UNIT 1

Introduction of Highways

Structure

1.0 Introduction
1.1 Importance of Transportation engineering
1.2 Classification of Roads
1.3 Cross section of Road structure
1.4 Road width for different classification of roads
1.5 Traffic lane width
1.6 Camber
1.7 Gradient
1.8 Super Elevation – Necessity

Learning Objectives

After studying this unit, the student will be able to understand

• The different ways how the transportation helps in development of region / countries.
• Learn different types of roads
• Understands different cross sectional elements of road structures.
• Learn about different road widths
1.0 Introduction

Transportation is the movement of people or goods from one place to another. Transport is important since it enables to trade between people, which in turn establishes civilizations. The transport system comprises of highways or roadways, Railways, water ways and air ways.

Road ways include highways, city roads, village roads, feeder roads and ghat roads. Roadways provide maximum service to one and all. It is possible to provide door to door services only by road.

1.1 Importance of Transportation Engineering

Transportation helps in economic, industrial, social and cultural development of a country. Transportation is very important for the economical development of any region since commodities produced like food, clothing, industrial products, medicine needs transport at all stages from production to distribution. It is also essential for strategic movement in emergency for defence of the country and to maintain better law and order. Transportation also helps in tourism development.

1.2 Classification of Roads

1.2.1 The roads are classified into two types depending on whether they can be used during different seasons of the year.

(i) All weather roads and (ii) Fair weather roads

Based on the type of carriage way the roads are classified as

(i) Paved roads – Provided with hard pavement course
(ii) Unpaved roads – Not provided with any hard pavement eg. Earth roads and gravel roads.

(iii) The roads based on traffic volume, are classified as heavy, medium and light traffic roads.

1.2.2 Classification of roads as per I.R.C (Indian Roads Congress)

Based on location and function, the Nagpur plan classifies the roads as

(i) National Highways (NH)
(ii) State Highways (SH)
(iii) Major district Roads (MDR)
(iv) Other district roads (ODR) and
(v) Village Rods

(i) National Highways (NH)

These are the main highways which connects ports, foreign highways, capital cities of large states and large industrial and tourist centres including roads of military importance. They are financed and constructed by central government. All the national highways are assigned the respective numbers. The highways Vijayawada and Pune, through Hyderabad is NH9. Nagpur – Hyderabad – Banglore road denoted as NH7.

![Map of National Highways in India](image_url)

Fig. 1.1 A map showing National highways
(ii) **State Highways (SH)**: These are important roads of a state. The state highways connect national highways of adjacent state, district headquarters and important cities within the state. They are financed and constructed by the State government.

(iii) **Major District Roads (MDR)**: These are important roads within a district serving areas of production and market and connecting the main highways of a district.

(iv) **Other District Roads (ODR)**: These roads are serving rural areas of production and connects them with market centres, Taluq head quarters, and other main roads.

(v) **Village roads**: These are the roads connecting villages or group of villages with each other to the nearest road of a higher category. They are financed and constructed by panchayaths with the help of zilla parishads and State governments.

**1.2.3 Modified Classification of Road System by Third Road development plan (1981 – 2001)**

The roads in the country are now classified into three classes

(i) Primary system

(ii) Secondary system

(iii) Tertiary system

Primary system consists of two categories of roads

(i) Express ways and

(ii) National Highways (NH)

Express ways are separated class of highways with superior facilities and design standards meant for very high volume traffic. These permit only fast moving vehicles.

The secondary system consists

(a) State highways (SH) and

(b) Major District Roads

The Tertiary system consists of

(a) Other District Roads (ODR) and

(b) Village Roads
1.2.4 Classification of Urban roads

The urban roads are classified as

(i) Arterial Roads
(ii) Sub – arterial roads
(iii) Collector streets and
(iv) Local streets

Arterial and sub arterial roads are the streets primarily for through traffic.

Collector streets collects and distributes traffic from and to local streets

1.3 Cross sections of Road Structure

Fig. 1.2 Cross sections of road structures

1.3.1 Sub Grade

The sub grade or soil sub grade is a layer of natural soil prepared to receive the layers of pavement placed over it. The sub grade should be sufficient strength so that the loads are received and dispersed to the earth mass. The sub grade should be well compacted under controlled conditions of optimum moisture content and maximum dry density. The sub grade supports the road structure and form the bed for the road.

1.3.2 Sub Base

Sub base or sub base course is a layer of granular material placed on sub grade, generally natural gravel. Boulder stone or bricks also may be used.
Functions of Sub base course

1. It reduces the traffic stresses on the sub grade and protects it.
2. Acts as a working platform for the construction of upper pavement layers.
3. Acts as a drainage layer by protecting the sub grade from wetting up.
4. Intercept the upward movement of water by capillary action.
5. It acts as a separating layer between subgrade and base course.

1.3.3 Base Course

Base course is a layer immediately under the weaning course. It is an important structural part of the road. It should be strong enough to bear the loads of the traffic. The material in a base course must be of extremely high quality. It must be well compacted.

1.3.4 Wearing Course or Surface Course

Wearing course is the top most layer of a road which is direct contact with the traffic. The purpose of the weaning course is to give a dense smooth riding surface. It resists the pressure exerted by tyres and takes up wear and tear due to the traffic. It acts as a water tight layer and prevents percolation of water.

1.3.5 Width of Pavement

The width of pavement or carriage way depends on the width of traffic lane and number of lanes. The carriage way intended for one line of traffic movement may be called as a traffic lane. The lane width is determined on the basis of the width of vehicle and the minimum side clearance provided for the safety. When the side clearance is increased there is an increase in speed of the vehicles and hence in increase in the capacity of the pavement. A width of 3.75 m is considered desirable for a road having single lane for vehicles of maximum width 2.44 m. For pavement having two or more lanes, width of 3.5 m per lane is sufficient.

1.3.6 Shoulders

Shoulders are provided along the road edge to serve as an emergency lane for vehicles to be taken out of the pavement. These also acts as service lanes for vehicles that have broken dawn. The minimum shoulder width recommended by the IRC is 2.5 m. The shoulders should have sufficient strength to support loaded even in wet weather. The surface of the shoulder should be
rougher than the traffic lanes so that the vehicles are discouraged to use the shoulder as a regular traffic lane.

1.3.7 Formation Width

Formation width or Road way width is the sum of the widths of pavements including separators if any and the shoulders formation width is the top width of the highway embankment on the bottom width of highways cutting excluding the side drains.

1.3.8 Right of Way

Right of way is the area of land acquired and reserved along its alignment for construction and development of a highway is known as right of way. A minimum land width is prescribed for different categories of road. The below table gives the minimum width of right of way for different categories of road.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Road Classification</th>
<th>Plains and Rolling Terrain</th>
<th>Mountaneous Terrain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open Area</td>
<td>Built up area</td>
<td>Open Area</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>Range</td>
<td>Normal</td>
</tr>
<tr>
<td>1</td>
<td>National and State highways</td>
<td>45 30-60</td>
<td>30 30-60</td>
</tr>
<tr>
<td>2</td>
<td>Major District Road</td>
<td>25 25-30</td>
<td>20 15-25</td>
</tr>
<tr>
<td>3</td>
<td>Other District Road</td>
<td>15 15-25</td>
<td>15 15-20</td>
</tr>
<tr>
<td>4</td>
<td>Village Road</td>
<td>12 12-18</td>
<td>10 10-15</td>
</tr>
</tbody>
</table>

1.3.9 Road Boundaries

The portion of the road beyond the road way can be generally called road boundaries.

Following are the road boundaries generally provided.

(i) Parking lanes
(ii) Bus bays
(iii) Service roads
(iv) Cycle track
(v) Foot path
(vi) Guard rails

(i) Parking lanes: Parking lanes are provided in urban roads for side parking.

(ii) Bus-bays: Bus-bays are provided by raising the kerbs for bus stops. They are provided so that they do not obstruct the movement of vehicles with carriage way.

(iii) Service roads give access to access controlled highways. Service roads run parallel to the highway and will be usually isolated by a separator and access to the highway will be provided at selected points.

(iv) Cycle track: Cycle tracks are provided in urban areas where the volume of cycle traffic is high. Minimum width of 2 metre is required.

(v) Foot paths: Foot paths are exclusive right of way to pedestrians especially in urban areas. They are provided for the safety of the pedestrians, where both the pedestrian traffic and vehicular traffic is high.

(vi) Guard rails: They are provided at the edge of the shoulder usually when the road is on an embankment. They serve to prevent the vehicles from running off the embankment, especially when the height of the embankment exceed 3 m.

### 1.4 Road for Different classification of Roads

| S.No. | Road Classification | Roadway width
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Plain terrace</td>
</tr>
</tbody>
</table>
| 1.    | National highways, State highways
       | (a) Single lane     | 12.0          | 6.25 |
       | (b) Two lane        | 12.0          | 8.80 |
| 2.    | Major District Road
       | (a) Single lane     | 9.0           | 4.75 |
       | (b) Two lanes       | 9.0           |      |
| 3.    | Other District Roads
       | (a) Single lane     | 7.5           | 4.75-|
       | (b) Two lanes       | 9.0           |      |
| 4.    | Village roads
       | (a) Single lane     | 7.5           | 4.00 |


### 1.5 Traffic Lane Width

<table>
<thead>
<tr>
<th>Class of Road</th>
<th>Width of the Carriage Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Single lane</td>
<td>3.75m</td>
</tr>
<tr>
<td>(ii) Two lanes, without raised kerbs</td>
<td>7.0 m</td>
</tr>
<tr>
<td>(iii) Two lanes, with raised kerbs</td>
<td>7.5 m</td>
</tr>
<tr>
<td>(iv) Intermediate carriage way</td>
<td>5.5 m</td>
</tr>
<tr>
<td>(v) Multi lane pavement</td>
<td>3.5 m per lane</td>
</tr>
</tbody>
</table>

The carriage way intended for one line of traffic movement may be called a traffic lane. The pavement may be of single lane, Two lane or multilane. The width of carriage way for various classes of Roads standardized by IRC are given in table above.

### 1.6 Camber

Camber is the cross slope provided to raise middle of the road surface in the transverse direction to drain off rain water from road surface. The camber is given a parabolic or elliptic or straight line shape in the cross section. The objectives of providing camber are

(i) Surface protection of roads especially for gravel and bituminous roads

(ii) Sub-grade protection by proper drainage

(iii) Quick drying of pavement which inturn increases safety.

Camber is measured in 1 in n or n % (eg. In 1 in 50 or 2%) and the value depends on the type of the pavement and the amount of rainfall.

### 1.6.1 Recommended IRC values of camber for different roads.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of Surface</th>
<th>Range of camber in areas of rainfall range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High type bituminous surfacing or cement concrete</td>
<td>1 in 50 (2%) to 1 in 60 1.7%</td>
</tr>
</tbody>
</table>
1.7 Gradient

Gradient is the rate of rise or fall along the length of the road with respect to the horizontal. It is expressed as a ratio of $1$ in $n$ (1 vertical unit to $n$ horizontal units). Some times, It is also expressed as a percentage, i.e. $n$ in 100.

In the alignment of a highway, the gradient is decided for designing the vertical curve. Very steep gradients are avoided as it is not difficult to climb the grade, but also the vehicle operation cost is not increased. The different types of highway gradients are

(i) Ruling gradient

(ii) Limiting gradient

(iii) Exceptional gradient

(iv) Minimum gradient

(i) Ruling gradient

It is the maximum gradient. The designer aims to provide a gradient within the ruling gradient. It is also known as design gradient. In selection of ruling gradient, several factors such as type of terrain, the length of the grade, the speed, the pulling power of vehicles and presence of horizontal curves are considered. The IRC has recommended ruling gradient values of 1 in 30 for plain and rolling terrain, 1 in 20 for mountainous terrain and 1 in 16.7 for steep terrain.

(ii) Limiting Gradient

In hill roads to reduce the earthwork, limiting gradients are to be adopted. Limiting gradient is the limit of steepest gradient. The IRC has recommended limiting gradient values of 1 in 20 for plain and rolling terrain, 1 in 15 for mountainous terrain.

(iii) Exceptional gradient

These gradient are steeper than the limiting gradient, which are provided
in exceptional cases. They are used only in very difficult situations where they cannot be avoided. IRC has recommended exceptional gradient values of 1 in 15 for plains and 1 in 12 for hills.

