

# Table of Contents

CHAPTER 10 – DIVISION OF DESIGN..... 10-1  
    Topic 11 – Organization and Functions ..... 10-1  
        Index 11.1 – Organization..... 10-1

CHAPTER 20 – DESIGNATION OF HIGHWAY ROUTES..... 20-1  
    Topic 21 – Highway Route Numbers ..... 20-1  
        Index 21.1 – Legislative Route Numbers and Descriptions ..... 20-1  
        21.2 Sign Route Numbers ..... 20-1

CHAPTER 40 – FEDERAL-AID ..... 40-1  
    Topic 41 – Enabling Legislation ..... 40-1  
        Index 41.1 – General ..... 40-1  
    Topic 42 – Federal-Aid System..... 40-1  
        42.1 National Highway System..... 40-1  
        42.2 Interstate..... 40-1  
    Topic 43 – Federal-Aid Programs ..... 40-2  
        43.1 Surface Transportation Program (STP) ..... 40-2  
        43.2 California Stewardship and Oversight Agreement with FHWA ..... 40-2  
        43.3 Congestion Mitigation and Air Quality Improvement Program (CMAQ) ..... 40-2  
        43.4 Bridge Replacement and Rehabilitation Program ..... 40-3  
        43.5 Federal Lands Program ..... 40-3  
        43.6 Highway Safety Improvement Program ..... 40-3  
        43.7 Special Programs ..... 40-3  
    Topic 44 – Funding Determination ..... 40-3  
        44.1 Funding Eligibility..... 40-3  
        44.2 Federal Participation Ratio ..... 40-4  
        44.3 Emergency Relief ..... 40-4

    CHAPTER 60 – NOMENCLATURE ..... 60-1  
    Topic 61 – Abbreviations ..... 60-1  
        Index 61.1 – Official Names..... 60-1

Topic 62 – Definitions .....	60-1
62.1 Geometric Cross Section.....	60-1
62.2 Highway Structures .....	60-3
62.3 Highway Types.....	60-5
62.4 Interchanges and Intersections at Grade.....	60-6
62.5 Landscape Architecture.....	60-8
62.6 Right of Way.....	60-8
62.7 Pavement .....	60-9
62.8 Highway Operations .....	60-13
62.9 Drainage.....	60-15
62.10 Users .....	60-15
CHAPTER 80 – APPLICATION OF DESIGN STANDARDS.....	80-1
Topic 81 – Project Development Overview .....	80-1
Index 81.1 – Philosophy .....	80-1
81.2 Highway Context .....	80-1
81.3 Place Types.....	80-2
81.4 Type of Highway.....	80-8
81.5 Access Control .....	80-9
81.6 Design Standards and Highway Context.....	80-9
Topic 82 – Application of Standards .....	80-6
82.1 Highway Design Manual Standards.....	80-6
82.2 Approvals for Nonstandard Design.....	80-9
82.3 FHWA and AASHTO Standards and Policies.....	80-10
82.4 Mandatory Procedural Requirements .....	80-10
82.5 Effective Date for Implementing Revisions to Design Standards.....	80-10
82.6 Design Information Bulletins and Other Caltrans Publications .....	80-11
82.7 Traffic Engineering .....	80-11
CHAPTER 100 – BASIC DESIGN POLICIES .....	100-1
Topic 101 – Design Speed .....	100-1
Index 101.1 – Highway Design Speed .....	100-1

101.2 Highway Design Speed Standards ..... 100-3

Topic 102 – Design Capacity & Level of Service ..... 100-4

102.1 Design Capacity (Automobiles) ..... 100-4

102.2 Design Capacity and Quality of Service (Pedestrians and Bicycles) ..... 100-5

Topic 103 – Design Designation ..... 100-5

103.1 Relation to Design ..... 100-5

103.2 Design Period ..... 100-6

Topic 104 – Control of Access ..... 100-6

104.1 General Policy ..... 100-6

104.2 Access Openings..... 100-6

104.3 Frontage Roads ..... 100-7

104.4 Protection of Access Rights..... 100-8

104.5 Relation of Access Opening to a Median Opening ..... 100-8

104.6 Maintaining Local Community Access ..... 100-8

104.7 Cross References ..... 100-8

Topic 105 – Pedestrian Facilities ..... 100-8

105.1 General Policy ..... 100-8

105.2 Sidewalks and Walkways ..... 100-9

105.3 Pedestrian Grade Separations..... 100-11

105.4 Accessibility Requirements ..... 100-12

105.5 Guidelines for the Location and Design of Curb Ramps ..... 100-13

105.6 Pedestrian Crossings..... 100-14

Topic 106 – Stage Construction and Utilization of Local Roads..... 100-14

106.1 Stage Construction ..... 100-14

106.2 Utilization of Local Roads ..... 100-16

Topic 107 – Roadside Installations ..... 100-17

107.1 Roadway Connections ..... 100-17

107.2 Maintenance and Police Facilities on Freeways ..... 100-17

107.3 Location of Border Inspection Stations ..... 100-18

Topic 108 – Coordination With Other Agencies ..... 100-18

108.1 Divided Nonfreeway Facilities..... 100-18

108.2 Transit Loading Facilities ..... 100-19

**July 1, 2020**

108.3	Commuter and Light Rail Facilities Within State Right of Way .....	100-21
108.4	Bus Loading Facilities.....	100-22
108.5	Bus Rapid Transit.....	100-22
108.6	High-Occupancy Toll and Express Toll Lanes.....	100-23
108.7	Coordination with the FHWA .....	100-23
Topic 109 – Scenic Values in Planning and Design.....		100-24
109.1	Basic Precepts .....	100-24
109.2	Design Speed.....	100-24
109.3	Aesthetic Factors.....	100-24
Topic 110 – Special Considerations .....		100-25
110.1	Design for Overloaded Material Hauling Equipment.....	100-25
110.2	Control of Water Pollution.....	100-26
110.3	Control of Air Pollution.....	100-31
110.4	Wetlands Protection .....	100-32
110.5	Control of Noxious Weeds - Exotic and Invasive Species .....	100-33
110.6	Earthquake Consideration .....	100-33
110.7	Traffic Control Plans .....	100-34
110.8	Safety Reviews.....	100-36
110.9	Value Analysis.....	100-38
110.10	Proprietary Items .....	100-38
110.11	Conservation of Materials and Energy.....	100-39
110.12	Tunnel Safety Orders .....	100-41
Topic 111 – Material Sites and Disposal Sites.....		100-45
111.1	General Policy .....	100-45
111.2	Investigation of Local Materials Sources .....	100-46
111.3	Materials Information Furnished to Prospective Bidders .....	100-47
111.4	Materials Arrangements .....	100-48
111.5	Procedures for Acquisition of Material Sites and Disposal Sites .....	100-48
111.6	Mandatory Material Sites and Disposal Sites on Federal-aid Projects .....	100-50
Topic 112 – Contractor's Yard and Plant Sites .....		100-50
112.1	Policy.....	100-50
112.2	Locating a Site.....	100-51

Topic 113 – Geotechnical Design Report ..... 100-51

    113.1 Policy ..... 100-51

    113.2 Content ..... 100-51

    113.3 Submittal and Review ..... 100-51

Topic 114 – Materials Report ..... 100-52

    114.1 Policy ..... 100-52

    114.2 Requesting Materials Report(s) ..... 100-52

    114.3 Content ..... 100-53

    114.4 Preliminary Materials Report ..... 100-53

    114.5 Review and Retention of Records ..... 100-54

Topic 115 – Designing for Bicycle Traffic ..... 100-54

    115.1 General ..... 100-54

Topic 116 – Bicyclists and Pedestrians on Freeways ..... 100-55

    116.1 General ..... 100-55

  

CHAPTER 200 – GEOMETRIC DESIGN AND STRUCTURE STANDARDS ..... 200-1

    Topic 201 – Sight Distance ..... 200-1

        Index 201.1 – General ..... 200-1

        201.2 Passing Sight Distance ..... 200-1

        201.3 Stopping Sight Distance ..... 200-3

        201.4 Stopping Sight Distance at Grade Crests ..... 200-3

        201.5 Stopping Sight Distance at Grade Sags ..... 200-3

        201.6 Stopping Sight Distance on Horizontal Curves ..... 200-4

        201.7 Decision Sight Distance ..... 200-4

    Topic 202 – Superelevation ..... 200-5

        202.1 Basic Criteria ..... 200-5

        202.2 Standards for Superelevation ..... 200-10

        202.3 Restrictive Conditions ..... 200-12

        202.4 Axis of Rotation ..... 200-12

        202.5 Superelevation Transition ..... 200-19

        202.6 Superelevation of Compound Curves ..... 200-22

        202.7 Superelevation on City Streets and County Roads ..... 200-22

**July 1, 2020**

Topic 203 – Horizontal Alignment .....	200-22
203.1 General Controls .....	200-22
203.2 Standards for Curvature .....	200-24
203.3 Alignment Consistency .....	200-24
203.4 Curve Length and Central Angle .....	200-24
203.5 Compound Curves .....	200-25
203.6 Reversing Curves .....	200-25
203.7 Broken Back Curves .....	200-25
203.8 Spiral Transition .....	200-25
203.9 Alignment at Bridges .....	200-25
Topic 204 – Grade .....	200-26
204.1 General Controls .....	200-26
204.2 Position With Respect to Cross Section .....	200-26
204.3 Standards for Grade .....	200-27
204.4 Vertical Curves .....	200-27
204.5 Sustained Grades .....	200-29
204.6 Coordination of Horizontal and Vertical Alignment .....	200-31
204.7 Separate Grade Lines .....	200-31
204.8 Grade Line of Structures .....	200-32
Topic 205 – Road Connections and Driveways .....	200-35
205.1 Access Openings on Expressways .....	200-35
205.2 Private Road Connections .....	200-35
205.3 Urban Driveways .....	200-36
205.4 Driveways on Frontage Roads and in Rural Areas .....	200-37
205.5 Financial Responsibility .....	200-38
Topic 206 – Pavement Transitions .....	200-38
206.1 General Transition Standards .....	200-38
206.2 Pavement Widening .....	200-38
206.3 Pavement Reductions .....	200-40
206.4 Temporary Freeway Transitions .....	200-40
Topic 207 – Airway-Highway Clearances .....	200-40
207.1 Introduction .....	200-40

207.2 Clearances ..... 200-41

207.3 Submittal of Airway-Highway Clearance Data ..... 200-41

Topic 208 – Bridges, Grade Separation Structures, and Structure Approach Embankment  
..... 200-46

