

Chapter-6

Road Construction Technology

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Introduction:

- Road construction technology is the branch of highway engineering which deals with **all kinds of activities and technology or operations for changing existing ground to desired shape, slope and to provide all necessary facilities** for smooth, safe and efficient traffic operation which also includes the reconstruction of existing roads.

Approach of RCT:

(1)Labor based intensive

- By petty contractor basically.
- More time required.
- (70-80)% labor used.

(2)Capital or equipped intensive

- By contractor system
- Less time required
- Used equipment
- More quality
- For large project
- Over (60-70)% equipment used.

Activities and Techniques used in Road Construction:

(1)Earthworks and site clearance:

- Site clearance
- Earthwork for filling for embankment
- Excavation for cutting
- Excavation for borrow pit
- Excavation for structural foundation
- Disposal of surplus earth

(2)Drainage work:

- Minor bridges
- Culverts
- Causeways
- Side drains
- Other surface and sub-surface drainage works

(3)Structural or protection works:

- Earth retaining structure
- Gully control structure
- Land slide stabilization
- Bridge protection works
- River training works.

(4)Pavement works:

- Sub-grade works
- Sub-base works
- Base works
- Surface works

(5)Miscellaneous works:

- Road Furniture
- Traffic sign/signal/markings etc.
- Bio engineering works.

Tools, Equipment and Plants used in Road Construction:

(1)Tools:

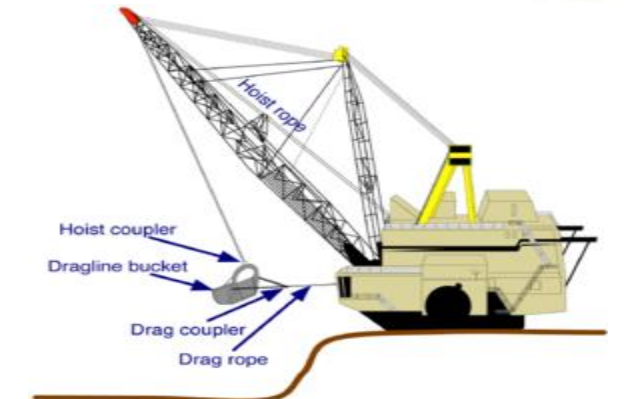
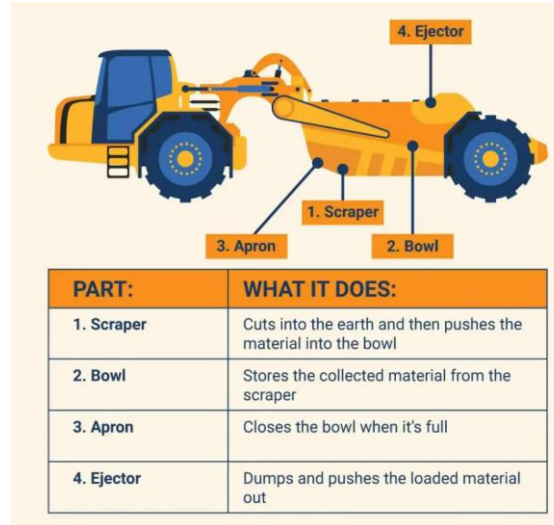
- Hand shovel, chisel, peak, spade, hand rammer, brushes, trowel, wheel barrows etc.



(2)Equipment:

(a)Earth Moving Equipment:

- Dozer(bull dozer, angle dozer, tree dozer)
- Scraper
- Loader
- Excavator
- Drag line
- Clamshell
- Trench digger



(b) Compaction equipment:

- **Smooth wheel rollers:** Useful for finishing operations after compaction of fills and for **compacting granular base course** of highway. They are suitable for compacting **gravel, sand, crushed rock** and any material where crushing is required.
- **Vibrating rollers:** most suitable for compacting **dry cohesionless granular material**.
- **Pneumatic tires rollers:** effective for **compacting both cohesive and cohesionless soils** especially non-plastic silts and fine sands.
- **Sheep foot rollers:** this type of roller consists of hollow steel cylinder with projecting feet. **They are most suitable to compact clayey soils**.
- **Rammers:** It is the block of iron or wood attached to a wooden rod. It is **useful to compact relatively small areas** where the rollers cannot operate due to space limit such as trenches, foundation, slopes.



(c)Leveling equipment:

- Grader



(d)Paving equipment:

- Binder spreader
- Heating kettle for binder
- Aggregate spreader
- Cement concrete mixer
- Bituminous paver
- Cement concrete paver.



(e)Lifting equipment:

- Backhoe(for low load)
- Crane(different capacity)



(f)Transporting equipment:

- Dumping trucks(tripper)
- Trucks(flat body)
- Mini dumpers



(g)Miscellaneous equipment:

- Rock driller
- Water tanker
- Drilling machine



(3)Plants:

- Cement concrete plant
- Asphalt concrete plant
- Aggregate crushing plant
- Screening plant
- Washing plant
- Sand blowing unit.

