AASHTO

AASHTO Guide Specifications for

LRFD SEISMIC BRIDGE DESIGN

October 2023 | 3rd Edition

FOREWORD

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

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

AASHTO Committee on Bridges and Structures

PREFACE

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

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

AASHTO Publications Staff

ABBREVIATED TABLE OF CONTENTS

TABLE OF CONTENTS

Section 1:

INTRODUCTION

1.1—BACKGROUND

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

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

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

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

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

C1.1

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

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

The term "should" indicates a strong preference for a given criterion.

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

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

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

1.2—GROUND MOTIONS

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

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

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

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

1.3—FLOWCHARTS

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

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

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

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

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

Alternate flowcharts are provided in Appendix B.

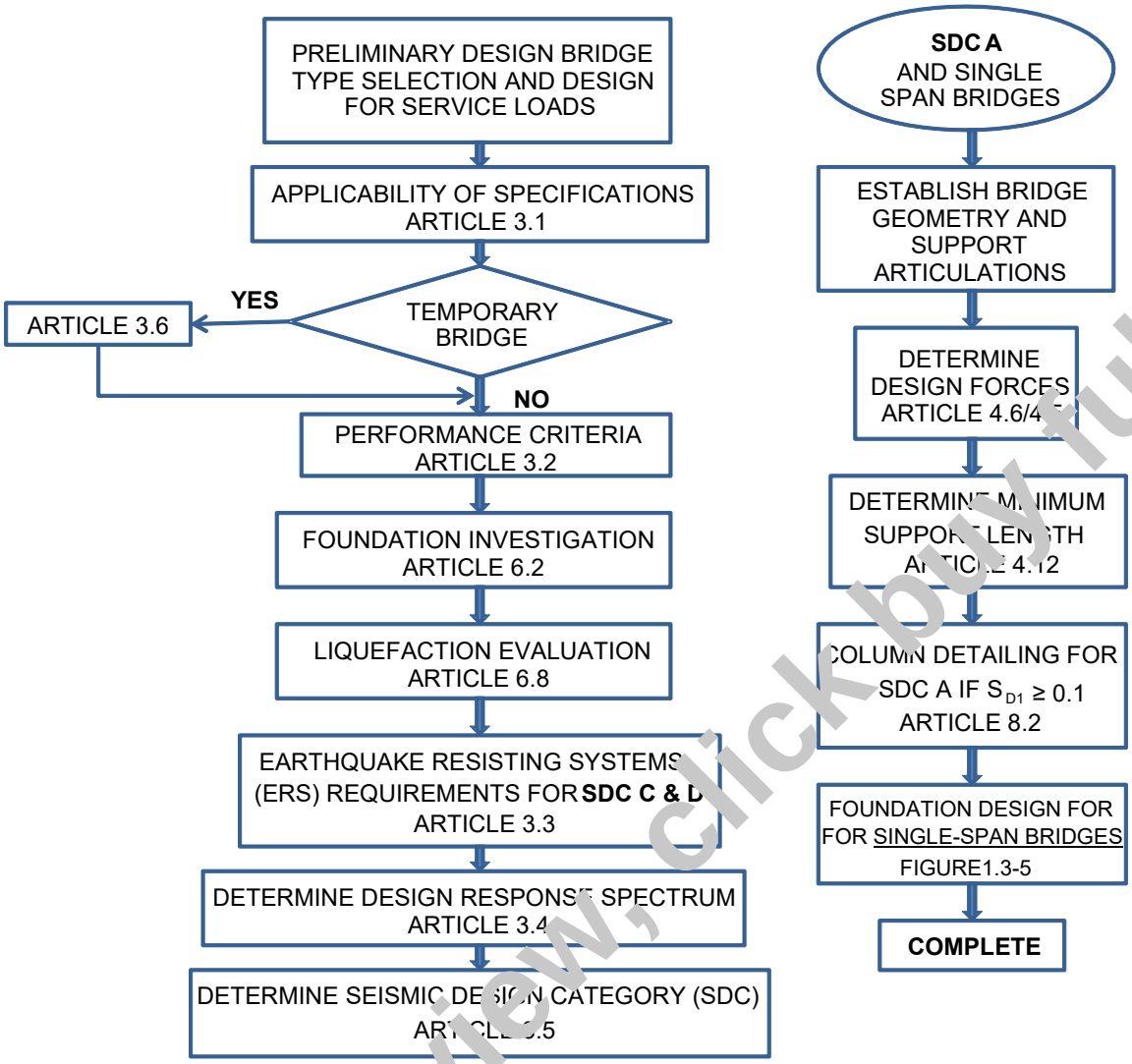

Figure 1.3-1—Applicability of the Guide Specifications and the Seismic Design Procedure for Bridges in SDC A and Single-Span Bridges

