Chapter 13: Bituminous Mix Design Methods

13.1 Introduction

Bituminous mix design is a crucial aspect of pavement construction and maintenance. It determines the proportioning of various components—aggregates, bitumen, fillers, and additives—to produce a bituminous mixture with adequate strength, durability, workability, and resistance to environmental factors and traffic loads. A well-designed bituminous mix ensures optimal performance, long service life, and cost-effectiveness of flexible pavements.

There are several bituminous mix design methods in practice globally. Each method follows a systematic approach to balance various mix parameters like stiffness, stability, voids, durability, and resistance to fatigue and rutting. This chapter provides an in-depth understanding of the different mix design methods, materials involved, testing procedures, evaluation parameters, and modern developments in mix design techniques.

13.2 Objectives of Bituminous Mix Design

- To achieve a bituminous mixture with adequate **stability** to resist deformation.
- To ensure sufficient **durability** to withstand environmental actions like water damage and oxidation.
- To maintain the right level of **flexibility** and **fatigue resistance** under repeated loading.
- To attain **resistance against rutting**, cracking, and stripping.
- To ensure proper **void content** for permeability and durability.
- To optimize **bitumen content** for economic and performance efficiency.

13.3 Components of Bituminous Mix

13.3.1 Aggregates

- **Coarse Aggregates**: Provide strength and load distribution.
- **Fine Aggregates**: Fill voids and improve workability.
- **Mineral Filler**: Fills micro-voids and enhances binder-aggregate adhesion.

13.3.2 Bituminous Binder

- Acts as a binding agent and provides waterproofing.
- Common types: VG-30, VG-40, CRMB (Crumb Rubber Modified Bitumen), PMB (Polymer Modified Bitumen), etc.

13.3.3 Additives and Modifiers

- Anti-stripping agents, warm mix additives, rubber, polymers.
- Used to enhance mix properties.

13.4 Bituminous Mix Design Parameters

- **Stability**: Resistance to deformation under traffic.
- **Flow Value**: Deformation before failure.
- **Air Voids (Va)**: Space between coated aggregates.
- **Voids in Mineral Aggregate (VMA)**: Total void space within aggregates.
- **Voids Filled with Bitumen (VFB)**: Percentage of VMA filled with bitumen.
- **Optimum Binder Content (OBC)**: Bitumen content at which mix properties are balanced.

13.5 Common Bituminous Mix Design Methods

13.5.1 Marshall Mix Design Method

Most widely used in India and several countries.

Procedure:

1. **Selection of Aggregates and Bitumen**.
2. **Preparation of Specimens** with varying bitumen content (e.g., 4%, 4.5%, 5%, 5.5%, 6%).
3. **Compaction** using Marshall Hammer (75 blows each face).
4. **Testing**: Stability and flow test.
5. **Calculations**: Va, VMA, VFB.
6. **Plotting Graphs**: Bitumen content vs properties.
7. **Determination of OBC** based on criteria.

Marshall Criteria for Bituminous Concrete (IRC: SP: 53–2010):

Property	Range
Stability	Min 9 kN
Flow	2–4 mm
Va	3–5%
VMA	Min 14%
VFB	65–75%

13.5.2 Superpave Mix Design Method

Developed under the SHRP (Strategic Highway Research Program) in the USA.

Features:

- Incorporates **climatic conditions** and **traffic loading**.
- Focus on **performance grading** of binders.
- Uses **gyratory compactor** instead of Marshall hammer.

Steps:

1. Selection of aggregates and PG binder.
2. Compaction using Superpave Gyratory Compactor.
3. Volumetric analysis at different binder contents.
4. Performance testing: Rutting, fatigue, moisture susceptibility.

Advantages:

- Better performance prediction.
- Suitable for high traffic and extreme climate regions.

13.5.3 Hveem Mix Design Method

Popular in western US states, developed by Francis Hveem.

Key Features:

- Uses **stabilometer** for stability measurement.
- Emphasizes aggregate quality and cohesion.

Steps:

1. Selection of materials.
2. Kneading compaction of specimen.
3. Stability testing with stabilometer.
4. Determination of OBC.

13.6 Modified Bituminous Mixes

13.6.1 Polymer Modified Bitumen (PMB) Mixes

- Improved elasticity, temperature susceptibility, and aging resistance.

13.6.2 Crumb Rubber Modified Bitumen (CRMB) Mixes

- Utilizes recycled rubber; better fatigue and rutting resistance.

13.6.3 Warm Mix Asphalt (WMA)

- Produced at lower temperatures.
- Advantages: Lower emissions, energy savings, improved workability.

13.7 Laboratory Tests for Mix Evaluation

- **Marshall Stability and Flow Test**
- **Indirect Tensile Strength (ITS) Test**
- **Moisture Susceptibility Test (Tensile Strength Ratio)**
- **Rutting Test (Wheel Tracking Device)**
- **Fatigue Test (Four-Point Bending Beam Test)**

13.8 Factors Affecting Bituminous Mix Design

- **Aggregate gradation**
- **Bitumen grade**
- **Mixing and compaction temperature**
- **Air void content**
- **Binder-aggregate compatibility**
- **Environmental conditions**

13.9 Recent Advancements in Mix Design

- **Use of Reclaimed Asphalt Pavement (RAP)**
- **Intelligent Compaction Systems**
- **Foamed Bitumen Technology**
- **Nano-modified Bitumen**
- **Sustainable practices using plastic waste, industrial by-products**