208.1 Bridge Lane and Shoulder Width..... 200-46

208.2 Cross Slope ..... 200-48

208.3 Median..... 200-48

208.4 Bridge Sidewalks ..... 200-48

208.5 Open End Structures ..... 200-48

208.6 Overcrossings and Undercrossings for Pedestrians and Bicycles..... 200-48

208.7 Equestrian Undercrossings and Overcrossings..... 200-49

208.8 Cattle Passes, Equipment, and Deer Crossings..... 200-49

208.9 Railroad Underpasses and Overheads..... 200-49

208.10 Bridge Barriers and Railings ..... 200-50

208.11 Structure Approach Embankment..... 200-57

Topic 209 – Structure Approach Slabs ..... 200-61

209.1 Purpose and Application..... 200-61

209.2 General Considerations ..... 200-61

209.3 Structural Approach System Drainage ..... 200-63

209.4 Structure Approach Slab Rehabilitation Considerations ..... 200-63

Topic 210 – Reinforced Earth Slopes and Earth Retaining Systems ..... 200-66

210.1 Introduction..... 200-66

210.2 Construction Methods and Types..... 200-66

210.3 Alternative Earth Retaining Systems (AERS) ..... 200-72

210.4 Value Engineering Change Proposal (VECP)..... 200-73

210.5 Aesthetic Consideration..... 200-74

210.6 Safety Railing, Fences, and Concrete Barriers..... 200-74

210.7 Design Responsibility ..... 200-75

210.8 Guidelines for Type Selection and Plan Preparation ..... 200-75

CHAPTER 300 – GEOMETRIC CROSS SECTION ..... 300-1

Topic 301 – Traveled Way Standards..... 300-1

**July 1, 2020**

Index 301.1 – Lane Width.....	300-1
301.2 Class II Bikeway (Bike Lane) Lane Width.....	300-1
301.3 Cross Slopes .....	300-4
Topic 302 – Highway Shoulder Standards.....	300-5
302.1 Width .....	300-5
302.2 Cross Slopes .....	300-5
302.3 Tapered Edge.....	300-7
Topic 303 – Curbs, Dikes, and Side Gutters.....	300-8
303.1 General Policy .....	300-8
303.2 Curb Types and Uses.....	300-9
303.3 Dike Types and Uses .....	300-11
303.4 Curb Extensions .....	300-13
303.5 Position of Curbs and Dikes .....	300-16
303.6 Curbs and Dikes on Frontage Roads and Streets .....	300-17
Topic 304 – Side Slopes.....	300-17
304.1 Side Slope Standards.....	300-17
304.2 Clearance From Slope to Right of Way Line .....	300-19
304.3 Slope Benches and Cut Widening.....	300-19
304.4 Contour Grading and Slope Rounding.....	300-19
304.5 Stepped Slopes .....	300-20
Topic 305 – Median Standards .....	300-21
305.1 Width .....	300-21
305.2 Median Cross Slopes .....	300-23
305.3 Median Barriers .....	300-23
305.4 Median Curbs .....	300-23
305.5 Paved Medians.....	300-23
305.6 Separate Roadways .....	300-24
Topic 306 – Right of Way .....	300-24
306.1 General Standards .....	300-24
306.2 Right of Way Through the Public Domain.....	300-24
Topic 307 – Cross Sections for State Highways .....	300-24
307.1 Cross Section Selection .....	300-24



307.2 Two-lane Cross Sections for New Construction ..... 300-26

307.3 Two-lane Cross Sections for 2R, 3R, and other Projects..... 300-26

307.4 Multilane Divided Cross Sections ..... 300-28

307.5 Multilane All Paved Cross Sections with Special Median Widths ..... 300-28

307.6 Multilane Cross Sections for 2R and 3R Projects ..... 300-32

307.7 Reconstruction Projects ..... 300-32

Topic 308 – Cross Sections for Roads Under Other Jurisdictions ..... 300-32

    308.1 City Streets and County Roads..... 300-32

Topic 309 – Clearances ..... 300-33

    309.1 Horizontal Clearances for Highways..... 300-33

    309.2 Vertical Clearances..... 300-36

    309.3 Tunnel Clearances..... 300-42

    309.4 Lateral Clearance for Elevated Structures ..... 300-42

    309.5 Structures Across or Adjacent to Railroads ..... 300-42

Topic 310 – Frontage Roads..... 300-47

    310.1 Cross Section ..... 300-47

    310.2 Outer Separation ..... 300-48

    310.3 Headlight Glare..... 300-48

  

CHAPTER 400 – INTERSECTIONS AT GRADE ..... 400-1

Topic 401 – Factors Affecting Design ..... 400-1

    Index 401.1 – General ..... 400-1

    401.2 Human Factors ..... 400-1

    401.3 Traffic Considerations..... 400-2

    401.4 The Physical Environment ..... 400-2

    Table 401.3 ..... 400-3

    401.5 Intersection Type ..... 400-3

    401.6 Transit..... 400-4

Topic 402 – Operational Features Affecting Design..... 400-4

    402.1 Capacity..... 400-4

    402.2 Collisions ..... 400-5

    402.3 On-Street Parking ..... 400-5

**July 1, 2020**

402.4 Consider All Users.....	400-6
402.5 Speed-Change Areas.....	400-6
Topic 403 – Principles of Channelization.....	400-6
403.1 Preference to Major Movements.....	400-6
403.2 Areas of Conflict.....	400-6
403.3 Angle of Intersection.....	400-7
403.4 Points of Conflict.....	400-8
403.5 (Currently not in Use).....	400-9
403.6 Turning Traffic.....	400-9
403.7 Refuge Areas.....	400-11
403.8 Prohibited Turns.....	400-11
403.9 Effective Signal Control.....	400-11
403.10 Installation of Traffic Control Devices.....	400-13
403.11 Summary.....	400-13
403.12 Other Considerations.....	400-13
Topic 404 – Design Vehicles.....	400-14
404.1 General.....	400-14
404.2 Design Considerations.....	400-14
404.3 Design Tools.....	400-15
404.4 Design Vehicles and Related Definitions.....	400-16
404.5 Turning Templates & Vehicle Diagrams.....	400-18
Topic 405 – Intersection Design Standards.....	400-26
405.1 Sight Distance.....	400-26
405.2 Left-turn Channelization.....	400-30
405.3 Right-turn Channelization.....	400-36
405.4 Traffic Islands.....	400-37
405.5 Median Openings.....	400-40
405.6 Access Control.....	400-41
405.7 Public Road Intersections.....	400-43
405.8 City Street Returns and Corner Radii.....	400-43
405.9 Widening of 2-lane Roads at Signalized Intersections.....	400-43
405.10 Roundabouts.....	400-46

Topic 406 – Ramp Intersection Capacity Analysis ..... 400-55

    CHAPTER 500 – TRAFFIC INTERCHANGES ..... 500-1

Topic 501 – General ..... 500-1

    Index 501.1 – Concepts ..... 500-1

    501.2 Warrants ..... 500-1

    501.3 Spacing ..... 500-1

Topic 502 – Interchange Types ..... 500-1

    502.1 General ..... 500-1

    502.2 Local Street Interchanges ..... 500-2

    502.3 Freeway-to-Freeway Interchanges ..... 500-7

Topic 503 – Interchange Design Procedure ..... 500-10

    503.1 Basic Data ..... 500-10

    503.2 Reviews ..... 500-11

Topic 504 – Interchange Design Standards ..... 500-11

    504.1 General ..... 500-11

    504.2 Freeway Entrances and Exits ..... 500-11

    504.3 Ramps ..... 500-16

    504.4 Freeway-to-Freeway Connections ..... 500-37

    504.5 Auxiliary Lanes ..... 500-38

    504.6 Mainline Lane Reduction at Interchanges ..... 500-38

    504.7 Weaving Sections ..... 500-40

    504.8 Access Control ..... 500-46

  

    Chapters 600 – 680 Pavement Engineering ..... 600-1

    Chapter 600 – General Aspects ..... 600-1

Topic 601 – Introduction ..... 600-1

Topic 602 – Pavement Structure Layers ..... 600-1

    Index 602.1 – Description ..... 600-1

Topic 603 – Types of Pavement Projects ..... 600-5

    603.1 New Construction ..... 600-5

    603.2 Widening ..... 600-5

**May 20, 2022**

603.3 Pavement Preservation .....	600-5
603.4 Roadway Rehabilitation .....	600-6
603.5 Reconstruction.....	600-7
603.6 Temporary Pavements and Detours.....	600-7
603.7 Stage Construction .....	600-7
Topic 604 – Roles, Resources, and Proprietary Items.....	600-8
604.1 Roles and Responsibilities for Pavement Engineering .....	600-8
604.2 Mechanistic-Empirical Design .....	600-9
604.3 Pavement Recommendations .....	600-11
604.4 Other Resources .....	600-11
Topic 605 – Record Keeping .....	600-13
605.1 Documentation .....	600-13
605.2 Subsequent Revisions.....	600-13
Topic 606 – Research and Special Designs .....	600-14
606.1 Research and Experimentation .....	600-14
606.2 Special Designs.....	600-14
606.3 Proprietary Items .....	600-15
CHAPTER 610 – PAVEMENT ENGINEERING CONSIDERATIONS.....	610-1
Topic 611 – Factors In Selecting Pavement Type .....	610-1
Index 611.1 – Pavement Type Selection .....	610-1
611.2 Selection Criteria .....	610-1
Topic 612 – Pavement Design Life .....	610-2
612.1 Definition .....	610-2
612.2 New Construction and Reconstruction .....	610-2
612.3 Widening .....	610-2
612.4 Pavement Preservation .....	610-3
612.5 Roadway Rehabilitation.....	610-3
612.6 Temporary Pavements and Detours.....	610-3
612.7 Non-Structural Wearing Courses.....	610-3
Topic 613 – Traffic Considerations .....	610-4
613.1 Overview .....	610-4

