
Contents

Preface to the Second Edition.....	xxi
Preface to the First Edition	xxiii
Acknowledgments.....	xxv
Authors.....	xxvii
Chapter 1 Introduction and Description of Pavements	1
1.1 Importance.....	1
1.2 Functions	1
1.3 Design and Construction	2
1.4 Maintenance and Rehabilitation.....	3
1.5 Important Issues	4
1.6 Functional Requirements.....	4
1.7 Types and Uses of Pavements.....	5
1.8 Different Features of Typical Asphalt Pavements	6
1.9 Different Features of Typical Concrete Pavements	8
1.9.1 Jointed Plain Concrete Pavements.....	8
1.9.2 Jointed Reinforced Concrete Pavements	9
1.9.3 Continuously Reinforced Concrete Pavements	10
1.9.4 Composite Pavements.....	11
1.9.5 Selecting the Type of Pavement	12
1.10 Research on Pavements	13
Questions	14
Chapter 2 Principles of Mix and Structural Design and Construction of Asphalt Pavement.....	15
2.1 Overview	15
2.2 Traffic and Load Distribution Concept	15
2.3 Materials and Layers	16
2.3.1 Soils.....	17
2.3.2 Aggregates.....	18
2.3.3 Asphalt	19
2.4 Environment	19
2.5 Mix Design.....	20
2.6 Structural Design.....	21
2.7 Link between Mix and Structural Design.....	23
2.8 Theoretical Considerations for Structural Design.....	23
2.8.1 Hooke's Theory of Elasticity.....	24
2.8.2 Boussinesq's Method.....	27
2.8.3 Application, Extension, and Refinement of Boussinesq's Method.....	30
2.8.4 Burmister's Method for Two-Layer Systems.....	31
2.8.5 Odemark's Method of Equivalent Layers.....	33

2.8.6	Fox and Acum and Fox's Solutions	34
2.8.7	Computer Programs	40
2.9	Principles of Good Construction	42
2.10	Putting Everything Together	42
	Questions	43
Chapter 3	Principles of Structural Design, Mix Design, and Construction of Concrete Pavements	45
3.1	Overview	45
3.2	Structural Design.....	46
3.3	Theoretical Considerations.....	47
3.3.1	Stresses Due to Curvature and Bending in Slabs.....	48
3.3.2	Stresses Due to Temperature Curling	49
3.3.3	Stresses and Deflections due to Applied Loading.....	53
3.3.3.1	Corner Slab Loading.....	53
3.3.3.2	Interior Slab Loading.....	56
3.3.3.3	Edge Slab Loading.....	57
3.4	Computer Programs for Rigid Pavements	59
3.5	Combined Stresses.....	60
3.6	Stresses Due to Friction.....	60
3.7	Joint Opening	63
3.8	Joints.....	63
3.8.1	Transverse Contraction Joints	64
3.8.2	Longitudinal Joints.....	66
3.8.3	Construction Joints.....	67
3.8.4	Expansion Joints.....	67
3.8.5	Joint Design.....	68
3.8.6	Joint Spacing for Airfields.....	69
3.8.7	Variable Joint Spacing.....	70
3.8.8	Skewed Joints	70
3.8.9	Aggregate Interlock between Joints	71
3.8.10	Design of Dowels	71
3.8.11	Dowel Diameter Design	72
3.8.11.1	Allowable Bearing Stress	72
3.8.11.2	Bearing Stress on One Dowel.....	72
3.9	Concrete Properties and Mix Design	79
3.9.1	Hydration, Strength, and Materials.....	80
3.9.1.1	Construction.....	82
	Questions	83
Chapter 4	Standards.....	87
4.1	Importance of Standards	87
4.2	The American Society of Testing and Materials.....	87
4.3	The American Society of State Highway and Transportation Officials.....	88
4.4	Use of Standards in Materials Selection, Mix Design, and Structural Design	89
4.5	Use of Standards in Quality Control in Construction	89
4.6	Important Specifications.....	89
	Questions	92

