal structure and Aphanitic structure if they are volcanic. If they are Hypabyssal or plutonic, they are dense, compact and exhibit interlocking texture.

Terminology related for the description of igneous rocks

1. **Texture**

Phaneric	If minerals are visible to naked eye by virtue of their size.
Aphanitic	If minerals are too fine to be seen by naked eye.
Phaneric coarse	If minerals are greater than 5mm in size.
Phaneric medium	If minerals are 2mm to 5mm in size.
Phaneric tine	If minerals are less than 2mm in size.
Equigranular	If minerals are nearly of same size.
Inequigranular	If some minerals are distinctly larger than others.
Porphyritic	If larger minerals are surrounded by smaller minerals.
Interlocking	If minerals are closely interlinked and cannot be separate without damaging surrounding minerals.
Graphic	If angular quartz grains occur with some orientation in feldspars.

2. **Colour**

Leucocratic	If the rock looks pale coloured or white coloured, it indicates that the rock may be acidic.
Melanocratic	If the rock looks dark coloured or black coloured, it indicates that the rock may be basic or ultra basic.
Mesocratic	If the rock is neither dark coloured nor pale coloured.

3. **Structure**

Vesicular	If the rock is having empty cavities
Amygdaloidal	If the rock has cavities filled with amygdales

4. Minerals

Primary	If the minerals are present from the beginning of formation of rock.

Secondary	If the minerals are present after the formation of rock.
Essential	If they are major constituents and decide the name of the rock.
Accessory	If they occur in small quantities and their presence or absence has nothing to do in naming a rock.

5. Silica Saturation

Oversaturated	If a rock has free quartz.
Under saturated	If a rock has unsaturated minerals like Olivine.
Saturated	If a rock has neither free quartz nor unsaturated minerals.

6. Depth of Formation

Plutonic/Hypabyssal	If a rock is Phaneric and has interlocking texture.
Volcanic	If a rock is vesicular or amygdaloidal and Aphanitic.

EXPERIMENT NO. CE(ES)493/3

Name: Identification of Sedimentary rocks in Hand specimens

Sedimentary rocks:

Occurrence of normal or cross bedding, cementing material, fossils, ripple marks, mud cracks, tracks and trails and peculiar forms such as modular, concretionary, pisolitic, Oolitic, etc indicate that the rocks under study of sedimentary rocks.

Details relevant for the study of sedimentary rocks

1. **Bedding or stratification**

a) Different beds can be recognized based on colour, grain size, texture, hardness and other physical properties.
b) In case of cross bedding sets of layers will not be parallel but mutually inclined.

2. Cementing Material

Calcareous	It imparts white colour and pale colour to sand stones and can be known by acid test.
Feriginous	Imparts shades of brown, red, or yellow colour to sand stone
Argillaceous	It provides only weak cohesion for sand particles, which fall of rubbing the sand stone
Siliceous	Resembles calcareous cementing material but provides competence and durability to sand stone.
Glaucontic	It provides green colour to sand stone.

3. Fossils

May be plant (leaf) fossils or shells (complete or broken) - common in shales and lime stones.

4. Ripple Marks

Rare, may appear in sandstones, shales and lime stones. These appear as ware undulations on rock surface.

5. Peculiar forms

Concretionary, nodular	Laterites, Lime stones
Pisolotic	Lime stones, Laterites
Oolitic	Lime stones
Solution cavities	Lime stones
Lamination	Shales

6. Flaggy

Tendency to break in to slab, due to parallel fractures. Sometimes these are noticed in lime stones and sand stones.

7. Fissility

Tendency to split along bedding planes. Some shale has this character. **8. Conchoidal fracture** In dense compact Lime stones, less distinctly in shales.

9. Composition

Argillaceous	Shales
Arinaceous	Sand stones
Calcareous	Lime stones

10. Grain Size

Too fine to be seen as separate particles in shales and lime stones.

11. Surface touch

Gritty or rough in sand stones, smooth in shales and lime stones.

12. Appearance

Panels of colours for laterites, dense very fine grained for lime stone.

EXPERIMENT NO. CE(ES)493/4

Name: Identification of Metamorphic rocks in Hand specimens

Metamorphic rocks

Occurrence of alignment of minerals (lineation, foliation) and metamorphic minerals indicate the rocks under the study of metamorphic group .

Details relevant for the study of metamorphic rocks

1. **Foliation**

It refers to the parallel alignment of platy or lamellar minerals in metamorphic rocks.

2. **Lineation**

It refers to the parallel alignment of prismatic or columnar minerals in metamorphic rocks.

3. **Metamorphic minerals**

Minerals like garnet, tale, chlorite, graphite are suggestive of metamorphic origin of a rock.

4. **Gneissosse structure**

It is generally observed in granite gneisses where in alternating black (bornblende) and white (feldspars and quartz) colour bands appear.

5. **Schistose structure**

They have predominantly lamellar (mica, tale, chlorite) or prismatic (bornblende, Kyanite, etc) minerals. These do not have any alternating colour bands.

EXPERIMENT NO.CE(ES)493/5

Name: Study of crystals with the help of crystal models

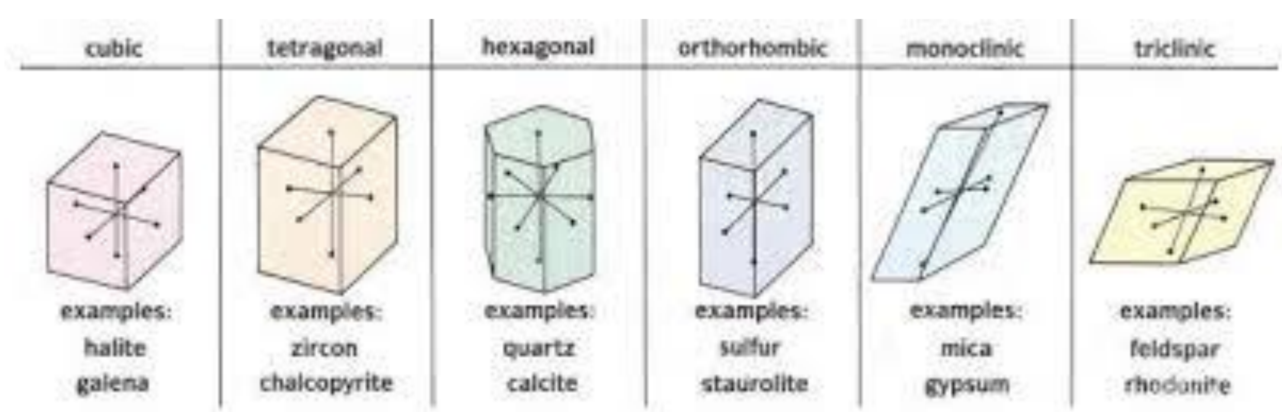
INTRODUCTION

The discipline of crystallography has developed a descriptive terminology which is applied to crystals and crystal features in order to describe their structure, symmetry, and shape. This terminology defines the crystal lattice which provides a mineral with its ordered internal structure. It also describes various types of symmetry. By considering what type of symmetry a mineral species possesses, the species may be categorized as a member of one of six crystal systems and one of thirty-two crystal classes.

The concept of **symmetry** describes the periodic repetition of structural features. Two general types of symmetry exist. These include **translational symmetry** and **point symmetry**. Translational symmetry describes the periodic repetition of a motif across a length or through an area or volume. Point symmetry, on the other hand, describes the periodic repetition of a motif around a point.

Reflection, rotation, inversion, and rotoinversion are all point symmetry operations.

A **reflection** occurs when a motif on one side of a plane passing through the centre of a crystal is the mirror image of a motif which appears on the other side of the plane. The motif is said to be reflected across the mirror plane which divides the crystal. **Rotational symmetry** arises when a structural element is rotated a fixed number of degrees about a central point before it is repeated. If a crystal possesses **inversion symmetry**, then every line drawn through the centre of the crystal will connect two identical features on opposite sides of the crystal. **Rotoinversion** is a compound symmetry operation which is produced by performing a rotation followed by an inversion.

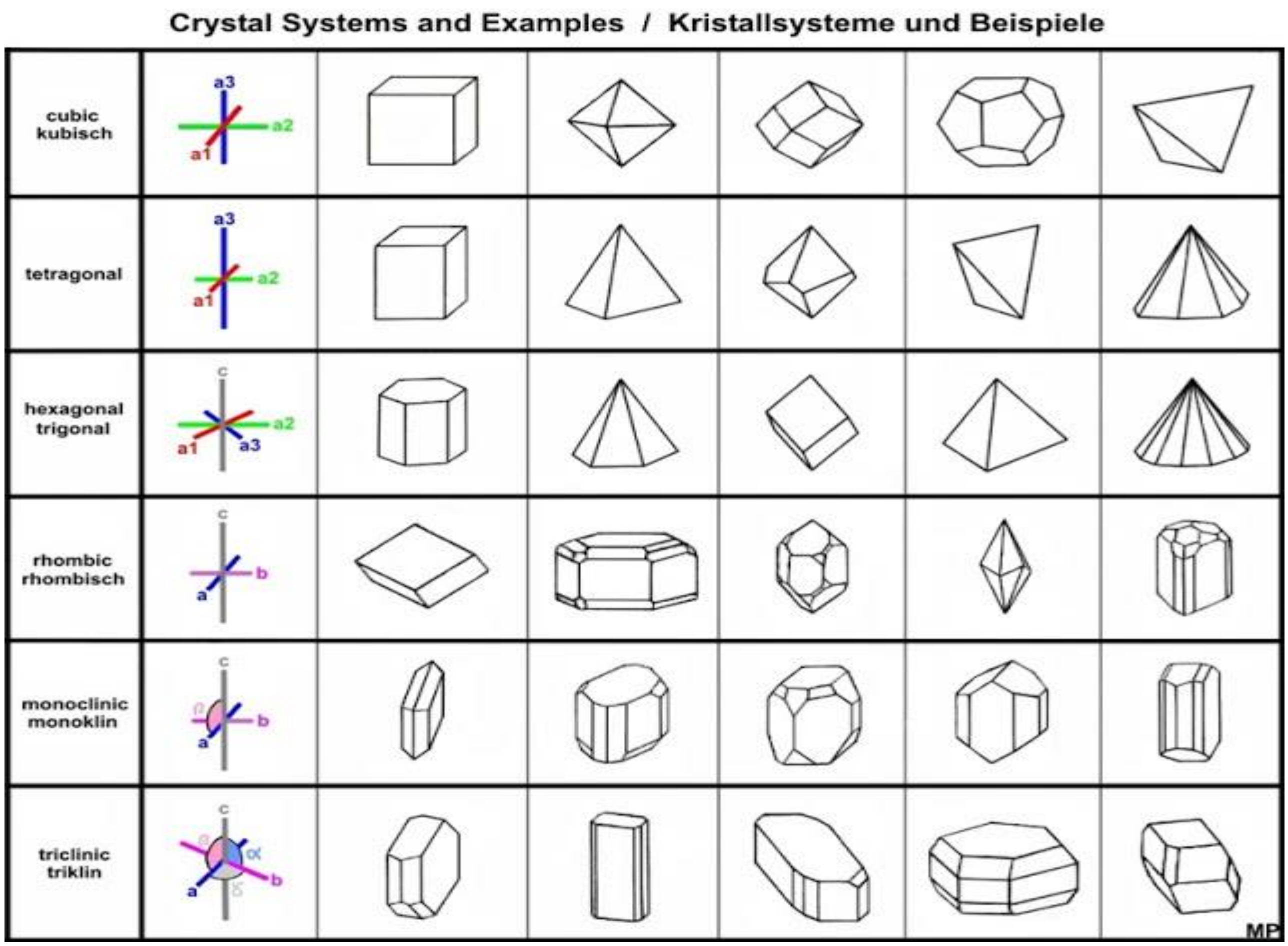


A specified motif which is translated linearly and repeated many times will produce a **lattice**. A lattice is an array of points which define a repeated spatial entity called a **unit cell**. The unit cell of a lattice is the smallest unit which can be repeated in three dimensions in order to construct the lattice. The corners of the unit cell serve as points which are repeated to form the lattice array; these points are termed **lattice points**.

The number of possible lattices is limited. In the plane only five different lattices may be produced by translation. The French crystallographer Auguste Bravais (1811-1863) established that in three-dimensional space only fourteen different lattices may be constructed. These fourteen different lattice structures are thus termed the **Bravais lattices**.

The reflection, rotation, inversion, and rotoinversion symmetry operations may be combined in a variety of different ways. There are thirty-two possible unique combinations of symmetry operations. Minerals possessing the different combinations are therefore categorized as members of thirty-two **crystal classes**; each crystal class corresponds to a unique set of symmetry operations. Each of the crystal classes is named according to the variant of a **crystal form** which it displays. Each crystal class is grouped as one of the six different **crystal systems** according to which characteristic symmetry operation it possesses.

A **crystal form** is a set of planar faces which are geometrically equivalent and whose spatial positions are related to one another by a specified set of symmetry operations. If one face of a crystal form is defined, the specified set of point symmetry operations will determine all of the other faces of the crystal form.



A simple crystal may consist of only a single crystal form. A more complicated crystal may be a combination of several different forms. The crystal forms of the five non-isometric crystal systems are the monohedron or pedion, parallelohedron or pinacoid, dihedron, or dome and sphenoid, disphenoid, prism, pyramid, dipyramid, trapezohedron, scalenohedron, rhombohedron and tetrahedron. Fifteen different forms are possible within the isometric system.

Each crystal class is a member of one of six **crystal systems**. These systems include the isometric, hexagonal, tetragonal, orthorhombic, monoclinic, and triclinic systems. The hexagonal crystal system is further broken down into the hexagonal and rhombohedral divisions. Every crystal of a certain crystal system will share a characteristic symmetry element with the other members of its system. The crystal system of a mineral species may sometimes be determined visually by examining a particularly well-formed crystal of the species.

SYEMMETRY AND LATTICE

Crystals possess a regular, repetitive internal structure. The concept of **symmetry** describes the repetition of structural features. Crystals therefore possess symmetry, and much of the discipline of crystallography is concerned with describing and cataloging different types of symmetry.

Two general types of symmetry exist. These consist of **translational symmetry** and **point symmetry**. Translational symmetry describes the periodic repetition of a structural feature across a length or through an area or volume. Point symmetry, on the other hand, describes the periodic repetition of a structural feature around a point. Reflection, rotation, and inversion are all point symmetries.

Lattices

The concept of a **lattice** is directly related to the idea of translational symmetry. A lattice is a network or array composed of single motif which has been translated and repeated at fixed intervals throughout space. For example, a square which is translated and repeated many times across the plane will produce a planar square lattice.

The **unit cell** of a lattice is the smallest unit which can be repeated in three dimensions in order to construct the lattice. In a crystal, the unit cell consists of a specific group of atoms which are bonded to one another in a set geometrical arrangement. This unit and its constituent atoms are then repeated over and over in order to construct the crystal lattice. The surroundings in any given direction of one corner of a unit cell must be identical to the surroundings in the same direction of all the other corners. The corners of the unit cell therefore serve as points which are repeated to form a lattice array; these points are termed **lattice points**. The vectors which connect a straight line of equivalent lattice points and delineate the edges of the unit cell are known as the **crystallographic axes**.

The number of possible lattices is limited. In the plane only five different lattices may be produced by translation. One of these lattices possesses a square unit cell while another possesses a rectangular unit cell. The third possible planar lattice possesses a centred rectangular unit cell, which contains a lattice point in the centre as well as lattice points on the corners. The unit cell of the fourth possible planar lattice is a parallelogram, and that of the final planar lattice is a hexagonal unit cell which may alternately be considered a rhombus.

Crystal class	Axis system
Cubic	$a = b = c, \alpha = \beta = \gamma = 90°$
Tetragonal	$a = b \neq c, \alpha = \beta = \gamma = 90°$
Hexagonal	$a = b \neq c, \alpha = \beta = 90°, \gamma = 120°$
Rhombohedral	$a = b = c, \alpha = \beta = \gamma \neq 90°$
Orthorhombic	$a \neq b \neq c, \alpha = \beta = \gamma = 90°$
Monoclinic	$a \neq b \neq c, \alpha = \gamma = 90°, \beta \neq 90°$
Triclinic	$a \neq b \neq c, \alpha \neq \beta \neq \gamma \neq 90°$

CRYSTAL SYSTEM

Every crystal class is a member of one of the six crystal systems. These systems include the isometric, hexagonal, tetragonal, orthorhombic, monoclinic, and triclinic crystal systems. The hexagonal crystal system is further broken down into hexagonal and rhombohedral divisions. Every crystal class which belongs to a certain crystal system will share a characteristic symmetry element with the other members of its system. For example, all crystals of the isometric system possess four 3-fold axes of symmetry which proceed diagonally from corner to corner through the centre of the cubic unit cell. In contrast, all crystals of the hexagonal division of the hexagonal system possess a single six-fold axis of rotation.
In addition to the characteristic symmetry element, a crystal class may possess other symmetry elements which are not necessarily present in all members of the same system. The crystal class which possesses the highest possible symmetry or the highest number of symmetry elements within each system is termed the holomorphic class of the system. For example, crystals of the holomorphic class of the isometric system possess inversion symmetry, three 4-fold axes of rotational symmetry, the characteristic set of four 3-fold axes of rotational symmetry which is indicative of the isometric crystal system, six 2-fold axes of rotational symmetry, and nine different mirror planes. In contrast, a crystal which is not a member of the holomorphic class yet still belongs to the isometric system may possess only three 2-fold axes of rotational symmetry and the characteristic four 3-fold axes of rotational symmetry.

The crystal system of a mineral species may sometimes be determined in the field by visually examining a particularly well-formed crystal of the species.

Isometric
The isometric crystal system is also known as the cubic system. The crystallographic axes used in this system are of equal length and are mutually perpendicular, occurring at right angles to one another. All crystals of the isometric system possess four 3-fold axes of symmetry, each of which proceeds diagonally from corner to corner through the centre of the cubic unit cell. Crystals of

the isometric system may also demonstrate up to three separate 4-fold axes of rotational symmetry. These axes, if present, proceed from the centre of each face through the origin to the centre of the opposite face and correspond to the crystallographic axes. Furthermore crystals of the isometric system may possess six 2-fold axes of symmetry which extend from the centre of each edge of the crystal through the origin to the centre of the opposite edge. Minerals of this system may demonstrate up to nine different mirror planes. Examples of minerals which crystallize in the isometric system are halite, magnetite, and garnet. Minerals of this system tend to produce crystals of equidimensional or equant habit.

Hexagonal

Minerals of the hexagonal crystal system are referred to three crystallographic axes which intersect at 120° and a fourth which is perpendicular to the other three. This fourth axis is usually depicted vertically. The hexagonal crystal system is divided into the hexagonal and rhombohedral or trigonal divisions. All crystals of the hexagonal division possess a single 6-fold axis of rotation. In addition to the single 6-fold axis of rotation, crystals of the hexagonal division may possess up to six 2-fold axes of rotation. They may demonstrate a center of inversion symmetry and up to seven mirror planes. Crystals of the trigonal division all possess a single 3-fold axis of rotation rather than the 6-fold axis of the hexagonal division. Crystals of this division may possess up to three 2-fold axes of rotation and may demonstrate a centre of inversion and up to three mirror planes. Minerals species which crystallize in the hexagonal division are apatite, beryl, and high quartz. Minerals of this division tend to produce hexagonal prisms and pyramids. Example species which crystallize in the rhombohedral division are calcite, dolomite, low quartz, and tourmaline. Such minerals tend to produce rhombohedra and triangular prisms.

Tetragonal

Minerals of the tetragonal crystal system are referred to three mutually perpendicular axes. The two horizontal axes are of equal length, while the vertical axis is of different length and may be either shorter or longer than the other two. Minerals of this system all possess a single 4-fold symmetry axis. They may possess up to four 2-fold axes of rotation, a centre of inversion, and up to five mirror planes. Mineral species which crystallize in the tetragonal crystal system are zircon and cassiterite. These minerals tend to produce short crystals of prismatic habit.

Orthorhombic

Minerals of the orthorhombic crystal system are referred to three mutually perpendicular axes, each of which is of a different length than the others. Crystals of this system uniformly possess three 2-fold rotation axes and/or three mirror planes. The holomorphic class demonstrates three 2-fold symmetry axes and three mirror planes as well as a centre of inversion. Other classes may demonstrate three 2-fold axes of rotation or one 2-fold rotation axis and two mirror planes. Species which belong to the orthorhombic system are olivine and barite. Crystals of this system tend to be of prismatic, tabular, or acicular habit.

Monoclinic

Crystals of the monoclinic system are referred to three unequal axes. Two of these axes are inclined toward each other at an oblique angle; these are usually depicted vertically. The third axis is perpendicular to the other two. The two vertical axes therefore do not intersect one another at right angles, although both are perpendicular to the horizontal axis. Monoclinic crystals demonstrate a single 2-fold rotation axis and/or a single mirror plane. The holomorphic class possesses the single 2-fold rotation axis, a mirror plane, and a centre of symmetry. Other classes display just the 2-fold rotation axis or just the mirror plane. Mineral species which adhere to the monoclinic crystal system include pyroxene, amphibole, orthoclase, azurite, and malachite, among many others. The minerals of the monoclinic system tend to produce long prisms.

Triclinic

Crystals of the triclinic system are referred to three unequal axes, all of which intersect at oblique angles. None of the axes are perpendicular to any other axis. Crystals of the triclinic system may be said to possess only a 1-fold symmetry axis, which is equivalent to possessing no symmetry at all. Crystals of this system possess no mirror planes. The holomorphic class demonstrates a centre of inversion symmetry. Mineral species of the triclinic class include plagioclase and axinite; these species tend to be of tabular habit.

EXPERIMENT NO. CE(ES)493/6

Name: Study of Geologiocal structure with the help of models

Theory

If the Earth's surface was flat, if there was no topography, then geological maps would be simple. They would be a direct reflection of the underlying geology. However, topography interacts with the geology to produce more complex but predictable patterns.

Horizontal and vertical strata:

Horizontal and vertical strata are the most straightforward to interpret on a map. Horizontal outcrops will always follow the topographic contours (figure 2a), whilst vertical layers will always form straight lines (figure 2b).

Dipping strata

Dipping layers interact with the topography in predictable ways. In valleys, beds will appear to'vee' either up or down the valley in the direction of dip (figure 2c and 2d). This is because the valley side acts as an approximate cross section–not always helpful on small scale maps but on large scale maps and in the field this is a useful aid in interpretation.

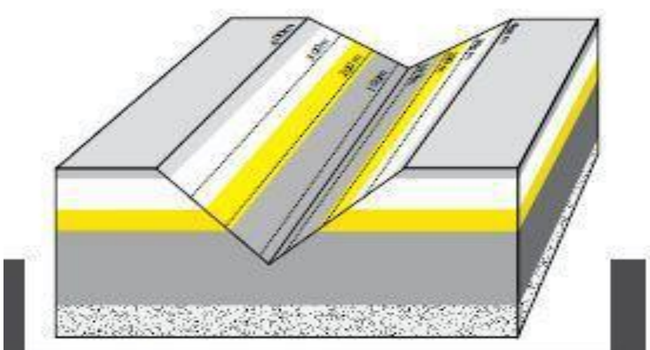


Figure 2a: Horizontal beds

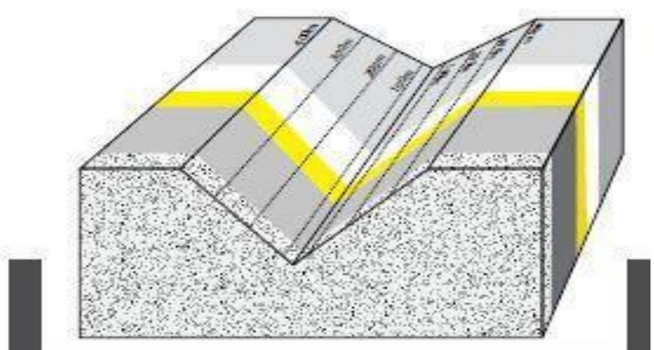


Figure 2b: Vertical beds

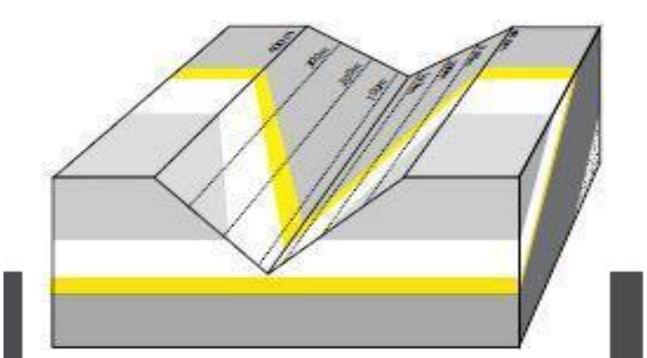


Figure 2c: Beds dipping towards viewer

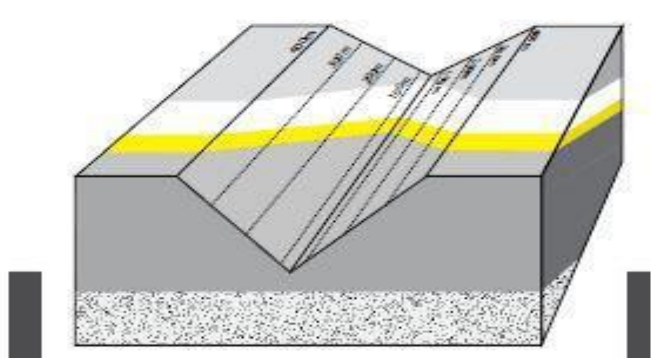


Figure 2d: Beds dipping away from viewer

Outcrop, structure and age relationships

A. Folding of rocks

a. L**ayer cake relations**

(1) oldest on bottom, youngest on top

b. **Fold Types**

(1) Anticlines-upfolded forms, results in older rocks becoming enclosed within younger strata

(2) synclines-downfolded forms, results in younger rocks becoming enclosed within older strata.

(3) symmetrical folds- both limbs of the fold dipping at same angle away from fold axis

(4) asymmetrical folds- both limbs of the fold not dipping at same angle away from fold axis

(5) overturned folds- condition in which one limb of fold has been tilted beyond vertical

(6) plunging folds- axis of fold is tilted

(7) Domes- more or less circular equivalent of anticline, oldest rocks exposed in centre of dome

(8) Structural Basin- more or less circular equivalent of syncline, youngest rocks exposed in centre of dome (not to be confused with depositional basin) **c**.

Outcrops Patterns Associated with Folded Rocks

(1) As rocks are folded, and subsequently subjected to erosion, regular patterns become evident in relation to type of rock that outcrops and age of the rock that outcrops in an area of folded strata. In essence, erosion exposes the interiors of the folds

(2) Non-plunging Folds- axis of fold is horizontal, results in parallel bands of dipping strata about the fold axis

(a) anticlines- oldest strata exposed along fold axis

(b) synclines- youngest strata exposed along fold axis

(3)Plunging Folds-axis of fold is tilted, results in alternating V-shaped bands of dipping strata oriented about the fold axis.

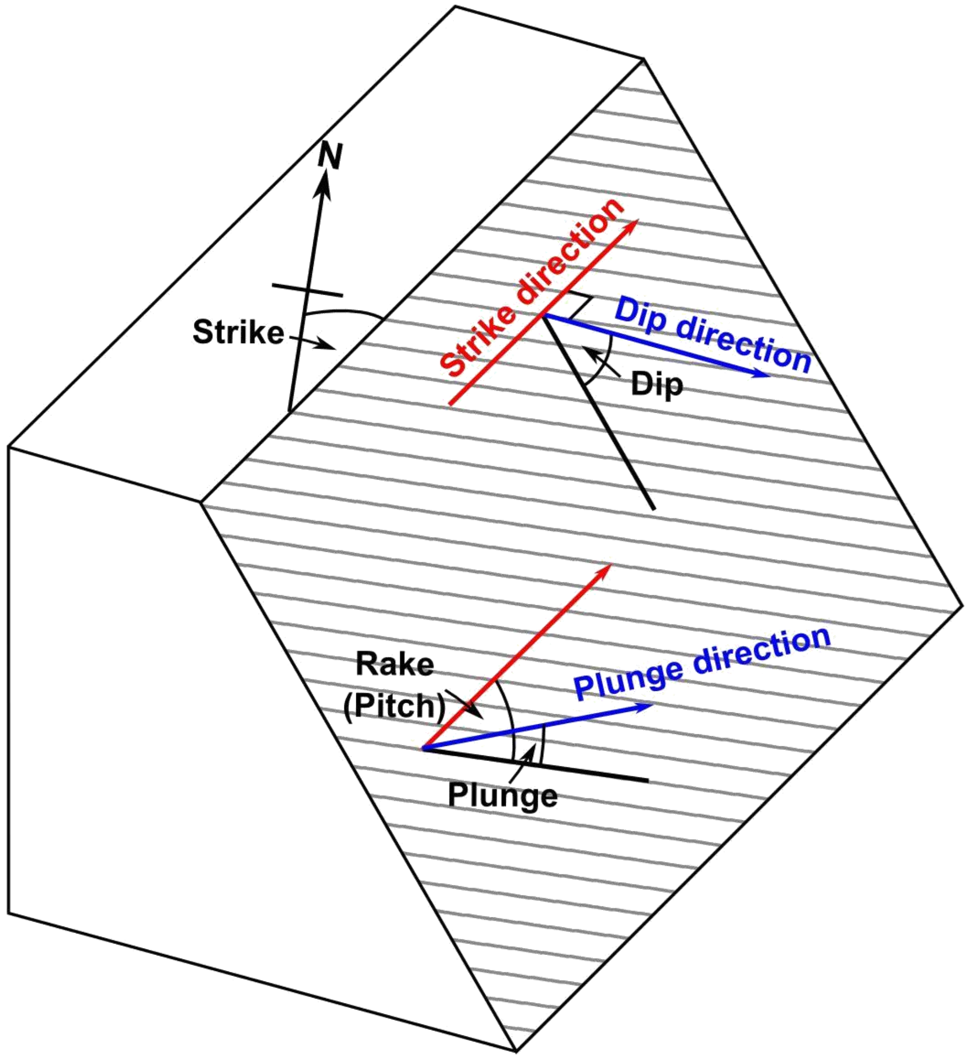
(a) anticlines- oldest strata exposed in the centre of the V, V points in direction of plunge of fold axis

(b) syncline- youngest strata exposed in the centre of the V, V points in opposite direction of plunge of fold axis.

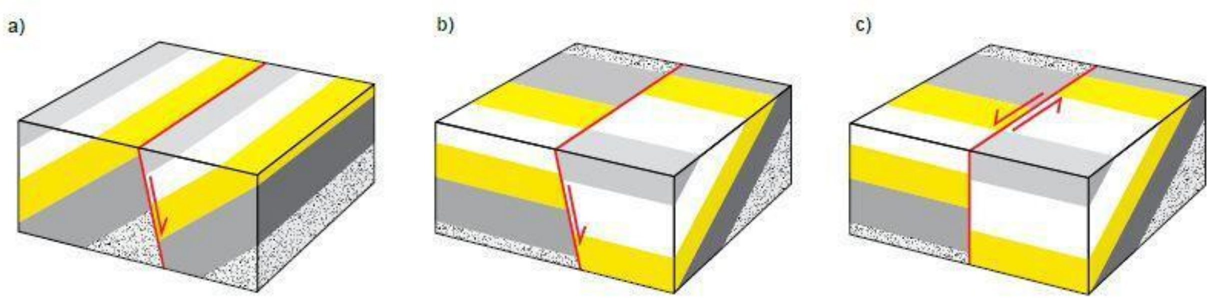
(4) Doubly Plunging Folds- fold axis is plunging in two opposite directions, results in a flattened oval pattern, or a double V-shaped pattern <<<>>>>.

(a) anticlines- oldest strata exposed in centre of flattened oval

(b) synclines-youngest strata exposed in centre of flattened oval.



Faults on maps:-Faults can occur at any angle with respect to bedding and so the outcrop patterns produced are not unique to any one fault type. Figure **a** and **b** show two potential outcrop patterns for a normal fault.



Fold on maps:- Figure shows the different outcrop patterns for folds. The limbs of the folds form a repeating pattern on either side of the axial plane. For anticlines, the oldest rocks are in core of the fold and the rocks get younger away from the axial trace (figure a). For synclines, the youngest rocks are in the core and the rocks get older away from the axial trace (figure b).

Plunging folds form the same repeating pattern as non-plunging folds, except their limbs converge around the axial traces. The limbs of synclines open in the direction they plunge (figure c); whilst the limbs of anticlines close in the direction they plunge (figure d).

EXPERIMENT NO. CE(ES)493/7

Name: Interpretation of geological maps :horizontal , vertical, uniclinal, folded and faulted structures

Geological Map

A map is described as representation of an area on a plain paper to a scale. The geological map is one which reveals the geological information in terms of topography, lithology, and geological structure, order of superposition, thickness of beds and geological history of that region. A geological map is a contour map over which geological formations, structures etc are marked.

Civil Engineering Importance

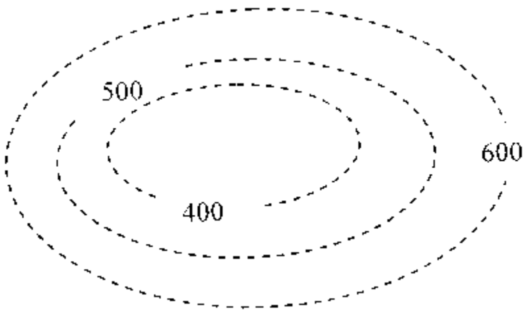
For safe, stable, successful and economical Civil Engineering constructions such as dams, reservoirs, tunnels, etc., detailed geological information is essential. Proper interpretation of a geological map provides all details which a Civil Engineer requires. This study of geological maps is of great importance. **Aim** The purpose of interpretation of the following maps is not to tackle any specific Civil Engineering project but to equip with all necessary geological information, so as to enable the concerned to utilize the same as the required by the context.

Interpretation

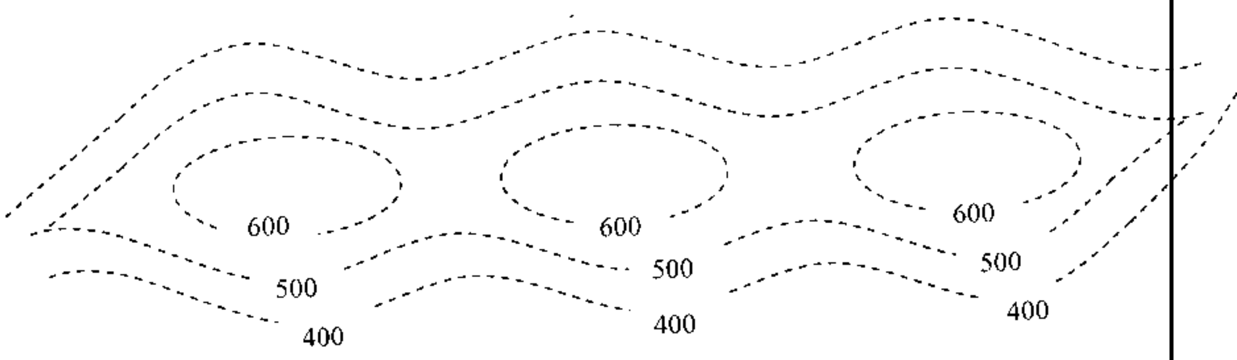
In a geological map, normally contours are marked as dotted lines with elevation value and bedding planes, fault planes etc are marked as continuous lines. The interpretation comprises of details of topography, lithology, structure and geological history. 57

Interpretation of Topography From the study of contour the information noted is about 1. Maximum height, Minimum height, Surface relief 2. Number of Hills, Valleys, ridges, etc 3. Nature of slope, whether it is uniform or irregular and steep or gentle Relevant details

1. **Hills or Hill ranges**
   - Closed contour with contour values increasing inwards
   - Repeated appearance of the same in a row is Hill Range
   - Contours also indicate shape of Hills



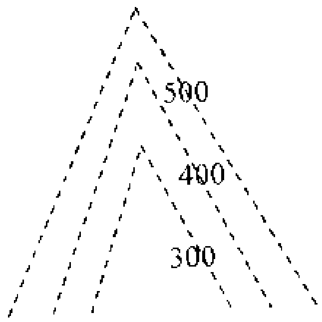
Hill

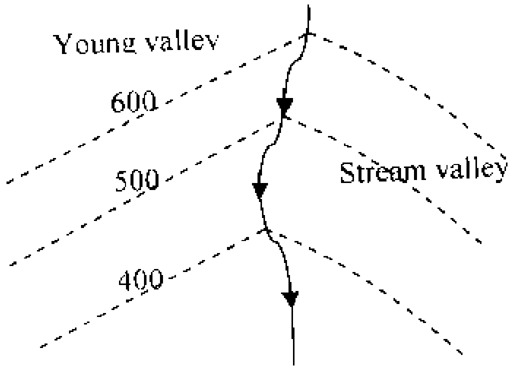


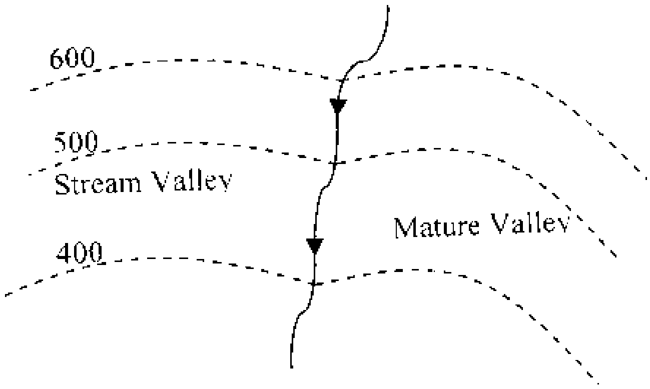
Hill Range

3(a) Maximum height is the elevation which is more than the highest contour marked in the map.
(b) Minimum height is the elevation which is less than the lowest contour marked in the map.
(c) Surface relief is the difference between the maximum height and the minimum height.

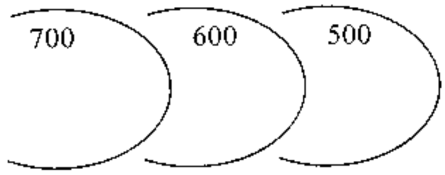
4(a) **Valleys**: These are a series of V shaped (sharply bent) contours with successively higher elevation towards the pointed ends (convex side) of the contours.
- The sharpness of bends indicates the stage of valley development
- Young valleys have sharply contours but mature valleys have bluntly curve contours


500
400
300


Young valley
600
500
Stream valley
400

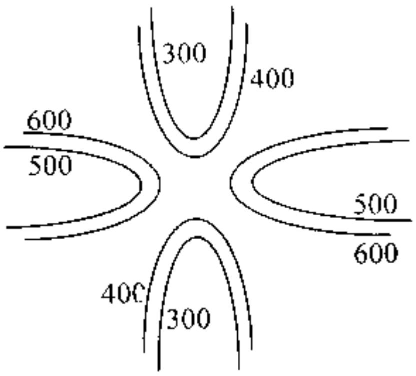

600
500
Stream Valley
Mature Valley
400

(b) Ridges: These resemble valleys but in these towards the convex side of the contours, successively lower elevations appear.



Ridges

(c) Saddle like structures:



Saddle like structure

EXPERIMENT NO. CE(ES)493/8

Name: Microscopic Study of Rocks and Minerals

A rock is defined as an aggregate of minerals. It is also described as unit of earth's crust. Based on their origin, geologically rocks are classified into igneous rocks, Sedimentary rocks, metamorphic rocks.

Igneous rocks:

These are characterized by vesicular structure, amygdaloidal structure and Aphanitic structure if they are volcanic. If they are Hypabyssal or plutonic, they are dense, compact and exhibit interlocking texture.

Sedimentary rocks:

Occurrence of normal or cross bedding, cementing material, fossils, ripple marks, mud cracks, tracks and trails and peculiar forms such as modular, concretionary, pisolitic, Oolitic, etc indicate that the rocks under study of sedimentary rocks.

Metamorphic rocks:

Occurrence of alignment of minerals (lineation, foliation) and metamorphic minerals indicate the rocks under the study of metamorphic group.

IGNEOUS ROCKS

Terminology related for the description of igneous rocks

1. Texture

Phaneric	If minerals are visible to naked eye by virtue of their size.
Aphanitic	If minerals are too fine to be seen by naked eye.
Phaneric coarse	If minerals are greater than 5mm in size.
Phaneric medium	If minerals are 2mm to 5mm in size.
Phaneric tine	If minerals are less than 2mm in size.
Equigranular	If minerals are nearly of same size.
Inequigranular	If some minerals are distinctly larger than others.
Porphyritic	If larger minerals are surrounded by smaller minerals.
Interlocking	If minerals are closely interlinked and cannot be separate without damaging surrounding minerals.
Graphic	If angular quartz grains occur with some orientation in feldspars.

2. Colour

Leucocratic	If the rock looks pale coloured or white coloured, it indicates that the rock may be acidic.
Melanocratic	If the rock looks dark coloured or black coloured, it indicates that the rock may be basic or ultra basic.
Mesocratic	If the rock is neither dark coloured nor pale coloured.

3. Structure

Vesicular	If the rock is having empty cavities
Amygdaloidal	If the rock has cavities filled with amygdales

4. Minerals

Primary	If the minerals are present from the beginning of formation of rock.
Secondary	If the minerals are present after the formation of rock.
Essential	If they are major constituents and decide the name of the rock.
Accessory	If they occur in small quantities and their presence or absence has nothing to do in naming a rock.

5. Silica Saturation

Oversaturated	If a rock has free quartz.
Under saturated	If a rock has unsaturated minerals like Olivine.
Saturated	If a rock has neither free quartz nor unsaturated minerals.

6. Depth of Formation

Plutonic/Hypabyssal	If a rock is Phaneric and has interlocking texture.
Volcanic	If a rock is vesicular or amygdaloidal and Aphanitic.

SEDIMENTARY ROCKS

Details relevant for the study of sedimentary rocks

J. Bedding or stratification

Different beds can be recognized based on colour, grain size, texture, hardness and other physical properties.

In case of cross bedding sets of layers will not be parallel but mutually inclined.

K. Cementing Material

Calcareous	It imparts white colour and pale colour to sand stones and can be known by acid test.
Feriginous	Imparts shades of brown, red, or yellow colour to sand Stone
Argillaceous	It provides only weak cohesion for sand particles, which fall of rubbing the sand stone
Siliceous	Resembles calcareous cementing material but provides competence and durability to sand stone.
Glaucontic	It provides green colour to sand stone.

3. Fossils

May be plant (leaf) fossils or shells (complete or broken) - common in shales and lime stones.

4. Ripple Marks

Rare, may appear in sandstones, shales and lime stones. These appear as ware undulations on rock surface.

5. Peculiar forms

Concretionary, nodular	Laterites, Lime stones
Pisolotic	Lime stones, Laterites
Oolitic	Lime stones
Solution cavities	Lime stones
Lamination	Shales

6. Flaggy

Tendency to break in to slab, due to parallel fractures. Sometimes these are noticed in lime stones and sand stones.

7. Fissility

Tendency to split along bedding planes. Some shale has this character.

8. Conchoidal fracture

In dense compact Lime stones, less distinctly in shales

9. Composition

Argillaceous	Shales
Arinaceous	Sand stones
Calcareous	Lime stones

10. Grain Size

Too fine to be seen as separate particles in shales and lime stones.

11. Surface touch

Gritty or rough in sand stones, smooth in shales and lime stones.

12. Appearance

Panels of colours for laterites, dense very fine grained for lime stone.

METAMORPHIC ROCKS

Details relevant for the study of metamorphic rocks

1. Foliation

It refers to the parallel alignment of platy or lamellar minerals in metamorphic rocks.

2. Lineation

It refers to the parallel alignment of prismatic or columnar minerals in metamorphic rocks.

3. Metamorphic minerals

Minerals like garnet, tale, chlorite, graphite are suggestive of metamorphic origin of a rock.

4. Gneissosse structure

It is generally observed in granite gneisses where in alternating black (bornblende) and white (feldspars and quartz) colour bands appear.

5. Schistose structure

They have predominantly lamellar (mica, tale, chlorite) or prismatic (bornblende, Kyanite, etc) minerals.
These do not have any alternating colour bands.

LABORATORY INSTRUCTION MANUAL

Quantity Survey Estimation and Valuation Sessional

CE(PC)695

DEPARTMENT OF CIVIL ENGINEERING

SILIGURI INSTITUTE OF TECHNOLOGY

SILIGURI INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

QUANTITY SURVEY ESTIMATION AND VALUATION SESSIONAL CODE:(CE(PC)-695)

CONTACT : 3P

CREDIT :2

LIST OF EXPERIMENTS

EXPERIMENT NO	EXPERIMENT NAME
CE(PC)695/1	**Quantity Surveying**: Types of estimates, approximate estimates, items of work, unit of measurement, unit rate of payment.
CE(PC)695/2	**Quantity estimate of a single storied building**
CE(PC)695/3	**Bar bending schedule.** Details of measurement and calculation of quantities with cost, bill of quantities, abstract of quantities.
CE(PC)695/4	**Estimate of quantities** of a) road, b) Underground reservoir, c) Surface drain, d) Septic tank
CE(PC)695/5	**Analysis and schedule of rates**: a) Earthwork, b) brick flat soling, c) DPC, d) PCC and RCC, e) brick work, f) plastering, g) flooring and finishing,
CE(PC)695/6	**Specification of materials**: Brick, cement, fine and coarse aggregates
CE(PC)695/7	**Specification of works**: Plain cement concrete, reinforced cement concrete, first class brickwork, cement plastering, pointing, white washing, colour washing, distempering, lime punning, painting and varnishing
CE(PC)695/8	**Valuation**: Values and cost, gross income, outgoing, net income, scrap value, salvage value, market value, Book Value, sinking fund, capitalised value, Y. P., depreciation, obsolescence, deferred income, freehold and leasehold property, mortgage, rent fixation, valuation table .

EXPERIMENT NO : CE(PC)695/1

Definition of estimate:- An estimate is the probable cost of work and is usually prepared before the construction is taken up. It is indeed calculations or computation of various items of an engineering work, so as to know its approximate cost or expenses likely to be incurred, the quantities of the various materials required, the labour involved for its construction and satisfactory completion. The estimate also gives an idea of the time required for its completion.

However the actual cost is known only after the completion of the work for the accounts of the completed work. An estimate for any public construction work is required to be prepared and submitted so that sanction of necessary funds may be obtained from the concerned authority.

To prepare an estimate, detailed drawing i.e., drawing consisting of plan, the elevation and the sections through important points and detailed specification of all workmanship, properties and proportion of materials are required.

Types of estimates :-

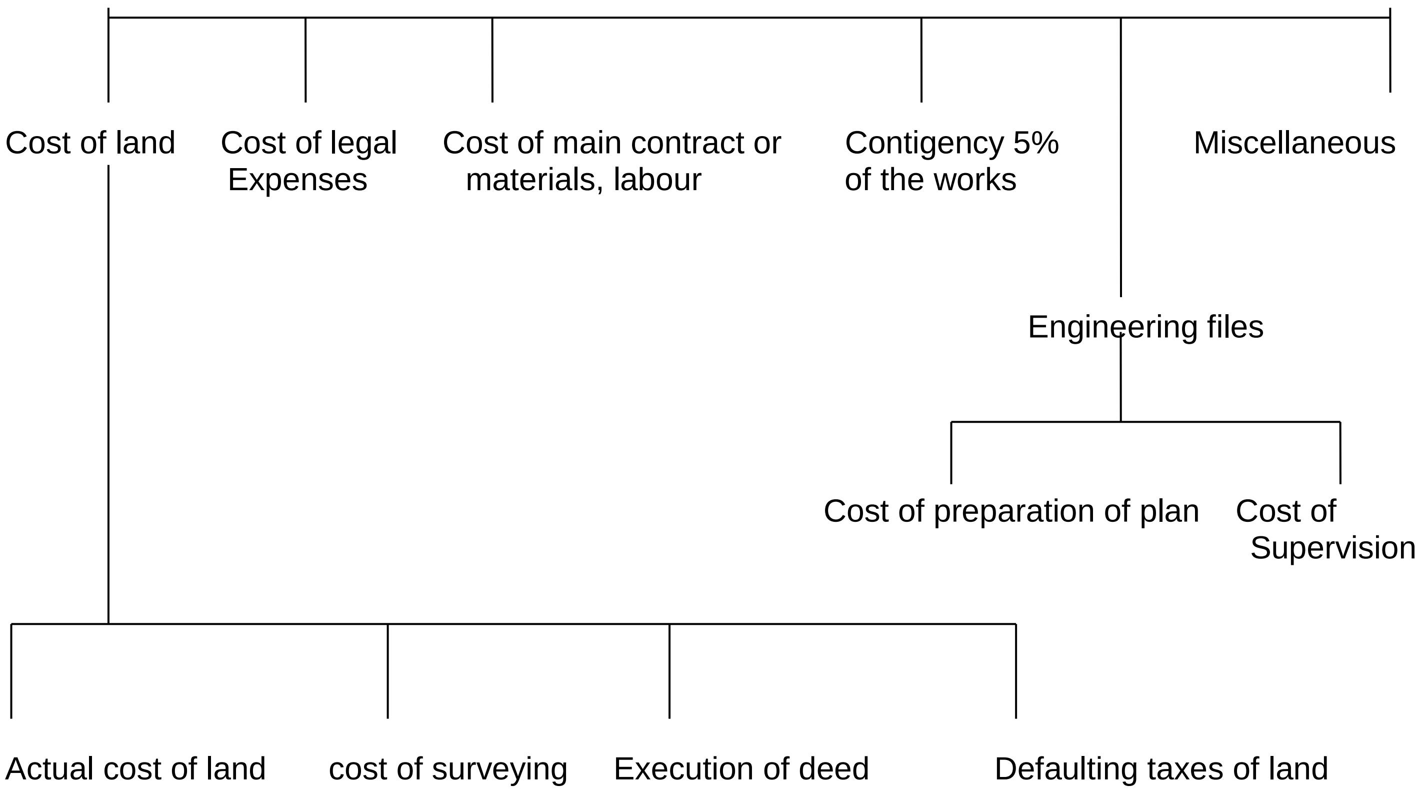
1. **Preliminary or rough cost or approximate estimate:-**
   This is an estimate to find out an approximate cost in short time. Such an estimate is prepared to decide the financial aspect and policy matter, giving an idea of the cost of the proposal after taking into consideration the requirements of the department concerned.
   a) Plinth area or sq.mt. method
   b) Cubic rate or cubic mt. method

2. **Quantity estimate:-**
   This is a complete estimate or list of quantities for all items of work required to complete the concerned project.
3. **Detailed estimate:-**
   Detailed estimate consist of the detailed particulars for the quantities, rates and costs of all items involved for satisfactory completion of a project. This estimate is the best and most accurate that can be prepared.
4. **Revised estimate:-**
   A revised estimate is a detailed estimate for the revised quantities and rates of items of work originally provided in the estimate without material deviations of a structural nature from the design originally approved for a project. A revised estimate is prepared and submitted for fresh technical sanction

5. **A Supplementary Estimate:-**
   While a work is in progress, some charges or additional works due to material deviation ofa structural nature from the design originally approved may be thought necessary for the development of a project

6. **Annual Maintenance or Repair Estimate:-**
   In order to keep the structures and roads etc in proper condition, annual repairs are carried out annually for which an estimate is prepared.

7. **Complete estimate:-**



Approximate Estimates:-

Aim : Estimating cost of building on plinth area method.

Requirement: Given the details of building works and there rates.

Procedure:

1. Find out the total area of building (including walls ,verandah ,corridors ,etc.)
2. Find out the total area and cost.
3. Find out other costs (water supply ,electricity ,special services).
4. Find grand total.

Calculation and formula:

1. Total area/plinth area =carpet area +corridor +stair +walls +etc.

Result: Total cost of building is………………

Aim : Estimating cost of building on volumetric area method.

Requirement: given the details of building works and there rates.

Procedure:

1. Find out the total area of building (including walls ,verandah ,corridors ,etc.)
2. Find out the total volume of building
3. Find out the total area and cost.
4. Find out other costs (water supply ,electricity ,special services).
5. Find grand total.

Calculation and formula:

1. Total area/plinth area=carpet area +corridor +stair +walls +etc.
2. Height = ½ of depth of foundation+G.L. to P.L. lev ht+(Floor to floor to ht x no. of floors)+Parapet ht.
3. Volume = Area x Ht.

Precaution:

1. All units of item of works are correct.
2. Calculation should be done carefully.

Result: Total cost of building is………………

Items of Work, Unit of Measurement, Unit Rate of Payment.

Sl. No.	Item of work	Unit of measurement	Unit rate
Earth work:			
1.	Earth work in excavation	Cu.m.	Per % cu.m
2.	Earth work in filling 9with sand or loose earth) in foundation trenches or plinth	Cu.m.	Per % cu.m
Brick work:			
3.	Brick work of one or more than one brick wall	Cu.m.	Per cu.m
4.	Brick work of half brick wall	sq.m.	Per sq.m
5.	Brick flat solling	sq.m.	Per sq.m
Concrete work:			
6.	Cement concrete in foundation	Cu.m.	Per cu.m
7.	Reinforced cement concrete (R.C.C)	Cu.m.	Per cu.m
8.	Reinforcement	Quintal	Per Quintal
9.	Damp proof course (D.P.C)	sq.m.	Per sq.m
10.	Form work	sq.m.	Per sq.m
Flooring:			
10.	Artificial Stone flooring	sq.m.	Per sq.m
11.	Mosaic/ Stone slab/ Ceramic flooring	sq.m.	Per sq.m
Wood Work:			
12.	Door and window shutter of different types	sq.m.	Per sq.m
13.	Wood work for door and window frames	Cu.m.	Per cu.m
14.	Shuttering , centering	sq.m.	Per sq.m
Steel work and iron work			
15.	Collapsible gate	sq.m.	Per sq.m
16.	Steel rolling shutters, grills	sq.m.	Per sq.m

17.	Steel doors and windows	sq.m.	Per sq.m
Finishing			
18.	Plastering with cement mortar or pointing to brick work.	sq.m.	Per sq.m
19.	White washing, colour washing, Distempering	sq.m.	Per sq.m
20.	Painting work in doors, windows	sq.m.	Per sq.m

EXPERIMENT NO : CE(PC)695/2a

NAME : Quantity estimate of a single storied building

AIM :
Preparation of detailed estimate of building (using long wall and short wall method).

Requirement:
given plan and section of building find out the length of long wall and length of short wall etc.

Procedure:

1. Longer walls in a building are considered as long walls and measured from out to out.
2. Shorter walls in a building are considered as short wall and measured from in to in.
3. These lengths of long wall and short wall are multiplied separately by the breath and height of the corresponding layer and added to get quantity and it changes according to area.
4. Find length of long and short wall.
5. First calculate centre to centre lengths individually from the plan.

Calculation:

1. Length of long wall=parallel to x-axis=(c/c distance +width of Item).
2. Length of short wall=parallel to y-axis=(c/c distance-width of item).

Precaution:

1. All units of item of works are correct.
2. Calculation should be done carefully.

Result: Total quantity of all item of work is……………….

EXPERIMENT NO : CE(PC)695/2b

AIM :
Preparation of detailed estimate of building (using center line method).

Requirement:
given plan and section of building find out the length of long wall and length of short wall etc.

Procedure:
1. In this method total length of wall is equal to sum of c/L length of long wall and c/L length of short wall.
2. These total length of walls are multiplied by the breath and height of the corresponding layer and added to get quantity.

Calculation:
Total centre Length of walls = centre length of long wall + centre length of short wall.

Precaution:
3. All units of item of works are correct.
4. Calculation should be done carefully.

Result: Total quantity of all item of work is……………….

Sl. No.	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
1.	Earth Work in excavation of foundation trenches or drain,in all sorts of soil (including mixed soil but excluding laterite or sandstone) including removing,spreading or stacking the spoils Within a laed of 75 m.as directed.The side of trenches, levelling dressing and ramming the bottom,bailing out water as required complete.Depth of excavation not exceeding 1.5 m.	Cum			

2.	Earth work in Filling in foundation trenches or plinth With good earth, in layers not exceeding 150 mm. including watering and ramming etc layer by layer complete.(payment to be made on the basis of measurement of finished quantity of work)With earth obtained from excavation of foundation.	Cum			
3.	Filling in foundation or plinth by silver sand in layers not exceeding 150 mm as directed and consolidating the same by thorough saturation with water, ramming complete including the cost of supply of sand. (Payment to be made on measurement of finished quantity).	Cum			
4.	Single Brick Flat Soling of picked jhama brick including ramming and dressing bed to proper level and filling joint With local sand.	Sqm			
5.	Cement Concrete (mix1:2:4) With graded stone chips (20 mm nominal size) excluding shuttering and reinforcement, if any, in ground floors per relevant IS codes.b) Rever bazree	Cum			
6.	Controlled Cement concrete with well graded stone chips (20 mm graded nominal size) excluding shuttering and reinforcement with complete design of concrete as per IS : 456 and relevant special publications, submission of job mix formula after preliminary mix design after testing of concrete cubes as per direction of Engineer-in charge. Consumption of cement will not be less than 300 Kg of cement with Super plasticiser per cubic meter of controlled concrete but actual consumption will be determined on the basis of preliminary test and job mix formula. [using concrete mixture] In ground floor and foundation. (a) M 20 Grade N.B. Variety (Stone Metal)	Cum			
7.	Controlled Cement concrete with well graded stone chips (20 mm nominal size) excluding shuttering and reinforcement with complete design of concrete as per IS :456 and relevant special publications, submission of job mix formula after preliminary mix design after testing of concrete cubes as per direction of Engineer-in charge. Consumption of cement will not be less than 300 Kg of cement with Super plasticiser per cubic meter of controlled concrete but actual consumption will be determined on the basis of preliminary test and job mix formula. [using concrete mixture] In ground floor and foundation.	Cum			

	(b) M 25 Grade N.B. Variety (Stone Metal)				
8.	Reinforcement for rein Concrete Work in all sorts of structures including distribution bars, stirrups, Binders etc initial straightening and removal of loose rust(if necessary),cutting to requisite length, hooking and bending to correct shape, placing in proper position and binding With, Complete as per drawing and direction. (a)For Works in foundation, basement and up to roof Tor Steel/Mild Steel	MT			
9.	Hire and labour charges for shuttering With Centering and necessary staging up to 4 m using approved stout props and thick hard Wood planks of approved thickness With required bracing for concrete slabs, beams and columns, lintels curved or Straight including fitting, fixing and striking out after completion of Works (up to roof of ground floor)(When the height of a particular floor is more then 4 m the equivalent floor height shall be taken as 4 m and extra for Works beyond the initial 4 mt. shall allowed under 12 (e) for every 4 m or part thereof)25 mm to 30 mm thick Wooden shuttering as per decision	Sqm			
10	125 mm thick brick Work With 1st Class bricks in cement mortar (1:4) in ground floor	Sqm			
11	Brick work with 1st class bricks in cement mortar (1:4)				
	i) in foundation and plinth	Cum			
	ii) in Superstructure, ground floor	Cum			
12	25 mm thick damp proof course With cement concrete With stone chips (1:1.5:3) With graded stone aggregate 10mm nominal size) and admixture of water proofing compound as per manufacturers specification followed by two coat of polymer based paint,(1st coat after 4 to 5 day of concrete laying and 2nd coat just before brick masonry Work)as directed (Cost of water proofing compound & polymer based paint to be paid separately)(chequering not required over concrete or painted surface).[Note :-Waterproofing as per item No 60,Polymer based paint as per item 59 (a) of Section(c)	Sqm			

13	Net cement punning about 1.5 mm. Thick in Wall, dado,Window,Sill,floor,drain etc. NOTE : Cement 0.152 cu.m. per 100 sq.m.	Sqm			
14	Plaster(to wall, floor,ceiling etc)With sand and cement mortar including rounding off or chamfering corners as directed and raking out joint including throating, nosing and drip course, Scaffolding/Staging Where necessary(Ground floor).[Excluding cost of chipping over concrete surface]i) With 1:6 cement mortar				
	20 mm thick plaster	Sqm			
	15 mm thick plaster	Sqm			
	10 mm thick plaster	Sqm			
15	Applying Interior grade Acrylic Primer of approved quality and brand on plastered or cencrete surface old or new surface to receive Distemper/ Acrylic emulsion paint including scraping and preparing the surface throughly, complete as per manufacturer's specification and as per direction of the EIC. Water based interior grade Acrylic Primer	Sqm			
16	Applying Plastic Emulsion Paint of approved make and brand on walls and ceiling including sand papering in intermediate coats (to be done under specific instruction of Superintending Engineer) : (Two coats)Luxury Quality	Sqm			
17	Wood work in door and window frame with rebate cutting, fitted and fixed in position complete including a protective coat of painting at the contact surface of the frame excluding cost of concrete, Iron Butt Hinges and M.S clamps. (The quantum should be correted up to three decimals) Sal : Siliguri.	Cum			
18	Supplying, fitting and fixing M.S. clamps for door and window frame made of flat bent bar, end bifurcated with necessary screws etc. by cement concrete(1:2:4) as per direction. (Cost of concrete will be paid separately)(a) 40mm X 6mm, 250mm Length	Each			
19	Supplying solid flush type doors of commercial quality, the timber frame consisting of top and bottom rails and side styles of well seasoned timber 65mm wide each and the entire frame fitted with 37.5mm wide battens places both ways in order to make the door of solid core and internal lipping with Garjan or similar wood veneers using phenol formaldehyde as glue etc. complete, including fitting, fixing shutters in position but excluding the cost of hinges and other fittings in ground floor.35 mm thick shutters (single leaf)	Sqm			

20	Supplying fitting, fixing decorative lamination conform ingto IS: 2046 : 1995 as per approved make, brand, finish and thickness with fitting, fixing the same on Particle/MDF / Ply Boards with recommended / approved adhesive with proper clipping the sides for better attachment as per direction of Engineer-in-charge.The rate includes the cost of labour, adhesive and all incidental charges thereof. Glossy/Matt/Suede excluding surface texture or metallic lustre. Thickness of laminate 1.5 mm	Sqm			

NAME : Bar Bending Schedule

EXPERIMENT NO : CE(PC)695/3

AIM :
Estimation of quantity of reinforcement(for beam)

requirement
given the details of reinforcement (for column ,beam ,slab ,etc.).

Procedure:

1. Find out the quantity of bent up bars.
2. Find out the quantity of stirrups.
3. Find out the quantity of hanger/top bars.
4. Find total quantity and rate.

Calculation and formula:

1. Length of straight bar=overall spans +length of hooks.
2. Hook length (for one end) =9 X dia. of bar.
3. Hook length (for both end) =18 X dia. of bar.
4. Total rate =rate of material + rate of labour.

Calculation table:

Bar mkd	Dia in mm	Shape of bending	Length (m)	Add. length(m)	Total length(m)	Weight kg/m	Total weight(kg)

Precaution:

1. All units of item of works are correct.
2. Calculation should be done carefully.

Result: Total rate of steels work is……………….

Estimate of quantities of a) road, b) Underground reservoir,

c) Surface drain, d) Septic tank

EXPERIMENT NO : CE(PC)695/4a

NAME : Estimate of quantities of a) road

AIM :
preparation of approximate estimate for road project.

Requirement
given the details of road work (like GL, natural surface level, gradient, side slopes, change of level, etc.)

Procedure:

1. Find out the cutting area.
2. Find out the filling area.
3. Find out the volume of cutting.
4. Find out the volume of filling.
5. Find out the total volume of cutting and filling.

Calculation table:

SN.	ROAD	DISTANCE(M)	LENGTH(M)	CUT AREA (M2)	MEAN AREA(M2)	CUTTING VOLUME(M3)

Formula used:

1. Area = (p/4)*d
2. Area of trapezoidal section

Precaution:

1. All units of item of works are correct.
2. Calculation should be done carefully.

Result: Total rate of road work is……………….

EXPERIMENT NO : CE(PC)695/4b

NAME: Estimate of quantities of b) Underground reservoir

AIM :
Prepare a quantity estimate of a RESERVOIR from the given drawing

Requirement
given the details of water reservoir

Procedure:

1. In this method total length of wall is equal to sum of c/L length of long wall and c/Llength of short wall.
2. These total length of walls are multiplied by the breath and height of the corresponding layer and added to get quantity.

Calculation table:

Details of Measurement and calculation of quantities

ITEM NO.	PARTICULARS OF ITEMS	UNIT	NOS	LENGTH (M)	BREADTH(M)	HT. OR DEPTH	QUANTITY	EXPLANATORY NOTES

Precaution:
1. All units of item of works are correct.
2. Calculation should be done carefully.

Result: Total rate of reservoir is……………….

EXPERIMENT NO : CE(PC)695/4c

NAME :Estimate of quantities of c) Surface drain

AIM :
Prepare a quantity estimate of a surface drain for 10 mt. length from the given section

Requirement
given the details of Surface drain

Procedure:

1. In this method total length of wall is equal to sum of C/L length of long wall and c/Llength of short wall.
2. These total length of walls are multiplied by the breath and height of the corresponding layer and added to get quantity.

Calculation table:

Details of Measurement and calculation of quantities:-

ITEM NO.	PARTICULARS OF ITEMS	UNIT	NOS	LENGTH (M)	BREADTH(M)	HT. OR DEPTH	QUANTITY	EXPLANATORY NOTES

Precaution:
1. All units of item of works are correct.
2. Calculation should be done carefully.

Result: Total rate of surface drain is……………….

EXPERIMENT NO : CE(PC)695/4d

NAME : Estimate of quantities of d) Septic Tank

AIM :
Prepare a quantity estimate of a septic tank for 25 users from the given drawing.

Requirement
given the details of Septic Tank

Procedure:

1. In this method total length of wall is equal to sum of c/L length of long wall and c/L length of short wall.
2. These total length of walls are multiplied by the breath and height of the corresponding layer and added to get quantity.

Calculation table:

Details of Measurement and calculation of quantities

ITEM NO.	PARTICULARS OF ITEMS	UNIT	NOS	LENGTH (M)	BREADTH(M)	HT. OR DEPTH	QUANTITY	EXPLANATORY NOTES

Precaution:
1. All units of item of works are correct.
2. Calculation should be done carefully.

Result: Total rate of Septic Tank is……………….