613.2 Manual Traffic Index Calculations..... 610-5

613.3 Axle Load Spectra ..... 610-7

613.4 Specific Traffic Loading Considerations..... 610-10

Topic 614 – Soil Characteristics..... 610-20

614.1 Engineering Considerations..... 610-20

614.2 Unified Soil Classification System (USCS) ..... 610-21

614.3 Resilient Modulus,  $M_r$ ..... 610-21

614.4 California R-Value..... 610-23

614.5 Expansive Soils ..... 610-23

614.6 Other Considerations..... 610-25

Topic 615 – Climate ..... 610-26

Topic 616 – Existing Pavement Type and Condition..... 610-27

Topic 617 – Materials..... 610-29

617.1 Availability of Materials ..... 610-29

617.2 Recycling ..... 610-29

617.3 Milling for Structural Changes..... 610-30

Topic 618 – Maintainability and Constructability ..... 610-30

618.1 Maintainability ..... 610-30

618.2 Constructability ..... 610-30

Topic 619 – Pavement Life-Cycle ..... 610-32

619.1 Life-Cycle Cost Analysis ..... 610-32

619.2 Life-Cycle Assessment ..... 610-33

619.3 Emission Savings Analysis and Table ..... 610-33

CHAPTER 620 – RIGID PAVEMENT ..... 620-1

Topic 621 – Types of Rigid Pavements ..... 620-1

Index 621.1 – Continuously Reinforced Concrete Pavement (CRCP)..... 620-1

621.2 Jointed Plain Concrete Pavement (JPCP) ..... 620-1

621.3 Precast Concrete Pavement (PCP) ..... 620-2

Topic 622 – Engineering Requirements ..... 620-4

622.1 Engineering Properties ..... 620-4

622.2 Performance Factors ..... 620-4

622.3 Types of Concrete .....	620-4
622.4 Pavement Joints .....	620-7
622.5 Transitions Panels, Terminal Joints and End Anchors .....	620-8
622.6 Joint Seals .....	620-10
622.7 Dowel Bars and Tie Bars .....	620-11
622.8 Base Interlayer .....	620-12
622.9 Texturing .....	620-12
622.10 Pavement Smoothness .....	620-13
Topic 623 – Engineering Procedure for New, Widening, and Reconstruction Projects	620-13
623.1 Catalog .....	620-13
Topic 624 – Engineering Procedures for Pavement Preservation .....	620-27
624.1 Preventive Maintenance .....	620-27
624.2 Capital Preventive Maintenance (CAPM) .....	620-27
Topic 625 – Engineering Procedures for Pavement Rehabilitation .....	620-28
625.1 Rehabilitation Warrants .....	620-28
625.2 Rigid Pavement Rehabilitation Strategies .....	620-28
Topic 626 – Other Considerations .....	620-29
626.1 Traveled Way .....	620-29
626.2 Shoulder .....	620-29
626.3 Intersections .....	620-34
626.4 Roadside Facilities .....	620-34
CHAPTER 630 – FLEXIBLE PAVEMENT .....	630-1
Topic 631 – Types of Flexible Pavements & Materials .....	630-1
Index 631.1 – Hot Mix Asphalt (HMA) .....	630-1
631.2 Dense Graded HMA .....	630-1
631.3 Rubberized Hot Mixed Asphalt Gap Graded (RHMA-G).....	630-1
631.4 Intersections .....	630-2
631.5 Rubberized HMA (RHMA) Use .....	630-3
631.6 Other Types of Flexible Pavement Surface Courses .....	630-3
631.7 Bonded Wearing Course (BWC).....	630-3

631.8 Warm Mix Asphalt..... 630-3

631.9 Pavement Interlayers..... 630-4

631.10 In-Place Recycled Flexible Pavement Layers..... 630-5

631.11 Bonding between Asphalt Layers ..... 630-6

Topic 632 – Asphalt Binder and Mix Specifications ..... 630-6

632.1 Binder Classification ..... 630-6

632.2 Binder Selection..... 630-7

632.3 Hot Mix Asphalt Specifications and Flexible Pavement Design ..... 630-9

Topic 633 – Engineering Procedures for New Construction and Reconstruction..... 630-10

633.1 Mechanistic-Empirical Method for New Flexible Pavement ..... 630-10

633.2 Mechanistic-Empirical Designs for Reconstruction of Flexible Pavement..... 630-16

Topic 634 – Engineering Procedures for Flexible Pavement Preservation ..... 630-17

634.1 Preventive Maintenance ..... 630-17

634.2 Capital Preventive Maintenance (CAPM) ..... 630-17

Topic 635 – Engineering Procedures for Flexible Pavement Rehabilitation..... 630-19

635.1 Rehabilitation Warrants ..... 630-19

635.2 Mechanistic-Empirical (ME) Design Method for Rehabilitation ..... 630-19

635.3 Rehabilitation of Existing RHMA-G, RHMA-O and HMA-O Surfaced Flexible Pavements..... 630-24

Topic 636 – Other Considerations ..... 630-24

636.1 Traveled Way ..... 630-24

636.2 Shoulders ..... 630-24

636.3 Intersections ..... 630-25

636.4 Roadside Facilities..... 630-25

Topic 637 - Engineering Analysis Software ..... 630-26

  

CHAPTER 640 – COMPOSITE PAVEMENTS..... 640-1

Topic 641 – Types of Composite Pavement ..... 640-1

Index 641.1 – Asphalt Over Concrete Composite Pavement..... 640-1

641.2 Concrete Over Asphalt Composite Pavement ..... 640-2

Topic 642 – Engineering Criteria..... 640-2

642.1 Engineering Properties ..... 640-2

**September 29, 2023**

642.2 Performance Factors .....	640-2
642.3 Overlay Limits.....	640-2
Topic 643 – Engineering Procedures for New Construction and Reconstruction .....	640-3
643.1 Mechanistic-Empirical Design Method.....	640-3
Topic 644 – Engineering Procedures for Pavement Preservation .....	640-3
644.1 Preventive Maintenance .....	640-3
644.2 Capital Preventive Maintenance (CAPM) .....	640-3
Topic 645 – Engineering Procedures for Pavement Rehabilitation.....	640-4
645.1 Empirical Method.....	640-4
645.2 Mechanistic-Empirical Design Method.....	640-5
CHAPTER 650 – PAVEMENT DRAINAGE.....	650-1
Topic 651 – General Considerations .....	650-1
Index 651.1 – Impacts of Drainage on Pavement.....	650-1
651.2 Drainage System Components and Requirements.....	650-1
Topic 652 – Subsurface Drainage and Storm Water Management.....	650-5
Topic 653 – Other Considerations .....	650-5
653.1 New Construction Projects .....	650-5
653.2 Widening Projects .....	650-7
653.3 Rehabilitation and Reconstruction Projects .....	650-7
653.4 Ramps.....	650-7
653.5 Roadside Facilities .....	650-7
CHAPTER 660 – PAVEMENT FOUNDATIONS .....	660-1
Topic 661 – Engineering Considerations .....	660-1
Index 661.1 – Description.....	660-1
661.2 Purpose .....	660-1
Topic 662 – Types of Bases and Subbase .....	660-2
662.1 Aggregate Base.....	660-2
662.2 Treated Base.....	660-2
662.3 Treated Permeable Base.....	660-3
662.4 Subbase and Stabilized Subgrade .....	660-4
Topic 663 – Engineering Properties for Base and Subbase Materials.....	660-5
663.1 Selection Criteria .....	660-5



663.2 Base and Subbase for Rigid Pavements ..... 660-5

663.3 Base and Subbase for Flexible Pavements ..... 660-5

Topic 664 - Subgrade Enhancement ..... 660-6

664.1 Subgrade Improvement Overview ..... 660-7

664.2 Mechanical Subgrade Enhancement ..... 660-8

664.3 Chemical Stabilization ..... 660-8

Topic 665 – Subgrade Enhancement Geosynthetic..... 660-9

665.1 Purpose ..... 660-9

665.2 Properties of Geosynthetics..... 660-9

665.3 Required Tests ..... 660-10

665.4 Mechanical Stabilization Using SEG..... 660-10

665.5 Selecting Geosynthetic Type and Design Parameters..... 660-11

665.6 Appropriate Application of SEG ..... 660-13

665.7 Other Design Considerations..... 660-13

665.8 Subgrade Stiffness Enhancement with SEG ..... 660-14

665.9 SEG Abbreviations and Definitions..... 660-14

Topic 666 – Foundation Mechanistic-Empirical Parameters for Flexible Pavements.. 660-15

666.1 Layer Stiffness ..... 660-15

666.2 Rutting Resistance..... 660-17

  

CHAPTER 670 – TAPERS AND SHOULDER BACKING ..... 670-1

Topic 671 – Pavement Tapers ..... 670-1

Index 671.1 – Background and Purpose..... 670-1

671.2 Engineering Requirements and Considerations ..... 670-1

671.3 Tapers into Existing Pavement or Structure ..... 670-2

Topic 672 – Shoulder Backing ..... 670-8

672.1 Background and Purpose ..... 670-8

672.2 Alternate Materials and Admixtures ..... 670-8

672.3 Design ..... 670-9

  

CHAPTER 680 – PAVEMENT DESIGN FOR WIDENING PROJECTS ..... 680-1

Topic 681 – Pavement Widening Overview ..... 680-1

Index 681.1 – Background..... 680-1

Topic 682 – Design Considerations ..... 680-1

**September 29, 2023**

682.1 Standards .....	680-1
682.2 Pre-Design Evaluation .....	680-2
682.3 Pre-Design Considerations.....	680-2
682.4 Design Considerations .....	680-3
682.5 Scoping, Estimating, and Detailing .....	680-4
682.6 Other Considerations.....	680-7
682.7 Life-Cycle Cost Analysis for Widening Projects.....	680-8
CHAPTER 700 – MISCELLANEOUS STANDARDS.....	700-1
Topic 701 – Fences .....	700-1
Index 701.1 – Type, Intent and Purpose of Fences.....	700-1
701.2 Freeway and Expressway Access Control Fence.....	700-2
701.3 Private Fences.....	700-4
701.4 Temporary Fences .....	700-4
701.5 Other Fences.....	700-4
Topic 702 – Miscellaneous Traffic Items.....	700-5
702.1 References .....	700-5
Topic 703 – Special Structures and Installation .....	700-5
703.1 Truck Weighing Facilities.....	700-5
703.2 Rockfall Restraining Nets .....	700-5
Topic 704 – Contrast Treatment .....	700-6
704.1 Policy.....	700-6
Topic 705 – Materials and Color Selection .....	700-6
705.1 Special Treatments and Materials .....	700-6
705.2 Colors for Steel Structures .....	700-6
Topic 706 – Roadside Management and Vegetation Control .....	700-7
706.1 Roadside Management .....	700-7
706.2 Vegetation Control.....	700-8
Topic 707 – Slope Treatment Under Structures.....	700-8
707.1 Policy.....	700-8
707.2 Guidelines for Slope Treatment.....	700-9
707.3 Procedure.....	700-9

