



AASHTO

AASHTO Guide Specifications for

# LRFD SEISMIC BRIDGE DESIGN

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## FOREWORD

The scope of the *AASHTO Guide Specifications for LRFD Seismic Bridge Design* covers the design and construction of new conventional bridges to resist the effects of earthquake motions, and applies to bridges not classified as Critical or Recovery. The title of the document reflects the fact that these Guide Specifications are approved as an alternate to the seismic provisions in the *AASHTO LRFD Bridge Design Specifications*. These Guide Specifications differ from the procedures in the *AASHTO LRFD Bridge Design Specifications* in the use of displacement-based design procedures, instead of the traditional, force-based design method. Also included are detailed guidance and commentary on earthquake-resisting elements and systems, global design strategies, demand modeling, capacity calculation, liquefaction effects, and risk-targeted ground motions. Similar to the LRFD force-based design method, capacity design procedures underpin the Guide Specifications methodology, and these procedures include prescriptive detailing for plastic hinging regions and design requirements for capacity protection of those elements that should not experience damage.

It is expected that these Guide Specifications will continue to be revised as refinements and improvements become available.

AASHTO Committee on Bridges and Structures

## PREFACE

This third edition of the *Guide Specifications for LRFD Seismic Bridge Design* includes technical content approved by the AASHTO Committee on Bridges and Structures. In addition to revising the second-edition content, the design ground motions have been updated to a risk-targeted approach, which differs from the previous uniform-hazard methodology. This is explained in detail in the new Appendix C, “Risk-Targeted Ground Motions.”

An abbreviated table of contents follows this preface. Detailed tables of contents precede each Section and Appendix.

AASHTO Publications Staff

## ABBREVIATED TABLE OF CONTENTS

SECTION 1: INTRODUCTION .....	1-i
SECTION 2: DEFINITIONS AND NOTATION.....	2-i
SECTION 3: GENERAL REQUIREMENTS .....	3-i
SECTION 4: ANALYSIS AND DESIGN REQUIREMENTS .....	4-i
SECTION 5: ANALYTICAL MODELS AND PROCEDURES .....	5-i
SECTION 6: FOUNDATION AND ABUTMENT DESIGN .....	6-i
SECTION 7: STRUCTURAL STEEL COMPONENTS .....	7-i
SECTION 8: REINFORCED CONCRETE COMPONENTS .....	8-i
REFERENCES.....	2-1
APPENDIX A: FOUNDATION-ROCKING ANALYSIS .....	A-i
APPENDIX B: DESIGN FLOWCHARTS .....	B-i
APPENDIX C: RISK-TARGETED GROUND MOTIONS .....	C-i

SECTION 1: INTRODUCTION  
**TABLE OF CONTENTS**

1.1—BACKGROUND..... 1-1  
1.2—TECHNICAL ASSISTANCE AGREEMENT BETWEEN AASHTO AND USGS ..... 1-2  
1.3—FLOWCHARTS..... 1-2

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SECTION 1:  
INTRODUCTION

## 1.1—BACKGROUND

The state of practice of the seismic design of bridges is continually evolving, and the *AASHTO Guide Specifications for LRFD Seismic Bridge Design* were developed to incorporate improvements in the practice that have emerged since publication of ATC 6, *Seismic Design Guidelines for Highway Bridges*, the basis of the current AASHTO seismic design provisions. While small improvements have been incorporated into the AASHTO seismic design procedures in the intervening years since ATC 6 was published in 1981, the publication of the First Edition of these Guide Specifications in 2009 and related changes to the current *AASHTO LRFD Bridge Design Specifications* represented a major overhaul of the AASHTO procedures.

The development of the First Edition of these Guide Specifications was performed in accordance with the recommendations of the NCHRP 20-07/Task 193 Task 6 Report. The Task 6 effort combined and supplemented existing completed efforts (i.e., AASHTO Standard Specifications Division I-A, NCHRP 12-49 guidelines, SCDOT specifications, Caltrans *Seismic Design Criteria*, NYCDOT *Seismic Intensity Maps* (1998), and ATC-32) into a single document that could be used at a national level to design bridges for seismic effects. Based on the Task 6 effort and that of a number of reviewers, including representatives from state departments of transportation, the Federal Highway Administration, consulting engineers, and academic researchers, these Guide Specifications were developed.

These Guide Specifications were subsequently updated in 2011 as a Second Edition to make revisions based on observations from use of the First Edition of the Guide Specifications. The Second Edition included the addition of design flowcharts.

This Third Edition of the Guide Specifications involves the following changes:

- Adopts a risk-targeted approach for development of a design spectrum.
- Updates the 2002 AASHTO Seismic Ground Motion Maps to 2018 United States Geological Survey (USGS) National Seismic Hazard Model (NSHM), including the direct use of site class based on the time-averaged shear wave velocity in the upper 100 feet of geologic profile.

## C1.1

This commentary is included to provide additional information to clarify and explain the technical basis for the specifications provided in the *Guide Specifications for LRFD Seismic Bridge Design*. These Guide Specifications are for the design of new bridges.

The term “shall” denotes a requirement for compliance with these Guide Specifications.

The term “should” indicates a strong preference for a given criterion.

The term “may” indicates a criterion that is usable, but other local and suitably documented, verified, and approved criterion may also be used in a manner consistent with the LRFD approach to bridge design.

The term “recommended” is used to give guidance based on past experiences. Seismic design is a developing field of engineering that has not been uniformly applied to all bridge types; thus, the experiences gained to date on only a particular type are included as recommendations.

- Adds additional site classifications to provide a smoother transition between site classes.
- Provides a webtool for accessing the updated Seismic Design Ground Motion Database for 22 periods of ground motion response between 0 s and 10 s at 5 percent damping.
- Identifies additional procedures and makes modifications to account for the risk-targeted ground motions being used in these updated Guide Specifications, including the addition of Appendix C with background on the risk-targeting procedure.

## 1.2—GROUND MOTIONS

The USGS has prepared the AASHTO–USGS Seismic Design Ground Motion Database for AASHTO based on the 2018 USGS NSHM.

