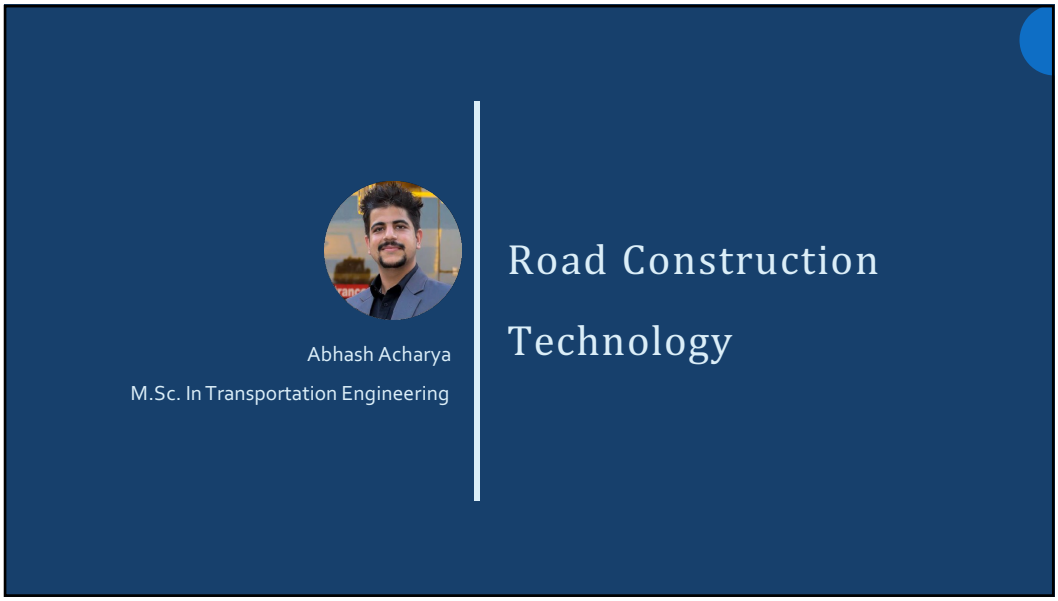

1

Road Construction Technology

- Activities and techniques used in road construction
- Tools, equipment and plants used in road construction
- Preparation of road bed: excavation, fill, compaction, soil stabilization, etc.
- Construction of low cost roads
- Construction of asphalt concrete layers, including prime coats, tack coats and seal coats
- Construction of surface dressing
- Construction of otta-seal
- Construction of grouted or penetration macadam
- Construction of different types of bituminous premixes
- Construction of cement concrete pavement

2

Road Construction Technology

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

- Highway construction project may be broadly divided into three phases:
  - Earthwork and preparation of sub-grade
  - Pavement construction
  - Protection work and drainage facilities

3

3

Activities and Techniques

Deals with all kinds of activities and technology or operation for changing existing ground to the desired shape, slope and to provide all necessary facilities for safe, smooth and efficient movement of traffic.

- Activities of Road Construction Include:
  - Earthwork and site clearance
  - Drainage works
  - Protection works
  - Pavement works
  - Miscellaneous works

4

4

Activities and Techniques

- Earthwork and Site Clearance
  - Site Clearance
  - Earthwork in filling for embankment
  - Excavation for cutting
  - Excavation for borrow pit
  - Excavation for structural foundation
  - Disposal of surplus earth
- Drainage Works
  - Minor Bridge
  - Culverts
  - Cause ways
  - Side drains
  - Other surface and sub surface drainage works
- Protection Works
  - Earth retaining structures
  - River training works
  - Gully control works
  - Land slide stabilization
  - Bridge protection works
- Pavement Works
  - Subgrade works
  - Sub base works
  - Base works
  - Surface works
- Miscellaneous Works
  - Road Ancillaries
  - Traffic signs/signals/markings
  - Bio-engineering works

Activities and Techniques

- Earthwork and Site Clearance
  - Site Clearance
  - Earthwork in filling for embankment
  - Excavation for cutting
  - Excavation for borrow pit
  - Excavation for structural foundation
  - Disposal of surplus earth
- Site Clearance
  - First operation to be started just after completion of survey works for fixing the road alignment and before the beginning of any earth works for the road construction.
  - Major works include:
    - Clearing hedges and shrubs at least covering the width.
    - Removal of existing tree stump and roots along the alignment.
    - Removal of existing structures along the alignment.

Activities and Techniques

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

- Earthwork
  - Includes all construction operations required to convert the road land from its natural condition and configuration to the sections and grades prescribed in the plans.
  - Process to prepare the sub-grade level bringing it to the desired grade and camber by compacting adequately.
  - Earthwork may be either in embankment (filling) or in excavation (cutting) depending on the topography.

7

Activities and Techniques

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

- Earthwork in excavation
  - In the process of cutting or loosening and removing earth including rock from its original position, transporting and dumping it as a fill bank.
  - The design elements of highway excavation works are;
    - Depth
    - Stability of foundation
    - Stability of slopes
    - Accommodation of road side drains

8

Activities and Techniques

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

- Earthwork in filling for embankment
  - Whenever it is required to raise the sub-grade of a highway above the existing ground level, it becomes necessary to construct embankments.
  - The grade line may be raised due to any of the following reasons:
    - To keep the sub-grade above the high ground water level.
    - 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.

9

Activities and Techniques

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

- Earthwork in filling for embankment
  - The design elements of highway embankment are:
    - Height of fill
      - Depends on the formation level and location of natural ground.
      - Dependent upon bearing capacity.
    - Fill materials
      - Granular soil is preferred.
      - Organic soils, silt should be avoided.
      - Best of locally available soil is used.
    - Settlement of embankment
      - Due to settlement of fill material itself.
      - Due to settlement of foundation.
      - Both of the above.

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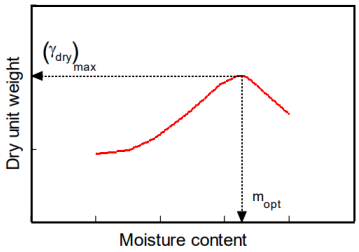
Activities and Techniques

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

- Stability of foundation
  - When embankment consists of weak soil just beneath or at a certain depth below.
- Stability of Slopes
  - Embankment slopes should be stable enough to eliminate the possibility of failure under adverse moisture and other conditions.
  - Flatter slopes are preferred in highway due to aesthetic and other reasons.
- Soil Compaction
  - (Field control of compaction – measurement of moisture content and dry density)

Compaction of Soils



- Compaction of Soils
  - Process that involves expulsion of air from the soil so as to increase their dry density.
  - Objectives of compaction involves improvement in its properties so as to increase its strength, bearing capacity. It also contributes for reduction in its compressibility.
  - Various factors affecting compaction are: moisture content, amount and type of compaction, soil type, use of admixtures.
  - The moisture content corresponding to maximum dry density is known as Optimum Moisture Content (OMC) or Optimum Water Content (OWC).

Compaction of Soils

- Compaction of Soils
  - Soil compaction can be achieved in the field either by rolling, ramming or by vibration.
  - Rollers
    - Principle of roller is the application of pressure, which is slowly increased and then decreased.
    - Smooth Wheeled Rollers
      - Compacting efficiency depends on the weight, width and diameter of each roller.
      - Useful for finishing operations after compaction of fills and for compacting granular base course of highways.
      - Suitable for compacting gravel, sand, crushed rock and any material where crushing action is required.
        - Three wheel or macadam rollers with gross weight of 4-18 t
        - Tandem rollers (two wheel) with gross weight of 1-14 t

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Compaction of Soils

- Compaction of Soils
  - Soil compaction can be achieved in the field either by rolling, ramming or by vibration.
  - Rollers
    - Principle of roller is the application of pressure, which is slowly increased and then decreased.
    - Smooth Wheeled Rollers

14

Compaction of Soils

- Compaction of Soils
  - Soil compaction can be achieved in the field either by rolling, ramming or by vibration.
  - Rollers
    - Pneumatic Tired Roller
      - Pneumatic wheels are mounted on two or more axles under a loading platform.
      - Pneumatic tires are so spaced that a complete coverage is obtained with each pass of the roller.
      - Most effective for compacting both cohesive soils and cohesionless soils especially non plastic silts and fine sands.
      - 50t and 2-4 passes are generally sufficient to achieve compaction of 60 cm thick.
      - Light rollers (weight upto 20t) are used for soil layers of small thickness up to 15 cm.

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Compaction of Soils

- Compaction of Soils
  - Soil compaction can be achieved in the field either by rolling, ramming or by vibration.
  - Rollers
    - Pneumatic Tired Roller

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Compaction of Soils

- Compaction of Soils
  - Soil compaction can be achieved in the field either by rolling, ramming or by vibration.
  - Rollers
    - Sheep foot rollers
      - Roller consists of hollow steel cylinder with projecting feet.
      - Weight of the roller can be increased by filling water or wet soil in the drum.
      - The weight, diameter and width of the roller may be varied and also the shape and size of the feet.
      - Most suitable to compact clayey soils.
      - Action of tamping and kneading to the soil during compaction.
      - Compaction of any roller depends upon the following factors:
        - Contact pressure, Layer thickness
        - Number of passes, speed of the roller

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Compaction of Soils

- Compaction of Soils
  - Soil compaction can be achieved in the field either by rolling, ramming or by vibration.
  - Rollers
    - Sheep foot rollers

18

Compaction of Soils




- Compaction of Soils
  - Soil compaction can be achieved in the field either by rolling, ramming or by vibration.
  - Rammers
    - Block of iron or stone attached to a wooden rod and may be of the following two types namely:
      - Hand operated of weight around 3.5 kg
      - Mechanical
    - Useful to compact relatively small areas and where the rollers cannot operate due to space limit such as trenches, foundation and slopes.
    - Output of the rammer is much lower than that of the rollers.

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Compaction of Soils




- Compaction of Soils
  - Soil compaction can be achieved in the field either by rolling, ramming or by vibration.
  - Vibrators
    - Most suitable for compacting dry cohesionless granular material.
    - There are also vibrator mounted rollers (vibratory roller) to give combined effects of rolling and vibration.
  - Watering (Jetting and pounding)
    - Considered to be an efficient method of compacting cohesionless sands.
    - Watering heavily and rolling by smooth wheel of pneumatic tyred roller may also give adequate compaction of cohesionless sands.

