

AMERICAN ASSOCIATION
OF STATE HIGHWAY AND
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AASHTO



LRFD BRIDGE DESIGN SPECIFICATIONS



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FOREWORD

The first broadly recognized national standard for the design and construction of bridges in the United States was published in 1931 by the American Association of State Highway Officials (AASHO), the predecessor to AASHTO. With the advent of the automobile and the establishment of highway departments in all of the American states dating back to just before the turn of the century, the design, construction, and maintenance of most U.S. bridges was the responsibility of these departments and, more specifically, the chief bridge engineer within each department. It was natural, therefore, that these engineers, acting collectively as the AASHTO Highway Subcommittee on Bridges and Structures (now the Committee on Bridges and Structures), would become the author and guardian of this first bridge standard.

This first publication was entitled *Standard Specifications for Highway Bridges and Incidental Structures*. It quickly became the *de facto* national standard and, as such, was adopted and used by not only the state highway departments but also other bridge-owning authorities and agencies in the United States and abroad. Rather early on, the last three words of the original title were dropped and it has been reissued in consecutive editions at approximately four-year intervals ever since as *Standard Specifications for Highway Bridges*, with the final 17th edition appearing in 2002.

The body of knowledge related to the design of highway bridges has grown enormously since 1931 and continues to do so. Theory and practice have evolved greatly, reflecting advances through research in understanding the properties of materials, in improved materials, in more rational and accurate analysis of structural behavior, in the advent of computers and rapidly advancing computer technology, in the study of external events representing particular hazards to bridges such as seismic events and stream scour, and in many other areas. The pace of advances in these areas has, if anything, stepped up in recent years.

In 1986, the Subcommittee submitted a request to the AASHTO Standing Committee on Research to undertake an assessment of U.S. bridge design specifications, to review foreign design specifications and codes, to consider design philosophies alternative to those underlying the Standard Specifications, and to render recommendations based on these investigations. This work was accomplished under the National Cooperative Highway Research Program (NCHRP), an applied research program directed by the AASHTO Standing Committee on Research and administered on behalf of AASHTO by the Transportation Research Board (TRB). The work was completed in 1987, and, as might be expected with a standard incrementally adjusted over the years, the Standard Specifications were judged to include discernible gaps, inconsistencies, and even some conflicts. Beyond this, the specification did not reflect or incorporate the most recently developing design philosophy, load-and-resistance factor design (LRFD), a philosophy which has been gaining ground in other areas of structural engineering and in other parts of the world such as Canada and Europe.

From its inception until the early 1970s, the sole design philosophy embedded within the Standard Specifications was one known as working stress design (WSD). WSD establishes allowable stresses as a fraction or percentage of a given material's load-carrying capacity, and requires that calculated design stresses not exceed those allowable stresses. Beginning in the early 1970s, WSD began to be adjusted to reflect the variable predictability of certain load types, such as vehicular loads and wind forces, through adjusting design factors, a design philosophy referred to as load factor design (LFD).

A further philosophical extension results from considering the variability in the properties of structural elements, in similar fashion to load variabilities. While considered to a limited extent in LFD, the design philosophy of load-and-resistance factor design (LRFD) takes variability in the behavior of structural elements into account in an explicit manner. LRFD relies on extensive use of statistical methods, but sets forth the results in a manner readily usable by bridge designers and analysts.

Starting with the Eighth Edition of the *AASHTO LRFD Bridge Design Specifications*, interim changes to the Specifications were discontinued, and new editions are published on a three-year cycle. Changes are balloted and approved by at least two-thirds of the members of the Committee on Bridges and Structures. AASHTO members include the 50 State Highway or Transportation Departments, the District of Columbia, and Puerto Rico. Each member has one vote. The U.S. Department of Transportation is a non-voting member.

Orders for Specifications may be placed by visiting the AASHTO Store, store.transportation.org; calling the AASHTO Publication Sales Office toll free (within the U.S. and Canada), 1-800-231-3475; or mailing to P.O. Box 933538, Atlanta, GA 31193-3538. A free copy of the current publication catalog can be downloaded from the AASHTO Store.

For additional publications prepared and published by the Committee on Bridges and Structures and by other AASHTO Committees, please look online in the AASHTO Store (store.transportation.org) under “Bridges and Structures.”

Suggestions for the improvement of the *AASHTO LRFD Bridge Design Specifications* are welcomed, just as they were for the *Standard Specifications for Highway Bridges* before them, at www.transportation.org.

The following have served as chair of the Committee on Bridges and Structures since its inception in 1921: E. F. Kelley, who pioneered the work of the Committee; Albin L. Gemeny; R. B. McMinn; Raymond Archiband; G. S. Paxson; E. M. Johnson; Ward Goodman; Charles Matlock; Joseph S. Jones; Sidney Poleynard; Jack Freidenrich; Henry W. Derthick; Robert C. Cassano; Clellon Loveall; James E. Siebels; David Pope; Tom Lulay; Malcolm T. Kerley; Gregg Fredrick; and Carmen Swanwick. The Committee expresses its sincere appreciation of the work of these individuals and of those active members of the past, whose names, because of retirement, are no longer on the roll.

The Committee would also like to thank John M. Kulicki, Ph.D., and his associates at Modjeski and Masters for their valuable assistance in the preparation of the *AASHTO LRFD Bridge Design Specifications*.

PREFACE AND ABBREVIATED TABLE OF CONTENTS

The *AASHTO LRFD Bridge Design Specifications*, Ninth Edition contains the following 15 sections and an index:

1. Introduction
 2. General Design and Location Features
 3. Loads and Load Factors
 4. Structural Analysis and Evaluation
 5. Concrete Structures
 6. Steel Structures
 7. Aluminum Structures
 8. Wood Structures
 9. Decks and Deck Systems
 10. Foundations
 11. Abutments, Piers, and Walls
 12. Buried Structures and Tunnel Liners
 13. Railings
 14. Joints and Bearings
 15. Design of Sound Barriers
- Index

Detailed Tables of Contents precede each section. The last article of each section is a list of references displayed alphabetically by author.

Figures, tables, and equations are denoted by their home article number and an extension, for example 1.2.3.4.5-1 wherever they are cited. In early editions, when they were referenced in their home article or its commentary, these objects were identified only by the extension. For example, in Article 1.2.3.4.5, Eq. 1.2.3.4.5-2 would simply have been called “Eq. 2.” The same convention applies to figures and tables. Starting with this edition, these objects are identified by their whole nomenclature throughout the text, even within their home articles. This change was to increase the speed and accuracy of electronic production (i.e., CDs and downloadable files) with regard to linking citations to objects.

Please note that the AASHTO materials standards (starting with M or T) cited throughout the LRFD Bridge Design Specifications can be found in *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, adopted by the AASHTO Highway Subcommittee on Materials. The individual standards are also available as downloads on the AASHTO Store, <https://store.transportation.org>. Unless otherwise indicated, these citations refer to the current edition. ASTM materials specifications are also cited and have been updated to reflect ASTM’s revised coding system, i.e., spaces removed between the letter and number.

CHANGED AND DELETED ARTICLES, 2020

SUMMARY OF AFFECTED SECTIONS

The revisions included in the *AASHTO LRFD Bridge Design Specifications*, Ninth Edition affect the following sections:

1. Introduction
3. Loads and Load Factors
4. Structural Analysis and Evaluation
5. Concrete Structures
6. Steel Structures
8. Wood Structures
10. Foundations
11. Walls, Abutments, and Piers
12. Buried Structures and Tunnel Liners
15. Design of Sound Barriers

SECTION 1 REVISIONS

Changed Articles

The following Articles in Section 1 contain changes or additions to the specifications, the commentary, or both:

1.3.5

Deleted Articles

No Articles were deleted from Section 1.

SECTION 3 REVISIONS

Changed Articles

The following Articles in Section 3 contain changes or additions to the specifications, the commentary, or both:

3.3.1	3.6.1.2.6a	3.6.5.2	3.11.5.6	3.11.5.9
3.4.1	3.6.5.1	3.11.5.4	3.11.5.8.2	3.16

Deleted Articles

No Articles were deleted from Section 3.

SECTION 4 REVISIONS

Changed Articles

The following Articles in Section 4 contain changes or additions to the specifications, the commentary, or both:

4.5.3.2.2b	4.6.2.2.1	4.6.2.2.2b	4.6.2.10.2	4.9
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Deleted Articles

No Articles were deleted from Section 4.

SECTION 5 REVISIONS

Changed Articles

The following Articles in Section 5 contain changes or additions to the specifications, the commentary, or both:

5.3	5.7.2.1	5.8.4.3.5	5.10.4.3	5.12.9.5.2
5.4.3.1	5.7.2.8	5.9.4.3.3	5.10.8.2.5	5.14.1
5.4.6.2	5.7.3.3	5.9.4.5	5.10.8.5.1	5.14.4
5.5.3.1	5.7.3.5	5.9.5.6.1	5.10.8.5.2	5.15
5.5.4.3	5.7.3.6.2	5.10.1	5.12.3.2.1	

Deleted Articles

No Articles were deleted from Section 5.

SECTION 6 REVISIONS

Changed Articles

The following Articles in Section 6 contain changes or additions to the specifications, the commentary, or both:

6.1	6.9.4.1.2	6.10.11	6.12.2.2.2d	6.14.4.4
6.2	6.9.4.1.3	6.10.11.1	6.12.2.2.2e	6.14.4.5
6.3	6.9.4.2	6.10.11.1.1	6.12.2.2.2f	6.14.4.6
6.4.9	6.9.4.2.1	6.10.11.2.2	6.12.2.2.2g	6.16.1
6.5.3	6.9.4.2.2	6.10.11.2.4b	6.12.2.2.3	6.16.2
6.5.4.2	6.9.4.2.2a	6.10.11.3	6.12.2.2.4a	6.16.4.1
6.5.5	6.9.4.2.2b	6.10.11.3.1	6.12.2.2.4b	6.17
6.6.1.2.3	6.9.4.2.2c	6.10.11.3.3	6.12.2.2.4c	A6
6.6.1.2.5	6.9.4.3.1	6.11	6.12.2.2.4d	A6.1
6.6.2.1	6.9.4.4	6.11.1.1	6.12.2.2.4e	A6.2.1
6.6.2.2	6.9.4.5	6.11.3.2	6.12.2.2.5	A6.2.2
6.7.2	6.9.6.1	6.11.5	6.12.2.3.3	A6.3.3
6.7.4.3	6.9.6.2	6.11.6.2.1	6.12.3.2.2	C6.4
6.7.4.4	6.10.1.1.1a	6.11.8.2.2	6.13.2.3.2	C6.4.4
6.7.4.4.1	6.10.1.4	6.11.8.3	6.13.2.5	C6.4.7
6.7.4.4.2	6.10.1.10.1	6.12.1	6.13.2.7	C6.5.1
6.7.4.4.3	6.10.1.10.2	6.12.1.1	6.13.2.9	C6.5.2
6.7.4.5	6.10.2.2	6.12.1.2.1	6.13.2.10.2	D6.2.1
6.7.8	6.10.3.3	6.12.1.2.2	6.13.2.11	D6.3.1
6.8.2.2	6.10.3.4.1	6.12.1.2.3	6.13.3.6	E6.1
6.8.2.3	6.10.3.4.2	6.12.1.2.3a	6.13.3.7	E6.1.1
6.8.2.3.1	6.10.5.2	6.12.1.2.3b	6.13.6.1.3a	E6.1.2
6.8.2.3.2	6.10.6.1	6.12.1.2.4	6.13.6.1.3b	E6.1.3
6.8.2.3.3	6.10.6.2.3	6.12.2	6.13.6.1.3c	E6.1.4
6.8.6.2	6.10.8.1.1	6.12.2.1	6.13.6.1.4	E6.1.5
6.9.2.2	6.10.8.2.3	6.12.2.2.2	6.14.2.4	E6.1.5.1
6.9.2.2.1	6.10.8.3	6.12.2.2.2a	6.14.4.1	E6.1.5.2
6.9.2.2.2	6.10.9.1	6.12.2.2.2b	6.14.4.2	
6.9.4.1.1	6.10.10.2	6.12.2.2.2c	6.14.4.3	

Deleted Articles

6.12.1.2.3c

SECTION 8 REVISIONS

Changed Articles

The following Articles in Section 8 contain changes or additions to the specifications, the commentary, or both:

8.2	8.4.1.2.1	8.4.1.2.3	8.4.4.9	8.14
8.4.1.1.4	8.4.1.2.2	8.4.1.3.1	8.13	

Deleted Articles

No Articles were deleted from Section 8.

SECTION 10 REVISIONS

Changed Articles

The following Articles in Section 10 contain changes or additions to the specifications, the commentary, or both:

10.3	10.5.3.1	10.6.2.4.2b	10.6.3.5	10.9.3.5.4
10.5.2.1	10.5.5.1	10.6.2.4.2c	10.7.2.1	10.10
10.5.2.2	10.5.5.2.1	10.6.2.4.4	10.7.3.1	
10.5.2.2.1	10.6.2.1	10.6.3.1.2a	10.7.8	
10.5.2.2.2	10.6.2.4.1	10.6.3.1.2c	10.8.3.5.1b	
10.5.2.4	10.6.2.4.2a	10.6.3.2.1	10.8.3.5.2b	

Deleted Articles

10.5.2.3	10.6.2.5
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SECTION 11 REVISIONS

Changed Articles

The following Articles in Section 11 contain changes or additions to the specifications, the commentary, or both:

11.1	11.6.5.1	11.10.5.2	11.10.6.4.1	11.10.10.3
11.2	11.8.3	11.10.5.6	11.10.6.4.2a	11.10.11
11.3.1	11.8.4.1	11.10.6.1	11.10.6.4.2b	11.11.4.6
11.5.2	11.8.6.1	11.10.6.2	11.10.6.4.3b	11.12
11.5.3	11.9.3	11.10.6.2.1	11.10.6.4.4a	11.12.7.2
11.5.4.2	11.9.4.3	11.10.6.2.1a	11.10.6.4.4b	11.12.9
11.5.5	11.9.4.4	11.10.6.2.1b	11.10.7.2	11.13
11.5.7	11.10.1	11.10.6.2.1c	11.10.7.3	A11.5.3
11.5.8	11.10.2.3.1	11.10.6.2.1d	11.10.7.4	B11.1
11.6.2	11.10.4	11.10.6.2.1e	11.10.8	B11.2
11.6.3.1	11.10.4.2	11.10.6.2.2	11.10.10.1	B11.3
11.6.3.7	11.10.4.3	11.10.6.3.2	11.10.10.2	

Deleted Articles

11.6.2.3	11.8.3.2	11.9.3.2
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SECTION 12 REVISIONS

Changed Articles

The following Articles in Section 12 contain changes or additions to the specifications, the commentary, or both:

12.1	12.5.4	12.7.2.7	12.10.2.1	12.12.3.10.2b
12.2	12.6.4	12.8.5.3	12.10.4.3.1	12.16
12.4.2.3	12.6.9	12.8.9.3.1	12.12.2.1	A12
12.4.2.10	12.7.2.1	12.10.1	12.12.3.5	

Deleted Articles

No Articles were deleted from Section 12.

SECTION 15 REVISIONS

Changed Articles

The following Articles in Section 15 contain changes or additions to the specifications, the commentary, or both:

15.9.3	15.9.7	15.9.8
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Deleted Articles

15.9.7.1

AASHTO Publications Staff
April 2020

SECTION 1: INTRODUCTION

TABLE OF CONTENTS

1.1—SCOPE OF THE SPECIFICATIONS.....	1-1
1.2—DEFINITIONS.....	1-2
1.3—DESIGN PHILOSOPHY	1-3
1.3.1—General.....	1-3
1.3.2—Limit States	1-3
1.3.2.1—General	1-3
1.3.2.2—Service Limit State.....	1-4
1.3.2.3—Fatigue and Fracture Limit State.....	1-4
1.3.2.4—Strength Limit State	1-4
1.3.2.5—Extreme Event Limit States	1-5
1.3.3—Ductility	1-5
1.3.4—Redundancy	1-6
1.3.5—Operational Importance	1-7
1.4—REFERENCES	1-7

SECTION 2: GENERAL DESIGN AND LOCATION FEATURES

TABLE OF CONTENTS

2.1—SCOPE	2-1
2.2—DEFINITIONS	2-1
2.3—LOCATION FEATURES	2-3
2.3.1—Route Location	2-3
2.3.1.1—General	2-3
2.3.1.2—Waterway and Floodplain Crossings	2-3
2.3.2—Bridge Site Arrangement	2-4
2.3.2.1—General	2-4
2.3.2.2—Traffic Safety	2-4
2.3.2.2.1—Protection of Structures	2-4
2.3.2.2.2—Protection of Users	2-4
2.3.2.2.3—Geometric Standards	2-5
2.3.2.2.4—Road Surfaces	2-5
2.3.2.2.5—Vessel Collisions	2-5
2.3.3—Clearances	2-5
2.3.3.1—Navigational	2-5
2.3.3.2—Highway Vertical	2-5
2.3.3.3—Highway Horizontal	2-6
2.3.3.4—Railroad Overpass	2-6
2.3.4—Environment	2-7
2.4—FOUNDATION INVESTIGATION	2-7
2.4.1—General	2-7
2.4.2—Topographic Studies	2-7
2.5—DESIGN OBJECTIVES	2-7
2.5.1—Safety	2-7
2.5.1.1—Structural Survival	2-7
2.5.1.2—Limited Serviceability	2-7
2.5.1.3—Immediate Use	2-7
2.5.2—Serviceability	2-8
2.5.2.1—Durability	2-8
2.5.2.1.1—Materials	2-8
2.5.2.1.2—Self-Protecting Measures	2-8
2.5.2.2—Inspectability	2-9
2.5.2.3—Maintainability	2-9
2.5.2.4—Rideability	2-9
2.5.2.5—Utilities	2-9
2.5.2.6—Deformations	2-10
2.5.2.6.1—General	2-10
2.5.2.6.2—Criteria for Deflection	2-11
2.5.2.6.3—Optional Criteria for Span-to-Depth Ratios	2-13
2.5.2.7—Consideration of Future Widening	2-14
2.5.2.7.1—Exterior Beams on Girder System Bridges	2-14
2.5.2.7.2—Substructure	2-14
2.5.3—Constructability	2-14
2.5.4—Economy	2-15
2.5.4.1—General	2-15
2.5.4.2—Alternative Plans	2-15
2.5.5—Bridge Aesthetics	2-15
2.6—HYDROLOGY AND HYDRAULICS	2-17
2.6.1—General	2-17
2.6.2—Site Data	2-18
2.6.3—Hydrologic Analysis	2-18
2.6.4—Hydraulic Analysis	2-19
2.6.4.1—General	2-19

2.6.4.2—Stream Stability	2-19
2.6.4.3—Bridge Waterway	2-20
2.6.4.4—Bridge Foundations	2-20
2.6.4.4.1—General.....	2-20
2.6.4.4.2—Bridge Scour	2-21
2.6.4.5—Roadway Approaches to Bridge.....	2-22
2.6.5—Culvert Location, Length, and Waterway Area.....	2-23
2.6.6—Roadway Drainage	2-23
2.6.6.1—General.....	2-23
2.6.6.2—Design Storm.....	2-23
2.6.6.3—Type, Size, and Number of Drains	2-23
2.6.6.4—Discharge from Deck Drains	2-24
2.6.6.5—Drainage of Structures.....	2-24
2.7—BRIDGE SECURITY.....	2-24
2.7.1—General	2-24
2.7.2—Design Demand	2-25
2.8—REFERENCES.....	2-25

SECTION 3: LOADS AND LOAD FACTORS

TABLE OF CONTENTS

3.1—SCOPE	3-1
3.2—DEFINITIONS.....	3-1
3.3—NOTATION.....	3-3
3.3.1—General.....	3-3
3.3.2—Load and Load Designation	3-8
3.4—LOAD FACTORS AND COMBINATIONS	3-9
3.4.1—Load Factors and Load Combinations	3-9
3.4.2—Load Factors for Construction Loads.....	3-19
3.4.2.1—Evaluation at the Strength Limit State	3-19
3.4.2.2—Evaluation of Deflection at the Service Limit State.....	3-20
3.4.3—Load Factors for Jacking and Post-Tensioning Forces	3-20
3.4.3.1—Jacking Forces	3-20
3.4.3.2—Force for Post-Tensioning Anchorage Zones.....	3-20
3.4.4—Load Factors for Orthotropic Decks	3-20
3.5—PERMANENT LOADS	3-21
3.5.1—Dead Loads: <i>DC</i> , <i>DW</i> , and <i>EV</i>	3-21
3.5.2—Earth Loads: <i>EH</i> , <i>ES</i> , and <i>DD</i>	3-22
3.6—LIVE LOADS	3-22
3.6.1—Gravity Loads: <i>LL</i> and <i>PL</i>	3-22
3.6.1.1—Vehicular Live Load	3-22
3.6.1.1.1—Number of Design Lanes	3-22
3.6.1.1.2—Multiple Presence of Live Load.....	3-22
3.6.1.2—Design Vehicular Live Load	3-23
3.6.1.2.1—General	3-23
3.6.1.2.2—Design Truck	3-24
3.6.1.2.3—Design Tandem.....	3-25
3.6.1.2.4—Design Lane Load.....	3-25
3.6.1.2.5—Tire Contact Area	3-25
3.6.1.2.6—Distribution of Wheel Load through Earth Fills	3-26
3.6.1.2.6a—General	3-26
3.6.1.2.6b—Traffic Parallel to the Culvert Span.....	3-27
3.6.1.2.6c—Traffic Perpendicular to the Culvert Span	3-28
3.6.1.3—Application of Design Vehicular Live Loads	3-29
3.6.1.3.1—General	3-29
3.6.1.3.2—Loading for Optional Live Load Deflection Evaluation	3-29
3.6.1.3.3—Design Loads for Decks, Deck Systems, and the Top Slabs of Box Culverts	3-30
3.6.1.3.4—Deck Overhang Load.....	3-31
3.6.1.4—Fatigue Load	3-31
3.6.1.4.1—Magnitude and Configuration.....	3-31
3.6.1.4.2—Frequency	3-31
3.6.1.4.3—Load Distribution for Fatigue	3-32
3.6.1.4.3a—Refined Methods.....	3-32
3.6.1.4.3b—Approximate Methods	3-32
3.6.1.5—Rail Transit Load.....	3-33
3.6.1.6—Pedestrian Loads.....	3-33
3.6.1.7—Loads on Railings	3-33
3.6.2—Dynamic Load Allowance: <i>IM</i>	3-33
3.6.2.1—General	3-33
3.6.2.2—Buried Components	3-34
3.6.2.3—Wood Components	3-35
3.6.3—Centrifugal Forces: <i>CE</i>	3-35
3.6.4—Braking Force: <i>BR</i>	3-35
3.6.5—Vehicular Collision Force: <i>CT</i>	3-38

3.6.5.1—Protection of Structures.....	3-38
3.6.5.2—Vehicle Collision with Barriers.....	3-45
3.7—WATER LOADS: <i>WA</i>	3-45
3.7.1—Static Pressure	3-45
3.7.2—Buoyancy.....	3-45
3.7.3—Stream Pressure	3-45
3.7.3.1—Longitudinal	3-45
3.7.3.2—Lateral	3-46
3.7.4—Wave Load	3-47
3.7.5—Change in Foundations Due to Limit State for Scour.....	3-47
3.8—WIND LOAD: <i>WL</i> AND <i>WS</i>	3-48
3.8.1—Horizontal Wind Load.....	3-48
3.8.1.1—Exposure Conditions	3-48
3.8.1.1.1—General.....	3-48
3.8.1.1.2—Wind Speed.....	3-48
3.8.1.1.3—Wind Direction for Determining Wind Exposure Category.....	3-52
3.8.1.1.4—Ground Surface Roughness Categories	3-52
3.8.1.1.5—Wind Exposure Categories	3-53
3.8.1.2—Wind Load on Structures: <i>WS</i>	3-53
3.8.1.2.1—General.....	3-53
3.8.1.2.2—Loads on the Superstructure.....	3-56
3.8.1.2.3—Loads on the Substructure.....	3-57
3.8.1.2.3a—Loads from the Superstructure	3-57
3.8.1.2.3b—Loads Applied Directly to the Substructure.....	3-57
3.8.1.2.4—Wind Loads on Sound Barriers.....	3-58
3.8.1.3—Wind Load on Live Load: <i>WL</i>	3-59
3.8.2—Vertical Wind Load.....	3-59
3.8.3—Wind-Induced Bridge Motions.....	3-60
3.8.3.1—General.....	3-60
3.8.3.2—Wind-Induced Motions	3-60
3.8.3.3—Control of Dynamic Responses.....	3-61
3.8.4—Site-Specific and Structure-Specific Studies	3-61
3.9—ICE LOADS: <i>IC</i>	3-62
3.9.1—General.....	3-62
3.9.2—Dynamic Ice Forces on Piers.....	3-63
3.9.2.1—Effective Ice Strength.....	3-63
3.9.2.2—Crushing and Flexing	3-64
3.9.2.3—Small Streams	3-65
3.9.2.4—Combination of Longitudinal and Transverse Forces	3-66
3.9.2.4.1—Piers Parallel to Flow.....	3-66
3.9.2.4.2—Piers Skewed to Flow.....	3-67
3.9.2.5—Slender and Flexible Piers.....	3-67
3.9.3—Static Ice Loads on Piers	3-67
3.9.4—Hanging Dams and Ice Jams	3-67
3.9.5—Vertical Forces Due to Ice Adhesion	3-67
3.9.6—Ice Accretion and Snow Loads on Superstructures	3-69
3.10—EARTHQUAKE EFFECTS: <i>EQ</i>	3-70
3.10.1—General.....	3-70
3.10.2—Seismic Hazard.....	3-71
3.10.2.1—General Procedure.....	3-71
3.10.2.2—Site-Specific Procedure.....	3-100
3.10.3—Site Effects	3-101
3.10.3.1—Site Class Definitions	3-101
3.10.3.2—Site Factors	3-105
3.10.4—Seismic Hazard Characterization	3-106
3.10.4.1—Design Response Spectrum.....	3-106

3.10.4.2—Elastic Seismic Response Coefficient.....	3-107
3.10.5—Operational Classification.....	3-107
3.10.6—Seismic Performance Zones.....	3-108
3.10.7—Response Modification Factors.....	3-108
3.10.7.1—General.....	3-108
3.10.7.2—Application.....	3-109
3.10.8—Combination of Seismic Force Effects.....	3-109
3.10.9—Calculation of Design Forces.....	3-110
3.10.9.1—General.....	3-110
3.10.9.2—Seismic Zone 1.....	3-110
3.10.9.3—Seismic Zone 2.....	3-112
3.10.9.4—Seismic Zones 3 and 4.....	3-112
3.10.9.4.1—General.....	3-112
3.10.9.4.2—Modified Design Forces.....	3-113
3.10.9.4.3—Inelastic Hinging Forces.....	3-113
3.10.9.4.3a—General.....	3-113
3.10.9.4.3b—Single Columns and Piers.....	3-113
3.10.9.4.3c—Piers with Two or More Columns.....	3-114
3.10.9.4.3d—Column and Pile Bent Design Forces.....	3-115
3.10.9.4.3e—Pier Design Forces.....	3-115
3.10.9.4.3f—Foundation Design Forces.....	3-115
3.10.9.5—Longitudinal Restrainers.....	3-116
3.10.9.6—Hold-Down Devices.....	3-116
3.10.10—Requirements for Temporary Bridges and Stage Construction.....	3-117
3.11—EARTH PRESSURE: <i>EH</i> , <i>ES</i> , <i>LS</i> , AND <i>DD</i>	3-117
3.11.1—General.....	3-117
3.11.2—Compaction.....	3-118
3.11.3—Presence of Water.....	3-118
3.11.4—Effect of Earthquake.....	3-119
3.11.5—Earth Pressure: <i>EH</i>	3-119
3.11.5.1—Lateral Earth Pressure.....	3-119
3.11.5.2—At-Rest Lateral Earth Pressure Coefficient, k_o	3-120
3.11.5.3—Active Lateral Earth Pressure Coefficient, k_a	3-121
3.11.5.4—Passive Lateral Earth Pressure Coefficient, k_p	3-124
3.11.5.5—Equivalent-fluid Method of Estimating Rankine Lateral Earth Pressures.....	3-127
3.11.5.6—Lateral Earth Pressures for Nongravity Cantilevered Walls.....	3-129
3.11.5.7—Apparent Earth Pressure (<i>AEP</i>) for Anchored Walls.....	3-134
3.11.5.7.1—Cohesionless Soils.....	3-134
3.11.5.7.2—Cohesive Soils.....	3-135
3.11.5.7.2a—Stiff to Hard.....	3-136
3.11.5.7.2b—Soft to Medium Stiff.....	3-136
3.11.5.8—Lateral Earth Pressures for Mechanically Stabilized Earth Walls.....	3-137
3.11.5.8.1—General.....	3-137
3.11.5.8.2—Internal Stability.....	3-138
3.11.5.9—Lateral Earth Pressures for Prefabricated Modular Walls.....	3-139
3.11.5.10—Lateral Earth Pressures for Sound Barriers Supported on Discrete and Continuous Vertical Embedded Elements.....	3-140
3.11.6—Surcharge Loads: <i>ES</i> and <i>LS</i>	3-143
3.11.6.1—Uniform Surcharge Loads (<i>ES</i>).....	3-144
3.11.6.2—Point, Line, and Strip Loads (<i>ES</i>): Walls Restrained from Movement.....	3-144
3.11.6.3—Strip Loads (<i>ES</i>): Flexible Walls.....	3-148
3.11.6.4—Live Load Surcharge (<i>LS</i>).....	3-151
3.11.6.5—Reduction of Surcharge.....	3-152
3.11.7—Reduction Due to Earth Pressure.....	3-152
3.11.8—Downdrag.....	3-152
3.12—FORCE EFFECTS DUE TO SUPERIMPOSED DEFORMATIONS: <i>TU</i> , <i>TG</i> , <i>SH</i> , <i>CR</i> , <i>SE</i> , <i>PS</i>	3-154

3.12.1—General	3-154
3.12.2—Uniform Temperature	3-155
3.12.2.1—Temperature Range for Procedure A	3-155
3.12.2.2—Temperature Range for Procedure B	3-155
3.12.2.3—Design Thermal Movements	3-157
3.12.3—Temperature Gradient	3-158
3.12.4—Differential Shrinkage	3-159
3.12.5—Creep	3-159
3.12.6—Settlement	3-160
3.12.7—Secondary Forces from Post-Tensioning, <i>PS</i>	3-160
3.13—FRICTION FORCES: <i>FR</i>	3-160
3.14—VESSEL COLLISION: <i>CV</i>	3-160
3.14.1—General	3-160
3.14.2—Owner’s Responsibility	3-162
3.14.3—Operational Classification	3-162
3.14.4—Design Vessel	3-162
3.14.5—Annual Frequency of Collapse	3-163
3.14.5.1—Vessel Frequency Distribution	3-164
3.14.5.2—Probability of Aberrancy	3-165
3.14.5.2.1—General	3-165
3.14.5.2.2—Statistical Method	3-165
3.14.5.2.3—Approximate Method	3-165
3.14.5.3—Geometric Probability	3-168
3.14.5.4—Probability of Collapse	3-169
3.14.5.5 Protection Factor	3-169
3.14.6—Design Collision Velocity	3-171
3.14.7—Vessel Collision Energy	3-171
3.14.8—Ship Collision Force on Pier	3-172
3.14.9—Ship Bow Damage Length	3-174
3.14.10—Ship Collision Force on Superstructure	3-174
3.14.10.1—Collision with Bow	3-174
3.14.10.2—Collision with Deck House	3-174
3.14.10.3—Collision with Mast	3-175
3.14.11—Barge Collision Force on Pier	3-175
3.14.12—Barge Bow Damage Length	3-176
3.14.13—Damage at the Extreme Limit State	3-176
3.14.14—Application of Impact Force	3-177
3.14.14.1—Substructure Design	3-177
3.14.14.2—Superstructure Design	3-178
3.14.15—Protection of Substructures	3-178
3.14.16—Security Considerations	3-179
3.15—BLAST LOADING: <i>BL</i>	3-180
3.15.1—Introduction	3-180
3.16—REFERENCES	3-180
APPENDIX A3—SEISMIC DESIGN FLOWCHARTS	3-189
APPENDIX B3—OVERSTRENGTH RESISTANCE	3-191

