Civil Engineering (Works)

Lesson- 2
Building Materials, Structures, Station Building & Water Supply

1.0 Building Materials

From times immemorial, man has been using materials found in nature for the construction of shelters for his survival from wild animals and adverse natural conditions. Most common materials are mud, stone, bricks, timber, steels, and aluminum. Brief description of these materials is given below:

1.1 Mud: This is the most primitive building material used by man for construction of huts. Good quality of clay reinforced with bamboo fibers or straw is used even now in villages. This is the cheapest material available but very poor in strength and structures built require heavy maintenance.

1.2 Stone: Stone has also been used for building construction since long, due to its easy availability and strength. Stone is found in natural form and can be used as such with little dressing. Stone as found in nature can be classified as -

(i) Soft stone such as sand stone, lime stone, marble.

(ii) Hard stone such as granite.

Depending upon the type of surface dressing of stone blocks, the stone masonry can be classified as rubble or ashlars masonry.

1.2.1 Test of Stones: the following tests are generally carried out for selecting as building materials:

1. **Strength test:** The crushing strength of a stone is tested with the help of a compression testing machine. The normal values of compressive strength of good stones vary between 1000 to 1400 kg/cm2. Weak stones may possess compressive strength as low as 250 to 300 kg/cm2.
2. **Hardness test:** The hardness of stones is tested by knife scratching. Hard stones normally do not show scratch.
3. **Attrition test:** This tests is carried out with the help of Deval's testing machine which consists of a circular drum. About 5 kg of angular pieces of stones and the required number of steel balls are placed in the drum which rotates at a rate of 30 r.p.m for 4 hours. There after, these stone pieces are removed, cleaned and weighed. A good quality stone should not lose appreciable weight, in the test.
4. **Water absorption test:** This test is usually performed to judge the porosity of the

stone. A good stone should not absorb water more than 5% of its weight when it remains immersed for 24 hours in cold water.

5. **Specific gravity test:** This test is performed to know the heaviness of the stones. Stones of higher specific gravity are preferred to those which have relatively lower specific gravity.

1.3 Brick Masonry: Brick masonry is most commonly used where stone is not available. Bricks are generally made from good quality clay and then backed in a kiln to achieve strength. Mortar for bonding is used which may be mud for temporary construction. A mix of lime with ash or Surkhi cement mortar mix of cement and sand in suitable proportion or Cement and sand maybe in the ratio of 1:3 to 1:6 depending upon the strength required. Most common size of bricks is 230 x 11.5 x 75mm. (9'x4 ½"x3") Brick wall thickness varies from one brick (230 mm), one and a half brick or two bricks (460 mm), depending on the strength required. Generally a thickness of 230 mm is sufficient upto two storey building.

Arrangement of bricks in various layers is called bonds which are commonly of two types namely English Bond and Flemish Bond.

Sampling and acceptance test of bricks. As per IS 3495 – 1992 brick samples are subjected to the following acceptance tests:

1.3.1 Sampling and Acceptance Tests of Bricks (IS: 3495, Part 1 to 4 – 1992): Samples of bricks are subjects to the following tests for acceptance:

a) Visual characteristics s

b) Dimensional tolerance

c) Water absorption

d) Compressive strength

e) Efflorescence

1.3.2 The sample size depends of the number of bricks in a lot. For this purpose bricks in the upper layers are removed to enable units to be sampled from places with the stack.

1.3.3 Visual Characteristics: Good brick should be thoroughly burnt so that they become hard and durable. Satisfactory burning of bricks is ascertained by a hard ringing sound emitted when two bricks are struck together. The bricks should have smooth rectangular faces with sharp corner and should be uniform in color. The bricks should be free from cracks, chips, warpage, large particles of lime and organic matters and should broadly conform to IS: 1077 – 1992.

1.3.4 Dimensional Tolerances: The twenty bricks in the randomly selected sample are arranged upon a level surface successively in contact with each other and in a straight line. The overall length of the assembled bricks is measured with a steel tape. Permissible variation in measured length, Width and height of 20 bricks should not exceed ± 80 mm, ± 40 mm, ± 40mm respectively.

1.3.5 Water Absorption: The amount of water a bricks will absorb is a guide to its density and therefore, its compressive strength and durability. The average water absorption of bricks after 24 hours of immersion in cold water should not be more than 20 percent.

1.3.6 Compressive Strength: The bricks when tested in accordance with the procedure laid down in IS: 3495-1992 should have a minimum average compressive strength for various classes of bricks.

1.3.7 Efflorescence: It is a whitish crystalline substance, which appears on the surface of the brick wall due to presence of salts in the bricks, sand, and sometimes even in water used in the construction work. When a newly constructed wall dries out, the soluble salts dissolved by moisture are drawn to the surface through pores. These salts absorb water from atmosphere and on drying; they get deposited in ugly patches on the surface in the form of white crystalline substance.

1.4 Concrete Construction: Concrete is a mix of cement, sand and stone pieces. Concrete can be plain cement Concrete or Reinforced Cement Concrete. In Reinforced cement concrete (RCC), steel rods or bars are used to reinforce or strengthen the concrete. Plain concrete is used when there is no tension expected in the structures such as ordinary walls, retaining walls or bridge piers (gravity type). Reinforced concrete is used where the loads are heavy and also tension is expected in the structure. Examples are slabs, beams, columns, towers, bridge girders.

1.4.1 Cement: Cement is an artificially prepared mixture, which is used as a binding agent for materials. It is obtained by mixing (i) calcareous (ii) siliceous and (iii) aluminous materials in a fixed proportion and calcining it at very high temperature and grinding to form a fine powder. When cement is mixed with ordinary water, a chemical reaction takes place emitting heat and causing the paste to set and gain strength.

Storing of Cement

Portland cement is packed in bags/stacks in 50 kg lots for transportation. The following precautions should be taken for storing cement especially when in stacks.

1. Cement shall be stored at the work site in a building or shed which is dry, leak proof and as moisture proof as possible.
2. The Building shall have minimum number of windows and close fitting doors which shall be kept closed as far as possible.
3. Cement stored in bags shall be stacked and shall be kept free from the possibility of any dampness or moisture coming in contact with the bags.
4. Cement bags shall be stored/ stacked off the floor on wooden planks in such a way as to be clear above the floor by 150mm to 200mm and a space of 450mm minimum alround between the bags and external walls.
5. In the stacks, cement bags shall be kept close together to reduce circulation of air as much as possible.

6. Owing to pressure on the bottom layer of bags 'Waterhouse Pack' is developed in these bags.
7. This can be removed easily by rolling the bags when the cement is taken for use.
8. The height of the stack shall be not more than 15 bags to prevent the possibility of lumping up under pressure.
9. The width of the stack shall not be more than four bags length of 3m.
10. In stacks more than 8 bags high, the cement bags shall be arranged alternately lengthwise and cross wise so as to tie the stacks together and minimize the danger of toppling over.
11. Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received.
12. During the monsoon or when it is expected to be stored for a long period, the stack shall be completely enclosed by waterproofing membrane, such as , polyethylene sheet.
13. Care shall be taken to see that the membrane is not damaged any time during use.
14. Different types of cements shall be stored separately.

Portland cement:

The most widely used cement is known as Portland cement. It is called so as it resembles in properties with a well known natural stone quarried at Portland (UK). The 3 main constituents of Portland cement are Lime, Silica and Alumina which are provided in ratio of 60-67%,17-25% and 3 to 8% respectively. In addition, Iron Oxide, Magnesia, Sulphur Tri-oxide and Alkalies (Soda and Potash) are also present in small quantities ranging from 0.5% to 5%. When water is mixed to cement, the paste starts getting stiffer which is mainly due to hydration and hydrolysis of Calcium Silicates, Calcium Aluminates and Calcium Alumino Ferrite compounds. Setting of cement takes place in two stages, the first being called as initial setting taking place due to setting of calcium silicates. Lots of heat is generated in the process of chemical reaction, which must be neutralized by addition of adequate water before and after setting, which is called curing.

Modification of Properties of Portland Cement:

By adding certain admixtures, the properties of Portland Cement can be modified to suite special applications. The special cements available are:

(a) Ordinary Portland Cement (OPC); (b) Rapid Hardening Portland Cement; (c) Low Heat Portland Cement;: (d) Sulphate Resisting Portland Cement; (e) Water Proof Portland Cement, (f) Quick Setting Portland Cement etc.

1.4.2 Sand: Sand used in concrete should be washed so that is free from silt, clay, salts and other organic matters. Coarse sand gives better strength than fine sand.

1.4.3 Coarse Aggregates: Coarse aggregates or stone pieces used in concrete should be angular in shape, made from hard stone and have a mix of different sizes so that the density produced is

maximum. Common size of coarse aggregate is 20 mm used for slabs, beams and columns whereas it can be 40 mm or even larger for use in bigger mass structures.

1.4.4 Reinforced Cement Concrete (R.C.C): Concrete is strong in compression but week in tension. Hence, main concrete can be used only in compression. Steel is equally good in tension and compression. But a long member in steel cannot develop full strength before buckling. Hence concrete reinforced with steel, is an ideal combination material which can take tension, compression and will not buckle.

Properties of reinforced concrete

The combination of steel and concrete becomes workable on account of the following three reasons:

(1) The concrete while setting grips very fast the surface of the steel bars. Therefore, the concrete is able to transmit to the steel bars those stresses which it cannot resist itself.

(2) The co-efficient of linear expansion of concrete and steel are almost the same. Therefore, no internal stresses are set up within reinforced concrete due to variations in temperature.

(3) The coating cement grout on the surface of steel bars protects them from corrosion and does not produce any adverse chemical effect.

Advantages of reinforced concrete are:

(1) It is economical in ultimate cost.

(2) Its monolithic character gives much rigidity to the structure.

(3) It is durable and fire-resistant. It does not rot or decay and is not attacked by termites.

(4) It is almost impermeable to moisture.

