MODULE I

INTRODUCTION:

What is civil engineering?--It is one of the oldest disciplines of engineering which deals with designing, construction and maintenance of naturally and physically build environments such as airport, roads, bridges, dams, canals. Specifically, it can be described as the professional art of applying Mathematics and Science to create and make a better place for people to live in.

Scope of Civil Engineering:

- Civil Engineering in Private Sector
- Civil Engineering in Govt. Sector
- Higher Education after B.Tech in Civil Engineering

Importance of civil engineering:

They are responsible for maintaining the overall safety of society in a number of ways including **rural engineering**. From constructing highways and buildings to bridges and tunnels, the responsibilities of civil engineers are many.

Civil engineers are responsible for planning and overseeing different construction efforts and apply civil engineering principles to ensure that the constructed structures are safe and sturdy.

Building Material and Building Construction:

Bricks have a crucial role in civil engineering construction. These are often used as an alternative for different stones and are generally used in the construction of buildings.

It is always desirable to use the best quality brick in constructions. Therefore, the Characteristics of a good brick must be investigated. Generally good bricks possesses following properties

1)Bricks should be uniform in color, size and shape. Standard size of brick should be maintained.

2)They should be sound and compact.

3)They should be free from cracks and other flaws such as air bubbles, stone nodules etc. with sharp and square edges.

4)Bricks should not absorb more than 1⁄5
of their own weight of water when immersed in water for 24 hours (15% to 20% of dry weight).

Here some main uses of construction brick are given below.

1)Construction of walls of any size

2)Construction of floors

3)Construction of arches and cornices

4)Construction of brick retaining wall

5)Making Khoa (Broken bricks of required size) to use as an aggregate in concrete

6)Manufacture of surki (powdered bricks) to be used in lime plaster and lime concrete

Constituents of good brick earth:

Bricks are the most commonly used construction material. Bricks are prepared by moulding clay in rectangular blocks of uniform size and then drying and burning these blocks. In order to get a good quality brick, the brick earth should contain the following constituents.

- Silica
- Alumina
- Lime
- Iron oxide
- Magnesia

Silica

- Brick earth should contain about 50 to % of silica.
- It is responsible for preventing cracking, shrinking and warping of raw bricks.
- It also affects the durability of bricks.
- If present in excess, then it destroys the cohesion between particles and the brick becomes brittle.

Alumina

- Good brick earth should contain about 20% to 30% of alumina.
- It is responsible for plasticity characteristic of earth, which is important in moulding operation.
- If present in excess, then the raw brick shrink and warp during drying.

Lime

- The percentage of lime should be in the range of 5% to 10% in a good brick earth.
- It prevents shrinkage of bricks on drying.
- It causes silica in clay to melt on burning and thus helps to bind it.
- Excess of lime causes the brick to melt and brick looses its shape.

Iron oxide

- A good brick earth should contain about 5% to 7% of iron oxide.
- It gives red colour to the bricks.
- It improves impermeability and durability.
- It gives strength and hardness.
- If present in excess, then the colour of brick becomes dark blue or blakish.
- If the quantity of iron oxide is comparatively less, the brick becomes yellowish in colour.

Magnesia

- Good brick earth should contain less a small quantity of magnesia about1%)
- Magnesium in brick earth imparts yellow tint to the brick.
- It is responsible for reducing shrinkage
- Excess of magnesia leads to the decay of bricks.

<u>Classification of Bricks</u>

Bricks, which are used in construction works, are burnt bricks. They are classified into four categories on the basis of its manufacturing and preparation, as given below.

1. First class bricks
2. Second class bricks
3. Third class bricks
4. Fourth class bricks

First Class Bricks:

These bricks are table moulded and of standard shape and they are burnt in kilns. The surface and edges of the bricks are sharp, square, smooth and straight. They comply with all the qualities of good bricks. These bricks are used for superior work of permanent nature.

Second Class Bricks:

These bricks are ground moulded and they are burnt in kilns. The surface of these bricks is somewhat rough and shape is also slightly irregular. These bricks may have hair cracks and their edges may not be sharp and uniform. These bricks are commonly used at places where brick work is to be provided with a coat of plaster.

Third Class Bricks:

These bricks are ground moulded and they are burnt in clamps. These bricks are not hard and they have rough surfaces with irregular and distorted edges. These bricks give dull sound when struck together. They are used for unimportant and temporary structures and at places where rainfall is not heavy.

Fourth Class Bricks:

These are over burnt bricks with irregular shape and dark colour. These bricks are used as aggregate for concrete in foundations, floors, roads etc, because of the fact that the over burnt bricks have a compact structure and hence they are sometimes found to be stronger than even the first class bricks.

STONES

Naturally occurring compact, solid and massive material in the earth's crust or on the surface are known as rocks. Rocks don't have definite shape and chemical composition. They are mixture of two or more minerals. Stones are derived from rocks and are used as construction material.
Minerals are naturally occurring inorganic substance having definite atomic structure and chemical composition. Minerals are divided into two types.

1. Rock forming minerals
2. Ore minerals

CLASSIFICATION OF ROCKS

The rocks from which stones are derived are broadly classified into three types. They are:

I. Geological classification
II. Structural or Physical classification
III. Chemical classification

Geological classification:

The classification of rock based on the mode of formation or the process of formation is known as geological classification. According to this classification rocks/ stones are are of three types.

a) Igneous rocks
b) Sedimentary rocks
c) Metamorphic rocks

Igneous rocks

Molten rock materials found below the earth's crust are known as magma. During volcanic eruption, this magma, under very temperature and pressure, and varieties of complex phenomena occurring below earth's crust beyond the comprehension of human being, comes out to the surface.
Depending on the depth of the solidification of molten magma, igneous rocks are divided into three types.

i. Plutonic rocks
ii. Volcanic rocks
iii. Hypabyssal rocks

Sedimentary rocks

The secondary rocks which are formed by chemical or mechanical activities of the weathering agents such as temperature, water, air, ice, etc. on the pre-existing rocks are known as sedimentary rocks. Weathering agents like wind, water, ice, atmospheric gases, etc.

Like igneous rocks, sedimentary rocks are formed in different ways. On the basis of the formation, sedimentary rocks are divided into three different categories.

a. Clastic rocks
b. Chemically formed sedimentary rocks
c. Organically formed sedimentary rocks

Metamorphic rocks

Igneous rocks and sedimentary rocks undergo structural change under the influence of high temperature, pressure and chemical action and thus the original character of the parent rock are partly or wholly changes. Such process is known as metamorphosis and the rocks so formed are known as metamorphic rocks. Examples: marble, slate, gneiss, etc. Marble is formed from limestone ($CaCO_3$) by gradual heating over a very large period of time.