TABLE OF CONTENTS

4.1—SCOPE	4-1
4.2—DEFINITIONS.....	4-2
4.3—NOTATION.....	4-7
4.4—ACCEPTABLE METHODS OF STRUCTURAL ANALYSIS.....	4-10
4.5—MATHEMATICAL MODELING	4-11
4.5.1—General.....	4-11
4.5.2—Structural Material Behavior.....	4-11
4.5.2.1—Elastic Versus Inelastic Behavior	4-11
4.5.2.2—Elastic Behavior.....	4-11
4.5.2.3—Inelastic Behavior	4-12
4.5.3—Geometry	4-12
4.5.3.1—Small Deflection Theory.....	4-12
4.5.3.2—Large Deflection Theory.....	4-13
4.5.3.2.1—General	4-13
4.5.3.2.2—Approximate Methods	4-14
4.5.3.2.2a—General	4-14
4.5.3.2.2b—Moment Magnification—Beam Columns	4-14
4.5.3.2.2c—Moment Magnification—Arches.....	4-16
4.5.3.2.3—Refined Methods.....	4-16
4.5.4—Modeling Boundary Conditions.....	4-16
4.5.5—Equivalent Members	4-17
4.6—STATIC ANALYSIS.....	4-17
4.6.1—Influence of Plan Geometry	4-17
4.6.1.1—Plan Aspect Ratio	4-17
4.6.1.2—Structures Curved in Plan	4-17
4.6.1.2.1—General	4-17
4.6.1.2.2—Single-Girder Torsionally Stiff Superstructures	4-18
4.6.1.2.3—Concrete Box Girder Bridges	4-18
4.6.1.2.4—Steel Multiple-Beam Superstructures	4-20
4.6.1.2.4a—General	4-20
4.6.1.2.4b—I-Girders	4-20
4.6.1.2.4c—Closed Box and Tub Girders	4-22
4.6.2—Approximate Methods of Analysis	4-22
4.6.2.1—Decks	4-22
4.6.2.1.1—General	4-22
4.6.2.1.2—Applicability	4-23
4.6.2.1.3—Width of Equivalent Interior Strips	4-23
4.6.2.1.4—Width of Equivalent Strips at Edges of Slabs	4-25
4.6.2.1.4a—General	4-25
4.6.2.1.4b—Longitudinal Edges.....	4-25
4.6.2.1.4c—Transverse Edges.....	4-25
4.6.2.1.5—Distribution of Wheel Loads	4-26
4.6.2.1.6—Calculation of Force Effects	4-26
4.6.2.1.7—Cross-Sectional Frame Action.....	4-27
4.6.2.1.8—Live Load Force Effects for Fully and Partially Filled Grids and for Unfilled Grid Decks Composite with Reinforced Concrete Slabs	4-27
4.6.2.1.9—Inelastic Analysis.....	4-29
4.6.2.2—Beam-Slab Bridges	4-29
4.6.2.2.1—Application	4-29
4.6.2.2.2—Distribution Factor Method for Moment and Shear	4-35
4.6.2.2.2a—Interior Beams with Wood Decks.....	4-35
4.6.2.2.2b—Interior Beams with Concrete Decks	4-36
4.6.2.2.2c—Interior Beams with Corrugated Steel Decks.....	4-38
4.6.2.2.2d—Exterior Beams	4-39
4.6.2.2.2e—Skewed Bridges	4-40

4.6.2.2.2f—Flexural Moments and Shear in Transverse Floorbeams.....	4-41
4.6.2.2.3—Distribution Factor Method for Shear	4-42
4.6.2.2.3a—Interior Beams.....	4-42
4.6.2.2.3b—Exterior Beams	4-44
4.6.2.2.3c—Skewed Bridges	4-46
4.6.2.2.4—Curved Steel Bridges	4-47
4.6.2.2.5—Special Loads with Other Traffic	4-47
4.6.2.3—Equivalent Strip Widths for Slab-Type Bridges.....	4-48
4.6.2.4—Truss and Arch Bridges.....	4-49
4.6.2.5—Effective Length Factor, K	4-49
4.6.2.6—Effective Flange Width	4-54
4.6.2.6.1—General.....	4-54
4.6.2.6.2—Segmental Concrete Box Beams and Single-Cell, Cast-in-Place Box Beams	4-55
4.6.2.6.3—Cast-in-Place Multicell Superstructures.....	4-59
4.6.2.6.4—Orthotropic Steel Decks	4-59
4.6.2.6.5—Transverse Floorbeams and Integral Bent Caps.....	4-60
4.6.2.7—Lateral Wind Load Distribution in Girder System Bridges.....	4-60
4.6.2.7.1—I-Sections	4-60
4.6.2.7.2—Box Sections	4-62
4.6.2.7.3—Construction.....	4-62
4.6.2.8—Seismic Lateral Load Distribution	4-62
4.6.2.8.1—Applicability	4-62
4.6.2.8.2—Design Criteria.....	4-62
4.6.2.8.3—Load Distribution	4-63
4.6.2.9—Analysis of Segmental Concrete Bridges.....	4-63
4.6.2.9.1—General.....	4-63
4.6.2.9.2—Strut-and-Tie Models	4-64
4.6.2.9.3—Effective Flange Width.....	4-64
4.6.2.9.4—Transverse Analysis.....	4-64
4.6.2.9.5—Longitudinal Analysis.....	4-64
4.6.2.9.5a—General.....	4-64
4.6.2.9.5b—Erection Analysis.....	4-65
4.6.2.9.5c—Analysis of the Final Structural System.....	4-65
4.6.2.10—Equivalent Strip Widths for Box Culverts	4-65
4.6.2.10.1—General.....	4-65
4.6.2.10.2—Case 1: Traffic Travels Parallel to Span	4-65
4.6.2.10.3—Case 2: Traffic Travels Perpendicular to Span.....	4-66
4.6.2.10.4—Precast Box Culverts.....	4-66
4.6.3—Refined Methods of Analysis.....	4-67
4.6.3.1—General.....	4-67
4.6.3.2—Decks	4-67
4.6.3.2.1—General.....	4-67
4.6.3.2.2—Isotropic Plate Model.....	4-68
4.6.3.2.3—Orthotropic Plate Model	4-68
4.6.3.2.4—Refined Orthotropic Deck Model	4-68
4.6.3.3—Beam-Slab Bridges	4-69
4.6.3.3.1—General.....	4-69
4.6.3.3.2—Grid and Plate and Eccentric Beam Analyses of Curved and/or Skewed Steel I-Girder Bridges.....	4-70
4.6.3.3.3—Curved Steel Bridges	4-70
4.6.3.3.4—Cross-Frames and Diaphragms	4-71
4.6.3.4—Cellular and Box Bridges.....	4-72
4.6.3.5—Truss Bridges	4-72
4.6.3.6—Arch Bridges	4-73
4.6.3.7—Cable-Stayed Bridges.....	4-73
4.6.3.8—Suspension Bridges.....	4-74
4.6.4—Redistribution of Negative Moments in Continuous Beam Bridges	4-74

4.6.4.1—General.....	4-74
4.6.4.2—Refined Method	4-75
4.6.4.3—Approximate Procedure	4-75
4.6.5—Stability.....	4-75
4.6.6—Analysis for Temperature Gradient.....	4-75
4.7—DYNAMIC ANALYSIS.....	4-77
4.7.1—Basic Requirements of Structural Dynamics	4-77
4.7.1.1—General.....	4-77
4.7.1.2—Distribution of Masses	4-77
4.7.1.3—Stiffness	4-78
4.7.1.4—Damping	4-78
4.7.1.5—Natural Frequencies	4-78
4.7.2—Elastic Dynamic Responses	4-78
4.7.2.1—Vehicle-Induced Vibration	4-78
4.7.2.2—Wind-Induced Vibration	4-79
4.7.2.2.1—Wind Velocities	4-79
4.7.2.2.2—Dynamic Effects	4-79
4.7.2.2.3—Design Considerations	4-79
4.7.3—Inelastic Dynamic Responses	4-79
4.7.3.1—General.....	4-79
4.7.3.2—Plastic Hinges and Yield Lines	4-80
4.7.4—Analysis for Earthquake Loads.....	4-80
4.7.4.1—General.....	4-80
4.7.4.2—Single-Span Bridges	4-80
4.7.4.3—Multispan Bridges.....	4-80
4.7.4.3.1—Selection of Method.....	4-80
4.7.4.3.2—Single-Mode Methods of Analysis	4-81
4.7.4.3.2a—General	4-81
4.7.4.3.2b—Single-Mode Spectral Method.....	4-81
4.7.4.3.2c—Uniform Load Method	4-83
4.7.4.3.3—Multimode Spectral Method	4-84
4.7.4.3.4—Time-History Method	4-85
4.7.4.3.4a—General	4-85
4.7.4.3.4b—Acceleration Time Histories.....	4-85
4.7.4.4—Minimum Support Length Requirements	4-87
4.7.4.5— P - Δ Requirements	4-88
4.7.5—Analysis for Collision Loads	4-89
4.7.6—Analysis of Blast Effects.....	4-89
4.8—ANALYSIS BY PHYSICAL MODELS	4-90
4.8.1—Scale Model Testing	4-90
4.8.2—Bridge Testing	4-90
4.9—REFERENCES	4-90
APPENDIX A4—DECK SLAB DESIGN TABLE.....	4-97

SECTION 5: CONCRETE STRUCTURES

TABLE OF CONTENTS

5.1—SCOPE	5-1
5.2—DEFINITIONS.....	5-1
5.3—NOTATION.....	5-6
5.4—MATERIAL PROPERTIES	5-15
5.4.1—General.....	5-15
5.4.2—Normal Weight and Lightweight Concrete	5-15
5.4.2.1—Compressive Strength.....	5-15
5.4.2.2—Coefficient of Thermal Expansion.....	5-17
5.4.2.3—Creep and Shrinkage.....	5-17
5.4.2.3.1—General	5-17
5.4.2.3.2—Creep	5-17
5.4.2.3.3—Shrinkage.....	5-19
5.4.2.4—Modulus of Elasticity.....	5-20
5.4.2.5—Poisson’s Ratio	5-20
5.4.2.6—Modulus of Rupture.....	5-20
5.4.2.7—Tensile Strength.....	5-21
5.4.2.8—Concrete Density Modification Factor.....	5-21
5.4.3—Reinforcing Steel	5-22
5.4.3.1—General	5-22
5.4.3.2—Modulus of Elasticity.....	5-22
5.4.3.3—Special Applications	5-22
5.4.4—Prestressing Steel.....	5-22
5.4.4.1—General	5-22
5.4.4.2—Modulus of Elasticity.....	5-23
5.4.5—Post-Tensioning Anchorages and Couplers	5-23
5.4.6—Post-Tensioning Ducts	5-23
5.4.6.1—General	5-23
5.4.6.2—Size of Ducts.....	5-24
5.4.6.3—Ducts at Deviation Saddles	5-24
5.5—LIMIT STATES AND DESIGN METHODOLOGIES.....	5-24
5.5.1—General.....	5-24
5.5.1.1—Limit-State Applicability	5-24
5.5.1.2—Design Methodologies	5-24
5.5.1.2.1—General	5-24
5.5.1.2.2—B-Regions	5-25
5.5.1.2.3—D-Regions.....	5-25
5.5.2—Service Limit State.....	5-26
5.5.3—Fatigue Limit State.....	5-26
5.5.3.1—General	5-26
5.5.3.2—Reinforcing Bars and Welded Wire Reinforcement	5-27
5.5.3.3—Prestressing Steel.....	5-28
5.5.3.4—Welded or Mechanical Splices of Reinforcement.....	5-28
5.5.4—Strength Limit State	5-29
5.5.4.1—General	5-29
5.5.4.2—Resistance Factors	5-29
5.5.4.3—Stability.....	5-32
5.5.5—Extreme Event Limit State.....	5-32
5.5.5.1—General	5-32
5.5.5.2—Special Requirements for Seismic Zones 2, 3, and 4.....	5-32
5.6—DESIGN FOR FLEXURAL AND AXIAL FORCE EFFECTS—B REGIONS	5-32
5.6.1—Assumptions for Service and Fatigue Limit States	5-33
5.6.2—Assumptions for Strength and Extreme Event Limit States.....	5-33
5.6.2.1—General	5-33
5.6.2.2—Rectangular Stress Distribution	5-36
5.6.3—Flexural Members	5-37

5.6.3.1—Stress in Prestressing Steel at Nominal Flexural Resistance	5-37
5.6.3.1.1—Components with Bonded Tendons	5-37
5.6.3.1.2—Components with Unbonded Tendons	5-38
5.6.3.1.3—Components with Both Bonded and Unbonded Tendons	5-39
5.6.3.1.3a—Detailed Analysis	5-39
5.6.3.1.3b—Simplified Analysis	5-39
5.6.3.2—Flexural Resistance	5-40
5.6.3.2.1—Factored Flexural Resistance	5-40
5.6.3.2.2—Flanged Sections	5-40
5.6.3.2.3—Rectangular Sections	5-41
5.6.3.2.4—Other Cross Sections	5-41
5.6.3.2.5—Strain Compatibility Approach	5-41
5.6.3.2.6—Composite Girder Sections	5-41
5.6.3.3—Minimum Reinforcement	5-42
5.6.3.4—Moment Redistribution	5-43
5.6.3.5—Deformations	5-43
5.6.3.5.1—General	5-43
5.6.3.5.2—Deflection and Camber	5-44
5.6.3.5.3—Axial Deformation	5-45
5.6.4—Compression Members	5-45
5.6.4.1—General	5-45
5.6.4.2—Limits for Reinforcement	5-46
5.6.4.3—Approximate Evaluation of Slenderness Effects	5-47
5.6.4.4—Factored Axial Resistance	5-48
5.6.4.5—Biaxial Flexure	5-49
5.6.4.6—Spirals, Hoops, and Ties	5-50
5.6.4.7—Hollow Rectangular Compression Members	5-51
5.6.4.7.1—Wall Slenderness Ratio	5-51
5.6.4.7.2—Limitations on the Use of the Rectangular Stress Block Method	5-52
5.6.4.7.2a—General	5-52
5.6.4.7.2b—Refined Method for Adjusting Maximum Usable Strain Limit	5-52
5.6.4.7.2c—Approximate Method for Adjusting Factored Resistance	5-52
5.6.5—Bearing	5-53
5.6.6—Tension Members	5-55
5.6.6.1—Resistance to Tension	5-55
5.6.6.2—Resistance to Combined Tension and Flexure	5-55
5.6.7—Control of Cracking by Distribution of Reinforcement	5-55
5.7—DESIGN FOR SHEAR AND TORSION—B-REGIONS	5-58
5.7.1—Design Procedures	5-58
5.7.1.1—Flexural Regions	5-58
5.7.1.2—Regions near Discontinuities	5-58
5.7.1.3—Interface Regions	5-58
5.7.1.4—Slabs and Footings	5-58
5.7.1.5—Webs of Curved Post-Tensioned Box Girder Bridges	5-58
5.7.2—General Requirements	5-59
5.7.2.1—General	5-59
5.7.2.2—Transfer and Development Lengths	5-61
5.7.2.3—Regions Requiring Transverse Reinforcement	5-61
5.7.2.4—Types of Transverse Reinforcement	5-62
5.7.2.5—Minimum Transverse Reinforcement	5-62
5.7.2.6—Maximum Spacing of Transverse Reinforcement	5-63
5.7.2.7—Design and Detailing Requirements	5-64
5.7.2.8—Shear Stress on Concrete	5-64
5.7.3—Sectional Design Model	5-66
5.7.3.1—General	5-66
5.7.3.2—Sections near Supports	5-66
5.7.3.3—Nominal Shear Resistance	5-67

5.7.3.4—Procedures for Determining Shear Resistance Parameters β and θ	5-69
5.7.3.4.1—Simplified Procedure for Nonprestressed Sections.....	5-70
5.7.3.4.2—General Procedure	5-70
5.7.3.5—Longitudinal Reinforcement	5-75
5.7.3.6—Sections Subjected to Combined Shear and Torsion	5-77
5.7.3.6.1—Transverse Reinforcement	5-77
5.7.3.6.2—Torsional Resistance	5-77
5.7.3.6.3—Longitudinal Reinforcement	5-78
5.7.4—Interface Shear Transfer—Shear Friction	5-79
5.7.4.1—General	5-79
5.7.4.2—Minimum Area of Interface Shear Reinforcement.....	5-79
5.7.4.3—Interface Shear Resistance	5-80
5.7.4.4—Cohesion and Friction Factors	5-81
5.7.4.5—Computation of the Factored Interface Shear Force for Girder/Slab Bridges	5-83
5.7.4.6—Interface Shear in Box Girder Bridges.....	5-85
5.8—DESIGN OF D-REGIONS	5-85
5.8.1—General.....	5-85
5.8.2—Strut-and-Tie Method (STM).....	5-85
5.8.2.1—General	5-85
5.8.2.2—Structural Modeling	5-87
5.8.2.3—Factored Resistance	5-93
5.8.2.4—Proportioning of Ties	5-93
5.8.2.4.1—Strength of Tie	5-93
5.8.2.4.2—Anchorage of Tie	5-93
5.8.2.5—Proportioning of Node Regions	5-94
5.8.2.5.1—Strength of a Node Face	5-94
5.8.2.5.2—Effective Cross-Sectional Area of the Node Face	5-94
5.8.2.5.3—Limiting Compressive Stress at the Node Face	5-95
5.8.2.5.3a—General	5-95
5.8.2.5.3b—Back Face of a CCT Node.....	5-96
5.8.2.6—Crack Control Reinforcement.....	5-97
5.8.2.7—Application to the Design of the General Zones of Post-Tensioning Anchorages.....	5-98
5.8.2.7.1—General	5-98
5.8.2.7.2—Nodes	5-100
5.8.2.7.3—Struts.....	5-100
5.8.2.7.4—Ties	5-101
5.8.2.8—Application to the Design of Pier Diaphragms	5-101
5.8.2.9—Application to the Design of Brackets and Corbels	5-102
5.8.3—Elastic Stress Analysis	5-103
5.8.3.1—General	5-103
5.8.3.2—General Zones of Post-Tensioning Anchorages.....	5-103
5.8.4—Approximate Stress Analysis and Design	5-103
5.8.4.1—Deep Components.....	5-103
5.8.4.2—Brackets and Corbels	5-104
5.8.4.2.1—General	5-104
5.8.4.2.2—Alternative to Strut-and-Tie Model	5-105
5.8.4.3—Beam Ledges	5-106
5.8.4.3.1—General	5-106
5.8.4.3.2—Design for Shear	5-107
5.8.4.3.3—Design for Flexure and Horizontal Force	5-108
5.8.4.3.4—Design for Punching Shear	5-108
5.8.4.3.5—Design of Hanger Reinforcement	5-110
5.8.4.3.6—Design for Bearing.....	5-112
5.8.4.4—Local Zones	5-112
5.8.4.4.1—Dimensions of Local Zone	5-112
5.8.4.4.2—Bearing Resistance	5-113
5.8.4.4.3—Special Anchorage Devices	5-114

5.8.4.5—General Zone of Post-Tensioning Anchorages	5-115
5.8.4.5.1—Limitations of Application	5-115
5.8.4.5.2—Compressive Stresses	5-117
5.8.4.5.3—Bursting Forces	5-118
5.8.4.5.4—Edge Tension Forces	5-119
5.8.4.5.5—Multiple Slab Anchorages	5-119
5.9—PRESTRESSING	5-120
5.9.1—General Design Considerations	5-120
5.9.1.1—General	5-120
5.9.1.2—Design Concrete Strengths	5-121
5.9.1.3—Section Properties	5-121
5.9.1.4—Crack Control	5-121
5.9.1.5—Buckling	5-121
5.9.1.6—Tendons with Angle Points or Curves	5-121
5.9.2—Stress Limitations	5-122
5.9.2.1—Stresses Due to Imposed Deformation	5-122
5.9.2.2—Stress Limitations for Prestressing Steel	5-122
5.9.2.3—Stress Limits for Concrete	5-123
5.9.2.3.1—For Temporary Stresses before Losses	5-123
5.9.2.3.1a—Compressive Stresses	5-123
5.9.2.3.1b—Tensile Stresses	5-123
5.9.2.3.2—For Stresses at Service Limit State after Losses	5-125
5.9.2.3.2a—Compressive Stresses	5-125
5.9.2.3.2b—Tensile Stresses	5-126
5.9.2.3.3—Principal Tensile Stresses in Webs	5-127
5.9.3—Prestress Losses	5-129
5.9.3.1—Total Prestress Loss	5-129
5.9.3.2—Instantaneous Losses	5-130
5.9.3.2.1—Anchorage Set	5-130
5.9.3.2.2—Friction	5-130
5.9.3.2.2a—Pretensioned Members	5-130
5.9.3.2.2b—Post-Tensioned Members	5-130
5.9.3.2.3—Elastic Shortening	5-132
5.9.3.2.3a—Pretensioned Members	5-132
5.9.3.2.3b—Post-Tensioned Members	5-133
5.9.3.2.3c—Combined Pretensioning and Post-Tensioning	5-134
5.9.3.3—Approximate Estimate of Time-Dependent Losses	5-135
5.9.3.4—Refined Estimates of Time-Dependent Losses	5-136
5.9.3.4.1—General	5-136
5.9.3.4.2—Losses: Time of Transfer to Time of Deck Placement	5-137
5.9.3.4.2a—Shrinkage of Girder Concrete	5-137
5.9.3.4.2b—Creep of Girder Concrete	5-138
5.9.3.4.2c—Relaxation of Prestressing Strands	5-138
5.9.3.4.3—Losses: Time of Deck Placement to Final Time	5-139
5.9.3.4.3a—Shrinkage of Girder Concrete	5-139
5.9.3.4.3b—Creep of Girder Concrete	5-139
5.9.3.4.3c—Relaxation of Prestressing Strands	5-140
5.9.3.4.3d—Shrinkage of Deck Concrete	5-140
5.9.3.4.4—Precast Pretensioned Girders without Composite Topping	5-141
5.9.3.4.5—Post-Tensioned Nonsegmental Girders	5-141
5.9.3.5—Losses in Multi-Stage Prestressing	5-141
5.9.3.6—Losses for Deflection Calculations	5-141
5.9.4—Details for Pretensioning	5-142
5.9.4.1—Minimum Spacing of Pretensioning Strand	5-142
5.9.4.2—Maximum Spacing of Pretensioning Strand in Slabs	5-142
5.9.4.3—Development of Pretensioning Strand	5-143
5.9.4.3.1—General	5-143

5.9.4.3.2—Bonded Strand	5-143
5.9.4.3.3—Debonded Strands.....	5-144
5.9.4.4—Pretensioned Anchorage Zones	5-146
5.9.4.4.1—Splitting Resistance	5-146
5.9.4.4.2—Confinement Reinforcement.....	5-147
5.9.4.5—Temporary Strands.....	5-147
5.9.5—Details for Post-Tensioning	5-148
5.9.5.1—Minimum Spacing of Post-Tensioning Tendons and Ducts	5-148
5.9.5.1.1—Post-Tensioning Ducts—Girders Straight in Plane	5-148
5.9.5.1.2—Post-Tensioning Ducts—Girders Curved in Plan	5-149
5.9.5.2—Maximum Spacing of Post-Tensioning Ducts in Slabs.....	5-149
5.9.5.3—Couplers in Post-Tensioning Tendons	5-149
5.9.5.4—Tendon Confinement	5-149
5.9.5.4.1—General	5-149
5.9.5.4.2—Wobble Effect in Slabs.....	5-150
5.9.5.4.3—Effects of Curved Tendons	5-150
5.9.5.4.4—Design for In-Plane Force Effects	5-151
5.9.5.4.4a—In-Plane Force Effects	5-151
5.9.5.4.4b—Shear Resistance to Pullout	5-152
5.9.5.4.4c—Cracking of Cover Concrete	5-154
5.9.5.4.4d—Regional Bending	5-154
5.9.5.4.5—Out-of-Plane Force Effects	5-155
5.9.5.5—External Tendon Supports	5-156
5.9.5.6—Post-Tensioned Anchorage Zones	5-156
5.9.5.6.1—General	5-156
5.9.5.6.2—General Zone	5-158
5.9.5.6.3—Local Zone.....	5-158
5.9.5.6.4—Responsibilities.....	5-159
5.9.5.6.5—Design of the General Zone.....	5-159
5.9.5.6.5a—Design Methods.....	5-159
5.9.5.6.5b—Design Principles.....	5-160
5.9.5.6.6—Special Anchorage Devices	5-164
5.9.5.6.7—Intermediate Anchorages	5-164
5.9.5.6.7a—General	5-164
5.9.5.6.7b—Crack Control behind Intermediate Anchors.....	5-164
5.9.5.6.7c—Blister and Rib Reinforcement	5-166
5.9.5.6.8—Diaphragms.....	5-166
5.9.5.6.9—Deviation Saddles	5-167
5.10—REINFORCEMENT	5-167
5.10.1—Concrete Cover	5-167
5.10.2—Hooks and Bends	5-169
5.10.2.1—Standard Hooks.....	5-169
5.10.2.2—Seismic Hooks	5-170
5.10.2.3—Minimum Bend Diameters.....	5-170
5.10.3—Spacing of Reinforcement.....	5-171
5.10.3.1 Minimum Spacing of Reinforcing Bars.....	5-171
5.10.3.1.1—Cast-in-Place Concrete	5-171
5.10.3.1.2—Precast Concrete	5-171
5.10.3.1.3—Multilayers.....	5-171
5.10.3.1.4—Splices.....	5-171
5.10.3.1.5—Bundled Bars	5-171
5.10.3.2—Maximum Spacing of Reinforcing Bars	5-172
5.10.4—Transverse Reinforcement for Compression Members.....	5-172
5.10.4.1—General.....	5-172
5.10.4.2—Spirals	5-172
5.10.4.3—Ties	5-173
5.10.5—Transverse Reinforcement for Flexural Members	5-174

5.10.6—Shrinkage and Temperature Reinforcement.....	5-174
5.10.7—Reinforcement for Hollow Rectangular Compression Members	5-175
5.10.7.1—General.....	5-175
5.10.7.2—Spacing of Reinforcement.....	5-175
5.10.7.3—Ties.....	5-175
5.10.7.4—Splices.....	5-176
5.10.7.5—Hoops.....	5-176
5.10.8—Development and Splices of Reinforcement.....	5-176
5.10.8.1—General.....	5-176
5.10.8.1.1—Basic Requirements	5-176
5.10.8.1.2—Flexural Reinforcement	5-177
5.10.8.1.2a—General.....	5-177
5.10.8.1.2b—Positive Moment Reinforcement	5-178
5.10.8.1.2c—Negative Moment Reinforcement	5-179
5.10.8.1.2d—Moment Resisting Joints.....	5-179
5.10.8.2—Development of Reinforcement	5-179
5.10.8.2.1—Deformed Bars and Deformed Wire in Tension	5-180
5.10.8.2.1a—Tension Development Length.....	5-180
5.10.8.2.1b—Modification Factors which Increase ℓ_d	5-181
5.10.8.2.1c—Modification Factors which Decrease ℓ_d	5-181
5.10.8.2.2—Deformed Bars in Compression.....	5-183
5.10.8.2.2a—Compressive Development Length.....	5-183
5.10.8.2.2b—Modification Factors.....	5-183
5.10.8.2.3—Bundled Bars.....	5-183
5.10.8.2.4—Standard Hooks in Tension.....	5-184
5.10.8.2.4a—Basic Hook Development Length.....	5-184
5.10.8.2.4b—Modification Factors.....	5-185
5.10.8.2.4c—Hooked-Bar Tie Requirements	5-185
5.10.8.2.5—Welded Wire Reinforcement	5-186
5.10.8.2.6—Shear Reinforcement.....	5-187
5.10.8.2.6a—General.....	5-187
5.10.8.2.6b—Anchorage of Deformed Reinforcement.....	5-188
5.10.8.2.6c—Anchorage of Wire Fabric Reinforcement.....	5-188
5.10.8.2.6d—Closed Stirrups.....	5-189
5.10.8.3—Development by Mechanical Anchorages.....	5-189
5.10.8.4—Splices of Bar Reinforcement	5-189
5.10.8.4.1—Detailing	5-190
5.10.8.4.2—General Requirements.....	5-190
5.10.8.4.2a—Lap Splices.....	5-190
5.10.8.4.2b—Mechanical Connections.....	5-191
5.10.8.4.2c—Welded Splices.....	5-191
5.10.8.4.3—Splices of Reinforcement in Tension	5-191
5.10.8.4.3a—Lap Splices in Tension.....	5-191
5.10.8.4.3b—Mechanical Connections or Welded Splices in Tension.....	5-192
5.10.8.4.4—Splices in Tie Members	5-192
5.10.8.4.5—Splices of Bars in Compression	5-192
5.10.8.4.5a—Lap Splices in Compression.....	5-192
5.10.8.4.5b—Mechanical Connections or Welded Splices in Compression.....	5-193
5.10.8.4.5c—End-Bearing Splices.....	5-193
5.10.8.5—Splices of Welded Wire Reinforcement.....	5-194
5.10.8.5.1—Splices of Deformed Welded Wire Reinforcement in Tension.....	5-194
5.10.8.5.2—Splices of Plain Welded Wire Reinforcement in Tension.....	5-194
5.11—SEISMIC DESIGN AND DETAILS	5-195
5.11.1—General.....	5-195
5.11.2—Seismic Zone 1.....	5-195
5.11.3—Seismic Zone 2.....	5-196
5.11.3.1—General.....	5-196

5.11.3.2—Concrete Piles	5-196
5.11.3.2.1—General	5-196
5.11.3.2.2—Cast-in-Place Piles	5-197
5.11.3.2.3—Precast Reinforced Piles	5-197
5.11.3.2.4—Precast Prestressed Piles	5-197
5.11.4—Seismic Zones 3 and 4	5-197
5.11.4.1—Column Requirements	5-197
5.11.4.1.1—Longitudinal Reinforcement	5-198
5.11.4.1.2—Flexural Resistance	5-198
5.11.4.1.3—Column Shear and Transverse Reinforcement	5-198
5.11.4.1.4—Transverse Reinforcement for Confinement at Plastic Hinges	5-199
5.11.4.1.5—Spacing of Transverse Reinforcement for Confinement	5-201
5.11.4.1.6—Splices	5-202
5.11.4.2—Requirements for Wall-Type Piers	5-203
5.11.4.3—Column Connections	5-203
5.11.4.4—Construction Joints in Piers and Columns	5-204
5.11.4.5—Concrete Piles	5-204
5.11.4.5.1—General	5-204
5.11.4.5.2—Confinement Length	5-204
5.11.4.5.3—Volumetric Ratio for Confinement	5-205
5.11.4.5.4—Cast-in-Place Piles	5-205
5.11.4.5.5—Precast Piles	5-205
5.12—PROVISIONS FOR STRUCTURE COMPONENTS AND TYPES	5-205
5.12.1—Deck Slabs	5-205
5.12.2—Slab Superstructures	5-205
5.12.2.1—Cast-in-Place Solid Slab Superstructures	5-205
5.12.2.2—Cast-in-Place Voids Slab Superstructures	5-206
5.12.2.2.1—Cross Section Dimensions	5-206
5.12.2.2.2—Minimum Number of Bearings	5-207
5.12.2.2.3—Solid End Sections	5-207
5.12.2.2.4—General Design Requirements	5-207
5.12.2.2.5—Compressive Zones in Negative Moment Area	5-207
5.12.2.2.6—Drainage of Voids	5-208
5.12.2.3—Precast Deck Bridges	5-208
5.12.2.3.1—General	5-208
5.12.2.3.2—Shear Transfer Joints	5-208
5.12.2.3.3—Shear-Flexure Transfer Joints	5-208
5.12.2.3.3a—General	5-208
5.12.2.3.3b—Design	5-209
5.12.2.3.3c—Post-Tensioning	5-209
5.12.2.3.3d—Longitudinal Construction Joints	5-209
5.12.2.3.3e—Cast-in-Place Closure Joints	5-209
5.12.2.3.3f—Structural Overlay	5-209
5.12.3—Beams and Girders	5-210
5.12.3.1—General	5-210
5.12.3.2—Precast Beams	5-210
5.12.3.2.1—Preservice Conditions	5-210
5.12.3.2.2—Extreme Dimensions	5-210
5.12.3.2.3—Lifting Devices	5-211
5.12.3.2.4—Detail Design	5-211
5.12.3.2.5—Concrete Strength	5-211
5.12.3.3—Bridges Composed of Simple Span Precast Girders Made Continuous	5-211
5.12.3.3.1—General	5-211
5.12.3.3.2—Restraint Moments	5-212
5.12.3.3.3—Material Properties	5-212
5.12.3.3.4—Age of Girder When Continuity Is Established	5-213
5.12.3.3.5—Degree of Continuity at Various Limit States	5-214

