CHAPTER 7

Highway Construction

INTRODUCTION

In this unit, it is attempted to discuss in detail the question how are the highways built i.e. highway construction. It is logical to see that the purpose of highway construction is to provide a firm and even surface for the carriageway. The pavement is prepared using broken stones or soil and binder material to bind the aggregates to form a homogenous pavement section. Engineers have always kept an open mind while adopting any material available to them for the purpose of construction depending upon the desired strength of the pavement, the aggregate gradations and the type & the proportion of binders are decided.

7.1 Pavement Types

The selection of base course and the surface course depends upon the following factors:

(*i*) Type and intensity of traffic
(*ii*) Funds available for the construction project and for the subsequent maintenance
(*iii*) Subgrade soil and drainage conditions
(*iv*) Availability of construction materials at site
(*v*) Climate condition
(*vi*) Plants and equipment available
(*vii*) Time available for completing the project
(*viii*) Topography at which construction has to be done

However the fundamental factor is the traffic volume or intensity. It is suggested that low cost roads could function successfully when the traffic intensity is 30 tonnes to 200 tonnes per day. The water bound macadam may take 500 tonnes per day. The bituminous pavements and cement concrete roads are considered suitable for heavier traffic intensity.

In the highway construction, usually stage construction technique is adopted which helps in improving the pavement structure in stages to match with the increase in road traffic.

7.2 Earthwork

The subgrade soil is prepared by bringing it to the desired grade and camber and by compacting adequately. The subgrade may be either in Embankment or in excavation depending on the topography. The earthwork quantities are estimated based on longitudinal and transverse section along the alignment of the road.

7.3 Excavation

Excavation is the process of cutting or loosening and removing earth including rock from its original position, transporting and dumping it as a fill or spoil bank. The depth of the excavation is decided, among other factors, on requirement of vertical profile of the road and slope to be provided is governed by the type of soil including stratification construction of side drains also require excavations along road side.

7.3.1 Classification of Excavation

All the materials involved in excavation are classified into the following groups:

(i) **Ordinary Soil:** This comprises of vegetable or organic soil, sand, silt, clay, mud, peat, black cotton soil, a mixture of these and similar material which yields to the ordinary application of pick and shovel, rake or other ordinary digging implements. Removal of gravel or any other nodular material having diameter in any one direction not exceeding 75 mm occurring in such strata are deemed to be covered under this category.

(ii) **Hard Soil:** Stiff heavy clay, hard shale, lime concrete, stone masonry, macadam surfaces, compact moorum requiring grafting tools and gravel and cobble stone having maximum diameter in any one direction between 75 and 300 mm comes under this category.

(iii) **Ordinary Rock:** Limestone, sand stone, laterite, disintegrated rock which may be quarried or split with crowbars, unreinforced cement concrete which may be broken up with crowbars and boulders which do not require blasting, having maximum diameter in any direction of more than 300 mm are covered under this category.

(iv) **Hard Rock:** Any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is required. Reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level.

(v) **Marshy Soil:** This includes soil excavated below the original ground level of marshes and swamps and soils excavated from other areas requiring continuous pumping out of water.

7.3.2 Excavation Equipment

Commonly used excavation equipment in highway projects are:

(i) **Bull Dozer:** It may be used for clearing site, opening up pilot roads, moving earth for short haul distance of about 100 m.

(ii) **Power Shovel:** It is used primarily to excavate earth of all classes except rock and to load it into wagons. It may be mounted on crawler tracks and so they can move at low speeds. Power Shovels can effectively operate to excavate earth from a lower level where it stands and when the depth of the face to be excavated is not too shallow.

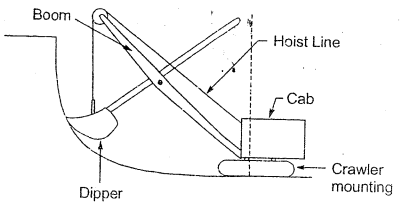

Figure-7.1 : Power Shovel

(iii) **Scraper:** It is considered as one of the useful earth moving equipment as it is self operating. It can dig, haul and discharge the material in uniformly thick layers. However, scrapers are not capable of digging very stiff material.