Chemical Classification

On the basis of dominant chemical composition, three main types of rocks are:

a. Silicious rocks
b. Calcareous rock
c. Argillaceous rocks

Silicious rocks

Silica is the predominant constituent of this rock and is more than 50% of the bulk composition of the rock. Some sedimentary and metamorphic rocks are entirely made of silica. These rocks are very strong and hence may be treated as good building stones. Examples of these rocks are granite, sandstone, gneiss.

Calcareous rocks

In these rocks carbonate is the dominant chemical component. These rocks generally belong to sedimentary and metamorphic rocks. Limestone, dolomite and marbles are entirely carbonate rocks and are very good building stones.

Argillaceous rocks

In these rocks clay (hydrous alumina silicate of K, Na, Ca and Mg) is the dominant component. These are mostly sedimentary and metamorphic rocks. These are very soft and hence not recommended as building stones. Examples of these rocks are slates and schists.

Structural Classification

On the basis of physical characteristics of the rocks, the manner and arrangement of different particles rocks are classified into three categories. They are:

1. Stratified
2. Unstratified
3. Foliated

Unstratified Rocks

These rocks occur in huge masses without showing any layered structure in them. Igneous rocks and many metamorphic rocks are unstratified in nature. Some of the sedimentary rocks may be of unstratified in nature.

Stratified Rocks

These rocks occur in distinct layers of same or different colour and composition. Most of the sedimentary rocks are stratified rocks. The different layers are called beds and separated by planes, called bedding planes.

Foliated rocks

Some rocks have in them profuse development of well defined bands of different composition. Such rocks are known as foliated rocks. Examples of such rocks are schists and gneiss. Sometimes such layers are induced under pressure. These are not very good building stones.

1. CHARACTERISTICS OF DIFFERENT TYPES OF STONES AND THEIR USES

Granite: It is a coarse to medium grained igneous rock. It is essentially made up of felspar, quartz and mica.

Characteristics

a. Its specific gravity is 2.64 and water absorption is less than 1%.
b. It has mottled (spotted) appearance.
c. Most granites excellent building properties and are significantly strong and durable. Crushing strength varies from 110 to 140 MN/m^2.
d. Granites have poor fire resistance and crack under strong fire.
e. Granites have the capacity to take very fine and glassy polish.
f. Quantity of felspar decides the colour of granite.

Uses

a. Fine grained granite is suitable for ornamental column, plinth, etc. as it takes very fine polish and exhibits glassy appearance.
b. High values of strength, hardness, specific gravity and durability make it suitable for construction of sea walls, light houses and bridge piers, etc.
c. Large pieces are used as building blocks for masonry structures, smaller ones as road metals or railway ballast and the chippings for manufacture of concrete.

Basalt: It is a volcanic type igneous rock. The main constituents are silica, alumina and felspar.

Characteristics

a. Its specific gravity is about 2.96.
b. It is very heavy and strong and is heavier than granite.
c. Its crushing strength varies from 70 to 80 MN/m^2.
d. It has greenish grey to dark grey colour.

Uses

a. Basalt is suitable for paving sets and as a road metal.
b. It is used as aggregate in concrete.
c. It is also used for manufacture of artificial stones.

Limestone: Limestone is a sedimentary rock of calcareous variety and of organic origin. In its purest form, it contains mainly $CaCO_3$, although some varieties may contain $MgCO_3$ and small amount of silica and alumina.

Characteristics

a. Its specific gravity is 2.6.
b. Its crushing strength is about 52 MN/m^2.
c. The colour of limestone depends on its composition, especially the type of finely dispersed impurities present throughout the carbonate matrix. However, they are available in three main colours viz., brown, yellow and dark grey colours.

Uses

a. Limestones are not very useful as building stone because of their poor strength values. However, dense, compact and massive varieties are used for stone masonry in walls.
b. It is used as road metal when better materials like basalt and granite are not available.
c. It is used in blast furnaces, bleaching, tanning and other industries.

Marble: It is metamorphic rock of calcareous variety. It is formed from the metamorphosis of limestone. Its main constituent is recrystallised hard and compact $CaCO_3$.

Characteristics

a. Its specific gravity is about 2.72.
b. Crushing strength of marble varies from 50 to 60 MN/m^2.
c. It is very hard and takes a fine polish.
d. It is available in a variety of colours such as white, yellow, grey, green, red, blue and black colours.
e. It is easy to work with marble.

Uses

a. It is for carving and decoration work.

b. It is also used for steps, wall linings, columns, electrical switch boards and table tops.

Sandstone: It is a sedimentary rock of siliceous variety. It contains sand or quartz cemented by lime, mica, magnesium, alumina, iron oxide.

Characteristics

a. Its specific gravity is 2.25.
b. Its structure shows sandy grains.
c. Crushing strength of sandstone varies from 35 to 40 MN/m2.
d. Sandstones occur in many colours viz., white, grey, pink, red, maroon and dark.
e. Fine grained sandstones with siliceous cementing material are strong and durable and are excellent building materials.
f. Sandstones of different hues are available e.g., white, grey, brown, pink, etc.

Slate: It is a metamorphic rock of argillaceous variety. It has a distinct foliated structure. It is composed of alumina mixed with sand or carbonate of lime.

Characteristics

a. Its specific gravity is 2.8.
b. A good slate is hard, tough and fine grained.
c. Crushing strength of slate varies from 60 to 70 MN/m^2.
d. It has grey or dark blue colour.
e. It can be split into thin sheets.
f. It is non-absorbent and durable.
g. It produces a sharp metallic sound on hammering.

Uses

a. Thin-layered slates having good compressive strength are used as sills and for pavements inside and outside palatial building.
b. Slate is practically impervious and hence very suitable for roofing stone and urinal partitions.

Laterite: It is sedimentary rock composed mostly of oxides of aluminium with varying amounts of oxides of iron.

Characteristics

Its specific gravity varies from 2 to 2.2.
It has a poor compressive strength, which varies from 20 to 30 MN/m^2.
It is light to dark red in colour.
It has a porous and spongy or cellular structure.

Uses

a. Laterite is used as a building material only in ordinary construction.
b. It is mostly used as road metals.