These guidelines use spectral response accelerations which have been determined to have a targeted risk of approximately 1.5 percent in 75 years based on a notional fragility function for incipient bridge column collapse as the basis of the seismic design requirements. The spectral accelerations are achieved through use of uniform hazard curves in conjunction with a notional fragility curve. Comparisons show that the risk-targeted ground motion at zero period—the Peak Ground Acceleration (PGA)—is also suitable for use in geotechnical hazard assessment.

This targeted risk-based approach produces uniform risk throughout the country, unlike the uniform hazard approach used previously which results in nonuniform risk due to the variance in the shape of hazard curves with location.

The risk-targeted ground motions can be accessed through the AASHTO–USGS Seismic Design Ground Motion Web Service available on the USGS website. The service includes features allowing the user to calculate the mapped spectral response acceleration coefficients,  $S_a$ , by latitude–longitude and for the specified site class. The design spectrum is developed from the  $S_a$  values provided at 22 different periods. Provisions are also available for conducting site-specific seismic hazard analyses using the risk-targeted approach, as well as conducting site-specific ground response analysis using ground motions developed from the risk-targeted spectrum.

## 1.3—FLOWCHARTS

The flowcharts herein provide the engineer with a simple reference to direct the design process needed for each of the four Seismic Design Categories (SDCs).

Flowcharts outlining the steps in the seismic design procedures implicit in these Guide Specifications are given in Figures 1.3-1 to 1.3-5.

These Guide Specifications were developed to allow three global seismic design strategies based on the characteristics of the bridge system, which include:

- *Type 1*—Design a ductile substructure with an essentially elastic superstructure.
- *Type 2*—Design an essentially elastic substructure with a ductile superstructure.
- *Type 3*—Design an elastic superstructure and substructure with a fusing mechanism at the interface between the superstructure and the substructure.

The flowcharts in Figures 1.3-1 through 1.3-5 address the design of bridges using the Type 1 design strategy. The flowchart in Figure 1.3-1 guides the designer on the applicability of these Guide Specifications and the seismic design procedure for bridges in SDC A and single-span bridges. Figures 1.3-2 through 1.3-4 show seismic design procedure flowcharts for bridges in SDC B through D respectively. Figure 1.3-5 shows foundation design and detailing flowcharts.

Alternate flowcharts are provided in Appendix B.

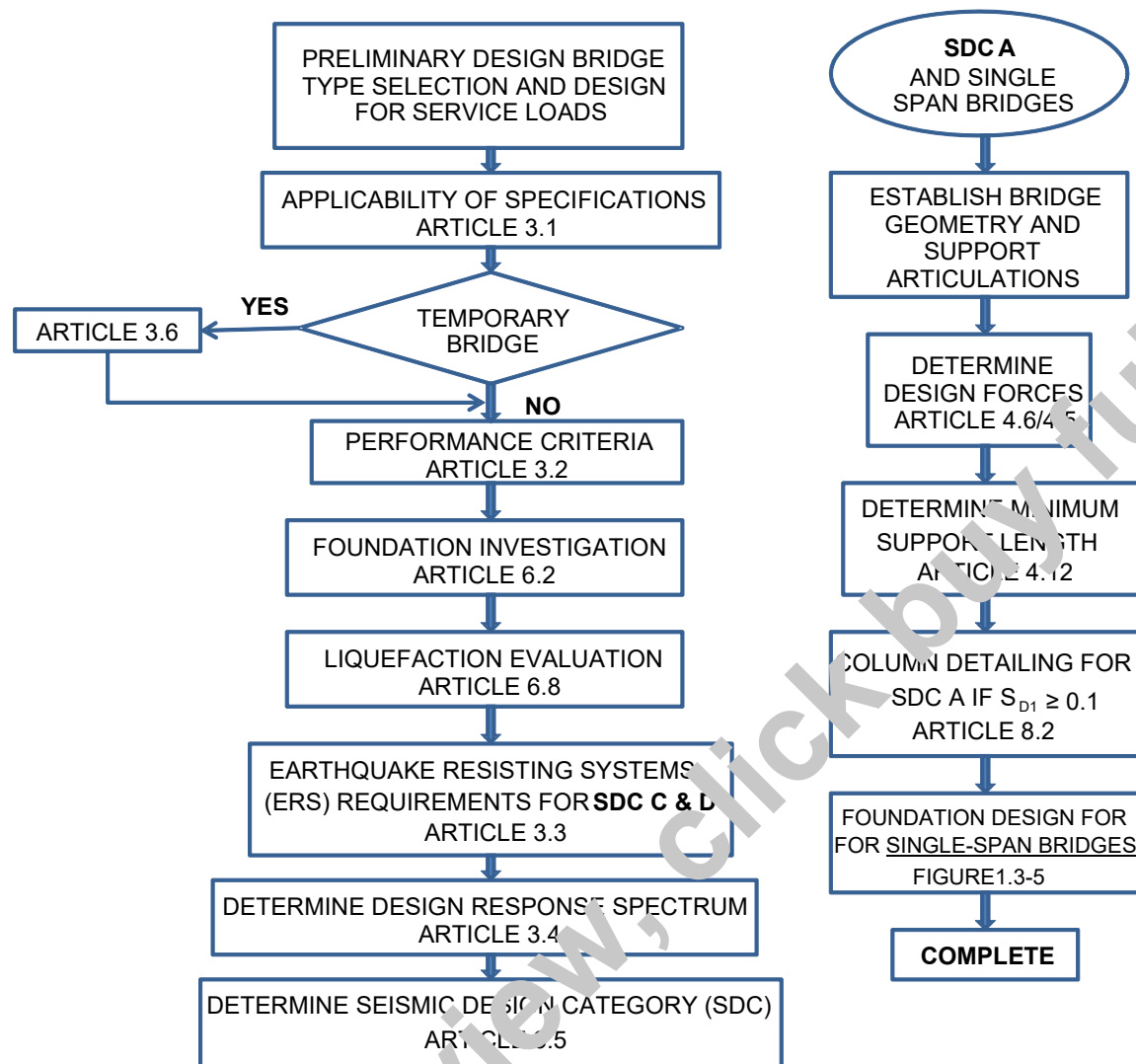


Figure 1.3-1—Applicability of the Guide Specifications and the Seismic Design Procedure for Bridges in SDC A and Single-Span Bridges