(5) The cost of maintenance of a reinforced concrete structure is almost nil.

(6) The materials used in the reinforced concrete constructions are easily obtainable.

(7) The flexibility of the reinforcement and the workability of the concrete make possible the reinforced concrete members to be molded in any desired shape. Thus reinforced concrete lends itself to range of architectural expressions.

1.4.5 Prestressed Reinforced Concrete (PRC): In a beam which is subjected to vertical loads, the section has compressive force in the top layers and tensile force in the bottom layers. In case of PRC, a reverse force is applied in such a manner which causes tension in the top layers and compression in the bottom layers. This is done by providing steel cables in the bottom layers and stretching it. When the external vertical load comes on

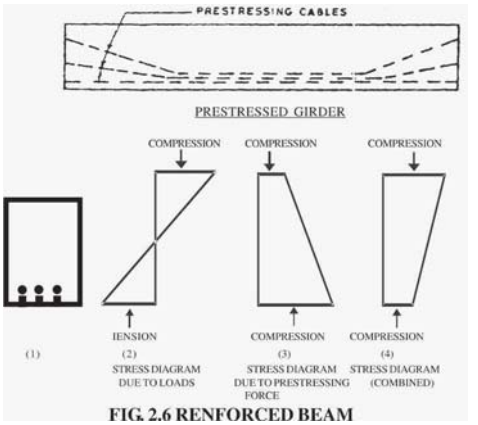

FIG. 2.6 RENFORCED BEAM

the girder, the compressive force created in the top fibers gets neutralized by force and similarly the tensile force created in the bottom layers gets neutralized by the prestressed force (already inducted by prestressing cables).

As can be seen from the final force diagram (Fig.2.6) above, there is compression through the section even after full loads are applied. By using cement rich mix it is possible to create a concrete having strength of 400-500 kg/cm2 and produce light girders in PRC which are much more economical.

1.5 Steel

Steel is used as construction material very widely these days. Girders of Long span Railway bridges are generally constructed in steel. Towers whether used in Electric Power transmission or to support telegraphic lines or supporting micro wave antenna are all made of steel. Large size water tanks, structure for supporting various equipments in a factory, large halls, platform covers are also built with steel. Most common use of steel in Railways is in rails, steel sleeper, high tensile bars in PRC sleepers, fastenings, locomotive, coaches, and wagons. It is strong enough to be used in structures and can be worked easily. In concrete it is used as reinforcement bars as prestressed wires.

Steel comes in different sections like bars, angle iron, T, H and Z section. Easy welding bolting and riveting makes it one of the ideal materials for construction.

Steel is available in various grades of strength which is achieved by varying percentage of carbon. High percentage of carbon makes it tough and strong. High percentage of manganese makes the steel wear resistant. Silicon provides spring qualities to the steel. Addition of Nickle and copper makes it rust resistant.

1.6 Timber

Wood has been as an important Engineering material from the inception of civilization. With the scientific development, the wood may be seasoned and preserved before using it in the construction works. The wood used for constructions of building or other engineering structures is called timber.

Advantages of Timber as Construction Material

The main advantages of timber as construction material over other materials are briefly given below;

(1) Timber is comparatively strong, easily workable and economical in cost.

(2) Timber can be easily converted to any size and shape.

(3) Decorative surfaces can be easily made on timber.

(4) There is very little wastage and in this aspect use of timber can become economical also.

(5) Timber is non-conductor of heat and sound.

(6) Timber has a scrap value which may be quite high in good quality wood.

Uses of Common type of Timber

(i) Teak wood: It is considered the best wood for retention of shape, good finish & durability. It is easy to saw & work to a good finish and takes polish well.

Teak wood is used for important building works & furniture etc. As it is costly timber, its use is limited to high class work only.

(ii) Sal Wood: It does not give good finish and hence it is unsuitable for ornamental work. Sal poles are mainly used as foundation piles and for other structures where shock resistance qualities are required.

(iii) Deodar Wood: Is used for the construction of building, railways sleepers, piles and bridges.

(iv) Babul Wood: It is used for the construction of buildings of inferior type, bodies of various type of carts and their wheels, and agricultural implements. It is very strong, hard & rough timber.

(v) Chir Wood: It is a soft wood used for construction of inferior work in building construction matches, etc.

(vi) Mango Wood: It is used for making cases, tonga bodies, inferior work, cheap furniture, etc. It possesses high tensile strength.

(vii) Shisham Wood: It is used for medium class furniture work, making carriage wheels used for decorative work and carvings.

1.7 The timber shall be free from decay, fungal growth, boxed heart, pitch pockets or streaks on the exposed edges, splits and cracks.

2.0 Foundations of Structures

2.1 Definition: Foundation is that part of a structure which transmits the load from the structure to the soil below. It provides a level base for the superstructure. Foundations include the portion of the structure below the ground level including the arrangement of concrete block, piles, raft, grillage etc.

2.2 Functions of Foundations: The main functions of foundation are as under:

(i) To transfer the load from the structure above including the self load of the structure to the ground below safely without causing yielding of the soil;

(ii) To provide a level surface for raising superstructure above it and

(iii) To distribute the load to the soil below evenly to prevent unequal settlement.

2.3 Safe Bearing Capacity: Safe bearing capacity is the capacity of soil or rock, which is

considered for designing the foundations. The value of safe bearing capacity for a few types of soils is indicated below:

Type of Soil	Safe Bearing capacity in Tonnes/m 2
Soft clay	10
Fine sand and silt	15
Hard stiff clay	25-40
Coarse sand compacted	45
Soft rock	45
Sand stone	165
Granite	330

2.4 Methods for Improving Safe Bearing Capacity:

In case the safe bearing capacity of available soil is poor, the same can be improved by the following methods:

(i) By increasing the depth of foundation:

(ii) By blending granular materials such as sand, gravel or crushed stone:

(iii) By providing sand piles and

(iv) By improving the drainage or lowering the water level.

2.5 Types of Foundations: Foundations can be classified mainly into two groups(i) shallow foundations and (ii) deep foundations.

2.5.1 Shallow Foundations: Among the shallow foundations, various types of foundations are: (i) Spread footings; (ii) Grillage foundations and (iii) Raft foundations.

(i) Spread Footings (Fig. 2.7): Under this category of foundations, the lower part is made wider than the width of wall or column so that the load is transmitted over large area. Spreading of foundation is done is steps. The bottom most layer can be of plain concrete or reinforced concrete or of inverted arch.

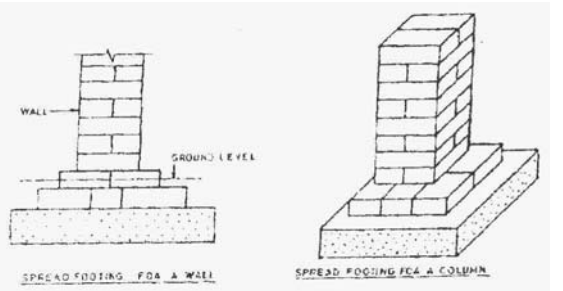

FIG 2.7 SPREAD FOUNDATION

(ii) Grillage foundation (fig; 2.8) this type of foundation is generally provided under a column when the load transmitted is very heavy and ordinary spread foundation can not serve the purpose. The foundation generally consists of two layers of steelbeam laid across. The bottom layer consists of large number of beams, while the upper layer consists of 3 or 4 number of beams; both the layers are encased by plain concrete

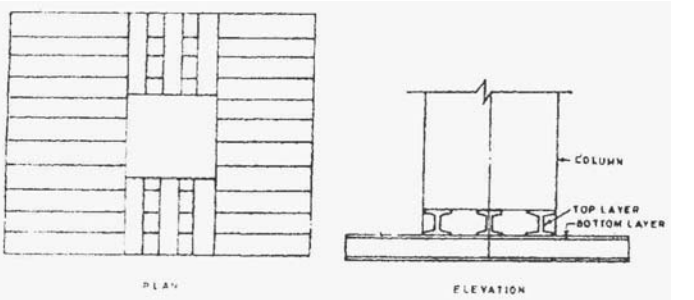

FIG. 2.8 GRILLAGE FOUNDATIION

(iii) Raft foundation (Fig. 2.9): When the soil is very soft or filled up soil having poor bearing capacity and loads are heavy, raft foundation is the most suitable type of foundation to be provided. Raft foundation consists of a bottom slab strengthened with reinforcement bars. Over the slab is provided main and cross beams crossing each other at right angle.

Columns are provided at junction points of the beams. In general raft foundation is a reversed form of roof slab with cross beams laid upside down.

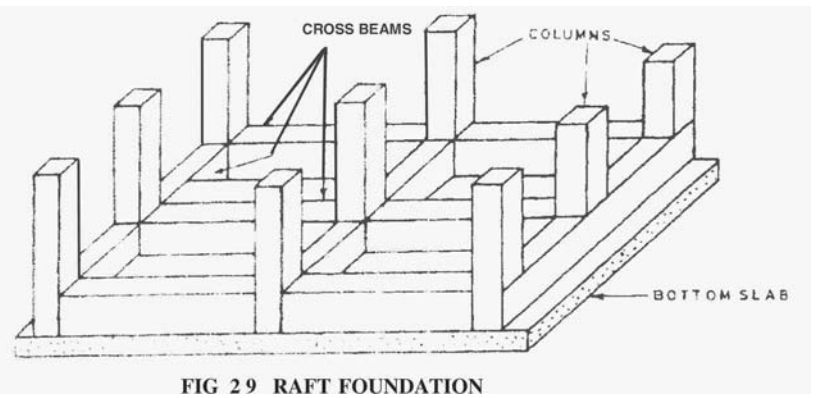

FIG 2 9 RAFT FOUNDATION

2.5.2 Deep Foundation Among the deep foundations are pile foundation, caissons or well foundation.

1. Pile foundation (Fig. 2.10): Pile foundations provided at such locations, where good soil is not available at shallow depths or it is not possible to provide spread foundation due to space restriction. The pile foundation is also provided in black cotton soil, which has a tendency to shrink and expand.