5.12.3.3.6—Service Limit State.....	5-215
5.12.3.3.7—Strength Limit State	5-215
5.12.3.3.8—Negative Moment Connections.....	5-216
5.12.3.3.9—Positive Moment Connections	5-216
5.12.3.3.9a—General.....	5-216
5.12.3.3.9b—Positive Moment Connection Using Nonprestressed Reinforcement	5-217
5.12.3.3.9c—Positive Moment Connection Using Prestressing Strand.....	5-217
5.12.3.3.9d—Details of Positive Moment Connection	5-218
5.12.3.3.10—Continuity Diaphragms	5-218
5.12.3.4—Spliced Precast Girders	5-219
5.12.3.4.1—General.....	5-219
5.12.3.4.2—Joints Between Spliced Girders	5-220
5.12.3.4.2a—General.....	5-220
5.12.3.4.2b—Details of Closure Joints	5-221
5.12.3.4.2c—Details of Match-Cast Joints	5-221
5.12.3.4.2d—Joint Design	5-221
5.12.3.4.3—Girder Segment Design.....	5-222
5.12.3.4.4—Post-Tensioning	5-222
5.12.3.5—Cast-in-Place Box Girders and T-Beams	5-223
5.12.3.5.1—Flange and Web Thickness	5-223
5.12.3.5.1a—Top Flange	5-223
5.12.3.5.1b—Bottom Flange	5-223
5.12.3.5.1c—Web.....	5-223
5.12.3.5.2—Reinforcement.....	5-223
5.12.3.5.2a—Deck Slab Reinforcement Cast-in-Place in T-Beams and Box Girders	5-223
5.12.3.5.2b—Bottom Slab Reinforcement in Cast-in-Place Box Girders.....	5-224
5.12.4—Diaphragms	5-224
5.12.5—Segmental Concrete Bridges	5-224
5.12.5.1—General	5-224
5.12.5.2—Analysis of Segmental Bridges	5-225
5.12.5.2.1—General.....	5-225
5.12.5.2.2—Construction Analysis.....	5-225
5.12.5.2.3—Analysis of the Final Structural System.....	5-225
5.12.5.3—Design	5-226
5.12.5.3.1—Loads.....	5-226
5.12.5.3.2—Construction Loads	5-226
5.12.5.3.3—Construction Load Combinations at the Service Limit State	5-227
5.12.5.3.4—Construction Load Combinations at Strength Limit States.....	5-230
5.12.5.3.4a—Superstructure Load Effects and Structural Stability	5-230
5.12.5.3.4b—Substructures.....	5-230
5.12.5.3.5—Thermal Effects During Construction.....	5-230
5.12.5.3.6—Creep and Shrinkage	5-230
5.12.5.3.7—Prestress Losses	5-231
5.12.5.3.8—Alternative Shear Design Procedure	5-232
5.12.5.3.8a—General.....	5-232
5.12.5.3.8b—Loading.....	5-232
5.12.5.3.8c—Nominal Shear Resistance	5-232
5.12.5.3.8d—Torsional Reinforcement	5-234
5.12.5.3.8e—Reinforcement Details.....	5-235
5.12.5.3.9—Provisional Post-Tensioning Ducts and Anchorages	5-235
5.12.5.3.9a—General.....	5-235
5.12.5.3.9b—Bridges with Internal Ducts	5-236
5.12.5.3.9c—Provision for Future Dead Load or Deflection Adjustment	5-236
5.12.5.3.10—Plan Presentation.....	5-236
5.12.5.3.11—Box Girder Cross section Dimensions and Details	5-237
5.12.5.3.11a—Minimum Flange Thickness.....	5-237
5.12.5.3.11b—Minimum Web Thickness.....	5-237

5.12.5.3.11c—Length of Top Flange Cantilever	5-238
5.12.5.3.11d—Overall Cross Section Dimensions	5-238
5.12.5.3.12—Seismic Design	5-239
5.12.5.4—Types of Segmental Bridges	5-239
5.12.5.4.1—General	5-239
5.12.5.4.2—Details for Precast Construction	5-240
5.12.5.4.3—Details for Cast-in-Place Construction	5-241
5.12.5.4.4—Cantilever Construction	5-241
5.12.5.4.5—Span-by-Span Construction	5-242
5.12.5.4.6—Incrementally Launched Construction	5-242
5.12.5.4.6a—General	5-242
5.12.5.4.6b—Force Effects Due to Construction Tolerances	5-242
5.12.5.4.6c—Design Details	5-243
5.12.5.4.6d—Design of Construction Equipment	5-244
5.12.5.5—Use of Alternative Construction Methods	5-245
5.12.5.6—Segmentally Constructed Bridge Substructures	5-247
5.12.5.6.1—General	5-247
5.12.5.6.2—Construction Load Combinations	5-247
5.12.5.6.3—Longitudinal Reinforcement of Hollow, Rectangular Precast Segmental Piers	5-247
5.12.6—Arches	5-247
5.12.6.1—General	5-247
5.12.6.2—Arch Ribs	5-247
5.12.7—Culverts	5-248
5.12.7.1—General	5-248
5.12.7.2—Design for Flexure	5-248
5.12.7.3—Design for Shear in Slabs of Box Culverts	5-248
5.12.8—Footings	5-249
5.12.8.1—General	5-249
5.12.8.2—Loads and Reactions	5-249
5.12.8.3—Resistance Factors	5-250
5.12.8.4—Moment in Footings	5-250
5.12.8.5—Distribution of Moment Reinforcement	5-250
5.12.8.6—Shear in Slabs and Footings	5-251
5.12.8.6.1—Critical Sections for Shear	5-251
5.12.8.6.2—One-Way Action	5-251
5.12.8.6.3—Two-Way Action	5-251
5.12.8.7—Development of Reinforcement	5-252
5.12.8.8—Transfer of Force at Base of Column	5-252
5.12.9—Concrete Piles	5-253
5.12.9.1—General	5-253
5.12.9.2—Splices	5-254
5.12.9.3—Precast Reinforced Piles	5-254
5.12.9.3.1—Pile Dimensions	5-254
5.12.9.3.2—Reinforcement	5-254
5.12.9.4—Precast Prestressed Piles	5-254
5.12.9.4.1—Pile Dimensions	5-254
5.12.9.4.2—Concrete Quality	5-255
5.12.9.4.3—Reinforcement	5-255
5.12.9.5—Cast-in-Place Piles	5-255
5.12.9.5.1—Pile Dimensions	5-256
5.12.9.5.2—Reinforcement	5-256
5.13—ANCHORS	5-256
5.13.1—General	5-256
5.13.2—General Strength Requirements	5-258
5.13.2.1—Failure Modes to be Considered	5-258
5.13.2.2—Resistance Factors	5-258
5.13.2.3—Determination of Anchor Resistance	5-259

5.13.3—Seismic Design Requirements.....	5-259
5.13.4—Installation.....	5-260
5.14—DURABILITY	5-260
5.14.1—Design Concepts	5-260
5.14.2—Major Chemical and Mechanical Factors Affecting Durability	5-261
5.14.2.1—General	5-261
5.14.2.2—Corrosion Resistance.....	5-263
5.14.2.3—Freeze–Thaw Resistance.....	5-263
5.14.2.4—External Sulfate Attack	5-264
5.14.2.5—Delayed Ettringite Formation.....	5-264
5.14.2.6—Alkali–Silica Reactive Aggregates	5-264
5.14.2.7—Alkali–Carbonate Reactive Aggregates	5-264
5.14.3—Concrete Cover	5-265
5.14.4—Corrosion-Resistant Reinforcement	5-265
5.14.5—Deck Protection Systems.....	5-265
5.14.6—Protection for Prestressing Tendons.....	5-265
5.15—REFERENCES.....	5-266
APPENDIX A5—BASIC STEPS FOR CONCRETE BRIDGES	5-279
A5.1—GENERAL	5-279
A5.2—GENERAL CONSIDERATIONS.....	5-279
A5.3—BEAM AND GIRDER SUPERSTRUCTURE DESIGN.....	5-279
A5.4—SLAB BRIDGES.....	5-280
A5.5—SUBSTRUCTURE DESIGN	5-281
APPENDIX B5—GENERAL PROCEDURE FOR SHEAR DESIGN WITH TABLES.....	5-283
B5.1—BACKGROUND	5-283
B5.2—SECTIONAL DESIGN MODEL—GENERAL PROCEDURE	5-283
APPENDIX C5—UPPER LIMITS FOR ARTICLES AFFECTED BY CONCRETE COMPRESSIVE STRENGTH.....	5-291
APPENDIX D5—ARTICLES MODIFIED TO ALLOW THE USE OF REINFORCEMENT WITH A SPECIFIED MINIMUM YIELD STRENGTH UP TO 100 KSI.....	5-293
APPENDIX E5—CROSSWALK BETWEEN 7 TH AND 8 TH EDITIONS	5-297

SECTION 6: STEEL STRUCTURES

TABLE OF CONTENTS

6.1—SCOPE	6-1
6.2—DEFINITIONS	6-2
6.3—NOTATION	6-12
6.4—MATERIALS	6-30
6.4.1—Structural Steels	6-30
6.4.2—Pins, Rollers, and Rockers	6-32
6.4.3—Bolts, Nuts, and Washers	6-32
6.4.3.1—High-Strength Structural Fasteners	6-32
6.4.3.1.1—High-Strength Bolts	6-32
6.4.3.1.2—Nuts Used with ASTM F3125 Bolts	6-32
6.4.3.1.3—Washers Used with ASTM F3125 Bolts	6-32
6.4.3.1.4—Direct Tension Indicators	6-33
6.4.3.2—Low-Strength Steel Bolts	6-33
6.4.3.3—Fasteners for Structural Anchorage	6-33
6.4.3.3.1—Anchor Rods	6-33
6.4.3.3.2—Nuts Used with Anchor Rods	6-33
6.4.4—Stud Shear Connectors	6-33
6.4.5—Weld Metal	6-34
6.4.6—Cast Metal	6-34
6.4.6.1—Cast Steel and Ductile Iron	6-34
6.4.6.2—Malleable Castings	6-34
6.4.6.3—Cast Iron	6-34
6.4.7—Stainless Steel	6-34
6.4.8—Cables	6-35
6.4.8.1—Bright Wire	6-35
6.4.8.2—Galvanized Wire	6-35
6.4.8.3—Epoxy-Coated Wire	6-35
6.4.8.4—Bridge Strand	6-35
6.4.9—Dissimilar Metals	6-35
6.5—LIMIT STATES	6-35
6.5.1—General	6-35
6.5.2—Service Limit State	6-35
6.5.3—Fatigue and Fracture Limit State	6-36
6.5.4—Strength Limit State	6-36
6.5.4.1—General	6-36
6.5.4.2—Resistance Factors	6-36
6.5.5—Extreme Event Limit State	6-37
6.6—FATIGUE AND FRACTURE CONSIDERATIONS	6-38
6.6.1—Fatigue	6-38
6.6.1.1—General	6-38
6.6.1.2—Load-Induced Fatigue	6-38
6.6.1.2.1—Application	6-38
6.6.1.2.2—Design Criteria	6-39
6.6.1.2.3—Detail Categories	6-40
6.6.1.2.4—Detailing to Reduce Constraint	6-53
6.6.1.2.5—Fatigue Resistance	6-56
6.6.1.3—Distortion-Induced Fatigue	6-60
6.6.1.3.1—Transverse Connection Plates	6-60
6.6.1.3.2—Lateral Connection Plates	6-61
6.6.1.3.3—Orthotropic Decks	6-61
6.6.2—Fracture	6-61
6.6.2.1—Member or Component Designations and Charpy V-Notch Testing Requirements	6-61
6.6.2.2—Fracture-Critical Members	6-64
6.7—GENERAL DIMENSION AND DETAIL REQUIREMENTS	6-65

6.7.1—Effective Length of Span	6-65
6.7.2—Dead Load Camber and Detailing of Structural Components	6-65
6.7.3—Minimum Thickness of Steel	6-71
6.7.4—Diaphragms and Cross-Frames	6-71
6.7.4.1—General	6-71
6.7.4.2—I-Section Members	6-72
6.7.4.3—Composite Box-Section Members	6-76
6.7.4.4—Noncomposite Box-Section Members	6-77
6.7.4.4.1—General	6-77
6.7.4.4.2—Square and Rectangular HSS Members	6-77
6.7.4.4.3—Welded and Nonwelded Built-Up Noncomposite Box-Section Members	6-78
6.7.4.5—Trusses and Arches	6-79
6.7.5—Lateral Bracing	6-79
6.7.5.1—General	6-79
6.7.5.2—I-Section Members	6-80
6.7.5.3—Tub Section Members	6-80
6.7.5.4—Trusses	6-83
6.7.6—Pins	6-83
6.7.6.1—Location	6-83
6.7.6.2—Resistance	6-83
6.7.6.2.1—Combined Flexure and Shear	6-83
6.7.6.2.2—Bearing	6-84
6.7.6.3—Minimum Size Pin for Eyebars	6-84
6.7.6.4—Pins and Pin Nuts	6-84
6.7.7—Heat-Curved Rolled Beams and Welded Plate Girders	6-85
6.7.7.1—Scope	6-85
6.7.7.2—Geometric Limitations	6-85
6.7.8—Bent Plates	6-85
6.8—TENSION MEMBERS	6-86
6.8.1—General	6-86
6.8.2—Tensile Resistance	6-86
6.8.2.1—General	6-86
6.8.2.2—Reduction Factor, U	6-87
6.8.2.3—Combined Axial Tension, Flexure, and Flexural and/or Torsional Shear	6-90
6.8.2.3.1—General	6-90
6.8.2.3.2—Interaction with Torsional and/or Flexural Shear	6-92
6.8.2.3.3—Tension Rupture under Axial Tension or Compression Combined with Flexure	6-93
6.8.3—Net Area	6-95
6.8.4—Limiting Slenderness Ratio for Tension Members	6-95
6.8.5—Builtup Members	6-96
6.8.5.1—General	6-96
6.8.5.2—Perforated Plates	6-96
6.8.6—Eyebars	6-96
6.8.6.1—Factored Resistance	6-96
6.8.6.2—Proportions	6-96
6.8.6.3—Packing	6-97
6.8.7—Pin-Connected Plates	6-97
6.8.7.1—General	6-97
6.8.7.2—Pin Plates	6-97
6.8.7.3—Proportions	6-98
6.8.7.4—Packing	6-98
6.9—COMPRESSION MEMBERS	6-98
6.9.1—General	6-98
6.9.2—Compressive Resistance	6-99
6.9.2.1—Axial Compression	6-99
6.9.2.2—Combined Axial Compression, Flexure, and Flexural and/or Torsional Shear	6-99
6.9.2.2.1—General	6-99
6.9.2.2.2—Interaction with Torsional and/or Flexural Shear	6-102

6.9.3—Limiting Slenderness Ratio for Compression Members	6-108
6.9.4—Noncomposite Members	6-109
6.9.4.1—Nominal Compressive Resistance	6-109
6.9.4.1.1—General	6-109
6.9.4.1.2—Elastic Flexural Buckling Resistance	6-113
6.9.4.1.3—Elastic Torsional Buckling and Flexural–Torsional Buckling Resistance	6-113
6.9.4.2—Effects of Local Buckling on the Nominal Compressive Resistance	6-115
6.9.4.2.1—Classification of Cross-Section Elements	6-115
6.9.4.2.2—Slender Longitudinally Unstiffened Cross-Section Elements	6-117
6.9.4.2.2a—General	6-117
6.9.4.2.2b—Effective Width of Slender Elements	6-119
6.9.4.2.2c—Effective Area of Circular Tubes and Round HSS	6-121
6.9.4.3—Built-Up Members	6-121
6.9.4.3.1—General	6-121
6.9.4.3.2—Perforated Plates	6-122
6.9.4.4—Single-Angle Members	6-123
6.9.4.5—Plate Buckling under Service and Construction Loads	6-126
6.9.5—Composite Members	6-128
6.9.5.1—Nominal Compressive Resistance	6-128
6.9.5.2—Limitations	6-130
6.9.5.2.1—General	6-130
6.9.5.2.2—Concrete-Filled Tubes	6-130
6.9.5.2.3—Concrete-Encased Shapes	6-130
6.9.6—Composite Concrete-Filled Steel Tubes (CFSTs)	6-130
6.9.6.1—General	6-130
6.9.6.2—Limitations	6-131
6.9.6.3—Combined Axial Compression and Flexure	6-132
6.9.6.3.1—General	6-132
6.9.6.3.2—Axial Compressive Resistance	6-133
6.9.6.3.3—Nominal Flexural Composite Resistance	6-134
6.9.6.3.4—Nominal Stability-Based Interaction Curve	6-134
6.10—I-SECTION FLEXURAL MEMBERS	6-135
6.10.1—General	6-135
6.10.1.1—Composite Sections	6-137
6.10.1.1.1—Stresses	6-137
6.10.1.1.1a—Sequence of Loading	6-137
6.10.1.1.1b—Stresses for Sections in Positive Flexure	6-137
6.10.1.1.1c—Stresses for Sections in Negative Flexure	6-138
6.10.1.1.1d—Concrete Deck Stresses	6-138
6.10.1.1.1e—Effective Width of Concrete Deck	6-139
6.10.1.2—Noncomposite Sections	6-139
6.10.1.3—Hybrid Sections	6-139
6.10.1.4—Variable Web Depth Members	6-139
6.10.1.5—Stiffness	6-141
6.10.1.6—Flange Stresses and Member Bending Moments	6-142
6.10.1.7—Minimum Negative Flexure Concrete Deck Reinforcement	6-144
6.10.1.8—Tension Flanges with Holes	6-146
6.10.1.9—Web Bend-Buckling Resistance	6-147
6.10.1.9.1—Webs without Longitudinal Stiffeners	6-147
6.10.1.9.2—Webs with Longitudinal Stiffeners	6-148
6.10.1.10—Flange-Strength Reduction Factors	6-150
6.10.1.10.1—Hybrid Factor, R_h	6-150
6.10.1.10.2—Web Load-Shedding Factor, R_b	6-151
6.10.2—Cross-Section Proportion Limits	6-157
6.10.2.1—Web Proportions	6-157
6.10.2.1.1—Webs without Longitudinal Stiffeners	6-157
6.10.2.1.2—Webs with Longitudinal Stiffeners	6-158
6.10.2.2—Flange Proportions	6-158

6.10.3—Constructibility.....	6-160
6.10.3.1—General.....	6-160
6.10.3.2—Flexure.....	6-160
6.10.3.2.1—Discretely Braced Flanges in Compression.....	6-160
6.10.3.2.2—Discretely Braced Flanges in Tension.....	6-162
6.10.3.2.3—Continuously Braced Flanges in Tension or Compression.....	6-162
6.10.3.2.4—Concrete Deck.....	6-163
6.10.3.3—Shear.....	6-163
6.10.3.4—Deck Placement.....	6-163
6.10.3.4.1—General.....	6-163
6.10.3.4.2—Global Displacement Amplification in Narrow I-Girder Bridge Units.....	6-165
6.10.3.5—Dead Load Deflections.....	6-167
6.10.4—Service Limit State.....	6-167
6.10.4.1—Elastic Deformations.....	6-167
6.10.4.2—Permanent Deformations.....	6-168
6.10.4.2.1—General.....	6-168
6.10.4.2.2—Flexure.....	6-168
6.10.5—Fatigue and Fracture Limit State.....	6-171
6.10.5.1—Fatigue.....	6-171
6.10.5.2—Fracture.....	6-171
6.10.5.3—Special Fatigue Requirement for Webs.....	6-171
6.10.6—Strength Limit State.....	6-172
6.10.6.1—General.....	6-172
6.10.6.2—Flexure.....	6-174
6.10.6.2.1—General.....	6-174
6.10.6.2.2—Composite Sections in Positive Flexure.....	6-174
6.10.6.2.3—Composite Sections in Negative Flexure and Noncomposite Sections.....	6-175
6.10.6.3—Shear.....	6-178
6.10.6.4—Shear Connectors.....	6-178
6.10.7—Flexural Resistance—Composite Sections in Positive Flexure.....	6-178
6.10.7.1—Compact Sections.....	6-178
6.10.7.1.1—General.....	6-178
6.10.7.1.2—Nominal Flexural Resistance.....	6-178
6.10.7.2—Noncompact Sections.....	6-181
6.10.7.2.1—General.....	6-181
6.10.7.2.2—Nominal Flexural Resistance.....	6-181
6.10.7.3—Ductility Requirement.....	6-182
6.10.8—Flexural Resistance—Composite Sections in Negative Flexure and Noncomposite Sections.....	6-182
6.10.8.1—General.....	6-182
6.10.8.1.1—Discretely Braced Flanges in Compression.....	6-182
6.10.8.1.2—Discretely Braced Flanges in Tension.....	6-183
6.10.8.1.3—Continuously Braced Flanges in Tension or Compression.....	6-183
6.10.8.2—Compression–Flange Flexural Resistance.....	6-183
6.10.8.2.1—General.....	6-183
6.10.8.2.2—Local Buckling Resistance.....	6-185
6.10.8.2.3—Lateral–Torsional buckling Resistance.....	6-186
6.10.8.3—Flexural Resistance Based on Tension Flange Yielding.....	6-193
6.10.9—Shear Resistance.....	6-193
6.10.9.1—General.....	6-193
6.10.9.2—Nominal Resistance of Unstiffened Webs.....	6-194
6.10.9.3—Nominal Resistance of Stiffened Webs.....	6-194
6.10.9.3.1—General.....	6-194
6.10.9.3.2—Interior Panels.....	6-195
6.10.9.3.3—End Panels.....	6-196
6.10.10—Shear Connectors.....	6-197
6.10.10.1—General.....	6-197
6.10.10.1.1—Types.....	6-197
6.10.10.1.2—Pitch.....	6-197

6.10.10.1.3—Transverse Spacing	6-199
6.10.10.1.4—Cover and Penetration	6-199
6.10.10.2—Fatigue Resistance	6-199
6.10.10.3—Special Requirements for Points of Permanent Load Contraflexure	6-200
6.10.10.4—Strength Limit State	6-201
6.10.10.4.1—General	6-201
6.10.10.4.2—Nominal Shear Force	6-202
6.10.10.4.3—Nominal Shear Resistance	6-203
6.10.11—Web Stiffeners	6-204
6.10.11.1—Web Transverse Stiffeners	6-204
6.10.11.1.1—General	6-204
6.10.11.1.2—Projecting Width	6-204
6.10.11.1.3—Moment of Inertia	6-205
6.10.11.2—Bearing Stiffeners	6-208
6.10.11.2.1—General	6-208
6.10.11.2.2—Minimum Thickness	6-208
6.10.11.2.3—Bearing Resistance	6-209
6.10.11.2.4—Axial Resistance of Bearing Stiffeners	6-209
6.10.11.2.4a—General	6-209
6.10.11.2.4b—Effective Section	6-209
6.10.11.3—Web Longitudinal Stiffeners	6-210
6.10.11.3.1—General	6-210
6.10.11.3.2—Projecting Width	6-212
6.10.11.3.3—Moment of Inertia and Radius of Gyration	6-213
6.10.12—Cover Plates	6-214
6.10.12.1—General	6-214
6.10.12.2—End Requirements	6-214
6.10.12.2.1—General	6-214
6.10.12.2.2—Welded Ends	6-215
6.10.12.2.3—Bolted Ends	6-215
6.11—COMPOSITE BOX-SECTION FLEXURAL MEMBERS	6-215
6.11.1—General	6-215
6.11.1.1—Stress Determinations	6-217
6.11.1.2—Bearings	6-220
6.11.1.3—Flange-to-Web Connections	6-221
6.11.1.4—Access and Drainage	6-221
6.11.2—Cross-Section Proportion Limits	6-222
6.11.2.1—Web Proportions	6-222
6.11.2.1.1—General	6-222
6.11.2.1.2—Webs without Longitudinal Stiffeners	6-222
6.11.2.1.3—Webs with Longitudinal Stiffeners	6-222
6.11.2.2—Flange Proportions	6-222
6.11.2.3—Special Restrictions on Use of Live Load Distribution Factor for Multiple Box Sections	6-222
6.11.3—Constructibility	6-223
6.11.3.1—General	6-223
6.11.3.2—Flexure	6-224
6.11.3.3—Shear	6-226
6.11.4—Service Limit State	6-226
6.11.5—Fatigue and Fracture Limit State	6-227
6.11.6—Strength Limit State	6-229
6.11.6.1—General	6-229
6.11.6.2—Flexure	6-229
6.11.6.2.1—General	6-229
6.11.6.2.2—Sections in Positive Flexure	6-229
6.11.6.2.3—Sections in Negative Flexure	6-230
6.11.6.3—Shear	6-230
6.11.6.4—Shear Connectors	6-231
6.11.7—Flexural Resistance—Sections in Positive Flexure	6-231

6.11.7.1—Compact Sections.....	6-231
6.11.7.1.1—General.....	6-231
6.11.7.1.2—Nominal Flexural Resistance	6-231
6.11.7.2—Noncompact Sections.....	6-231
6.11.7.2.1—General.....	6-231
6.11.7.2.2—Nominal Flexural Resistance	6-232
6.11.8—Flexural Resistance—Sections in Negative Flexure	6-233
6.11.8.1—General.....	6-233
6.11.8.1.1—Box Flanges in Compression	6-233
6.11.8.1.2—Continuously Braced Flanges in Tension	6-234
6.11.8.2—Flexural Resistance of Box Flanges in Compression	6-235
6.11.8.2.1—General.....	6-235
6.11.8.2.2—Unstiffened Flanges	6-235
6.11.8.2.3—Longitudinally Stiffened Flanges.....	6-237
6.11.8.3—Flexural Resistance Based on Tension Flange Yielding	6-238
6.11.9—Shear Resistance	6-238
6.11.10—Shear Connectors	6-239
6.11.11—Stiffeners	6-240
6.11.11.1—Web Stiffeners	6-240
6.11.11.2—Longitudinal Compression–Flange Stiffeners.....	6-240
6.12—MISCELLANEOUS FLEXURAL MEMBERS	6-243
6.12.1—General.....	6-243
6.12.1.1—Scope.....	6-243
6.12.1.2—Strength Limit State	6-244
6.12.1.2.1—Flexure	6-244
6.12.1.2.2—Combined Flexure, Axial Load, and Flexural and/or Torsional Shear	6-245
6.12.1.2.3—Flexural Shear and/or Torsion.....	6-245
6.12.1.2.3a—General.....	6-245
6.12.1.2.3b—Circular Tubes and Round HSS.....	6-247
6.12.1.2.4—Special Provisions for HSS Members	6-248
6.12.2—Nominal Flexural Resistance	6-248
6.12.2.1—General.....	6-248
6.12.2.2—Noncomposite Members	6-248
6.12.2.2.1—I- and H-Shaped Members	6-248
6.12.2.2.2—Rectangular Box-Section Members	6-249
6.12.2.2.2a—General.....	6-249
6.12.2.2.2b—Cross-Section Proportion Limits.....	6-251
6.12.2.2.2c—Classification of Sections with a Longitudinally Unstiffened Compression flange	6-253
6.12.2.2.2d—Classification of Sections with a Longitudinally Stiffened Compression Flange...	6-261
6.12.2.2.2e—General Yielding, Compression–Flange Local Buckling and Lateral–Torsional Buckling	6-263
6.12.2.2.2f—Service and Fatigue Limit States and Constructibility	6-265
6.12.2.2.2g—Flange Effective Width or Area Accounting for Shear Lag Effects	6-266
6.12.2.2.3—Circular Tubes and Round HSS	6-268
6.12.2.2.4—Tees and Double Angles	6-269
6.12.2.2.4a—General.....	6-269
6.12.2.2.4b—Yielding	6-269
6.12.2.2.4c—Lateral–Torsional Buckling	6-269
6.12.2.2.4d—Flange Local Buckling.....	6-271
6.12.2.2.4e—Local Buckling of Tee Stems and Double Angle Web Legs.....	6-272
6.12.2.2.5—Channels	6-274
6.12.2.2.6—Single Angles.....	6-276
6.12.2.2.7—Rectangular Bars and Solid Rounds.....	6-277
6.12.2.3—Composite Members	6-278
6.12.2.3.1—Concrete-Encased Shapes	6-278
6.12.2.3.2—Concrete-Filled Tubes.....	6-279
6.12.2.3.3—Composite Concrete-Filled Steel Tubes (CFSTs).....	6-279

6.12.3—Nominal Shear Resistance of Composite Members	6-283
6.12.3.1—Concrete-Encased Shapes	6-283
6.12.3.2—Concrete-Filled Tubes	6-283
6.12.3.2.1—Rectangular Tubes	6-283
6.12.3.2.2—Composite Concrete-Filled Steel Tubes.....	6-283
6.13—CONNECTIONS AND SPLICES	6-284
6.13.1—General.....	6-284
6.13.2—Bolted Connections.....	6-285
6.13.2.1—General.....	6-285
6.13.2.1.1—Slip-Critical Connections.....	6-285
6.13.2.1.2—Bearing-Type Connections	6-286
6.13.2.2—Factored Resistance	6-286
6.13.2.3—Bolts, Nuts, and Washers.....	6-287
6.13.2.3.1—Bolts and Nuts	6-287
6.13.2.3.2—Washers	6-287
6.13.2.4—Holes.....	6-288
6.13.2.4.1—Type.....	6-288
6.13.2.4.1a—General.....	6-288
6.13.2.4.1b—Oversize Holes	6-288
6.13.2.4.1c—Short-Slotted Holes.....	6-288
6.13.2.4.1d—Long-Slotted Holes.....	6-288
6.13.2.4.2—Size	6-288
6.13.2.5—Size of Bolts.....	6-288
6.13.2.6—Spacing of Bolts.....	6-289
6.13.2.6.1—Minimum Spacing and Clear Distance	6-289
6.13.2.6.2—Maximum Spacing for Sealing Bolts.....	6-289
6.13.2.6.3—Maximum Pitch for Stitch Bolts	6-289
6.13.2.6.4—Maximum Pitch for Stitch Bolts at the End of Compression Members.....	6-290
6.13.2.6.5—End Distance.....	6-290
6.13.2.6.6—Edge Distances	6-290
6.13.2.7—Shear Resistance	6-290
6.13.2.8—Slip Resistance.....	6-291
6.13.2.9—Bearing Resistance at Bolt Holes.....	6-295
6.13.2.10—Tensile Resistance	6-296
6.13.2.10.1—General	6-296
6.13.2.10.2—Nominal Tensile Resistance	6-296
6.13.2.10.3—Fatigue Resistance	6-296
6.13.2.10.4—Prying Action.....	6-296
6.13.2.11—Combined Tension and Shear	6-297
6.13.2.12—Shear Resistance of Anchor Rods.....	6-298
6.13.3—Welded Connections	6-298
6.13.3.1—General.....	6-298
6.13.3.2—Factored Resistance	6-298
6.13.3.2.1—General	6-298
6.13.3.2.2—Complete Penetration Groove-Welded Connections	6-299
6.13.3.2.2a—Tension and Compression.....	6-299
6.13.3.2.2b—Shear.....	6-299
6.13.3.2.3—Partial Penetration Groove-Welded Connections	6-299
6.13.3.2.3a—Tension or Compression	6-299
6.13.3.2.3b—Shear.....	6-299
6.13.3.2.4—Fillet-Welded Connections	6-300
6.13.3.3—Effective Area.....	6-300
6.13.3.4—Size of Fillet Welds	6-300
6.13.3.5—Minimum Effective Length of Fillet Welds.....	6-301
6.13.3.6—Fillet Weld End Returns	6-301
6.13.3.7—Fillet Welds for Sealing.....	6-301
6.13.4—Block Shear Rupture Resistance	6-302
6.13.5—Connection Elements	6-303