(iv) Minimum Gradient

When the drainage of a road is to be effected by means of longitudinal ditches, as in wet sections or hill roads, a certain minimum longitudinal gradient is necessary for efficient drainage. This minimum gradient depends on the type of side drains. If the side drains are lined it may be taken as 0.5% and if the side drains are not lined it is taken as 1%.

1.8 Super Elevation – Necessity

When a vehicle passes over a horizontal curve, it is subjected to centrifugal force which is equal to \( \frac{WV^2}{gR} \) acting at centre of gravity of the vehicle. This centrifugal force gives over turning moment to the vehicle. The centrifugal force also tends to push the vehicle off the road. It is resisted by the friction between the tyres and the road. If the friction is not sufficient the vehicle skids side ways.

In order to counter act the effect of the centrifugal force and to reduce the tendency of the vehicle to over turn, the outer edge of the pavement is raised with the respect to the inner edge, thus providing a transverse slope through out the length of the horizontal curve. This transverse slope to the pavement surface is known as super elevation or banking. The super elevation ‘e’ is expressed as the radio of the height of outer edge with respect to the horizontal width.

![Fig. 1.3 Superelevated pavement section](image)

From fig. 1.3 it may be seen that the super elevation, \( e = \frac{NL}{ML} = \tan \theta \)
Analysis of Super Elevation

The forces acting on the vehicle while moving on a circular of radius R metres at speed of \( V_m / \text{sec} \).

(i) The centrifugal force \( P = Wv^2 / gR \)

(ii) The weight of the vehicle = \( W \)

(iii) Frictional force between wheels vehicle and pavement.

![Fig. 1.4 Analysis of Super elevation](image)

Considering the equilibrium of the component forces acting parallel to the plan \( P \cos \theta \), \( w \sin \theta \) and the frictional force \( F_A \) and \( F_B \).

\[
P \cos \theta = w \sin \theta + F_A + F_B
\]

The limiting equilibrium is reached when the full values of the frictional forces are developed and the values of \( F_A \) and \( F_B \) reach their maximum value of \( F \times R_A \) and \( f \times R_B \) respectively. Where ‘\( f \)’ is the coefficient of lateral friction and \( R_A \) and \( R_B \) are the normal reactions at wheels A and B.

Therefore \( P \cos \theta = w \sin \theta + f (R_A + R_B) \)

\[
= w \sin \theta + f (w \cos \theta + P \sin \theta)
\]

\[i.e \ P(\cos \theta - f \sin \theta) = w \sin \theta + fW \cos \theta\]
Dividing by \( W \cos \theta \)

\[
P/W (1 – f \tan \theta) = \tan \theta + f
\]

\[
P/W = \tan \theta + f / (1 - f \tan \theta)
\]

\[
1 - f \tan \theta = 1 \text{ as}
\]

\[
P/W = \tan \theta + f = e + f
\]

But \( P/W = V^2 / gR \)

Therefore \( e + f = V^2 / gR \)

Here \( e = \) rate of super elevation

\( f = \) friction coefficient = 0.15

\( v = \) Speed of the vehicle, m/sec

\( R = \) Radius of the horizontal curve, m

\( g = \) acceleration due to gravity = 9.8 m/sec²

If the speed of the vehicle represented in V Kmph

\[
e + f = (0.278 V)^2 / 9.8 R = V^2 / 127 R
\]

\[
e + f = V^2 / 127 R, \text{ If the friction in neglected}
\]

\( f = 0 \) the super elevation required to counteract the centrifugal force fully

given by

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**Short Answer Type Questions**

1. Write types of roads as per ISI classification.
2. What is a National highway?
3. What is state highway?
4. What is a MDR?
5. What is a ODR?
6. What is a VR?
7. Give the classification of urban roads.
8. What is sub grade?
9. What is sub base course?
10. What is surface course?
11. Write any two functions of sub base course.
12. What is shoulder?
13. What is formation width?
14. What is right of way?
15. What is camber?
16. Write any two objectives of camber.
17. What is gradient?
18. Write types of gradients.
19. What is ruling grading?
20. What is exceptional gradient?
21. What is super elevation?
22. What is minimum gradient?

**Long Answer Type Questions**

1. Explain the importance of traffic engineering.
2. Explain IRC classification of roads.
3. What is gradient and explain classification of gradient?
4. Draw the diagram of cross section of road structure and explain the following in brief.
   
   (a) Sub grade  (b) Sub base  (c) Base course
5. What is super elevation? Derive expression of super elevation.
6. What is super elevation? and explain importance of super elevation.
UNIT 2

Highway Survey and Traffic Engineering

Structure

2.1 Alignment
2.2 Factors influencing alignment of roads in plain and hilly areas
2.3 Surveys – Reconnaissance - Preliminary and final location survey
2.4 Road Junctions or Intersections
2.5 Traffic Islands
2.6 Traffic Signs

Learning Objectives

After studying this unit, the student will be able to understand

• What is alignment of roads
• The basic requirement of alignment
• Factors influencing the alignment of roads
• About surveys required for alignment of road
• Traffic islands and types of traffic islands
• Traffic signs and different types
• About road markings
2.1 Alignment

The position or the layout of the centre line of the highway on the ground is called the alignment. The horizontal alignment includes the straight path, the horizontal curves. The vertical alignment of roads include changes in gradient and vertical curves. Alignment of a new road should be done carefully. If it is not properly aligned it results in the following disadvantages.

(a) Increase in construction cost
(b) Increase in maintenance cost
(c) Increase in vehicle operation cost
(d) Increase in accident rate.

The basic requirements of alignment between two stations are that it should be

(a) Short
(b) Easy
(c) Safe and
(d) Economical

2.2 Factors influencing alignment of roads in plain and hilly area

There are a number of factors which are to be considered while selecting the alignment of roads. These factors also vary according to the type of roads and the areas through which these roads pass.

2.2.1 Factors influencing alignment of roads in plain areas.

Following are the factors which control the alignment of roads in plain areas.

(1) Class and Purpose: The alignment of the road may be decided, keeping in mind the class and purpose of the road. National and state highways between two stations should be aligned as straight as possible. In other type of roads, if it is necessary the deviation may be permitted. If it is found necessary.

(2) Obligatory Points: The roads are basically constructed for the development of the areas. Their alignment should necessarily pass through important towns, group of villages and places of workship, social, political and commercial importance.
(3) **Type of vehicular Traffic**: For fast moving traffic, the road alignment should be as straight as possible where as in case of bullock carts, tongas etc, the alignment may even have sharp bunds.

(4) **Gradient**: The alignment of roads should be such that longitudinal slopes are not steeper than ruling gradient. For this, alignment may be deviated from straight path.

(5) **Horizontal Curve**: The alignment should be provided with flat curves where ever found necessary. In case of national and state highways the radius of horizontal curves should not be less than 230 m. To have minimum radius the alignment must be changed.

(6) **Sight Distance**: The alignment should be such that minimum sight distance is available for the drivers of the vehicles.

(7) **Obstruction**: The alignment is decided, keeping in mind the obstructions. The alignment should be changed to avoid marshy land, ponds, wells, grave yards, historical, monumental and religious places etc.

(8) **Cross Drainage Works**: The alignment should be such that minimum number of cross drainage works are required.

(9) **Formation Bed**: The alignment should pass through such areas which provide good formation bed.

(10) **Bridges**: While crossing a river, the site should provide all the requirements needed for a good bridge construction. The alignment of the road should cross the river at 90° to avoid skew bridges.

(11) **Railway Crossing**: A road alignment should cross a railway line preferably at 90°.

(12) **Earth work**: Alignment should be such that there is minimum earth work in cutting or filling.

(13) **Agricultural land and dense forests**: In alignment of road, the agricultural land and dense forest should be avoided as far as possible.

### 2.2.2 Special considerations in alignment of hilly roads

In alignment of hill roads, special care should be taken to align the road along the side of the hill which is stable.

**Drainage**: Hill side drains should be provided for adequate drainage facility across the road.
Geometric Standards: The alignment of the hill road should be selected on the hill slope which easily provide recommended geometric standards. Hairpin bends should be avoided and if found necessary, these should be on gentle and stable slopes.

Resisting Length: The resisting length of the alignment should be kept as low as possible.

2.3 Surveys: Reconnaissance - Preliminary and final location survey

Before a highway alignment is finalized in a highway project, the following engineering surveys are to be carried out.

The stages of engineering surveys are

(a) Reconnaissance survey
(b) Preliminary surveys
(c) Final location surveys.

(a) Reconnaissance Survey: It is a rapid and rough survey both visual and instrumental over the area lying between the terminals of a proposed road. In this survey, the physical characteristics of the area are inspected and most feasible routes are decided for detailed studies. Only simple instruments like abney level, tangent clinometers, barometer etc., are used to collect the details not available in the map and are noted down. Following are some of the details to be collected during reconnaissance survey.

(i) Valleys, ponds, lakes, hills, permanent structures along the route.
(ii) Approximate values of geometrics
(iii) Number and type of cross drainage works, natural ground water level along the routes.
(iv) Soil types and observation of geological features.
(v) Sources of construction materials etc.

(b) Preliminary Survey: This is an accurate open traverse survey done over the narrow strip of land selected. Steel tape or chain is used to measure the distances and the offsets. A transit Theodolite is used to measure angles. For filling in details, a plane table survey or tacheometric survey is done. The total land width to be acquired for the route is then decided. Then the necessary plans and a rough estimate for the cost of the road and its ancillary works are
prepared. If the preliminary survey is made for two or more routes, the economic route is selected after comparing different proposals in view of the requirements of a good alignment.

(c) Final Location Survey: After the proposed route is marked on the plan, it is then set out on the ground by a theodolite. The centre line of the road is marked. The longitudinal leveling and the cross sectional leveling are carried out. Fly leveling may also be done to check levels. Bench marks must be left at 0.5m intervals and at places where bridges tunnels, level crossings and cross drainage structures are located. The longitudinal sections and cross sections along the route are then prepared. After the detailed survey works, the final plans, designs and detailed estimates are prepared and the probable cost for the construction of the road and its ancillary works are found out.

2.4 Road Junctions or Intersections

Roads cross each other or join with one another. Road junctions are places where two or more roads meet or cross each other at different angles. At the junctions the capacity as well as the speed of traffic of intercepting roads are affected. There are merging, crossing and diverging movements of vehicles.

Road Junctions not only cause serious interruptions to the flow of vehicles from approach roads, they are also the sources of potential danger to both vehicular and pedestrian traffic. For safe movement of traffic and junctions must be well planned and designed considering traffic volume, turning movements and availability of area.

Streams of Traffic, Demand Primary consideration in the design of junctions

To design a simple traffic junction, it is necessary to know the number of approach roads and their widths along with their layout plan.

The following points should be kept in mind while planning and designing a road junction.

(i) The junctions or intersections should be as far as possible at right angles.

(ii) The traffic in the main road should be independent and the traffic from the branch road be diverted.

(iii) At the junction, proper visibility should be provided.

(iv) When more than three roads cross at a junction, round about or road islands should be provided.
2.4.1 Road Intersection

Road intersections can be classified as

(i) Square junctions
(ii) Acute or Skew junctions
(iii) T-Junctions
(iv) Y – Junctions
(v) Staggered Junctions
(vi) Multiple junctions

These junctions have their own advantages and disadvantages.

(i) Square junctions: In square junction, two roads cross each other at right angle.

(ii) Acute or Skew Junction: In acute junction, two roads cross each other at an angle other than right angle.

(iii) T – Junction: In a T – junction one road joins another road at right angles.
(iv) **Y – Junction**: In a Y – junction, two roads meet but do not cross at right angle.

![Fig. 2.4 Y - Junctions](image)

(v) **Staggered junction**: When two roads meet another road on either sides at right angles. It is called staggered junction.

![Fig. 2.5 Staggered Junctions](image)

(vi) **Multiple Junction**: When more than two roads meet, the junction is called as multiple junction.

![Fig. 2.6 Staggered Junctions](image)
2.5 Traffic Islands

Traffic islands are raised areas constructed within the roadway to establish physical channels through which the vehicular traffic may be guided. These are also called as Rotaries or Roundabouts.

Traffic islands are provided when two or more roads of equal importance are crossing each other and to avoid crossing at right angles.

Following are the different types of traffic islands.

(i) Circular
(ii) Elliptical
(iii) Rhombus
(iv) Turbine and
(v) Tangent shape.

(i) **Circular Island**: Circular island is suitable when two roads of equal importance and of equal width intersect with each other.

(ii) **Elliptical Island**: Elliptical island is adopted where the traffic on one road is more than the traffic on another road.

(iii) **Rhombus Island**: This is similar to the elliptical island but in rhombus shape.

