Chapter 16: Cement Concrete for Pavement Construction

Introduction

Cement concrete pavements, also known as rigid pavements, are a crucial component of modern road infrastructure. They provide high structural strength, long service life, and excellent durability, particularly in areas with heavy traffic loads and extreme climatic conditions. Unlike flexible pavements which derive their strength primarily from the bituminous layers, rigid pavements transfer loads through slab action and are supported by a well-prepared sub-base.

This chapter explores the complete process of cement concrete pavement construction — from material selection to laying, finishing, and curing. Emphasis is also laid on joints, reinforcement, quality control, and modern construction techniques to ensure high performance and cost-efficiency.

16.1 Types of Concrete Pavements

1. **Plain Cement Concrete Pavement (PCC)**
    - No reinforcement
    - Suitable for light to medium traffic loads
    - Relies on expansion, contraction, and construction joints to manage cracking
2. **Reinforced Cement Concrete Pavement (RCC)**
    - Includes steel reinforcement
    - Resists temperature stresses and heavy loading
    - Reduced number of joints
3. **Prestressed Concrete Pavement**
    - Use of pre-tensioned or post-tensioned tendons
    - Counteracts tensile stresses
    - High initial cost but long service life
4. **Continuously Reinforced Concrete Pavement (CRCP)**
    - Continuous steel reinforcement
    - No transverse joints (except at structures)
    - Controls crack widths and locations

16.2 Materials Used in Cement Concrete Pavement

16.2.1 Cement

- Ordinary Portland Cement (OPC) – 43 or 53 grade
- Should conform to IS: 269 or IS: 12269
- Should be fresh and stored properly

16.2.2 Aggregates

- **Coarse Aggregates:** Crushed stone, angular in shape; size usually 20 mm down
- **Fine Aggregates:** Natural sand or crushed stone sand
- Conforming to IS: 383
- Free from deleterious materials

16.2.3 Water

- Potable water free from oils, acids, alkalis, salts, and organic matter
- As per IS: 456

16.2.4 Admixtures

- Water reducers, retarders, superplasticizers, or air-entraining agents
- Improves workability, durability, and resistance to freeze-thaw

---

16.3 Design of Cement Concrete Mix

- **Nominal Mix vs. Design Mix**
  - Nominal mix for low-grade concrete (e.g., 1:2:4)
  - Design mix based on structural design and strength requirements
- **Target Strength**
  - Achieved by calculating characteristic compressive strength and adding a margin for quality control
- **Water-Cement Ratio**
  - Critical for strength and durability
  - Typical range: 0.4 to 0.5
- **Workability**
  - Determined using slump test
  - Slump values: 20–40 mm for pavements
- **Durability Considerations**
  - Resistance to abrasion, sulphate attack, and freeze-thaw cycles

16.4 Subgrade and Sub-base Preparation

16.4.1 Subgrade

- Properly compacted to 95% of Modified Proctor Density
- Should be well-drained and free from organic material

16.4.2 Sub-base

- Often made from granular material or lean concrete
- Thickness: 100 mm to 150 mm
- Acts as a working platform and load transfer medium

16.5 Concrete Batching and Mixing

16.5.1 Batching

- Measured by weight for higher accuracy
- Batching plants with automated controls preferred

16.5.2 Mixing

- Performed in transit mixers or central batching plants
- Uniform and thorough mixing for minimum 90 seconds

16.5.3 Transportation

- Transported using tippers or transit mixers
- Delivery within initial setting time (typically 30–45 minutes)

16.6 Laying and Compaction of Concrete

16.6.1 Equipment Used

- Paver machines (slip-form or fixed-form types)
- Vibrators (needle or surface vibrators)

16.6.2 Procedure

- Concrete laid in panels
- Compacted and vibrated thoroughly to eliminate air voids
- Screeding for surface level control

16.6.3 Edge Support

- Temporary side forms or pre-set forms ensure edge stability
- Forms must be rigid and properly aligned

16.7 Finishing of Surface

- **Initial Finishing:** Done using longitudinal and transverse screeds
- **Final Finishing:** Texturing using burlap drag, broom finish, or tining for skid resistance
- Surface tolerance: ± 3 mm over 3 m straightedge

16.8 Curing of Concrete Pavement

Methods of Curing

1. **Water Curing** – Sprinkling, ponding, or wet burlap
2. **Membrane Curing** – Application of curing compounds
3. **Steam Curing** – Used in precast applications

Curing Duration

- Minimum 7 days (or as per mix requirement)
- Extended curing in hot or windy conditions

16.9 Joints in Cement Concrete Pavement

16.9.1 Types of Joints

1. **Expansion Joints** – Accommodate thermal expansion
2. **Contraction Joints** – Control cracking
3. **Construction Joints** – Between successive placements
4. **Warpage Joints** – Address slab warping

16.9.2 Joint Sealants

- Hot-poured rubber, polysulphide, or silicone sealants
- Prevent ingress of water and debris

16.9.3 Load Transfer Devices

- **Dowel Bars:** For expansion and contraction joints
- **Tie Bars:** For longitudinal joints

16.10 Reinforcement in Concrete Pavement

- Used in RCC and CRCP
- Steel bars or mesh placed according to structural design
- Spacers used to maintain proper cover
- Prevents crack widening and improves load distribution

16.11 Quality Control in Concrete Pavement Construction

Tests on Fresh Concrete

- Slump Test (IS: 1199)
- Compaction Factor Test

Tests on Hardened Concrete

- Compressive Strength (IS: 516)
- Flexural Strength
- Core Testing for in-situ quality

Surface Regularity Tests

- Straight edge testing
- Profilographs for smoothness evaluation

16.12 Modern Techniques in Concrete Pavement Construction

Slip Form Paving

- High-speed, mechanized laying of concrete
- Integrated functions: laying, vibrating, shaping, and texturing

Precast Concrete Panels

- Used for rapid repair or replacement
- Factory-controlled quality
- Quick installation reduces traffic disruptions

Roller Compacted Concrete (RCC) Pavements

- Low-slump concrete laid using earthwork equipment
- No formwork or finishing required

16.13 Maintenance of Concrete Pavements

- **Preventive Maintenance:** Sealing joints, surface cleaning
- **Corrective Maintenance:** Crack filling, partial depth patching
- **Overlays:** Bonded or unbonded concrete overlays

16.14 Environmental and Sustainability Aspects

- Use of supplementary cementitious materials (fly ash, slag)
- Recycling old concrete
- Use of permeable concrete for better drainage
- Lower life cycle cost and carbon footprint
