Chapter 10: Bituminous Binders – Types and Selection

Introduction

Bituminous binders are the core binding agents used in road construction, especially in flexible pavements. Their role is crucial in holding together the aggregates, providing waterproofing, and ensuring the road's overall performance under varying traffic loads and climatic conditions. Understanding the various types of bituminous binders, their characteristics, and the criteria for their selection is essential for any transportation or highway engineer.

This chapter delves deep into the classifications of bituminous binders, their properties, different forms such as cutbacks and emulsions, and the practical considerations involved in selecting the appropriate binder for a given road project.

10.1 Definition and Role of Bituminous Binders

Bitumen is a hydrocarbon material that is soluble in carbon disulfide and composed mainly of asphaltenes and maltenes. It is a viscous, black, semi-solid material obtained as a residual product in the distillation of crude oil. Bituminous binders are used to bind aggregate particles together, provide waterproofing, and enhance load distribution properties of flexible pavements.

Key Functions:

- Binding the aggregates into a cohesive mass
- Providing waterproofing
- Imparting flexibility and fatigue resistance
- Enabling resistance to temperature-induced cracking

10.2 Types of Bituminous Binders

Bituminous binders can be broadly classified into:

10.2.1 Conventional Bitumen (Penetration Grade Bitumen)

- These are straight-run bitumen categorized based on penetration values (e.g., 30/40, 60/70, 80/100).
- Penetration value indicates the hardness or softness of the binder.

10.2.2 Viscosity Graded Bitumen

- Classified based on viscosity measurements at standard temperatures (VG-10, VG-20, VG-30, VG-40).
- Replaces penetration grading in many countries due to better performance correlations.

10.2.3 Polymer Modified Bitumen (PMB)

- Bitumen modified with polymers like SBS, SBR, EVA, etc.
- Improves elasticity, temperature susceptibility, and fatigue resistance.
- Types include PMB-40, PMB-70, etc.

10.2.4 Crumb Rubber Modified Bitumen (CRMB)

- Bitumen modified with recycled rubber from tires.
- Enhances elasticity, resistance to rutting and cracking.

10.3 Bituminous Emulsions

Bituminous emulsions are dispersions of bitumen in water, stabilized by emulsifying agents.

10.3.1 Types of Emulsions:

- **Cationic Emulsions:** Most commonly used due to better adhesion with aggregates.
- **Anionic Emulsions:** Limited use due to poor adhesion with acidic aggregates.

10.3.2 Setting Time Classification:

- Rapid Setting (RS)
- Medium Setting (MS)
- Slow Setting (SS)

10.3.3 Applications:

- Prime coats, tack coats, surface dressing, slurry seals, and cold mix asphalt.

10.4 Cutback Bitumen

Cutbacks are bitumen diluted with volatile solvents to reduce viscosity for ease of application at lower temperatures.

10.4.1 Types of Cutbacks:

- **Rapid Curing (RC):** Uses petrol or naphtha as solvent.
- **Medium Curing (MC):** Uses kerosene.
- **Slow Curing (SC):** Uses diesel or heavy oils.

10.4.2 Applications:

- RC: Patch repairs, surface dressing
- MC: Prime coat
- SC: Cold mix preparation

10.4.3 Environmental Considerations:

- Cutbacks release volatile organic compounds (VOCs), hence less preferred now due to environmental regulations.

10.5 Properties and Tests of Bituminous Binders

Several laboratory tests are carried out to assess the quality and suitability of bituminous binders:

10.5.1 Penetration Test:

- Measures hardness.
- Penetrometer used under standard load, time, and temperature.

10.5.2 Ductility Test:

- Measures the extent a bitumen sample can stretch before breaking.
- Indicator of binder flexibility.

10.5.3 Softening Point Test (Ring and Ball Method):

- Measures the temperature at which bitumen softens.
- Indicates temperature susceptibility.

10.5.4 Viscosity Test:

- Measures flow behavior at high temperatures.
- Done using viscometers like Saybolt Furol and Brookfield.

10.5.5 Flash and Fire Point Tests:

- Indicates the temperature beyond which the material may ignite.
- Important for safe storage and handling.

10.5.6 Specific Gravity Test:

- Affects aggregate-bitumen mixing and pavement density.

10.6 Desirable Properties of Bituminous Binders

An ideal binder should:

- Be adhesive and cohesive
- Have temperature susceptibility suitable for the local climate
- Exhibit plasticity and elasticity
- Be water-resistant
- Be durable against aging and oxidation
- Be economical and readily available

10.7 Criteria for Selection of Bituminous Binders

The choice of binder is influenced by:

- **Climatic Conditions:** High-viscosity grades in hot regions; softer grades in cold regions.
- **Traffic Volume and Type:** Modified binders (PMB, CRMB) for heavy and high-speed traffic.
- **Layer Type:** Emulsions for tack/prime coat; viscosity-graded bitumen for base and surface layers.
- **Construction Techniques:** Use of emulsions for cold applications; cut-backs for limited access areas.

10.8 Performance-Based Bitumen Selection

With advancements in pavement design, performance-based binder selection (e.g., Superpave PG grading) is gaining popularity:

10.8.1 Superpave Performance Grade (PG) Bitumen:

- Based on expected pavement temperature ranges.
- Examples: PG 64-22, PG 76-10.

10.8.2 Advantages:

- Better correlation with field performance.
- Facilitates binder selection based on expected climate and load.

10.9 Modifiers and Additives in Bituminous Binders

Various modifiers enhance binder performance:

10.9.1 Types of Modifiers:

- **Polymers (Elastomers and Plastomers)**
- **Rubber Powder**
- **Anti-stripping Agents**
- **Adhesion Improvers**
- **Waxes and Resins**

10.9.2 Effects:

- Improve resistance to rutting, fatigue, low-temperature cracking.
- Increase service life of the pavement.

10.10 Handling, Storage, and Transportation of Bitumen

10.10.1 Storage:

- Must be stored in well-insulated, thermostatically controlled tanks.
- Prevent overheating to avoid oxidation.

10.10.2 Transportation:

- Done using bitumen tankers.
- For emulsions and cutbacks, ensure compatibility and prevent contamination.

10.10.3 Safety Measures:

- Avoid direct contact and inhalation.
- Use protective gear during handling.
