UNIT - 3

BITUMINOUS EMULSIONS AND CUTBACKS: Preparation, characteristics, uses and tests. Adhesion of Bituminous Binders to Road Aggregates: Adhesion failure, mechanism of stripping, tests and methods of improving adhesion. [8 Hours]

Emulsions

An emulsion is a two-phase system consisting of two immiscible liquids (unmixable or unblendable). The dispersed or internal phase is the liquid that is broken up into globules and the surrounding liquid is known as the continuous or external phase. Oil-in-water emulsions have the oil as the dispersed phase and water as the continuous phase. The reverse occurs when the emulsion is of water-in-oil type. Oil phase consisting of bitumen or tar.

In the preparation of emulsion of asphaltic bitumen or tar, emulsifiers have to be added in small proportions both to facilitate the formation of dispersion and to keep the globules of dispersed binder in permanent suspension.

If no emulsifier is present, a dispersion of oil droplets in water brought about by stirring will rapidly separate into 2 layers. With emulsifier present, an adsorbed film of the emulsifier is formed round each globule in the emulsion.

Emulsion are classified into 3 types based on setting time

1. Rapid setting: If the bitumen emulsion is intended to break rapidly, the emulsion is said to possess rapid-set quality and this type is used in surface dressing & penetration macadam.

2. Medium setting: Emulsion which does not break spontaneously on contact with stone but break during mixing or by fine mineral dust are MC. Used in premixing with coarse aggregate.

3. Slow setting: When specified type of emulsifying agent is used to make the emulsion relatively stable, they are called slow setting grade. Used in surface course along with the coarse aggregate.

Emulsifiers for road emulsions may be divided into four main groups:

a) Anionic emulsifiers

b) Cationic emulsifiers
c) Non-ionic emulsifiers  
d) Colloidal emulsifiers

**Anionic Emulsifiers**

It is characterised by having a large organic anion forming a salt with an alkali. A typical example of sodium stearate CH₃(CH₂)₁₆COONa. When dissolved in water, this dissociates into the (negative) stearate anion CH₃(CH₂)₁₆COO⁻ and the (positive) sodium cation Na⁺. The long-chain fatty-acid stearate anion is soluble in bitumen, the carboxylic group (COO⁻) which carries the negative charge being the least soluble part. Each bitumen globule is surrounded by stearate ions with negative charge on the surface and it becomes much more difficult for the globules to coalesce because all have surface negative charges and so tend to repel each other.

![ANIONIC EMULSIFIERS](image)

**Cationic Emulsifiers**

These are compounds in which it is the cation which is the large organic fraction soluble in bitumen. Typical example is cetyl trimethyl-ammonium bromide C₁₆H₃₃(CH₃)₃NBr dissociates in water into the (positive) cetyl trimethyl-ammonium cation and the (negative) bromine anion Br⁻. The cation is soluble in bitumen and when this compound is present in a system of globules of bitumen in water is established, so that each globule of bitumen is surrounded by a positively charged layer.
Non-Ionic Emulsifiers

The non-ionic emulsifiers do not ionise in aqueous solution, are limited in use. They comprise esters and ethers of fatty acids and alcohols.

Colloidal Emulsifiers

It includes naturally occurring fine powders which are used for industrial purpose than for road emulsions. Examples of these are casein and gelatine and fine powders such as clays and bentonites.

Preparation of Emulsion

Materials

Almost all grades of bitumen can be emulsified, from hard penetration grades to softer grades. Harder grades of bitumen are used for industrial purposes.

Methods of Making Road Emulsion

a) Colloid mill method
b) High-speed mixer method
The main difference between the methods is that with the colloid mill the emulsion is produced continuously where as with the high-speed mixer a number of separate batches are produced.

a) Colloid Mill Method

The colloid mill consists of a high-speed rotor which revolves in a stator, the clearance between the rotor and the stator being approximately 15 to 20 thousands of an inch.

