Chapter 9: Properties and Tests of Bitumen

Introduction

Bitumen, a viscoelastic and thermoplastic material derived from the distillation of crude petroleum, is one of the most crucial binding agents used in road construction. It is primarily utilized in flexible pavement structures as a binder for aggregates. The performance and durability of a bituminous pavement depend significantly on the physical and chemical properties of bitumen. This chapter explores the essential characteristics of bitumen, their significance in pavement design and construction, and the various laboratory tests that are conducted to evaluate its suitability.

9.1 Origin and Composition of Bitumen

Bitumen is produced from the fractional distillation of crude oil in refineries. It is the heaviest fraction left behind after the removal of lighter fuels like gasoline, diesel, and kerosene.

9.1.1 Chemical Composition

Bitumen is a complex mixture of hydrocarbons containing:

- **Asphaltenes**: High molecular weight compounds that contribute to the stiffness.
- **Resins**: Contribute to adhesion and ductility.
- **Aromatics**: Contribute to flow characteristics.
- **Saturates**: Paraffinic hydrocarbons that influence aging.

9.2 Desirable Properties of Bitumen for Pavements

A good quality bitumen should exhibit the following properties:

9.2.1 Adhesion

Bitumen should adhere well to aggregates and maintain that adhesion in the presence of water.

9.2.2 Viscosity

It should have suitable viscosity to facilitate pumping and mixing at high temperatures and to provide adequate stiffness at service temperatures.

9.2.3 Ductility

Bitumen must be ductile enough to accommodate thermal movements and minor deformations in pavement without cracking.

9.2.4 Durability

It should resist weathering, oxidation, and aging caused by UV rays and atmospheric conditions.

9.2.5 Temperature Susceptibility

It should exhibit minimal variation in stiffness with changes in temperature.

9.2.6 Resistance to Water

Bitumen should be hydrophobic in nature and must maintain bonding with aggregates in wet conditions.

9.3 Tests on Bitumen

Various standardized laboratory tests are conducted to evaluate the properties of bitumen. These tests help ensure that the material is suitable for specific climatic and loading conditions.

9.3.1 Penetration Test (IS: 1203)

Purpose: Measures the hardness or softness of bitumen by determining the depth a standard needle penetrates into it under specified conditions.

Apparatus:

- Penetrometer
- Needle
- Water bath
- Timer

Test Conditions:

- Load: 100 g
- Time: 5 seconds
- Temperature: 25°C

Result Interpretation:

- Expressed in tenths of a millimeter.
- Higher value → Softer bitumen

Significance:

- Helps classify bitumen grade (e.g., 80/100, 60/70, etc.)

9.3.2 Softening Point Test (Ring and Ball Method) (IS: 1205)

Purpose: Determines the temperature at which bitumen softens under specific conditions.

Apparatus:

- Ring and Ball apparatus
- Heating bath
- Thermometer

Test Method:

- Bitumen is heated and placed in brass rings.
- Steel balls are placed on top.
- Temperature is recorded when balls touch the base plate.

Significance:

- Indicates temperature susceptibility.
- Used to assess behavior at high service temperatures.

9.3.3 Ductility Test (IS: 1208)

Purpose: Measures the elongation of bitumen before it breaks.

Apparatus:

- Ductility testing machine
- Briquette mold

Procedure:

- A molded briquette of bitumen is stretched at 5 cm/min at 27°C.
- Distance stretched before breaking is recorded.

Significance:

- Higher ductility → Better crack resistance

9.3.4 Viscosity Test

Viscosity is crucial for mixing, compaction, and laying processes.

Types of Viscosity Tests:

- **Saybolt Furol Viscosity (IS: 1206 Part I)** – for cutbacks
- **Rotational Viscometer (IS: 1206 Part II)** – for paving-grade bitumen

Significance:

- Controls the flow characteristics.
- Important for selection during mixing and laying temperatures.

9.3.5 Flash and Fire Point Test (IS: 1209)

Purpose: Determines the temperature at which bitumen vapors ignite (flash point) and sustain burning (fire point).

Apparatus: Pensky-Martens Apparatus

Significance:

- Important for safety during heating and handling of bitumen.

9.3.6 Specific Gravity Test (IS: 1202)

Purpose: Measures the density of bitumen relative to water.

Significance:

- Used for weight-volume conversions.
- Affects bituminous mix calculations.

9.3.7 Water Content Test (IS: 1211)

Purpose: Measures the moisture content present in bitumen.

Significance:

- High water content can lead to foaming during heating.

- Indicates storage and handling quality.

9.3.8 Loss on Heating Test (IS: 1212)

Purpose: Evaluates the volatility of bitumen by measuring weight loss on heating.

Procedure:

- Bitumen sample is heated at 163°C for 5 hours.
- Weight loss is recorded.

Significance:

- High weight loss indicates excessive volatile content.
- Useful for evaluating aging resistance.

9.3.9 Solubility Test (IS: 1216)

Purpose: Determines the percentage of pure bitumen in the sample by dissolving it in a solvent like carbon tetrachloride or trichloroethylene.

Significance:

- Assesses bitumen purity.
- Impurities like inert materials reduce solubility.

9.3.10 Elastic Recovery Test

Purpose: Measures the ability of bitumen to regain its original shape after deformation.

Method:

- Typically used for polymer-modified bitumen.
- The stretched sample is cut and allowed to recover; recovery is recorded as a percentage.

Significance:

- Indicates resistance to permanent deformation.

9.4 Grading of Bitumen

Based on penetration and viscosity tests, bitumen is classified into various grades:

Penetration Grade Examples:

- 80/100
- 60/70
- 30/40 (The first number is the minimum penetration, the second is the maximum.)

Viscosity Grade Examples:

- VG-10, VG-20, VG-30, VG-40 (The higher the number, the more viscous the bitumen.)

9.5 Modified Bitumen and Testing

Modified bitumen is bitumen blended with polymers, rubber, or other materials to improve performance.

Common Types:

- Polymer Modified Bitumen (PMB)
- Crumb Rubber Modified Bitumen (CRMB)

Tests for Modified Bitumen:

- Elastic recovery
- Softening point
- Penetration
- Storage stability

9.6 Field Quality Control of Bitumen

In the field, it is essential to verify the quality of bitumen delivered to the site through:

- Visual inspection (absence of foam or water)
- Temperature checks before application
- Sampling and lab testing for penetration and viscosity