NAME : Analysis and schedule of rates: a) Earthwork, b) brick flat soling, c) DPC, d) PCC and RCC, e) brick work, f) plastering, g) flooring and finishing

EXPERIMENT NO : CE(PC)695/5

AIM :
analysis of rate

Requirement

1. Materials Rate, 2. Labour wages, 3. Cost of Tools and Plants 4. Profit and overhead charges

consider 10 m^3

Particulars	Quantity	Rate		Amount	
		Rs.	P	Rs.	P.
a) Materials					
b) Labour					
c) Water Charges					
d) Tools & Plants					
e) Profit and overhead					

Total

Rate for 10 m^3 ………………………
Rate for 1 m^3 ………………………

EXPERIMENT NO : CE(PC)695/6

AIM :
Specifications of Materials

Requirement
Details Specification of materials

BRICK :-

Bricks Shall be first class made from good brick free from saline deposits and shall be sand molded thoroughly burnt without being vitrified, of good colour, shall be regular and uniform in shape & size with sharp and square arises and parallel faces. Emits a clear ringing sound when struck, shall be free from flaws, cracks etc. should not absorb more than 20% of water by weight after being soaked in water for 24 hours.

CEMENT :-

Cement shall be Portland cement of the Indian standard Specifications as perIS: 269. All cement shall be brought to the site of work in bags with the seals in tack. Fresh and from moisture. All cement shall be gauged by weight and shall be added at the mixture in whole 50kg.bags.

COARSE AGGREGATE :-

(I) 65mm, Nominal size: For unreinforced mass concrete word on ordinary work.

(II) 40mm, Nominal size: For unreinforced mass work of cement concrete on small jobs over 15 cm minimum dimensions. For reinforced works, it shall be used where the dimension of members exceed 45cm.

(III) 20mm Nominal size: Unless otherwise mentioned, if will be used as under-
(a) Unreinforced cement concrete work between 5cm minimum size.
(b) Conglomerate floor.
(c) R.C.C. works exceeding 12cm but not exceeding 45cm in minimum dimension.

(iv) 15mm Nominal size. Unless otherwise mentioned and specified, this aggregate shall be used in cement concrete works of the following description.

(a) R.C.C. lintels and slabs under12cm and more than 5cm.

(b) R.C.C. posts and battens less than 40cm sectional area.

FINE AGGREGATE :-

Fine Aggregate (Sand) It shall consist of clean, hard, uncoated grains of natural sand or crushed stone sand rushed gravel sand or combination of any of these free clay, loam, silt, organic or other deleterious substances.

EXPERIMENT NO : CE(PC)695/7

AIM :
Specifications of Works

Requirement
Details Specification of works

a) CEMENT CONCRETE

- Ingredients Cement, sand, brick or stone aggregate, gravel or shingle and water
- **Cement** :-Cement shall be Portland cement of the Indian standard Specifications as perIS: 269. All cement shall be brought to the site of work in bags with the seals in tack. Fresh and from moisture. All cement shall be gauged by weight and shall be added at the mixture in whole 50kg.bags.
- Fine Aggregate (Sand):- It shall consist of clean, hard, uncoated grains of natural sand or crushed stone sand rushed gravel sand or combination of any of these free clay, loam, silt, organic or other deleterious substances.
- **COURSE AGGREGATE:-** Coarse aggregate (bajri or grit) shall consist of good hard tough and clear water worn bajri obtained from natural streams. The girl shall be free from dirt, clay, leaves or other organic matter and soft or decayed stone and shall be of the gauge specified according to the nature of the work.
- **WATER**:- Water used in construction shall be clean, free from earthly, vegetable or organic impurities: like alkalis, salts etc. which cause efflorescence and affect setting time of mortar.
- **MIXING (CEMENT CONCRETE:-** In all proportions of cement concrete except 1:1 ½:3, 1:2:4 and 1:3:6, the measured quantity of cement is to be placed on top of the measured quantity of the aggregate (fine and coarse) and the whole mass mixed three or four times so that it shall be thoroughly incorporated. The required quantity of water (clean, rather drinking water) shall then be added and the entire wet mass shall be turned over unto the homogeneous mixture of the required consistency is obtained.
- **LAYING AND CONNSOLIDATION OF CEMENT CONCRETE IN FOUNDATIONS:-** Concrete shall be handed from the mixing platform to the place of final deposit as rapidly as possible. It shall be laid slowly and gently in layers of 15cm (not thrown from a height) and thoroughly consolidated with 5.5 kg. Rammers.
- **FARMA OR BATCH BOX :-**The design of the farma 15” x 15” x 9 x 5”/8 = 1.25 cft. Or 38cm x 38 cm x 25cm = .036m

B) BRICK WORK

Brick work consists of first class bricks laid in the mortar specified.

BRICK WORK IN CEMENT MORTAR.

Bricks

Shall be first class made from good brick free from saline deposits and shall be sand molded thoroughly burnt without being vitrified, of good colour, shall be regular

and uniform in shape & size with sharp and square arises and parallel faces. Emits a clear ringing sound when struck, shall be free from flaws, cracks etc. should not absorb more than 20% of water by weight after being soaked in water for 24 hours.

Cement mortar: cement mortar shall consist of mixture of 1:3, 1:5,or1:6 according to the nature of work.

Mixing: cement and sand shall be thoroughly mixed dry and then water is added with a fine rose to make the mortar workable. Mortar to which the water has been added shall be used within 30 minutes of the addition of water.

Joints

The thickness of the joints shall be 6mm and in no case exceeds 10mm. All brick work shall be taken truly plumb, laid in English bond. The thickness of joints shall be regulated so that height of 10 courses when laid with Horizontal joints shall measure one meter in height.

The joints in faces which are to be plastered or pointed should be racked out while the mortar is green i.e not later than 24 hours after the work is done.

Watering:- Walls as they progress shall be kept thoroughly well watered on their faces and tops.

C) REINFORCED CEMENT CONCRETE

The standard mix for reinforced cement concrete is (1:2:4).

In addition to this, round steel bars are embedded to make the structure strong to take up all the tensile stresses.

MIXING

The two ingredients i.e. cement and sand shall be hand mixed dry, three or more times until the mix comes to a uniform colour. The measured quantity of coarse aggregate shall then be added to the mixture and whole mixed dry thoroughly. The required quantity of water shall then be added.

Reinforcement

Round steel bars as far as possible shall be used in preference to square bars. The bars shall be thoroughly cleaned of rust, scale and of coatings that might destroy or reduce bond. The ends of all bars shall be properly hooked and bends shall be made as per drawing and design supplied. In case of joints in reinforcement an overlay of not less than 40 diameters shall be given for tension member.

MIXING CEMENT CONCRETE (1:2:4 OR 1:3:6)

The two ingredients i.e. cement and sand shall be mixed dry, three or more times until the mix comes to a uniform colour. The measured quantity of coarse aggregate shall than be added to the mixture and whole mixed dry thoroughly.
The required quantity of water shall then be added with a rose.

PLACING AND HANDLING THE CONCRETE

Concrete shall be handled from the mixing platform to the final deposit as rapidly as possible. After depositing, the concrete is to be ridded, vibrated, tamped or worked to ensure that no hollow places are left.

FORMS AND CENTRING

Forms wherever required shall be sufficiently rigid and strong to withstand the weight placing and putting of concrete and the movement of labor, material and plant. Forms shall be sufficiently water right to prevent leakage of mortar. Forms shall be supported or fixed by wedges of the load being eased and the forms removed without sock to the work and without hammering.

LAYING

Before depositing the concrete, the reinforcement shall be correctly laid in position and secured against displacement by tying with soft iron wire. The bars shall remain in position 20 mm. above the surface of centering.

CURING

The concrete when laid shall be carefully protected from the extremes of weather and temperature and from unequal or too repaid drying. It shall be thoroughly kept wet for at least 15 days.

EXPERIMENT NO : CE(PC)695/8

NAME : VALUATION

Value: Present day cost of a Engineering structure (Saleable value)

Cost: Original cost of construction.It is used to find out the loss of value of property due to various reasons.
Net Income: Total amount of the income received from a property during the year, without deducting outgoing.

Gross Income : Total amount of the income received form a property during the year, without deducting outgoing.

Out goings:- These are expenses which are incurred on a building so that it may give back revenue. The following are-various outgoings.

(i) Taxes:- These are annual taxes paid by the owner, such as wealth tax, property tax and municipal taxes (varies from 10% to 25% of net income).

(ii) Management:- Upto 10% of the gross revenue is kept aside for this expenses. This includes, chowkidar sweeper etc. this is applicable only for big buildings or apartments

(iii) Repairs:- For this 1 ½ % of the total construction is set aside for annual repairs of the building. These repairs are must to maintain the building. It is also calculated as 10% of the gross income.

(iv) Sinking fund:- This is also taken as outgoings (For details see definition)

(v) Miscellaneous:- This is again suitable for big buildings. Lighting of common place, expenditure of liftman etc. are to be paid by the owner.

(vi) Loss of Rent:- This is also an outgoing in case a building in not fully occupied by the tenants. This has to be deducted from gross income.

(vii) Insurance:- Premium given against fire or for theft policy.

Scrap Value:- If a building is to be dismantled after the period of its utility is over, some amount can be fetched from the sale of old materials. The amount is known as Scrap Value of a building. If varies from 8% to 10% of the cost of construction according to the availability of the material.In case where Wood & Steel are available, the scrap value is more than as R.C.C. structure, as in the latter case, the material has less reuse value.

Salvage Value:- If property after being discarded at the end of the utility period is sold without being broken into pieces, the amount thus realized by sale is known as its Salvage Value.For example, railway sleepers can be re-used as posts and even old iron rails taken out can be used as beams in a roof or sheds of a building.

Market Value:-It is defined as the value which a property can fetch when sold out in open market. This value is variable, depending upon the will to buy or sell.

Book Value:-It is the amount of a property shown in the books, after allowing necessary depreciations year-wise. The book value is independent of market-value.

Book value = Original value – Depreciation

Gradulally reduces year by year

At the end of utility period book value will be same as scrap value

Capitalized value:- It is defined as the amount of money whose annual interest at the highest prevailing rate will be equal to the net income received from the property. To calculate the capitalized value, it is necessary to know highest rate of interest prevailing on such properties and net income form the property.

Sinking Fund:- A fund which is gradually accumulated and aside to reconstruct the property after the expiry of the period of utility is known as sinking Fund. The sinking funds may be found out by taking a sinking fund policy with any insurance company or depositing some amount in the bank. Generally while calculating the sinking fund, life of the building is considered. 90% of cost of construction is used for calculations & 10% is left out as scrap value.

$$\text{The forumulaused to find out theannual sinking fund is } I \; \frac{Si}{(1+i)^n - 1}$$

Where

I = Annual instalment required

N = Number of years required to creat sinking fund.

I = Rate of interest expressed in decimal i.e.5% as.05. S = Amount of sinking fund.

Depreciation :-Loss of property due to Structural detoriaration, Usage, Decay and Obsolescence

Method to calculate depreciation

a) Straight line method (Property loss will be same every year)
   Annual depreciation = (Original cost- scrap value)/ Life of the structure
b) Constant percentage method
   Annual depreciation = 1-(scrap value/ original cost of the structure)$^{1/n}$,
c) Sinking fund method
   Annual depreciation = Annual sinking fund+interest on sinking fund original cost of the structure)$^{1/n}$
d) Quantity Survey Method

Year's Purchase:- Capital sum required to be invested to receive an annuity of Rs. 1.00 at certain rate of interest. Year's Purchase =100/rate of interest

Obsolescence:- The value of property decreases if its style and design are outdated i.e. rooms not properly set, thick walls, poor ventilation etc. the reasons of this is fast changing techniques of construction, design, ideas leading to more comfort etc.

Deferred Income:- The income receivable after a lapse of certain period is termed as deferred income

Free hold Property:- It is the highest form of ownership of land property i.e. the worker (freeholder) is in absolute possession of the property. He is not required to pay any rent. The free holder has the right to do what he likes with his property. He is not required to pay any rent. The freeholder has the right to do what he likes with his property subject to the rules and regulation of Government and Local authorities. The ownership of a free hold land can be said to be for period of indefinite duration and the owner has the right to develop it or to give it in rental basis or to sell or to transfer it and to loose it without the consent of any other person

A leasehold property: The leaseholder is known as lessee and holds the physical possession(under) of the property for the definite period under terms and condition specified in the lease document.

Fixation of rent:

Security of loans or mortgage: When the loans are taken against the security of the property, its valuation is required.

Rent fixation :The rent of building is fixed upon the basis of certain percentage of annual interest on the capital cost and all possible annual expenditure on outgoings.
The capital cost includes the cost of construction of the building, the cost of sanitary and water supply work and the cost of electric installation and alteration if any.
The cost of construction also includes the expenditures on the following: a) raising, levelling and dressing of site b) construction of compound wall, fences and gates c) storm water drainage d) approach roads and other roads within the compound.

In order to determine the rent of a property, valuation is required. Rent is usually fixed on certain percentage of valuation (6% to 10% of the valuation).

LABORATORY INSTRUCTION MANUAL

SURVEYING &GEOMATICS LAB

CE (PC)493

DEPARTMENT OF CIVIL ENGINEERING

SILIGURI INSTITUTE OF TECHNOLOGY

SILIGURI INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

SURVEYING GEOMATICS LAB

CODE:(CE(PC)-493)
CONTACT : 2P
CREDIT :1

LIST OF EXPERIMENTS

EXPERIMENT NO	EXPERIMENT NAME
CE(PC)493/1	**Traverse Survey by Prismatic Compass** : Procedure, Computations and checks on closed traverse Preparation of field book; Plotting the traverse ; Sources of errors.
CE(PC)493/2	**Theodolite Survey**: Closed traverse by transit theodolite; Preparation of field book
CE(PC)493/3	**Differential leveling using Dumpy Level**: Collimation Method ; Rise and fall method ; Field book preparation
CE(PC)493/4	**Total Station Survey** : Traversing; Levelling
CE(PC)493/5	**Visual image interpretation**
CE(PC)493/6	**Satellite image Pre- processing**
CE(PC)493/7	**Digital Image Classification and Accuracy Assessment**
CE(PC)493/8	**Stereoscopic fusion of aerial photographs using mirror stereoscope**

EXPERIMENT NO : CE(PC)493/1

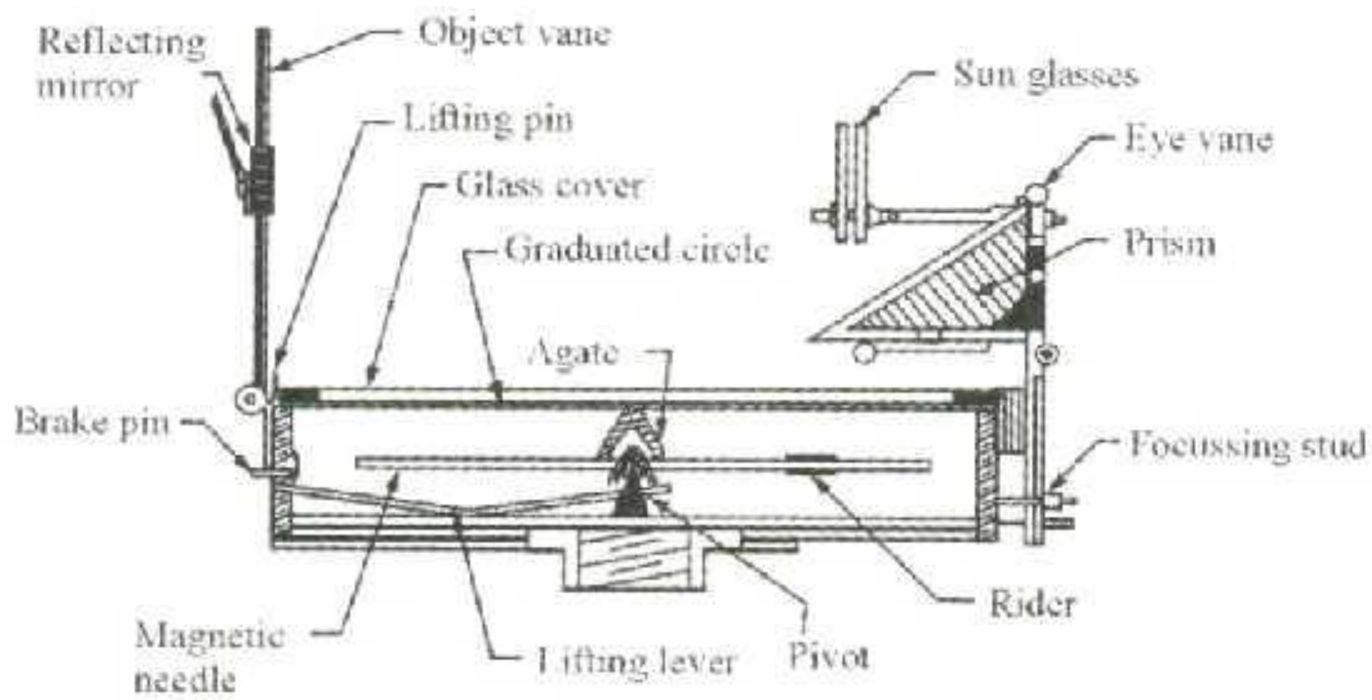
Traverse Survey by Prismatic Compass: Procedure, Computations and checks on closed traverse Preparation of field book; Plotting the traverse ; Sources of errors.

AIM :

To plot the plan of a given area by compass traversing.

APPARATUS USED

Prismatic compass, stand, chain, tape, ranging rods, pegs, plumb bob, hammer, field-book, pencils, eraser.



Principle:

Traverse is the framework of survey lines connecting the control points. A series of control points (stations), each one being intervisible with its adjacent stations are chosen. The survey lines joining the control points are called traverse lines. In this method of traversing linear measurements are taken with either chain or tape and every bearing is observed directly from the magnetic meridian established at each station by the floating needle of prismatic compass. Both fore and back bearings of lines are observed at each station. The offsets necessary to locate the details are taken along the traverse lines in the usual way and recorded in the fieldbook.

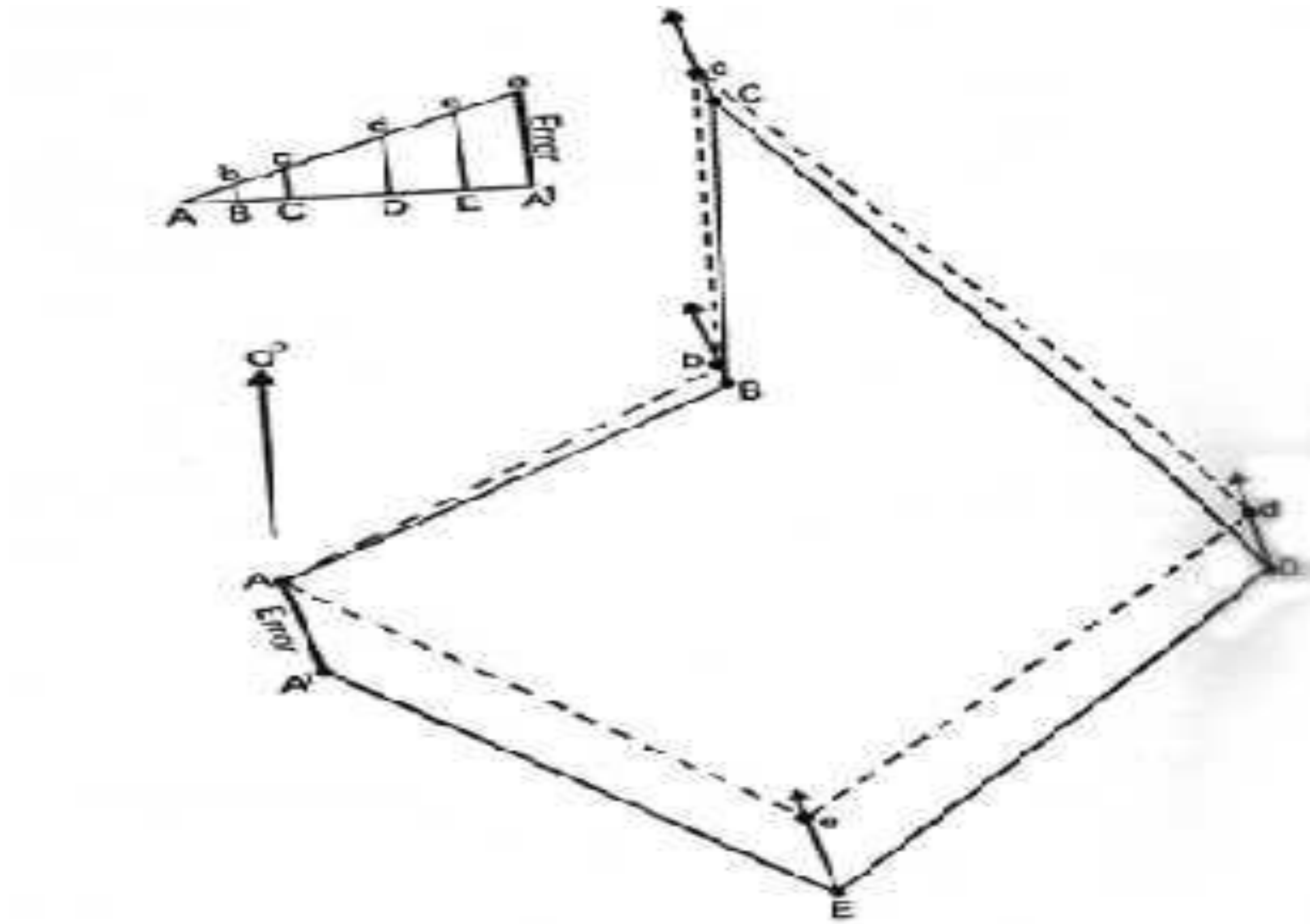
Fieldwork

1. Select the traverse stations *A, B, C, D & E* (say as shown in figure given below) along the boundary of the given area. Traverse stations must be chosen such a way that the preceding and succeeding traverse stations must be visible from any traverse station.
2. Set up the prismatic compass on a tripod over station *'A'* and level it to allow the needle to swing freely.
3. Rotate the case until the back station *E* is sighted and observe the WCB of line *AE* and record it in the table.
4. Rotate the case until the forward station *B* is sighted and observe the WCB of line *AB* and record it in the table.
5. Measure the distance *AB* and record it in the table.
6. Shift the prismatic compass to the forward station *B* and carry out similar measurements and recordings as is done in steps 3, 4 and 5.
7. Similarly complete the work on remaining stations *C, D* and *E*.

Graphical Plot

1. Using the observations recorded in the table obtain the corrected bearings in order to eliminate the local attraction.
2. Draw a line up the drawing sheet to represent the reference direction of the magnetic meridian and mark the starting point *A*.
3. Place the circular protractor with its centre at *A* and zero lined up with the reference direction. Mark on the paper against the protractor edge the corrected bearing of line *AB*.
4. Remove the protractor, draw the direction of the line *AB*, scale the distance and plot the position of *B*.

5. The direction of *BC* is plotted by placing the centre of the protractor at *B* and orienting it by rotating it until its zero direction is parallel to the reference direction as before. This is achieved when the line *BA* cuts the protractor at the corrected bearing of *BA*.
6. Mark the bearing *BC* and plot *C* in the same way as *B* was plotted before.
7. Continue the process for all remaining stations. And thus obtain the figure *ABCDEA'*.
8. The figure *ABCDEA′* as now plotted does not truly represent the actual figure on the ground because the plotted figure gives two positions for *A*, where as only on exist on the ground. This apparent displacement of *A* is due to the build-up of error in surveying and plotting around the traverse. The total error in the figure indicated by the line *AA′* may be distributed back around the figure graphically in the following way:
a) *A′* should be at a and must be moved the distance *AA′* in the direction shown. The effect of this movement will be to move the plotted position of the other points proportionally alon the parallel directions.
b) Draw lines parallel to the direction of the closing error through the other plotted points.
c) Draw a straight line and scale off the lengths of the traverse legs along it. The scale of this construction need not be the same as for the original traverse plot and is more conveniently drawn to a smaller scale.
d) Erect perpendiculars at each point along the line. Pick off the length of the closing error on the plot with a pair of dividers and mark it on the perpendicular erected at *A*'. Join *aA*
e) The intersection of *aA* with the perpendiculars indicates the extent of adjustment needed for each station, illustrating also the proportional build-up or error from nothing at *A* to the maximum amount of *A′*.
f) The amount of error at *E*, being *eE*, is picked off the diagram and transferred to the line drawn through *E* on the plot parallel to the closing error, giving the adjusted position *e*. The other errors at each station are transferred to the plot in the same way.
g) Join up the positions of the adjusted points giving the figure *AbcdeA*, which now forms the graphically adjusted traverse. This figure represents more closely the actual layout on the ground than the original plot did prior to adjustment.



Closed traverse – compass survey

Observations and Calculations:

TABLE

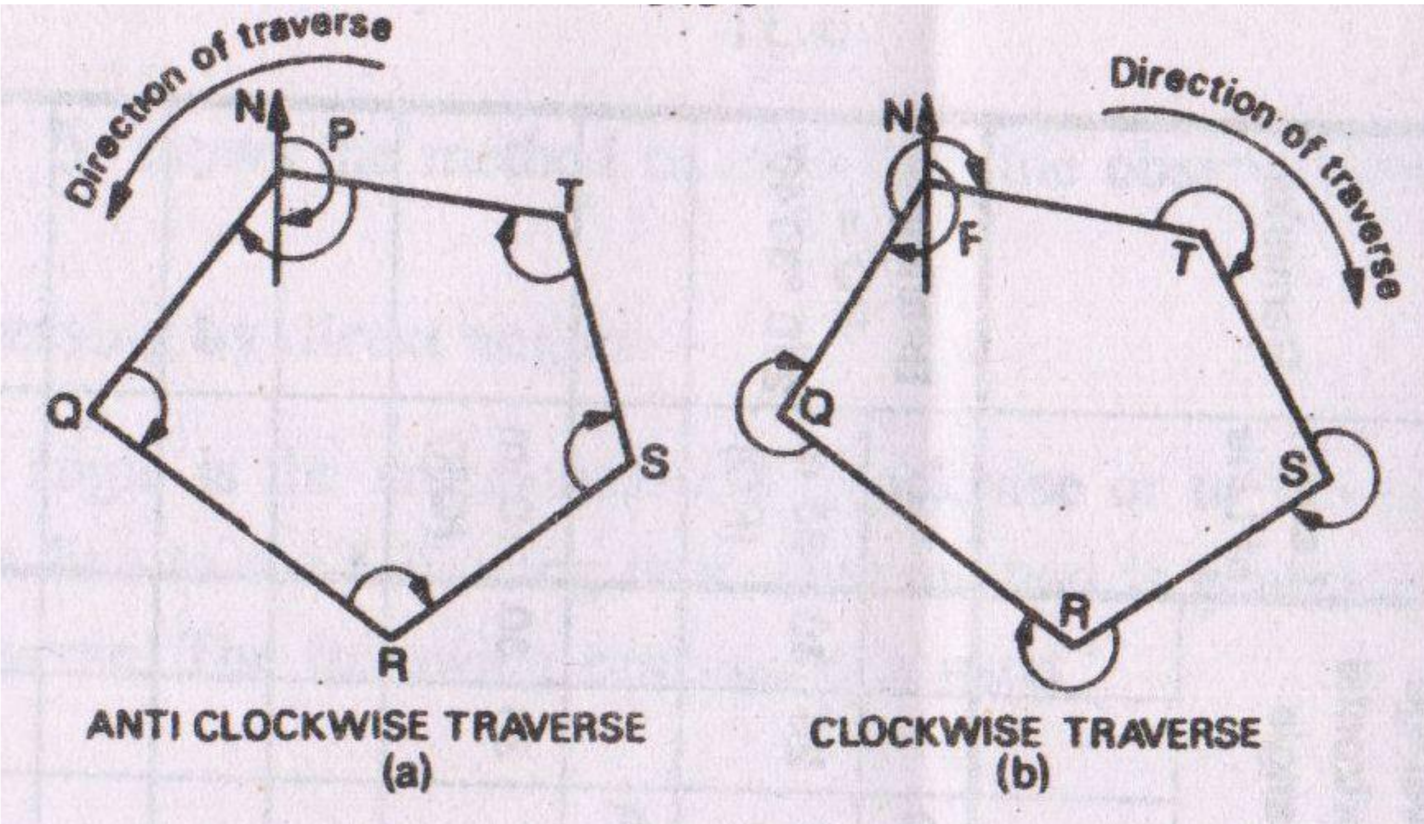
S.L.No	Station Observed	Line	Length (m)	WCB	Correction	Corrected WCB

Result: Plan of the given area is shown on the drawing sheet.

EXPERIMENT NO : CE(PC)493/2

Theodolite Survey: Closed traverse by transit theodolite; Preparation of field book

THEODOLITE TRAVERSING –



INCLUDED ANGLE METHOD

AIM :
To determine the lengths and included angles between the lines of closed traverse with the use of Theodolite.

APPARATUS USED

1.Theodolite, 2.Ranging rods,3.Pegs or Arrows.

GENERAL
This method is normally provided for closed traverse. In this method included angle between two successive lines is measured.

PROCEDURE

1. The instrument is set up over the station “P” and all the temporary adjustments are made. Telescope is oriented along the magnetic meridian and the magnetic meridian of PQ is measured.

2. The reading of 0°0’0” is set at vernier A by using upper clamp and tangent screw and the face of Theodolite is kept as left.

3. The telescope is brought back in the line of PT with the help of lower clamp and tangent screw, the reading in vernier A is kept as 0°0’0” and the reading in vernier B is kept as 180°0’0”.

4. Upper clamp is loosened and the telescope is turned clockwise and “Q” is bisected. Upper clamp is clamped and “Q” is bisected exactly using tangent screws.

5. Both the verniers of A and B are read and noted. Mean of the two verniers is determined as an included angle QPT.

6. Face is changed and all the above steps are repeated to determine one more included angle QPT.The average of the two included angle QPT is measured.

7. The Theodolite is shifted to second station Q. The station P is bisected and the whole process is repeated to get an included angle of RQP.

8. Similarly included angles at R,S and T are measured.

9. Lengths of traverse lines PQ,QR, RS, ST and TP are measured using a tape or chain.

NAME : **Leveling**: Temporary adjustment of Dumpy level, Differential leveling Longitudinal and cross sectioning, Gradient of line and setting out grades, Sensitiveness of Bubble tube

TEMPORARY ADJUSTMENTS:

These consist of setting up, levelling, and elimination of parallax.

Setting Up

Since the level is not to be set at any fixed point. the setting up of a level is much simple as compared to other instruments. While locating the level the ground point should be so chosen that

(a) the instrument is not too low or too high to facilitate reading on a bench mark

(b) the length of the backsight should preferably not be more than 98.0 m

(c) the backsight distance and foresight distance should be equal, and the foresight should be so located that it advances the line of levels. Setting up includes fixing the instrument and approximate levelling by leg adjustment.

Fixing the instrument over tripod

The clamp screw of the instrument is released. The level is held in the right hand. It is fixed on the tripod by turning round the lower part with the left hand and is firmly screwed over the tripod.

Leg adjustment

The instrument is placed at a convenient height with the tripod legs spread well apart and so adjusted that the tripod head is as nearly horizontal as can be judged by the eye.

Levelling Up

1. The telescope is held parallel to two foot screws, the two foot screws are turned uniformly towards each other or away from each other until the circular bubble is central.
2. Turn the telescope through 90° and bring the circular bubble in centre by turning the third foot screw.
3. Now the circular bubble should be central for any orientation of telescope.

Elimination of Parallax

Focussing the eyepiece

This operation is done to make the cross-hairs appear distinct and clearly visible. The following steps are involved:

1. The telescope is directed skywards or a sheet of white paper is held in front of the objective.
2. The eyepiece is moved in or out till the cross-hairs appear distinct.

Focussing the objective

This operation is done to bring the image of the object in the plane of the cross-hairs. The following steps are involved:

1. The telescope is directed towards the staff.
2. The focussing screw is turned until the image appears clear and sharp.

Automatic level

EXPERIMENT NO : CE(PC)493/3

Differential leveling using Dumpy Level: Collimation Method ; Rise and fall method ; Field book preparation

3a :- Longitudinal and Cross Sectioning by Collimation method

AIM :
To plot the longitudinal section and cross section along a proposed alignment of a highway.

APPARATUS USED

Automatic Level, tripod, Levelling staff, chain, tape, cross staff, arrows, ranging rods, pegs,hammer, Levelling book, pencil and eraser.

Principle:
Profile Levelling is an operation to determine elevations of points spaced apart at known distances along a given line. The purpose of profile Levelling is to provide data from which a vertical section of the ground surface along a surveyed line can be plotted. Longitudinal sectioning and cross sectioning are examples of profile Levelling.
a) Longitudinal sectioning: to find out the elevations of the points on the ground at fixed intervals along the centre line of proposed sewer lines, pipelines, highways, railways, canals, etc.
b) Cross sectioning: to find out the elevations of the points on the ground at fixed intervals on either side and perpendicular to centre line of proposed highways, canals, etc.
Procedure:
1. Establish points on the ground at fixed interval say 5 m along the proposed centre line of the highway by direct ranging and fix arrows as shown in figure given below.
2. Establish perpendicular lines on either side of the proposed centre line of the highway using cross staff as shown in figure given below.
3. Along the perpendicular lines that are established in the previous step fix arrows on the ground at a fixed interval say 2 m as shown in figure given below.
4. Carry out differential Levelling to find the R.Ls of every arrow point and enter the readings in table.
5. Calculate the R.Ls of all the points.
6. Draw the longitudinal section along the centre line of the proposed highway to a suitable scale.

7. Draw cross section in the transverse direction at each chainage point along the centre line of the proposed highway to a suitable scale.

Observations and Calculations:

S. No.	Chainage of centre line	Chainage Left C.S.	Chainage Right C.S.	B.S. (m)	I.S. (m)	F.S. (m)	H.I. (m)	R.L. (m)	Remarks

Height of Instrument = R.L. of B.M. + B.S.
R.L. of each arrow point = H.I. – I.S. or F.S.

Result:
Profile of the centre line of the proposed highway and various cross sections along the centre line of the proposed highway are shown on the drawing sheet.

The arithmetic check for the rise and fall method is : ∑BS-∑FS = LAST RL -1ST RL

3b :- Longitudinal and Cross Sectioning by Rise & Fall method

AIM :
To plot the longitudinal section and cross section along a proposed alignment of a highway.

APPARATUS USED

Automatic Level, tripod, Levelling staff, chain, tape, cross staff, arrows, ranging rods, pegs,hammer, Levelling book, pencil and eraser.

Principle:
Profile Levelling is an operation to determine elevations of points spaced apart at known distances along a given line. The purpose of profile Levelling is to provide data from which a vertical section of the ground surface along a surveyed line can be plotted. Longitudinal sectioning and cross sectioning are examples of profile Levelling.
a) Longitudinal sectioning: to find out the elevations of the points on the ground at fixed intervals along the centre line of proposed sewer lines, pipelines, highways, railways, canals, etc.
b) Cross sectioning: to find out the elevations of the points on the ground at fixed intervals on either side and perpendicular to centre line of proposed highways, canals, etc.
Procedure:
1. Establish points on the ground at fixed interval say 5 m along the proposed centre line of the highway by direct ranging and fix arrows as shown in figure given below.
2. Establish perpendicular lines on either side of the proposed centre line of the highway using cross staff as shown in figure given below.
3. Along the perpendicular lines that are established in the previous step fix arrows on the ground at a fixed interval say 2 m as shown in figure given below.
4. Carry out differential Levelling to find the R.Ls of every arrow point and enter the readings in table.
5. Calculate the R.Ls of all the points.
6. Draw the longitudinal section along the centre line of the proposed highway to a suitable scale.
7. Draw cross section in the transverse direction at each chainage point along the centre line of the proposed highway to a suitable scale.

Observations and Calculations:

S. No.	Chainage of centre line	Chainage Left C.S.	Chainage Right C.S.	B.S. (m)	I.S. (m)	F.S. (m)	Rise	Fall	R.L. (m)	Remarks

Height of Instrument = R.L. of B.M. + B.S.
R.L. of each arrow point = H.I. – I.S. or F.S.

Result:

Profile of the centre line of the proposed highway and various cross sections along the centre line of the proposed highway are shown on the drawing sheet.

The arithmetic check for the rise and fall method is : ∑BS-∑FS = ∑RISE - ∑FALL= LAST RL -1ST RL

EXPERIMENT NO : CE(PC)493/4

4a :- Total Station Survey : Traversing; Levelling

1. PREPARATION
1.1 Precautions

1. Never point the instrument at the sun without a filter.

2. Never store the instrument in extreme temperatures and avoid sudden changes of temperature.

3. When not using the instrument, place it in the case to avoid shock, dust, and humidity.

4. If there is a great difference in temperature between the work site and the instrument storage location leave the instrument in the case until it adjusts to the temperature of the surrounding environment.

5. Please remove the battery for separate storage if the instrument is to be in storage for an extended time. The battery should be charged once a month during storage.

6. The instrument should be placed in its carrying case during transportation. It is recommended that the original packing case be used for cushioning during extended transportation.

7. Be sure to secure the instrument with one hand when mounting or removing from the tripod.

8. Clean exposed optical parts with degreased cotton or lens tissue only.

9. Clean the instrument's surface with a woolen cloth when finished with use. Dry it immediately if it gets wet.

10. Check the battery, functions, and indications of the instrument as well as its initial setting and correction parameters before operating.

11. Unless you are a maintenance specialist do not attempt to disassemble the instrument for any reason. Unauthorized disassembly of the instrument can result in a void warranty.

12. The total stations emit a laser during operation. DO NOT stare into the beam or laser source when instrument is operation.

1.2 Nomenclature

1.3 Unpacking and Storage of the Instrument

Unpacking of the Instrument

Place the case lightly with the cover upward, unlock the case and take out the instrument.

Storage of the Instrument

Replace the cover on the telescope lens, place the instrument into the case with the vertical clamp screw and circular vial upward (objective lens toward the tribrach), tighten the vertical clamp screw, close and lock the case.

1.4 Instrument Set Up

Mount the instrument onto the tripod and secure firmly. Level and center the instrument precisely to ensure the best performance. Use the tripod with a 5/8” tripod screw.
Operation Reference: Leveling and Centering the Instrument

1) Setting up the tripod

First extend the extension legs to suitable length and tighten the screws, firmly plant the tripod in the ground over the point of beginning.

2) Attaching the instrument to the tripod
Secure the instrument carefully on the tripod and slide the instrument by loosening the tripod mounting screw. If the optical plumb site is positioned over the center of the point tighten the mounting screw.

3) Roughly leveling the instrument by using the circular vial

Turn the leveling screw A and B to move the bubble in the circular vial, in which case the bubble is located on a line perpendicular to a line running through the centers of the two leveling screw being adjusted. Turn the leveling screw C to move the bubble to the center of the circular vial. Recheck the position of the instrument over the point and adjust if needed.

4) Leveling by using the plate vial

Rotate the instrument horizontally by loosening the Horizontal Clamp Screw and place the plate vial parallel with the line connecting leveling screws A and B, then bring the bubble to the center of the plate vial by turning the leveling screws A and B. Rotate the instrument 90° (100g) around its vertical axis and turn the remaining leveling screw or leveling C to center the bubble once more. Repeat the procedures for each 90 ° (100g) rotation of the instrument and check whether the bubble is correctly centered in all directions.

5) Centering by using the optical plummet

Adjust the eyepiece of the optical plummet telescope to your eyesight. Slide the instrument by loosening the tripod screw; place the point on the center mark of the optical plummet. Sliding the instrument carefully as to not rotate the axis will allow you to get the least dislocation of the bubble.

6) Complete leveling the instrument

Level the instrument precisely as in Step 4. Rotate the instrument and check to see that the bubble is in the center of the plate level regardless of the telescope direction then tighten the tripod screw firmly.

1.5 Battery Removal & Insertion - Information and Recharging

Battery removal & insertion

Insert the battery into the battery slot and push the battery until it clicks. Press the right and left buttons of the battery compartment to remove the battery.

Battery information

2 Reflector Prisms

When doing distance measuring in prism mode a reflector prism needs to be placed as the target. Reflector systems can be single or multiple prisms which can be mounted with a tripod / tribrach system or mounted on a prism pole. Unique mini prism systems allow setups at 10 corners that are hard to reach. Reflector less targets extends the range of the instrument when used in reflector less mode. Illustrated are some prisms and a reflector compatible with instruments:

AIM :
To determine the lengths and included angles between the lines of closed traverse with the use of TOTAL STATION

3. ANGLE MEASUREMENT

3.1 Measuring Horizontal Angle Right and Vertical Angle

Make sure the mode is in Angle measurement.

Operating procedure	Operation	Display
1 Collimate the first target A	Collimate A	V : 90°10'20" HR : 120°30'40" 0SET HOLD HSET P1↓
2 Set horizontal angle of target A at 0° 00' 00". Press the [F1](0 set) key and press the [F3](YES) key.	[F1]	H ANGLE 0 SET > 0K? --- --- [YES] [NO]
	[F3]	V : 90°10'20" HR : 0°00'00" 0SET HOLD HSET P1↓
3 Collimate the 2nd target (B).The required V/H angle to target B will be displayed.	Collimate target B	V : 98°36'20" HR : 160°40'20" 0SET HOLD HSET P1↓

Reference : How to Collimate the target

1 Point the telescope toward the light. Turn the diopter ring and adjust the diopter so that the cross hairs are clearly observed.(Turn the diopter ring toward you first and then backward to focus)

2 Aim the target at the peak of the triangle mark of the sighting collimator. Allow a certain space between the sighting collimator and yourself for collimating.

3 Focus the target with the focusing knob.

3.2 Switching Horizontal Angel (Right/Left)

Make sure that it is under the Angle measurement mode.

Operating procedure	Operation	Display
1 Press[F4](↓)key twice to get the function on P3.	[F4] Twice	V : 90°10'20" HR : 120°30'40" 0SET HOLD HSET P1 TILT REP V% P2 H-BZ R / L CMPS P3
2 Press[F2] (R / L)key. The mode Horizontal angle Right (HR) switches to Left (HL) mode.	[F2]	V : 90°10'20" HL : 239°29'20" H-BZ R / L CMPS P
3 measure as HL mode		

• Every time pressing the [F2](R/L) key, HR/HL mode switches.

3.3 Measuring from the Required Horizontal Angle

3.3.1 Setting by Holding the Angle

Make sure the mode is Angle measurement

Operating procedure	Operation	Display
1 Set the required horizontal angle, using Horizontal tangent screw.	Display angle	V : 90°10′20″ HR : 130°40′20″ 0SET HOLD HSET P1↓
2 press[F2](HOLD)key	[F2]	H ANGLE HOLD HR = 130°40′20″ >SET? --- --- [YES] [NO]
3 Collimate the target		
4 press[F3](yes)key to finish holding horizontal angle.*1) ,the display turns back to normal angle measurement mode	Collimate [F3]	V : 90°10′20″ HR : 130°40′20″ 0SET HOLD HSET P1↓
*1) To return to the previous mode, press the [F4](NO) key.		

3.3.2 Setting a Horizontal Angle from the Keys

Make sure the mode is Angle measurement

Operating procedure	Operation	Display
1 Collimate the target	Collimate	V : 90°10′20″ HR : 170°30′20″ 0SET HOLD HSET P1↓
2 press[F3](HSET)key	[F3]	H ANGLE SET HR= --- --- [CLR] [ENT]
3 Input the required horizontal angle by using keys. *1) *1) such as: 70°40′20″	70.4020 [F4]	V : 90°10′20″ HR : 70°40′20″ 0SET HOLD HSET P1↓
Then normal measurement can be done from the required horizontal angle Refer to Section 2.5 "How to Enter Alphanumeric characters"		

4. DISTANCE MEASUREMENT

4.1 Setting of the Atmospheric Correction

When setting atmospheric correction, the correction value can be acquired by measurement of temperature and air pressure,
Refer to 12.2 "setting of atmospheric correction value ".

4.2 Setting of the Correction for Prism Constant

If the prism is of another manufacture, the appropriate constant shall be set beforehand, Refer to 11 "Setting the prism constant value", even the power is off, The setting value is kept in the memory.

4.3 Distance Measurement (Continuous Measurement)

Make sure that it is under the angle measurement mode.

Operating procedure	Operation	Display
1 Collimate the center of prism.	Collimate P	V : 90°10'20" HR : 120°30'40" 0SET HOLD HSET P1↓
2 Press the [◢] key. Distance measurement starts. *1), *2)	[◢]	HR : 120°30'40" HD* [r] <<m VD : m MEAS MODE S / A P1↓
The measured distances are shown. *3)~*5)		HR : 120°30'40" HD* 123.456m VD : 5.678m MEAS MODE S / A P1↓
• Pressing the [◢] key again, the display changes to horizontal (HR) and vertical (V)angle and slope distance(SD). *6)	[◢]	V : 90°10'20" HR : 120°30'40" SD : 131.678m MEAS MODE S / A P1↓

*1)When EDM is working, the " * " mark appears in the display.
*2)To change mode from Fine to Coarse or Tracking, refer to section 4.5 "Fine Mode/Tracking Mode/Coarse Mode".To set the instrument power supply that when it is on, it will enter distance measurement mode, refer to Mode 16"Selecting mode"."
*3)The distance unit indicator "m" (for meter) , "f" (for feet or feet inch) appears and disappears alternatively with buzzer sounds at every renewal of distance data.
*4)Measurement may repeat automatically in the instrument if the result is affected by shimmer etc.
*5)To return to the normal measuring angle mode from a distance measuring mode, press the [ANG] key.
*6)It is possible to choose the display order (HR, HD, VD) or (V, HR, SD) for initial measuring distance mode. Refer to Chapter 16 "SELECTING MODE".

4.4 Distance Measurement (N-time Measurement/Single Measurement)

When the number of times measurement is preset, the TKS-202 measures the distance the set number of times. The average distance will be displayed. When presetting the number of times as 1, it does not display the average distance, because of single measurement. Single measurement is set at the factory. Make sure that it is under angle measurement mode.

Operating procedure	Operation	Display
1 Collimate the prism center	Collimate	V : 90°10'20" HR : 120°30'40" 0SET HOLD HSET P1↓
2 press [◢] key,continuous measurement starts.*1)	[◢]	HR : 120°30'40" HD* [r] <<m VD : m MEAS MODE S / A P1↓
3 Press [F1](MEAS) key while continuous measuring is exceeding. *2). The average value is displayed and "*" mark disappears.	[F1]	HR : 120°30'40" HD* [n] <<m VD : MEAS MODE S / A P1↓ ↓

EXPERIMENT NO : CE (PC)/493/4B

USE OF TOTAL STATION FOR LEVELLING:–

AIM :

To levelling and contouring a land.

APPARATUS USED

1.Total station, 2. Reflector , 3. Measurement Tape, 4. Ranging rods,5.Pegs or Arrows.

SELECTING FILE FOR DATA COLLECTION:-

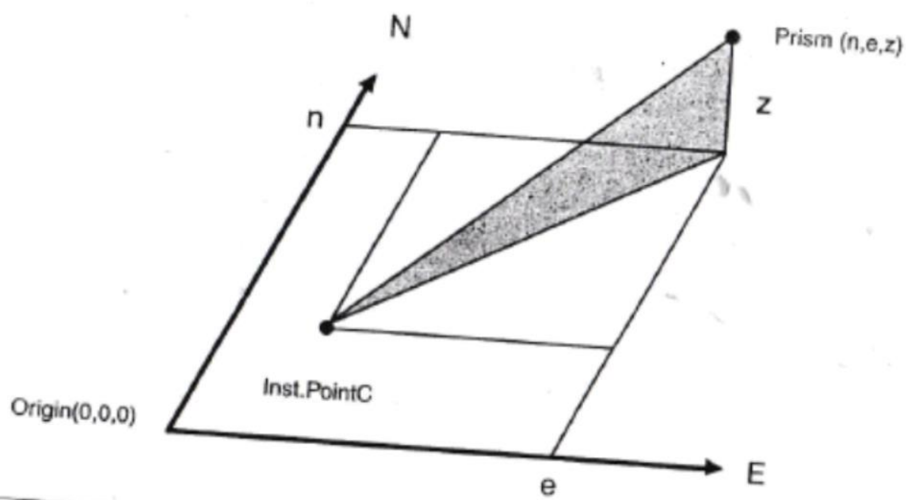
- A file used by data collection mode must be selected at first.
- Select a file before beginning data collection mode because selection screen of a file is displayed.
- Setting out the occupied point .

5. COORDINATE MEASUREMENT

5.1 Setting Coordinate Values of Occupied Point

Set the coordinates of the instrument (occupied point) according to coordinate origin and the instrument automatically converts and displays the unknown point (prism point) coordinates following the origin.

It is possible to retain the coordinates of the occupied point after the power is off. Refer to Chapter 16 "SELECTING MODE".



Operating procedure	Operation	Display
①Under coordinate measurement mode press[F4](↓)key,enter P2 function	[F4]	N: 123.456 m E: 34.567 m Z: 78.912 m MEAS MODE S/A P1↓ R.HT INSHT OCC P2↓
②Press[F3](OCC)key	[F3]	N= 0.000 m E: 0.000 m Z: 0.000 m --- --- [CLR] [ENT]

③Enter N coordinate value *1)	Enter data. [F4]	N: -72.000 m E= 0.000 m Z: 0.000 m --- --- [CLR] [ENT]
④Enter E and Z coordinate enter data with same method, the display backs to coordinate measurement show		N: 51.456 m E: 34.567 m Z: 78.912 m MEAS MODE S/A P1↓

*1) Refer to 2.5 "How to Enter Alphanumeric characters".

- Input Range -99999999.9990 ≤ N.E.Z ≤ + 99999999.9990 m
  -99999999.999 ≤ N.E.Z ≤ + 99999999.999 ft
  -99999999.11.7 ≤ N.E.Z ≤ +99999999.11.7 ft+inch

5.2 Setting Height of the Instrument

It is possible to retain the instrument height after the power is off. Refer to Chapter 16 "SELECTING MODE".

Operating procedure	Operation	Display
①Under coordinate measurement mode press[F4](↓)key,enter P2 function	[F4]	N: 123.456 m E: 34.567 m Z: 78.912 m MEAS MODE S/A P1↓ R.HT INSHT OCC P2↓
②Press the [F2](INSHT) key. The current value is displayed.	[F2]	Instrument Height Enter INS.HT. 0.000m --- --- [CLR] [ENT]
③Enter instrument height*1)	Enter Inst.HT [F4]	N: 123.456 m E: 34.567 m Z: 78.912 m MEAS MODE S/A P1↓

EXPERIMENT NO : CE (PC)/493/5

VISUAL IMAGE INTERPRETATION:–

AIM :

To interpret the image

APPARATUS USED
QGIS SOFTWARE

Pocedure:-

Pre-interpretation is carried out through following four steps:

Step 1 :- Identification of each land use category

Step 2:- Delineation of block and compartment boundary lines and tentative lines of the land use categories on the aerial photographs

Step 3 :- Examining for classification of forest vegetation and cover types

Step 4 :- Marking of places which are unclear and questionable to be checked at the time of field verification.

Standardization for Interpretation

After field verification, standard for interpretation of aerial photographs including land use categories and classification of forest vegetation and cover types should be decided, and prepare aerial photo interpretation cards.

Determining Standard for the Interpretation

The standards for the land use categories and classification of forest vegetation and cover types should be determined.The procedures for standardization for the interpretation of aerial photographs are as follows:

a) Results from pre-interpretation of aerial photographs must be re-examined and amended based on results and information obtained from field verification including sample plot surveys.

b) Using the mirror stereoscope, compare the aerial photograph imagery with the detailed data obtained from field surveys. After making these comparisons, determine the factors such as shape, size and color tone needed for preparing the standards. For the determination, It is important to select the factors which interpreter can distinguish.

c) The standards should be determined based on the entire information collected through the process of the aerial photograph interpretation just before the standardization such as pre-interpretation and field verification.

Main interpretation

After standardization for the interpretation of aerial photographs, the main interpretation for categorization of land use and forest vegetation and cover types should be implemented, based on the standards of the classification prepared.

Regarding land use categories, since delineation of tentative lines of the land use categories on the aerial photographs is carried out at the stage of the pre-interpretation, the tentative lines should become definite and analysts/interpreters should decide to which land use category each surrounded area other than forest comfort.

Regarding classification of forest types, analysts/interpreters should draw lines on the aerial photographs dividing the forest area into forest types categorized.

When analysts/interpreters carry out the work, the following should be taken into account:

The size of each forest area to be surrounded by the delineation is different, depending on the extent and distribution of the categories according to the standard of land use and forest vegetation and cover types decided. However, smallest unit should be approx. 1 X 1 cm on a scale of 1:10,000 because we cannot verify surrounded area with smaller size than area of 1 x 1 cm on the aerial photo and map on the same scale.

a) Thecolortoneofaerialphotographscanchangedependingonaerialphotographyconditions, photograph development processes or other processes applied to the photos. To deal with this problem, analysts/interpreters have to analyse not only the aerial photographs but also related data and information. In this connection, the importance of actual observation in the field, and field verification including surveys cannot be over-emphasized. These measures will make enable the analyst/interpreter to overcome problems arising from color change and other technical imperfections in the aerial photos while also providing the basic knowledge required for efficient interpretation.

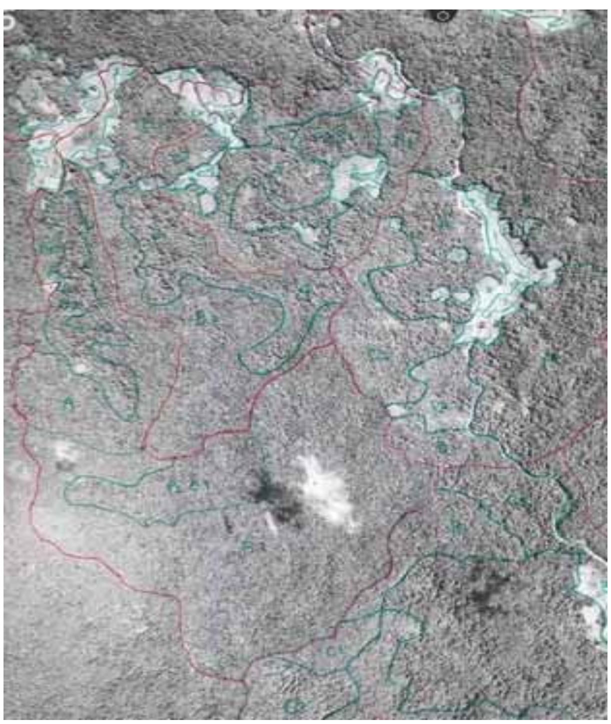
Transferring each line on the aerial photographs to the topographic map

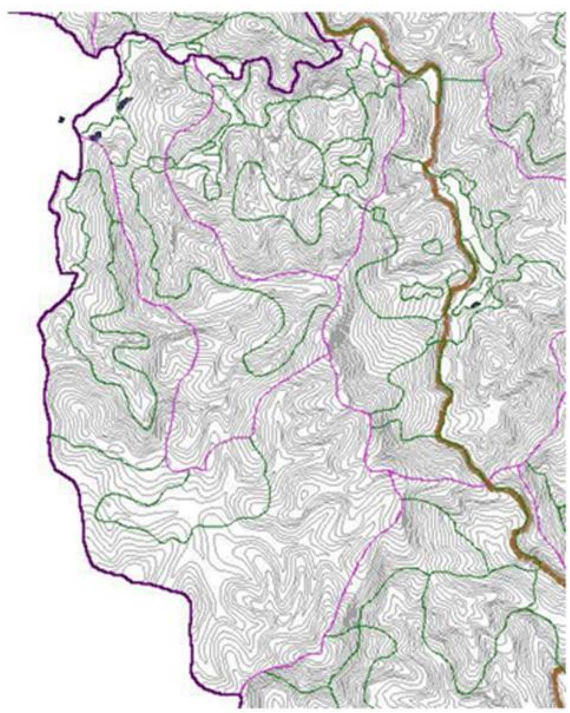
Then the interpretation work approaches the final stage. After completing the delineation on the aerial photographs, the all of the lines on the aerial photographs have to be transferred to the topographic map. This map should be on the same scale as the aerial photographs. To make the transfer it will be necessary to prepare an transparency topographic map.

Place the aerial photographs under the topographic map. Trace the lines previously entered on the aerial photographs onto the topographic map. As previously explained, slanting has an effect on the information presented by the aerial photographs. Slanting is minimal at the center of the photograph and increases as one moves to the frame (edge) of the image. Therefore, tracing is confined to the central part of the photograph in order to avoid tracing those portions of the photograph near the frame (edge) that are subject to the slanting effect. Those portions subject to the slanting effect are covered by making use of the overlap features of aerial photographs. When placing the photos under the transparency map, place them in an over-lapped position so that all the portions that are traced correspond with the central parts of the picture not affected by slanting.

The figure shows example of the transfer of the lines, such as block and compartment boundary (red lines) and land use categories and classification of the forest types (green lines), to a topographic map.

The transferred lines on the topographic map should be applied into GIS. For the methods for storing the data in GIS, please refer to the "Operation Manual on GIS Arc View for Forest Management Planning" within the technical manual series on the Study.





EXPERIMENT NO : CE (PC)/493/6

Satellite image Pre- processing:–

AIM :
To Pre –processing the image

APPARATUS USED

QGIS SOFTWARE

PROCEDURE:-

- Launch QGIS from

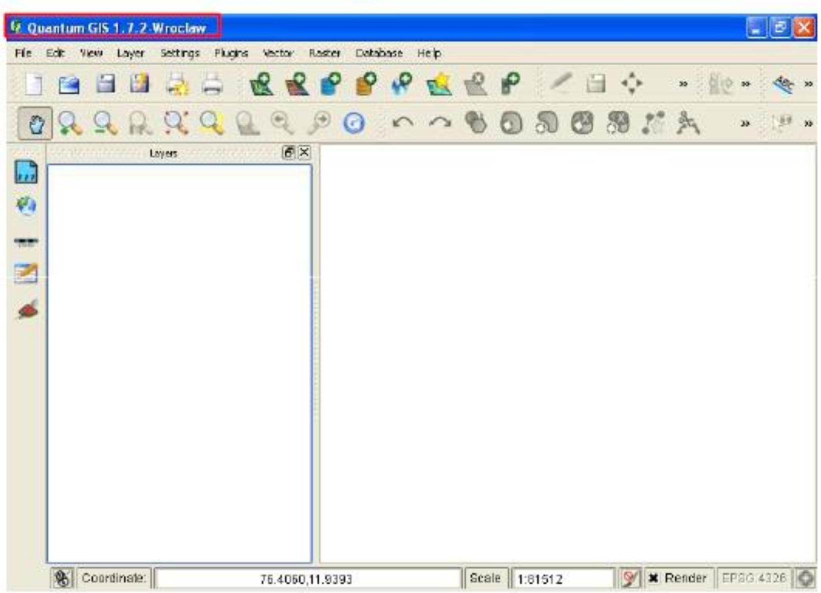
Start → **All Programs** → **Quantum GIS**

OR

QGIS Icon on the desktop

- Open window Quantum GIS (Figure1.1below)

Figure 1.1



Opening Raster

- For this exercise we demonstrate two types of GIS data
  - point
  - line

  .
- These require geo-referenced base data.Such bas edata could be in the form of
  - ✓ Topo sheets
  - ✓ Cadastral maps(villagemaps)
  - ✓ Remotesensed images

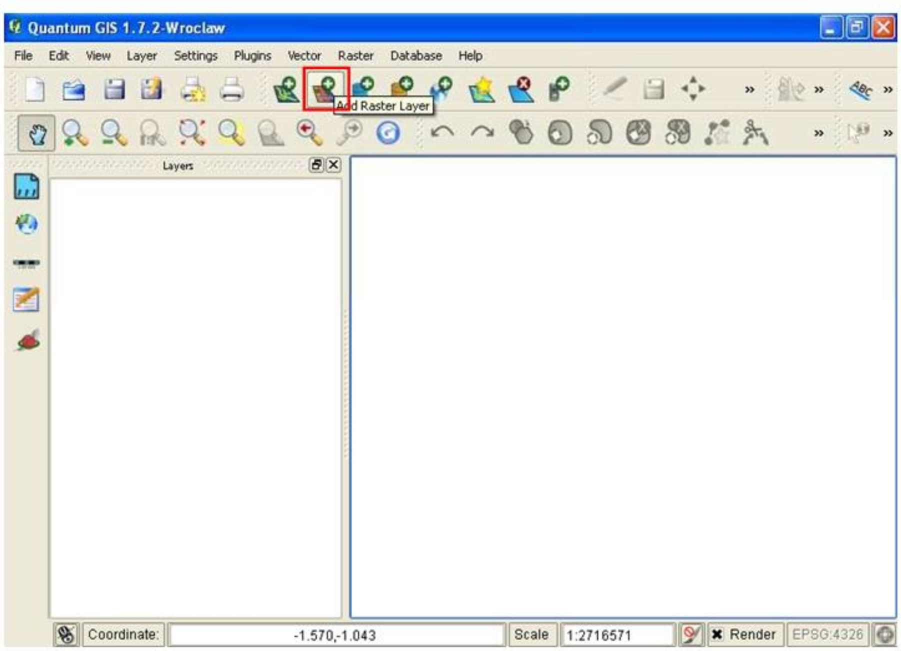
    eg., Google earth images, IRS data, LANDSAT data.

- The accompanying CD provides are glistered image named

  nugu.tif.