A hot solution of the emulsifiers in water and the heated bitumen are fed separately at a constant rate into the machine in the appropriate constant proportions so that an emulsion of uniform binder content is continuously produced. It has been shown that the degree of hardness of the water used has an influence on the degree of dispersion and water-softening plants may need to be installed in areas of very hard water. Road emulsions can be continuously produced in colloid mills at rates of up to 2500 gallons per hour.

b) High-Speed Mixer Method

This method is not widely used because it is a batch process and therefore more labour is required.

The procedure is to run appropriate amount of water at hust below boiling point into a 200 or 300 gallon mixer, the diameter of which is equal to depth of liquid it is proposed to mix. The mixer is fitted with a high speed propeller type. Stirrer mounted off-centre to avoid the production of a vortex. Alkali is added to the water in the mixer and bitumen at about 100°C is slowly run in with continuous stirring.

Dispersions obtained by this method are not so uniform as those obtained in a colloidal mill. After emulsification by either method, the material is pumped into storage tanks where it is allowed to cool.

Properties of Emulsion

The following are the properties pertaining largely to the constitution of emulsion before use.

a) Residue on sieving
b) Stability to mixing with coarse-graded aggregate
c) Stability to mixing with cement
d) Water content
e) Viscosity
f) Coagulation at low temperature
g) Sedimentation
h) Stability on long-period storage

Residue on Sieving

Practically all road bitumen and tars are slightly heavier than water and the globules of binder will tend to sediment in emulsion; the rate at which it sediments depends on the size of the particle. Hence percentage of large particles should be controlled and hence is to ensure that not more than 0.25% by weight of emulsion consists of particles greater than 0.006 inch in diameter.

Stability to Mixing With Coarse-Graded Aggregate

When mixing bitumen emulsions with coarse aggregates, break down of the emulsion and coating off the aggregates with bitumen should not take place too early in the mixing cycle. Stable emulsions should have sufficient mechanical and chemical stability for all purposes involving mixing with fines and cement.

Stability to Mixing With Cement

Stable emulsions should have sufficient mechanical and chemical stability for all purposes involving mixing with aggregates including those containing large proportions of fines. Cement is used as a standard fine aggregate.

Water Content

Road emulsions may contain up to 65% of water. It is essential to know this percentage if the quantity of bituminous binder actually used in the surfacing is to be measured accurately. The water content of an emulsion is often varied to suit particular forms of application.

Viscosity

It is determined by the proportion of bitumen or tar in the emulsion and by the particle-size distribution. The viscosity of the emulsion should be low enough to spray through conventional jets or to coat stone. It is measured by Engler out flow viscometer.
Coagulation at Low Temperature

All emulsions contain water they are affected by extremes of heat and cold. Exposure to temperatures below 0°C will result in freezing and the degree of recovery on thawing depends on type of emulsion.

Sedimentation

Some sedimentation may occur when a drum of emulsion is left standing before use; provided however the sediment redisperses on agitation, the emulsion can be used satisfactory.

Stability on Long-Period Storage

When stored in drums under normal atmospheric conditions, the emulsion should not separate in a form which cannot be redispersed by agitation.

Classification of Emulsions

Bitumen emulsions are divided into 3 main classes depending on the rates at which they break. The classes are sub-divided, depending on the bitumen contents and viscosity ranges of the emulsions.

Class-1: Labile or Quick-Breaking

This class embraces emulsions characterized by rapid breakdown on application and suitable for surface-dressing and grouting work. They are normally unsuitable for mixing with aggregate and subdivided into following classes: 1A, 1B, 1C.

Class-2: Semi-Stable

These are emulsions of sufficient stability to permit mixing with certain grades of aggregate before breakdown occurs. They contain more stabilizer than the labile emulsions and are sub-divided as class 2A, 2B.

Class-3: Stable

These are emulsions with sufficient mechanical and chemical stability for all purposes involving mixing with aggregates including fines like cement, hydrated lime, etc.

