UNIT 2 CARBONACEOUS CEMENTING MATERIALS

Structure

2.1 INTRODUCTION

We have seen in Unit 1 that cementing materials are classified into three groups. The first two groups namely argillaceous and calcareous cementing materials, were discussed in Unit 1. They mainly consisted of lime, gypsum and cement. In this Unit we shall study and discuss the third class of cementing materials, i.e the carbonaceous materials. These materials are also known as Bituminous materials. Bitumen is a hydrocarbon material, either natural or pyrogenous origin, found in gaseous, liquid, semi-solid or solid form. Bituminous materials are those materials which primarily consist of bitumen or contain a large proportion of bitumen. Bitumen is a complex organic material and occurs either naturally or may be obtained artificially during the distillation of petroleum. Bituminous materials are very commonly used in road construction and building construction because of their binding arid water proofing properties. Bituminous road materials have been extensively used for over a century in construction and maintenance of roads and highways. However, its early use was confined mostly to important roads only. Till the beginning of 1900, most of the rural roads were constructed with layers of broken stone, known as water bound macadam. However, experiments were already in hand to evolve an effective adhesive called coal tar available as byproduct from carbonization of coal in gas works. Subsequently, bitumens made available from distillation of petroleum were used for surface dressing and coated macadam which are the principal methods of maintaining

road surfaces. With time, mechanization has become widespread and the use of mixing plants has automated the application of bituminous materials in roads and buildings. While bituminous materials continue to be used extensively in road construction, their water proofing and adhesive properties have led to their incorporation in building construction also in a big way. In the form of bitumen primer, bitumen mastic or bituminous felts, they are suitable for stopping leaks and water proofing of porous masonry and cracked concrete. Therefore in this unit, we propose to describe the bituminous materials, their types, basic characteristics and applications in civil engineering.

Objectives

In this unit, we shall introduce you to different types of bitumen and tar, their grades, testing and uses. After studying of this unit, you should be able to

* identify different types of bitumen, their properties and applications,
* explain the requirements of bitumen in paving mixes,
* elucidate the Marshall method of bituminous mix design,
* spell out the common tests of bitumen and their significance, and
* describe the function of bitumen as a water proofing agent in buildings.

2.2 TYPES OF BITUMINOUS MATERIALS

Bituminous materials used in construction may be broadly divided into

i) Bitumen, and

ii) Tar.

While bitumen could occur naturally in the form of asphalt or produced in the processing of petroleum, is a by product of coal carbonization industry. The viscosity of bitumen is sometimes reduced by adding a volatile material, and it is then called ***cutback.*** Further, when bitumen is suspended in a finely divided condition in an aqueous medium and stabilized with an emulsifier, it is called **an *Emulsion.*** We shall now study about these materials in more detail.

2.3 BITUMEN

In the petroleum and construction industry, bitumen is understood to be a viscous liquid or solid material, black or brown in colour, having adhesive properties, consisting essentially of hydrocarbons. It is derived from petroleum, or occurs in natural asphalt, and is soluble in carbon disulphide. Therefore the source of bitumen is either natural asphalt or petroleum.

2.3.1 Natural Asphalt

Natural asphalts are generally formed by natural processes as a result of geological forces and are frequently found in intimate association with mineral aggregate. Such asphalts are spread all over the world. Two prominent natural asphalts are rock asphalt and lake asphalt.

i) Rock Asphalt

This consists of a porous limestone, naturally impregnated with bitumen. In this the mineral matter is about 90 percent, while the bitumen content is only 10 percent. The underground deposits are mined by blasting. The material is then ground to a suitable fineness. Sometimes, blending of rocks of different bitumen contents may be necessary to satisfy required specifications.

ii) Lake Asphalt

In this natural asphalt the mineral matter is finely divided and well dispersed with bitumen which is present in good quantity. The whole mass is capable of flow. The. largest deposits of lake asphalt are near Trinidad.

23.2 Bitumen from Petroleum

Bitumen is produced from selected crude oils by a process of concentration by distillation. Crude petroleums obtained from different sources are quite different in their composition. The bituminous material content varies with the source. These crude petroleums contain considerable amounts of water alongwith the crude oil. Therefore, the crude is to be dehydrated before distillation is carried out. The distillation processes generally employed are fractional distillation and destructive distillation. The diagrammatic representation of the

processing of bituminous products is shown in Figure 2.1.