- Open this file by selecting **AddRasterLayer**icon(Figure 1.2)

Figure 1.2



Opening Raster
• **Open a GDAL Supported Raster Data Source** window opens (Figure 1.3)
• Select **nugu.tif** and select **Open** (Figure 1.3)
• Observe the **nugu.tif** opened in the window (Figure 1.4)

Figure 1.3

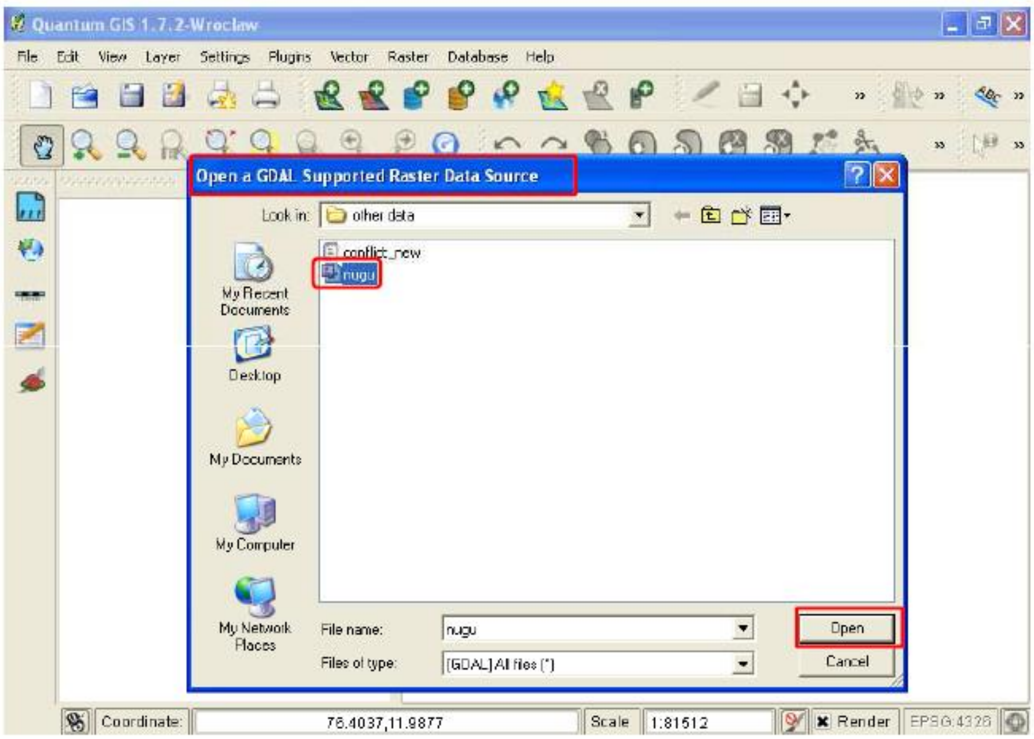
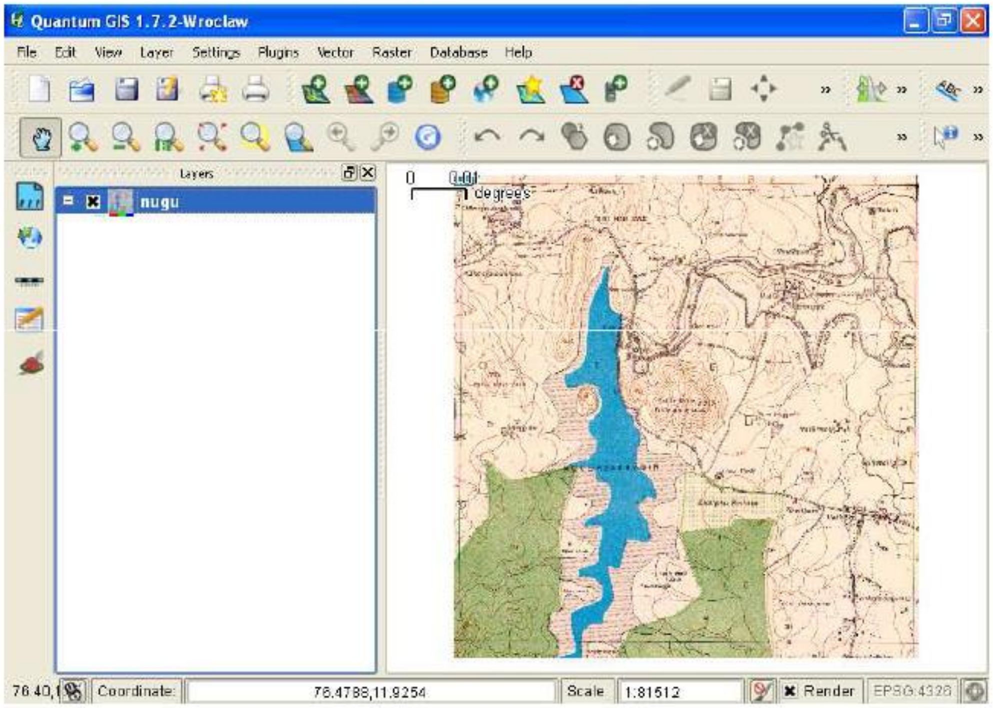


Figure 1.4



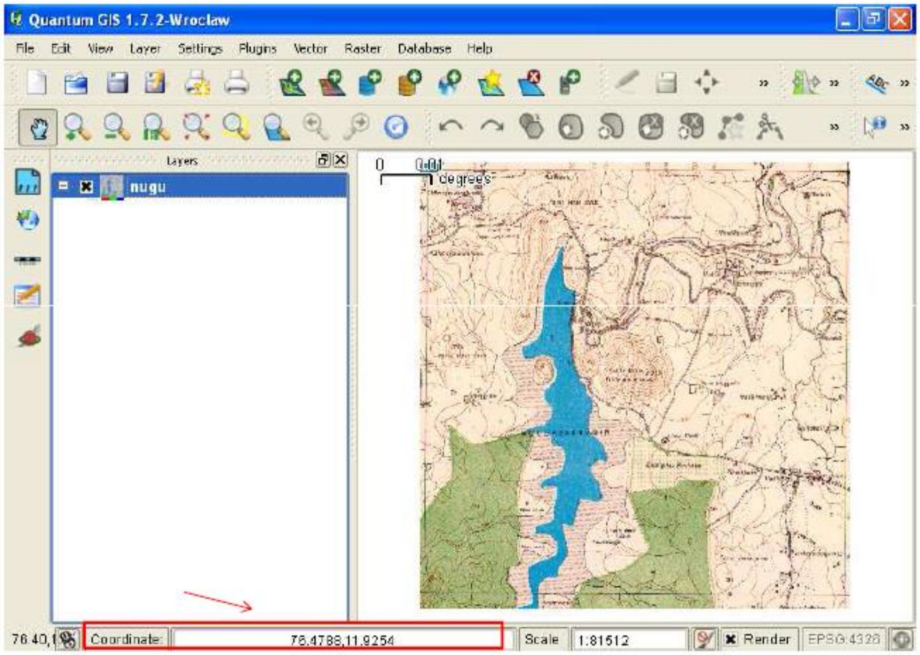
Verifying geo-referencing

• The opened raster file is geo-referenced

• To confirm the geo-referencing move the
cursor on the opened map; coordinates change in the coordinate window at the

bottom of the screen (Figure 1.5)

Figure 1.5



Creation of Vector Point Data

To create a new point layer select the icon New Shape file Layer (Figure 1.6)

• A window pops up titled "Coordinate
Reference System Selector" (Figure 1.7)

Step 1

• Select as the coordinate reference system
WGS 84 (Figure 1.7)

• Select **OK**

• A window titled New Vector Layer is displayed (Figure 1.8)

Figure 1.6

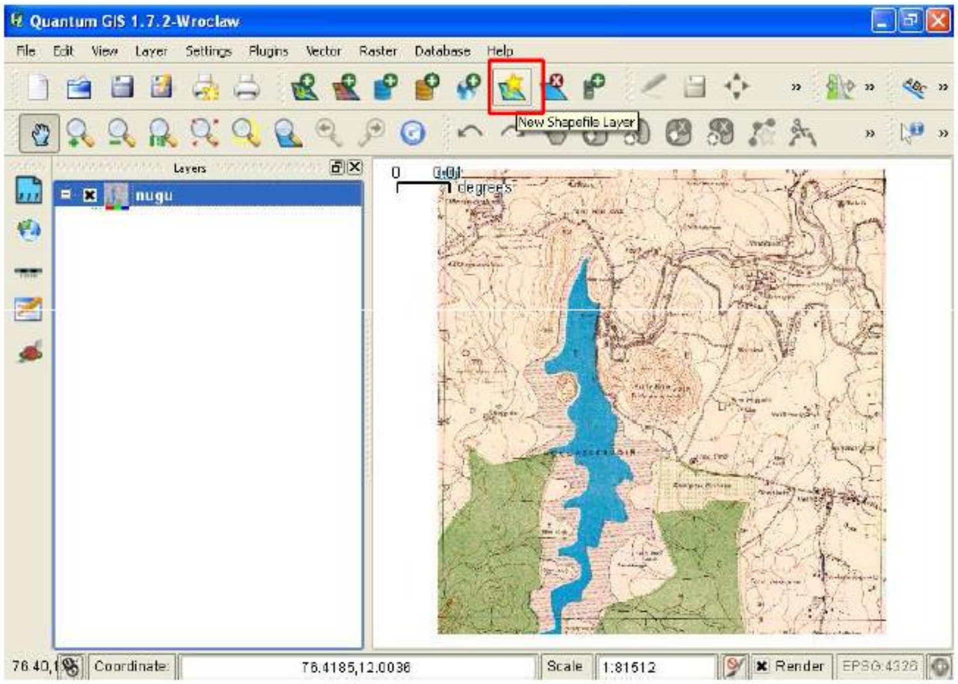


Figure 1.7

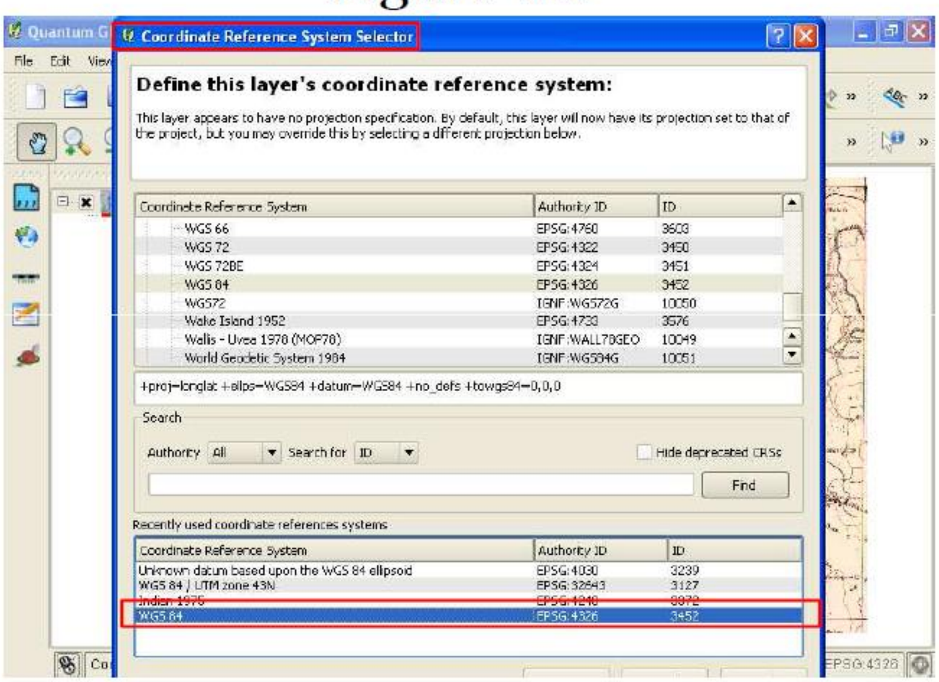
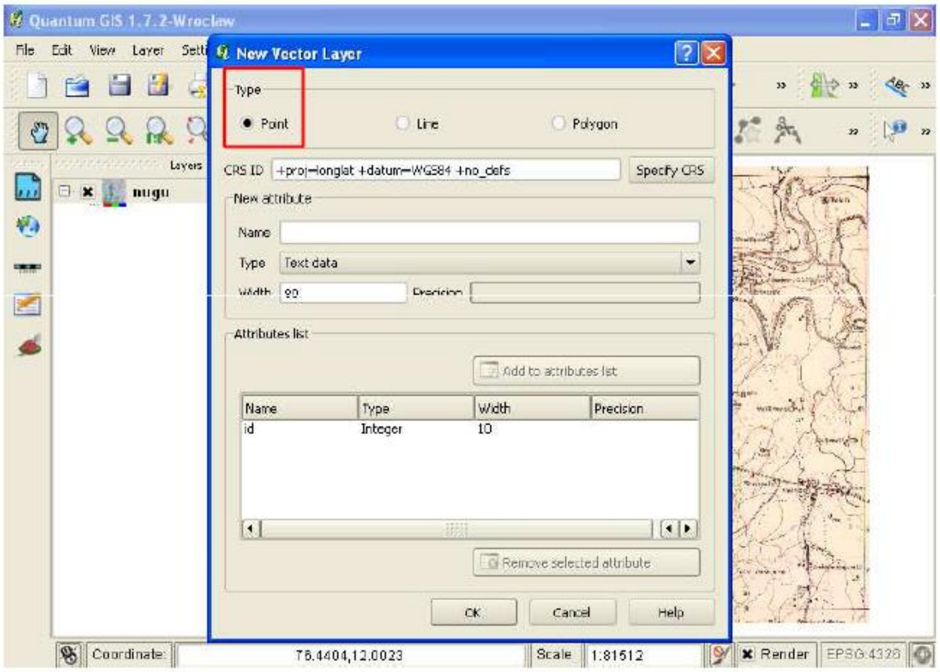
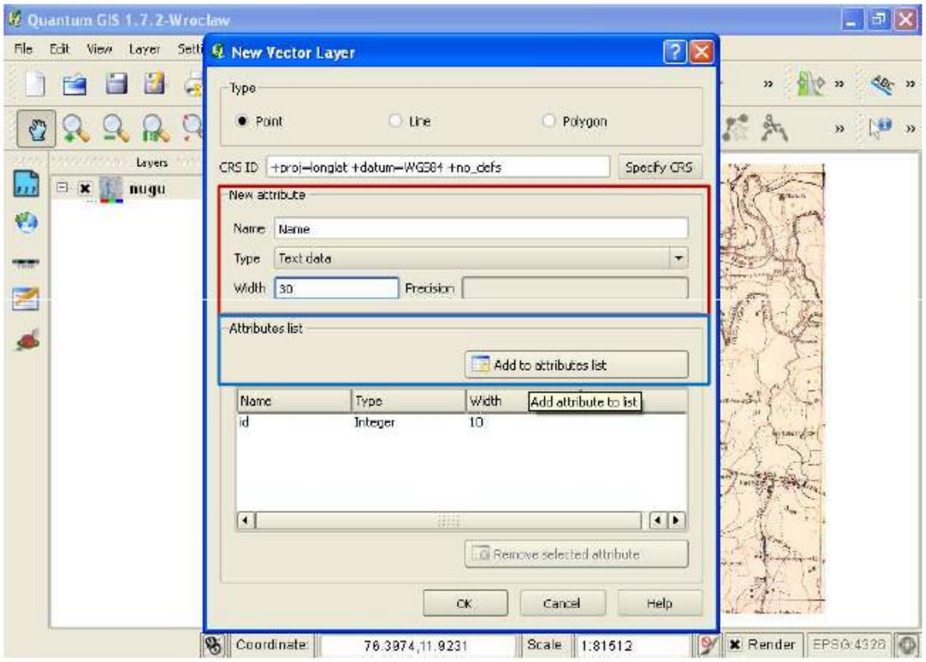


Figure 1.8



Creation of Vector Point Data
• In Figure 1.8 select option **Type** and then **Point**
• We need to add 'attributes' next. This step requires planning in detail. For eg., an anti- poaching camp can have the attributes:
1. Number of staff
2. Number of GPS etc
Next create layer of villages with attributes such as:
1. Name2. Taluk3.District4. Population Creation of Vector Point Data
• In the same window note the **New attribute** box: it has attributes of **Name**, **Type**, **Width** and **Precision**
• Add new attributes (Figure 1.9)
Step 2
_***Name***: village
_***Type***: text
_***Width***: 40 (this is subjective decision as place names are generally within 40 characters)
• Come to **Attribute List** box (Figure 1.9) Select **Add to attribute list**

Figure 1.9



Creation of Vector Point Data

• Add taluk and district data in village attributes by repeating **Step 2**

• Add population data: to do this, we need to set **Type** of data in whole number, repeat **Step 2** • After this select **OK**

• You will be guided to the **Save As** window**.** Select the directory in which you would like to save the data. For this example name it as '**Village' .**Select **Save**.

Creation of Vector Point Data

• On saving, layer is stored in specified folder

• This layer is automatically added to the QGIS window.

Creation of Vector Point Data

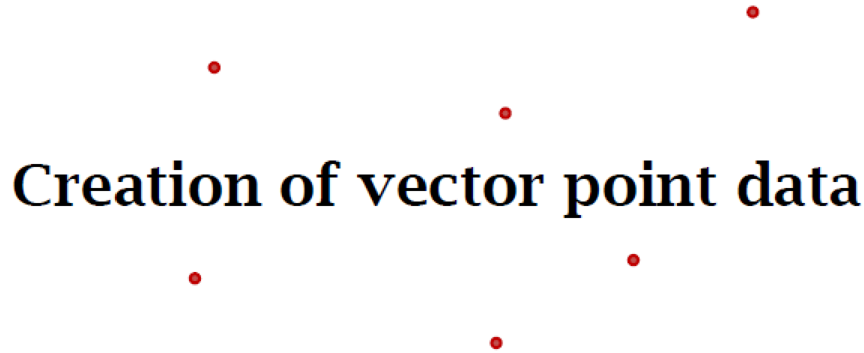
• Next, add villages (features) to the village layer

• To do this the layer has to be made editable

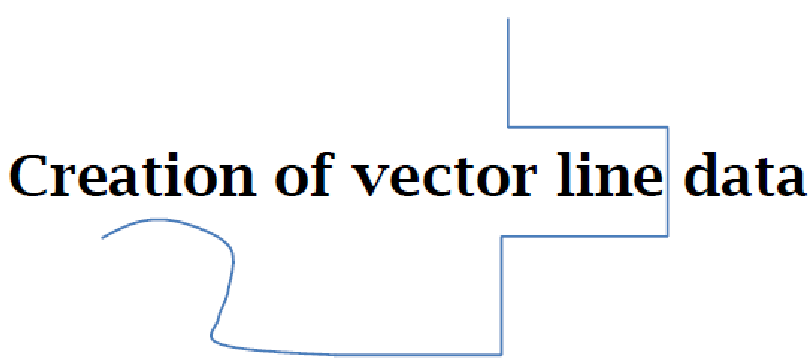
• Select the layer and then select **Toggle editing** icon

Step 3

• On enabling, in the layer window, the toggle active icon is enabled • On its enabling, other icons related next to T**oggle editing** icon are also activated



Creation of Vector Point Data
• Select the icon of **Zoom In.** Now zoom to the
area of interest by • Place the on the interested area and click
• We have zoomed to the area • Select the icon **Capture point**
Creation of Vector Point Data
• A window with title **Attributes** is opened
• Enter the values for different attributes
Step 4
_**Id (default)**: 1
_**Name (as in the topo-sheet)**: Heggudlu
_**Taluk**: HD Kote
_**District**: Mysore
_**Population (from census)**: 50
• Select **OK**
Creation of Vector Point Data
• Notice marked village can be seen on the map
• Repeat **Step 4**
• Finally a map with villages in the Nugu is displayed



Creation of vector line data - road

• To create new line layer select the icon **New**
shape layer • Complete **Step 1** • As in Figure 1.8 where under Type, 'point' was selected, *s*elect 'Line'• Next we need to add attributes _ Attributes associated
_ Type of the road
• After this step, select **OK**
Creation of vector line data
• You will be guided to **Save** as window as
previously done in Figure 1.12– Select the directory in which you would like to save the data. In this example name it as '**road**'

• Select **Save**; on saving, layer is stored in specified folder
• This layer is automatically added to the QGIS window
Creation of vector line data
• Next we need to add roads (features) to the road layer.
• To do this we have to make this layer editable.
• Select the layer and then select **Toggle editing** icon
• On enabling, in the layer window, the **Toggle active** icon is enabled
Creation of vector line data
• Zoom to the area of interest by selecting the icon of **Zoom In** • Then place the on the interested area and click • We have zoomed to the area • Select the icon **Capture Line** (Figure 1.28)
• Place marker on road that we have to
digitize and **left click**
Step 5
Creation of vector line data
• Place the marker to next position and **left click**
• Repeat the same process till the next junction (for e.g.,change in direction is required)
• Similarly, continue till where you would like to end the process, **right click.**
• A window with title **Attributes** is opened • Enter the information for different attributes

_Id (default): 1
_Type : Mud road
• Select **OK** Creation of vector line data
• We can notice digitized road can be seen on the map (end of **Step 5**)
• Before starting the next segment, to avoid the problems of a) undershoot and b) dangles, we need to enable snapping option.
• To enable snapping: **Setting Snapping option** Creation of vector line data
• A window of **Snapping options** appears (
• Select the layer roads,– Mode to vertex– Tolerance 0.0005 (this is a subjective decision)

– Units map units
• Select **OK**
• Repeat **Step 5** till all roads are digitized and remove the **Toggle editing**
• **Save** the layer
Creation of vector line data
• Finally we need to disable snapping option_ Select **Setting Snapping options** unselect road layer

EXPERIMENT NO : CE (PC)/493/8

STEREOSCOPIC FUSION OF AERIAL PHOTOGRAPHS USING MIRROR STEREOSCOPE:–

AIM :
To interpret the image

APPARATUS USED

MIRROR STEREOSCOPE

Proper Use of Stereoscopes:-

The following are some guidelines that will help you use your stereoscopes properly. They are important and should be kept in mind when performing stereo based interpretations:

1. Be sure that the photos are properly aligned, preferably with the shadows toward the viewer. (Having the shadows away from the viewer can cause terrain reversalor "false stereo".)

2. Be sure to keep the eye base and the long axis of the stereoscope parallel to the flight line.

3. Try to maintain an even glare free illumination of the images and make yourself comfortable.

4. Keep the lenses of your stereoscope clean.

5. Do Not Attempt Stereo viewing For Long Periods in the Beginning.

Problems/Issues Involved in Viewing Stereo

1. People with eyes of unequal strength may have difficulty seeing stereo. If you wear glasses it is best that they be worn when stereo viewing.

2. Poor photographic illumination, misaligned prints or uncomfortable viewing positions may result in eye fatigue.

3. Illness or severe emotional distress may create sensations of dizziness when using stereoscopes'.

4. Pseudo stereo can be caused by:

A. Erroneous reversal of prints;

B. Viewing photos with shadows falling away rather than towards the interpreter.

5. Objects which change position from one photo to another cannot be viewed in stereo.

6. In areas of high vertical relief, scale differences in adjacent photos may make it difficult to obtain a 3-Defect.

7. Dark shadows or clouds may prohibit stereoscopic study by obscuring details of the scene on one print or the other.

8. Individuals, who have difficulty with stereoscopic viewing, should not attempt unaided eye stereo viewing.

Precedure:-

Height Measurement

There are a number of methods for measuring the heights of objects using aerial photography. I will briefly discuss three that I feel are important for photo interpreters to be familiar with. Two deal with the measurement of height from a single photo; while the third deals with the determination of height by measuring parallax differences. The types of parallax being measured here are:

1. Absolute Parallax; and,

2. Differential Parallax.

Remember that according to the American Society of Photogrammetric and Remote Sensing's: Manual of Photogrammetric, 3rd. ed.: Parallax= The apparent displacement of the position of a body, with respect to a reference point or system, caused by a shift in the point of observation.

Absolute Parallax= Considering a pair of aerial photographs of equal principle distance, the absolute parallax is the difference of a point is the algebraic difference of the distances of the two images from their respective photo nadirs measured in a horizontal plane and parallel to the airbase.

Differential Parallax= The difference in the absolute stereoscopic parallaxes of two points imaged on a pair of photographs. This is usually employed in the determination of the differences in the elevation of objects.

Shadow Height Method:

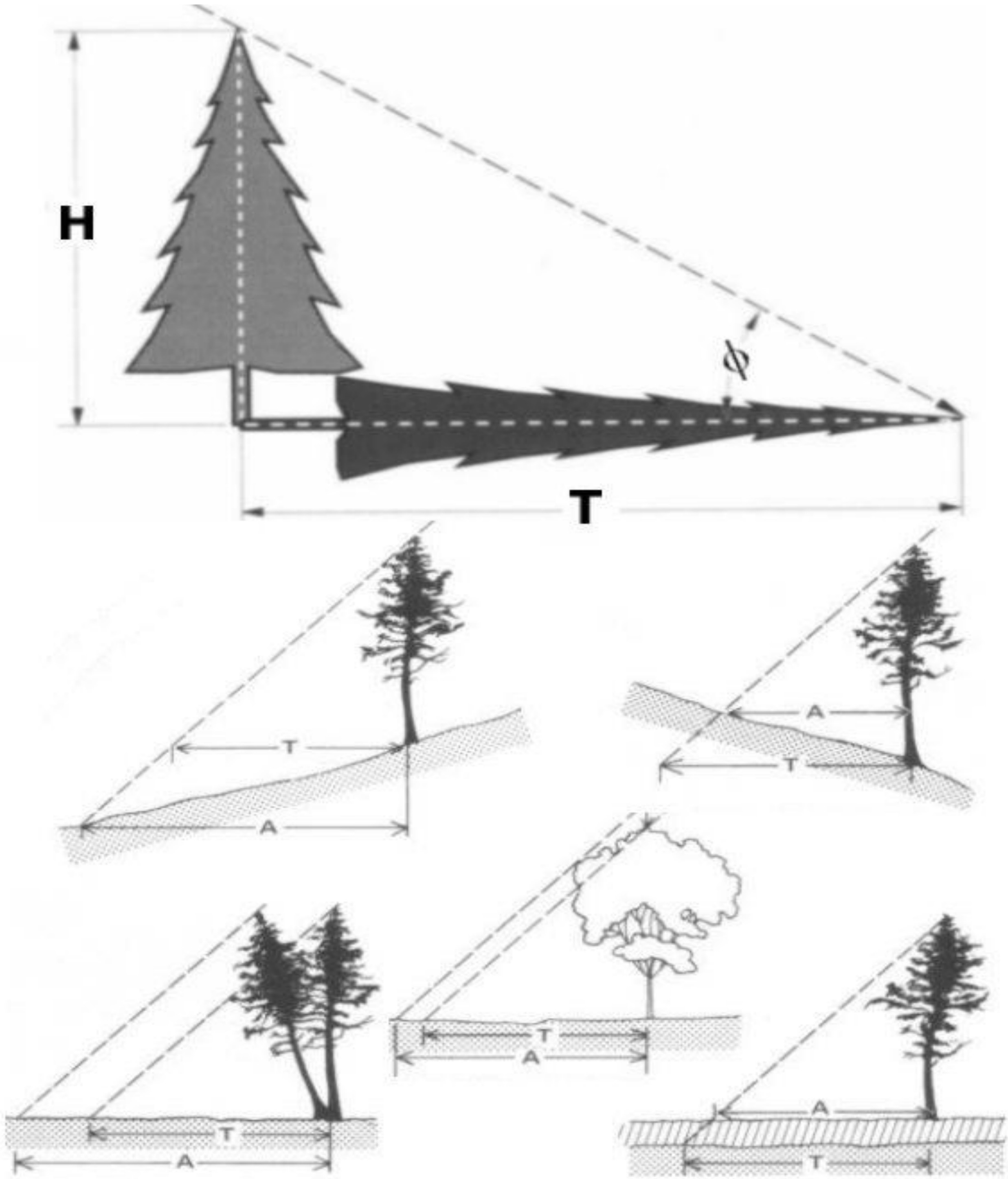
Basically, if the shadow cast by an object can be measured and the sun angle causing the shadow is known or can be derived (from latitude, date and time) then the height of the object can be calculated using simple trigonometry, as follows:

h = Ls x tan a

Where tan a = the tangent of the sun angle from the ground surface.

andLs = Length of the shadow.

Here we assume that the shadow on which the ground falls is level and that the object is vertical. The objects top must be sharply defined so that it creates a distinct image.
There are many sources of error here.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Displacement Method:

In this method of height determination from a single aerial photo we:

1. accept the principle point as the photo nadir (we're assuming a vertical photo);
2. Must precisely know or be able to determine the altitude from
3. Which the photo was acquired.
4. Both the top and the bottom of the object to be measured should be clearly visible.
5. The degree of image displacement must be great enough to be accurately measured with available equipment.

If the above conditions are met the formula for the displacement method of height determination from a single aerial aerial photo can be written as:

Ho = Ha x D R

Where: Ho = Height of the object;

Ha = Altitude above the surface where the photo is taken; D

= Length of the displaced image;

R = Radial distance from the photo nadir to the top of the object.

Parallax Height Measurement

This is the most used method of measuring heights on air photos. There are many forms of the parallax equations. Avery and Berlin give one; Paine in his book lists three: 1) for mountainous terrain; 2) for level terrain; and, 3) the short cut equation.

What I will give here is the basic form of the equation:

Ho = Ha x dP Pb + dP

Where: Ho = The height of the object of interest; Ha

= Platform height or altitude above datum; dP =

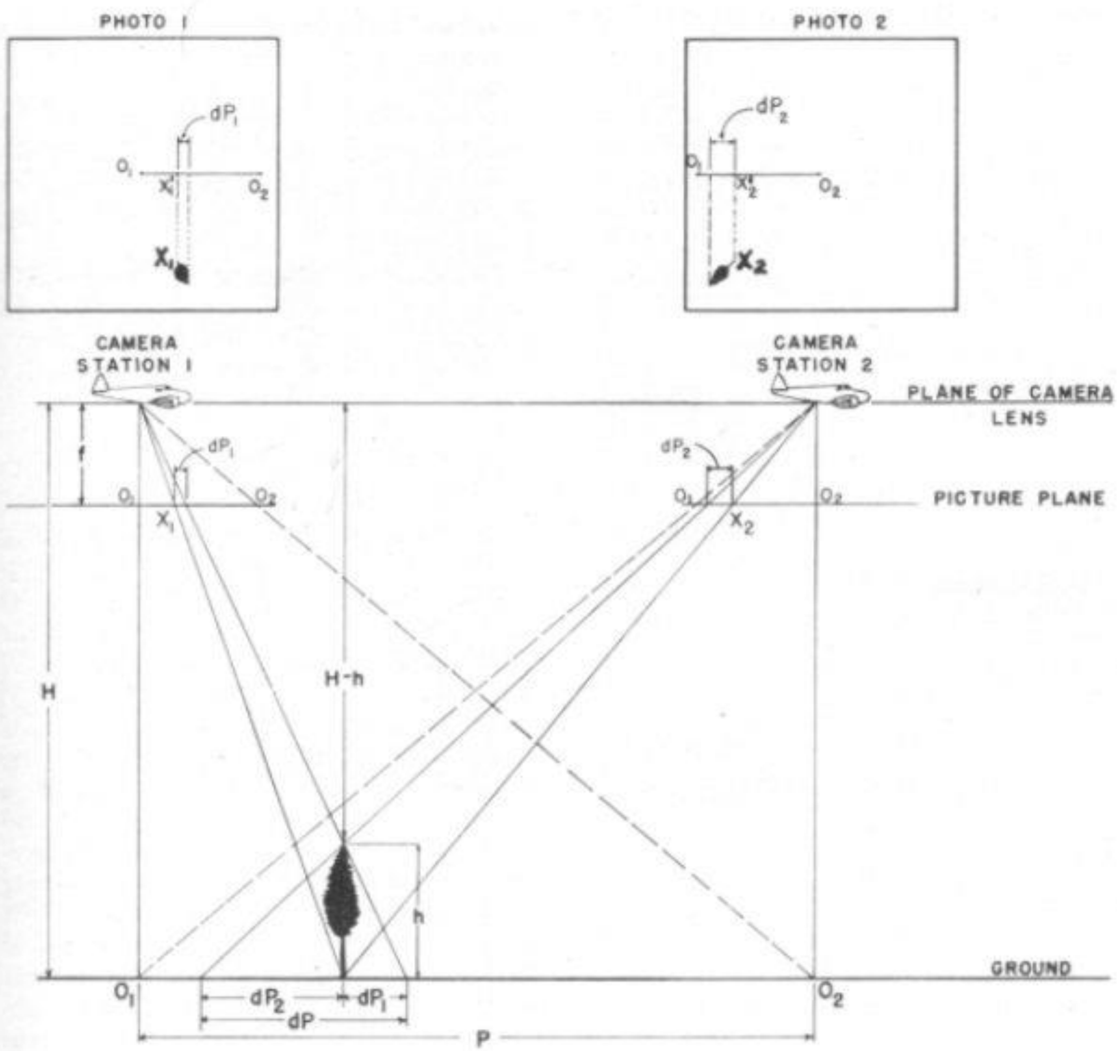
Differential Parallax; and

Pb = Absolute Parallax.

So if the altitude of the aircraft above datum is: 1. known or can be calculated; and,

2. if, from the available stereo pairs, we can calculate the differential and the absolute parallax; then, 3. We can ascertain the heights of objects in the photos.

FUNDAMENTALS OF PHOTO INTERPRETATION



h = ht. of tree

H = ht. of camera lens above base of tree

P = Absolute parallax of base of tree (photo equivalent = $O_1 O_2 = O_1 X_1' + O_2 X_2'$)

dP = Parallax difference of top of tree referred to base plane (photo equivalent = $dP_1 - dP_2$)

From similar triangles: $\frac{h}{H-h} = \frac{dP}{P}$

Transposing: $h = \frac{H \cdot dP}{P + dP}$

Line drawing showing derivation of the parallax equation. From Colwell (1955).

Important things to remember here include:

Ha, the height of the aircraft should be in the same units as the objects height. Feet are typically employed. dP and Pb, should also be in the same units. Yet, here you would typically use hundredths of inches. you need accurate measuring devices to get accurate measurements. Now for a small trick:
If we can assume that:

1. Photo tilt is less than3Â°;

2. Both negatives or positive transparencies of the stereo pair were taken from the same flying height;

3. Both nadirs and principle points are at essentially the same ground elevation; and,

4. The base of the objects to be measured is, essentially, at the same elevation as that of the principle point.

Then, we can substitute the average photo base of the stereo pairs being used can be substituted for Pb (absolute parallax).

Let's say, as Avery and Berlin do in their book (5th. ed.) on Pg. 78 and 79; that we are going to measure the height of the Washington Monument from a stereo pair.

The nominal photo scale we have is 1:4,800. We have gone in and corrected this in the area of the monument monument to 1: 4,600 at the base of the Monument. The camera focal length was 12 inches. So the flying height was what? 4,600 feet. The average photo base (P) of the stereopair is calculated to be: 4.40 inches.

Absolute stereo parallax at the base; and at the top of the monument is measured paralleltothelineofflightwithanengineersscale.Thedifferenceis:2.06in.--1.46 in. This gives a dP of 0.60 in. So, 0.60 inches is the differential parallax of the displaced images.

Add scanned image here from my notes Substituting

these values into a form of our formula:

Ho = [H] dP

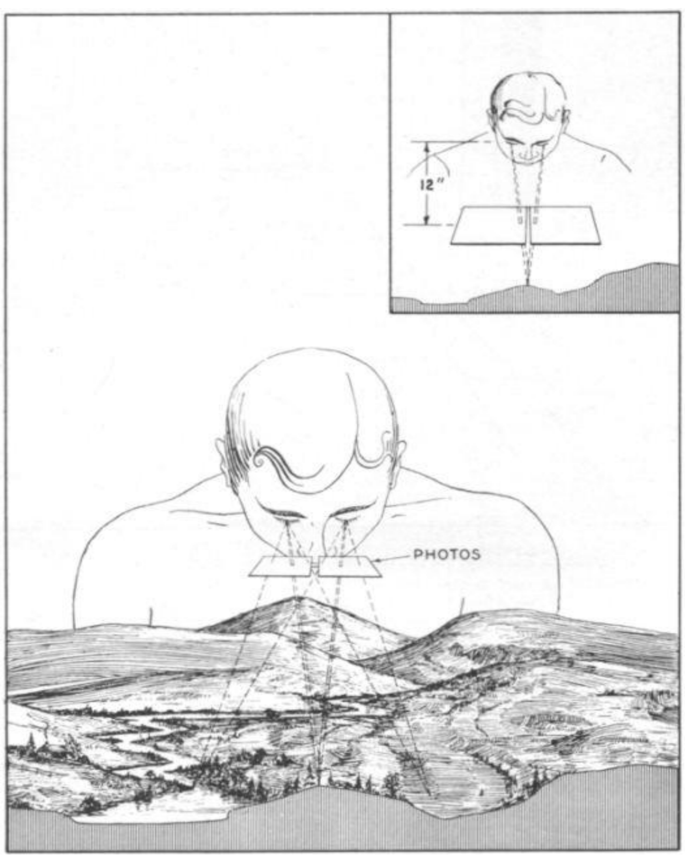
Pb + dP

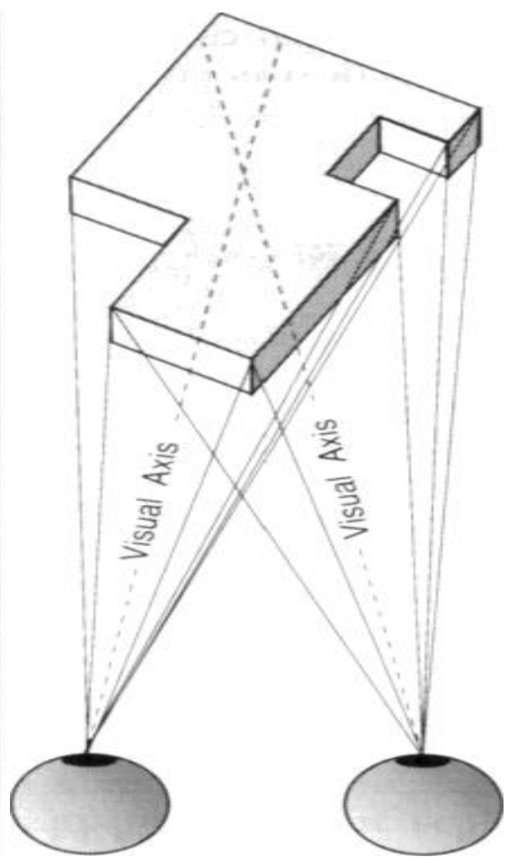
Ho = 4,600 Ft. 0.60 in. = 552 feet

4.40 in. --0.60 in.

The actual height of the Washington Monument is 555 feet. This is a very accurate measurement for this type of exercise. For example, if we had used the nominal

photo scale of 1: 4,800; instead of the corrected 1: 4,600 scale we would have gotten a height of576feet. A 21-foot error as opposed to the3-foot error we did get. It just goes to show that the more time you put in setting up the problem and the more precise the instruments are the better (up to a point) the measurements that you can achieve.





LABORATORY INSTRUCTION MANUAL

Steel Structure Design Sessional

CE(PC)694

DEPARTMENT OF CIVIL ENGINEERING

SILIGURI INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

SILIGURI INSTITUTE OF TECHNOLOGY

Steel Structure Design Sessional

CE(PC)694

CONTACT : 2P
CREDIT :2

LIST OF EXPERIMENTS

EXPERIMENT NO	EXPERIMENT NAME
CE(PC)694/1	Design of a factory shed including preparation of necessary working drawings and report in accordance with CE(PC)604
CE(PC)694/1A	A) PREPARATION OF LAYOUT PLAN OF TRUSS
CE(PC)694/1B	B) LOAD CALCULATION AS PER IS CODE
CE(PC)694/1C	C) DESIGN AND ANALYSIS OF TRUSS
CE(PC)694/1D	D) DESIGN CONNECTION
CE(PC)694/1E	E) PREPARATION OF DRAWING

Q. Determine the design forces in the members of a Fink type roof truss for an industrial building for the following data. Also find the reactions.

- **Overall length of the building- 48 m**
- **Overall width of the building – 16.5 m**
- **Width (c/c of roof columns – 16 m**
- **c/c spacing of trusses – 8 m**
- **Rise of truss – ¼ of span**
- **Self wt. of purlins – 318 N/m**
- **Height of Columns – 11m**
- **Roofing and side coverings – Asbestos cement sheets (dead weight = 130 N/m^2**

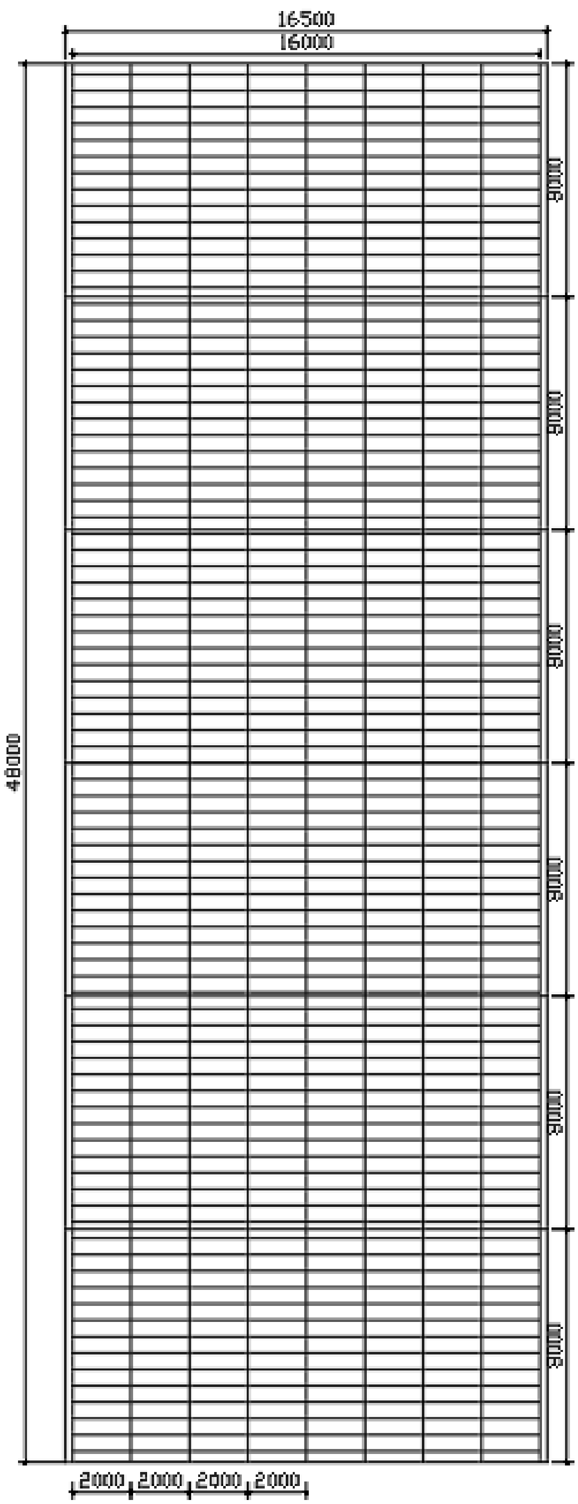
The building is located is in industrial area Naini, Allahabad. Both the ends of the truss are hinged.
Use steel of grade Fe 410

Soln. **Truss configuration**
Let α be the inclination of the roof with the horizontal
tan α= 4/8 = ½
α = 26º34'= 26.566 º
Length of rafter = $\sqrt{16/2^2 + 4^2}$ **= 8.94 m**

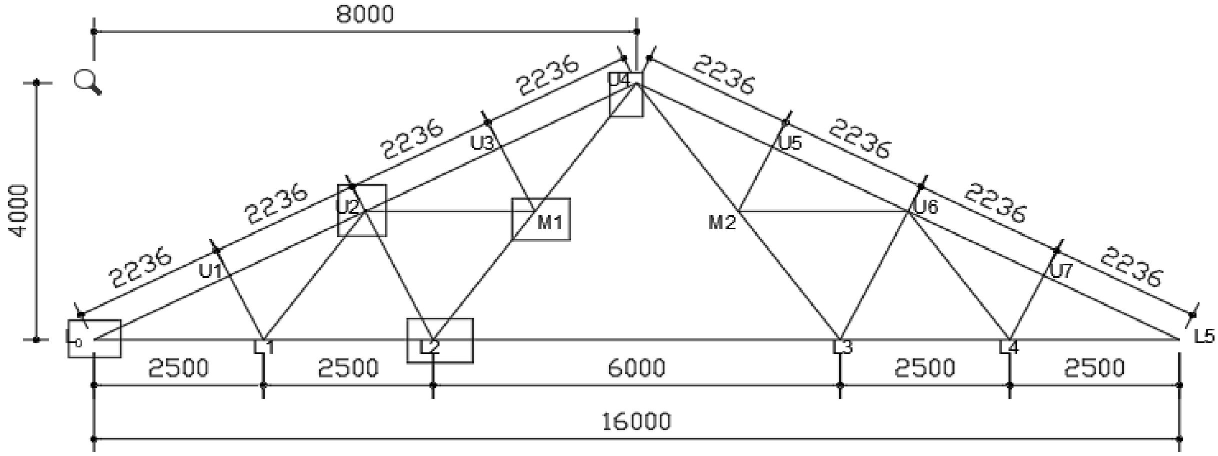
Length of each panel L_0U_1, U_1U_2,U_2U_3,U_3U_4= 8.94/4=2.235 M

EXPERIMENT:1 CE(PC)694/1A

NAME OF EXPERIMENT:- A) PREPARATION OF LAYOUT PLAN OF TRUSS



PLAN VIEW OF TRUSS



TRUSS CONFIGURATION

SHEET -1

EXPERIMENT:2 CE(PC)694/1B

LOAD CALCULATION:-

Plan and inclined area:-
Panel length = 2.235 m

The panel length in plan = 2.235 cos $26^0 34'$ = 2.0 m

I) Plan area = plan spacing of purlin x spacing of truss= 2 x 8 = 16m^2

II) Inclined area = inclined spacing of purlin x spacing of truss = 2.235 x 8 =17.88 m^2

NOW, LOAD CALCULATION :-

A) DEAD LOAD

I) Assume weight of bracing = 12 N/m^2

II) Dead weight of AC sheets = 130 N/m^2

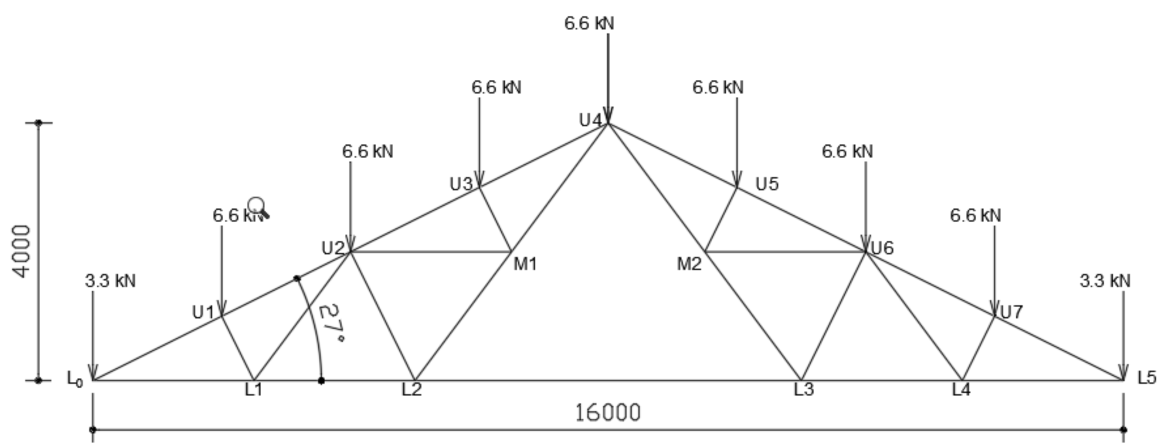
III) Self wt of Purlin = 318N/M = 318 X 8 = 2544 N

IV) Self weight of Roof Truss =(span/3 +5) x 10

= (16/3 + 5) x 10 = 103.33 N/m^2 (empirical formula) = 110 N/m^2

Load on each intermediate panel due to dead load = (wt . of Bracing+wt. of Covering +Truss wt.)X planed area + (wt. of Purlin x spacing of Truss)

Load on each intermediate panel due to dead load = (12+130+110) x (8x2) + 2544
= 6576 N = 6.576 kN = 6.6 kN
Load on end panel points of the rafter =6.6/2 =3.3 kN



DEAD LOAD AT PANEL POINTS

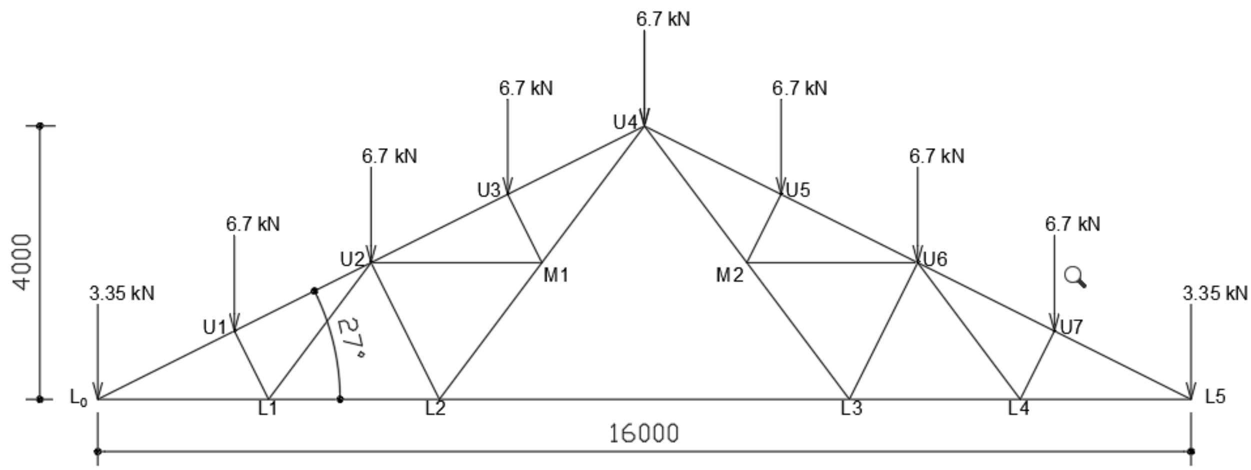
B) LIVE LOAD

α = 26º34'= 26.566 º
Let us assume that no access is provided to the roof. The live load is reduced by 20 N/m2 for each one degree above 10^0 slope

Live load = 750 - {20 x (26.566-10)} = 418.68 N/m^2 [IS:875-Part I Page 14 Table 2 (ii)]

The load on each intermediate panel = 418.68 x 8 x 2 = 6698.88 N = 6700N = 6.7kN

The load on each end panel point = 6700/2 = 3350 N =3.35kN



LIVE LOAD AT PANEL POINTS

C) WIND LOADS IS875 PART III, 2015

6.3 Design Wind Speed (V_z)

The basic wind speed (V_b) for any site shall be obtained from Fig. 1 and shall be modified to include the following effects to get design wind speed, V_z at any height z, for the chosen structure:

a) Risk level,
b) Terrain roughness and height of structure,
c) Local topography, and
d) Importance factor for the cyclonic region.

It can be mathematically expressed as follows:

$$V_z = V_b\, k_1\, k_2\, k_3\, k_4$$

where

V_z = design wind speed at height z, in m/s;

k_1 = probability factor (risk coefficient) (*see* **6.3.1**);

k_2 = terrain roughness and height factor (*see* **6.3.2**);

k_3 = topography factor (*see* **6.3.3**); and

k_4 = importance factor for the cyclonic region (*see* **6.3.4**).

Let us assume the life of the industrial building to be 50 years and the land to be plain and surrounded by small buildings.

K1 = 1.0 (for 50 years) (CLAUSE 6.3.1)

K2 = 0.922 (for terrain category 3, building ht = 11m) (CLAUSE 6.3.2)

K3 = 1.0 (for plain land) (CLAUSE 6.3.3)

K4 = 1.15 (for industrial structure) (CLAUSE 6.3.4)

Vb = 47 m/s

Design Wind Speed , Vz = k1 k2 k3 k4 Vb

= 1.0 x 0.922 x 1.0 x 1.15 x 47 = 49.834 m/s

7.2 Design Wind Pressure

The wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind speed:

$p_z = 0.6\, V_z^2$

where

p_z = wind pressure at height z, in N/m²; and

V_z = design wind speed at height z, in m/s.

The design wind pressure p_d can be obtained as,

$p_d = K_d\, K_a\, K_c\, p_z$

where

K_d = wind directionality factor,

K_a = area averaging factor, and

K_c = combination factor (*see* **7.3.3.13**).

The value of p_d, however shall not be taken as less than 0.70 p_z.

Wind pressure , $p_z = 0.6\ Vz^2 = 0.6 \times 49.834^2 = 1490\ N/m^2 = 1.49\ kN/m^2$

Design wind pressure Pd = kd ka kc p_z

Kd = 0.9 (CLAUSE 7.2.1)

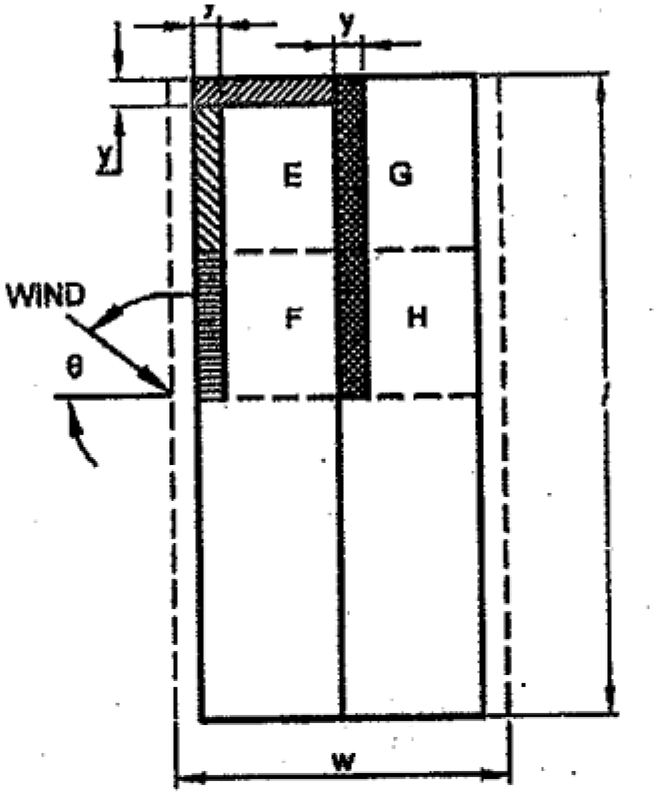
Ka = 0.8 (area>100m²) (CLAUSE 7.2.2)
Kc = 0.9 (CLAUSE 7.3.3.13)

Design wind pressure Pd = kd ka kc p_z = 0.9 x 0.8 x 0.9 x 1.49 = 0.9655 kN/m²
Pd should not less than 0.7 pz = 0.7 x 1.49 = 1.043 kN.m²
Therefore Pd = 1.043 kN/m²

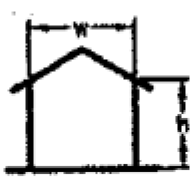
Cpe = external pressure coefficient

Cpi = internal pressure coefficient +0.2 and -0.2 (CLAUSE 7.3.2.1)

Height of building column above ground level , h= 11m
Width of building, w=16m
h/w = 11/16 = 0.6875 (1/2<h/w<3/2) [IS:875: PART 3 PAGE 14]



KEY PLAN

			(0°)		(90°)	
			EF	GH	EG	FH
$\frac{1}{2} \le \frac{h}{w} \le \frac{3}{2}$		0	-0.8	-0.6	-1.0	-0.6
		5	-0.9	-0.6	-0.9	-0.6
		10	-1.1	-0.6	-0.8	-0.6
		20	-0.7	-0.5	-0.8	-0.6
		30	-0.2	-0.5	-0.8	-0.8
		45	+0.2	-0.5	-0.8	-0.8
		60	+0.6	-0.5	-0.8	-0.8

F = (Cpe-Cpi) Pd x A

Wind angle	Pressure coefficient			Cpe-Cpi		Wind load (F)	
A=26.566	EF Cpe GH		Cpi	windward	leeward	windward	leeward
case	Windward	Leeward					
Normal to eave strut (0°)	-0.372	-0.5	+0.2	-0.572	-0.7	-10.72	-13.05
	-0.372	-0.5	-0.2	-0.172	-0.3	-3.2	-5.594
Normal to ridge strut (90°)	-0.8	-0.731	+0.2	-1.0	-0.931	-18.648	-17.36
	-0.8	-0.731	-0.2	-0.6	-0.531	-11.18	-9.90

The calculation of critical wind loads on panel points are as follows:

i) Windward side

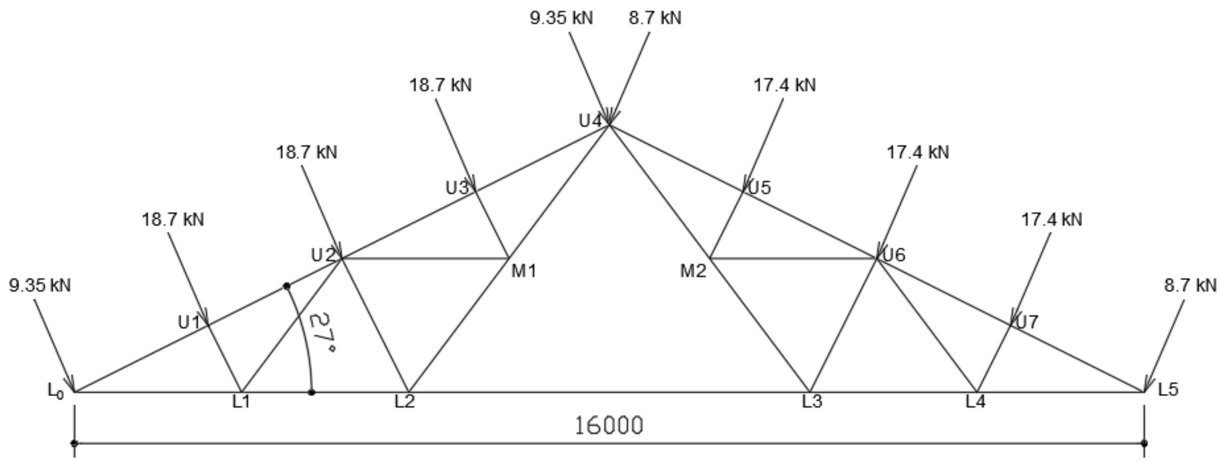
F1= (Cpe-Cpi) Pd x A = (-0.8 -0.2) x 1.043 x (8 x 2.235) = -18.65 = -18.7 kN (intermediate panel points)

F2 = -18.7/2 = 9.35 kN (end panel points)

ii) Leeward side

F1= (Cpe-Cpi) Pd x A = (-0.731 -0.2) x 1.043 x (8 x 2.235) = -17.36 = -17.4 kN (intermediate panel points)

F2 = -17.4/2 = -8.7 kN (end panel points)



WIND LOAD AT PANEL POINTS

EXPERIMENT:3 CE(PC)694/1C

DESIGN AND ANALYSIS OF TRUSS:- USING STAADPRO SOFTWARE

1. STEP 1 (Creation of Geometry):
2. New Project → Select Plane → Length =meters; Force=KN;
3. File Name=SPACE → Next
4. By using node and beam prepare truss model according to drawing
5. STPE 2 (Member Properties):
6. Select the member → From Main menu → Commands → Member Property → section database → Indian →select section → Assign → Close.
7. De select the member.
8. STEP 3 (Supports):
9. Change to Node cursor (joint) and select the nodes (joints).

10. (If more than one node use CTRL key and select the nodes) → From Main menu → Commands → Support specification → fixed → Assign → Close → De select the nodes and change to beam cursor.
11. STEP 4 (Loading):
12. From Main menu → Commands → Loading → Primary Load → Load case 1 → Add → Close → Select Load case 1(DL) → Add → Self Wt → Factor -1→Add →Member Load → Concentrated Force → value → Add,
    Load case 2 → Add → Close → Select Load case 2(LL) → Add → Member Load → Concentrated Force → value → Add
    Load case 3 → Add → Close → Select Load case 3(WL) → Add → Member Load → Concentrated Force → value → Add
13. Select the Load self wt →Assign to selected beam→ Assign→OK.
14. Select the Load→ Assign to selected node → Assign → OK.

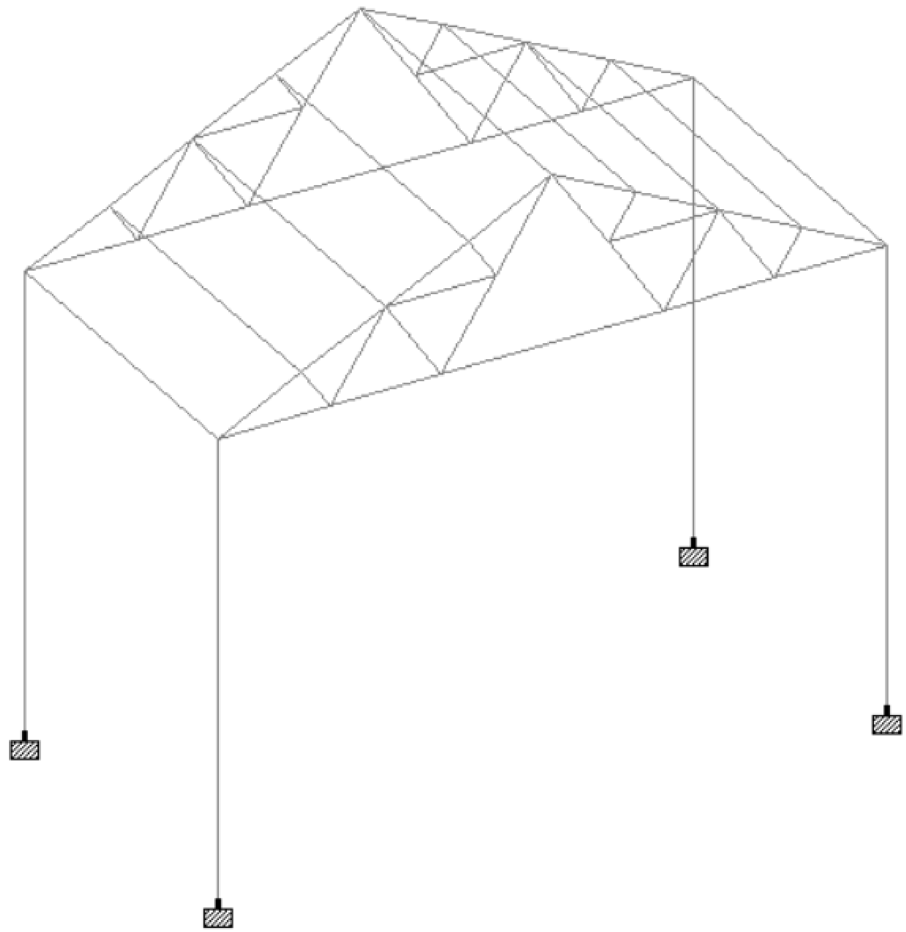
15. STEP 5(Analysis):
16. From Main menu → Commands – Analysis → Perform Analysis → ⊙ No print → OK.

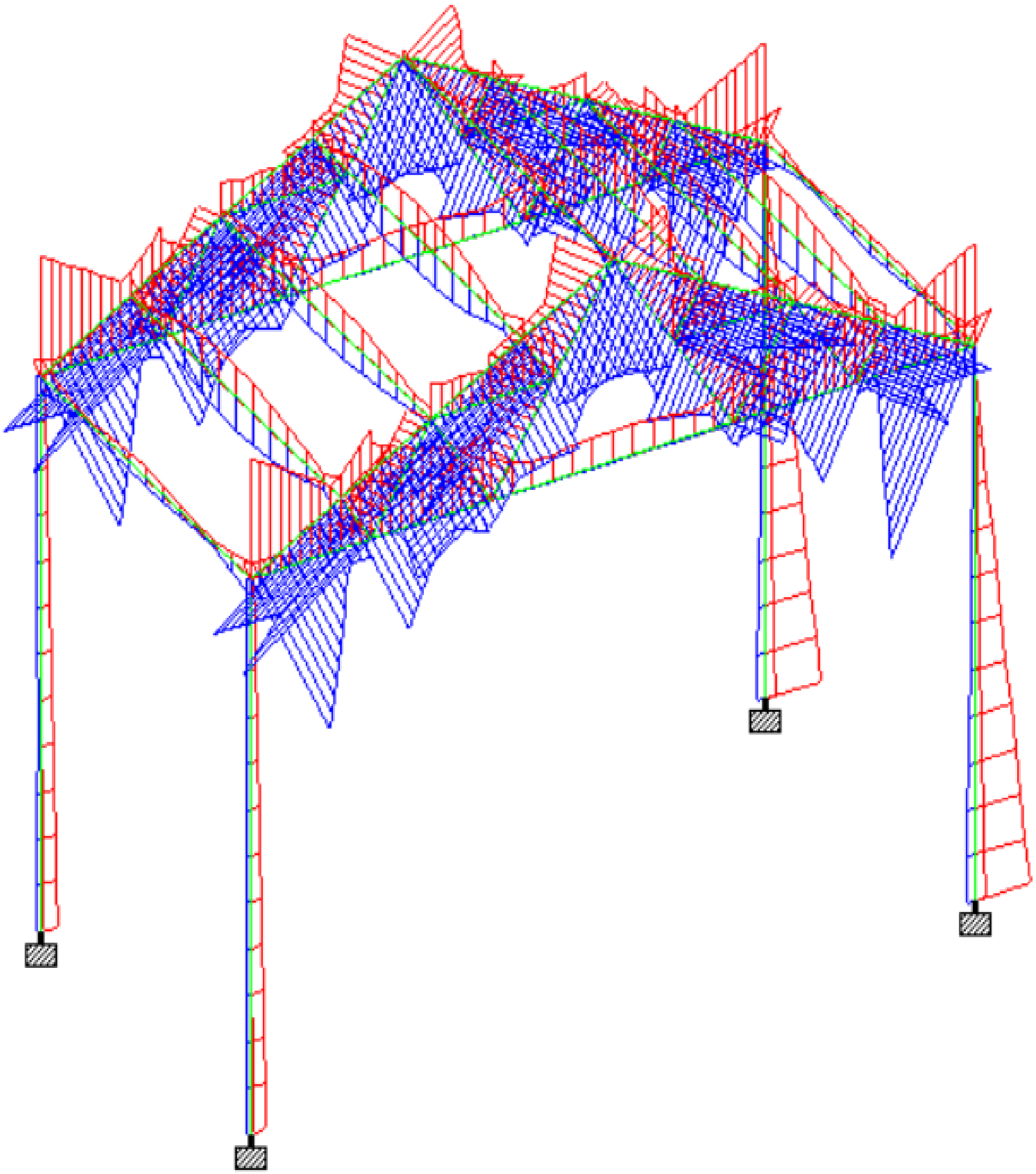
17. STEP 6 (Post Analysis Print):
18. From Main Menu → Commands → Post Analysis Print → Support Reactions →
19. ⊙ To view → OK.

20. STEP 7(Design) :
21. From Main menu → Commands → Design → steel Design → Current code=IS 800 → Select the member → Define parameters→ fyld =250000 select→ fyld→assign to view
22. Commands (Steel Design) → check code → Assign to view→ select→ assign to view→ select optimized→assign to view → Take off → Assign to view→ Close.
23. Note: Save the File and Run the Program.

24. STEP 8 (Analysis):

25.From Main Menu → ` Analysis → Run Analysis → Run Analysis → Done.

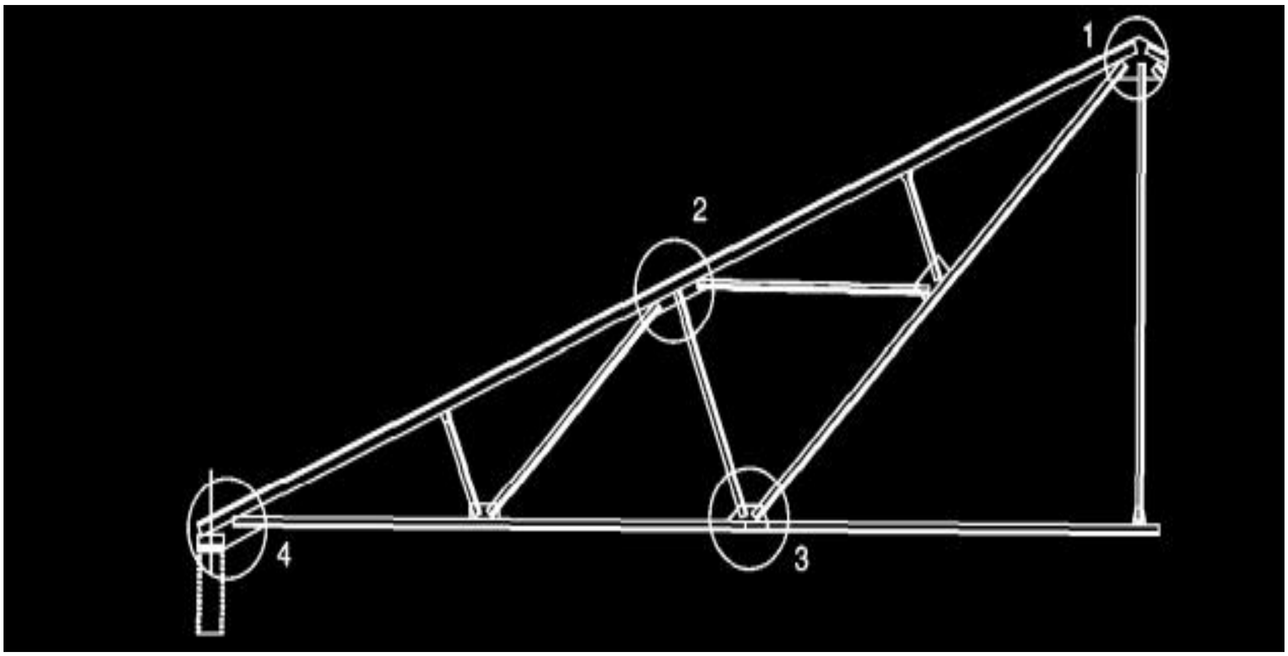




Load 4 : Beam Stress : Bending Z : Displacement

EXPERIMENT:4 CE(PC)694/1D

Design Connection and Prepare Working Drawing



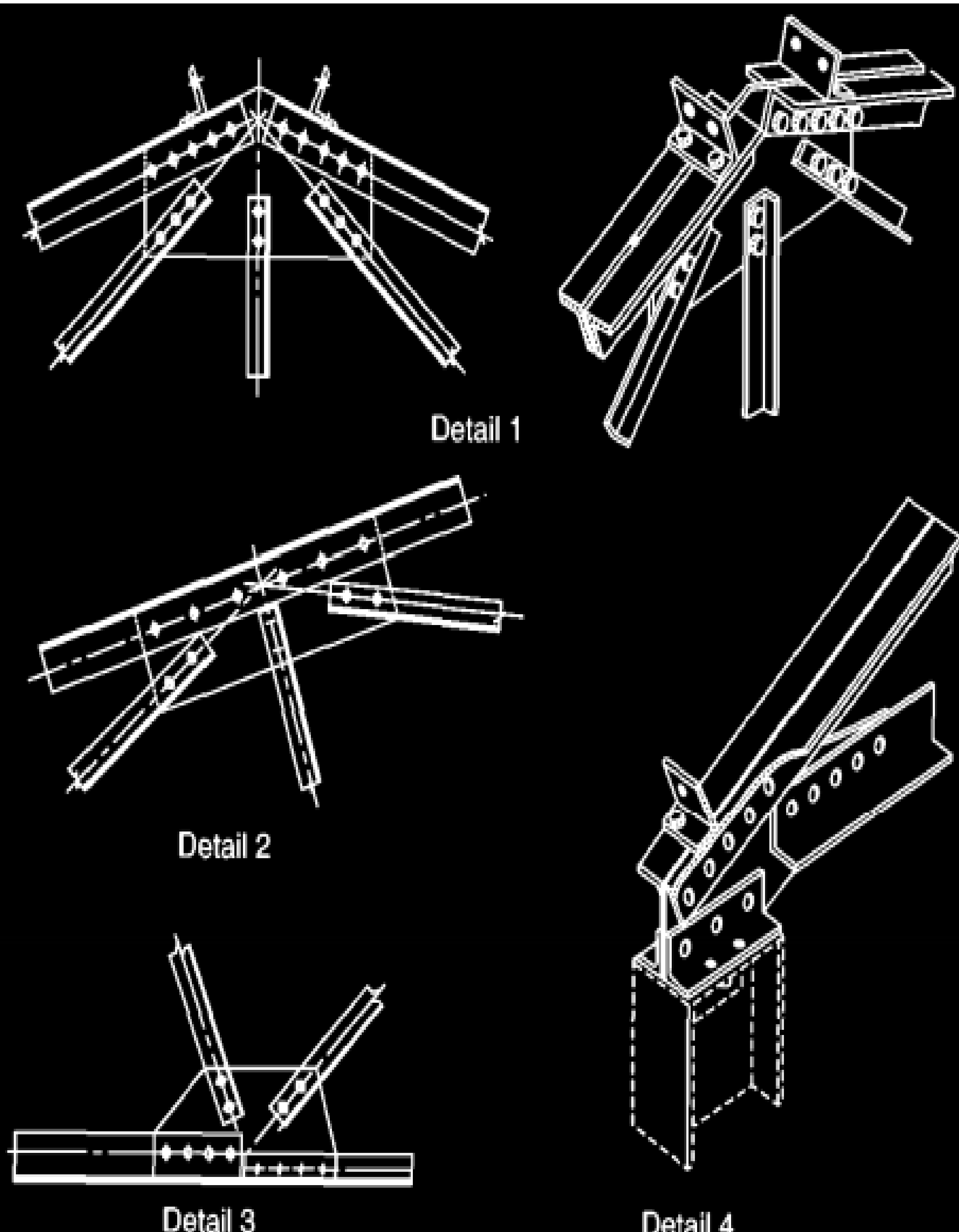


Fig. 12.14 Connections of bolted fink roof trusses

EXPERIMENT NO. CE(ES) 491/1

NAME: Determination of Orifice co-efficient.