(iv) **Turbine Island**: In turbine island, the traffic is forced to slow down while entering the rotary as it has to take a left hand turn. The traffic leaves through a tangential exit.
Fig. 2.9 Rhombus Island

Fig. 2.10 Turbine Island

Fig. 2.11 Tangent Island
(v) **Tangent Shape Island**: In Tangent shape island the traffic from more than two roads enter a rotary and leave it tangentially.

### 2.6 Traffic signs

Traffic signs or road signs are traffic aids or traffic devices. They are planned, designed and erected, for the purpose of regulating, warning and guiding the traffic.

Traffic signs must attract the visual attention of the driver at a range greater than the reaction distance. Size, shape, colour of signs and lettering are very important for their effectiveness. Symbols are more valuable in aiding rapid message than letters.

#### 2.6.1 Types of Traffic signs

According to Indian motor vehicles Act, Traffic signs have been divided in to three types. These are (i) Regulatory signs (ii) Warning signs and (iii) Informatory signs.

**(i) Regulatory Signs**: Regulatory signs are meant to inform the road users of certain laws, regulations, and prohibitions. The regulatory signs are of the following types.

(a) Stop and Give-way signs

(b) Prohibitory signs

(c) No parking signs

(d) Speed limit and vehicle control signs

(e) Compulsory direction control and other signs.

**(a) Stop and Give way signs**: The stop sign is intended to stop the vehicles on a road way. It is octagonal in shape and red in colour with a white border. The Give-way sign is used to control the vehicles on a road so as to assign right of way to traffic on other road ways. This sign is triangular in shape with a apex downwards and white in colour with a red border. These are shown in figure.

![Fig. 2.13 Stop and Giveway signs](image_url)
(b) Prohibitory signs: Prohibitory signs are meant to prohibit certain traffic movements, use of horns, or entry of certain vehicles. These are circular in shape, and white in colour with a red border. The common prohibitory signs are straight prohibited, no entry, one-way over taking prohibited, right/left turn prohibited, U-turn prohibited.

Fig. 2.14 Prohibitory Sign
(c) No Parking and No Stopping signs: No parking signs are meant to prohibit parking of vehicles at that place. The NO parking signs is circular in shape with a blue background, a red border and an oblique red bat at angle of 45°. No stopping sign is meant to prohibit stopping of vehicles at that place.

![Fig. 2.15 No Parking and No Stopping signs](image)

(d) Speed Limit and Vehicle Control Signs: These signs are meant to restrict the speed of all or certain classes of vehicles on a particular stretch of a road. These signs are circular in shape and have white background, red border and black numerals indicating the speed limit. In vehicle control signs symbols are used instead of numerical. The common controls are width limit, height limit, length limit, load limit and Axle load limit.

![Fig. 2.16 Speed limit sign](image)

(e) Compulsory Direction Control Signs: These signs are indicated by arrows, the appropriate directions in which the vehicles are to be proceed.
(ii) **Warning Signs**: Warning signs are used to warn the road users of certain hazardous conditions that exists on or adjacent to the road way. These signs are in shape of equilateral triangle with its apex pointing upwards. They have white background, red border and black symbols. The warning signs are to be located at sufficient distance in advance of the hazard. The common warning signs are Right / Left hand curve, Hair pin bend, Narrow bridge, School Zone and Men at work etc.
(iii) Informatory Signs: These signs are used to guide the traffic along routes, inform them of destination and distance and provide with information to make travel easier, safe and pleasant. The information signs are of the following types.

(a) Direction Signs
(b) Facility information signs
(c) Parking signs
(d) Flood gauges

Below figure shows some of informatory signs.

![Informatory sign](image)

Fig. 2.19 Informatory sign
2.7 Pavement Marking and Kerb marking

Road marking are special signs intended to control, warn guide or regulate the traffic. The marking are made of lines, patterns, words, symbols within or near the roadway. The markings are made using paints in contrast with colour and brightness of the pavement.

2.7.1 Pavement Marking

Pavement or carriage way markings may generally be of white paint. Yellow colour markings are used to indicate parking restrictions and for the continuous centre line markings. Longitudinal solid lines are used as guiding or regulating lines. Transverse solid lines indicate the position of stop lines for vehicular traffic.

Some of the common types of pavement markings are

(a) Centre lines
(b) Lane lines
(c) Turn marking
(d) Stop lines
(e) Cross walk lines
(f) Approach to Obstructions
(g) Parking space limit
(h) Border or lines
(i) Bus stops

Fig. 2.20
Fig. 2.21 Different Pavement markings
2.7.2 Kerb Markings: These markings are provided to indicate certain regulations like parking regulations. The markings on the kerb with alternate black and yellow line increase the visibility from a long distance.

![Fig. 2.22 Different kerb markings](image)

### Short Answer Type Questions

1. What is alignment of road?
2. Write the basic requirement of alignment of road
3. What is preliminary survey?
4. What is final location survey?
5. Write various types of engineering surveys.
6. What is road intersection?
7. Write the different types of road intersections.
8. What is traffic island?
9. Write about different types of traffic islands.
10. What are traffic signs?
11. What are regular signs?
12. What are prohibitory signs?
13. What are informatory signs?
14. What are road markings?

### Long Answer Type Questions

1. Explain factors influencing road alignment.
2. Explain various engineering surveys in detail.
3. Explain various road junctions in detail.
4. Explain various traffic islands in detail.
5. Explain various traffic signs in detail.
UNIT 3

Highway Construction and Maintenance

Structure

3.1 Purpose of Road Drainage
3.2 Surface and Sub surface Drainage
3.3 Typical cross section of highway in cutting and embankment
3.4 Water bound macadam roads
3.5 Bitumen roads
3.6 Premix - methods
3.7 Cement concrete roads

Learning Objectives

After studying this unit, the student will be able to understand

• About road drainage system
• About WBM road and how to construct WBM roads
• About premix and different premix methods.
• Construction procedures of various bituminous roads.
• About cement concrete roads, and various joints in C.C roads.
3.1 Purpose of Road Drainage

Highway drainage is the process of removing and controlling excess surface and sub-surface water within the right of way. The provision of suitable surface and sub-surface drainage system is an essential for design and construction of highways.

Following are the purposes of road drainage:

(a) Prevent softening of the road surface
(b) Prevents formation of ruts on road surfaces
(c) Prevents erosion of surface, side slopes of formation
(d) Prevents the subgrade from losing its bearing capacity

3.2 Surface and Sub-Surface Drainage

3.2.1 Surface Drainage

The surface water is to be collected and the water to be disposed off. The water is first collected in side drains and then the water is disposed off at the nearest stream.

The following are provided for effective surface drainage:

(a) Impervious road surface
(b) Camber and longitudinal gradient
(c) Side drains to collect water
(d) Kerb grades in urban roads

3.2.2 Sub Surface Drainage

The strength of sub-grade depends upon its moisture content. Changes in the moisture content of subgrades are caused by ground water table, seepage flow, percolation of rain water and movement of capillary water. In sub-surface drainage system of highways, it is needed to see that the variation of moisture content in subgrade soil is minimum. It is done by the following measures:

(a) Controlling seepage flow by providing intercepting drains.
(b) Lowering the water table to a depth at least 1.2 m from the road structure. This is achieved by providing longitudinal and lateral sub soil drains.
(c) By using porous sub base the water percolating through the road surface is drained off.

(d) By producing surface dressing to the formation.

3.3 **Typical cross section of highway in cutting and embankment**

The following figures shows the typical cross section of roads in embankment in cutting and both in embankment and cutting.

![Fig. 1.1 Cross section of Road in Embankment](image1.png)

![Fig. 1.2 Cross section of a hill road](image2.png)
3.4 Water Bound Macadam Roads

Water bond macadam roads consists one or more courses of coarse aggregate whose voids are partially filled with finer material usually gravel. The whole mass is inter-locked together with angular fragments and rolling. Water is added to make the gravel a slurry. This slurry fills the voids and keeps the aggregate in the inter locked position. The details of water bound macadam road is shown in fig. below.

The structure of the water bond macadam road consists of the following.

(i) A foundation course of boulder stones placed on the compacted subgrade to thickness of about 25 cms

(ii) A gravel layer of thickness 6 mm to 12 mm is placed at the top.
3.4.1 Construction procedure of Water Bond Macadam

(i) Preparation of foundation for receiving the WBM course

The foundation for receiving the new layer of water bound macadam may be either the subgrade or sub-base or base course. To this foundation layer required camber and grade are provided and the dust and other loose materials are removed.

(ii) Provision of Lateral Confinement

Lateral confinement is done by constructing the shoulders in advance. Thickness of the shoulders are equal to that of compacted water bound macadam layer. The inner sides of the shoulders trimmed vertically.

(iii) Spreading of course aggregate

The coarse aggregates which are stored along the road are spread uniformly and evenly upon the prepared base in required quantities. The aggregate should be spread to proper profile by using templates placed across the road about 6 m apart.

(iv) Rolling

After spreading the course aggregate properly, compaction is done by a three wheeled power roller of capacity 6 to 10 tonnes. Rolling is started from the edges, the roller being run forward and backward until the edges are compacted. The run of the roller is then gradually shifted towards the centre line of the road, uniformly overlapping each proceeding rear wheel track by one-half width. This process is repeated until required compaction is achieved.

On super elevated portions of the road, rolling is started from the inner edge and progressed gradually towards outer edge of the road.

(v) Application of screenings

After rolling, screenings are applied over the surface to fill the voids in three or more applications, after screenings are applied dry rolling should be continued.

(vi) Sprinkling and Grouting

After the application of screenings, the surface is sprinkled with water, swept and rolled. Wet screenings are swept into voids using hand brooms. Additional screenings are applied and rolled till the coarse aggregates are well bonded and firmly set.
(vii) Application of binding material

Binding material is applied after the application of screenings. Binding material is applied at a uniform slow rate in two or three thin layers, after application of binding materials, the surface is sprinkled with water and slurry swept with brooms to fill the voids. This is followed by rolling with a 6 to 10 tonne roller.

(viii) Setting and Drying

The surface is allowed to set over night. If depressions are found on the next day, they are filled up with screenings or binding material if necessary after lightly sprinkling with water they are rolled.

3.4.2 Material used in Water Bound Macadam Road Construction.

In the construction of WMB road the following materials are used

i. Coarse aggregate

ii. Screenings

iii. Binding material

i. Coarse aggregate : The coarse aggregate used in WBM road consists of hard varieties of crushed aggregates or broken stones. Soft aggregates like over burnt bricks, kankar or laterite may be used. Slag from blast furnace may also be used.

Indian Roads Congress (I.R.C) has specified the following physical requirements of coarse aggregate for WBM construction.

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirements for pavement layer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sub-base</td>
</tr>
<tr>
<td>(i) Los Angles abrasion value (maximum value, percent)</td>
<td>60</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>(ii) Aggregate impact value (maximum value, percent)</td>
<td>50</td>
</tr>
<tr>
<td>(iii) Flakiness index (maximum value, percent)</td>
<td>-</td>
</tr>
</tbody>
</table>

Properties of Coarse Aggregates
The crushed aggregates for layer of construction should be well graded to any one of the three grades shown in below table.

<table>
<thead>
<tr>
<th>Grading No.</th>
<th>Size range, mm</th>
<th>Sieve size, mm</th>
<th>Percent passing the sieve by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90 to 40</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80</td>
<td>65 - 85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>63</td>
<td>25 - 60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
<td>0 - 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>0 - 5</td>
</tr>
<tr>
<td>2</td>
<td>63 to 40</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>63</td>
<td>90 - 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>30 - 70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
<td>0 - 15</td>
</tr>
<tr>
<td></td>
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<td>20</td>
<td>0 - 5</td>
</tr>
<tr>
<td>3</td>
<td>50 to 20</td>
<td>63</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>95 - 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
<td>35 - 70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>0 - 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>0 - 5</td>
</tr>
</tbody>
</table>

Thickness of each layer for grading no. 1 is more than 90 mm and is more suitable for sub base. The thickness of each layer for grading no 1 is usually 90 mm and for the grading no. 3 is 75 mm.

ii. Screenings

The screenings are used to fillup the voids in the compacted layer of coarse aggregates. The screenings are aggregates of smaller size generally of the same material as the coarse aggregates. The grading requirement of screening of WBM construction are given below.

IRC has suggested the following requirement for screenings.