Preparation of sub-grade soil or road bed:

Site Clearance:

- Site operation is the **first operation** for fixing road alignment before the commencement of any earthworks for road construction.
- Clearing hedges and shrubs at least covering toe width.
- **Removal of existing trees, stumps and roots along the alignment.**
- **Removal of existing structures along the alignment.**

Preparation of subgrade:

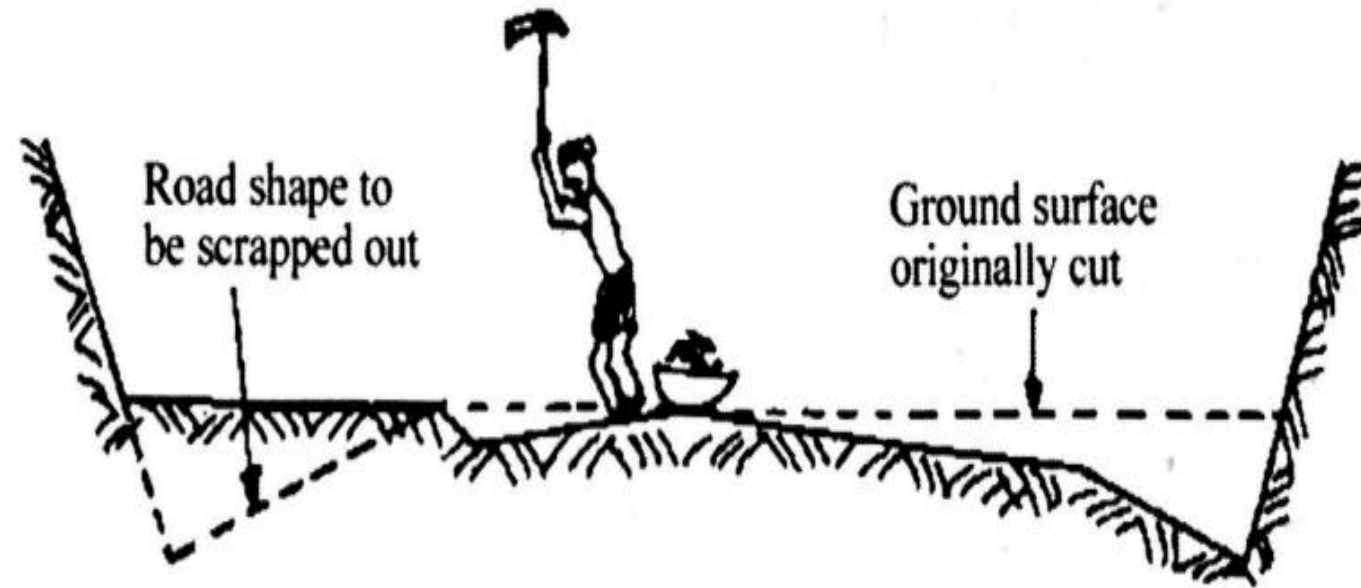
- Subgrade preparation includes all operation before the pavement structures could be laid over it.
- **Subgrade may be situated on embankment, excavation or at the existing ground surface.**
- The **top of the subgrade should be well compacted** before placing the pavement layer.

Earthwork:

- It includes all construction operations required to convert the road land from its natural condition and configuration to the sections and grades prescribed in the plan.
- **Earthwork, which may be excavated or filling** can be performed manually or using machine.

Earthwork in excavation:

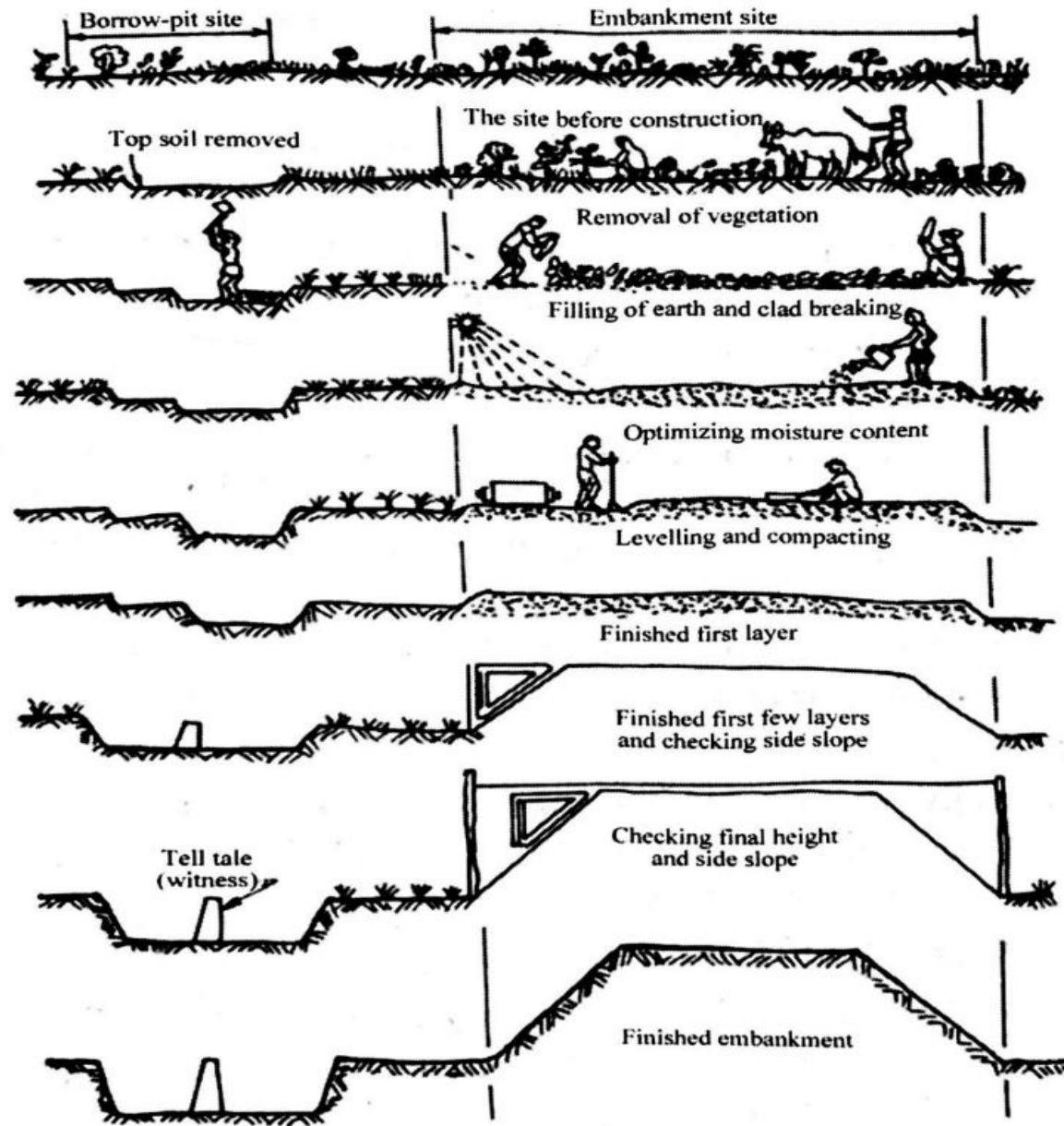
- The **process of cutting or loosening and removing the earth** including rock from its original position , transporting and dumping it to the site as a fill or spoil bank is known as excavation.
- It may be needed in soil , soft rock or even in hard rock before preparing the subgrade.
- It is **done when the natural ground level is higher than the designed grade line level.**
- The **depth of cutting depends upon the height of grade line below natural ground level** and can be calculated from longitudinal section and cross section of the road.
- The slope to be provided for excavation depends upon the nature and type of soil and depth of cutting.



Scraping to shape road in cuts.

Earthwork in embankment:

- Earthwork in embankment is the **filling of earth or soil to achieve the desired grade line** with the consideration of vertical alignment.
- It is necessary when **natural ground level is below the grade line level or formation level.**
- The grade line may be raised due to any of the following reasons:
 - To **keep the subgrade above** the high **ground water table.**
 - To **prevent** damage to pavement due to **surface water and capillary water.**
 - To maintain the **design standards** of the highway **with respect to the vertical alignment.**
- **The design elements of highway embankment are:**
 - Height of fill: depends on the formation level and location of natural ground.
 - Fill material: generally granular soil is preferred.
 - Settlement of embankment.
 - Stability of foundation
 - Stability of slopes.

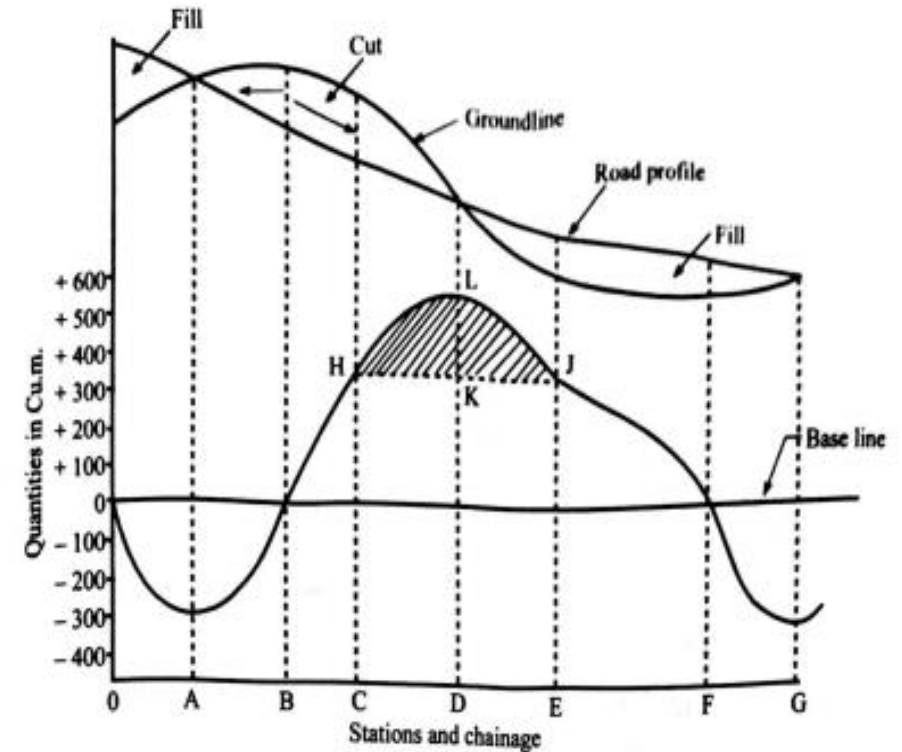


Stages of embankment construction.