(iv) **Dragline:** It is used to excavate soft earth and to deposit in nearby banks or to load into wagons. It can operate on natural ground while excavating from a pit with the bucket. Thus it is not necessary for the dragline to go into the pit in order to excavate.

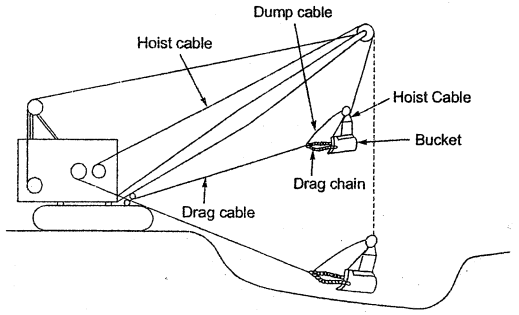

Figure-7.2 : Dragline

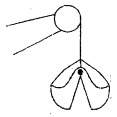

Figure-7.3 : Clampshell

(v) **Clampshell:** It is useful for excavation of soft to medium materials and loose material at or below existing ground surface.

(vi) **Hoe:** It is meant to excavate below the natural surface where the machine is stationed and is capable of having precise control of depth of excavation at close range work. Hoe can excavate stiff material which normally cannot be excavated by dragline.

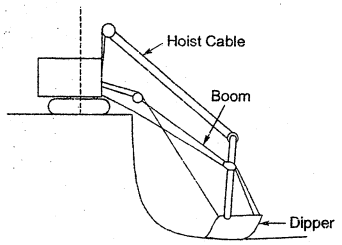

Figure-7.4 : Hoe

7.4 Embankment

Construction of embankment is necessary when we have to raise the grade line of a highway above existing ground level.

The grade line may be raised due to any of the following reasons:

(*i*) To keep the subgrade above the high ground water table.

(*ii*) To prevent damage to pavement due to surface water and capillary water.

(*iii*) To maintain the design standards of the highway with respect to the vertical alignment.

7.4.1 Selection and Placement of Materials in Embankment and Subgrades

Only suitable and satisfactory material obtained from roadway, excavation from structures or from borrow-pits should be placed in embankment. The materials used in embankments are soil, moorum, gravel, reclaimed material from pavement, fly ash or a mixture of these. Materials used should be free of logs, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment.

If due to lack of sufficient good materials, it is essential to use some materials which are undesirable, they should be placed where their adverse effect will be minimum. The best subgrade material should always be saved for top portion of the embankment.

The following types of material shall be considered unsuitable for embankment construction:

(*i*) Materials from swamps and marshes

(*ii*) Peat, stump and perishable materials any soil that classifies as OL, OI, OH or Peat in accordance with IS 1948

(*iii*) Materials susceptible to spontaneous combustion

(*iv*) Materials in a frozen condition

(*v*) Clay having liquid limit exceeding 70% and plasticity index exceeding 45%

(*vi*) Materials with salts resulting in leaching of the embankment

(*vii*) Expansive clay having free swelling index exceeding 50%

7.4.2 Design Elements in Highway Embankments

The design elements of highway embankments are:

(i) **Height:** The height of embankment depends on the desired grade line of the highway, topography, stability of foundation and the soil profile.

(ii) **Fill Material:** Granular soil is generally preferred as highway embankment material. The best of the soils available locally is often selected with a view to keep the lead and lift as low as possible.

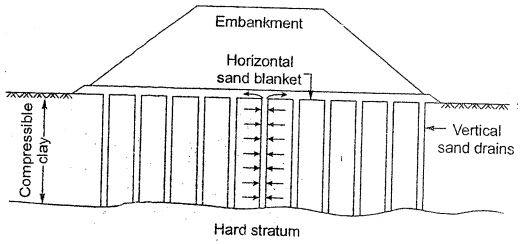

***Figure-7.5** : Embankment with vertical sand drains at foundation*

(iii) **Settlement:** If the embankment foundation consists of compressible soil with high moisture content, the consolidation can occur due to increase in the load. The settlement of the fill is generally due to inadequate compaction during construction and hence by proper compaction this type of settlement may be almost eliminated. To accelerate the rate of consolidation of saturated foundation clay, vertical Sand drains are constructed.

(iv) **Stability of foundation:** Stability of foundation is required in case of weak soil just beneath or at a certain depth below of embankment foundation and in case of high embankments.