(1) The plastic limit should be less than 20 %
(2) The plasticity index should be less than 6 %
(3) The portion of fine passing 0.075 mm size screening is less than 10%
iii. Binding Material

Binding material consisting of fine graded material used in WBM construction to prevent raveling of the stones. Kankar nodules or lime stone dust may be utilized as the binding material. If the screenings used consists of morrum or soft gravel, there is no need to use binding material.

3.4.4 Machinery used in the construction of W.B.M road

Following machines are used in the construction of water bond macadam (WBM) road.

i. For the site clearance : Bull dozer, scraper, Showels

ii. For Conveyance and spreading of Coarse Aggregates : Dumpers and Graders

iii. For rolling – Flat wheeled roller

iv. For brooming – Mechanical brooms.

3.4.5 Maintenance of WBM road

WBM roads are damaged rapidly due to the heavy mixed traffic and adverse climatic conditions. In dry weather dust is formed and during rains mud is formed. The steel tyred bullock carts cause severe wear and tear to the WBM surface.

<table>
<thead>
<tr>
<th>Grading No.</th>
<th>Size range, mm</th>
<th>Sieve size, mm</th>
<th>Percent passing the sieve by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12.5</td>
<td>12.5</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>90 - 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.75</td>
<td>Oct-30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.15</td>
<td>0 - 8</td>
</tr>
<tr>
<td>B</td>
<td>10.0</td>
<td>10.0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.75</td>
<td>85 - 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.15</td>
<td>10 - 30</td>
</tr>
</tbody>
</table>
The maintenance of WBM roads consists
- Replacing the soil binder periodically to prevent the aggregate from getting loosened from the surface course.
- Providing bituminous surface dressing to prevent dust.
- Patch work of pot holes and ruts formed. The patch repair work is carried out by first cutting at a rectangular shape of the defective area. Then with the coarse aggregate of the same size the patch is filled up and well compacted.

### 3.5 Bitumen roads

#### 3.5.1 Introduction

Bitumen road is a road constructed by bitumen. Bitumen is black viscous mixture of hydrocarbons obtained by distillation of petroleum. Previously Tar was also used in construction of bituminous roads, as the tar was susceptible for high temperatures, bitumen replaced tar in road construction. Bitumen roads are flexible pavements consists of sub grade, sub-base course, base course and a bituminous surface course.

#### 3.5.2 Types of Bitumen roads

Number of types and methods are in use for bituminous pavement construction. Following are the types of bitumen roads based on the methods of construction.

i. Interface treatments like prime coat and tack coat.

ii. Surface dressing

iii. Seal coat

iv. Grouted or penetration type constructions.
   (a) Full grout
   (b) Semi grout constructions

v. Premix construction

#### 3.5.3 Interface Treatment

Before construction of any type of bituminous layer over a surface, the surface of the existing pavement layer is to be cleaned and a thin layer of bituminous binder is to be sprayed. This treatment with bituminous material is called interface treatment and it is necessary to provide the bond between the
old and the new layers. The interface treatment may be either a prime coat or
tack coat and in some cases, the prime coat followed by a tack coat.

a. **Prime Coat**: Prime coat is the first application of a low viscosity
liquid bituminous material over an existing porous pavement surface like the
WBM base course. The main object of prime coat is to plug the voids of the
porous surface and to bond the loose mineral particles on the existing surface,
using a binder of low viscosity which can penetrate into the voids. The prime
coated surface is allowed to cure for at least 24 hours.

b. **Tack Coat**: Tack coat is the application of bituminous material over
an existing pavement surface which is relatively impervious like an existing
bituminous surface or a WBM surface which has already been treated by a
prime coat.

3.5.4 Surface Dressing

Bituminous surface dressing is provided over an existing pavement to
serve as thin wearing course. The single coat surface dressing consists of a
single application of bituminous binder material followed by spreading of aggregate
cover and rolling. If the surface dressing is done in two layers, it is called two
ccoat bituminous surface dressing. The main purpose of bituminous surface
dressing are:

(a) To serve as wearing course and to protect base course
(b) To prevent infiltration of surface water
(c) To provide dust free pavement surface in dry weather and mud-free
pavement in wet weather.

3.5.5 Seal Coat

Seal coat is a very thin surface treatment or a single coat surface dressing
which is usually applied over an existing black top surface. Seal coat is usually
recommended as a top coat over certain bituminous pavements which are not
impervious. The main functions of seal coat are

(a) To seal the surface against percolation of water
(b) To develop skid resistant texture
(c) To improve an existing dry or weathered bituminous surface.

3.5.6 **Grouted or Penetration macadam**

Bituminous grouted Macadam or penetration macadam is used as a
base or binder course. The coarse aggregates are first spread and compacted
well in dry state and after that hot bituminous binder of relatively high viscosity is sprayed in fairly large quantity at the top. The bitumen penetrates into the voids from the surface of the compacted aggregates, the bitumen fills the voids and binds stone aggregates together.

Depending upon the quantity of bitumen spread and the extent of penetrated the gourted macadam are two types (a) full grout and (b) Semi grout

(a) Full grout : When bitumen penetrated to full depth of compacted aggregate it is called full grout macadam. Full grout is adopted in regions of heavy rainfall and high traffic.

(b) Semi-grout : When bitumen penetrates upto about half depth of compacted aggregate it is called semi-grout macadam. Semi grout macadam is adopted in regions of moderate rainfall and traffic.

3.6 Premix – Methods – Construction procedure

3.6.1 Premix

The aggregates and the bitumen are mixed thoroughly before spreading and compacting. It is possible to coat each aggregate particle with less quantity of bitumen binder.

The following are common premix methods.

(a) Bituminous macadam

(b) Bituminous carpet

(c) Bituminous Concrete or Asphalt concrete

(d) Sheet Asphalt.

3.6.2 Construction procedure of Bituminous Macadam

The Bituminous Macadam (BM) is a premix laid immediately after mixing and then compacted. It is suitable only as a base course or binder course. When this course is exposed as a surface course, at least a seal coat is necessary. The construction procedure consists following steps:

i. Preparation of existing layer : The existing layer is prepared to a proper profile. Pot holes are patched and irregularities are made free. The surface is cleared and made form dust and other organic material.

ii. Tack coat application : A tack coat is applied in thin layer of bitumen binder with the help of mechanical sprayer or a pouring can.
iii. Preparation of Premix: The bitumen and aggregates as per recommended gradings are separately heated to the specified temperatures and are placed in the mixer. The mixing temperatures also specified. The mixing is done till a homogenous mixture is obtained. The mixture is then carried to the site for its placement.

iv. Placement: The premix mixer is then immediately placed on the desired location and is spread to specified thickness. The camber profile is checked with a template. It should be seen that minimum time is spent between the placement of the mix and the rolling operation.

v. Rolling and finishing the paving mix: The rolling is done with 8 to 10 tonnes tandem roller. The rolling is started from the edges towards the centre and uniform overlapping is provided. The finished surface should not show separate lines of markings due to the defective rolling. The roller wheels are kept damp, otherwise the paving mix may stick to the wheels and finishing may not be good.

3.6.3 Construction Procedure of premixed bituminous carpet

This premixed bituminous carpet usually laid on the base as wearing course.

The construction of bituminous carpet is as follows

i. Preparation of the road surface: Before the carpet is applied to the existing layer, it is necessary to fill the pot holes or depressions with precoated chippings. The surface is to be cleaned.

ii. Application of tack coat: The bitumen is heated to a specified temperature and it is applied on the existing pavement surface just before spreading the premix.

iii. Preparation of premix: Premix should be prepared in a central mixing plant or in mechanical mixture at the site. The aggregate and the bitumen are heated separately up to the required temperature. After the thorough mixing and homogenous mix is obtained, the mix is taken out and carried at the site for spreading and rolling. The camber of the laid material is checked with templates.

iv. Rolling: Immediately after spreading the mix, the rolling is started. At one operation 15 m of the premix is laid and rolled. A tandem or pneumatic roller of 6 to 9 tonnes is used.

v. Application of seal coat: In high rainfall areas, seal coat is laid with premix of 6 mm size chippings or coarse sand with bitumen. In low rainfall areas the seal coat is laid with premix of medium coarse sand and bitumen.
vi. **Surface finish**: The surface finishing is to be checked for cross profile. If there are any depressions they are to be rectified.

vii. **Opening to Traffic**: The road surface may be opened to traffic after 24 hours of laying of seal coat.

### 3.6.4 Construction procedure of bituminous concrete

The bituminous concrete is the highest quality of construction of bituminous roads. The bituminous mixes are properly designed to the specification. The mixture contains dense course aggregate, fine aggregate and mineral filler coated with bituminous binder. The mix is prepared in hot-mix plant.

**Construction Steps**

i. **Preparation of the existing base course layer**: The base course is made true to camber and grade. Pot holes and depressions are filled with premix chippings.

ii. **Application of Tack coat**: The heated bitumen is sprayed at 6.0 to 7.5 kg per 10 m² area, just before spreading the premix.

iii. **Preparation and placing the premix**: The premix is prepared in hot mix plant with the desired quality. The hot mixed material is collected from the mixer by the transporters, carried to the location and is spread by a mechanical paver. The camber and the thickness of the layer are accurately checked.

iv. **Rolling**: After placing the mix on the base course, it is rolled and thoroughly compacted by 8 to 10 tonnes wheeled roller at a speed not more than 5 km per hour. The wheels of the roller are kept damp with water. The number of passes required depends on the thickness of the layer.

v. **Finishing and opening to traffic**: The surface is to be checked for camber and depressions if any are rectified.

vi. **Opening to traffic**: The surface is to be opened to traffic after 24 hours of laying the finished surface.

### 3.6.5 Sheet Asphalt

Sheet Asphalt is a dense sand – bitumen premix of compacted thickness of 25 mm used as a wearing course. This is usually laid over cement concrete pavement to provide an excellent riding surface. The construction procedure is as follows.

i. **Preparation of surface**: The surface is cleaned.
ii. **Application of Tack coat**: The bitumen binder is heated to the required temperature and sprayed on the surface first before the spreading of sheet asphalt.

iii. **Preparation of premix**: Graded dry sand, filler and bitumen are mixed in the mixer and the temperature is maintained between 135°C to 177°C.

iv. **Spreading the sheet Asphalt**: The prepared mix of sheet asphalt is conveyed and it is immediately placed on the road surface. Camber and grades are to be checked.

v. **Rolling**: The surface is to be rolled with a 10 tonne roller. The rolling should start from the sides and proceed towards the crown. In case where super elevation is provided, the rolling should start form inner edge and proceed towards the outer edge.

vi. **Finishing and Opening to Traffic**: The surface is to be checked for camber and if there are any depressions they are to be rectified. The surface is to be opened to traffic after 24 hours of laying of sheet asphalt.

3.7 **Cement Concrete Roads**

The cement concrete roads have a very high recognition due to the excellent riding surface and pleasing appearance. The life of the cement concrete road is much more than any other type of road. The maintenance cost of the concrete road is very less when compared with other roads.

The cement concrete roads requires very high initial investment and the method is not suitable for stage construction. The cement concrete roads are constructed with or without the sub-base course.

The construction of cement concrete roads is carried out in the following groups.

1. Construction of pavement (Road) Slab
2. Construction of joints.

3.7.1 **Types of construction of cement concrete roads**

The following are the two methods of construction of CC roads.

i. Alternate bay method

ii. Continuous bay method.

i. In alternate bay method, alternate concrete slabs are laid. The subsequent slabs are laid subsequently.
In alternate bay construction, the slabs constructed are in sequence of AB’Cs etc. leaving gaps of bay A’ B and C’ etc.

ii. Continuous bay method: In this may all the slab bays are laid in sequence ie. ABC or A’B’C’.

### 3.7.2 Construction of Cement concrete slabs

Following are the steps in construction of C.C. slabs.

i. Preparation of sub grade and sub base

ii. Placing of forms

iii. Batching of material and mixing

iv. Transportation and placing of concrete

v. Compaction and finishing

vi. Curing of cement concrete.

#### i. Preparation of sub grade and sub base

The sub grade or sub base for laying the concrete should be well compacted as per the requirement and should extend at least 300 mm on either side of the width to be concreted. The sub grade should be prepared and checked at least two days before the concreting pipes of the sufficient diameter and provided where ever cables are taken across road.

#### ii. Placing of Forms

The wooden or steel forms are used for the purpose. Wooden forms are dressed on one side and have minimum width of 100 mm for slab thickness of 200 mm. Depth should be equal to the thickness of the pavement. The forms
are joined neatly and are set true to the required grade and alignment. The forms should be rigidly fixed such that they do not deviate during the entire operation compacting and finishing. The tolerance allowed may be 3 mm from a straight edge 3 m in length.