CHAPTERS 800 – 890 HIGHWAY DRAINAGE DESIGN..... 800-1

CHAPTER 800 – GENERAL ASPECTS..... 800-1

Topic 801 – General ..... 800-1

    Index 801.1 – Introduction ..... 800-1

    801.2 Drainage Design Philosophy ..... 800-1

    801.3 Drainage Standards..... 800-1

    801.4 Objectives of Drainage Design ..... 800-2

    801.5 Economics of Design ..... 800-3

    801.6 Use of Drainage References ..... 800-3

Topic 802 – Drainage Design Responsibilities..... 800-4

    802.1 Functional Organization..... 800-4

    802.2 Culvert Committee..... 800-6

    802.3 Bank and Shore Protection Committee..... 800-6

Topic 803 – Drainage Design Policies ..... 800-7

    803.1 Basic Policy ..... 800-7

    803.2 Cooperative Agreements ..... 800-7

    803.3 Up-Grading Existing Drainage Facilities ..... 800-7

Topic 804 – Floodplain Encroachments..... 800-8

    804.1 Purpose ..... 800-8

    804.2 Authority ..... 800-8

    804.3 Applicability..... 800-9

    804.4 Definitions..... 800-9

    804.5 Procedures ..... 800-10

    804.6 Responsibilities..... 800-10

    804.7 Preliminary Evaluation of Risks and Impacts for Environmental Document Phase..  
    ..... 800-11

    804.8 Design Standards ..... 800-12

    804.9 Coordination with the Local Community ..... 800-12

    804.10 National Flood Insurance Program ..... 800-12

    804.11 Coordination with FEMA..... 800-16

Topic 805 – Preliminary Plans ..... 800-17

**September 29, 2023**

805.1 Required FHWA Approval .....	800-17
805.2 Bridge Preliminary Report .....	800-17
805.3 Storm Drain Systems.....	800-17
805.4 Unusual Hydraulic Structures .....	800-17
805.5 Levees and Dams Formed by Highway Fills .....	800-18
805.6 Geotechnical .....	800-18
805.7 Data Provided by the District .....	800-18
Topic 806 – Definitions of Drainage Terms.....	800-19
806.1 Introduction.....	800-19
806.2 Drainage Terms.....	800-19
Topic 807 – Selected Drainage References .....	800-45
807.1 Introduction.....	800-45
807.2 Federal Highway Administration Hydraulic Publications.....	800-45
807.3 American Association of State Highway and Transportation Officials (AASHTO) .... .....	800-47
807.4 California Department of Transportation.....	800-48
807.5 U.S. Department of Interior - Geological Survey (USGS).....	800-48
807.6 U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) .....	800-49
807.7 California Department of Water Resources .....	800-49
807.8 University of California - Institute of Transportation and Traffic Engineering (ITTE) .....	800-49
807.9 U.S. Army Corps of Engineers .....	800-49
Topic 808 – Selected Computer Programs .....	800-49
CHAPTER 800 – HYDROLOGY .....	810-1
Topic 811 – General.....	810-1
Index 811.1 – Introduction.....	810-1
811.2 Objectives of Hydrologic Analysis .....	810-1
811.3 Peak Discharge .....	810-2
811.4 Flood Severity .....	810-2
811.5 Factors Affecting Runoff.....	810-2
Topic 812 – Basin Characteristics .....	810-3

812.1 Size ..... 810-3

812.2 Shape ..... 810-3

812.3 Slope ..... 810-4

812.4 Land Use ..... 810-4

812.5 Soil and Geology ..... 810-4

812.6 Storage ..... 810-4

812.7 Elevation ..... 810-5

812.8 Orientation ..... 810-5

Topic 813 – Channel and Floodplain Characteristics ..... 810-5

813.1 General ..... 810-5

813.2 Length and Slope ..... 810-6

813.3 Cross Section ..... 810-6

813.4 Hydraulic Roughness ..... 810-6

813.5 Natural and Man-made Constrictions ..... 810-6

813.6 Channel Modifications ..... 810-7

813.7 Aggradation - Degradation ..... 810-7

813.8 Debris ..... 810-7

Topic 814 – Meteorological Characteristics ..... 810-8

814.1 General ..... 810-8

814.2 Rainfall ..... 810-8

814.3 Snow ..... 810-9

814.4 Evapo-transpiration ..... 810-9

814.5 Tides and Waves ..... 810-9

Topic 815 – Hydrologic Data ..... 810-10

815.1 General ..... 810-10

815.2 Categories ..... 810-11

815.3 Sources ..... 810-11

815.4 Stream Flow ..... 810-12

815.5 Precipitation ..... 810-13

815.6 Adequacy of Data ..... 810-13

Topic 816 – Runoff ..... 810-13

816.1 General ..... 810-13

**September 29, 2023**

816.2 Overland Flow .....	810-13
816.3 Subsurface Flow.....	810-13
816.4 Detention and Retention.....	810-14
816.5 Flood Hydrograph and Flood Volume.....	810-14
816.6 Time of Concentration (Tc) and Travel Time (Tt) .....	810-15
Topic 817 – Flood Magnitude.....	810-19
817.1 General .....	810-19
817.2 Measurements.....	810-19
Topic 818 – Flood Probability And Frequency.....	810-20
818.1 General .....	810-20
818.2 Establishing Design Flood Frequency .....	810-22
818.3 Stationarity and Climate Variability.....	810-23
Topic 819 – Estimating Design Discharge.....	810-24
819.1 Introduction.....	810-24
819.2 Empirical Methods.....	810-24
819.3 Statistical Methods .....	810-31
819.4 Hydrograph Methods.....	810-32
819.5 Transfer of Data .....	810-34
819.6 Hydrologic Software .....	810-36
819.7 Region-Specific Analysis.....	810-37
CHAPTER – 820 CROSS DRAINAGE.....	820-1
Topic 821 – General .....	820-1
Index 821.1 – Introduction.....	820-1
821.2 Hydrologic Considerations.....	820-2
821.3 Selection of Design Flood.....	820-2
821.4 Headwater and Tailwater.....	820-3
821.5 Effects of Tide and Storm .....	820-4
Topic 822 – Debris Control .....	820-37
822.1 Introduction.....	820-37
822.2 Debris Control Methods.....	820-37
822.3 Economics .....	820-38

822.4 Classification of Debris ..... 820-38

822.5 Types of Debris Control Structures..... 820-38

Topic 823 – Culvert Location ..... 820-38

823.1 Introduction..... 820-38

823.2 Alignment and Slope..... 820-38

Topic 824 – Culvert Type Selection ..... 820-39

824.1 Introduction..... 820-39

824.2 Shape and Cross Section ..... 820-39

Topic 825 – Hydraulic Design of Culverts ..... 820-40

825.1 Introduction..... 820-40

825.2 Culvert Flow..... 820-40

825.3 Computer Programs ..... 820-41

825.4 Coefficient of Roughness..... 820-41

Topic 826 – Entrance Design..... 820-41

826.1 Introduction..... 820-41

826.2 End Treatment Policy ..... 820-42

826.3 Conventional Entrance Designs..... 820-42

826.4 Improved Inlet Designs ..... 820-43

Topic 827 – Outlet Design ..... 820-44

827.1 General..... 820-44

827.2 Embankment Protection ..... 820-44

Topic 828 – Diameter and Length..... 820-45

828.1 Introduction..... 820-45

828.2 Minimum Diameter..... 820-45

828.3 Length..... 820-45

Topic 829 – Special Considerations..... 820-46

829.1 Introduction..... 820-46

829.2 Bedding and Backfill ..... 820-46

829.3 Piping..... 820-47

829.4 Joints ..... 820-48

829.5 Anchorage ..... 820-48

829.6 Irregular Treatment..... 820-48

**September 29, 2023**

829.7 Siphons and Sag Culverts .....	820-49
829.8 Currently Not In Use .....	820-49
829.9 Dams .....	820-49
829.10 Reinforced Concrete Box Modifications.....	820-50
CHAPTER 830 – TRANSPORTATION FACILITY DRAINAGE .....	830-1
Topic 831 – General .....	830-1
Index 831.1 – Basic Concepts .....	830-1
831.2 Highway Grade Line .....	830-2
831.3 Design Storm and Water Spread .....	830-2
831.4 Other Considerations.....	830-3
831.5 Computer Programs .....	830-6
Topic 832 – Hydrology .....	830-6
832.1 Introduction.....	830-6
832.2 Rational Method .....	830-6
832.3 Time of Concentration .....	830-6
Topic 833 – Roadway Cross Sections .....	830-7
833.1 Introduction.....	830-7
833.2 Grade, Cross Slope and Superelevation .....	830-7
Topic 834 – Roadside Drainage .....	830-7
834.1 General.....	830-7
834.2 Median Drainage .....	830-7
834.3 Ditches and Gutters.....	830-8
834.4 Overside Drains.....	830-10
Topic 835 – Dikes and Berms.....	830-11
835.1 General.....	830-11
835.2 Earth Berms .....	830-11
835.3 Dikes .....	830-11
Topic 836 – Curbs and Gutters.....	830-12
836.1 General.....	830-12
836.2 Gutter Design .....	830-12
Topic 837 – Inlet Design .....	830-13



837.1 General..... 830-13

837.2 Inlet Types ..... 830-13

837.3 Location and Spacing ..... 830-17

837.4 Hydraulic Design..... 830-18

837.5 Local Depressions ..... 830-20

Topic 838 – Storm Drains ..... 830-21

838.1 General..... 830-21

838.2 Design Criteria ..... 830-22

838.3 Hydraulic Design..... 830-22

838.4 Standards ..... 830-22

838.5 Appurtenant Structures..... 830-23

Topic 839 – Pumping Stations ..... 830-25

839.1 General..... 830-25

839.2 Pump Type ..... 830-25

839.3 Design Responsibilities..... 830-25

839.4 Trash and Debris Considerations ..... 830-25

839.5 Maintenance Consideration ..... 830-26

839.6 Groundwater Considerations ..... 830-26

  

CHAPTER 840 – SUBSURFACE DRAINAGE ..... 840-1

Topic 841 – General ..... 840-1

Index 841.1 – Introduction ..... 840-1

841.2 Subsurface (Groundwater) Discharge ..... 840-1

841.3 Preliminary Investigations ..... 840-2

841.4 Exploration Notes ..... 840-2

841.5 Category of System ..... 840-2

Topic 842 – Pipe Underdrains..... 840-4

842.1 General..... 840-4

842.2 Single Installations..... 840-4

842.3 Multiple Installations ..... 840-4

842.4 Design Criteria ..... 840-4

842.5 Types of Underdrain Pipe ..... 840-5

842.6 Design Service Life.....	840-5
842.7 Pipe Selection .....	840-6
<b>CHAPTER 850 – PHYSICAL STANDARDS</b>	<b>850-1</b>
Topic 851 – General.....	850-1
Index 851.1 – Introduction .....	850-1
851.2 Selection of Material and Type .....	850-1
Topic 852 – Pipe Materials .....	850-3
852.1 Reinforced Concrete Pipe (RCP).....	850-3
852.2 Concrete Box and Arch Culverts .....	850-3
852.3 Corrugated Steel Pipe, Steel Spiral Rib Pipe and Pipe Arches .....	850-4
852.4 Corrugated Aluminum Pipe, Aluminum Spiral Rib Pipe and Pipe Arches.....	850-7
852.5 Structural Metal Plate .....	850-9
852.6 Plastic Pipe.....	850-10
852.7 Special Purpose Types.....	850-11
Topic 853 – Pipe Liners and Linings for Culvert Rehabilitation .....	850-11
853.1 General.....	850-11
853.2 Caltrans Host Pipe Structural Philosophy.....	850-12
853.3 Problem Identification and Coordination.....	850-12
853.4 Alternative Pipe Liner Materials .....	850-12
853.5 Cementitious Pipe Lining.....	850-14
853.6 Invert Paving with Concrete.....	850-14
853.7 Structural Repairs with Steel Tunnel Liner Plate .....	850-17
Topic 854 – Pipe Connections .....	850-17
854.1 Basic Policy .....	850-17
Topic 855 – Design Service Life.....	850-20
855.1 Basic Concepts.....	850-20
855.2 Abrasion .....	850-23
855.3 Corrosion.....	850-34
855.4 Protection of Concrete Pipe and Drainage Structures from Acids, Chlorides and Sulfates .....	850-35
855.5 Material Susceptibility to Fire.....	850-40