6.13.5.1—General	6-303
6.13.5.2—Tension	6-303
6.13.5.3—Shear	6-303
6.13.6—Splices	6-304
6.13.6.1—Bolted Splices	6-304
6.13.6.1.1—Tension Members	6-304
6.13.6.1.2—Compression Members	6-304
6.13.6.1.3—Flexural Members	6-304
6.13.6.1.3a—General	6-304
6.13.6.1.3b—Flange Splices	6-305
6.13.6.1.3c—Web Splices	6-308
6.13.6.1.4—Fillers	6-311
6.13.6.2—Welded Splices	6-312
6.13.7—Rigid Frame Connections	6-313
6.13.7.1—General	6-313
6.13.7.2—Webs	6-313
6.14—PROVISIONS FOR STRUCTURE TYPES	6-314
6.14.1—Through-Girder Spans	6-314
6.14.2—Trusses	6-314
6.14.2.1—General	6-314
6.14.2.2—Truss Members	6-315
6.14.2.3—Secondary Stresses	6-315
6.14.2.4—Diaphragms	6-315
6.14.2.5—Camber	6-315
6.14.2.6—Working Lines and Gravity Axes	6-316
6.14.2.7—Portal and Sway Bracing	6-316
6.14.2.7.1—General	6-316
6.14.2.7.2—Through-Truss Spans	6-316
6.14.2.7.3—Deck Truss Spans	6-316
6.14.2.8—Gusset Plates	6-316
6.14.2.8.1—General	6-316
6.14.2.8.2—Multilayered Gusset and Splice Plates	6-317
6.14.2.8.3—Shear Resistance	6-317
6.14.2.8.4—Compressive Resistance	6-319
6.14.2.8.5—Tensile Resistance	6-320
6.14.2.8.6—Chord Splices	6-321
6.14.2.8.7—Edge Slenderness	6-323
6.14.2.9—Half Through-Trusses	6-323
6.14.2.10—Factored Resistance	6-323
6.14.3—Orthotropic Deck Superstructures	6-323
6.14.3.1—General	6-323
6.14.3.2—Decks in Global Compression	6-324
6.14.3.2.1—General	6-324
6.14.3.2.2—Local Buckling	6-324
6.14.3.2.3—Panel Buckling	6-324
6.14.3.3—Effective Width of Deck	6-325
6.14.3.4—Superposition of Global and Local Effects	6-325
6.14.4—Solid Web Arches	6-325
6.14.4.1—General	6-325
6.14.4.2—Web Slenderness	6-327
6.14.4.3—Moment Amplification	6-327
6.14.4.4—Nominal Compressive Resistance	6-327
6.14.4.5—Nominal Flexural Resistance	6-327
6.14.4.6—Combined Axial Compression or Tension with Flexure and Torsion	6-328
6.15—PILES	6-328
6.15.1—General	6-328
6.15.2—Structural Resistance	6-328
6.15.3—Compressive Resistance	6-330

6.15.3.1—Axial Compression	6-330
6.15.3.2—Combined Axial Compression and Flexure	6-330
6.15.3.3—Buckling.....	6-330
6.15.4—Maximum Permissible Driving Stresses	6-330
6.16—PROVISIONS FOR SEISMIC DESIGN	6-330
6.16.1—General.....	6-330
6.16.2—Materials	6-332
6.16.3—Design Requirements for Seismic Zone 1.....	6-332
6.16.4—Design Requirements for Seismic Zones 2, 3, or 4.....	6-332
6.16.4.1—General.....	6-332
6.16.4.2—Deck.....	6-333
6.16.4.3—Shear Connectors	6-335
6.16.4.4—Elastic Superstructures.....	6-337
6.17—REFERENCES	6-337
APPENDIX A6—FLEXURAL RESISTANCE OF COMPOSITE I-SECTIONS IN NEGATIVE FLEXURE AND NONCOMPOSITE I-SECTIONS WITH COMPACT OR NONCOMPACT WEBS IN STRAIGHT BRIDGES	6-353
A6.1—GENERAL	6-353
A6.1.1—Sections with Discretely Braced Compression Flanges	6-354
A6.1.2—Sections with Discretely Braced Tension Flanges	6-355
A6.1.3—Sections with Continuously Braced Compression Flanges	6-356
A6.1.4—Sections with Continuously Braced Tension Flanges	6-356
A6.2—WEB PLASTIFICATION FACTORS	6-356
A6.2.1—Compact Web Sections	6-356
A6.2.2—Noncompact Web Sections	6-358
A6.3—FLEXURAL RESISTANCE BASED ON THE COMPRESSION FLANGE	6-359
A6.3.1—General.....	6-359
A6.3.2—Local Buckling Resistance.....	6-360
A6.3.3—Lateral-Torsional buckling Resistance	6-361
A6.4—FLEXURAL RESISTANCE BASED ON TENSION FLANGE YIELDING	6-365
APPENDIX B6—MOMENT REDISTRIBUTION FROM INTERIOR-PIER I-SECTIONS IN STRAIGHT CONTINUOUS-SPAN BRIDGES	6-367
B6.1—GENERAL	6-367
B6.2—SCOPE	6-367
B6.2.1—Web Proportions.....	6-368
B6.2.2—Compression Flange Proportions	6-368
B6.2.3—Section Transitions.....	6-369
B6.2.4—Compression Flange Bracing	6-369
B6.2.5—Shear	6-369
B6.2.6—Bearing Stiffeners.....	6-370
B6.3—SERVICE LIMIT STATE.....	6-370
B6.3.1—General	6-370
B6.3.2—Flexure	6-370
B6.3.2.1—Adjacent to Interior-Pier Sections	6-370
B6.3.2.2—At All Other Locations	6-370
B6.3.3—Redistribution Moments	6-371
B6.3.3.1—At Interior-Pier Sections	6-371
B6.3.3.2—At All Other Locations	6-371
B6.4—STRENGTH LIMIT STATE	6-372
B6.4.1—Flexural Resistance	6-372
B6.4.1.1—Adjacent to Interior-Pier Sections	6-372
B6.4.1.2—At All Other Locations	6-372
B6.4.2—Redistribution Moments	6-372
B6.4.2.1—At Interior-Pier Sections	6-372
B6.4.2.2—At All Other Sections	6-373
B6.5—EFFECTIVE PLASTIC MOMENT	6-373
B6.5.1—Interior-Pier Sections with Enhanced Moment-Rotation Characteristics	6-373
B6.5.2—All Other Interior-Pier Sections	6-374

B6.6—REFINED METHOD	6-374
B6.6.1—General	6-374
B6.6.2—Nominal Moment-Rotation Curves	6-376
APPENDIX C6—BASIC STEPS FOR STEEL BRIDGE SUPERSTRUCTURES	6-379
C6.1—GENERAL	6-379
C6.2—GENERAL CONSIDERATIONS	6-379
C6.3—SUPERSTRUCTURE DESIGN	6-379
C6.4—FLOWCHARTS FOR FLEXURAL DESIGN OF I-SECTION MEMBERS	6-382
C6.4.1—Flowchart for LRFD Article 6.10.3	6-382
C6.4.2—Flowchart for LRFD Article 6.10.4	6-383
C6.4.3—Flowchart for LRFD Article 6.10.5	6-384
C6.4.4—Flowchart for LRFD Article 6.10.6	6-385
C6.4.5—Flowchart for LRFD Article 6.10.7	6-386
C6.4.6—Flowchart for LRFD Article 6.10.8	6-387
C6.4.7—Flowchart for Appendix A6.....	6-389
C6.4.8—Flowchart for Article D6.4.1	6-391
C6.4.9—Flowchart for Article D6.4.2	6-392
C6.4.10—Moment Gradient Modifier, C_b (Sample Cases).....	6-393
C6.5—FLOWCHARTS FOR LRFD ARTICLES 6.9.4 AND 6.12.2.2.2	6-395
C6.5.1—Flowchart for LRFD Article 6.9.4	6-395
C6.5.2—Flowchart for LRFD Article 6.12.2.2.2.....	6-397
APPENDIX D6—FUNDAMENTAL CALCULATIONS FOR FLEXURAL MEMBERS.....	6-400
D6.1—PLASTIC MOMENT	6-401
D6.2—YIELD MOMENT	6-405
D6.2.1—Noncomposite Sections	6-405
D6.2.2—Composite Sections in Positive Flexure	6-405
D6.2.3—Composite Sections in Negative Flexure	6-406
D6.2.4—Sections with Cover Plates.....	6-406
D6.3—DEPTH OF THE WEB IN COMPRESSION	6-406
D6.3.1—In the Elastic Range (D_c).....	6-406
D6.3.2—At Plastic Moment (D_{cp}).....	6-407
D6.4—LATERAL-TORSIONAL BUCKLING EQUATIONS FOR $C_B > 1.0$, WITH EMPHASIS ON UNBRACED LENGTH REQUIREMENTS FOR DEVELOPMENT OF THE MAXIMUM FLEXURAL RESISTANCE	6-408
D6.4.1—By the Provisions of Article 6.10.8.2.3	6-408
D6.4.2—By the Provisions of Article A6.3.3	6-409
D6.5—CONCENTRATED LOADS APPLIED TO WEBS WITHOUT BEARING STIFFENERS	6-410
D6.5.1—General	6-410
D6.5.2—Web Local Yielding	6-410
D6.5.3—Web Crippling.....	6-411
APPENDIX E6—NOMINAL COMPRESSIVE RESISTANCE OF NONCOMPOSITE MEMBERS CONTAINING LONGITUDINALLY STIFFENED PLATES.....	6-413
E6.1—NOMINAL COMPRESSIVE RESISTANCE	6-413
E6.1.1—General	6-413
E6.1.2—Classification of Longitudinally Stiffened Plate Panels.....	6-415
E6.1.3—Nominal Compressive Resistance and Effective Area of Plates with Equally-Spaced Equal-Size Longitudinal Stiffeners	6-415
E6.1.4—Longitudinal Stiffeners	6-419
E6.1.5—Transverse Stiffeners	6-421
E6.1.5.1—General	6-421
E6.1.5.2—Moment of Inertia.....	6-424

SECTION 7: ALUMINUM STRUCTURES

TABLE OF CONTENTS

7.1—SCOPE	7-1
7.2—DEFINITIONS.....	7-1
7.3—NOTATION.....	7-1
7.4—MATERIALS.....	7-5
7.4.1—Aluminum Alloys	7-5
7.4.2—Pins, Rollers, and Rockers	7-6
7.4.3—Bolts, Nuts, and Washers	7-7
7.4.3.1—Bolts.....	7-7
7.4.3.2—Nuts Used with ASTM F3125 Bolts.....	7-7
7.4.3.3—Washers Used with ASTM F3125 Bolts.....	7-7
7.4.3.4—Direct Tension Indicators.....	7-7
7.4.4—Shear Connectors	7-7
7.4.5—Weld Metal	7-7
7.5—LIMIT STATES.....	7-8
7.5.1—General.....	7-8
7.5.2—Service Limit State.....	7-8
7.5.3—Fatigue Limit State.....	7-8
7.5.4—Strength Limit State	7-8
7.5.4.1—General.....	7-8
7.5.4.2—Resistance Factors	7-8
7.5.4.3—Buckling Constants	7-9
7.5.4.4—Nominal Resistance of Elements in Uniform Compression.....	7-10
7.5.4.4.1—General	7-10
7.5.4.4.2—Flat Elements Supported on One Edge	7-11
7.5.4.4.3—Flat Elements Supported on Both Edges	7-11
7.5.4.4.4—Flat Elements Supported on One Edge and with a Stiffener on the Other Edge.....	7-12
7.5.4.4.5—Flat Elements Supported on Both Edges and with an Intermediate Stiffener	7-13
7.5.4.4.6—Round Hollow Elements and Curved Elements Supported on Both Edges	7-14
7.5.4.4.7—Alternative Method for Flat Elements	7-15
7.5.4.5—Nominal Resistance of Elements in Flexural Compression	7-15
7.5.4.5.1—General	7-15
7.5.4.5.2—Flat Elements Supported on Both Edges	7-16
7.5.4.5.3—Flat Elements Supported on Tension Edge, Compression Edge Free	7-17
7.5.4.5.4—Flat Elements Supported on Both Edges and with a Longitudinal Stiffener	7-17
7.5.4.5.5—Pipes and Round Tubes	7-18
7.5.4.5.6—Alternative Method for Flat Elements	7-18
7.5.4.6—Nominal Resistance of Elements in Shear	7-19
7.5.4.6.1—General	7-19
7.5.4.6.2—Flat Elements Supported on Both Edges	7-19
7.5.4.6.3—Flat Elements Supported on One Edge	7-21
7.5.4.6.4—Pipes and Round or Oval Tubes	7-22
7.5.4.7—Elastic Buckling Stress of Elements	7-23
7.5.5—Extreme Event Limit State.....	7-23
7.6—FATIGUE	7-24
7.6.1—General.....	7-24
7.6.2—Load-Induced Fatigue	7-24
7.6.2.1—Application	7-24
7.6.2.2—Design Criteria.....	7-24
7.6.2.3—Detail Categories	7-24
7.6.2.4—Detailing to Reduce Constraint.....	7-30
7.6.2.5—Fatigue Resistance	7-30
7.6.3—Distortion-Induced Fatigue	7-31
7.6.3.1—Transverse Connection Plates.....	7-31
7.6.3.2—Lateral Connection Plates	7-31
7.7—GENERAL DIMENSION AND DETAIL REQUIREMENTS.....	7-31

7.7.1—Effective Length of Span	7-31
7.7.2—Dead Load Camber	7-31
7.7.3—Minimum Thickness.....	7-31
7.7.4—Diaphragms and Cross-Frames	7-32
7.7.5—Lateral Bracing.....	7-32
7.8—TENSION MEMBERS	7-32
7.8.1—General.....	7-32
7.8.2—Tensile Resistance.....	7-32
7.8.2.1—General.....	7-32
7.8.2.2—Effective Net Area	7-33
7.8.2.3—Combined Tension and Flexure	7-33
7.8.3—Net Area.....	7-34
7.8.4—Limiting Slenderness Ratio	7-34
7.8.5—Built-Up Members	7-35
7.9—COMPRESSION MEMBERS	7-35
7.9.1—General.....	7-35
7.9.2—Axial Compression Resistance.....	7-35
7.9.2.1—Member Buckling	7-35
7.9.2.1.1—General.....	7-35
7.9.2.1.2—Flexural Buckling	7-36
7.9.2.1.3—Torsional and Flexural–Torsional Buckling	7-37
7.9.2.2—Local Buckling.....	7-38
7.9.2.2.1—General.....	7-38
7.9.2.2.2—Weighted Average Local Buckling Resistance.....	7-38
7.9.2.2.3—Alternative Local Buckling Resistance.....	7-38
7.9.2.3—Interaction between Member Buckling and Local Buckling.....	7-38
7.9.3—Limiting Slenderness Ratio	7-39
7.9.4—Combined Axial Compression and Flexure	7-39
7.10—FLEXURAL MEMBERS	7-40
7.10.1—General.....	7-40
7.10.2—Yielding and Rupture	7-40
7.10.3—Local Buckling.....	7-41
7.10.3.1—Weighted Average Method	7-41
7.10.3.2—Direct Strength Method.....	7-42
7.10.3.3—Limiting Element Method.....	7-42
7.10.4—Lateral–Torsional Buckling.....	7-42
7.10.4.1—Bending Coefficient, C_b	7-43
7.10.4.1.1—Doubly Symmetric Shapes.....	7-43
7.10.4.1.2—Singly Symmetric Shapes	7-44
7.10.4.2—Slenderness for Lateral–Torsional Buckling.....	7-44
7.10.4.2.1—Shapes Symmetric about the Bending Axis.....	7-44
7.10.4.2.2—Singly Symmetric Open Shapes Asymmetric about the Bending Axis	7-45
7.10.4.2.3—Closed Shapes.....	7-45
7.10.4.2.4—Rectangular Bars.....	7-45
7.10.4.2.5—Any Shape.....	7-45
7.10.4.3—Interaction between Local Buckling and Lateral–Torsional Buckling.....	7-46
7.11—MEMBERS IN SHEAR.....	7-47
7.11.1—General.....	7-47
7.11.2—Stiffeners	7-47
7.11.2.1—Crippling of Flat Webs.....	7-47
7.11.2.2—Bearing Stiffeners	7-48
7.11.2.3—Combined Crippling and Bending of Flat Webs	7-48
7.12—CONNECTIONS AND SPLICES.....	7-49
7.12.1—General.....	7-49
7.12.2—Bolted Connections	7-49
7.12.2.1—General.....	7-49
7.12.2.2—Factored Resistance.....	7-49

7.12.2.3—Washers	7-50
7.12.2.4—Holes.....	7-50
7.12.2.5—Size of Bolts.....	7-50
7.12.2.6—Spacing of Bolts.....	7-51
7.12.2.6.1—Minimum Spacing and Clear Distance	7-51
7.12.2.6.2—Minimum Edge Distance	7-51
7.12.2.7—Shear Resistance	7-51
7.12.2.8—Slip Resistance.....	7-51
7.12.2.9—Bearing Resistance at Holes and Slots	7-51
7.12.2.10—Tensile Resistance	7-52
7.12.2.11—Combined Tension and Shear	7-52
7.12.2.12—Shear Resistance of Anchor Bolts.....	7-52
7.12.3—Welded Connections	7-52
7.12.3.1—General.....	7-52
7.12.3.2—Factored Resistance	7-52
7.12.3.2.1—General	7-52
7.12.3.2.2—Complete Penetration Groove-Welded Connections	7-53
7.12.3.2.2a—Tension and Compression.....	7-53
7.12.3.2.2b—Shear.....	7-53
7.12.3.2.3—Partial Penetration Groove-Welded Connections	7-53
7.12.3.2.3a—Tension and Compression.....	7-54
7.12.3.2.3b—Shear.....	7-54
7.12.3.2.4—Fillet-Welded Connections	7-55
7.12.3.3—Effective Area.....	7-55
7.12.3.4—Size of Fillet Welds	7-55
7.12.3.5—Fillet Weld End Returns	7-56
7.12.4—Block Shear Rupture Resistance	7-56
7.12.5—Connection Elements	7-57
7.12.5.1—General.....	7-57
7.12.5.2—Tension	7-57
7.12.5.3—Shear	7-57
7.12.6—Splices.....	7-57
7.12.7—Pins	7-58
7.12.7.1—Factored Resistance	7-58
7.12.7.2—Minimum Edge Distance	7-58
7.12.7.3—Holes.....	7-59
7.12.7.4—Shear Resistance	7-59
7.12.7.5—Flexural Resistance.....	7-59
7.12.7.6—Bearing Resistance.....	7-60
7.12.7.7—Combined Shear and Flexure.....	7-60
7.13—PROVISIONS FOR STRUCTURE TYPES	7-60
7.13.1—Deck Superstructures	7-60
7.13.1.1—General.....	7-60
7.13.1.2—Equivalent Strips.....	7-61
7.14—REFERENCES	7-61

SECTION 8: WOOD STRUCTURES

TABLE OF CONTENTS

8.1—SCOPE	8-1
8.2—DEFINITIONS	8-1
8.3—NOTATION	8-4
8.4—MATERIALS	8-6
8.4.1—Wood Products	8-6
8.4.1.1—Sawn Lumber	8-6
8.4.1.1.1—General	8-6
8.4.1.1.2—Dimensions	8-6
8.4.1.1.3—Moisture Content	8-7
8.4.1.1.4—Reference Design Values	8-7
8.4.1.2—Structural Glued Laminated Timber (Glulam)	8-12
8.4.1.2.1—General	8-12
8.4.1.2.2—Dimensions	8-13
8.4.1.2.3—Reference Design Values	8-14
8.4.1.3—Tension-Reinforced Glulams	8-18
8.4.1.3.1—General	8-18
8.4.1.3.2—Dimensions	8-18
8.4.1.3.3—Fatigue	8-19
8.4.1.3.4—Reference Design Values for Tension-Reinforced Glulams	8-19
8.4.1.3.5—Volume Effect	8-20
8.4.1.3.6—Preservative Treatment	8-21
8.4.1.4—Piles	8-21
8.4.2—Metal Fasteners and Hardware	8-21
8.4.2.1—General	8-21
8.4.2.2—Minimum Requirements	8-21
8.4.2.2.1—Fasteners	8-21
8.4.2.2.2—Prestressing Bars	8-22
8.4.2.2.3—Split Ring Connectors	8-22
8.4.2.2.4—Shear Plate Connectors	8-22
8.4.2.2.5—Nails and Spikes	8-22
8.4.2.2.6—Drift Pins and Bolts	8-22
8.4.2.2.7—Spike Grids	8-22
8.4.2.2.8—Toothed Metal Plate Connectors	8-22
8.4.2.3—Corrosion Protection	8-23
8.4.2.3.1—Metallic Coating	8-23
8.4.2.3.2—Alternative Coating	8-23
8.4.3—Preservative Treatment	8-23
8.4.3.1—Requirement for Treatment	8-23
8.4.3.2—Treatment Chemicals	8-23
8.4.3.3—Inspection and Marking	8-24
8.4.3.4—Fire Retardant Treatment	8-24
8.4.4—Adjustment Factors for Reference Design Values	8-24
8.4.4.1—General	8-24
8.4.4.2—Format Conversion Factor, C_{KF}	8-25
8.4.4.3—Wet Service Factor, C_M	8-26
8.4.4.4—Size Factor, C_F , for Sawn Lumber	8-26
8.4.4.5—Volume Factor, C_V , (Glulam)	8-27
8.4.4.6—Flat-Use Factor, C_{fu}	8-28
8.4.4.7—Incising Factor, C_i	8-29
8.4.4.8—Deck Factor, C_d	8-29
8.4.4.9—Time Effect Factor, C_λ	8-30
8.5—LIMIT STATES	8-30
8.5.1—Service Limit State	8-30
8.5.2—Strength Limit State	8-30
8.5.2.1—General	8-30

8.5.2.2—Resistance Factors.....	8-31
8.5.2.3—Stability.....	8-31
8.5.3—Extreme Event Limit State	8-31
8.6—COMPONENTS IN FLEXURE.....	8-31
8.6.1—General.....	8-31
8.6.2—Rectangular Section.....	8-31
8.6.3—Circular Section.....	8-33
8.7—COMPONENTS UNDER SHEAR	8-33
8.8—COMPONENTS IN COMPRESSION.....	8-33
8.8.1—General.....	8-33
8.8.2—Compression Parallel to Grain	8-33
8.8.3—Compression Perpendicular to Grain	8-34
8.9—COMPONENTS IN TENSION PARALLEL TO GRAIN.....	8-35
8.10—COMPONENTS IN COMBINED FLEXURE AND AXIAL LOADING	8-35
8.10.1—Components in Combined Flexure and Tension.....	8-35
8.10.2—Components in Combined Flexure and Compression Parallel to Grain	8-36
8.11—BRACING REQUIREMENTS	8-36
8.11.1—General.....	8-36
8.11.2—Sawn Wood Beams	8-36
8.11.3—Glued Laminated Timber Girders	8-37
8.11.4—Bracing of Trusses.....	8-37
8.12—CAMBER REQUIREMENTS	8-37
8.12.1—Glued Laminated Timber Girders	8-37
8.12.2—Trusses	8-37
8.12.3—Stress Laminated Timber Deck Bridge	8-37
8.13—CONNECTION DESIGN	8-37
8.14—REFERENCES.....	8-37

TABLE OF CONTENTS

9.1—SCOPE.....	9-1
9.2—DEFINITIONS.....	9-1
9.3—NOTATION.....	9-4
9.4—GENERAL DESIGN REQUIREMENTS.....	9-4
9.4.1—Interface Action	9-4
9.4.2—Deck Drainage	9-4
9.4.3—Concrete Appurtenances	9-5
9.4.4—Edge Supports	9-5
9.4.5—Stay-in-Place Formwork for Overhangs.....	9-5
9.5—LIMIT STATES.....	9-5
9.5.1—General.....	9-5
9.5.2—Service Limit States	9-5
9.5.3—Fatigue and Fracture Limit State.....	9-6
9.5.4—Strength Limit States.....	9-6
9.5.5—Extreme Event Limit States.....	9-6
9.6—ANALYSIS.....	9-6
9.6.1—Methods of Analysis	9-6
9.6.2—Loading.....	9-6
9.7—CONCRETE DECK SLABS	9-7
9.7.1—General.....	9-7
9.7.1.1—Minimum Depth and Cover	9-7
9.7.1.2—Composite Action	9-7
9.7.1.3—Skewed Decks.....	9-7
9.7.1.4—Edge Support	9-8
9.7.1.5—Design of Cantilever Slabs.....	9-8
9.7.2—Empirical Design	9-8
9.7.2.1—General	9-8
9.7.2.2—Application	9-9
9.7.2.3—Effective Length	9-9
9.7.2.4—Design Conditions.....	9-10
9.7.2.5—Reinforcement Requirements.....	9-11
9.7.2.6—Deck with Stay-in-Place Formwork	9-12
9.7.3—Traditional Design	9-12
9.7.3.1—General	9-12
9.7.3.2—Distribution Reinforcement.....	9-12
9.7.4—Stay-in-Place Formwork	9-13
9.7.4.1—General	9-13
9.7.4.2—Steel Formwork.....	9-13
9.7.4.3—Concrete Formwork	9-13
9.7.4.3.1—Depth	9-13
9.7.4.3.2—Reinforcement	9-13
9.7.4.3.3—Creep and Shrinkage Control.....	9-14
9.7.4.3.4—Bedding of Panels.....	9-14
9.7.5—Precast Deck Slabs on Girders.....	9-14
9.7.5.1—General	9-14
9.7.5.2—Transversely Joined Precast Decks	9-15
9.7.5.3—Longitudinally Post-Tensioned Precast Decks.....	9-15
9.7.6—Deck Slabs in Segmental Construction	9-15
9.7.6.1—General	9-15
9.7.6.2—Joints in Decks	9-15
9.8—METAL DECKS.....	9-16
9.8.1—General.....	9-16
9.8.2—Metal Grid Decks.....	9-16
9.8.2.1—General	9-16
9.8.2.2—Open Grid Floors.....	9-17

9.8.2.3—Filled and Partially Filled Grid Decks.....	9-17
9.8.2.3.1—General.....	9-17
9.8.2.3.2—Design Requirements	9-18
9.8.2.3.3—Fatigue and Fracture Limit State.....	9-18
9.8.2.4—Unfilled Grid Decks Composite with Reinforced Concrete Slabs.....	9-19
9.8.2.4.1—General.....	9-19
9.8.2.4.2—Design.....	9-19
9.8.2.4.3—Fatigue Limit State.....	9-20
9.8.3—Orthotropic Steel Decks	9-20
9.8.3.1—General.....	9-20
9.8.3.2—Wheel Load Distribution.....	9-20
9.8.3.3—Wearing Surface.....	9-20
9.8.3.4—Analysis of Orthotropic Decks	9-21
9.8.3.4.1—General.....	9-21
9.8.3.4.2—Level 1 Design	9-23
9.8.3.4.3—Level 2 Design	9-24
9.8.3.4.3a—General.....	9-24
9.8.3.4.3b—Decks with Open Ribs	9-24
9.8.3.4.3c—Decks with Closed Ribs	9-24
9.8.3.4.4—Level 3 Design	9-24
9.8.3.5—Design	9-25
9.8.3.5.1—Superposition of Local and Global Effects	9-25
9.8.3.5.2—Limit States	9-26
9.8.3.5.2a—General.....	9-26
9.8.3.5.2b—Service Limit State.....	9-26
9.8.3.5.2c—Strength Limit State	9-26
9.8.3.5.2d—Fatigue Limit State.....	9-26
9.8.3.6—Detailing Requirements.....	9-27
9.8.3.6.1—Minimum Plate Thickness.....	9-27
9.8.3.6.2—Closed Ribs	9-27
9.8.3.6.3—Welding to Orthotropic Decks	9-27
9.8.3.6.4—Deck and Rib Details	9-27
9.8.4—Orthotropic Aluminum Decks	9-28
9.8.4.1—General.....	9-28
9.8.4.2—Approximate Analysis.....	9-28
9.8.4.3—Limit States	9-29
9.8.5—Corrugated Metal Decks.....	9-29
9.8.5.1—General.....	9-29
9.8.5.2—Distribution of Wheel Loads	9-29
9.8.5.3—Composite Action	9-29
9.9—WOOD DECKS AND DECK SYSTEMS	9-30
9.9.1—Scope.....	9-30
9.9.2—General	9-30
9.9.3—Design Requirements	9-30
9.9.3.1—Load Distribution	9-30
9.9.3.2—Shear Design	9-30
9.9.3.3—Deformation	9-31
9.9.3.4—Thermal Expansion	9-31
9.9.3.5—Wearing Surfaces	9-31
9.9.3.6—Skewed Decks.....	9-31
9.9.4—Glued Laminated Decks	9-31
9.9.4.1—General.....	9-31
9.9.4.2—Deck Tie-Downs	9-32
9.9.4.3—Interconnected Decks	9-32
9.9.4.3.1—Panels Parallel to Traffic.....	9-32
9.9.4.3.2—Panels Perpendicular to Traffic.....	9-32
9.9.4.4—Noninterconnected Decks	9-32

9.9.5—Stress-Laminated Decks.....	9-32
9.9.5.1—General	9-32
9.9.5.2—Nailing	9-33
9.9.5.3—Staggered Butt Joints	9-33
9.9.5.4—Holes in Laminations	9-34
9.9.5.5—Deck Tie-Downs	9-34
9.9.5.6—Stressing.....	9-34
9.9.5.6.1—Prestressing System	9-34
9.9.5.6.2—Prestressing Materials.....	9-36
9.9.5.6.3—Design Requirements	9-37
9.9.5.6.4—Corrosion Protection.....	9-38
9.9.5.6.5—Railings.....	9-38
9.9.6—Spike-Laminated Decks	9-38
9.9.6.1—General	9-38
9.9.6.2—Deck Tie-Downs	9-39
9.9.6.3—Panel Decks	9-39
9.9.7—Plank Decks	9-40
9.9.7.1—General	9-40
9.9.7.2—Deck Tie-Downs	9-40
9.9.8—Wearing Surfaces for Wood Decks.....	9-40
9.9.8.1—General	9-40
9.9.8.2—Plant Mix Asphalt	9-40
9.9.8.3—Chip Seal.....	9-41
9.10—REFERENCES	9-41

SECTION 10

FOUNDATIONS

10.1—SCOPE	10-1
10.2—DEFINITIONS.....	10-1
10.3—NOTATION.....	10-3
10.4—SOIL AND ROCK PROPERTIES.....	10-8
10.4.1—Informational Needs	10-8
10.4.2—Subsurface Exploration.....	10-8
10.4.3—Laboratory Tests	10-11
10.4.3.1—Soil Tests	10-11
10.4.3.2—Rock Tests	10-11
10.4.4—In-Situ Tests.....	10-11
10.4.5—Geophysical Tests.....	10-12
10.4.6—Selection of Design Properties.....	10-13
10.4.6.1—General.....	10-13
10.4.6.2—Soil Strength	10-15
10.4.6.2.1—General	10-15
10.4.6.2.2—Undrained Strength of Cohesive Soils.....	10-15
10.4.6.2.3—Drained Strength of Cohesive Soils.....	10-16
10.4.6.2.4—Drained Strength of Granular Soils	10-16
10.4.6.3—Soil Deformation	10-18
10.4.6.4—Rock Mass Strength.....	10-21
10.4.6.5—Rock Mass Deformation.....	10-26
10.4.6.6—Erodibility of Rock	10-29
10.5—LIMIT STATES AND RESISTANCE FACTORS	10-29
10.5.1—General.....	10-29
10.5.2—Service Limit States	10-29
10.5.2.1—General.....	10-29
10.5.2.2—Tolerable Movements and Movement Criteria	10-30
10.5.2.2.1—General	10-30
10.5.2.2.2—Assessment of Differential Movement and Its Effects	10-31
10.5.2.3—Abutment Transitions	10-32
10.5.3—Strength Limit States	10-32
10.5.3.1—General.....	10-32
10.5.3.2—Spread Footings	10-32
10.5.3.3—Driven Piles	10-33
10.5.3.4—Drilled Shafts	10-33
10.5.3.5—Micropiles.....	10-33
10.5.4—Extreme Events Limit States.....	10-33
10.5.4.1—Extreme Events Design.....	10-33
10.5.4.2—Liquefaction Design Requirements.....	10-34
10.5.5—Resistance Factors.....	10-40
10.5.5.1—Service Limit States	10-40
10.5.5.2—Strength Limit States	10-40
10.5.5.2.1—General	10-40
10.5.5.2.2—Spread Footings	10-42
10.5.5.2.3—Driven Piles	10-42
10.5.5.2.4—Drilled Shafts.....	10-48
10.5.5.2.5—Micropiles.....	10-50
10.5.5.3—Extreme Limit States	10-51
10.5.5.3.1—General	10-51
10.5.5.3.2—Scour.....	10-51
10.5.5.3.3—Other Extreme Limit States	10-52
10.6—SPREAD FOOTINGS	10-52
10.6.1—General Considerations.....	10-52
10.6.1.1—General.....	10-52