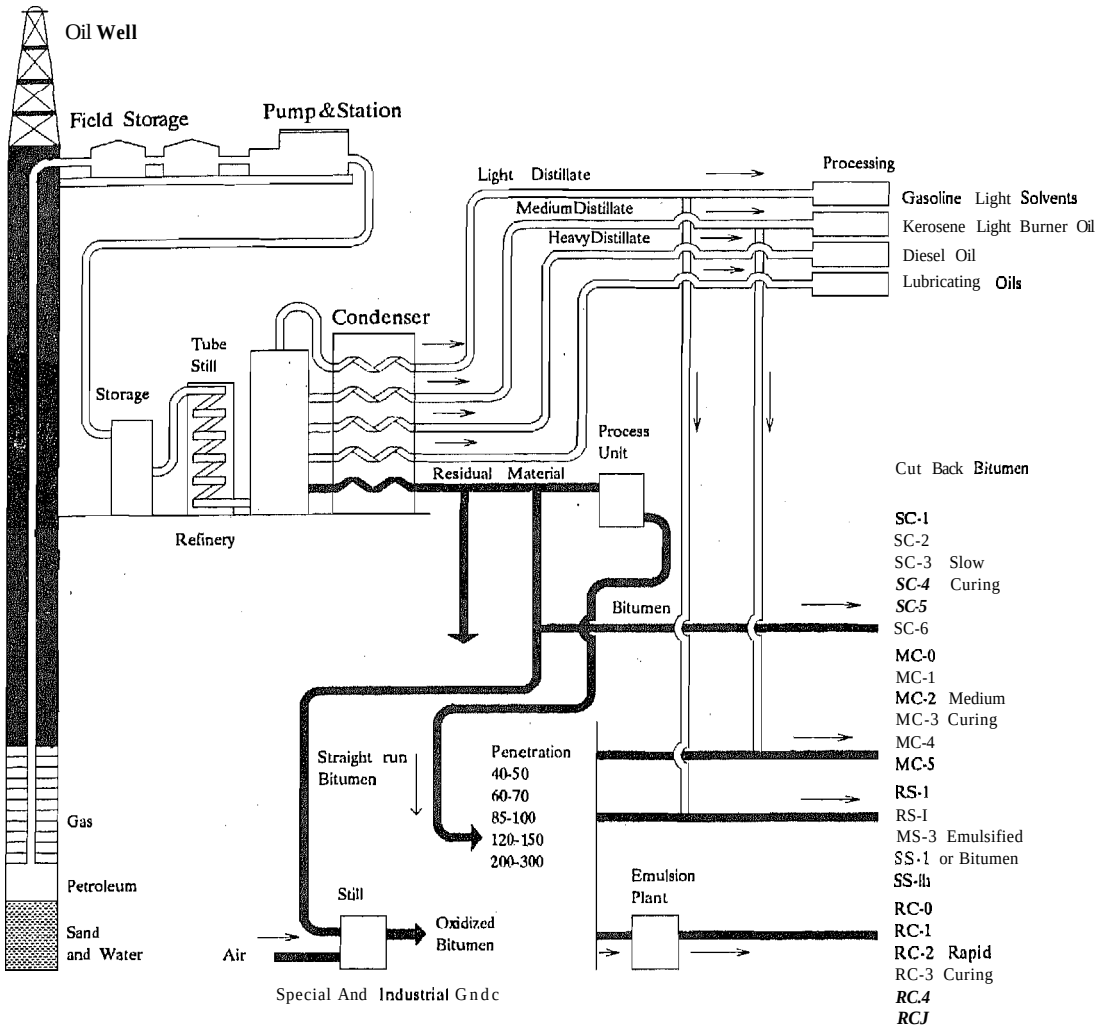

Fig 2.1 : Processing of Bituminous Products

In fractional distillation, the different volatile constituents are separated at successively higher temperatures without substantial chemical change. The successive fractions obtained yield gasoline, naptha, kerosene, diesel and lubricating oils. The residual material obtained is bitumen. In destructive distillation, the material undergoes chemical change under the application of heat and pressure. This process is usually applied for the manufacture of tar.

When the residue is distilled to a definite consistency without further treatment, the bitumen obtained as residue is known as *Straight Run Bitumen*. The blown grades of bitumens have high softening point and are produced by oxidation by blowing air at high temperatures. These are used for industrial purposes and not as road binders.

2.3.3 Specification for Industrial Bitumen and Uses

IS:702 lays down the specification for industrial bitumen.