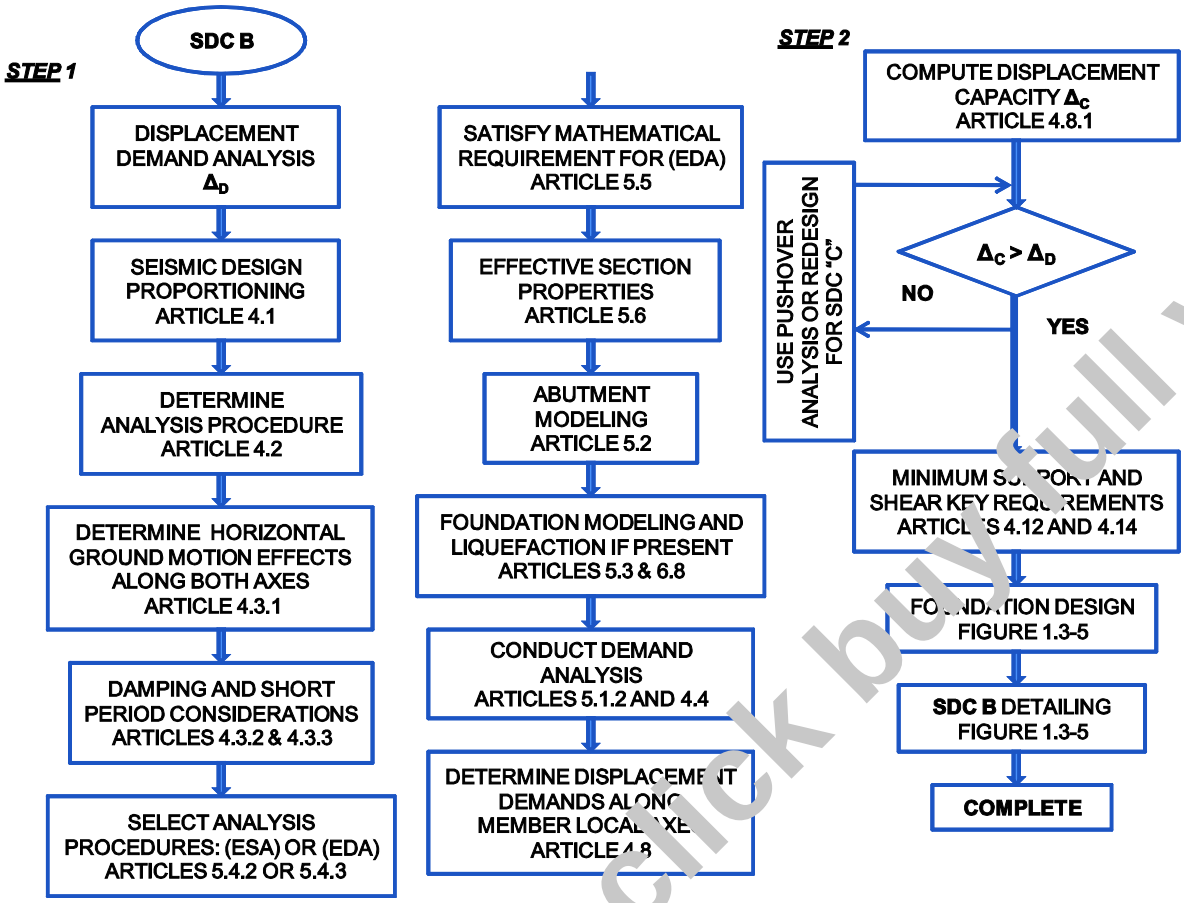

Figure 1.3-2—Seismic Design Procedure Flowchart for Bridges in SDC B