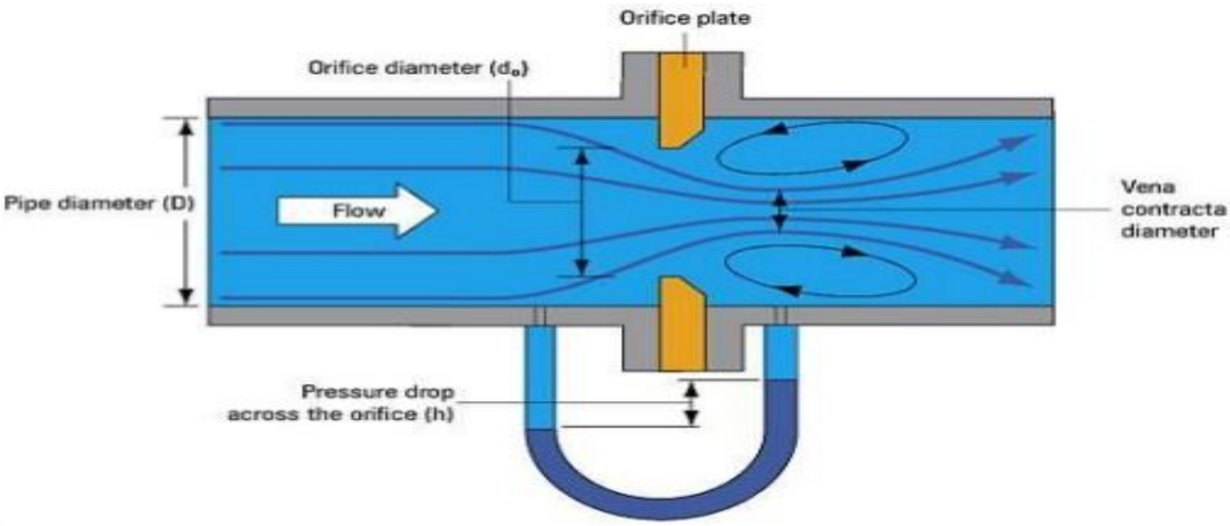
APPARATUS:

Orifice meters are widely used for determination of flow of fluid. While using the orifice meters their calibration is important. The equipment enables to determine the co-efficient of discharge of orifice meter.

SPECIFICATIONS:

1. Supply pipe of Φ 25 mm. (1'') connected to inlet manifold.
2. Orifice meter size inlet Φ 25mm and throat Φ 15 mm.
3. Differential mercury manometer tapings provided at inlet and throat of orifice meter. Manometer size 50 cm height. Measuring tank size 300mm x 300mm x 450mm height.

DIAGRAM:



EXPERIMENTAL PROCEDURE:

Before starting the experiment, please see that;

1) The pressure relief valves above the manometer tubes are fully open.
2) The pressure valves of both the meters are fully closed.
3) The drain valve of the measuring tank and the gate valve of the meter (say orifice meter) which is to be calibrated are kept open while that of the gate valve of the other meter is kept fully closed. Now, start the flow.
4) Open the manometer pressure cocks of the orifice meter. Let the water flow through the pressure relief valves above the manometer. Remove all the air bubbles and then close both the pressure relief cocks slowly and

simultaneously so that mercury does not get lifted out from the manometer. Observe the mercury head difference in the manometer.

5) Close the gate valve of measuring tank and measure the time required for 10 cm rise of the water in the measuring tank. Repeat the procedure by changing the discharge

OBSERVATION TABLE:

SL. NO.	TYPE OF METER	MANOMETER DIFFERENCE h (m)	TIME FOR 10CM RISE IN MEASURING TANK. (SEC)
1.	ORIFICE METER		
2.			
3.			

CALCULATIONS:

1) Actual discharge, $Q_a = \frac{0.3x0.3x0.1}{t}$
2) Theoretical discharge,
   For Orifice meter,
   $Q_{th2} = C_{orifice}\ (2.g.h)^{0.5}\ m^3/s$
   $Q_{th2} = 0.00378\ x\ (h)^{0.5}\ m^3/s$
3) Co-efficient of discharge $C_d = \frac{Qa}{Qth}$

PRECAUTIONS:

1) Operate manometer valve gently while removal of air bubble so that mercury in manometer does not get lifted out from the manometer.
2) Drain all the water from the sump tank after completion of the experiment.

CONCLUSION:

1) Calibrated values of co-efficient of discharge for Orifice meter is……………..

EXPERIMENT NO. CE(ES) 491/2

NAME: Determination of efficiency of a Centrifugal pump.

APPARATUS:

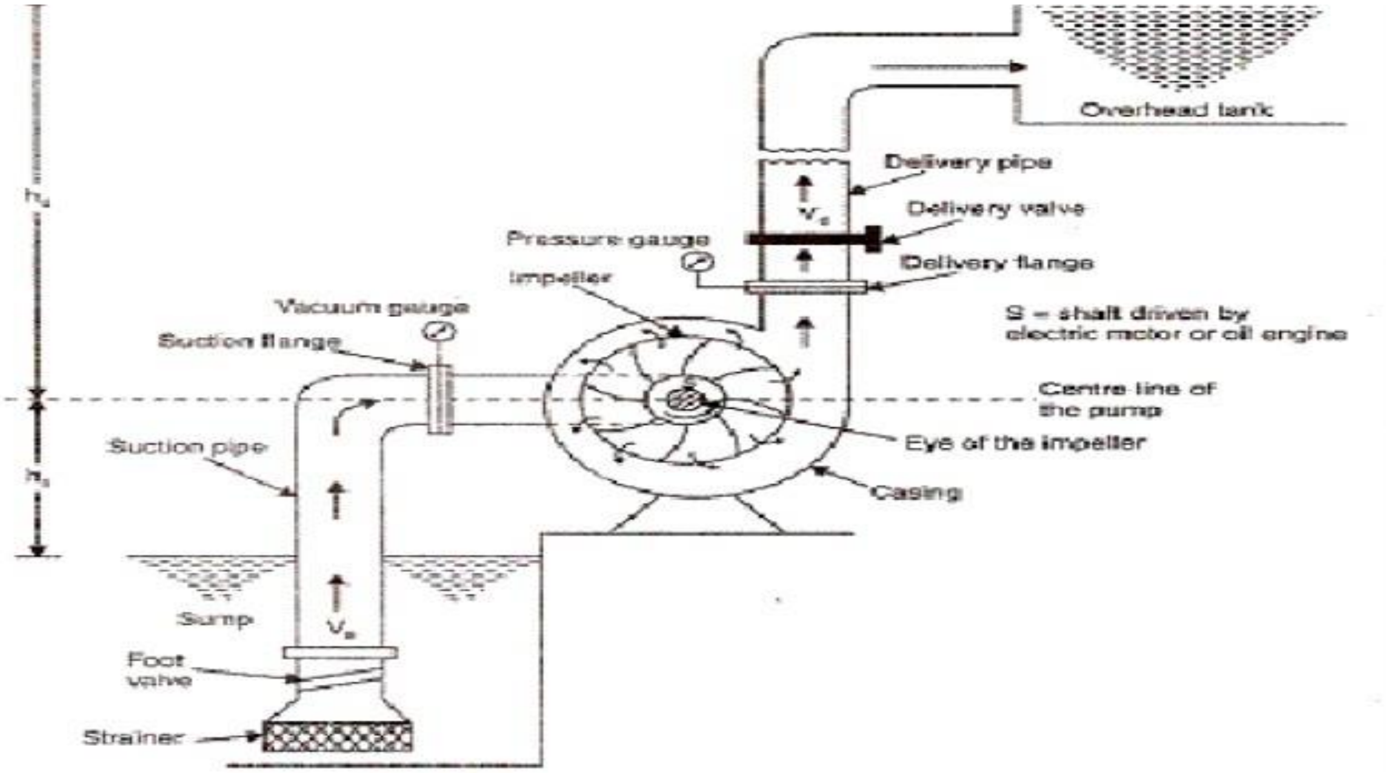
Centrifugal pump is a roto dynamic machine which develops dynamic pressure of liquid by virtue of rotation for pumping of liquid to a higher height. In centrifugal pump, liquid in the impeller of a pump is made to rotate by external force, so that it is thrown away from the centre of rotation. As constant supply of liquid is made available at the centre, liquid can be pumped to higher level.

The unit consists of a centrifugal pump driven by a A.C motor. Input to motor is measured by energy meter. A measuring tank is provided to measure the discharge. Suction vacuum and discharge pressure is measured by gauges. A gate valve on discharge pipe varies the head. Thus, performance of pump can be estimated at various speed and heads.

SPECIFICATIONS:

1) Centrifugal pump – 25 x 25 mm. size, base mounted, maximum head 10 meters, maximum discharge 84 lpm at 2700 rpm.
2) Motor: - A.C 1 HP, 3ph. Induction motor.
3) Measuring tank 300 x 300 x 450 mm. height, fitted with gauge tube and drain valve.
4) Sump tank 900 x300 x400 mm. height.
5) Gate valve to control the head.
6) Pressure gauge to measure discharge pressure.
7) Vacuum gauge to measure suction vacuum.
8) Energy meter to measure input the motor.

DIAGRAM:



EXPERIMENTAL PROCEDURE:

1) Fill up sufficient water in the sump tank.
2) Open the priming cock (fitted on the delivery pipe) and fill up water upto the funnel. Close the cock properly.
3) Shut off the discharge valve.
4) Start the pump. As discharge valve is closed, no discharge will be observed, but discharge pressure will be indicated. This is called 'shut off head' of the pump.
5) Slowly open the discharge valve, so that the small discharge is observed.
6) Note down discharge head, suction vacuum, time required for 10 cm rise in the measuring tank, 10 impulses of energy meter.
7) Note down the observations at different valve openings.

OBSERVATION TABLE:

SL. NO.	DISCHARGE PR. KG/CM^2	SUCTION VACUUM 'mm of hg'	TIME FOR 10 CM RISE OF WATER 'sec'	TIME FOR 10 imp. OF ENERGY METER 'sec'
1.				
2.				
3.				

CALCULATIONS:

1) Discharge pressure, $\mathbf{P_d}$ **= ………………..kg/cm^2**
   For water, 10 m height corresponds to 1 kg/cm^2
   So, discharge head $\mathbf{h_d = P_d \times 10\ m}$ of water.
2) Suction vacuum, $\mathbf{P_s}$ **= …………….mm of Hg.**
   So, suction head, $\mathbf{h_s = \frac{Ps}{1000} \times \frac{13.6}{1}}$
   Where,
   Sp. Gravity of hg = 13.6
   Sp. Gravity of water = 1
3) Total Head, $\mathbf{h_t = h_d + h_s + h_f}$
   Where, $\mathbf{h_f = 2}$ **mtr**. Is the assumed head loss due to friction.
4) Discharge:
   Let time for 10 cm rise of water in measuring tank be 't' sec.
   Then,
   Discharge, $\mathbf{Q = \frac{0.3 \times 0.3 \times 0.1}{t}}$ **m^3/sec.**
5) Output power (or water power), $\mathbf{W_p = \frac{W.Q.ht}{1000}}$ **KW**
   Where,
   W = Specific weight of water = 9810 N/m^3
   Q = Discharge m^3/sec.
   H_t = Total head m.
6) Electrical input:
   Let time required for 10 blinks of energy meter be t_e sec.
   Electrical input power, $\mathbf{IP = \frac{10}{te} \times \frac{3600}{1600}}$ **KW**.
   Taking motor efficiency as 74% we have input shaft power.
   So, **SP = IP x 0.74**
7) Overall efficiency of the pump:
   So, $\eta_o = \mathbf{\frac{WP}{SP} \times 100\%}$

PRECAUTIONS:

1) Priming is must before starting the pump. Pump should never run dry.
2) Use clean water in the sump tank.
3) Use all the controls and switches carefully.
4) Do not disturb the pressure gauge connections.
5) Drain all the water from the sump tank after the experiment is complete.

EXPERIMENT NO. CE(ES) 491/3

NAME: Determination of efficiency of a Reciprocating pump.

APPARATUS:

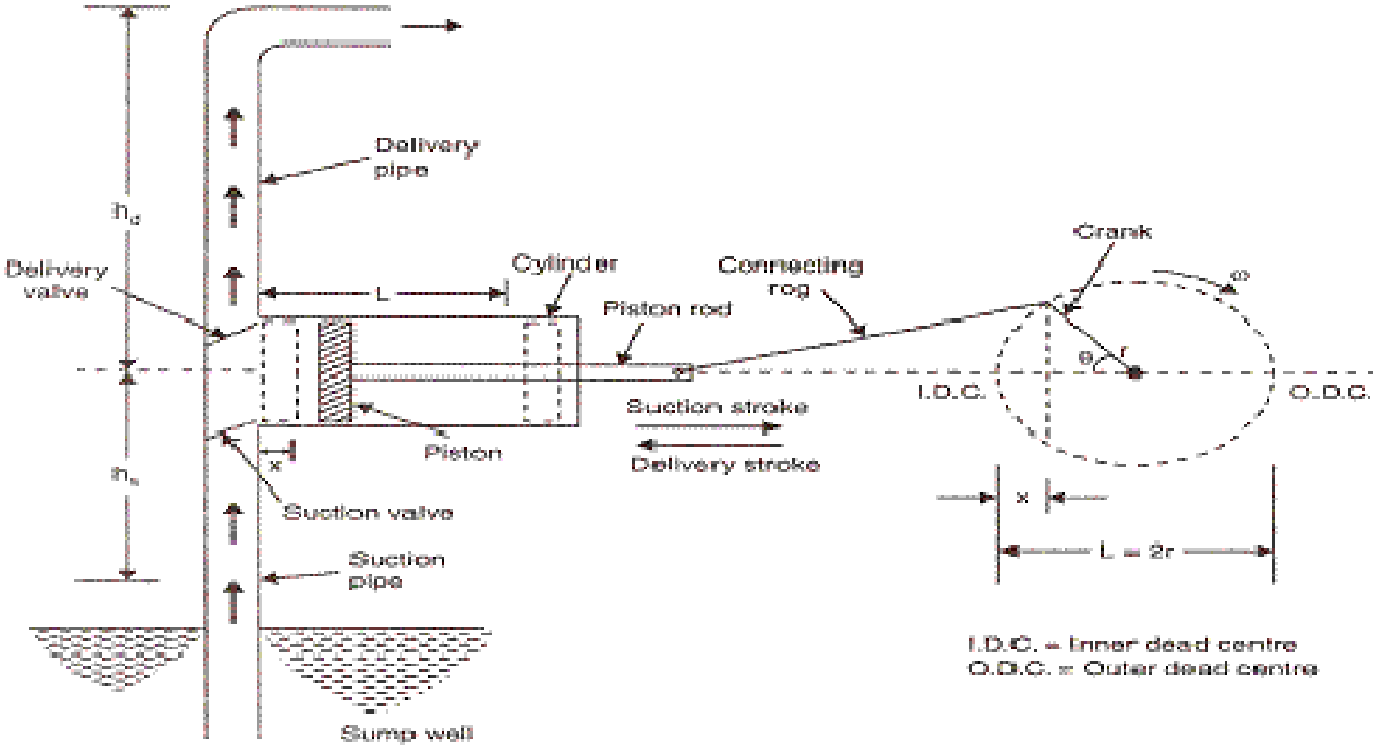
Reciprocating pump is a positive displacement pump. It is often used where relatively small quantity of water is to be handled and delivery pressure is quite large. Reciprocating pump is widely used as automobile service stations, chemical industries or as metering and dosing pumps.

The apparatus consists of a triple cylinder, single acting reciprocating pump mounted over the sump tank. The pump is driven by A.C motor with stepped cone pulley. An energy meter measures electrical input to motor. Measuring tank is provided to measure discharge of the pump. The pressure and vacuum gauges provided to measure the delivery pressure and suction vacuum respectively.

SPECIFICATIONS:

1) Reciprocating pump Φ 55 mm bore, stroke length 40 mm, single acting with air vessel on discharge side, triple cylinder.
2) A.C motor, 1 HP, speed variations controlled by a stepped cone pulley.
3) Measuring tank 300 x 300 x 450 mm height provided with gauge tube.
4) Sump tank of sufficient capacity.
5) Measurements.
   a) Pressure gauge for discharge pressure.
   b) Vacuum gauge for suction vacuum.
   c) Energy meter for motor input measurement.

DIAGRAM:



EXPERIMENTAL PROCEDURE:

1) Fill up sufficient water in sump tank.
2) Open the gate valve in the discharge pipe of the pump fully.
3) Close the drain valve of the measuring tank.
4) Check the nut bolts & the driving belt for proper tightening.
5) Start the pump & slightly close the discharge valves. Note down the various readings in the observations table. Repeat the procedure for different gate valves opening.
   Take care that discharge pressure does not rise above 3 kg/cm^2.
   For this being a reciprocating pump, the suction vacuum reading will continuously oscillate from zero to maximum for a particular valve setting (zero for delivery stroke end position and max for suction stroke end position). So it's needed to take the average value in between those two.
6) Change the speed and take readings for different gate valve openings. Repeat the procedure for different speeds and complete the observation table.

OBSERVATION TABLE:

SL. NO.	DISCHARGE PRESSURE kgs/cm2	SUCTION VACUUM mm of hg	TIME FOR 5cm RISE IN MEASURING TANK, 't' SEC	TIME FOR 10 BLINKS OF ENERGY METER 'te' SEC
1.				
2.				
3.				

CALCULATIONS:

1) Suction head
   H_s = Suction vacuum of Hg x (ρHg-ρw)
   Where,
   ρHg = Sp. Gravity of mercury = 13.6
   ρw = Sp. Gravity of water = 1
   So, H_s = suction vacuum mtrs. X 12.6
2) Delivery head
   H_d = Discharge pressure in kg/cm2 x 10
   (as 10 m of water = 1 kg/cm^2)
3) Total head
   $H_t = H_s + H_d + 3$ mtrs.
   Where,
   Loss of head in piping and fittings is assumed to be 3 mtrs.
4) Actual discharge
   $Q_a = \frac{0.3 \ x\ 0.3\ x\ 0.05}{t}$ m^3/sec
5) Output power of pump
   $Pw = \frac{W.Qa.Ht}{1000}$ Kw
   Where,
   W = Specific weight of water = 9810 N/m^3
   Q_a = Discharge m^3/sec
   H_t = Total head m.
6) Electrical input:
   Let time required for 10 blinks of energy meter be t_e sec.

Electrical input power, **IP** = $\frac{10}{te}$ **x** $\frac{3600}{1600}$ **KW**.
Taking motor efficiency as 74% we have input shaft power.
So, **SP = IP x 0.74**

7) Overall efficiency of the pump:
So, $\eta_o = \frac{WP}{SP}$ **x 100%**

PRECAUTIONS:

1) Priming is must before starting the pump. Pump should never run dry.
2) Use clean water in the sump tank.
3) Use all the controls and switches carefully.
4) Do not disturb the pressure gauge connections.
5) Drain all the water from the sump tank after the experiment is complete.

EXPERIMENT NO. CE(ES) 491/4

NAME: Determination of efficiency of a Pelton wheel turbine.

APPARATUS:

Hydro-power is one of major cheap source of power available on earth and hence it is widely used for generation of electric power worldwide. Water stored in the dam contains potential energy. The water flows through the turbine so that power is generated by impact of water or reaction power. Thus, turbines are of great importance.

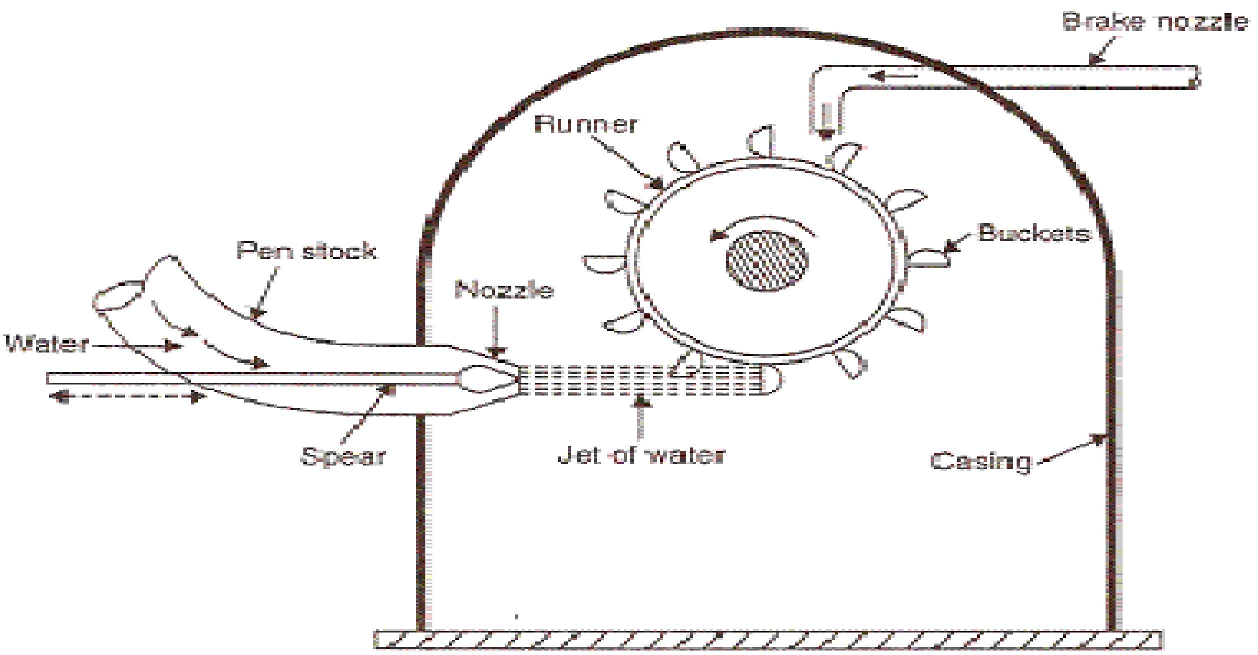
Turbines are basically of two types, impulse turbines and reaction turbines. In impulse turbines, water coming from high head acquires high velocity. The high velocity water jet strikes the buckets of the turbine runner and causes it to rotate by impact. In reaction turbine, total head of water is partly converted into velocity head as it approaches turbine runner and it fills the runner and pressure of water gradually changes as it flows through runner. In impulse turbine, the only turbine used now-a-days is Pelton wheel turbine. In reaction turbines, Francis turbine and Kaplan turbine are the examples.

The Pelton wheel turbine consists of runner mounted over the main shaft. Runner consists of buckets fitted to the disc. The buckets have a shape of double ellipsoidal cups. The runner is encased in a casing provided with a Perspex window for visualization. A nozzle fitted in the side of casing directs the jet over the ‘Splitter’ or centre ridge of the buckets. A spear operates inside the nozzle to control the water flow. On the other side of the shaft, a rope brake is mounted for loading the turbine.

SPECIFICATIONS:

1) Turbine power – 1 h.p, speed 600 rpm, fitted with 18 no of buckets, mounted over the sump tank provided with nozzle and spear.
2) Pump – 1.5 h.p monoblock pump, provided with D.O.L starter.
3) Measurement – a) Orifice meter with pressure gauges for discharge measurement.
   b) Rope brake pulley dia. 0.294 m. with spring balance & belt thickness 6mm.
   c) Pressure gauge to note down the pressure.

DIAGRAM:



EXPERIMENTAL PROCEDURE:

1) Fill up sufficient water in the sump tank.
2) Close nozzle by operating the spear. Press ‘green’ button of starter, so that pump starts running.
3) Observe direction of pump rotation during starting. It should be clockwise, as seen from fan end. If it is reverse, interchange any two phases in supply line.
4) Slowly close the bypass valve. Turbine will start rotating.
5) Load the brake drum to about 1 kg. Note down the readings in observation table.
6) Repeat the procedure for different loads and flows.

OBSERVATION TABLE:

SL. NO.	SPRING BALANCE DIFF. (kg)	PRESSURE GAUGE DIFF. (kg/cm^2)	TURBINE SPEED, N (rpm)
1.			
2.			
3.			

CALCULATIONS:

1) Head over the turbine,
   H = Pressure gauge reading kg/cm^2 x 10 mtr.
   Avg. pressure of Orifice out let & inlet x 10 mtr.
   Since 10 m of water head corresponding to 1 kg/cm^2
2) Water flow rate,
   Q = C_d x$\frac{\pi}{4} x d^2 \sqrt{2gh}$ m^3/sec
   Where,
   C_d = Co-efficient of discharge = 0.64
   h = Pressure head across Orifice meter.
   = Pressure gauge difference (H) x 10 m of water.
   d = Orifice Diameter= Pipe diameter x 0.5 (Pipe dia= 60mm)
3) Power supplied to turbine,
   Pin = WQH x 9.81 watts
   Where,
   W = Specific weight of water = 1000 kg/m^3
4) Break power,
   T = (spring balance diff. kgs) x 9.81 x 0.0825 N.m
   Break power = $\frac{2\pi NT}{60}$ $watts$
   Note – i) Turbine speed is to be noted from laboratory tachometer.
5) Overall efficiency of turbine,
   $\eta = \frac{BP}{P_{in}} x\ 100$ %

PRECAUTIONS:

1) While putting ‘ON’ the pump see that the nozzle is closed by the spear and load on the break drum is released.
2) Use clean water in the tank.
3) Operate all the controls and switches gently.
4) Lubricate the bearings, before experiment.
5) Drain the water after completion of experiment.

EXPERIMENT NO. CE(ES) 491/5

NAME: Measurement of velocity of water in an open channel using a Pitot tube.

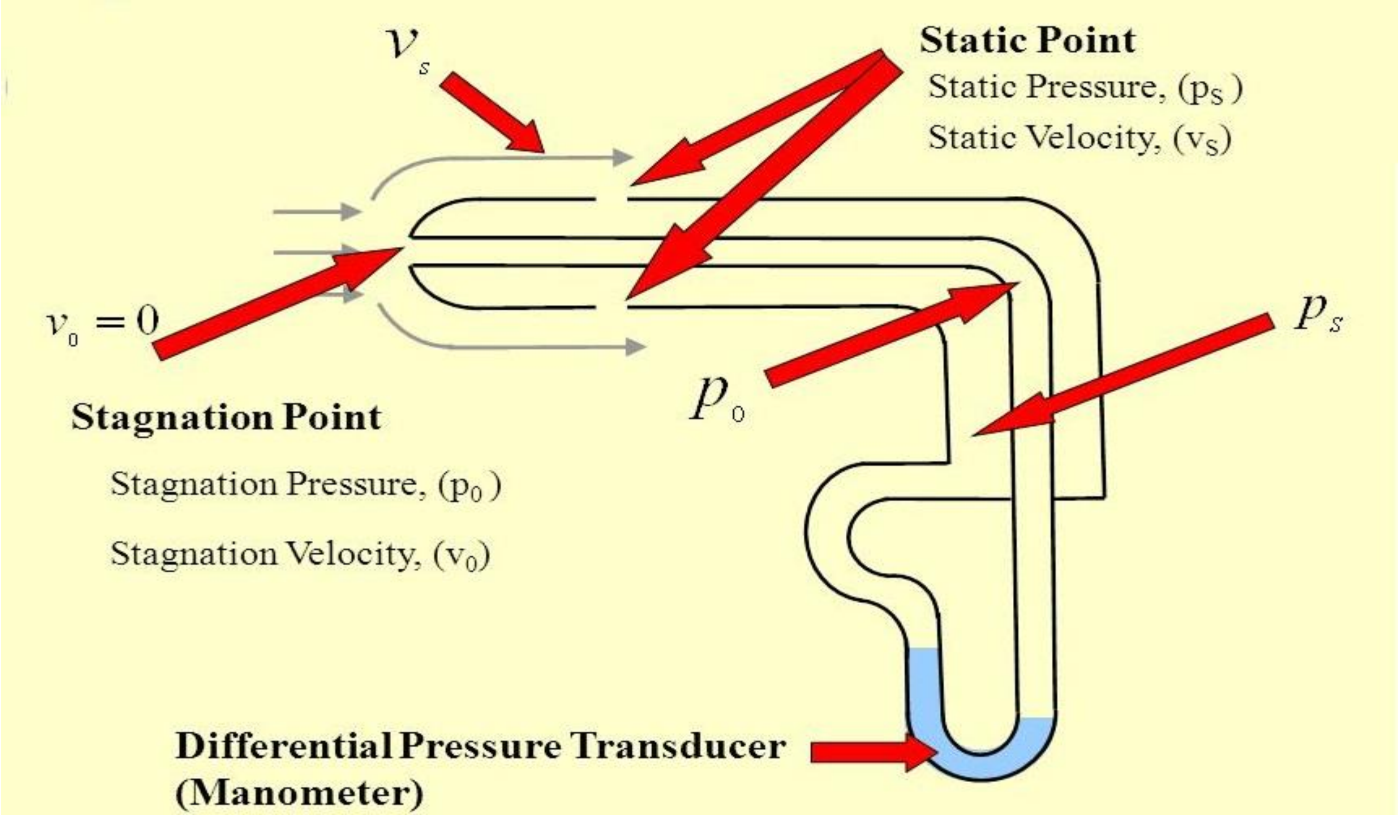
APPARATUS:

Pitot tube is a small 'L' shaped tube, with both end open. The bend side portion is inserted in the pipe line & the other end is kept open to the atmosphere. This end may be connected to a sensitive manometer to measure the head in that plan i.e. path of flow. From this head we can find out the velocity of flow.

SPECIFICATIONS:

A Pitot tube made up of small SS tube is held in a pipe line. The open end is connected to a manometer.

DIAGRAM:



PROCEDURE:

1) Start the flow of air by starting the blower.
2) Then connect the open end of Pitot tube to the manometer.
3) The liquid in the manometer will be displaced due to pressure head in the pitot tube. Note down the reading or deflection of manometer.
4) Enter the readings in observation table.

OBSERVATION TABLE:

SL. NO.	VALVE OPENING	MANOMETER READING	DIFFERENCE ‘h’ IN mm.
1.	Full		
2.	Medium		
3.	Zero		

CALCULATIONS:

The last reading or reading no. 3, there will not be any difference observed on the manometer. For other readings we get difference on the manometer.

Difference is say ‘h’

So, velocity of fluid, **v** = $\sqrt{(\mathbf{2}.\boldsymbol{g}.\boldsymbol{h})}$

Where,

h =……………… in cm.

g = 981 cm/sec

PRECAUTION:

1) Operate the screw assembly very carefully.
2) Do not press the Pitot tube otherwise it is likely to be damaged.

ALLOCATION OF MARKS:

<table>
<tr><th>INTERNAL</th><th>EXTERNAL</th></tr>
<tr><td>40 MARKS</td><td>60 MARKS</td></tr>
<tr><td>Attendance (10)</td><td>Lab Examination (40)</td></tr>
<tr><td>Performance (20)</td><td rowspan="2">Viva voice (20)</td></tr>
<tr><td>Report submission (10)</td></tr>
<tr><td colspan="2">Grand total = 100</td></tr>
</table>

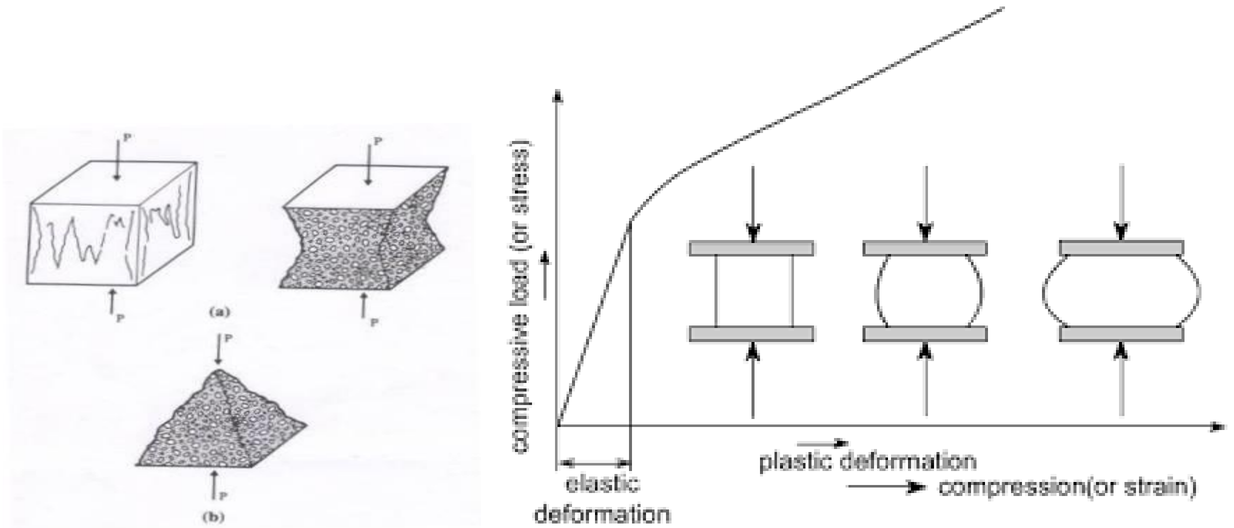
EXPERIMENT NO. CE(ES) 492/1

NAME: Determine compressive strength of brick & concrete cube.

APPARATUS:

Bricks, Measuring tape & UTM.

DIAGRAM:



THEORY :

Bricks are used in construction of either load bearing walls or in portion walls incase of frame structure. In bad bearing walls total weight from slab and upper floor comes directly through brick and then it is transverse to the foundation. In case the bricks are loaded with compressive nature of force on other hand in case of frame structure bricks are used only for construction of portion walls, layers comes directly on the lower layers or wall. In this case bricks are loaded with compressive nature of force. Hence for safely measures before using the bricks in actual practice they have to be tested in laboratory for their compressive strength.

EXPERIMENTAL PROCEDURE:

Before starting the experiment, please see that;

1) At first, on the main switch of the machine and on the switch of computer which is connected with the machine.
2) Take a brick specimen.
3) Measure the dimensions of the brick.
4) Then, put the brick on the operation table on the under the movable jaw.
5) Move up and down the middle cross head according to necessity.
6) Then, open the computer program.
7) Make a new file according to your experiment and put the all types of data about the specimen.
8) Take the program on 'comport' position by selecting the given option on the computer screen. But not click on the start button.

9) Close the relief valve on controlling unit.
10) Switch on the pump and watch the load changing on the controlling unit screen. When the load changing will stop then switch off the pump.
11) After that, click on **STOP, TARE, ENTER** and **START** button.
12) After clicking the **START** button on controlling unit, immediately click on the **START** button also on computer screen.
13) Switch on the pump.
14) Then watch the experiment on the machine and follow the graph on the computer screen.

OBSERVATION TABLE:

SL.NO.	L X B X H mm^3	Area L X B mm^3	Load (N) (P)	Compressive Strength P/A(N/mm^2)

CALCULATIONS:

$$\text{Compressive Strength} = \frac{\text{Max. Load at failure}}{\text{Loaded Area of brick}}$$

PRECAUTIONS:

1) Measure the dimensions of Brick accurately.
2) Specimen should be placed as for as possible in the lower plate.
3) The range of the gauge fitted on the machine should not be more than double the breaking load of specimen for reliable results.

CONCLUSION:

The average compressive strength of new brick sample is found to be ………. (N/mm^2)

EXPERIMENT NO. CE(ES) 492/2

NAME: Study the UTM and perform the tensile test on H.Y.S.D bar.

APPARATUS:

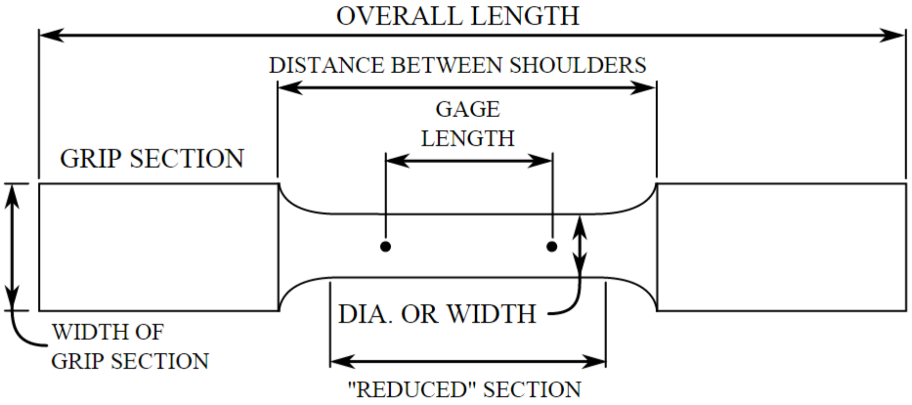
1. Universal Testing Machine,
2. Mild steel specimen,
3. Vernier caliper/micrometer,
4. Dial gauge.

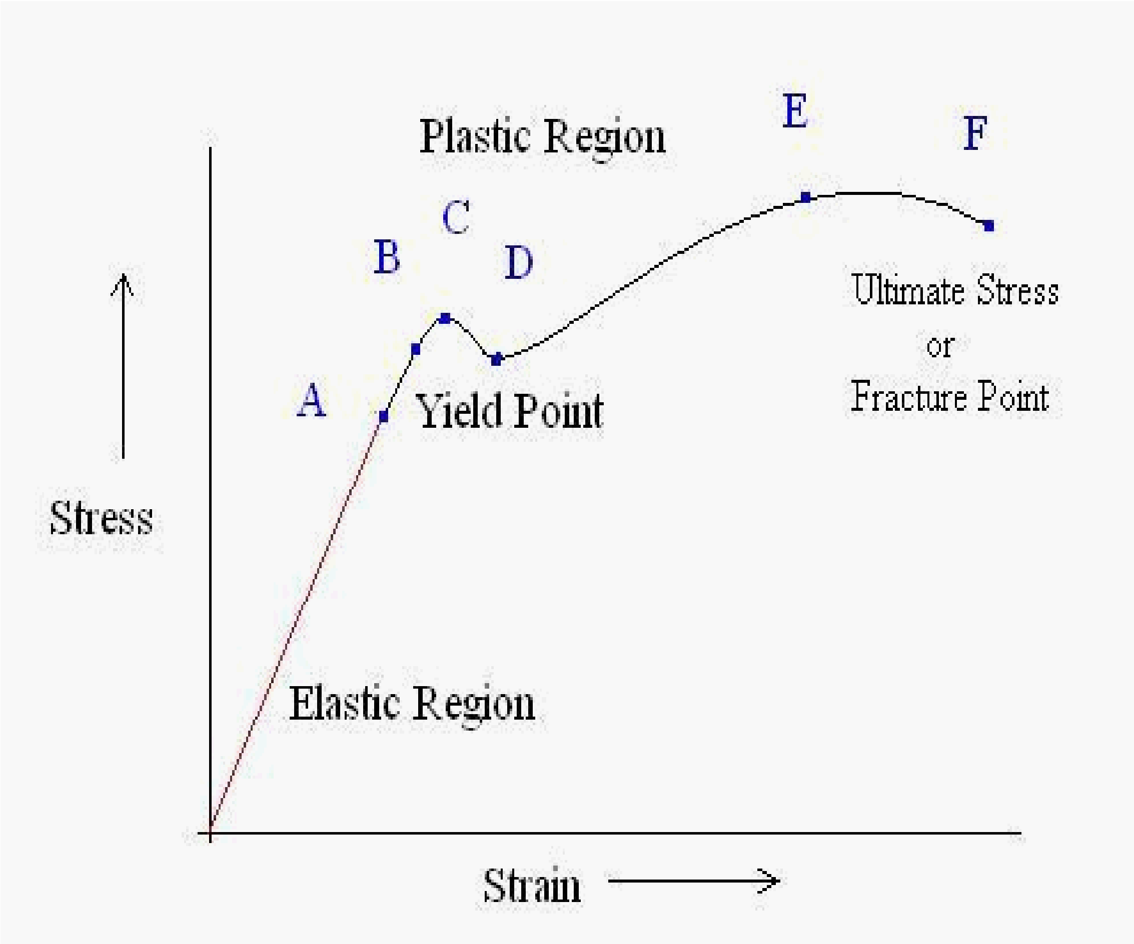
THEORY :

Various m/c and structure components are subjected to tensile loading in numerous application. For safe design of these components, there ultimate tensile strength and ductility one to be determine before actual use. Tensile test can be conducted on UTM.
A material when subjected to a tensile load resists the applied load by developing internal resisting force. These resistances come due to atomic bonding between atoms of the material. The resisting force for unit normal cross-section area is known as stress.
The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength. The end of elastic limit is indicated by the yield point (load). This can be seen during experiment as explained later in procedure with increase in loading beyond elastic limit original cross-section area (A_o) goes on decreasing and finally reduces to its minimum value when the specimen breaks.

ABOUT OF UTM & ITS SPECIFICATIONS:

The tensile test is conducted on UTM. It is hydraulically operates a pump, oil in oil sump, load dial indicator and central buttons. The left has upper, middle and lower cross heads i.e; specimen grips (or jaws). Idle cross head can be moved up and down for adjustment.





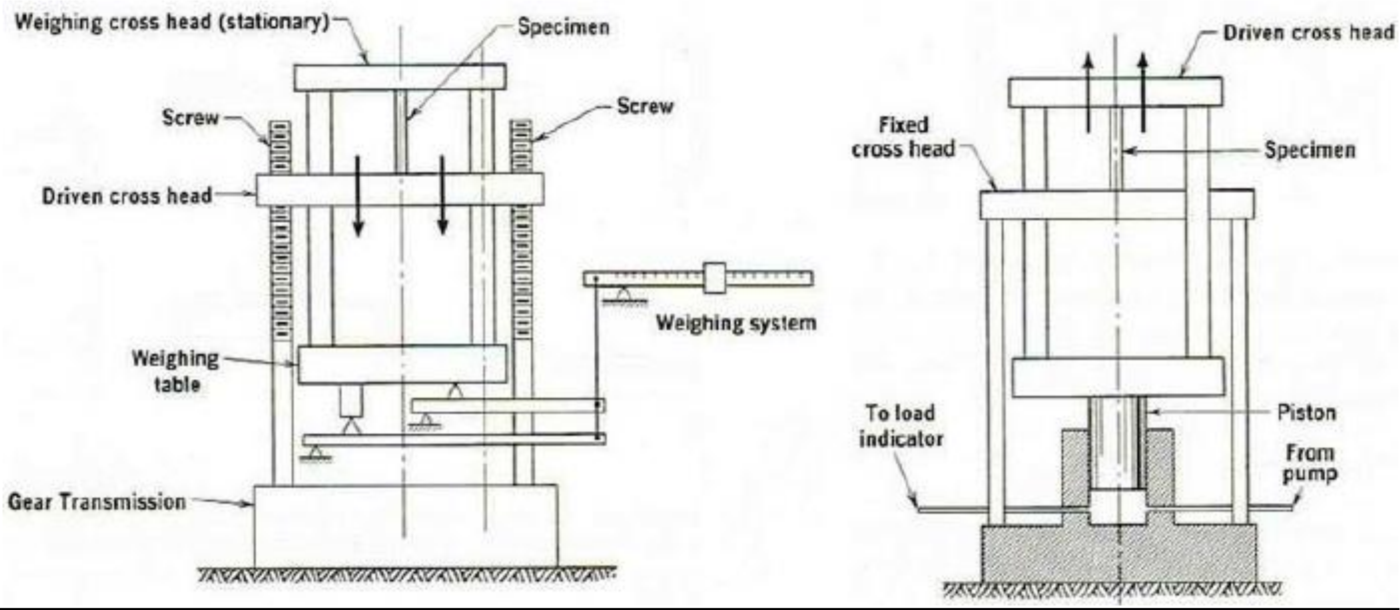
A typical stress-strain curve of HYSD bar

NOTE: **Point A**: At origin, there is no initial stress or strain in the test piece. Up to point A Hooke's Law is obeyed according to which stress is directly proportional to strain. That's why the point A is also known as proportional limit. This straight line region is known as elastic region and the material can regain its original shape after removal of load. **Point B:** The portion of the curve between AB is not a straight line and strain increases faster than stress at all points on the curve beyond point A. Point B is the point after which any continuous stress results in permanent, or inelastic deformation. Thus, point B is known as the elastic limit or yield point. **Point C & D:** Beyond the point B, the material goes to the plastic stage till the point C is reached. At this point the cross- sectional area of the material starts decreasing and the stress decreases to point D. At point D the workpiece changes its length with a little or without any increase in stress up to point E. **Point E:** Point E indicates the location of the value of the ultimate stress. The portion DE is called the yielding of the material at constant stress. From point E onwards, the strength of the material increases and requires more stress for deformation, until point F is reached. **Point F:** A material is considered to have completely failed once it reaches the ultimate stress. The point of fracture, or the actual tearing of the material, does not occur until point F. The point F is also called ultimate point or fracture point.

SPECIFICATIONS :

1. Load capacity = 0-1000 KN.
2. Least count = 0.1KN.
3. Power supply = 440V

DIAGRAM:



EXPERIMENTAL PROCEDURE:

1) At first, on the main switch of the machine and on the switch of computer which is connected with the machine.
2) Take the specimen and mark the gripping area within 40-60mm.
3) Measure the diameter of the gripping area on three different points.
4) Take the average diameter and calculate the experiment length on the specimen and then put a mark on it.
5) after that, again mark the gripping area within 40-60mm on bottom of the experimental length of the specimen.
6) Then, grip the specimen on the upper cross head in the jaws by rotating the lever over there.
7) Move up and down the middle cross head according to necessity to grip the specimen from bottom side.
8) Then, open the computer program.
9) Make a new file according to your experiment and put the all types of data about the specimen.
10) Take the program on 'comport' position by selecting the given option on the computer screen. But not click on the start button.
11) Close the relief valve on controlling unit.
12) Switch on the pump and watch the load changing on the controlling unit screen. When the load changing will stop then switch off the pump.
13) Then grip the specimen on the middle crosshead by the jaws.
14) After that, click on **STOP, TARE, ENTER** and **START** button.
15) After clicking the **START** button on controlling unit, immediately click on the **START** button also on computer screen.
16) Switch on the pump.
17) Then watch the experiment on the machine and follow the graph on the computer screen.

OBESERVATION:

A) Original dimensions

Length = ------------

Diameter = ---------   Area = --------------

B) Final dimensions:

Length = -------------------

Diameter = -----------------   Area = ------------------------

OBSERVATION TABLE:

SL.NO.	LOAD (N)	ORIGINAL GAUGE LENGTH	EXTENTION (MM)	STRESS $= \frac{\text{LOAD}}{\text{AREA}}$ N/mm^2	STRAIN $= \frac{\text{INCREASE IN LENGTH}}{\text{ORIGINAL LENGTH}}$
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

To plot the stress strain curve and determine the following:

(i)**Limit of proportion** $= \frac{\text{Load at limit of proportionality}}{\text{Original area of cross-section}}$

(ii) Elastic limit $= \frac{\text{Load at elastic limit}}{\text{Original area of c/s}}$

(iii) Yield strength $= \frac{\text{Yield load}}{\text{Original area of cross-section}}$

(iv) Ultimate strength $= \frac{\text{Maximum tensile load}}{\text{Original area of cross-section}}$

(v)Young's modulus, E $= \frac{\text{Stress below proportionality limit}}{\text{Corresponding strain}}$

(vi) Percentage elongation $= \frac{\text{Final length (at fracture) – original length}}{\text{Original length}}$

(vii) Percentage reduction in area $= \frac{\text{Original area} - \text{area at fracture}}{\text{Original area}}$

PRECAUTIONS:

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the jaws.
3. Take reading carefully.
4. After breaking specimen stop to m/c

. CONCLUSION:

The modulus of elasticity of mild steel is **-------**

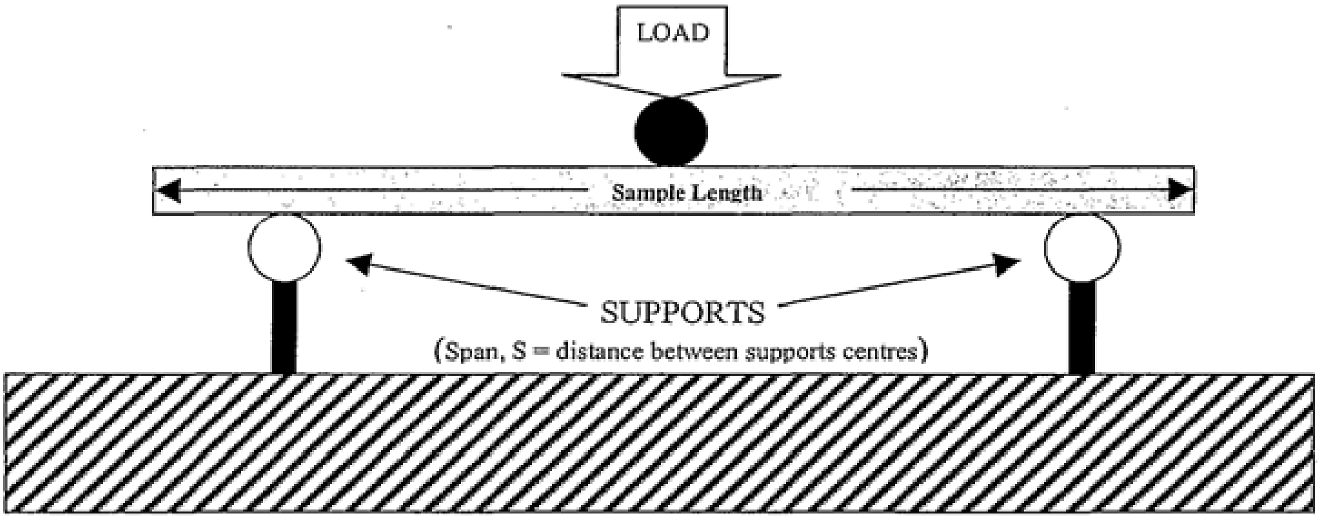
EXPERIMENT NO. CE(ES) 492/3

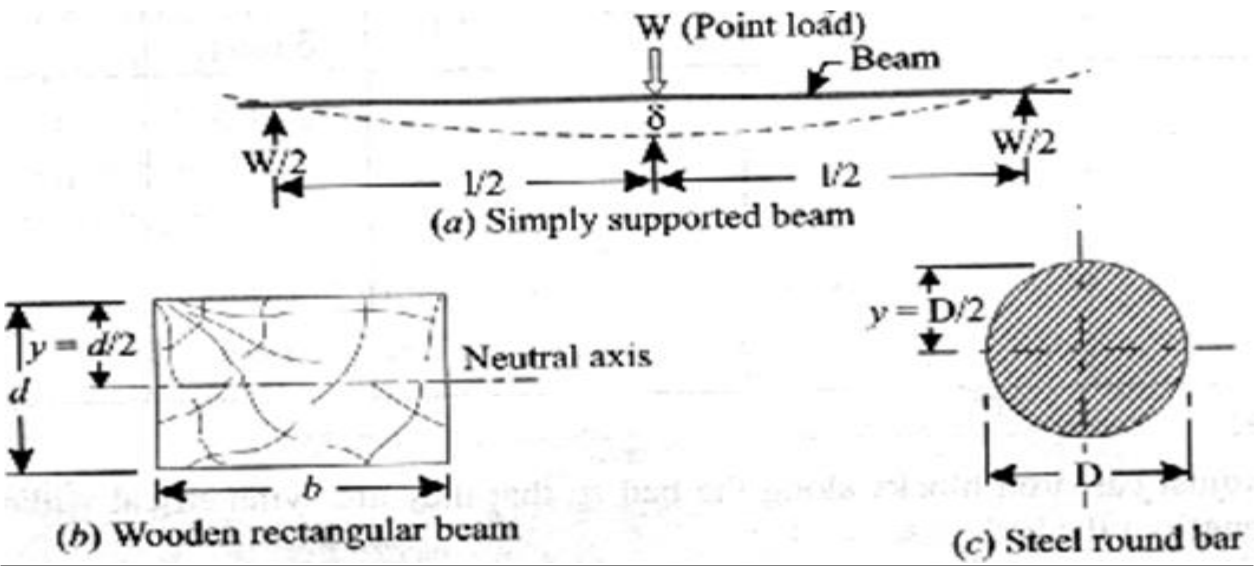
NAME: Determined young's modulus of elasticity of material of beam simply supported at ends by Bending Test.

APPARATUS:

1.Universal testing machine.
2. H.Y.S.D bar.

DIAGRAM:-





SPECIFICATION:-

If a beam is simply supported at the ends and carries a concentrated load at its centre, the beam bends concave upwards. The distance between the original position of the beams and its position after bending at different points along the length of the beam, being maximum at the centre in this case. This difference is known as 'deflection' In this particular type of loading the maximum amount of deflection (δ) is given by the relation,

$$\delta = \frac{W\,L^3}{48\,EI} \text{ …….. (i)}$$

$$E = \frac{W\,L^3}{48\,\delta\,I} \text{ …….. (ii)}$$

W =Load acting at the center, N
L =Length of the beam between the supports mm
E =Young's modulus of material of the beam, N/mm^2
I =Second moment of area of the cross- section (e.i., moment of Inertia) of the beam, about the neutral axis, mm**.**

BENDING STRESS:-

As per bending equation,

$$\frac{M}{I} = \frac{\sigma_b}{Y}$$

Where,
M = Bending moment, N-mm
I = Moment of inertia, mm^4
σ_b = Bending stress, N/mm^2, and
Y = Distance of the top fiber of the beam from the neutral axis

EXPERIMENTAL PROCEDURE:

1) At first, on the main switch of the machine and on the switch of computer which is connected with the machine.
2) Take a H.Y.S.D specimen.
3) Measure the dimensions of the specimen.
4) Then, put the specimen on the operation table just like a simply supported beam.
5) Move up and down the middle cross head according to necessity.
6) Then, open the computer program.
7) Make a new file according to your experiment and put the all types of data about the specimen.
8) Take the program on 'comport' position by selecting the given option on the computer screen. But not click on the start button.
9) Close the relief valve on controlling unit.
10) Switch on the pump and watch the load changing on the controlling unit screen. When the load changing will stop then switch off the pump.
11) After that, click on **STOP, TARE, ENTER** and **START** button.
12) After clicking the **START** button on controlling unit, immediately click on the **START** button also on computer screen.
13) Switch on the pump.
14) Then watch the experiment on the machine and follow the graph on the computer screen.

OBSERVATION TABLE:

SL. NO.	**Load W (N)**	**Bending Moment** $M = \frac{WI}{4}$ (Nmm)	**Bending stress** $\sigma_b = \frac{MY}{I}$ N/mm^2	**Deflection,** δ (mm)	**Young's Modulus of elasticity,** $E = \frac{WI^3}{48\delta I}$

PRECAUTIONS:

1) Make sure that beam and load are placed a proper position.
2) The cross- section of the beam should be large.
3) Note down the readings of the vernier scale carefully.

CONCLUSION:

1**.** The young's modulus for steel beam is found to be----- N/mm^2.

EXPERIMENT NO. CE(ES) 492/4

NAME: Determine the impact strength of steel by Izod impact test

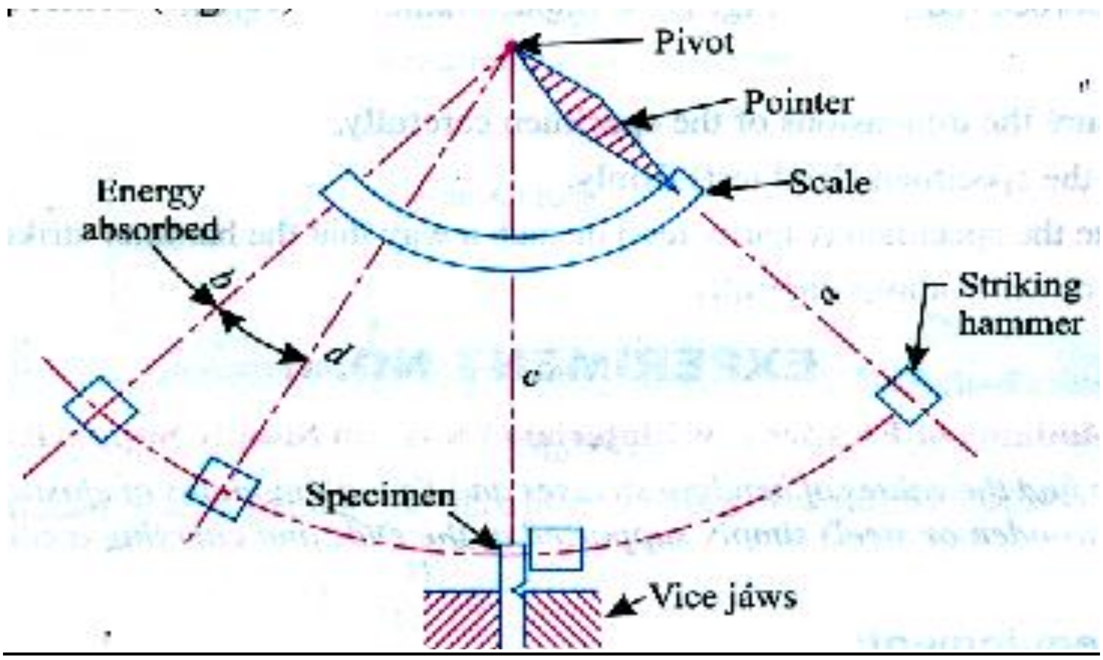
APPARATUS:

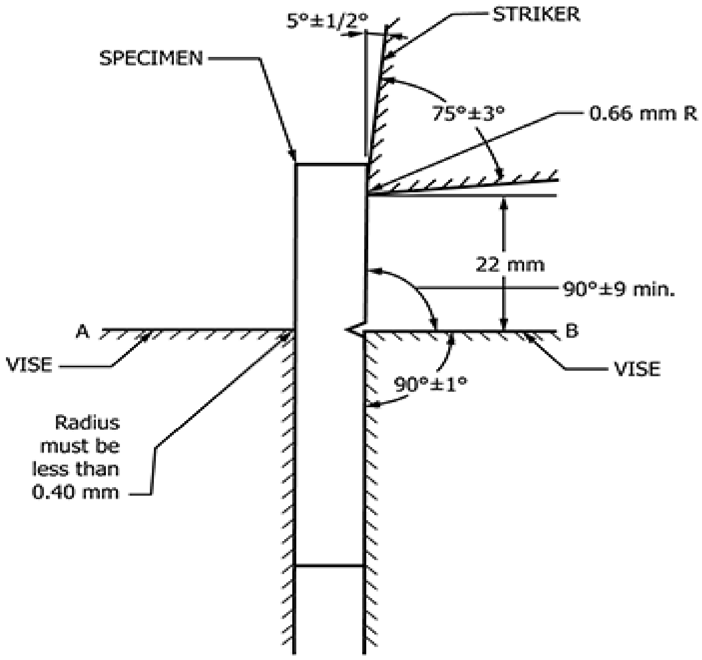
1. Impact testing m/c,
2. Izod test specimens of mild steel, 75 mm X 10mm X 10mm
3. Vernier caliper,
4. Specimen setting fixture.

SPECIFICATIONS:

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of unnotched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determined by impact test. Toughness takes into account both the strength and ductility of the material. Several engineering materials have to withstand impact or suddenly applied loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads. Of all types of impact tests, the notch bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notch bar by applying an impulse load. The test measures the notch toughness of material under shock loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. Still it is important to note that it provides a good way of comparing toughness of various materials or toughness of the same material under different condition. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature.

DIAGRAM:





EXPERIMENTAL PROCEDURE:

1. Raise the hammer and note down initial reading from the dial, which will be energy to be used to fracture the specimen. For the standard Izod test the energy stored should be 164j.
2. Place the specimen for test and see that it is placed center with respect to hammer. Check the position of notch.
3. Release the hammer. The hammer will break the piece and shoot up the other side of the specimen.
4. Note the residual energy indicated on the scale by the hammer.
5. Impact strength of the test specimen is the difference of the initial energy stored in hammer and the residual energy.

.OBSERVATION TABLE:

SL.No.	Initial Energy (E_1) in joule	Residual Energy (E_2) in Joule	Absorb Energy (E_1-E_2)

CALCULATIONS:

• Modulus of rupture = Rupture / Effective volume of specimen

• Notch impact strength = Absorb energy / Effective cross section area

PRECAUTION:

1. The specimen should be prepared in proper dimensions.
2. Take reading more frequently.
3. Make the loose pointer in contact with the fixed pointer after setting the pendulum.
4. Do not stand in front of swinging hammer or releasing hammer.
5. Place the specimen proper position.

CONCLUSION:

The impact strength of given specimen = -------joule/mm^2

EXPERIMENT NO. CE(ES) 492/5

NAME: To determine the impact strength of steel by (Charpy test)

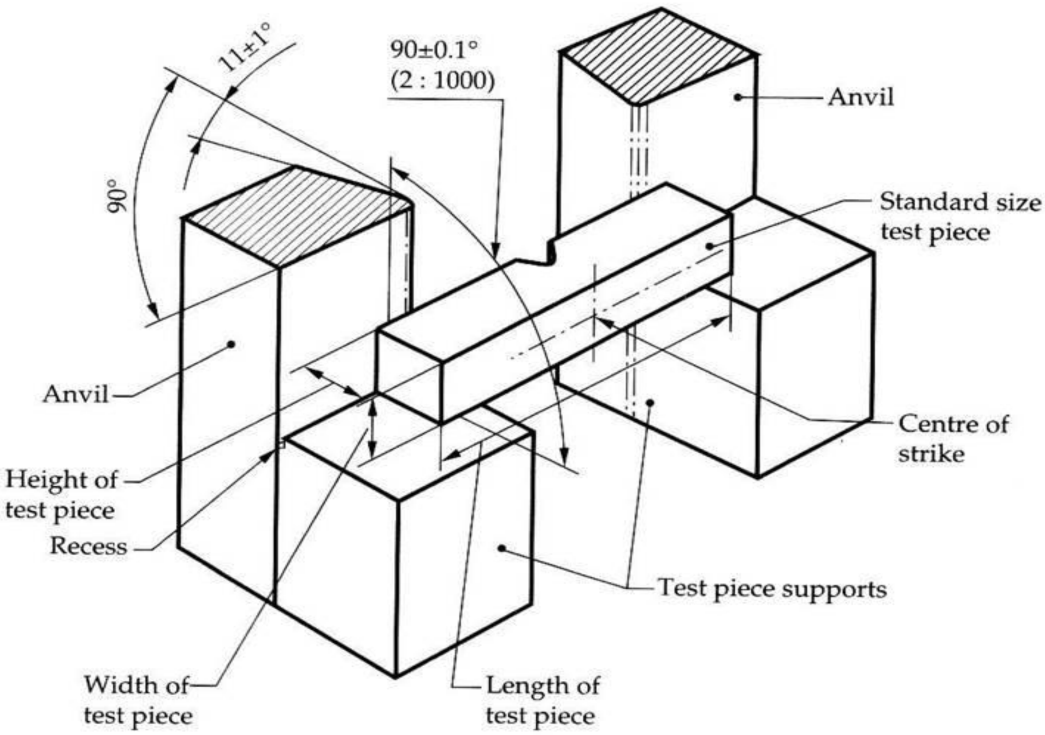
APPARATUS:

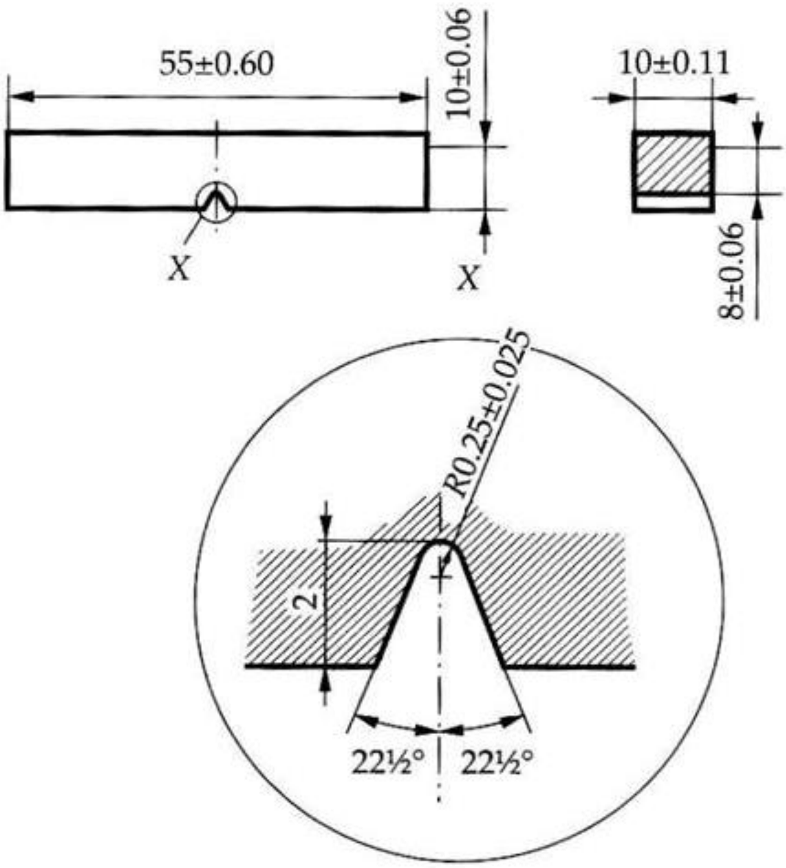
1. Impact testing m/c,
2. Charpy test specimens of mild steel, 10 mm x 10 mm X 55mm
3. Vernier caliper,
4. Specimen setting fixture.