Topic 856 – Height of Fill..... 850-41

856.1 Construction Loads..... 850-41

856.2 Concrete Pipe, Box and Arch Culverts ..... 850-41

856.3 Metal Pipe and Structural Plate Pipe ..... 850-42

856.4 Plastic Pipe..... 850-43

856.5 Minimum Height of Cover ..... 850-43

Topic 857 – Alternate Materials..... 850-61

857.1 Basic Policy ..... 850-61

857.2 Alternative Pipe Culvert Selection Procedure Using AltPipe..... 850-61

857.3 Alternative Pipe Culvert (APC) and Pipe Arch Culvert List ..... 850-64

CHAPTER 860 – ROADSIDE CHANNELS ..... 860-1

Topic 861 – General ..... 860-1

Index 861.1 – Introduction ..... 860-1

861.2 Hydraulic Considerations..... 860-2

861.3 Selection of "Design Flood" ..... 860-3

861.4 Safety Considerations..... 860-3

861.5 Maintenance Considerations ..... 860-4

861.6 Economics ..... 860-5

861.7 Coordination with Other Agencies ..... 860-5

861.8 Environment ..... 860-5

861.9 Unlined Channels ..... 860-5

861.10 Lined Channels..... 860-6

861.11 Water Quality Channels..... 860-6

861.12 References ..... 860-6

Topic 862 – Roadside Drainage Channel Location ..... 860-7

862.1 General..... 860-7

862.2 Alignment and Grade..... 860-7

862.3 Point of Discharge ..... 860-8

Topic 863 – Channel Section ..... 860-8

863.1 Roadside and Median Channels..... 860-8

863.2 Triangular ..... 860-8

**September 29, 2023**

863.3 Trapezoidal.....	860-8
863.4 Rectangular .....	860-9
Topic 864 – Channel Stability Design Concepts .....	860-9
864.1 General.....	860-9
864.2 Stable Channel Design Procedure .....	860-10
864.3 Side Slope Stability.....	860-12
Topic 865 – Channel Linings.....	860-12
865.1 Flexible Verses Rigid.....	860-12
865.2 Rigid .....	860-13
865.3 Flexible .....	860-15
865.4 Composite Lining Design.....	860-17
865.5 Bare Soil Design and Grass Lining.....	860-17
865.6 Rolled Erosion Control Products.....	860-22
Topic 866 – Hydraulic Design of Roadside Channels .....	860-23
866.1 General.....	860-23
866.2 Flow Classifications .....	860-23
866.3 Open Channel Flow Equations .....	860-24
866.4 Water Surface Profiles.....	860-29
Topic 867 – Channel Changes.....	860-29
867.1 General.....	860-29
867.2 Design Considerations .....	860-30
Topic 868 – Freeboard Considerations .....	860-30
868.1 General.....	860-30
868.2 Height of Freeboard.....	860-30
CHAPTER 870 – BANK PROTECTION – EROSION CONTROL .....	870-1
Topic 871 – General.....	870-1
871.1 Introduction.....	870-1
871.2 Design Philosophy .....	870-1
871.3 Selected References .....	870-3
Topic 872 – Planning and Location Studies .....	870-4
872.1 Planning .....	870-4

872.2 Class and Type of Protection..... 870-6

872.3 Geomorphology and Site Consideration ..... 870-6

872.4 Data Needs..... 870-27

872.5 Rapid Assessment..... 870-28

Topic 873 – Design Concepts ..... 870-28

873.1 Introduction..... 870-28

873.2 Design High Water and Hydraulics ..... 870-29

873.3 Armor Protection..... 870-30

873.4 Training Systems..... 870-52

873.5 Summary and Design Check List..... 870-59

873.6 Coordination with the Division of Engineering Services and Structures Maintenance and Investigations..... 870-61

  

CHAPTER 880 – SHORE PROTECTION ..... 880-1

Topic 881 – General ..... 880-1

Index 881.1 – Introduction ..... 880-1

881.2 Design Philosophy..... 880-1

881.3 Selected References ..... 880-2

Topic 882 – Planning and Location Studies ..... 880-2

882.1 Planning ..... 880-2

882.2 Class and Type of Protection..... 880-3

882.3 Site Consideration ..... 880-4

Topic 883 – Design..... 880-5

883.1 Introduction..... 880-5

883.2 Design High Water, Design Wave Height and Sea-Level Rise..... 880-5

883.3 Armor Protection..... 880-21

  

CHAPTER 890 – STORM WATER MANAGEMENT ..... 890-1

Topic 891 – General ..... 890-1

Index 891.1 – Introduction ..... 890-1

891.2 Philosophy ..... 890-1

Topic 892 – Storm Water Management Strategies ..... 890-1

892.1 General.....	890-1
892.2 Types of Strategies.....	890-2
892.3 Design Considerations .....	890-3
892.4 Mixing with Other Waste Streams .....	890-3
Topic 893 – Maintenance Requirements for Storm Water Management Features .....	890-5
893.1 General.....	890-5
CHAPTER 900 – LANDSCAPE ARCHITECTURE – ROADSIDES.....	900-1
Topic 901 – Landscape Architecture General.....	900-1
Index 901.1 – Landscape Architecture Program .....	900-1
901.2 Landscape Architecture Design Standards .....	900-1
901.3 Landscape Architecture Administered Facilities .....	900-4
Topic 902 – Sight Distance and Clear Recovery Zone Standards.....	900-4
902.1 Landscape Sight Distance and Clear Recovery Zone Standards.....	900-4
Topic 903 – Landscape Site Design .....	900-4
903.1 Landscape Site Analysis .....	900-4
903.2 Landscape Site Layout.....	900-5
903.3 Roadside Amenities.....	900-5
903.4 Additional Roadside Site Design Considerations .....	900-5
Topic 904 – Planting Design.....	900-5
904.1 Planting Design General.....	900-5
904.2 Site Preparation.....	900-6
904.3 Plant Selection .....	900-7
904.4 Locating Plants.....	900-8
904.5 Locating Trees.....	900-9
904.6 Locating Plants in Conformance with Sight Distances.....	900-10
904.7 Vine Planting .....	900-12
904.8 Planting in the Vicinity of Airports and Heliports .....	900-12
904.9 Plant Establishment.....	900-12
Topic 905 – Irrigation Design.....	900-13
905.1 Irrigation Design General.....	900-13
905.2 Water Supply.....	900-13

905.3 Irrigation Conduit ..... 900-13

905.4 Irrigation System Equipment..... 900-14

905.5 Temporary Irrigation ..... 900-16

Topic 906 – Erosion Control..... 900-16

906.1 Erosion Control General ..... 900-16

906.2 Soil Surface Protection ..... 900-16

906.3 Planting..... 900-17

906.4 Sediment Control..... 900-18

906.5 Permanent Erosion Control Establishment..... 900-18

  

CHAPTER 910 – LANDSCAPE ARCHITECTURE – ROADSIDE SITES..... 910-1

Topic 911 – General ..... 910-1

Index 911.1 Roadside Sites General ..... 910-1

Topic 912 – Roadside Sites Design ..... 910-1

912.1 Roadside Sites Layout..... 910-1

912.2 Parking Area Design..... 910-2

912.3 Site Furnishings..... 910-4

Topic 913 – Safety Roadside Rest Areas ..... 910-4

913.1 Safety Roadside Rest Areas General ..... 910-4

913.2 Safety Roadside Rest Area Site Selection..... 910-5

913.3 Safety Roadside Rest Area Layout..... 910-5

913.4 Safety Roadside Rest Area Buildings and Structures..... 910-6

913.5 Safety Roadside Rest Area Utilities and Facilities ..... 910-7

913.6 Safety Roadside Rest Area Parking ..... 910-9

913.7 Safety Roadside Rest Area Signage ..... 910-9

913.8 Public Information Display ..... 910-10

913.9 Vending Facilities..... 910-10

Topic 914 – Vista Points ..... 910-11

914.1 Vista Points General ..... 910-11

914.2 Vista Point Site Selection..... 910-11

914.3 Vista Point Amenities..... 910-11

914.4 Vista Point Parking ..... 910-12

Topic 915 – Park & Ride Facilities .....	910-12
915.1 Park & Ride Facilities General.....	910-12
915.2 Site Selection .....	910-13
CHAPTER 1000 – BICYCLE TRANSPORTATION DESIGN .....	1000-1
Topic 1001 – Introduction .....	1000-1
Index 1001.1 – Bicycle Transportation .....	1000-1
1001.2 Streets and Highways Code References.....	1000-1
1001.3 Vehicle Code References .....	1000-2
1001.4 Bikeways .....	1000-2
Topic 1002 – Bikeway Facilities.....	1000-3
1002.1 Selection of the Type of Facility.....	1000-3
Topic 1003 – Bikeway Design Criteria .....	1000-5
1003.1 Class I Bikeways (Bike Paths).....	1000-5
1003.2 Class II Bikeways (Bike Lanes) .....	1000-16
1003.3 Class III Bikeways (Bike Routes).....	1000-16
1003.4 Trails.....	1000-17
1003.5 Miscellaneous Criteria .....	1000-18
CHAPTER 1100 – HIGHWAY TRAFFIC NOISE ABATEMENT .....	1100-1
Topic 1101 – General Requirements .....	1100-1
Index 1101.1 – Introduction.....	1100-1
1101.2 Objective .....	1100-1
1101.3 Terminology.....	1100-2
1101.4 Procedures for Assessing Noise Impacts .....	1100-2
1101.5 Prioritizing Construction of Retrofit Noise Barriers.....	1100-2
Topic 1102 – Design Criteria .....	1100-3
1102.1 General.....	1100-3
1102.2 Noise Barrier Location .....	1100-5
1102.3 Noise Barrier Height and Position.....	1100-16
1102.4 Noise Barrier Length.....	1100-16
1102.5 Alternative Noise Barrier Designs.....	1100-17



1102.6 Noise Barrier Aesthetics .....	1100-17
1102.7 Maintenance Consideration in Noise Barrier Design .....	1100-17
1102.8 Emergency Access Considerations in Noise Barrier Design .....	1100-17
1102.9 Drainage Openings in Noise Barrier .....	1100-17