(v) **Stability of slope:** The embankment slopes should be stable enough to eliminate the possibility of a failure under adverse moisture and other conditions. Often much flatter slopes are preferred in highway embankments due to aesthetic and other reasons.

7.4.3 Construction of Embankment

The embankment may be constructed either by rolling in relatively thin layers or by hydraulic fills. The formed is called rolled earth method and is preferred in highway embankments. Compaction of each layer is carried out at on optimum moisture content so as to attain the maximum dry density of soil using a specified compacting effort and equipment. The thickness of layers may vary between 10 and 30 cm depending upon factors like soil, compaction equipment etc.

7.4.4 Preparation of Subgrade

The preparation of subgrade includes all operations before the pavement structure could be laid over it and compacted such as site dearness, grading and compaction. Site should be cleared off and top soil consisting organic matter like grass, roots are to be removed. After that the grading operation is started to bring the vertical profile of the subgrade to design grade and camber. It is most essential to compact the top of subgrade upto a depth of about adequately before placing the pavement layer.

7.4.5 Compacting Equipment

Various compacting equipments which are used in the compaction of subgrade are:

(i) **Rollers:** The principle of rollers is the application of pressure, which is slowly increased and decreased. The various types of rollers which are used for compaction are given below

Smooth wheeled rollers: These are suitable to roll a wide range of soils, preferably granular soils. These are particularly found to be useful in compacting and other materials where a crushing action is advantageous.

Pneumatic Tyred Roller: They are suitable to compact non-plastic silts and fine sands. In addition to the direct pressure due to rolling, there is also a slight kneading action (Figure 7.6).

Sheepfoot Roller: These type of roller are suitable to compact clayey soils. The efficiency of the sheepfoot roller depends on the weight of the roller and the number of feet in contact with the ground at a time (Figure 7.7).

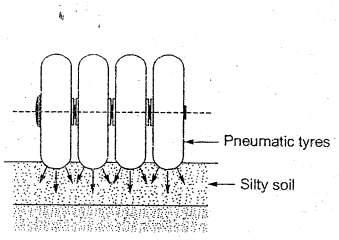

***Figure-7.6** : Compaction by pneumatic tyred roller*

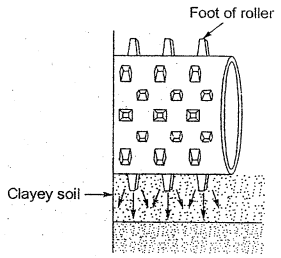

***Figure-7.7** : Compaction by sheepfoot Roller*

(ii) **Rammers:** These are useful to compact relatively small areas and where the rollers cannot operate such as compaction of trenches, foundation and slopes.

(iii) **Vibrators:** They are most suited for compacting dry cohesionless granular material. There are also vibrator mounted roller to give the combined effects of rolling and vibration.

(iv) **Watering:** This method is considered to be an efficient method of compacting cohesionless sands.

7.5 Types of Highway Construction

The highway construction types are classified as below:

(*i*) Earth roads
(*ii*) Gravel roads
(*iii*) Soil stabilized roads
(*iv*) Water Bound Macadam (WBM) roads
(*v*) Bituminous roads
(*vi*) Cement concrete roads

7.5.1 Construction of Earth Roads

An earth road is the cheapest type of road prepared from natural soil. The pavement section is totally made up of the soil available at site. The maximum cross slope of 1 in 20 is recommended to avoid erosion due to rain water and formation of cross ruts. The steep cross slope helps to keep the pavement surface free of standing water, otherwise the soil being pervious the water would damage the pavement section by softening.

The construction of earth road may be divided into following steps:

(i) **Material:** The pavement section is totally made up of the soil available at site or nearby which is free from organic matters. Specification of material considered satisfactory for earthern roads is given in Table 7.1.

Table-7.1 : Specification of material

	Base course	Wearing courses
Clay content	< 5%	10 to 18%
Silt content	9 to 32%	5 to 15%
Sand content	60 to 80%	65 to 80%
Liquid limit	< 35%	< 35%
Plasticity index	< 6%	4 to 10%

(ii) **Location:** The centre line and road edges are marked on the ground along the alignment by driving wooden pegs. The spacing of reference pegs depends on the estimated length of road construction in a day.

