HIGHWAY CONSTRUCTION

Introduction

The science of highway engineering raises some fundamental questions as to what is a road or highway, how is it planned and designed and lastly how is it built. By now in the preceding chapters, depending upon the desired strength of the pavement, the aggregate gradations and the type and proportion of binders are decided. These three basic binder medium give rise to a number of construction methods.

Types of Highway Construction

The highway types are classified as below:

(i) Earth road and gravel roads

(ii) Soil stabilized roads

(iii) Water bound macadam (WBM) road

(iv) Bituminous or black-top roads

(v) Cement concrete roads

The roads in India are classified based on location and functions. All the roads do not cater for the same amount of traffic volume or intensity. Since the funds available at hand for financing the construction projects are also meager, it is necessary to have roads which cost less. The adoption of low cost roads is now preferred in developing countries like India where large lengths of roads are to be constructed in the rural areas with the limited finances available in the country. Earth roads and stabilized roads are typical examples of low cost roads. Stabilized soil roads are gaining importance in the form of low cost roads.

EARTHWORK

General

The subgrade soil is prepared by bringing is to the desired grade and camber and by compacting adequately. The subgrade may be either in embankment or in excavation, depending on the topography and the finalized vertical alignment of the road to be constructed.

Excavation

Excavation is the process of cutting or loosening and removing earth including rock form its original position. Transporting and dumping it as a fill or spoil bank. The excavation or cutting mat is needed in soil, soft rock or even in hard rock, before preparing the subgrade.

Embankment

When it is required to raise the grade line 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

i) To keep the subgrade above the high ground water table.
ii) To prevent damage to pavement due to surface water and capillary water.
iii) To maintain the design standards of the highway with respect to the Vertical alignment.

The design elements in highway embankments are:

a) Height
b) Fill material
c) Settlement
d) Stability of foundation, and
e) Stability of slopes

Height

The height of the embankment depends on the desired grade line of the highway and the soil profile or topography. Also, the height of the fill is some times governed by stability of foundation, particularly when the foundation soil is weak.

Fill Material

Granular soil is generally preferred as highway embankment material. Silts, and clays are considered less desirable. Organic soils, particularly peat are unsuitable. The best of the soils available locally is often selected with a view to keep the lead and lift as low as possible. At times light-weight fill material like cinder may be used to reduce the weight when foundation soil is weak.

Settlement

The embankment may settle after the completion of construction either due to consolidation and settlement of the foundation or due to settlement of the fill or due to both. If the embankment foundation consists of compressible soil with high moisture content, the consolidation can occur due to increase in the load. The settlement of the fill is generally due to inadequate compaction during construction and hence by proper compaction this type of settlement may be almost eliminated. Whatever be the type of settlement, it is desirable that the settlement is almost complete before the construction of pavement.

Stability of Foundation

When the embankment foundation consists of weak soil just beneath or at a certain depth below in the form of a weak stratum, it is essential to consider the stability of the foundation against a failure. This is all the more essential in the case of high embankments.

a) The foundation stability is evaluated and the factor of safety is estimated by any of the following approaches:
b) Estimating the average shear stress and strength at the foundation layers by approximate methods and estimating the factor of safety.

c) Using theoretical analysis based on elastic theory.

The factor of safety in the case of compressible soil foundation is likely to be minimum just after the completion of the embankment. Later due to consolidation of foundation and consequent gain in strength there will be an increase in the foundation factor of safety.

Stability of Slopes

The embankment slopes should be stable enough to eliminate the possibility of a failure under adverse moisture and other conditions. Hence the stability of the slope should be checked or the slope should be designed providing minimum factor of safety of 1.5. Often much flatter slopes are preferred in highway embankments due to aesthetic and other reasons.

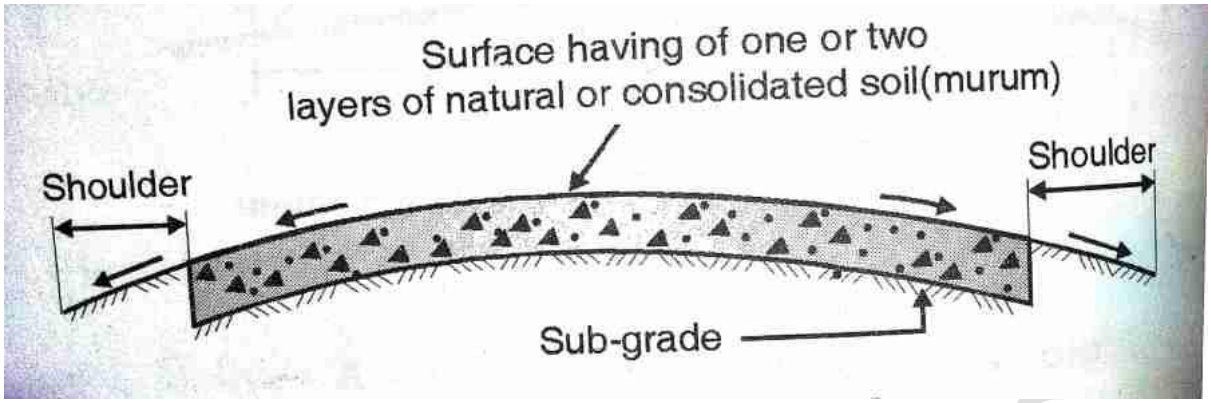
CONSTRUCTION OF PAVEMENTS

Various equipments for construction of the pavements:

1. Bull dozer
2. Scrapper
3. Power shovel
4. Hoe
5. Dragline
6. Clamp shell
7. Pavers

Earth Road : Types and Construction Procedure

When the foundation and wearing surface of the road consists of one or two compacted layers of an ordinary soil or stabilized soil then such road is called as “Earth Road”.



Types of Earth Roads :

There are mainly two types of earth roads :

- Ordinary Earth Road.
- Stabilized Earth Road.