Gneiss: It is a metamorphic rock. It is formed by the metamorphosis of granite and has the same constituents as granite. It is siliceous in composition and foliated in structure.

Characteristics

a. Gneisses are coarsely crystalline rocks.
b. It can be freely split into slabs.
c. Gneiss is more easy to work with than granite.
d. It is available in different colours.

Uses

a. Coarsely crystalline and uniformly textured gneisses are as good building materials as granites.
b. It is used for ornamental and decorative purpose.

Quartzite: It is composed of silica. It is dense, hard and glassy in structure. Some varieties of quartzite are very hard and strong and are considered to be very good as building stone. It is strong and durable and used as road metal or railway ballast. it is also used in concrete.

CEMENT

Composition of cement :-

The cement consists of the following chemicals

i. Lime - CaO- 62%
ii. Silica –SiO_2-22%
iii. Alumina - Al_2O_3 -5%
iv. Calcium sulphate-$CaSo_4$-4%
v. Iron Oxaide-Fe_2O_3-3%
vi. Magnesia-MgO-2%
vii. Sulphur-S-1%
viii. Alcaline and other material-1%

Types of cement:-

According to the creation of the cement it is classified into two type.

* Natural cement
* Artifical cement

Natural Cement :-

The natural cement is obtained by buring and crushing the stones containing clay carbonates of lime and some amount of carbonates of magnesia.

* The quantity of clay in natural cement is 20-40%.
*The color of this cement is brown.
*This cement sets repidly when mixed with water.
* The cost of this type of cement is very high.
* This type of cement is rarely used in India.

Artificial cement:-

-> This type of cement is prepared in different verities.
-> The manufacturing of this types of cement includes the following process.

* Mixing of raw materials.
* Burning.
* Crushing.
* Grinding.

Types of artificial cement:-

:- Acid resistant cement.
:- Blast forness cement.
:- Coloured cement.
:- Expanding cement.
:- High alumina cement.
:- Hydyophobic cement.
:- Lowhit cement.ral
:- Pozzuolana cement.
:- Quick setting cement.
:- Rapid hardening cement.
:- Sulphate resisting cement.
:- White cement.

Acid resisting cement:-

An acid resisting cement is composed of the following ingradients.

i. Acid resisting aggregate.
ii. Additives like sodium fluosilicate.

iii. Aques solution of sodium silicate.

The addition of fluosilicate accelerates the hardening process of sodium silicate & it also increases the resistance of cement to acid & water.

Blast franace cement:-

-> For this cement the slag which is obtained from blast furnace is used.

-> The slag is a waste product in the manufacturing process of iron.

=> The clinker of cement is mixed with 60 – 65 % of slag.

=> The strength of this cement is less & it requires longer quiring period .

Coloured cement:-

-> The cement of desired colour is obtained by mixing the mineral pigments with ordinary cement.

-> The amount of colouring material is between 5-10%.

=> The coloured cement is widely used for finishing of floors, external surfaces etc.

=> The chromium oxide gives green colour , cobalt gives blue colour & iron oxide gives brown red or yellow colour in different proportions.

Expanding cement:-

-> This type of cement is produced by adding the expanding material or ingradients likes sulpher alluminate to ordinary cement.

=> This type of cement is used for the construction of water retaining structures & for repairing the damaged concrete structures.

Hydrophobic Cement :-

- ⇨ This type of cement contains the admixtures which decreases wetting ability of cement grains.
- ⇨ Usually the admixtures are oxides, petroliums etc.
- ⇨ These substances form a thin layer arround cement grains .
- ⇨ When this cement is used , the water resistance of concrete is increased.

High alumina cement:-

- ⇨ This cement is produced by grainding the clinkers fromed by calcining bauxite and lime.
- ⇨ This cement is rarely used in India.

Low heat cement:-

- ⇨ In this cement a considerable heat is produced during the setting action.
- ⇨ It contains higher %age of dicalcium silicate & lower %age of tricalcium aluminate.
- ⇨ This cement possess less compressive strength.

Pozzuolona cement:-

- ⇨ It can be produced by surkhi which is prepared by burning bricks made from ordinary soils.
- ⇨ This cement is used for concrete work under water.
- ⇨ The %age of pozzuolana material should be between 10 to 30.
- ⇨ It is cheap.

Quick setting cement:-

- ⇨ This cement is produced by adding small percentage of aluminium sulphate and by finely grinding the cement.
- ⇨ Thew setting action of this cement starts within 5 minutes.
- ⇨ This cement is used to lay concrete under static water & running water.

Rapid hardening cement:-

- ⇨ It is just similar to ordinary cement but is gives more strength than ordinary cement.
- ⇨ It is not damaged easily .
- ⇨ It contains high percentages of tri calclium silicate .
- ⇨ The structures with heavy load are constructed with this cement.
- ⇨ This cement is costlier than ordinary cement & is very light.

Sulphate registing cement:-

- ⇨ The ordinary cement is mixed with calsium hydroxide and finally grinded.

- ⇨ The cement is used for the structre which are to be damaged by alkaline conditions such as canal linings, culverts , siphons etc.
- ⇨ The cement is used in marine construction.

White cement:-

- ⇨ This cement is prepared from the raw materials which are practically free from colouring oxides of iron,manganese or chromium.
- ⇨ It is used for plastering work, floor finishing etc.
- ⇨ It is also costly than ordinary cement.

USES OF CEMENT

- ➢ Cement mortar for Masonry work, plaster and pointing etc.
- ➢ Concrete for laying floors, roofs and constructing lintels,beams,weathershed,stairs,pillars etc.
- ➢ Construction for important engineering structures such asbridge,culverts,dams,tunnels,light house,clocks,etc. • Construction of water,wells, tennis courts,septic tanks, lamp posts, telephone cabins etc.
- ➢ Making joint for joints,pipes,etc.
- ➢ Manufacturing of precast pipes,garden seats, artistically designed wens, flower posts, etc.
- ➢ Preparation of foundation, water tight floors, footpaths, etc.

Various tests on cement:

Basically two types of tests are under taken for assessing the quality of cement. These are either field test or lab tests. The current section describes these tests in details.

Field test: There are four field tests may be carried out to as certain roughly the quality of cement.There are four types of field tests to access the colour, physical property, and strength of the cement as described below. **Colour:**

- ➢ The colour of cement should be uniform.
- ➢ It should be typical cement colour i.e. grey colour with a light greenish shade.