Pile foundations are either precast piles or cast in situ piles. The precast piles are made of reinforced concrete, steel or timber. These are manufactured under controlled conditions and

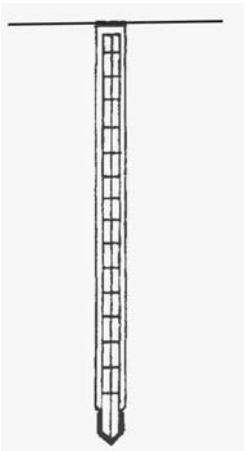

FIG. 2.10 REINFORCED CONCERETE PILE

then transported to site and driven with the help of power hammer. These piles require heavy steel reinforcement due to hammering action. The cast in situ are such piles, where a hole is drilled first, then concrete is poured and allowed to set. These may have small amount of steel reinforcement. The cast in situ piles are generally larger in diameters than the precast piles. Piles are provided either single (piles are in group) or more number of piles, which are connected at the top through a common slab called as pile cap.

2. Well foundations (Fig. 2.11): Caissons type foundations are provided, where the foundations are provided deep and below water level. Caisson is a water tight structure, square, rectangular or circular in shape and provides enough space for excavation and concreting. The caisson in most cases becomes part of the foundation.

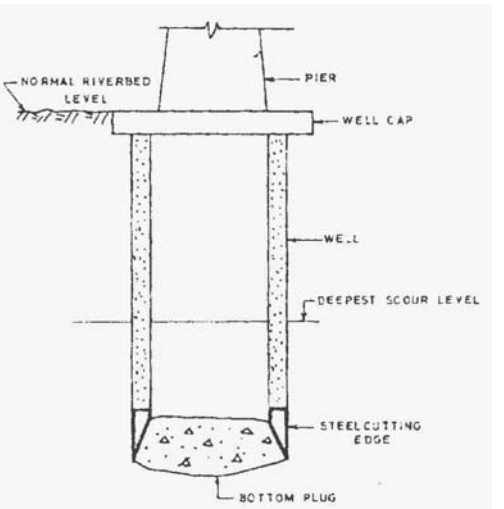

FIG. 2.11 WELL FOUNDATION

Wells are generally used for deep foundations in bridges, where these are often called as well foundations .The well kerb is first placed on a dry piece of land exactly where the final position of the foundation is to be located. In case dry land is not available, the structure is made to float and has its vertical walls high enough so that when the lower edge finally settles on river bed, the upper edge remains above the water level. While the soil is excavated from inside the caisson, its wall height is increased in stages by concrete .With the soil coming out using clamshell, the caisson structure keeps on sinking into the river bed either by its own weight or by adding dead weight by putting sand bags or rail pieces on the top. When hard clay or rock is encountered , the excavation becomes difficult and in such a case, the excavation is done by using rail-chisels or pneumatic sinking method is adopted. The water level is forced down with the help of pressurized air while the top face is provided with the air tight seal .In case of major bridges, the depth of foundations may be sometimes 50 to 60 metres below the water level .The depth of foundation is generally controlled by the depth of maximum bed scour that takes place during high floods .The bottom of foundation is kept in such a way that at least one third of its height remains below the deepest scour level to provide stability .The shape of the foundation is either in the form of a single circle or double “D” as shown in the plan .

3.0 Design of Structures

3.1 Definition of a Structure: Any thing which is designed to carry out a specific purpose or a function is a structure .It must perform the function efficiently and safely without failing. Examples of a structure are a building, bridge, chair, table or even a cot.

3.2 Designing: It is a well defined process which takes into consideration the required function which a structure is supposed to serve or perform and produces a structure which is functionally efficient ,economical in cost, strong with reference to materials of construction used and aesthetically good in looks .

3.3 Loads: Consideration of loads is very important .Structures are supposed to be designed for certain well defined loads .Accuracy in defining these loads is of utmost importance. Any mistake in estimation of loads may either result into an uneconomical design or an unsafe one. Loads may be grouped as under:

(a) Dead Load: This is the weight of the structure itself .For example, in case of design of a building, the roof slab will be designed for its own weight where as walls supporting the slab will be designed not for self weight of the wall but also for the weight of the slab also. It can be seen that the dead weight of the structure will be minimum at the top and maximum towards the bottom.

(b) Live Loads: Live loads are due to the persons using the structure. In case of a bridge structure, live loads are caused by the vehicles using the bridge. Live loads are sometimes referred to as~ moving loads also. Position of moving loads is very important while working out the effect for the purpose of designing. The effect of a moving load will be maximum when its position is at the mid point in case of a bridge girder as far as the bending stresses are concerned. Similarly for working out the maximum shear force, the moving loads will give maximum effect when the same is placed near the support of the girder.

(c) Wind Loads: Wind loads play important role for all structures. Sometimes wind loads may cause more stresses in the structure than other loads like live loads or dead loads. Wind loads are generally horizontal in direction. The intensity of wind loads may depend on the wind velocity, area of surface of the structure, ratio of solid area to the open area and direction of the wind. In coastal areas, wind loads are more intensive due to high wind velocities.

(d) Seismic Loads: Loading caused due to earthquakes is known as seismic load which is very important for designing structures situated in earthquake prone areas. India has been divided into various zones for the purpose of seismic loads. Certain areas which are more earthquake prone have to be designed for higher seismic forces.

(e) Thermal Loads: As is widely known, the metals expand in length/volume when the temperature increases. If the structures which are constructed with steel or other metals are not allowed to expand or contract freely, the same may develop high intensity thermal

forces. Thermal forces are very important while designing steel girders. Special arrangements have to be provided for allowing expansion caused by the rise in temperature. One end of the girder is provided with fixed bearings while the other end is provided moveable bearings which allow expansion while transmitting vertical loads. **(Please see Fig. 2.12)**

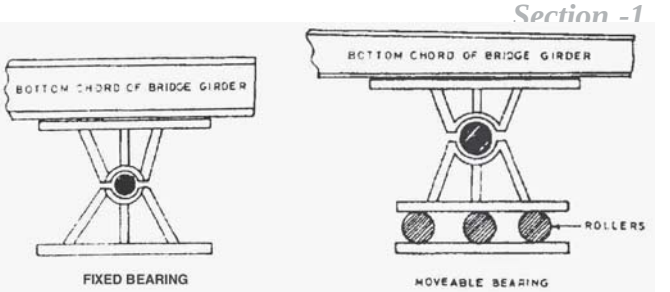

FIG. 2.12 FIXED & MOVABLE BEARINGS

(f) Hydraulic Forces: Hydraulic loads are caused by forces such as moving or standing water. These loads are of special significance for designing piers, locks and shutters and gates for spillways and other hydraulic structures.

3.4 Stresses

Stress is the effect of forces in a structure. Whenever certain forces are applied on a structure, the internal molecules of the structure are subjected to either tension or compression. As soon as the external forces are removed, the internal state of forces also comes to a neutral state. The stresses may be classified into various groups as described below:

(a) Direct stresses: Direct stress may be a result of direct forces on the member of a structure. These may be of two types:

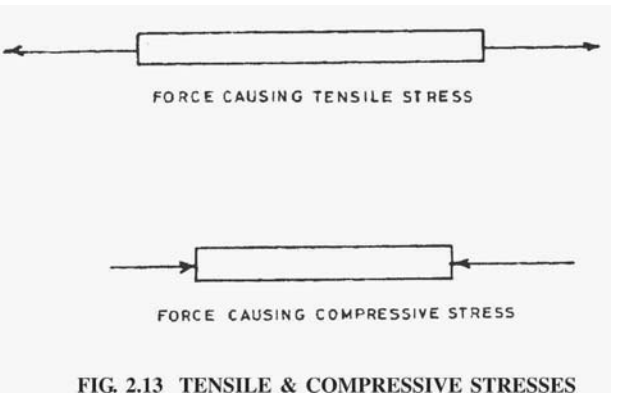

FIG. 2.13 TENSILE & COMPRESSIVE STRESSES

(i) Tensile stress (Fig. 2.13): This is as a result of tensile force applied axially on the member. This causes a positive strain (extension) in the member. Examples of tensile stress are bottom chord of a simply supported bridge girder, cable bridge any guy wires.

(ii) Compressive stress (Fig 2.13): This is caused by compressive force applied on a member. This causes a negative strain (compression) or shortening in the length of the member. Examples are: top chord of a simply supported bridge girder, columns of a building, walls.

(b) Bending stresses (Fig. 2.14): Bending stresses are caused as a result of application of transverse loads. Whenever a beam, supported at ends, is loaded with a vertical load, either a point load or a series of point loads or a uniformly distributed Load, the beam takes a circular shape due to bending, as shown in the diagram. (b)

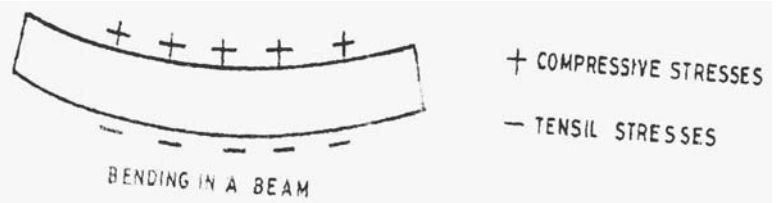

FIG. 2.14 BENDING STRESSES

This causes the lower surface to expand and the upper surface to contract. Bending results in tensile stress in the bottom fibers and compressive stress in the top fibers. In case of a cantilever where one end remains suspended, the top fibers do have tensile stress and the bottom fibers have compressive stress. At any section, the sum total of the compressive forces is always equal to the sum total of tensile forces.