10.6.1.2—Bearing Depth	10-52
10.6.1.3—Effective Footing Dimensions.....	10-53
10.6.1.4—Bearing Stress Distributions.....	10-53
10.6.1.5—Anchorage of Inclined Footings.....	10-54
10.6.1.6—Groundwater	10-54
10.6.1.7—Uplift.....	10-54
10.6.1.8—Nearby Structures.....	10-54
10.6.2—Service Limit State Design.....	10-54
10.6.2.1—General.....	10-54
10.6.2.2—Tolerable Movements	10-54
10.6.2.3—Loads.....	10-55
10.6.2.4—Settlement Analyses.....	10-55
10.6.2.4.1—General.....	10-55
10.6.2.4.2—Settlement of Footings on Cohesionless Soils	10-56
10.6.2.4.2a—General.....	10-56
10.6.2.4.2b—Hough Method	10-58
10.6.2.4.2c—Schmertmann Method.....	10-59
10.6.2.4.3—Settlement of Footings on Cohesive Soils	10-62
10.6.2.4.4—Settlement of Footings on Rock.....	10-66
10.6.2.5—Bearing Resistance at the Service Limit State.....	10-67
10.6.2.5.1—Presumptive Values for Bearing Resistance	10-67
10.6.2.5.2—Semiempirical Procedures for Bearing Resistance	10-68
10.6.3—Strength Limit State Design	10-69
10.6.3.1—Bearing Resistance of Soil	10-69
10.6.3.1.1—General.....	10-69
10.6.3.1.2—Theoretical Estimation	10-70
10.6.3.1.2a—Basic Formulation	10-70
10.6.3.1.2b—Considerations for Punching Shear.....	10-73
10.6.3.1.2c—Considerations for Footings on Slopes.....	10-74
10.6.3.1.2d—Considerations for Two-Layer Soil Systems—Critical Depth.....	10-79
10.6.3.1.2e—Two-Layered Soil System in Undrained Loading.....	10-79
10.6.3.1.2f—Two-Layered Soil System in Drained Loading	10-81
10.6.3.1.3—Semiempirical Procedures	10-81
10.6.3.1.4—Plate Load Tests.....	10-82
10.6.3.2—Bearing Resistance of Rock	10-83
10.6.3.2.1—General.....	10-83
10.6.3.2.2—Semiempirical Procedures	10-83
10.6.3.2.3—Analytic Method	10-83
10.6.3.2.4—Load Test	10-83
10.6.3.3—Eccentric Load Limitations	10-83
10.6.3.4—Failure by Sliding.....	10-84
10.6.3.5—Overall Stability.....	10-85
10.6.4—Extreme Event Limit State Design.....	10-86
10.6.4.1—General.....	10-86
10.6.4.2—Eccentric Load Limitations	10-86
10.6.5—Structural Design.....	10-86
10.7—DRIVEN PILES	10-86
10.7.1—General.....	10-86
10.7.1.1—Application.....	10-86
10.7.1.2—Minimum Pile Spacing, Clearance, and Embedment into Cap	10-87
10.7.1.3—Piles through Embankment Fill.....	10-87
10.7.1.4—Batter Piles	10-87
10.7.1.5—Pile Design Requirements	10-88
10.7.1.6—Determination of Pile Loads	10-88
10.7.1.6.1—General.....	10-88
10.7.1.6.2—Downdrag.....	10-88
10.7.1.6.3—Uplift Due to Expansive Soils.....	10-89
10.7.1.6.4—Nearby Structures	10-89

10.7.2—Service Limit State Design	10-89
10.7.2.1—General.....	10-89
10.7.2.2—Tolerable Movements	10-90
10.7.2.3—Settlement	10-90
10.7.2.3.1—Equivalent Footing Analogy.....	10-90
10.7.2.3.2—Pile Groups in Cohesive Soil.....	10-92
10.7.2.4—Horizontal Pile Foundation Movement.....	10-93
10.7.2.5—Settlement Due to Downdrag.....	10-95
10.7.2.6—Lateral Squeeze.....	10-95
10.7.3—Strength Limit State Design.....	10-95
10.7.3.1—General.....	10-95
10.7.3.2—Point Bearing Piles on Rock	10-96
10.7.3.2.1—General	10-96
10.7.3.2.2—Piles Driven to Soft Rock	10-96
10.7.3.2.3—Piles Driven to Hard Rock.....	10-96
10.7.3.3—Pile Length Estimates for Contract Documents.....	10-97
10.7.3.4—Nominal Axial Resistance Change after Pile Driving.....	10-99
10.7.3.4.1—General	10-99
10.7.3.4.2—Relaxation.....	10-99
10.7.3.4.3—Setup.....	10-99
10.7.3.5—Groundwater Effects and Buoyancy	10-100
10.7.3.6—Scour.....	10-100
10.7.3.7—Downdrag	10-101
10.7.3.8—Determination of Nominal Bearing Resistance for Piles	10-102
10.7.3.8.1—General	10-102
10.7.3.8.2—Static Load Test.....	10-103
10.7.3.8.3—Dynamic Testing.....	10-104
10.7.3.8.4—Wave Equation Analysis	10-105
10.7.3.8.5—Dynamic Formula	10-105
10.7.3.8.6—Static Analysis	10-106
10.7.3.8.6a—General.....	10-106
10.7.3.8.6b— α -Method.....	10-107
10.7.3.8.6c— β -Method	10-108
10.7.3.8.6d— λ -Method	10-109
10.7.3.8.6e—Tip Resistance in Cohesive Soils.....	10-110
10.7.3.8.6f—Nordlund/Thurman Method in Cohesionless Soils	10-110
10.7.3.8.6g—Using SPT or CPT in Cohesionless Soils	10-115
10.7.3.9—Resistance of Pile Groups in Compression	10-118
10.7.3.10—Uplift Resistance of Single Piles.....	10-119
10.7.3.11—Uplift Resistance of Pile Groups.....	10-120
10.7.3.12—Nominal Lateral Resistance of Pile Foundations	10-122
10.7.3.13—Pile Structural Resistance	10-123
10.7.3.13.1—Steel Piles	10-123
10.7.3.13.2—Concrete Piles	10-123
10.7.3.13.3—Timber Piles.....	10-123
10.7.3.13.4—Buckling and Lateral Stability	10-123
10.7.4—Extreme Event Limit State.....	10-124
10.7.5—Corrosion and Deterioration	10-125
10.7.6—Determination of Minimum Pile Penetration	10-126
10.7.7—Determination of R_{ndr} Used to Establish Contract Driving Criteria for Nominal Bearing Resistance.....	10-126
10.7.8—Drivability Analysis	10-127
10.7.9—Probe Piles	10-128
10.8—DRILLED SHAFTS.....	10-128
10.8.1—General.....	10-128
10.8.1.1—Scope	10-128
10.8.1.2—Shaft Spacing, Clearance, and Embedment into Cap.....	10-129
10.8.1.3—Shaft Diameter and Enlarged Bases.....	10-129

10.8.1.4—Battered Shafts	10-130
10.8.1.5—Drilled Shaft Resistance	10-130
10.8.1.6—Determination of Shaft Loads	10-131
10.8.1.6.1—General	10-131
10.8.1.6.2—Downdrag	10-131
10.8.1.6.3—Uplift	10-132
10.8.2—Service Limit State Design	10-132
10.8.2.1—Tolerable Movements	10-132
10.8.2.2—Settlement	10-132
10.8.2.2.1—General	10-132
10.8.2.2.2—Settlement of Single-Drilled Shaft	10-132
10.8.2.2.3—Intermediate Geo Materials (IGMs)	10-135
10.8.2.2.4—Group Settlement	10-135
10.8.2.3—Horizontal Movement of Shafts and Shaft Groups	10-135
10.8.2.4—Settlement Due to Downdrag	10-136
10.8.2.5—Lateral Squeeze	10-136
10.8.3—Strength Limit State Design	10-136
10.8.3.1—General	10-136
10.8.3.2—Groundwater Table and Buoyancy	10-136
10.8.3.3—Scour	10-136
10.8.3.4—Downdrag	10-136
10.8.3.5—Nominal Axial Compression Resistance of Single Drilled Shafts	10-137
10.8.3.5.1—Estimation of Drilled Shaft Resistance in Cohesive Soils	10-138
10.8.3.5.1a—General	10-138
10.8.3.5.1b—Side Resistance	10-138
10.8.3.5.1c—Tip Resistance	10-140
10.8.3.5.2—Estimation of Drilled Shaft Resistance in Cohesionless Soils	10-140
10.8.3.5.2a—General	10-140
10.8.3.5.2b—Side Resistance	10-141
10.8.3.5.2c—Tip Resistance	10-142
10.8.3.5.3—Shafts in Strong Soil Overlying Weaker Compressible Soil	10-142
10.8.3.5.4—Estimation of Drilled Shaft Resistance in Rock	10-143
10.8.3.5.4a—General	10-143
10.8.3.5.4b—Side Resistance	10-144
10.8.3.5.4c—Tip Resistance	10-145
10.8.3.5.4d—Combined Side and Tip Resistance	10-145
10.8.3.5.5—Estimation of Drilled Shaft Resistance in Intermediate Geo Materials (IGMs)	10-146
10.8.3.5.6—Shaft Load Test	10-147
10.8.3.6—Shaft Group Resistance	10-147
10.8.3.6.1—General	10-147
10.8.3.6.2—Cohesive Soil	10-148
10.8.3.6.3—Cohesionless Soil	10-148
10.8.3.6.4—Shaft Groups in Strong Soil Overlying Weak Soil	10-149
10.8.3.7—Uplift Resistance	10-149
10.8.3.7.1—General	10-149
10.8.3.7.2—Uplift Resistance of Single Drilled Shaft	10-149
10.8.3.7.3—Group Uplift Resistance	10-150
10.8.3.7.4—Uplift Load Test	10-150
10.8.3.8—Nominal Horizontal Resistance of Shaft and Shaft Groups	10-150
10.8.3.9—Shaft Structural Resistance	10-150
10.8.3.9.1—General	10-150
10.8.3.9.2—Buckling and Lateral Stability	10-150
10.8.3.9.3—Reinforcement	10-150
10.8.3.9.4—Transverse Reinforcement	10-151
10.8.3.9.5—Concrete	10-151
10.8.3.9.6—Reinforcement into Superstructure	10-151
10.8.3.9.7—Enlarged Bases	10-151
10.8.4—Extreme Event Limit State	10-151

10.9—MICROPILES	10-152
10.9.1—General	10-152
10.9.1.1—Scope	10-152
10.9.1.2—Minimum Micropile Spacing, Clearance, and Embedment into Cap	10-153
10.9.1.3—Micropiles through Embankment Fill	10-153
10.9.1.4—Battered Micropiles	10-153
10.9.1.5—Micropile Design Requirements	10-153
10.9.1.6—Determination of Micropile Loads	10-153
10.9.1.6.1—Downdrag	10-153
10.9.1.6.2—Uplift Due to Expansive Soils	10-153
10.9.1.6.3—Nearby Structures	10-154
10.9.2—Service Limit State Design	10-154
10.9.2.1—General	10-154
10.9.2.2—Tolerable Movements	10-154
10.9.2.3—Settlement	10-154
10.9.2.3.1—Micropile Groups in Cohesive Soil	10-154
10.9.2.3.2—Micropile Groups in Cohesionless Soil	10-154
10.9.2.4—Horizontal Micropile Foundation Movement	10-154
10.9.2.5—Settlement Due to Downdrag	10-154
10.9.2.6—Lateral Squeeze	10-154
10.9.3—Strength Limit State Design	10-154
10.9.3.1—General	10-154
10.9.3.2—Ground Water Table and Bouyancy	10-155
10.9.3.3—Scour	10-155
10.9.3.4—Downdrag	10-155
10.9.3.5—Nominal Axial Compression Resistance of a Single Micropile	10-155
10.9.3.5.1—General	10-155
10.9.3.5.2—Estimation of Grout-to-Ground Bond Resistance	10-156
10.9.3.5.3—Estimation of Micropile Tip Resistance in Rock	10-157
10.9.3.5.4—Micropile Load Test	10-158
10.9.3.6—Resistance of Micropile Groups in Compression	10-158
10.9.3.7—Nominal Uplift Resistance of a Single Micropile	10-158
10.9.3.8—Nominal Uplift Resistance of Micropile Groups	10-158
10.9.3.9—Nominal Horizontal Resistance of Micropiles and Micropile Groups	10-159
10.9.3.10—Structural Resistance	10-159
10.9.3.10.1—General	10-159
10.9.3.10.2—Axial Compressive Resistance	10-159
10.9.3.10.2a—Cased Length	10-160
10.9.3.10.2b—Uncased Length	10-160
10.9.3.10.3—Axial Tension Resistance	10-161
10.9.3.10.3a—Cased Length	10-161
10.9.3.10.3b—Uncased Length	10-162
10.9.3.10.4—Plunge Length Transfer Load	10-162
10.9.3.10.5—Grout-to-Steel Bond	10-163
10.9.3.10.6—Buckling and Lateral Stability	10-163
10.9.3.10.7—Reinforcement into Superstructure	10-163
10.9.4—Extreme Event Limit State	10-163
10.9.5—Corrosion and Deterioration	10-163
10.10—REFERENCES	10-163
APPENDIX A10—SEISMIC ANALYSIS AND DESIGN OF FOUNDATIONS	10-172
A10.1—INVESTIGATION	10-172
A10.2—FOUNDATION DESIGN	10-172
A10.3—SPECIAL PILE REQUIREMENTS	10-176

TABLE OF CONTENTS

11.1—SCOPE	11-1
11.2—DEFINITIONS	11-1
11.3—NOTATION	11-2
11.3.1—General	11-2
11.4—SOIL PROPERTIES AND MATERIALS	11-7
11.4.1—General	11-7
11.4.2—Determination of Soil Properties	11-7
11.5—LIMIT STATES AND RESISTANCE FACTORS	11-7
11.5.1—General	11-7
11.5.2—Service Limit States	11-8
11.5.3—Strength Limit State	11-9
11.5.4—Extreme Event Limit State	11-9
11.5.4.1—General Requirements	11-9
11.5.4.2—Extreme Event I, No Analysis	11-9
11.5.5—Resistance Requirement	11-11
11.5.6—Load Combinations and Load Factors	11-11
11.5.7—Resistance Factors—Service and Strength	11-15
11.5.8—Resistance Factors—Extreme Event Limit State	11-18
11.6—ABUTMENTS AND CONVENTIONAL RETAINING WALLS	11-19
11.6.1—General Considerations	11-19
11.6.1.1—General	11-19
11.6.1.2—Loading	11-19
11.6.1.3—Integral Abutments	11-20
11.6.1.4—Wingwalls	11-20
11.6.1.5—Reinforcement	11-20
11.6.1.5.1—Conventional Walls and Abutments	11-20
11.6.1.5.2—Wingwalls	11-20
11.6.1.6—Expansion and Contraction Joints	11-21
11.6.2—Movement at the Service Limit State	11-21
11.6.2.1—Abutments	11-21
11.6.2.2—Conventional Retaining Walls	11-21
11.6.3—Bearing Resistance and Stability at the Strength Limit State	11-21
11.6.3.1—General	11-21
11.6.3.2—Bearing Resistance	11-21
11.6.3.3—Eccentricity Limits	11-24
11.6.3.4—Subsurface Erosion	11-24
11.6.3.5—Passive Resistance	11-24
11.6.3.6—Sliding	11-24
11.6.3.7—Overall Stability	11-24
11.6.4—Safety against Structural Failure	11-25
11.6.5—Seismic Design for Abutments and Conventional Retaining Walls	11-25
11.6.5.1—General	11-25
11.6.5.2—Calculation of Seismic Acceleration Coefficients for Wall Design	11-27
11.6.5.2.1—Characterization of Acceleration at Wall Base	11-27
11.6.5.2.2—Estimation of Acceleration Acting on Wall Mass	11-28
11.6.5.3—Calculation of Seismic Active Earth Pressures	11-29
11.6.5.4—Calculation of Seismic Earth Pressure for Nonyielding Abutments and Walls	11-32
11.6.5.5—Calculation of Seismic Passive Earth Pressure	11-32
11.6.5.6—Wall Details for Improved Seismic Performance	11-34
11.6.6—Drainage	11-35
11.7—PIERS	11-35
11.7.1—Load Effects in Piers	11-35
11.7.2—Pier Protection	11-35
11.7.2.1—Collision	11-35
11.7.2.2—Collision Walls	11-35
11.7.2.3—Scour	11-36

11.7.2.4—Facing.....	11-36
11.8—NONGRAVITY CANTILEVERED WALLS	11-36
11.8.1—General.....	11-36
11.8.2—Loading	11-36
11.8.3—Movement at the Service Limit State.....	11-36
11.8.3.1—Movement	11-36
11.8.4—Safety against Soil Failure at the Strength Limit State.....	11-36
11.8.4.1—Overall Stability	11-36
11.8.5—Safety against Structural Failure	11-38
11.8.5.1—Vertical Wall Elements	11-38
11.8.5.2—Facing.....	11-38
11.8.6—Seismic Design of Nongravity Cantilever Walls.....	11-39
11.8.6.1—General.....	11-39
11.8.6.2—Seismic Active Lateral Earth Pressure.....	11-40
11.8.6.3—Seismic Passive Lateral Earth Pressure.....	11-41
11.8.6.4—Wall Displacement Analyses to Determine Earth Pressures.....	11-42
11.8.7—Corrosion Protection	11-44
11.8.8—Drainage.....	11-44
11.9—ANCHORED WALLS.....	11-44
11.9.1—General.....	11-44
11.9.2—Loading	11-45
11.9.3—Movement at the Service Limit State.....	11-45
11.9.3.1—Movement	11-45
11.9.4—Safety against Soil Failure.....	11-46
11.9.4.1—Bearing Resistance.....	11-46
11.9.4.2—Anchor Pullout Capacity	11-47
11.9.4.3—Passive Resistance	11-50
11.9.4.4—Overall Stability.....	11-50
11.9.5—Safety Against Structural Failure	11-50
11.9.5.1—Anchors.....	11-50
11.9.5.2—Vertical Wall Elements	11-52
11.9.5.3—Facing.....	11-52
11.9.6—Seismic Design.....	11-53
11.9.7—Corrosion Protection	11-54
11.9.8—Construction and Installation	11-54
11.9.8.1—Anchor Stressing and Testing	11-54
11.9.9—Drainage.....	11-55
11.10—MECHANICALLY STABILIZED EARTH WALLS	11-55
11.10.1—General.....	11-55
11.10.2—Structure Dimensions.....	11-57
11.10.2.1—Minimum Length of Soil Reinforcement.....	11-58
11.10.2.2—Minimum Front Face Embedment	11-59
11.10.2.3—Facing.....	11-60
11.10.2.3.1—Stiff or Rigid Concrete, Steel, and Timber Facings	11-60
11.10.2.3.2—Flexible Wall Facings	11-61
11.10.2.3.3—Corrosion Issues for MSE Facing	11-61
11.10.3—Loading	11-61
11.10.4—Movement at the Service Limit State.....	11-61
11.10.4.1—Settlement	11-61
11.10.4.2—Lateral Displacement	11-62
11.10.4.3—Soil Failure (Internal Stability)	11-63
11.10.5—Safety against Soil Failure (External Stability).....	11-64
11.10.5.1—General.....	11-64
11.10.5.2—Loading	11-64
11.10.5.3—Sliding.....	11-65
11.10.5.4—Bearing Resistance.....	11-66
11.10.5.5—Overturning.....	11-66
11.10.5.6—Overall and Compound Stability.....	11-66
11.10.6—Safety against Structural Failure (Internal Stability).....	11-68

11.10.6.1—General.....	11-68
11.10.6.2—Loading (Internal Stability)	11-68
11.10.6.2.1—Maximum Reinforcement Loads	11-69
11.10.6.2.1a—Special Loading Conditions.....	11-70
11.10.6.2.1b—Reinforcement Spacing for Calculation of T_{max}	11-72
11.10.6.2.1c—Calculation of Lateral Earth Pressure Coefficients for Determination of T_{max}	11-73
11.10.6.2.1d—Coherent Gravity Method.....	11-74
11.10.6.2.1e—Stiffness Method.....	11-76
11.10.6.2.2—Reinforcement Loads at Connection to Wall Face	11-79
11.10.6.3—Reinforcement Pullout.....	11-79
11.10.6.3.1—Boundary between Active and Resistant Zones.....	11-79
11.10.6.3.2—Reinforcement Pullout Design.....	11-81
11.10.6.4—Reinforcement Strength	11-84
11.10.6.4.1—General	11-84
11.10.6.4.2—Design Life Considerations	11-88
11.10.6.4.2a—Steel Reinforcements	11-88
11.10.6.4.2b—Geosynthetic Reinforcements.....	11-90
11.10.6.4.3—Design Tensile Resistance	11-93
11.10.6.4.3a—Steel Reinforcements	11-93
11.10.6.4.3b—Geosynthetic Reinforcements.....	11-94
11.10.6.4.4—Reinforcement/Facing Connection Design Strength.....	11-94
11.10.6.4.4a—Steel Reinforcements	11-94
11.10.6.4.4b—Geosynthetic Reinforcements.....	11-95
11.10.7—Seismic Design of MSE Walls.....	11-97
11.10.7.1—External Stability	11-97
11.10.7.2—Internal Stability	11-99
11.10.7.3—Facing Reinforcement Connections.....	11-103
11.10.7.4—Wall Details for Improved Seismic Performance	11-104
11.10.8—Drainage.....	11-106
11.10.9—Subsurface Erosion	11-106
11.10.10—Special Loading Conditions.....	11-106
11.10.10.1—Concentrated Dead Loads.....	11-106
11.10.10.2—Traffic Loads and Barriers	11-109
11.10.10.3—Hydrostatic Pressures.....	11-110
11.10.10.4—Obstructions in the Reinforced Soil Zone.....	11-111
11.10.11—MSE Abutments.....	11-112
11.11—PREFABRICATED MODULAR WALLS	11-113
11.11.1—General.....	11-113
11.11.2—Loading	11-114
11.11.3—Movement at the Service Limit State.....	11-114
11.11.4—Safety against Soil Failure	11-115
11.11.4.1—General.....	11-115
11.11.4.2—Sliding.....	11-115
11.11.4.3—Bearing Resistance.....	11-115
11.11.4.4—Overturning.....	11-115
11.11.4.5—Subsurface Erosion	11-116
11.11.4.6—Overall Stability.....	11-116
11.11.4.7—Passive Resistance and Sliding	11-116
11.11.5—Safety against Structural Failure	11-116
11.11.5.1—Module Members.....	11-116
11.11.6—Seismic Design for Prefabricated Modular Walls.....	11-117
11.11.7—Abutments.....	11-117
11.11.8—Drainage.....	11-118
11.12—SOIL NAIL WALLS	11-118
11.12.1—General Considerations.....	11-118
11.12.2—Loading	11-120
11.12.3—Movement at the Service Limit State.....	11-122
11.12.4—Safety against Soil Failure (External and Overall Stability—Strength Limit State).....	11-122
11.12.4.1—Sliding.....	11-122

11.12.4.2—Overall Stability	11-122
11.12.5—Safety against Soil Failure (Internal and Compound Stability—Strength Limit State).....	11-123
11.12.5.1—Soil Shear Strength.....	11-123
11.12.5.2—Soil Nail Pullout.....	11-123
11.12.6—Safety against Structural Failure (Internal and Compound Stability—Strength Limit State)	11-125
11.12.6.1—Soil Nail in Tension	11-125
11.12.6.2—Soil Nail Wall Facing—Strength Limit State.....	11-126
11.12.6.2.1—General.....	11-126
11.12.6.2.2—Facing Flexure	11-127
11.12.6.2.3—Facing Punching Shear Resistance	11-130
11.12.6.2.4—Headed Stud in Tension	11-132
11.12.7—Seismic Design of Soil Nail Walls	11-133
11.12.7.1—External and Global Stability	11-133
11.12.7.2—Internal Stability.....	11-134
11.12.8—Corrosion Protection	11-134
11.12.9—Soil Nail Testing	11-136
11.12.10—Drainage	11-136
11.13—REFERENCES.....	11-137
APPENDIX A11—SEISMIC DESIGN OF RETAINING STRUCTURES	11-143
A11.1—GENERAL	11-143
A11.2—PERFORMANCE OF WALLS IN PAST EARTHQUAKES.....	11-143
A11.3—CALCULATION OF SEISMIC ACTIVE PRESSURE.....	11-144
A11.3.1—Mononobe–Okabe Method.....	11-144
A11.3.2—Modification of Mononobe–Okabe Method to Consider Cohesion	11-146
A11.3.3—Generalized Limit Equilibrium (GLE) Method.....	11-149
A11.4—SEISMIC PASSIVE PRESSURE	11-149
A11.5—ESTIMATING WALL SEISMIC ACCELERATION CONSIDERING WAVE SCATTERING AND WALL DISPLACEMENT	11-154
A11.5.1—Kavazanjian et al., (1997).....	11-155
A11.5.2—NCHRP Report 611—Anderson et al. (2008).....	11-155
A11.5.3—Bray et al. (2010), and Bray and Travasarou (2009)	11-158
A11.6—APPENDIX REFERENCES	11-158
APPENDIX B11—DETERMINATION OF T_{MAX} FOR MSE WALLS USING THE SIMPLIFIED METHOD...	11-161
B11.1—GENERAL	11-161
B11.2—DETERMINATION OF T_{MAX}	11-161
B11.3—APPENDIX REFERENCE.....	11-163

TABLE OF CONTENTS

12.1—SCOPE	12-1
12.2—DEFINITIONS.....	12-1
12.3—NOTATION.....	12-2
12.3.1—Abbreviations.....	12-6
12.4—SOIL AND MATERIAL PROPERTIES	12-6
12.4.1—Determination of Soil Properties.....	12-6
12.4.1.1—General.....	12-6
12.4.1.2—Foundation Soils	12-7
12.4.1.3—Envelope Backfill Soils	12-7
12.4.2—Materials	12-8
12.4.2.1—Aluminum Pipe and Structural Plate Structures	12-8
12.4.2.2—Concrete.....	12-8
12.4.2.3—Precast Concrete Pipe	12-8
12.4.2.4—Precast Concrete Structures	12-8
12.4.2.5—Steel Pipe and Structural Plate Structures	12-8
12.4.2.6—Deep Corrugated Structures.....	12-8
12.4.2.7—Steel Reinforcement.....	12-8
12.4.2.8—Thermoplastic Pipe	12-9
12.4.2.9—Fiberglass Pipe.....	12-9
12.4.2.10—Steel-Reinforced Thermoplastic Culverts.....	12-9
12.5—LIMIT STATES AND RESISTANCE FACTORS	12-9
12.5.1—General.....	12-9
12.5.2—Service Limit State.....	12-10
12.5.3—Strength Limit State	12-10
12.5.4—Load Modifiers and Load Factors.....	12-11
12.5.5—Resistance Factors.....	12-11
12.5.6—Flexibility Limits and Construction Stiffness	12-13
12.5.6.1—Corrugated Metal Pipe and Structural Plate Structures.....	12-13
12.5.6.2—Spiral Rib Metal Pipe and Pipe Arches.....	12-13
12.5.6.3—Thermoplastic and Fiberglass Pipe	12-14
12.5.6.4—Steel Tunnel Liner Plate	12-14
12.6—GENERAL DESIGN FEATURES	12-14
12.6.1—Loading	12-14
12.6.2—Service Limit State.....	12-15
12.6.2.1—Tolerable Movement.....	12-15
12.6.2.2—Settlement	12-15
12.6.2.2.1—General	12-15
12.6.2.2.2—Longitudinal Differential Settlement	12-15
12.6.2.2.3—Differential Settlement between Structure and Backfill	12-15
12.6.2.2.4—Footing Settlement.....	12-15
12.6.2.2.5—Unbalanced Loading.....	12-16
12.6.2.3—Uplift.....	12-19
12.6.3—Safety Against Soil Failure	12-19
12.6.3.1—Bearing Resistance and Stability	12-19
12.6.3.2—Corner Backfill for Metal Pipe Arches	12-20
12.6.4—Hydraulic Design	12-20
12.6.5—Scour.....	12-20
12.6.6—Soil Envelope.....	12-20
12.6.6.1—Trench Installations	12-20
12.6.6.2—Embankment Installations.....	12-21
12.6.6.3—Minimum Cover.....	12-21
12.6.7—Minimum Spacing between Multiple Lines of Pipe.....	12-22
12.6.8—End Treatment.....	12-23
12.6.8.1—General.....	12-23
12.6.8.2—Flexible Culverts Constructed on Skew.....	12-23

12.6.9—Corrosive and Abrasive Conditions	12-24
12.7—METAL PIPE, PIPE ARCH, ARCH STRUCTURES, AND STEEL-REINFORCED THERMOPLASTIC CULVERTS	12-24
12.7.1—General	12-24
12.7.2—Safety Against Structural Failure	12-24
12.7.2.1—Section Properties	12-25
12.7.2.2—Thrust	12-25
12.7.2.3—Wall Resistance	12-26
12.7.2.4—Resistance to Buckling	12-26
12.7.2.5—Seam Resistance	12-27
12.7.2.6—Handling and Installation Requirements	12-27
12.7.2.7—Profile Evaluation for Steel-Reinforced Thermoplastic Culverts	12-27
12.7.3—Smooth Lined Pipe	12-27
12.7.4—Stiffening Elements for Structural Plate Structures	12-28
12.7.5—Construction and Installation	12-28
12.8—LONG-SPAN STRUCTURAL PLATE STRUCTURES	12-28
12.8.1—General	12-28
12.8.2—Service Limit State	12-29
12.8.3—Safety Against Structural Failure	12-29
12.8.3.1—Section Properties	12-30
12.8.3.1.1—Cross-Section	12-30
12.8.3.1.2—Shape Control	12-31
12.8.3.1.3—Mechanical and Chemical Requirements	12-31
12.8.3.2—Thrust	12-31
12.8.3.3—Wall Area	12-31
12.8.3.4—Seam Strength	12-31
12.8.3.5—Acceptable Special Features	12-31
12.8.3.5.1—Continuous Longitudinal Stiffeners	12-31
12.8.3.5.2—Reinforcing Ribs	12-31
12.8.4—Safety Against Structural Failure—Foundation Design	12-31
12.8.4.1—Settlement Limits	12-31
12.8.4.2—Footing Reactions in Arch Structures	12-32
12.8.4.3—Footing Design	12-33
12.8.5—Safety Against Structural Failure—Soil Envelope Design	12-33
12.8.5.1—General	12-33
12.8.5.2—Construction Requirements	12-34
12.8.5.3—Service Requirements	12-34
12.8.6—Safety Against Structural Failure—End Treatment Design	12-35
12.8.6.1—General	12-35
12.8.6.2—Standard Shell End Types	12-35
12.8.6.3—Balanced Support	12-37
12.8.6.4—Hydraulic Protection	12-37
12.8.6.4.1—General	12-37
12.8.6.4.2—Backfill Protection	12-38
12.8.6.4.3—Cut-Off (Toe) Walls	12-38
12.8.6.4.4—Hydraulic Uplift	12-38
12.8.6.4.5—Scour	12-38
12.8.7—Concrete Relieving Slabs	12-38
12.8.8—Construction and Installation	12-39
12.8.9—Deep Corrugated Structural Plate Structures	12-39
12.8.9.1—General	12-39
12.8.9.2—Width of Structural Backfill	12-39
12.8.9.2.1—Deep Corrugated Structures with Ratio of Crown Radius to Haunch Radius ≤ 5	12-39
12.8.9.2.2—Deep Corrugated Structures with Ratio of Crown Radius to Haunch Radius > 5	12-39
12.8.9.3—Safety Against Structural Failure	12-40
12.8.9.3.1—Structural Plate Requirements	12-40
12.8.9.3.2—Structural Analysis	12-40