Physical properties

- ➢ Cement should feel smooth when touched between fingers.
- ➢ If hand is inserted in a bag or heap of cement,it should feel cool.

Presence of lumps

- ➢ Cement should be free from lumps.
- ➢ For a moisture content of about 5 to 8%,this increase of volume may be much as 20 to 40 %,depending upon the grading of sand.

Strength

- ➢ A thick paste of cement with water is made on a piece of thick glass and it is kept under water for 24 hours.
- ➢ It should set and not crack.

Laboratory tests: Six laboratory tests are conducted mainly for assessing the quality of cement. These are: fineness, compressive strength, consistency, setting time, soundness and tensile strength.

Fineness

- ➢ This test is carried out to check proper grinding of cement.
- ➢ The fineness of cement particles may be determined either by sieve test or permeability apparatus test.
- ➢ In sieve test ,the cement weighing 100 gm is taken and it is continuously passed for 15 minutes through standard BIS sieve no. 9.The residue is then weighed and this weight should not be more than 10% of original weight.
- ➢ In permeability apparatus test,specific area of cement particles is calculated.This test is better than sieve test.The specific surface acts as a measure of the frequency of particles of average size.

Compressive strength

- ➢ This test is carried out to determine the compressive strength of cement.

- The mortar of cement and sand is prepared in ratio 1:3.
- Water is added to mortar in water cement ratio 0.4.
- The mortar is placed in moulds.The test specimens are in the form of cubes and the moulds are of metals.For 70.6 mm and 76 mm cubes ,the cement required is 185gm and 235 gm respectively.
- Then the mortar is compacted in vibrating machine for 2 minutes and the moulds are placed in a damp cabin for 24 hours.
- The specimens are removed from the moulds and they are submerged in clean water for curing.
- The cubes are then tested in compression testing machine at the end of 3days and 7 days. Thus compressive strength was found out.

Consistency

- The purpose of this test is to determine the percentage of water required for preparing cement pastes for other tests.
- Take 300 gm of cement and add 30 percent by weight or 90 gm of water to it.
- Mix water and cement thoroughly.
- Fill the mould of Vicat apparatus and the gauging time should be 3.75 to 4.25 minutes.
- Vicat apparatus consists of aneedle is attached a movable rod with an indicator attached to it.
- There are three attachments: square needle,plungerand needle with annular collar.
- The plunger is attached to the movable rod.the plunger is gently lowered on the paste in the mould.
- The settlement of plunger is noted.If the penetration is between 5 mm to 7 mm from the bottom of mould,the water added is correct.If not process is repeated with different percentages of water till the desired penetration is obtained.

Setting time

- This test is used to detect the deterioration of cement due to storage.The test is performed to find out initial setting time and final setting time.
- Cement mixed with water and cement paste is filled in the Vicat mould.
- Square needle is attached to moving rod of vicat apparatus.
- The needle is quickly released and it is allowed to penetrate the cement paste.In the beginningthe needle penetrates completely.The procedure is repeated at regular intervals till the needle does not penetrate completely.(upto 5mm from bottom)
- Initial setting time =<30min for ordinary Portland cement and 60 min for low heat cement.
- The cement paste is prepared as above and it is filled in the Vicat mould.
- The needle with annular collar is attached to the moving rod of the Vicat apparatus.
- The needle is gently released. The time at which the needle makes an impression on test block and the collar fails to do so is noted.
- Final setting time is the difference between the time at which water was added to cement and time as recorded in previous step,and it is =<10hours.

Soundness

- The purpose of this test is to detect the presence of uncombined lime in the cement.
- The cement paste is prepared.
- The mould is placed and it is filled by cement paste.
- It is covered at top by another glass plate.A small weight is placed at top and the whole assembly is submerged in water for 24 hours.
- The distance between the points of indicator is noted.The mould is again placed in water and heat is applied in such a way that boiling point of water is reached in about 30 minutes. The boiling of water is continued for one hour.
- The mould is removed from water and it is allowed to cool down.
- The distance between the points of indicator is again measured.The difference between the two readings indicates the expansion of cement and it should not exceed 10 mm.

Tensile strength

- This test was formerly used to have an indirect indication of compressive strength of cement.
- The mortar of sand and cement is prepared.
- The water is added to the mortar.
- The mortar is placed in briquette moulds.The mould is filled with mortar and then a small heap of mortar is formed at its top.It is beaten down by a standard spatula till water appears on the surface.Same procedure is repeated for the other face of briquette.
- The briquettes are kept in a damp for 24 hours and carefully removed from the moulds.
- The briquettes are tested in a testing machine at the end of 3 and 7 days and average is found out.

CONCRETE

Concrete is a composite material composed mainly of water, aggregate, and cement. Often, additives and reinforcements are included in the mixture to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape.

Workability

Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. Concrete is said to be workable when it is easily placed and compacted homogeneously i.e without bleeding or Segregation. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs &/or pockets may also be visible in finished concrete.Definition of Workability "The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product."

Factors affecting workability:

- Water content in the concrete mix
- Amount of cement & its Properties
- Aggregate Grading (Size Distribution)
- Nature of Aggregate Particles (Shape, Surface Texture, Porosity etc.)
- Temperature of the concrete mix
- Humidity of the environment
- Mode of compaction
- Method of placement of concrete
- Method of transmission of concrete

How to improve the workability of concrete

- Increase water/cement ratio
- Increase size of aggregate
- Use well-rounded and smooth aggregate instead of irregular shape
- Increase the mixing time
- Increase the mixing temperature
- Use non-porous and saturated aggregate
- With addition of air-entraining mixtures

GRADING OF AGGREGATES:

In order to obtain concrete of denser quality, the fine and coarse aggregates are properly graded. The grading of fine aggregate is expressed in terms of BIS test sieves nos. 480, 240, 120, 60, 30 and 15.

GRADING LIMITS FOR FINE AGGREGATES

BIS sieve	Percentage by weight through seive	
	Natural or crushed gravel sand	Crushed stone sand
No. 480	95-100	90-100
No. 240	70-95	60-90
No. 120	45-85	40-80
No. 60	25-60	20-50
No. 30	5-30	5-30
No. 15	0-10	0-15

REINFORCED CEMENT CONCRETE (R.C.C.)