Ordinary Earth Road :

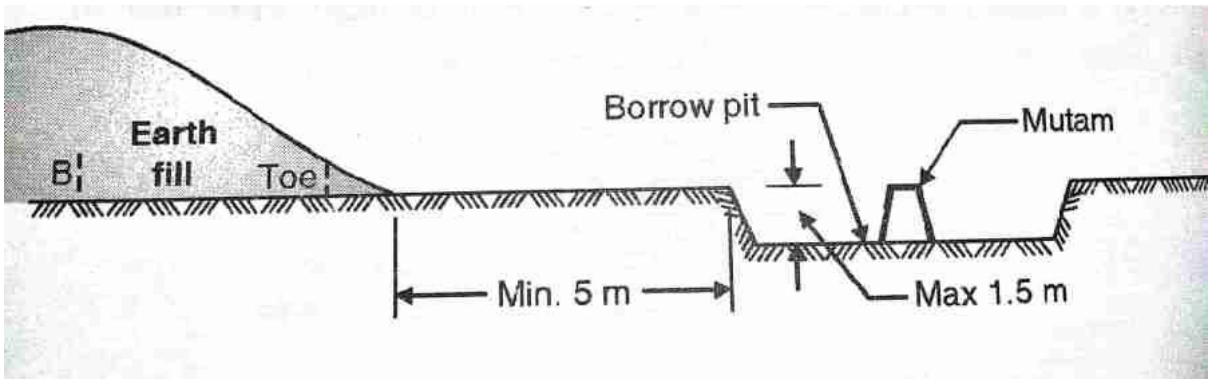
When the foundation and wearing surface of the road is constructed by one or two compacted layers of a natural soil available along alignment of the road then such type of road is called as are the ordinary *Earth Road.*

Stabilized Earth Road :

When the foundation and wearing surface of the road is constructed by one or two compacted layers of stabilized soil it is called as stabilized *Earth Road*.

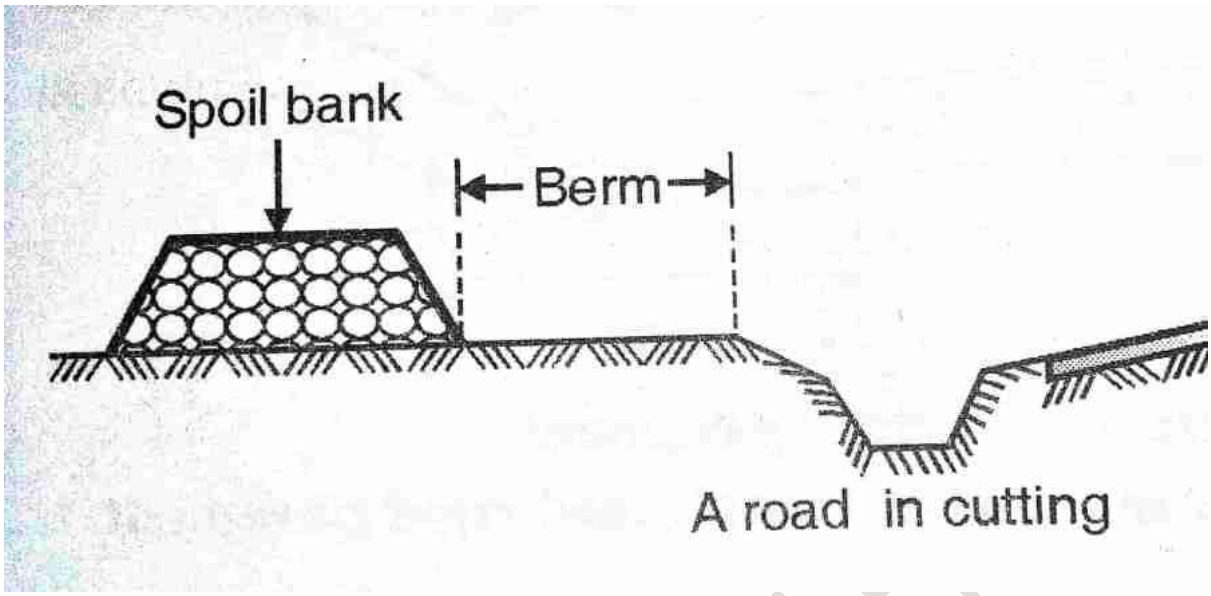
Different Terms Used in the Construction of Earth Road.

1. Borrow Pits :



Borrow pits are nothing but the pits dug Doug along the alignment of the road . They are generally dug to use the earth material from the pits for the construction of road embankment. Borrow pits should always be dug 5 meters away from the toe of the embankment.

2. Spoil Banks :



Spoil banks are generally constructed from excavated soil on the sides of cutting. They are generally constructed parallel to the alignment of road. Height of spoil bank should not be less than 1.5 m. Care should be taken that they are constructed 3 m away from top edge of cutting.

3. Lead :

At the time of construction of road soil is excavated to use it for the construction. The horizontal distance between the excavated earth and the point of placing that excavated soil is called as lead. Generally, on site, 30 m lead is taken as initial for which contractors do not get any additional payments.

4. Lift :

Lift is the vertical distance of the lifting of excavated earth required for the construction. Generally on site, 15 m lift is taken as initial for which contractors do not get any additional payments.

5. Balancing Earth Work :

Excavation of earth is required for the construction process but at the same time balancing of the earth work is also recommended. There should be no large difference in the earth obtained from cutting to earth required for filling. To minimize this difference proper selection of gradient is required.

Construction Procedure of Earth Work:

There are only 2 materials required for the construction of earth road. Natural soil or the soil that is available locally and suitable stabilizer if required for the given conditions.

1. First of all proper survey of the site is done. Selection of area for borrow pits is kept outside the land with of earth road. Center line is fixed and pegs are driven for reference of verticals profile of road.

2. Before excavation the site is totally cleaned from shrubs, trees, grass and other organic matter.

3. After the excavation process, the sub-grade of road is prepared. It is provided with sufficient camber and proper gradient. Generally, the thickness of the pavement construction decides the depth of sub-grade.

4. After the preparation of the sub-grade it is properly compacted by rolling operation with the help of rollers. Sufficient amount of water is sprinkled along with rolling operation for proper compaction.

5. After the compaction another layer of graded soil is laid after sprinkling of water. The thickness of this layer is kept between 8-12 cm.

6. After the final work the camber of the earth road is properly checked and if found faulty it is then needed to be corrected.