The steel forms are of usually M.S. channel sections and their depth should be equal to the thickness of the pavement. When set to grade the maximum deviation of the top surface of any section from a straight line is not exceeded by 3 mm.

**iii. Batching of material and mixing**

The fine aggregate and coarse aggregates for the concrete should be properly proportioned by weight in a weight batching plant and placed in to the hopper along with the necessary quantity of cement. The mixing of concrete is done in batch, which will ensure a uniform distribution of the materials throughout the mass, so that the mix is uniform in colour and homogenous.

**iv. Transportation and placing of concrete**

The cement concrete should be mixed in quantities required for the immediate use. The concrete should be placed within the form work correct to the depth. While placing there should be no bleeding and segregation. The mix concrete should be placed within 30 minutes.

**v. Compaction and Finishing**

The surface of the pavement is compacted either by means of a power driven finishing machine or by a vibrating hand screed. For areas where the width of the slab is very small, hand compaction and finishing may be adopted. As soon as the concrete is placed, it should be uniformly spreaded to the required cross section of the pavement to conform the grade.

**(a) Floating and Straight Edging**

The concrete is further compacted by means of longitudinal float. The longitudinal float which is 1.2 m long and 75 mm wide wooden log held in position parallel to carriage way centre line and passed gradually from one side of a pavement to other. After the compacted the surface is tested for grade and level with straight edge.

**(b) Belting** : Just before the concrete becomes hard, the surface is bolted with a two ply canvas belt. The short strokes are applied traversely to the carriage way.
(c) Brooming : After belting, the pavement is given a broom finish with steel or fibre broom brush. Brooming is done perpendicular to the centre line of the pavement.

vi. Curing of Cement concrete

Initial curing : The surface of the finished pavement shall be entirely covered with the wet jute mats. The covering is maintained fully wetted for 24 hours.

Final Curing : The final curing is done with any one of the following methods.

(a) Curing with wet soil, clay bounds 75 mm wide and 75 mm high may be laid forming squares all over the surface. The surface is flooded with water upto a depth of 20 to 50 mm.

(b) Impervious membrane : The object of this type of curing is to prevent evaporation. This type of curing is done by the membrane which consists of a colourless impervious liquid. This liquid is applied immediately after the finishing of the surface and before the set of the cement.

3.7.3 Joints in Cement concrete roads (Longitudinal joints – Tranverse joints – Construction joints

3.7.3 Longitudinal joints

Longitudinal joints are provided in cement concrete roads with a width over 4.5m. the longitudinal joints are provided to prevent longitudinal cracking in the cement concrete pavements. Longitudinal joint acts as a hinge and helps to maintain two stabs together at the same level. The various type of longitudinal joints are shown in fig 1.6.

3.7.4 Transverse joints

Transverse joints are classified as

(a) Expansion joint

(b) Contraction joint

(c) Warping joint

(a) Expansion joint : Expansion joint are obtained to allow expansion of the slabs due to increase in slabs temperature. These joints also permit the contraction of slabs. In India expansion joints are provided at an interval of 50
to 60 m for roads laid in winter and 90 to 120 m for roads laid in summer and typical expansion joint in shown in fig 1.7.

(a) Plain Butt Joint

(b) Butt Joint with Tie Bar

(c) Tongue and Groove Warping joints

Fig. 1.6 Longitudinal Joints

Fig. 1.7 Expansion Joint with Dowel Bar
(b) **Contraction Joint:** Contraction joints are provided to permit the contraction of the slab. These joints are spaced closer than expansion joints. As per IRC specifications, the maximum spacing of contraction joints in unreinforced CC slabs is 4.5 m and in reinforced slabs is 14 m. Typical contraction joint is shown in fig below.

![Contraction Joint Diagram](image1)

(c) **Warping Joint:** The warping joints are known as hinged joints are provided to relieve stresses included due to warping. Longitudinal joints provided with the bars belong to this type of joints. These joints are not needed if the suitable expansion and contraction joints are provided.

### 3.7.5 Construction Joints

In cement concrete road construction apart from expansion joints and contraction joints construction joints are also provided. The compulsory break provided in continuity of the slabs is due to close of days work and the
commencement of the same, the next day with a construction joint. Normally the construction joint is planned to coincide with an expansion joint.

Location of the above discussed joints are shown in fig given below

![Fig. 1.9 Location of Joints](image)

3.7.6 Machinery used for construction of cement concrete road

Machinery used for cutting, filling and for preparation of formation or sub grade is as follows.

(a) Tractor
(b) Dozer
(c) Rooter
(d) Rippers
(e) Graders
(f) Scrapers
(g) Road roller
(h) Mixer
(i) Wheel borrows
(j) Vibrator

**Tractors:** Tractors are used for different kinds of works. Tractors are generally fitted with various attachment such as dozers scraper etc. tractors are two types.
(i) Tract type tractor

(ii) Crawler type tractor

Track type tractor moves on pneumatic type of tyres and suitable for even and smooth country whereas crawler type tractor moves on endless chain and is used for uneven and rough country.

Fig. 1.10 Track - Type Tractor

Crawler type tractor

This tractor moves on endless chain and is used for uneven and rough country.

Fig. 1.11 Crawler Type Tractor

(b) Dozers: These are normally attached to a tractor for excavation of material and pushing the material.
Types of Dozers

(i) Bull Dozer

(ii) Angle Dozer

(iii) Tree Dozer

(i) Bull Dozer: Bull Dozer is used for excavating the material and pushing the material in forward direction. It consists of blade attached to the front side of the tractor.

(ii) Angle Dozer: Angle Dozer consists a blade attached to the tractor obliquely can be set at any angle to the direction of motion of the tractor. It is used to push the material to the side right or left.

(iii) Tree Dozer: Tree Dozer is used to uproot the trees.
(c) **Rooters or Rippers**: Rooter is mounted on wheels and it is towed to a tractor and is used to remove stiff clay, soft rock or other hard soils.

1.14 **Rippers**

(d) **Scraper**: This is mounted on wheels and drawn by a tractor. It consists a cutting edge to cut the earth and also consists a bowl to take in or throw out the cut earth.

1.15 **Scraper**

(e) **Grader**: Grader are used to shape the sub grade
1.16 Grader

(f) Road rollers: Road rollers are used for compaction of sub grade base coarse etc.

Following are the types of Roller

(i) Flat Wheeled Roller
(ii) Pneumatic type roller
(iii) Sheep foot roller
(g) **Concrete mixer**: Concrete mixer of adequate capacity of the batch is provided. The mixer is equipped with a water measuring device.

1.18 Concrete Mixer

(h) **Wheel Borrow**: A wheel borrow consists of two wheels and is used to transport concrete for short distances from the mixer.

1.19 Wheel Borrow

(i) **Vibrators**: Vibrators are used to compact and consolidate the concrete. Vibrators are of the following types:

1. Surface vibrators
2. Internal vibrators
1.20 Surface Vibrator

1.21 Internal Vibrator

1.22 Needle Vibrator

**Short Answer Type Questions**

1. What is highway drainage?
2. Write any two purposes of road drainage.
3. Write the systems of road drainage.
4. Write the requirements of an effective surface drainage.
5. Write the material used in WBM road construction.
6. List out the machinery used in WBM construction.
7. What is prime coat?
8. What is seal coat?
9. What is Tack coat?
10. Write any two purposes of surface dressing.
11. What is full grout?
12. What is semi grout?
13. Write about premix methods.

**Long Answer Type Questions**

1. What is Road drainage? Explain road drainage systems.
2. Explain construction of WBM roads.
3. Explain material used in WBM road construction.
4. Explain the following in briefly
   (a) Surface dressing
   (b) Penetration macadam.
5. Explain construction of bituminous macadam.
6. Explain construction of premixed bituminous carpet.
7. Explain construction of bituminous concrete.
8. Explain the construction of sheet asphalt road.
9. Explain various joints in constructions of cement concrete roads.
10. Explain construction of cement concrete roads.
4.1 Construction in India

India has great heritage of construction work. The earliest known organized structures at Mohenjo Daro date back to 3000 B.C. Skills in construction work is evident in the structures such as temple of Madura Meenakshi, cave temple at Ellora and Tajmahal. During the period of British,
construction was confined to certain irrigation schemes, and to the development of urban areas.

After the independence, the Government adopted different plans for fast development of the country. The Government spent crores or rupees for the construction of dams, irrigation, and power projects, heavy industries, urban development communication etc.

At present the construction work in India is one of the most widespread activities, involving a range of people from the small builder in villages and towns to large private companies, public undertaking and various state agencies. A broad category of agencies which initiate and execute construction work are given below

(i) The Government and its agencies, such as the central and sate public works departments, the military engineering services, municipalities etc.

(ii) Public undertakings such as Railways, National Building Construction corporation etc.

(iii) Private companies

(iv) Individuals.

4.2. Classification of construction work

Construction works can be classified as

(a) **Light Construction** : Light construction work is the work with light structural members. Heavy machinery usually not required for these works. E.g. Residential buildings, School, Village roads, Light industry sheds etc.

(b) **Heavy construction** : Heavy construction works are the works, with heavy structural members on massive foundation, requires heavy machinery and equipment and large quantities of material, labour and finances. E.g. Bridges, railways, hydroelectric power generation plants etc.

(c) **Industrial construction** : Industrial construction works are the works related to industries which needs special equipment and skill e.g. Oil refineries, steel mills, Atomic reactors, etc.

4.3. Stages in construction work

Following are the stages in construction

(i) Conception

(ii) Study and Evaluation
(iii) Design
(iv) Contract
(v) Construction and
(vi) Utilization and Maintenance.

4.4. Construction team

The construction team includes the owner, engineers and builders.

The owner is an individual group, private or public body that promotes the work and provides finances and facilities for its execution.

The engineers are responsible for the economical and safe design and construction of the work under his supervision. The builder may be any one from a small contractor to a large construction company undertaking projects worth crores of rupees.

4.5. Resource of construction

The resources needed for the construction industry are

1. Men, Skilled and Unskilled
2. Materials such as Cement, Steel, bricks aggregates etc.
3. Machines such as trucks, cranes etc, to facilitate construction

Limited resources have to be utilized within a given time to get maximum benefit in terms of construction output.

4.6. Functions of construction management

The aims of management in construction work are to execute the construction work in a planned and efficient manner.

Following are the functions of management to achieve its aims

(i) Planning
(ii) Organizing
(iii) Directing
(iv) Controlling
(v) Coordinating

(i) Planning: In execution of construction works, deciding what to do, when and how to do, is known as planning. In planning of a construction works,
various alternative methods of executing the work are studied and decisions are taken regarding the time of starting and completion, labour, materials, machines and finance needed for the provision of construction facilities from time to time.

(ii) Organizing: The function relates to the creation of an organizational set up capable of executing planned activity. The type of organization depends on the type of work, volume of works as well as the method of execution of work.

(iii) Directing: Directing involves motivating, guiding, supervising and leading the employees of an organization. The function can be achieved by establishing good communication between the employees and the management.

(iv) Controlling: Controlling is the function of monitoring the progress achieved in comparison with the planned program and identifying areas of deficiency, if any, so that remedial steps can be taken.

(v) Coordinating: Coordinating is the management function of harmonizing the action, approach of various employees, and groups of employees to achieve a common goal.

4.7. Scientific methods of construction management

Scientific methods are adopted in construction management to carry out the construction work in systematic and economical manner. Scientific management is an approach to management, where in procedures followed are not based on traditional thumb rules but are carefully planned and analysed.

The aim of scientific management is to organize and execute the works, results in maximum productivity out of each worker.

Scientific methods of management are depends on network techniques which graphical representation of inter-relationship among the elements of a project.

Uses of network techniques:

(a) Helps the management in planning, scheduling and controlling the activities.

(b) Helps in guiding and directing the team more effectively

(c) Permits advance planning, indicates current progress, and warns trouble spots when there may still be time to avoid them.

(d) Helps in handling uncertainties regarding time schedules co-ordination of different activities.
Following are the scientific methods of management

1. CPM
2. PERT

**Critical path method**: CPM is a network technique used for the planning and controlling the most logical sequence of operation for completing a project. The projects is analysed in to different activities whose relationship are shown on the networks diagram. The network then utilized for optimizing the use of resources and, progress of the management project.