Uses of Emulsions:

*They are more tolerant than penetration grade bitumen, of the presence of dampness, although they should not be used in the presence of free water on the road surface or on aggregate.
Because emulsion is of relatively low viscosity at normal temperature, they eliminate the need to heat the aggregate and binder and thus they conserve energy.

They can be used when the weather is relatively cold.

They are ideal for patching and repairing work, particularly they do not require heating before use.

They are used for surface dressing, grouting, pre-mixing, sealing, and soil stabilization with cement.

Disadvantages

Emulsions are however, costly.

Since they contain a substantial quantity of water, the transportation coat is higher.

Tests for Road Emulsions

a) Determination of Water Content

Road emulsions may contain up to 65% of water and it is essential to know this percentage. The determination is made by Dean and Stark method.

The sample is placed in a round-bottomed flask fitted with a graduated receiver (Dean and Stark tube) and a condenser. An organic liquid immiscible with water. Ex: Benzene and xylene, white spirit or solvent naphtha is added and the flask is heated. The organic liquid distils into the reciver, carrying with it, water which then separates into lower layer. The excess carrier liquid over flows into the flask.

APPARATUS FOR DETERMINATIONN OF WATER CONTENT
(Dean-and-Stark Method)
b) Measurement of Viscosity

The viscosity of an emulsion is a measure of flow properties of emulsion itself and has no relation to the viscosity of the bitumen or tar and it is determined by means of Engler viscometer.

Emulsions are available having viscosities in the range 5 to 20ºEngler. The viscosity must be chosen so that the emulsions is sufficiently fluid to flow and coat the stone but at the same time is viscous enough not to drain from the stone.

It is first calibrated by filling to the level with distilled water which is adjusted to 20ºC by the surrounding water bath. The time in seconds for 200 ml to run out is recorded. The viscometer is dried and the test is repeated using emulsion. The viscosity in Engler degrees is the ratio of the times of flow for emulsion and water.
c) **Determination of Residue on Sieving**

This test determines the amount of binder present in a bituminous road emulsion in particles large enough to be retained on a gauge of specified mesh. Emulsions must not give more than 0.25 g of residue per 100 ml of emulsion when passed through appropriate sieve.

The appropriate sieve is washed, dried, weighed and moistened. 100 ml of emulsion are poured through and the sieve is washed with distilled water, after drying in a vacuum desiccator, the residue is weighed.

**d) Coagulation on Storage (Short-Period Test)**

This test indicates the tendency of the particles of binder in an emulsion to agglomerate when the emulsion is stored or transported in ordinary commercial containers. Not more than 0.1 g of coagulain per 100 ml of emulsion should be produced under the conditions of test.

100 ml of sieved emulsion are allowed to stand for 7 days in a stoppered measuring cylinder. At the end of this period the emulsion is again sieved and the residue weighed after washing and drying. The weight of residue is reported as coagulated binder per 100 ml of emulsion.

e) **Long-period storage stability**

This method indicates the tendency of the binder in a bituminous road emulsion stored in drums to separate in a form which cannot be redispersed by agitation. An emulsion should not possess more than 2% of water content difference between before and after storage.

A drum of emulsion is selected and the water content is determined by Dean and Stark method. The emulsion is transferred to a clean drum leaving 5% air space. The drum is sealed and left for 3 months at temperature range 5 to 30°C. At the end of storage period, the test portion is sieved and the water content determined. The difference between the water content of the emulsion before and after storage is reported as storage stability.
f) Coagulation at Low Temperature

This test is intended to show if any coagulation of the binder occurs on exposure to low temperatures. This emulsion is first sieved and preheated to 60°C and it is then cooled in a series of baths to a temperature of -3°C to -4°C. After remaining quiescent for 30 minutes. The temperature of the emulsion is allowed to regain air-temperature, when the emulsion is sieved. Any coagulated binder will be retained, the emulsion fails the test if any coagulation occurs.

g) Sedimentation

Some sedimentation may occur when a drum of emulsion is left standing before use. 10 g of bitumen emulsion is weighed into a glass tube which is then centrifuged for five minutes to sediment the emulsion. 30 ml of 1% soft soap is added and tube is stoppered. The tube is then rotated end-over-end at one complete inversion per second, after each five turns the table is allowed to drain towards the stopper for ten seconds to observe if any sediment remains. The number of inversions until the sediment disperses is noted and should not be less than 50 for the emulsion.