Mass Haul Diagram:

Mass haul diagram is the graphical representation of the amount of earthwork involved in road construction and the manner in which the earth to be hauled economically.

- **Haul:** In earthwork calculation the term haul has dual meaning . It is used to describe the distance over which material is moved and also the volume of material used.
- **Free Haul:** It is distance to which the contractor is supposed to move the earth without any additional charge. The charge for free haul is covered by the unit rate of earthwork. It is generally 50m
- **Overhaul:** It is the distance in excess of free haul for which the contractor will paid extra for each unit of haulage.
- **Economical haul:** Economical haul distance is a distance to which material from the excavation to embankment can be moved more economically than to get material from borrow opening.



Construction of low cost roads:

(1)Earthen Road:

- Earthen road is the type of road whose whole pavement section is **constructed with the locally available earth material.**
- It is the **cheapest type of road** prepared from natural soil.
- It is also the **first stage of road development.**
- Normally camber is provided of 4-5%.

Equipment's used:

-Excavator, dozer, bull dozer –smooth wheel roller for compaction
–grader for providing camber –water tanker

Materials:

The soil having following properties is suitable for preparation of subgrade:

- Liquid limit(LL)<75%
- Plasticity index(PI)<40%

Construction steps:

- **Soil survey:** soil should be **free from organic matter**. Before excavating earth from borrow pit for the construction the trees, shrubs, roots and top soil should be removed.
- Centre line and reference points are fixed with the wooden pegs.
- Preparation of sub grade.
- Pavement Construction: The borrowed soil are dumped on the prepared sub-grade and pulverized. The field moisture content is checked and additional water is mixed if necessary to bring it up to OMC. Soil thus mixed is spread over carriageway and rolled in layers of compacted thickness not exceeding as specified.
- Open to traffic after setting of compacted earth.

Quality control:

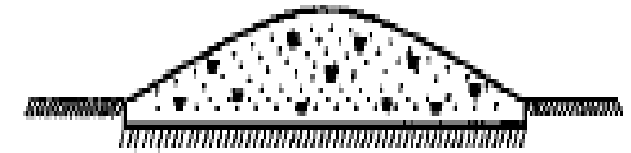
- Conducting Atterberg's limit and proctor density tests.
- Checking of camber and grade.
- Checking of field moisture and field dry density(95% minimum.)

(2)Gravel Road:

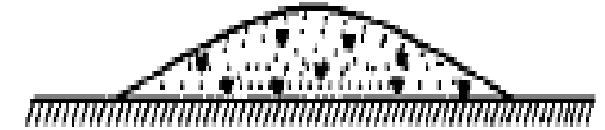
- Gravel roads are considered superior to earth roads as they can carry heavier traffic loads.
- Compacted gravel mix makes the carriage way of these roads.
- Normally camber is provided of 3.3-4%
- There are two methods in the construction of gravel road:
 - **Feather edge type** with varying thickness across the pavement width **to attain the desired camber.**
 - **Trench type with cutting to trench shape** on the prepared subgrade covering the pavement width **for the better confinement.**

Materials:

- Hard, durable, strong variety of crushed stone or gravel of specified gradation is used for the road construction.
- Liquid limit value not exceed 25%.
- Plasticity index not greater than 6%.
- CBR value > 60%.
- FI<30%.



Trench Type



Feather Edge Type

Equipment's:

- The road can be constructed manually with hand tools or using other equipment's for excavation, hauling, compaction.
- Grader, smooth steel wheel roller, transporting vehicle(tripper, truck etc.), water tanker.

Construction step:

- Existing surface is prepared.
- Gravel to be used for construction is stacked along the sides of the proposed road.
- Wooden pegs for center line and reference points for carriage way are driven.
- Gravel or crushed stone are placed carefully by grader.
- Gravel or crushed stone is spread with greater thickness at center and less towards the edges so as to obtain the desired camber.
- Compaction with smooth wheel roller or vibratory roller. The compaction always starts from edges and proceeding towards center at straight section and from inner edge to outer edge on super elevated section with half width of roller overlapping.
- Open to traffic after few days of completion.

Quality control:

- Conducting Atterberg's limit, gradation, CBR, Flakiness Index
- Checking of camber and grade.
- Checking of field moisture and dry density(>98%).

(3)Construction procedure of water bound macadam(WBM) roads:

- The water bound macadam road construction technique was given by John Macadam.
- The main principle of this pavement structure is that the **crushed broken stone aggregates are bound together by the action of rolling or traffic compaction.**
- The **binding is achieved by stone dust used as filler material in presence of water.**
- WBM may be used as a sub-base, base or surface course.
- The thickness of each compacted layer of WBM ranges from 10cm to 7.5 cm depending on size and the gradation of aggregate used.
- Generally camber of 1 in 36 to 1 in 48 is provided in WBM road.