(iii) **Preparation of Sub-grade:** The various operations involved in the construction of subgrade are clearing site, excavating and construction of fills to bring the road to a desired grade and shaping of subgrade.

(iv) **Pavement Construction:** The soil is mixed, spread and rolled in layers such that the compacted thickness of each layer does not exceed 10 cm. Atleast 95% of maximum dry density is considered desirable.

(v) **Opening to Traffic:** The compacted earth road is allowed to dry out for a few days before opening to traffic.

7.5.2 Construction of Gravel Roads

Gravel roads are considered superior to earth roads as they can carry heavier traffic. This type of road can take about 100 tonnes of pneumatic tyred vehicle or 60 tonnes of iron tyred vehicles per day per lane. The camber provided on this type of road is between 1 in 25 and 1 in 30.

Two types of construction methods are:

(i) **Feather Edge Type:** It is constructed over the subgrade with varying thickness, so as to obtain the desired cross slope for the pavement surface.

(ii) **Trench Type:** In the trench type, the subgrade is prepared by excavating a shallow trench. Since there is better confinement for the gravel, the trench type is preferred.

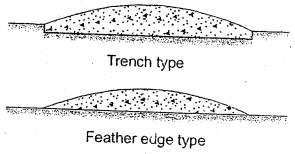

Figure-7.8 : Types of gravel road sections

The construction of gravel roads may be divided into following steps:

(i) **Material:** Hard variety of crushed stone or gravel of specified gradation is used. Rounded stones and river gravel are not preferable as there is poor interlocking. Gravel to be used for the construction is stacked along the sides of the proposed road.

(ii) **Location:** The centre line and road edges are marked on the ground along the alignment with the help of reference pegs.

(iii) **Pavement Construction:** The layer is rolled using smooth wheel rollers starting from the edges and proceeding towards the centre with an overlap of atleast half the width of roller in the longitudinal direction.

(iv) **Opening to Traffic:** A few days after the final rolling and drying out, the road is opened to the traffic

7.5.3 Construction of Water Bound Macadam Roads

The term macadam in the present day means, the pavement base course made of crushed or broken aggregate mechanically interlocked by rolling and the voids filled with screening and binding material with the assistance of water. When WBM, used as a surface course then it gets deteriorated rapidly under adverse conditions of traffic and weather. Therefore it is desirable to provide a bituminous surfacing course over the WBM layer.

Specifications of Materials for WBM Pavement

(i) **Types of Coarse Aggregate:** The coarse aggregates used in *WBM* pavement generally consists of hard varieties of crushed aggregates or broken stones. The weaker varieties of aggregates which get crushed during rolling need not strictly confirm to the requirements of gradation.

Table-7.2 : Varieties of coarse aggregates

Property	Requirements for pavement layer		
	Sub-base	Base course	Surfacing course
Los Angeles abrasion value (maximum value, percent)	60	50	40
Aggregate impact value (maximum value, percent)	50	40	30
Flakiness index (maximum value, percent)	–	15	15

(ii) **Size and Grading Requirements of Coarse Aggregates:** The coarse aggregates for each layer of construction should be of any one of the three gradings given below:

(a) Grading number 1 consists of coarse aggregates of size range 90 to 40 mm and is more suitable for sub-base course. Thickness of compacted layer is usually 100 mm.

(b) Grading number 2 consists of aggregates of size range 63 to 40 mm.

(c) Grading number 3 consists of range 50 to 20 mm and compacted thickness of each layer is normally 75 mm.

Table-7.3 : Grading of coarse aggregates

Grading No.	Size range (mm)	Sieve size (mm)	Percent passing the seive by weight
1	90 - 40	100	100
		80	65 - 85
		63	25 - 60
		40	0 - 15
		20	0 - 5
2	63 - 40	80	100
		63	90 - 100
		50	30 - 70
		40	0 - 15
		20	0 - 5
3	50 - 20	63	100
		50	95 - 100
		40	35 - 70
		20	0 - 10
		10	0 - 5

(iii) Properties of Coarse Aggregates: The crushed stone aggregates should be generally hard, durable and of acceptable shape, free from flaky and elongated particles.