Chapter 5	Traffic	93
5.1	Different Types of Highway Traffic	93
5.2	Measurement of Traffic Loads	93
5.3	Load Equivalency Factor and Equivalent Single-Axle Load	96
5.3.1	Flexible Pavements	97
5.3.2	Rigid Pavements	98
5.4	Alternative Load Equivalent Factor Concept	103
5.5	Equivalent Single-Wheel Load	103
5.5.1	Conversion to Equivalent Gear	105
5.5.2	Conversion to Equivalent Annual Departure	106
5.6	Truck Tire Pressure	107
5.7	Truck Speed	108
5.7.1	Effect of Load and Tire Pressure	108
5.8	Aircraft Loading, Gear Configuration, and Tire Pressure	109
	Questions	111
Chapter 6	Drainage	113
6.1	Source and Effect of Water	113
6.2	Estimating Flow	113
6.2.1	Return Period	114
6.2.2	Rainfall Intensity	116
6.3	Hydroplaning and Surface Drainage System	118
6.4	Inlets	124
6.5	Subsurface Drainage System	124
6.5.1	Groundwater	125
6.5.2	Water Entering through Cracks	125
6.5.3	Artesian Aquifers	127
6.5.4	Melting Snow	127
6.6	Design of Subsurface Drainage Structures	128
6.6.1	Design of Permeable Base	131
6.6.1.1	Materials for Permeable Base	134
6.6.2	Design of Separator or Filter Layer	134
6.6.2.1	Geotextile Separator Layer	135
6.6.3	Design of Edge Drains	136
6.7	Consideration of Drainage in Pavement Design	139
6.8	Pumping in Rigid Pavements	143
6.9	Use of Software for Design of Drainage Structures	143
	Questions	151
Chapter 7	Soil	153
7.1	Overview	153
7.2	Soils in Subgrade	153
7.3	Mass–Volume Relationships	154
7.4	Grain Size Distribution: Gradation	155
7.5	Effect of Water	158
7.6	Soil Classification	159
7.6.1	AASHTO Method	159
7.6.2	Unified Soil Classification System (ASTM)	162
7.7	Density and Optimum Moisture Content	163

7.8	Hydraulic Conductivity	167
7.9	Frost Susceptibility	169
7.10	Swell Potential	173
7.11	Stiffness and Strength of Soils	174
7.11.1	California Bearing Ratio Test (AASHTO T-193).....	176
7.11.2	Resilient Modulus Test (AASHTO T-307).....	177
7.11.3	Dynamic Cone Penetrometer (ASTM D6951)	181
7.12	Subgrade Soil Tests for Rigid Pavements	181
7.12.1	Plate Load Test	181
7.13	Subbase and Unstabilized Base	184
7.14	Soil Stabilization Concepts and Methods: Chemical and Mechanical	184
7.14.1	Mechanical Stabilization by Densification or Compaction.....	184
7.14.1.1	Effect of Compaction on Soil Properties	185
7.14.1.2	Field Compaction.....	185
7.14.1.3	Field Control	185
7.14.1.4	Measuring Devices	185
7.14.1.5	Intelligent Soil Compaction System	186
7.14.2	Use of Geosynthetics.....	186
7.14.3	Lime Treatment of Soils.....	187
7.14.4	Cement Treatment of Soil.....	189
7.14.4.1	Mixture Design Process	191
7.14.5	Asphalt (Bituminous) Treated Soil.....	193
7.14.5.1	Stabilization Mechanism with Asphalt Treatment	193
7.14.5.2	Mix Design Procedure.....	193
7.15	Dust Control	194
	Questions	195