**Program Evaluation and Review Technique**: PERT is a network technique used for scheduling and controlling the management projects, whose activities are subjected to considerable degree of uncertainties in the performance time. The method of start and finish, critical path and project time are similar to CPM method. CPM is an activity-oriented method and PERT is the event-oriented method.

**Synopsis**

1. Construction work is classified as
   (i) Light construction (ii) Heavy construction (iii) Industrial construction
2. Light construction works are works with light structural members
   e.g. Residential buildings, School etc.
3. Heavy construction works are works with heavy structural members on massive foundation and these require heavy machinery and equipment e.g. Bridge, Dams, Railways etc.
4. Stages of Construction
   (i) Conception (ii) Study and evaluation (iii) Design
   (iv) Contract (v) Construction and (vi) Utilization and maintenance
5. Construction Team (i) Owner (ii) Engineer (iii) Builder
6. Resources of construction work
7. Functions of management
   (i) Planning (ii) Organizing (iii) Directing
   (iv) Controlling and (v) Coordinating
9. Planning: In execution of works deciding what to do, when and how to is known as planning.

10. Scientific methods of management (i) CPM (ii) PERT

**Short Answer Type Questions**

1. Write classification of construction work.
2. What is light construction?
3. What is industrial construction?
4. Write stages in a construction work.
5. Write Resources of construction work.
6. Write the functions of management.
7. Mention the scientific methods of construction management.

**Long Answer Type Questions**

1. Explain the functions of construction management.
5.1 Job planning

While planning a construction project usually it is needed to divide the entire project for phasing out the sequence of construction, and for dividing the operation of one phase into number of jobs. Each Job has be planned with respect to the following.

1. Method of execution of the work: Whether the work is executed departmentally or through contract.
2. **Duration of the job**: This depends upon the urgency of the work and availability of the resources of the construction work.

3. **Planning of resources**: The job should be planned such that the resources of construction i.e. man power and materials should be used economically.

### 5.2 Technical Planning

Technical planning is done by the engineers for economical execution of the construction work.

**Objects of the Technical Planning**

Following are the objects of Technical planning

- (i) Preparation of Layout plan.
- (ii) Finalisation of design and specifications.
- (iii) Preparation of detailed drawings
- (iv) Preparation of detailed estimates
- (v) Finalising method of execution of work and initiating procurement action.

### 5.3 Pretender and construction planning -scheduling

The contractor does pretender planning after receipt of tender notice and before submitting a bid. This helps the contractor in making a proper bid for the contract.

Pretender planning includes the following steps.

- (i) Careful study of the drawings, time limit and other conditions of the work.
- (ii) Working out quantities of required material, labour, equipment and their availability etc.
- (iii) Studying the biddings trends of other competitors.
- (iv) Considering the profit margin and limits of risks that could be taken.

#### 5.3.1 Contract Planning

After the tender has been accepted and the work is allotted to the contractor for execution of the work, the contractor has to undertake further intensive planning. This planning at this stage is known as contract planning.
Contract Planning involves the following steps

(i) Studying alternatives to the construction methods decided at pretender stage to arrive at the most economical method and deciding about the sub contracting.

(ii) Working out the quantities of materials, labour, equipment at various stages of work and locating the sources of supply of material equipment, etc. and comparative cost from the various sources.

(iii) Planning location of camp offices, layout of the site, service roads, facilities for labour and their accommodation and other related matters.

(iv) Studying inter-dependencies of the different items of work.

(v) Finalising the work program for each item of work and fixing dates for the start and completion of each item of work.

5.3.2 Scheduling

Scheduling means the preparation in advance of a list of different activities and their order of sequence to carry out any work as per planned programme.

For completing a project as per the plan, scheduling should be known to not only to the project managers but also to all the links in the system namely engineers, supervisors contractor and other coordinating agencies.

Scheduling includes the following

1. Determination of the amount of work to be done
2. The order in which the work is to be performed at each stages
3. The time when each part of the work will start
4. Allocation of the quantity and rate of output of departments
5. The date of starting of each unit of work at each stage along the route to be followed.

5.3.3 Need for Scheduling

A project usually is a one-time effort. Every project will have its own features and they are of non-repetitive nature. In order to complete a project efficiently, the project manager must plan and schedule. During the course of project he will have to replan and schedule due to unexpected progress, delay or due to technical conditions. The main aspect of project management will be scheduling different activities in an acceptable time span and finally with controlling the progress of scheduled work.
5.3.4 Advantages of Scheduling

For construction work of any importance, planning and scheduling is indispensable the following advantages are obtained thereby.

1. Alternative methods of construction and the effects of likely constraints can be examined at the planning stage and the most economical methods identified.

2. The time of starting each activity is known and therefore prior and adequate arrangement for the provision of resources, such as men, materials, machines and money at each stage of construction can be made.

3. Resource utilization can be optimized and the available resources directed towards various activities to the best advantage.

4. The actual progress of each activity can be monitored with reference action in speeding up the work taken up, before it causes a hindrance in other related activities.

5. The effect of any changes that takes place due to variation in productivity errors, whether geological conditions or modifications made in the original plan can be properly evaluated and the program suitably amended.

6. The inter-relationship of various activities and the relative importance of each at any stage of construction are known and this helps in fixing priorities properly.

7. The ultimate advantage to be gained by scheduling is that the construction work can be executed in an efficient manner without wastage of any of the inputs, resulting in maximum possible economy.

5.4 Procurement of Labour, materials and equipment

In any construction project, it is necessary to estimate the required labour, material and equipment required for completion of the project. This can be done with the help of construction schedules. Separate schedules are prepared for labour, materials and equipment.

These schedules help in procurement of labour, material and equipment at proper time and their efficient usage and storage.

Labour: Labour schedule, helps in providing future labour requirement and efficient and optimum deployment of labor force where ever necessary.
**Materials** : Materials schedules help in providing types of materials required along with their quantities and the actual time by which the materials are kept ready so as to avoid any delay in completing a construction project.

**Equipment** : Equipment schedules are prepared to find the type of equipment required, time and period for which particular equipment is needed. It helps in avoiding the equipment keeping it idle.

### 5.5 Program of Work

Programming is very important and essential for completing a project successfully. It guides and controls the execution of work.

Programming of work involves in

1. Identifying the various outputs.
2. Fixing accountability to carry out contribution.
3. Preparing detailed schedules for the construction resources.
4. Controlling the quality and quantity of work.
5. Minimizing the time required to complete the project.

#### 5.5.1 Scheduling by Bar charts

A construction project consists of a sequence of various activities like preparation of the site, foundation, substructure, super structure, fittings, finishing and other activities. Some of the activities may be of critical nature and if the activity is not completed in estimated time, it delays the entire project. The sequence of activities in the construction of a building is given below.

1. Earth work in excavation
2. P.C.C. bed and BW in foundation
3. D.P.C (Damp proof course)
4. Precasting RCC lintels
5. Casting RCC columns
6. BW in super structure
7. Sanitary work
8. RCC roof slab
9. Door panels
10. Plastering
11. Flooring
12. Electrical works
13. Sanitary works
14. White washing
15. Sanitary fittings
16. Clearing up site

**Construction Planning**

The bar chart lists various activities involved in a construction project and the period of time that each activity takes for completion. Indicate in the form of a horizontal bar plotted to a suitable time scale against each activity.

The convention commonly used in bar chat are sown in the fig below

![Fig 5.1](image)

The planned program is shown by a thick or double line with the planned start and finish by short vertical lines. The float is shown by a hyphenated horizontal line and indicates that, although the item is scheduled to be completed by certain date, yet subsequent items are not likely to be held up in case of delay up to the period represented by the hyphenated line.

A hyphenated vertical line, connecting the start of the item with the completion of the item on which it is dependant, indicates the dependency of one work on another. In fig 5.1, item 3 is dependent on item 1 cannot be started
till item 1 is completed. The actual progress shown in single line drawn below the line showing planned program.

Bar Charts are suitable for determining the resources, such as material, labour, machinery and finance required for construction work. Fig 5.2 shows the resources aggregation chart for RCC work.

Bar Chart is simple easily understandable and widely used method of scheduling. However it has certain limitations, firstly it is difficulty to depict complicated interdependencies of various items of work. It does not give actual progress of the work. It is not possible to know the peak rate of work necessary for timely completion of a project. The bar chart, therefore, is a static representation and does not respond to the dynamic happenings on the construction site of a complex project.

Synopsis

1. Job planning is needed to divide the entire project for phasing out the sequence of construction and for dividing the operations of one phase into number of jobs.

2. Technical planning is done by engineers for economical execution of the construction work.

3. Pretender planning is done by the contractor after receipt of tender notice and before submitting a bid.

4. Contract planning is done by the contractor after getting the contract

5. Scheduling means the preparation in advance of a list of different activities and their order of sequence to carry out any work as per the planned program.

6. Bar Chart lists various activities of a construction project and the period of time that each activity takes for completion indicated in the form of a horizontal bar plotted against each activity.

Short Answer Type Questions

1. Define Job Planning.

2. What is contract Planning?

3. What is pretender planning?

4. What is scheduling?

5. Write different methods of scheduling.

6. What is a Bar Chart?
Long Answer Type Questions

1. Describe the different methods of scheduling a construction project and explain the advantage and disadvantages of each.

2. What is meant by scheduling? What are the advantages of scheduling a construction job?
Structure

6.1 Types of Labour
6.2 Labour welfare human relation
6.3 Labour Insurance
6.4 Payment of wages
6.5 Time rate system
6.6 Piece rate system
6.7 Minimum wages Act, 1948
6.8 Workmen compensation Act 1923
6.9 Contract labour act, 1970

Learning Objectives

After studying this unit, student will be able to

- Understand types of labour, labour insurance, methods of payment of wages
- Understand about minimum wages Act 1948, workman compensation Act 1923 and contract labour act 1970
6.1 Types of Labour

Construction labour can broadly divided into two types

1. Casual Labour  
2. Regular establishment

1. Casual Labour: Casual labour is employed as and when required for the execution of work, payment is made on the basis of the number of days the labour works. There is no provision of leave, except the weekly holidays. This is also known as daily labour.

2. Regular Establishment: Regular establishment generally includes supervisory personnel that are required for more or less continuous period during construction. They are paid monthly wages and entitled to leave and other benefits. The employees may be temporary or permanent. Permanent employees have great security and may be entitled to more service benefits than the temporary employees.

6.2 Labour Welfare-Human relation

Construction is the largest industry in India and most of the employees who are working in construction industry are labour and skilled workers. As the nature of construction work is temporary the workers are recruited as and when required for the execution of work and are retrenched when no longer needed. Construction labour is migratory in nature, moving from one site to another site, and the labour attached to big contractors tends to migrate to new work sites taken up by them.

Construction labour has not been able to organize itself to the extent that labour in factories and other organized sector of trade has. This is mainly because the construction labour do not have a permanent place of work. Consequently construction labour has extremely poor bargaining power and this situation is fully exploited by employers. The construction labour beside low wages, they live in crowded unsanitary temporary huts built at the construction sites in unhygienic surroundings without basic amenities of life.

For the welfare of the labour the Government have, from time to time brought out labour laws.

Labour laws are classified into the following types

- Laws concerning the working conditions of labour
- Laws concerning wages and other payments to labour
- Laws concerning the social security of labour
These laws are proved very much helpful to the labour for improving their living conditions.

6.3 Labour Insurance

Insurance laws are applicable only to regular employees. In construction industry most of the labour is of casual nature and insurance laws are not applicable to them. For the welfare of casual labour, different Acts such as Minimum wages Act, Compensation Act etc. are passed by the Government.

6.4 Payment of Wages

The remuneration given to workers for work performed by them is known as wages. (a) Nominal wage (b) Real wage

Wages are of two types

1. Nominal Wages: This is the remuneration paid to the worker in the form of money, but it does but include the value of any other benefit that may be provided.

2. Real Wage: Labour is often entitled to different benefits such as leave, medical care, house rent allowance, bonus etc. If the value of such benefits is added to the nominal wage, it is known as real wage.

Wages are paid to the labour based on two methods

1. Depending upon time devoted to the work. This method is known as time rate system

2. Depending upon the quantity of work performed

This method is known as piece rate system.

6.5 Time Rate System

In time rate system of payment of wages, a suitable rate of payment is fixed per unit of time devoted to work buy the labour. The unit of time can be hours, days weeks or months.

The rate of payment for casual labour is fixed per day and that of regular employees per month in the construction industry.