(iv) Screenings: The screenings are used to fill up the voids in the compacted layer of coarse aggregate.

NOTE

IRC has suggested that from economic considerations, non plastic material such as kankar nodules, moorum or gravel may be utilized as screening material provided the $W_L < 20\%$, $I_P < 6\%$ and 75 $\mu < 10\%$.

(v) Binding Material: Binding material consisting of fine grained material is used to prevent ravelling of the stones. It is not required if crushable type screening is used, unless the plasticity index (I_P) value is low. Binding material with I_P ranges between 4 to 9% for surface course and less than 6% for base or sub-base course.

The construction of WBM roads may be divided into following steps:

(i) Preparation of foundation for receiving the WBM course: The foundation layer i.e. subgrade, subbase or base course is prepared to required grade and camber. On existing road surfaces, the depressions and pot holes are filled and corrugations are removed by scarifying and reshaping the surface to the required grade and camber.

(ii) Provision of Lateral Confinement: It may be done by constructing the shoulders to advance to a thickness equal to that of compacted *WBM* layer.

(iii) Spreading of Coarse Aggregate: The coarse aggregates are spread uniformly to proper profile to even thickness upon the prepared foundation.

(iv) Rolling: Rolling is started from the edges and then gradually shifted towards the centreline of the road.

(v) Application of screenings: After the coarse aggregates are rolled adequately, the dry screenings are applied gradually over the surface to fill the interstices in three or more applications.

(vi) Sprinkling and Grouting: After screeching, the surface is sprinkled with water, swept and rolled.

(vii) Application of Binding Material

(viii) Setting and Drying

Check of surface evenness and rectification of defects are mentioned below:

(*i*) The surface evenness of longitudinal direction is checked by 3.0 m straight edge and the number of undulations exceeding 12 mm in the case of grading no. 2 and 3 are recorded in each completed length of 300 m.

(*ii*) The maximum number of undulations permitted in each case is 30 mm. The spots with 15 mm undulations are marked for rectification of defects.

(*iii*) The cross profile is checked by using camber template and the maximum variation from special profile should not exceed 12 mm in the case of aggregate grading number 1 and 8 mm in the case of grading number 2 and 3.

7.5.4 Construction of Bituminous Pavements

It is possible to construct relatively thin bituminous pavement layers over an existing pavement. Therefore these are commonly adopted as wearing course. There are a wide range of construction techniques in use. The main problem associated with the construction of bituminous pavements is control of the proper viscosity of the bituminous-aggregate mixture during mixing and compaction operations. This is different from the cement concrete surfacing which would require very high cost of construction and a substantial caring period before opening the road to traffic, the bituminous surfacing has a distinct advantage in this respect. Also stage development is possible in the case of bituminous roads, depending on traffic demands.

The following construction techniques used in the bituminous construction are:

(i) Interface Treatments: The surface of the existing pavement layer is to be cleaned to remove dust and direct and a thin layer of bituminous binder is to be sprayed before the construction of any type of bituminous layer over this surface. This treatment is necessary to provide the bond between the old and the new layer.

Types of Interface treatments are:

(a) Prime coat: Bituminous prime coat is the first application of a low viscosity liquid bituminous material over an existing porous or absorbent pavement surface like the WBM base course. The main objective of priming is to plug in the capillary 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. Generally MC and SC cutbacks are used. The primed surface is allowed to cure for atleast 24 hours during which no traffic is allowed.

(b) Tack coat: Bituminous tack coat is the application of bituminous material over an existing pavement surface which is relatively impervious like an existing bituminous surface or cement concrete pavement or a pervious surface like the WBM which has already been treated by a prime coat. Bituminous material of higher viscosity like hot bitumen is used and in cold state, bituminous emulsion may also be applied.

(ii) Surface Dressing: Bituminous surface dressing is provided over an existing pavement to serve as thin wearing coat. The single coat surface dressing consists of a single application of bituminous binder material followed by spreading of aggregate cover and rolling.

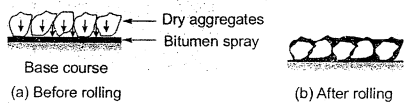

Figure-7.9 : Principle of bituminous surface dressing construction

The main functions of bituminous surface dressing are:

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

(iii) Seal Coat: Seal coat usually recommended as a top coat over certain bituminous pavements which are not impervious. Such as open graded bituminous constructions like premixed carpet and grouted macadam. It is also provided over a worn out existing bituminous pavement.