(c) Shear stresses (Fig. 2.15) Shear stresses are caused along the plane parallel to direction of external force applied. It can be seen from the following diagram that along a plane AB which is parallel to the force F, the shear stress will be equal to F divided by the area at AB which resists the force F. In case of beams also the shear force acts parallel to both the planes i.e. vertical as well as horizontal plane.

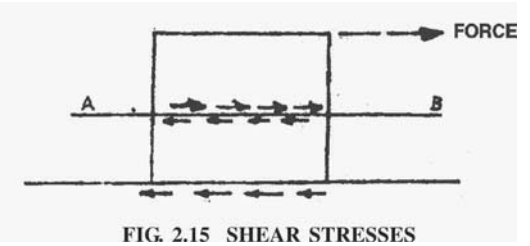

FIG. 2.15 SHEAR STRESSES

(d) Torsional stresses (Fig. 2.16) Torsional stresses are caused due to a torque which is an effect of force applied away from the axis of the member. The torsional stresses are applied on the plane which is parallel to the plane of torque. Examples are tightening of nuts with the help of a wrench or a driving axle transmitting torque from engine to the axle.

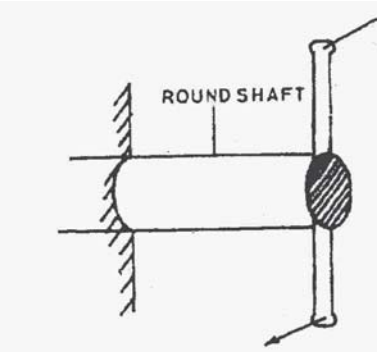

FIG. 2.16 TORSIONAL STRESSES

3.5 Elasticity and Young's Modules

Common metals like steel, brass, aluminum behave in a predetermined fashion when subjected to external force. When a metal rod is pulled gradually, its length increases and the stress and strain graph when drawn will appear as shown below: (Fig. 2.17)

It can be seen that from A to B, the graph is a straight line which means that the elongation is proportionate to force applied.

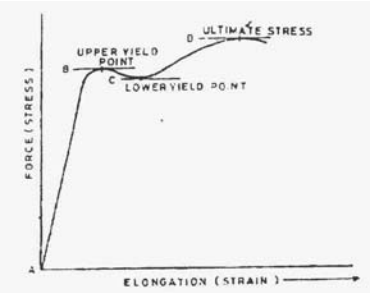

FIG. 2.17 STRESS & STRAIN GRAPH

Beyond the Point B, the metal yields and elongation is much more than the force applied. Then at Point C there is ultimate failure. The point B denotes yield strength and Point C denotes ultimate strength. The ratio between stress and strain within elastic limit is known as Modulus of Elasticity or Young's Modulus (denoted as E) on the name of the Scientist who worked on elasticity of materials. Standard value of 'E' for steel is 2.15 x 10^6 kg/cm^2 or 2150 Tonnes per cm^2.

4.0 Stairs

4.1 A stair may be defined as an arrangement of steps for the purpose of connecting floors of a building. The enclosure containing the complete stairway is termed as stair case.

4.2 Technical Definitions

Some of the common technical terms used generally in respect of a stair case are described below:

1. **Steps:** A portion of a stairway which permits ascent or descent from one floor to another. It consists of one tread (horizontal) and one rise (vertical).
2. **Tread:** The upper part of the step on which foot is placed while ascending or descending.
3. **Rise:** The vertical portion of the step separating two treads.
4. **Flight:** A series of steps without any platform, break or landing.
5. **Landing:** A platform or a resting place provided between two flights. A landing may be half landing or quarter landing according to its size and position.

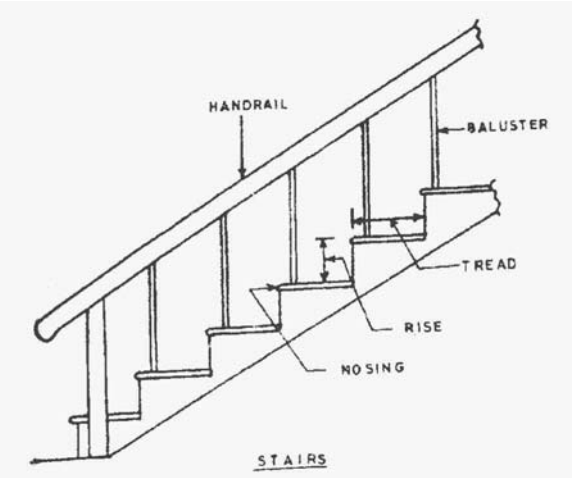

FIG. 2.18 A FLIGHT OF STAIRS

6. **Winders:** These are tapering steps which are provided for changing the direction of a stair.
7. **Hand rails:** These are parallel members provided sloping in direction to render assistance while climbing up or getting down.
8. **Baluster:** These are vertical members supporting a hand rail.

4.3 Location of Stairs:

Location of a stair case is very important. In the advent of fire or any such emergency, Stairs provide the only means of exit; as such these are so located as to serve the purpose for which they are provided. Stairs should be located near the main entrance in the public buildings and should be placed centrally in residential buildings so as to provide access from all the rooms and to maintain privacy at the same time.

4.4 Fixing of Rise and Tread:

Size of rise and tread vary with the location, importance and space available but certain thumb rules give good results. These rules are given below:

1. Tread+TwoxRise in cms. =60
2. Rise x Tread in cms. =400 to 410

Provide tread size as 30 cm and rise size as 14 cm. For each 25 mm deducted from tread, the rise should be increased by 12 to 13 mm. For residential buildings, the standard size of steps may be adopted as 25cm x 16 cm. For public buildings, the steps may be from 27cm x 15 cm x 13 cm.

4.5 Escalators: Escalators are power driven steps where one has to just stand while the steps keep on moving in the direction of flight. The steps move continuously along an endless loop. The main components of an escalator are a steel trussed frame work, hand rails and an endless belt of steps. Escalators are recommended in places, where movement of large number of people at a controlled rate in the minimum space is involved e.g. in a departmental store, railway station, airport etc.

4.6 Floors: Floors are provided to divide a building into different levels for creating more accommodation one above the other within certain limited space. If any accommodation is constructed below natural ground level, it is known as basement.

A floor may consist of two main components.

(i) A sub-floor, which provides proper support to floor covering and the super imposed loads carried by it.

(ii) Floor coverings which provide a smooth, clean, impervious and durable surface.

4.6.1 Floor coverings: Floor coverings are provided to improve the appearance, cleanliness noiselessness and damp proofing of the floors. The following types of floor coverings are generally employed.

1. Brick floor covering
2. Stone floor covering
3. Concrete floor covering
4. Tiled floor covering
8. Asphalt floor covering
9. Rubber floor covering
10. Linoleum floor covering
11. Glass floor covering

5. Wood –Block floor covering
6. Terrazzo floor covering
7. Mosaic floor covering
12. Magnetite floor covering
13. Plastic floor covering
14. Vinyl asbestos covering

4.7 Roofs & Roof Coverings:

A roof is the upper most part of a building which is constructed to protect the building so that rain, wind, heat, snowfall etc. may not damage it. Generally roofs are made of RCC slabs which are covered with mud phuska insulation and brick tile cover protection T-iron- slab roofing is also used in certain buildings. Alternatively Roof covering material is laid over network of frames. The availability of material and climate of the place may govern the particular type of roof. The roofs are classified as: (i) Pitched or sloping roof (ii) Flat roofs (iii) Shell roofs and (iv) Domes.

4.7.1 Roof Coverings: Roof covering material is provided to protect the surface of roof structure. It also prevents heat, moisture, rain water etc. to enter into building. The following are the various roof covering materials which are commonly used,

(i) Thatch
(ii) Ordinary country tiles &Patented tiles
(iii) Slates
(iv) Shingles
(v) RCC Slab / Reinforced brick slab
(vi) T-iron stone slab
(vii) Asbestos cement sheets
(viii) Corrugated G. I. Sheets
(ix) Bituminous felts
(x) Fiber Glass / Glass covering.

5.0 Paints, Varnishes and Distempers

5.1 Paints: Paints are applied on woodwork, metal or brick/cement surface in order to protect the surface from weathering effects. At the same time paints provide decorative finish also. For metals these provide a good protection against corrosive effect of weather.

Paint is composed of mainly two components, viz. pigment and organic binder. Pigment is the solid ingredient of the paint while the liquid part is called vehicle. Vehicle is usually linseed oil, varnish or water.

Pigment or the solid component of the paint comes in three forms i.e. base, inert filler and colouring pigment. Base is generally a metallic oxide like white lead, red lead, zinc oxide, iron oxide and titanium whites. Inert filler is a cheap pigment added to reduce the cost and may consist of barytes, lithopone, silica, silicates of magnesia or alumina, gypsum, charcoal etc. Colouring pigments add colour to the paint.

Liquid ingredient comes in 3 forms viz vehicle, thinner and drier. Refined linseed oil is a good example of vehicle where as turpentine oil, petroleum Spirit and naptha are the examples of thinners which make the vehicle thin enough to give a workable and uniform layer of paint. Driers are used to accelerate the drying of paint. Litherage, lead acetate, manganese all-oxide and cobalt are the commonly used driers.

Characteristics of a good paint:

1. Its consistency should provide easy workability.
2. It should have good adhesion to the surface on which is applied.
3. It should dry fast.
4. The dried film of paint should provide adequate protection against weather effects, cracking and flaking.
5. Its colour should not fade with time.

Various types of paints commonly used:

Following are the types of paints used commonly:

1. Aluminum Paint –good for metal surface, pipes, tanks and bridge girders.
2. Anti Corrosive Paint – good for protecting metal against corrosion
3. Bituminous Paint – good for water proofing to protect iron and steel.
4. Bronze Paint – good for metallic surfaces.
5. Cement Based Paints–water based paints for wall etc.
6. Enamel Paint–good for decorative painting, woodwork or metal surfaces.
7. Rubber Based Paints–good for cement concrete floors and masonry surface in toilets etc.