# Table of Contents

## Figures and Tables

CHAPTER 10 – DIVISION OF DESIGN .....	10-1
Figure 11.1          Division of Design Functional Organization Chart.....	10-2
CHAPTER 20 – DESIGNATION OF HIGHWAY ROUTES .....	20-1
Figure 21.1          Interstate Highway System in California .....	20-2
CHAPTER 60 – NOMENCLATURE.....	60-1
Figure 62.2          Types of Structures.....	60-4
CHAPTER 80 – APPLICATION OF DESIGN STANDARDS.....	80-1
Figure 81.3          Place Types .....	80-3
Table 82.1A          Boldface Standards .....	80-16
Table 82.1B          Underlined Standards .....	80-23
Table 82.1C          Decision Requiring Other Approvals.....	80-30
CHAPTER 100 – BASIC DESIGN POLICIES .....	100-1
Table 101.2          Vehicular Design Speed .....	100-3
Figure 105.6          Typical Pedestrian Crossings at “T” Intersections.....	100-15
Figure 110.12          California Mining and Tunneling Districts.....	100-43
CHAPTER 200 – GEOMETRIC DESIGN AND STRUCTURE STANDARDS .....	200-1
Table 201.1          Sight Distance Standards .....	200-2
Table 201.7          Decision Sight Distance .....	200-5
Figure 201.4          Stopping Sight Distance on Crest Vertical Curves.....	200-6
Figure 201.5          Stopping Sight Distance on Sag Vertical Curves .....	200-7
Figure 201.6          Stopping Sight Distance on Horizontal Curves .....	200-8
Figure 201.7          Decision Sight Distance on Crest Vertical Curves .....	200-9
Table 202.2A          Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=4\%$ .....	200-13

Table 202.2B	Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=6\%$ .....	200-14
Table 202.2C	Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=8\%$ .....	200-15
Table 202.2D	Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=10\%$ .....	200-16
Table 202.2E	Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=12\%$ .....	200-17
Figure 202.2	Maximum Comfortable Speed on Horizontal Curves* .....	200-18
Figure 202.5A	Superelevation Transition .....	200-20
Figure 202.5B	Superelevation Transition Terms & Definitions .....	200-21
Figure 202.6	Superelevation of Compound Curves .....	200-23
Table 204.3	Maximum Grades for Type of Highway and Terrain Conditions .....	200-27
Figure 204.4	Vertical Curves.....	200-28
Figure 204.5	Critical Lengths of Grade for Design .....	200-30
Table 204.8	Falsework Span and Depth Requirements.....	200-34
Figure 205.1	Access Openings on Expressways .....	200-36
Figure 206.2	Typical Two-lane to Four-lane Transitions .....	200-39
Figure 207.2A	Airway-Highway Clearance Requirements (Civil Airports) .....	200-42
Figure 207.2B	Airway-Highway Clearance Requirements (Heliport) .....	200-43
Figure 207.2C	Airway-Highway Clearance Requirements (Military Airports).....	200-44
Figure 207.2D	Airway-Highway Clearance Requirements (Navy Carrier Landing Practice Field) .....	200-45
Figure 208.1	Offsets to Safety-Shape Barriers .....	200-47
Figure 208.10A	Vehicular and Combination Barriers and Railings.....	200-51
Figure 208.10B	Pedestrian/Bicycle Chain Link Railings.....	200-54
Figure 208.11A	Limits of Structure Approach Embankment Material .....	200-59
Figure 208.11B	Abutment Drainage Details .....	200-60
Figure 209.1	Structure Approach Slab Layout .....	200-62
Figure 209.4A	Structure Approach Drainage Details (Rehabilitation).....	200-64
Figure 209.4B	New Structure Approach Pavement Transition Details .....	200-65
Table 210.2	Types of Reinforced Earth Slopes and Earth Retaining Systems <sup>(1)</sup>	200-67
Figure 210.8	Type Selection and PS&E Process for Reinforced Earth Slopes and Earth Retaining Systems.....	200-77

CHAPTER 300 – GEOMETRIC CROSS SECTION.....	300-1
Figure 301.2A Typical Class II Bikeway (Bike Lane) Cross Sections .....	300-3
Table 302.1 Boldface Standards for Paved Shoulder Widths on Highways.....	300-6
Table 303.1 Selection of Curb Type .....	300-10
Figure 303.3 Dike Type Selection and Placement <sup>(1)</sup> .....	300-12
Figure 303.4A Typical Bulbout with Class II Bikeway (Bike Lane) .....	300-14
Figure 303.4B Typical Bulbout without Class II Bikeway (Bike Lane) .....	300-15
Figure 305.6 Optional Median Designs for Freeways with Separate Roadways	300-25
Table 307.2 Shoulder Widths for Two-lane Roadbed .....	
New Construction Projects.....	300-26
Figure 307.2 Geometric Cross Sections for Two-lane Highways (New Construction) ....	
.....	300-27
Figure 307.4A Geometric Cross Sections for Freeways and Expressways.....	300-29
Figure 307.4B Geometric Cross Sections for Freeways and Expressways.....	300-30
Figure 307.5 Geometric Cross Sections for All Paved Multilane Highways .....	300-31
Table 309.2A Minimum Vertical Clearances .....	300-38
Figure 309.2 Department of Defense Rural and Single Interstate Routes .....	300-39
Table 309.2B California Routes on the Rural and Single Interstate Routing System.....	
.....	300-40
Table 309.5A Minimum Vertical Clearances Above Highest Rail .....	300-43
Figure 309.5A Typical Horizontal Railroad Clearance from Grade Separated Structures .	
.....	300-44
Figure 309.5B Permanent Railroad Clearance Envelope.....	300-45
Table 309.5B Minimum Horizontal Clearances to Centerline of Nearest Track ...	300-46
CHAPTER 400 – INTERSECTIONS AT GRADE.....	400-1
Table 401.3 Vehicle Characteristics/Intersection Design Elements Affected.....	400-3
Figure 403.3A Angle of Intersection (Minor Leg Skewed to the Right).....	400-8
Figure 403.3.B Class II Bikeway Crossing Railroad .....	400-8
Figure 403.6A Typical Bicycle and Motor Vehicle Movements at Intersections of Multilane Streets without Right-Turn-Only Lanes.....	400-10
Figure 403.6B Bicycle Left-Turn-Only Lane .....	400-12
Figure 404.5A STAA Design Vehicle 56-Foot Radius .....	400-19

Figure 404.5B	STAA Design Vehicle 67-Foot Radius .....	400-20
Figure 404.5C	California Legal Design Vehicle 50-Foot Radius .....	400-21
Figure 404.5D	California Legal Design Vehicle 60-Foot Radius .....	400-22
Figure 404.5E	40-Foot Bus Design Vehicle.....	400-23
Figure 404.5F	45-Foot Bus & Motorhome Design Vehicle .....	400-24
Figure 404.5G	60-Foot Articulated Bus Design Vehicle.....	400-25
Table 405.1B	Application of Sight Distance Requirements .....	400-28
Figure 405.1	Corner Sight Distance (b).....	400-29
Table 405.1A	Corner Sight Distance Time Gap (T <sub>g</sub> ) for Unsignalized .....	Intersections..... 400-29
Figure 405.2A	Standard Left-turn Channelization .....	400-31
Figure 405.2B	Minimum Median Left-turn Channelization (Widening on one Side of Highway).....	400-32
Figure 405.2C	Minimum Median Left-turn Channelization (Widening on Both Sides in Urban Areas with Short Blocks) .....	400-33
Table 405.2A	Bay Taper for Median Speed-change Lanes.....	400-35
Table 405.2B	Deceleration Lane Length .....	400-35
Table 405.4	Parabolic Curb Flares Commonly Used .....	400-39
Figure 405.4	Pedestrian Refuge Island.....	400-40
Figure 405.5	Typical Design for Median Openings .....	400-42
Figure 405.7	Public Road Intersections .....	400-44
Figure 405.9	Widening of Two-lane Roads at Signalized Intersections .....	400-45
Figure 405.10	Roundabout Geometric Elements .....	400-47
Table 406	Vehicle Traffic Flow Conditions at Intersections at Various Levels of Operation .....	400-57
Figure 406A	Spread Diamond .....	400-58
Figure 406B	Tight Diamond.....	400-59
Figure 406C	Two-quadrant Cloverleaf.....	400-60
CHAPTER 500 – TRAFFIC INTERCHANGES.....		500-1
Figure 502.2	Typical Local Street Interchanges .....	500-3
Figure 502.2	Typical Local Street Interchanges (Cont.).....	500-4
Figure 502.3	Typical Freeway-to-freeway Interchanges .....	500-9

Figure 502.3	Typical Freeway-to-freeway Interchanges (Cont.) .....	500-10
Figure 504.2A	Single Lane Freeway Entrance.....	500-13
Figure 504.2B	Single Lane Freeway Exit .....	500-14
Figure 504.2C	Location of Freeway Ramps on a Curve.....	500-15
Table 504.3	Ramp Widening for Trucks .....	500-17
Figure 504.3A	Typical Freeway Entrance Loop Ramp Metering (1 GP Lane + 1 HOV Preferential Lane) .....	500-19
Figure 504.3B	Typical Successive Freeway Entrance Ramp Metering (1 GP Lane + 1 HOV Preferential Lane).....	500-20
Figure 504.3C	Restrictive Condition Freeway Entrance Ramp Metering (1 GP Lane) .....	500-22
Figure 504.3D	Restrictive Condition Freeway Entrance Loop Ramp Metering (1 GP Lane).....	500-23
Figure 504.3E	Typical Multilane Freeway Diagonal Entrance Ramp Metering (2 GP Lanes + 1 HOV Preferential Lane).....	500-25
Figure 504.3F	Typical Multilane Freeway Loop Entrance Ramp Metering (2 GP Lanes + 1 HOV Preferential Lane).....	500-26
Figure 504.3G	Typical Freeway-to-Freeway Connector Ramp Metering (1 GP Lane + 1 HOV Preferential Lane).....	500-28
Figure 504.3H	Typical Freeway-to-Freeway Connector Ramp Metering (2 GP Lanes + 1 HOV Preferential Lane).....	500-29
Figure 504.3I	Location of Ramp Intersections on the Crossroads .....	500-33
Figure 504.3J	Transition to Two-lane Exit Ramp .....	500-34
Figure 504.3K	Two-Lane Connectors and Entrance/Exit Ramps .....	500-35
Figure 504.4	Diverging Branch Connections .....	500-39
Figure 504.7A	Design Curve for Freeway and Collector Weaving .....	500-41
Figure 504.7B	Lane Configuration of Weaving Sections .....	500-42
Table 504.7C	Percent of Through Traffic Remaining in Outer Through Lane (Level of Service D Procedure).....	500-43
Figure 504.7D	Percentage Distribution of On- and Off-ramp Traffic in Outer Through Lane and Auxiliary Lane (Level of Service D Procedure).....	500-44
Figure 504.7E	Percentage of Ramp Traffic in the Outer Through Lane (No Auxiliary Lane) (Level of Service D Procedure).....	500-45
Figure 504.8	Typical Examples of Access Control at Interchanges .....	500-47