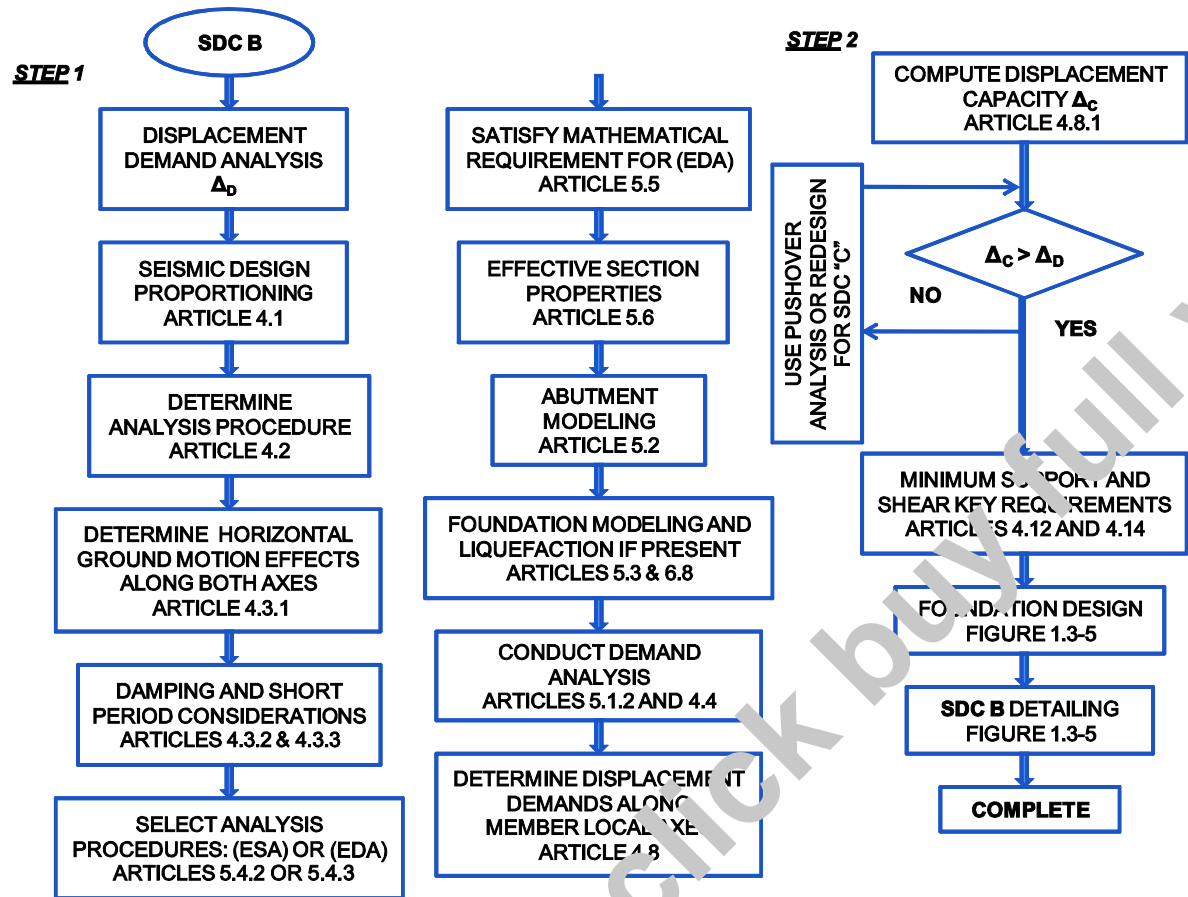


Figure 1.3-2—Seismic Design Procedure Flowchart for Bridges in SDC B

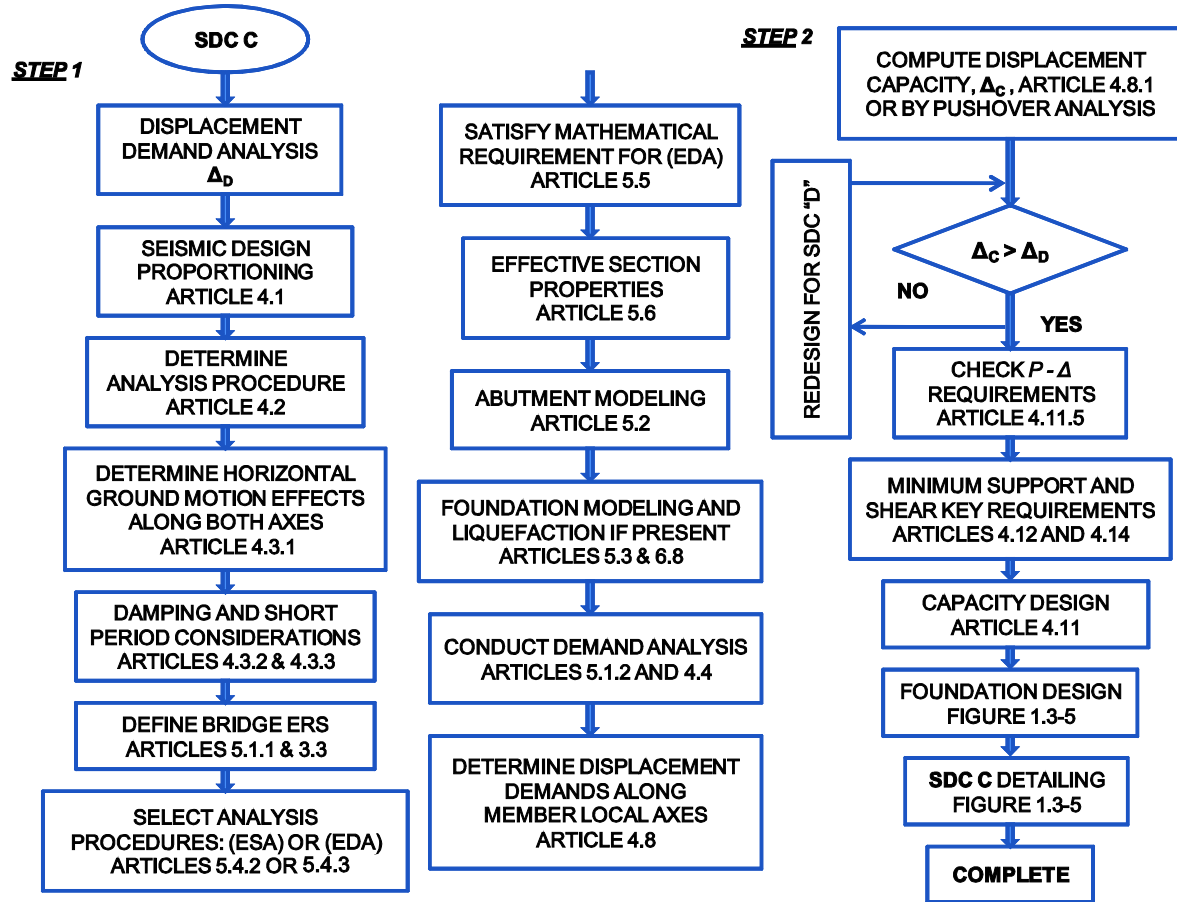