The advantages of this system are

1. It is simple and easily understood by labour.

2. The quality of work will be good.

3. The workers do not get overstrained.
There are, however, the following disadvantages in the system

1. Constant supervision is required
2. Effective cost control cannot be ensured

6.6 Piece Rate System

In this system payment is made on the basis of the output of the workers. The work done by each labour is measured and payment is made at the agreed rate. Thus a worker can make more money by increasing his output. The rate of each item of work is fixed on the basis of the past record of output.

The piece rate system has the following advantages

1. The overall productivity is increased
2. The need of supervision is reduced
3. Effective cost control can be ensured
4. The system is fair to the workers and employers
5. The better workers with higher outputs get higher payment.

However the system has following disadvantages

1. The system is unsuitable for works which cannot be measured.
2. The quality of work is lowered
3. There are no guaranteed wages for workers what ever the system may be, there must be an adequate compensation for the labour put in and this is known a “fair wages”.

6.7 Minimum Wages Act, 1948

The minimum wages Act of 1948 was passed for the welfare of labour and provided for fixing the minimum rate of wages of labour. The Act aims at making provisions for the statutory fixation for the minimum rate of wages in number of industries where there are extensive chances for the exploitation of labour.

The main provisions of minimum wages Act are

1. The setting of advisory committees to collect information on which the minimum wages are based.
2. The wages of a worker in any scheduled employment shall be paid on a working day by.
(i) The 7th day after the last day of the wage period if the establishment has less than 1,000 employees.

(ii) The 10th day after the last day of the wage period if the establishment has more than 1,000 employees.

3. The wages of an employee should be paid without any deductions except those items given below.

(i) Fines in respect of acts of omission

(ii) Absence from duty

(iii) Loss of goods directly attributed to the neglect of the employee.

(iv) House accommodation provided by the employer.

(v) Amenities and services provided by the employer

(vi) Income tax

(vii) Subscription to the provident fund

(viii) Recovery of advances

(ix) Deduction ordered by the court

(x) Payments to co-operative societies / life insurance corporation.

6.8 Workmen Compensation Act 1923

The workmen compensation Act passed to protect the victims of accidents and their families from hardship out of hand in the course of employment. The Act covers workers employed in hazardous occupation as specified in the schedule but excludes those employed in clerical or administrative work. The Act provides for payment of compensation in case of accidents on work sites. The compensation, however, is not payable for injuries due to.

(i) Disobedience of negligence

(ii) Non observance of safety measures

(iii) Consumption of liquor

(iv) Diseases which are not contracted as a result of the occupation

(v) In case of the death of a worker, compensation is paid under all circumstances
Accidents are due to

(i) Human causes such as poor eye sight, negligence effect of intoxicants

(ii) Mechanical causes such as inadequate safety devices, live electrical equipment, unreliable scaffolding etc. and

(iii) Environmental causes, such as poor lighting heat, noise etc.

The result of an accident, may be

1. Temporary disablement, which may be total or partial
2. Permanent total disablement
3. Permanent partial disablement
4. Death

The compensation to be paid depends on the result of the accident.

The Act provides for the appointment of Commissioner for the quick disposal of claims for compensation. The employers are required to notify fatal or serious accidents to the commissioner within seven days. Civil courts are debarred from considering cases rising out of the Act and these are under the jurisdiction of the commissioner.

6.9 Contract labour act, 1970

The contract labour Act, 1970 was passed to regulate the employment of contract labour in certain establishments. It also provides for improving the service conditions of contract labour. The Act is of importance to the construction industry where works are executed through contractor or by contract labour. The act applies to every establishment and contractor employing twenty or more workmen. The act does not apply to establishment in which only work of an intermittent or casual nature is performed.

The Act provides for the constitution of a central Advisory Contract Labor Board under the Central Government and state Advisory contract labour Board under each State Government to advise the central and State Governments on matters arising out of the administration of the Act and to carry out the functions assigned to it under the Act.

The main provision of the Act are

1. Registration of Establishment: Every principal employer of an establishment to which Act applies is required to make an application
to the registering officer on the prescribed form for the registration of the establishment.

2. **Licensing of contractors**: Every contractor executing any work through contract labour is required to obtain a license.

3. **Welfare and Health of Contractor Labour**: Under the Act, the following facilities are required to be provided for the welfare and health of the contractor labour.

   (i) For works likely to continue for more than three months, where labour is required to halt at night in connection with the working of the establishment, the contractor should provide rest rooms, separate rooms should be provided for women.

   (ii) For works likely to continue for more than six months and employing more than 100 or more labour, an adequate canteen should be provided.

   (iii) Latrines and urinals must be maintained on clean and sanitary conditions.

4. **Payment of Wages**: Responsibility for the payment of wages rests upon the contractor.

**Synopsis**

1. Type of labour
   
   (a) Casual Labour (b) Regular labour

2. Nominal wages is the remuneration paid to the worker in the form of money. But does not include the value of any other benefits.

3. Real wage is the wage in which value of benefit is added to nominal wage.

4. Methods of wage payment
   
   (i) Time Rate System (ii) Piece Rate system

5. **Time-rate system**: In this system the wages are fixed on the basis of unit of time devoted to work by the labour.

6. **Piece Rate system**: In this system the wages are fixed on the basis of output of the worker.

7. Minimum wages Act passed for fixing the minimum rates of wages of labour.
8. Workmen compensation Act passed to protect the victims of accidents and their families from hardships out of and in the course of employment.


**Short Answer Type Questions**

1. Write types of labour.
2. Mention methods of payment of wages to labour.
3. What is nominal wage?
4. What is real wage?
5. What is piece Rate System?
6. What is Time Rate System?

**Long Answer Type Questions**

1. Explain the payment of wages of contract labour.
2. Explain minimum wages Act.
4. Explain contract labour Act.
7.1 Introduction

Quality control of construction is one of the important function of management. It has to be ensured that the quality of work is in accordance with prescribed specification. This can be achieved by carrying out inspection of the work as it progress through various stages. Inspection is the art of comparing the materials, performance or products with the laid down standards. The standards prescribed generally specify limits of permissible variability and the purpose of inspection is to find out by observation or testing whether the quality
of work done falls within the acceptable limits of variability. If the work is got done though a contractor, it is the interest of the contractor to concentrate on quality to satisfy the owner or the inspector about the quality of work.

As it very difficult to rectify a structure after its construction it is necessary to inspect the structure during different stages of construction. For large projects, a separate inspection agency is generally appointed for effective inspection and quality control.

7.2 Methods of Quality Control

Generally quality control begins by inspecting the construction work at different stages like:

1. Sampling, examination and field testing of all the materials of construction.
2. Measurement and proportioning of material
3. Examination of layout, form work, foundations etc
4. Testing the specimens in the laboratory
5. Observation of construction equipment
6. Skill levels of labour

7.3 Functions of Inspection Department

The inspection department has to perform the following functions regarding the quality control of construction work.

1. Inspection of Sub-Soil
2. Inspection of materials
3. inspection of equipment and
4. Inspection of works at each stage.

1. Inspection of Sub Soil: Inspection of sub soil is necessary to test the bearing capacity of the sub soil.

2. Inspection of Materials: Supplies of material for construction work need to be inspected before they are used. Field and laboratory tests may be conducted for this purpose.

3. Inspection of Equipment: Supply of equipment must be inspected before the items are recorded in books.
Therefore, regular periodical inspections are necessary to ensure that the equipment is kept in serviceable condition.

4. **Inspection of works at each stage**: The inspectors must inspect the work before the contractor proceeds with the next stage. For example, inspections are necessary after excavation has been complete, before all underground work is covered up; for the form work and steel before concrete is poured. In case any defects are noticed, they must be got rectified before proceeding to the next stage. Inspection if mixing and placing of concrete is also necessary in some cases to ensure that the proper procedure is being followed.

### 7.4 Major items of Quality Control

Some major items which need to be carefully watched from the quality control point of view.

1. Concrete
2. Steel
3. Form works
4. Masonry
5. Water proofing
6. Joinery and Timber work and
7. Services

**1. Concrete**: Concrete is usually specified by nominal mix, but for large and important works, controlled concrete may be specified. Adequate control should be there on the quality of material and the process of mixing, placing, compacting and curing. The minimum quantity of water that gives the specified slump should be used. In the case of controlled concrete, the aggregates must be tested at regular intervals to ensure that the grading is within acceptable limits. Regular field tests must by conducted to ensure the proper slump and compressive strength of the samples taken from compaction mix. The time between the mixing of water and the final compaction of concrete should be within the initial setting time of the cement used. Concrete should be placed carefully to avoid segregation of aggregates. Curing should be carried out for the full period in the prescribed manner.

**2. Steel**: Steel constitutes a major part of expenditure in most of works. For structural work it is necessary to see that there is minimum wastage. In Reinforced Cement concrete, the process of bending, binding, placing should be checked carefully to ensure proper spacing and shape of the bent bars. It
should also be ensured that the bars are free from rust, scales, oil and or other coatings.

3. **Form Works**: The shape and surface finish of concrete depends upon the form work. The form work must be strong enough to support the wet concrete and have a smooth surface so that the finished concrete requires the least amount of rendering.

4. **Masonry**: It is necessary to see that the bricks used are of the specified quality and have the required bearing capacity when used in load bearing walls. The bond should be maintained properly. The dimensions and verticality of masonry are also important items to be controlled.

5. **Water Proofing**: Water proofing also needs quality control. The damp proof course and the damp proofing of roofs, etc. are very important items needing special attention.

6. **Joinery and Timber Work**: In this item both the quality of timber used and workmanship are important for quality control.

7. **Services**: Services include such as electrical, sanitary, water supply, air conditioning etc.

**Synopsis**

1. Inspection is the art of comparing the material, performance of products with the laid down standards.

2. Function of inspection department
   (i) Inspection of sub soil
   (ii) Inspection of material
   (iii) Inspection of equipment
   (iv) Inspection of works at each stage.

3. Major items of quality control
   (i) Concrete
   (ii) Steel
   (iii) Masonry
   (iv) Waterproofing
   (v) Joinery and Timber work
(vi) Services

4. Service include electrical, sanitary, water supply, air conditioning etc.

**Short Answer Type Questions**

1. What inspection?
2. List out any two functions of inspection department.
3. Mention major items of quality control.

**Long Answer Type Questions**

1. Explain the function of inspection Department.
2. Explain major items of quality control.
8.1 Introduction

Contract is an undertaking by a person or a firm to do any work under certain terms and conditions, which should invariably be in writing. The work may be for construction or maintenance and repairs, for the supply of labour or the transport of materials etc.
Contractor means a person or a firm who undertakes any type of contract. Usually this term is confined to the contractors who are engaged in construction or execution of works or repairs.

The system through which the works are carried out by the contractor, who arrange all the materials, labour and equipment required for proper completion of the works is known as the contract system. The work should satisfy the specifications with expected quality. It should also be completed with the stipulated time.

8.2 Legality of contracts

All the contract conditions should be according to the law because the court can force only those conditions, which are according to the established public policy and should put up good examples on the morals of the society as a whole.

As per the Indian Contract Act Sections 10, 11 and 68 the parties entering into the contract should be legally competent. The law relating to contract imposes upon each party of the contract a legal obligation to observe the terms of contract and give the other party the right to enforce fulfillment of the loss suffered in consequence of the breach of the contract.

The obligation, which a contractor accepts, which he submits a tender are determined by the condition of the tender such acceptance of tender gives rise legally to a binding contract.

Some of the legal aspects concerning the performance and completion of contracts are given below.

(i) For a contract to complete a definite piece of work recovery is possible only after completion.

(ii) The impracticality of a work cannot be excuse for nonperformance.

(iii) A contractor who refuse to carry out the work before completion can be subjected for breach of contract.

(iv) When an employer makes it impossible for contractor to complete the work in accordance with the contract, the contractor can sue for the rate of completed work.

(v) The penalties described in the penalty clause will not be applicable if the execution of the contract is delayed because of the fault of the employer.

(vi) In case of the contractor’s inability to complete the work, after part execution the employer can consider the contract as rescinded and take an
action for the damages. The contractor under such circumstances has no lien for the money spent on the work by the contractor.

(vii) When a contractor has finished part of a work and refused to complete the entire work and the employer without the consent of the contractor takes the work in his own hands for completion. In this case law implies that the employer has to pay for the work, which has done by the contractor.

(viii) When a contractor without lawful excuse, refuses to carry on the work after part performance, the employer may have to pay for the materials delivered on the site by the contractor as distinguished from the materials which have become fixed in the work.

(ix) When a contract is formed and it becomes impossible to perform the work immediately or at later date, it may be possible to adjust the rights and liabilities of the parties.

