Unit-2 Highway Pavement and Material

(15CE54T)

Bitumen

Bitumen is used as a binding material.It is a complex organic material and it occurs either naturally or may be obtained during distillation of petroleum. It is a hydrocarbon It is insoluble in water and soluble in carbon bi sulphate,It is solid or Semisolid state and black or brown in colour.

Bitumen= 87% Carbon + 11% Hydrogen + 2% Oxygen

Types of Bitumen

1. Cutback bitumen
2. Bitumen emulsion
3. Asphalt

Cutback bitumen

When bitumen is mixed with comparatively volatile solvents so as to get a solution which enables the application of bitumen at a considerably lower temperature, it is known as cutback bitumen.The presence of volatile solvent reduces the viscosity of bitumen and improves the workability of the material.

The cutback bitumen is used in the road construction work, the volatile solvent gets evaporated leaving behind the bitumen to develop the binding properties.

Bitumen Emulsion

Bitumen emulsion is a liquid product in which bitumen is suspended in a finely divided condition in an aqueous medium and stabilised by suitable material.

Water +Emulsifying agents = Emulsion

1. Hot water and emulsifiers are mixed in the correct proportion at required temperature.The emulsifier or stability agent type depend upon the type of emulsion
2. To the mixer of water and emulsifier bitumen is added thoroughly in the mixing drum.
3. when thoroughly mixed the solution, There is formation of globules bitumen which is covered by emulsion

When bitumen is applied on the road, the globules break emulsion gets applied on the surface and the water is removed by evaporation. Usually used for repair and maintenance Work.

Asphalt

Asphalt is a mixture of aggregates both fine (sand and filler) and coarse (stone) and a bituminous binder. It typically contains approximately 4-7% of bitumen. Asphalt is primarily used in road construction and its properties depend upon the type, size and amount of aggregate used in the mixture, all of which can be adjusted to provide the required properties for the desired application

Properties of Bitumen

Adhesive:

Binds together all the components without bringing about any positive or negative change in their properties.

Waterproof:

Bitumen is insoluble in water and can serve as an effective sealant.

Strength:

Though the coarse aggregates are the main load bearing component in a pavement, bitumen also plays a vital role in distributing the traffic loads to the layers beneath.

Durable:

Bitumen lives up to 20 years if maintained properly throughout the pavement life.

Versatile:

Bitumen is a relatively easy to use material because of its thermoplastic property throughout the pavement life.

Economical:

It is available at cheaper rates almost all over the world.

Soil stabilisation

Soil stabilization refers to the process of changing soil properties to improve strength and durability.Due to stabilization the shear strength, the capacity to take load without deformation or

cracking characteristics will be improved.Soil stabilization is used in the varieties of engineering works e.g., for the construction of earth roads or other cheap roads.

Soil stabilisation principles

1. Evaluating the properties of the given soil
2. Deciding the method of supplementing the lacking properties by the effective and economical method of stabilization.
3. Designing the stabilized soil mix for intended stability and durability value
4. considering the construction procedure by adequately compacting the stabilized layer

Methods of Soil stabilization

Mechanical Soil stabilization

Correctly proportioned materials when adequately compacted to get a mechanically stable layer the method is called as mechanical Soil stabilization.

soil-cement stabilization

soil sement is an intimate mix of soil cement and water which is well compacted to form a strong base course. cement treated or cement modified soil refers to the compacted mix when cement is used in small proportion to impart some strength or to modify the properties of soil.

Soil- Lime stabilization

Soil lime are widely used either as a modifier clayey soil or as a binder in fine grain soil there can be pozzolanic action resulting in added strength

Soil-bitumen stabilization

The basic principle in bituminous stabilization are water proofing and binding. by water proofing the inherent strength and other properties of the soil could be retained.

Requirements of highway pavements

1. It should be cheap and easy to construct

2. It should structurally strong to withstand all types of stresses imposed upon it
3. It should have adequate coefficient of friction to prevent skidding of vehicles
4. It should produce least noise from moving vehicles.
5. Itm should be dust proof surface so that traffic safety is not impaired by reducing visibility
6. It should provide a safe and comfortable riding surface under all weather condition
7. It should not cause glare in the sun
8. It should have a long life.