Figure 1.3-3—Seismic Design Procedure Flowchart for Bridges in SDC C

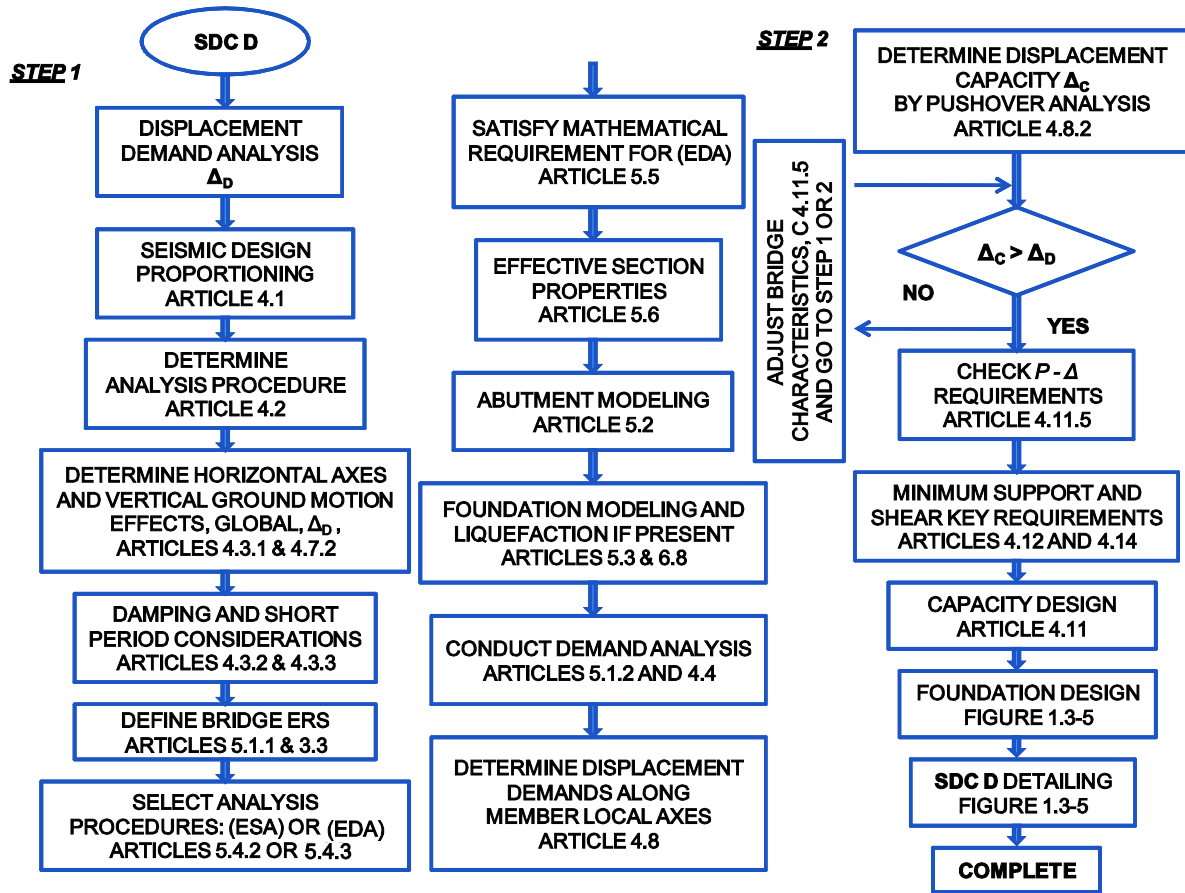
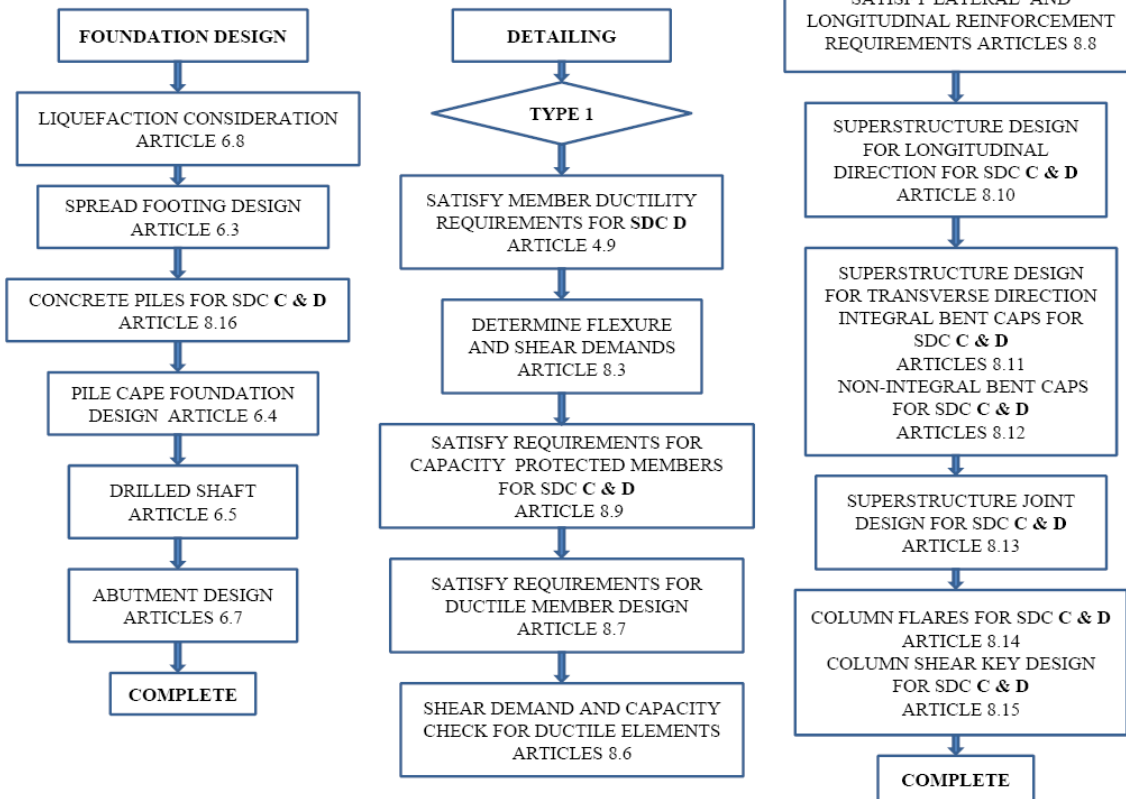