SPECIFICATIONS:

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of unnotched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determined by impact test. Toughness takes into account both the strength and ductility of the material. Several engineering materials have to withstand impact or suddenly applied loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads. Of all types of impact tests, the notch bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notch bar by applying an impulse load. The test measures the notch toughness of material under shock loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. Still it is important to note that it provides a good way of comparing toughness of various materials or toughness of the same material under different condition. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature.

DIAGRAM:





Charpy V-notch impact test piece

EXPERIMENTAL PROCEDURE:

1. Raise the hammer and note down initial reading from the dial,which will be energy to be used to fracture the specimen. For the standard Charpy test the energy stored should be 300j.
2. Place the specimen for test and see that it is placed center with respect to hammer. Check the position of notch.
3. Release the hammer. The hammer will break the piece and shoot up the other side of the specimen.
4. Note the residual energy indicated on the scale by the hammer.
5. Impact strength of the test specimen is the difference of the initial energy stored in hammer and the residual energy.

OBSERVATION TABLE:

SL.No.	Initial Energy (E_1) in joule	Residual Energy (E_2) in Joule	Absorb Energy (E_1-E_2)

CALCULATIONS:

• Notch impact strength = Absorb energy / Effective cross section area

PRECAUTIONS:

1. The specimen should be prepared in proper dimensions.
2. Take reading more frequently.
3. Make the loose pointer in contact with the fixed pointer after setting the pendulum.
4. Do not stand in front of swinging hammer or releasing hammer.
5. Place the specimen proper position.

CONCLUSION:

The impact strength of given specimen = -------joule/mm^2

EXPERIMENT NO. CE(ES) 492/6

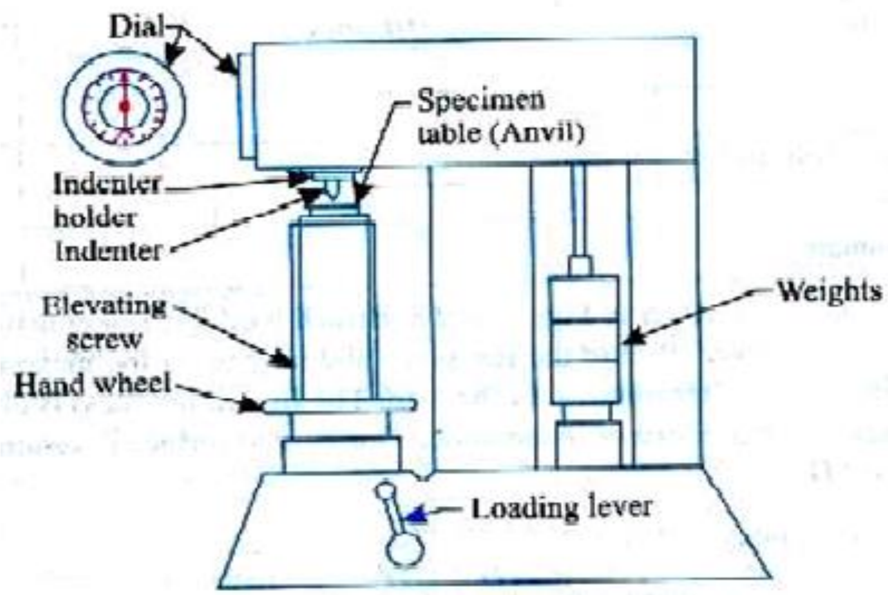
NAME: Study the Brinell Hardness testing machine and the Brinell hardness test.

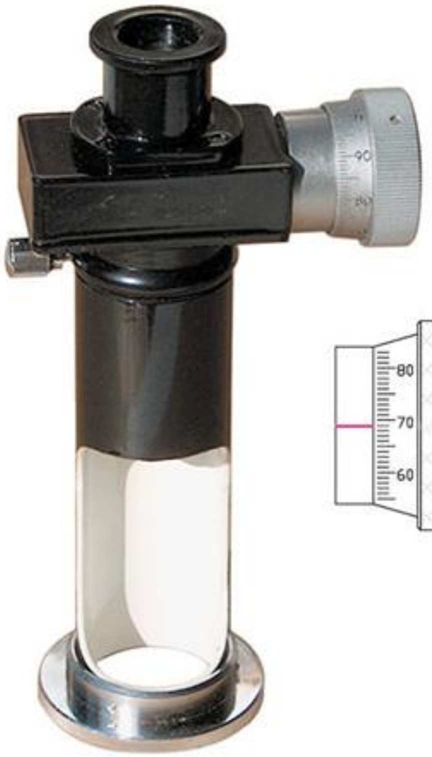
APPARATUS:

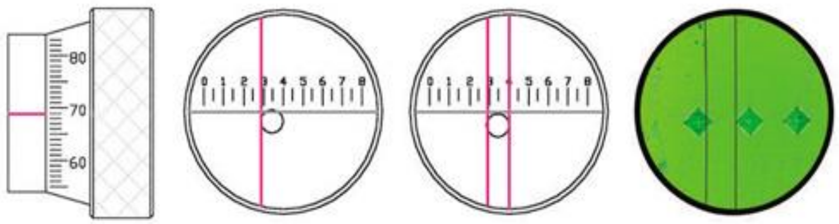
1. Brinell Hardness testing machine,
2. Specimen of mild steel / cast iron/ non ferrous metals
3. Brinell microscope.

SPECIFICATION: -

Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear identification of strength. In all hardness testes, a define force is mechanically applied on the test piece for about 15 seconds. The indentor, which transmits the load to the test piece, varies in size and shape for different testes. Common indenters are made of hardened steel or diamond. In Brinell hardness testing, steel balls are used as indentor. Diameter of the indentor and the applied force depend upon the thickness of the test specimen, because for accurate results, depth of indentation should be less than 1/8th of the thickness of the test pieces. According to the thickness of the test piece increase, the diameter of the indentor and force are changed.
A hardness test can be conducted on Brinell testing m/c or Rockwell hardness m/c. the specimen may be a cylinder, cube, thick or thin metallic sheet. A Brinell- cum-Rockwell hardness testing m/c along with the specimen is shown in figure.Its specification are as follows:
1. Ability to determine hardness upto 500BHN.
2. Diameter of ball (as indentor) used D = 2.5mm
3. Maximum application load = 187.5 kgf.
4. Method of load application = Lever type
DIAGRAM:







EXPERIMENTAL PROCEDURE:

1. Insert ball of diameter ‘D’ in ball holder of the m/c.
2. Make the specimen surface clean by removing dust, dirt, oil and grease etc.
3. Make contact between the specimen surface and the ball by rotating the jack adjusting wheel.
4. Push the required button for loading.
5. Pull the load release level and wait for minimum 15 second. The load will automatically apply gradually.
6. Remove the specimen from support table and locate the indentation so made.
7. View the indentation through microscope and measure the diameter ‘d’ by micrometer fitted on microscope.
8. Repeat the entire operation, 3-time.

OBSERVATION TABLE:

SL. NO.	SPRING BALANCE DIFF. (kg)	PRESSURE GAUGE DIFF. (kg/cm^2)	TURBINE SPEED, N (rpm)
1.			
2.			
3.			

CALCULATIONS:

BHN = Load Applied (kgf.)/ Spherical surface area indentation (in mm.)

BHN= πr^2

$2P/\pi D(D-\sqrt{D^2 - d^2})$

PRECAUTIONS:

1. The specimen should be clean properly.
2. Take reading more carefully and correct.
3. Place the specimen properly.
4. Jack adjusting wheel move slowly
5. After applying load remove the load.

CONCLUSION:

The Brinell hardness number of the specimen is --------

EXPERIMENT NO. CE(ES) 492/7

NAME: To study the Rockwell Hardness testing machine and perform the Rockwell hardness test.

APPARATUS:

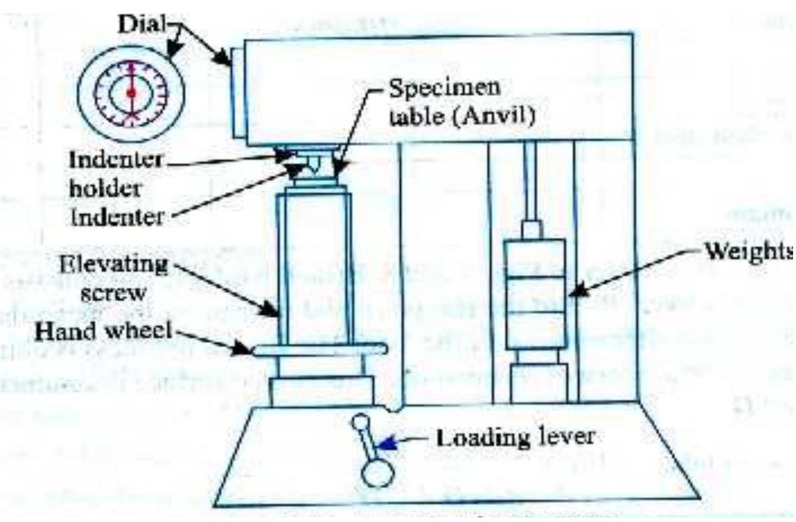
1. Rockwell Hardness testing machine,
2. Specimen of mild steel or other material

SPECIFICATIONS:

Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear indication of strength. In all hardness tests, a define force is mechanically applied on the piece, varies in size and shape for different tests. Common indentors are made of hardened steel or diamond. Rockwell hardness tester presents direct reading of hardness number on a dial provided with the m/c. principally this testing is similar to Brinell hardness testing.
It differs only in diameter and material of the indentor and the applied force. Although there are many scales having different combinations of load and size of indentor but commonly 'C' scale is used and hardness is presented as HRC. Here the indentor has a diamond cone at the tip and applied force is of 150 kgf. Soft materials are often tested in 'B' scale with a 1.6mm dia. Steel indentor at 100kgf.
A hardness test can be conducted can be conducted on Brinell testing m/c, Rockwell hardness m/c. The specimen may be a cylinder, cube, thick or thin metallic sheet. A Brinell-cum-Rockwell hardness testing m/c is shown in figure below.
Various scales in Rockwell hardness test are given below:-

Scale	Type of indentor	Initial load	Major load	Pointer Position	Kind of material
A	Cone, 120o	10	50	0	Much harder material
B	Ball,1.58mm	10	100	30	Soft steels, copper,aluminum
C	Cone, 120o	10	150	0	Hard steels, Ti, W, Va, etc

DIAGRAM:



PROCEDURE:

1. Insert cone or ball pointer according to load given.
2. Make the specimen surface clean by removing dust, dirt, oil and grease etc.
3. Make contact between the specimen surface and the ball by rotating the jack adjusting wheel.
4. Push the required button for loading.
5. Pull the load release lever wait for minimum 15 second. The load will automatically apply gradually.
6. Remove the specimen from support table and locate the indentation so made.
7. Repeat the entire operation, 3-times.

OBSERVATION TABLE:

Following observation are recorded are from a test on steel specimen using a hardened steel ball as indentor.

• Test piece material =-----------

Sl.No.	Scale using	Readings		
		1st	2nd	3rd
1.	A			
2.	B			
3.	C			

PRECAUTION:

• The specimen should be clean properly.

• Take reading more carefully.

CONCLUSION:

Rockwell hardness of given specimen is --------

EXPERIMENT NO. CE(ES) 492/8

NAME: Torsion test on mild steel rod.

APPARATUS:

1. A torsion testing machine.
2. Twist meter for measuring angles of twist
3. A steel rule and Vernier Caliper or micrometer.

SPECIFICATIONS:

A torsion test is quite instrumental in determining the value of modulus of rigidity of a metallic specimen. The value of modulus of rigidity can be found out thought observations made during the experiment by using the torsion equation

$$\frac{T}{I_p} = \frac{C\,\theta}{L} = \frac{q}{r}$$

Where,
T = Torque applied,
I_p = Polar moment of inertia,
C = Modulus of rigidity,
θ = Angle of twist (radians), and
L = Length of the shaft
q = Shear stress
r = Distance of element from center of shaft

DIAGRAM:

PROCEDURE:

1. Before the test is started, ensure that the display shows 000.0 when there is no torque applied to the sample. If it not, press the zero button to set the load value to zero.
2. Consisting of approximate breaking torque of test piece to be tested.
3. The rod is fixing in to the grip of machine.
4. Set the pointer on the torque measuring scale.
4. Switch “ON” the main of the machine by rotating the main switch provided on the side of the measuring panel.
5. Once the machine is switched on, see that the indicator is also “ON”.
6. Start the geared mortar with the help of the starter switch.

OBSERVATION TABLE:

Gauge length of the specimen, l = ………

Diameter of the specimen, d = ………

Polar moment of inertia,

$$C = \frac{TL}{I_p}$$

$$I_p = \frac{\pi d^4}{32}$$

PRECAUTION:

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the jaws.
3. Take reading carefully.
4. After breaking specimen stop to m/c.

CONCLUSION:

Modulus of rigidity of mild steel rod is ------------- N/mm^2

EXPERIMENT NO. CE(ES) 492/9

NAME: To determine the modulus of rigidity and stiffness of the given compression spring specimen

APPARATUS:

1. Spring test machine.
2. Compression spring specimen.
3. Vanier calliper.

DIAGRAM:

PROCEDURE:

1. Measure the outer diameter (D) and diameter of the spring coil (d) for the given compression spring.
2. Count the number of turn i.e. coil (n) in the given compression specimen.
3. Place the compression spring at the centre of the bottom beam of the spring test machine.
4. Rise the bottom beam by rotating right side wheel till the spring top rouches the middle cross beam.
5. Note down the initial reading from the scale in the machine.
6. Apply a load of 25 kg and note down the scale reading. Increase the load at the rate of 25 kg upto a maximum of 100kg and note down the corresponding scale readings.

7. Finding the actual deflection of the spring for each load by deducting the initial scale reading from the corresponding scale reading.
8. Calculate the modulus of rigidity for each load applied by using the following formula.
   Modulus of rigidity, $N = 64PR^3nd^4\delta$

Where, P = Load in N
R = Mean radius of the spring in mm (D-d/2)
d = Diameter of the spring coil in mm
δ= Deflection of the spring in mm
D= Outer diameter of the spring in mm

9. Determine the stiffness for each load applied by using the following formula:

   Stiffness, $K = \frac{P}{\delta}$

10. Find the values of modulus of rigidity and spring constant of the given spring by taking average values.

OBSERVATION TABLE:

1. Material of the spring specimen =
2. Outer diameter of the spring, D = mm
3. Diameter of the spring coil, d = mm
4. Number of coil/turns ,n = Nos
5. Initial scale reading = Cm= mm

Sl. No.	**Applied load in**		**Scale reading in**		**Actual deflection in mm**	**Modulus of rigidity in N/mm^2**	**Stiffness in N/mm**
	kg	**N**	**cm**	**mm**			
						Average	

PRECAUTION:

• The specimen should be clean properly.

• Take reading more carefully.

CONCLUSION:

The modulus of rigidity of the given spring = N/mm^2

The stiffness of the given spring = N/mm^2

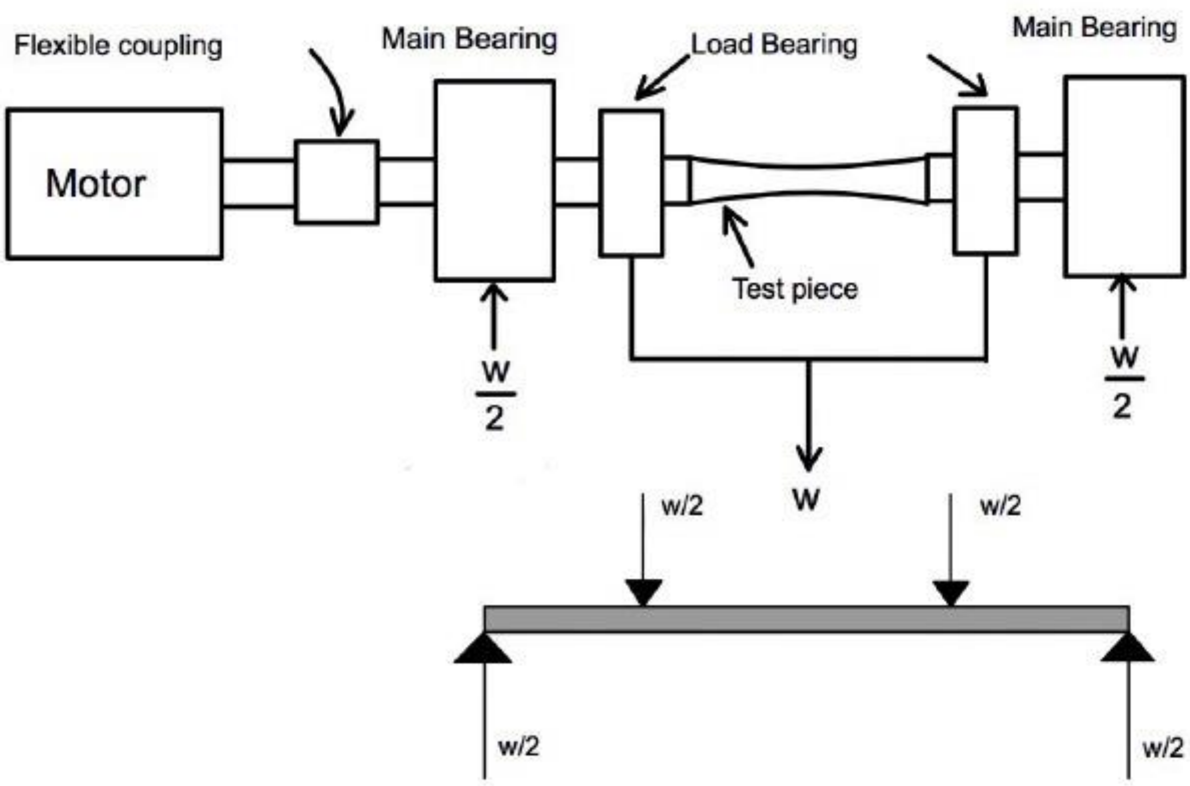
EXPERIMENT NO. CE(ES) 492/10

NAME: Fatigue test on a Mild Steel specimen

APPARATUS:

1. Basic machine with motor, electronic counter, proximity switch, electric box.
2. Spanner for collet.
3. Sample specimen.
4. Special spanner.
5. Calibrated weight Assy. For, 200 kg-cm range
6. Lever balance weight.
7. Lever lock pin.

DIAGRAM:



PROCEDURE:

Fix the specimen to the specimen pulling out stud in the tapping provided over face. Insert the specimen with stud into the bore of LH swiveling body and push it further till it insert in the collets of RH swiveling body and rest against the specimen locator. Now you will fill that the specimen cannot be pushed further. By pressing down the locking rod such that it inserts into the slots of locking rod and prevent hollow shaft from rotating, tighten the specimen by rotating the clamping cum loosening ring with help of special spanner. The locking rod is spring loaded and hence it will immediately come out of the slots, as soon as hand is released. In on case should be the locking enters the slots when machine is in running condition. Repeat the procedure for other side assembly.

Take out the specimen pulling out stud by removing it from the tap in specimen. Select the load required, depending upon the bending moment to be imposed, by moving the loading weight and selecting proper set of additional weights. Lock the loading weight by locking screw. Use the pin support while moving the loading weight, so that the lever is not moved. Remove the pin from support before starting the motor, otherwise the specimen will rotate without application of any bending moment. Check the direction of rotation. Reset the counter to show all 0's before running the specimen. In electronic counter there is a reset knob whereas in mechanical counter there is a reset key. Start the motor, thus starting the test. The motor will have recorded the number of revolutions completed by the specimen.

OBSERVATION TABLE:

The specimen loading arrangement results in a constant bending moment PL/2 over the test length of specimen.

Where: P = Load applied over the specimen kg.

L =Length of the specimen in cm.

Now, Bending moment (M_b) = $\frac{PL}{2}$ kgcm

Bending stress (f_b) = $\frac{M_b}{Z}$ kg/cm^2

Where, Z = Section modulus =$\frac{\pi d^3}{32}$ for circular cross section

So,$f_b = \frac{M_b x 32}{\pi x d^3}\ kg/cm^2$

Note: The load P indicated on the scale includes the weight of swilling bodies, hanger etc.

Note 2: Final revolution count should be noted down for S-N diagram.

PRECAUTION:

- The specimen should be clean properly.
- Take reading more carefully.

CONCLUSION:

Bending Stress (f_b) = kg/cm^2

ALLOCATION OF MARKS:

<table>
<tr><th>INTERNAL</th><th>EXTERNAL</th></tr>
<tr><td>40 MARKS</td><td>60 MARKS</td></tr>
<tr><td>Attendance (10)</td><td>Lab Examination (40)</td></tr>
<tr><td>Performance (20)</td><td rowspan="2">Viva voice (20)</td></tr>
<tr><td>Report submission (10)</td></tr>
<tr><td colspan="2">Grand total = 100</td></tr>
</table>

LABORATORY INSTRUCTION MANUAL

R C DESIGN SESSIONAL

(CE (PC) -591)

DEPARTMENT OF CIVIL ENGINEERING
SILIGURI INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

NAME: ____GROUP: _____________

ROLL NO.__________________

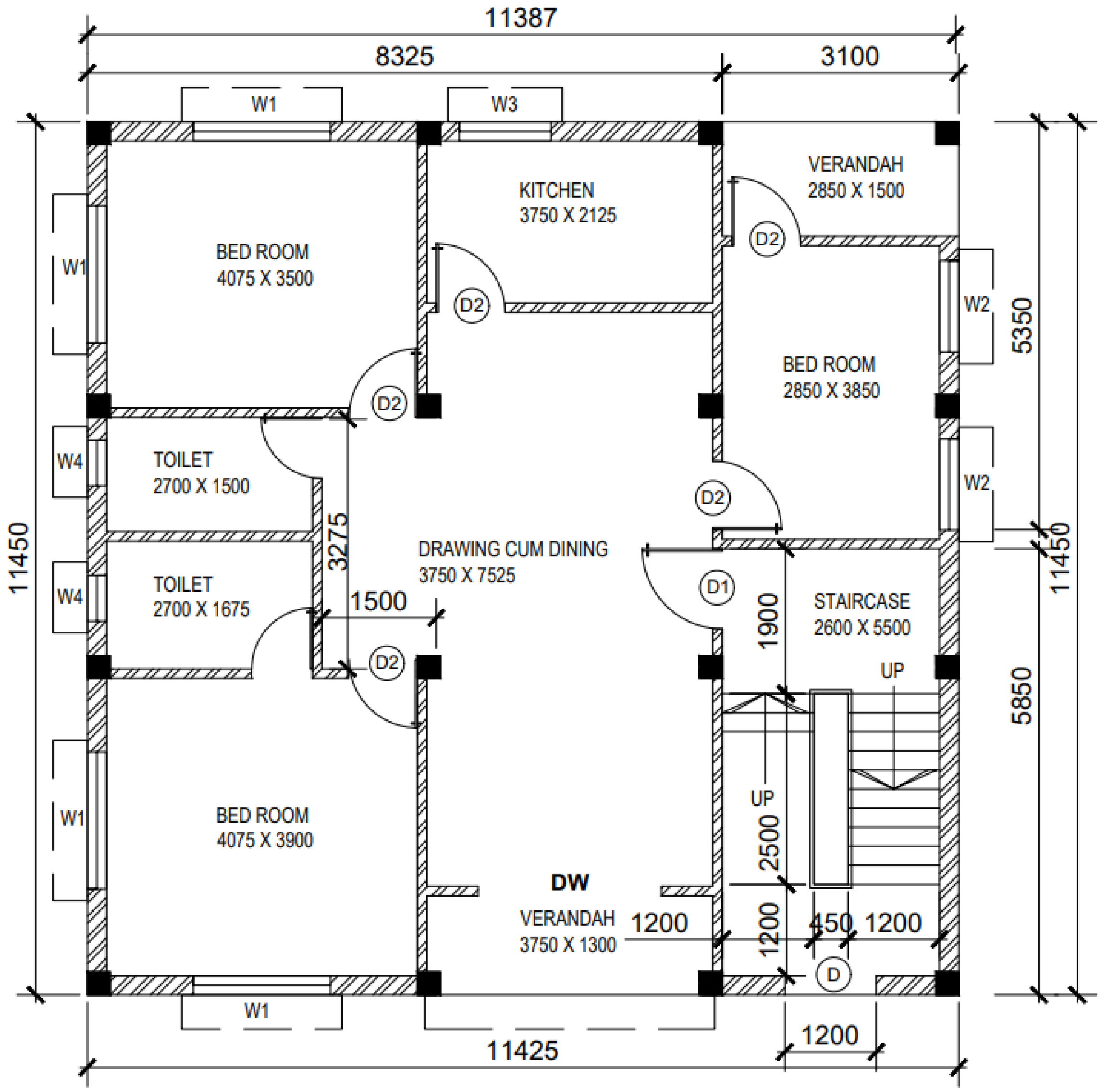
LIST OF EXPERIMENTS

EXPERIMENT NO	EXPERIMENT NAME
CE(PC)-591/1	Design of a small RCC framed building using Limit State method of design including preparation of necessary working drawing and report in accordance with CE(PC)501
CE(PC)-591/1A	General arrangement of column layout, tie beam layout, roof beam layout
CE(PC)-591/1B	Reinforcement drawings for typical beam (Rectangular, T Beam)
CE(PC)-591/1C	Reinforcement drawings for typical slabs
CE(PC)-591/1D	Reinforcement drawings for Staircase
CE(PC)-591/1E	Reinforcement detail drawing of column, column beam junction
CE(PC)-591/1F	Reinforcement detail drawing of Isolated column foundation

EXPERIMENT NO. CE (PC) 591/1A

Name: General arrangement of column layout, tie beam layout, roof beam layout

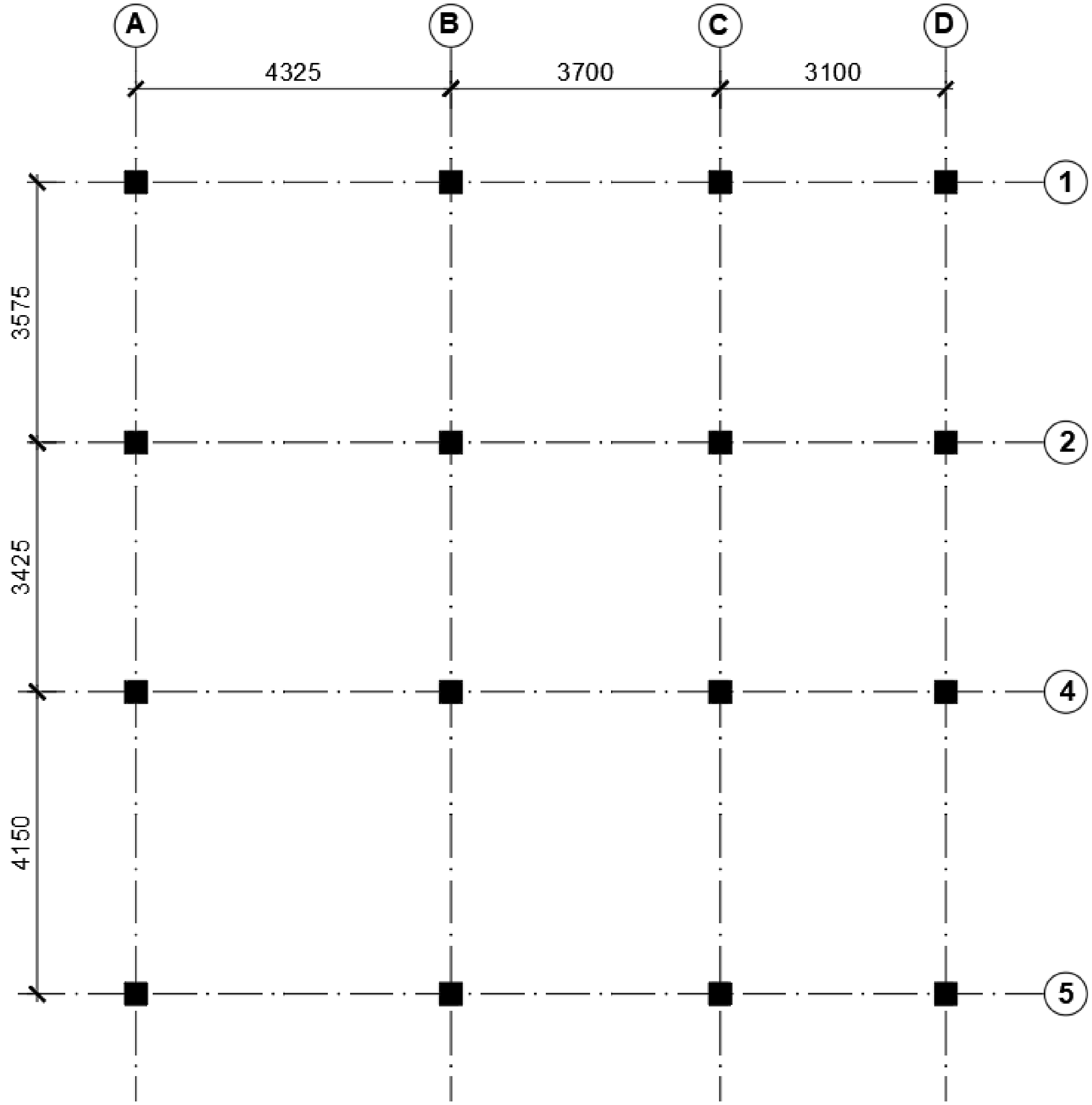
SHEET :-1



GROUND FLOOR PLAN

SCALE 1:100

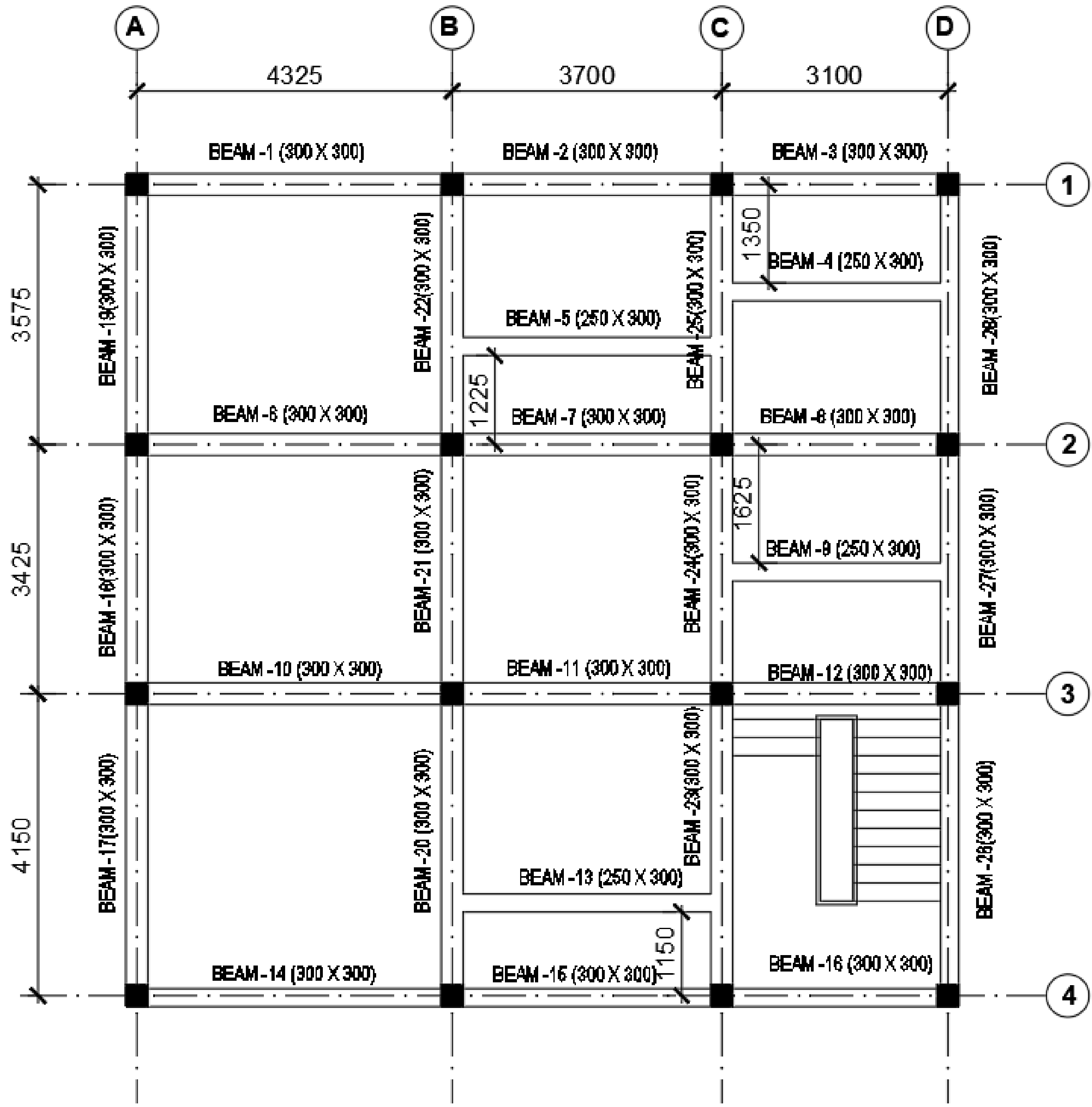
SHEET :-2



COLUMN LAYOUT PLAN

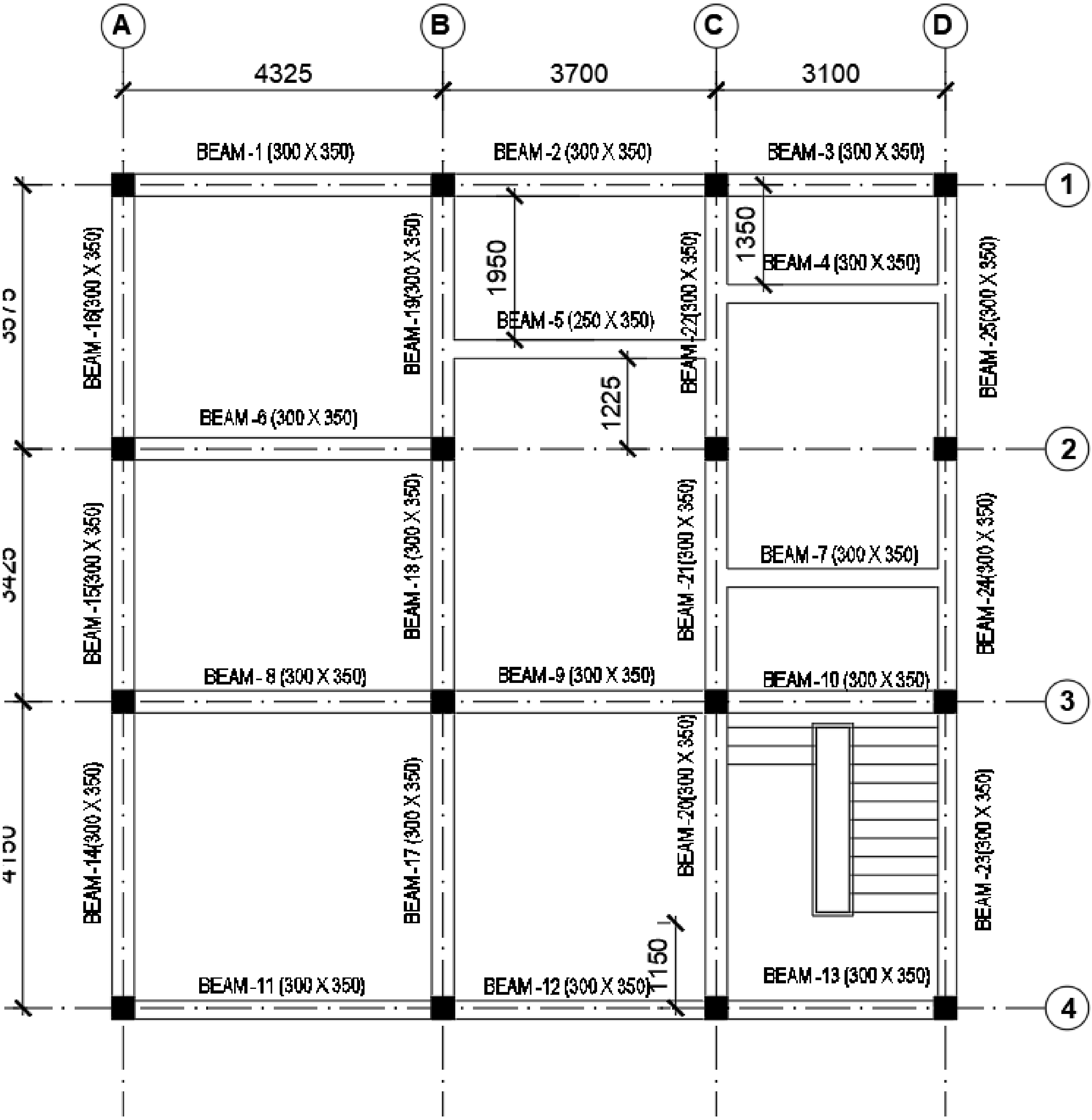
SCALE 1:100

SHEET :-3



TIE BEAM AT GR. LEVEL
SCALE 1:100

SHEET:-4

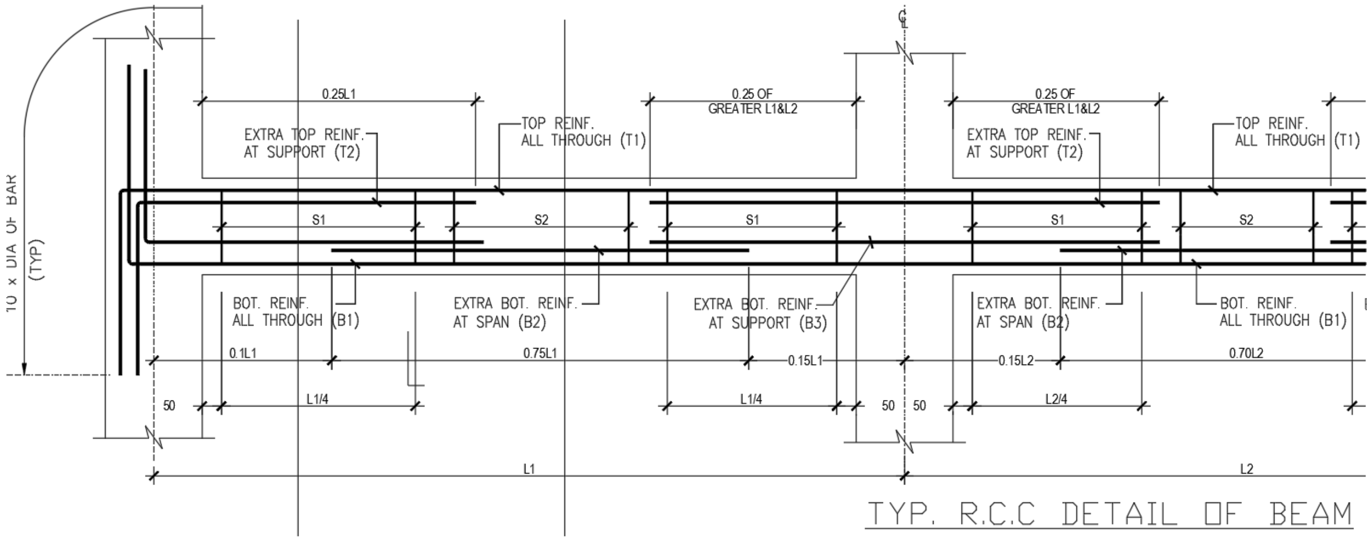


ROOF BEAM LAYOUT
SCALE 1:100

CE (PC)591/1B

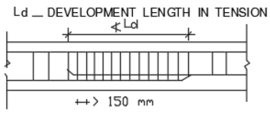
Name: Preparation of detailed drawing of beam

SHEET:-5



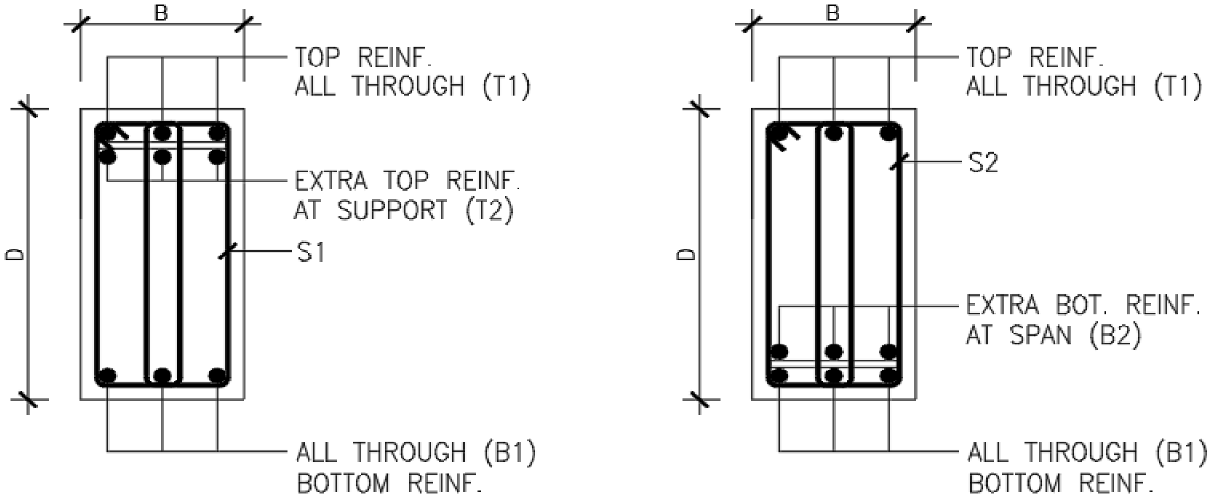
TYP. R.C.C DETAIL OF BEAM

SCALE 1:25



LAP , SPLICE IN BEAM

SHEET:-6



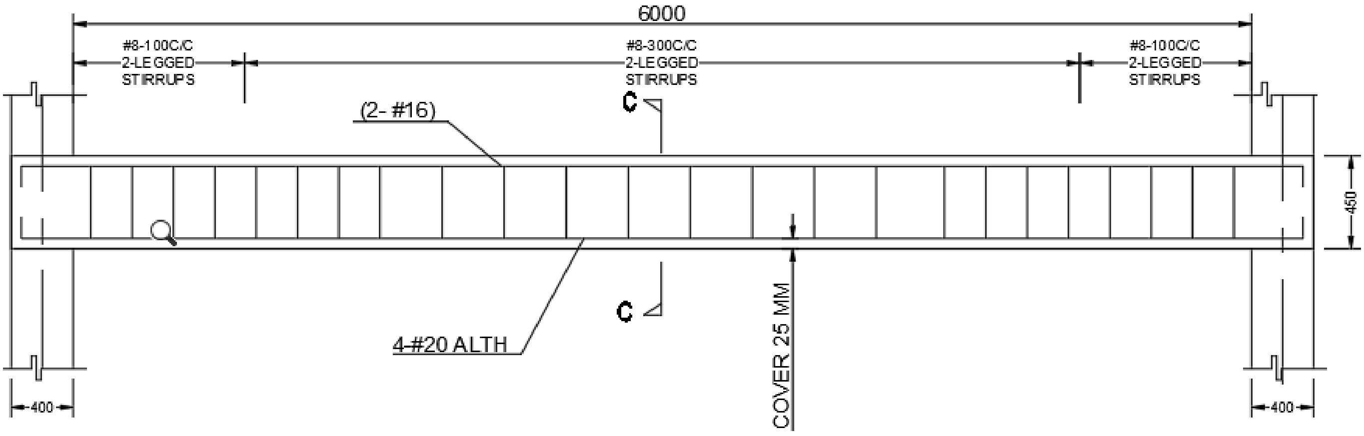
AT SUPPORT   AT SPAN

TYP. REINF. DETAIL OF BEAM

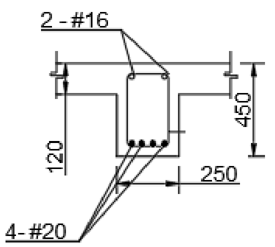
FLOOR BEAM SCHEDULE (M25:Fe500)

BEAM NUMBERS	SIZE		BOT. REINFORCEMENT		TOP REINFORCEMENT		SHEAR STIRRUPS	
	B	D	SUPPORT	SPAN	SUPPORT	SPAN	SUPPORT(S1)	SPAN(S2)

SHEET:-7



LONGITUDINAL SECTION OF T-BEAM WITH REINFORCEMENT DETAILS



CROSS SECTION CC

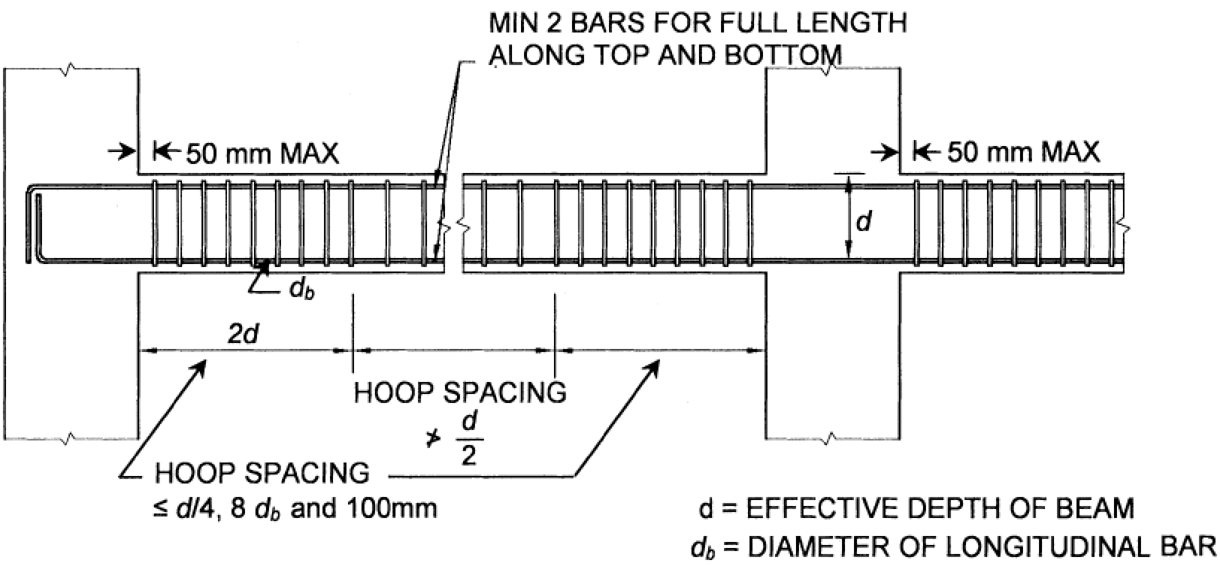
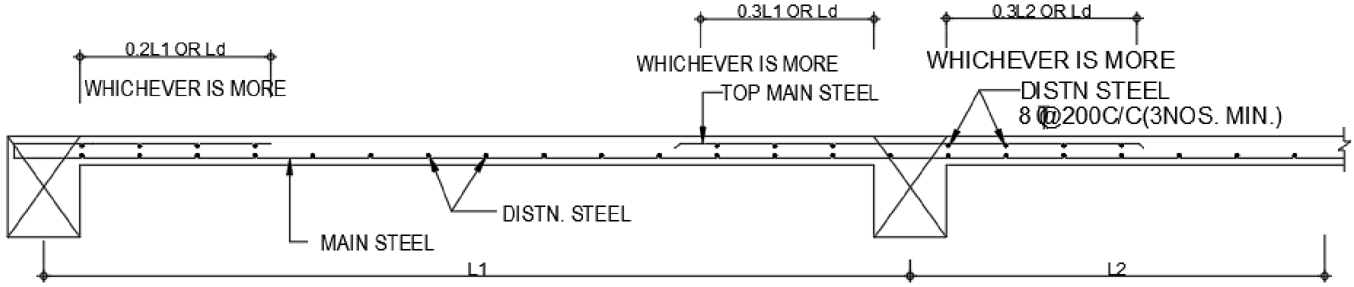


Fig. 6 Details of Transverse Reinforcement in Beams

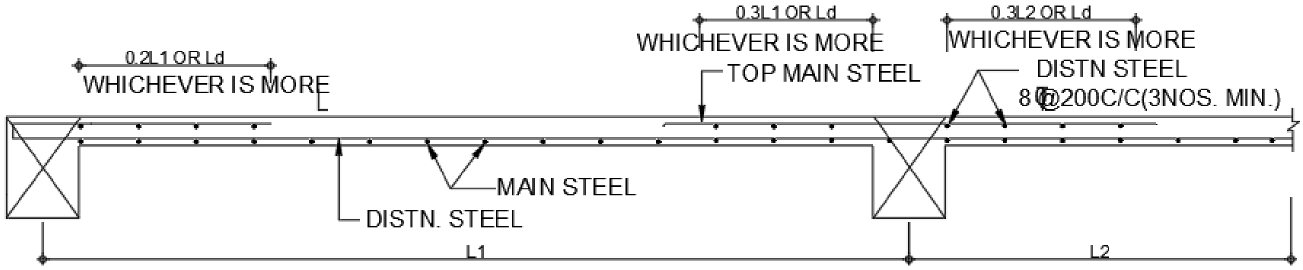
CE (PC)591/1c

Name: Preparation of detailed drawing of slab

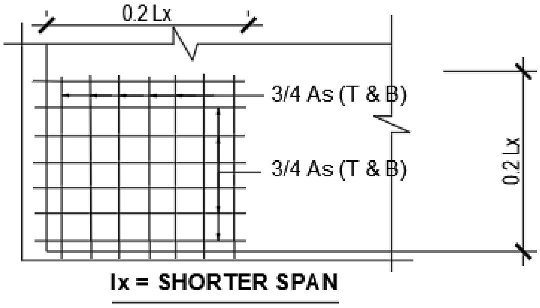
SHEET:-8



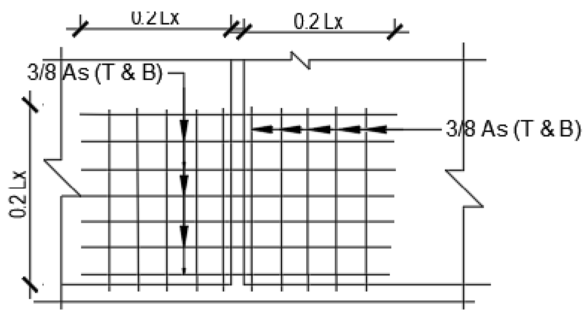
TYP. SEC. OF SLAB ALONG SHORTER DIRECTION



TYP. SEC. OF SLAB ALONG LONGER DIRECTION



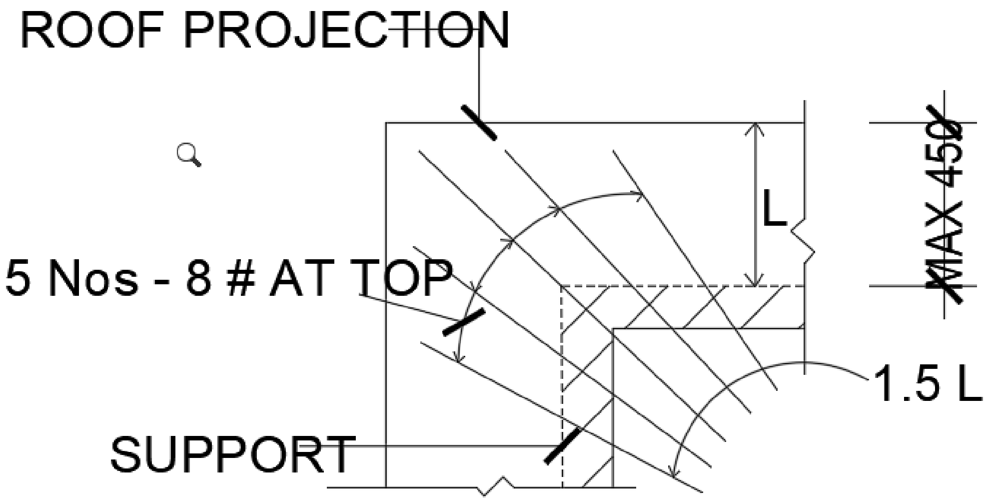
CORNER WITH TWO DISCONTINUOUS ENDS



CORNER WITH ONE DISCONTINUOUS ENDS

TORSIONAL REINFORCEMENT IN SLAB

SHEET:-9

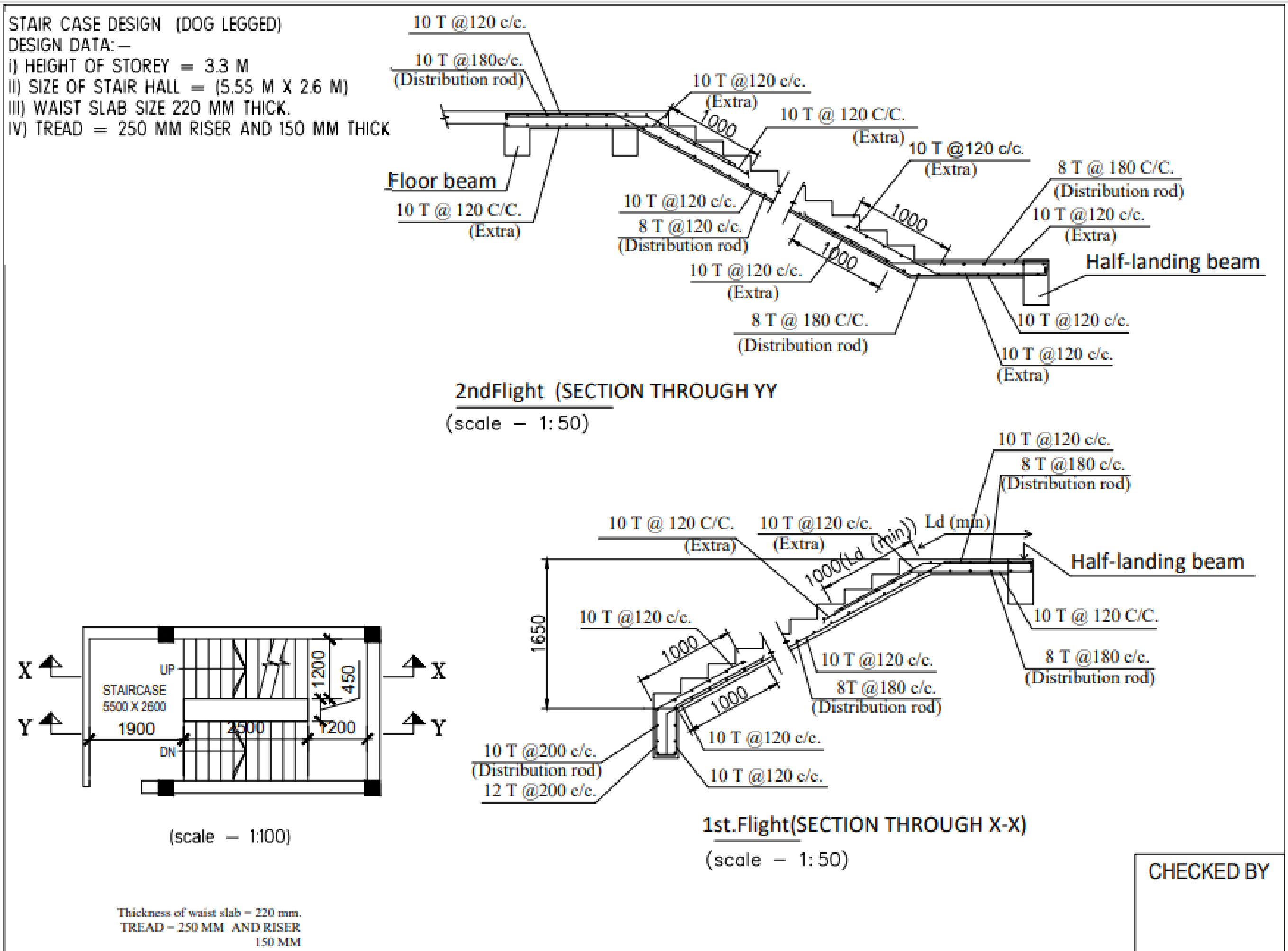


PLAN SHOWING ARRANGEMENT OF REINFORCEMENT AT CORNERS HAVING ROOF PROJECTION

CE(PC)-591/1D

Name: Preparation of detailed drawing of STAIRCASE

SHEET:-10

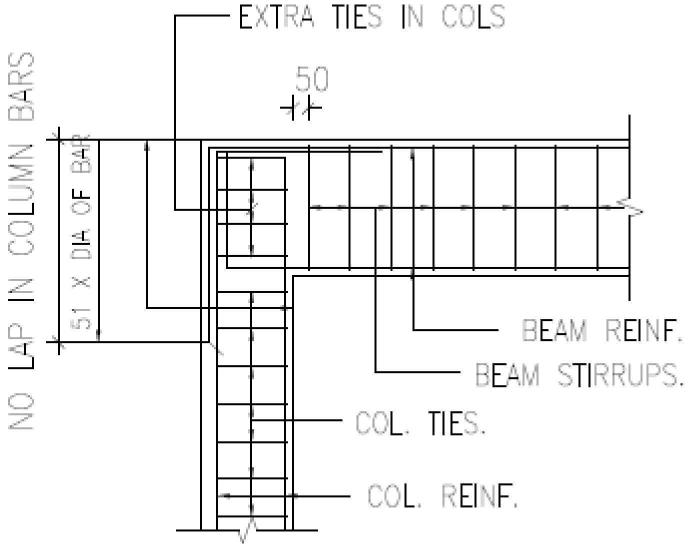


				CHECKED BY
DEPT. & SEM	COLLEGE NAME	DRG. DETAIL	SHEET No.	
DATE	STUDENT NAME		REINFORCEMENT DETAIL OF STAIRCASE	

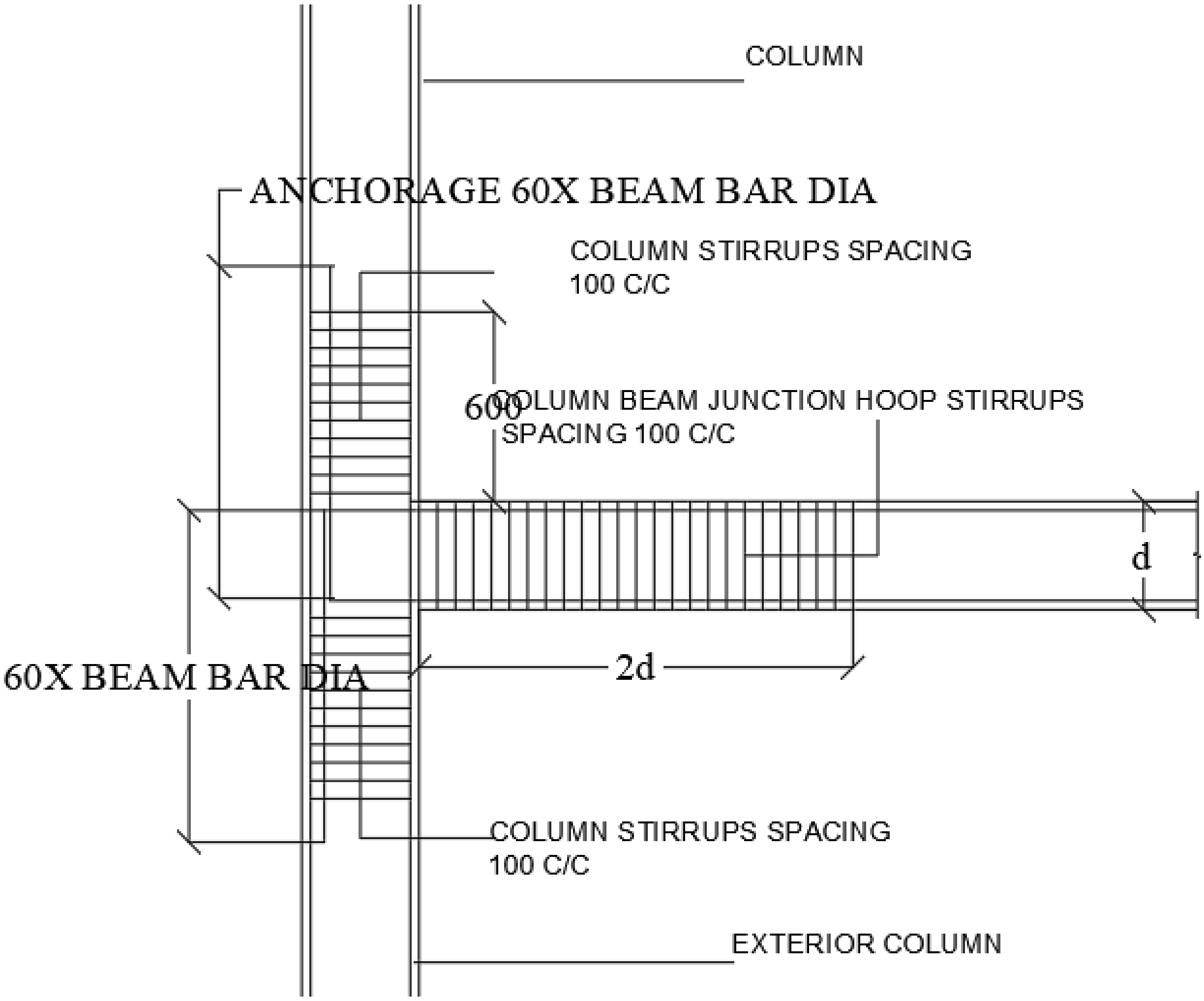
CE(PC)-591/1E

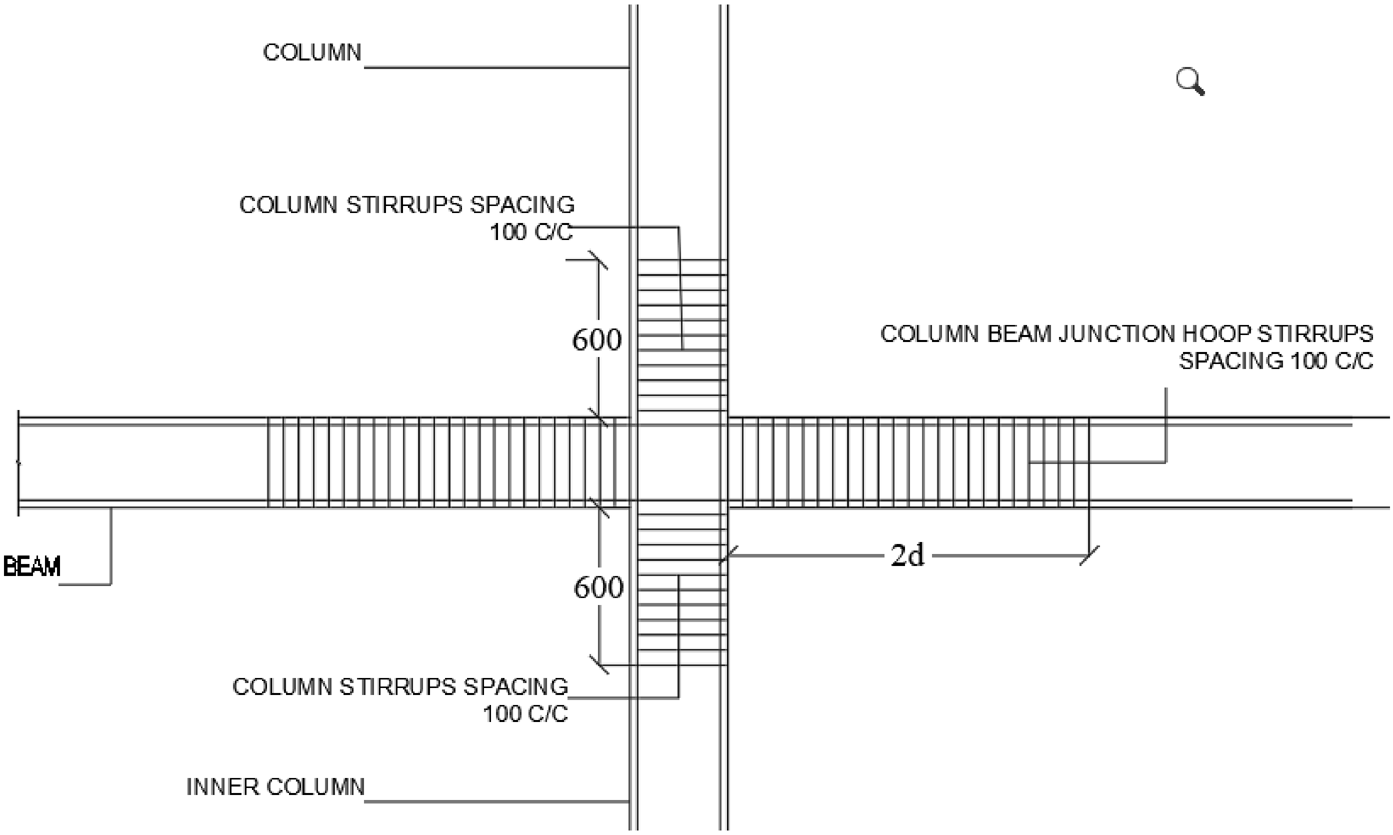
Name: Preparation of detailed drawing of COLUMN, COLUMN BEAM JUNCTION

SHEET:-11



TYP. DETAILS OF BEAM–COLUNMN JUNCTION AT EXTERIOR COLUMN


COLUMN
ANCHORAGE 60X BEAM BAR DIA
COLUMN STIRRUPS SPACING
100 C/C
600
COLUMN BEAM JUNCTION HOOP STIRRUPS
SPACING 100 C/C
d
60X BEAM BAR DIA
2d
COLUMN STIRRUPS SPACING
100 C/C
EXTERIOR COLUMN

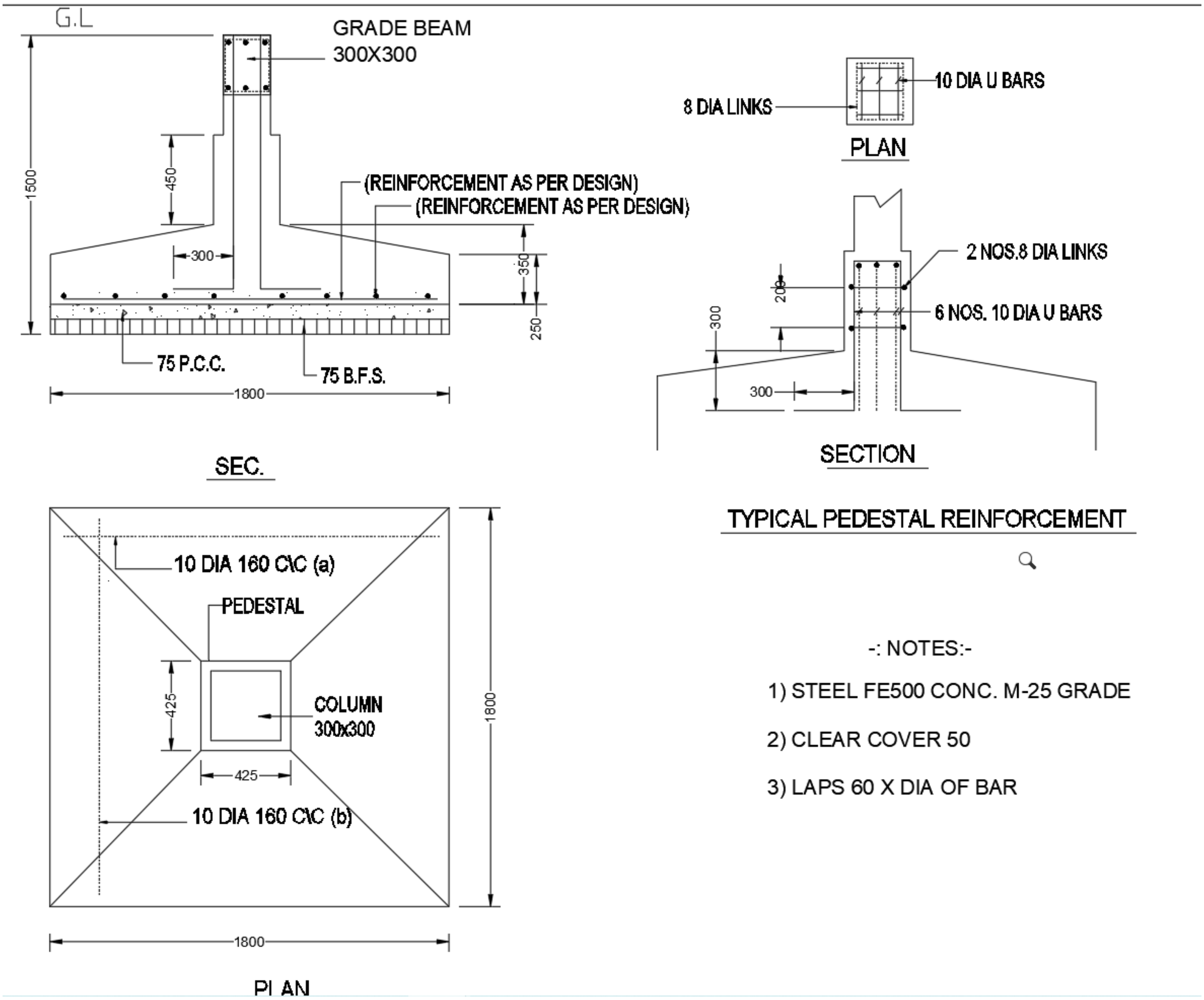


COLUMN BEAM JUNCTION SEISMIC DUCTILITY DETAILS

CE(PC)-591/1F

Name: Preparation of detailed drawing of ISOLATED COLUMN FOUNDATION

SHEET:-12



Siliguri Institute of Technology
Civil Engineering Department

Soil Mechanics Laboratory CE(PC)594

SOIL MECHANICS LABORATORY **(CE(PC)594)**

DEPARTMENT OF CIVIL ENGINEERING

NAME: ____ GROUP: __________________

ROLL NO.__________________________

Soil Mechanics Laboratory

CE(PC)594

LIST OF EXPERIMENT

EXPERMENT NO.	EXPERIMENT NAME
CE(PC)594/1	DETERMINATION OF NATURAL MOISTURE CONTENT
CE(PC)594/2	DETERMINATION OF SPECIFIC GRAVITY
CE(PC)594/3	DETERMINATION OF IN SITU DENSITY
CE(PC)594/4	DETERMINATION OF GRAIN SIZE DISTRIBUTION
CE(PC)594/5	DETERMINATION OF ATTERBERG LIMITS
CE(PC)594/6	DETERMINATION OF PERMEABILITY
CE(PC)594/7	DETERMINATION OF COMPACTION
CE(PC)594/8	DETERMINATION OF UNCONFINED COMPRESSION
CE(PC)594/9	DETERMINATION OF DIRECT SHEAR TEST
CE(PC)594/10	DETERMINATION OF VANE SHEAR TEST
CE(PC)594/11	DETERMINATION OF TRIAXIAL TEST

EXPERIMENT NO. 1

DETERMINATION OF NATURAL MOISTURE CONTENT

NAME: Moisture content determination oven drying method.