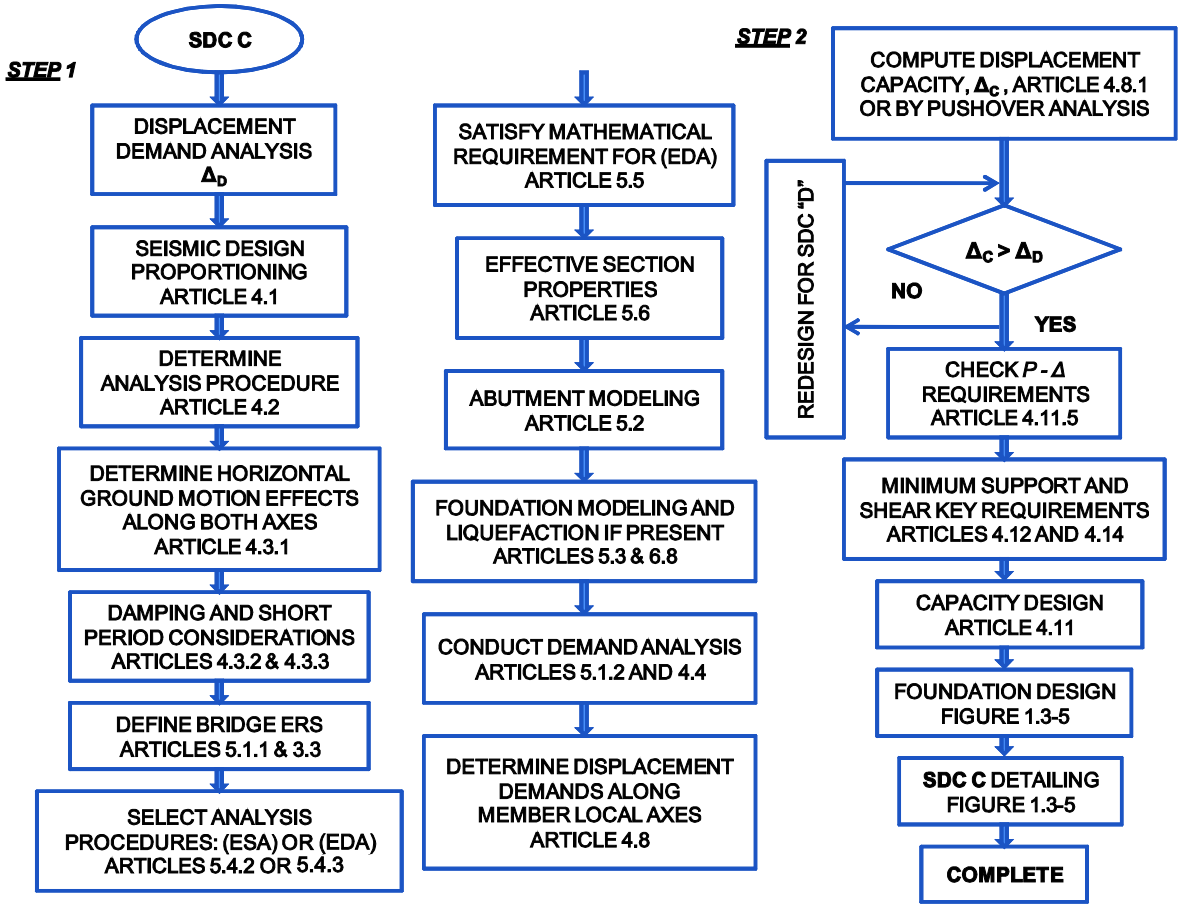

Figure 1.3-3—Seismic Design Procedure Flowchart for Bridges in SDC C