Figure 1.3-4—Seismic Design Procedure Flowchart for Bridges in SDC D

-TYPE 1: Ductile Substructure with an essentially elastic Superstructure



THE DETAILING FLOWCHARTS OF OTHER TYPES ARE SHOWN IN THE APPENDIX B

Figure 1.3-5—Foundation and Detailing Flowcharts

SECTION 2: DEFINITIONS AND NOTATION  
**TABLE OF CONTENTS**

2.1—DEFINITIONS ..... 2-1  
2.2—NOTATION ..... 2-2

SECTION 3: GENERAL REQUIREMENTS  
**TABLE OF CONTENTS**

3.1—APPLICABILITY OF GUIDE SPECIFICATIONS . . . . . 3-1

3.2—PERFORMANCE CRITERIA . . . . . 3-2

3.3—EARTHQUAKE-RESISTING SYSTEMS (ERS) REQUIREMENTS FOR SDCS C AND D . . . . . 3-4

3.4—SEISMIC DESIGN GROUND MOTION. . . . . 3-14

    3.4.1—Design Spectra Based on General Procedure. . . . . 3-16

    3.4.2—Site Effects on Ground Motions . . . . . 3-17

        3.4.2.1—Site Class Definitions . . . . . 3-18

        3.4.2.2—Definitions of Site Class Parameters . . . . . 3-20

    3.4.3—Response Spectra Based on Site-Specific Procedures . . . . . 3-22

        3.4.3.1—Site-Specific Hazard Analysis . . . . . 3-23

        3.4.3.2—Site-Specific Ground Motion Response Analysis. . . . . 3-24

    3.4.4—Acceleration Time Histories. . . . . 3-27

3.5—SELECTION OF SEISMIC DESIGN CATEGORY (SDC). . . . . 3-29

3.6—TEMPORARY AND STAGED CONSTRUCTION . . . . . 3-32

3.7—LOAD AND RESISTANCE FACTORS. . . . . 3-33

## TABLE OF CONTENTS

4.1—GENERAL . . . . .	4-1
4.1.1—Application . . . . .	4-1
4.1.2—Balanced Stiffness SDC D . . . . .	4-1
4.1.3—Balanced Frame Geometry SDC D . . . . .	4-4
4.1.4—Adjusting Dynamic Characteristics . . . . .	4-4
4.1.5—End Span Considerations . . . . .	4-5
4.2—SELECTION OF ANALYSIS PROCEDURE TO DETERMINE SEISMIC DEMAND . . . . .	4-5
4.2.1—Special Requirements for Curved Bridges . . . . .	4-6
4.2.2—Limitations and Special Requirements . . . . .	4-7
4.3—DETERMINATION OF SEISMIC LATERAL DISPLACEMENT DEMANDS . . . . .	4-7
4.3.1—Horizontal Ground Motions . . . . .	4-7
4.3.2—Displacement Modification for Other than Five Percent Damped Bridges . . . . .	4-8
4.3.3—Displacement Magnification for Short-Period Structures . . . . .	4-8
4.4—COMBINATION OF ORTHOGONAL SEISMIC DISPLACEMENT DEMANDS . . . . .	4-10
4.5—DESIGN REQUIREMENTS FOR SINGLE-SPAN BRIDGES . . . . .	4-10
4.6—DESIGN REQUIREMENTS FOR SEISMIC DESIGN CATEGORY A . . . . .	4-11
4.7—DESIGN REQUIREMENTS FOR SEISMIC DESIGN CATEGORIES B, C, AND D . . . . .	4-13
4.7.1—Design Methods for Lateral Seismic Displacement Demands . . . . .	4-13
4.7.2—Vertical Ground Motion, Design Requirements for SDC D . . . . .	4-14
4.8—STRUCTURE DISPLACEMENT DEMAND/CAPACITY FOR SDCs B, C, AND D . . . . .	4-15
4.8.1—Local Displacement Capacity for SDCs B and C . . . . .	4-17
4.8.2—Local Displacement Capacity for SDC D . . . . .	4-18
4.9—MEMBER DUCTILITY REQUIREMENT FOR SDC D . . . . .	4-19
4.10—COLUMN SHEAR REQUIREMENTS FOR SDCs B, C, AND D . . . . .	4-22
4.11—CAPACITY DESIGN REQUIREMENT FOR SDCs B, C, AND D . . . . .	4-22
4.11.1—Capacity Design . . . . .	4-22
4.11.2—Plastic Hinging Forces . . . . .	4-23
4.11.3—Single Columns and Piers . . . . .	4-26
4.11.4—Bents with Two or More Columns . . . . .	4-28
4.11.5— $P$ - $\Delta$ Capacity Requirement for SDCs C and D . . . . .	4-29
4.11.6—Analytical Plastic Hinge Length . . . . .	4-30
4.11.7—Reinforced Concrete Column Plastic Hinge Region . . . . .	4-31
4.11.8—Steel Column Plastic Hinge Region . . . . .	4-31
4.12—MINIMUM SUPPORT LENGTH REQUIREMENTS . . . . .	4-32
4.12.1—General . . . . .	4-32
4.12.2—Seismic Design Categories A, B, and C . . . . .	4-32
4.12.3—Seismic Design Category D . . . . .	4-33
4.13—SUPPORT RESTRAINTS . . . . .	4-34
4.13.1—Longitudinal Restrainers . . . . .	4-34
4.13.2—Simple Span Superstructures . . . . .	4-34
4.13.3—Detailing Restrainers . . . . .	4-35
4.14—SUPERSTRUCTURE SHEAR KEYS . . . . .	4-35