5.2 Varnish

Varnish is a solution of a resinous substance dissolved in oil, alcohol or turpentine. The solution on drying forms a hard, transparent and glossy film. It is generally used to give a protective and decorative surface to wooden surfaces of doors, windows and furniture.

Types of Varnishes: Depending upon the solvent used, varnishes are classified as below:

1. **Oil Varnish:** a mixture of drying oil (linseed oil), resin dissolved in a volatile thinner (turpentine or benzene) and good for interior as well as exterior surfaces.
2. **Spar Varnish:** good for exterior surfaces.
3. **Flat Varnish:** good where a dull appearance is to be obtained.
4. **Asphalt Varnish:** good for giving a black shop-coat to fabricated iron and steel.
5. **Spirit Varnish:** It is a solution of a resin dissolved in a volatile liquid and used for wooden furniture items. French polish, Lacquered and Shellac varnish fall in this category.

5.3 Distempers:

Distempers are water paints consisting of whiting (powdered chalk), colouring pigment and glue. Distemper may be washable or non-washable depending upon the medium used. Distempers act as a good sealer over porous surfaces and are good for plastered surfaces. Distempers for exterior use on cement concrete and brick surfaces are provided with weather resistant ingredient. Distempers are more durable and present a smooth and pleasing appearance. Regarding cost, it is a good material compared to ordinary white wash in the long run. It has good results in dry climate as in wet conditions, it gives poor results.

Oil bound distemper is provided with the drying oil mixable with water. It is available in paste form. When required to use, it is diluted in water. On drying, the oil content of the distempers hardens and forms a durable coating which can be cleaned by washing with water.

Now a days Low VOC (Volatile Organic Compound) paints are being used as a norm of Green Buildings.

6.0 Station Building

Railways Station is a public premise. It is the first contact point of the railway environment with the passengers. Being public premises, all the required facilities detailed below are to be made available in the station premises.

6.1 Classification of Stations as per earning Considerations

The railways stations are also classified as per consideration of passenger earning per year. Depending upon the passenger earning of the railway stations and some other important considerations, the stations have been classified in seven categories viz A1,A,B,C,D,E &F which is also an indicator of the passenger traffic. These categories are(RB/L&A/005/2012/LM(PA)/3/5 dt.09/5/2011):

S.No.	Category	Criteria
1.	A1	Non-Suburban stations with an annual passenger earning of more than Rs.60 crores.
2.	A	Non-Suburban stations with an annual passenger earnings of Rs.8 crores and upto Rs. 60 crores.
3.	B	I. Non-Suburban stations with annual passenger earnings between Rs. 4 crores to Rs. 8 crores.
		II. Stations of tourist importance or an important junction station (to be decided by G.M.)
4.	C	All suburban stations *.
5.	D	Non suburban stations with passenger earnings between Rs.60 lakhs and Rs. 4 crores.

6.	E	Non suburban stations with passenger earnings less than Rs.60 lakhs.
7.	F	Halts

* For station dealing with both suburban / non-suburban traffic, the Railway may take a view regarding up-gradation of classification depending upon station earnings, quantum of non-suburban traffic, etc.,

Note: Annual Passenger Earnings at the station for the purpose of the amenities shall be worked out as per para 2.3 of the instructions.

Minimum Essential Amenities

The minimum essential amenities required for each category of station has been indicated in the table. The railway should generally ensure that these essential facilities are provided at all the stations.

Minimum Essential Amenities at Various Categories of Stations

SL. NO.	AMENITIES	STATION CATEGORY						
		A1	A	B	C	D	E	F
1.	Booking Facility	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.	Drinking water Piped/Hand Pump	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3.	Waiting hall	Yes	Yes	Yes	-	Yes	Yes	Yes
4.	Seating arrangement	Yes	Yes	Yes	Yes	Yes	Yes	-
5.	Platform shelter	Yes	Yes	Yes	Yes	Yes	Yes	-
	Shady trees	-	-	-	-	-	-	Yes
6.	Urinals	Yes	Yes	Yes	Yes	Yes	Yes	-
7.	Latrines	Yes	Yes	Yes	Yes	Yes	Yes	-
8.	Platforms –							
	High level-	Yes	Yes	-	Yes	-	-	-
	Medium level-	-	-	Yes	-	Yes	-	-
	Rail level-	-	-	-	-	-	Yes	Yes
9.	Lighting #	Yes	Yes	Yes	Yes	Yes	Yes	Yes@
10.	Fans	Yes	Yes	Yes	Yes	Yes	Yes	-
11.	Foot over bridge	Yes*	Yes *	Yes	Yes	©	-	-
12.	Time Table Display	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13.	Clock	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Sl. No.	Amenities	Station Category						
		A1	A	B	C	D	E	F
14.	Water cooler	Yes	Yes	Yes	Yes	Yes	-	-
15.	Public Address system/ Computer based announcement	Yes	Yes	Yes	-	-	-	-
16.	Parking –cum-circulatory area, with lights	Yes	Yes	-	-	-	-	-
17.	Electronic Train indicator board	Yes**	Yes	-	-	-	-	-
18.	Public phone booth	Yes	Yes	-	-	-	-	-
19.	Signage (standardized)	Yes	Yes	Yes	-	-	-	-

* With Cover.

** At station entrance/concourse , on Foot-over bridges (at landing locations) and on platforms located appropriately to guide passengers at every stage.

Stations may be electrified as per provisions of Board's circular No.95/Elec(G)/109/1 dt. 1.2.95

@Where train stops at night.

©Foot over-bridges shall be provided at all crossing stations during doubling/gauge conversion upto 'D' category stations , wherever the same are not available.

Norms Of Minimum Essential Amenities at Various Categories of Stations

Sl. No.	**Amenities**	**Station Category**						
		A1	A	B	C	D	E	F
1.	Booking Facility% (No. of Counters)	15	10	6	4	4	2	1
2.	UTS as per norms	Yes	Yes	Yes	Yes	Yes	Yes	-
3.	Drinking water^ (No. of taps/PF)$^^	20	20	20	6	8	2*	Appropriate drinking water facility**
4.	Waiting hall @ sq m	250	125	75	0	30	15	10 sqm booking office cum Wtg.hall

Sl. No.	Amenity	Station Category						
		A1	A	B	C	D	E	F
5.	Seating arrangement (No. of seats/PF)	150	125	100	10	50	10	-
6.	Platform shelter (on each PF)#	500 Sqm	400 Sqm	200 Sqm	200 Sqm	50 Sqm+	50 Sqm+	Shady trees
7.	Urinals ##	12	10	6	4	4	1	-
8.	Latrines ##	12	10	6	2	4	1	-
9.	Foot over bridge ®	1 with cover	1 with cover	1	1	®®		
10.	Water cooler £	2 on each PF	2 on each PF	2 on each PF	2 on main PF	1on - main PF	-	
11.	Signage (standardized)	Yes	Yes	Yes	-	-	-	-
12.	Platforms ***	High Level	High Level	Medium Level	High Level	Medium Level	Rail Level	
13.	Lighting +++ (Lux level)	As per Annexure II of Board's letter No.2004/Elec(G)/109/1 dated 18.5.2007						
14.	Fans ©	As given below						
15.	Time table display	As per extant instructions						
16.	Clock	To be decided by zonal railways						
17.	Public Address System/ Computer based announcements	As per extant instructions						
18.	Parking –cum – circulatory area, with lights	As per extant instructions						
19.	Electronic Train indicator board	As per extant instructions						
20.	Public phone booth	As per extant instructions						

% At A1,A,B,C & D category of stations , the booking counters to operate round the clock except at stations where there is no night working.

^ At stations falling in water scarcity zones or where water source dries up in summer, drinking water facility should be ensured at every platform by means of syntax tanks/ CANS/ Matkas / Piaos etc.,. as decided by GM of the Railways. At less important stations , particularly those falling under category E & F , one water supply source at a location convenient to passengers may be provided. Drinking water

facility would include all necessary units whether donated by private parties or Railways themselves.
$ There should be one drinking water tap suitable for use by disabled persons on alternate water booths at every platforms .
^^ Adequate number of water taps should be suitably located to serve passengers of GS coaches, i.e., at the end of platforms.
* At 'E' category stations , wherever piped water supply is not feasible due to local conditions, separate arrangement for portable water at each platforms shall be made available with the approval of General Manager of the concerned Zonal Railway.
** Drinking water arrangements should be made at halt stations by means of water taps/hand pumps/ tubewells / sintex tanks/ piaos as decided by the General Manager of the concerned Zonal Railway.
@ If the variation is marginally on the lower side (upto – 5 sqm), then it can be taken to be adequately provided.
Shelter should be suitably spaced ensuring natural light and ventilation and covering areas from where passengers aboard the General Coach.
+ Preferably light weight shelters.
1. Number of latrines/ urinals/includes provision in waiting room/halls. 1/3rd of the toilet may be reserved for ladies. In case of 2 toilets existing, one should be earmarked for ladies &gents.
2. Number of latrines/urinals can be reduced in water scarcity areas by the Railway with the approval of GM.
3. Includes pay and use toilets. The policy for setting up such toilets be referred in terms of Board's letter No.05/TGIV/10 SAN/32/Pay & Use Policy Dt.7.6.06.
®New FOBs should be at least 6 m wide at 'A-1', 'A' and 'C' category stations wherever feasible. New FOBs at 'A1' & 'A' category stations should be compatible for installation of escalators.
®® Foot over-bridges shall be provided at all crossing stations during doubling/gauge conversion upto 'D' category stations, wherever the same are not available.
£ To be provided as per Board's letter No.69/Elec(g)/730/8 Dt.30.03.1971.
***(a) On all New lines, Gauge conversion & Doubling projects, minimum level of platforms shall be medium level(Board's letter No. 2003/LMB/14/29 Dt.26.4.2005).Wherever medium level of platform is to be provided as per norms, the same shall be with the foundation for high level platform. (Board's letter No.2012/LM(PA)/03/07/Policy dated 06.07.12).
(b) Wherever platform height gets reduced on account of track works , the same should be restored(Board's letter No. 2003 /LMB/14/29 Dt.03.02.2005)
(c) Platform should be high level, irrespective of category ,wherever EMU trains are dealt with (Board's letter No.2006/LMB/2/121 Dt.11.8.2006)
++Solar energy based lighting needs to be introduced to provide emergency lighting at "D" and "E" category stations, wherever feasible, in non-electric traction areas.
©For covered platforms having width of 6-9mts;one row of fans should be provided @one fan in the centre of supporting columns. For covered platforms with more than 9 mts width, fans should be provided in 2 rows.