7. After the construction of earth road, it is needed to be cured with sufficient amount of water for 4-5 days.

8. After proper curing is done the earth road is allowed to dry for minimum of 3 days and then it is opened for traffic.

Precaution to be Taken While Constructing Earth Road.

1. The camber to be provided in the construction of this road should be very steep i.e values from between 1 in 20 to 1 in 33 should be adopted.

2. To prevent the erosion of soil due to rain water, the maximum gradient should be 1 in 20.

3. To dispose off the rain water, the height of the embankment should be above 600 mm.

Advantages :

- The construction of earth road is a fast process.
- Proper selection of the gradient give balanced earthwork.
- In future if other type of road is going to be constructed on the existing earth road, it gives good foundation.
- The overall process is relatively cheaper than other road types.

Disadvantages :

- These roads are only useful for light traffic. It cannot sustain the lifespan of the road if it is allowed for heavy traffic.
- This type of road wears quickly and the maintenance is little bit costlier.

- This type of road cannot be constructed or it will be worthless in the areas where monsoon is on peak or areas that have maximum rainfall, as constant and excess rainfall lashes out these Kind of roads.

Construction of Flexible pavement

Material for construction Flexible pavement/Bituminous pavement:

The common types of flexible pavements in India is made from wet mix macadam (WMM) and (WBM) water bound macadam.

Wet mix macadam construction procedure

Steps

1. The compaction test is conducted in the laboratory using the selected WMM material.
2. The optimum moisture content of the WMM material is found out in the laboratory under heavy compaction.
3. The selected WMM material is prepared in a pug mill by adding water equal to the optimum moisture content.
4. Then the WMM material is transported to the field and spread over the site by using a paver to attain required slope, thickness & grade.
5. Then the compaction is done using the vibratory roller of minimum weight 10 times and with a rolling speed of 5 Kmph.
6. The WMM layer is checked for defects before the construction of the bituminous surface course.
7. After the WMM layer is dried in a dry weather for 24 hours the bituminous pavement layer is applied & the real is opened for traffic.

WATER BOUND MACADAM COSTRUCTION

Material used for the WBM construction

a) Coarse aggregate
b) Screening
c) Binding material

Construction process

Steps

1. The soil surface prepared by leveling & filling of the depressions and patching the pot holes up to the required grade and slope.
2. The dust and other loose materials are cleaned.
3. The total boundary for the formation of the pavement was confined by constructing the shoulders.

4. Then the coarse aggregates are properly spread to a uniform profile and thickness.
5. The compaction is done by using power rollers of 3-10 tons by vibration & rolling, starting from the edge towards the center line.
6. After the compaction is over the dry screening are applied on the surface to fill the interspaces in 3-4 applications.
7. The surface is sprinkled with water & rolled. The rolling is done till the coarse aggregates get firmly bonded.
8. The binding material is applied at a uniform & slow rate followed with sprinkling of water. Then rolled to desired level.
9. After the final compaction the layer is allowed for drying 24 hours. The bituminous surfacing is layered which comprises of tar & aggregate of range (1-1.5 cm) in hot condition.
10. Then the rolling is done followed by sprinkling of additional bitumen & after the drying of road completely this is made open to the traffic.

WBM Road (Water Bound Macadam Road)

WBM road means water bound macadam road. The wearing surface of WBM road consist of clean and crushed aggregates which are mechanically interlocked by rolling operation. The material is bound with filler material (which are also called as screenings) and water, laid on prepared base course.

Materials Required For WBM Road Construction.

There are mainly 3 types of materials which are used in the construction of WBM road.

- Coarse Aggregate
- Screenings (filler material)
- Binding Material

a) Coarse Aggregate :

Unlike other coarse aggregates it consist of mixture of hard and durable crushed aggregates and broken stones. The aggregates used for each layer of the WBM road construction should be properly graded. Below table shows the standard gradation of the aggregates that can be adopted.

Grading number	Size range (mm)	Sieve size (mm)	Percentage by weight passing the sieve
1.	90 to 40	100	100
		80	65 – 85
		63	25 – 60
		40	0 – 15
		20	0 – 5
2.	63 to 40	80	100
		63	90 – 100
		50	35 – 70
		40	0 – 15
		20	0 – 5
3.	50 to 20	63	100
		50	95 – 100
		40	35 – 70
		20	0 – 10
		10	0 – 5

The coarse aggregates used in the construction of WBM road should hold the following properties.

- It should be hard and durable.
- The coarse aggregate should be free from flaky and elongated particles.
- The coarse aggregate should be in acceptable shape and size.

Physical requirements of course aggregates required for construction of WBM road in terms of test values for different pavement layers is given below.

Sr. no.	Property	Requirements for pavement layer (maximum percent)		
		Sub-base	Base course	Surfalling course
1.	Los Angeles abrasion value	60	50	40
2.	Aggregate impact value	50	40	30
3.	Flakiness index	–	15	15

b) Screenings :

The material which is used up to fill up the excess voids present in the compacted layer of course aggregate is called as screenings.

Screening material is nothing but the aggregates of smaller size than the course aggregates. Below table shows the standard grading required of screening for construction of WBM road.

Grading classification	Size of screenings (mm)	Sieve size (mm)	Percentage by weight passing the sieve
A	12.5	12.5	100
		10.0	90-100
		4.75	10-30
		0.15	0-8
B	10.0	10.00	100
		4.75	85-100
		0.15	10-30