## TABLE OF CONTENTS

5.1—GENERAL . . . . .	5-1
5.1.1—Analysis of a Bridge ERS . . . . .	5-1
5.1.2—Global Model . . . . .	5-2
5.2—ABUTMENTS . . . . .	5-4
5.2.1—General . . . . .	5-4
5.2.2—Wingwalls . . . . .	5-4
5.2.3—Longitudinal Direction . . . . .	5-5
5.2.3.1—Abutment Longitudinal Response for SDCs B and C . . . . .	5-6
5.2.3.2—Abutment Longitudinal Response for SDC D . . . . .	5-6
5.2.3.3—Abutment Stiffness and Passive Pressure Estimate . . . . .	5-7
5.2.3.3.1—Calculation of Best Estimate Passive Pressure $p_p$ . . . . .	5-8
5.2.3.3.2—Calculation of Soil Stiffness . . . . .	5-8
5.2.4—Transverse Stiffness . . . . .	5-9
5.2.4.1—Abutment Transverse Response for SDCs B and C . . . . .	5-10
5.2.4.2—Abutment Transverse Response for SDC D . . . . .	5-11
5.3—FOUNDATIONS . . . . .	5-12
5.3.1—General . . . . .	5-12
5.3.2—Spread Footing . . . . .	5-13
5.3.3—Pile Foundations . . . . .	5-14
5.3.4—Drilled Shafts . . . . .	5-14
5.4—ANALYTICAL PROCEDURES . . . . .	5-15
5.4.1—General . . . . .	5-15
5.4.2—Procedure 1: Equivalent Static Analysis (ESA) . . . . .	5-15
5.4.3—Procedure 2: Elastic Dynamic Analysis (EDA) . . . . .	5-18
5.4.4—Procedure 3: Nonlinear Time History Method . . . . .	5-19
5.5—MATHEMATICAL MODELING USING EDA (PROCEDURE 2) . . . . .	5-20
5.5.1—General . . . . .	5-20
5.5.2—Superstructure . . . . .	5-20
5.5.3—Substructure . . . . .	5-20
5.6—EFFECTIVE SECTION PROPERTIES . . . . .	5-21
5.6.1—Effective Reinforced Concrete Section Properties for Seismic Analysis . . . . .	5-21
5.6.2— $E_c I_{eff}$ and $(GA)_{eff}$ for Ductile Reinforced Concrete Members . . . . .	5-21
5.6.3— $I_{eff}$ for Box Girder Superstructures . . . . .	5-23
5.6.4— $I_{eff}$ for Other Superstructure Types . . . . .	5-23
5.6.5—Effective Torsional Moment of Inertia . . . . .	5-23

## TABLE OF CONTENTS

6.1—GENERAL . . . . .	6-1
6.2—FOUNDATION INVESTIGATION . . . . .	6-1
6.2.1—Subsurface Investigation . . . . .	6-1
6.2.2—Laboratory Testing . . . . .	6-2
6.2.3—Foundation Investigation for SDC A. . . . .	6-3
6.2.4—Foundation Investigation for SDCs B, C, and D . . . . .	6-3
6.3—SPREAD FOOTINGS . . . . .	6-3
6.3.1—General . . . . .	6-3
6.3.2—Modeling of Footings. . . . .	6-4
6.3.3—Spread Footings in Liquefiable Soils. . . . .	6-4
6.3.4—Resistance to Overturning . . . . .	6-5
6.3.5—Resistance to Sliding . . . . .	6-6
6.3.6—Flexure . . . . .	6-6
6.3.7—Shear . . . . .	6-7
6.3.8—Joint Shear . . . . .	6-7
6.3.9—Foundation Rocking . . . . .	6-7
6.4—PILE CAP FOUNDATION . . . . .	6-8
6.4.1—General . . . . .	6-8
6.4.2—Moment Capacity of Pile Foundations . . . . .	6-8
6.4.3—Lateral Capacity of Pile Foundations . . . . .	6-12
6.4.4—Other Pile Requirements . . . . .	6-13
6.4.5—Footing Joint Shear for SDCs C and D . . . . .	6-13
6.4.6—Effective Footing Width. . . . .	6-16
6.4.7—Footing Joint Shear Reinforcement for SDCs C and D. . . . .	6-16
6.5—DRILLED SHAFTS . . . . .	6-17
6.6—PILE EXTENSIONS . . . . .	6-18
6.7—ABUTMENT DESIGN REQUIREMENTS . . . . .	6-19
6.7.1—Longitudinal Direction Requirements . . . . .	6-19
6.7.2—Transverse Direction Requirements . . . . .	6-20
6.7.3—Other Requirements for Abutments . . . . .	6-20
6.8—LIQUEFACTION DESIGN REQUIREMENTS. . . . .	6-21