Note: (1) At stations where only one ASM is posted, only one booking window will be provided. In respect of 'E' category stations, where the earnings is less than Rs.20 lakh per annum, the quantum of amenities to be provided could be decided by General Managers based on actual requirements.

(2) Scale of all the amenities prescribed above are the bare minimum to be provided at appropriate category of stations. Amenities over and above the prescribed minimum scales will continue to be provided as per norms for provision of amenities at "Recommended Level".

Recommended Amenities

Once the essential amenities as indicated in above table are available at a station to the prescribed levels, further augmentation of these amenities can be made to higher recommended norms. Details of these amenities are given in the Table below:

Nmax = Maximum number of trains dealt with in any interval of half an hour at the station multiplied by the average number of passengers dealt per train at that station. The average number of passengers per train at a station shall be the average number of daily passengers dealt with at the station divided by the number of trains stopping at the station during 24 hours.

Ndb = Design figure for number of passenger for 'A' & 'B' stations to be calculated as Ndb=0.3(Nmax)

Nds = Design figure for number of passenger for 'C' , 'D' & 'E' stations to be calculated as Nds=0.45(Nmax)

(Norms for Recommended level of Amenities at various categories of stations)

S.No.	Amenities	Recommended scale for provision	
		Cat. A1, A & B	Other stations
1.	Booking Facility	1 window per 800 tickets per shift tickets sold should be taken)	(shift with maximum number of
2.	Drinking water (No. of tapes)	No. of taps= Nmax/25. Taps should be distributed so that every alternate coach gets benefit of a tap.	No. of taps= Nmax/25.
3.	Waiting hall /Shed	1.394 Ndb sqm	1.394 Nds sqm(Excluding C)
4.	Seating Arrangement (No.of Seats)	0.4Ndb	0.4 Nds
5.	Platform Shelter* (on each PF)	0.28 Nmax	0.28 Nmax
6.	Urinals #	Ndb/200	Nds/200
7.	Latrines#	Ndb/200	Nds/200
8.	Platform Level	To be decided by the Zonal Railways	
9.	Lighting ®	As per Board's letter no.95/Elec(G) /138/5 dated 19.3.96 .Norms indicated in Note below.	

S.No.	Amenities	Recommended scale for provision	
		Cat. A1, A & B	Other stations
10.	Fans **	As per Board's letter no.95/Elec(G) /138/5 dated 19.3.96	
11.	Foot over bridge	To be decided by the Zonal Railways	
12.	Time Table Display	To be decided by the Zonal Railways	
13.	Clock	To be decided by the Zonal Railways	
14.	Bathrooms #	1/400Ndb	1/400 Ndb at other junction & terminal stations only
15.	Water Coolers	To be provided if total number of passengers ,inward and outward is more than 1000 per day (As per Board's letter no.69/Elec(g) /730/8 dated 30.3.71. To be decided by Zonal Railways	
16.	IVRS	A-48 lines (calls 72000) B-24 lines (calls 5000-20000)	A central IVRS with adequate lines should be provided to cover all suburban stations-Minimum 6 lines if IVRS is otherwise justified.
17.	Public Address System/Computer based Announcement	To be decided by the Zonal Railways	
18.	Parking-cum-circulatoryarea,with lights	To be decided by the Zonal Railways	
19.	Electronic Train indicator board	To be decided by the Zonal Railways	
20.	Public phone booth	To be decided by the Zonal Railways	
21.	Signage (standardized)	To be decided by the Zonal Railways	

*At important A1, 'A' category and suburban stations, efforts should be to cover the entire PF.

#1/3rd of urinals/latrines be reserved for ladies.

® (a) Emergency light: From Auxiliary Transformer (AT) connected to traction supply,10 light points for A1 and A category stations on each platform. Emergency light from DG set/Solar supply on each platform at all stations where traction supply is not available, except E & F category stations. (b) Minimum one light in ASM room, Booking Window, Waiting Hall each, one light on each FOB at every 30 meter,03 lights on each platform and one light in circulating area shall be provided as emergency light with suitable back up power source such as Solar/wind etc.,.

**For covered platforms having width of 6-9 mts, one row of fans should be provided @one fan in the centre of supporting columns. For covered platforms with more than 9 mts width , fans should be provided in 2 rows.

$At suburban stations, bathrooms need not be provided.

Note:Norms for recommended level illumination at various categories of stations are as follows (Ref Bd's Circular No.2005/Elec(G)/150/1 Dt.28.2.06)

S.No.	Area	Proposed lux level for category I/II/III station
1.	Station circulating area	50/30/20
	Outdoor car parking	20/20/20
2.	Station concourse area	100/100/100
3.	Booking office, reservation office, enquiry office	200 (localized above counter) & 100 in remaining areas for category I, II, III stations.
4.	Parcel & luggage office counter	150/150/150 150/150/150
5.	Platform covered open area	50/30/20
6.	Waiting halls/rooms	100/100/100
7.	Retiring rooms	100/100/100
8.	Restaurant & kitchen in general building area: i. Restaurant area: ii. Kitchen: iii. Stores:	 150/150/150 100/100/100 100/100/100
9.	Foot over bridge	50/30/20
10.	Other service buildings inside Railway station area	200 for SM's office for category I, II , III stations.

Category (I) – Stations on Zonal railway HQs/State capitals and all A1 & A category stations.
Category (II) - Stations on Rlys. Divisional Hq./ State Distt. HQs & all B category stations.
Category (III) – Stations in remaining categories.

Desirable Amenities

Desirable amenities are those which are considered desirable to further improve customer satisfaction and interface process at the station. The quantum of these amenities would depend upon the category of the station. A comprehensive list of the desirable amenities is given in table. The provision of desirable amenities need not wait for complete provision of amenities to levels recommended. These amenities should be provided based on the need and relative importance of the station.

Sl. No.	Amenity	Station Category						
		A1	A	B	C	D	E	F
1.	Retiring room	Yes[1]	Yes	Yes	-	-	-	-
2.	Waiting room (with bathing facilities) Upper class	Yes[1]	Yes	-	-	-	-	-
	2nd class	Yes[1]	Yes	Yes	-	Yes	-	-
	Separate for ladies (combines upper and 2nd class)	Yes[1]	Yes	-	-	-	-	-
3.	Cloak room	Yes	Yes	Yes	-	-	-	-
4.	Enquiry Counter	Yes	Yes	Yes	-	-	-	-
5.	NTES	Yes	Yes	-	-	-	-	-
6.	IVRS	Yes	Yes	Yes	-	-	-	-
7.	Public Address system/ Computer based announcement	Yes	Yes	Yes	Yes	Yes	-	-
8.	Book stalls/ other – stalls of essential goods	Yes[2]	Yes	Yes	Yes	Yes	-	-
9.	Refreshment room	Yes	Yes	Yes	-	-	-	-
10.	Parking / circulatory area with lights ***	Yes	Yes	Yes	Yes	Yes	-	-
11.	Washable apron with jet cleaning #	Yes	Yes	Yes	-	-	-	-
12.	Electronic Train indicator board	Yes	Yes	Yes	Yes	-	-	-
13.	Touch Screen Enquiry system	Yes	Yes	Yes	-	-	-	-
14.	Water vending machines	Yes	Yes **	Yes **	-	-	-	-
15.	Foot Over Bridges	Yes	Yes	Yes	Yes	Yes ®		
16.	Escalators	Yes[3]	Yes[3]	-	Yes3	-	-	-
17.	Travellator	Yes[4]	Yes[4]	-	-	-	-	-
18.	Signage (standardized)	Yes	Yes	Yes	Yes	Yes	-	-
19.	Modular Catering Stalls *	Yes	Yes	Yes	Yes	Yes	-	-

Sl. No.	Amenities	Station Category						
		A1	A	B	C	D	E	F
20.	Automatic Vending Machines	Yes	Yes**	Yes **	Yes **	-	-	-
21.	Pay & Use Toilets on end of platforms & circulating area.	Yes	Yes	Yes	Yes	Yes	Yes	-
22.	Provision of cyber cafes	Yes[4]	-	-	-	-	-	-
23.	Provision of ATMs (preferably with ticketing facility)	Yes	Yes	Yes	Yes	Yes**	Yes **	-
24.	Provision of at least one AC VIP/ Executive Lounge	Yes	-	-	-	-	-	-
25.	Food plaza	Yes	-	-	-	-	-	-
26.	Train coach indication system	Yes	-	-	-	-	-	-
27.	CCTV for announcement & security purpose	Yes	-	-	-	-	-	-
28.	Coin operated Ticket Vending Machines	Yes	Yes	Yes	Yes	-	-	-
29.	Pre-paid Taxi service	Yes[5]	-	-	-	-	-	-
30.	High Level Platform	Yes	Yes	Yes	Yes	Yes[6]	-	-

Yes (in italics): Also prescribed as minimum Essential Amenity under Annex. II.

*** should include high mast lighting wherever feasible.

Washable aprons with water hydrant/jet system should be provided at all platforms where morning train stops for longer duration to ensure cleanliness and better maintenance.

® On double line sections.

* In end platforms, all stalls should be preferably embedded in walls.