The main functions of seal coat are:

(a) To seal the surfacing against the action of water
(b) To develop skid resistant texture.
(c) To enliven on existing dry or weathered bituminous surface.

(iv) Penetration Macadam: Bituminous penetration macadam or grouted 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, thus filling up a part of the voids and binding some stone aggregates together. Full grout is adopted in regions of heavy rainfall and semi-grout is adopted in regions of moderate rainfall and traffic.

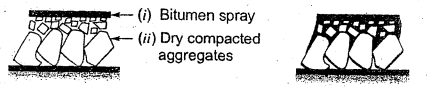

***Figure-7.10:** Principle of bituminous penetration macadam construction*

(v) **Built-up Spray Grout:** Built-up spray grout consists of two layer composite construction of compacted crushed aggregates with application of bituminous binder after each layer for bonding and finished with key aggregates at the top to provide a total compacted thickness of 75 mm. This method is commonly used for strengthening of existing bituminous pavements. A suitable wearing course is invariably provided over this layer before opening to traffic.

(vi) **Premixed Method:** In this method the aggregates and the bituminous binder are mixed thoroughly before spreading and compacting. It is possible to coat each particle of aggregate with the binder still the quantity of binder used may be considerably less than penetration macadam type construction. Depending on the gradation macadam type construction.

Depending on the gradation of the aggregates chosen, premixed constructions may be classified as:

(a) Bituminous Macadam: It is base course or binder course and should be covered by a suitable surface course before exposing to traffic. Bituminous Macadam base course is considered to be much superior than other types of base course such as Water Bound Macadam with respect to load dispersion characteristics and durability.

(b) Bituminous Premixed Carpet: It is used as surface course. Bituminous premixed carpet is open graded and should be covered by suitable seal coat. It consists of all aggregates passing seal coat. It consists of all aggregates passing 20 mm and retained on 6.3 mm sieve.

(c) Bituminous Concrete or Asphalt Concrete: It is a dense graded premixed bituminous mix which is well compacted to form a high quality pavement surface course. The asphalt concrete consists of a carefully proportioned mixture of coarse aggregates, fine aggregates, mineral filler and bitumen and mix is designed by an appropriate method.

(d) Sheet Asphalt: Sheet asphalt is a dense sand-bitumen premix of compacted thickness 25 mm, used as a wearing course. This is usually laid over cement concrete pavement to provide on excellent riding surface.

(e) Mastic Asphalt: It is a mixture of bitumen, fine aggregates and filler in suitable proportions which yield voidless and impermeable mass. Mastic asphalt can absorbs vibrations and has a property of self healing of cracks without bleeding. It is a suitable surfacing material for bridge deck slabs.

Construction Procedure of Bituminous Pavements

(i) **Preparation of Surface:** This work includes the preparing on existing granular to specified lines, grades, and cross section in advance of laying a bituminous course. The work shall consist of scarifying and relaying the granular base course, filling of potholes, sealing of cracks and application of a profile corrective course as necessary

(ii) **Materials:**

(a) For scarifying and relaying the granular surface: Materials used should be coarse aggregates salvaged from scarification of the existing granular base course provided by fresh coarse aggregates.

(b) For patching potholes and sealing crack: For patching potholes, approved material having same specification as that of profile corrective course shall be used and for Sealing Small Cracks finer than 3 mm, a fog seal shall be applied while larger cracks wider than 3 mm, is treated with an emulsion slurry seal.

(c) For profile corrective course: It is essentially a pavement base material course for correcting the existing pavement a new shape to meet the requirement of specified lines, grades and cross-sections.

(iii) **Construction Operations:**

(a) Preparing existing granular surface: Where the existing surface is granular, all loose and disintegrated materials shall be removed and the surface lightly watered if the profile corrective course to be provided as a separate layer is also granular.

(b) Scarifying existing bituminous surface: Where necessary, the existing bituminous layer in the specified width shall be removed with care without causing under disturbance to the underlying layer.