Concrete is good in resisting compression but is very weak in resisting tension. Hence reinforcement is provided in the concrete wherever tensile stress is expected. The best reinforcement is steel, since tensile strength of steel is quite high and the bond between steel and concrete is good. As the elastic modulus of steel is high, for the same extension the force resisted by steel is high compared to concrete. However in tensile zone, hair cracks in concrete are unavoidable. Reinforcements are usually in the form of mild steel or ribbed steel bars of 6 mm to 32 mm diameter. A cage of reinforcements is prepared as per the design requirements, kept in a form work and then green concrete is poured. After the concrete hardens, the form work is removed. The composite material of steel and concrete now called R.C.C. acts as a structural member and can resist tensile as well as compressive stresses very well.

DEFINITION OF PRESTRESS:

Prestress is defined as a method of applying pre-compression to control the stresses resulting due to external loads below the neutral axis of the beam tension developed due to external load which is more than the permissible limits of the plain concrete. The pre-compression applied (may be axial or eccentric) will induce the compressive stress below the neutral axis or as a whole of the beam c/s. Resulting either no tension or compression.

Basic Concept

Prestressed concrete is basically concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from the external loads are counteracted to a desired degree.

STEEL:

Depending upon the carbon content, the steel is designated as the mild steel or medium carbon steel or high carbon steel. The various uses of steel are governed by the amount of carbon contained in it.

The carbon content of mild steel is about 0.10 to 0.25 per cent. When carbon content is less than 0.10 per cent, it is known as the dead steel or very low carbon steel.

The carbon content of medium carbon steel is about 0.25 to 0.60 per cent. The high carbon steel is also known as the hard steel and its carbon content varies from 0.60 to 1.10 per cent or so.

USES OF STEEL:

Name of steel	Carbon content	Uses
Mild steel	Up to 0.10%	Motor body ,Sheet metal ,tin plate, etc.
Medium carbon Steel	Up to 0.25%	Boiler plates , structural steel , etc.
	Up to 0.45%	Rails , tyres , etc.
	Up to 0.60%	Hammers ,large stamping and pressing dies etc.
High carbon steel	Up to 0.75%	Sledges hammers ,springs , stamping dies ,etc.
Or hard steel	Up to 0.90%	Miner's drills,smith's tools,stone mason's tools etc.
	Up to 1.00%	Chisels ,hammers ,saws,wood working tools,etc.
	Up to 1.10%	Axes,Cutlery,drills,knives,picks,punches,etc.

MODULE II

Surveying:

- It is defined as the process of measuring horizontal distances, vertical distances and included angles to determine the location of points on, above or below the earth surfaces.
- The term surveying is the representation of surface features in a horizontal plane.
- The process of determining the relative heights in the vertical plane is referred as levelling.

Objectives of Surveying:

- The data obtained by surveying are used to prepare the plan or map showing the ground features.
- When the area surveyed is small and the scale to which its result plotted is large, then it is known as Plan
- When the area surveyed is large and the scale to which its result plotted is small, then it is called as a Map
- Setting out of any engineering work like buildings, roads, railway tracks, bridges and dams involves surveying

Chain Surveying – Principle:

- In chain surveying only linear distances on the field are measured.
- These distances are used to define the boundary of field and mark simple details.

Principle :

- It is to form a network of triangles by using the distances measured.
- Better accuracy will be obtained if the triangles thus formed are nearly equilateral in shape.

Accessories used in Chain Surveying:

The different accessories used in chain surveying are

(a) Metre Chain
(b) Chain Pins (arrows)
(c) Measuring Tape
(d) Ranging rod/Offset rod.

Metric surveying chain:

- A surveying chain is a device used to measure distance between two points on the ground.
- Metric chains are available in lengths of 5 m, 10m, 20m and 30 m.
- 20m – 30 m chain is normally used for the field of surveying.
- A surveying chain contains brass handles with brass eyebolt and collar, galvanized mild steel links and wire rings.
- In the case of 20 m and 30 m chains, brass tallies are provided at every 5 m length and indicating brass wire rings are attached at every metre length except where tallies are provided.
- The distance between the outside faces of handles of a fully stretched out chain is the length of the chain.
- The length of the chain, like 20m is engraved on the handles.
- While measuring the long distance, the chain will have to be used a number of times.
- Arrows are driven at the end of every chain length.
- For holding the arrows in position, grooves are cut in the outside face of the handles.
- The radius of the groove is the same as that the arrows.
- For convenient handling of the chain, the handle joint is made flexible so that it is possible to swivel to handle round the eye bolt.

Chain Pins:

- Chain pins or arrows are used with the chain for marking each chain length on the ground.
- The arrow is driven into the ground at the end of each chain length is measured.
- Chain pins the arrow should be made of good quality hardened and tempered steel wire of minimum tensile strength of 70 kg/mm^2.
- The overall length is 400 mm and thickness is 4mm.
- The wire should be black enamelled.
- The arrow has a circular eye at the one end is pointed at the other end .

Pegs:

- Wooden pegs of 15cm length and 3 cm square in section are used to establish the station points or the end points of a line on the ground.
- They are tapered one end and are driven into the ground by using a wooden hammer.
- About 4 cm is left projecting above the ground.

Measuring Tape:

- There are different types of tapes are used. They are

(a) Cloth or linen type
(b) Metallic Tape
(c) Steel Tape
(d) Invar Tube.

Metallic tape and steel tapes are most commonly used.

- Metallic Tape is made of varnished waterproof linen.
- It is reinforced with fine brass copper or bronze wires.
- Tapes are available in lengths of 10, 15, 20, 30 or 50 metres.
- In metallic tapes every metre is divided into 100 divisions (cms).
- In steel tapes, the centimetre division are also subdivided.

Ranging Rod:

- It is also known as ranging pole or picket.
- Ranging rod is used for ranging or aligning long lines on the ground in field surveying.
- Ranging is a straight line means fixing a series of pegs or other marks such that they all lie on a straight line.Ranging rods are used marking points on the ground so that the positions of the points are distinctly visible from some distant way.
- The length of ranging rod may be 2 m and 3 m and its diameter is 30 mm.
- Ranging rod made of steel tube has an internal diameter of 32 mm.
- The ranging rods are made of well seasoned, straight grained timber of circular cross section.
- Ranging rods should be straight and free from warps.
- The deviation in straightness should not exceed 5mm in a 2 m length.
- The ranging rod is painted in red and white in alternate band lengths of 200 mm each.
- The bottom end of the rod is fitted with a pointed, hollow, cast iron shoe or steel shoe of 15 cm length.