IS Code: IS:2720 (Part-2)-1973)]

OBJECTIVE:

The object of this test is to determine the water content of a soil sample in the laboratory by oven drying. This experiment forms an essential part of many other laboratory experiment..

APPARATUS:

Sl. No.	Name of the Equipments used
1.	Non- Corrodible airtight containers.
2.	Balance of sufficient sensitivity to weigh soil samples to an accuracy of 0.04 percent of the weight of the solid taken for the test. For fine grained soils the balance should have an accuracy of 0.01g and for coarse-grained soil, it should have an accuracy of 0.1 g.
3.	Desicator with any suitable desicating agent
4.	Thermostatically controlled oven, with interior of non- corroding
5.	Material to maintain temperature between 105^0C to 110°C.

THEORY:

The natural water content also called the natural moisture content is the ratio of the weight of water to the weight of the solids in a given mass of soil. This ratio is usually expressed as percentage.

PROCEDURE:

(i) Clean the container and weigh it with lid (W1)

(ii) Put the required quantity of the moist soil sample in the container and replace The lid. Take the weight W2. The quantity of the soil sample to be taken depends upon its gradation and maximum size of panicles. The following quanties are recommended for laboratory use.

Size of Particles more than 90% passing	Minimum quantity of soil specimen to be taken for test in gm.
425-micron IS Sieve	25
2.36mm IS Sieve	50
475mm IS Sieve	200

10mm IS Sieve	300
20mm IS Sieve	500
40mm IS Sieve	1000

(iii) Keep the container in the oven with lid removed and maintain the temperature of the oven between 105°C to 1 10°C for about 16 to 24 hours.
(iv) Take out the container, replace the lid and cool it in the desiccators. Find the weight W3 of the container with lid and dried soil sample.

DATA AND OBSERVATION SHEET

Determination No.	1	2	3
1. Container. No 2. Wt: of container (W1) g 3. Wt: of container +wet soil (W2) g 4. Wt: of container + dry soil (W3)g 5. Wt : of dry soil(W3-Wl)g 6. Wt: of water (W2-W3)g 7. Moisture content W= (W2-W3)/(W3-W1)x 100%			

RESULT

Moisture content 'w' =

EXPERIMENT NO. 2

DETERMINATION OF SPECIFIC GRAVITY

NAME: Specific gravity determination by Pycnometer method.
IS Code: IS:2720 (Part-3)-1980)]

OBJECT:

The object of the test is to determine the specific gravity of soil fraction passing 4.75 mm IS Sieve by pycnometer.

APPARATUS:

Sl. No.	Name of the Equipments used
1	Pycnometer of about 900ml capacity with the conical brass cap screwed at its top
2	Balance sensitive to 1 g
3	Glass rod
4	Deaired. distilled water

THEORY:

Specific gravity is the ratio of the weight in air of a given volume of the soil particles to the weight in air of equal volume of distilled water at 4°C. It is an important factor which is used in computing other soil properties. For example void ratio , panicle size determination by means of the hydrometer method etc.

PROCEDURE:

(i) Clean the pycnometer and dry it. Find the weight (W1) of the pycnometer brass cap and washer, accurate to 1g.
(ii) Take about 200 to 400 g oven dried soil and put it in the pycnometer. Weigh the pycnometer plus soil (W2)
(iii) Fill the pycnometer to half its height with distilled water, and mix it thoroughly with glass rod. Add more water and stir it. Replace the screw top and fill the pycnometer flush with hole in the conical can Dry the pycnometer from outside and weigh it (W3)
(v) Empty the pycnometer, clean it thoroughly and fill it with distilled water, to the hole of the conical cap and weigh it (W2)
(vi) Repeat step 2 to 4 for two more determinations of specific gravity.

DATA AND OBSERVATION SHEET

Determination No.	1	2	3
Weight of Pycnometer (W1)g Weight of Pyc + soil (W2)g Weight of Pyc + soil +water (W3)g Weight of Pyc +water (W4)g			

CALCULATION:
The Specific gravity is calculated from
G= (W2-W1)/ [(W2-W1)-(W3-W4)]

RESULT

Specific gravity of the given soil (G) =

EXPERIMENT NO. 3

DETERMINATION OF IN SITU DENSITY

NAME: Determination of Field Density and dry unit weight by Core Cutter Method.

IS Code: IS: 2720(Part 29) - 1975

OBJECTIVE:

To determine the dry density of soil in place by Core Cutter.

APPARATUS:

Sl. No.	Name of the Equipments used
1	Cylindrical core cutter of steel, 130 mm long and 10 cm internal diameter with wall thickness 0f 3 mm, beveled at one end.
2	Steel dolly 2.5 cm high and 10 cm internal diameter with wall thickness 7.5 mm. fitted with a lip to enable it to be on top of the Core cutter.
3	Steel rammer
4	Palette knife
5	Steel rule
6	Balance accurate to 1g.
7	Spade or pick axe or grafling tool
8	Container for water content determination

THEORY:

A cylindrical core cutter is a seamless steel tube. For determination of the dry density of the soil, the cutter is pressed into the soil mass so that it is filled with the soil. The cutter filled with the soil is lifted up. The mass of the soil in the cutter is determined. The dry density is obtained as

$$\rho_d = \gamma / (1+w) = (M/V)/(1+w)$$

Where M= mass of the wet soil in the cutter.

V= internal volume of the cutter.

W= water content.

PROCEDURE:

1. Measure the inside dimensions of core cutter and calculate its volume. Find the mass of the core cutter.
2. Expose the small area, about 30 cm square to be tested and level it.
   Put the dolly on the top of the core cutter and drive the entire assembly into the soil with the help of the rammer until the top of the dolly protrudes about 1.5 cm above the surface.
3. Dig out the container from the surrounding soil and allow some soil to project from the lower end of the cutter. With the help of the straight edge, trim flat the end cutter. Take out the dolly and also trim flat the other end of the cutter.
4. Find the mass of cutter full of soil.
5. Keep some representative specimen of soil for water content determination.
6. Repeat the test at least two or three locations nearby and get the average dry density.

CALCULATIONS:

Sl. No.	Determination no.	1	2	3
1.	Mass of core cutter + wet soil (g)			
2.	Mass of core cutter (g)			
3.	Mass of wet soil (g)			
4.	Volume of core cutter (ml)			
5.	Bulk density (g/cm^3)			
6.	Container no.			
7.	Mass of container + wet soil(g)			
8.	Mass of container + dry soil(g)			
9.	Mass of empty container (g)			
10.	Mass of dry soil(g)			
11.	Mass of water (g)			
12.	Water content (%)			
13.	Dry Density $\rho_d = \gamma /(1+w)$ (g/cm^3)			

RESULT:

The Dry density of the soil sample is………

NAME: Determination of Field Density and dry unit weight by Sand Replacement Method.
IS Code: IS: 2720(Part 28) - 1975

OBJECTIVE:
To determine the dry density of soil in place using sand pouring cylinder.

APPARATUS:

Sl. No.	Name of the Equipments used
1	Sand pouring cylinder of 3 lts. Capacity mounted above a pouring cone and separated by a shutter cover plate.
2	Tool for excavating holes, suitable tools, such as scraper tools to make a level surface.
3	Cylindrical calibrating container with a internal diameter of 100 mm and an internal depth 150mm.
4	Balance to weight up to an accuracy of 1kg.
5	Metal contains to collect excavated soil.
6	Metal tray hole with 100 mm diameter of hole at the centre.
7	Glass plate about 450 sq.mm and 10 mm thick.
8	Clear, informally graded natural sand passing 1mm IS sieve and retained on the 600 μ IS sieve.
9	Suitable non- corrodible air tight containers.
10	Thermostatically controlled oven with on interior non-corroding material the temperature between 105°c to 110°c.
11	A desiccator with a desiccating agent

THEORY:
This method has a major limitation in the case of soils containing coarse- grained particles such as gravel, stones and aggregates. Under such circumstances, field density test by sand replacement method is advantageous, as the presence of coarse grained particles will adversely affect the test results.
The basic principle of sand replacement method is to measure the in- situ volume of hole from which the material was excavated from the weight of sand with known density filling in the hole. The in- situ density of material is given by the weight of the excavated material divided by the in- situ volume.

PROCEDURE:

A) Calibration of the Cylinder

1. Fill the sand pouring cylinder with clean sand so that the level of the sand in the cylinder is within 10mm from the top. Find out the initial weight of the cylinder plus sand (W1) and the weight should be maintained constant throughout the test for which the calibration is used.
2. Allow the sand of volume equal to that of the calibrating container to remount of the cylinder by opening the shutter, close the shutter and place the cylinder on the glass plate. Open the shutter and allow the sand to run out. When no further movement of the sand takes place in the cylinder close the shutter and remove the cylinder carefully. Weight the sand collected on the glass plate. Its weight (W2) gives the weight of sand filling cone portion of the sand pouring cylinder. Repeat this at least three times and take the mean weight (W2). Put the sand back into the sand pouring cylinder to have the same initial constant weight (W1).

B) **Determination of bulk density of soil**

1. Determine the volume (v) of the calibrating container by filling water to the brim. Check this volume by calculating from the measured internal dimensions of the container.
2. Place the sand pouring cylinder concentrically on the top of the calibrating container, after being filled to constant mass (M1). Open the shutter and permit the sand to run into container. When no further movement of sand takes place, close the shutter. Remove the pouring cylinder and find the mass nearest to (M3).

C) **Determination of dry density of soil in place**

1. Exposed about 450 sq.mm area of the soil to be tested and trim it down to level surface. Keep the tray on the level surface and excavate soil in the tray. Find the mass of the excavated soil (M).
2. Remove the tray and place the sand pouring cylinder, so that the base of the cylinder concentrically covers the hole. The cylinder should have a constant mass (M1). Open the shutter and permit the sand to run into the hole. Close the shutter when no further movement of the sand is seen. Remove the cylinder and determine its mass (M4).
3. Keep a representative sample of the excavated soil for water content determination.

CALCULATIONS:

Table 1 Determination of Bulk Density of Sand in the Calibrating Container

Sl. No.	Determination no.	Reading
1	Mass of sand+ Cylinder before pouring (M1)(g)	
2	Mass of sand in cylinder after pouring in cone (M2)(g)	
3	Mean mass of sand in cone (Mc) (M1-M2)(g)	
4	Mass of Cylinder + Sand after pouring in calibrating container (M4)	
5	Mean mass of sand in calibrating container (Mcc) (M1-M4-Mc)	
6	Volume of sand in calibrating container (Vc) (cm^3)	
7	Bulk Density of sand ρ (Mcc/Vc) (g/cm^3)	

Table 2 Determination of In situ Bulk Density and Dry Density

Sl. No.	Determination	Reading
1.	Mass of sand + Cylinder before pouring (W1) (g)	
2.	Mass of sand in cylinder after filling the test hole (W2) (g)	
3.	Mass of sand filling the test hole (W3)(W1-W2-Mc) (g)	
4.	Mass of soil in test hole (Ms) (g)	
5.	Volume of soil in test hole (Vh) (W3/ρ) (cm^3)	
6.	In situ density of the soil in the test hole (Ms/Vh) (g/cm^3)	

RESULT:

The Dry density of the soil sample is………

EXPERIMENT NO. 4

DETERMINATION OF GRAIN SIZE DISTRIBUTION

NAME: Determination of Particle size by Grain Size Analysis.

IS Code: IS: 2720(Part IV) - 1975

OBJECTIVE:

To determine the particle size distribution of a soil by sieving.

APPARATUS:

Sl. No.	Name of the Equipments used
1	Set of fine sieves 2mm, 1mm, 600μ, 425 μ, 212 μ, 150 μ, and 75 μ.
2	Set of coarse sieves 100mm, 80mm, 40mm, 20 mm, 10 mm, and 4.75 mm.
3	Weighing balance with accuracy of 0.1% of the mass of sample.
4	Oven
5	Mechanical Shaker
6	Trays
7	Mortar, with a rubber covered pestle
8	Brushes
9	Riffler

THEORY:

The soil is sieved through a set of IS Sieve. The material retained on different sieves is determined. The percentage of material retained on any sieve is given by

$$p_n = M_n/M \times 100$$

Where, M_n= Mass of soil retained on sieve n.

And M = Total mass of the soil sample.

The cumulative percentage of material retained,

$$C_n = p_1+p_2+p_3+\ldots\ldots+p_n$$

Where, p_1, p_2 etc. are the percentage retained on sieves 1, 2, etc. which are coarser than sieve size n. The percentage finer than sieve n.

$$N_n = 100-C_n$$

PROCEDURE:

Part I. Coarse Sieve Analysis:

1. Take the required of the sample. Sieve it through a 4.75 mm IS sieve. Take the soil fraction retained on 4.75 mm IS sieve for the coarse sieve analysis (Part I) and that passing through the sieve for the sieve analysis(Part II)
2. Sieve the sample through the set of coarse sieves by hand.
   While sieving through each sieve, the sieve should be agitated such the sample rolls I irregular motion over the sieve. The material retained on the sieves may be rubbed with the rubber pestle in the mortar shall be taken so as not to break the individual particles. The quantity of the material taken for sieving on each sieve shall be such that the maximum mass of material retained on each sieves does not exceed the specified value.
3. Determine the mass of the material retained on each sieve.
4. Calculate the percentage of soil retained on each sieve on the basis of the total mass of the sample, taken in step (1)
5. Determine the percentage passing through each sieve.

Part II . Fine Sieve Analysis:

1. Take the portion of the soil passing through 4.75mm IS sieve. Oven dry it at 105° C to 110°C. Weigh it to 0.1% of the total mass.
2. Sieve the soil through the nest of fine sieves. The sieves should be agitated so that the sample rolls in irregular motion over the sieves. However, no particles should be pushed through the sieve.
3. Take the material retained on various sieves in a mortar. Rub it with the rubber pestle, but do not try to break individual particles.
4. Resize the material through the nest of sieves.
5. A minimum of 10 minutes of shaking is retained if a mechanical sieve shaker is used.
6. Determine the percentage retained, cumulative percentage retained, and the percentage finer, based on the total mass taken in step (1).

NOTE:

If the fine fraction contains an appreciable amount of clay particles, the wet sieve analysis is required. Alternatively the following method may be used.

Before conducting step (7) add the water containing sodium- hexametaphosphate at the rate of 2g per litre of water to the soil fraction .Stir the mix thoroughly and leave for soaking. Wash the soaked specimen on a 75µ IS sieve until the water passing the sieve is clear. Take the fraction retained on the sieve and dry it in a oven. Sieve the oven dried soil through the nest of sieves as discussed in step (7). Perform further steps, as before. As a check, the mass of material which would have been retained on pan is equal to the original mass of the soil before washing minus the dry mass of the soil retained on 75µ IS sieve after washing.

CALCULATIONS:

Total mass of dry soil=

Mass of the soil retained on 4.75 mm sieve=

Mass of the soil passing 4.75 mm sieve=

Sl.no.	**Observations**			**Calculations**		
	IS sieve	**Size of opening**	**Mass of soil retained**	**% Mass of soil retained**	**Cumulative % mass retained**	**% finer**
	Coarse fraction (Part I)					
		80 mm				
		40 mm				
		20 mm				
		12.5mm				
		10 mm				
		4.75 mm				
	Finer fraction (Part II)					
		2.36 mm				
		1.18 mm				
		600 µ				
		300 µ				
		150 µ				
		75 µ				
	pan					

RESULT:

Find the particle size distribution curve by plotting particle as abscissa on log scale and the percentage finer as ordinate.

NAME: Grain size analysis of soils by hydrometer analysis test.

SPECIFIC OBJECTIVE

1. To determine the grain size distribution of soil sample containing appreciable amount of fines.

2. To draw a grain size distribution curve.

NEED AND SCOPE OF THE EXPERIMENT

For determining the grain size distribution of soil sample, usually mechanical analysis (sieve analysis) is carried out in which the finer sieve used is 63 micron or the nearer opening. If a soil contains appreciable quantities of fine fractions in (less than 63 micron) wet analysis is done. One form of the analysis is hydrometer analysis. It is very much helpful to classify the soil as per ISI classification. The properties of the soil are very much influenced by the amount of clay and other fractions.

APPARATUS

1. Hydrometer

2. Glass measuring cylinder-Two of 1000 ml capacity with ground glass or rubber stoppers about 7 cm diameter and 33 cm high marked at 1000 ml volume.

3. Thermometer- To cover the range 0 to 50^o C with an accuracy of 0.5 ^{o}C .
4. Water bath.
5. Stirring apparatus.
6. I.S sieves apparatus.
7. Balance-accurate to 0.01 gm.
8. Oven-105 to 110.
9. Stop watch.
10. Desiccators
11. Centimeter scale.
12. Porcelain evaporating dish.
13. Wide mouth conical flask or conical beaker of 1000 ml capacity.
14. Thick funnel-about 10 cm in diameter.

15. Filter flask-to take the funnel.
16. Measuring cylinder-100 ml capacity.
17. Wash bottle-containing distilled water.
18. Filter papers.
19. Glass rod-about 15 to 20 cm long and 4 to 5 mm in diameter.
20. Hydrogen peroxide-20 volume solution.
21. Hydrochloric acid N solution-89 ml of concentrated hydrochloric acid.(specific gravity 1.18) diluted with distilled water one litre of solution.
22. Sodium hexametaphosphate solution-dissolve 33 g of sodium hexametaphosphate and 7 gms of sodium carbonate in distilled water to make one litre of solution.

CALIBRATION OF HYDROMETER

Volume

(a) Volume of water displaced: Approximately 800 ml of water shall be poured in the 1000 ml measuring cylinder. The reading of the water level shall be observed and recorded.

The hydrometer shall be immersed in the water and the level shall again be observed and recorded as the volume of the hydrometer bulb in ml plus volume of that part of the stem that is submerged. For practical purposes the error to the inclusion of this stem volume may be neglected.

(b) From the weight of the hydrometer: The hydrometer shall be weighed to the nearest 0.1 gm.

The weight in gm shall be recorded as the volume of the bulb plus the volume of the stem below the 1000 ml graduation mark. For practical purposes the error due to the inclusion of this stem may be neglected.

Calibration

(a) The sectional area of the 1000 ml measuring cylinder in which the hydrometer is to used shall be determined by measuring the distance between the graduations. The sectional area is equal to the volume include between the two graduations divided by the measured distance between them.

Place the hydrometer on the paper and sketch it. On the sketch note the lowest and highest readings which are on the hydrometer and also mark the neck of the bulb. Mark the center of the bulb which is half of the distance between neck of the bulb and tip of the bulb.

(b) The distance from the lowest reading to the center of the bulb is (R_h) shall be recorded

($R_h = H_L + L/2$).

(c) The distance from the highest hydrometer reading to the center of the bulb shall be measured and recorded.

(d) Draw a graph hydrometer readings vs H_H and R_H. A straight line is obtained. This calibration curve is used to calibrate the hydrometer readings which are taken with in 2 minutes.

(e) From 4 minutes onwards the readings are to be taken by immersing the hydrometer each time. This makes the soil solution to rise, there by rising distance of free fall of the particle. So correction is applied to the hydrometer readings.

(f) Correction applied to the R_h and H_H

V_h= Volume of hydrometer bulb in ml.

A =Area of measuring cylinder in cm^2.

From these two corrected readings draw graph (straight line)

Grain Size Distribution in Soil-Data and Calculation Chart

Date:

Sample No:

Total weight of dry soil taken, W =

Specific Gravity of soil, G =

Hydrometer No.______________ Wt. Of soil gone into solution ,W_s =

Meniscus correction, C_n = Dispersion agent correction =

Reading in water RW =

Temperature correction =

% finer for wt. Of soil W_s gone into solution $N=[(100G)/\{W_s \times (G-1)\}] \times R$

Date	Time	Elapsed Time in Sec	Hydrometer reading upper Meniscus R_h 1000	Corrected hydrometer Reading (1- lower meniscus C_m)	Z_r or Z^l_r	Velocity Cms/sec V=Zr/K or Z^l_r / t	Equivalent dia. Of Particle D_{mm}	R	N(% finer Than for soil)	REMARKS

EXPERIMENT NO. 5

DETERMINATION OF ATTERBERG LIMITS

NAME: Determination of liquid limit.
IS Code: IS:2720 (Part-5)-1985)]

OBJECT:

To find the atterberg limits, namely the liquid limit of the sample of soil as per IS:2720 (Part 5)-1985. These limits are helpful in classifying clayey soils.

APPARATUS:

Sl. No.	Name of the Equipments used
1.	Mechanical liquid limit device:- It shall conform to IS 9259-1987
2	Grooving tool:- It shall conform to IS.9259-1987.
3	Porcelain Evaporating dish:- About 12 to 15cm in diameter
4	Flat glass plate:- 10mm thick and about 45 cm square or larger
5	Spatula:- Flexible, with the blade about 8cm long and 2cm wide for mixing soil and water in the Porcelain evaporating dish
6	Balance:- sensitive to 0.01 g
7	Oven :- Thermostatically controlled with interior of non-corroding material to maintain the temperature between 105 and 110°C
8	Wash bottle or Beaker:- containing distilled water
9	Containers- air tight and non-corrodible for determination of moisture content.

THEORY:

It is the minimum water content at which the soil flows under its own weight. With reference to Casagrande's liquid limit device, it is defined as the moisture content at which a soil mass cut by a grooving tool of standard dimensions will flow together for a distance of ½ inch. under the impact of 25 blows.

PROCEDURE:

About 120g of the soil sample passing 425-micron IS sieve shall be mixed thoroughly with distilled water in the evaporating dish to form a uniform paste. The paste shall have a consistency that will require 30 to 35 drops of the cup to cause the required closure of the standard groove. In the case of clayey soils, the soil paste
shall be left to stand for a. sufficient time (24 hours) so as to ensure uniform distribution of moisture throughout the soil mass The soil should then be re-mixed thoroughly before the test. A portion of the paste shall be placed in the cup above the spot where the cup rests on the base, squeezed down and spread into position with as few strokes of the spatula as possible and at the same time trimmed to a depth of one centimeter at the point of maximum thickness, returning the excess soil to the dish. The soil in the cup shall be divided by firm strokes of the grooving tool along the diameter through the centre line of the cam follower so that a clean, sharp groove of the proper dimension is formed. The cup shall be lifted and dropped by tinning the crank at the rate of 2 revolutions per second until the two halves of the soil cake come in contact with bottom of the groove along a distance of about 12mm. This length shall be measured with end of the grooving tool or a ruler. The number of drops required to cause the groove close for the length of

12mm shall be recorded. A representative slice of soil approximately the width of the spatula, extending from about edge to edge of the soil cake at right angle to the groove and including that portion of the groove in which the soil flowed together, shall be taken for moisture content determination. Repeat the experiment with samples of soil with three more additional moisture contents so as to get me number of blows ranging from 10 to 40.

Draw a graph with log (No: of blows) along X- axis and moisture content in percentage along the Y- axis. From the graph get the moisture content corresponding to 25 blows. According to Atterberg, this gives the liquid limit of the soil.The slope **of the** graph, gives the flow- index.

DATA AND OBSERVATION SHEET

Determination No.	1	2	3
1. Container No			
2. Wt. of container gms			
3. Wt. of container +wet soil			
4. wt. of container +dry soil			
5. wt.of water			
6. wt.of drysoil			
7. water content % = (weight of water / weight of **dry** soil) x100 %			
8. No: of blows **(N)**			

CALCULATION:

The Specific gravity is calculated from

G= (W2-W1)/ [(W2-W1)-(W3-W4)]

RESULT

Specific gravity of the given soil (G) =

NAME: Determination of Shrinkage Limit of a soil sample.
IS Code: IS: 2720(Part 6) - 1972

OBJECTIVE:
1. To determine the shrinkage limit of a sample of the remolded soil.

APPARATUS:

Sl. No.	Name of the Equipments used
6.	Shrinkage dish, having a flat bottom, 45 mm diameter
7.	Two large evaporating dishes about 120 mm diameter, with a pour out and flat bottom
8.	One small mercury dish, 60mm diameter
9.	Two glass plate, one plain and one with prongs, 75x75x3 mm size
10.	Glass cup, 50 mm diameter and 25mm high
11.	IS sieve 425 μ
12.	Oven
13.	Desiccators
14.	Weighing balance, accuracy 0.01g
15.	Mercury

THEORY:
The Shrinkage limit is the water content of the soil when the water is just sufficient to fill all the pores of the soil, and the soil is just saturated. The volume of the soil does not decrease when the water content is reduced below the shrinkage limit. It can be determined from the relation

$$W_s = [(M1 - Ms) - (V1 - V2)\rho w]/Ms \times 100$$

Where, M1 = Initial wet mass, V1 = Initial volume
M_s = Dry mass , V2 = Volume after drying.

PROCEDURE:
1. Take a sample of mass about 100 g from thoroughly mixed soil passing 425 μ sieve.
2. Take about 30 gm of the soil sample in a large evaporating dish. Mix it with distilled water to make a creamy paste which can be readily worked without entrapping the air bubbles.
3. Take the shrinkage dish. Clean it and determine its mass.
4. Fill mercury in the shrinkage dish. Remove the excess mercury.

5. Transfer the mercury of the shrinkage dish to a mercury weighing dish and determine the mass of the mercury to an accuracy of 0.1 g. The volume of the shrinkage dish is equal to the mass of mercury in grams divided by the sp. Gravity of mercury.

CALCULATIONS:

Sl. No.	**Determination no.**	**1**	**2**	**3**
1	Mass of core cutter + wet soil (g)			
2	Mass of core cutter (g)			
3	Mass of wet soil (g)			
4	Volume of core cutter (ml)			
5	Bulk density (g/cm^3)			
6	Container no.			
7	Mass of container + wet soil(g)			
8	Mass of container + dry soil(g)			
9	Mass of empty container (g)			
10	Mass of dry soil(g)			
11	Mass of water (g)			
12	Water content (%)			
13	Dry Density $\rho_d = \gamma /(1+w)$ (g/cm^3)			

RESULT:

The Dry density of the soil sample is………

SOIL MECHANICS LABORATORY**(CE(PC)594)**

NAME: Determination of Plastic Limit of a soil sample

IS Code: IS: 2720(Part 5) - 1985

OBJECTIVE:
To determine the plastic limit of a sample of remoulded soil.

NEED AND SCOPE

Soil is used for making bricks , tiles , soil cement blocks in addition to its use as foundation for structures.

APPARATUS REQUIRED

1.Porcelain dish.
2.Glass plate for rolling the specimen.
3.Air tight containers to determine the moisture content.
4.Balance of capacity 200gm and sensitive to 0.01gm
5.Oven thermostatically controlled with interior of non-corroding material to maintain the temperature around 105^0 and 110^0C.

PROCEDURE

1. Take about 20gm of thoroughly mixed portion of the material passing through 425 micron I.S. sieve obtained in accordance with I.S. 2720 (part 1).

2. Mix it thoroughly with distilled water in the evaporating dish till the soil mass becomes plastic enough to be easily molded with fingers.

3. Allow it to season for sufficient time (for 24 hrs) to allow water to permeate throughout the soil mass

4. Take about 10gms of this plastic soil mass and roll it between fingers and glass plate with just sufficient pressure to roll the mass into a threaded of uniform diameter throughout its length. The rate of rolling shall be between 60 and 90 strokes per minute.

5. Continue rolling till you get a threaded of 3 mm diameter.

6. Kneed the soil together to a uniform mass and re-roll.

7. Continue the process until the thread crumbles when the diameter is 3 mm.

8. Collect the pieces of the crumbled thread in air tight container for moisture content determination.

9. Repeat the test to atleast 3 times and take the average of the results calculated to the nearest whole number.

OBSERVATION AND REPORTING

Compare the diameter of thread at intervals with the rod. When the diameter reduces to 3 mm, note the surface of the thread for cracks.

PRESENTATION OF DATA

Container No.		
Wt. of container + lid, W_1		
Wt. of container + lid + wet sample, W_2		
Wt. of container + lid + dry sample, W_3		
Wt. of dry sample = $W_3 - W_1$		
Wt. of water in the soil = $W_3 - W_2$		
Water content (%) = $(W_3 - W_2) / (W_3 - W_1) \times 100$		

Average Plastic Limit=

Plasticity Index(Ip) = (LL - PL)=

Toughness Index =Ip/I_F

EXPERIMENT NO. 6

DETERMINATION OF PERMEABILITY

NAME: Determination of Co- efficient of Permeability by Constant head and Variable head parameter.
IS Code: IS: 2720(Part 36) - 1987

OBJECTIVE:

2. To determine the Co efficient of Permeability using Constant Head and Variable Head Method.

APPARATUS:

Sl. No.	Name of the Equipments used
16.	Permeameter mould- 1000ml capacity with detachable base plate.
17.	Removable extension collar.
18.	Drainage base
19.	Dummy plate
20.	Drainage cap
21.	Two porous discs, one of the size of Dummy plate and the other for inserting into the drainage cap.
22.	Metal ring for connecting drainage cap with mould and base plate.
23.	Compaction rammer 2.6 kg with 310mm height of fall.
24.	Rubber seals, glass, stand pipes, constant head tank, meter scale, measuring cylinder, stop watch, thermometer, deaired water, filter paper etc.

THEORY:

The ease with which water flows through soils is indicated by its permeability. The co – efficient of permeability is the rate of flow of water through a unit cross- sectional area of a soil mass under unit hydraulic gradient which maintains laminar flow.
The permeability of soil is a very important engineering property because it has a dominating influence on the total engineering behavior of soils. Permeability is required in all problems involving flow of water through soil such as seepage under dams, dewatering and drainage of sub grades, embankments, excavation, etc. The permeability characteristic governs the selection of soil to be used for cores in earth dams and drains in clay.

PROCEDURE:

A. **Constant Head Method**
   1. Measure the inside diameter and height of permeameter.
   2. Prepare the remoulded specimen.
   3. Attach the Constant head reservoir to the drainage base for sometime such that a steady state is established.
   4. De-air the top by opening the air vent.
   5. Allow water to flow under constant head.
   6. Collect the water discharged in a graduated jar and note the time interval for specified discharge or the discharge for a specified time.
   7. Note head causing flow.
   8. Repeat the experiment under the same head for three times.
   9. Note the temperature of water used for the test.

B. **Variable head method**
   1. Measure the inside diameter and height of permeameter.
   2. Prepare the remoulded specimen.
   3. Attach the stand pipe to the drainage cap and allow to flow out from drainage base for sometime so that the specimen will be saturated before the test is begun.
   4. De-air the top by opening the air vent.
   5. Find the inside diameter of the Stand pipe.
   6. Measure the time required for the water level to fall from initial head (h1) to a known final level (h2).
   7. Re-fill the stand pipe and repeat the test till three successive readings give the same time interval for a fall of head from h1 to h2.

PRECAUTIONS:

1. Ensure there is no air in the tubes connecting constant head tank to permeameter.
2. Assembly is to be tightened so that there is no leakage.
3. Allow enough time to attain steady state flow.
4. Make sure that the soil is fully saturated.

CALCULATIONS:

A. Constant Head method

Length (L) - 127.3 mm   Diameter (d) - 100 mm

Area (A) -

Sl. No.	**Head level**	**Time in minutes**	**K (cm/sec)**

K= (Q x L)/ (A x h x t) cm/s

K= Co- efficient of permeability.

Q= Quantity of water flowing in time interval t (sec)

L= Length of sample. (cm)

A= area of c/s of sample (cm^2)

h = head causing flow (cm)

B. Variable head method

Length (L) - 127.3 mm   Diameter (d) - 100 mm

Area (A) -   Diameter of stand pipe= 50mm

Area of c/s of stand pipe “a”=

Sl. No.	h1	h2	Time interval sec “t”	K	Avg. K

t= Time interval for head to fall from h1 to h2.

RESULT:

1. Coefficient of permeability by Constant head method=
2. Coefficient of permeability by Variable head method

EXPERIMENT NO. 7

DETERMINATION OF COMPACTION

NAME: Determination of Bulk Density and Dry Density by Standard Proctor Test.
IS Code: IS: 2720(Part 7) - 1983

OBJECTIVE:

3. To determine the compaction characteristics of a soil sample.

APPARATUS:

Sl. No.	Name of the Equipments used
25.	Compaction mould, capacity 1000ml.
26.	Rammer, mass 2.6 kg.
27.	Collar 60mm high.
28.	IS Sieve 4.75 and 20 mm
29.	Oven
30.	Weighing balance
31.	Spatula
32.	Mixing tools

THEORY:

Compaction is the process of determination of soil by reducing air voids. The degree of compaction of a given soil is measured in term of its density. The dry density is maximum at the optimum water content. The dry density is obtained as

$$\rho_d = \gamma /(1+w) = (M/V)/(1+w)$$

Where M= Total mass of the soil.
V= Volume of the soil.
W= water content.

PROCEDURE:

1. Take out 20 kg of air dried soil. Sieve it through 20 mm and 4.75 mm sieve. Determine the ratio of retain and that passing 4.75mm sieve.
2. If the % retained on 4.75 mm sieve is greater than 20%, use the larger mould of 150 mm diameter, if it is less than 20%, the mould of 100mm diameter can be used.
3. Mix the soil retained on 4.75 mm sieve and that passing 4.75 mm sieve in the proportions to obtain 16 to 18 kg of soil specimen.
4. Clean and dry the mould. Grease them lightly.
5. Weigh the mould.
6. Take 16-18 kg of soil specimen. Add water to it to bring the water content to about 4%. Keep the soil for maturing. Mix the mature soil thoroughly and divide in to 6 to 8 parts.
7. Attach the collar to the mould. Place the mould on a solid base.
8. Take 2.5 kg of the processed soil, and place it in the mould in equal 3 layers with 25 blows in each layer with the rammer.
9. Remove the collar, and trim off the excess soil projecting above the mould using a spatula.
10. Clean the base plate and the mould from outside. Weigh it.
11. Take the soil sample for water content determination from the top of the mould.
12. Add about 3% of the water to the fresh portion of the processed soil, and repeat the steps 8-11.

CALCULATIONS:

Sl. No.	**Determination no.**	**1**	**2**	**3**
14.	Mass of empty mould + Base mould + compacted soil (g)			
15.	Mass of empty mould + base plate (g)			
16.	Mass of compacted soil (g)			
17.	Volume of mould (ml)			
18.	Bulk density (g/cm^3)			
19.	Container no.			
20.	Mass of container + wet soil(g)			
21.	Mass of container + dry soil(g)			
22.	Mass of empty container (g)			
23.	Mass of dry soil(g)			
24.	Mass of water (g)			
25.	Water content (%)			
26.	Dry Density $\rho_d = \gamma /(1+w)$ (g/cm^3)			

RESULT:

The Dry density of the soil sample is………

EXPERIMENT NO. 8

DETERMINATION OF UNCONFINED COMPRESSION

NAME: UNCONFINED COMPRESSION TEST
IS Code: IS:2720 Part (10)-1991

OBJECT AND SCOPE OF THE TEST:

To determine the unconfined compression of clayey soils using controlled strain.

DEFINITION AND THEORY:

Unconfined compressive strength is the maximum compressive stress which a cylindrical soil sample is able to carry when its sides ere net confined The U.C.C. test is sometimes referred to as undrained test, because the condition φ =0 is same as that developed in unconsolidated undrained test of saturated soils. In a plot of normal stress vs shear stress all the Mohr circles will pass through the origin. Mohr-envelop is horizontal. Shear strength due to cohesion is given by half the compressive strength. Because of the lack of Lateral support, the compressive strength is given by
UCC test is lower than those given by other tests. Some amount of confining effect is provided by the surface tension due to moisture in the soil and will be more if the soil is saturated. But in this test the internal soil condition like pore water pressure and degree of saturation can't be controlled. The friction at the ends of the test specimen provides a lateral restraint which alters the internal stress and this friction can be minimised by using special conical, lubricated end plates. In this test more uniform stresses and strains are developed and failure surface will tend to form in the weakest portion and not along a predetermined surface.

APPARATUS:

(i) Load frame to apply compressive load at constant rate of strain
(ii) Proving ring
(iii)Dial gauge
(iv)Vernier callipers
(v) Split moulds and compaction device for making remoulded specimens

TEST PROCEDURE:

1. The cylindrical soil sample at the required density and water content is prepared
2. Measure the length and cross-sectional area (A) 01 the sample
3. Place the cylindrical soil sample in the machine
4. Set up the dial gauge and the proving to measure deflection and axial load
5. Use a strain -rate of 0.5 to 1.0 percent per minute
6. Record the proving ring reading corresponding to specific deformation dial readings.
7. Compress the sample until failure planes have definitely developed or the stress strain cure is well past its peak or until an axial strain of 20 percent is reached

8. Sketch the failure pattern
9. Moisture content of the specimen is found

PRECAUTIONS:

As unconfined compressive strength of soil may be small, use sensitive proving rings of lower capacity to measure loads

GRAPH:

Draw the stress Vs % strain graph with stress in kg/cm2 along Y axis and % of strain along X-axis

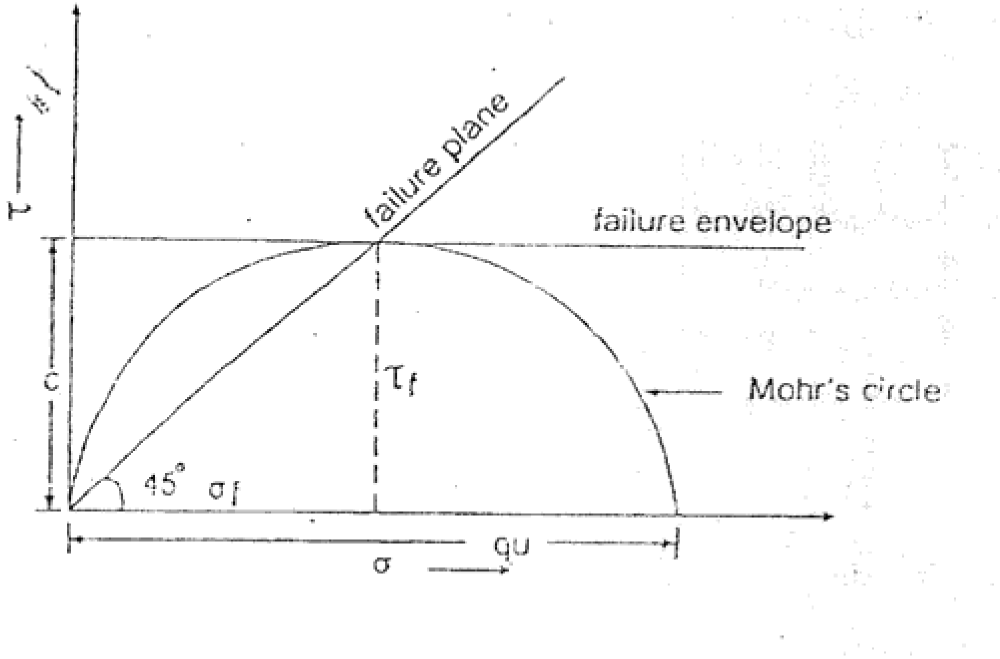
DATA AND OBSERVATION SHEET:

Sample diameter —
Cross-sectional area of the sample (A) =
Height of the sample =
Strain rate =
Proving ring constant =
Least count of deformation dial gauge =

Sl.No	Proving ring reading	Load kg	Deformation Dial gauge reading	Compression $\delta 1$	Strain $\delta 1$ = e	Increased c/s area of sample $A_1 = A/(1-e)$	Actual stress (load/A1)

CALCULATIONS:

(i) The unconfined compressive strength (qu) is got from the graph
(ii) The Mohr's circle is drawn for the soil sample.



RESULT:

1) Unconfined compressive strength of the soil (qu)=
2) The angle of internal friction of soil (φ) =
3) The shear strength of soil at failure =
4) The normal stress at failure =
5) Cohesion of soil (c) =

EXPERIMENT NO. 9

DETERMINATION OF DIRECT SHEAR TEST

NAME: DIRECT SHEAR TEST
IS Code: IS 2720 (Part 13)-1986.

OBJECT AND SCOPE OF THE TEST:

To determine the shear parameters (cohesion and angle of internal friction) of a soil sample and to determine the stress-strain characteristics.

DEFINITION AND THEORY:

By shear strength of the soil we mean the maximum resistance offered by the soil against shearing forces. Failure occurs by slip for cases where the shearing force exceeds this particular value.
By Coulomb's law, we have
$S = C+\sigma \tan \varphi$
Where S= shear resistance or shear strength of soil
σ= the normal stress applied
C= cohesion of the soil
φ= Angle of internal friction of the soil
A direct shear test is one in which failure of a soil specimen in shear is caused along a pre determined plane. The shear force and the normal load are applied directly to the specimen.

APPARATUS:

(i) Shear box. container for shear box, grid plates, porous stones, base plate, loading pad
(ii) Loading frame for applying shear force at a constant rate of shearing displacement (with different speeds)
(iii)Loading yoke for applying normal loads
(iv)Weights.
(v) Proving ring- to measure shear load
(vi)Dial gauges- 2 nos with least count of 0.01 mm
(vii) Balance, spatula, straight edge etc.

TEST PROCEDURE:

(1) Weigh the required quantity of sand to make the volume of the test specimen in shear box as per the density specified.
(2) The two halves of the shear box are held together by locking pins, insert the bottom plate and on the top of this, place the plane grid with segregations at right angles to the direction of shear.
(3) Prepare the sample over this
(4) Insert the plane grid on the top of the specimen and insert the top loading plate
(5) Keep the shear box in the container for shear and set up the loading frame.
(6) Keep the loading arm of the shear box in contact with the proving ring. The normal load is applied on the soil sample.
(7) The locking pins are removed

(8) The sample is sheared at a constant rate of deformation (1.25mm/rnin)
(9) The maximum reading of the proving ring is noted which gives the shear load
(10) The test is repeated on fresh samples of sand with different normal loads and the shear load at failure is noted in each case.
(11) For the last normal load, dial gauges are attached so that the normal and shear displacements are measured until the soil fails.

PRECAUTIONS:

1. The specimen should be set up without causing any initial disturbance to the sample
2. Remove the locking pins before starting the test.
3. Verify the capacity of the proving ring and ensure that it is not exceeded
4. Select the rate of application of shear load based on the type of test

OBSERVATION AND CALCULATION SHEET:

Size of shear box –

Normal stress =

Sl.No	Proving ring reading	Load kg	Deformation Dial gauge reading	Displacement Δl	Strain e = Δl/l	Increased c/s area of sample A_1=A/(1-e)	Shear stress (load/A1)

Normal stress vs Shear stress:

Sl. No.	Normal load (kg)	Shear stress

RESULT:

From plot,
C’=
Φ’=

EXPERIMENT NO. 10

DETERMINATION OF VANE SHEAR TEST

NAME: VANE SHEAR TEST

IS Code: IS: 2720 (Part 30)-1980

OBJECT AND SCOPE OF THE TEST:

The laboratory vane shear test for the measurement of shear strength of cohesive soils is useful for soils of low shear strength of less than about 0.5 kgf/cm2 .This test gives the undrained strength of the soil, and the undisturbed and remoulded strength obtained are used for evaluating the sensitivity of the soil.

APPARATUS:

i) Vane- The vane shall consists of four blades each fixed at 90° to the adjacent blades. The vane blades shall be welded together suitably to a central rod, the maximum diameter of which should preferably not exceed 2.5 mm in the portion of the rod which goes into the specimen during the test.
(ii) The apparatus may be either of the hand operated type or motorized. Provisions should be made in the apparatus for the following.
(a) Fixing of vane and shaft to the apparatus in such a way that the vane can be lowered gradually and vertically into the soil specimen
(b) Fixing the tube containing the soil specimen to the base of the equipment, for which it should have suitable hole.
(c) Arrangement for lowering the vane into the soil specimen gradually and vertically, and for holding the vane properly and securely in the lowered position.
(d) Arrangement for rotating the vane steadily and for measuring the rotation of the vane.
(e) A torque applicator to rotate the vane in the soil and a device for measuring the torque applied.
(f) A set of springs capable of measuring shear strength of 0.5 kgf/cm2.

TEST PROCEDURE:

The specimen in the tube should be at least 30 mm in diameter and 75 mm long.
Mount the specimen container with specimen on the base of the vane shear apparatus and fix it securely to the base.
Lower she shear vanes into the specimen to their full length gradually with minimum disturbance of the soil specimen so that the top of the vane is at least 10mm below the top of the specimen. Note the strain and torque indicators.
Rotate the vane at a uniform rate approximately 0.1% sec by suitably operating the torque applicator handle until the specimen fails.
Note the final reading of the torque indicator.
Torque readings and the corresponding strain readings may also be noted at desired intervals of time as the test proceeds.

OBSERVATION AND CALCULATION:

Sl. No.	Initial reading (Deg)	Final reading (Deg.)	Difference (Deg.)	T= Spring constant/180 x Difference Kg-cm	G=1/ $\pi(D^2H/2+D^3/6)$	S= T x G Kg/cm^2	Avg. S	Spring constant Kg-cm

Shear strength, $S = T/ \pi(D^2H/2+D^3/6)$
Where S= shear strength of soil in kg/cm^2
T= Torque in kg-cm
D= overall diameter of vane in cm.

RESULT:

Shear strength =

EXPERIMENT NO. 11

DETERMINATION OF TRIAXIAL TEST

NAME: TRIAXIAL COMPRESSION TEST

IS Code: IS 2720 (Part 11) – 1993

OBJECT AND SCOPE OF THE TEST:

To determine shear parameters of undisturbed soil specimen in the triaxial compression apparatus by unconsolidated undrained test without the measurement of pore pressure.

DEFINITION AND THEORY:

The triaxial compression test is used for the determination of shear characteristics of all types of soils under different drainage conditions. In this test, the application of the all-round pressure and of the deviator stress form two separate stages of the test. The first stage is known as the consolidation stage and the specimen is subjected to an all round confining pressure (σc). In the second stage of the test, called the shearing stage, an additional axial stress, known as the deviator stress (σd) is applied on the top of the specimen through a ram. Thus the total stress in the axial direction at the time of shearing is equal is (σc + σd).

APPARATUS:

(i) Triaxial cell, with all accessories.
(ii) Apparatus for applying and maintaining the desired fluid pressure in the cell
(iii)Compression machine, capable of applying axial compression to the specimen, at convenient speeds
(iv)Dial gauge to measure axial compression
(v) Seamless rubber membranes
(vi)Membrane stretcher
(vii) Rubber rings
(viii) Split mould, trimming knife, sample extruder, thin walled rubes
(ix)Water content determination containers
(x) Balance
(xi)Stop watch

TEST PROCEDURE:

a. Preparation of specimen

Take air dried soil. Mix up with required amount of water to give a require density for a given volume. Compact the soil in constant volume. Press hollow cylindrical cutters into the compacted soil and obtain the requisite size specimen

(i) Cover the pedestal in the triaxial cell with a solid end cap or keep the drainage valve closed. Place the specimen assembly centrally on the pedestal. Assemble the cell, with the loading ram initially clear of the top of the specimen, and place it in the loading machine

(ii) Admit the operating fluid in the cell, and raise its pressure to the desired value. Adjust the loading machine to bring the loading ram a short distance away from the seat on the top cap of the specimen. Read the initial reading of the load measuring gauge.

Adjust the loading machine so that the loading ram comes just in contact with the seat of the top of the specimen. Note the initial reading of the dial measuring axial compression

(iii)Apply the compressive force at constant rate of axial compression. Take the simultaneous readings of load and deformation dials, define the stress strain curve. Continue the test until failure or 20% axial strain

(iv)Upon completion of the test, the loading is shut off. Unload the specimen and drain off cell fluid.Dismantle the cell and take out the specimen. Keep samples for water content determination.

(v) Repeat the test on three or more identical specimens under different cell

DATA AND OBSERVATION SHEET

Height of specimen 'I' - Area 'A0' -
Diameter - Volume-
Initial weight: Initial water content
Final weight: Final water content
Cell pressure (σ3)

Table 1

Comp dial reading	Load gauge reading	Comp of sample 'δ'	Strain 'e'	Corrected area	Load	Vertical Stress σ1	Deviator Stress σ1- σ3

Table 2

Test No	Cell pressure (σ3)	Deviator stress at failure (σ1-σ3)	σ1 at failure

GRAPHS

1. A graph with deviator stress on the Y axis and % strain on the X'-axis is plotted to obtain deviator stress at failure. The deviator stress at failure (σ -σ3) is known as the compressive strength of the soil.
2. Mohr's circles are plotted with minor principal stress (σ3) is equal to the cell pressure (σc). The major principal stress (σ1) is equal to the sum of the cell pressure and the deviator stress. For different cell pressures, Mohr circles are drawn and thus obtaining the failure envelopes.

RESULTS

Cohesion (c) =

Angle of internal friction =

Siliguri Institute of Technology
Civil Engineering Department

Transportation Engineering Laboratory CE(PC)596

LIST OF EXPERIMENT

EXPERMENT NO.	EXPERIMENT NAME
CE596/1	AGGREGATE IMPACT VALUE ON COARSE AGGREGATES
CE596/2	AGGREGATE CRUSHING VALUE TEST
CE596/3	LOS ANGELES ABRASION VALUE TEST
CE596/4	FLAKINESS INDEX AND ELONGATION INDEX OF COARSE AGGREGATES
CE596/5	SPECIFIC GRAVITY AND WATER ABSORPTION TESTS OF AGGREGATES
CE596/6	SOFTENING POINT TEST
CE596/7	STANDARD PENETRATION TEST FOR BITUMEN
CE596/8	STRIPPING VALUE OF AGGREGATE

Experiment No. 1

AGGREGATE IMPACT VALUE ON COARSE AGGREGATES

AIM: To determine the impact value of aggregate.

Apparatus for Aggregate Impact Test

The apparatus as per IS: 2386 (Part IV) – 1963 consists of:

(i) A testing machine weighing 45 to 60 kg and having a metal base with a painted lower surface of not less than 30 cm in diameter. It is supported on level and plane concrete floor of minimum 45 cm thickness. The machine should also have provisions for fixing its base.

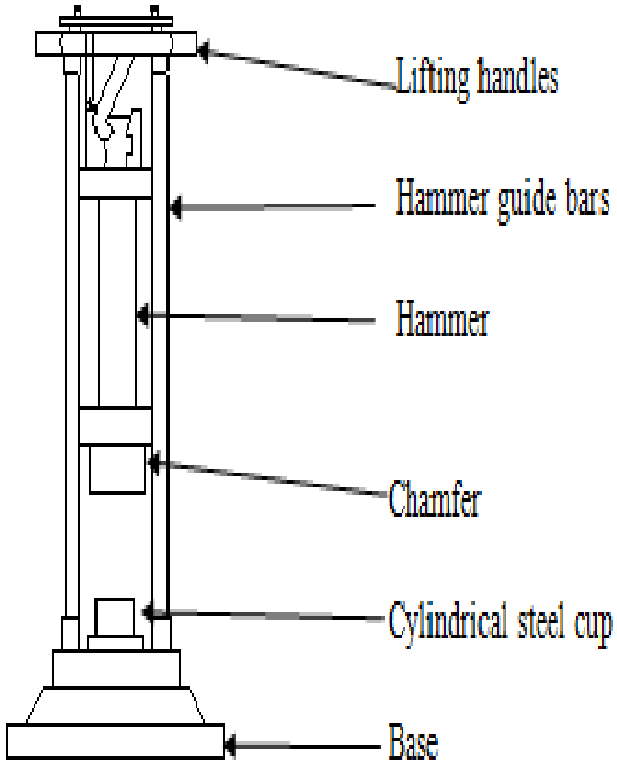
(ii) A cylindrical steel cup of internal diameter 102 mm, depth 50 mm and minimum thickness 6.3 mm.

(iii) A metal hammer or tup weighing 13.5 to 14.0 kg the lower end being cylindrical in shape, 50 mm long, 100.0 mm in diameter, with a 2 mm chamfer at the lower edge and case hardened. The hammer should slide freely between vertical guides and be concentric with the cup. Free fall of hammer should be within 380±5 mm.

(iv)A cylindrical metal measure having internal diameter 75 mm and depth 50 mm for measuring aggregates.

(v) Tamping rod 10 mm in diameter and 230 mm long, rounded at one end.

(vi) A balance of capacity not less than 500g, readable and accurate up to 0.1 g.



AGGREGATE IMPACT TESTING MACHINE

Theory of Aggregate Impact Test

The property of a material to resist impact is known as toughness. Due to movement of vehicles on the road the aggregates are subjected to impact resulting in their breaking down into smaller pieces.

The aggregates should therefore have sufficient toughness to resist their disintegration due to impact. This characteristic is measured by impact value test.

The aggregate impact value is a measure of resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load.

Procedure of Aggregate Impact Test

The test sample consists of aggregates sized 10.0 mm 12.5 mm. Aggregates may be dried by heating at 100-110° C for a period of 4 hours and cooled.

(i) Sieve the material through 12.5 mm and 10.0mm IS sieves. The aggregates passing through 12.5mm sieve and retained on 10.0mm sieve comprises the test material.

(ii) Pour the aggregates to fill about just 1/3 rd depth of measuring cylinder.

(iii) Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.

(iv) Add two more layers in similar manner, so that cylinder is full.

(v) Strike off the surplus aggregates.

(vi) Determine the net weight of the aggregates to the nearest gram(W).

(vii) Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.

(viii) Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.

(ix) Raise the hammer until its lower face is 380 mm above the surface of aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 such blows at an interval of not less than one second between successive falls.

(x) Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm. Also, weigh the fraction retained in the sieve.

Compute the aggregate impact value. The mean of two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

Observations of Impact Test

Observations	Sample 1	Sample 2
Total weight of dry sample (W_1 gm)		
Weight of portion passing 2.36 mm sieve (W_2 gm)		
Aggregate Impact Value (percent) = W_2 / W_1 X 100		

Mean =

Sample calculation

Observations	Sample 1	Sample 2
Total weight of dry sample (W_1 gm)	370	375
Weight of portion passing 2.36 mm sieve (W_2 gm)	50	55
Aggregate Impact Value (percent) = W_2 / W_1 X 100	13.51	14.66

Mean **=14.085**

Result of Impact Test

Aggregate Impact Value =

Recommended Aggregate Impact Test Values

Classification of aggregates using Aggregate Impact Value is as given below:

Aggregate Impact Value	**Classification**
<20%	Exceptionally Strong
10 – 20%	Strong
20-30%	Satisfactory for road surfacing
>35%	Weak for road surfacing

Specified limits of percent aggregate impact value for different types of road construction by Indian Roads Congress is given below.

Sl No	**Type of pavement**	**Aggregate impact value not more than**
1.	Wearing Course	
a)	Bituminous surface dressing	
b)	Penetration macadam	30
c)	Bituminous carpet concrete	
d)	Cement concrete	
2.	Bitumen bound macadam base course	35
3.	WBM base course with bitumen surfacing	40
4	Cement concrete base course	45

Experiment No. 2

AGGREGATE CRUSHING VALUE TEST

AIM:

- To determine the aggregate crushing value of the aggregates.
- To assess the suitability of the aggregates to be used in different road pavements.

Introduction:

The aggregates used in roads and pavement construction must be strong enough to withstand crushing under roller and traffic. Aggregate crushing value test on coarse aggregates gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load.

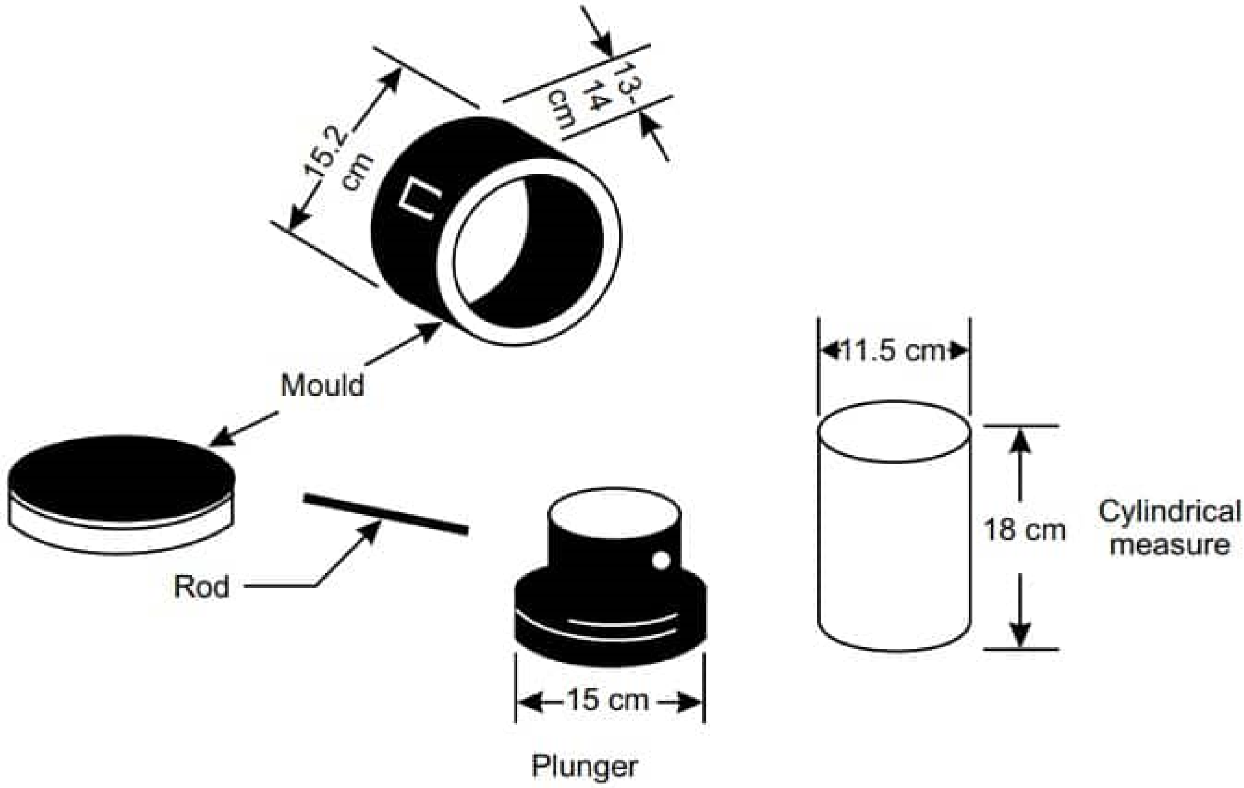
Aggregate crushing value is a numerical index of the strength of the aggregate and it is used in construction of roads and pavements. Coarse aggregate crushing value is the percentage by weight of the crushed material obtained when test aggregates are subjected to a specified load under standardized conditions.

Principle:

The aggregate crushing value gives a relative measure of the resistance of an aggregates to crushing under a gradually applied compressive load. Crushing value is a measure of strength of the aggregates. The aggregate should therefore have minimum crushing value.