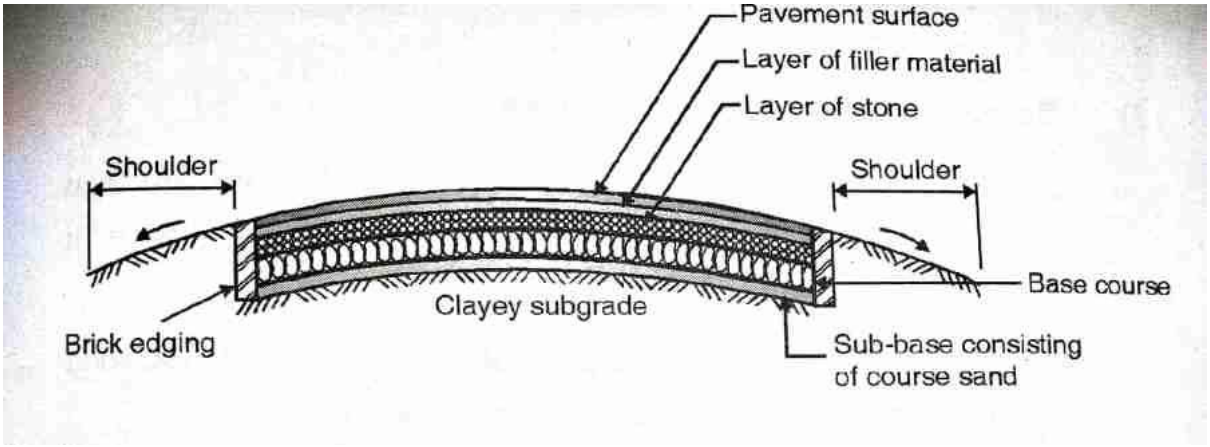
In order to reduce the overall cost of WBM road, IRC has recommended to use non-plastic materials such as kankar nodules, murum or gravel.

c) Binding Material:

Binding material which is going to be used for the construction of WBM road should be properly approved by engineer and it should have plasticity index value less than 6.

Generally, the binding materials are not required if screenings used for the construction of WBM road is murum or gravel as they have crushable property.

Construction Procedure of WBM Road



1) Preparation of Foundation for WBM Road:

The subgrade or base course is properly prepared for the required grade and camber of WBM road. The potholes and the depressions on the surface of the road are properly filled up and compacted.

2) Provision for Lateral Confinement:

Before laying of aggregates the shoulders having thickness as that of compacted WBM layer should be constructed. They should be constructed with proper quality of moorum or earth.

The main purpose of constructing shoulders is that the road surface to be constructed retain in between them and it becomes easy for further laying of course aggregates.

3) Spreading of Coarse Aggregates:

The coarse aggregates are uniformly spread on the prepared base after the construction of the shoulders. Total number of layers and thickness of WBM road depends upon the details of design pavement.

In general, for ordinary roads, single layer of compacted thickness 75 mm may be sufficient. For special roads, 2 layers of 150 mm each compacted thickness may be provided.

If the coarse aggregate is used of number 1 grade as shown in above course aggregate grading table then it is compacted to thickness of 100 mm.

4) Rolling Operation:

Rolling operation is carried out for compacting the course aggregates. Generally it is done with the help of 3- wheeled power rollers weighing 6-10 tonnes or with the help of vibratory rollers.

Skilled operators should be used for driving the rollers as the fault rolling operations causes formation of corrugations, unequal finish of road surface, wearing of road in few months of construction.

5) Application of Screenings:

After the rolling operation is properly finished screenings is applied to properly fill the voids remained after the compaction of aggregates. The screening may be applied in 3 or more layers as per the site conditions.

After uniformly spreading of screening compaction is carried out with the help of dry rollers for each layer of screenings. After compaction brooming of the each layer should be properly done to remove the uncompacted screening material.

6) Sprinkling of Water and Grouting:

After the application of screening the road surface is properly sprinkled with plenty of water. After the water is sprinkled brooming is done to sweep the wet screening properly into the voids.

Rolling operation is further carried out for proper compaction. If the voids are still visible then additional screenings can also be applied and properly compacted.

7) Application of Binding Material:

Same procedure is used for the application of binding material as that of screenings. Here after each layer water is sprinkled and rolling operation is carried out.

At the time of rolling operation the wheels of the roller should be constantly watered so as to washout the binding material that gets stuck to the wheels of the rollers.

8) Setting and Drying of Surface:

After the final rolling operation the road is allowed to cure or set over-night. The next day if the depressions or voids are visible then again sufficient amount of screenings or binding materials can be used and compaction is done.

9) Preparation of Shoulders:

At the time of Curing of road, shoulders are constructed alongside by filling earth to specified cross slope. They are properly compacted.

10) Open for Traffic:

After proper drying and without any depressions, the road is then made upon for traffic. For few days the traffic should be well distributed over full width of road by placing obstacles longitudinally in the form of drums, barricade etc.

Maintenance of WBM Road :

- Whenever the potholes and ruts occur on the road by the period of time, they should be be filled with adequate materials and proper compacting should be done.
- The corrugations occured on the roads should be removed by means of dragging. If not could make the condition worse.
- Broken materials of the roads should be properly restored by fresh materials.
- The surface of the road should be renewed in 2-5 years or based according to the traffic volume.
- The loose aggregates starts coming on the top of the surface of the road, they should be removed and lavelled surface should be added by fresh binding material and it should be properly watered and compacted.

Advantages of WBM Road :

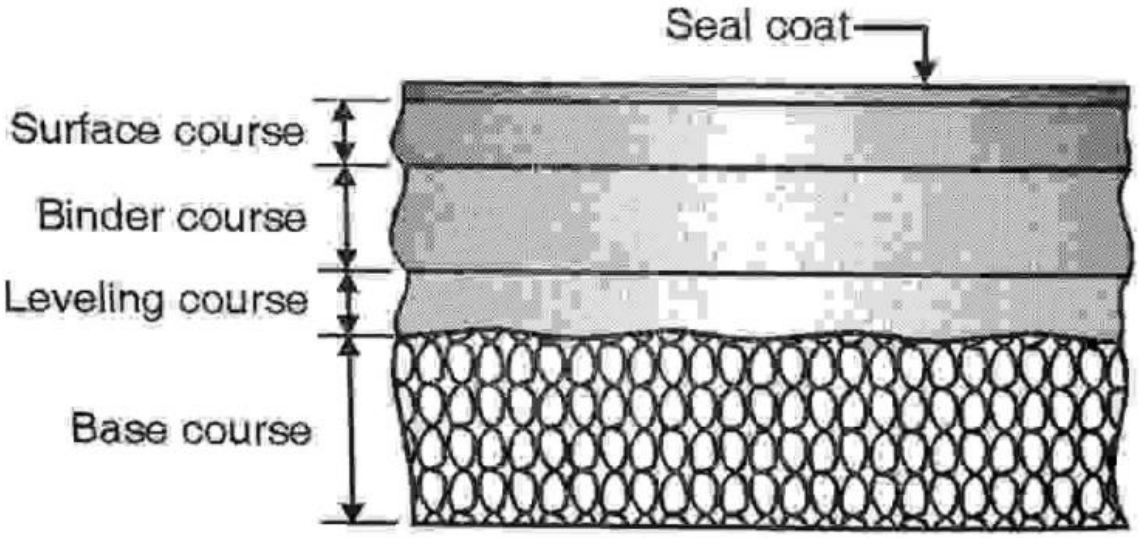
- The construction cost of WBM road is comparatively low.
- In the construction of WBM road no skilled labours are required.
- They are constructed from locally available materials.
- If the WBM roads are maintained properly and from time to time, it can resist load of traffic of about 900 tonnes per lane per day.