** Optional items vide Board's letter No.94/LMB/2/175 dated 16.1.05

Numbered subscripts:

1: Up gradation to be taken up preferably public-private partnership schemes. Retiring Rooms need not be provided at 'D' category stations.

2: Should provide for minimum essential medicines.

3: Escalators at 'A1', 'A' & 'C' category stations and stations of Tourist importance.

4: Subject to availability of space & feasibility.

5: Subject to availability / clearance from local authorities.

6: With the approval of General Manager.

7.0 Water Supply

Water supply is one of the important functions assigned to the Civil Engineers in Railways. Water supply includes planning for the requirement of total water supply, survey for the location of source, storage and distribution system. The Civil Engineers are also responsible for the treatment of water to ensure that its quality is fit for human consumption.

7.1 Water Supply Sources

7.1.1 Open wells: These are the most common source of water supply at way side stations where the electric power is not available. The open wells are provided with masonry walls and have diameter of 2 to 3 meters. The masonry wall must project at least a meter above the ground level and the ground surface should be provided with concrete apron having slope away from the well. The wells should invariably be provided with a cover to prevent falling of leaves ete. into them. Open wells are generally successful in areas having sandy strata at reasonable depth. As a preventive measure against pollution, the ground around the well for a radius of at least 50 metres should be kept thoroughly clean and no bathing or washing of clothes should be permitted near the well supplying drinking water. The open well should be cleaned out when necessary preferably during hot weather. After cleaning and scrapping the wells, quick lime should be applied to the sides, and bottom of the wells.

7.1.2 Hand Pumps: Hand pumps are generally preferred over the open wells as the water remains clean and pollution free in a hand pump. Minimum depth of strainer should be not less than 30 metres so that the water from the upper layers which is usually polluted does not get mixed up. Normally India Mark II type design of hand pumps, which are robust in design, should be installed with depth of strainer-pipe not less than 30 metres. These hand pumps require very little maintenance. At least 2 nos. of hand pumps should be provided at each platform whereas one hand pump is sufficient for a cluster of 4 to 6 houses at wayside stations.

7.1.3 Tube wells: Tube wells are provided where the demand of water is considerable. Where electric power is not available, diesel engine driven pumps are provided. Diameter and depth of strainer depend on the quantity of water required. But generally the depth at which strainer is provided, is not less than 50 metres (even though water bearing strata is available at shallow depth) and may be as much as 500 metres in case of deep tube wells. The minimum diameter of strainer may be 150 mm and may be as large as 450 mm. Strainers may be made from mild steel pipes with slits in size 1.5 mm x 75mm and 3.0 mm x 75 mm. The quantity of water supply depends on the thickness of aquifer and the diameter of well developed. The velocity of water at

the exit point i.e. where it leaves the aquifer, should not be more then 0.75 to 1.0meter per second. The tube well is developed by using pea- sized stone pebbles. During the process of development of the tube well, water is pumped out which takes away silt and sand particles and the sand is replaced by a natural inverted filter of graded stones.

7.1.4 Selection of tube well site

1. While selecting the site for a new tube well, a number of factors must be known or assumed either by close examination of nearby wells or a knowledge of the area gained through earlier exploration of ground water system.
2. Central Ground Water Board Geological Department, Drilling contractors who have operated in the area should whenever possible be consulted and a plan of the area indicating tube wells and open wells with depth of water bearing strata, yield static water level and quality of water tapped be obtained.
3. Wherever availability of good underground potable water source is not already proved by earlier experience, services of specialized agencies like Central Ground Water Board should be used before deciding location of tube well. Test drilling may also be resorted to determine the underground water level, aquifer and quality of water.
4. There should be no kutcha sullage water drain, septic tank, chemical factories or sugar mills in the vicinity, causing contamination of sub-soil water.
5. A careful investigation should be made while locating wells in areas containing coarse gravel, fissured rocks or limestone formations, since pollution may be carried directly to the ground water supply through solution channels and without natural filtration.
6. Distance between the proposed and existing well, if any, should not be less than 150 metres so that yield from the new source does not affect the yield of the old source.
7. There should be no high building, main line track or overhead tank within a radius of 30 metres to avoid collapse due to cavity formation.
8. There should be no cavity within a radius of 45 metres, In such case, sometimes the cavity starts absorbing the water fed into the well and due to lack of hydraulic pressure, the hole may collapse,
9. There should be equal distribution of water to the adjacent areas and pipe layout required should be minimum.
10. The well should be so located as to facilitate access for pump repair, cleaning, treatment, inspection and power connection.
11. The well should be located on the highest ground available.

7.2 Pumps

Different types of pumps are suitable for different pumping conditions. Great care has to

be exercised in selecting the right type of pump as apart from consuming more energy, wrong type, of pump may not be able to give the design discharge. Various types of pumps are described below:

(i) **Reciprocating pumps:** Reciprocating type pumps are good for small discharge and high heads. These pumps may be duplex, triplex or quadruple according to the number of ~ water cylinders and are suitable for pumping from open wells. These pumps are not suitable for tube wells due to intermittent suction and consequent pulsating action. Another problem of reciprocating pumps is limited suction head which should not exceed 6 m or otherwise the pump has to be installed below the ground level in the well.

(ii) **Centrifugal pumps:** Centrifugal pumps are quite efficient, economical and need very little maintenance due to robust and simple design and construction. The suction head is limited to 6 m and in case of water level being deeper than this, the pump should be installed inside the well which is not very convenient. These pumps are good for medium discharge.

(iii) **Vertical Spindle Pumps (V.S.Pumps):** V. S. Pumps are high efficiency pumps and good for large size tube wells and also for such situation where level is quite low. The motor unit is kept above the ground level with rotating ~ shaft going down vertically and connected to the vertical pump which is placed deep inside the pipe of the tube well below the water level. However, great care is required to be exercised in boring of the tube well, with reference to its verticality.

(iv) **Submersible Pumps:** These are suitable for small discharge tube wells. Both the motor and pump units are placed below the water level. The length o f the pump unit depends on the stages used which may be 1.5 m to 2.5 m so. The number of stages used depends on the head for which pumping is to be done.

7.3 Capacity of water source and pumping

For ensuring satisfactory supply of water during the hot season, sufficient source and pumping capacity should be provided. Ordinarily, in the summer season, wells or other sources including auxiliary sources, if any, should be able to supply in eight hours, the quantity of water consumed in 24 hours. The pumping system should be so designed and provided that it should be capable of supplying:-

(i) In 12 hours or less normal quantity required in 24 hours;

(ii) In 16 hours or less, the present maximum quantity required in 24 hours;

(iii) In about 20 hours or less, the estimated future requirement in 24 hours.

In addition to above, at important stations, pumps and driving units should be duplicated so that a standby is assured in case of breakdown.

7.4 Norms for working out Water Requirement For Railways

First of all we have to consider the water requirement for operation and maintenance of trains and platforms. Then we have to cater for the requirements of service building and the travelling rail users and last, but not the least for the Railways staff and colonies.

Table standards of Water requirement proposed to be implemented areas per IRWM(2000):

S. No.	Particulars	Demand (Litre per day)
1.	(a) Residential houses consumption for Officers and staff (b) Offices and workshop	200 per capita (includes 45 lit liters required for flushing)
	(i) Office per head	45
	(ii) Workshop per head	35
2.	Stations and Platform (i) Apron washing	10 per sq. M
	(ii) Platform washing	5 per sq. M
	(iii) Passengers on Railway stations	25 per passenger
	(iv) Washing of a carriage on washing lines	3600 (B.G.) &2600 (M.G.) per carriage.
	(v) Cleaning of a carriage 0n platform	500 per carriage.
	(vi) Carriage watering	As per actualrequirements.
3.	Miscellaneous (i) Garden per hectare	22500 approx
	(ii) Hospital	450 per Bed
	(iii) Fire service	Occasional sumps and hydrants to be adequate for emergencies

Note: (i) The requirement of water worked out on the basis of above table has to be further enhanced based on future developmental growth of the station.

(iii) In addition, adequate water supply has to be made available at railway stations for passengers.

7.4.1 Method of Treatment:

The aim of water treatment is to produce and maintain water that is hygienically safe,

clean and potable in an economical manner. Treatment should ensure the desired quality at end points of consumption.

The method of treatment to be employed depends on the nature of raw water and the desired standards of water quality. The unit operations in water treatment constitute aeration flocculation (rapid and slow mixing) and clarification, filtration disinfection, softening, defluoridation and water conditioning. Many different combinations are possible to achieve the required quality of water to suit the above requirements. The choice of any particular sequence of treatment will depend not only on the quality of the raw water available and treated water desired but also on the comparative economics of alternative treatment steps applicable.

In the case of ground water storage which is well protected, where the water has turbidity below 10 NTU and water is free from odour and colour, plain disinfection by chlorination is adopted before supply.

Where ground water contains excessive iron, dissolved carbon dioxide and odorous gases, aeration followed by flocculation and sedimentation, rapid gravity or pressure filtration and disinfection may be necessary.

Conventional treatment including pre-chlorination, aeration, flocculation and sedimentation, rapid gravity filtration and post – chlorination are adopted for highly polluted surface water laden with algae or other micro organisms.

Water with excessive hardness will need softening, by conventional method or by ION exchange method.

7.4.2. Disinfection of water:

Water treatment processes described in Para above remove micro organisms to varying degrees. For utmost safety of water for drinking purposes, disinfection of water has to be done to remove disease producing organisms before it enters distribution system. Disinfection is also required to prevent contamination of water during its transit from the treatment plant to the place of its consumption. The efficiency of disinfection depends on the nature of disinfectants. For treatment on large scale, chlorination is generally used as treatment for disinfection. Chlorine can be applied in water by using bleaching powder, chloronomes or as free chlorine gas. A minimum of 30 to 60 minutes contact time must be provided before delivery of water to the consumer.

Utmost care shall be taken for storage and use of disinfectants. All safety precautions as laid down in relevant codes shall be taken.