Apparatus:

1. A steel cylinder 15 cm diameter with plunger and base plate.
2. A straight metal tamping rod 16mm diameter and 45 to 60cm long rounded at one end.
3. A balance of capacity 3 kg readable and accurate to one gram.
4. IS sieves of sizes 12.5mm, 10mm and 2.36mm
5. A compression testing machine.
6. Cylindrical metal measure of sufficient rigidity to retain its from under rough usage and of 11.5cm diameter and 18cm height.
7. Dial gauge

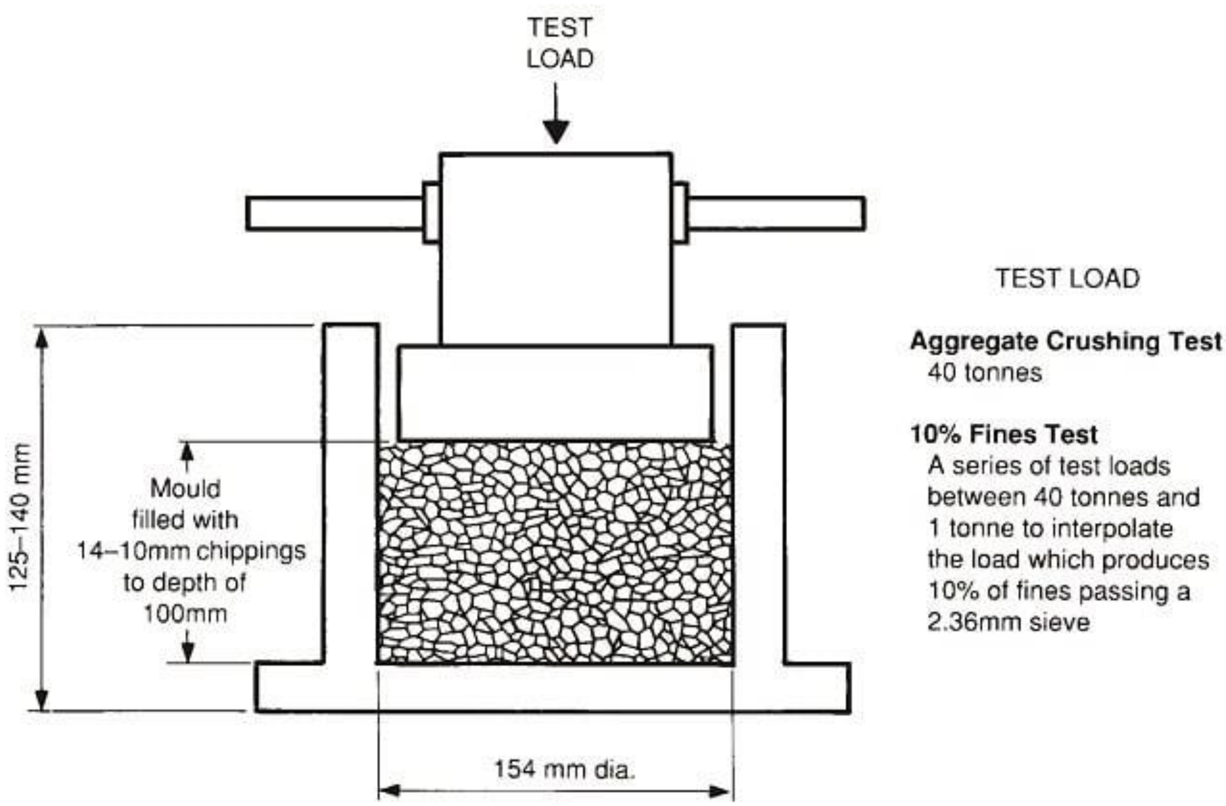



Aggregate crushing value test apparatus

Sampling of aggregates:
Coarse aggregate passing 12.5mm IS sieve and retained on a 10mm IS sieve are selected and heated at 100 to 110°C for 4 hours and cooled to room temperature.
The quantity of aggregate shall be such that the depth of material in the cylinder, after tamping as described below shall be 10 cm. The appropriate quantity may be found conveniently by filling the cylinder.
Measure in three layers of approximately equal depth, each layer being tamped 25 times with the tamping rod and finally leveled off using the tamping rod as straight edge.
Care being taken in the case of weaker materials not to break the particles. The weight of the material comprising the test sample shall be determined (weight A) and the same weight of sample shall be taken for the repeat test.
Test procedure:

1. Put the cylinder in position on the base plate and weigh it **(W)**.
2. Put the sample in 3 layers, each layer being subjected to 25 strokes using the tamping rod. Care being taken in the case of weak materials not to break the particles and weigh it **(W1)**.
3. Level the surface of aggregate carefully and insert the plunger so that it rests horizontally on the surface. Care being taken to ensure that the plunger does not jam in the cylinder.
4. Place the cylinder with plunger on the loading platform of the compression testing machine.
5. Apply load at a uniform rate so that a total load of 40T is applied in 10 minutes.
6. Release the load and remove the material from the cylinder.
7. Sieve the material with 2.36mm IS sieve, care being taken to avoid loss of fines.

8. Weigh the fraction passing through the IS sieve **(W2)**.



Calculation:

The ratio of weight of fines formed to the weight of total sample in each test shall be expressed as a percentage, the result being recorded to the first decimal place.

Aggregate crushing value = (W2 x 100) / (W1-W)

W2 =Weight of fraction passing through the appropriate sieve

W1-W =Weight of surface dry sample.

The mean of two result to nearest whole number is the aggregate crushing value.

Sample data:

Sample number	Total weight of dry sample, W_1 g	Weight of fines passing 2.36 mm IS sieve, W_2 g	Aggregate crushing value=W_2/W_1* 100 percent	Average aggregate crushing value
1	3500	340	340/3500*100=9.71%	9.428%
2	3500	320	320/3500*100=9.143%	

Conclusion: This aggregate can be used in any pavement layers based on the crushing value result, following the MORT&H specification.

Result:

The aggregate crushing value of the sample is _____.

MORT&H specification for aggregate crushing value

(Ministry of road transport and highways, Govt. of India)

Types of Road/Pavement	Aggregate crushing value limit
Flexible pavement	
Soling	50
Water bound macadam	40
Bituminous macadam	40
Bituminous surface dressing or thin premix carpet	30
Dense mix carpet	30
Rigid pavement	
Other than wearing course	45
Surface or wearing course	30

QUESTIONS:

- Explain aggregate crushing value? And how is the value expressed?
- Briefly explain the aggregate crushing value test procedure.
- What is the specified standard size of aggregate for the test?
- What are the Indian standard codes that specifies the aggregate crushing value?
- Aggregate crushing value of material A is 40 and that of B is 25. Which one is stronger/better and why?
- What are the applications of aggregate crushing value test?
- What are the recommended maximum values of aggregate crushing value for the aggregate to be used in base and surface coarse of cement concrete pavement?
- How is the crushing strength test carried out in cylindrical stone specimen?
- Why is the test not carried out commonly?

Experiment No. 3

LOS ANGELES ABRASION VALUE TEST

AIM:

To determine the Los Angeles abrasion value of the aggregate and assess the suitability of aggregates to be used in the different road pavements.

INTRODUCTION

Due to the movement of traffic, the road stones used in the surfacing course are subjected to wearing action at the top. Resistance to wear or hardness is an essential property for road aggregates, especially when used in wearing course. Thus road stones should be hard enough to resist the abrasion due to traffic. When fast moving traffic fitted with pneumatic tyres to move on the road, the soil particles present between the wheel and road surface causes abrasion on the road stone. Steel tires of animal-drawn vehicles, which rub against the stones, can cause considerable abrasion or rubbing of the stones on the road surface. Hence in order to test the suitability of road stones to resist the abrasion action due to traffic, tests are carried out in the laboratory.

Abrasion test on aggregates are generally carried out by any one of the following methods:

1. Los Angeles abrasion test
2. Deval's abrasion test
3. Dorry's abrasion test

Of these tests, the Los Angeles abrasion test is more commonly adopted as the test values of aggregates have been correlated with the performance of studies. The ISI has suggested that wherever possible, Los Angeles abrasion test should be preferred.

<u>Los Angeles Abrasion Test</u>

THEORY:

The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between aggregates and steel balls used as an abrasive charge. The pounding action of these balls also exits while conducting the test. Some investigators believe this test to be more dependable as rubbing and pounding action simulate the field conditions where both abrasion and impact occur. Los Angeles abrasion test has been standardized by the ASTM (American Society for Testing and Materials), AASHTO (American Association of State Highway and Transportation Officials) and also by the ISI. The standard specification of Los Angeles abrasion values is also available for various types of pavement constructions.

APPARATUS:

The apparatus consists of a Los Angeles machine and sieves.

Los Angeles machine consists of a hollow steel cylinder, closed at both ends having an inside diameter 70cm and an inside length of 50cm, mounted on stub shafts about which it rotates on a horizontal axis. An opening is provided in the cylinder for the introduction of the test sample. A removable cover of the opening is provided in such a way that when closed and fixed by bolts and nut, it is dust-tight and the interior surface is perfectly cylindrical. A removable steel shelf projecting radially 8.8 cm into the cylinder and extending to the full length of it is mounted on the interior surface of the cylinder rigidly parallel to the axis. The shelf is fixed at a distance of 125 cm from the opening, measured along the circumference in the direction of rotation, Refer to Figure 1. Abrasive charge, consisting of cast iron spheres approximately 4.8 cm in diameter and 390 to 445 g in weight are used. The weight of the sphere used as the abrasive charge and the number of spheres to be used are specified depending on the gradation of the aggregates tested. The aggregate grading has been standardized as A. B. C, D. E, F, and G for this test and the IS specifications for the grading and abrasive charge to be used are given in Table 1. IS sieve with l.70 mm opening is used for separating the fines after the abrasion test.

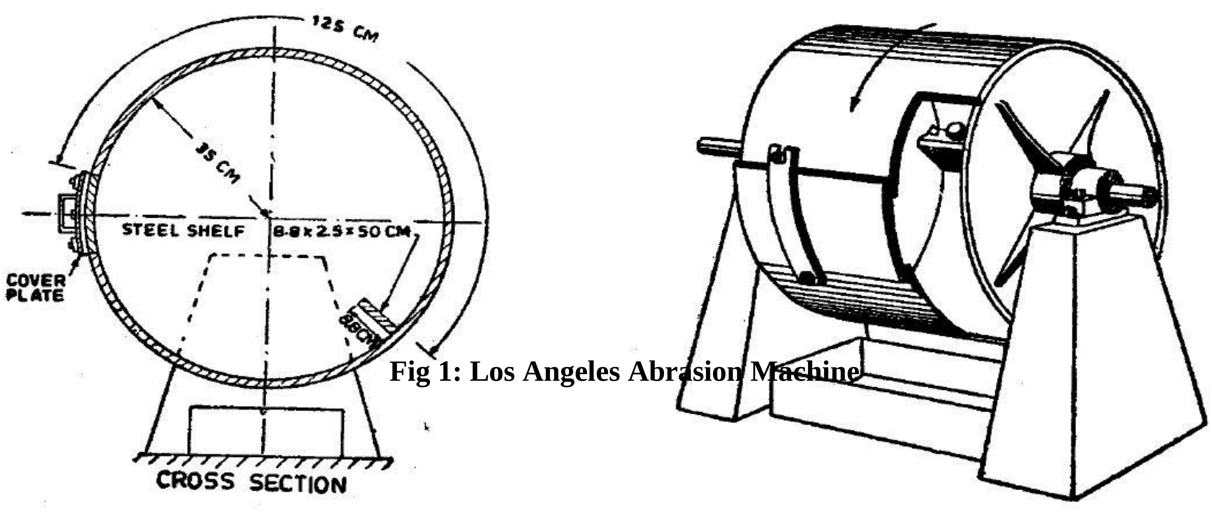
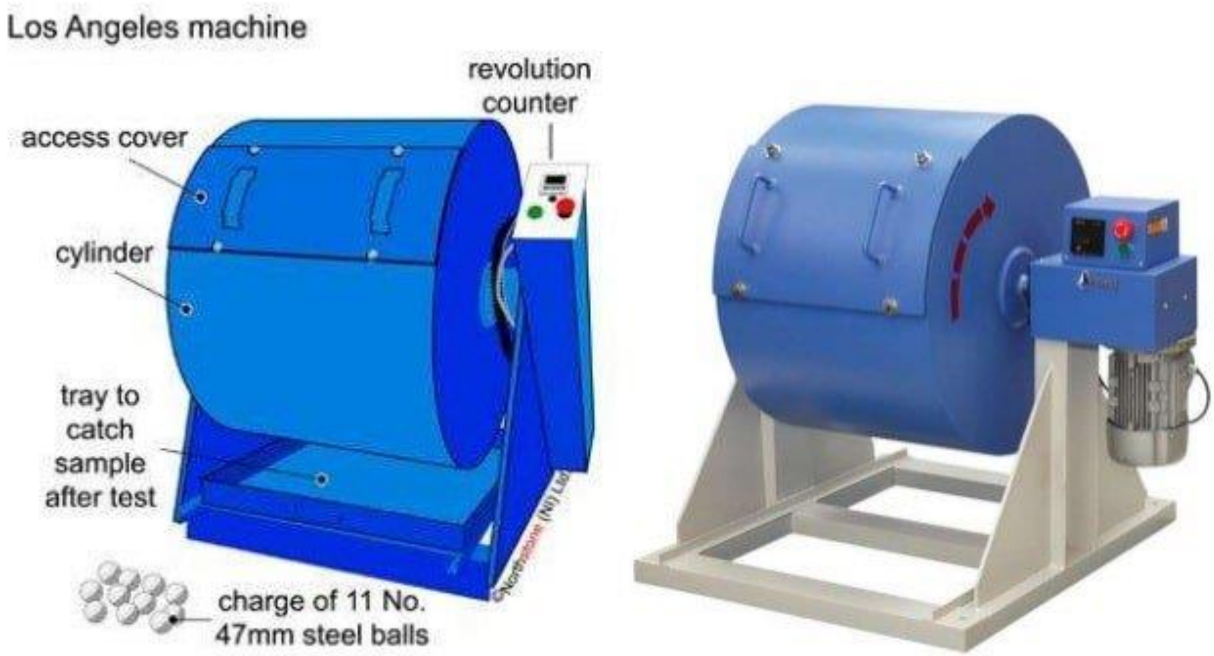


Fig 1: Los Angeles Abrasion Machine



Los Angeles abrasion test setup

Table 1. Los Angeles Abrasion grading table

Grading	Weight in grams of each test sample in the size range, mm (Passing and retained on square holes)										Abrasive Charge	
	80- 63	63- 50	50-40	40-25	25-20	20-12.5	12.5 - 10	10 - 6.3	6.3 - 4.75	4.75-2.36	No. of Spheres	Weight of charge, g
A	-	-	-	1250	1250	1250	1250	-	-	-	12	5000±25
B	-	-	-	-	-	2500	2500	-	-	-	11	4584±25
C	-	-	-	-	-	-	-	2500	2500	-	8	3330±20
D	-	-	-	-	-	-	-	-	-	5000	6	2500±15
E	2500*	2500*	5000*	-	-	-	-	-	-	-	12	5000±25
F	-	-	5000*	5000*	-	-	-	-	-	-	12	5000±25
G	-	-	-	5000*	5000*	-	-	-	-	-	12	5000±25

*****Tolerance of ±2 percent is permitted.

PROCEDURE:

Clean aggregates dried in an oven at 105-110°C to constant weight. Conforming to anyone of the grading A, to G, as per Table l. is used for the test. The grading or gradations used in the test should be nearest to the grading to be used in the construction. Aggregates weighing 5 kg for grading A. B, C or D, and 10 kg for grading E, F or G may be taken as a test specimen and placed in the cylinder. The abrasive charge is also chosen in accordance with Table 1 depending on the grading of the aggregate and is placed in the cylinder of the machine. The cover is then fixed dust-tight. The machine is rotated at a speed of 30 to 33 revolutions per minute. The machine is rotated for 500 revolutions for gradations A. B, C, and D, for gradations E, F, and G, it shall be rotated for 1,000 revolutions. The machine should be balanced and driven in such a way as to maintain uniform peripheral speed.

After the desired number of revolutions, the machine is stopped and the material is discharged from the machine taking care to take out entire stone dust. Using a sieve of a size larger than 1.70 mm IS sieve, the material is first separated into two parts and the finer position is taken out and sieved further on a 1.7 mm IS sieve. The portion of material coarser than 1.7mm size is washed and dried in an oven at 105 to ll0°C to constant weight and weighed correct to one gram.

OBSERVATION SHEET

Table 2. Results of Los Angeles abrasion test

(i) Type of aggregate = (ii) Grading =

(iii) Number of Spheres used = (iv) Weight of Charge =

(v) Number of revolutions = (vi) Speed of rotation =

Test values and calculations	**Test Number**		**Average**
	1	**2**	
Weight of specimen, W_1 g =			
Weight of specimen after abrasion test, retained on 1.70 mm test Sieve, W_2 g =			
Los Angeles abrasion value =Percentage wear = $\frac{W_1 - W_2}{W_1} \times 100$			

CALCULATIONS:

The difference between the original and final weights of the sample represents the actual wear that has taken place and this value is expressed as a percentage of the original weight of the sample and is reported as the percentage wear.

Let the original weight of aggregate $= W_1$ gm

Weight of aggregate retained on 1.70mm IS sieve after the test $= W_2$ gm

Loss in weight due to wear test $= (W_1 - W_2)$ gm

$$\text{Los Angeles abrasive value} = \text{Percentage wear} = \frac{W_1 - W_2}{W_1} \times 100$$

SAMPLE CALCULATION:

OBSERVATION SHEET

Table 3. Results of Los Angeles abrasion test

(i) Type of aggregate = B

(ii) Grading = B

(iii) Number of Spheres used = 11

(iv) Weight of Charge = 4594gm

(v) Number of revolutions = 500

(vi) Speed of rotation = 33 rpm

Test values and calculations	Test Number		Average
	1	2	
Weight of specimen, W_1 g =	5000	5000	5000
Weight of specimen after abrasion test, retained on 1.70 mm test Sieve, W_2 g =	3708	3668	3608
Los Angeles abrasion value =Percentage wear = $\frac{W_1 - W_2}{W_1} \times 100$	25.84%	26.64%	26.24%

Conclusion: The above Los Angeles Abrasion value for the aggregate is within the MoRT&H Specification to be used in any pavement layers.

RESULT:

The result of the Los Angeles abrasion test is expressed as a percentage wear and the average value of two tests may be reported as the Los Angeles abrasion value.

Los Angeles Abrasion Value = _________%

DISCUSSION:

It may seldom happen that the aggregates desired for a certain construction project have the same grading as anyone of the specified gradations. In all the cases, standard grading or gradations nearest to the gradation of the selected aggregates may be chosen.

Different specification limits may be required for gradations E, F and G, when compared with A, B, C and D. Further investigations are necessary before any such specifications could be made.

Los Angeles abrasion test is very commonly used to evaluate the quality of aggregates for use in pavement construction, especially to decide the hardness of stones. The allowable limits of Los Angeles abrasion values have been specified by different agencies based on extensive performance studies in the field. The ISI has also suggested that this test should be preferred wherever possible. However, this test may be considered as one in which resistance to both abrasion and impact of aggregate may be obtained simultaneously, due to the presence of abrasive charge. Also, the test condition is considered more representative of field conditions. The result obtained on stone aggregates is highly reproducible.

Applications of Los Angeles Abrasion Test:

Los Angeles Abrasion test is very widely accepted as a suitable test to assess the hardness of aggregates used in pavement construction. Many agencies have specified the desirable limits of the test, for different methods of pavement construction. The maximum allowable Los Angeles abrasion values of aggregates as specified by Indian Roads Congress for different methods of construction are given in Table 4.

In addition to the above abrasion tests, another test, which is carried out to test the extent to which the aggregates in the wearing surface get polished under traffic, is “Polishing stone value” test. Samples of aggregates are subjected to an accelerated polishing test in a machine and a friction test is carried out on the polished specimen. The results of this test are useful only for comparative purpose and specifications are not yet available.

TABLE 4. Maximum Allowable Los Angeles Abrasion Values of Aggregates in Different Types of Pavement Layers (As Per Ministry of Road Transport & Highways (MoRT&H), GOI)

S. No.	Type of Pavement Layer		Los Angeles Abrasion Value, Maximum %
1	(i)	WBM Sub-base, WBM, WMM and CRM base course	40
	(ii)	Bituminous Macadam base / binder course	
	(iii)	Bituminous Penetration Macadam, Built-up spray grout base course	
2	(i)	Dense-graded Bituminous Macadam binder course	35
	(ii)	Cement Concrete Pavement	
3	(i)	Bituminous carpet surface course	40

	(ii)	Bituminous surface dressing, single or two coats	
	(iii)	Close graded bituminous surface / Mixed seal surfacing	
4	Bituminous concrete surface course		30

QUESTIONS:

1. Why is the Los Angeles abrasion test considered superior to other tests to determine the hardness of aggregates?
2. How is Los Angeles abrasion value expressed?
3. The abrasion value found from Los Angeles test for aggregates A and B is 35% and 25% respectively. Which aggregate is harder? Why? For what type of construction are they suitable?
4. Briefly explain the Los Angeles abrasion test procedure.
5. What are the desirable limits of Los Angeles abrasion values specified for different types of pavement surface course?
6. What are the other different methods of carrying out abrasion tests on aggregates?

Experiment No. 4

FLAKINESS INDEX AND ELONGATION INDEX OF COARSE AGGREGATES

AIM:

i. To determine the elongation index of the given aggregates

ii. To determine the flakiness index of the given aggregates

APPARATUS:

The apparatus for the shape tests consists of the following:
(i) A standard thickness gauge
(ii) A standard length gauge
(iii) IS sieves of sizes 63, 50 40, 31.5, 25, 20, 16, 12.5,10 and 6.3mm
(iv) A balance of capacity 5kg, readable and accurate up to 1 gm.

THEORY:

The particle shape of aggregates is determined by the percentages of flaky and elongated particles contained in it. For base course and construction of bituminous and cement concrete types, the presence of flaky and elongated particles are considered undesirable as these cause inherent weakness with possibilities of breaking down under heavy loads. Thus, evaluation of shape of the particles, particularly with reference to flakiness and elongation is necessary.

The Flakiness index of aggregates is the percentage by weight of particles whose least dimension (thickness) is less than three- fifths (0.6times) of their mean dimension. This test is not applicable to sizes smaller than 6.3mm.

The Elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than nine-fifths (1.8times) their mean dimension. This test is not applicable for sizes smaller than 6.3mm.

Thickness Gauge **Length Gauge**

PROCEDURE:

(i) Sieve the sample through the IS sieves (as specified in the table).
(ii)Take a minimum of 200 pieces of each fraction to be tested and weigh them.
(iii) In order to separate the flaky materials, gauge each fraction for thickness on a thickness gauge. The width of the slot used should be of the dimensions specified in column (4) of the table for the appropriate size of the material.
(iv) Weigh the flaky material passing the gauge to an accuracy of at least 0.1 per cent of the test sample.
(v) In order to separate the elongated materials, gauge each fraction for length on a length gauge. The width of the slot used should be of the dimensions specified in column (6) of the table for the appropriate size of the material.
(vi) Weigh the elongated material retained on the gauge to an accuracy of at least 0.1 per cent of the test sample.

Size of aggregates		Weight of fraction consisting of at least 200 pieces	Thickness gauge size, mm	Weight of aggregates in each fraction passing thickness gauge, mm	Length gauge size, mm	Weight of aggregates in each fraction retained on length gauge, mm
Passing through IS Sieve, mm	Retained on IS Sieve, mm					
1	2	3	4	5	6	7
63	50	W1	23.90	X1	-	-
50	40	W2	27.00	X2	81.00	Y1

40	31.5	W3	19.50	X3	58.00	Y2
31.5	25	W4	16.95	X4	-	-
25	20	W5	13.50	X5	40.5	Y3
20	16	W6	10.80	X6	32.4	Y4
16	12.5	W7	8.55	X7	25.5	Y5
12.5	10	W8	6.75	X8	20.2	Y6
10	6.3	W9	4.89	X9	14.7	Y7
Total		W =		X =		Y =

OBSERVATIONS:

Flakiness Index = (X1+ X2+…..) / (W1 + W2 + ….) X 100

Elongation Index = (Y1 + Y2 + …) / (W1 + W2 + ….) X 100

RESULT:

i) Flakiness Index =

ii) Elongation Index =

Sample Calculation

Size of aggregates		Weight of fraction consisting of at least 200 pieces	Thickness gauge size, mm	Weight of aggregates in each fraction passing thickness gauge, mm	Length gauge size, mm	Weight of aggregates in each fraction retained on length gauge, mm
Passing through IS Sieve, mm	Retained on IS Sieve, mm					
1	2	3	4	5	6	7
63	50	W1= 0	23.90	X1=0	-	-
50	40	W2= 0	27.00	X2=0	81.00	Y1=0
40	31.5	W3=0	19.50	X3=0	58.00	Y2=0
31.5	25	W4= 0	16.95	X4=0	-	-
25	20	W5=2562	13.50	X5=235	40.5	Y3=154
20	16	W6=1653	10.80	X6=216	32.4	Y4=135
16	12.5	W7=854	8.55	X7=135	25.5	Y5=195
12.5	10	W8=462	6.75	X8=169	20.2	Y6=142
10	6.3	W9=263	4.89	X9=63	14.7	Y7=69
Total		W = 5794		X =818		Y =695

RESULT:

i) Flakiness Index = 14.12%

ii) Elongation Index = 12.00%

RECOMMENDED VALUE:

The shape tests give only a rough idea of the relative shapes of aggregates. Flaky and elongated particles should be avoided in pavement construction, particularly in surface course. If such particles are present in appreciable proportions, the strength of pavement layer would be adversely affected due to possibility of breaking under loads. Workability is reduced for cement concrete. IRC recommendations for maximum limits of flakiness index are as given.

Sl No:	Type of pavement	Maximum limits of flakiness index, %
1	Bituminous carpet	30
2 (i)	Bituminous / Asphaltic concrete	
(ii)	Bituminous Penetration macadam	
(iii)	Bituminous surface dressing (single coat, two coats & precoated)	
(iv)	Built up spray grout	25
3 (i)	Bituminous macadam	
(ii)	WBM base course and surface course	15

Experiment No. 5

SPECIFIC GRAVITY AND WATER ABSORPTION TESTS OF AGGREGATES

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AIM

To determine the specific gravity and water absorption of the given aggregate.

INTRODUCTION

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Aggregates having low specific gravity are generally weaker than those with high specific gravity. This property helps in a general identification of aggregates.

Water absorption also gives an idea on the internal structure of aggregate. Aggregates having more absorption are more porous in nature and are generally considered unsuitable for good construction, unless found to be acceptable based on strength, impact and hardness tests.

Apparent specific gravity is the ratio of the weight in air of a given volume of the water impermeable portion of a permeable material at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature.

Bulk specific gravity is the ratio of the mass of volume of material (including the mass of the mass of the water within the voids, but excluding the voids between particles) at a stated temperature to the mass of an equal volume of distilled water at a stated temperature.

Apparatus:

The apparatus required for these tests are:

1. A balance of at least 3 kg capacity, with a accuracy to 0.5 g.
2. An oven to maintain a temperature range of 100 to 110^0 C.
3. A wire basket of not more than 6.3 mm mesh or a perforated container of convenient size with thin wire hangers for suspending it from the balance.
4. A container for filling water and suspending the wire basket in it.
5. An airtight container of capacity similar to that of basket, a shallow tray and two dry absorbent clothes.
6. Pycnometer of 100ml for aggregates finer than 6.3 mm and Specific gravity bottle

Procedure for aggregate coarser than 6.3 mm:

1. About 2 kg of aggregate sample is taken, washed to remove fines and then placed in the wire basket. The wire basket is then immersed in water, which is at a temperature of 22^0 C to 32^0 C.
2. Immediately after immersion the entrapped air is removed from the sample by lifting the basket 25 mm above the base of the tank and allowing it to drop, 25 times at a rate of about one drop per second.
3. The basket, with aggregate are kept completely immersed in water for a period of 24 ± 0.5 hour.
4. The basket and aggregate are weighed while suspended in water, which is at a temperature of 22^0 C to 32^0 C.
5. The basket and aggregates are removed from water and dried with dry absorbent cloth.
6. The empty basket is suspended back in water tank and weighed.
7. The surface dried aggregates are also weighed.
8. The aggregate is placed in a shallow tray and heated to about 110 ^{0}C in the oven for 24 hours. Later, it is cooled in an airtight container and weighed.

Procedure for specific gravity determination of aggregate finer than 6.3 mm :

1. A clean, dry pycnometer is taken and its empty weight is determined.
2. About 1000g of clean sample is taken into the pycnometer, and it is weighed.
3. Water at 27 ^{0}C is filled up in the pycnometer with aggregate sample, to just immerse sample.
4. Immediately after immersion the entrapped air is removed from the sample by shaking pycnometer, placing a finger on the hole at the top of the sealed pycnometer.
5. Now the pycnometer is completely filled up with water till the hole at the top, and after confirming that there is no more entrapped air in it, it is weighed.
6. The contents of the pycnometer are discharged, and it is cleaned.
7. Water is filled up to the top of the pycnometer, without any entrapped air. It is then weighed.

For mineral filler, specific gravity bottle is used and the material is filled up to one-third of the capacity of bottle. The rest of the process of determining specific gravity is similar to the one described for aggregate finer than 6.3 mm.

Observations and Calculations:

1. **Aggregate coarser than 6.3 mm**

Table 1. Observation table for Specific gravity and water absorption

S. No.	Details	Observed Values
1	Weight of saturated aggregate and basket in water: W_1 g	
2	Weight of basket in water: W_2 g	
3	Weight of saturated aggregates in air: W_3 g	
4	Weight of oven dry aggregates in air: W_4 g	
5	Apparent Specific Gravity: $W_4 / [W_4 – (W_1 - W_2)]$	
6	Bulk Specific Gravity: $W_4 / [W_3 – (W_1 - W_2)]$	
7	Water Absorption: $[(W_3 – W_4) \times 100]/ W_4$	

Sample Observations and Calculations:

Table 2. Observation table for Specific gravity and water absorption

S. No.	Details	Observed Values
1	Weight of saturated aggregate and basket in water: W_1 g	
2	Weight of basket in water: W_2 g	
3	Weight of saturated aggregates in air: W_3 g	
4	Weight of oven dry aggregates in air: W_4 g	
5	Apparent Specific Gravity: $W_4 / [W_4 – (W_1 - W_2)]$	
6	Bulk Specific Gravity: $W_4 / [W_3 – (W_1 - W_2)]$	
7	Water Absorption: $[(W_3 – W_4) \times 100]/ W_4$	

Results:

Bulk Specific Gravity = ________

Apparent Specific Gravity = ________

Water Absorption = ________%

2.Aggregate of size finer than 6.3 mm

Table 3. Observation table for Specific gravity test (finer than 6.3 mm)

S. No.	Details	Observed Values
1	Weight of Pycnometer in air: W_1 g	
2	Weight of aggregates and Pycnometer: W_2 g	
3	Weight of aggregates, Pycnometer and water: W_3 g	
4	Weight of water and Pycnometer in air: W_4 g	
5	Apparent Specific Gravity: $(W_2 – W_1) / [(W_4 – W_1) - (W_3 - W_2)]$	

Sample Observations and Calculations:

Table 4. Observation table for Specific gravity test (finer than 6.3 mm)

S. No.	Details	Observed Values
1	Weight of Pycnometer in air: W_1 g	
2	Weight of aggregates and Pycnometer: W_2 g	
3	Weight of aggregates, Pycnometer and water: W_3 g	
4	Weight of water and Pycnometer in air: W_4 g	
5	Apparent Specific Gravity: $(W_2 – W_1) / [(W_4 – W_1) - (W_3 - W_2)]$	

Results:

Apparent Specific Gravity = __________

Specifications:

The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0 with an average value of about 2.68. Water absorption value ranges from 0.1 to about 2.0 percent for aggregates normally use in road surfacing.

Applications:

Specific gravity of aggregates is considered as an indication of strength. Material having higher specific gravity is generally considered as having higher strength. Water absorption of aggregate is a measure of porosity. This value is considered as a measure of resistance to frost action, and as a measure of sustaining weathering action.

QUESTIONS

1. Discuss the importance of :
    a. Specific gravity test
    b. Water absorption test on road aggregates
2. Differentiate between true and apparent specific gravity of aggregates.
3. What are the applications of specific gravity test in mix design?
4. Mention the allowable limits of water absorption values in:
    a. Bituminous concrete surface coarse
    b. Bituminous surface dressing
    c. Wet mix macadam base course

Experiment No. 6

SOFTENING POINT TEST

AIM

To determine the softening point of a given bitumen**.**

Introduction:

Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test. The test is conducted by using Ring and Ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5ºC per minute. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below. Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates.

Apparatus:

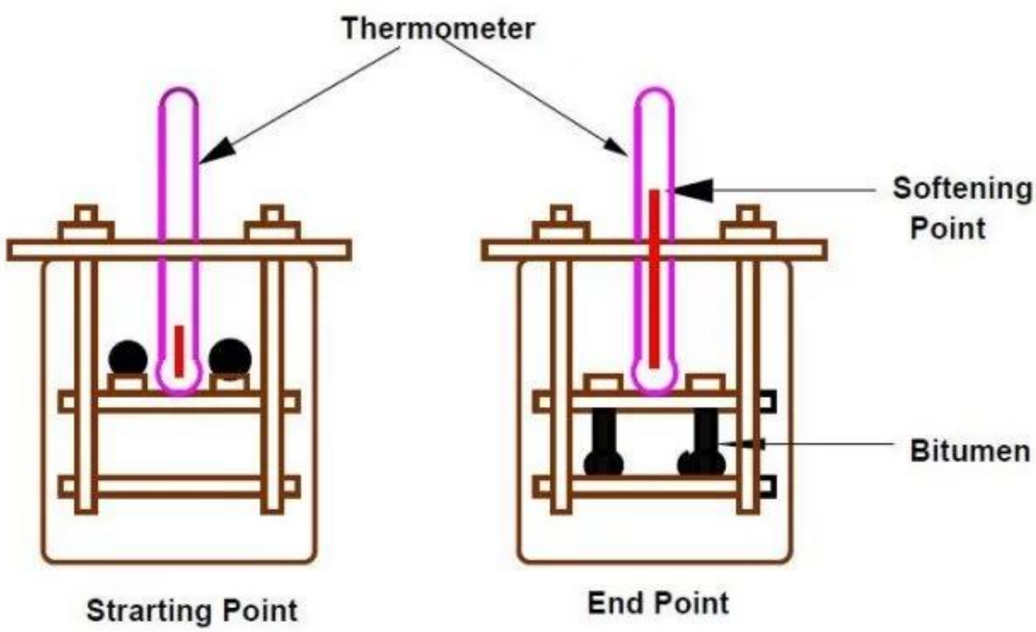
- Standard Ring and Ball Apparatus.
- Steel balls 2 No, each 9.5mm in diameter and weighing 3.5 + 0.05 grams.
- Brass rings 2 No, the rings shall be tampered and shall confirm to the following

  Depth : 6.4 + 0.1mm

  Inside diameter at bottom : 15.9 + 0.1mm

  Inside diameter at top : 17.5 + 0.1mm

  Outside diameter : 20.6 + 0.1mm
- Thermometer capable of reading temperature up to 0 to 250 0 C.
- Water bath should be a heat resistant glass vessel not less than 85mm in diameter and 120mm in depth.
- Stirrer shall be manual or mechanical to ensure uniform heat distribution at all times throughout the water bath.



Ring and Ball Apparatus

Procedure:

- Sample material is heated to a temperature between 75° and 100°C above the approximate softening point until it is completely fluid and is poured in heated rings placed on the metal plate.
- To avoid sticking of the bitumen to metal plate, coating is done to this with a solution of glycerin and dextrin.
- After cooling the rings in air for 30 minutes, the excess bitumen is trimmed and rings are placed in the support.
- At this time the temperature of distilled water is kept at 5°C. This temperature IS maintained for 15 minutes after which the balls are placed in position.
- Then the temperature of water is raised at uniform rate of 5°C per minute with a controlled heating unit, until the bitumen softens and touches the bottom plate by sinking of balls. At least two observations are made. For material whose softening point is above 80°C, glycerin is used for heating medium and the starting temperature is 35°C instead of 5°C.

Observations and Calculations

The temperature at the instant when each of the ball and sample touches the bottom plate of support is recorded as softening point value.An average value of two tests is reported as softening point value.

Sample	(1)	(2)
Temperature when the ball touches bottom, °C		

Sample Calculations

The temperature at the instant when each of the ball and sample touches the bottom plate of support is recorded as softening point value.An average value of two tests is reported as softening point value.

Sample	(1)	(2)
Temperature when the ball touches bottom, °C	48	50

An average value of two tests is reported as softening point value=(48+50)/2=49°C

Conclusion: The above Softening point value for the bitumen is within the BIS Specification to be used in VG 30.

<u>Results</u>

Softening point of bitumen = --------- °C

<u>Application of Bitumen Softening Point Test</u>

Softening point indicates the temperature at which binders possess the same viscosity. Bituminous materials do not have a melting point. Rather, the change of state from solid to liquid is gradual over a wide range of temperature.

Softening point has particular significance for materials to be used as joint and crack fillers. Higher softening point ensures that they will not flow during service. Higher the softening point, lesser the temperature susceptibility. Bitumen with higher softening point is preferred in warmer places.

As per the Bureau of Indian Standards the requirement of softening point for paving bitumen are as follows:

Property	Paving grades				Method of test
	VG 10	VG 20	VG 30	VG 40	
Softening point^{0}C	40	45	47	50	IS 1205-1978

Viva Questions

1) What is softening point?
2) What does softening point of bituminous material indicate?
3) What are the applications of ring and ball test results?
4) What are the factors which affect the ring and ball test results?
5) Indicate the common rangeof softening point test valus of the paving bitumen used in bituminous mixes for road construction.

Experiment No. 7

STANDARD PENETRATION TEST FOR BITUMEN

AIM

To determinate the penetration of bitumen.

Apparatus:

The apparatus required for the Penetration test are as follow:

- Penetration Apparatus
- Needle
- Container
- Water Bath
- Thermometer for Water Bath
- Stop watch

Theory: In this test we examine the consistency of a sample of bitumen by determining the distance in tenths of a millimetre that a standard needle vertically penetrates the bitumen specimen under known conditions of loading, time and temperature. This is the most widely used method of measuring the consistency of a bituminous material at a given temperature. It is a means of classification rather than a measure of quality.

Procedure for Bitumen Penetration Test

(a) **Preparation of test specimen:**

i. Soften the material to a pouring consistency at a temperature not more than 60°C for tars and 90°C for bitumen above the approximate softening point and stir it thoroughly until it is homogeneous and is free from air bubbles and water.
ii. Pour the melt into the container to a depth at least 10mm in excess of the expected penetration. Protect the sample from dust and allow it to cool in an atmosphere at a temperature between 15° to 30° C for one hour. Then place it along with the transfer dish in the water bath at 25° ± 0.1 °C, unless otherwise stated.
iii. Fill the transfer dish with water from the water bath to depth sufficient to cover the container completely, place the sample in it and put it upon the stand of the penetration apparatus.
iv. Clean the needle with benzene, dry it and load with the weight. The total moving load required is 100 ± 0.25 gms, including the weight of the needle, carrier and super-imposed weights.
v. Adjust the needle to contact the surface of the sample. This may be done by placing the needlepoint in contact with its image reflected by the surface of the bituminous material.

(b) Test

i. Make the pointer of the dial to read zero or note the initial dial reading.
ii. The needle is released by pressing a button and a stop watch is started. The needle is released exactly for a period of 5.0 secs.
iii. Adjust the penetration machine to measure the distance penetrated.
iv. Make at least 3 readings at points on the surface of the sample not less than 10 mm apart and not less than l0mm from the side of the dish. After each test return the sample and transfer dish to the water bath and wash the needle clean with benzene and dry it.

Observations for Penetration Test:

Actual test temperature = °C

Penetration dial reading	**Test 1**	**Test 2**	**Test 3**	**Average**
(a) Initial				
(b) Final				
Penetration Value = (a)- (b)				

Sample Calculations:

Actual test temperature = 25 °C

Penetration dial reading	**Test 1**	**Test 2**	**Test 3**	**Average**
(a) Initial	190	180	185	185
(b) Final	140	144	139	141
Penetration Value = (a)- (b)	50	36	46	44

Report:
The average penetration value of 3 tests of a given bitumen sample is reported.
Mean Penetration value = 44
The grade of bitumen is 40/50 penetration grade.

Safety & Precautions:

- Use hand gloves, apron while removing containers from hot plate after switching off the hot plate.
- No disturbance occurs at time of penetration.
- Use safety shoes & Apron at the time of test.
- Equipment should be cleaned thoroughly before testing & after testing.

Uses and Significance:

Penetration test is used to measure the consistency of bitumen, so that they can be classified into standard grades. Greater value of penetration indicates softer consistency. Generally higher penetration bitumen is preferred for use in cold climate and smaller penetration bitumen is used in hot climate areas.

- It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimetre to which a standard loaded needle will penetrate vertically in 5 seconds
- The penetrometer consists of a needle assembly with a total weight of 100g and a device for releasing and locking in any position
- The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers at a depth at least 15 mm in excess of the expected penetration.
- The test should be conducted at a specified temperature of 25 °C
- It may be noted that penetration value is largely influenced by any inaccuracy with regards to size of the needle, weight placed on the needle and the test temperature
- A grade of 40/50 bitumen means the penetration value is in the range 40 to 50 at standard test conditions
- In hot climates, a lower penetration grade is preferred.

Recommended Penetration Value of Bitumen

Penetration test is a commonly adopted test on bitumen to grade the material in terms of its hardness. A 80/100 grade bitumen indicates that its penetration value lies between 80 & 100.
Grading of bitumen helps to assess its suitability in different climatic conditions and types of construction. For bituminous macadam and penetration macadam, IRC suggests bitumen grades 30/40, 60/70, 80/100.
In warmer regions, lower penetration grades are preferred to avoid softening whereas higher penetration grades like 180/200 are used in colder regions to prevent the occurrence of excessive brittleness. High penetration grade is used in spray application works.

Experiment No. 8

STRIPPING VALUE OF AGGREGATE

1. AIM

To find out the stripping value of the road aggregates

2. PRINCIPLE

The film stripping device is used to measure resistance of bituminous mixtures to stripping of the bitumen from the rock particles and is generally used to evaluate the mineral aggregate. However, it may be used to judge the adhesive capacity of the bituminous material. Stone screenings for use in seal coats or open graded mixes are usually subjected to this test. The test is applied to the aggregate fraction passing 10mm sieve and retained on 2.36mm sieve. Four specimens can be tested simultaneously.

3. APPARATUS

Film Stripping Apparatus: Four bottles are positioned in the rotating drum. The rotating drum is connected to a gear box which is coupled to a motor. The drum rotates at the rate of approximately 100rpm.

4. PROCEDURE

1) Coat 60g sample of aggregate which passes through 10mm IS Sieves and retained on 2.36mm IS Sieve with the bitumen to be tested.
2) Keep it in the bottle and cure the sample for 15hours at 60°C.
3) Allow it to cool to room temperature at 25°C.
4) Add 175ml of distilled water.
5) Similarly take the specimens in the other three bottles and screw on the caps to the bottles having the rubber gasket in between the bottle top and the cap. Clamp the bottles to the disc.
6) Switch on the unit and agitate the mixture for 15 minutes.
7) Estimate the percentage of aggregate stripped by visual observation.

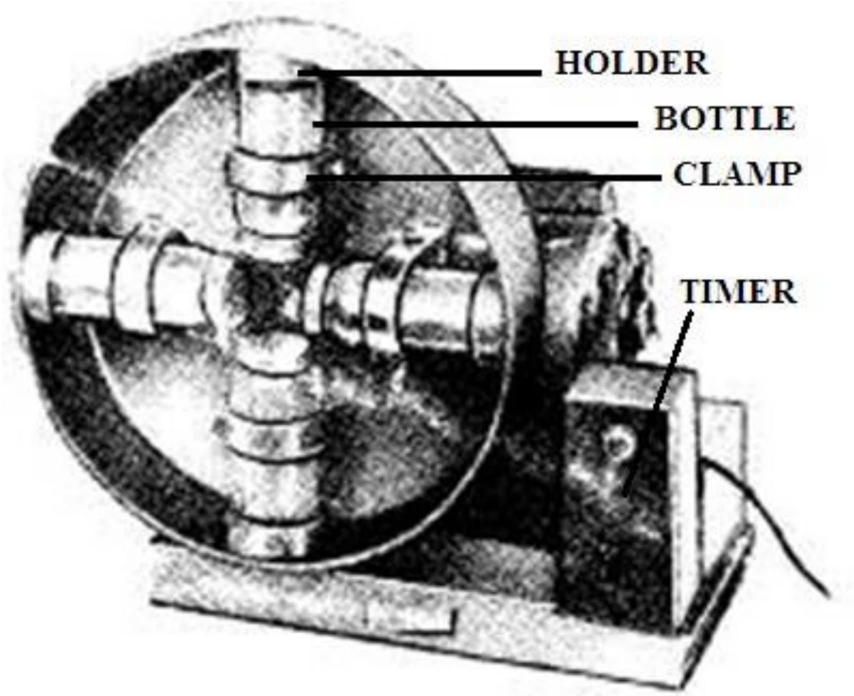


Fig 8. FILM STRIPPING DEVICE

5. PRECAUTIONS

Keep the bottles and washers clean. When not in use keep the bottles mounted in the position as shown in Fig 8.

6. RESULT

The Stripping value of aggregate=

BASIC ELECTRONICS LAB MANUAL

B.Tech (ECE)

COURSE CODE: CE(ES)391

DEPARTMENT OF

ELECTRONICS & COMMUNICATION

ENGINEERING

Introduction

There are 3 periods allocated to a laboratory session in Digital Electronics. It is a necessary part of the course at which attendance is compulsory.

Here are some guidelines to help you perform the experiments and to submit the reports:

1. Read all instructions carefully and carry them all out.

2. Ask a demonstrator if you are unsure of anything.

3. Record actual results (comment on them if they are unexpected!)

4. Write up full and suitable conclusions for each experiment.

5. If you have any doubt about the safety of any procedure, contact the demonstrator beforehand.

6. THINK about what you are doing!

SYLLABUS

LABORATORY/ SESSIONAL

CE(ES)391 Basic Electronics 2 Credits

Practical

Module 1 Laboratory Sessions covering, Identification, Specifications, Testing of R, L, C Components (Colour Codes), Potentiometers, Switches (SPDT, DPDT and DIP), Bread Boards and Printed Circuit Boards (PCBs); Identification, Specifications, Testing of Active Devices – Diodes,BJTs, JFETs, MOSFETs, Power Transistors, SCRs and LEDs;

Module 2 Study and Operation of Digital Multi Meter, Function / Signal Generator, Regulated Power Supply (RPS), Cathode Ray Oscilloscopes; Amplitude, Phase and Frequency of Sinusoidal Signals using Lissajous Patterns on CRO; (CRO);

Module 3 Experimental Verification of PN Junction Diode Characteristics in A) Forward Bias B) Reverse Bias, Zener Diode Characteristics and Zener Diode as Voltage Regulator, Input and Output Characteristics of BJT in Common Emitter (CE) Configuration, Drain and Transfer Characteristics of JFET in Common Source (CS) Configuration;

Module 4 Study of Half Wave and Full Wave Rectification, Regulation with Filters, Gain and Bandwidth of BJT Common Emitter (CE) Amplifier, Gain and Bandwidth of JFET Common Source(CS) Amplifier, Gain and Bandwidth of BJT Current Series and Voltage Series Feedback Amplifiers,Oscillation Frequency of BJT based RC Phase Shift, Hartley and Colpitts Oscillators;

Module 5 Op-Amp Applications – Adder, Subtractor, Voltage Follower and Comparator; Op-Amp Applications – Differentiator and Integrator, Square Wave and Triangular Wave Generation, Applications of 555 Timer – Astable and MonostableMultivibrators;

Module 6 Truth Tables and Functionality of Logic Gates – NOT, OR, AND, NOR, NAND, XOR and XNOR Integrated Circuits (ICs); Truth Tables and Functionality of Flip-Flops – SR, JK and DFlip-Flop ICs; Serial-In-Serial-Out and Serial-In-Parallel-Out Shift operations using 4-bit/8-bit ShiftRegister ICs; Functionality of Up-Down / Decade Counter ICs;

IINTRODUCTION -1

AIM: Familiarisation with passive and active electronic components.

What is electronics components?

Electronic components have a number of electrical terminals or leads. These leads connect to other electrical components, often over wire, to create an electronic circuit with a particular function (for example an amplifier, radio receiver, or oscillator). Basic electronic components may be packaged discretely, as arrays or networks of like components, or integrated inside of packages such as semiconductor integrated circuits, hybrid integrated circuits, or thick film devices. The following list of electronic components focuses on the discrete version of these components, treating such packages as components in their own right.

Components can be classified as

- I) **Passive components,**
- II) **Active components**

PASSIVE COMPONENTS

These types of components cannot use mesh energy into the electronic circuit because they don't rely on a power source, excluding what is accessible from the AC circuit they are allied to. As a result, they cannot amplify, although they can increase a current otherwise voltage or current. These components mainly include two-terminals like resistors, inductors, transformers & capacitors

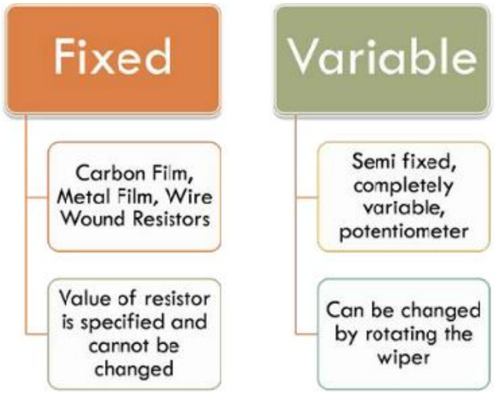
ACTIVE COMPONENT

These components are used to amplify electrical signals to generate electric power. The functioning of these components can be done like an AC circuit within electronic devices to protect from voltage and enhanced power. An active component executes its functions because it is power-driven through an electricity source. All these components require some energy source that is normally removed from a DC circuit. Any quality type of active component will include an oscillator, IC (integrated circuit) &

What is resistor?

Pass current in proportion to voltage (Ohm's law) and oppose current.

Types of Resistors



Carbon Film Resistors:

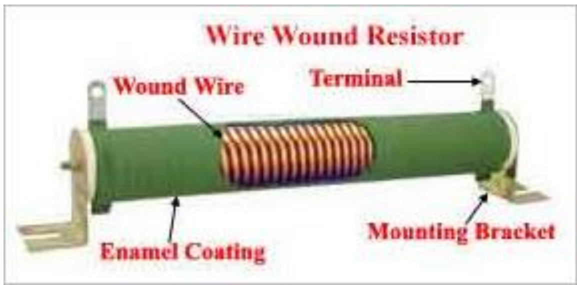
- Most general purpose ,cheap resistor
- Tolerance of Resistance value is usually +/- 5%
- Power ratings of 1/8 W ,1/4 W and ½ W are usually used .

Metal Film Resistor

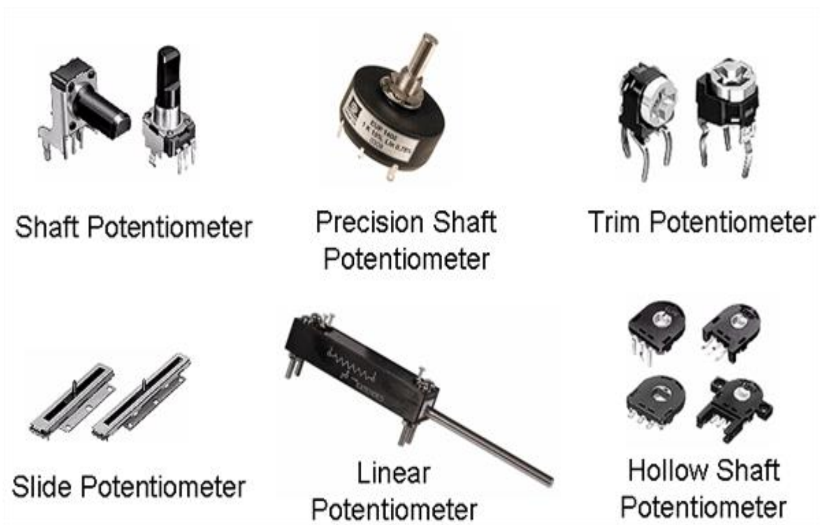
- Used when higher tolerance is needed , ie more value.
- They have about +/- 0.05% tolerance

Wire Wound Resistors:

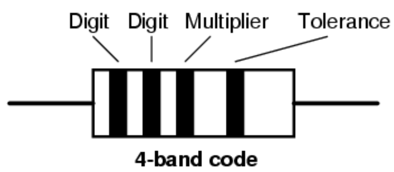
- A wire wound resistor is made of metal resistance wire, and because of this they can be manufactured to precise values
- Also, high wattage resistors can be made by thick wire material
- Wire wound resistors in a ceramic case are called as ceramic resistors
- Wire wound resistors in a ceramic case are called as ceramic resistors

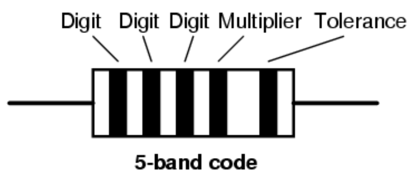


Variable resistors

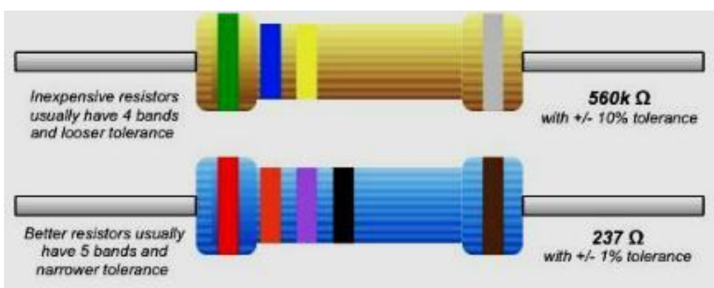


Reading Value of Fixed Resistors::

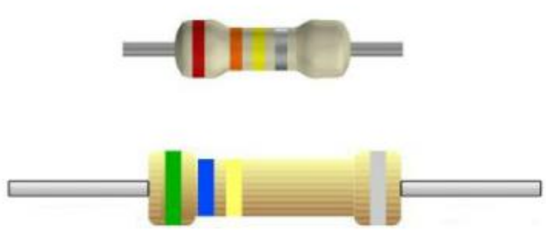




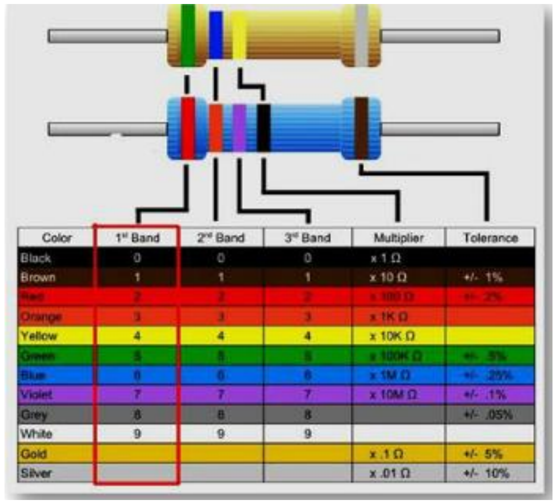
- Resistors are colour coded as they are too small for the value to be written on them.
- There are 4 or 5 bands of colour . Value of a Resistor is decoded from these band of colours.



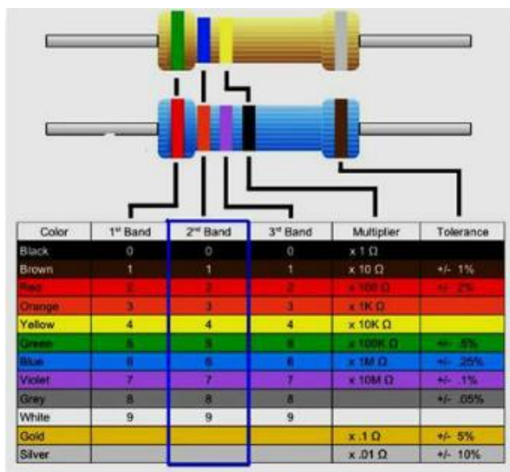
- If your resistor has four colour bands ,turn the resistor so that the gold or silver band is on right hand side or the end with more bands should point left.



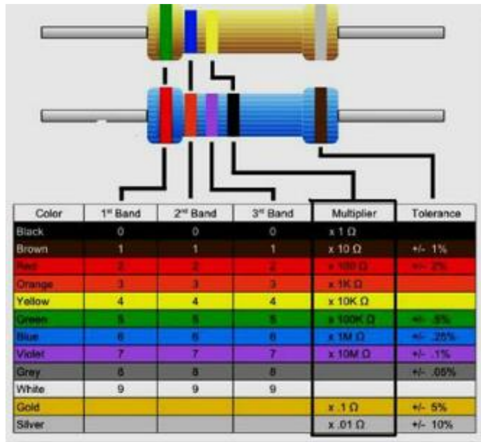
The first band is now on the left hand side. This represents the first digit .Based on the colour make a note of the digit .In this case- 4 band its '5' and for 5 band its '2'.



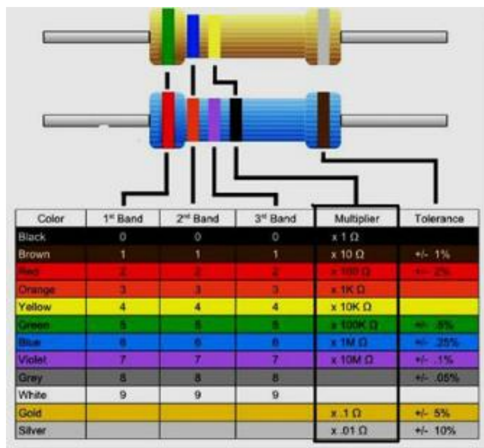
The second band represents the second digit. The colours represent the same numbers as did the first digit .In this case -4 band its'6' and for 5 band its'3'.



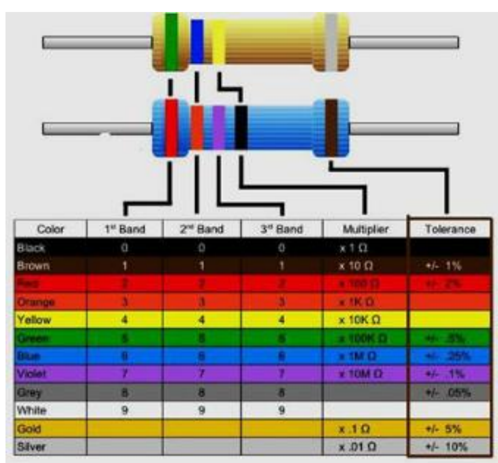
The third band divulges how many zeros to add/divide to the first two numbers -for a 4 band Resistor . In this case – 4 band its '4' zeroes to be added . So value is 560K.



The third band denotes the 3rd digit – for a 5 band Resistor. In this case –5 band its '7' . So the value of the 5 band resistor is 237 Ohms as its multiplier digit is '0.



The last band denotes the tolerance. So the value of the 4 band resistor it is +/- 10% while for the 5 band resistor it is +/- 1%.



- Tolerance of a Resistor is also an important property to consider .
- A 100 ohm resistor with a 10 % tolerance can mean its value can be any fixed value between 90 to 110 Ohms.

- A 120 Ohm resistor with a 10 % tolerance can mean its value can be any fixed value between 108 and 132 Ohms.

Mnemonic to Remember

Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9
Gold	

“B B ROY of Great Britain had a Very Good Wife”

Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

What is Capacitor?

It is one of the passive components like resistor. Capacitor is also known as condenser. Capacitor is generally used to store the charge. The charge is stored in the form of “electrical field”. Capacitors play a major role in many electrical and electronic circuits.

Classification of Capacitors

UN-POLARIZED	POLARIZED
Ceramic	Electrolytic
Multilayer	Tantalum
Polystyrene Film	Super
Polyster Film	They have positive and negative electrode
Polypropylene	
Mica	
They don't have positive and negative electrode	

Ceramic Capacitors:

Ceramic capacitors are the most used capacitors in the electronics industry. Ceramic capacitors are fixed capacitance type capacitors and they are usually very small (in terms of both physical dimensions and capacitance). The capacitance of ceramic capacitors is usually in the range of pico farads to few micro farads (less than 10μF). They are non-polarised type capacitors and hence can be used in both DC as well as AC circuits

.

Electrolytic Capacitor

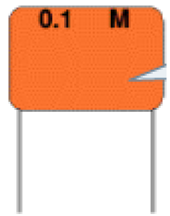
Electrolytic capacitors are polarized and they must be connected the correct way round , at least one of their leads will be marked + or – . It is very easy to find the

values of electrolytic capacitors because they are clearly printed with their capacitance and voltage rating.

Tantalum Capacitor:

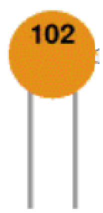
Tantalum bead capacitors are polarized and have low voltage ratings like electrolytic capacitors . Usually , the "+" symbol is used to show the positive component lead . Modern tantalum bead capacitors are printed with their capacitance voltage and polarity in full. However older ones use a colour – code systems which has two stripes (for the two digits) and a spot of colour for the number of zeros to give the value in fun.

Un-polarized Capacitors- small values(up to 1uF)



The value printed but without a multiplier, so you need to use experience to work out what the multiplier should be! For example 0.1 means 0.1 pF. Sometimes the multiplier is used in place of the decimal point: For example: 4n7 means 4.7n

Un-polarized Capacitors — Capacitor Number Code



A number code is often used on small capacitors where printing is difficult: The 1st number is the 1st digit, the 2nd number is the 2nd digit, the 3rd number is the number of zeros to give the capacitance in pF. Ignore any letters - they just indicate tolerance and voltage rating. For example: 102 means 1000pF (not 102pF!) For example: 472J means 4700pF (J means 5% tolerance).

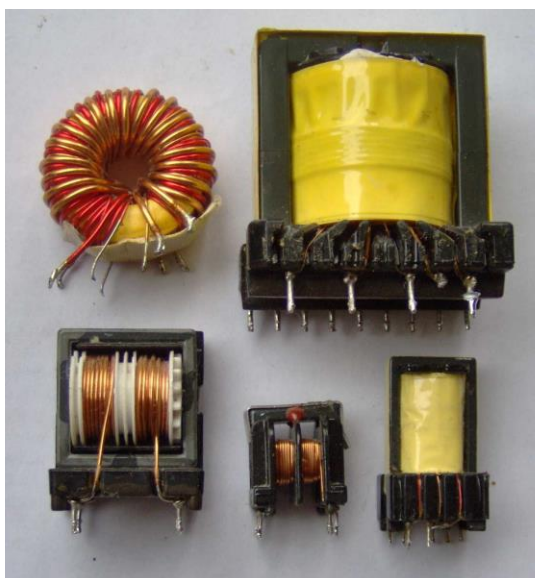
Un-polarized Capacitors — Capacitor Colour Code

Structure of an Inductor

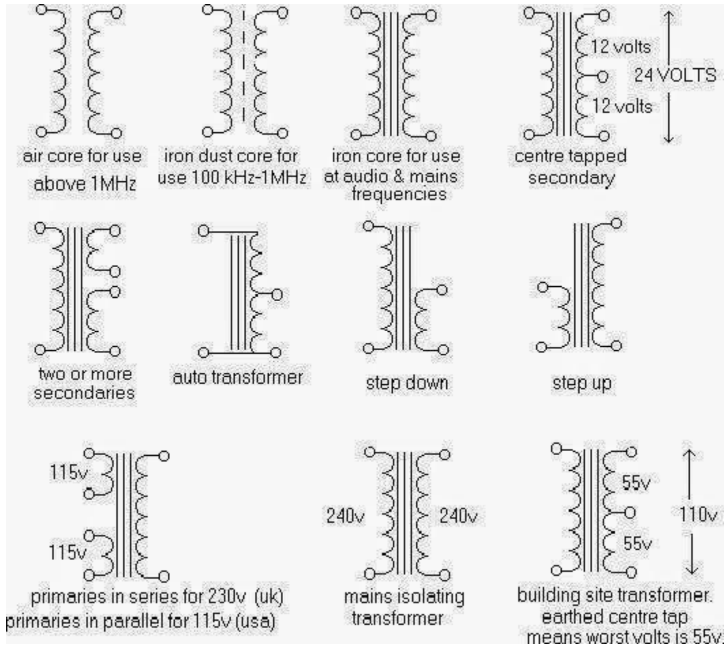
Inductance

1. No of turns of wire wound around the coil
2. Cross sectional area of the coil
3. The material type of the coil
4. The Length of the coil

Transformers



Various transformers

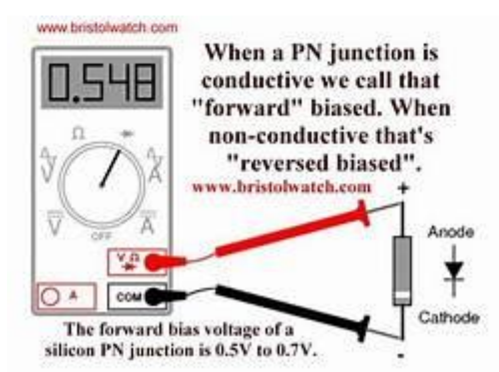


INTRODUCTION-2

AIM:

Familiarization with measuring and testing equipment like CRO, Signal generators etc.

Digital Multimeter



The Breadboard

The breadboard consists of two terminal strips and two bus strips (often broken in the centre). Each bus strip has two rows of contacts. Each of the two rows of contacts are a node. That is, each contact along a row on a bus strip is connected together (inside the breadboard). Bus strips are used primarily for power supply connections, but are also used for any node requiring a large number of connections. Each terminal strip has 60 rows and5 columns of contacts on each side of the centre gap. Each row of 5 contactsis a node.You will build your circuits on the terminal strips by inserting the leads ofcircuit components into the contact receptacles and making connections with22-26 gauge wire. There are wire cutter/strippers and a spool of wire in thelab. It is a good practice to wire +5V and 0V power supply connections toseparate bus strips.