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Compaction of Soils

- Compaction of Soils
  - Field Control of Compaction
    - Two field control tests are:
      - Measurement of moisture content
      - Measurement of dry density
    - Measurement of moisture content is done by Proctor's Needle.
    - Measurement of dry density can be done by:
      - Core Cutter Method
      - Sand Replacement Method
    - Around 95% of standard density is generally aimed at in the field compaction.

Tools and Equipment

- Tools
  - Hand shovel
  - Chisel
  - Spade
  - Hand rammer
  - Brushes
  - Trowel
  - Wheel barrows

Tools and Equipment

- Equipment
  - Earth moving equipment
  - Compaction equipment
  - Leveling equipment
  - Paving equipment
  - Lifting equipment
  - Transporting equipment

- Earth moving equipment
  - Dozer (Bull dozer, angle dozer, tree dozer)
  - Scrapper
  - Loader
  - Excavator
  - Dragline
  - Clamshell
  - Trench digger






Tools and Equipment

- Equipment
  - Earth moving equipment
  - Compaction equipment
  - Leveling equipment
  - Paving equipment
  - Lifting equipment
  - Transporting equipment

- Compaction equipment
  - Smooth wheel roller
  - Vibrating roller
  - Pneumatic roller
  - Sheep foot roller
  - Rammer
- Leveling equipment
  - Grader






Tools and Equipment

- Equipment
  - Earth moving equipment
  - Compaction equipment
  - Leveling equipment
  - Paving equipment
  - Lifting equipment
  - Transporting equipment

- Paving equipment
  - Binder Spreader
  - Heating kettle for binder
  - Aggregate Spreader
  - Cement Concrete Mixer
  - Bituminous Paver
  - Cement Concrete Paver

Tools and Equipment

- Equipment
  - Earth moving equipment
  - Compaction equipment
  - Leveling equipment
  - Paving equipment
  - Lifting equipment
  - Transporting equipment

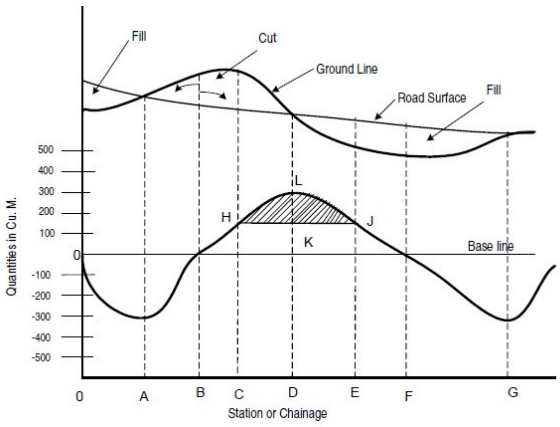
- Lifting equipment
  - Backhoe
  - Crane
- Transporting equipment
  - Dump trucks
  - Trucks
  - Mini dumpers

Tools and Equipment

- Plants
  - Cement Concrete Plant
  - Asphalt Concrete Plant
  - Cold Premix Mixing Plant
  - Aggregate Crusher Plant
  - Screening Plant
  - Washing Plant

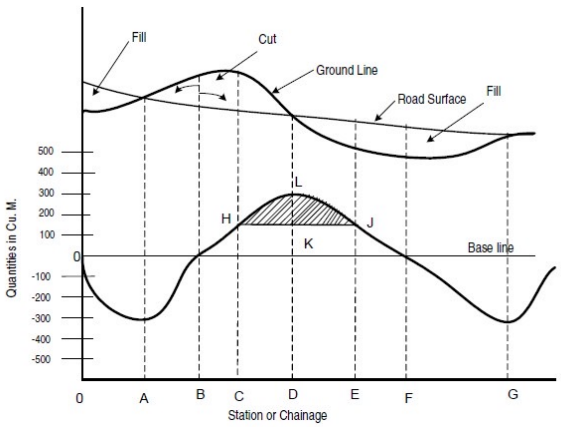
Mass Haul Diagram

- Graphical representation of amount of earthwork involved in road construction and manner in which the earth can be hauled economically.
- MHD is plotted below the L-profile.
- Horizontal distances are the chainage along the center line.
- Ordinate at any point: Earthwork quantity accumulated up to that point.



Mass Haul Diagram

- Max. ordinate: Change from cut to fill.
- Min. ordinate: Change from fill to cut.
- Upward sloping curve indicate (rising left to right) a cut.
- Downward sloping (falling left to right) curve occurs in a fill section.



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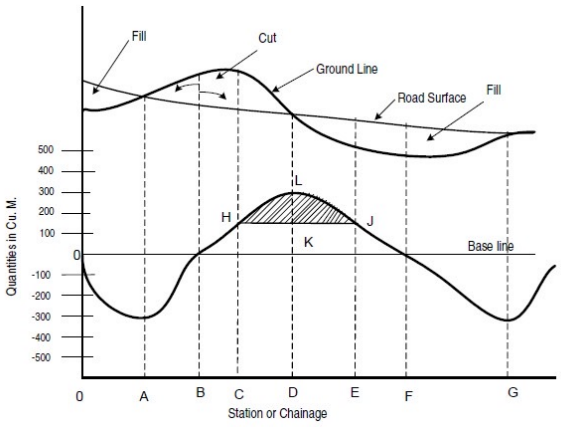
Mass Haul Diagram

- Balance point is defined as a point where the volume in excavation balances the volume in embankment.
- Any line drawn parallel to the base line and intersecting two points within the same curve indicates a balance of cut and fill between these two points (C and E). Such a line (HJ) is called a balancing line.
- The area between a balancing line and the mass diagram is a measure of the haul between the balance points.



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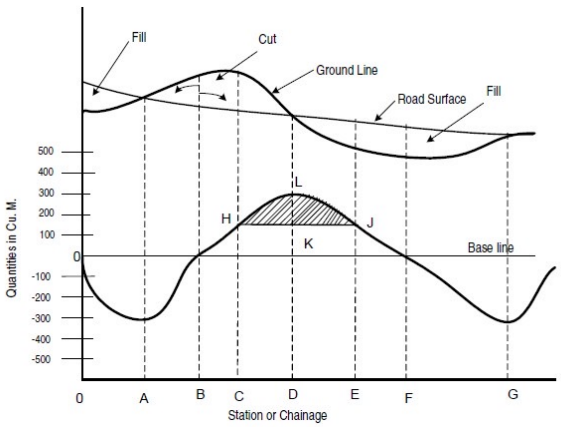
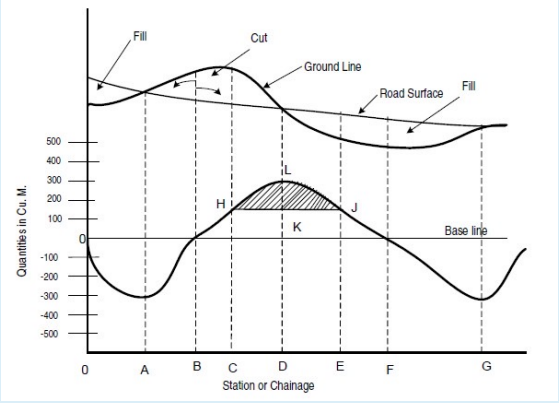
Mass Haul Diagram

- Hatched area divided by the maximum ordinate between the balance line and the curve (KL) gives the average distance of haulage of the cut to make the fill.
- When the earth excavation and the embankment quantities balance at the end of the section, the mass diagram curve would end at the end at the base line at the zero point.



Mass Haul Diagram

- Free Haul: The certain amount of haulage in included in the earthwork rate itself and the contractor is expected to carry earth over this haulage within his quoted rate.
- Over Haul: The haulage over the free haul distance paid for extra rate called over haul.
- Economic Haul: Distance to which material from excavation to embankment can be moved more economically than to get material from borrow opening.



a = cost of roadway excavation per m^3

b = cost of overhaul and tipping per m^3 per station

c = cost of borrow material per m^3

L = economic overhaul distance in stations

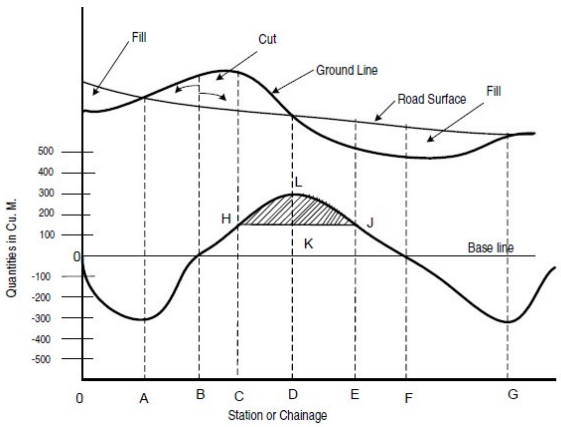
a + b * L = c + a

L = c/b stations

If the free haul distance is denoted by F stations, then the economic haul distance is given by: F + L = F + c/b

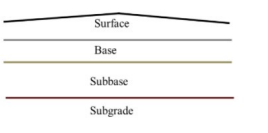
Mass Haul Diagram

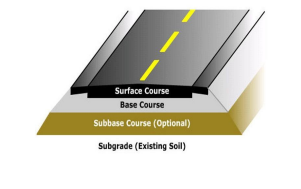
- When the earth is excavated from the borrow area and deposited on the embankment, its volume increases. But as the compaction is done, the final volume of the compacted bank becomes less than the borrow area volume. This is known as shrinkage. The actual shrinkage factor depends upon the soil deposit and may vary from 10 to 20 percent.
- When rock is excavated and deposited in the bank, the volume of material may occupy a larger volume and is known as swell which may vary from 20-40%.