Materials:

(i)Course aggregate:

- They are **crushed aggregate or broken stones** and should be hard , durable , acceptable and free from flaky and elongated particle.

(ii)Screening:

- Screening are used to fill up the roads in compacted layer of course aggregate. **They are consider of small sized course aggregates with non-plastic materials.**

LL ≤ 20%, Plastic index ≤ 6%, proportion of fines passing 0.075mm sieved ≤ 10%.

(iii)Binding materials:

- Binding materials are used to prevent reveling of the stones.
- **Fine grain and locally available material like lime, stone dust etc. may be used.**
- Plasticity index=4% to 9% in surface course
- Plasticity index ≤ 6% for base and sub-base course.

Equipment:

- Aggregate spreader, Roller, tipper and water tanker or manually for small project.

Construction steps:

- Preparation of sub-grade or foundation.
- **Lateral confinement** is to be provided before starting WBM construction.
- **Spreading the course aggregate:** Course aggregate is stacked along the length of the road at suitable intervals. The course aggregates should be spread uniformly and evenly on the prepared sub-base.
- **Rolling:** Compaction of course aggregate is done by wheel power roller of 6 to 10 ton.
- **Application of screening:** After rolling the course aggregate layer, screening consisting of stone grit is spread uniformly over it in three or more application.
- **Sprinkling and wet rolling:** After light dry rolling , the surface of the layer is sprinkled with water and rolled again. It will help to fill about 50% of total voids.
- **Application of binding material:** A suitable filler material is then applied at uniform and slow rate in two or more successive thin layers.
- **Setting and drying:** After final compaction of course the layer shall be allowed to dry overnight. Next morning , hungry spots shall be filled.

Quality control:

- Conducting Atterberg's limit of filler materials.
- Gradation of aggregate, flakiness index, Los angles abrasion, CBR value of aggregates for its suitability.
- Checking of camber and grades.

(4) Soil Stabilized Roads:

- Soil stabilization is the **process of improving the bearing capacity of the soil by propitiating and controlled compaction with suitable admixtures or binders.**
- It can be said as a method of processing available materials for the development of stable strips of low cost roads.
- The **construction cost can be considerably lowered** by selecting local materials.
- In general if the stability of the soil is not adequate for supporting wheel loads the properties are improved by soil stabilizing techniques.

Mechanics of soil stabilization:

- Evaluating the properties of available soil.
- Deciding the effective and economical method of stabilization (depending upon the lacking property in the soil)
- Designing the stabilized soil mix for intended stability and durability value.
- Adequate compaction of the stabilized soil layer.
- After stabilization it may result in any one or more of the following changes:
 - **Increase in stability, change in physical properties like density, swelling, change in physical character.**
 - Change in chemical properties.
 - Retaining the desired minimum strength by water proofing.

Techniques of Soil Stabilization:

- *Proportioning Technique:* Locally available soils and aggregate mixed in suitable proportion.
- *Cementing agent:* adding Portland cement, lime, bituminous materials.
- *Modifying agent:* Portland cement, lime for highly clayey soil.
- *Water proofing agents:* Bituminous materials.
- *Water repelling agent:* Organic compound(vinyl resin, resinous materials)
- *Water retaining agents:* Calcium chloride for non-cohesive soil.
- *Heat treatment:* heat treated for clayey soil.
- *Chemicals:* several chemicals < 0.5% by weight of soil.

Note: In all above methods, adequate compaction of the stabilized layer is most essential.

Method of Soil Stabilization:

1. Mechanical stabilization.-(Granular stabilization or as soil aggregate roads.)
2. Soil-cement stabilization.
3. Soil-lime stabilization.
4. Soil-bitumen stabilization.

Soil Cement Stabilization:

- It is an intimate mix of soil, cement and water which is well compacted to form a strong base course.
- Refers to the compacted mix when cement is used in small properties to impart some strength or to modify the properties of soil.
- Soil cement can be used as sub base or base course but not as surface course as the material has poor resistance to abrasion and impact. A bituminous wearing surface is placed over the base course.

Material:

- Collection of borrow pit materials and pulverization having $LL < 40\%$, $PI < 18\%$.
- Portland cement.

Equipment:

- mix in place: could be done manually using minor equipment.
- Plant mix method: mixing plants are used which can batch the materials.
- Compacting equipment.

Construction Procedure:

- Preparation of sub-grade or sub-base.
- Pulverization of soil.
- Application of cement and dry mixing.
- Addition or spraying water and remixing.
- Spreading and grading.
- Compaction: By smooth wheel roller. The compaction is done with minimum possible delay after wet mixing.
- Curing: The soil cement layer is allowed moist curing.

Quality control:

- Checking of moisture content in soil and mix.
- Checking of degree of pulverization.(sieve through 4.75mm)
- Testing of mixing efficiency.
- Checking cement content of mix.
- Determination of dry density of the compacted layer.

Construction of Prime coat, Tack coat and Seal coat:

Prime Coat:

- It is the 1st application of low viscosity liquid bituminous material to the surface of existing bases to seal the surface to prevent the penetration of moisture into the sub-grade.
- Functions:
 - Develop bond between the base and the wearing surface.
 - Seals the pores and capillary voids thus making it water proofing.
 - Binds together any loose aggregates on the existing surface.