Offset Rod:

- It is a ranging rod with two short, narrow, vertical sighting slots passing through the centre of the section.
- A hook is fitted of a groove is cut at the top to enable pulling or pushing of the chain through obstruction like hedges.
- Offset rods are meant for setting outlines approximately at right angles to the main line.

Cross Staff:

- It is used to set out right angles in chain surveying
- It consists of four metal arms vertical slits mounted on a pole.
- Two opposite slits are positioned along the length of a line (Main Line)
- A line perpendicular to the main line is formed or sighted through the other two slits

Plumb Bob:

- It consists of a solid conical piece and a string attached to it at its centre.
- When in use, the solid piece is at the bottom.
- It is used to test the verticality of the ranging rods and to transfer the points to the ground.
- Plumb bob is used while doing chain surveying on sloping ground.

Unfolding and folding of chain:

- Both the handles of the chain are held in the left hand and the other portions in the right hand.
- The portion held in the right hand is thrown forward;
- The person throwing moving backward himself.
- The leader takes one handle of the chain and moves forward himself.
- The leader takes one handle of the chain and moves forward till the chain is stretched to its full length.
- The chain should be free from any kinks or bends.
- After the completion of the work, the two handles are brought together and the chain is folded started with the middle pair.
- The links are placed obliquely across each pair.
- The folded chain is securely tied with a rope

Ranging a line:

- It means fixing a series of pegs or other marks such that they all lie on a straight line.
- Suppose P and Q are the two ends of a survey line.
- One ranging rod is driven Q.
- The surveyor holds another ranging rod at P and stands at about 30 cm behind ranging rod.
- The assistant goes with another ranging rod along the survey line and positions himself approximately in line with PQ at a distance less than a chain length from P.
- The surveyor at P keeps his eye in line with PQ and signals to the assistant by way of adjusting the position of the ranging rod held by the assistant traversely.
- This adjustment is continued till the intermediate ranging rod is truly in line with P and Q.

Compass Surveying – Prismatic Compass:

- Whenever a number of base lines are to be run for obtaining the details as in traversing, just linear measurements made by chain surveying will not be sufficient.
- The angles included between the adjacent lines should also be measured
- Compass is one of the instruments used to measure the angles.

Prismatic Compass:
Description:

- A magnetic needle is balanced over a pivot in a circular box of 85 mm to 110 mm in diameter.
- A graduated aluminium ring is attached to the magnetic needle.
- An agate cap keeps the aluminium ring stable.
- The box is covered by a glass lid.
- Object vane and eye vane are provided at diametrically opposite ends.
- Eye vane caries a reflecting prism which can be raised or lowered as desired.
- A vertical horse hair or fine wire is provided at the middle of the object vane.

How to take reading using compass:

- The compass is centered over the station by dropping a small piece of stone from the centre of the bottom of the compass.
- A plumb bob is used for centering.
- The compass is levelled by adjusting the ball and socket till the top of the box is horizontal.
- The graduated ring should move freely after having levelled the instrument.
- Suppose the bearing of a line PQ is to be observed.
- The compass is centered over P.
- It is levelled.
- The prism and the object vane are kept in vertical position.
- The compass is turned slowly till the ranging rod already erected at Q is bisected.
- In this position, the ranging rod, the object and the eye vane all lie in the same line.
- The focusing prism is raised or lowered till the readings were clear and sharp.
- The reading in the ring cut by the object hair line is taken after damping the oscillations of the ring by pressing the brake pin.

Definitions:

Magnetic Bearing:

- It is the angle between the magnetic meridian and the line.
- The angle is always measured in the clockwise direction
- It is the direction shown by a freely suspended magnetic needle The magnetic meridian is also called bearing.

True Bearing:

- True bearing of a line is the angle between the true meridian and the line.
- The angle is always measured in the anticlockwise direction.
- The true meridian is the line joining the geographical north and south bearings.

Whole Circle Bearing:

- The bearing of lines measured from the North is called Whole Circle Bearing.
- The angle is reckoned in the clockwise direction from 0^o coinciding with the north.

Quadrant Bearing:

- The whole circle is divided into four quadrants.
- The bearing is expressed with N or S as prefix and E or W as suffix.
- Quadrant Bearing is also known as Reduced Bearing.

Fore Bearing and Back bearing:

- Every line has two bearing namely fore bearing and back back bearing
- Fore bearing is the bearing taken in the direction of surveying and Back bearing is the bearing taken in the reverse direction.
- The difference between the fore bearing and the back bearing should be 180^o.
- It means that one or both stations of the line are subjected to local attraction.
- Thus, local attraction is the influence caused on the measured bearings of lines due to the presence of materials like railway track, current carrying wires or cables, etc.,

Local attraction is the influence that prevents magnetic needle pointing to magnetic north pole
Detection of Local attraction

- By observing the both bearings of line (F.B. & B.B.) and noting the difference (1800 in case of W.C.B. & equal magnitude in case of R.B.)
- We confirm the local attraction only if the difference is not due to observational errors.

MODULE III

The term "soil" can have different meanings, depending upon the field in which it is considered. To a geologist, it is the material in the relative thin zone of the Earth's surface within which roots occur, and which are formed as the products of past surface processes. The rest of the crust is grouped under the term "rock".

Visual Classification Soils possess a number of physical characteristics which can be used as aids to identification in the field. A handful of soil rubbed through the fingers can yield the following:

SAND (and coarser) particles are visible to the naked eye.

SILT particles become dusty when dry and are easily brushed off hands.

CLAY particles are sticky when wet and hard when dry, and have to be scraped or washed off hands.

Soil classification using group symbols is as follows:

Group Symbol	Classification
Coarse soils	
GW	Well-graded GRAVEL
GP	Poorly-graded GRAVEL
GM	Silty GRAVEL
GC	Clayey GRAVEL
SW	Well-graded SAND
SP	Poorly-graded SAND
SM	Silty SAND
SC	Clayey SAND
Fine soils	
ML	SILT of low plasticity
MI	SILT of intermediate plasticity
MH	SILT of high plasticity
CL	CLAY of low plasticity
CI	CLAY of intermediate plasticity
CH	CLAY of high plasticity
OL	Organic soil of low plasticity
OI	Organic soil of intermediate plasticity
OH	Organic soil of high plasticity
Pt	Peat

Foundation:

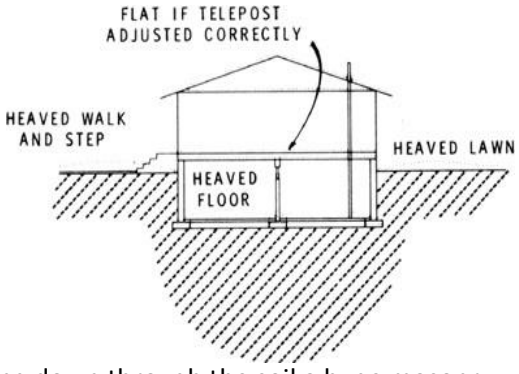
Objectives of foundation:

- To distribute the total load coming on the structure on a larger area
- To support the structures
- To give enough stability to the structure against various disturbing forces, such as wind and rain.