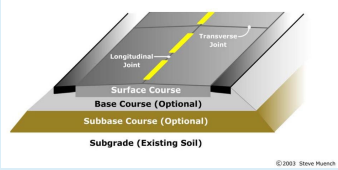


Pavement

- A relatively stable layer with even surface constructed over natural soil for the movement of traffic.
- Functions:
  - Support and distribute wheel load of vehicle over a wide underlying area of subgrade soil.
  - Keep the temporary deformation within permissible limit.
- Types:
  - Flexible Pavement
  - Rigid Pavement
  - Composite Pavement







Construction of Low Cost Roads

- Construction of Earthen Roads
  - 4-5 percent camber is provided
  - Performance depends upon maintenance and drainage
  - Can be constructed manually or using equipment
  - Material Specification:

Soil Type	Base Course	Wearing Course
Clay	<5%	10-18%
Silt	9-32%	5-15%
Sand	60-80%	65-80%
Liquid Limit	<35%	<35%
Plasticity Index	<6%	4-10%

- Construction Procedure:
  - Soil Survey – Materials should be free from organic matter. The trees, shrubs, grass, roots and top soil are removed before excavating earth for construction.
  - Location: Marking center line and edge line by pegs, benchmark pegs for vertical profile
  - Preparation of subgrade
    - Site Clearance
    - Excavation and construction of fills
    - Shaping of subgrade
    - Compaction before placing pavement
  - Pavement construction: Compaction at OMC in layers of 10 cm. Choice of equipment is based on the type of soil. At least 95% dry density should be achieved.
  - Open to Traffic: After drying

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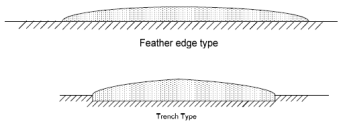
Construction of Low Cost Roads

- Construction of Gravel Roads
  - Considered superior to earth roads as they can carry heavier traffic.
  - 3.3 – 4 % of camber.
  - Two types of construction methods:
    - Feather edge type
    - Trench type



- Materials: Hard durable and strong varieties of crushed stone or gravel of specified gradation is used. Proper gradation is chosen to have maximum density.
- Equipment: Manually with hand tools or other mechanical equipment.
- Construction Procedure:
  - Gravel aggregates to be used for construction is stacked along the sides of proposed road.
  - Wooden pegs for center line and reference pegs for carriage way are driven.
  - Preparation of subgrade:
    - Site Clearance
    - Grading – cut or fill
    - Trench excavation to desired depth and width
    - Compaction before spreading gravel

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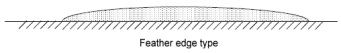

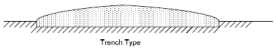

- Construction Procedure (contd….)
  - Pavement Construction:
    - Gravel aggregates are placed carefully in trench to avoid segregation.
    - Greater thickness at the center and less towards edge to achieve desired camber.
    - Compaction with smooth wheeled roller from edge to center overlapping at least half width of the roller.
    - Water need to be sprayed and rolling is to be done.
    - Camber is checked and corrected time to time.
  - Opening to traffic:
    - Few days after the final rolling and drying out, the road is opened to the traffic.

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Construction of Low Cost Roads

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  - 3.3 – 4 % of camber.
  - Two types of construction methods:
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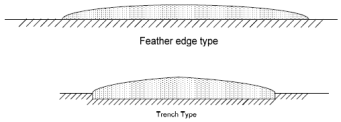
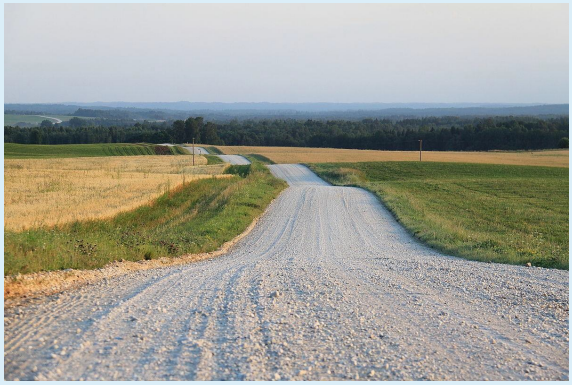
    - Trench type





Construction of Low Cost Roads

- Construction of Water Bound Macadam
  - Named after John Macadam.
  - At present day – refers to the base course made of crushed or broken aggregates.
  - Crushed aggregates are bound together by the action of rolling.
  - Binding is achieved by stone dust used as filler in presence of water.
  - Thickness of each compacted layer ranges from 10 cm to 7.5 cm.
  - Camber of 1 in 36 to 1 in 48.

- Materials
  - Coarse Aggregate:
    - Hard, durable, strong and free from excess of flaky, elongated, soft and disintegrated particles and dirt.
    - Soft aggregates like over burnt bricks metal or naturally occurring soft aggregates as kankar or laterite may also be used.
    - Specifications:

Property	Requirements for pavement layer		
	Sub-base	Base course	Surfacing course
LAA (max %)	60	50	40
AIV (max %)	50	40	30
FI (max %)	-	15	15

Construction of Low Cost Roads

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  - Thickness of each compacted layer ranges from 10 cm to 7.5 cm.
  - Camber of 1 in 36 to 1 in 48.

- Materials (contd….)
  - The coarse aggregates for each layer of construction should confirm to any one of the three grading specified below:

Grading No.	Size range, mm	Sieve size	% passing 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

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Construction of Low Cost Roads

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  - Crushed aggregates are bound together by the action of rolling.
  - Binding is achieved by stone dust used as filler in presence of water.
  - Thickness of each compacted layer ranges from 10 cm to 7.5 cm.
  - Camber of 1 in 36 to 1 in 48.

- Materials (contd….)
  - Screening Materials:
    - Used to fill up the voids in the compacted layer of coarse aggregates.
    - Consists of aggregates of smaller size, generally of the same material as the coarse aggregate.
    - Grading requirements:

Grading	Size of screening, mm	Sieve size, mm	% passing by weight
A	12.5	12.5	100
		10	90-100
		4.75	10-30
		0.15	0-8
B	10	10	100
		4.75	85-100
		0.15	10-30

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Construction of Low Cost Roads

- Construction of Water Bound Macadam
  - Named after John Macadam.
  - At present day – refers to the base course made of crushed or broken aggregates.
  - Crushed aggregates are bound together by the action of rolling.
  - Binding is achieved by stone dust used as filler in presence of water.
  - Thickness of each compacted layer ranges from 10 cm to 7.5 cm.
  - Camber of 1 in 36 to 1 in 48.

- Materials (contd….)
  - Binding materials
    - Stone dust, stone grit.
    - Binding material with plasticity index 4-9 % is used in WBM surface course constructions.
  - Quantity of materials
    - The approximate quantities of loose materials required in m^3 for 7.5 compacted thickness of WBM base course or surfacing with coarse aggregate of grading 2 per 10 m^2.

Coarse aggregate, 63 to 40 mm	0.91 to 1.07
Stone screening type A base course (12.5 mm) Surfacing	 0.18 to 0.21 0.15 to 0.17
Stone screening type B Base course (9 mm) Surfacing	 0.3 to 0.33 0.24 to 0.26
Binding materials Base course Surfacing	 0.06 to 0.09 0.1 to 0.15

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Construction of Low Cost Roads

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- Construction Procedure
  - Preparation of foundation for WBM
    - Foundation may be sub-grade, sub-base or base course.
    - Prepared to the required grade and camber and the dust and loose materials are cleaned.
    - On existing surface, the pot holes are filled and corrugations are removed.
  - Lateral Confinement
    - May be done by constructing the shoulders in advance, to a thickness equal to that of the compacted WBM.
    - Coarse aggregates are spread uniformly to proper profile to even thickness upon the prepared foundation.
    - Normally compacted thickness is 7.5 cm.

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Construction of Low Cost Roads

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- Construction Procedure (contd….)
  - Dry Rolling
    - Done by three wheeled power roller of capacity of 6 to 10 tones or by equivalent vibratory roller.
    - Compaction from edge to center is done.
    - On superelevated portions of the road, rolling is started from the inner or lower edge and progressed towards the outer or upper edge of the pavement.
  - Application of Screening
    - Dry screenings are applied gradually over the surface to fill the interstices in three or more applications after the coarse aggregates are rolled adequately.
    - Dry rolling is continued as the screening are being spread and brooming carried out.

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Construction of Low Cost Roads

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- Construction Procedure (contd….)
  - Sprinkling, grouting and rolling
    - Surface is sprinkled with water, swept and rolled after the application of screenings.
    - Wet screenings are swept into the voids using hand brooms.
    - Screenings are applied and rolled till the coarse aggregates are well bound and firmly set.
  - Application of binding material
    - Applied at uniform and slow rate at two or more successive layers.
    - After each application, the surface is sprinkled with water and wet slurry swept with brooms to fill the voids.
    - Followed by rolling with 6 to 10 tonnes roller.

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Construction of Low Cost Roads

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  - Camber of 1 in 36 to 1 in 48.

- Construction Procedure (contd….)
  - Setting and drying:
    - WBM course is allowed to set over-night.
    - On the next day the 'hungry spots' are located and filled with screening or binding materials, lightly sprinkled with water and rolled.
  - Opening to traffic:
    - After the WBM layers sets and dries out.

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Construction of Low Cost Roads

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Complete network of road system is limited due to less capital available.
  - Compels the construction of low cost roads which could be achieved by stage construction.
  - Selection of local materials with their properties improved by soil stabilization techniques.
  - Principle includes utilization of local soil and other suitable stabilization agent with low cost.

- Mechanics of soil stabilization
  - Means the improvement of the stability or bearing power of the soil by the use of controlled compaction, proportioning and the addition of the suitable admixture.
  - Deals with physical, physio-chemical and chemical methods to make the stabilized soil serve as a pavement component material.
- Principles of stabilization
  - Evaluating the properties of soil.
  - Deciding the effective and economical method of soil stabilization.
  - Designing the stabilized soil mix for intended stability and durability values.
  - Considering construction procedure compact the stabilized soil adequately.

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
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- Changing the properties
  - Increase in stability, change in physical properties like density, swelling characteristics.
  - Change in chemical properties.
  - Retaining the desired minimum strength by water proofing.

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
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  - Compels the construction of low cost roads which could be achieved by stage construction.
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  - Principle includes utilization of local soil and other suitable stabilization agent with low cost.