12.8.9.4—Minimum Depth of Fill.....	12-40
12.8.9.5—Combined Thrust and Moment	12-41
12.8.9.6—Global Buckling.....	12-42
12.8.9.7—Connections	12-42
12.9—STRUCTURAL PLATE BOX STRUCTURES	12-42
12.9.1—General.....	12-42
12.9.2—Loading	12-43
12.9.3—Service Limit State.....	12-43
12.9.4—Safety Against Structural Failure	12-43
12.9.4.1—General.....	12-43
12.9.4.2—Moments Due to Factored Loads.....	12-44
12.9.4.3—Plastic Moment Resistance	12-46
12.9.4.4—Crown Soil Cover Factor, C_H	12-47
12.9.4.5—Footing Reactions	12-47
12.9.4.6—Concrete Relieving Slabs.....	12-48
12.9.5—Construction and Installation	12-49
12.10—REINFORCED CONCRETE PIPE	12-49
12.10.1—General.....	12-49
12.10.2 Loading.....	12-50
12.10.2.1 Standard Installations.....	12-50
12.10.2.2 Pipe Fluid Weight.....	12-54
12.10.2.3—Live Loads	12-54
12.10.3—Service Limit State.....	12-54
12.10.4—Safety Against Structural Failure	12-55
12.10.4.1—General.....	12-55
12.10.4.2—Direct Design Method.....	12-55
12.10.4.2.1—Loads and Pressure Distribution	12-55
12.10.4.2.2—Analysis for Force Effects with the Pipe Ring.....	12-57
12.10.4.2.3—Process and Material Factors	12-57
12.10.4.2.4—Flexural Resistance at the Strength Limit State	12-57
12.10.4.2.4a—Circumferential Reinforcement	12-57
12.10.4.2.4b—Minimum Reinforcement	12-58
12.10.4.2.4c—Maximum Flexural Reinforcement without Stirrups	12-58
12.10.4.2.4d—Reinforcement for Crack Width Control	12-59
12.10.4.2.4e—Minimum Concrete Cover	12-61
12.10.4.2.5—Shear Resistance without Stirrups	12-61
12.10.4.2.6—Shear Resistance with Radial Stirrups	12-62
12.10.4.2.7—Stirrup Reinforcement Anchorage	12-63
12.10.4.2.7a—Radial Tension Stirrup Anchorage	12-63
12.10.4.2.7b—Shear Stirrup Anchorage	12-63
12.10.4.2.7c—Stirrup Embedment.....	12-63
12.10.4.3—Indirect Design Method	12-64
12.10.4.3.1—Bearing Resistance	12-64
12.10.4.3.2—Bedding Factor	12-64
12.10.4.3.2a—Earth Load Bedding Factor for Circular Pipe	12-64
12.10.4.3.2b—Earth Load Bedding Factor for Arch and Elliptical Pipe.....	12-65
12.10.4.3.2c—Live Load Bedding Factors.....	12-66
12.10.4.4—Development of Quadrant Mat Reinforcement.....	12-66
12.10.4.4.1—Minimum Cage Reinforcement	12-66
12.10.4.4.2—Development Length of Welded Wire Fabric.....	12-67
12.10.4.4.3—Development of Quadrant Mat Reinforcement Consisting of Welded Plain Wire Fabric.....	12-67
12.10.4.4.4—Development of Quadrant Mat Reinforcement Consisting of Deformed Bars, Deformed Wire, or Deformed Wire Fabric	12-67
12.10.5—Construction and Installation	12-68
12.11—REINFORCED CONCRETE CAST-IN-PLACE AND PRECAST BOX CULVERTS AND REINFORCED CAST-IN-PLACE ARCHES	12-68
12.11.1—General.....	12-68

12.11.2—Loads and Live Load Distribution	12-68
12.11.2.1—General.....	12-68
12.11.2.2—Modification of Earth Loads for Soil–Structure Interaction	12-69
12.11.2.2.1—Embankment and Trench Conditions.....	12-69
12.11.2.2.2—Other Installations.....	12-71
12.11.2.3—Distribution of Concentrated Loads to Bottom Slab of Box Culvert	12-71
12.11.2.4—Distribution of Concentrated Loads in Skewed Box Culverts	12-72
12.11.3—Strength Limit State	12-72
12.11.4—Service Limit State	12-72
12.11.5—Safety Against Structural Failure	12-73
12.11.5.1—General.....	12-73
12.11.5.2—Design Moment for Box Culverts	12-73
12.11.5.3—Minimum Reinforcement.....	12-73
12.11.5.3.1—Cast-in-Place Structures.....	12-73
12.11.5.3.2—Precast Box Structures	12-73
12.11.5.4—Minimum Cover for Precast Box Structures	12-73
12.11.6—Construction and Installation	12-74
12.12—THERMOPLASTIC PIPES	12-74
12.12.1—General.....	12-74
12.12.2—Service Limit States	12-74
12.12.2.1—General.....	12-74
12.12.2.2—Deflection Requirement	12-74
12.12.3—Safety Against Structural Failure	12-75
12.12.3.1—General.....	12-75
12.12.3.2—Section Properties	12-75
12.12.3.3—Chemical and Mechanical Requirements	12-76
12.12.3.4—Thrust	12-77
12.12.3.5—Factored and Service Loads	12-78
12.12.3.6—Handling and Installation Requirements	12-82
12.12.3.7—Soil Prism.....	12-82
12.12.3.8—Hydrostatic Pressure	12-83
12.12.3.9—Live Load.....	12-84
12.12.3.10—Wall Resistance.....	12-84
12.12.3.10.1—Resistance to Axial Thrust	12-84
12.12.3.10.1a—General.....	12-84
12.12.3.10.1b—Local Buckling Effective Area	12-84
12.12.3.10.1c—Compression Strain.....	12-85
12.12.3.10.1d—Thrust Strain Limits	12-86
12.12.3.10.1e—General Buckling Strain Limits	12-86
12.12.3.10.2—Bending and Thrust Strain Limits	12-87
12.12.3.10.2a—General.....	12-87
12.12.3.10.2b—Combined Strain	12-87
12.12.4—Construction and Installation	12-89
12.13—STEEL TUNNEL LINER PLATE	12-89
12.13.1—General.....	12-89
12.13.2—Loading	12-89
12.13.2.1—Earth Loads	12-90
12.13.2.2—Live Loads	12-91
12.13.2.3—Grouting Pressure.....	12-91
12.13.3—Safety Against Structural Failure	12-91
12.13.3.1—Section Properties	12-91
12.13.3.2—Wall Area	12-91
12.13.3.3—Buckling.....	12-91
12.13.3.4—Seam Strength	12-91
12.13.3.5—Construction Stiffness	12-91
12.14—PRECAST REINFORCED CONCRETE THREE-SIDED STRUCTURES	12-93
12.14.1—General.....	12-93

12.14.2—Materials	12-93
12.14.2.1—Concrete	12-93
12.14.2.2—Reinforcement	12-93
12.14.3—Concrete Cover for Reinforcement	12-93
12.14.4—Geometric Properties	12-93
12.14.5—Design	12-93
12.14.5.1—General	12-93
12.14.5.2—Distribution of Concentrated Load Effects in Top Slab and Sides	12-94
12.14.5.3—Distribution of Concentrated Loads in Skewed Culverts	12-94
12.14.5.4—Shear Transfer in Transverse Joints between Culvert Sections	12-94
12.14.5.5—Span Length	12-94
12.14.5.6—Resistance Factors	12-95
12.14.5.7—Crack Control	12-95
12.14.5.8—Minimum Reinforcement	12-95
12.14.5.9—Deflection Control at the Service Limit State	12-95
12.14.5.10—Footing Design	12-95
12.14.5.11—Structural Backfill	12-95
12.14.5.12—Scour Protection and Waterway Considerations	12-95
12.15—FIBERGLASS PIPE	12-95
12.15.1—General	12-95
12.15.2—Section Properties	12-96
12.15.3—Mechanical Requirements	12-96
12.15.3.1—Circumferential Flexural Modulus	12-96
12.15.3.2—Long-Term Ring-Bending Strain	12-96
12.15.4—Total Allowable Deflection	12-96
12.15.5—Service Limit States	12-97
12.15.5.1—General	12-97
12.15.5.2—Deflection Requirement	12-97
12.15.6—Safety Against Structural Failure	12-97
12.15.6.1—General	12-97
12.15.6.2—Flexure	12-98
12.15.6.3—Global Buckling	12-98
12.15.6.4—Flexibility Limit	12-99
12.15.7—Construction and Installation	12-99
12.16—REFERENCES	12-99
APPENDIX A12—PLATE, PIPE, AND PIPE ARCH PROPERTIES	12-103

SECTION 13: RAILINGS

TABLE OF CONTENTS

13.1—SCOPE	13-1
13.2—DEFINITIONS	13-1
13.3—NOTATION	13-3
13.4—GENERAL	13-4
13.5—MATERIALS	13-5
13.6—LIMIT STATES AND RESISTANCE FACTORS	13-5
13.6.1—Strength Limit State	13-5
13.6.2—Extreme Event Limit State	13-5
13.7—TRAFFIC RAILINGS	13-5
13.7.1—Railing System	13-5
13.7.1.1—General	13-5
13.7.1.2—Approach Railings	13-6
13.7.1.3—End Treatment	13-6
13.7.2—Test Level Selection Criteria	13-7
13.7.3—Railing Design	13-8
13.7.3.1—General	13-8
13.7.3.1.1—Application of Previously Tested Systems	13-8
13.7.3.1.2—New Systems	13-9
13.7.3.2—Height of Traffic Parapet or Railing	13-9
13.8—PEDESTRIAN RAILINGS	13-9
13.8.1—Geometry	13-9
13.8.2—Design Loads	13-10
13.9—BICYCLE RAILINGS	13-11
13.9.1—General	13-11
13.9.2—Geometry	13-11
13.9.3—Design Live Loads	13-11
13.10—COMBINATION RAILINGS	13-12
13.10.1—General	13-12
13.10.2—Geometry	13-12
13.10.3—Design Live Loads	13-12
13.11—CURBS AND SIDEWALKS	13-12
13.11.1—General	13-12
13.11.2—Sidewalks	13-13
13.11.3—End Treatment of Separation Railing	13-13
13.12—REFERENCES	13-13
APPENDIX A13	13-15
A13.1—GEOMETRY AND ANCHORAGES	13-15
A13.1.1—Separation of Rail Elements	13-15
A13.1.2—Anchorage	13-17
A13.2—TRAFFIC RAILING DESIGN FORCES	13-17
A13.3—DESIGN PROCEDURE FOR RAILING TEST SPECIMENS	13-19
A13.3.1—Concrete Railings	13-19
A13.3.2—Post-and-Beam Railings	13-21
A13.3.3—Concrete Parapet and Metal Rail	13-22
A13.3.4—Wood Barriers	13-24
A13.4—DECK OVERHANG DESIGN	13-25
A13.4.1—Design Cases	13-25
A13.4.2—Decks Supporting Concrete Parapet Railings	13-25
A13.4.3—Decks Supporting Post-and-Beam Railings	13-26
A13.4.3.1—Overhang Design	13-26
A13.4.3.2—Resistance to Punching Shear	13-27

SECTION 14: JOINTS AND BEARINGS

TABLE OF CONTENTS

14.1—SCOPE	14-1
14.2—DEFINITIONS	14-1
14.3—NOTATION	14-3
14.4—MOVEMENTS AND LOADS	14-6
14.4.1—General	14-6
14.4.2—Design Requirements	14-10
14.4.2.1—Elastomeric Pads and Steel Reinforced Elastomeric Bearings	14-11
14.4.2.2—High Load Multirotational (HLMR) Bearings	14-12
14.4.2.2.1—Pot Bearings and Curved Sliding Surface Bearings	14-12
14.4.2.2.2—Disc Bearings	14-12
14.5—BRIDGE JOINTS	14-12
14.5.1—Requirements	14-12
14.5.1.1—General	14-12
14.5.1.2—Structural Design	14-13
14.5.1.3—Geometry	14-14
14.5.1.4—Materials	14-14
14.5.1.5—Maintenance	14-14
14.5.2—Selection	14-15
14.5.2.1—Number of Joints	14-15
14.5.2.2—Location of Joints	14-15
14.5.3—Design Requirements	14-16
14.5.3.1—Movements during Construction	14-16
14.5.3.2—Design Movements	14-16
14.5.3.3—Protection	14-17
14.5.3.4—Bridging Plates	14-17
14.5.3.5—Armor	14-18
14.5.3.6—Anchors	14-18
14.5.3.7—Bolts	14-18
14.5.4—Fabrication	14-18
14.5.5—Installation	14-19
14.5.5.1—Adjustment	14-19
14.5.5.2—Temporary Supports	14-19
14.5.5.3—Field Splices	14-19
14.5.6—Considerations for Specific Joint Types	14-20
14.5.6.1—Open Joints	14-20
14.5.6.2—Closed Joints	14-20
14.5.6.3—Waterproofed Joints	14-20
14.5.6.4—Joint Seals	14-21
14.5.6.5—Poured Seals	14-21
14.5.6.6—Compression and Cellular Seals	14-21
14.5.6.7—Sheet and Strip Seals	14-22
14.5.6.8—Plank Seals	14-22
14.5.6.9—Modular Bridge Joint Systems (MBJS)	14-22
14.5.6.9.1—General	14-22
14.5.6.9.2—Performance Requirements	14-24
14.5.6.9.3—Testing and Calculation Requirements	14-25
14.5.6.9.4—Loads and Load Factors	14-25
14.5.6.9.5—Distribution of Wheel Loads	14-27
14.5.6.9.6—Strength Limit State Design Requirements	14-28
14.5.6.9.7—Fatigue Limit State Design Requirements	14-29
14.5.6.9.7a—General	14-29
14.5.6.9.7b—Design Stress Range	14-31
14.6—REQUIREMENTS FOR BEARINGS	14-36
14.6.1—General	14-36

14.6.2—Characteristics	14-37
14.6.3—Force Effects Resulting from Restraint of Movement at the Bearing	14-38
14.6.3.1—Horizontal Force and Movement	14-38
14.6.3.2—Moment	14-39
14.6.4—Fabrication, Installation, Testing, and Shipping	14-41
14.6.5—Seismic and Other Extreme Event Provisions for Bearings	14-41
14.6.5.1—General	14-41
14.6.5.2—Applicability	14-41
14.6.5.3—Design Criteria	14-41
14.7—SPECIAL DESIGN PROVISIONS FOR BEARINGS	14-43
14.7.1—Metal Rocker and Roller Bearings	14-43
14.7.1.1—General	14-43
14.7.1.2—Materials	14-44
14.7.1.3—Geometric Requirements	14-44
14.7.1.4—Contact Stresses	14-44
14.7.2—PTFE Sliding Surfaces	14-45
14.7.2.1—PTFE Surface	14-45
14.7.2.2—Mating Surface	14-46
14.7.2.3—Minimum Thickness	14-46
14.7.2.3.1—PTFE	14-46
14.7.2.3.2—Stainless Steel Mating Surfaces	14-47
14.7.2.4—Contact Pressure	14-47
14.7.2.5—Coefficient of Friction	14-48
14.7.2.6—Attachment	14-49
14.7.2.6.1—PTFE	14-49
14.7.2.6.2—Mating Surface	14-49
14.7.3—Bearings with Curved Sliding Surfaces	14-50
14.7.3.1—General	14-50
14.7.3.2—Bearing Resistance	14-50
14.7.3.3—Resistance to Lateral Load	14-51
14.7.4—Pot Bearings	14-52
14.7.4.1—General	14-52
14.7.4.2—Materials	14-52
14.7.4.3—Geometric Requirements	14-52
14.7.4.4—Elastomeric Disc	14-54
14.7.4.5—Sealing Rings	14-54
14.7.4.5.1—General	14-54
14.7.4.5.2—Rings with Rectangular Cross-Sections	14-55
14.7.4.5.3—Rings with Circular Cross-Sections	14-55
14.7.4.6—Pot	14-55
14.7.4.7—Piston	14-56
14.7.5—Steel-Reinforced Elastomeric Bearings—Method B	14-57
14.7.5.1—General	14-57
14.7.5.2—Material Properties	14-58
14.7.5.3—Design Requirements	14-60
14.7.5.3.1—Scope	14-60
14.7.5.3.2—Shear Deformations	14-60
14.7.5.3.3—Combined Compression, Rotation, and Shear	14-61
14.7.5.3.4—Stability of Elastomeric Bearings	14-64
14.7.5.3.5—Reinforcement	14-65
14.7.5.3.6—Compressive Deflection	14-66
14.7.5.3.7—Seismic and Other Extreme Event Provisions	14-67
14.7.5.4—Anchorage for Bearings without Bonded External Plates	14-67
14.7.6—Elastomeric Pads and Steel-Reinforced Elastomeric Bearings—Method A	14-68
14.7.6.1—General	14-68
14.7.6.2—Material Properties	14-70

14.7.6.3—Design Requirements	14-71
14.7.6.3.1—Scope	14-71
14.7.6.3.2—Compressive Stress	14-71
14.7.6.3.3—Compressive Deflection.....	14-72
14.7.6.3.4—Shear.....	14-74
14.7.6.3.5—Rotation	14-74
14.7.6.3.5a—General	14-74
14.7.6.3.5b—Rotation of CDP	14-75
14.7.6.3.6—Stability.....	14-76
14.7.6.3.7—Reinforcement	14-76
14.7.6.3.8—Seismic and Other Extreme Event Provisions	14-76
14.7.7—Bronze or Copper Alloy Sliding Surfaces.....	14-77
14.7.7.1—Materials	14-77
14.7.7.2—Coefficient of Friction	14-78
14.7.7.3—Limit on Load	14-78
14.7.7.4—Clearances and Mating Surfaces	14-78
14.7.8—Disc Bearings.....	14-78
14.7.8.1—General	14-78
14.7.8.2—Materials	14-79
14.7.8.3—Elastomeric Disc	14-79
14.7.8.4—Shear Resisting Mechanism	14-80
14.7.8.5—Steel Plates.....	14-80
14.7.9—Guides and Restraints	14-80
14.7.9.1—General	14-80
14.7.9.2—Design Loads	14-81
14.7.9.3—Materials	14-81
14.7.9.4—Geometric Requirements	14-81
14.7.9.5—Design Basis	14-81
14.7.9.5.1—Load Location.....	14-81
14.7.9.5.2—Contact Stress	14-82
14.7.9.6—Attachment of Low-Friction Material	14-82
14.7.10—Other Bearing Systems.....	14-82
14.8—LOAD PLATES AND ANCHORAGE FOR BEARINGS	14-83
14.8.1—Plates for Load Distribution.....	14-83
14.8.2—Tapered Plates.....	14-84
14.8.3—Anchorage and Anchor Bolts	14-84
14.8.3.1—General	14-84
14.8.3.2—Seismic and Other Extreme Event Design and Detailing Requirements	14-85
14.9—CORROSION PROTECTION.....	14-85
14.10—REFERENCES	14-86

TABLE OF CONTENTS

15.1—SCOPE	15-1
15.2—DEFINITIONS.....	15-1
15.3—NOTATION.....	15-1
15.4—GENERAL FEATURES.....	15-2
15.4.1—Functional Requirements	15-2
15.4.1.1—General.....	15-2
15.4.1.2—Lateral Clearance	15-2
15.4.2—Drainage.....	15-2
15.4.3—Emergency Responders and Maintenance Access	15-2
15.4.4—Differential Settlement of Foundations.....	15-3
15.5—LIMIT STATES AND RESISTANCE FACTORS	15-3
15.5.1—General.....	15-3
15.5.2—Service Limit State.....	15-3
15.5.3—Strength Limit State	15-3
15.5.4—Extreme Event Limit State.....	15-4
15.6—EXPANSION DEVICES	15-4
15.6.1—General.....	15-4
15.6.2—Structure-Mounted Sound Barriers	15-4
15.6.3—Ground-Mounted Sound Barriers.....	15-4
15.7—SOUND BARRIERS INSTALLED ON EXISTING BRIDGES	15-5
15.8—LOADS	15-5
15.8.1—General.....	15-5
15.8.2—Wind Load	15-5
15.8.3—Earth Load	15-5
15.8.4—Vehicular Collision Forces	15-6
15.9—FOUNDATION DESIGN.....	15-8
15.9.1—General.....	15-8
15.9.2—Determination of Soil and Rock Properties	15-9
15.9.3—Limit States.....	15-9
15.9.4—Resistance Requirements	15-9
15.9.5—Resistance Factors.....	15-9
15.9.6—Loading	15-10
15.9.7—Movement at the Service Limit State.....	15-10
15.9.8—Safety against Geotechnical Failure at the Strength Limit State.....	15-10
15.9.9—Seismic Design	15-10
15.9.10—Corrosion Protection	15-10
15.9.11—Drainage.....	15-10
15.10—REFERENCES	15-10

INDEX

- Abutments and retaining walls
 - *See* Earth Pressure, 11-19
 - backfill 11-7
 - bearing resistance 11-21
 - conventional walls and abutments 11-20
 - drainage 11-35
 - dynamic load allowance 3-34
 - expansion and contraction joints 11-21
 - extreme event limit state 11-18
 - general considerations 11-19
 - integral abutments 11-20
 - loading 11-19
 - movement and stability 11-21
 - overturning 11-24
 - passive resistance 11-24
 - protection 2-4
 - reinforcement 11-20
 - safety against structural failure 11-25
 - seismic design 11-25
 - sliding 11-24
 - subsurface erosion 11-24
 - transitions 10-32
 - wingwalls 11-20
- Aeroelastic instability
 - aeroelastic phenomena 3-59
 - control of dynamic responses 3-60
 - wind tunnel tests 3-60
- Alkali-silica reactive aggregates 5-264
- Aluminum
 - camber *See* Camber
 - coefficient of thermal expansion 7-6
 - culverts 12-8
 - effective area 7-39
 - fracture 7-24
 - local buckling 7-48
 - minimum thickness 7-34
 - net section 7-39
 - nondestructive testing 7-32
 - orthotropic decks *See* Orthotropic aluminum decks
 - shear and torsion 7-56
 - slenderness ratios 7-32
 - tensile resistance 7-35
 - unit weight 3-21
 - welding procedures and requirements 7-31
- Anchor bolts
 - bearings 14-84
 - elastomeric bearings 3-109
 - deck joints 14-18
 - seismic design 14-85
- Anchorage
 - anchored walls 11-45
 - bearings 14-84
 - deck joints 14-18
 - design live loads 13-11
 - footings 10-54
 - geometry 13-11
 - parapets 13-15
 - post-tensioning 5-23
 - railings 13-15
 - seismic design 14-85
 - tension tie 5-93
- Anchored walls 11-44
 - anchor pullout capacity 11-47
 - anchor stressing and testing 11-54
 - anchors 11-47, 11-50
 - bearing resistance 11-46
 - construction and installation 11-54
 - corrosion protection 11-54
 - drainage 11-55
 - dynamic load allowance 3-34
 - earth pressure 3-133
 - facing 11-52
 - loading 11-45
 - movement and stability 11-45
 - passive resistance 11-50
 - safety against soil failure 11-46
 - safety against structural failure 11-50
 - seismic design 11-53
 - vertical wall elements 11-52
- Anchors 5-256
- Angles
 - floorbeam/stringer end connection 6-285
 - shelf 6-285
 - thickness of metal 6-285
- Annual frequency of collapse
 - geometric probability 3-166
 - probability of aberrancy 3-163
 - probability of collapse 3-167
 - vessel frequency distribution 3-162
- Approximate methods of analysis
 - beam-slab bridges 4-29
 - decks 4-22
 - effective flange width 4-54
 - effective length factor 4-49
 - equivalent strip widths for slab-type bridges 4-48
 - moment magnification 4-14, 4-16
 - seismic lateral load distribution 4-62
 - truss and arch bridges 4-49
- Arches
 - arch ribs 5-247
 - effective length factor 4-16
 - minimum reinforcement 5-248
 - moment magnification 4-16
 - splices 6-304
 - steel, diaphragms 6-79
- Backfill *See* Abutments and retaining walls
- Barriers
 - anchorage 3-109
 - seismic forces 3-109
- Basic requirements of structural dynamics
 - damping 4-78
 - distribution of masses 4-77
 - natural frequencies 4-78

stiffness	4-78	rock	10-83
Beam ledges		semiempirical procedures	10-68
design for bearing	5-112	spread footings	10-69, 10-70
design for flexure and horizontal force	5-108	Bicycles	
design for punching shear	5-108	deck joint provisions	14-17
design for shear	5-107	railing	13-9, 13-11
design of hanger reinforcement	5-110	Bolted connections	6-285
Beam-slab bridges		bearing-type connections	6-286, 6-288
moment and shear	4-35	eccentric	6-285
special loads with other traffic	4-47	edge distance	6-290
Bearing area		end distance	6-290
brackets	5-105	holes	6-288
concrete	5-54	maximum pitch for stitch bolts	6-289
fasteners	6-295	maximum spacing for sealing bolts	6-289
post-tensioning anchorage	5-113	minimum number of bolts	6-285
Bearing plates	See Bearings	minimum spacing and clear distance	6-289
Bearing stiffeners	6-208	minimum weld	6-285
axial resistance	6-209	nuts	6-84
bearing resistance	6-209	slip-critical connections	6-285, 6-288
effective section	6-209	washers	6-84, 6-287
projecting width	6-208	Bolted splices	
steel	6-370	compression members	6-304
Bearing-type connections	6-286	fillers	6-311
Bearings		flange splices	6-308
<i>See</i> Disc bearings, Elastomeric bearings, Pot		flexural members	6-304
bearings, <i>and</i> Railing		tension members	6-304
anchor bolts	14-84	web splices	6-305
anchorage	14-84	Bolts	
applicability	14-41	bearing resistance	6-286, 6-295
bearing plates	5-67, 5-113	combined tension and shear	6-297
bronze or copper alloy sliding surfaces	14-77	effective bearing area	6-295
characteristics	14-37	fatigue resistance	6-296
curved sliding surfaces	14-50	gauge	6-95, 6-289
design criteria	14-41	materials	8-21
disc bearings	14-78	minimum number in a connection	6-285
elastomeric bearings	14-57, 14-68	prying action	6-296
fabrication, installation, testing and shipping		shear resistance	6-286, 6-290, 6-303
.....	14-41	size	6-288
force effects resulting from restraint of movement		slip resistance	6-291
at the bearing	14-38	tensile resistance	6-286, 6-296, 6-303
guides and restraints	14-80	Box girders	
horizontal force and movement	14-38	analysis	4-36
launching bearings	5-242	effective flange width	4-59
load plates	14-83	live load distribution factors	4-36
metal rocker and roller bearings	14-43	wind bracing	4-62
moment	14-39	wind load distribution	4-62
movements and loads	14-6	Bracing	
other bearing systems	14-82	<i>See</i> Diaphragms and cross-frames, <i>and</i> Lateral	
pot bearings	14-52	bracing	
PTFE sliding surfaces	14-45	box sections	4-62
seismic provisions for bearings	14-41	connections	6-61, 6-286
special design provisions	14-43	glued laminated timber girders	8-37
suitability	14-37	portal bracing	8-37
tapered plates	14-84	sawn wood beams	8-36
uplift	14-36, 14-80	slenderness ratio	6-96, 6-109
Bearing resistance		sway bracing	8-37

- temporary 4-62, 5-210, 6-71
- trusses 6-83
- wood trusses 8-37
- Brackets and corbels
 - alternative to strut-and-tie model 5-105
- Braking force 3-35
- Bridge scour *See* Scour
- Bridge site arrangement
 - traffic safety 2-4
- Bridge testing 4-90
- Bronze or copper alloy sliding surfaces
 - clearances and mating surfaces 14-78
 - coefficient of friction 14-78
 - limit on load 14-78
 - materials 14-77
- Built-up members
 - noncomposite sections 6-121
 - perforated plates 6-96, 6-122
 - steel tension members 6-96
- Bundled reinforcement
 - development length 5-183
 - number of bars in a bundle 5-171
 - splices 5-190
 - termination 5-171
 - ties 5-173
- Buoyancy 3-44
- Buried structures
 - bearing resistance and stability 12-19
 - corner backfill for metal pipe arches 12-20
 - corrosive and abrasive conditions 12-24
 - differential settlement of backfill 12-15
 - embankment installations 12-21
 - end treatment 12-23
 - flexibility limits and construction stiffness 12-13
 - flexible culverts constructed on skew 12-23
 - footing settlement 12-15
 - hydraulic design 12-20
 - loading 12-14
 - minimum soil cover 12-21
 - minimum spacing of pipe 12-22
 - safety against soil failure 12-19
 - scour 12-20
 - service limit state 12-15
 - settlement 12-15
 - soil envelope 12-20
 - tolerable movement 12-15
 - trench installations 12-20
 - unbalanced loading 12-16
 - uplift 12-19
- Cables
 - bridge strand 6-35
 - bright wire 6-35
 - epoxy-coated wire 6-35
 - galvanized wire 6-35
 - modulus of elasticity 4-74
- Caissons *See* Drilled shafts
- Camber
 - aluminum structures 7-31
 - concrete structures 5-44, 5-121, 5-141, 5-242
 - glued laminated timber girders 8-37
 - steel structures 6-65
 - stress laminated decks 8-37
 - wood structures 8-12
 - wood trusses 8-37
- Cantilever retaining walls 11-36
 - corrosion protection 11-44
 - drainage 11-44
 - earth pressure 3-128
 - facing 11-38
 - loading 11-36
 - movement 11-36
 - overall stability 11-36
 - safety against structural failure 11-38
 - seismic design 11-39
 - soil failure 11-36
 - vertical wall elements 11-38
- Cantilever slabs
 - cantilever length 3-28
 - design 3-28, 4-23, 9-9, 13-4, 13-5
 - reinforcement, concrete boxes 5-223
 - strip width 4-24
 - thickness 13-9
 - wheel load position 3-28
- Cast metal
 - cast iron 6-34
 - cast steel and ductile iron 6-34
 - malleable castings 6-34
- Cast-in-place box culverts and arches
 - cast-in-place structures 12-73
 - concentrated loads 12-71
 - construction and installation 12-74
 - design moment for box culverts 12-73
 - distribution of concentrated loads in skewed box culverts 12-72
 - embankment and trench conditions 12-69
 - loads and live load distribution 12-68
 - minimum cover for precast box structures 12-74
 - minimum reinforcement 12-73
 - other installations 12-71
 - precast box structures 12-73
 - safety against structural failure 12-73
 - service limit state 12-72
 - soil structure interaction 12-69
- Cast-in-place girders and box and T-beams
 - bottom flange 5-223
 - bottom slab reinforcement in box girders 5-224
 - deck slab reinforcement in T-beams/box girders 5-223
 - effective flange width 4-55
 - flange and web thickness 5-223
 - reinforcement 5-223
 - top flange 5-223

web.....	5-223	Compression flange proportions.....	6-368
Cast-in-place piles	<i>See</i> Concrete piles	Compression members	
Cast-in-place voided slab superstructures		concrete.....	5-45, 5-48
compressive zones in negative moment area.....	5-207	hollow rectangular compression members.....	5-51
cross-section dimensions.....	5-206	steel.....	6-99
drainage of voids.....	5-208	steel composite members	6-128
general design requirements.....	5-207	steel noncomposite members	6-109
minimum number of bearings	5-207	wood.....	8-33
solid end sections	5-207	Compressive resistance	
Centrifugal forces	3-34	concrete.....	5-48
Charpy V-notch test		steel.....	6-99
temperature zones	6-64	steel composite members	6-128
Clearances.....	2-5	steel noncomposite members	6-109
drilled shafts.....	10-129	wood.....	8-33
highway horizontal.....	2-6	Concrete	
highway vertical.....	2-5	air-entrained	5-260, 5-263
navigational.....	2-5	bearing resistance.....	5-30, 5-53, 5-252
pedestrian bridges	2-6	bearings.....	5-242
piles.....	10-87	box girders	<i>See</i> Concrete box girders
railroad overpass	2-6	camber.....	<i>See</i> Camber
Coefficient of thermal expansion		coefficient of thermal expansion.....	5-17
aluminum	7-6	combined force effects.....	5-49, 5-55
concrete.....	5-17	compressive strength.....	5-15
steel.....	6-30	cover.....	5-167, 5-265, 9-14
wood.....	9-30	creep.....	5-17
Combination railing.....	13-12	culverts.....	<i>See</i> Concrete culverts
design live loads.....	13-12	deck slabs.....	<i>See</i> Concrete slabs
geometry	13-12	extreme event limit state	5-32, 5-33, 5-291
Combined force effects		formwork	<i>See</i> Concrete formwork
concrete.....	5-49, 5-55	modulus of elasticity	5-20, 5-291
steel.....	6-99, 6-129, 6-245	modulus of rupture	5-20
wood.....	8-35	piles.....	<i>See</i> Concrete piles
Compact sections		Poisson's ratio.....	5-20
nominal flexural resistance	6-178, 6-231	properties	5-15
Composite box girders	4-36, <i>See also</i> Box girders	shrinkage.....	5-19
bracing.....	6-80	slabs	<i>See</i> Concrete slabs
design conditions	6-215	stress limits	<i>See</i> Concrete stress limits
diaphragms.....	6-76, 6-78	strut-and-tie method.....	5-85
fatigue	6-215	tensile strength	5-21
lateral bracing	6-80	T-beams	<i>See</i> Concrete T-beams
live load distribution factors	4-36	Concrete box girders	
wind effects.....	4-62	effective flange width.....	4-59
Composite sections		effective flange width.....	4-55
concrete deck stresses	6-138	live load distribution factors	4-36
concrete-encased shapes	6-130, 6-278	Concrete culverts	
concrete-filled tubes.....	6-130, 6-279	bottom slab.....	5-210
modular ratio.....	6-138	confinement reinforcement	5-147
sequence of loading.....	6-137	dimensions, minimum	5-210
steel.....	6-128	distribution reinforcement.....	5-206
Compression chords		dynamic load allowance.....	3-34
continuity	6-315	seismic effects.....	3-69
lateral bracing.....	6-83	top slab.....	5-210
splices.....	6-304	web thickness.....	5-210
Compression flange flexural resistance	6-183	Concrete deck slabs	<i>See</i> Concrete slabs
lateral torsional buckling resistance .	6-186, 6-361	Concrete formwork.....	<i>See</i> Stay-in-place formwork
local buckling resistance	6-185, 6-360	bedding of panels	9-14