Tack Coat:

- It is the light spray application of diluted bituminous emulsion between two relatively impervious layers designed to create a strong adhesive bond without slippage.
- It is a single application of bituminous material on existing pavement surface which is relatively impervious such as existing bituminous, cement concrete or a previous surface like WBM which has already been treated by a prime coat.
- Tack coat is usually applied by spraying bituminous material of higher viscosity.

Seal Coat:

- It is the **thin protective wearing surface** that is applied to a pavement base course.
- It is single coat surface dressing which is either **applied as a final step in the construction of certain bituminous, surfaces or to existing surfaces, which have cracked or worn out.**
- A **mixed sand bitumen seal coat is commonly used** over the premixed carpet.

Function:

- Water proofing layer to protect the underlaying pavement.
- Increased skid resistance.
- A filler for existing cracks or reveled surface.
- An anti- glare surface during wet weather and an increased reflecting for night driving.

Construction of Bituminous Surface Dressing:

- Surface dressing is a cost effective road that is used on many roads that makes up the rural road network.
- It is provided over an existing pavement to serve as a wearing coat.

The main functions of surface dressing are:

- To provide a dust free pavement surface over a base course in dry weather and mud free pavement in wet weather.
- To provide a waterproof layer and to prevent infiltration of surface water.
- To prevent the base course from reeling and abrasive action of traffic.

Surface dressing may be:

- **Single coat surface dressing.**
- **Double coat surface dressing.**

(a)Single coat surface dressing:

- It **includes the single application of thin layer of bitumen followed by the cover material** of specified size stone aggregates which is then completed by rollers.

(b)Doble coat surface dressing:

- In this type of surface treatment, **immediately after laying the first coat, second application of binder is applied and followed by uniform spreading of the cover material** of smaller size aggregate and then rolled.

Material required for bituminous surface dressing:

- Depends on whether the surface dressing is done in a single coat or two coats, on black top pavements or on a WBM pavement.
- Bitumen grades: 80/100 or 180/200
- The chipping should exhibit:
 - Los Angles abrasion value $\leq 35\%$
 - Aggregate impact value $\leq 30\%$
 - Flakiness index $\leq 25\%$
 - Water absorption $\leq 1\%$

Plants and equipment's:

- Mechanical blower and hand brushes.
- Mechanical sprayer.
- Equipment for heating of bitumen.

Construction steps:

(i)Preparation of existing surface:

- The surface defects such as pot holes, ruts, depression etc. are repaired and is cleaned.

(ii)Application of binder:

- The bituminous binder is applied at specified rate using mechanical sprayer on prepared surface.

(iii)Application of stone chipping:

- Stone chipping as per requirement is spread after the application of binder to cover surface uniformly.

(iv)Rolling of first or final coat:

- Rolling is done with tandem roller of 6 to 8 tones weight starting from edges preceding towards the center longitudinally with overlapping not less than one third of the roller tread.

(v)Application of binder and chipping for 2nd coats:

- The binder is again applied to the prepared surface as per requirements.
- Immediate stone chipping is spread as before and rolling is done as before.

(vi)Finish and opening to traffic:

- The surface is checked for longitudinal and cross profile.
- Then the road surface is opened to traffic after 24hrs.

Quality Control:

- Checking the temperature of binder.
- Checking of dust content in stone chipping.
- Tests conduction on binder at least penetration, viscosity and ductility.
- Checking of rate of application of binder and stone chipping by placing rectangular tray during spreading

Construction of Otta Seal:

- It is an asphalt or bituminous surface treatment **constructed by placing a graded aggregate on top of thick application of relatively soft bituminous binding agent.**
- It is the bituminous surfacing consisting of graded aggregates ranging from natural gravel to crushed rock in combination with relatively soft (low viscosity) binders with or without sand cover seal.

Materials:

- Bitumen: MC 3000 or MC 800 cutback.
- Aggregate: Clean, strong, hard and durable with following properties:
 - Los Angeles Abrasion value $\leq 40\%$
 - Aggregate impact value $\leq 30\%$
 - Flakiness index $\leq 25\%$
 - Plasticity index < 5
 - Gradation as per the specification either open, medium or dense.

Plants and equipment:

- Equipment for heating of bitumen.
- Mechanical blower or hand brushes.
- Roller
- Aggregate spreader.
- Bitumen distributor.
- Air compressor

Construction Procedure:

- Preparation and intensive cleaning of the existing surface by mechanical broom or hand brushes and air compressor.
- Application of the prime coat at specified rate if necessitate in design.
- Spreading of binder as per specified rate of application.
- Spreading of aggregate of specified grading as per specified rate of application.
- Rolling by pneumatic roller at a minimum weight of 12 tons or more at the day of construction.
- A minimum of 15 passes with a pneumatic roller is required.
- After the initial rolling is completed it is advantage to apply one pass with 10-12 tones static steel roller to improve the embedment of the large aggregate.
- During the first two days after sealing, extensive rolling shall be applied to ensure all particles embedded in the binder are properly coated.
- Aggregates dislodged by traffic during the immediate post construction period shall be broom back.
- Spreading of binder as per specified rate of application.
- Spreading of sand as per specified rate of application.
- Rolling with pneumatic roller and curing till four weeks.
- After 8-12 weeks second coat is executed following the above mentioned construction steps.