- Techniques of Soil Stabilization
  - Proper proportioning
    - Locally available soils and aggregates are mixed in suitable proportion and compacted to get the desired objective.
    - Stability of a fine grained soil can be improved by the addition of gravel and sand components in suitable proportion.
    - Stability of a cohesionless sand may be improved by the addition of some cohesive soil.
  - Cementing agent
    - Can be increased using cementing agents like Portland cement, lime or fly ash.
    - Bituminous material imparts binding property to non-cohesive soils like pure sand.
  - Modifying agents
    - To improve the performance of soil, modifier as lime, cement can be used.

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Construction of Low Cost Roads

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  - Compels the construction of low cost roads which could be achieved by stage construction.
  - Selection of local materials with their properties improved by soil stabilization techniques.
  - Principle includes utilization of local soil and other suitable stabilization agent with low cost.

- Techniques of Soil Stabilization
  - Water proofing and repelling agent
    - Proofing agents are provided to prevent loss of strength properties of soil while it comes in contact with water (Bituminous material).
    - Vinyl resin and other resinous materials are used as water repelling agents.
  - Water retaining agents
    - Soil may become loose and less stable when dried completely.
    - Calcium chloride helps to absorb moisture from the atmosphere and thus retains soil stability.
  - Heat treatment
    - Contributes for reduction in swelling properties and heat treated soil may be used as a soft aggregate in mechanical soil stabilization.
  - Chemical stabilization
    - Less than 0.5% by weight of soil can be added to impart changes in soils.

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Mechanical soil stabilization/Granular stabilization
  - Correctly proportioned materials (aggregates and soils) when adequately compacted to get a mechanically stable layer, the method is called mechanical stabilization.
    - Proportioning
    - Compaction
  - Desirable properties of soil-aggregate mixtures:
    - Strength
    - Incompressibility
    - Less changes in volume and stability with variation in moisture content
    - Good drainage
    - Less frost susceptibility
    - Ease of compaction

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Mechanical soil stabilization/Granular stabilization
  - **Typical states of soil aggregate mix:**
    - **When aggregate is without fines (very little Fines):** Stable under confined condition; no frost action; no variation in volume and stability with change in moisture
    - **Voids in compacted aggregate are just filled with compacted binder:** Good stability in unconfined condition as well; less permeable and likely to be affected by frost action; may undergo change in volume and stability with moisture variation
    - **When aggregate is mixed with excess fines and compacted:** aggregates float in binder; angle of friction and stability decrease; poor drainage; high variability in volume and stability with moisture variation; high frost susceptibility; workable mix and easy compaction

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Mechanical soil stabilization
  - Factors affecting mechanical stability
    - Mechanical strength of aggregate
    - Gradation – well graded aggregate soil mix for better stability and maximum density
    - Properties of soil
    - Presence of salt and mica, etc.
    - Compaction

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Mechanical soil stabilization
  - Design of Mix
    - Factors to be considered: gradation, density, index properties and stability
    - Fuller's formula for theoretical gradation that can achieve maximum density:
    - $P = 100*(d/D)^n$ Where,

      P = Percentage finer than diameter, d mm

      D = diameter of largest particle, mm

      n = gradation index (0.3 to 0.5); for spherical 0.5

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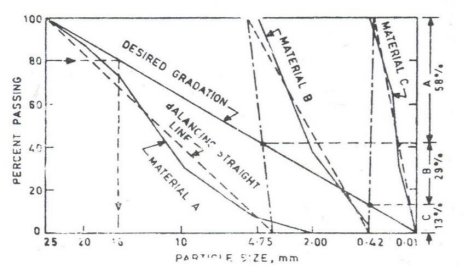
Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Mechanical soil stabilization
  - Proportioning
    - When a few materials are available in the near vicinity, it is necessary to mix with them in such proportion which would produce a mix with high density.
      - Rothfutch's method



Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Mechanical soil stabilization
  - Construction Procedure
    - Materials: Stacked along the sides of road in a desired proportion.
    - Equipment: Machinery or manual labor may be used for excavation or haulage, compacting equipment is necessary.
  - Construction steps
    - Preparation of sub grade
    - Mixing of materials to desired proportion as per design
    - Checking of moisture – if required addition of water and remix
    - Wet mix is spread and compacted by rollers
    - Field control test: Determination of OMC and dry density
    - Opening to traffic after the compacted layers gets hardens

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Mechanical soil stabilization
  - Stabilization using soft aggregate
    - When hard varieties of aggregate are not locally available, the local soft aggregate may be used for the construction of low cost roads used for sub-base even for surface course.
    - Kankar, moorum, laterite and broken brick aggregates.
    - Crushing problem of soft aggregate during compaction can be overcome by using more soil so that the aggregate are enveloped by the soil, and then there will be no problem of crushing.
    - Best results are obtained when the proportion of soft aggregates to soil is approximately 1:2.

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Mechanical soil stabilization
  - Mehra's Method of Stabilization using Soft Aggregates:
    - Soil is collected from borrow pits and stacked on road side.
    - Water is added up to OMC, and soil is mixed and spread to a desired camber and grade.
    - 11.5 cm thick loose base course material (sandy soil) is spread and rolled by 8 tonnes power roller to a compacted thickness of about 7.5 cm.
    - Surface course materials (brick aggregate + soil in ratio 1:2) mixed with water is spread and rolled to a compacted thickness of about 7.5 cm.
    - After rolling, the surface is watered and left overnight.
    - The surface is again rolled and finished.
    - The road is closed to traffic for 4-5 days and kept sprinkled with water.

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Mechanical soil stabilization

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Cement Stabilization
  - Principle and Application
    - Mix of soil, cement and water is well compacted to form strong base course.
    - Cement imparts strength and modifies the properties of the soil.
    - In granular soil, stabilization is due to the development of bond between the cement and the compacted soil particles.
    - In find grained soil, it is due to reduction of plasticity.
    - Increase in percentage of the cement added, will increase in the strength and durability of soil-cement and decrease in volume change, moisture movement and plasticity.

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Cement Stabilization
  - Factors Influencing Properties
    - Soil (particle size, clay content, specific surface, LL, PI, etc.)
    - Cement (quantity)
    - Pulverization and mixing (better pulverization higher strength)
    - Compaction (OMC, dry density)
    - Curing (adequate moisture)
    - Additives-lime for clayey soil, also calcium chloride, sodium hydroxide, sodium carbonate might be used for better results.

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Cement Stabilization
  - Procedure
    - Materials
      - Materials from borrow pit are collected and are pulverized.
        - Passing 4.75 mm > 50%
        - Passing 0.075 mm < 50%
        - LL < 40%
        - PI < 18%
    - Plants and Equipment
      - Mix-in –place method
      - Plant mix method

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Cement Stabilization
  - Procedure
    - Design of Soil-Cement Mix
      - AASHTO Method

AASHTO Soil Group	Cement, percentage by weight of soil
A-1-a	3-5
A-1-b	5-8
A-2-4	
A-2-5	5-9
A-2-6	
A-2-7	
A-3	7-11
A-4	7-12
A-5	8-13
A-6	9-15
A-7	10-16

Construction of Low Cost Roads

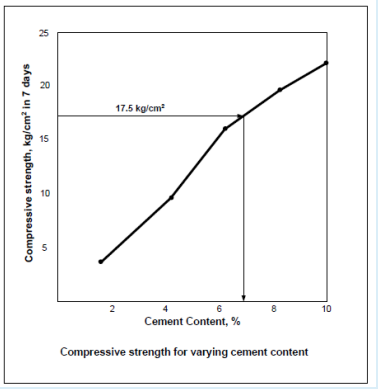
- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Cement Stabilization
  - Procedure
    - Design of Soil-Cement Mix [British Method]
      - Mix design is based on the compressive strength of specimens cured for 7 days.
      - The cement content corresponding to strength of 17.5 kg/cm^2 is taken as design cement content for base course in highway pavement with light to medium traffic.
      - However, for heavy traffic, highest strength factor of 28 to 35 kg/cm^2 may be adopted for mix design.

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Cement Stabilization
  - Procedure
    - Mix design



Compressive strength for varying cement content

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Cement Stabilization
  - Procedure
    - Construction Steps
      - Preparation of sub-grade or base
      - Pulverization of soil
      - Application of cement and dry mixing
      - Addition or spraying water and remixing
      - Spreading and grading
      - Compaction by smooth wheeled roller
      - Curing the soil-cement layer is allowed (Moist curing either by preventing the moisture to escape or by covering with moist soil)
      - Joint with old work

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Cement Stabilization

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Cement Stabilization
  - Procedure
    - Field Control Test
      - Checking of moisture content in soil and mix
      - Degree of pulverization (sieve through 4.75 mm)
      - Cement content
      - Testing of mixing efficient by compressive strength
      - Determination of dry density
      - Checking depth

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Lime Stabilization
  - Soil-Lime has been widely used either as a modifier for clayey soil or as binder.
  - When clay is treated with lime, it reduces the plasticity index.
  - The soil can easily be crumbled.
  - Easy to be pulverized.
  - Lime also imparts some binding action even in granular soils.
  - Soil-Lime is suitable as sub-base course for high types of pavements and base course for pavement with low traffic.
  - It is not suitable for surface course because it has very poor resistance to abrasion and impact.

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Lime Stabilization
  - Factors affecting properties of soil-lime
    - Soil type
    - Lime content
    - Types of lime
    - Compaction
    - Curing and additives
  - Design
    - No standard method of mix design
    - Lime content may be decided based on higher value to reduce plasticity index and swelling values up to the desired limits

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Lime Stabilization
  - Materials
    - Scarified soil
    - Fresh stock of hydrated lime or quick lime (fine powder)
  - Equipment
    - For scarifying, pulverizing, mixing and compaction.

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Lime Stabilization
  - Construction Procedure
    - Preparation of sub-grade
    - Pulverization of soil to be stabilized
    - Addition of part of lime as dry powder or as slurry with water and mixing
    - Allowing mixture to age for about a day and remixing when pulverization becomes easy
    - Adding rest of the lime and water if necessary and remixing
    - Spreading to desired grade, shape and compacting
    - Curing soil-lime is protected from drying out and allowed moist curing
    - Field control tests- checking moisture content at the time of compaction and checking of dry density soon after compaction.