Types of pavement

Flexible Pavement

The road pavement which can change their shape to some extent without rupture are known as flexible pavements. Any change of shape occurring in the sub grade and subsequent layer provided on it, is reflected by these pavement

Rigid Pavement

The road pavement which cannot change their shape without rupture are known as rigid pavements Any change occurring in the shape of subgrade is not reflected by the surface of these pavement . The rigid pavement are made of cement concrete which may either be plan, reinforcement or prestressed

Water Bound Macadam road

The road having its wearing surface consisting of clean, crushed aggregates mechanically interlocked by rolling and bound together with filler material and water, laid on a prepare base course is called water bound macadam.

Construction of WBM

Prepare the base

The subgrade in this case is prepared according to the specified grade and required chamber. Any defect such as ruts, potholes or weak spots are corrected.

Spreading coarse aggregates

After preparing the subgrade or the base, the coarse aggregate is spread evenly upon it in such a way that the thickness of the compacted layer does not exceed 7.5cm.

Rolling

After spreading the coarse aggregate, dry rolling is done by means of a three wheeled roller of capacity 6 to 10 tonnes. Dry rolling, rolling should be started from the edge and gradually shifted towards the centre.

Application of Screening

Consisting of stone screening,spread at a slow and uniform rate so as to ensure filing of all voids.

Sprinkling and grouting

After application of screening the surface is sprinkled over with water swept and rolled Hand broom should be continued until the coarse aggregate is firmly set in it full depth

Application of binding material

After sprinkling and grouting the binding material consisting of sandy soil is applied in two or more thin layers. over which water is sprinkled and swept in with hand brooms to fill the void properly and the surface is rolled.

Finishing the surface

The surface is then allowed to cure for 7 to 9 days. in dry season, the surface should be sprinkled with water during the curing period

Setting and Drying

The surface is then allowed to cure for 7 to 9 days

Opening to traffic

After drying the road is opened to traffic

Water Mix Macadam

Preparation of base

It is done by the WBM layer as we have discussed earlier.

Provision of lateral confinement of aggregates

while constructing WMM, arrangement shall be made for lateral confinement of wet mix. This shall be done by laying in adjoining shoulders along with WMM.

Preparation of mix

WMM is prepared in a mixing plant where a pug mill or pan type mixer of concrete batching plant is used. Optimum moisture for mixing is determined at the time of compaction, water in the WMM should not vary from optimum value. The mixed material should be uniformly wet & no segregation is permitted.

Spreading of mix

1. Immediately after mixing it is spread uniformly & evenly on prepared subgrade / subbase /Base.
2. In no case it should be dumped in heaps.
3. The mix may be spread by paver finisher or motor grader.
4. The motor grader is able to spread the material uniformly so as to achieve the specified slope & grade.
5. .No segregation of large & fine particles should be allowed.

Compaction

1. After the mix has been laid to required thickness, grade & cross fall the same shall be compacted uniformly to the full depth by roller.
2. If the thickness is 100mm single layer, smooth wheel roller is used. For compacted single layer upto 200mm vibratory roller is used.
3. Along forms, kerbs, walls or other inaccessible places for rollers, mechanical tampers or plate compactor is used.
4. Rolling should not be done when the subgrade is soft.
5. If irregularities develop during rolling which exceed 12mm when tested with 3m straight edge,
6. the surface should be loosened & premixed material added or removed.
7. Rolling shall be continued till the density achieved is at least 98% of the max dry density for the material.
8. After completion, the surface of any finished layer is well closed, free from movement under compaction equipment or any compaction planes, ridges, cracks & loose material.

9. All loose, segregated areas shall be made good to the full thickness of layer & recompacted.
10. .Setting & Drying – After final compaction of wet mix macadam course, the rolad shall be allowed to dry for 24 hours.