Quality Control:

- Check cross and longitudinal profile.
- Checking the condition of the equipment's.
- Checking the temperature of binder.
- Test for binder –viscosity, ductility etc.
- Test for aggregates-Flakiness, LAAV etc.
- Checking the rate of application of binder and aggregates.

Construction of grouted or penetration macadam:

- Depending upon the **quality of bitumen spread** penetration macadam is classified as **full grout** when the bitumen penetrates to the full depth and **semi grout** when bitumen penetrates up to about half the depth.
- Full grout is adopted in regions of heavy rain where as semi grout on average rain fall and traffic.
- Usual thickness of the layer is 7.5 cm for full grout and 5 cm for semi grout.

Materials:

- Bitumen: Normally 80/100 grade
- Aggregate: Clean, strong, hard and durable with following properties:
 - Los Angeles Abrasion value $\leq 40\%$
 - Aggregate impact value $\leq 30\%$
 - Flakiness index $\leq 25\%$
 - Stripping Value $\leq 25\%$
 - Gradation of aggregates is chosen depending upon thickness layer. Maximum size of course aggregate and key aggregate for 7.5 cm thick is 63mm down and 25mm down respectively and for 5cm thick 50mm down and 20mm down respectively.

Equipment Requirement:

- Bitumen heating device.
- Bitumen distributor.
- Aggregate spreader.
- Rollers.

Construction steps:

- Preparation and intensive cleaning of the existing surface by broom and air compression.
- Spreading the course aggregate as per the specified rate of application.
- Dry rolling of the spread course aggregate at least with 10 ton roller.
- Spreading of bitumen as per specified rate of application.
- Spreading of key aggregate as per specified rate of application.
- Rolling of key aggregate at least 10 ton roller.
- Application of seal coat.
- Opening to traffic.

Quality Control:

- Checking the condition of equipment's.
- Checking the temperature of binder.
- Test for binder –viscosity, ductility etc.
- Test for aggregates-Flakiness, LAAV etc.
- Checking the rate of application of binder and aggregates.

Construction of different types of bituminous premix:

(A)Bitumen Bound Macadam:

It is **the premix laid immediately after mixing and their compacted**. Seal coat is necessary when this layer is exposed as a surface course.

Specification of materials:

(a)Bitumen :- The grades of bitumen are 30/40, 60/70 and 80/100. Road tar RT-4, cut back and emulsion can be used in cold mix construction technique.

(b)Aggregate: Aggregate should have low porosity and following requirement.

Los Angles abrasion value $\leq 50\%$

Aggregate impact value $\leq 35\%$

Flakiness index $\leq 15\%$

Stripping at 40°C after 24 hours immersion (CRRl test $\leq 25\%$)

Equipment Requirement:

Storage Tank with Bitumen Heating Device.

Mechanical Broom or Hand Brushes

Air Compressor

Bitumen Distributor

Hot mix plant or manual mixing (for small area coverage):

Mechanical paver or manual

Pneumatic Roller/smooth wheel roller

Constructions Procedure:

- i. Preparing existing layer:** The existing surface is repaired by removing pot holes, ruts etc. and surface is swept to clean dirt and other foreign materials.
- ii. Tack coat or prime coat application:** Tack coat is applied on existing layer at the rate of $50\text{kg}/100\text{m}^2$ or as per specification.
- iii. Premix preparation:** The bitumen binder and aggregates as per recommended grading are separately heated to the specified temperatures, placed in the mixer and the mixing is done till a homogenous mixer is obtained.
- iv. Placement:** The bituminous paving mixture is then immediately placed on the desired location and is spread with rakes to a predetermined thickness. The camber profile is checked with a template.
- V. Rolling and finishing the paving mix:** The rolling is done with 8 to 10 tone from edge and processing towards center with uniform overlapping. Then finished regular surface is prepared on opening for traffic after at least 24 hours.

Quality Control:

- Checking the condition of equipment.
- Checking the temperature of binder.

(B) Bituminous carpet:

Premix carpet consist of coarse aggregate of 12.5 and 10.0mm size premixed with bitumen or tar binder are compacted to a thickness of 20 mm to serve as a surface course of the pavement.

Specification of material:

(a)Bitumen: The bitumen binder of 80/100 grade or road tar of grade RT-3 is used.

(b)Aggregate: They should be hard durable, angular and clean with following requirements.

Los angles abrasion value= 35% max

Flakiness index= 30% max

Stripping value= 30% max

Water absorption= 2.0% max

Plants and equipment:

Sprayer

Mechanical mixer

Spreader

Roller

Construction procedure:

(i)Preparing existing layer: The existing layer is prepared to a proper profile. The pot holes are patched and irregularities are made even and surface is cleaned.

(ii)Application of tack coat: The tack coat or prime coat is applied just before spreading of premix.