Cutback Bitumen

Cutback bitumen is defined as the bitumen, the viscosity of which has been reduced by a volatile diluents. For use in surface dressings, some type of bitumen macadam and soil-bitumen stabilization, it is necessary to have a fluid binder which can be mixed relatively at low temperatures. Hence to increase the fluidity of the bituminous binder at low temperatures the binder is blended with volatile solvent. After the cutback mix is used in construction work, the volatile gets evaporated and the cutback develops the binding properties. The viscosity of cutback and rate of which it hardens on the road depend on the characteristics and quantity of both bitumen and volatile oil used as the diluents.

Types of Cutback Bitumen and Uses

Cutback bitumen is available in three types, namely:

a) Rapid Curing (RC)

b) Medium Curing (MC)
c) Slow Curing (SC)

This classification is based on the rate of curing or hardening after the application.

**Rapid Curing Cutbacks (RC)**

These are bitumens, fluxed or cutbacks with a petroleum distillate such as naphtha or gasoline, which will rapidly evaporate after using in construction, leaving the bitumen binder. The grade of the RC cutback is governed by the proportion of the solvent used. The penetration value of residue from distillation upto 360°C of RC cutback bitumen 80 to 120.

**Medium Curing Cutbacks (MC)**

This bitumen fluxed to greater fluidity by blending with a intermediate boiling-point solvent like kerosene or light diesel oil. MC cutbacks evaporate relatively at slow rate because the kerosene-range solvents will not evaporate rapidly as the gasoline-range solvents used in the manufacture of RC cutbacks. MC products have good wetting properties and so satisfactory coating of fine grain aggregate and sandy soils is possible.

**Slow Curing Cutbacks (SC)**

These are obtained either by blending bitumen with high-boiling-point gas, oil or by controlling the rate of flow and temperature of the crude during the first cycle of refining. SC cutbacks or wood soils hardens or set way slowly as it is a semi volatile material.

**Tests on Cutback Bitumen**

Various tests carried out on cutback bitumen are:

a) Viscosity test: Same as bitumen at specified temperature using specified size orifice.

b) Penetration test, ductility test and test for matter soluble in carbon-disulphide on residue from distillation up to 360°C.

c) Flash point test on cutback using Pensky Martens’s closed type apparatus.

d) Distillation test to find distillation fractions, up to specified temperature and to find the residue from distillation up to 360°C.
CUT-BACK BITUMEN DISTILLATION APPARATUS

The apparatus is as shown in figure. 22 ml of cutback bitumen is introduced into flask and the apparatus is assembled, note that the thermometer reaches almost to the bottom of flask. Heat is applied so that the distillation commences in 5 to 15 minutes and the distillation is continued at a rate of 50 to 70 drops per minute. The volume of distillate is observed at 175°C and at 25°C intervals thereafter upto 325°C, the heat source is removed when the temperature reaches 360°C. The total volume of oil is observed after draining the condenser. The bitumen residue is poured immediately into an open tin and allowed to cool below its fuming point.

Adhesion of Bituminous Binders to Road Aggregates

Introduction

One of the principal functions of a bituminous binder is, as its name suggests, acting as an adhesive either between road stones or between road stone and the underlying road surface. Neither bitumen nor tar can be regarded as an ideal adhesive but in general when proper precautions are exercised, both are adequate.