It identifies ten grades of industrial bitumen either fully blown or semi-blown belonging to following grades :

75/15	90/15
65/25	105/20
75/30	115/15
85/25	135/10
85/40	155/6

a) The two figures given in the grade denote approximate values of softening point and penetration) in that order. For example 85/25 grade, means that industrial bitumen of this grade has approximately a softening point of 85°C and a penetration of 25. We

shall study about softening point and penetration in more detail under the heading Tests on Bitumen.

b) **Uses**

Of the above mentioned grades, any single grade or blend of two grades or more could be used by you for the following purposes :

1) Manufacture and fixing of roofing and damp proofing felts,
2) Manufacture of plastic bitumen for leak stops,
3) Fixing of heat insulation material for buildings, refrigeration and cold storage equipment,
4) Manufacture of water-proof packing paper,
5) Manufacture of pipe asphalts,
6) Manufacture of joint fillers, and
7) Manufacture of bituminous filling compounds for cable boxes for sealing accumulators and batteries.

2.3.4 Requirements of Bitumen

One of the principal functions of a bituminous binder is to act as an adhesive either between road and aggregate or between road aggregate and underlying road surface. However, neither bitumen nor tar can be regarded as ideal adhesives but when proper precautions are taken, both are adequate. The desirable properties of bitumen depend on the mix type and the construction. It is seen that the general problems which crop up while using bitumen in paving mixes are

1) mixing of aggregate and bitumen
2) . attainment of desired stability of the mix
3) to maintain the stability under adverse weather
4) to maintain sufficient flexibility so as to avoid cracking of bituminous surface
5) to have sufficiently enough adhesion with the aggregates in the mix in the presence of water.

Therefore, you can see that for a bitumen to be successfully used in road surfacings, it must have the following characteristics

a) The viscosity of the bitumen at the time of mixing and compaction should be adequate. You could achieve this by heating the bitumen and aggregate prior to mixing or by suitable use of cutbacks or emulsions. (We shall study cutbacks and emulsions in sections 2.4 and 2.5 of this Unit). This means that it should be capable of being made sufficiently fluid, either by heat or by the addition of a volatile solvent, to be pumped or sprayed.

b) Bitumen should not be easily affected by temperature variations. During the hottest weather of the region, the bituminous mix should not become too soft or unstable. Similarly, during cold weather it should not become too hard and brittle, so as to cause surface cracks. On the whole, it should be durable and resist deformation, fracture and disintegration.

c) And lastly, in presence of water, the bitumen should not strip off the aggregate. This is possible if there is adequate bond and adhesion between the bitumen and the aggregate.

2.3.5 Tests on Bitumen

As we have mentioned earlier, bitumen is available in a variety of types and grades. In order to ensure their suitability several tests have been specified by ISI and other agencies. Out of these, penetration and ductility tests are essential for classifying bitumen and to study the performance of bituminous pavements. The various tests on bituminous inaterials are :

a) Penetration test
b) Ductility test
c) Viscosity test
d) Float lest
e) Specific gravity test
f) Softening test
g) Flash and Fire point test
h) Solubility test

i) Spot test
j) Loss on heating test
k) Water content test

We shall discuss, in this unit, only the first three test, which are most common and the reference to these tests would be there in the subsequent part of the Unit. For more details and for study of all tests you may refer to IS:1201, 1978. Methods for testing tar and bituminous material.

1. Penetration Test

This test is conducted to determine the hardness or softness of bitumen by measuring the depth, in tenths of a millimeter, to which a standard loaded needle will penetrate vertically in five seconds. Three readings are taken and their mean is taken as the penetration value.

The bitumen grade is specified in terms of penetration value as 80/100, which means that the penetration value of the bitumen is in the range of 80 to 100 at standard test conditions. The penetration values of various types of bitumen used in pavement construction in India range between 20 to 225. Bitumen grades 30/40 and 80/100 are more commonly used. In hot climates, a lower penetration grade bitumen, like 30/40, is preferred.