(iii)Preparation and placing of premix: The premix is prepared in mechanical mixer. The aggregate and bitumen are heated up to required temperature separately. Then they are mixed thoroughly and homogeneously. The mix is taken out and carried out at the site for spreading and rolling. The spreading is done with suitable rakes.

(iv)Rolling and finishing: After spreading rolling is done with tandem or pneumatic roller of 6 to 9 tones.

(v)Application of seal coat: The seal coat is applied depending upon the areas of low rainfall or high rainfall.

(vi)Opening to traffic: The road may be opened to traffic 24 hours after providing the seal coat.

Quality Control:

- Checking the condition of equipment.
- Checking the temperature of binder.
- Tests conducted on binder at least penetration, viscosity and ductility etc.
- Conduction of tests on aggregates.

(c)Asphalt or Bituminous Concrete:

It is a **dense graded premixed bituminous mix** which is well completed to form a high **quality pavement surface course**.

Specification of materials:

(a) Binder: Bitumen of grade 30/40, 60/70 or 80/100 can be used - depending upon climatic condition.

(b)Aggregates and filler: The coarse aggregates should fulfill the following requirements:
Aggregate impact value= 30% max.

or Los Angles abrasion value= 40% max.

Flakiness index= 25% max

Stripping at 40° after 24 hours= 25%

(c)Bituminous concrete mix:

Marshall stability, Test number of blows to be applied on either side of specimen=50

Marshall stability value, minimum kg= 340

Void in mix = 3% to 5%

Voids filled with bitumen = 75% to 85%

Plants and equipment:

-Hot bituminous mix plant

-Mechanical finisher

-Rollers.

Construction Procedure:

- (i)Preparing existing base course layer:** The existing surface is repaired by removing pot holes irregularities. The surface is cleaned.
- (ii)Application of tack coat:** A tack coat of bitumen is applied at 6.0 to 7.5 kg per $10m^2$ area for bituminous base course and this quantity may be increased to 7.5 to 10 kg for non bituminous base.
- (iii)Preparation and placing of premix:** The premix is prepared in a hot mix plant of a required capacity with desired quality control. The bitumen may be heated up to $150-177^{\circ}C$ and aggregate temperature should not differ by over $14^{\circ}C$ from the binder temperature. The hot materials is mixed at 121° to $163^{\circ}C$ and carried to the desired site.
- (iv)Rolling:** After placing the mix is thoroughly compacted by initially 8 to 12 tones roller and intermediately by 15 to 30 tones roller.
- (v)Finished surface:** The finished surface check for longitudinal and cross profile. Then the road may be opened to traffic 24 hours after providing seal coat.

Quality control:

The checks are made for

- a. Aggregate grading
- b. Grade of bitumen
- c. Temperature of aggregate
- d. Temperature of paving mix during mixing and compaction.

Sheet asphalt:

- Carpet of sand-bitumen mix of compacted thickness 25 mm without coarse aggregate.
- Material used are sand, filler and bitumen.
- Mix is durable, stable, dense and impervious.

Mastic asphalt:

- Mixture of bitumen, fine aggregate and filler in suitable proportion yielding a void less and impermeable mass.
- Ingredients similar to bituminous concrete but different properties
- Mastic asphalt when cooled results in hard, durable, stable layer which is suitable to withstand heavy traffic. This material can also absorb vibrations and has a property of self healing of cracks without bleeding.
- Mostly used on the surfaces on bridge deck slab etc.

Construction of Cement Concrete Pavement:

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

(i) Construction of pavement slab

(ii) Design and placement of joints

Concrete pavement are rigid pavements having very high flexural strength. They have excellent riding surface and pleasing appearance. It required very high initial investment but provides strong and durable pavement for long time. Concrete pavements can be constructed using two:

(1) Alternate bay method

(2) Continuous bay method

In alternate bay method concrete pavement slab are laid on whole width of pavement in alternate bays.

In continues bay method, concrete pavement slab are laid continuous. Only on one bay and another bay is open for the traffic. This method is generally more preferred.

Material specification:

(a)Cement: OPC or rapid hardening cement

(b)Aggregates

- max size not greater than one forth of slab thickness
- gradation of coarse aggregate- 50 to 4.75 mm or 40 to 4.75m in two size ranges, one below and other above 20 mm.
- Crushing value - 30% max
- Impact value- 30% max
- Los Angles abrasion value-35% max

(c)Concrete:

Min modulus of Rupture of 40 kg/cm^2 after 28 days of curing or compressive strength of 280 kg/cm^2

Plants & Equipment's:

- Concrete mixer and batching device
- Internal vibrator
- Straight edge
- Belt
- Fiber brush
- Edging tool

Construction steps:

- Preparation of sub grade and sub-base:
 - Uniformly compacted sub grade extending 30 cm on either side of width to be concreted.
 - Properly drained
 - Min 'K' value of 5.54 kg/cm^2
 - To be kept in moist condition
- Placing of forms:
 - Steel or wooden forms
- Batching of material and mixing
- Transporting and placing of concrete
- Compaction and finishing
- Belting, Brooming and Edging
- Curing of cement concrete

Quality Control:

- Making of concrete cubes for strength test.
- Proper curing covering with jute bags.
- Construction of joints.