Road stones are wetted can lead to difficulties, either in the initial coating of damp road stone in maintaining an adequate bond between the binder and stone. Failure of a bond already
formed is commonly referred to as ‘stripping’ which is brought about by the displacement of the bituminous binder from the stone surface by water. The greater the viscosity, the less readily and the more slowly does the binder wet the stone. The problems with water mixing in two ways, firstly due to aggregates being wet before laying, secondly due to effect of rain after it has been laid.

Types of Adhesion Failure

a) Wet-Weather Damage to Surface Dressings

Wet chippings are frequently used for surface dressing. With untreated stone and binder, adhesion will not take place until the stone dries out. In good weather, this process is rapid but with high atmospheric humidity the chippings may remain wet for several hours or even days. Rain may cause displacement of the binder from stone. Once the chippings have been removed, the binder is carried by vehicle tyres and extensive damage may be expected.

In other words, under the higher atmospheric humidity condition, the surface dressing materials will be generally in wet condition. These chips will be loosened under the wheel loads, resulting in extensive damages.

b) Stripping in Pre-Mixed Bituminous Materials

The problem of stripping is experienced only with bituminous mixtures which are permeable in water. If the material is really impermeable such as with rolled asphalt, then stripping is most improbable.

Permeable bituminous surfacing materials are widely used and an average life of five or six years is commonly obtained from bitumen-macadam wearing courses before surface treatment of some kind is required. The binder displaced from the stone surface generally moves upwards under the action of traffic and collects in the surface forming ‘fat patches’. If the stripping becomes extensive, the strength of the bituminous mixture is impaired and deformation takes place under traffic.

It is characteristic of stripping failures of pre-mixed surfacing that the stripping is found only in those parts of the road subjected to medium or heavy traffic.
In other words; it is the stripping of the bituminous mixtures which are permeable to water. It is the displacement of the binder from aggregate. The process is popularly explained by the theory or mechanism of stripping.

**Mechanism of Stripping**

Stripping is the displacement of the binder from the surface of aggregates by water. The process of displacement depends on the viscosity of the binder. The binders of high viscosity resist displacement by water than those of low viscosity.

It has been shown practically that water may penetrate through a film of binder and reach the stone surface. The transfer of water to the stone surface may occur with water in liquid or vapour form.

The speed with which water can penetrate and detach the binder depends on:

a) Type and viscosity of the binder  
b) Thickness of binder film  
c) Nature of road stone

Stripping was found throughout the length of the surface but failure was observed only on the parts of the flexible base. If the failure occurs it may be due to the following ways:

a) The binder is undetached and hence unstripped  
b) The binder is partially detached but unstrapped  
c) The binder is attached but unstripped  
d) The binder is detached and stripped leading to the disintegration and failure.

**Fundamental Properties of Binder/Stone/Water System**

The displacement of one liquid by another on a solid surface arises from the physical-chemical forces acting in the system. Road stones have surfaces that are electrically charged. For example, silica possesses weak negative surface charge. Constituents of bituminous binders have little polar activity. The bond between bituminous binder and stone is therefore primarily due to relatively weak ‘dispersion’ forces. The polar liquid water is strongly attracted to charged road stone surfaces by ‘orientation’ forces.
Both water and hydrocarbon such as bitumen or tar will adhere to a stone surface, the forces of attraction are appreciably greater in the water. The stone surface possesses hydrophilic properties. Two important conclusions follow from this at once:

a) If a stone is already coated with water, it is impossible for a normal bituminous binder to displace the water and adhere to the stone.

b) If a stone is already coated with a binder; it is possible for water to ‘strip’ the binder from the stone.

The indication of strength of bond for heat of wetting between silica surface by water and by benzene which which gives 600 and 150 ergs/sg.cm respectively. Shows that water is more attracted to aggregates than a bitumen product. Again heat of wetting is an expression of tendency of a liquid to wet a solid surface. Greater is the heat of wetting, greater is the energy released and stronger is the bond between solid and liquid. Hence if a aggregate is already coated by water it is impossible for a normal binder to displace the water where as if a aggregate is already coated by bitumen is possible for water to strip binder from road stone.