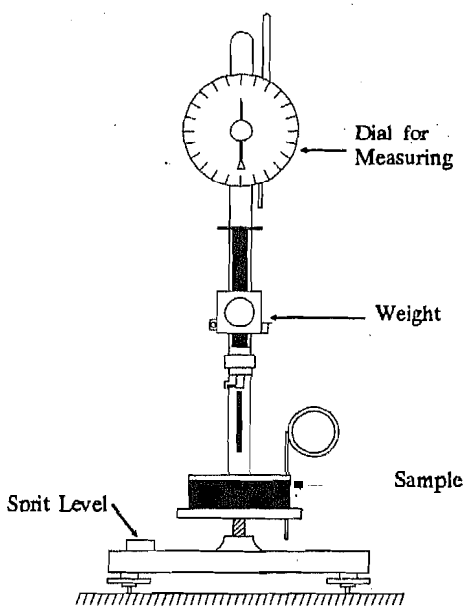

Fig 2.2 : Penetrometer

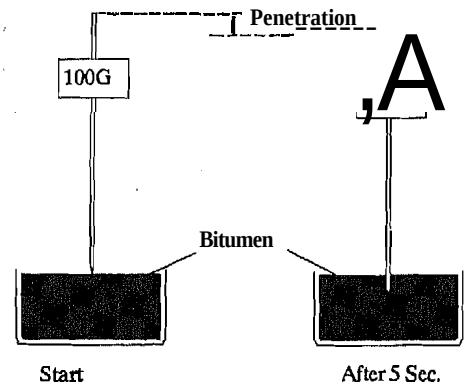

Fig 2.3 : Penetration Test

2. Ductility Test

One of the characteristics of bituminous binders is their ductility or ability to remain coherent under large strains when stretched in tension. Under traffic, the bituminous pavement is subjected to repeated deformation and recoveries. The binder material, if not ductile, would crack and result in a permeable surface through which moisture can enter. The ductility test is designed to test this important property of the bitumen.

The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched till there is a break. An outline of the test set-up is as shown in Figure 2.4.

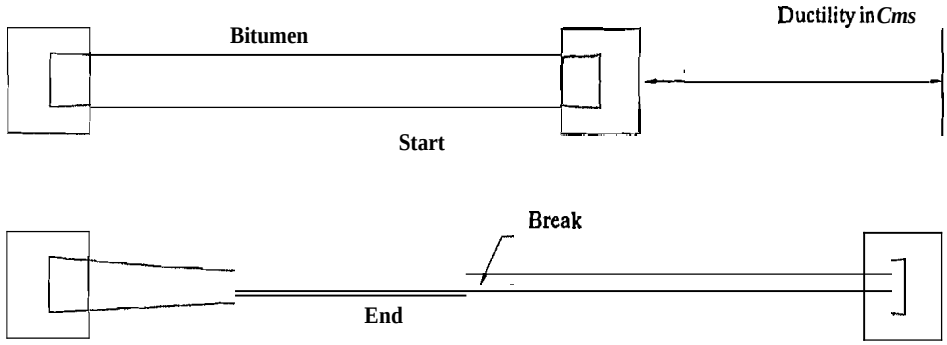

Fig 2.4 : Ductility Test

The distance upto the point of breaking of thread is reported in centimeters as ductility value. The ductility value of bitumens varies from 5 to over 100 for different grades. But you should generally see that ductility value of bitumen is not less than 50 for satisfactory performance.

3. Viscosity Test

The viscosity of a liquid is the property that retards flow. It is also defined as inverse of fluidity or measure of resistance to flow. The degree of fluidity of the binder at the application temperature greatly influences the characteristics of resulting paving mixes. Also it is seen that there is an optimum value of viscosity for each gradation of aggregate and bitumen grade.

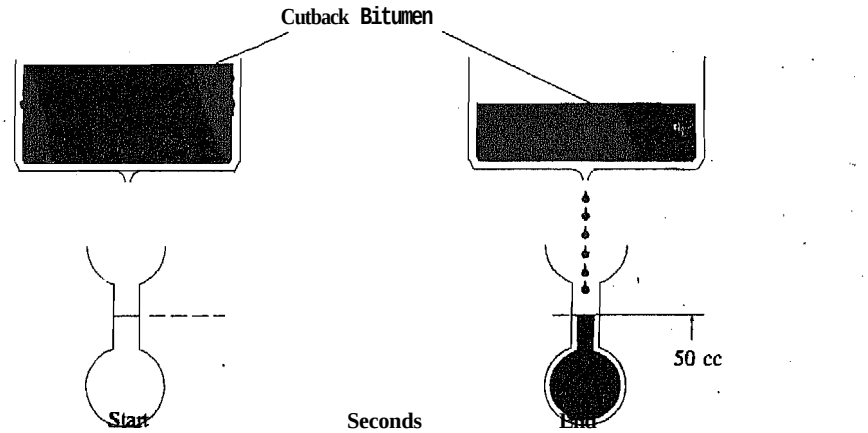

Figure 2.5 : Viscosity Test

Orifice type viscometer may be used to indirectly determine the viscosity of liquid.

Let us now understand what is kinematic viscosity, as the same is required to be determined for paving grade and cut back bitumens. The kinematic viscosity is related to absolute or dynamic viscosity. The dynamic viscosity is an internal friction such that a tangential force of 0.00001 N acting on planes of unit area, separated by unit distance of liquid produces unit tangential velocity. Its unit is **Poise.**

Therefore, the kinematic viscosity may be defmed as the quotient of the absolute or dynamic viscosity divided by the density of the liquid under test, both at the same temperatures. It is generally expressed in Centistokes (cST).