Chapter 8	Aggregates for Asphalt and Concrete Mixes	197
8.1	Definition, Parent Rock, and Types.....	197
8.2	Suitability for Application	198
8.3	Production.....	199
8.4	Overview of Desirable Properties	201
8.4.1	Properties Critical for Structural Layers	201
8.4.2	Properties Critical for Drainage Layers	201
8.4.3	Properties Critical for Asphalt Mix Layers.....	202
8.4.4	Properties Critical for Cement Concrete Layers	202
8.5	Gradation for Asphalt Pavements	202
8.5.1	Aggregate Tests	204
8.6	Specific Gravities and Absorption.....	208
8.7	Cleanliness and Deleterious Materials.....	210
8.8	Toughness or Resistance against Abrasion Loss	211
8.9	Particle Shape and Surface Texture.....	212
8.10	Durability/Soundness	213
8.11	Expansive Characteristics.....	214
8.12	Polishing and Frictional Characteristics	214
8.13	Aggregate Tests Specifically for Concrete	215
8.13.1	Fineness Modulus (FM; ASTM C125)	215
8.13.2	Gradation.....	215
8.13.3	Bulk Density and Voids in Aggregates Test.....	216

8.14	Automated Aggregate Analysis (AASHTO TP81 and PP64).....	216
8.15	Artificial Aggregates.....	216
	Questions.....	217
Chapter 9	Asphalt and Emulsions.....	219
9.1	Asphalt Binder.....	219
9.2	Naturally Occurring Asphalts.....	219
9.2.1	Lake Asphalt.....	219
9.2.2	Rock Asphalt.....	219
9.2.3	Gilsonite.....	220
9.3	Refined Asphalt from Crude Oil.....	220
9.4	Safe Delivery, Storage, and Handling of Asphalts.....	220
9.4.1	Causes of Hazards and Precautions.....	221
9.4.2	Health Hazards.....	221
9.4.3	Precautions and Good Practices.....	221
9.5	Asphalt Binder Properties.....	222
9.5.1	Specific Gravity: ASTM D-70.....	222
9.5.2	Cleveland Open Cup Method (Flash Point): ASTM D-92.....	222
9.5.3	Solubility Test: ASTM D-2042.....	222
9.5.4	Spot Test: AASHTO T-102.....	222
9.5.5	Penetration: ASTM D-5.....	223
9.5.6	Viscosity Tests.....	223
9.5.7	Softening Point (Ring and Ball) Test: ASTM D-36.....	224
9.5.8	Fraass Breaking Point Test: BS EN 12593, BS 2000-8.....	224
9.5.9	Ductility: ASTM D113.....	224
9.5.10	Thin Film Oven Test (TFOT): ASTM D1754.....	224
9.5.11	Rolling Thin Film Oven Test (RTFOT): ASTM D-2872, BS EN 12591, AASHTOT-240.....	224
9.6	Asphalt Binder Properties and Pavement Distress and Performance.....	224
9.6.1	Aging of Asphalt Binder.....	225
9.6.1.1	Hardening.....	227
9.7	Stiffness.....	228
9.7.1	Viscosity for Stiffness.....	230
9.8	Viscoelastic Nature of Asphalt and Direct Measurement of Stiffness.....	231
9.9	Tensile Behavior.....	233
9.10	Superpave (Superior Performing Asphalt Pavements).....	233
9.10.1	High-Temperature Viscosity.....	235
9.10.2	Complex Modulus and Phase Angle.....	236
9.10.3	Aging Tests.....	236
9.10.4	DSR Tests Conducted on Aged Asphalt.....	236
9.10.5	Low-Temperature Stiffness (ASTM D-6648, AASHTO T-313).....	239
9.10.6	Direct Tension Test (ASTM D-6723, AASHTO T-314).....	239
9.10.7	Superpave Requirements.....	239
9.10.7.1	Explanation.....	242
9.10.8	Multiple Stress Creep Recovery Test (AASHTO TP70, Specification, AASHTO MP19).....	244
9.11	Recovery of Asphalt Binder from Asphalt Mix.....	246
9.12	Adhesion Properties.....	248
9.13	Asphalt Emulsions.....	248