Construction of Low Cost Roads

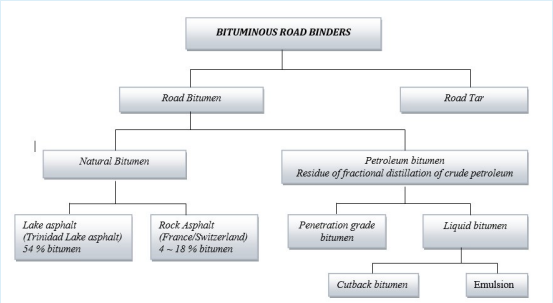
- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

– Soil-Lime Stabilization

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

– Bitumen



Cutback bitumen is the bitumen the viscosity of which has been reduced by using volatile solvent and can be applied directly in road construction. The usual practice is to use petrol, kerosene oil or diesel.

If the bitumen is mixed with low volatile (diesel) and non – volatile oils, it is known as Slow Curing (SC) cut back bitumen. Binding action takes place very slowly since it takes quite a long time to drive away liquefying agent. If the fluidity is increased by adding medium volatile agent such as kerosene, the cut back bitumen is called Medium Curing (MC). Mixing of bitumen with highly volatile solvent such as petrol or naphtha is used to prepare the Rapid Curing (RC) cutback bitumen.

An emulsion is relatively stable suspension of one liquid in a stage of minute subdivision, dispersed throughout another liquid in which it is not soluble. In bitumen emulsion, bitumen is the dispersed liquid. It is called internal phase of emulsion. The surrounding liquid, water is called external or continuous phase.

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Bitumen Stabilization
  - Basic Principles
    - Water proofing
    - Binding
  - For cohesionless soil binding and for clayey particles, water proofing is important.
  - Mostly used materials for this type of soil are cutbacks and emulsion.
  - Because stabilized layer may be used as a sub-base or base course of ordinary roads and surface course for low traffic and low rainfall regions.

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Bitumen Stabilization
  - Factors affecting properties of Soil-Bitumen Mix
    - Soil: Size, shape and gradation, small proportion of fines
    - Types of bituminous materials: Depending upon climatic condition. Emulsion gives slightly inferior results than cutback.
    - Amount of bitumen – Optimum Binder Content for maximum stability 4% to 6% (Refer figure)
    - Mixing – First mix with water then with cutback and it is better to have low mixing period
    - Compaction – Compaction characteristics depends upon compaction moisture content, temperature, amount and type of compaction. OMC and maximum dry density.
    - Curing – allowed to evaporate allowing the bitumen to impart binding and water proofing
    - Additives: anti stripping and reactive chemical additives, Portland cement for more stability

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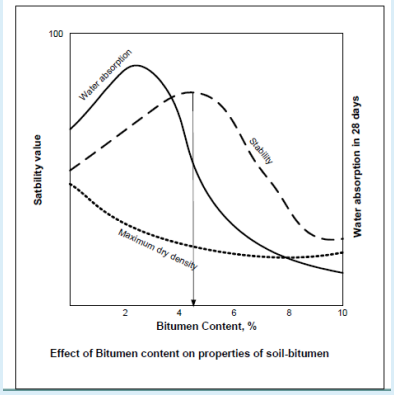
Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Bitumen Stabilization
  - Effect of bitumen content



Effect of Bitumen content on properties of soil-bitumen

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Bitumen Stabilization
  - Design
    - No standard of mix design.
    - Soil water bitumen mix is generally compacted at OMC corresponding to maximum dry density.
    - Specimens are prepared with various bitumen contents, and are tested for stability and water absorption (CBR test).
    - A graph may be plotted with bitumen content versus stability value and the optimum bitumen content corresponding to maximum stability value may be found.

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Bitumen Stabilization
  - Construction procedure
    - Materials: Stacking of pulverized soil
      - Passing 4.75 mm sieve < 50%
      - Passing 0.425 mm sieve 35 – 100%
      - Passing 0.075 mm sieve 10 – 50%
      - LL < 40%
      - PI < 18%
    - Plant and equipment: for scarifying, pulverizing, mixing and compaction.

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Bitumen Stabilization
  - Construction procedure
    - Construction Steps
      - The soil to be stabilized is pulverized
      - Addition of water to soil and mixed
      - Addition of cut back or emulsion and remixed
      - Spreading of the mix to desired grade and compaction
      - The compaction layer is allowed for curing-moisture and volatile elements evaporates
      - Field control tests:
        - Checking for pulverization
        - Checking of moisture content and bitumen content
        - Checking for dry density after compaction

Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Bitumen Stabilization
  - Construction procedure
    - Construction Steps: Sub-base course
    - **Material:** clean, strong, hard, durable gravel or crushed stone
    - River bed material or soil mixed quarry gravel or crusher run material
    - LL <25%, PI <6% CBR >60% FI <30%
    - **Plants and Equipment**: Grader, roller, tipper, water tanker
    - **Steps:**
    - Preparation of subgrade
    - Transportation and dumping of approved sub-base material
    - Mixing of sub-base material with the help of grader and spreading to required thickness
    - Checking moisture content and spreading water if required
    - Compaction
    - **Field Controls:** Atterberg's limits, CBR, FI , camber and grade, field moisture and dry density (>95-98%)

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Bitumen Stabilization
  - Construction procedure
    - Construction Steps: Base course
    - **Material:** clean, strong, hard, durable gravel or crushed stone
    - Crushed stones either from boulders or quarry stones
    - CBR >80% FI <30%, LAA < 40% and gradation as per specification
    - **Plants and Equipment**: Grader, roller, tipper, water tanker
    - **Steps:**
    - Preparation of sub base
    - Transportation and dumping of approved crushed stone base material
    - Mixing of base material at site with the help of grader and spreading to required thickness
    - Checking moisture content and spreading water if required
    - Compaction
    - **Field Controls:** Gradation, CBR, FI , camber and grade, field moisture and dry density (>98%)

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Soil-Bitumen Stabilization

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Construction of Low Cost Roads

- Construction of Soil Stabilized Roads
  - Methods
    - Mechanical soil stabilization
    - Soil-Cement stabilization
    - Soil-Lime stabilization
    - Soil-Bitumen stabilization

- Problems in Stabilization
  - Choice of stabilization technique
  - Design of stabilized mix
  - Thickness design of stabilized layers

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Construction of bituminous pavement

- Popular in construction.
- Possible to construct relatively thin bituminous pavement layers over existing pavement. Therefore, used as wearing course.
- Excessive binder content over an optimum value for a given mix is detrimental to the good performance of the black top pavements.

- Construction with varying aggregate sizes and composition with different bituminous binder types.
- Thickness may be very thin to 20 cm.
- Contrary to cement concrete, excess of bitumen content the strength decreases.
- Provided usually for surface course but sometimes for base course in heavy traffic.
- Advantage of early opening of traffic compared to cement concrete pavement.
- Stage development possible depending upon traffic demand.

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Construction of bituminous pavement

- Popular in construction.
- Possible to construct relatively thin bituminous pavement layers over existing pavement. Therefore, used as wearing course.
- Excessive binder content over an optimum value for a given mix is detrimental to the good performance of the black top pavements.

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- Types of Bituminous Construction Roads
  1. **Classification based on construction technique**
     - ❖ Interface Treatment (prime coat and tack coat)
     - ❖ Surface dressing and seal coat
     - ❖ Grouted or penetration macadam
     - ❖ Premix construction (Bituminous bound macadam, bituminous carpet, bituminous concrete, rolled or sheet asphalt and mastic asphalt)
  2. **Classification based on temperature of binder**
     - ❖ Hot mix (bitumen and tar require heating)
     - ❖ Cold mix (cutback and emulsion)
  3. **Classification based on method of mixing**
     - ❖ Road mix method
     - ❖ Control plant mix method
  4. **Classification based on texture exhibited by compacted layers**
     - ❖ Open Graded (premixed carpet)
     - ❖ Dense graded (bituminous concrete)

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Interface Treatment
  - Existing pavement layer is to be cleaned to remove dust and dirt and the thin layer of bituminous binder is sprayed before the construction of any types of bituminous layer over this surface.
  - This treatment with bituminous material is called interface treatment which is necessary bond between the old and the new layers.
  - May be:
    - Prime coat
    - Tack coat

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
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  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Prime Coat
  - Applied over an existing porous or absorbent pavement surface (WBM) with low viscosity.
  - Main function includes:
    - To seal the pores and waterproof the underlying layer
    - To develop interface condition for bonding (adhesion development)
  - Usually MC or SC cutback binders with suitable grades are used.
  - Quantity of primer
    - 7.3 – 14.6 kg per 10 m^2 depending upon the porosity of the surface.
    - Primed surface is allowed to cure for at least 24 hours, during which no traffic is allowed.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
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- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

– Prime Coat

Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
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- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

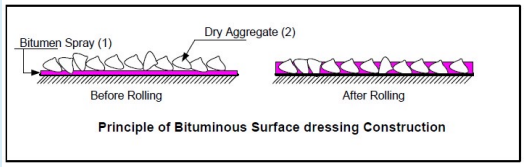
– Tack coat

- Applied on relatively impervious layer (Existing bituminous or cement concrete pavement or a previous layer like the WBM which has already been treated by prime coat).
- Usually applied by spraying bituminous material of higher viscosity like the hot bitumen.
- Quantity: 4.9 to 9.8 kg per 10 m^2 area.
- Ensures adhesion between existing surface and new bituminous surface

Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Surface Dressing
  - Provided over an existing pavement to serve as thin wearing coat.
  - Can be done in two layers.
  - Functions
    - To provide a dust free/mud free surface over a base course.
    - To provide a waterproof layer to prevent infiltration of surface water.
    - To protect the base course.