Disadvantages of WBM Road :

- The maintenance cost of WBM roads is high.
- The overall life span of these roads is very less.
- If the WBM roads are not properly maintained they can cause inconvenience and danger to traffic.
- As WBM roads are permeable to rain water, it leads to softening and yielding of subsoil.

Bituminous Road: Types & Construction Procedure

Bituminous road consist of their surface with bituminous materials which is also called as Asphalt. It is sticky dark viscous liquid obtained from natural deposits like crude petroleum.



Different Types of Bituminous Surfaces.

1. Prime Coat :

This is a single coat of low viscosity bituminous binder. This coat is applied to existing untreated pervious layer like WBM. The main purpose is to improve the adhesion between base and bituminous surface.

Functions :

- The most important function is to imporve the adhesion between existing pervious base and wearing surface.
- To bind the dust and loose particles together to form hard and tough surface.
- It provides temporary seal to prevent the surface water from penetrating through the surface.

2. Tack Coat :

This is single coat of low viscosity bituminous binder applied to the existing treated impervious layer such as bitumen or cement-concrete base. This boat is applied between treated base and bituminous surface.

Function :

- It is provided to improve the adequate bond between existing impervious base and wearing surface.

3. Seal Coat :

Seal coat is the final coat of bituminous material that is applied on the top of surface to prevent the entry of moisture through the voids.

Function :

- To provide water tight surface.

- It improves the visibility at night and develops skid resistant texture.
- To improve the wearing resistance of an existing road surface.

ALSO READ : Earth Road : Types and Construction Procedure

4. Surface Dressing :

It is the process in which two or more coats of bituminous materials are applied to prepared base. This coat consist of bituminous binders sprayed on which chipped aggregates are properly rolled.

Function :

- It prevents the removal of binding material and prevents the damage of road due to waterproofing effects.
- Roads can be easily cleaned and washed as it reduces dust nuisance.
- Smooth surface of the road reduces the wear and tear of tyres.

Bituminous Road Construction Steps and Procedure :

1. Bituminous Penetration Macadam Road :

In this type of bituminous road the aggregates are bound together by grouting bitumen into the voids of the compacted aggregates. This type of bituminous road is generally adopted for the thickness of 50 and 75 mm.

Materials Required :

- The grade of bitumen to be used for this type of road suggested by IRC ranges from 80/ 100, 60/ 70 & 30/ 40. Any one of the above grade can be adopted.
- Road tars of grades such as RT-4 & RT-5 can also be used.
- Physical properties of the aggregates must fulfill the following standard test values given below :

Sr. no.	Property	Requirement maximum percent
i.	Los Angeles abrasion value	40
ii.	Aggregate impact value	30
iii.	Flakiness index	25
iv.	Stripping at 40°C after 24 hours immersion (CRRI test)	25

Equipments and Plants Required :

- Bitumen heating device.
- Bitumen distributor.
- Roller for compacting operation.
- Aggregate spreader.

Construction Procedure of Bituminous Penetration Macadam Road :

• Preparation of Existing Surface :

First of all the surface on which bitumen macadam is to be applied is cleaned from dust and other debries. The gradient and the camber of the road is properly checked. Priming coat can be also applied if necessary for porous surfaces.

• Spreading of Course Aggregates :

Spreading of aggregates can be done manually or by machine. To achieve the desired profile in cross-section, template cat or camber profile may be used.

• Rolling Operation :

After speeding of aggregates they are dry rolled with a minimum of 10 tonnes roller. It is assured that the aggregates are properly compacted and interlocked.

• Bitumen Application :

The uniform layer of bitumen binder is applied on the dry rolled compacted aggregates with the help of pressure distributor or mechanical hand sprayer.

• Spreading of Key Aggregates :

Once the bitumen is properly applied key aggregated are properly laid and rolling operation again continued for proper compaction. Cross Profile is also checked at the same time.

• Seal Coat Application :

If the road is going to be made open for the traffic and another surface course is not required then the seal coat is applied. It consist of sand bitumen or it may be of surface dressing type.

• Finishing :

Cross profile of the road should be checked with template and the longitudinal profile by straight edge of the road. The permissible undulation on 3 m road is 12 mm.

• Open to Traffic :

The road is made open to traffic after minimum of 24 hours after its construction.

2. Bitumen Carpet Road.

In the construction of bitumen carpet road the recommended bitumen binder is 80/ 100 grade and the tar required should be of grade RT-3. The stone chippings required for 2 cm carpet thickness should be 12 mm and 10 mm. Below table should the requirement that should be satisfied by the aggregates to be used.

Sr. no.	Property	Percentage in maximum
i.	Los Angeles abrasion value	35
ii.	Flakiness index	30
iii.	Aggregate impact value	30
iv.	Stripping value	25
v.	Water absorption	20

Construction Procedure of Bitumen Carpet Road :

• Preparation of the Existing Surface :

For the existing layer if potholes or depressions are found then they are required to be filled with percolated chippings before the layer of carpet is applied. After the preparation of the surface the tack coat is applied to WBM surface or old bitumen surface. If there is presence of softer aggregates such as laterite, kankar or murum, then prime coat application is necessary to be applied first.

• Application of Tack Coat :

The bitumen binder is heated up to required temperature and a tack coat is applied to the surface.