9.13.1	Properties	249
9.13.2	Tests for Asphalt Emulsions	250
9.13.3	Classification of Emulsions and Selection.....	251
Questions	.....	253
Chapter 10	Concrete Fundamentals for Rigid Pavements	255
10.1	Concrete.....	255
10.2	Aggregates.....	256
10.3	Cement.....	256
10.3.1	Types of Portland Cement	258
10.4	Water.....	259
10.5	Hydration	259
10.6	Steel in Concrete.....	261
Questions	.....	262
Chapter 11	Distress and Performance.....	263
11.1	Distresses in Asphalt Pavements	263
11.1.1	Bleeding	263
11.1.2	Block Cracking.....	263
11.1.3	Corrugations	263
11.1.4	Delamination	265
11.1.5	Edge Cracks.....	265
11.1.6	Fatigue Cracks and Edge Fatigue Cracks.....	265
11.1.7	Longitudinal Joint Cracks	265
11.1.8	Polished Aggregate.....	265
11.1.9	Potholes	266
11.1.10	Raveling.....	266
11.1.11	Reflective Cracking	266
11.1.12	Rutting.....	266
11.1.13	Slippage Crack.....	266
11.1.14	Thermal Cracks.....	266
11.2	Distresses in Concrete Pavements	267
11.2.1	Corner Breaks	267
11.2.2	Durability Cracking (or “D” Cracking).....	267
11.2.3	Longitudinal Cracking	267
11.2.4	Transverse Cracking.....	268
11.2.5	Spalling of Transverse Joints	268
11.2.6	Map Cracking and Scaling.....	269
11.2.7	Polished Aggregate.....	269
11.2.8	Popouts	269
11.2.9	Blowups.....	269
11.2.10	Faulting of Transverse Joints and Cracks.....	269
11.2.11	Lane-to-Shoulder Dropoff.....	269
11.2.12	Lane-to-Shoulder Separation	269
11.2.13	Patch/Patch Deterioration	270
11.2.14	Water Bleeding and Pumping	270
11.2.15	Punchouts	270
11.2.16	Joint Seal Damage.....	270
11.3	Consideration of Performance.....	270

11.4 Damage..... 272

11.5 Forensic Investigation for Determination of Type and Cause of Distress..... 273

 11.5.1 Forensic Investigation Plan 273

 11.5.2 Nondestructive and Destructive Tests 273

Questions 276

Chapter 12 Consideration of Major Distress Mechanisms and Material Characterization