If the angle of contact between the 3 phases is ‘θ’ and the energies of solid/binder, solid/water and binder/water interfaces are γsb, γsw, γbw respectively, then the work displacing water from unit area of stone is given by:

\[ W = \gamma_{sb} + \gamma_{bw} - \gamma_{sw} \]  

For equilibrium, Young and Dupre’s equation

\[ \gamma_{sb} = \gamma_{sw} + \gamma_{bw} \cos \theta \]  

\[ W = \gamma_{bw} (1+\cos \theta) \]
Hence the work required to displace water by binder is directly proportional to interfacial energy between binder and water and it is also related to the angle of contact.

Adhesion Test

Numerous tests have been described, most of which fall into 6 basic types. A sample of aggregates is coated with a bituminous binder and then immersed in water under controlled conditions. The degree of stripping of binder from the aggregate after a known period of time is measured. Six types of tests are:

a) Static Immersion Test
   i. In this type of test, aggregate coated with binder is immersed in water and the degree of stripping is estimated.
   ii. Single-sized chippings are coated with a constant quantity of binder under controlled conditions.
   iii. Coated stone is immersed in distilled water for 48 hours.
   iv. The percentage of stripped surface is estimated visually.
   v. One more approach is to measure the quantity of light reflected by sample of coated aggregate before and after immersion in water.

b) Dynamic Immersion Test
   i. It is similar to static immersion test but the sample is agitated mechanically by shaking or kneading.
   ii. Coated aggregates are shaken in water for a known time and then the amount of stripping is estimated visually.
c) **Chemical Immersion Test**
   i. Stone coated with binder is boiled in distilled water and if necessary, solutions of sodium carbonate is added.
   ii. The strength of the solution of sodium carbonate in which stripping is first observed is used as a measure of the adhesivity.
   iii. Attempts have been made to improve this test, for example by reducing the temperature and using larger stone or by measuring the amount off uncoated aggregate which separates from coated mass.

d) **Immersion Mechanical Test**
   i. Degree of stripping of the binder from aggregate is observed indirectly by measuring the change in a specified mechanical property of a bituminous material after it has been immersed in water.
   ii. In this test, a number of identical cylindrical specimens of the bituminous mixture to be tested are prepared.
   iii. After few hours ‘curing’ some are used to determine the compressive strength under constant rate of strain.
   iv. The remainder are immersed in water for some days and then tested similarly.
   v. The reduction in strength gives an indication of the extent of any damage by water that has occurred.

e) **Coating Test**
   i. In this test an attempt is made to obtain adhesion between an aggregate and binder when water is also present.
   ii. Test involves immersion of tray of binder in water and then the application of chippings to the surface of the binder. It is known as Immersion tray test.
   iii. No adhesion is obtained under these conditions with normal road stones and binders but the test is helpful for examining how surface-active agents improve adhesion between binders and aggregates in surface dressing under wet conditions.
**Immersion Trafficking Test**

Traffic may play an important role in stripping. A number of tests have been described in which the bituminous sample is subjected not only to the action of water but also to stresses produced by some form of traffic.

These tests may be carried out on circular track machines or on machines where traffic simulated by reciprocating wheels which passes over the specimens while it is immersed in water.

**Wheel Tracking Test:** This consists of three solid tyred wheels each 8 inch in diameter and 2 inch wide which traverse three specimens of road material. The wheels travel with a reciprocating motion of frequency 25 cycles/minute and stroke of about 11 inch. Each wheel is coated to give a total weight of 30 lb per sq. inch bearing on the specimen.