4. Softening Point

It is the temperature at which the bitumen attains a particular degree of softening under specified condition of test. Hard grade bitumen possesses a higher softening point than soft grade bitumens.

2.4 CUTBACK BITUMEN

In certain situations like, surface dressing, soil-bitumen stabilization and some type of bitumen macadam it is necessary to have fluid binder which can be mixed at low temperature. This is achieved by blending the binder with a volatile solvent. As you can appreciate, after this mix is used in construction work, the volatile solvent gets evaporated and the binder develops its binding properties. Such a bitumen, the viscosity of which has been reduced by fluxing or cutting back by a volatile dilutent, is called Cutback Bitumen. Cutback bitumen is most widely used in road construction work.

2.4.1 Types of Cutback Bitumen

The cutback bitumen is produced by fluxing bitumen with distillates of petroleum or coal tar and is widely used in road construction. Three types of cutback bitumen are produced in India. There are

a) Rapid curing (RC),

b) Medium curing (MC), and

c) Slow curing (SC).

These three types of cutback bitumen are classified further into grades on the basis of initial kinematic viscosity.

2.4.2 Rapid Curing (RC)

These bitumens are fluxed or cutback with a petroleum distillate, such as naptha gasoline, which rapidly evaporates after use, leaving behind bitumen, hence the name rapid. RC cutback is used with aggregates containing practically no fine aggregates passing through 2.36 mm sieve. Based on initial kinematic viscosity at 60 degree C measured as per IS:1206 (part 3) 1978, this cutback is classified into four grades with the following designations.

a) RC 70
b) RC 250
c) RC 800
d) RC 3000

While RC stands for rapid curing, the designation "70" indicates the minimum kinematic viscosity at 60 degree C of the RC 70. Also RC 70 would contain higher proportion of solvent when compared with a higher grade like RC 3000.

2.4.3 Medium Curing (MC)

The medium curing cutback bitumens are imparted fluidity by blending with a intermediate-boiling-point solvent like kerosene or light diesel oil. These cutbacks evaporate relatively at slow rate compared to RC cutback and therefore they are called **Medium Curing.** However, they possess good wetting properties and therefore, coating of fine grade aggregates and sandy soil is possible. They are used with aggregates containing less than 20 percent of fine aggregates passing through 2.36 mm sieve, and are classified into five grades with designations.

a) MC 30
b) MC70
c) MC 250
d) MC 800
e) MC 3000

MC 30 grade is used as primer.

2.4.4 Slow Curing (SC)

These cutback bitumens 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. They set slowly as the name indicates. These are used with aggregates containing more than 20 percent of fine aggregates passing through 2.36 mm sieve and are classified into four grades with designations :

a) SC70
b) SC 250
c) SC 800
d) SC 3000

2.4.5 Uses

The major uses of cutback bitumen are

a) Road construction work,
b) Soil stabilization,
c) Water proofing, and
d) As primer in road and building work.

2.5 BITUMINOUS EMULSIONS

So far you have learned about the natural asphalts, bitumen from petroleum and cutback bitumen. Another form of bitumen is Bituminous Emulsion.

A bituminous emulsion is a liquid product in which a substantial amount of bitumen is suspended in a finely divided condition in an aqueous medium and stabilized by means of one or more suitable materials. You can therefore visualize, that unlike cutback bitumen, an emulsion is a two-phase system consisting of two immiscible liquids, one liquid being dispersed as fine globules in the other. Generally, it is bitumen or tar which is broken up into fine globules and kept in suspension in water. An emulsifier is used to facilitate the formation of dispersion. The emulsifier forms a protective coating around the globules of bitumen thus preventing them From combining with each other. The globules are of average diameter of 2 microns. Normal road emulsions contain emulsifier which is half to one percent of the total emulsion. The water content in the emulsion ranges from 40 to 60 percent.

2.5.1 Types of Bituminous Emulsions

The emulsions are classified into three main classes i.e. IA, IB, IC. Their important characteristics are, given in Table 1.

Class of Emulsion	IA	IB	IC
Bitumen content %	not less than 60	not less than 55	30 to 50
Viscosity (Engler at 20 degree Celsius)	6 to 20	5 to 9	less than 5

Table 1: Types of Bituminous Emulsions

2.5.2 Functioning of Emulsion

When the bituminous emulsion is applied on the road, the water starts evaporating, and the binder starts binding the aggregates. You can observe the process of break down of emulsion which is indicated by a change of colour of the film from chocolate brown to black. Just like cutback bitumen, emulsions are also imparted the characteristics of rapid set, medium set, and slow set by using different emulsifying agents.