## TABLE OF CONTENTS

7.1—GENERAL . . . . .	7-1
7.2—PERFORMANCE CRITERIA . . . . .	7-3
7.2.1—Type 1 . . . . .	7-4
7.2.2—Type 2 . . . . .	7-4
7.2.3—Type 3 . . . . .	7-5
7.3—MATERIALS . . . . .	7-5
7.4—MEMBER REQUIREMENTS FOR SDCS C AND D . . . . .	7-6
7.4.1—Limiting Slenderness Ratios . . . . .	7-6
7.4.2—Limiting Width–Thickness Ratios . . . . .	7-8
7.4.3—Flexural Ductility for Members with Combined Flexural and Axial Load . . . . .	7-10
7.4.4—Combined Axial and Bending . . . . .	7-11
7.4.5—Weld Locations . . . . .	7-11
7.4.6—Ductile Cross-Frames . . . . .	7-11
7.4.7—Shear Connectors . . . . .	7-12
7.5—DUCTILE MOMENT-RESISTING FRAMES AND SINGLE-COLUMN STRUCTURES FOR SDCS C AND D . . . . .	7-12
7.5.1—Columns . . . . .	7-13
7.5.2—Beams . . . . .	7-14
7.5.3—Panel Zones and Connections . . . . .	7-15
7.5.4—Multitier Frame Bents . . . . .	7-15
7.6—CONCRETE-FILLED STEEL PIPES FOR SDCS C AND D . . . . .	7-16
7.6.1—Combined Axial Compression and Flexure . . . . .	7-18
7.6.2—Flexural Strength . . . . .	7-19
7.6.3—Beams and Connections . . . . .	7-20
7.7—CONNECTIONS FOR SDCS C AND D . . . . .	7-20
7.7.1—Minimum Strength for Connections to Ductile Members . . . . .	7-20
7.7.2—Yielding of Gross Section for Connections to Ductile Members . . . . .	7-21
7.7.3—Welded Connections . . . . .	7-21
7.7.4—Gusset Plate Strength . . . . .	7-21
7.7.5—Limiting Unsupported Edge Length-to-Thickness Ratio for a Gusset Plate . . . . .	7-22
7.7.6—Gusset Plate Tension Strength . . . . .	7-22
7.7.7—Compression Strength of a Gusset Plate . . . . .	7-23
7.7.8—In-Plane Moment (Strong Axis) . . . . .	7-23
7.7.9—In-Plane Shear Strength . . . . .	7-23
7.7.10—Combined Moment, Shear, and Axial Forces . . . . .	7-24
7.7.11—Fastener Capacity . . . . .	7-25
7.8—ISOLATION DEVICES . . . . .	7-25
7.9—FIXED AND EXPANSION BEARINGS . . . . .	7-25
7.9.1—Applicability . . . . .	7-25
7.9.2—Design Criteria . . . . .	7-25
7.9.3—Design and Detail Requirements . . . . .	7-26
7.9.4—Bearing Anchorage . . . . .	7-27

## TABLE OF CONTENTS

8.1—GENERAL . . . . .	8-1
8.2—SEISMIC DESIGN CATEGORY (SDC) A . . . . .	8-2
8.3—SEISMIC DESIGN CATEGORIES B, C, AND D . . . . .	8-2
8.3.1—General . . . . .	8-2
8.3.2—Force Demands for SDC B. . . . .	8-2
8.3.3—Force Demands for SDCs C and D . . . . .	8-3
8.3.4—Local Ductility Demands for SDC D . . . . .	8-3
8.4—PROPERTIES AND APPLICATIONS OF REINFORCING STEEL, PRESTRESSING STEEL, AND CONCRETE FOR SDCS B, C, AND D . . . . .	8-3
8.4.1—Reinforcing Steel . . . . .	8-3
8.4.2—Reinforcing Steel Modeling . . . . .	8-4
8.4.3—Prestressing Steel Modeling. . . . .	8-5
8.4.4—Concrete Modeling . . . . .	8-6
8.5—PLASTIC MOMENT CAPACITY FOR DUCTILE CONCRETE MEMBERS FOR SDCS B, C, AND D. . . . .	8-7
8.6—SHEAR DEMAND AND CAPACITY FOR DUCTILE CONCRETE MEMBERS FOR SDCS B, C, AND D . . . . .	8-9
8.6.1—Shear Demand and Capacity . . . . .	8-9
8.6.2—Concrete Shear Capacity . . . . .	8-10
8.6.3—Shear Reinforcement Capacity . . . . .	8-12
8.6.4—Maximum Shear Reinforcement. . . . .	8-13
8.6.5—Minimum Shear Reinforcement . . . . .	8-14
8.6.6—Shear Reinforcement Capacity of Interlocking Spirals . . . . .	8-14
8.6.7—Minimum Vertical Reinforcement in Interlocking Portion . . . . .	8-14
8.6.8—Pier Wall Shear Capacity in the Weak Direction . . . . .	8-15
8.6.9—Pier Wall Shear Capacity in the Strong Direction . . . . .	8-15
8.6.10—Pier Wall Minimum Reinforcement . . . . .	8-16
8.7—REQUIREMENTS FOR DUCTILE MEMBER DESIGN. . . . .	8-16
8.7.1—Minimum Lateral Strength . . . . .	8-16
8.7.2—Maximum Axial Load in a Ductile Member in SDCs C and D. . . . .	8-16
8.8—LONGITUDINAL AND LATERAL REINFORCEMENT REQUIREMENTS . . . . .	8-17
8.8.1—Maximum Longitudinal Reinforcement . . . . .	8-17
8.8.2—Minimum Longitudinal Reinforcement . . . . .	8-17
8.8.3—Splicing of Longitudinal Reinforcement in Columns Subject to Ductility Demands for SDCs C and D. . . . .	8-18
8.8.4—Minimum Development Length of Reinforcing Steel for SDCs C and D . . . . .	8-18
8.8.5—Anchorage of Bundled Bars in Ductile Components for SDCs C and D . . . . .	8-19
8.8.6—Maximum Bar Diameter for SDCs C and D . . . . .	8-19
8.8.7—Lateral Reinforcement Inside the Plastic Hinge Region for SDCs C and D . . . . .	8-19
8.8.8—Lateral Column Reinforcement Outside the Plastic Hinge Region for SDCs C and D . . . . .	8-20
8.8.9—Requirements for Lateral Reinforcement for SDCs B, C, and D. . . . .	8-21
8.8.10—Development Length for Column Bars Extended into Oversized Pile Shafts for SDCs C and D	8-22