• Preparation and Placing of Premix :

Preparation of premix is carried out in mechanical rotary mixer or hand drum mixer. For this mix, aggregates and bitumen are separately heated for specified temperature. Mixing is done to obtain through and homogeneous mix. These mix is then carried out to site and it is ready to be placed on the surface. Cross profile is effectively checked after its application.

• Rolling and Finishing :

Rolling operation for compaction is carried out once the premix application is finished. It is carried out for completion of every 15 m surface of road. The rollers which are generally used are tandem type or pneumatic type rollers having capacity of 6-10 tonnes. The wheels of the rollers are kept damp to prevent the adhesion of mix to the wheels of roller.

Note : for heavy rainfall areas liquid seal is sprayed on the carpet at 9-10 kg per 10m2 area. It is then covered with layer of tone chippings and properly compacted.

• Surface Finish :

The surface is properly checked for undulations. For 3 m straight edge the undulation should not exceed 10mm. Cross profile should not have undulations exceeding 6mm

• Open to Traffic :

Road is opened for the traffic after 24 hours of application of seal coat or surface dressing.

Advantages of Bituminous Road :

- Generally Bituminous road do not develop cracks on the surface for long period.
- Maintenance cost of this road is also very less.
- Bituminous road are waterproof, non-slippery, smooth, durable and it provides comfortable road surface for the traffic.
- It can withstand the adverse natural effects caused by heavy rain, excess heat and change in temperature.

Disadvantages of Bituminous Road :

- The viscosity of the bitumen and aggregate mix plays important role in defining the performance of bituminous road.
- If the bituminous material is used in excess than the value for given mix, it effects the performance of the bituminous road.

CONSTRUCTION OF CEMENT CONCRETE/RIGID PAVEMENTS

Construction of C.C. pavements can be done in two methods

1. Alternate bay method

   Here the C.C slabs are layered alternatively after an interval of 1 week or 2 days in case of rapid hardening cement (High alumina cement).

2. Continuous construction

   In this method all the bays of one traffic lane are laid continuously without any break.

Materials required for the construction of C.C. pavements

a) Cement – OPC & Rapid hardening (High alumina cement)

b) Coarse aggregate

- Abrasion value < 35 %
- Impact value < 30 %
- Crushing value < 30 %
- Soundness value < 12

Note: The maximum size of the aggregate used should be ¼ th the slab thickness.

c) Fine aggregate – Natural sand, Crushed gravel/stone

d) water

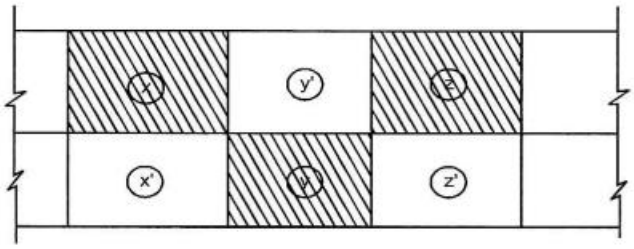
There are two methods of construction of cement concrete road slabs

- Alternate bay method
- Continuous bay method

Alternate bay method

In this method, constructing a bay or one slab in alternate succession leaving the next or intermediate bay. The next construction is done after time gap of one week or so.

For example, the alternate bays X, Y and Z are constructed at one stretch. Others, viz., X^1, Y^1 and Z^1 are constructed after one week. This technique provides additional working convenience during the laying of slabs. Provision of construction joints is easier.



Modes of construction of cement concrete road

This mode of construction has the following setbacks:

- More number of transverse joints have to be provided and thereby increasing the cost.
- Possibility of collection of surface water on the base or sub grade and thereby disturbing the base or sub grade.
- Diversion of traffic is needed as the construction is done on alternate bays covering the entire width.

Continuous bay method

In the continuous bay method X, Y, Z, etc are done at a stretch in sequence. Construction joints are however provided at the end of the day's job.

In general, the second method is preferred as constructed while the other half is being used by traffic.

Construction procedure:

Normally the C.C. pavements are constructed in the dry weather at temperature between (4 – 40^0 C).

Construction procedure of pavement slab

- Preparation of sub grade and base
- Placing of forms
- Installation of joints
- Batching of aggregates and cement
- Mixing and placing concrete
- Consolidation and finishing concrete
- Curing of concrete

Preparation of sub grade and base

The sub grade and base should be prepared complying with the following conditions:

- No soft spots are present in the sub grade or base
- Sub grade or base should be uniformly compacted and extended about 30 cm on either side of the width of pavement to be concreted.
- Sub grade or base should be adequately drained.
- Plate load test conducted on the sub grade should yield a minimum modulus of sub grade reaction of 5.5 kg/cm^3.

Placing of forms

- Wooden or steel forms are used.

- Wooden forms have minimum base width 10 cm for 20 cm slab thickness and of 15 cm for slabs over 20 cm thicknesses.
- Forms are jointed nearly and are set with exact grade and alignment.
- Forms are rigidly fixed such that during the entire operation of concreting they should not deviate more than 3mm from straight edge of 3m length.
- Steel forms commonly used are straight 3m sections.
- They are aligned vertically and horizontally by slip joints and held in position by three or more steel stakes.

Installation of joints

- Extreme care should be taken in all operations connected with joints.
- Face of transverse joints should be straight, perpendicular to the centre line of pavement and also perpendicular to the surface of the finished slab.
- Load transfer devices like dowel bars used in expansion joint should be aligned and placed accurately.
- There should be free movement of slab ends in longitudinal direction.

Batching of aggregate and cement

- Based on the design concrete mix, the proportion of ingredients like coarse aggregate and fine aggregate are proportioned by weight in a weigh batching plant. These are placed in the hopper of the mixer along with the necessary quantity of cement.
- Cement is measured by the bag which measures 50kg. Thus all batching of material is done on the basis of one or more whole bags of cement taking the unit weight of cement is taken as 1440kg/m^2.
- Mixing and placing concrete.
- The ingredients are mixed in required quantity for immediate use and are deposited on the sub grade or base.
- Deposited concrete should be to the correct depth and width of pavement section within the formwork.
- The operation of placing concrete should be continuous.