Opening to traffic

Preferably no vehicular traffic or any kind should be allowed on finished WMM surface till it has dried & the wearing course is laid.

Bituminous roads

Bituminous Surface (Wearing Course).

The bituminous surface, or wearing course, is made up of a mixture of various selected aggregates bound together with asphalt cement or other bituminous binders. This surface prevents the penetration of surface water to the base course.

Base Course.

The base course serves as the principal structural component of the flexible pavement. It distributes the imposed wheel load to the pavement foundation, the subbase, and the subgrade. The base course must have sufficient quality and thickness to prevent failure in the subgrade and subbase.

Subbase.

This layer is used in areas where frost action is severe or the subgrade soil is extremely weak. The subbase course functions like the base course. The material requirements for the sub base are not as strict as those for the base course since the subbase is subjected to lower load stresses. The subbase consists of stabilized or properly compacted granular material.

Subgrade.

The subgrade is the compacted soil layer that forms the foundation of the pavement system. Subgrade soils are subjected to lower stresses than the surface, base, and subbase courses.Since load stresses decrease with depth, the controlling subgrade stress usually lies at the top of the subgrade. The combined thickness of the sub base, base, and wearing surface must be great enough to reduce the stresses occurring in the subgrade to values that will not cause excessive distortion or displacement of the subgrade soil layer.

Bituminous Macadam layer

Construction Procedure

Preparation of existing layer

The existing layer is properly profiled & even & cleaned.

Tack Coat or Prime Coat application

A tack coat is applied of thin layer of bitumen binder using sprayer or pouring can.

Premix Preparation

The bitumen binder & aggregates are separately heated and then placed in mixer & is mixed till a homogenous mixture is formed & carried to site by transporter or wheelbarrow.

Placement –

Paving mixture is placed in a desired location & is spread with rakes to predetermined thickness. The camber profile is checked with template.

Rolling & finishing the Paving Mix –

The rolling is done using a tandem roller. The rolling is commenced from edge of pavement to centre.. The number of undulations exceeding 10mm should not be less than 30 in 300m length of pavement

Cement Concrete Pavement

The rigid characteristics of the pavement are associated with rigidity or flexural strength or slab action so the load is distributed over a wide area of subgrade soil. Rigid pavement is laid in slabs with steel reinforcement.

Advantages of Rigid Pavement

1. Rigid lasts much, much longer i.e 30+ years compared to 5-10 years of flexible pavements.
2. In the long run it is about half the cost to install and maintain. But the initial costs are somewhat high.
3. Rigid pavement has the ability to bridge small imperfections in the subgrade.
4. Less Maintenance cost and Continuous Traffic and Flow.
5. High efficiency in terms of functionality

Disadvantages of Rigid Pavement

The initial cost of construction is very high

1. The construction of such roads require skilled supervision.
2. They cause noise under iron wheeled traffic
3. They are liable to crack and wrap due to temperature variations
4. They does not permit easy access to the subsoil when trenches have to be opened to locate water mains, sewers and electric cables.
5. They cause glare due to reflected sunlight.

Construction of Cement Concrete (CC) roads

Preparation of subgrade and sub base –

1. No soft pots are present in subgrade or sub base.
2. It should extend at least 30 cm on either side of width to be connected.
3. Subgrade is properly drained; minimum modulus of subgrade reaction is 5.54Kg/Cm2
4. The layers should be kept moist when cement concrete is placed.
5. Waterproof paper may also be used when CC is laid directly.