for Asphalt Pavements..... 277

12.1 Fatigue Cracking 277

 12.1.1 Material Characterization Tests 280

 12.1.1.1 Indirect Tensile Strength: Test Method 280

 12.1.1.2 Resilient Modulus 280

 12.1.1.3 Dynamic Modulus (AASHTO TP62-03) 283

 12.1.2 Models..... 285

 12.1.3 Definition of Failure 290

 12.1.4 Use of Models..... 291

 12.1.5 Relationship between Mix Design and Fatigue Performance 292

 12.1.6 Relationship between Pavement Structure
and Fatigue Performance..... 292

 12.1.6.1 Steps for Avoiding Premature Fatigue Cracking 292

12.2 Thermal Cracking 292

 12.2.1 Material Characterization 293

 12.2.2 Models..... 295

 12.2.2.1 Environmental Conditions 295

 12.2.2.2 Regression Equation Approach 296

 12.2.2.3 Fracture Mechanics Approach: SHRP Thermal
Cracking Model 296

 12.2.2.4 Models for Cracking 299

 12.2.3 Cracking and Properties of Asphalts and Aggregates 300

12.3 Rutting or Permanent Deformation 300

 12.3.1 Material Characterization 301

 12.3.1.1 Creep Testing 302

 12.3.1.2 Triaxial Test 304

 12.3.2 Models..... 305

 12.3.2.1 Consideration of Rutting in Asphalt Mix Only 306

 12.3.2.2 Statistical Predictive Models on the Basis
of Different Properties 306

 12.3.2.3 Layered Vertical Permanent Strain Approach..... 307

 12.3.2.4 Permanent Strain Rate Method 307

 12.3.2.5 Plastic–Elastic Vertical Strain Ratio Method 309

 12.3.2.6 Rutting Rate Method 310

 12.3.2.7 Alternate Model Relating Tertiary Flow
Characteristics to Mix Properties 310

 12.3.2.8 Models for Unbound Materials..... 311

 12.3.2.9 Ayres Combined Model for Subgrade
and Granular Materials..... 311

 12.3.2.10 Equivalent Temperature Concept 313

 12.3.2.11 El-Basyouny and Witzak Mode! 314

 12.3.3 Definition of Failure 315

12.4 Smoothness Consideration 315

12.5	Top-Down Cracking	315
12.5.1	Pavement Surface Characteristics	319
	Questions	320
Chapter 13	Distress Models and Material Characterization for Concrete Pavements.....	323
13.1	Distresses and Models	323
13.1.1	Cracking	323
13.1.1.1	Fatigue Cracking in JPCP.....	323
13.1.1.2	Zero-Maintenance Design Fatigue Model.....	325
13.1.1.3	Calibrated Mechanistic Design Fatigue Model	326
13.1.1.4	ERES-COE Fatigue Model.....	326
13.1.1.5	PCA Fatigue Model	326
13.1.1.6	ARE Fatigue Model.....	326
13.1.1.7	Vesic Distress Model	326
13.1.1.8	RISC Distress Function	327
13.1.1.9	Transverse Cracking	327
13.1.2	Transverse Joint Faulting in Jointed Plain Concrete Pavements	328
13.1.2.1	Models to Predict Faulting.....	329
13.1.2.2	Slab Corner Deflections	329
13.1.3	Erosion Characterization of Base/Subbase	334
13.1.4	Characterizing Free Water within a Pavement Structure.....	335
13.1.5	PRS M-E Transverse Joint-Faulting Prediction Model	335
13.1.6	Punchouts in Continuously Reinforced Concrete Pavements	336
13.1.6.1	Development of CRCP Punchout Models.....	337
13.1.6.2	Punchout Distress Model.....	338
13.1.7	Smoothness Considerations.....	338
13.2	Tests for Concrete	341
13.2.1	Flexural Strength Tests.....	341
13.2.2	Compressive Strength.....	343
13.2.3	Tensile Strength.....	343
13.2.4	Coefficient of Thermal Expansion Test.....	343
13.2.5	Fatigue Testing for PCC	344
	Questions	345
Chapter 14	Mix and Structural Design of Asphalt Mix Layers.....	347
14.1	Physical and Volumetric Properties of Asphalt Mix	347
14.1.1	Bulk-Specific Gravity of Compacted Asphalt Mix (G_{mb})	349
14.1.2	Theoretical Maximum Density or Maximum Specific Gravity of the Mix (G_{mm})/Rice Specific Gravity	351
14.2	Mix Design Methods	352
14.2.1	Hveem Method (ASTM D-1560, D-1561)	352
14.2.2	Marshall Method.....	354
14.2.3	Superpave Method.....	356
14.2.3.1	Mix Design Systems of South Africa, France, the United Kingdom and Australia.....	365
14.3	Structural Design.....	371
14.3.1	Empirical Methods.....	371
14.3.1.1	California Bearing Ratio Method.....	371
14.3.1.2	American Association of State Highway and Transportation Officials Method	371