8.8.11—Lateral Reinforcement Requirements for Columns Supported on Oversized Pile Shafts for SDCs C and D . . . . .	8-22
8.8.12—Lateral Confinement for Oversized Pile Shafts for SDCs C and D. . . . .	8-23
8.8.13—Lateral Confinement for Non-Oversized Strengthened Pile Shafts for SDCs C and D. . . . .	8-23
8.9—REQUIREMENTS FOR CAPACITY-PROTECTED MEMBERS. . . . .	8-23
8.10—SUPERSTRUCTURE CAPACITY DESIGN FOR INTEGRAL BENT CAPS FOR LONGITUDINAL DIRECTION FOR SDCS C AND D . . . . .	8-24
8.11—SUPERSTRUCTURE CAPACITY DESIGN FOR TRANSVERSE DIRECTION (INTEGRAL BENT CAP) FOR SDCS C AND D . . . . .	8-25
8.12—SUPERSTRUCTURE DESIGN FOR NONINTEGRAL BENT CAPS FOR SDCS C AND D . . . . .	8-26
8.13—JOINT DESIGN FOR SDCS C AND D. . . . .	8-27
8.13.1—Joint Performance. . . . .	8-27
8.13.2—Joint Proportioning . . . . .	8-27
8.13.3—Minimum Joint Shear Reinforcing. . . . .	8-30
8.13.4—Integral Bent Cap Joint Shear Design . . . . .	8-31
8.13.4.1—T Joints . . . . .	8-31
8.13.4.1.1—General . . . . .	8-31
8.13.4.1.2—T Joint Reinforcement . . . . .	8-32
8.13.4.1.2a—Vertical Stirrups . . . . .	8-32
8.13.4.1.2b—Horizontal Stirrups . . . . .	8-34
8.13.4.1.2c—Horizontal Side Reinforcement . . . . .	8-34
8.13.4.1.2d—J-Bars . . . . .	8-34
8.13.4.2—Knee Joints . . . . .	8-35
8.13.4.2.1—General . . . . .	8-35
8.13.4.2.2—Knee Joint Reinforcement . . . . .	8-36
8.13.4.2.2a—Vertical Stirrups . . . . .	8-36
8.13.4.2.2b—Horizontal Stirrups . . . . .	8-37
8.13.4.2.2c—Horizontal Side Reinforcement . . . . .	8-38
8.13.4.2.2d—Additional Longitudinal Bent Cap Reinforcing. . . . .	8-39
8.13.4.2.2e—Horizontal Cap End Ties . . . . .	8-39
8.13.4.2.2f—J-Bars. . . . .	8-40
8.13.4.2.2g—Additional Transverse Reinforcing . . . . .	8-41
8.13.5—Nonintegral Bent Cap Joint Shear Design . . . . .	8-42
8.13.5.1—Joint Shear Reinforcement. . . . .	8-42
8.13.5.1.1—Vertical Stirrups Outside the Joint Region . . . . .	8-42
8.13.5.1.2—Vertical Stirrups Inside the Joint Region . . . . .	8-44
8.13.5.1.3—Additional Longitudinal Cap Beam Reinforcement . . . . .	8-44
8.13.5.1.4—Horizontal J-Bars. . . . .	8-45
8.14—COLUMN FLARES FOR SDCS C AND D . . . . .	8-45
8.14.1—Horizontally Isolated Flares . . . . .	8-45
8.14.2—Integral Column Flares . . . . .	8-46
8.14.3—Flare Reinforcement. . . . .	8-46
8.15—COLUMN SHEAR KEY DESIGN FOR SDCS C AND D . . . . .	8-47
8.16—CONCRETE PILES. . . . .	8-47

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8.16.1—Transverse Reinforcement Requirements . . . . .	8-47
8.16.2—Cast-in-Place and Precast Concrete Piles . . . . .	8-48

TABLE OF CONTENTS

A.1—ANALYSIS ..... A-1  
A.2—FIGURES ..... A-3

APPENDIX B: DESIGN FLOWCHARTS  
**TABLE OF CONTENTS**

B.1—Introduction . . . . . B-1  
B.2—Figures . . . . . B-2

TABLE OF CONTENTS

C.1—INTRODUCTION . . . . . C-1

C.2—UNIFORM-HAZARD GROUND MOTIONS . . . . . C-1

C.3—RISK-TARGETED GROUND MOTIONS . . . . . C-2

    C.3.1—Fragility Functions . . . . . C-4

    C.3.2—Notional Fragility Function for Bridge Design . . . . . C-4

C.4—EXAMPLE CALCULATION OF RISK-TARGETED GROUND MOTIONS. . . . . C-6

C.5—APPLICATION OF RISK-TARGETED PEAK GROUND ACCELERATION (PGA) IN  
GEOTECHNICAL DESIGN . . . . . C-11

    C.5.1—Adoption of Notional Fragility for Bridge Columns . . . . . C-11

    C.5.2—Comparison between RTGM and Uniform Hazard Ground Motion. . . . . C-12

    C.5.3—Application to Geotechnical Hazard Assessment . . . . . C-14

C.6—SITE-SPECIFIC HAZARD AND/OR GROUND RESPONSE ANALYSES WITH RISK-TARGETED  
GROUND MOTIONS. . . . . C-14

C.7—PROCEDURE FOR DISAGGREGATING RISK-TARGETED GROUND MOTIONS . . . . . C-16

C.8—REFERENCES . . . . . C-16