Placing of Forms

1. The steel or wooden forms are used.
2. The steel forms are M.S. Channel sections and their depts. Is equal to thickness of pavement and length at least 3m except on curves < 45m radius.
3. Wooden forms are dressed on side, these have minimum base width of 100n for slab thickness or 20cm.
4. The forms are jointed neatly and are set with exactness to the required grade and alignment

Batching of Material & Mixing –

1. The proportioned mixture is placed into holper in weigh batching plant.
2. .All batching of material is done on the basis of one or more whole bags of cement, wt of onebag is 50 kg or unit wt of cement is taken as 1440 Kg/m3
3. The mixing of concrete is done in a batch mixer. So that uniform distribution, uniform color and homogenous mix is obtained.
4. The batch of cement, fine aggregate and coarse aggregate is led together into the mixer. Water for mixing is introduced into the drum within fifteen seconds of mixing

Transportation & Placing of Concrete –

1. The cement concrete is mixed in quantities required for immediate use.
2. It should be seen that no segregation of materials results while transporting.
3. Spreading is done uniformly; certain amount of redistribution is done with shovel

Compaction & Finishing –

1. The surface of pavement is compacted either by means of a power driven finishing machine orby vibrating hand screed.
2. Areas where the width of slab is small, hand consolidation and finishing is adopted.
3. The concrete is further compacted by longitudinal float. It is held parallel to the carriage way and passed gradually from one site to another.
4. The slab surface is tested for its grade and level with a straight edge.
5. Just before the concrete becomes hard, the surface is belted with two ply canvas belts.
6. Broom finish is given with fibre broom brush and it is done perpendicular to the centerline of pavement.
7. Before concrete develops the initial set, the edges of slab are carefully finished with an edging tool.

Curing of cement concrete

1.Initial curing – The surface of pavement is entirely covered with burlap cotton or jute mats prior to placing it is saturated with water and wet side is placed on pavement.

2.Final curing – Curing with wet soil exposed edges of slabs are banked with soil berm. A blanket of sandy soil free from stones is placed. The soils is thoroughly kept saturated with water for 14 days.

Joints in CC roads

Provisions of joints are necessitated due to:

Expansion, contraction and warping of concrete slabs resulting from temperature and moisture changes;Facilitate a break in the construction at the end of day's work or for any unexpected interruption to work progress; Construction of pavements in lanes of convenient width.

Joints are the discontinuities in the concrete pavement slab, and help to release stresses due to temperature variation, subgrade moisture variation, shrinkage of concrete etc.There are various types of joints in concrete pavement, e.g. contraction joint, construction joint, expansion joint and warping joint.

1. Contraction joint:

   Contraction joints are provided along the transverse direction to take care of the contraction of concrete slab due to its natural shrinkage.

2. Construction joint:

   Construction joints are provided whenever the construction work stops temporarily. The joint direction could be either along the transverse or longitudinal direction.

3. Expansion joint:

   Expansion joints are provided along the transverse direction to allow movement (expansion/ contraction) of the concrete slab due to temperature and subgrade moisture variation.

4. Warping joint:

Warping joints are provided along the longitudinal direction to prevent warping of the concrete slab due to temperature and subgrade moisture variation.

Flexible Pavement	Concrete Pavement
Deformation in the subgrade is transferred to the upper layers	Deformation in the subgrade is not transferred to subsequent layers
Design is based on load distributing characteristics of the component layers	Design is based on flexural strength or slab action
Have low flexural strength	Have high flexural strength
Load is transferred by grain to grain contact	No such phenomenon of grain to grain load transfer exists
Have low completion cost but repairing cost is high	Have low repairing cost but completion cost is high
Have low life span (High Maintenance Cost)	Life span is more as compared to flexible (Low Maintenance Cost)
Surfacing cannot be laid directly on the sub grade but a sub base is needed	Surfacing can be directly laid on the sub grade
That's why expansion joints are not needed	That's why expansion joints are needed

Overlay

Pavements which have been in service deteriorate due to a variety of factors. Due to constant wear and tear the maintenance of the road becomes a costly affair. If roads are subjected to increased traffic density and load repetitions they are subjected to distress and to maintain the desired standard of serviceability becomes impossible.

In such cases the pavement is strengthened by providing an additional layer of adequate thickness. These additional layer are called overlay

Types of Overlay

1. Asphalt overlay over asphalt pavements
2. Asphalt overlays on CC pavements

3. CC overlays on asphalt pavements
4. CC overlays on CC pavements