Principle of Bituminous Surface dressing Construction

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Surface Dressing
  - Construction Procedure
    - Either is single coat or in two coats over the existing bituminous pavement and for renewal or as a wearing course over a WBM road.
    - Done only in dry weather when the atmospheric temperature is above 16 degree Celsius.
  - Materials
    - Bitumen grades between 80/100 and 180/200 are used.
    - Tar and cutback may also be used.
    - Coarse aggregate should be crushed stone, clean, strong and durable with the following properties.
      - LAA – 35% max, AIV – 30% max, FI – 25% max, Water absorption – 1% max, Stripping value – 25% max.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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– Bituminous Surface Dressing

- Materials

Base course type	Binder requirement kg per 10 m2 area					
	First or single coat			Second coat		
	bitumen	tar	cutback	bitumen	tar	cutback
WBM	17 to 19.5	17 to 22	19 to 22	10 to 12	10 to 15	12 to 15
Renewal or black top surfacing	10 to 12	10 to 17	10 to 12	10 to 12	10 to 17	10 to 12

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
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- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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– Bituminous Surface Dressing

- Materials

	Sieve size, mm			Quantity in m3 for 10 m2 area
	passing	retained	normal	
First coat 12 mm thick	18	19	12	0.14 to 0.15
Second coat or renewal coat, 9 mm thick	12	6	9	0.09 to 0.11

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
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  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Bituminous Surface Dressing
  - Plants and equipment
    - Bitumen heating device, bitumen sprayer
    - Mechanical sweeper or hand brush
    - Aggregate spreader
    - Pneumatic roller, etc.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
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  - Penetration Macadam
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  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Bituminous Surface Dressing
  - Construction Steps
    - Preparation of existing surface
      - Existing surface is prepared to proper profile
      - Rut, depressions, etc. are rectified
      - The surface is made free from dust or loose materials
      - Prime coat is applied over previous surface such as WBM or soil stabilized roads
    - Application of binder
      - Uniform spraying of bituminous binder at specified rate on the prepared surface using a mechanical sprayer or pouring can
    - Application of stone chipping
      - Cover material over the binder is spread uniformly

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Surface Dressing
  - Construction Steps
    - Rolling of first or (final coat)
      - Rolling is done by 6 to 8 tons rollers after the covering the surface by chippings.
      - Rolling starts from edge towards the center longitudinally with overlapping not less than one third of the rolled tread.
    - Application of binder and stone chipping for second coat
      - Done immediately after the first coat
    - Brooming and cleaning of loose aggregate
    - Rolling of second coat
    - Finishing and opening to traffic
      - Surface is checked for longitudinal and cross profile
      - Road is opened to traffic after 24 hours

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
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- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Seal coat
  - Usually recommended as a top coat over certain bituminous pavements which are not impervious, such as open graded bituminous construction like premixed carpet and grouted macadam.
  - Also provided over an existing bituminous pavement which is worn out.
  - Very thin surface treatment or a single coat surface dressing which is usually applied over an existing black top surface.
  - Premixed sand bitumen (hot mix) seal coat is commonly used over the premixed carpet.
  - Function
    - To seal the surface against the entrance of water
    - To develop skid resistance texture
    - To enliven an existing dry or weathered bituminous surface

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
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- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Otta-Seal
  - Bituminous surfacing consisting of graded aggregates in combination with low viscosity binders, with or without sand cover seal.
  - **Types: Based on Layer, sand cover seal and gradation of aggregates:**
    - Single otta seal with or without sand cover seal with aggregate grading open, medium or dense
    - Double otta seal with or without sand cover seal with aggregate grading open, medium or dense
  - Materials:
    - **Bitumen:** MC 3000 or MC 800 Cutback
    - **Aggregate:** LAA ≤40%, AIV ≤30%, FI ≤30%, PI < 5 or Non-plastic; **Coarse sand** passing 6.7mm sieve and NP
  - **Equipment:** Storage tank with bitumen heating device, mechanical broom or hand brushes, air compressor, bitumen distributor, aggregate spreader, pneumatic roller

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Otta-Seal

Construction steps:

- Preparation and intensive cleaning of existing surface by mechanical broom and air compressor
- Application of prime coat at specified rate if necessary
- Spreading of binder as per specified rate of application
- Spreading of aggregate of specified grading as per specification
- Minimum 15 passes of rolling by two pneumatic rollers at a minimum weight of 12 tons or more on the day of construction
- Rolling by a 10-12 ton static steel roller at the end of the day of construction
- During first two days, extensive rolling by pneumatic roller (min 15 passes)
- Aggregates dislodged by traffic during immediate post construction period shall be broom back into wheel track during first 2-3 weeks
- Spreading binder as per specified rate of application
- Spreading sand as per specified rate of application
- Rolling with pneumatic roller and curing surface till 4 weeks
- After 8 -12 weeks, second coat is applied following similar procedure

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
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  - Bituminous bound macadam
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  - Mastic Asphalt

Otta-Seal

Quality Control

- Checking condition of equipment
- Checking temperature of binder
- Conducting test on binder for penetration, viscosity and ductility
- Conducting tests on aggregates; gradation, LAA, AIV, FI, PI,
- Checking rate of application of binder and aggregates by placing rectangular tray during spreading

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
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  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Penetration Macadam (Grouted Macadam)
  - Used as a base or binder course.
  - Coarse aggregate are first spread and compacted well in dry state.
  - Hot bitumen of relatively high viscosity is sprayed in fairly large quantity at the top.
  - The bitumen penetrates into the voids and binding stone aggregates together.
  - After the penetration of bitumen, key aggregates are spread over the previous layer and is compacted.
  - Grouted macadam may be of full and half depth.
  - Full grout is adopted in heavy rainfall region and semi grouted is in moderate rainfall and traffic.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
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  - Penetration Macadam
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- Premix
  - Bituminous bound macadam
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  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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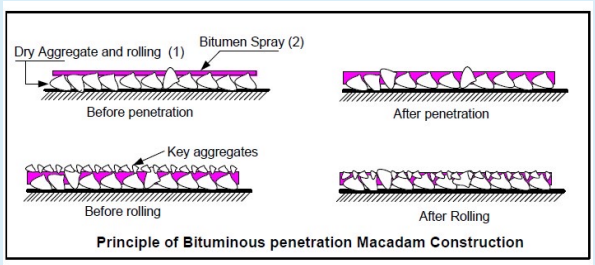
- Penetration Macadam (Grouted Macadam)



Principle of Bituminous penetration Macadam Construction

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Penetration Macadam (Grouted Macadam)
  - Construction Procedure
    - Construction of penetration macadam is recommended for thickness of 50 mm and 75 mm.
    - Material
      - Bitumen 80/100, 60/70, 30/40
      - Quantity of binder depends upon desired degree of penetration
      - Aggregate used for this construction should be hard, strong, durable and clean.
        - LAA – 40% max
        - AIV – 30% max
        - FI – 25% max

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Penetration Macadam (Grouted Macadam)
  - Construction procedure
  - Material
    - Aggregate
      - Grading of aggregates and key aggregates as recommended by IRC is given by: Grading of coarse aggregate

Percentage passing, mm	Compacted thickness, mm	
	50	75
63	-	100
50	100	-
38	-	35-70
25	35-70	-
19	-	0-15
12	0-15	-
9	-	-
4.75	-	-
2.36	0-5	0-5

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
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  - Bituminous bound macadam
  - Bituminous carpet
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- Penetration Macadam (Grouted Macadam)
  - Construction procedure
  - Material
    - Aggregate
      - Grading of aggregates and key aggregates as recommended by IRC is given by:
      - Grading of key aggregate

Percentage passing, mm	Compacted thickness, mm	
	50	75
38	-	-
25	-	100
19	100	35-70
12	35-70	-
9	-	0-15
4.75	0-15	-
2.36	0-15	-

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
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  - Bituminous concrete
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  - Mastic Asphalt

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- Penetration Macadam (Grouted Macadam)
  - Construction procedure
  - Material
    - Aggregate
      - Quantity required
        - Coarse aggregates
          - 50 mm PM: 0.06 m^3 for 10 m^2 area
          - 75 mm PM: 0.9 m^3 for 10 m^2 area
        - Key aggregates
          - 0.15 and 0.18 m^3 for 50 mm and 75 mm thickness PM for 10 m^2 area

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
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  - Sheet Asphalt
  - Mastic Asphalt

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- Penetration Macadam (Grouted Macadam)
  - Construction procedure
    - Plants and equipment
      - Bitumen heating device
      - Bitumen distributor
      - Aggregate spreader
      - Pneumatic roller, etc.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Penetration Macadam (Grouted Macadam)
  - Construction procedure
    - Construction Steps
      - Preparation of existing surface
        - Existing surface should be uniform grade, and it is lightly scarified and brushed.
        - Prime coat may be applied if required.
      - Spreading of coarse aggregate
        - Spread is done by proper edge protection
      - Rolling with 10 tonnes roller
        - Dry rolled until they are interlocked and compacted
        - Done from edge towards center with 30 cm overlap

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Penetration Macadam (Grouted Macadam)
  - Construction procedure
    - Construction Steps
      - Bitumen Application
        - Over dry and compacted coarse aggregates, the binder is applied uniformly with pressure distributor
        - Quantity of bitumen is 50 and 68 kg per $10m^2$ for 50 to 75 mm thickness respectively
      - Spreading of key aggregates and rolled
      - Seal coat is applied if another surfacing course is not constructed immediately and traffic is to be allowed. Premix sand bitumen seal coat may be applied.
      - Finishing: Cross profile is checked.
      - Opening to traffic 24 hours if the surface course is done by surface dressing or seal coat.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
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  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Built-up-spray grout
  - Consists of two layer composite construction of compacted crushed aggregate with the application of bitumen binder after each layer for bounding and finished with key aggregates at the top to provide a total compacted thickness of 75 mm.
  - This method is commonly used for strengthening for existing bituminous pavements.