Types of foundation

Foundation may be broadly classified,

- Shallow Foundation
- Deep Foundation



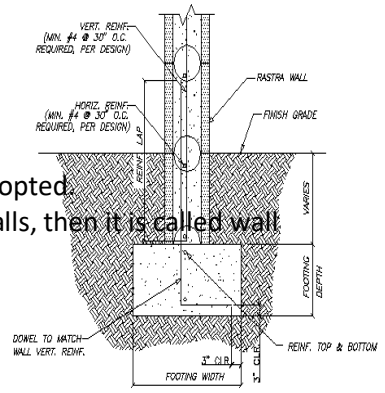
Shallow Foundation:

When the depth of the foundation is less than or equal to its width, it is defined as shallow foundation.

Deep foundation :

Deep foundation consists of pile and pier foundation.Pier foundations are rarely used for buildings.This consists in carrying down through the soil a huge masonry cylinder which may be supported on solid rock.

Types of shallow foundation:



Types of shallow foundation:

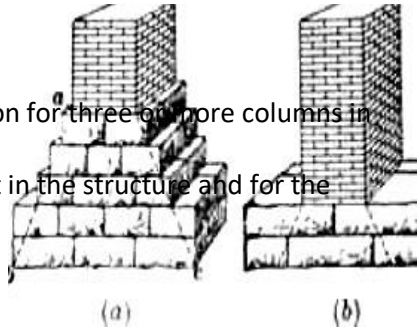
- Isolated column footing :

It is used in framed structures where several columns are to be constr can be adopted.

- Wall footing: It is the footing provided throughout the length load bearing walls, then it is called wall footing.

Stepped Footing:

- When the ground is sloping, stepped footings are provided.
- It consists of two or more footings of brick or stone masonry the ground level.
- The overlap between two layers of foundation concrete slab is equal to the depth of concrete slab or two times the height of the step, whichever is more.



Continuous footing:

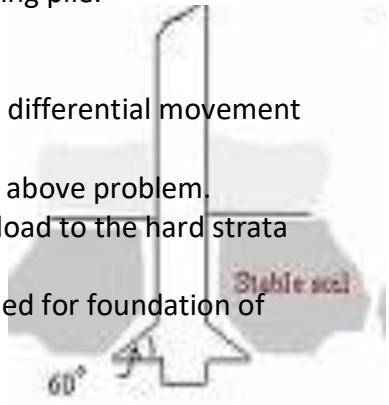
- In this type of footing, a single continuous RC slab is provided as foundation for three or more columns in a row.
- This type of footing is more suitable to prevent the differential settlement in the structure and for the safety against the

Types of deep foundation

1. Pile foundation:
   - Pile is an element of construction used as foundation.
   - It may be driven in the ground vertically or with some inclination to transfer the load safely.
   - Loads are supported in two ways. i.e., either by the effect of friction between the soil and the pile skin or by resting the pile on a very hard stratum.
   - The former is called friction pile and later one is the load bearing pile.

Pile Foundation

2. Under reamed pile:
   - Structures build on expansive soils often crack due to the differential movement caused by the alternative swelling and shrinking of the soil.
   - Under reamed piles provide a satisfactory solution to the above problem.
   - The principle of this type of foundation is to transfer the load to the hard strata which has sufficient bearing capacity to take the load.
   - Single and double under reamed piles may also be provided for foundation of structures in poor soils overlying firm soil strata.



HYDRAULIC STRUCTURES

Siphon Aqueduct:

In case of the siphon Aqueduct, the HFL of the drain is much higher above the canal bed, and water runs under siphonic action through the Aqueduct barrels. The drain bed is generally depressed and provided with pucca floors, on the upstream side, the drainage bed may be joined to the pucca floor either by a vertical drop or by glacis of 3:1. The downstream rising slope should not be steeper than 5:1. When the canal is passed over the drain, the canal remains open for inspection throughout and the damage caused by flood is rare. However during heavy floods, the foundations are susceptible to scour or the waterway of drain may get choked due to debris, tress etc.

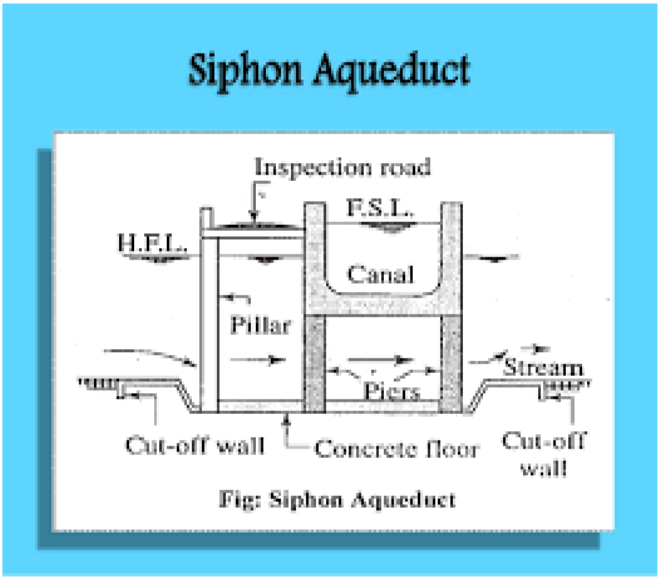
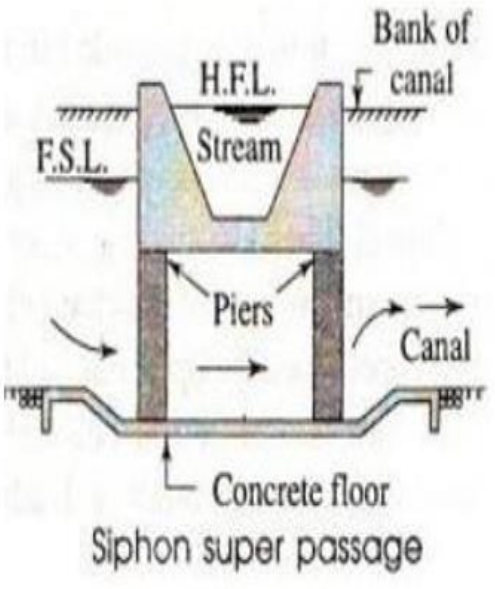