14.3.2	Mechanistic-Empirical Methods.....	375
14.3.2.1	Example of Structural Design Procedure Using Mechanistic Principles.....	379
14.3.2.2	NCHRP 1-37A Mechanistic-Empirical Design Guide	382
	Questions	397
Chapter 15	Mix Design and Structural Design for Concrete Pavements	399
15.1	Mix Design	399
15.1.1	Concrete Strength.....	399
15.1.2	Water-to-Cementitious Materials Ratio.....	399
15.1.3	Selection of the Water-to-Cementitious Materials Ratio.....	400
15.1.4	Aggregates.....	401
15.1.5	Air Content in Concrete	405
15.1.6	Slump.....	405
15.1.7	Water Content	405
15.1.8	Cementing Materials Content and Type.....	407
15.1.9	Admixtures	408
15.1.10	Example of Mix Design.....	408
15.2	Structural Design.....	414
15.2.1	AASHTO Method	414
15.2.2	Design Input Parameters	415
15.2.2.1	Reliability.....	415
15.2.2.2	Serviceability	415
15.2.2.3	Drainage Coefficient (C_d).....	416
15.2.2.4	Load Transfer Coefficient (J)	416
15.2.3	Rigid Foundation at Shallow Depth	421
15.2.4	Effective Modulus of Subgrade Reaction.....	422
15.2.4.1	Software Solutions	425
15.2.4.2	AASHTO 1998 Supplement to Design Guide	426
15.2.4.3	MEPDG Design Guide.....	432
15.2.4.4	Continuously Reinforced Concrete Pavements.....	432
15.2.4.5	CRCP Design Criteria.....	444
15.2.4.6	Structural Performance.....	445
15.2.4.7	Functional Performance.....	446
15.2.4.8	Reinforcement for CRCP	446
15.2.4.9	Design Methods for CRCP.....	446
15.2.4.10	AASHTO Interim MEPDG	447
15.2.4.11	AASHTO-86/93 Design Procedure	447
15.2.4.12	Reinforcement Design.....	448
15.2.4.13	Design Variables for Longitudinal Reinforcement: AASHTO Method.....	449
15.2.4.14	Limiting Criteria	451
15.2.4.15	Longitudinal Reinforcement Design Procedure	455
	Questions	455
Chapter 16	Construction of Asphalt Pavements	457
16.1	Overview	457
16.1.1	Production	457
16.1.2	Transportation and Laydown.....	458

16.2	Description and Requirements of Components in Hot Mix Asphalt–Producing Plants	458
16.2.1	Aggregate Stockpiles.....	458
16.2.2	Cold Feed Bins	459
16.2.3	Dryer Drum	460
16.2.4	Hot Elevator and Bins	461
16.2.5	Pugmill.....	461
16.2.6	Hauling and Storage.....	462
16.2.7	Drum Plant.....	463
16.2.8	Dust Collection from HMA Plants.....	464
16.2.9	Asphalt Storage Tanks.....	464
16.3	Equipment Used for Transportation, Laydown, and Compaction	465
16.3.1	Trucks.....	465
16.3.2	Pavers	466
16.3.3	Rollers	467
16.4	Important Factors	467
16.5	Specifications.....	468
16.5.1	Variability of Materials	471
16.5.2	Use of Quality Control Charts	476
16.6	Preparation of Subgrade and Construction of Base and Subbase Layers.....	477
16.7	Quality Control and Quality Assurance.....	478
16.8	Construction of Longitudinal Joints.....	479
16.8.1	Techniques of Constructing Good Longitudinal Joints	480
16.8.1.1	Combination of Notched Wedge Joint, Rubberized Asphalt Tack Coat, and Minimum Joint Density Requirements.....	480
16.8.1.2	Rubberized Asphalt Tack Coat and Minimum Joint Density Requirements.....	482
16.8.1.3	Notched Wedge Joint and Minimum Joint Density Requirements.....	482
16.8.1.4	Cutting Wheel and Minimum Joint Density Requirements.....	482
16.8.1.5	Infrared Joint Heating and Minimum Joint Density Requirements.....	482
	Questions	482
Chapter 17	Construction of Concrete Pavements	485
17.1	Overview	485
17.2	Concrete Production.....	486
17.3	Preparation of Subgrade and Base.....	486
17.4	Presetting Reinforcements such as Dowel Bars, Tiebars, and Continuous Reinforcement	488
17.4.1	Dowel Bars.....	488
17.4.2	Tiebars.....	488
17.4.2.1	Reinforcing Steel (CRCP)	489
17.5	PCC Slab Construction.....	490
17.5.1	Slipform Paving.....	490
17.5.2	Stringlines for Slipform Paver.....	492
17.5.3	Fixed Form Paving	493
17.5.4	Concrete Placement.....	494