11 4

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
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  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Built-up-spray grout
  - Construction Procedure
    - Materials
      - Bitumen grades 80/100 to 30/40 or RT – 4 and RT – 5 may be used as binder
      - Aggregates have the same specification (grading and size) and as the penetration macadam
    - Construction Steps
      - Preparation of existing base
        - Depressions and pot holes are filed and surface is prepared to the required grade and camber
        - Surface is cleaned and prime coat is applied and cured

11 5

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
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  - Penetration Macadam
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  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Built-up-spray grout
  - Construction Procedure
    - Construction Steps
      - Tack coat is applied at a rate of 7.5 tot 10 kg on WBM surface and 6 to 8 kg on back top surface per 10 m^2 area
      - Spreading first layer
        - Coarse aggregates are sprayed or hand packed at a rate of 0.5 m^3 per 10 m^2 area
        - Rolled using 8 to 10 tones roller
      - Bitumen binder is sprayed uniformly at the rate of 2.5 to 15 kg per 10 m^2 area over dry and compacted surface.
      - Second layer of coarse aggregates is spread immediately after application of binder at 0.5 m^3 per 10 m^2 area

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Built-up-spray grout
  - Construction Procedure
    - Rolling: Starting from edge towards center.
    - Second application of binder at the rate of 12.5 to 15 kg per 10 m^2 area
    - Application of key aggregates
      - Immediately after application of the binder key aggregates are spread at the rate of 0.13 per 10 m^3 area and rolled
    - Surface finish
      - Unevenness is checked
      - Undulation more than 12 mm should be rectified
    - Open to traffic
      - Built-up spray grout should not be exposed to traffic before providing surface course.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Premix Methods
  - In this group of methods the aggregates and the bituminous binder are mixed thoroughly before spreading and compacting..
  - Each particle of aggregate is mixed with the binder still the quantity of binder used may be considerably lesser than penetration macadam type of construction.
  - Bitumen quantity is precisely controlled and they offer increased stability of mix.
  - May be: open graded, semi dense and dense mixes.
  - Common types are: Bituminous macadam, bituminous carpet and bituminous concrete.
  - Sheet and mastic asphalts also fall under this category.

11 8

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Bituminous Bound Macadam
  - Premixed type of construction consisting one or more courses of compacted crushed aggregates premixed with bituminous binder laid immediately after mixing.
  - Laid in compacted thickness of 75 mm or 50 mm.
  - Three different gradations of aggregates have been suggested for each thickness to provide open graded and semi dense construction.
  - BM is base course or binder course and should be covered by surfacing course before exposing to traffic.

11 9

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
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  - Bituminous bound macadam
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  - Mastic Asphalt

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- Bituminous Bound Macadam
  - Construction Procedure
    - Material
      - Bitumen 80/100, 60/70, 30/40, the binder content used varies from 3.0 – 4.5 by weight of the mix.
      - Aggregate should be hard, tough, durable and clean, etc. with the following properties

Properties	Base Course	Binder Course
LAA	≤50%	≤40%
AIV	≤35%	≤30%
FI	≤15%	≤15%
Stripping	≤25%	≤25%
Loss with Na_2SO_4	≤12%	≤12%

      - Gradation and quantity should be as per the specification which depends upon traffic intensity and thickness of layer

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Bituminous Bound Macadam
  - Construction Procedure
    - Material
      - Gradation for 75 mm thick layer

Percentage passing, mm	Base course		Base or Binding course
	Grading 1	Grading 2	Grading 3
63	100	100	-
50	-	90-100	-
40	35-70	35-65	100
25	-	20-40	70-100
20	0-15	-	50-80
12.5	-	5-20	-
10	-	-	25-50
4.75	-	-	10-30
2.36	0-5	0-5	5-20
0.075	0-3	0-5	0-4
Binder content, % by wt of mix	3.0-4.5	3.0-4.5	3.0-6.0

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Bound Macadam
  - Construction Procedure
    - Material
      - Gradation for 50 mm thick layer

Percentage passing, mm	Base course		Base or Binding course
	Grading 1	Grading 2	Grading 3
50	100	100	-
40	-	90-100	-
25	35-70	50-80	100
20	-	-	70-100
12.5	0-15	10-30	-
10	-	-	35-60
4.75	-	-	15-35
2.36	0-5	-	5-20
0.075	0-3	0-5	0-4
Binder content, % by wt of mix	3.0-4.5	3.0-4.5	3.0-6.0

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Bound Macadam
  - Construction Procedure
    - Material
      - Quantity of materials
        - Quantity of aggregates required for 10 m^2 area of BBM for
          - 50 mm compacted thickness: 0.6 to 0.75 m^3
          - 75 mm compacted thickness: 0.9 to 1.0 m^3
      - Plants and equipment
        - Bitumen heating device, Bitumen distributor
        - Hot mix plant or mechanical mixer or hand mixer
        - Pneumatic roller, etc.

12 3

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Bound Macadam
  - Construction Procedure
    - Construction Steps
      - Preparation of existing layer
        - Pot holes are patched, irregularities are made even.
        - Surface is properly cleaned.
      - Tack cost or prime coat application
      - Premix production
        - Bitumen and aggregates of recommended gradation are heated separately and then placed in the mixer.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Bound Macadam
  - Construction Procedure
    - Construction Steps
      - Placement of the mix at site immediately after the mixing.
      - Camber and profile should be checked.
    - Rolling and finishing
      - Compacted by 8-10 tones pneumatic roller.
      - Rolling is started from the edge of towards the center of the pavement.
      - Roller wheels are kept damp.
    - Application of seal coat.
    - Opening to the traffic after 24 hours.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
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  - Bituminous bound macadam
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  - Mastic Asphalt

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- Bituminous Premixed Carpet
  - PC consists of coarse aggregates of 12.5 mm and 10 mm sized premixed with bitumen or tar binder compacted to a thickness of 20 mm to serve as a surface course of the pavement.
  - Being open graded construction, PC is to be covered by a suitable seal coat such as premixed sand-bitumen seal coat before opening to traffic.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

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- Bituminous Premixed Carpet
  - Construction Procedure
    - Material
      - Bitumen binder: 80/100 grade or Road Tar of grade RT-3 is used
      - Aggregates: 20 mm down and retained on 2.5 mm sieve
      - Aggregate requirements
        - LAA – 35% max
        - AIV – 30% max
        - FI – 30% max
        - Stripping - 25% max
        - Water absorption – 2% max

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Premixed Carpet
  - Construction Procedure
    - Material
      - Quantity of materials
        - Prime coat on WBM surface 7.3 to 9.8 kg bitumen
        - Tack coat: On an existing black top surface: 4.9 to 7.3 kg bitumen
        - Bitumen for premixing depending upon the size of the aggregates 14.92 kg per 10 m^2 of the prepared surface

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Premixed Carpet
  - Construction Procedure
    - Material
      - Quantity of materials
        - For 20 mm thick carpet
          - Stone chippings 12 mm size (passing 20 mm and retained in 10 mm sieve): 0.83 m^3 per 10 m^2 area
          - Stone chippings 10 mm size (passing 12 mm sieve and retained on 6 mm sieve): 0.091 m^3 per 10 m^2 area
      - Plant and equipment
        - Various equipment required are already mentioned in the previous type of construction

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Premixed Carpet
  - Construction Procedure
    - Construction Steps
      - Preparation of existing surface
        - Existing surface is prepared by filling the potholes and depression grade and camber is provided.
        - Prime coat is applied over the WBM.
      - Application of tack coat
        - Bitumen is heated for tack coat and sprayed over the prime coat surface just before spreading the premixed carpet.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous Premixed Carpet
  - Construction Procedure
    - Construction Steps
      - Preparation and placing of premix
        - Premix is prepared in mechanical mixer or manually by heating aggregate and bitumen separately and then mixed to the homogenous mix
      - Rolling and finishing by pneumatic roller
      - Application of seal coat
        - In the areas of low rain fall premixed sand-bitumen seal coat is applied over the carpet
      - Surface finish: Variation of 6mm over 3m is allowed. Number of undulations exceeding 10 mm should be less than 30 in 300 m length.
      - Opening to traffic after 24 hours after providing the seal coat

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous concrete or Asphalt concrete
  - Dense graded premixed bituminous mix which is well compacted to form a high quality pavement surface.
  - Consists of carefully proportioned mixture of coarse aggregates, fine aggregates, mineral filler and bitumen.
  - Mix is prepared in hot-mix plant.
  - Mix is designed by an appropriate method such as Marshall Stability method to fulfill the requirements of stability, density, flexibility and voids.
  - Thickness depends upon the traffic and quality of base course.
  - Thickness usually ranges from 40 to 75 mm.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Bituminous concrete or Asphalt concrete
  - Materials
    - Binder
      - Bitumen or grade of 30/40, 60/70 or 80/100 may be used depending upon the climatic conditions.
    - Coarse Aggregate
      - Impact Value: 30% max
      - LA Value: 40% max
      - Flakiness Index: 25% max
      - Stripping at 40 degree after 24 hours: 25% max

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
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  - Mastic Asphalt

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- Bituminous concrete or Asphalt concrete
  - Gradation

Sieve size, mm	Percent passing by weight	
	Grading 1	Grading 2
20	-	100
12.5	100	80-100
10	80-100	70-90
4.75	55-75	50-70
2.36	35-50	35-50
0.6	18-29	18-29
0.3	13-23	13-23
0.15	8-16	8-16
0.075	4-10	4-10

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
  - Penetration Macadam
  - Built-up spray grout
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- Bituminous concrete or Asphalt concrete
  - Bituminous Concrete Mix
    - Marshall Stability Test

Properties of design mix			
	Heavy	Medium	Light
Stability	340	227	227
Flow Value	2-4 mm	2-4.5 mm	2-5mm
Voids in mix %	3- 5	3 - 5	3 – 5

  - Plants and equipment
    - Hot mix plant is used for mixing the concrete.
    - Mechanized construction equipment are used for laying the pavement mix.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
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  - Penetration Macadam
  - Built-up spray grout
- Premix
  - Bituminous bound macadam
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  - Mastic Asphalt

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- Bituminous concrete or Asphalt concrete
  - Construction Steps
    - Preparation of existing base course layer
      - Removing potholes and ruts, etc., fill in with premix chippings at least week before construction.
      - If the existing pavement is extremely wavy, bituminous leveling course is provided as binder course.
    - Application of tack coat
      - It is desirable that AC layer is used over bituminous base course or binder course.
      - A tack coat is applied at 6 to 7.5 kg per $10m^2$ area.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
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  - Mastic Asphalt

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- Bituminous concrete or Asphalt concrete
  - Construction Steps
    - Preparation and placing of premix
      - Premix is prepared in hot mix plant.
      - Bitumen may be heated up to 150-177°C.
      - Aggregate temperature should not be differ by over 14°C from the binder temperature.
      - Mix is spread at the temperature of 121 to 163°C.
      - Camber and thickness is verified.
      - Rolling by roller at the speed not more than 5 km/hr.
        - Initial Rolling 8 – 10 t roller
        - Intermediate rolling 15 – 30 t pneumatic roller with tire pressure 7 Kg/cm^2
        - Final Rolling: 8 – 12 t roller; In warm climate, rolling on next day helps increase density if initial rolling was not adequate

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Construction of bituminous pavement

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- Bituminous concrete or Asphalt concrete
  - Construction Steps
    - Quality Control
      - Aggregate grading
      - Grade of bitumen
      - Temperature of aggregates
      - Temperature of paving mix, during mixing and compaction
      - Rolling operation should be completed before temperature falls below 100 °C
      - Longitudinal undulations should not exceed 8 mm in 3 m straight edge and number of undulations higher than 6 mm should not exceed 10 in length of 300 m. Cross profile should not have undulations exceeding 4 mm.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
- Surface dressing and seal coat
- Grouted or penetration macadam
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  - Bituminous bound macadam
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  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Sheet Asphalt
  - Dense sand-bitumen premix of compacted thickness 25 mm used for wearing course.
  - Consists of well graded coarse to fine sand and suitable grade bitumen to form a dense and impervious layer.
  - Mix should be durable, stable, dense and impervious.
  - Surface is laid over cement concrete pavement to provide an excellent riding surface.
  - Protects joints in cement concrete pavements and could cause a reduction in warping stress due to temperature variations between top and bottom layer of cement concrete pavement.