Sufficient number of chlorinators in working conditions should be available with the inspectors of works. To decide the quantity of chlorine to be added, inspector of works should find out breakpoint chlorination and accordingly chlorinate the supply.

7.4.3 Residual chlorine:

Minimum residual chlorine available at the farthest end shall be 0.2 mg per litre. However, where distribution is long and complex it may be difficult to maintain the minimum residual value and in such cases re-chlorination may be carried out in the distribution system.

During monsoon months or if specific complaints are there, super-chlorination (2 ppm of chlorine) may be resorted to effectively get rid of bacteria.

Inspectors of Works should frequently check the concentration of residual chlorine at the consumer point by orthotolidine test. In this test 100 ml. of chlorinated water sample is collected in the test tube. I ml of orthotolidine solution is added to it. The colour formed is noted, value of the residual chlorine is directly determined by comparing the colour so obtained with the standard colours of non-chlorine residuals. Divisional Engineer should ensure sufficient number of equipment with all the field units.

8.0 Sanitary Engineering

8.1 Introduction

Sanitary engineering is that part of public health engineering, which deals basically with collection and disposal of sewage and other wastes. The main purpose of sanitation is to maintain such environments as will not affect the public health in general. Sanitary Engineers are mainly responsible for keeping clean and healthy environments.

8.2 Definition of Terms

(i) **Refuse:** The term refuse is used to indicate the rejected, worthless and waste matter from society. The refuse can be in form of garbage, sewage, storm water and sullage.

(ii) **Garbage:** The term garbage is used to indicate the dry refuse of society including paper pieces, decayed fruit and vegetable. grass, leaves etc.

(iii) **Sewage:** The term sewage is used to indicate the liquid waste of society including sullage industrial waste, storm water and discharge from urinals, latrines etc. Human and animal excreta is termed as night soil.

(iv) **Sewers:** The sewage is conveyed from one point to another in closed conduits or drains known as sewers. Following are the different type of sewers.

(a) Main sewer carries the sewage conveyed from branch sewers to the sewage treatment plant.

(b) Branch or sub-main sewer is the lateral pipe which conveys the sewage from the building to the branch sewers which further carries the sewage to the main sewers.

(c) Lateral sewer obtains the discharge directly from the building. It indicates the first stage of sewage collection.

(d) Intercepting sewer intercepts the discharge from two or more main sewers for carrying it to the treatment plant.

(e) Out fall sewer the length of the main or trunk sewer between the lowest branch and final point of disposal.

(f) Trunk sewer obtains its discharge from two or more main sewers.

(v) **Sewerage:** The entire technology of collecting and carrying sewage by water carriage system through sewers is known as sewerage. The sewage thus, collected and conveyed is taken to a suitable place for its disposal.

(vi) **Plumbing:** Plumbing is the art of installing in building the pipes, fixtures and other apparatus for bringing in water-supply and removing liquid and water carried wastes.

(vii) **Trap:** Trap is fitting or device so constructed as to prevent the passage of air or gas through a pipe without materially affecting the flow of sewage or waste water through it.

(viii) **Vent pipe:** is a pipe provided to ventilate house drainage system and to prevent trap syphonage and back pressure.

(ix) **Soil pipe:** is a pipe which conveys the discharge of water closets or urinals to the drain. In 'One pipe' and single stack' system, the soil pipe also conveys to drain the discharges from bath, wash-basins and sinks and similar appliances.

(x) **Waste pipe:** is a part which receives the discharge of any fixture, except water closets, and conveys the same to the house drain, soil or waste stacks.

(xi) **Drain:** A conduit/channel for the carriage of storm water or other used water.

(xii) **Drainage:** A system for removal of any unwanted liquid.

(xiii) **Manhole:** An opening by which a man may enter and leave a drain, a sewer or other closed structure for inspection, cleaning and other maintenance operations fitted with a suitable cover.

(xiv) **Soil waste:** The discharge from water closets, urinals, slop sinks, cattle sheds, gullies etc.

(xv) **Invert:** The lowest point of the inside surface of the sewer or drain at any point is called invert. The reduced level of the invert is called invert level.

(xvi) **Sewage collection:** The process consists of collecting sewage from different points of occurrence and conveying the same to a desired point with the help of sewer system.

(xvii) **Sewage treatment:** The artificial process to which the sewage is subjected to for removing its objectionable constituents before it is disposed, is called sewage treatment

(xviii) Sewage disposed: The act of disposing of the treated or untreated sewage into a river or on land is called sewage disposal.

Sewage Treatment

The sewage carried in the sewers has to be disposed off properly. Raw sewage is very harmful if not given appropriate treatment before disposal and can cause serious health hazards to the community. There are two methods of disposing off sewage viz. Natural methods and artificial methods.

(1) Natural methods: In this method, the untreated or treated sewage is disposed off directly:

(2) Artificial methods: In this method, sewage is disposed off only after subjecting it to various processes of treatment.

Detail of Natural Method

This method is suitable for the areas situated near large rivers or sea in which treated or untreated sewage is directly thrown into natural waters. The sewage, in due course of time, gets purified automatically by the self purification capacity of natural waters.

Sometimes, primary treatment, i.e. removal of floating matter and settleable solids is given to raw sewage before disposing off, particularly when the raw sewage is being disposed off in a river, where it can otherwise contaminate the water.

The organic matter of the sewage gets oxidized by the dissolved oxygen content present in natural water, converting it into harmless matter. The oxygen consumed in the process of oxidation is replaced by the atmospheric oxygen. This phenomenon which occurs in all natural waters in known as 'Self purification'

Disposal by land Treatment

This is also known as sewage farming as the treated or untreated sewage is directly thrown on the surface of land which adds to the fertilizing value of land and crops can be preferably raised on such land.

This method is adopted in areas away from natural water i.e. rivers and sea, where large open areas are available in the surrounding locality. The sewage farming is possible only in area with sandy, loamy or alluvial soils over soft moorum as such soils are easily aerated and it is easy to maintain aerobic conditions in them. The depth of water-table should not be very low even in rainy season so that the underground water source is not polluted by land treatment.

Sewage Treatment by Artificial Methods

If it is not possible to dispose off raw sewage by natural methods, then it becomes very necessary to treat the sewage to make it harmless and odorless before disposing off.

The treatment of sewage can be divided into.

(i) Primary treatment

(ii) Secondary treatment

(I) Primary Treatment

In primary treatment large solids present in the sewage are removed and the complex compounds are broken down to simpler compounds by decomposition. It includes: (a) screens, (b) grit chambers, (c) detritus tanks, (d) skimming tanks, and (e) sedimentation tanks.

(II) Secondary Treatment

The effluent coming out of sedimentation tanks contains 45 to 50 to percent of unstable organic matter originally present in sewage. Large solids are completely removed during primary treatment and the effluent contains organic matter in suspended or colloidal form.

The main function of secondary treatment of sewage is to convert the remaining organic matter into stable form by oxidation or nitrification. The various methods involved in secondary treatment can broadly be classified into two categories:

(i) Filtration-for the treatment of effluent.

(ii) Activated sludge process for the treatment of sludge.

8.3 Sewage Disposal by Septic Tank

Standard sewerage systems are meant primarily to transport human waste from the toilet to the treatment plant located at few kms away or to connect the Railway sewerage system to the Municipal sewers. Therefore, this standard sewerage system is appropriated only where underground sewerage system exists.

Where there is no underground sewerage system or where the quantity of sewage to be disposed off is not large, septic tank system of disposal of sewage is normally adopted.

Modern septic tank system is an on site disposal method of sewage, which uses standard flushing. The septic tank acts as sedimentation-cum-digestion tank. Anaerobic digestion of the settled sludge occurs in its bottom zone and supernatant liquid has to undergo treatment in a soak pit/filter bed.

Septic tank should be cleaned when a large quantity of sludge has collected in the bottom of the tank. The interval of cleaning should not normally exceed 12 months. After cleaning 3 or 4 shovelful of surface, earth containing grass roots and decaying vegetable matter should provide a good start. No disinfectants should be used in latrines attached to septic tanks as they kill the organisms which digest sewage.

8.4 Appropriate toilet system on Railways.

(i) There is a general shortage of water supply in India and in some parts even the drinking water is scarce. Therefore, it has to be seen that water is conserved to the maximum extent possible and that it is not polluted and the waste disposal system should be designed with these ends in view. This applies to both ground water and surface water. In case of nonresidential toilets at stations etc., and community toilets provide with 'standard flushing' arrangement, instead of flushing cisterns of 3 gallons capacity, the use of 'coach' handles should be preferred so that

the required amount of water is used. In case of urinals, instead of automatic flushing cisterns, dripping ferrules may be used to conserve water.

(ii) For providing any soak pit/filter bed with septic tanks the water table must be well below their depth and the rain water from surface also should not interfere with their functioning. Hence, these are not usually suitable where water tables are high or where ground slopes are flat.

8.5 Maintenance of sewerage and drainage

Full consideration should be given to maintenance requirement at the time of designing sewerage system. Provision of openings stair cases and due provisions for eliminating gas hazards should be ensured.

Maintenance of sewers involves removal of stoppages and clearing out the deposits. Clogging may be due to grit deposition, penetration of roots from adjoining trees, growth of fungi or stagnation of sewage.

Sewers should be flushed by fire-hose pipes from the nearest fire hydrant if conveniently located if the stoppage is too stubborn to respond to flushing it may be removed by rodding from he next manhole or it may be necessary to dig down to the point where the trouble exists.

Sub-soil drains should be periodically examined for obstruction at the open joint due to roots of plants or collection of plastic discharge into the drain.

Similarly open slugged drains, storm water drains and disposal works including septic tanks should be examined frequently. Septic tanks should be cleaned out in coordination with medical staff when an appreciable quantity of grit is collected in them.

Now a days, Effluent treatment plants / Sewerage treatment plants are required to be provided as per pollution control norms.

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