- creep and shrinkage control 9-14
- depth 9-13
- reinforcement 9-13
- Concrete piles
 - anchorage 5-196, 5-253
 - cast-in-place piles 5-255
 - embedment 5-196, 5-253
 - end region 5-198
 - pile dimensions 5-256
 - precast prestressed piles 5-254
 - precast reinforced piles 5-254
 - reinforcement 5-197, 5-205
 - reinforcing steel 5-256
 - seismic requirements 5-205
 - shells for cast-in-place piles 5-256
 - spacing of transverse reinforcement 5-256
 - splices 5-254
 - structural resistance 10-123
 - tensile stresses, precast piles 5-125
 - tolerance 5-249
 - uplift 5-197
- Concrete slabs 9-7
 - abrasion 5-167
 - application of empirical design 9-9
 - composite action 9-7
 - concrete cover 5-167
 - design conditions 9-10
 - design of cantilever slabs 9-8
 - distribution reinforcement 5-206
 - edge support 5-205, 9-8
 - effective length 9-9
 - effective width 6-139
 - empirical design 9-8
 - minimum depth and cover 9-7
 - precast deck slabs on girders 9-14
 - reinforcement 5-206, 9-11
 - segmental construction 9-15
 - shear 5-58
 - skewed bridges 4-49
 - skewed decks 9-7, 9-12
 - slab bridges 5-205
 - stay-in-place formwork 9-12
 - stay-in-place formwork 9-13
 - top slab, box girders 9-15
 - traditional design 9-12
 - uplift and slip of deck slabs 7-32
- Concrete stress limits
 - service stresses 5-125
 - stress limits for concrete 5-123, 5-291
 - temporary stresses before losses 5-123
- Concrete T-beams
 - negative moment reinforcement 5-57
- Concrete-filled tubes
 - circular tubes 6-283
 - rectangular tubes 6-283
- Cone Penetration Test 10-82
- Connections 6-284
 - See Bolted connections, Splices, and Welded connections*
 - block shear rupture resistance 6-302
 - bolted connections 6-285
 - rigid frame connections 6-313
 - splices 6-304
 - welded connections 6-298
- Connectors
 - lacing bars 6-96, 6-130
 - tie plates 6-96, 6-130
- Constructibility
 - dead load deflections 6-167
 - deck placement 6-163
 - flexure 6-160, 6-224
 - shear 6-226
- Continuously braced compression flanges 6-356
- Continuously braced tension flanges 6-356
- Corrosion
 - prestressing systems, concrete 5-23, 5-265
 - steel structures 6-71
- Constructibility
 - design objectives 2-14
- Continuous spans loading 3-28
- Corrosion
 - bearings 14-49
 - MSE facing 11-61
 - piles 10-125
- Corrosion protection 14-85
 - alternative coating 8-23
 - metallic coating 8-23
- Corrugated metal decks
 - composite action 9-29
 - distribution of wheel loads 9-29
- Cover plates 6-214
 - end requirements 6-214
- CPT *See Cone Penetration Test*
 - cohesionless soils 10-115
- Creep effect 5-17, 5-122
- Cross-section proportion limits
 - flange proportions 6-222
 - web proportions 6-222
- Culverts
 - additional provisions for culverts 5-248
 - aluminum 12-8
 - design for flexure 5-248
 - design for shear in slabs of box culverts 5-248
 - location, length, and waterway area 2-23
 - seismic effects 3-69
- Curbs and sidewalks *See Sidewalks*
 - end treatment of separation railing 13-13
 - sidewalks 13-13
- Curved structures
 - deck joints 14-15
 - deflections 2-12

single girder superstructures	4-18	isotropic plate model	4-68
Curved tendons		live loads	3-28
effects of curved tendons	5-150	live load effects on grids	4-27
in-plane force effects	5-151	longitudinal edges	4-25
out-of-plane force effects	5-155	orthotropic plate model	4-68
Dead loads		stay-in-place formwork	9-5
load factors	3-17, 5-229	traditional design	9-12
unit weight of materials	3-21	transverse edges	4-25
Deck analysis		unfilled composite grids	9-18
loading	9-6	Deep beams	5-224
methods of analysis	9-6	Deflection	
Deck joints		concrete	5-44
adjustment	14-19	criteria	2-11
anchors	14-18	span-to-depth ratios	2-13
armor	14-18	Deformations	
bolts	14-18	axial deformation	5-45
bridging plates	14-17	concrete	5-43
closed joints	14-20	steel	6-168
compression and cellular seals	14-21	Deformed bars and deformed wire in tension	
design requirements	14-16	tension development length	5-180
fabrication	14-18	Deformed bars in compression	
field splices	14-19	compressive development length	5-183
geometry	14-14	modification factors	5-183
installation	14-19	Depth of the web in compression	
joint seals	14-21	at plastic moment	6-407
location of joints	14-15	in the elastic range	6-406
maintenance	14-14	Design lane load	3-25
materials	14-14	Design lanes	
modular bridge joint systems	14-22	width	3-22
movements during construction	14-16	Design objectives	
number of joints	14-15	bridge aesthetics	2-15
open joints	14-20	constructibility	2-14
plank seals	14-22	economy	2-15
poured seals	14-21	safety	2-7
protection	14-17	serviceability	2-8
requirements	14-12	Design philosophy	1-3
selection	14-15	ductility	1-5
sheet and strip seals	14-22	limit states	1-3
structural design	14-13	operational importance	1-7
temporary supports	14-19	redundancy	1-6
waterproofed joints	14-20	Design tandem	3-25
Deck overhang design	9-9, 13-25	Design truck	3-24
decks supporting concrete parapet railings ..	13-25	Development of reinforcement	
decks supporting post-and-beam railings	13-26	basic requirements	5-176
design cases	13-25	bonded strand	5-143
resistance to punching shear	13-27	bundled bars	5-183
stay-in-place formwork	9-5	deformed bars and deformed wire in tension.	
Decks See Deck joints, and Deck overhang design			5-180, 5-291
applicability	4-23	development by mechanical anchorages	5-189
concrete appurtenances	9-5	flexural reinforcement	5-177
deck drainage	9-4	modification factors	5-181, 5-183, 5-185
distribution of wheel loads	4-26	prestressing strand	5-143
edge supports	9-5	shear reinforcement	5-187
empirical design	9-8	standard hooks in tension	5-184
inelastic analysis	4-29	welded wire fabric	5-187
interface action	9-4	Diaphragms and cross-frames	

- aluminum structures..... 7-34
- concrete structures 5-243
- steel arches..... 6-79
- steel box girders 6-76
- steel I-girders 6-72
- steel structures 6-71
- steel trusses 6-79, 6-316
- Disc bearings *See* Bearings
- elastomeric disc 14-79
- materials 14-79
- shear resisting mechanism 14-80
- steel plates..... 14-80
- suitability 14-37
- Discretely braced compression flanges 6-354
- Discretely braced tension flanges 6-355
- Distortion-induced fatigue
 - lateral connection plates 6-61
 - orthotropic decks 6-61, 9-29
- Distribution of load
 - cantilever slabs 4-24
 - concrete slabs..... 4-24
 - exterior beams..... 4-39, 4-44
 - interior beams 4-35, 4-36, 4-38, 4-42
 - skewed bridges 4-40, 4-46
 - steel grid flooring..... 4-24
 - transverse floorbeams 4-41
 - trusses 4-49
 - wheel loads through earth fills..... 3-25
 - wood flooring 4-23
- Dowels
 - concrete columns 5-253
 - concrete interface..... 5-204
 - pile anchorage..... 5-196, 5-253
 - wood decks 9-32, 9-38
- Downdrag 10-101, 10-102, 10-131, 10-136
 - determination of pile loads 10-88
 - settlement due to 10-95
- Drainage
 - sound barrier 15-2, 15-10
 - spandrel fill 5-248
- Drilled shafts 10-128
 - battered shafts 10-130
 - buckling 10-150
 - clearance 10-129
 - combined side and tip resistance 10-145
 - definition..... 10-2
 - design of 10-33
 - diameter 10-129
 - embedment into cap..... 10-129
 - enlarged bases..... 10-129, 10-151
 - estimation of resistance in IGMs 10-146
 - estimation of resistance in rock 10-143
 - group resistance 10-147
 - group resistance in cohesionless soil 10-148
 - group resistance in cohesive soil 10-148
 - group resistance in strong soil overlying weak soil..... 10-149
 - horizontal movement 10-135
 - horizontal resistance 10-150
 - lateral stability 10-150
 - reinforcement..... 10-150
 - resistance in cohesive Soils..... 10-138
 - service limit state design..... 10-132
 - settlement..... 10-132
 - shaft resistance..... 10-130
 - side resistance 10-144
 - spacing 10-129
 - strength limit state 10-48
 - structural resistance 10-150
 - tip resistance 10-140, 10-142, 10-145
 - transverse reinforcement..... 10-151
- Driven piles
 - design of 10-33
- Ductility 1-5
- Ductility requirements
 - reinforcing bars..... 5-22
- Ducts
 - bundling 5-148
 - curvature, minimum..... 5-23
 - ducts at deviation saddles 5-24
 - grouting..... 5-24, 5-150, 5-236
 - materials 5-23
 - size of ducts 5-24
 - spacing..... 5-148
- Durability
 - concrete cover 5-167, 5-265
 - materials 2-8
 - self-protecting measures 2-8
- Dynamic analysis 4-77
 - analysis for collision loads..... 4-89
 - analysis for earthquake loads..... 4-80
 - basic requirements 4-77
 - inelastic dynamic responses..... 4-79
- Dynamic load allowance 3-33
 - buried components..... 3-34
 - deck joints..... 3-33
 - wood components 3-34
- Earth loads
 - sound barrier 15-5
 - steel tunnel liner plate 12-90
- Earth pressure 3-116
 - active..... 3-120
 - anchored walls 3-133
 - at-rest 3-119
 - buried structures 12-14
 - cantilevered walls 3-128
 - compaction..... 3-117
 - downdrag 3-151
 - effect of earthquake 3-118
 - equivalent-fluid method..... 3-126
 - lateral earth pressure 3-118

modular walls.....	3-138	liquefaction design requirements	10-34
MSE walls.....	3-136	load combinations	3-10, 3-17
passive.....	3-123	prestressing steel	5-123
presence of water	3-117	railing	13-5
reduction due to earth pressure	3-151	sound barrier	15-3
surcharge loads.....	3-142	steel structures.....	6-37
Earthquake effects	<i>See</i> Seismic loads	wood structures	8-31
Economy		Extreme limit states	10-51
alternative plans	2-15	Eyebars	
Edge distance.....	6-290	factored resistance.....	6-96
Edge supports, slabs.....	5-205, 9-5, 9-8, 9-17	packing.....	6-97
Effective area		proportions	6-96
aluminum	7-39	Fasteners	<i>See</i> Bolts, and Connectors
perforated plates.....	6-315	countersunk	6-295
welds	6-300	Fatigue	
Effective flange width		distortion-induced	6-60
box girders	4-59	load-induced.....	6-38
cast-in-place multicell superstructures.....	4-59	Fatigue and fracture limit state	1-4, 9-5
orthotropic steel decks	4-59	aluminum structures.....	7-8
segmental box beams and CIP box beams	4-55	concrete structures	5-33
Effective length		decks	9-19, 9-29
slabs	9-10	elastomeric bearings.....	14-65
span	7-32	load combinations	3-17
Effective plastic moment	6-373	modular bridge joint systems	14-29
all other interior-pier sections	6-374	prestressing steel	5-28
interior-pier sections	6-373	reinforcing bars	5-27
Effective width		steel structures.....	6-36
concrete slabs.....	6-139	welded or mechanical rebar splices.....	5-28
orthotropic decks.....	9-28	Fatigue design	
Elastic dynamic responses		cycles	6-57
wind-induced vibration	4-79	deck joints.....	14-6
Elastomeric bearings.....	<i>See</i> Bearings	elastomeric bearings.....	14-65
anchorage	3-109	metal grid decks	9-19
combined compression and rotation.....	14-65	orthotropic decks.....	9-28
compressive deflection.....	14-61, 14-72	steel webs.....	6-215
compressive stress.....	14-60, 14-71	Fatigue load	3-30
design method A	14-68	approximate methods	3-32
design method B	14-57	frequency	3-31
movements and loads.....	14-11	load distribution for fatigue.....	3-32
Elastomeric pads.....	<i>See</i> Elastomeric bearings	refined methods.....	3-32
Emergency responder access to sound barriers....	15-2	FHWA Gates Formula	10-105
End distance.....	6-290	Filled and partially filled grid decks	
End requirements		design requirements	9-18
bolted ends	6-215	fatigue and fracture limit state	9-18
welded ends.....	6-215	Fillet-welded connections	
Engineering News formula	10-106	effective throat	6-300
Erosion control.....	11-20	size of weld	6-300
Expansion	<i>See</i> Coefficient of thermal expansion	Flange-strength reduction factors	
Expansion devices for sound barriers	15-4	hybrid factor.....	6-150
Exterior stringers		web load-shedding factor	6-151
capacity	4-32	Flexibility limits and construction stiffness	
distribution factors	4-39, 4-44	corrugated metal pipe and structural plate	
Extreme event limit state	1-5, 9-6, 10-33	structures	12-13
abutments, piers, and walls	11-18	spiral rib metal pipe and pipe arches.....	12-13
concrete structures	5-32, 5-33, 5-291	steel tunnel liner plate	12-14
drilled shafts.....	10-124	thermoplastic pipe.....	12-14

- Flexural members
 - concrete.....5-37, 5-40
 - steel..... 6-229, 6-230, 6-370
 - wood 8-31
- Flexural resistance
 - composite members 6-278
 - noncomposite steel members 6-248
 - steel.....6-244, 6-372
 - wood 8-31
- Footings 5-249
 - critical section for flexure..... 5-250
 - development of reinforcement 5-252
 - distribution of moment reinforcement 5-250
 - loads and reactions..... 5-249
 - moment in footings 5-250
 - reactions..... 12-47
 - resistance factors..... 5-250
 - shear in slabs and footings 5-58, 5-251
 - stepped 5-249
 - transfer of force at base of column 5-252
- Foundation design
 - seismic design forces 3-111
- Foundation investigation 2-7
 - topographic studies 2-7
- Free-standing abutments..... 11-144
 - design for displacement 11-146
- Friction
 - angle for dissimilar materials..... 3-123
 - coefficient 14-48, 14-78
- Friction forces..... 3-158
 - forces 5-242
 - post-tensioning tendons 5-132
- General zone..... 5-158
 - blister and rib reinforcement..... 5-166
 - design methods 5-159
 - design principles 5-160
 - deviation saddles..... 5-167
 - diaphragms..... 5-166
 - intermediate anchorages 5-164
 - multiple slab anchorages..... 5-119
 - responsibilities 5-159
 - special anchorage devices..... 5-164
 - tie-backs..... 5-164
- Geometry
 - large deflection theory 4-13
 - small deflection theory 4-12
- Geophysical tests
 - soil and rock..... 10-12
- Glued laminated decks
 - deck tie-downs 9-31
 - interconnected decks..... 9-31
 - noninterconnected decks..... 9-32
 - thermal expansion 9-30
- Glued laminated timber *See* Wood
 - bracing 8-37
 - camber 8-37
 - dimensions 8-13
 - marking 8-12
- Groove-welded connections
 - complete penetration..... 6-299
 - partial penetration 6-299
- Grout
 - joints 5-208
 - prestressing ducts 5-24, 5-150, 5-236
- Guides and restraints
 - attachment of low-friction material 14-82
 - contact stress..... 14-82
 - design basis..... 14-81
 - design loads 14-81
 - geometric requirements 14-81
 - load location 14-81
 - materials 14-81
- Gusset plates..... 6-303, 6-314
- Gravel
 - unit weight 3-21
- Gravity loads
 - design vehicular live load 3-23
 - fatigue load 3-30
 - pedestrian loads 3-32
 - rail transit load 3-32
- Groundwater
 - effects and buoyancy 10-100
- Ground-mounted sound barriers..... 15-4
- Grout
 - joints 9-15
- High load multirotational (HLMR) bearings..... 14-12
 - curved sliding surface bearings..... 14-12
 - disc bearings 14-12
 - pot bearings..... 14-12
- Holes..... 6-288
 - bolted connections 6-288
 - chains 6-95
 - long-slotted holes..... 6-288
 - oversize holes 6-288
 - pin holes..... 6-97, 6-98
 - short-slotted holes 6-288
 - size 6-288
 - type 6-288
- Hollow rectangular compression members
 - hoops..... 5-176
 - rectangular stress block limitations..... 5-52
 - spacing of reinforcement 5-175
 - splices 5-176
 - ties..... 5-175
 - wall slenderness ratio..... 5-51
- Hooks and bends
 - basic hook development length..... 5-184
 - hooked-bar tie requirements 5-185
 - minimum bend diameters 5-170
 - modification factors 5-185
 - seismic hooks..... 5-170
 - standard hooks 5-169

Horizontal wind pressure	
wind pressure on structures	3-52
wind pressure on vehicles	3-58
Hydraulic analysis	
approaches	2-22
bridge foundations	2-20
bridge waterway	2-20
stream stability	2-19
Hydrology and hydraulics	2-17
drainage	2-23
hydraulic analysis	2-19
hydrologic analysis	2-18
site data	2-18
Ice loads	3-61
adhesion	3-66
combination of forces	3-65
crushing and flexing	3-63
dynamic ice forces on piers	3-62
effective ice strength	3-62
hanging dams and ice jams	3-66
ice and snow load	3-68
slender and flexible piers	3-66
small streams	3-64
static ice loads on piers	3-66
Idealization	<i>See</i> Mathematical modeling
IGMs	10-135
Impact	<i>See</i> Dynamic load allowance
Inelastic dynamic responses	
plastic hinges and yield lines	4-80
Influence of plan geometry	
curved structures	4-17
plan aspect ratio	4-17
Instantaneous losses	
anchorage set	5-130
elastic shortening	5-134
friction	5-130
posttensioned members	5-130, 5-133
pretensioned members	5-130, 5-132
Interconnected decks	
panels parallel to traffic	9-31
panels perpendicular to traffic	9-31
Interior beams	
distribution factors	4-35, 4-36, 4-38, 4-42
Intermediate Geo Materials	<i>See</i> IGMs
Interaction systems	<i>See</i> Culverts
Keys	
construction joints	5-209
precast decks	5-208, 9-14
segmental bridges	5-240, 5-244
Laboratory tests	
geophysical tests	10-12
in-situ tests	10-11
rock tests	10-11
soil tests	10-11
Lacing bars	6-96, 6-130
Lap splices	5-190
bundled bars	5-190
non-contact splices	5-190
spiral reinforcement	5-173
Large deflection theory	
approximate methods	4-14
moment magnification	4-14
refined methods	4-16
Lateral bracing	<i>See</i> Bracing, and Diaphragms and
cross-frames	
steel	6-369
straight I-sections	6-80
trusses	6-83
Lateral clearance	
sound barrier	15-2
Lateral-torsional buckling (LTB)	6-408
resistance	6-186
Lightweight concrete	<i>See</i> Concrete
development length	5-181
development length	5-185
resistance factors	5-30
shear resistance	5-204
shear resistance	5-105
unit weight	3-21
Limit states	<i>See</i> Extreme event limit state,
Fatigue and fracture limit state, Service limit	
state, and Strength limit state	
resistance factors	10-29
sound barriers	15-3
Live loads	<i>See</i> Distribution of load
application	3-28
bicycle loads	3-33
braking force	3-35
centrifugal forces	3-34
continuous spans loading	3-28
deck overhang load	3-30
decks and box culverts	3-29
design lane load	3-25
design tandem	3-25
design truck	3-24
dynamic load allowance	3-33
gravity loads	3-22
live load deflection	3-29
multiple presence	3-22
tire contact area	3-25
vehicular collision force	3-37
Load factors	3-9
abutments, piers, and walls	11-11
buried structures	12-11
combinations	3-9, 3-17
construction loads	3-19, 5-229
definition	1-4
jacking	3-20
post-tensioning	3-20
Load-induced fatigue	
application	6-38, 7-10, 7-11, 7-12
design criteria	6-39

- detail categories 6-40
- fatigue resistance 6-56
- Loads 10-55
- Local zone 5-158
 - bearing resistance 5-113
 - dimensions of local zone 5-112
 - responsibilities 5-159
 - special anchorage devices 5-114
- Location features
 - bridge site arrangement 2-4
 - environment 2-6
 - route location 2-3
- Long-span structural plate structures 12-28
 - acceptable special features 12-31
 - backfill protection 12-38
 - balanced support 12-37
 - construction and installation 12-34, 12-39
 - continuous longitudinal stiffeners 12-31
 - cross-section 12-30
 - cut-off (toe) walls 12-38
 - end treatment design 12-35
 - footing design 12-33
 - footing reactions in arch structures 12-32
 - foundation design 12-31
 - hydraulic protection 12-37
 - hydraulic uplift 12-38
 - mechanical and chemical requirements 12-31
 - reinforcing ribs 12-30, 12-31
 - relieving slabs 12-38
 - safety against structural failure 12-29
 - scour 12-38
 - seam strength 12-31
 - section properties 12-30
 - service limit state 12-29
 - service requirements 12-34
 - settlement limits 12-31
 - shape control 12-31
 - soil envelope design 12-33
 - standard shell end types 12-35
 - thrust 12-31
 - wall area 12-31
- Longitudinal stiffeners
 - moment of inertia and radius of gyration 6-213
 - projecting width 6-212
- Long-slotted holes 6-288
- Loss of prestress
 - approximate lump sum estimate 5-135
 - creep losses 5-139
 - instantaneous losses 5-130
 - losses for deflection calculations 5-141
 - refined estimate 5-136
 - relaxation losses 5-141
 - shrinkage losses 5-137
 - total prestress loss 5-129
- Maintenance access to sound barriers *See*
 - Emergency responder and maintenance access to sound barriers
- Materials 6-30
 - aluminum and plate structures 12-8
 - aluminum sheet, plate, and shapes 7-6
 - bolts, nuts, and washers 6-32
 - bronze or copper alloy sliding surfaces 14-77
 - cables 6-35
 - cement 5-16
 - concrete 5-15, 12-8
 - disc bearings 14-79
 - elastomer 14-58, 14-70
 - glued laminated timber 8-12
 - metal fasteners and hardware 8-21
 - pins, rollers, and rockers 6-32
 - pot bearings 14-52
 - precast concrete pipe 12-8
 - precast concrete structures 12-8
 - preservative treatment 8-23
 - prestressing steel 5-22
 - PTFE sliding surface 14-45
 - reinforcing steel 5-22
 - sawn lumber 8-6
 - stainless steel 6-34
 - steel pipe and structural plate structures 12-8
 - steel reinforcement 12-8
 - structural steels 6-30
 - stud shear connectors 6-33
 - thermoplastic pipe 12-9
 - weld metal 6-34
- Mathematical modeling 4-11
 - equivalent members 4-17
 - geometry 4-12
 - modeling boundary conditions 4-16
 - structural material behavior 4-11
- Mechanically stabilized earth walls... *See* MSE walls
- Metal decks 9-15
 - analysis 4-27
 - corrugated metal decks 9-29
 - limit states 9-25
 - metal grid decks 9-16, 9-17, 9-18
 - orthotropic aluminum decks 9-28
 - orthotropic steel decks 9-20
 - superposition of local and global effects 9-25
- Metal fasteners and hardware
 - corrosion protection 8-23
 - drift pins and bolts 8-22
 - fasteners 8-21
 - minimum requirements 8-21
 - nails and spikes 8-22
 - prestressing bars 8-22
 - shear plate connectors 8-22
 - spike grids 8-22
 - split ring connectors 8-22
 - toothed metal plate connectors 8-22

Metal pipe, pipe arch, and arch structures	
construction and installation	12-28
handling and installation	12-27
resistance to buckling.....	12-26
safety against structural failure	12-24
seam resistance.....	12-27
section properties	12-25
smooth lined pipe	12-27
stiffeners.....	12-28
thrust	12-25
wall resistance	12-26
Methods of analysis.....	<i>See</i> Dynamic analysis, Mathematical modeling, <i>and</i> static analysis
Micropiles.....	10-152
axial compressive resistance	10-159
axial tension resistance.....	10-161
battered.....	10-153
corrosion and deterioration	10-163
definition.....	10-2
design of.....	10-33
design requirements	10-153
determination of loads.....	10-153
downdrag	10-153, 10-155
estimation of grout-to-ground bond resistance	10-156
estimation of tip resistance in rock.....	10-157
extreme event limit state	10-163
ground water table and bouyancy	10-155
groups in cohesionless soil.....	10-154
groups in cohesive soil.....	10-154
grout-to-steel bond	10-163
horizontal foundation movement	10-154
lateral squeeze	10-154
load test.....	10-158
nearby structures	10-154
nominal axial compression resistance of single	10-155
nominal horizontal resistance of single and groups.....	10-159
nominal uplift resistance of a single micropile	10-158
nominal uplift resistance of groups	10-158
plunge length transfer load.....	10-162
resistance of groups in compression	10-158
scour.....	10-155
service limit state design.....	10-154
settlement.....	10-154
settlement due to downdrag	10-154
spacing, clearance, embedment.....	10-153
strength limit state design	10-154
strength limit states	10-50
structural resistance.....	10-159
through embankment fill.....	10-153
tolerable movements	10-154
types	10-152
uplift.....	10-153
Modular bridge joint systems (MBJS)	
design stress range	14-31
distribution of wheel loads.....	14-27
fatigue limit state design requirements	14-29
loads and load factors.....	14-25
performance requirements.....	14-24
strength limit state design requirements.....	14-28
testing and calculation requirements	14-25
Modular ratio	
long-term.....	6-138
short-term.....	6-138
Modulus of elasticity	
cables	4-74
concrete.....	5-20, 5-291
prestressing steel	5-23
reinforcing steel	5-22
steel	6-30
wood piles	8-21
Moment redistribution	
approximate procedure.....	4-75
concrete	5-43
refined method	4-75
steel	6-371, 6-372, 6-373
Mononobe–Okabe analysis.....	11-144
MSE walls.....	11-55
abutments	11-112
bearing resistance.....	11-66
boundary between active and resistant zones	11-79
concentrated dead loads	11-106
corrosion issues for MSE facing	11-61
design life considerations.....	11-88
design tensile resistance	11-93
drainage.....	11-106
dynamic load allowance.....	3-34
earth pressure	3-136
external stability.....	11-97
facing	11-60
facing reinforcement connections	11-103
geosynthetic reinforcements	11-90, 11-94, 11-95
hydrostatic pressures	11-110
internal stability	3-137, 11-99
lateral displacement	11-62
loading	11-61, 11-64, 11-68
minimum front face embedment.....	11-59
minimum length of soil reinforcement.....	11-58
obstructions in the reinforced soil zone.....	11-111
overall stability.....	11-66
overturning	11-66
reinforcement/facing connection design	11-94
reinforcement pullout.....	11-79, 11-81
reinforcement strength	11-84
safety against soil failure.....	11-64
safety against structural failure	11-68
seismic design	11-97
settlement	11-61