- 17.5.5 Consolidation 494
- 17.5.6 Screeding..... 495
- 17.6 Finishing..... 495
 - 17.6.1 Bullfloating..... 495
 - 17.6.2 Texturing 496
 - 17.6.3 Protection of Pavement Surface from Rain..... 497
 - 17.6.4 Construction Headers..... 497
- 17.7 Curing..... 498
 - 17.7.1 Evaporation Rate 498
- 17.8 Paving in Hot and Cold Weather Conditions..... 500
 - 17.8.1 Edge Slump 501
 - 17.8.2 Smoothness 501
- 17.9 Jointing 502
- 17.10 HIPERPAV Software..... 503
- 17.11 Joint Sealing 507
 - 17.11.1 Quality Assurance/Quality Control (QC/QA)..... 508
 - 17.11.2 Differential Scanning Calorimeter 509
 - 17.11.3 Blaine Fineness 510
 - 17.11.4 Gradation..... 510
 - 17.11.5 Penetration Resistance 510
 - 17.11.6 Cement Materials Temperature Profile (the “Coffee Cup Test”) 510
 - 17.11.7 Water–Cement Ratio (Microwave Oven Test) 510
 - 17.11.8 Concrete and Subgrade Temperature
and Environmental Conditions 510
 - 17.11.9 Concrete Strength (Early Age)..... 510
 - 17.11.10 Air Void Analyzer..... 511
 - 17.11.11 Maturity Test..... 511
 - 17.11.11.1 Consistency 512
 - 17.11.11.2 Air Content 513
 - 17.11.11.3 Density and Yield..... 513
 - 17.11.11.4 Sampling Fresh Concrete..... 514
- Questions 514

Chapter 18 Maintenance and Rehabilitation of Pavements: Pavement Management Systems..... 515

- 18.1 Overview 515
- 18.2 Steps in PMS 515
- 18.3 Different PMS Approaches 516
 - 18.3.1 Criteria for Making Decisions..... 518
- 18.4 Distress Survey..... 519
- 18.5 Maintenance and Rehabilitation of Asphalt Pavements..... 521
 - 18.5.1 Maintenance 521
 - 18.5.1.1 Primary Corrective Maintenance Activities..... 522
 - 18.5.1.2 Primary Preventive Maintenance Activities..... 523
 - 18.5.2 Recycling 524
 - 18.5.2.1 Hot In-Place Recycling 524
 - 18.5.2.2 Cold Recycling..... 525
 - 18.5.2.3 Hot Mix Recycling 530
- 18.6 Maintenance and Rehabilitation of Concrete Pavements..... 534
 - 18.6.1 Joint and Crack Sealing..... 534
 - 18.6.2 Slab Stabilization..... 534

18.6.3	Diamond Grinding	534
18.6.4	Load Transfer Devices	535
18.6.5	Precast Panels for Repair and Rehabilitation.....	535
18.6.6	Portland Cement Concrete Overlays	536
18.7	Warranty Projects.....	536
	Questions.....	537
Chapter 19	Airport Pavements.....	539
19.1	Types, Importance, and Specifications.....	539
19.2	Structural Design of Airport Asphalt Mix Pavements.....	540
19.2.1	Design of Flexible Pavement over Existing Pavement.....	547
19.2.1.1	HMA Overlay on Existing Flexible Pavement	547
19.2.1.2	HMA Overlay on Existing Rigid Pavement with or without Existing HMA Overlay.....	549
19.3	Design of Concrete Pavements	550
19.4	Design for Airport Pavements with Light Aircrafts.....	551
19.5	Advanced Design Methods.....	551
19.5.1	Asphalt Pavements	554
19.5.1.1	For Vertical Strain ϵ_v on Top of the Subgrade.....	555
19.5.1.2	For Horizontal Strain ϵ_h at the Bottom of the Surface Layer.....	555
19.5.2	Rigid Pavements	555
19.6	Nondestructive Testing and Rehabilitation of Airfield Pavements.....	558
19.7	ACN-PCN.....	565
19.8	Rehabilitation of PCC Airport Pavements	566
19.9	Construction Quality Control and Acceptance Testing.....	567
19.10	Constructing, Checking, and Improving Friction/Skid Resistance Drainage of Runways	568
19.11	Asphalt Mixes for Airport Pavement	570
19.11.1	Fuel-Resistant Mix	570
19.11.2	Construction and Maintenance of Longitudinal Joints.....	570
19.11.3	Time of Construction	571
19.11.4	De-Icing and Anti-Icing	571
19.12	Maintenance of Airport Pavements.....	571
	Questions.....	572
Chapter 20	Nondestructive Tests	573
20.1	Nuclear Gage	573
20.2	Falling Weight Deflectometer.....	573
20.2.1	Direct Use of Deflections	574
20.2.1.1	Relationship between Deflection Bowl Parameters and Stresses and Strains at Various Locations in the Pavement.....	576
20.2.2	Back-Calculation	577
20.2.2.1	Steps in Performing Back-Calculation with Evercalc Program	578
20.2.2.2	Detection of Voids in PCC Pavements	580
20.2.2.3	Detection of Nonresilient Pavement Layer Behavior	580