(c) Patching of potholes and sealing of cracks: Before applying profile corrective course on the existing pavement, potholes, if any, shall be drained of water, cut to regular shape with sides vertical upto the affected depth and slightly beyond the limits of affected area and dried. The cracks in the old pavement surface shall be sealed with a fog seal if cracks are small.

(d) Laying the profile correct course: After preparing the granular surface, the profile corrective course shall be laid and compacted. Where a bituminous profile corrective course is to be laid over a primed granular surface a tack coat shall be applied prior to laying profile corrective course.

(e) Covering the profile corrective course: Work of profile corrective course shall be so planned that it shall be covered by the designed base/wearing course at the earliest, before opening to regular traffic.

7.5.5 Construction of cement concrete pavements

The cement concrete pavements are constructed with or without the subbase course. This decision is made depending upon the soil type, design load and economic consideration. The variation purpose of the subbase course beneath the cement concrete pavements are to

(*i*) provide a strong supporting layer.

(*ii*) provide a capillary cut off preventing the damage due to mud pumping.

(*iii*) reduce thickness requirements of cement concrete slab and lower the cost of construction

(*iv*) increase the service life of the cement concrete pavement.

In considering the drawbacks of the cement concrete pavement type, it may be stated that it requires a very high initial investment and the method is not adopted for the stage construction.

The construction of the cement concrete pavement is dealt under the following groups:

(*i*) Construction of pavement slab

(*ii*) Construction of joints

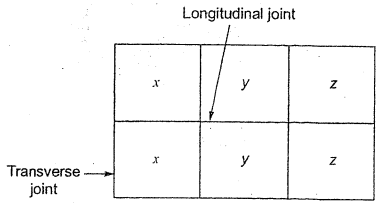

***Figure-7.11** : Construction of cement concrete road*

Specification of Material for Cement Concrete Pavement Slab

(i) Cement: Ordinary portland cement is generally used. In case of urgency rapid hardening cement may be used to reduce curing time.

(ii) Coarse Aggregates: The maximum size of coarse aggregate should not exceed one fourth the slab thickness. The desirable limits of important properties are given in Table 7.4.

Table 7.4 : Properties of coarse aggregates

Properties	Maximum Value
Aggregate crushing value	30%
Aggregate impact value	30%
Los angels abrasion value	30% as per ISI and 35% as per IRC
Soundness	12% in Sodium Sulphate 18% in Magnesium Sulphate

(iii) Fine Aggregate: Natural sands should be preferred as fine aggregate though crushed stones may be also be used.

(iv) Proportioning of Concrete: The concrete may be proportioned so as to obtain a minimum modulus of rupture of 40 kg/cm^2 on field specimens after 28 days curing or to develop a minimum compressive strength of 280 kg/cm^2 at 28 days, or higher value as desired in the design.

Construction Steps of Cement Concrete Pavements

(i) Preparation of subgrade and sub-base: The minimum modulus of subgrade reaction obtained with a plate bearing test should be 5.54 kg/cm^2. The subgrade is prepared and checked at least two days in advance of concreting . The subgrade should be saturated with water for 6 to 20 hours in advance of placing concrete.

(ii) Placing of forms:

(iii) Batching of Materials and Mixing: The coarse aggregates and fine aggregates are proportioned by weight in a weigh-batching plant and placed into hopper along with necessary quantity of cement.

(iv) Transportation and Placing of Concrete:

(v) Compaction and Finishing

(vi) Floating and Straight Edging

(vii) Belting, Brooming and Edging: Just before the concrete becomes hard, the surface is belted with a two ply canvas belt. After belting, the pavement is given a broom finish with fibre broom brush.

(viii) Curing of Cement Concrete: In initial curing the pavement is entirely covered with cotton or jute mats. The mats are thoroughly saturated with water. In the final curing, the soil is thoroughly kept saturated with water for 14 days.

Construction of Joints in Cement Concrete Pavements

Joints are provided in cement concrete roads for expansion, contraction and warping of the slabs due to the variation in the temperature of slabs.

During the mid-day the top of the pavement slab has higher temperature than the bottom of the slab. This causes the top fibres of the slab to expand more than the bottom fibres and the slab curls at the edges as shown in Figure 7.12. This phenomena is know as warping down of the slab.