2.53 Uses

You could use bituminous emulsions to great advantage in the following situations

a) Road construction, in maintenance and patch repair works,
b) Wet weather construction,
c) Soil stabilization, and
d) As a slip coat to prevent bonding between successive layers of concrete.

SAQ 1 :

1. What is the meaning of the grade 85/40 bitumen ?

2. What are the desirable characteristics of a bitumen for road work ?

3. List the uses of cutback bitumen.

4. Describe the functioning of bituminous emulsion ?

2.6 TAR

Tar is the viscous liquid, which is produced when natural organic materials like wood and coal are carbonized or destructively distilled in the absence of air. Depending upon the material from which it is derived, it is called as wood tar or coal tar. You must be already familiar with the name **Coal Tar,** as it is most widely known and used for road work.

2.6.1 Production and Grades

There are three stages in the production of coal tar,

a) Carbonization of coal to produce coal tar in coke ovens or retorts,

b) Refining or distillation of crude tar, and

c) Blending of distillation residue with distillate oil fractions to give the desired road tar.

Based on their viscosity and other properlies like softening point and specific gravity, the road Lars have been classified into the following five grades

i) RT - 1 ii) RT - 2

iii) RT - 3 iv) RT - 4

v) RT - 5

A summary of the important propertics of the road tars is given in table 2 to enable you to distinguish their characteristics clearly :

S.No.	Property	RT-1	RT-2	RT-3	RT-4	RT-5
1.	Viscosity by std. tar viscometer (10 mm) a) temperalurc in°C b) viscosity range in seconds		35 33 – 35	40 30 – 55	45 35 – 60	55 40 – 60
2.	Equiviscous Temp. (EVT) range in "C	32 – 36	37 – 41	43 – 46	53 – 57	63 – 67
3.	Softening point in °C	–	–	–	–	45 – 50
4.	Sp. gravity range at 27°C	1.16 – 1.26	1.16 – 1.26	1.18 – 1.28	1.18 – 1.28	1.18 – 1.28

Table 2 : Specification **of** TAR

2.6.2 Uses

As you haven seen just now from the table that while RT-1 possesses the lowest viscosity, RT-4 has the highest viscosity. Therefore, the uses of the tars also vary accordingly in road work :

a) RT-1, is used for surface painting under exceptionally cold weather,

b) RT-2, is used for standard surface painting under normal Indian climatic conditions,

c) RT-3, may be used for surface painting, renewal coats and premixing chips for top course and light carpets,

d) RT-4, is generally recommended for use in premixed tar macadam in base course of road structure, and

e) - RT-5, may be used for grouting work.

2.7 BITUMEN AND TAR : A COMPARISON

While we have studied bitumen and tar in isolation so far, let us see how they compare with each other, very broadly so as to get a better idea, and to crystallize your thoughts of the Unit covered so far.

a) Both bitumen and tar have black to dark brown colour, but perhaps their similarity ends there.

b) While bitumen is a natural asphalt or petroleum product, tar is produced by destructive distillation of coal or wood. Coal tar is more popular in road construction.

c) The chemical constituents of bitumen and tar are quite different as is evident from their entirely different origins.

d) Though tar coats aggregates more easily and retains it better in the presence of water, on the whole, tar is considered to have much inferior weather resisting property compared to bitumen.

e) Tar is more susceptible than bitumen, to temperature and hence its viscosity varies considerably with temperature.

f) The free carbon content in tar is more than in bitumen as can be seen from carbon disulphide solubility test.

2.8 BITUMINOUS MIX DESIGN FOR ROAD WORK

Let us now have a brief look at a mix design method which ensures proper performance of the bituminous materials in good work.

2.8.1 Desirable Properties

The mix design method should aim at a mix, which has the following properties :

a) sufficient stability to satisfy the service requirements and traffic conditions without undue displacements,

b) sufficient bitumen to ensure durability,

c) sufficient voids in the compacted mix so as to provide a reservoir space for a slight amount of additional compaction due to traffic, and to avoid flushing, bleeding and loss of stability,

d) sufficient workability during placing and compaction, and

e) mix should be economical.

In order to achieve these desirable properties, three mix design methods are available i.e.

i) The Marshal method,

ii) Hubbard-Field method, and

iii) Hveem method.