Fig: Siphon Aqueduct

Canal Syphon:

- If two canals cross each other and one of the canals is siphoned under the other, then the hydraulic structure at crossing is called "canal siphon". For example, lower Jhelum canal is siphoned under the Rasul-Qadirabad (Punjab, Pakistan) link canal and the crossing structure is called "L.J.C siphon"
- In case of siphon the FSL of the canal is much above the bed level of the drainage trough, so that the canal runs under the siphonic action.
- The canal bed is lowered and a ramp is provided at the exit so that the trouble of silting is minimized.
- Reverse of an aqueduct siphon
- In the above two types, the inspection road cannot be provided along the canal and a separate bridge is required for roadway.



Weir: A low dam built across a river to raise the level of water upstream or regulate its flow.

Barrage: An artificial barrier across a river or estuary to prevent flooding, aid irrigation or navigation, or to generate electricity by trial power.

Weir	Barrage
Low cost	High cost
Low control on flow	Relatively high control on flow and water levels by operation of gates
No provision for transport communication across the river	Usually, a road or a rail bridge can be conveniently and economically combined with a barrage wherever necessary
Chances of silting on the upstream is more	Silting may be controlled by judicial operation of gates
Afflux created is high due to relatively high weir crests	Due to low crest of the weirs (the ponding being done mostly by gate operation), the afflux during high floods is low. Since the gates may be lifted up fully, even above the high flood level.

Dams and Reservoirs:

The barrier constructed across a river in the form of dam, so that water gets stored in it on the upstream side of the barrier,forming a pool of water is called reservoir.

Depending upon purpose there are 3 types of reservoirs mainly found

- Storage/ conservation type
- Flood control type
- Multipurpose type

Dams constructed out of masonry or concrete and which rely solely on its self weight for stability fall under the nomenclature of gravity dams. Masonry dams have been in use in the past quite often but after independence, the last major masonry dam structure that was built was the Nagarjunsagar Dam on river Krishna which was built during 1958-69. Normally, coursed rubble masonry was used which was bonded together by lime concrete or cement concrete.

MODULE IV

Means of Transport

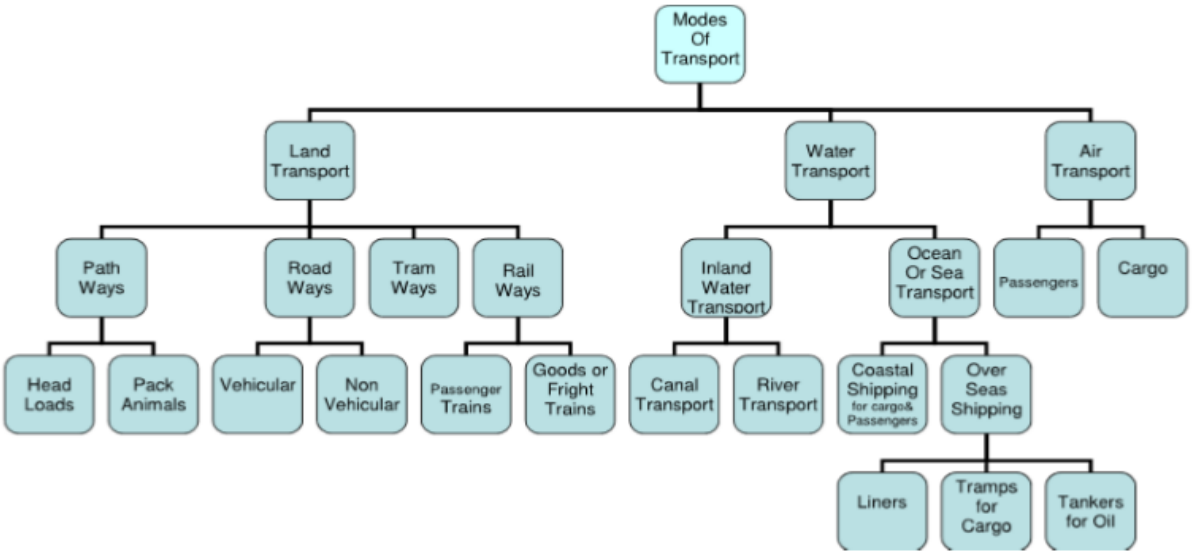


Fig.1.1 Means of Transport

Advantage and Disadvantage Different Modes of Transport

(A) Road Transport

Advantages	Disadvantages
1. Less Capital Outlay 2. Door to Door Service 3. Service in Rural Areas 4. Flexible Service 5. Suitable for Short Distance 6. Lesser Risk of Damage in Transit 7. Saving in Packing Cost 8. Rapid Speed 9. Less Cost	1. Seasonal Nature 2. Accidents and Breakdowns 3. Unsuitable for Long Distance and Bulky Traffic 4. Slow Speed 5. Lack of Organisation

(B) **Railway Transport**

Advantages	Disadvantages
1. Dependable 2. Better Organised 3. High Speed over Long Distances 4. Suitable for Bulky and Heavy Goods 5. Cheaper Transport 6. Safety 7. Larger Capacity 8. Public Welfare 9. Administrative Facilities of Government 10. Employment Opportunities	1. Huge Capital Outlay 2. Lack of Flexibility 3. Lack of Door to Door Service 4. Monopoly 5. Unsuitable for Short Distance and Small Loads 6. Booking Formalities 7. No Rural Service 8. Under-utilised Capacity 9. Centralised Administration

(C) Air Transport

Advantages	Disadvantages
1. High Speed 2. Comfortable and Quick Services 3. No Investment in Construction of Track 4. No Physical Barriers 5. Easy Access 6. Emergency Services 7. Quick Clearance 8. Most Suitable for Carrying Light Goods of High Value 9. National Defence 10. Space Exploration	1. Very Costly 2. Small Carrying Capacity 3. Uncertain and Unreliable 4. Breakdowns and Accidents 5. Large Investment 6. Specialised Skill 7. Unsuitable for Cheap and Bulky Goods 8. Legal Restrictions