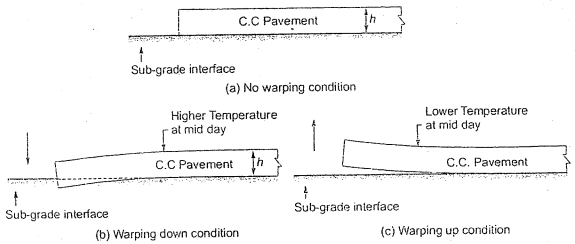

***Figure-7.12** : Warping of cement concrete pavement slab*

At the mid night the temperature of the bottom of the slab is higher than the temperature of the slab top. The slab works up during this time.

NOTE: In reality weight of the pavement resist the warping of slab thereby developing stress in slab which is known as warping stress.

Joints are classified depending upon their direction of placement:

(*i*) Transverse Joint:
- (a) Expansion Joint
- (b) Contraction Joint
- (c) Warping Joint
- (d) Construction Joint

(*ii*) Longitudinal Joints

Requirement of a good joint are:

(*i*) Joint must move freely

(*ii*) Joint must not allow infiltration of rain water and ingress of stone grits

(*iii*) Joint must not protrude out the general level of the slab

Summary

- The bituminous pavements and cement concrete roads are considered suitable for heavier traffic intensity.
- Subgrade may be in either embankment or in excavation depending on the topography.
- Power shovel is used primarily to excavate earth of all classes except rock.
- Hoe is meant to excavate below the natural surface where the machine is stationed.
- Compacting equipments used in the compaction of subgrade are rollers, rammers, vibrators and watering.
- In earth roads maximum cross slope of 1 in 20 is recommended to avoid erosion due to rain water.
- Camber provided on the gravel road is between 1 in 25 and 1 in 30.
- The surface evenness of longitudinal direction is checked by 3.0 m straight edge and the maximum number of undulations permitted is 30 mm.
- The main problem associated with the construction of bituminous pavements is control of the proper viscosity of the bituminous aggregate mixture during mixing and compaction operations.

- Prime coat is the first application of a low viscosity liquid bituminous material over an existing porous surface.
- Tack coat is the application of bituminous material over an existing pavement surface which is relatively impervious.
- Cement concrete pavement required a very high initial investment and the method is not adopted for the stage construction.

Objective Brain Teasers

Q.1 The first coat of bituminous surfacing over an existing
(a) Seal coat (b) Prime Coat
(c) Tack coat (d) Cut back

Q.2 Thickness of pavement may be reduced considerably by
(a) Compaction of soil
(b) Stabilization of soil
(c) Drainage of soil
(d) All of the above

Q.3 To indicate proper control of consistency of a freshly mixed concrete for pavement construction, the slump should be between
(a) 7.5 (b) 6.5
(c) 5.0 (d) 8.0

Q.4 Pick up the correct statement for W.B.M. roads.
(a) Screening consists of aggregates of smaller size, generally of the some material as the course aggregates.
(b) Purpose of binding material is to prevent revelling of stones.
(c) Lime stone of kankar can be used as binding material
(d) Rolling is done from camber to edges.

Q.5 Tack Coat is provided on
(a) An existing black top
(b) WBM
(c) Both (a) and (b)
(d) None of these

Q.6 In grouted or penetration macadam construction the bitumen is
(a) Premixed with aggregates
(b) Sprayed after aggregates are used
(c) Sprayed before aggregates are spread
(d) None of these

Direction: Each of the next consists of two statements, one labelled as the **'Assertion (A)'** and the other as **'Reason (R)'**. You are to examine these two statements carefully and select the answers to these items using the codes given below:

Codes:
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.7 **Assertion (A):** The prime coat is an interface bituminous treatment when the existing base course has a pervious texture like water bound macadam.
Reason (R): The primer has to get into the capillary voids in the existing base and it should be of low viscosity. Bituminous emulsion is generally use as a prime coat.

Q.8 **Assertion (A):** In water bound macadam construction, grade 1 has better load dispersion characteristics as compared to grade III aggregates.
Reason (R): The plasticity index of the binding material should be less than 6%

Answers

1. (b) **2.** (d) **3.** (a) **4.** (d) **5.** (a)
6. (b) **7.** (a) **8.** (d)