2.8.2 Steps in Design - Marshall Method

The important steps involved in the design of bituminous mixes are :

a) selection of aggregate – crushed aggregate and sharp sands produce higher stability and hence preferred,

b) selection of aggregate grading – in base course maximum aggregate size used is 2.6 to 5 cm, while in surface course 1.25 to 1.87 cm sizes are used,

c) determination of specific Gravity,

d) proportioning of aggregates – this is done based on the design grading which depends upon type of construction, thickness of layer and availability of aggregates,

e) preparation of specimen – in the Marshall method, the approximate value of optimum bitumen cement is chosen based on the gradation of the selected aggregate. Four bitumen contents with half percent difference, two above and two below the estimated optimum value, are selected for preparation of specimen. Three specimens per bitumen content are prepared in a specified manner,

f) determination of specific gravity of compacted specimen – this is determined and knowing specific gravity of aggregate and bitumen, density of mix (unit weight) percent voids in total mix and percent voids filled with bitumen are calculated,

g) stability tests on compacted specimen – the Marshall method deploys stability flow test for this purpose in which a cylindrical sample of 10.16 cm diameter and 6.35 cm height is tested by applying a load on its periphery perpendicular to its axis in a loading machine of 5 tones capacity at the rate of 5 cm per minute. The maximum flow value (deformation) and load value (stability) are noted. The tests are repeated with different bitumen contents and the following graphs are plotted :

i) Stability versus bitumen content

ii) Unit weight versus bitumen content

iii) Percent age voids in total mix versus bitumen content, and

iv) Percent age voids filled with bitumen versus bitumen content.

h) selection of optimum bitumen content – in the Marshall method, the optimum bitumen content for mixing is found by taking average of the following three bitumen contents determined from the graphs of the test results :

i) Bitumen content corresponding to the maximum stability,

ii) Bitumen content corresponding to the maximum Unit weight, and

iii) Bitumen content corresponding to maximum of designed limits of percent air voids in total mix, usually 4% for surfacing.

2.9 BITUMEN IN WATERPROOFING OF BUILDINGS

Bitumen is widely used in building construction as a waterproofing material both as a membrane and as a binder. It is suitable for expansion joints and fills up cracks in roofs. Its waterproofing properties favor its use in floors of bathrooms, kitchens, terrace roofing and as damp proof course in walls and basements. It is also used for making bituminous paints. Let us now study a few selected uses of bitumen in buildings.

2.9.1 Bitumen Primer for use in Waterproofing

Bitumen primer is commonly used for priming concrete and masonry surfaces before the application of the first mopping coat of melted bitumen while executing waterproofing treatment on roofs. The primary aim of this primer is to promote bonding between the bitumen of the water proofing treatment and the surface. Bitumen primer is prepared from bitumen of low viscosity ranging from 4 to 24, so that it can penetrate into a prepared surface on application. The penetration value as per IS:1203 is 20 to 50. Care is taken to ensure that bitumen primer is preferably rnadc from the same grade of bitumen as is used in bonding. Bitumen primer, thus, is the most common application of bitumen in construction engineering as it is required to be applied first of all, prior to the main treatment.

2.9.2 Bitumen Mastic for Use in Waterproofing of Roofs

Bitumen Mastic consists of a mixture of bitumen, aggregates and mineral filler in suitable proportions, so as to obtain semi-fluid consistency at about 180" C. The mastic at this temperature should be compressible by trowels so as to be formed into a compact and uniform layer of not less than 10 mm in thickness.

a) Material Properties

The bitumen used for mastic possesses penetration value between 10 to 30, softening point between 55° C to 90° C, and ductility from 3 to 30.

The aggregates which are considered suitable for bitumen mastic are :

i) Crushed rock, and

ii) Gravel of siliceous, granite or limestone origin, while mineral fillers used are limestone dust or cement.

b) Composition

The composition of bitumen mastic when determined as per Appendix B of IS:1195-1958 Specification for Mastic Asphalt for Flooring, should be as given in Tabnle **3.**

Table 3 : Specification **of Mastic** Asphalt

S. No.	**Requirement** of Total Mastic	Percentage by Weight
1.	Bitumen aggregate passing	15 to 20
2.	4.75 mm IS sieve and retained on 2.00 mm	18 to 20
3.	2.00 mm IS sieve & retained on 425 micron IS sieve	12 to 18
4.	425 micron IS sieve & retained on 75 microns IS sieve	12 to 18
5.	75 micron IS sieve (mineral filter)	35 to 40

c) Bitumen Mastic Preparation

i) Heat aggregate, excepting the portion passing 75 micron IS sieve (filler) to temperature between 175° C to 205° C,

ii) Heat bitumen separately between 170° C to 175° C,

iii) Mix requisite quantity of bitumen and the filler at a temperature of 175°C to 205°C,

iv) Now add requisite quantity of the rest of aggregate to this mix, and mixing be done preferably in a mechanical mixer, and

v) The mixing is done at site, and laid immediately, or done in a central plant and cast into blocks of convenient size for storage, which could be remelted for use when required.