Consolidation and finishing

- Concrete is spread uniformly by shovels with redistribution wherever needed. Needle vibrator is used for compaction.
- Surface of the pavement is compacted either using a power driven finishing machine or using a vibrating hard screed.

Curing of concrete

It is very important to ensure proper curing of the finished concrete. Following are the methods usually adopted:

- Bonding or each cover kept wet.
- Hay or straw cover kept wet.
- Cover of wet felt mats cotton mats.
- Saw dust kept wet

Merits of cement concrete roads

- Capable to take unlimited amount of traffic of any type.
- Ease, comfort and safety.
- Smooth, dust free and skid resistance surface High
- Degree of visibility during day and night times.
- Economical because of low cost of maintenance and relative performance.
- Standard material highway for urban and expressways.
- Because of rigidity can span or bridge over some minor irregulaties in the sub grade or sub base.
- Wear and tear of tyres and mechanical breakdown is less and hence less operational cost.
- Even failed surface due to some reason forms a very economical base for the new coat.

Demerits

- Initial cost of construction is high and needs skilled labour.
- Long construction period because of curing time.
- Providing and maintenance of joint are difficult.
- Because of smooth surface, there will be glare on the eye of driver which is objectionable.
- Repairing of cracks is difficult.

Comparison of the WBM and WMM road construction:

Although the cost of construction of the WMM is said to be more than that of the WBM sub-base and bases but the advantages given below will compensate for that. Here are the points of difference:

1. The WMM roads are said to be more durable.

2. The WMM roads gets dry sooner and can be opened for traffic withing less time as compare to the WBM roads which take about one month for getting dry.

3. WMM roads are soon ready to be black topped with the Bituminous layers.

4. WMM roads are constructed at the faster rate.

5. The consumption of the water is less in case of the WMM roads.

6. Stone aggregates used in WBM is larger in size which varies from 90 mm to 20 mm depending upon the grade but in case of the WMM size varies from 4.75 mm to 20 mm.

7. In case of WBM, stone aggregates, screenings and binders are laid one after another in layers while in WMM, aggregates and binders are premixed in the batching plants and then brought to the site for overlaying and compacting.

8. Materials used in the WBM are the stone aggregates, screenings and binder material (Stone dust with water) while in WMM material used are only stone aggregates and binders.

9. Quantity of the WBM is generally measured in cubic meters while that of the WMM in square meters.

Surfacing:

Surface Dressing

- A Surface Dressing is a process of spraying a road surface with bituminous binder and then covering the binder with clean, crushed aggregate or natural gravel.
- These layers are then rolled in order to press the aggregate into the binder film.
- Traffic movement commences the process of chipping movement which will produce eventually an interlocking matrix.

The main objective of adopting surface dressing as a wearing coat over bituminous macadam is to achieve water proofed, anti-skid but comparatively less expensive wearing coat which can last for more duration as compare to other wearing surfaces.

(i) Premix carpet

Premix carpet (PC) is the oldest hot mix in India. It is a good, economical, bituminous wearing course mix to be placed directly on water bound macadam (WBM) of low-volume rural roads. The premix carpet is also provided with a bituminous sand seal coat to minimize direct penetration of rainwater into it.

(ii) Semi dense carpet

The semi-dense bituminous concrete mixes have neither dense or open graded characteristics. It consists of the so called pessimism voids when they are fully

constructed. This will create the separation of aggregate and the bitumen in the BM layer.

Bituminous concrete (BC)

- BC is a dense graded bituminous mix used as wearing course for heavily trafficked roads.
- BC mix consists of coarse aggregates, fine aggregates, filler and binder blended as per Marshall mix design.

Quality control operations involved are:

- Design of mix in laboratory, and control of mixing, laying and rolling temperatures
- Density, Marshall Stability, Flow, Air Voids, Retained Stability, Bitumen Content, Gradation of aggregates are controlled
- Riding quality is a control

Grouting:

Grouting is generally a mixture of cement, sand and water. Different type of grouting are used for different purposes but generally They are used in the purpose of repairing of concrete cracks, filling seams and gaps in tiles, seal and fill gaps for waterproofing courses, and for soil stabilization in boring well and foundation. It is also used to give extra strength to the foundations of load-bearing structures.

Grouting in civil engineering refers to the injection of pumpable materials into a soil or rock formation to change its physical characteristics. It is one of the ways ground water can be controlled during civil engineering works.

Grouting is suitable where soil permeability would create a heavy demand on pumping or where ground conditions mean it may be economically inefficient to bore wells. Grout may also be used in the formation of pile foundations, ground anchors, under-reaming, underpinning, in road construction, dam construction, and other applications.

Different materials may be used for grouting depending upon factors such as the soil or rock type and the area to be grouted. However, the basic process is the same: the soil or rock is injected with fluid grout which sets and reduces or acts as a sealant on the material's permeability.

Grouting is relatively costly and so wastage must be controlled. This is achieved by the use of additives which improve the gelling properties of the grout and limit its spread through the ground.

CONSTRUCTION EQUIPMENTS

Preliminary ideas of the following plant and equipment:

Hot mixing plant:

Asphaltic concrete is a mixture of asphalt, coarse aggregates, fine aggregates & filler material. After mixing, we are heating them up to final product called "HOT MIX".

There are two basic types of plants used to manufacture hot mix asphalt:

- Batch type plant
- Drum(continuous) type plant

The various parts of Batch mix plant are given below as per flow of material:

1. Cold aggregate four-bin feeder.
2. Cold conveyor.
3. Aggregate dryer.
4. Mixing Chamber
5. Asphalt tank.
6. Mineral filler unit.
7. Load-out conveyor.
8. Centralized control panel.