CHAPTER 600 – GENERAL ASPECTS .....	600-1
Figure 602.1      Basic Pavement Layers of the Roadway.....	600-2
CHAPTER 610 – PAVEMENT ENGINEERING CONSIDERATIONS .....	610-1
Table 613.3A      ESAL Constants.....	610-8
Table 613.3B      Lane Distribution Factors .....	610-8
Table 613.3C      Conversion of ESAL to Traffic Index .....	610-9
Table 613.4A      Traffic Index (TI) Values for Ramps and Connectors .....	610-11
Figure 613.4A      Shoulder Design for Design Traffic or TI Equal to Adjacent Lane Design Traffic or TI.....	610-14
Figure 613.4B      Shoulder Design for Design Traffic or TI Less Than Adjacent Lane Design Traffic or TI.....	610-15
Table 613.4B      Minimum TI's for Safety Roadside Rest Areas.....	610-20
Table 614.2      Unified Soil Classification System (from ASTM D 2487) .....	610-22
Table 614.3      Typical Resilient Modulus and Poisson's Ratios for Subgrade Soils.....	610-24
Figure 615.1      Pavement Climate Regions.....	610-28
CHAPTER 620 – PAVEMENT ENGINEERING CONSIDERATIONS .....	620-1
Figure 621.1      Types of Rigid Pavement.....	620-3
Table 622.1      Concrete Properties Used in Developing Rigid Pavement .....	620-5
Table 622.2      Concrete Pavement Performance Factors .....	620-6
Table 622.5      Use of Terminal Joints and Expansion Joints in CRCP.....	620-9
Figure 622.5      Expansion Terminal Joint System Between CRCP and Structure Approach Slab .....	620-10
Table 623.1A      Assumptions Adopted in PMED for JPCP Design.....	620-15
Table 623.1B      Assumptions Adopted in PMED for SJPCP COA Design.....	620-16
Table 623.1C(a)    Group I Climate (SC and NC) and WIM 1 2 .....	620-18
Table 623.1C(b)    Group I Climate (SC and NC) and WIM 3 .....	620-18
Table 623.1C(c)    Group I Climate (SC and NC) and WIM 4 5 .....	620-19
Table 623.1C(d)    Group II Climate (CC, LM, SM, HM, and HD) and WIM 1 2 .....	620-19
Table 623.1C(e)    Group II Climate (CC, LM, SM, HM, and HD) and WIM 3 .....	620-20

**September 29, 2023**

Table 623.1C(f)	Group II Climate (CC, LM, SM, HM, and HD) and WIM 4 5.....	620-20
Table 623.1C(g)	Group III Climate (IV and DE) and WIM 1 2.....	620-21
Table 623.1C(h)	Group III Climate (IV and DE) and WIM 3.....	620-21
Table 623.1C(i)	Group III Climate (IV and DE) and WIM 4 5.....	620-22
Table 623.1D	Requirements for JPCP and CRCP Bases .....	620-22
Table 623.1E	Requirements for JPCP and CRCP Subbases .....	620-23
Table 623.1F(a)	Type I Subgrade and Group I Climate (CC and NC).....	620-25
Table 623.1F(b)	Type I Subgrade and Group II Climate (SM, DE, HD, IV, LM, SC, and HM)	620-25
Table 623.1F(c)	Type II Subgrade and Group I Climate (CC and NC).....	620-26
Table 623.1F(d)	Type II Subgrade and Group II Climate (SM, DE, HD, IV, LM, SC, and HM)	620-26
Figure 626.1	Preferred Limits of Rigid Pavement at Flexible Pavement Ramp .....	620-30
	or Connector Gore Area.....	620-30
Table 626.2	Shoulder Concrete Pavement Designs (“S” Dimension).....	620-32
Figure 626.2A	Rigid Shoulders Through Ramp and Gore Areas .....	620-33
Figure 626.2B	Widened Slab Shoulder with Concrete Remainder Designs.....	620-34
Figure 626.4	Rigid Bus Pad .....	620-36
CHAPTER 630 – FLEXIBLE PAVEMENT .....		630-1
Table 632.1	Asphalt Binder Performance Grade Selection .....	630-8
Table 633.1A	Selecting ME Project Type and Materials .....	630-13
Table 633.1B	Minimum Class 2 AB Thicknesses for Different Subgrade Soils....	630-16
Table 636.4	Minimum Pavement Structures for Park & Ride Facilities.....	630-26



CHAPTER 650 – PAVEMENT DRAINAGE ..... 650-1

Figure 651.2A Typical Section with Treated Permeable Base Drainage Layer ..... 650-3

Figure 651.2B Cross Drain Interceptor Details For Use with Treated Permeable Base ..... 650-5

Figure 651.2C Cross Drain Interceptor Trenches ..... 650-6

CHAPTER 660 – PAVEMENT FOUNDATIONS ..... 660-1

Table 663.3 Default Resilient Moduli for Bases and Subbases Used in Flexible Pavement Design..... 660-7

Figure 665.5 Flowchart for SEG Selection ..... 660-12

CHAPTER 670 – TAPERS AND SHOULDER BACKING ..... 670-1

Figure 671.2A Tapering Into a Previously Overlaid Pavement ..... 670-2

Figure 671.2B New Structure Approach Pavement Transition Details ..... 670-3

Figure 671.3A Transverse Transition Tapers for Pavement Preservation Projects . 670-5

Figure 671.3B Longitudinal Tapers at Shoulders, Curbs, Dikes, Inlets, and Guardrail ..... 670-6

Figure 671.3C Transition Taper Underneath Overcrossing/Bridge ..... 670-7

Figure 672.3A Typical Application of Shoulder Backing ..... 670-10

Figure 672.3B Alternative Placement for Existing Slopes Steeper than 6:1 ..... 670-10

Figure 672.3C Placement of Shoulder Backing Thickness Greater Than 0.50 foot for Slope Repair ..... 670-11

Figure 672.3D Placement of Shoulder Backing Behind Dikes ..... 670-11

Figure 672.3E Longitudinal Drainage (Roadside Ditches/Gutters) ..... 670-12

CHAPTER 680 – PAVEMENT DESIGN FOR WIDENING PROJECTS ..... 680-1

Figure 682.4A Typical Concrete Pavement Widening Median Lane and Outer Lane ..... 680-9

Figure 682.4B Widening Previously Cracked, Sealed, and HMA Overlay Concrete Pavement in Good Condition ..... 680-10

Figure 682.4C Widening Asphalt Pavement in Good Condition ..... 680-11

CHAPTER 800 – GENERAL ASPECTS ..... 800-1

Figure 804.7A Technical Information for Location Hydraulic Study ..... 800-13

Figure 804.7B Floodplain Evaluation Report Summary ..... 800-15

Table 808.1	Summary of Related Computer Programs and Web Applications	800-50
CHAPTER 800 – HYDROLOGY		810-1
Figure 812.1	Automated Watershed Delineation	810-3
Figure 813.1	Post-Fire Debris	810-8
Figure 816.5	Typical Flood Hydrograph	810-14
Table 816.6A	Roughness Coefficients For Sheet Flow	810-16
Table 816.6B	Intercept Coefficients for Shallow Concentrated Flow	810-17
Figure 816.6	Velocities for Upland Method of Estimating Travel Time for Shallow Concentrated Flow	810-18
Figure 816.7	Digital Elevation Map (DEM)	810-19
Figure 817.2	Gaging Station	810-20
Figure 817.3	High Water Marks	810-20
Figure 818.1	Overtopping Flood	810-22
Figure 818.2	Maximum Historic Flood	810-22
Figure 819.2A	Runoff Coefficients for Undeveloped Areas Watershed Types	810-27
Table 819.2B	Run off Coefficients for Developed Areas <sup>(1)</sup>	810-28
Figure 819.2C	Regional Flood-Frequency Regions	810-30
Figure 819.4	Basic Steps to Developing and Applying a Rainfall-runoff Model for Predicting the Required Design Flow	810-34
Table 819.5A	Summary of Methods for Estimating Design Discharge	810-35
Figure 819.7A	Desert Regions in California	810-38
Table 819.7A	Regional Regression Equations for California’s Desert Regions	810-39
Table 819.7B	Runoff Coefficients for Desert Areas	810-41
Table 819.7C	Watershed Size for California Desert Regions	810-41
Figure 819.7B	Example Depth-Area Reduction Curve	810-43
Table 819.7D	Hydrologic Soil Groups	810-44
Table 819.7E	Curve Numbers for Land Use-Soil Combinations	810-46
Figure 819.7C	San Bernardino County Hydrograph for Desert Areas	810-48
Figure 819.7D	USBR Example S-Graph	810-49
Table 819.7F	Channel Routing Methods	810-51
Table 819.7G	Channel Method Routing Guidance	810-52

Table 819.7H	Design Storm Durations.....	810-53
Table 819.7I	Bulking Factors & Types of Sediment Flow.....	810-55
Figure 819.7E	Soil Slips vs. Slope Angle .....	810-55
Figure 819.7F	Alluvial Fan .....	810-56
Table 819.7J	Adjustment-Transportation Factor Table.....	810-60
Figure 819.7H	Recommended Bulking Factor Selection Process .....	810-61
CHAPTER – 820 CROSS DRAINAGE.....		820-1
Figure 821.1	Annual exceedance probability (AEP) of daily maximum ocean water level .....	820-6
Table 821.1	Boundaries, Locations and Length Scales of Water-level Provinces .....	820-8
Figure 821.2	California Open Coast and Bayfront Water Level Province Map.....	820-9
Figure 821.3A	One-Percent Compound Frequency Curve for Province 1, (Based on NOAA # 9419750, Crescent City).....	820-10
Figure 821.3B	One-Percent Compound Frequency Curve for Province 2, (Based on NOAA # 9418767, North Spit, Humboldt) .....	820-11
Figure 821.3C	One-Percent Compound Frequency Curve for Province 2a, (Based on NOAA # 9414290, Golden Gate Bridge).....	820-12
Figure 821.3D	One-Percent Compound Frequency Curve for Province 3, (Based on NOAA # 9413450, Monterey).....	820-13
Figure 821.3E	One-Percent Compound Frequency Curve for Province 4, (Based on NOAA # 9412110, Port San Luis).....	820-14
Figure 821.3F	One-Percent Compound Frequency Curve for Province 5, (Based on NOAA # 9411340, Santa Barbara) .....	820-15
Figure 821.3G	One-Percent Compound Frequency Curve for Province 6, (Based on NOAA # 9410660, Los Angeles).....	820-16
Figure 821.3H	One-Percent Compound Frequency Curve for Province 7, (Based on NOAA # 9410230, La Jolla Scripps Pier).....	820-17
Figure 821.3I	One-Percent Compound Frequency Curve for Province 8, (Based on NOAA # 9414750, Alameda) .....	820-18
Figure 821.3J	One-Percent Compound Frequency Curve for Province 9, (Based on NOAA # 9415056, Pinole Point, San Pablo Bay).....	820-19
Figure 821.3K	One-Percent Compound Frequency Curve for Province 9a, (Based on NOAA # 9415144, Port Chicago).....	820-20