20.2.2.4	Evaluation of Experimental Paving Materials.....	580
20.2.2.5	Determination of Load Transfer Efficiency for Jointed PCC Pavements.....	581
20.3	Portable Falling Weight Deflectometer	581
20.4	Rolling Wheel Deflectometer	581
20.5	GeoGauge (Soil Stiffness Gauge) for Soil Compaction	582
20.6	Ground-Penetrating Radar	583
20.7	Portable Seismic Pavement Analyzer.....	583
20.8	Free Free Resonant Column Test	584
20.9	Ultrasonic Test.....	584
20.10	Magnetic Induction Tomography	586
	Question	586
Chapter 21	Economic Analysis and Cost-Saving Concepts	587
21.1	Economic Analysis.....	587
21.1.1	Engineering Economy.....	587
21.1.2	Concept of Life Cycle Cost	587
21.1.3	Techniques.....	587
21.1.4	Costs in Life Cycle Cost Analysis.....	589
21.1.5	Probabilistic versus Deterministic Approach.....	590
21.1.6	Information on Life Cycle Cost Analysis for Pavements	590
21.1.7	Software for Running Life Cycle Cost Analysis.....	590
21.2	Cost-Saving Concepts.....	592
21.2.1	Principles of Perpetual Pavements	592
21.2.2	Economic Benefits of Recycling	594
	Questions	594
Chapter 22	Instrumentation in Asphalt and Concrete Pavement.....	597
22.1	Temperature.....	597
22.2	Soil Moisture Content.....	597
22.3	Frost Depth	597
22.4	Strain in Asphalt or Concrete Pavement and Soil Layers	598
22.5	Stress in Soil Layers	599
22.6	Deflection in Layers.....	600
22.7	Data Acquisition Systems.....	600
	Questions	602
Chapter 23	Specialty Applications.....	603
23.1	Asphalt Mixtures	603
23.1.1	Polymer-Modified Asphalt	603
23.1.2	Asphalt Rubber Mixes.....	604
23.1.3	Stone Matrix Asphalt	604
23.1.4	Porous Friction Course.....	605
23.1.5	Warm Mix Asphalt.....	606
23.1.6	Ultrathin Wearing Course	607
23.2	Concrete Whitetopping.....	608
	Questions	608

Chapter 24	Sustainable Pavement Engineering	611
24.1	Need for Pavements	611
24.2	First Consideration	611
24.3	Design of Layout of Pavements	611
24.4	Construction of Pavements	612
24.5	Use of Waste and Byproducts in Pavements	614
24.6	Workers.....	620
24.7	Pavement–Building–Nature Symbiosis	620
24.8	Regulatory Bodies and Impetus for Sustainability	621
24.9	Human Factor	622
	Questions	622
Chapter 25	Environmental Mitigation in Transportation Projects	623
25.1	How Transportation Impacts the Environment	623
25.2	Model for Assessing Impacts and Developing Mitigation Measures	624
25.3	Project Conception	628
25.4	Impact Assessment	629
25.5	Alternatives Analysis.....	629
25.6	Public Involvement and Review	631
25.7	Enforcement and Post-Project Monitoring	632
25.8	Transportation Planning and Regional Mitigation Approaches	634
	Questions	637
Conversion Factors	.....	639
References	.....	641
Bibliography	.....	649