- sliding 11-65
- special loading conditions..... 11-106
- steel reinforcements 11-88, 11-93, 11-94
- structure dimensions 11-57
- subsurface erosion 11-106
- traffic loads and barriers 11-109
- Multiple presence of live load 3-22
- Multispan bridges
 - general 4-81
 - multimode spectral method..... 4-84
 - selection of method..... 4-80
 - single-mode methods of analysis 4-81
 - single-mode spectral method 4-81
 - uniform load method..... 4-83
- Noncompact sections
 - nominal flexural resistance 6-181, 6-232
- Noncomposite sections
 - built-up members 6-121
 - channels, angles, tees, and bars..... 6-269
 - circular tubes..... 6-253
 - I- and H-shaped members 6-248
- Nondestructive testing
 - aluminum 7-32
- Nordlund/Thurman Method..... 10-110
- Operational importance 1-7
- Orthotropic aluminum decks
 - approximate analysis 9-28
 - limit states..... 9-28
- Orthotropic deck superstructures 6-323
 - effective width of deck 6-325
 - superposition of global and local effects 6-325
- Orthotropic decks.....*See* Orthotropic aluminum decks, *and* Orthotropic steel decks
- Orthotropic steel decks
 - design..... 9-25
 - detailing requirements 9-26
 - wearing surface..... 9-20
 - wheel load distribution 9-20
- Oversize holes 6-288
- Painting
 - box sections 6-215
 - slip-critical joints 6-293
- Parapets *See* Railing
- Pedestrian loads 3-32
- Pedestrian railing 8-23, 13-9
 - design live loads 13-10
 - geometry 13-9
- Perforated plates
 - effective area..... 6-315
- Permanent loads 3-21
 - dead loads 3-21
 - earth loads..... 3-21
- Piers 11-35
 - barge collision force 3-173
 - collision walls 11-35
 - facing 11-36
 - load effects in piers 11-35
 - protection 2-4, 2-5, 3-176, 11-35
 - reinforcement spacings 5-203
 - scour 11-36
 - seismic design..... 3-107, 5-197
 - ship collision force..... 3-170
- Pile bents *See* Piles
- pile tolerance..... 5-249
- Pile foundations
 - nominal lateral resistance 10-122
- Pile structural resistance
 - buckling 10-123
 - lateral stability 10-123
- Piles
 - α -Method 10-107
 - β -Method 10-108
 - λ -Method 10-109
 - batter 10-87
 - definition..... 10-2
 - design requirements 10-88
 - determination of loads 10-88
 - determination of nominal bearing resistance 10-102
 - downdrag 10-88
 - drivability analysis..... 10-127
 - driven 10-86
 - driven to hard rock..... 10-96
 - driven to soft rock..... 10-96
 - dynamic testing 10-104
 - embedment into cap..... 10-87
 - groups in cohesive soil..... 10-92
 - horizontal foundation movement 10-93
 - lateral squeeze..... 10-95
 - length estimates for contract documents..... 10-97
 - minimum penetration..... 10-126
 - nearly structures..... 10-89
 - nominal axial resistance change after driving 10-99
 - nominal bearing resistance..... 10-126
 - Nordlund/Thurman Method in cohesionless soils 10-110
 - probe 10-128
 - resistance of groups in compression 10-118
 - service limit state design..... 10-89
 - settlement..... 10-90
 - settlement due to downdrag 10-95
 - spacing 10-87
 - static analysis 10-106
 - static load test 10-103
 - strength limit state design 10-95
 - structural resistance 10-123
 - tip resistance in cohesive soils 10-110
 - tolerable movements 10-90
 - uplift due to expansive soils..... 10-89
 - uplift resistance of groups..... 10-120
 - uplift resistance of single 10-119

wave equation analysis.....	10-105	lifting devices.....	5-211
Pin-connected plates		preservice conditions	5-210
packing.....	6-98	Precast deck bridges	
pin plates.....	6-97	cast-in-place closure joints.....	5-209
proportions	6-98	design	5-209
Pins		longitudinal construction joints.....	5-209
holes.....	6-97, 6-98	longitudinally post-tensioned precast decks.....	9-15
length	6-84	post-tensioning.....	5-209
location.....	6-83	shear transfer joints	5-208
materials.....	6-32	shear-flexure transfer joints	5-208
minimum size pin for eyebars.....	6-84	structural overlay	5-209
resistance.....	6-83	transversely joined precast decks	9-14
Pipes	<i>See also</i> Culverts	Precast prestressed piles	
flexibility factor	12-13	concrete quality	5-255
Plank decks	<i>See</i> Wood decks and deck systems	pile dimensions	5-254
Plastic		reinforcement.....	5-255
polyethylene pipes (PE)	12-9	Precast RC three-sided structures	12-93
polyvinyl chloride (PVC).....	12-9	concrete.....	12-93
Plastic moment.....	6-401	concrete cover for reinforcement	12-93
Point bearing piles		crack control.....	12-95
on rock	10-96	deflection	12-95
Poisson's Ratio		design.....	12-93
intact rock	10-28	footing design.....	12-95
Polytetrafluorethylene sliding surfaces.....		geometric properties.....	12-93
.....	<i>See</i> PTFE sliding surfaces	materials.....	12-93
Portal and sway bracing		minimum reinforcement.....	12-95
deck truss spans.....	6-316	reinforcement.....	12-93
through-truss spans	6-316	resistance factors.....	12-95
Post-tensioned anchorage zones		scour.....	12-95
anchorage and couplers	5-23	shear transfer in joints	12-94
bursting forces.....	5-118	span length	12-94
compressive stresses	5-117	structural backfill	12-95
design of local zones.....	5-112	Precast reinforced piles	
design of the general zone.....	5-159	pile dimensions	5-254
edge tension forces.....	5-119	reinforcing steel	5-254
limitations of application	5-115	Prefabricated modular walls	<i>See</i> Earth pressure
Pot bearings	<i>See</i> Bearings	abutments	11-117
elastomeric disc.....	14-54	bearing resistance.....	11-115
geometric requirements.....	14-52	drainage.....	11-118
materials.....	14-52	dynamic load allowance.....	3-34
piston.....	14-56	earth pressure	3-138
pot	14-55	limitations	11-114
sealing rings	14-54	loading	11-114
suitability	14-37	module members.....	11-116
reinforcement.....	14-76	movement at the service limit state.....	11-114
rotation	14-74	overall stability.....	11-116
seismic provisions.....	14-67	overturning.....	11-115
shape factor	14-57, 14-72	passive resistance and sliding	11-116
shear deformation.....	14-64, 14-74	safety against soil failure.....	11-115
shear modulus	14-58, 14-70	safety against structural failure	11-116
stability.....	14-66, 14-76	seismic design	11-117
suitability	14-37	sliding.....	11-115
Precast beams		subsurface erosion.....	11-116
concrete strength.....	5-211	Preservative treatment for wood	
detail design.....	5-211	fire retardant treatment.....	8-24
extreme dimensions	5-210	inspection and marking	8-24

- requirement for treatment 8-23
- treatment chemicals 8-23
- Prestressed concrete..... *See* Prestressing steel
- buckling 5-121
- concrete cover 9-14
- construction load, formwork 9-13
- crack control 5-121
- curved tendons 5-23
- design concrete strengths 5-121
- eccentric prestressing 5-48
- prestress losses 5-129
- reinforcement limits 5-198
- section properties 5-121
- service stresses 5-125
- stress limitations for prestressing steel 5-122
- stresses due to imposed deformation 5-122
- tendon confinement 5-147
- tendons with angle points or curves 5-121
- Prestressing steel
- concrete cover 9-14
- corrosion protection 5-260, 5-265
- materials 5-22
- modulus of elasticity 5-23
- stress at nominal flexural resistance 5-37
- Pretensioned anchorage zones
- confinement reinforcement 5-147
- factored bursting resistance 5-146
- Probability of aberrancy
- approximate method 3-163
- statistical method 3-163
- Protective coatings 5-265
- Provisional ducts and anchorages
- bridges with internal ducts 5-236
- provision for future dead load or deflection
- adjustment 5-236
- Provisions for structure types 5-228
- arches 5-247
- beams and girders 5-210
- segmental construction 5-224
- slab superstructures 5-205
- PTFE sliding surfaces 14-45
- attachment 14-49
- coefficient of friction 14-48
- contact pressure 14-47
- dimples 14-45
- filler 14-45
- mating surface 14-46, 14-49
- minimum thickness 14-46
- PTFE surface 14-45
- stainless steel mating surfaces 14-47
- PVC pipes *See* Plastic
- Railing *See* Bicycle railing, Combination railing, Pedestrian railing, *and* Traffic railing
- Railing design
- anchorage 13-17
- application of previously tested systems 13-8
- approach railings 13-6
- end treatment 13-6
- geometry 13-15
- height of traffic parapet or railing 13-9
- materials 13-4
- new systems 13-9
- protection of users 2-4
- test specimens 13-20
- Railroad
- rail transit load 3-32
- rails, dead load weight 3-21
- Redundancy 1-6
- Rectangular stress block limitations
- approximate method 5-52
- refined method 5-52
- Refined method 6-374
- nominal moment-rotation curves 6-376
- Refined methods of analysis
- arch bridges 4-73
- beam-slab bridges 4-69
- cable-stayed bridges 4-73
- cellular and box bridges 4-72
- decks 4-67
- general 4-67
- suspension bridges 4-74
- truss bridges 4-72
- Reinforced concrete pipe 12-49
- bearing resistance 12-64
- bedding factor 12-64
- circumferential reinforcement 12-57
- concrete cover 12-61
- construction and installation 12-68
- crack width control 12-59
- development of quadrant mat reinforcement 12-66
- direct design method 12-55
- flexural resistance 12-57
- indirect design method 12-64
- live loads 12-54
- loading 12-50
- loads and pressure distribution 12-55
- maximum reinforcement without stirrups 12-58
- minimum reinforcement 12-58
- pipe fluid weight 12-54
- pipe ring analysis 12-57
- process and material factors 12-57
- safety against structural failure 12-55
- service limit state 12-54
- shear resistance 12-61, 12-62
- standard installations 12-50
- stirrup anchorage 12-63
- stirrup embedment 12-64
- Reinforcement *See* Spacing of reinforcement
- anchorage 5-188
- closed stirrups 5-189
- compression members 5-46

corrosion protection	5-260	load test.....	10-83
crack control.....	5-55	mass deformation.....	10-26
development length.....	5-183	mass strength.....	10-21
distribution, slabs	5-206	semiempirical procedures	10-83
external tendon supports	5-156	sound barrier	15-8
footings	5-250	Rocker bearings	
hollow rectangular compression members.....	5-175	alignment	14-43
hooks and bends.....	5-169	contact stresses.....	14-44
limits	5-197, 5-256	geometric requirements.....	14-44
materials.....	5-22	materials	6-32
modulus of elasticity	5-22	suitability	14-37
posttensioned anchorage zones	5-156	Roller bearings	
pretensioned anchorage zones.....	5-146	alignment	14-43
seismic requirements.....	5-197	contact stresses.....	14-44
shrinkage and temperature	5-174	geometric requirements.....	14-44
spacing of reinforcement.....	5-171	materials.....	6-32
spacing, longitudinal reinforcement....	5-57, 5-97, 5-171, 5-224	minimum diameter	6-32
spacing, transverse reinforcement.....	5-63, 5-172, 5-173, 5-197, 5-201, 5-202, 5-205, 5-235, 5-255, 5-256	suitability	14-37
special applications	5-22	Route location.....	2-3
spirals and ties.....	5-50	waterway and floodplain crossings	2-3
tendon confinement.....	5-149	Sawn lumber	<i>See</i> Wood
transverse reinforcement.....	5-61, 5-62, 5-63, 5-172, 5-174	base resistance.....	8-7
Reinforcing steel.....	<i>See</i> Reinforcement	bracing	8-36
Relieving slabs.....	12-38, 12-48	modulus of elasticity	8-7
Resistance factors	10-40	moisture content.....	8-7
abutments, piers, and walls	11-15	Scour.....	2-21, 10-51, 10-100, 11-36
aluminum structures.....	7-8	buried structures.....	12-20
buried structures.....	12-11	change in foundations	3-46
concrete structures	5-198	long-span structural plate structures.....	12-38
driven piles.....	10-47	micropiles.....	10-155
geotechnical resistance of axially loaded micropiles.....	10-51	piers.....	11-36
geotechnical resistance of drilled shafts.....	10-50	precast RC three-sided structures.....	12-93
seismic zones 3 and 4.....	5-32	water loads	3-46
steel	6-36	Sealing rings	
structural resistance of axially loaded micropiles	10-51	rings with circular cross-sections	14-55
wood structures	8-31	rings with rectangular cross-sections	14-55
Retaining walls ...	<i>See</i> Abutments and retaining walls	Section transitions.....	6-369
Rigid frame connections		Sectional design model	
webs	6-313	combined shear and torsion.....	5-77
Roadway		determination of β and θ	5-69
width	3-22, 13-12	longitudinal reinforcement	5-75
Roadway drainage		nominal shear resistance	5-67, 5-232
design storm.....	2-23	sections near supports	5-66
discharge from deck drains	2-24	Segmental bridge analysis	5-225
drainage of structures.....	2-24	analysis of the final structural system	5-225
type, size and number of drains.....	2-23	construction analysis.....	5-225
Rock properties		erection analysis.....	4-65
analytic method.....	10-83	final structural system	4-65
erodibility.....	10-29	longitudinal analysis	4-64
informational needs.....	10-8	strut-and-tie models	4-64
		transverse analysis	4-64
		Segmental bridge design	
		alternative construction methods.....	5-245
		cantilever construction	5-241
		construction loads	5-226, 5-227, 5-230
		creep and shrinkage.....	5-230

- deck joints.....9-15
- design.....5-226
- design details5-243
- design of construction equipment5-244
- details for cast-in-place construction5-241
- details for precast construction5-240
- effective flange width4-64
- force effects due to construction tolerances.....5-242
- incrementally launched construction5-242
- launching bearing5-242
- launching tendons5-244
- length of top flange cantilever5-238
- loads.....5-226
- minimum flange thickness5-237
- minimum web thickness5-237
- overall cross-section dimensions5-238
- post-tensioning.....5-236
- prestress losses.....5-231
- provisional ducts and anchorages5-235
- resistance factors.....5-230
- seismic design.....5-239
- span-by-span construction5-242
- substructures5-247
- tensile stresses at joint locations5-125, 5-127
- thermal effects during construction5-230
- types of segmental bridges.....5-239
- Segmental bridge substructures
 - construction load combinations5-247
 - longitudinal pier reinforcement5-247
- Seismic design
 - acceleration coefficient.....3-70
 - column connections5-203
 - concrete columns5-196, 5-197
 - confinement length5-204
 - construction joints.....5-204
 - elastomeric bearings14-67
 - hold-down devices3-115
 - importance categories3-106
 - lateral load distribution.....4-62
 - longitudinal restrainers3-115
 - seismic performance zones3-107
 - soil liquefaction3-69
 - temporary bridges/stage construction3-115
 - volumetric ratio for confinement5-205
 - wall-type piers5-203
- Seismic loads
 - combination of seismic force effects3-108
 - design forces3-109
 - direction.....3-108
 - orthogonal forces3-108
 - response modification factors3-107
 - seismic zone 1.....3-109
 - seismic zone 2.....3-111
 - seismic zones 3 and 43-111
- Seismic requirements
 - minimum displacement requirements4-87
 - multispan bridges.....4-80
 - single-span bridges4-80
- Seismic zone 1.....3-109
- Seismic zone 2.....3-111
- Seismic zones 3 and 4
 - column and pile bent design forces.....3-114
 - foundation design forces.....3-114
 - inelastic hinging forces.....3-112
 - modified design forces.....3-112
 - pier design forces3-114
 - piers with two or more columns3-113
 - single columns and piers.....3-112
- Service limit states1-4, 9-5, 10-29, 10-40, 12-10
 - abutments, piers, and walls11-8
 - aluminum structures.....7-8
 - concrete structures5-26, 5-33
 - construction load combinations5-229
 - decks9-28
 - elastomeric bearings14-65
 - load combinations.....3-9, 3-17
 - prestressing steel.....5-122
 - sound barrier15-3
 - steel structures6-35
 - wood structures.....8-30
- Service limit state design
 - micropiles10-154
 - piles.....10-89
 - spread footings.....10-54
- Serviceability
 - deformations2-10
 - durability.....2-8
 - inspectability.....2-9
 - maintainability2-9
 - rideability.....2-9
 - utilities2-9
 - widening2-14
- Settlement.....12-15
 - force effects3-158
 - foundations15-3
 - group.....10-135
 - long-span structural plate structures12-31
 - MSE walls.....11-61
 - single-drilled shaft10-132
- Settlement Analyses10-55
- Shaft load tests.....10-147
- Shaft loads
 - determination of.....10-131
- Shear and torsion
 - aluminum7-56
 - brackets.....5-104
 - concrete.....5-58, 5-64, 5-67
 - corbels.....5-104
 - interface shear transfer—shear friction.....5-79
 - longitudinal reinforcement.....5-78
 - prestressed concrete5-67
 - reinforcement, seismic design.....5-197

skewed bridges.....	4-49	deformation.....	10-18
slabs and footings.....	5-251	determination.....	11-7, 12-6
steel.....	6-369	drained strength of cohesive soils.....	10-16
torsional resistance.....	5-77	drained strength of granular soils.....	10-16
transfer and development lengths.....	5-61	envelope backfill soils.....	12-7
transverse reinforcement.....	5-77	foundation soils.....	12-7
Shear connectors.....	6-197	informational needs.....	10-8
cover and penetration.....	6-199	laboratory tests.....	10-11
design force.....	9-4	semiempirical procedures.....	10-81
fatigue resistance.....	6-199	sound barrier.....	15-8
nominal shear force.....	9-4	strength.....	10-15
permanent load contraflexure.....	6-200	subsurface exploration.....	10-8
pitch.....	6-197	undrained strength of cohesive soils.....	10-15
strength limit state.....	6-201	unit weight.....	3-21
studs.....	6-33	Soil–structure interaction systems.....	<i>See Culverts</i>
transverse spacing.....	6-199	Solid web arches.....	6-325
types.....	6-197	Sound barrier	
Shear keys.....	<i>See Keys</i>	corrosion protection.....	15-10
Shear resistance		definition.....	15-1
concrete.....	5-67	drainage.....	15-10
concrete-encased shapes.....	6-283	earth loads.....	15-5
concrete-filled tubes.....	6-283	extreme event limit state.....	15-3
prestressed concrete.....	5-67	foundation design.....	15-8
steel.....	6-245	functional requirements.....	15-1
wood.....	8-33	ground-mounted.....	15-4
Ship collision force.....	<i>See Vessel collision</i>	limit states and resistance factors.....	15-3
Shock transmission unit (STU).....		movement and stability at the service limit state.....	15-9
.....	4-5, 4-87, 14-3, 14-43	seismic design.....	15-10
Short-slotted holes.....	6-288	structure-mounted.....	15-4
Shrinkage.....	5-19	vehicular collision forces.....	15-6
Sidewalks		wind load.....	15-5
curb height.....	13-12, 13-13	Sound barrier installation	
railing.....	13-5, 13-9, 13-10	on existing bridges.....	15-5
thickness of plank decks.....	9-29	Spacing of reinforcement	
Skewed bridges		bundled bars.....	5-171
deck joints.....	14-15, 14-21	cast-in-place concrete.....	5-171
live load distribution.....	4-40, 4-46, 4-49	couplers in posttensioning tendons.....	5-149
skewed decks.....	9-12, 9-32, 9-34	curved posttensioning ducts.....	5-149
Slab bridges.....	5-280	maximum spacing of prestressing tendons and ducts in slabs.....	5-142
Slab superstructures		maximum spacing of reinforcing bars.....	5-172
cast-in-place solid slab superstructures.....	5-205	minimum spacing of reinforcing bars.....	5-171
cast-in-place voided slab superstructures.....	5-206	multilayers.....	5-171
precast deck bridges.....	5-208	post-tensioning ducts not curved in the horizontal plane.....	5-148, 5-149
Slabs.....	<i>See Concrete slabs</i>	precast concrete.....	5-171
Slenderness effects and limits		pretensioning strand.....	5-142
concrete.....	5-47	splices.....	5-171
ice load, piers.....	3-61	Spike laminated decks	
Slenderness ratios.....	<i>See Aluminum and Steel</i>	deck tie-downs.....	9-38
Slip-critical connections.....	6-285	panel decks.....	9-38
Soil bearing resistance		Splices.....	
plate load tests.....	10-82	<i>See Bolted splices, Splices of bar reinforcement, and Splices of welded wire fabric</i>	
two-layered soil system in drained loading.....	10-81	bar reinforcement.....	5-190
two-layered soil system in undrained loading	10-79		
Soil liquefaction.....	4-11		
Soil properties			

- bolted splices 6-304
- reinforcement, deck slabs 9-14
- welded splices 6-312
- welded wire fabric 5-194
- Splices of bar reinforcement.....*See* Lap splices
- bars in compression 5-192
- detailing 5-190
- end-bearing splices 5-193
- lap splices 5-190
- lap splices in compression 5-192
- lap splices in tension 5-191
- mechanical connections 5-191
- mechanical/welded splices in compression.. 5-193
- mechanical/welded splices in tension 5-192
- reinforcement in tension 5-191
- tension tie members 5-192
- welded splices 5-191
- Splices of welded wire fabric
- deformed wire in tension 5-194
- smooth wire in tension 5-194
- Spread footings..... 10-52
- bearing depth 10-52
- bearing resistance at the service limit state.. 10-67
- bearing stress distributions..... 10-53
- design of 10-32
- effective footing dimensions..... 10-53
- groundwater and 10-54
- nearby structures and 10-54
- safety against geotechnical failure at the strength limit state..... 15-9
- service limit state design..... 10-54
- settlement of footings on cohesionless soils 10-56
- settlement of footings on cohesive soils 10-62
- settlement on rock..... 10-66
- tolerable movements..... 10-54
- SPT*See* Standard Penetration Test
- cohesionless soils..... 10-115
- St. Venant torsion
- aluminum 7-52
- Stainless steel 6-34
- Standard Penetration Test..... 10-82
- Static analysis*See* Approximate methods of analysis, *and* Refined methods of analysis
- analysis for temperature gradient..... 4-75
- approximate methods..... 4-22
- influence of plan geometry 4-17
- moment redistribution..... 4-74
- refined methods of analysis 4-67
- stability 4-75
- Static load test 10-103
- Stay-in-place formwork..... *See* Concrete formwork
- concrete formwork..... 9-13
- deck overhangs 9-5
- steel formwork..... 9-13
- Steel
- bearing stiffeners 6-370
- box-section flexural members..... *See* Steel box-section flexural members
- camber *See* Camber
- closed voids in structures..... 6-221
- coefficient of thermal expansion..... 6-30
- combined force effects..... 6-99, 6-129, 6-245
- dimension and detail requirements*See* Steel dimension and detail requirements
- extreme event limit state..... 6-37
- fracture..... 6-146
- I-girders *See* Steel I-section flexural members
- I-section flexural members*See* Steel I-section flexural members
- I-section proportioning*See* Steel I-section proportioning
- modulus of elasticity 6-30
- net section 6-86
- orthotropic decks *See* Decks *and* Orthotropic steel decks
- piles..... *See* Steel piles
- slenderness ratios 6-108
- spiral rib pipes 12-107
- tension members*See* Steel tension members
- thickness of metal 6-31, 6-285
- tunnel liner plate*See* Steel tunnel liner plate
- web crippling 6-411
- Steel box-section flexural members 6-215
- access and drainage..... 6-221
- access holes..... 6-76, 6-221
- bearings..... 6-220
- compact sections..... 6-231
- constructibility 6-223
- cross-section proportion limits..... 6-222
- fatigue and fracture limit state 6-227
- flange-to-web connections 6-221
- flexural resistance of compression flange..... 6-233, 6-235
- flexural resistance of tension flange .6-234, 6-238
- flexural resistance—negative flexure 6-233
- flexural resistance—positive flexure 6-231
- live load distribution factor..... 6-222
- noncompact sections..... 6-231
- painting..... 6-221, 6-223
- service limit state 6-226
- shear connectors 6-239
- shear resistance 6-238
- stiffeners 6-240
- strength limit state 6-229
- stress determinations..... 6-217
- Steel dimension and detail requirements 6-65
- dead load camber 6-65
- diaphragms and cross-frames..... 6-71
- effective length of span..... 6-65
- lateral bracing 6-79
- minimum thickness of steel 6-71
- pins 6-83

Steel I-girders .. <i>See</i> Steel I-section flexural members	
Steel I-section flexural members	6-135
compact sections	6-178
composite sections	6-137
composite sections in negative flexure and noncomposite	6-175
composite sections in positive flexure	6-174
constructibility	6-160
cover plates	6-214
ductility requirement	6-182
flange stresses and member bending moments	6-142
flange-strength reduction factors.....	6-150
flexural resistance	6-178, 6-193
flowcharts for design.....	6-382
hybrid sections	6-139
minimum deck reinforcement—negative flexure	6-144
net section fracture	6-146
noncompact sections	6-181
noncomposite sections	6-139
service limit state	6-167
shear connectors.....	6-197
steel I-section proportioning	6-157
stiffeners.....	6-204
stiffness	6-141
strength limit state.....	6-172
variable web depth members.....	6-139
web bend-buckling resistance	6-147
wind effect on flanges	4-60
Steel I-section proportioning	
flange proportions	6-158
web proportions	6-157
Steel orthotropic decks.....	
..... <i>See</i> Decks and Orthotropic steel decks	
Steel piles.....	6-328
axial compression.....	6-330
buckling	6-330
combined axial compression and flexure	6-330
compressive resistance.....	6-330
maximum permissible driving stresses	6-330
structural resistance.....	6-328, 10-123
Steel tension members	6-86
built-up members	6-96
eyebars	6-96
limiting slenderness ratio	6-95
net area.....	6-95
pin-connected plates.....	6-97
tensile resistance	6-86
Steel tunnel liner plate	
buckling	12-91
construction stiffness	12-91
earth loads	12-90
grouting pressure.....	12-91
live loads	12-91
loading	12-89
safety against structural failure	12-91
seam strength	12-91
section properties	12-91
wall area.....	12-91
Stiffened webs	
end panels	6-196
nominal resistance.....	6-194
Stiffeners..... <i>See</i> Longitudinal stiffeners and Transverse intermediate stiffeners	
bearing stiffeners.....	6-208
longitudinal compression-flange stiffeners ..	6-240
longitudinal stiffeners	6-210
rigid frame connections.....	6-314
structural plate culverts	12-42
transverse intermediate stiffeners.....	6-204
web stiffeners	6-240
wood decks	9-31, 9-38
Stirrups..... <i>See</i> Transverse reinforcement	
Stream pressure	
lateral	3-45
longitudinal	3-44
Strength limit state	1-4, 9-6, 10-32, 10-40, 12-10
abutments, piers, and walls	11-9
aluminum structures.....	7-8
concrete structures	5-29, 5-33, 5-291
drilled shafts.....	10-33, 10-48
driven piles.....	10-33, 10-42
flexure	6-174, 6-229
load combinations	3-17
micropiles.....	10-33
modular bridge joint systems	14-28
prestressing steel	5-123
railing.....	13-5
resistance factors.....	6-36
shear connectors.....	6-178, 6-231
sound barrier	15-3
spread footings	10-32, 10-42
stability.....	5-32
steel structures.....	6-244, 6-284
wood structures	8-30
Strength limit state design.....	10-136
micropiles.....	10-154
piles.....	10-95
spread footings	10-69
Stress laminated decks... <i>See</i> Decks and Wood decks and deck systems	
camber.....	8-37
deck tie-downs	9-33
holes in laminations	9-33
nailing	9-33
staggered butt joints	9-33
stressing	9-33
thermal expansion	9-30
Stressing	
corrosion protection	9-37
design requirements	9-36

- prestressing materials.....9-35
- prestressing system.....9-33
- railings.....9-37
- Structural material behavior
 - elastic behavior.....4-11
 - elastic versus inelastic behavior.....4-11
 - inelastic behavior.....4-12
- Structural plate box structures.....12-42
 - concrete relieving slabs.....12-48
 - construction and installation.....12-49
 - footing reactions.....12-47
 - geometric requirements.....12-44
 - loading.....12-43
 - movements.....12-44
 - plastic moment resistance.....12-46
 - safety against structural failure.....12-43
 - service limit state.....12-43
 - soil cover factor.....12-47
 - stiffeners.....12-42
- Structure-Mounted Sound Barriers.....15-4
- Strut-and-tie model
 - crack control reinforcement.....5-97
 - general zone.....5-98, 5-291
 - nodes.....5-100
 - struts.....5-100
 - ties.....5-101
- Substructures
 - design.....5-281, 6-379
 - frictional forces, launched girders.....5-242
 - vessel collision.....2-5
- Superimposed deformations
 - creep.....3-157
 - differential shrinkage.....3-157
 - settlement.....3-158
 - temperature gradient.....3-156
 - uniform temperature.....3-153
- Superstructure design.....5-279
- Surcharge loads
 - live load surcharge.....3-149
 - point, line and strip loads—restrained walls.....3-143
 - reduction of surcharge.....3-150
 - strip loads—flexible walls.....3-147
 - uniform surcharge.....3-143
- Temporary stresses before losses
 - compression stresses.....5-123
 - tension stresses.....5-123
- Tendon confinement
 - wobble effect in slabs.....5-150
- Tensile resistance
 - aluminum.....7-35
 - wood.....8-35
- Tension flange yielding.....6-365
- Tension members
 - concrete.....5-55
 - wood.....8-35
- Tension ties
 - anchorage of tie.....5-93
 - proportioning of tension ties.....5-93
 - strength of tie.....5-93
- Thermal forces
 - temperature gradient.....3-156
 - temperature zones.....6-64, 14-59
 - uniform temperature.....3-153
- Thermoplastic pipes.....12-74
 - flexibility limit.....12-14
- Through-girder spans.....6-314
- Tie plates.....6-96, 6-130
- Timber.....*See* Wood
- Timber floors.....*See* Wood decks and deck systems
- Timber piles.....*See* Wood piles
- Tire contact area.....3-25
- Tolerable Movements and Movement Criteria. 10-30
- Traffic lanes
 - width.....3-22
- Traffic railing.....13-5
 - design forces.....13-17
 - railing design.....13-8
 - railing system.....13-5
 - test level selection criteria.....13-6
- Traffic safety
 - geometric standards.....2-5
 - protection of structures.....2-4
 - protection of users.....2-4
 - road surfaces.....2-5
 - vessel collisions.....2-5
- Transverse intermediate stiffeners
 - moment of inertia.....6-205
 - projecting width.....6-204
- Transverse reinforcement
 - compression members.....5-172, 5-199, 5-201, 5-204
 - flexural members.....5-174
 - piles.....5-197, 5-255, 5-256
- Trusses.....6-314
 - camber.....6-315, 8-37
 - diaphragms.....6-79, 6-315
 - factored resistance.....6-323
 - gusset plates.....6-316
 - half through-trusses.....6-323
 - lateral bracing.....6-83, 8-37
 - load distribution.....4-49
 - members.....6-315
 - portal and sway bracing.....6-316, 8-37
 - secondary stresses.....6-315
 - splices.....6-304
 - working lines and gravity axes.....6-316
- Unfilled grid decks composite with reinforced concrete slabs
 - design.....9-19
 - fatigue limit state.....9-19
- Uplift
 - bearings.....14-36, 14-80
 - group resistance.....10-150

ice loads	3-61	Web proportions	6-368
load test	10-150	webs with longitudinal stiffeners	6-158, 6-222
micropiles	10-153	webs without longitudinal stiffeners	6-157, 6-222
pile anchorage	5-197	Welded connections	
resistance of a single drilled shaft	10-149	effective area	6-300
resistance of pile groups	10-120	factored resistance	6-298
resistance of single piles	10-119	fillet weld end returns	6-301
spread footings	10-54	minimum effective length of fillet welds	6-301
Vehicular collision force	3-37	seal welds	6-301
protection of structures	3-37	size of fillet welds	6-300
vehicle and railway collision with structures	3-44	Welded wire fabric	
Vehicular live load		bend diameter	5-170
multiple presence of live load	3-22	transverse reinforcement	5-62
number of design lanes	3-22	Welding	
Vertical wind pressure	3-58	procedures for aluminum	7-31
Vessel collision	3-158	requirements for aluminum	7-31
annual frequency of collapse	3-161	weld metal	6-34, 6-298
barge bow damage length	3-174	Widening	
barge collision force on pier	3-173	exterior beams	2-14
damage at the extreme limit state	3-174	substructure	2-14
design collision velocity	3-169	Wind load	
design vessel	3-160	aeroelastic instability	3-59
impact force	3-175	horizontal wind pressure	3-47
impact force, substructure design	3-175	minimum wind velocity for erection	5-241
impact force, superstructure design	3-176	vertical wind pressure	3-58
importance categories	3-160	Wind pressure on structures	3-52
owner's responsibility	3-160	box sections	4-62
protection of substructures	3-176	construction	4-62
ship bow damage length	3-172	I-sections	4-60
ship collision force on pier	3-170	loads from superstructures	3-55, 3-56
ship collision force on superstructure	3-172	substructure forces	3-56
ship collision with bow	3-172	Wind pressure on vehicles	3-58
ship collision with deck house	3-172	Wind-induced vibration	
ship collision with mast	3-173	design considerations	4-79
vessel collision energy	3-169	dynamic effects	4-79
Washers	6-84, 6-287	wind velocities	4-79
Water loads		Wood	
buoyancy	3-44	bracing	8-36
drag coefficient	3-45	camber	<i>See</i> Camber
scour	3-46	coefficient of thermal expansion	9-30
static pressure	3-44	combined flexure and axial loading	8-35
stream pressure	3-44	compression	8-33
wave load	3-46	extreme event limit state	8-33
Wearing surface		flexure	8-31
chip seal	9-40	glued laminated timber	8-12
orthotropic decks	9-28	piles	8-21
plant mix asphalt	9-39	preservative treatment	<i>See</i> Preservative treatment
unit weight	3-21	for wood	
wood decks	9-39	sawn lumber	8-6
Web bend-buckling resistance		shear	8-33
webs with longitudinal stiffeners	6-148	tension	8-35
webs without longitudinal stiffeners	6-147	trusses	8-37
Web local yielding	6-410	Wood decks and deck systems	9-29
Web plastification factors		deck tie-downs	9-39
compact web sections	6-356	deformation	9-30
noncompact web sections	6-358	design requirements	9-30

load distribution	9-30
plank decks	9-30, 9-39
shear design	9-30
skewed decks	9-31
spike laminated decks	9-30, 9-37
stress laminated decks	9-32
thermal expansion	9-30
wearing surfaces	9-31
Wood piles	<i>See</i> Wood
modulus of elasticity	8-21
resistance	8-21
structural resistance	10-123
Yield moment	6-405
Yield strength	
composite columns	6-130
fasteners, wood structures	8-22
prestressing steel	5-23
reinforcing steel	5-22
steel tunnel liner	12-92
structural steel	6-31
transverse reinforcement	5-64, 5-199