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Construction of bituminous pavement

- Interface treatment like prime coat and tack coat.
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  - Bituminous bound macadam
  - Bituminous carpet
  - Bituminous concrete
  - Sheet Asphalt
  - Mastic Asphalt

- Mastic Asphalt
  - Mixture of bitumen, sand and mineral filler in suitable proportions which yields a void less and impervious mass.
  - Ingredients are same as in bituminous concrete; properties of mastic asphalt are quite different.
  - This material can also absorb vibrations and has property of self healing of cracks without bleeding.
  - Suitable for RCC bridge deck slabs.
  - Penetration grade 10/20 is very good bitumen for this construction.
  - Prepared by heating aggregate, bitumen and filler to 200 – 223 °C for 5 hrs.
  - Can be laid and spread without compaction to a thickness of 2.5 – 5 cm @ 200 °C.

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Various specifications of cement concrete pavements
    - Cement grouted layer
      - Open graded compacted aggregate (18 to 25 mm) layer is prepared and cement grout is laid over it.
      - Cement grout consists of cement, sand and water grout is allowed to seep through the aggregate matrix.
    - Rolled concrete layer
      - Lean mix concrete is used. Aggregate, sand, water and cement with less plasticity is prepared and laid over sub-grade or sub-base course and compacted.
    - Cement grout layer and rolled concrete is suitable for base course only.
    - Cement concrete slab.

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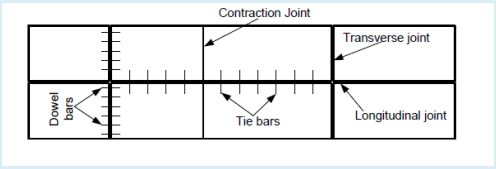
Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Materials
    - Portland cement
    - Coarse aggregate
    - Fine aggregate
    - Ratio of ingredients should be designed at least to achieve the strength of 280kg/cm^2.



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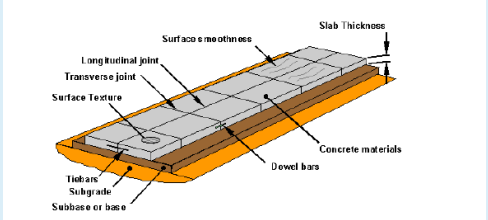
Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Expansion joints
    - Provided to allow for expansion of the slabs due to rise in slab temperature.
    - Permits the contraction of slabs.
    - Range of spacing is 50-60 m for smooth interface.
    - Expansion gap should have 20-25 mm.
    - Dowel bar is used for load transfer across the transverse joint.



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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Contraction joint
    - Provided to permit the contraction of the slab.
    - Spaced closer than expansion joints.
    - Load transference across the joint is provided through the physical interlocking by the aggregates projecting out at the joint faces.
    - Spacing of joints is 4.5 m (PCC) and 14 m (RCC).
  - Warping joint (Hinged joint)
    - Provided to relieve stresses induced due to warping.
    - Longitudinal joints with tie bars falls under this category. Designed to prevent cracking.

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Longitudinal Joints
    - These are provided in cement concrete roads which have width over 4.5m.
    - These are provided to prevent longitudinal cracking in the pavements.
    - This type of joint acts as a hinge and helps to maintain the two slabs together at the same level.

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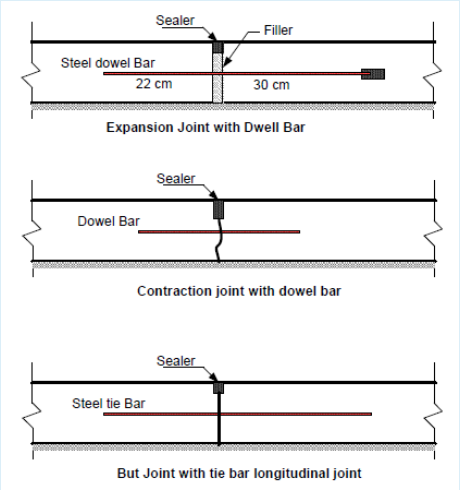
Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement



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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Joint Filler and Sealer
    - Joints form the break in the cement concrete pavement and these can allow the infiltration of water and ingress of stone grits.
    - The infiltrated water damages the soil sub-grade and gives rise to the phenomena as mud pumping.
    - Joint filler properties
      - Compressibility, Elasticity, Durability
    - Types of joint filler materials
      - Soft wood, impregnated fibre board, cork or cork bound bitumen
    - Joint sealer properties
      - Adhesion to cement concrete edges, extensibility without fracture, resistance to ingress of grit, durability.

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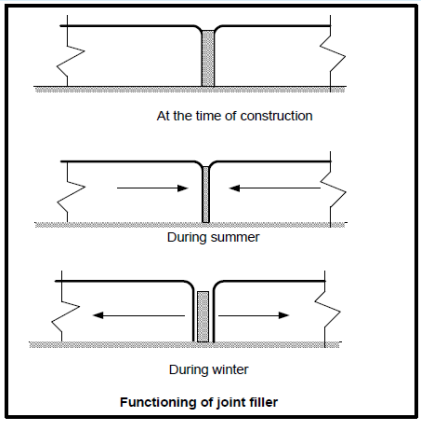
Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

– Cement Concrete Pavement



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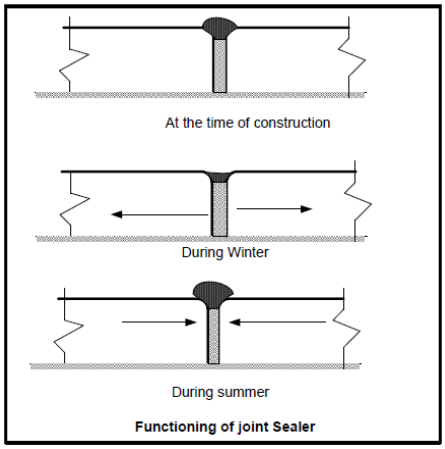
Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

– Cement Concrete Pavement



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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Construction
    - Alternative bay method
    - Continuous bay method
  - Material
    - Cement (OPC or RHC)
    - Coarse aggregate
      - Maximum size of coarse aggregate should not exceed the one-fourth of the slab thickness.
      - Gradation 50 to 4.75 mm or 40 to 4.75 mm.
      - Aggregate should be free from harmful materials as iron, pyrites, coal, mica, alkali, organic impurities, etc.

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Material
    - Cement (OPC or RHC)
    - Coarse aggregate
      - Aggregate crushing value: 30% max
      - Aggregate impact value: 30% max
    - Fine aggregate
      - Natural sands should be preferred as fine aggregates.
      - Crushed stones may also be used.
    - Proportioning of concrete
      - So as to obtain a minimum modulus of rupture of 40 kg/cm^2 on field specimens after 28 days

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Plants and equipment
    - Concrete mixture
    - Batching device
    - Wheel barrow
    - Needle vibrator
    - Brush
    - Concrete paver
    - Float
    - Fibre brush

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Construction Steps
    - Preparation of sub-grade/sub base
      - Soft spots are uniformly compacted.
      - Sub-grade is prepared and checked at least two days in advance of concreting.
      - Sub-grade and sub-base is kept in moist conditions while concreting.
    - Placing of forms
      - Steel or wooden forms equal to the slab thickness are used.

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Construction Steps
    - Batching of materials and mixing
      - After the proportions are determined, the fine and coarse aggregates are proportioned by weight.
      - Cement is proportioned by cement bag.
      - Mixing is done in a batch mixer which will ensure a uniform distribution of materials throughout the mass.

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Construction Steps
    - Transporting and placing of concrete
      - Cement concrete is mixed in quantities required for immediate use.
      - Deposited on the soil sub-grade or sub-base to the required depth and width of the pavement.
      - Segregation should be avoided.
      - Spreading is done uniformly.
      - Needle vibrator is used for splicing of concrete.

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Construction Steps
    - Compacting and finishing
      - Surface is compacted by power driven finishing machine.
    - Floating and straight edging
      - Further compacted by longitudinal float.
      - Held parallel to the center line of carriageway.
    - Brooming and edging
      - Pavement is given a broom finish with a fibre broom brush.

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Construction Steps
    - Curing of cement concrete
      - Entire pavement is cured as
        - Initial curing
          - The surface of the pavement is covered with wet mat of cotton or jut bags.
        - Final curing
          - Curing with wet soil exposed edges of the slab and are banked by soil berm.
          - Blanket of sandy soil is placed.
          - Saturated thoroughly with water for 14 days.

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Cement Concrete Pavement

Construction of cement concrete pavement is dealt in two groups

- Construction of pavement slab
- Construction of joints

- Cement Concrete Pavement
  - Construction Steps
    - Open to traffic
      - When concrete attains required strength or after 28 days of curing the concrete.

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M.Sc. In Transportation Engineering

Thank You!

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