### 8.3 Types of Contract Agreements

Contract agreements fall into the following two clauses

1. Piece work contracts
2. Contract

### 8.4 Piece work contracts

These are agreements for doing works at agreed rates, without reference to the total quantity of work or time. Small works or piecework up to Rs.5000/- are got done through the contractors by piecework agreements.

Piece work agreements are of the following types

1. Piece work  
2. Work order

**1. Piece work**: In piece-work the quantity of work is not mentioned and only the rate is mentioned.

**This agreement is used**

(i) For small works

(ii) When it is necessary to start work in anticipation of the formal acceptance of the contract and

(iii) For running contract.
2. Work order: Work is used is used for petty works; work orders may sometimes also mention the time limit within which the work is to be completed. No formal agreement is drawn up with the contractor as in the case of piece-work when the work is awarded by a work order.

8.5 Types of contracts

Contracts are of the following types

1. Item rate contract
2. Percentage Rate Contracts
3. Lump sum contracts

8.6 Item rate contract

In this type of contract, the contractor undertakes the work on the item rate basis. The payment is done on the basis of quantities of items done and the respective rates. The quantities of various items are worked out by detailed measurement. This type of contract is also known as unit price contract. The approximate quantities of all possible items of work are worked out and are shown in the tender form. Every contractor quotes his rates against each item and arrives at the final total amount of the work. This is the most common type of contract system which is widely adopted.

Following are the advantages of item-rate contract

1. The additions and alterations in the plan and specification can be easily made at any stage.
2. As the contractor gets the payments against the actual quantities of items done by him, the method is economical. No possibility for excess payment.
3. As the rates are item-wise the contractor is not worried regarding the uncertainties in the plan and specifications.
4. The work can be started after accepting the tenders without waiting for all detailed drawings and specifications.

Disadvantages

1. The total cost of the work can only be computed after completion of entire project. In such case the contractor may face financial difficulties if final cost increase abnormally.
2. Before preparing the bills for payments of money to the contractor, all measurements of various items of work have to be carefully taken and suitably entered in the measurement book.

3. Great care shall be taken by the department officers to strictly enforce the specifications during execution of work to avoid the using of substandard materials by the contractor.

### 8.7 Percentage rate contract

This is also known as cost-plus percentage contract. In this type of contract the contractor agrees to take the work of construction for fixed percentage over the actual cost of construction. This type of contract is given when no contractor is agreeing to do work on other types due to uncertainties and fluctuations in the market rates of materials and labour. The department keeps the actual up to date records of the expenditure incurred on the work and pays the fixed percentage as agreed over it to the contractor. The contractor arranges for the labour, materials required for completion of the work and maintain proper account of the construction costs.

The cost plus or percentage contracts can be of the following types

1. Fixed Percentage of Cost
2. Cost plus a fixed sum
3. Cost plus fixed sum with profit sharing
4. Cost plus variable percentage.

### Synopsis

1. Contract is an undertaking by person or a firm to do any work under certain terms and conditions.
2. Contractor means a person or a firm who undertakes any type of contracts.
3. Types of contracts
   (i) Item rate contract
   (ii) Percentage rate contract
   (iii) Lump sum contract
4. Types of piece-rate agreements
   (i) Piece - work
(ii) work Order

5. Item rate contract : In this contract the contractor undertakes the work on the items rate basis.

6. Percentage rate contract : In this contract agrees to take the work of construction or fixed percentage over the actual cost of construction.

7. Work Order is used for pitty works and no formal agreement is drawn with the contractor.

Short Answer Type Questions

1. What is a contract ?
2. Define contractor .
3. Write types of contract agreements .
4. What is a work order ?
5. Write types of contract .
6. What is item rate contract ?
7. What is percent rate contract ?

Long Answer Type Questions

1. Explain legal aspects of contacts .
2. What is Item rate contract ? Write its advantages and disadvantages
3. Explain different types of contract.
4. Explain the features of percentage rate contract.
UNIT 9

Tender and Tender Notice

Structure

9.1 Tender
9.2 Necessity of tender
9.3 Tender notice
9.4 E.M.D
9.5 Security money deposit
9.6 Publicity and sale of tenders
9.7 Opening of tenders and their scrutiny
9.8 Acceptance of tenders
9.9 Work order
9.10 Contract agreement
9.11 Conditions of contract

Learning Objectives

After studying this unit student will be able to

• Understand about tender and tender procedure
• Understand about work order, contract agreement, condition of contract
9.1 Tender

A Tender is the contractors bid in writing offering to execute the specified work of construction, supply of materials etc., at the rates and amounts indicated within the time limit and under condition specified and agreed to.

9.2 Necessity of tender

Works, which are to be awarded to contractors are publicized to enable a sufficient number of interested parties to bid. The lowest bid is generally accepted, unless there are good reasons for not doing so. The process of inviting bids and accepting them is known as tendering.; The bid is usually made on the tender forms specified by the owner.

The following tender documents are made available along with the tender forms to enable contractors to bid for the job.

1. Layout plan
2. Set of drawings, including working drawings
3. Detailed specifications or reference to standard specifications for each item of work
4. Schedule of stores to be issued by the owner indicating the rates and their place and issue
5. Schedule of tools and plant and other facilities to be made available by the owner, indicating the conditions, hire changes and the place of delivery.
6. General condition of the contract including time limits.
7. Special conditions of the contract that may have to be highlighted.
8. Amount of Security deposit to be paid / deducted.

9.3 Tender notice

Whenever works are to be let out on contract tenders are to invited from the registered contractor or both, registered and unregistered contractors depending on the magnitude and nature of the work by issuing notice in newspapers. The notice that includes various particulars of work is named as Tender Notice.
9.4 E.M.D

Earnest Money Deposit is the amount which the contractor has to deposit with the department at the time of submitting a tender. This accompanies the tender form and this is usually 2% of the total estimated cost of the project. This serves as a check to prevent the contractor from refusing to accept the work when the tender has been accepted. The other objects of collecting earnest money are

1. To reduce unnecessary competition: If no earnest money is collected heavy competition may start among the tenderers. The contractor who do not have sound financial status may also offer their tenders, which increase the unnecessary competition among the tenderers.

2. To Act as a tool for punishment: In case the contractors quote lower without intention of doing work, to earnest money shall be forfeited by the department as a punishment to such contractors.

3. To Act as compensation: When the lowest contractor refuses to take up the work, the work can be allotted to the second lowest contractor. The earnest money forfeited from the first lowest contractor compensates to loss of the department.

9.5 Security money deposit (S.D)

The contractor has to deposit about 10% of the tendered amount with department as soon as his tender is accepted. This is inclusive of the earnest money already deposited by the contractor. This money is kept as a check as that the contractor fulfills all the terms and conditions of the contract and carries out the work satisfactorily in accordance with the specifications and maintains a satisfactory progress for completion of the work. In case he fails to fulfill the terms of the contract, the whole of the security money or part of it forfeited by the department.

When the contractor completes the work as per drawings, specification and direction of the department within the specified time, the security money is refunded to the contractor. Normally the security deposit is refunded after the maintenance period, which may be 6 to 12 months after the completion of work, and it's handing over to the department.

9.6 Publicity and sale of tenders

It is essential that tenders be given adequate publicity so that a sufficient number of contractors may bid and the most attractive offer may be obtained. At the same time it is also necessary that bids be obtained from contractors who
have the capability and capacity to undertake the work. For this purpose,
organization like the Railways and Public works Departments which regularly
get works executed through contractors, maintain list of approved contractors.
These lists are prepared after examining the past performance and capacity of
the contractor. Approved contractors may be classified in term of the value of
work that could be assigned to them.

Tenders are publicized by the issue of a notice inviting tenders, which
indicates.

1. Name and description of the work
2. Estimated cost
3. Completion time
4. Earnest money payable indicating the manner in which payment is to
   be made.
5. Security deposit
6. Time and place where tender documents may be inspected or
   obtained
7. Last date and place of obtaining tenders paper and submission thereof
8. Time and place of opening the tenders
9. Authority competent to accept tenders.

The tender notice may be advertised in newspapers and issued to
registered contractors by post. Copies of the tender notice are also put up on
the notice boards of various offices of the organization. For very large works or
those involving special techniques, which may not be within the capacity of the
construction industry in the country, global tenders will be issued all over the
world inviting bids for the work. Contractor are given a reasonable period of
time, depending upon the size of the work to prepare and submit their tenders.
Tender documents are usually priced and are issued on payment of the prescribed
amount. The sale of tender papers starts and closes at the time notified in the
tender notice.

9.7 Opening of tenders and their scrutiny

Tenders must be submitted latest by the prescribed date and time in a
sealed cover to ensure secrecy till they are opened. The name of the work and
the due date should be written on the envelope for the purpose of identify,
dispensing with the need to open the envelop. Tenders may be delivered by
post or deposited in the sealed tender box generally provided in the premises of the owner.

The earnest money if any must be deposited in the manner prescribed along with the tenders. Tenders submitted without earnest money, if prescribed are rejected. The amount is refundable if tenders are not accepted and is usually adjusted against the contractor’s security money of the bid is accepted. Generally about 2% of the estimated amount is asked for as earnest money. In the case a contractor, whose tender is accepted, fails to under take the work, the earnest money deposited by him is forfeited.

Tenders received after the due date and time is rejected. The valid tenders are opened at the time notified in the presence of representatives of the tenders, who may choose to be present. Each tender is carefully scrutinized and any cuttings or over writings are initialed to ensure that tenders are not tampered with at a later stage. A record of the tenders received is also kept.

9.8 Acceptance of Tenders

The rates and amounts quoted in all the valid tenders are tabulated in the form of a comparative statement to enable a comparison of the bids made. While preparing the comparative statement, careful note is made of all conditions that may have been mentioned and their financial implications worked out. For example, in the case of the supply of materials, if a tenderer does not quote rate inclusive of sale-tax, octroi and other charges a required, the financial implication thereof should be worked out, so that a proper comparison can be made. The arithmetical calculations with respect to rates quantities, amounts and totaling should also be checked.

The lowest tender is generally accepted unless there are good reason not to do so, such as poor past performance and limited financial or physical capacity of the tender.

If the rates quoted are on the high side, all tenders may be rejected and re-invited to obtain a reasonable bid. In order to ensure that there is no legal complications in not accepting any tender, a clause is added in the tender notice reserving the right to reject any or all tenders without assigning any reason. The tenderer whose bid accepted is intimated in writing and asked to sign the contract documents within a specified period of time. If the fails to do so, the offer is cancelled; the security deposit forfeited and the work allotted to the contractor whose tender is the next highest.

After signing the contract agreement, the site of the work is formally handed over to the contractor, then he can start the work. The time for completion is reckoned for the day the site handed over to the contractor.
9.9 Work order

Work order is used for petty works; work orders may sometimes also mention the time limit within which the work is to be completed. No formal agreement is drawn up with the contractor as in the case of piece-work when the work is awarded by a work order.

9.10 Contract agreement

Contract agreements are fall into the following categories

1. Contracts
2. Piece work agreements

Contracts are classified as

1. Percentage Rate contracts
2. Item Rate contracts
3. Lump Sum contracts

Piece work agreements are of following types

1. Piece work
2. Work order

9.11 Condition of contract

The condition of contract includes the following

1. Time of completion of work
2. Volume of work
3. Specification of work
4. Rates of payment
5. Penalties for default on the part of the contractor etc.

Synopsis

1. Tender is the contractor’s bid in writing offering to execute the specified work of construction, supply of material etc, at the rate and amount indicated, within the time limit and under conditions specified and agreed to.

2. Tender notice is the notice, which includes various particulars of work through which tenders are invited from contractors for a contract.
3. EMD: Earnest Money Deposit is the amount, which the contractor has to deposit with the department at the time of submitting a tender. This is usually 2% of the total estimated cost of the projects.

4. Security Deposit (SD) is the amount, which the contractor has to deposit about 10% of the tendered amount with the department as soon as his tender is accepted.

5. Piece work agreements are
   (i) Piece work
   (ii) Work order

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### Short Answer Type Questions

1. Define Tender.

2. What is Tender notice?

3. What is E.M.D?

4. What is Security Deposit?

5. Define work order.

6. List out the conditions of contract.

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### Long Answer Type Questions

1. Explain the procedure of scrutiny of tender.

2. Write about the following.
   (a) EMD   (b) Security Deposit

3. Explain the procedure of accepting a Tender.

4. Explain the procedure of publicity and sale of tenders.