You would, of course, already be aware that before application of bitumen mastic to any surface, it should be clean and dust free so as to have proper adhesion.

2.9.3 Bituminous Compounds for Waterproofing and Caulking

Bituminous compounds are suitable in a wide variety of applications for stopping leaks and waterproofing of porous masonry, concrete floors, walls and roofs. They can also be used as caulking agents for crevices and vertical joints between steel plates, folded sections, wood joints, precast coucrete cladding etc.

The bituminous compound consists of bitumen and flux oils with or without addition of vegetable or resinous oils, cutback with volatile thinners (as studied in 2.6) and intimately mixed with non-gritty absorbent fillers in suitable proportions. These bituminous compounds are semi-stiff, smooth and homogeneous pastes which could be applied in cold state at temperatures not less than 27°C.

Another important method of waterproofing of buildings by bitumen is through use of bituminous felts which are more durable and do not melt or soften unduly under heat. They are flexible and impervious and can be laid quickly as they are light in weight.

Activity :

In order to have ready reference for your daily use, prepare a list, indicating the bituminous product, brand name, size of package, manufacturer's name and address and the cost per unit. You may take tbe help of newspapers and engineering journals as well as conduct a market survey.

SAQ 2 :

The following queries are aimed at enabling you to carry out a quick self assessment. Answers may be written in the space given below :

1) What do you think are the important tests which should be carried out to ascertain the suitability of bitumen ?

2) Carry out a comparison of bitumen and tar.

3) Enumerate the important steps in the design of a bituininous mix by Marshall methodfor road work.

2.10 SUMMARY

In this unit, you gainecl knowledge of bituminous materials. Bituminous materials are an important cementing or binding material. They primarily fall into two categories of bitumen and tar.

Bitumen can be obtained in the natural form as asphalt, otherwise its main source is from distillation of crude petroleum. The use of bitumen and its success depends largely on its properties like viscosity, penetration and ductility, which need to be tested for every application, whether in road work or in buildings.

As you saw, sometimes bitumen is modified by addition of a volatile solvent to facilitate its use at low temperatures. This is known as cutback bitumen. Another form is bituminous emulsion wherein bitumen is suspended in a finely divided condition in an aqueous medium, and stabilized by an emulsifier. Both cutbacks and emulsions are available in different grades, and are widely used in road work and soil stabilization.

Tar, on the other hand is obtained by destructive distillation of wood or coal in the absence of air. Coal tar is the most popular form in which it is used in road work in all layers, depending upon the grade of tar.

Marshall's method is mostly usecl for bituminous mix design for road work to obtain a stable, durable and workable mix.

In damp proofing and waterproofing of buildings, bitumen is used extensively as a primer, mastic and as caulking material. Bituminous felts are light and durable, and find extensive use in waterproofing of roofs.

Thus, you can see that like cement and chemical bonding agents, bituminous materials are also very important binding materials which play an important role both in roads and buildings.

2.11 KEY WORDS

Bitumen	Hydrocarbon material obtained on distillation of petroleum.
Bituminous Emulsions :	Bitumen suspended in finely divided form in an aqueous solution with a stabilizer.
Cutback Bitumen	Bitumen whose viscosity has been reduced by, addition of a volatile dilutent.
Ductility	Ability to remain coherent under large strains
Viscosity	Property that retards flow.

2.12 FURTHER READINGS

Khanna, S.K. and Justo, C.E.G., **Highway Engineering,** Nem Chand & Bros., Roorkee (U.P.).

Ministry of Transport, Road Research Laboratories, **Bituminous Materials in Road Construction,** 'Her Majesty's Stationery Office, London.

IS:702, **Specification for Industrial Bitumen.**

IS:1201 to IS:1220 - 1978, **Methods for Testing Tar and Bitumen.**

IS:1195 - 1958.

IS:3384, **Specification for Bitumen Primer for use in Waterproofing and Damp-proofing.**

2.13 ANSWERS TO SAQs

SAQ 1 :

1. The figure 85 means that this bitumen has a softening point of 85°C and the figure 25 indicates the penetration value of the bitumen.
2. The desirable characteristics are
   a) the viscosity of the bitumen at the time of mixing and compaction should be adequate.
   b) the Bitumen should not be easily affected by temperature variation.
   c) the Bitumen should not strip off the aggregate in presence of water.
3. The uses of cutback bitumen are
   a) Road construction work,
   b) Soil stabilization,
   c) Water proofing, and
   d) In road and building work as primer.
4. For detailed answer, again go through 2.5.2.

SAQ 2 :

Compare your answers with the preceeding text.