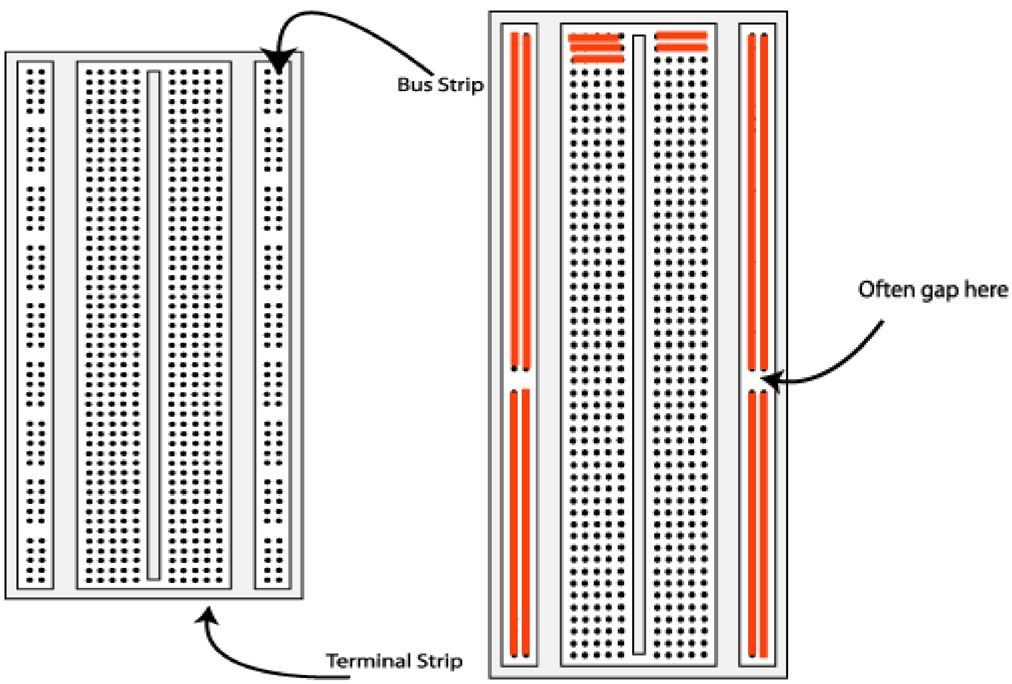
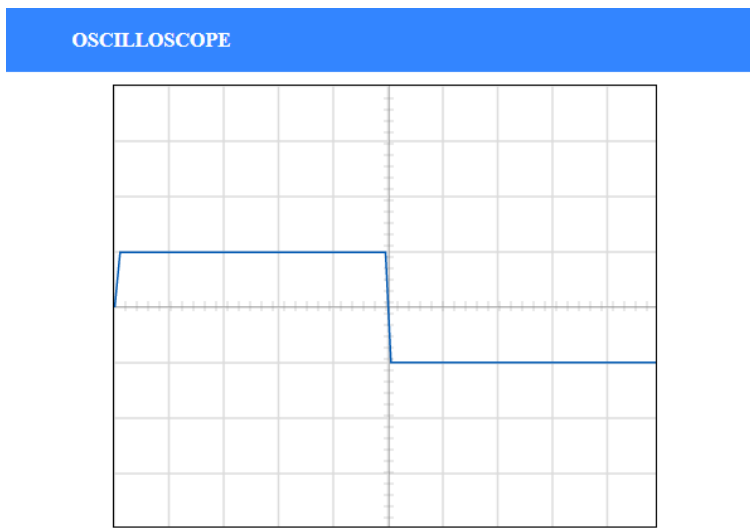


Fig 1. The breadboard. The lines indicate connected holes.

CATHODE RAY TUBE

The screen is cathode ray tube found in most television sets where the face of the screen is divided up into a 2 dimensional grid (or axes or scale); In this experiment we consider 8x10 grid. The vertical grid is divided up into 8 (major) divisions and the horizontal grid is divided into 10 major divisions. To improve the precision, each of these divisions is further broken up into 5 minor divisions. The horizontal axis (X-axis) represents time and the vertical axis (Y-axis) represents voltage. The scope displays (also called a signal trace or trace) the input signal voltage along the vertical (or Y-axis) while an internally generated signal (called the horizontal sweep or sweep signal) is simultaneously produced along the X-axis creating a 2- dimensional time trace of the input signal.



volts/div- This control lets you change how many volts are represented by each vertical increment of grid (vertical axis) on the screen. Basically, it allows you to zoom in and out along the y axis.

time/div- This control lets you change how much time is represented by each horizontal increment of the grid overlay on the screen. It allows you to zoom in and out along the x axis.

If volt/div is set to 1 volt which implies each major vertical division is 1 volt where as each minor vertical division is 0.2 volt. And time/div is set to 0.1ms/div which implies each major horizontal division is 0.1ms. Voltage on the vertical scale is 1 volt/div multiply by (number of division). Time on the horizontal scale is 0.1msec multiply by (number of division). In the figure 2, 1 volt/div and amplitude of the input signal is 1 volt. Here 0.1mses/div, the frequency is 1 kHz and its period is 1 complete cycle in 1m sec.if volt/div is set to 2volt/div, which implies each major division is 2 volt where as each minor division is 0.5volt.

Note: If you set the Volts/Div too low, you'll clip the signal. Similarly, setting it too high, and you'll won't find the signal, i.e. the signal will b flat. Increasing the Timebase will display more cycles of a periodic signal. Conversely, reducing the Timebase, fewer cycles will be displayed.

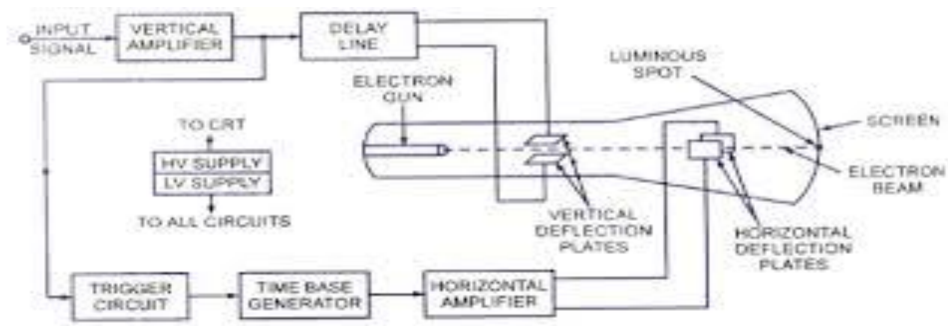
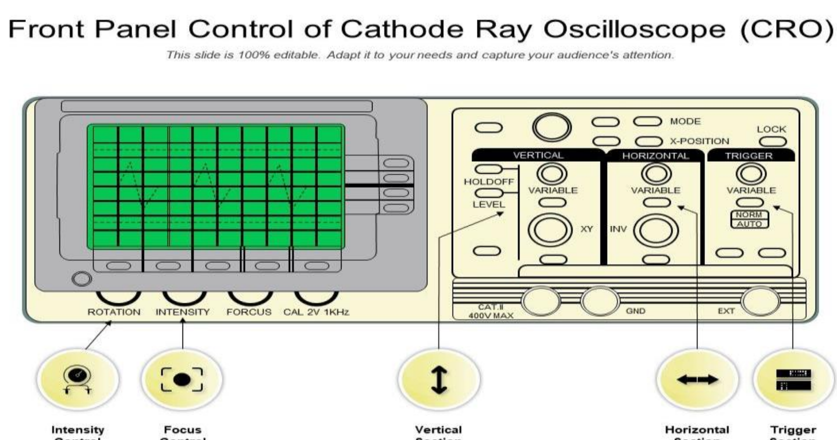


Figure - Block Diagram of General Purpose CRO



DC power supply

A regulated power supply is an embedded circuit; it converts unregulated AC (Alternating Current) into a constant DC. With the help of a rectifier it converts AC supply into DC. Its function is to supply a stable voltage (or less often current), to a circuit or device that must be operated within certain power supply limits. The output from the regulated power supply may be alternating or unidirectional, but is nearly always DC (Direct Current).[1] The type of stabilization used may be restricted to ensuring that the output remains within certain limits under various load conditions, or it may also include compensation for variations in its own supply source. The latter is much more common today.

Signal generator

A signal generator is one of a class of electronic devices that generates electronic signals with set properties of amplitude, frequency, and wave shape. These generated signals are used as a stimulus for electronic measurements, typically used in designing, testing, troubleshooting, and repairing electronic or electroacoustic devices, though it often has artistic uses as well.There are many different types of signal generators with different purposes and applications and at varying levels of expense. These types include function generators, RF and microwave signal generators, pitch generators, arbitrary waveform generators, digital pattern generators, and frequency generators. In general, no device is suitable for all possible applications.

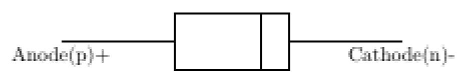
Experiment-1

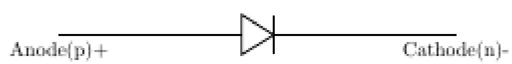
AIM: Study the V-I characteristics of a p-n junction diode.

Component used:

1. IN4007
2. Bread Board
3. Power supply
4. DMM
5. Connecting wire

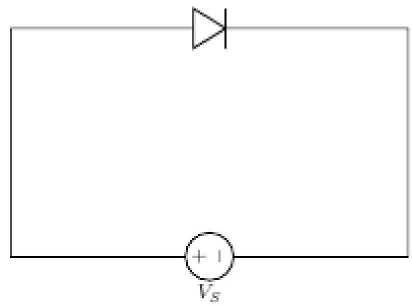
The diode is a device formed from a junction of n-type and p-type semiconductor material. The lead connected to the p-type material is called the anode and the lead connected to the n-type material is the cathode. In general, the cathode of a diode is marked by a solid line on the diode.



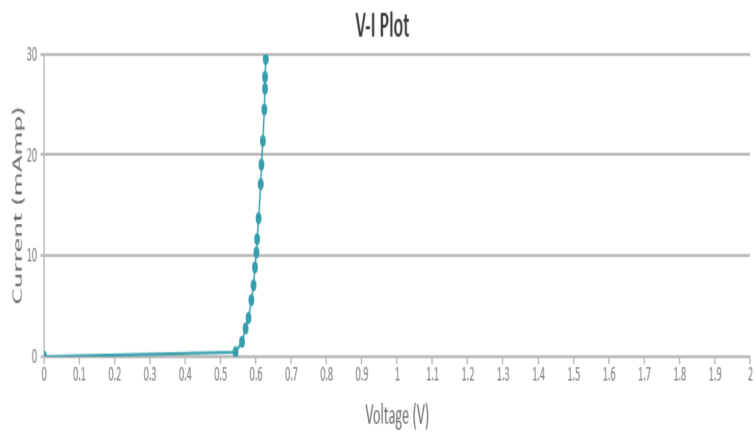


THEORY:

The positive terminal of battery is connected to the P side (anode) and the negative terminal of battery is connected to the N side (cathode) of a diode, the holes in the p-type region and the electrons in the n-type region are pushed toward the junction and start to neutralize the depletion zone, reducing its width. The positive potential applied to the p-type material repels the holes, while the negative potential applied to the n-type material repels the electrons. The change in potential between the p side and the n side decreases or switches sign. With increasing forward-bias voltage, the depletion zone eventually becomes thin enough that the zone's electric field cannot counteract charge carrier motion across the p–n junction, which as a consequence reduces electrical resistance. The electrons that cross the p–n junction into the p-type material (or holes that cross into the n-type material) will diffuse into the nearby neutral region. The amount of minority diffusion in the near-neutral zones determines the amount of current that may flow through the diode.



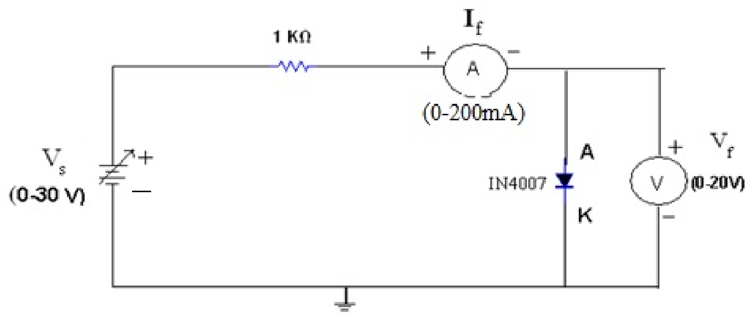
In forward biasing, the positive terminal of battery is connected to the P side and the negative terminal of battery is connected to the N side of the diode. Diode will conduct in forward biasing because the forward biasing will decrease the depletion region width and overcome the barrier potential. In order to conduct, the forward biasing voltage should be greater than the barrier potential. During forward biasing the diode acts like a closed switch with a potential drop of nearly 0.6 V across it for a silicon diode. The forward and reverse bias characteristics of a silicon diode. From the graph, you may notice that the diode starts conducting when the forward bias voltage exceeds around 0.6 volts (for Si diode). This voltage is called cut-in voltage.



Procedure

1. Set DC voltage to 0.2 V .
2. Select the diode.
3. Set the resistor.
4. Voltmeter is placed parallel to Silicon diode and ammeter series with resistor.
5. The positive side of battery to the P side (anode) and the negative of battery to the N side (cathode) of the diode.
6. Now vary the voltage up to 5V and note the Voltmeter and Ammeter reading for particular DC voltage .
7. Take the readings and note Voltmeter reading across Silicon diode and Ammeter reading.

8. Plot the V-I graph and observe the change.
9. Calculate the dynamic resistance of the diode. rd.=ΔV/ΔI
10. Therefore from the graph we see that the diode starts conducting when the forward bias voltage exceeds around 0.6 volts (for Si diode). This voltage is called cut-in voltage.



OBSERVATION TABLE

Serial No.	Forward Voltage(Volt)	Forward Current(m - Amp)

Experiment-2

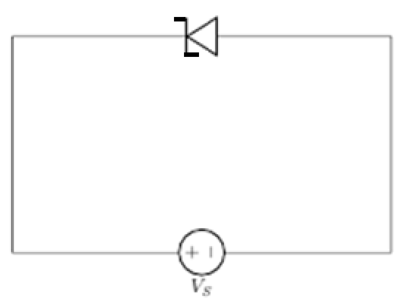
AIM: Study of I-V characteristics of Zener diodes.

Component used:

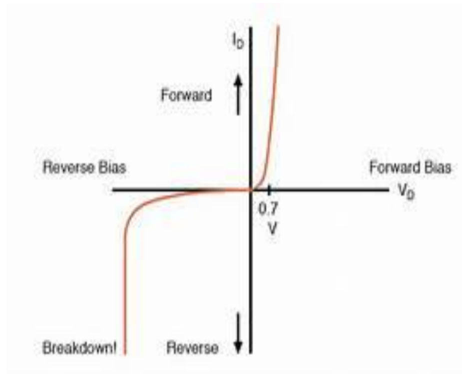
1. Zenger diode
2. Bread Board
3. Power supply
4. Connecting wire
6. DMM

THEORY:

In reverse biasing, the positive terminal of battery is connected to the N side and the negative terminal of battery is connected to the P side of a diode. In reverse biasing, the diode does not conduct electricity, since reverse biasing leads to an increase in the depletion region width; hence current carrier charges find it more difficult to overcome the barrier potential. The diode will act like an open switch and there is no current flow.



When a diode is reverse biased a leakage current flows through the device. This current can be effectively ignored as long as the reverse breakdown voltage of the diode is not exceeded. At potentials greater than the reverse breakdown voltage, charge is pulled through the p-n junction by the strong electric fields in the device and large reverse current flows. This usually destroys the device. There are special diodes that are designed to operate in breakdown. Such diodes are called **sneer diodes and used as voltage regulators.**



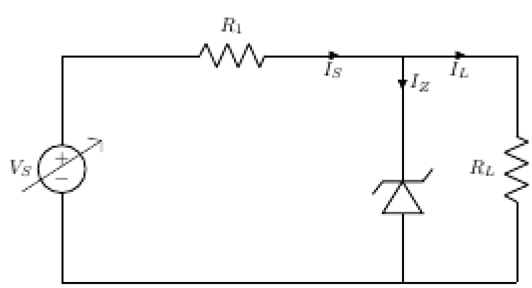
Zener Diode As A Voltage Regulator

A voltage regulator is an electronic circuit that provides a stable DC voltage independent of the load current, temperature and AC line voltage variations. A Zener diode of break down voltage V_Z is reverse connected to an input voltage source V_I across a load resistance R_L and a series resistor R_S. The voltage across the zener will remain steady at its break down voltage V_Z for all the values of zener current I_Z as long as the current remains in the break down region. Hence a regulated DC output voltage $V_0 = V_Z$ is obtained across R_L, whenever the input voltage remains within a minimum and maximum voltage. Basically there are two type of regulations such as:

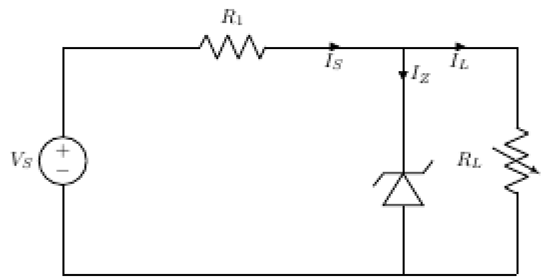
Line Regulation: In this type of regulation, series resistance and load resistance are fixed, only input voltage is changing. Output voltage remains the same as long as the input voltage is maintained above a minimum value.

Load Regulation: In this type of regulation, input voltage is fixed and the load resistance is varying. Output volt remains same, as long as the load resistance is maintained above a minimum value.

Line Regulation



Load Regulation



Procedure

Reverse Bias-Diode

1. Set DC voltage to 0.2 V .

2. Select the diode.

3. Set the resistor.

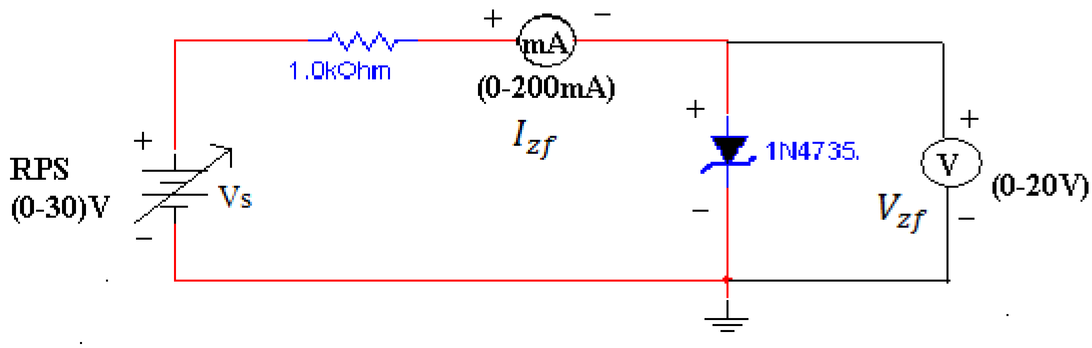
4. Voltmeter is placed parallel to diode and ammeter series with resistor.

5. The positive side of battery to the P side(anode) and the negative of battery to the N side(cathode) of the diode.

6. Now vary the voltage upto 5V and note the Voltmeter and Ammeter reading for particular DC voltage .

7. Take the readings and note Voltmeter reading across diode and Ammeter reading.

8. Plot the V-I graph and observe the change.



OBSERVATION TABLE

Serial No.	Reverse Voltage(Volt)	Reverse Current(mAmp)

OBSERVATION TABLE (Line Regulation)

Serial No.	Supply Voltage(Volt)	Diode Voltage(Volt)

Experiment-3

AIM: Study thewave form of half wave and full wave rectifier and determine its ripple factor.

Component used:

1.IN4007

2.Bread Board

3.Transformer

4.Connecting wire

6.DMM

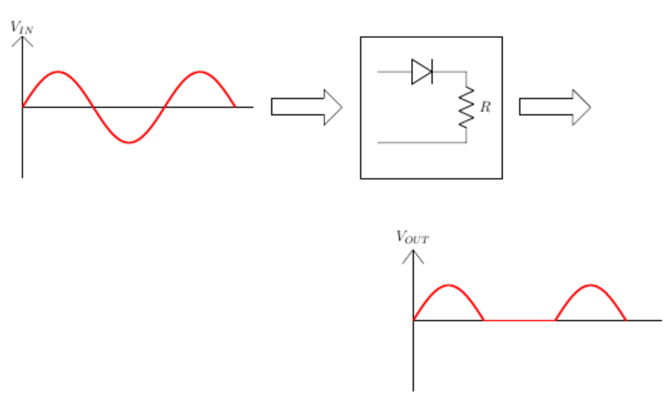
7. Capacitor

8. Resistor

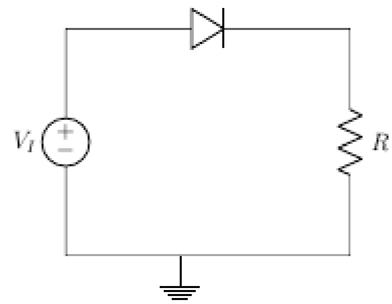
Rectification

A rectifier is a device that converts alternating current (AC) to direct current (DC), a process known as rectification. Rectifiers are essentially of two types – a half wave rectifier and a full wave rectifier.

Half Wave Rectification

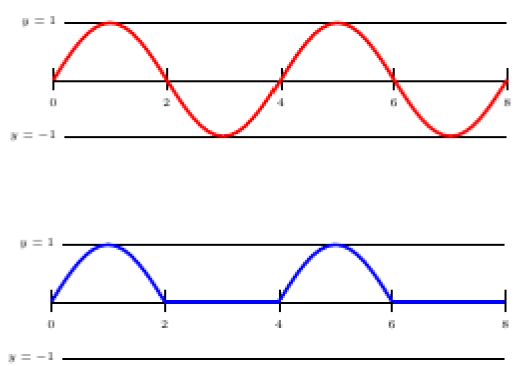


On the positive cycle the diode is forward biased and on the negative cycle the diode is reverse biased. By using a diode we have converted an AC source into a pulsating DC source. In summary we have 'rectified' the AC signal.

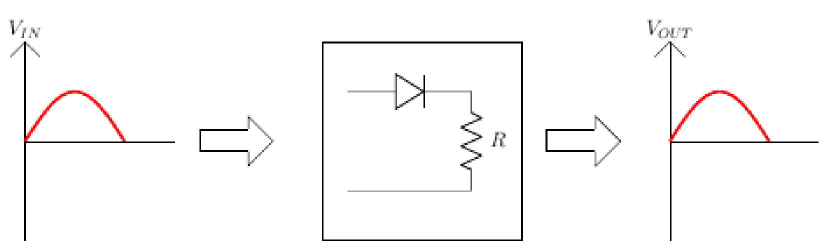


The simplest kind of rectifier circuit is the half-wave rectifier .The half-wave rectifier is a circuit that allows only part of an input signal to pass. The circuit is simply the combination of a single diode in series with a resistor, where the resistor is acting as a load.

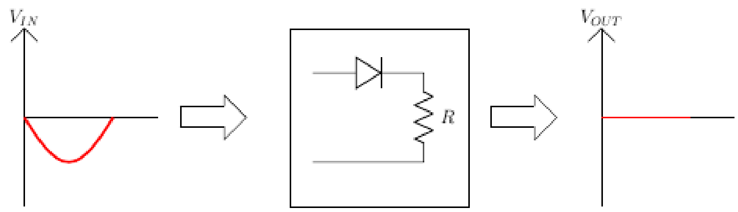
Half Wave Rectifiers – Waveforms



Half Wave Rectification: For Positive Half Cycle

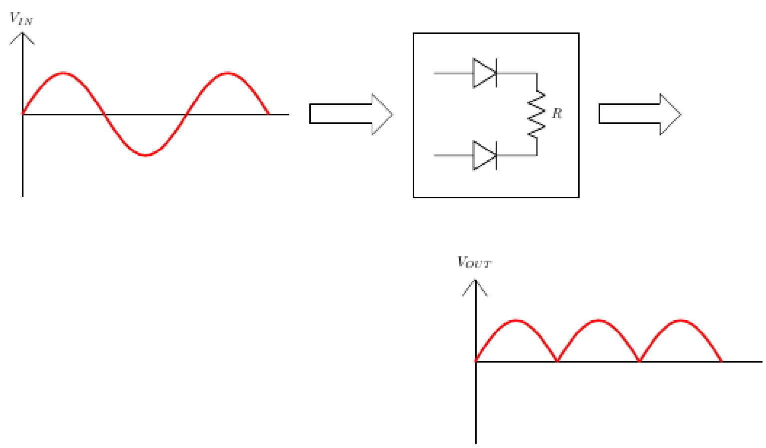


Half Wave Rectification: For Negative Half Cycle

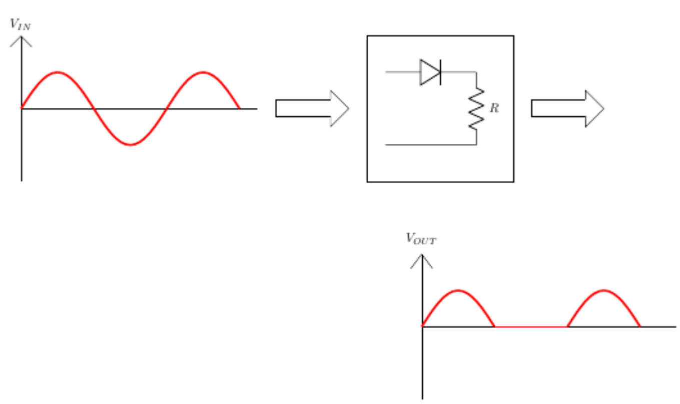


Full Wave Rectifier

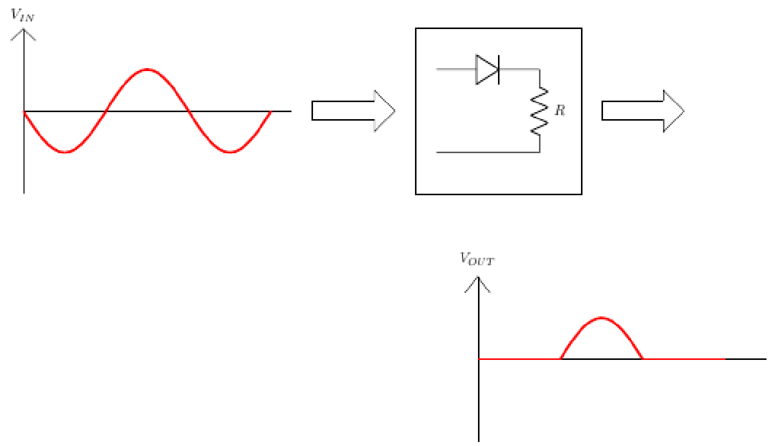
A full-wave rectifier is exactly the same as the half-wave, but allows unidirectional current through the load during the entire sinusoidal cycle (as opposed to only half the cycle in the half-wave). A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output.



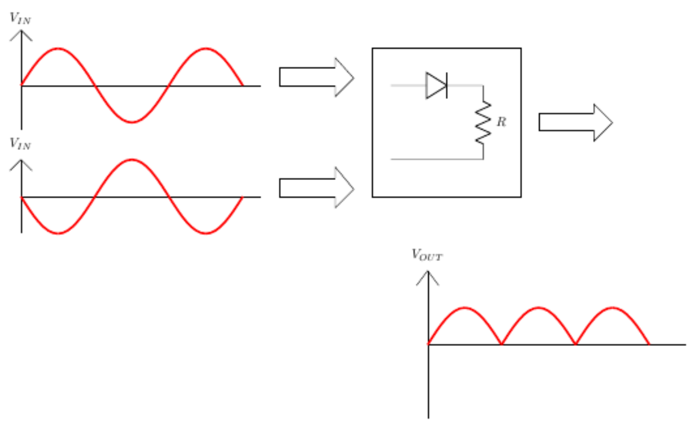
For a half wave Rectifier this is what we have observed



If we change the phase of the input waveform by 180 degrees

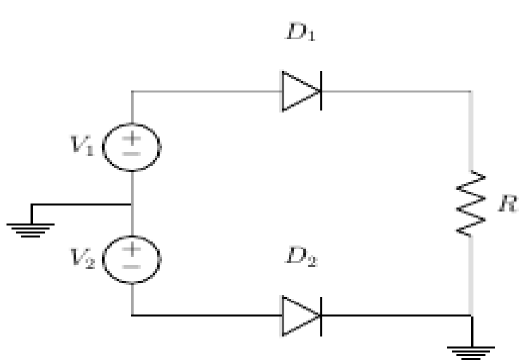


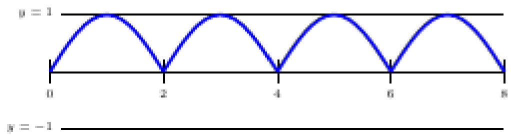
Now if we add these two circuits, we would get



Full Wave Rectifier - Circuit

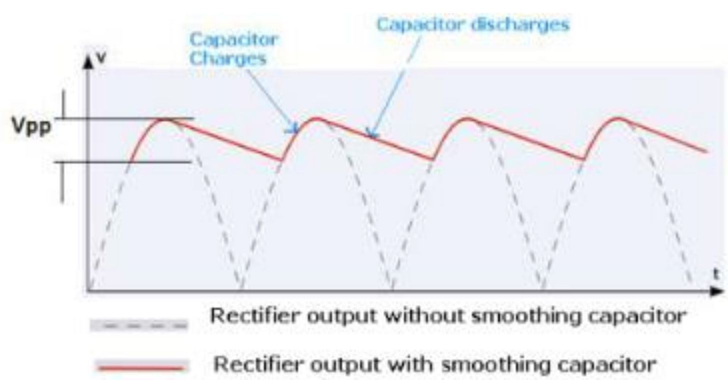
So, we have seen that this rectifier circuit consists of two sources which have a phase difference along with two diodes. When V1 is positive, V2 is negative. Hence the top diode(D1) will be a short and the bottom diode(D2) will be an open. On the other hand, when V1 is negative, V2 is positive. Hence the bottom diode(D2) will be on and the top diode(D1) will be an open circuit.





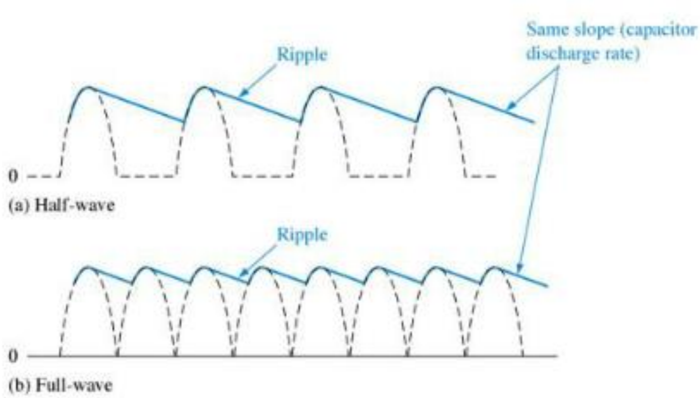
Ripple Voltage and Ripple Factor

Assuming a finite capacitor is connected, since a new charging pulse occurs every half cycle the capacitor charges and discharges very frequently. We can observe that smaller the Vpp, the more the waveform will resemble a pure DC voltage. The variable portion is known as 'ripple' and the value Vpp is known as the ripple voltage. Further the ratio of the ripple voltage to the DC or average voltage is known as the ripple factor.

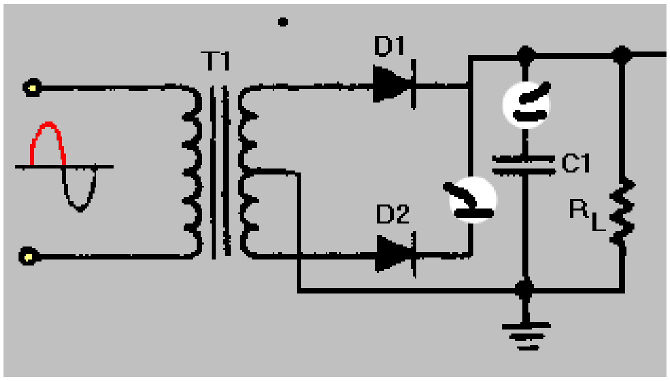


Half Wave vs Full Wave Capacitive Rectification

If the capacitance and voltage sources used are the same, which one among the two – half wave or full wave gives lesser ripple effectThe advantage of a full-wave rectifier over a half-wave is quite clear. The capacitor can more effectively reduce the ripple when the time between peaks is shorter.



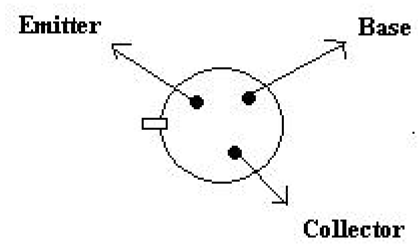
Combine circuit of Full Wave and Half wave

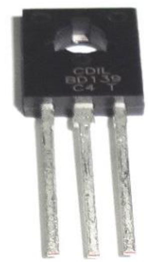


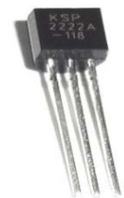
OBSERVATION TABLE:

Sl no.	$V_{rms(Volt)}$	$V_{DC(Volt)}$	Ripple factor

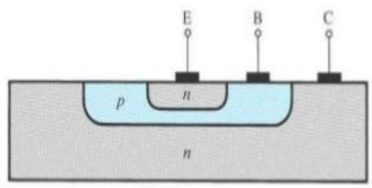
<u>IDENTIFICATION OF BJT (PIN)</u>

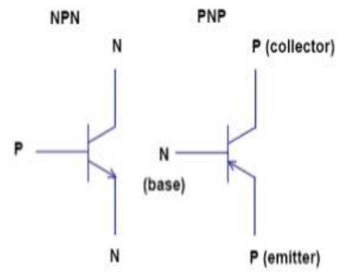




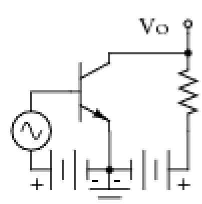
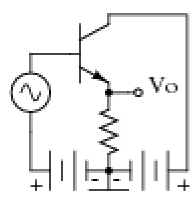
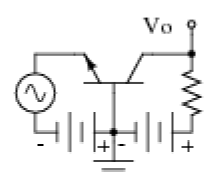
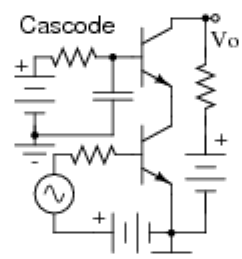


BJT Modes





characteristics of Bipolar junction transistor in various mode

Basic circuit	Common emitter	Common collector	Common base	Cascode
				
Voltage gain	high	less than unity	high, same as CE	high, same as CB
Current gain	high	high	less than unity	high, same as CE
Power gain	high	moderate	moderate	highest
Phase inversion	yes	no	no	yes
Input impedance	moderate ≃ 1 k	highest ≃ 300 k	low ≃ 50 Ω	same as CE, ≃ 1 k
Output impedance	moderate ≃ 50 k	low ≃ 300 Ω	highest ≃ 1 Meg	same as CB, ≃ 1 Meg

Experiment-4

AIM: To study the VI charecteistics of Bipolar junction transistor in CE mode and calculate the following:

1. **Voltage gain**
2. **Current gain**
3. **Input impedance**
4. **Output impedance**

Component used:

1.BC107

2.Bread Board

3.Connecting wire

4.DMM

5. Resistor

Theory

The common emitter configuration is widely used as a basic amplifier as it has both voltage and current amplification. Resistors R_{B1} and R_{B2} form a voltage divider across the base of the transistor. The function of this network is to provide necessary bias condition and ensure that emitter-base junction is operating in the proper region. In order to operate transistor as an amplifier, biasing is done in such a way that the operating point is in the active region. For an amplifier the Q-point is placed so that the load line is bisected. Therefore, in practical design V_{CE} is always set to $V_{CC}/2$. This will confirm that the Q-point always swings within the active region. This limitation can be explained by maximum signal handling capacity. For the maximum input signal, output is produced without any distortion and clipping.

Circuit diagram

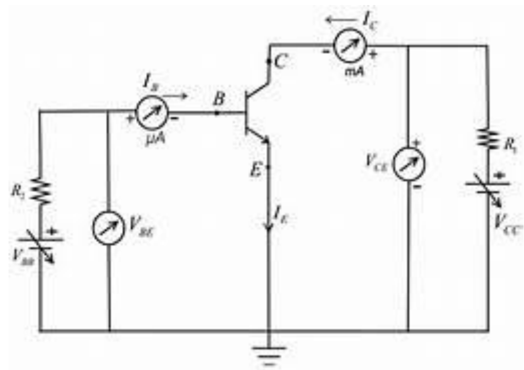
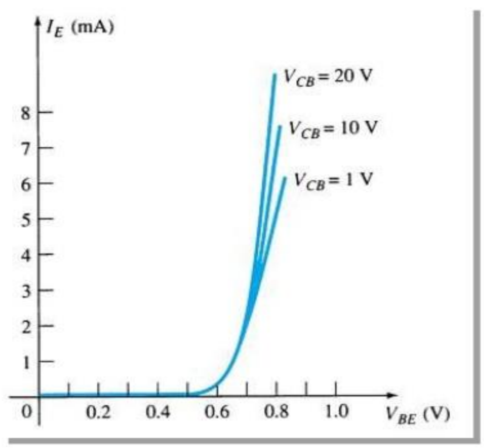
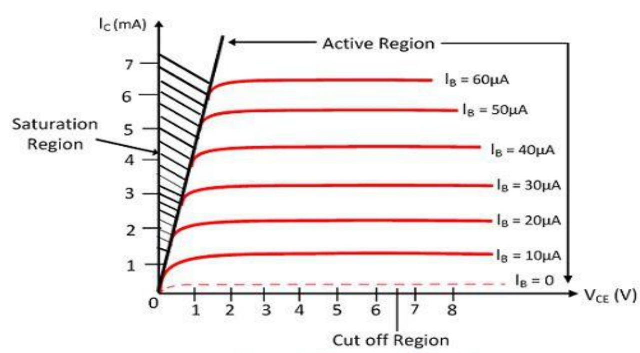


Figure 3- Circuit arrangement for studying input and output characteristics of npn transistor in CE configuration

Input Characteristics





Output Characteristic Curve

OBSERVATION TABLE: Input characteristic

S.No	V_{CE} =1V		V_{CE} =2V	
	I_B (μA)	I_C (mA)	I_B (μA)	I_C (mA)

OBSERVATION TABLE: Output characteristic

Sl no.	I_B=10μA		I_B=20μA	
	V_{CE} (volt)	I_C (mA)	V_{CE} (volt)	I_C (mA)

Experiment-5

AIM: To study the VI characteristics of Field effect transistor in n-channel mode and calculate the following:

1. **Drain resistance(r_d)**
2. **Amplification factor(μ)**
3. **Transconductance (g_m)**

Component used:

1.BFW10

2.Bread Board

3.Connecting wire

4.DMM

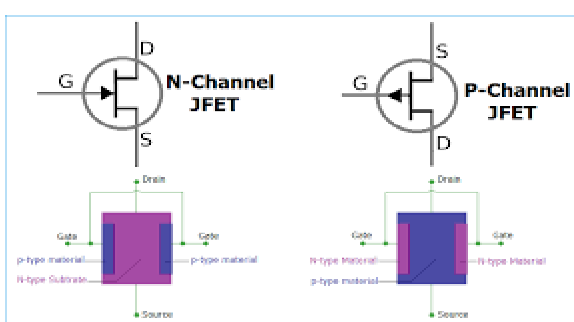
5. Resistor

6. Power supply

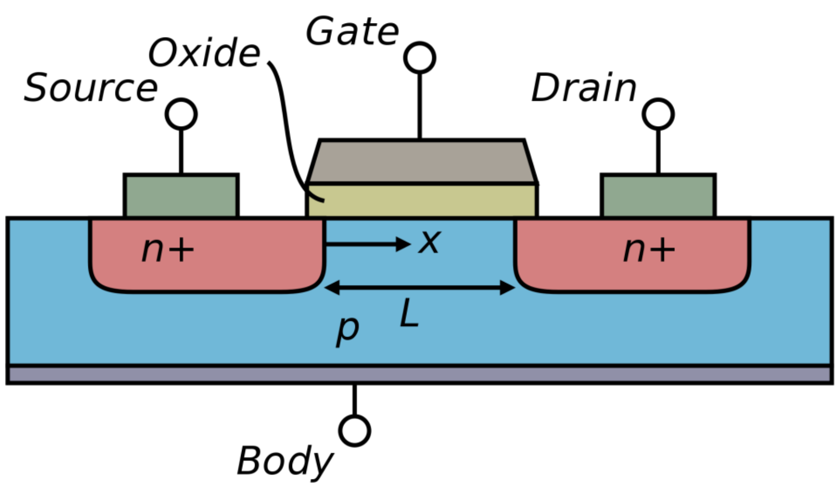
THEORY

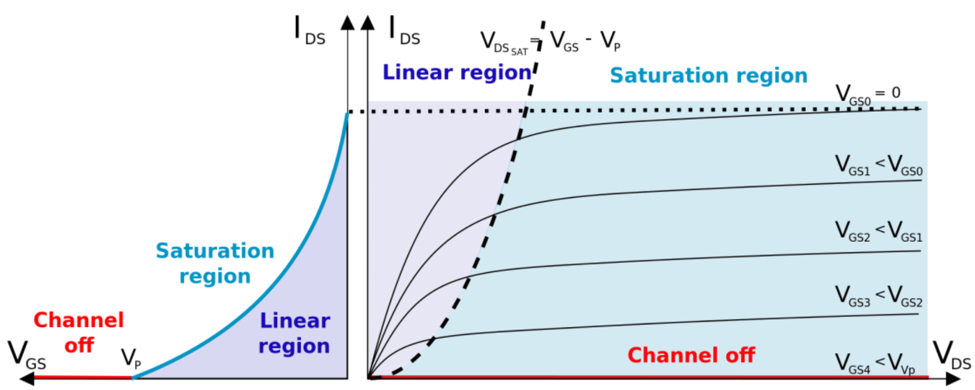
The field-effect transistor (FET) is a type of transistor that uses an electric field to control the flow of current. FETs are devices with three terminals: source, gate, and drain. FETs control the flow of current by the application of a voltage to the gate, which in turn alters the conductivity between the drain and source.

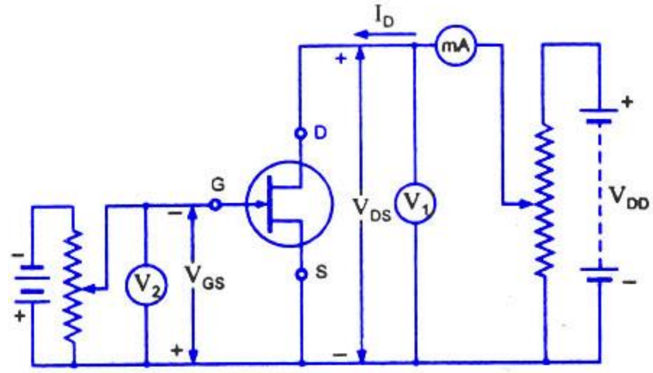
In an n-channel "depletion-mode" device, a negative gate-to-source voltage causes a depletion region to expand in width and encroach on the channel from the sides, narrowing the channel. If the active region expands to completely close the channel, the resistance of the channel from source to drain becomes large, and the FET is effectively turned off like a switch (see right figure, when there is very small current). This is called "pinch-off", and the voltage at which it occurs is called the "pinch-off voltage". Conversely, a positive gate-to-source voltage increases the channel size and allows electrons to flow easily (see right figure, when there is a conduction channel and current is large).



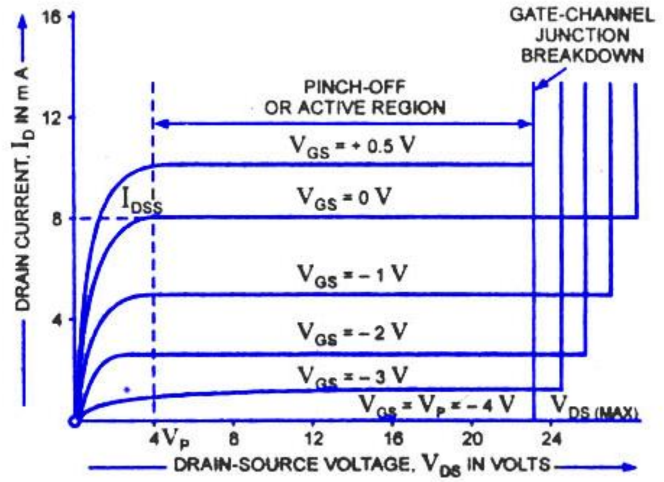
In an n-channel "enhancement-mode" device, a conductive channel does not exist naturally within the transistor, and a positive gate-to-source voltage is necessary to create one. The positive voltage attracts free-floating electrons within the body towards the gate, forming a conductive channel. But first, enough electrons must be attracted near the gate to counter the dopant ions added to the body of the FET; this forms a region with no mobile carriers called a depletion region, and the voltage at which this occurs is referred to as the threshold voltage of the FET. Further gate-to-source voltage increase will attract even more electrons towards the gate which are able to create a conductive channel from source to drain; this process is called inversion.







Circuit Diagram For Determining Drain Characteristic With External Bias For An N-Channel JFET



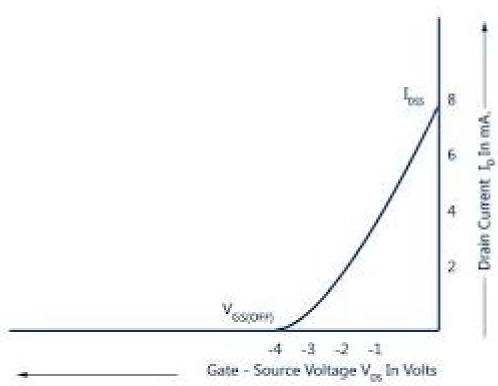
JFET Drain-Characteristics With External Bias

<u>Drain Characteristic</u>

SL no.	V_{GS}= 1V		V_{GS} = 2V	
	V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)

Transfer characteristics

Sl no.	V_{DS}= (V)	I_D((mA)



Experiment-6

Experiment Name: Realization of Basic gates using universal logic gates.

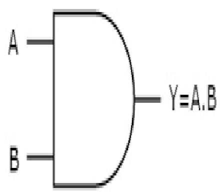
components used:

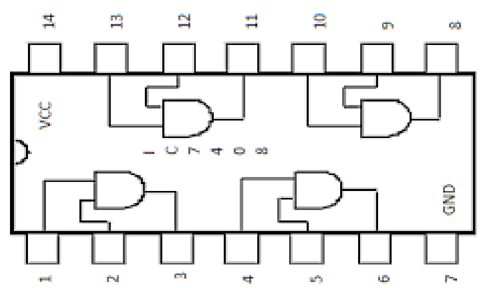
1. Digital I.C Trainer Kit.
2. Single strand wire.
3. Cutter.
4. Tweezers.
5. I.C.—i) 7408 –AND ii) 7432-OR, iii) 7404-NOT ,iv) v) 7400- NAND v) 7402- NOR

THEORY: **BASIC GATES-** i) AND, ii) OR, iii) NOT

AND gate- The AND gate is a basic digital logic gate that implements logical conjunction - it behaves according to the truth table to the right. A HIGH output (1) results only if all the inputs to the AND gate are HIGH (1). If none or not all inputs to the AND gate are HIGH, LOW output results.

Truth Table

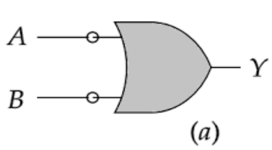


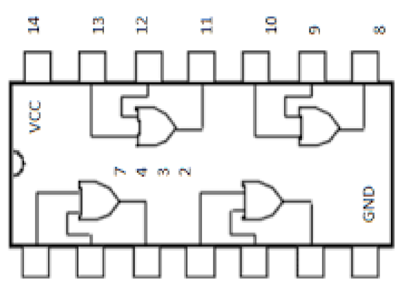


Input		O/P
X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

OR gate- The AND gate is an electronic circuit that gives a high output (1) only if all its inputs are high. A dot (.) is used to show the AND operation i.e. A.B. Bear in mind that this dot is sometimes omitted i.e. AB

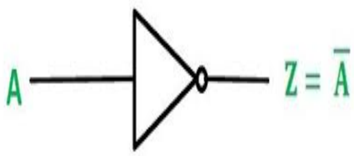
Truth Table

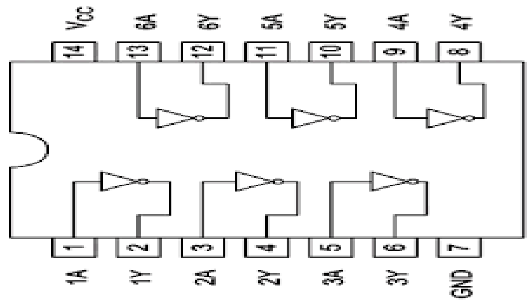




Input		O/P
X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	1

NOT gate- The NOT gate is an electronic circuit that produces an inverted version of the input at its output. It is also known as an inverter. If the input variable is A, the inverted output is known as NOT A. This is also shown as A', or A with a bar over the top, as shown at the outputs. The diagrams below show two ways that the NAND logic gate can be configured to produce a NOT gate. It can also be done using NOR logic gates in the same way.



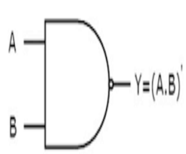


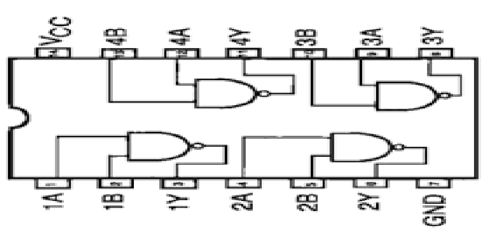
Input	Output
X	Y
0	1
1	0

UNIVERSAL GATES- i) NAND ii) NOR

NAND gate- This is a NOT-AND gate which is equal to an AND gate followed by a NOT gate. The outputs of all NAND gates are high if any of the inputs are low. The symbol is an AND gate with a small circle on the output. The small circle represents inversion

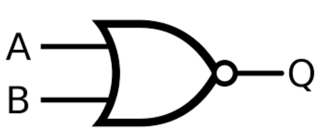
Truth Table

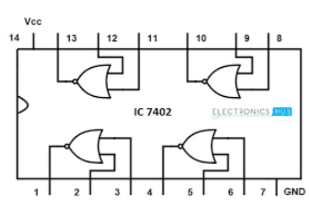




Input		O/P
X	Y	Z
0	0	1
0	1	1
1	0	1
1	1	0

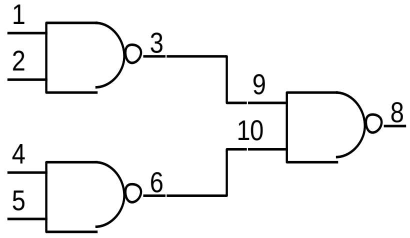
NOR gate- This is a NOT-OR gate which is equal to an OR gate followed by a NOT gate. The outputs of all NOR gates are low if any of the inputs are high.
The symbol is an OR gate with a small circle on the output. The small circle represents inversion.



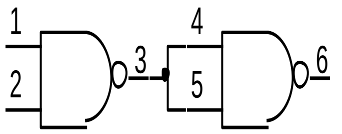


Input		O/P
X	Y	Z
0	0	1
0	1	0
1	0	0
1	1	0

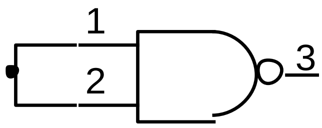
CIRCUIT: <u>Basic gates using NAND gates</u>



OR gate using NAND gate

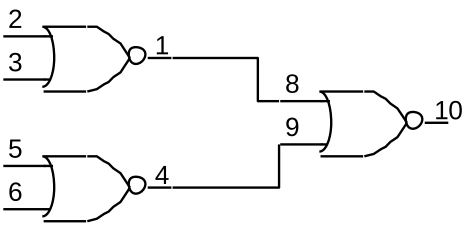


AND gate using NAND gate

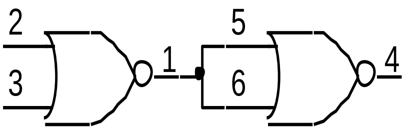


NOT gate using NAND gate

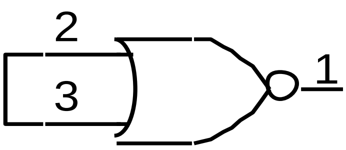
<u>Basic gates using NOR gates</u>



AND gate using NOR gate



OR gate using NOR gate



NOT gate using NOR gate

Experiment-7

AIM: To study and calculate the gain of different types of op-amp. They are

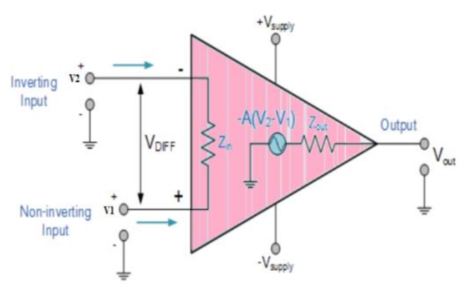
1. INVERTING AMPLIFIER
2. NON- INVERTING AMPLIFIER
3. SUMMING AMPLIFIER
4. INTEGRATING AMPLIFIER
5. DIFFERENTIATOR

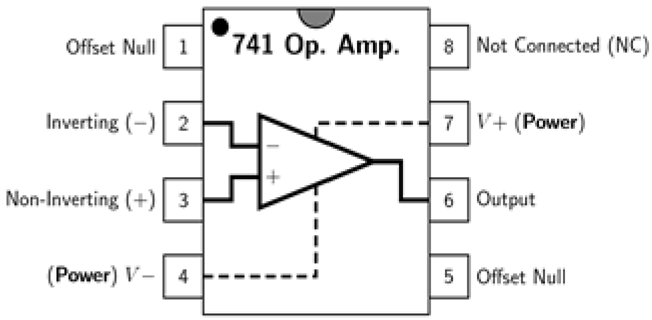
components used:

1. Op -amp Ic-741
2. Bread board
3. Resistor
4. Capacitor
5. Connecting wires

THEORY

Operational Amplifier commonly known as Op-Amp, is a linear electronic device having three terminals, two high impedance input and one output terminal. Op-Amp can perform multiple function when attached to different feedback combinations like resistive, capacitive or both. Generally it is used as voltage amplifier and the output voltage of the Op-Amp is the difference between the voltages at its two input terminals.

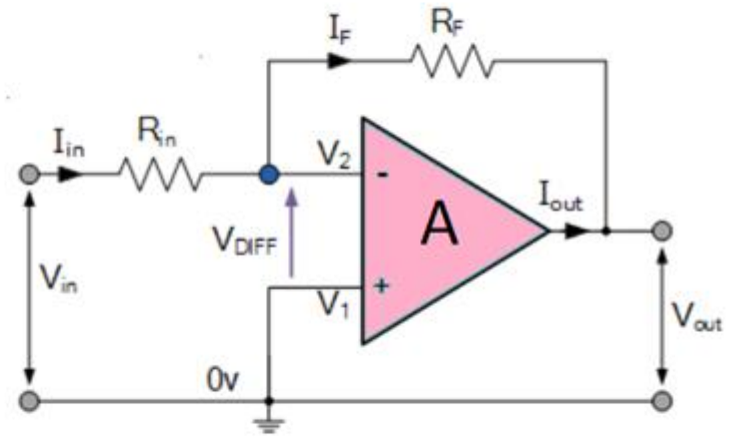




Op-Amp shows some properties that make it an ideal amplifier, its open loop gain and input impedance is infinite (i.e. Practically very high), Output impedance and offset voltage is zero(i.e. Practically very low) and bandwidth is infinite(i.e. Practically limited to frequency where its gain become unity).

Inverting Op-Amp:

The open loop gain(Ao) of the Om-Amp is very high which makes it very unstable, so to make it stable with a controllable gain, a feed back is applied through some external resistor(Fry) from its output to inverting input terminal(i.e. Also known as negative feedback) resulting in reduced gain(closed loop gain, Av). So the voltage at inverting terminal is now the sum of the actual input and feedback voltages, and to separate both a input resistor(RI) is introduced in the circuit. The non inverting terminal of the pomp is grounded, and the inverting terminal behaves like a virtual ground as the junction of the input and feedback signal are at the same potential.



The close loop gain (A_{cl}) is given by :-_ $A_{cl}=V_{ou}tV_{in}=-R_{F}/R_{in}$

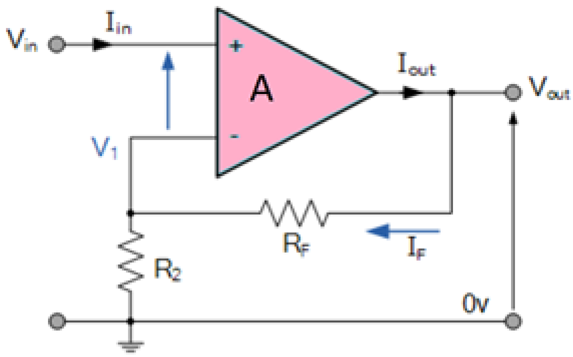
Output voltage ($V_{ou}t$) is given by :- $V_{out}=-R_F/R_{in}\times V_{in}$

OBSERVATION TABLE:

Sl no.	V_{in}(volt)	$A_V=-R_F/R_{in}$	V_{out} (volt)

Non-Inverting Op-Amp

In this configuration of Op-amp the input signal is directly fed to the non inverting terminal resulting in a positive gain and output voltage in phase with input as compared to inverting Op-amp where the gain is negative and output voltage is out of phase with input , and to stabalize the circuit a negative feedback is applied through a resistor(Rf) and the inverting terminal is grounded with input resistor(R2).This inverting Op-Amp like layout the at inverting terminal creates a virtual ground at the summing point make the Rf and R2 a potential divider across inverting terminal, Hence determines the gain of the circuit.



Output Voltage (Vout) is given by:

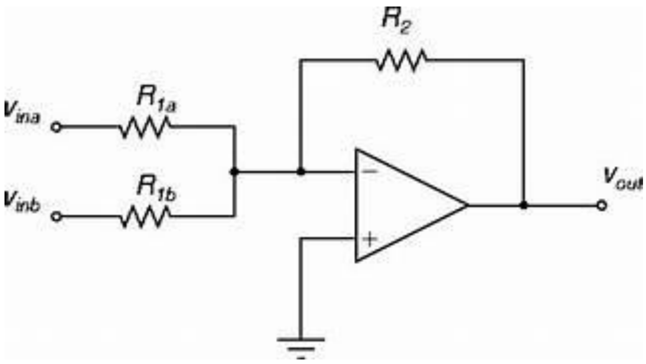
OBSERVATION TABLE:

Sl no.	V_{in}(volt)	$A_v=1+R_F/R_{in}$	V_{out} (volt)

Summing amplifier

Summing amplifier is basically an op amp circuit that can combine numbers of input signal to a single output that is the weighted sum of the applied inputs. The summing Amplifier is one variation of inverting amplifier. In inverting amplifier there is only one voltage signal applied to the inverting input as shown below,

Summing Amplifier or Op Amp Adder Circuit Diagram

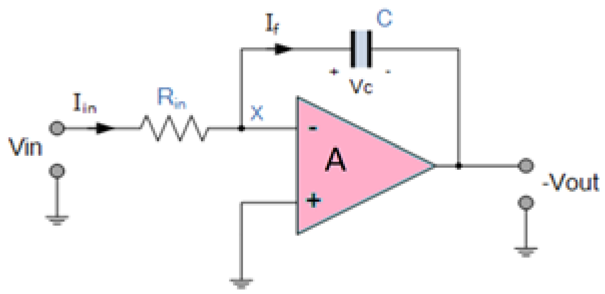


OBSERVATION TABLE:

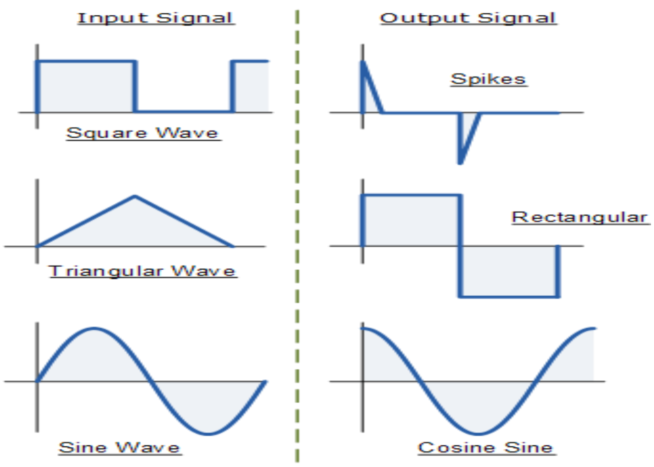
Sl no.	V_{in}(volt)	V_{out} (volt)

The Integrator

It is a circuit designed with Op-Amp in such a way that it performs the mathematical Integration operation, its output is proportional to the amplitude and time duration of the input applied. The integrator circuit layout is same as a inverting amplifier but the feedback resistor is replaced by a capacitor which make the circuit frequency dependent. In this case the circuit is derived by the time duration of input applied which results in the charging and discharging of the capacitor. Initially when the voltage is applied to integrator the uncharged capacitor allows maximum current to pass through it and no current flows through the Op-Amp due to the presence of virtual ground, the capacitor starts to charge at the rate of RC time constant and its impedance starts to increase with time and a potential difference is develops across the capacitor resulting in charging current to decrease. This results in the ratio of capacitor's impedance and input resistance increasing causing a linearly increasing ramp output voltage that continues to increase until the capacitor becomes fully charged.

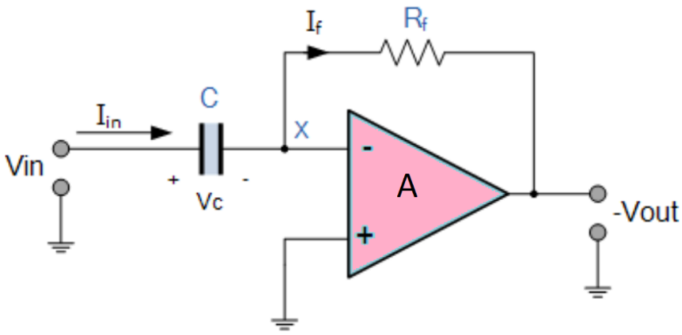


Waveforms-

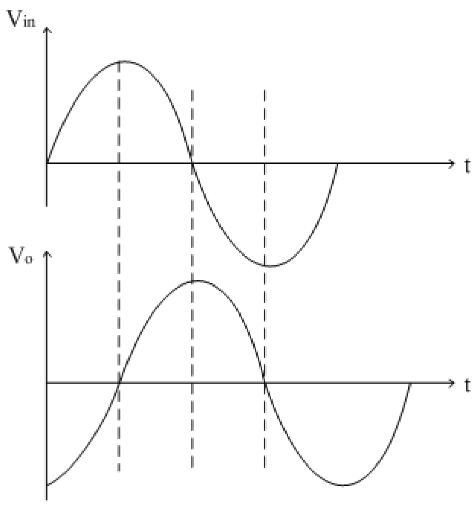


The Differentiator

In the differentiator circuit the input is connected to the inverting output of the Op-Amp through a capacitor(C) and a negetive feedback is provided to the inverting input terminal through a resistor(Rf), which is same as an integrator circuit with feedback capacitor and input resistor being replaced with each other. Here the circuit performs a mathematical differentiation operation, and the output is the first derivative of the input signal, 180' out of phase and amplified with a factor Rf*C. The capacitor on the input allows only the AC component and restrict the DC, at low frequency the reactance of capacitor is very high causing a low gain and high frequency vice versa but and high frequency the circuit becomes unstable.



Waveforms



Experiment-8

AIM: Schmitt trigger circuit using IC 555

components used:

1. Timer Ic-555

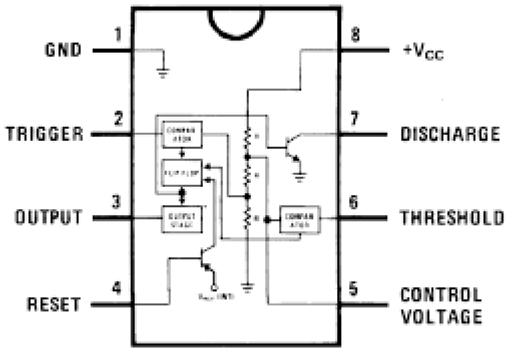
2. Bread board

3. Resistor

4. Capacitor

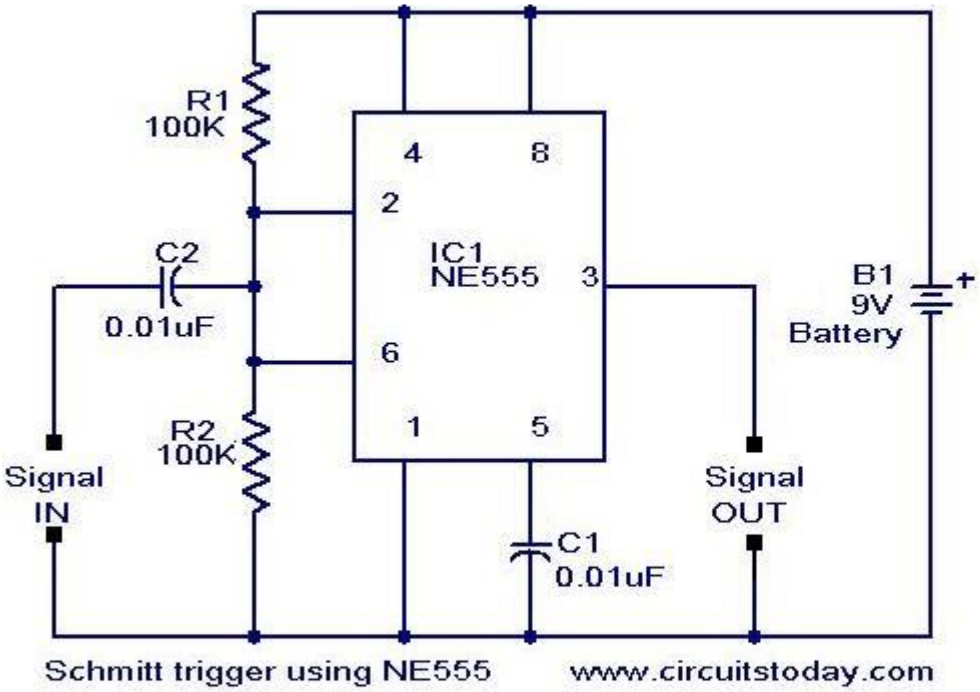
5. Connecting wires

Schmitt trigger is a comparator circuit with hysteresis implemented by applying positive feedback to the no inverting input of a comparator or differential amplifier. It is an active circuit which converts an analog input signal to a digital output signal. The circuit is named a "trigger" because the output retains its value until the input changes sufficiently to trigger a change. In the non-inverting configuration, when the input is higher than a chosen threshold, the output is high. When the input is below a different (lower) chosen threshold the output is low, and when the input is between the two levels the output retains its value. This dual threshold action is called hysteresis and implies that the Schmitt trigger possesses memory and can act as a bistable multivibrator (latch or flip-flop). There is a close relation between the two kinds of circuits: a Schmitt trigger can be converted into a latch and a latch can be converted into a Schmitt trigger.



LM555 Timer

<u>CIRCUIT DIAGRAM</u>



<u>OBSERVATION TABLE</u>

Sl no.	R_1 kΩ	R_2kΩ	$+V_{sat}$(cal)	$-V_{sat}$(cal)	$+V_{sat}$(obs)	$-V_{sat}$(obs)

WAVEFORMS