The Specimens are contained in Perforated metal moulds 1½ inch deep, 12 inch long and 4 inch wide, maintained horizontally in water level is well above the top of the specimens. The road material is compacted in moulds under standardized conditions and cured for short time before immersion. The temperature of the water bath is 40° C. The test machine is shown in diagram below.
TEST MACHINE FOR IMMERSION WHEEL-TRACKING TEST

The criterion which is adopted to measure stripping is that of the time necessary to produce failure, if the depth of penetration of the wheels, in the specimen of road material is recorded with time, it is found that, at first there is a small and steady compaction of the specimen under the loaded wheels and then suddenly there is a sharp break in the curve where the wheels penetrate into the Specimen at a greater rate.
FAILURE RECORDS OBTAINED FROM IMMERSION WHEEL-TRACKING TEST

Methods of Improving Adhesion

1) Binder of high viscosity resists stripping more readily than those of low viscosity & hence there is an advantage that the viscosity of the binder should be as high as possible.

2) It is usually necessary to compromise between the lower viscosity needed to give the best initial coating on the aggregate & the higher viscosity desirable to give better protection against stripping.

3) Addition of filler to a mixture increases the viscosity of the binder & hence it will control the rate of stripping.

4) There are certain fillers, hydrated lime & portland cement which when added to bituminous mixture in 1 to 2% weight of total mix will reduce or even completely prevent stripping.

5) Chemically active fillers are also used in the mixing of cold & wet aggregate with bituminous binders.
6) Organic acids present in binders react with filler to form calcium naphthanate or calcium phenate to improve adhesion.

7) Addition of upto 10% of road tar to bitumen improves adhesion in some coated macadam wearing courses.

8) By adding surface-active chemicals to the binder, it has been claimed that some soaps of metals (Ca, Pb, Fe) may improve adhesion.

9) Additives which show cationic surface activity such as cetyl pyridinium bromide & cetyl trimethyl ammonium bromide increases the adhesive bond.

10) Powerful agents like organic amines which have high molecular weight are sprinkled on the surface dressing to increase adhesion.

1. What are emulsions and cutbacks? How are they prepared? Mentions under what conditions these are used.
2. Explain the different tests conducted on bituminous emulsions.
3. Explain the common adhesion problem in bituminous construction. List the various lab tests to determine the adhesion of bituminous binder to an aggregate and explain any one.
4. Briefly explain the mechanism of stripping of bituminous binder and the methods of improving adhesion.
5. What are cutbacks? What are their characteristics?
6. Explain Anionic, cationic and non-ionic emulsions.
7. Write short notes on types of cutback Bitumen.
8. Explain the common adhesion problem in bituminous construction. List the various laboratory tests to determine the adhesion of bituminous binder to an aggregate and explain any one.
9. Explain the constituents of a bituminous mix.
10. Explain the desirable properties of a bituminous mix.
11. What are emulsions? Discuss their merits and list out the various tests on emulsions.
12. Explain the mechanism of stripping of bituminous binder and method to improve adhesion.
13. List the different types of modifies binders used in construction and explain briefly the
requirements of modified binders.
14. What are adhesion tests? Explain any one briefly.
15. Explain mechanism of its adhesion failure.
16. How do you improve the adhesion?
17. List difference adhesion tests. Explain immersion trafficking test with neat sketches.
18. Mention difference types of emulsions and cut backs. Under what conditions they are used.
19. What are bituminous emulsions? Mention the types of emulsions and advantages of emulsions.
20. Mention the various laboratory tests to determine adhesion. Briefly explain any one test.
21. Write a note on the symptoms, causes and the treatment for stripping distress.
22. Explain proportioning of materials by rotfuch’s method with the help of a graph.
23. Define fuller’s curve equation. List different factor’s contributing mechanical strength in soil-aggregate stabilization of well graded materials.

TEXT BOOKS:

REFERENCES BOOKS:
2. RRL, DSIR, ‘Soil Mechanics for Road Engineers’, HMSO Publication.
3. Relevant IRC codes and MoRT & H specifications.