**September 29, 2023**

Figure 821.3L	One-Percent Compound Frequency Curve for Province 10, ..... (Based on NOAA # 9414523, Redwood City) .....	820-21
Figure 821.3M	One-Percent Compound Frequency Curve for Province 11, ..... (Based on NOAA # 9410170, San Diego Bay, Navy Pier) .....	820-22
Figure 821.3N	One-Percent Compound Frequency Curve for Province 12, ..... (Based on Otay River Sonde) .....	820-23
Figure 821.4	Distances needed to guide interpolation .....	820-24
Figure 821.5	Weighting factor, Kx for interpolation .....	820-25
CHAPTER 830 – TRANSPORTATION FACILITY DRAINAGE.....		830-1
Table 831.3	Desirable Roadway Drainage Guidelines .....	830-4
Figure 834.3	Side Gutter and Trapezoidal Channel.....	830-9
Figure 837.1	Storm Drain Inlet Types .....	830-14
Table 838.4	Minimum Pipe Diameter for Storm Drain Systems.....	830-23
CHAPTER 840 – SUBSURFACE DRAINAGE.....		840-1
Table 842.4	Suggested Depth and Spacing of Pipe Underdrains .....	840-6
CHAPTER 850 – PHYSICAL STANDARDS .....		850-1
Table 851.2	Manning "n" Value for Alternative Pipe Materials <sup>(1)</sup> .....	850-2
Table 853.1A	Allowable Alternative Pipe Liner Materials .....	850-13
Table 853.1B	Guide for Plastic Pipeliner Selection in Abrasive Conditions <sup>(2)</sup> .....	850-15
Table 854.1	Joint Leakage Selection Criteria .....	850-21
Figure 855.1	Minor Bedload Volume.....	850-24
Figure 855.2	Abrasion Test Panels.....	850-25
Table 855.2A	Abrasion Levels and Materials .....	850-26
Table 855.2B	Bed Materials Moved by Various Flow Depths and Velocities .....	850-30
Table 855.2C	Guide for Anticipated Service Life Added to Steel Pipe by .....	850-31
Table 855.2D	Guide for Anticipated Wear to Metal Pipe by Abrasive .....	850-32
	Channel Materials .....	

Table 855.2E	Relative Abrasion Resistance Properties of Pipe and Lining Materials* .....	850-32
Table 855.2F	Guide for Minimum Material Thickness of Abrasive Resistant Invert Protection to Achieve 50 Years of Maintenance-Free Service Life .....	850-33
Figure 855.3A	Minimum Thickness of Metal Pipe for 50-Year Maintenance-Free Service Life <sup>(2)</sup> .....	850-36
Figure 855.3B	Chart for Estimating Years to Perforation of Steel Culverts .....	850-37
Table 855.4A	Guide for the Protection of Cast-In-Place and Precast Reinforced and Unreinforced Concrete Structures <sup>(5)</sup> Against Acid and Sulfate Exposure Conditions <sup>(1),(2)</sup> .....	850-38
Table 855.4B	Guide for Minimum Cover Requirements for Cast-In-Place and Precast Reinforced Concrete Structures <sup>(3)</sup> for 50-Year Design Life in Chloride Environments .....	850-39
Table 856.3A	Corrugated Steel Pipe Helical Corrugations.....	850-44
Table 856.3B	Corrugated Steel Pipe Helical Corrugations.....	850-45
Table 856.3C	Corrugated Steel Pipe 2 <sup>2</sup> / <sub>3</sub> " x 1/2" Annular Corrugations.....	850-46
Table 856.3D	Corrugated Steel Pipe Arches 2 <sup>2</sup> / <sub>3</sub> " x 1/2" Helical or Annular Corrugations .....	850-47
Table 856.3E	Steel Spiral Rib Pipe 3/4" x 1" Ribs at 11 1/2" Pitch.....	850-48
Table 856.3F	Steel Spiral Rib Pipe 3/4" x 1" Ribs at 8 1/2" Pitch.....	850-49
Table 856.3G	Steel Spiral Rib Pipe 3/4" x 3/4" Ribs at 7 1/2" Pitch.....	850-50
Table 856.3H	Corrugated Aluminum Pipe Annular Corrugations .....	850-51
Table 856.3I	Corrugated Aluminum Pipe Helical Corrugations.....	850-52
Table 856.3J	Corrugated Aluminum Pipe Arches 2 <sup>2</sup> / <sub>3</sub> " x 1/2" Helical or Annular Corrugations .....	850-53
Table 856.3K	Aluminum Spiral Rib Pipe 3/4" x 1" Ribs at 11 1/2" Pitch.....	850-54
Table 856.3L	Aluminum Spiral Rib Pipe 3/4" x 3/4" Ribs at 7 1/2" Pitch.....	850-54
Table 856.3M	Structural Steel Plate Pipe 6" x 2" Corrugations .....	850-55
Table 856.3N	Structural Steel Plate Pipe Arches 6" x 2" Corrugations .....	850-56
Table 856.3O	Structural Aluminum Plate Pipe 9" x 2 1/2" Corrugations.....	850-57
Table 856.3P	Structural Aluminum Plate Pipe Arches 9" x 2 1/2" Corrugations.....	850-58
Table 856.4	Thermoplastic Pipe Fill Height Tables.....	850-59
Table 856.5	Minimum Thickness of Cover for Culverts.....	850-60
Table 857.2	Allowable Alternative Materials .....	850-63

CHAPTER 860 – ROADSIDE CHANNELS.....	860-1
Figure 861.1 Small Roadside Channel .....	860-1
Figure 861.2 Roadside Channel Outlet to Storm Drain at Drop Inlet .....	860-2
Figure 861.3 Damaged Channel .....	860-4
Figure 861.4 Concrete Lined Channel with Excessive Weed Growth.....	860-5
Figure 862.1 Small-Rock Lined Channel Outside of Clear Recovery Zone .....	860-7
Figure 863.1 Small-Rock Lined Triangular Channel with Rounded Bottom .....	860-9
Figure 865.1 Steep-Sloped Channel with Composite Vegetative Lining .....	860-13
Table 865.1 Concrete <sup>(2)</sup> Channel Linings.....	860-14
Figure 865.2 Concrete Lined Channel .....	860-14
Figure 865.3 Long-Term Flexible Lining .....	860-16
Figure 865.4 Grass-Lined Median Channel .....	860-18
Table 865.2 Permissible Shear and Velocity for Selected Lining Materials <sup>(2)</sup> ....	860-20
Table 866.3A Average Values for Manning's Roughness Coefficient (n).....	860-26
Figure 866.3C Specific Energy Diagram .....	860-27
Table 868.2 Guide to Freeboard Height .....	860-31
CHAPTER 870 – BANK PROTECTION – EROSION CONTROL.....	870-1
Table 872.1 Guide to Selection of Protection .....	870-3
Figure 872.1 Stream Classification .....	870-10
Figure 872.2 Diagram of a Braided River Channel .....	870-11
Figure 872.3 Bed Load and Suspended Load .....	870-14
Figure 872.4 Longitudinal Encroachments.....	870-15
Figure 872.5 Slope Failure Due to Loss of Toe .....	870-19
Table 872.2 Failure Modes and Effects Analysis for Riprap Revetment.....	870-20
Figure 872.6 Mature Valley with Meandering Stream .....	870-23
Figure 872.7 Alternative Highway Locations Across Debris Cone .....	870-25
Figure 872.8 Alluvial Fan .....	870-26
Figure 872.9 Desert Wash Longitudinal Encroachment.....	870-26
Figure 872.10 Stage Construction .....	870-27
Figure 873.3A Stone Shape .....	870-35

Table 873.3A	RSP Class by Median Particle Size <sup>(3)</sup> .....	870-36
Table 873.3B	RSP Class by Median Particle Weight <sup>(3)</sup> .....	870-37
Figure 873.3B	Medium Density Vegetation .....	870-44
Figure 873.3C	Gabion Lined Streambank .....	870-45
Figure 873.3D	Rock Slope Protection.....	870-46
Figure 873.3E	Concreted-Rock Slope Protection.....	870-47
Figure 873.3F	Toe Failure – Concreted RSP .....	870-48
Figure 873.4A	Thalweg Redirection Using Bendway Weirs .....	870-53
Figure 873.4B	Bendway Weir Typical Cross Section and Layout.....	870-55
Figure 873.4C	Bendway Weir Rock Size Chart .....	870-56
Figure 873.4D	Example of Spur Design .....	870-57
Figure 873.4E	Bridge Abutment Guide Banks.....	870-58
Figure 873.6A	Bridge Abutment Failure Example .....	870-61
Figure 873.6B	Habitat Enhancement Example.....	870-62
Figure 873.6C	Lateral Stream Migration Within a Canyon Setting Example.....	870-63
Figure 873.6D	Conceptual Geotechnical Failures Resulting from .....	
	Abutment Scour .....	870-63
CHAPTER 880 – SHORE PROTECTION .....		880-1
Figure 883.2A	Nomenclature of Tidal Ranges.....	880-7
Figure 883.2B	Significant Wave Height Prediction Nomograph .....	880-11
Figure 883.2C	Design Breaker Wave .....	880-12
Figure 883.2D	California 12 Tide Gauges .....	880-14
Figure 883.2E	Crescent City Example.....	880-16
Table 883.1A	Crescent City Example Comparison for 2060 .....	880-17
Table 883.1B	Projected Sea-Level Rise (feet) at Crescent City.....	880-18
Figure 883.2F	Crescent City MHHW .....	880-20
Figure 883.2G	Wave Run-up on Smooth Impermeable Slope.....	880-22
Figure 883.2H	RSP Lined Ocean Shore.....	880-22
Table 883.2	Dimensionless Breaker Parameter and Wave Types.....	880-24
Figure 883.2I	Rock Slope Protection.....	880-26
Figure 883.2J	Typical Groin Layout with Resultant Beach Configuration .....	880-29

**September 29, 2023**

Figure 883.2K	Alignment of Groins to an Oblique Sea Warrants Shortening Proportional to Cosine of Obliquity.....	880-30
Figure 883.2L	Typical Stone Dike Groin Details .....	880-31
CHAPTER 890 – STORM WATER MANAGEMENT .....		890-1
Figure 892.3	Example of Cumulative Hydrograph With and Without Detention....	890-4
CHAPTER 900 – LANDSCAPE ARCHITECTURE – ROADSIDES .....		900-1
Table 904.5	Large Tree Setback Requirements on Conventional Highways.....	900-11
CHAPTER 910 – LANDSCAPE ARCHITECTURE – ROADSIDE SITES .....		910-1
Table 912.2	Vehicle Parking Stall Standards.....	910-3
CHAPTER 1000 – BICYCLE TRANSPORTATION DESIGN .....		1000-1
Figure 1003.1A	Two-Way Class I Bikeway (Bike Path).....	1000-7
Figure 1003.1B	Typical Cross Section of Class I Bikeway (Bike Path) Parallel to Highway .....	1000-9
Table 1003.1	Bike Path Design Speeds .....	1000-11
Figure 1003.1C	Minimum Length of Bicycle Path Crest Vertical Curve (L) Based on Stopping Sight Distance (S).....	1000-12
Figure 1003.1D	Minimum Lateral Clearance (m) on Bicycle Path Horizontal Curves .....	1000-13
Figure 1003.5	Railroad Crossing Class I Bikeway .....	1000-19