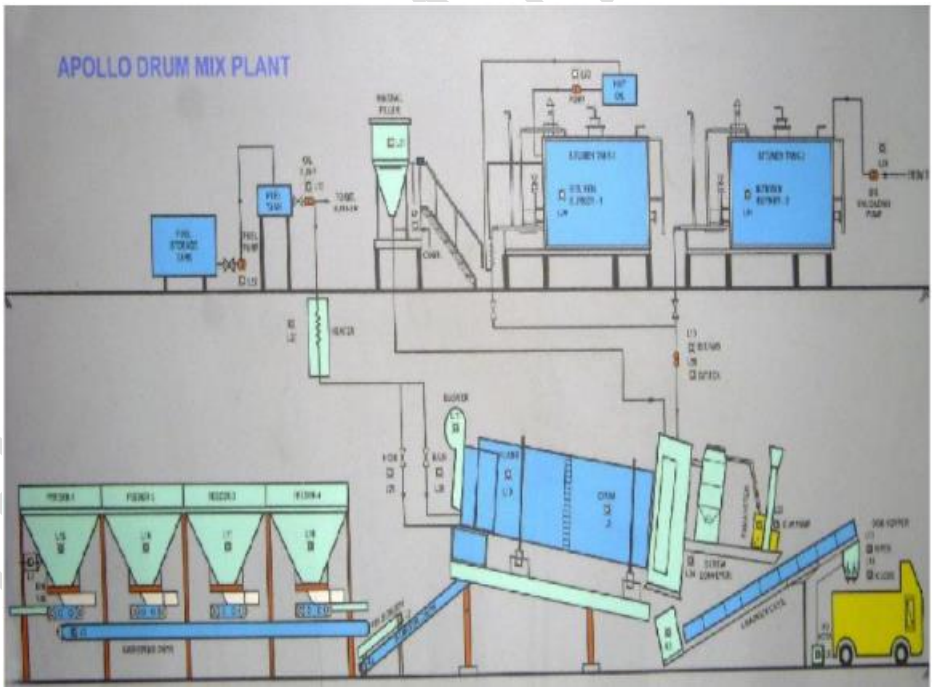


Fig. Schematic Diagram of Drum Mix Plant

Cold aggregates four – bin feeder: -

1. It consists of FOUR independent top open type bins having being fabricated from MS plate mounted on rigid Channel supported on channel. Each bin consists of an independent

and synchronized variable speeds D.C. motor for feeding the aggregates at a predetermined rate through a precisely adjustable bin quadrant gate.

2. Gathering conveyor belt equipped with an electronic weigh bridge and driven by electric motor.

3. Single deck screen provided at the discharge end of the gathering conveyor for rejection of any paver size material above permissible limit.

4. Single main transfer conveyor to receive the aggregates from the gathering conveyor and discharge it into the dryer under the combustion zone driven by electric motor and reduction gear.

Separate detachable slinger conveyor is provided to transfer the aggregates received from the vibratory screen to feed into the thermo- drum. Slinger conveyor is driven by constant speed electric motor coupled with reduction gearbox.

The rigid frame of conveyor is fabricated from appropriate channel sections and the conveyor belt is supported by uniformly spaced roller stands. Any sagging on the return travel of the belt is also taken care of by roller.

Fig. Aggregate Dryer

From the cold aggregates conveyor, aggregates are delivered to the dryer. The dryer removes moisture from the aggregates and rises temperature to the desired level.

The dryer has an oil or gas burner with a blower fan to provide the primary air for combustion of the fuel, and an exhaust fan to create a draft through the dryer.

Proper aggregate temperature is essential. Aggregates that are heated to an excessive temperature can harden the binder during mixing. Under heated aggregates are difficult to coat thoroughly with binder and the resulting mix is difficult to place on the roadway.

Fig. Mixing Chamber

In this chamber the binder & aggregates are mixed. It consists of a lined mixing chamber with horizontal shaft about which the drum rotates. The chamber is so designed that there are no dead areas formed. The temperature of the mix shall be maintained properly so as to have homogeneous mix.

The whole assembly of Chamber is supported over prefabricated steel sections preferably of channel or I-sections.

Fig. Asphalt Tank

The bitumen section of batch mix plant mainly consists of bitumen tank, bitumen heating burner, bitumen pumping & metering unit and hot oil system.

The tank is fully insulated to minimize heat losses and is of 15,000 liters. capacity. The bitumen inside the tank is heated by U-shaped heating tube fitted with automatic burner of adequate capacity. A jacketed bitumen pump driven by variable speed motor through reduction gearbox is provided to pump the bitumen to the drum. The bitumen flow rate is controlled by varying the RPM of motor.

Hot mix storage silos can be offered with options to store different types of mix Designs to meet varied site demands.

Fig. Hot mix storage silo

Mineral filler unit:

The Filler hopper is provided to add mineral filler from a separate hopper, in the mix to the extent pre-selectable in percentage by weight of the maximum plant output.

The unit is fabricated from 5 m thick steel plate and mounted on steel structure.

The system is powered by a variable speed motor coupled with gearbox to rotary valve and also synchronized with aggregate & bitumen output.

The filler material from this unit is conveyed automatically up to coated zone in the pug-mill.

Fig. Mineral filler unit

Fig. Load Out Conveyor

Hot mix material discharged from the pugmill is carried by inclined hot conveyor belt and discharged into the tipper / truck through hydraulically operated surge storage hopper.

Hydraulically operated storage hopper is provided at the discharge end of the conveyor which stores the hot mix and allows it to fall as mass in the batches and thus avoids segregation and spillage during out cycle.

CONTROL SYSTEM

The plant is supplied with centralized control panel. All controls, including the motor control, center circuit breakers are provided in the control panel. The control panel controls feeder bin controls and electric switchgear. All the parameters like, temperature of bitumen-hot mix material exhaust gases and aggregate weight, asphalt percentage, hot mix material weight etc. are displayed on the control panel.

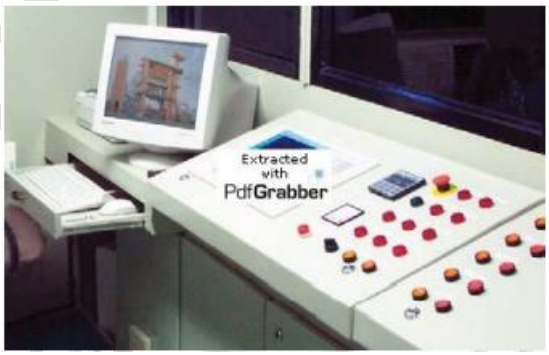


Fig. Control Panel