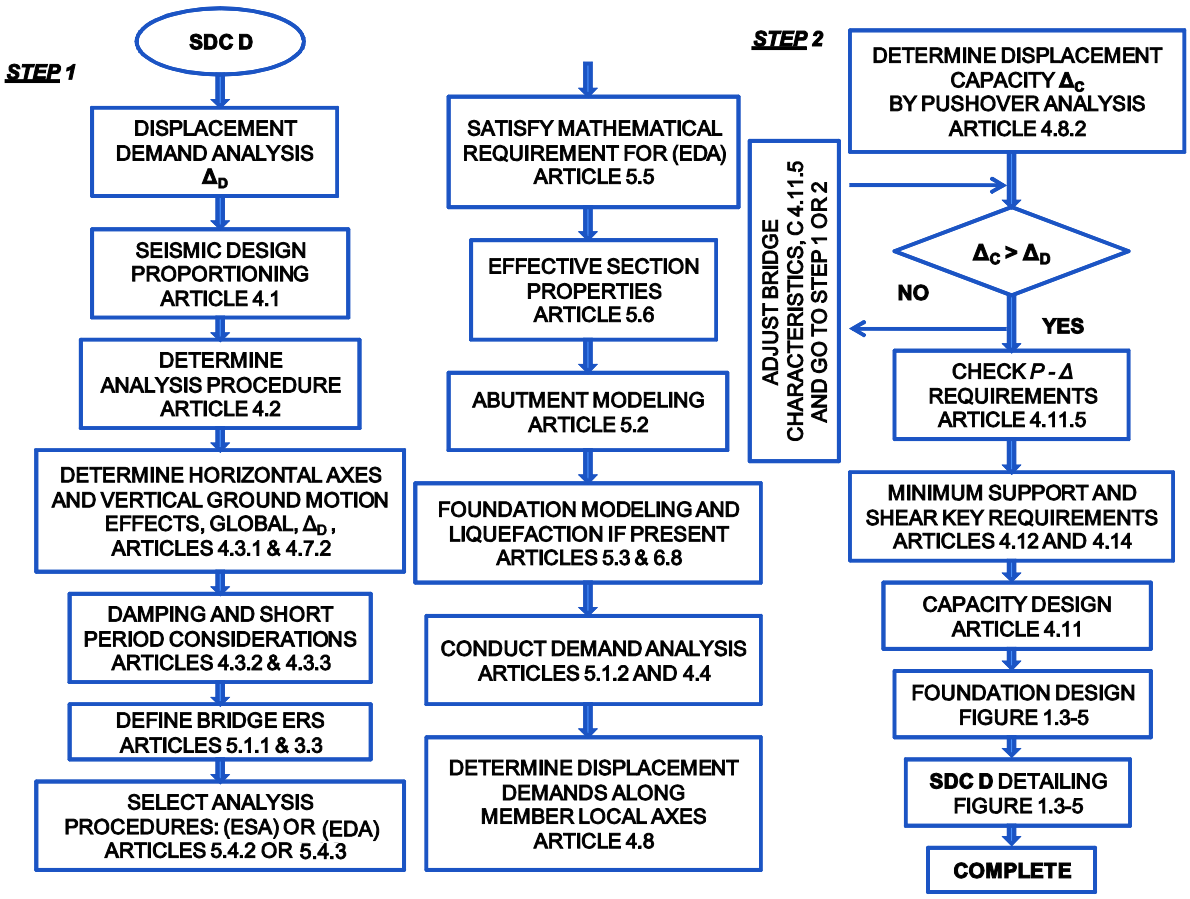

Figure 1.3-4—Seismic Design Procedure Flowchart for Bridges in SDC D

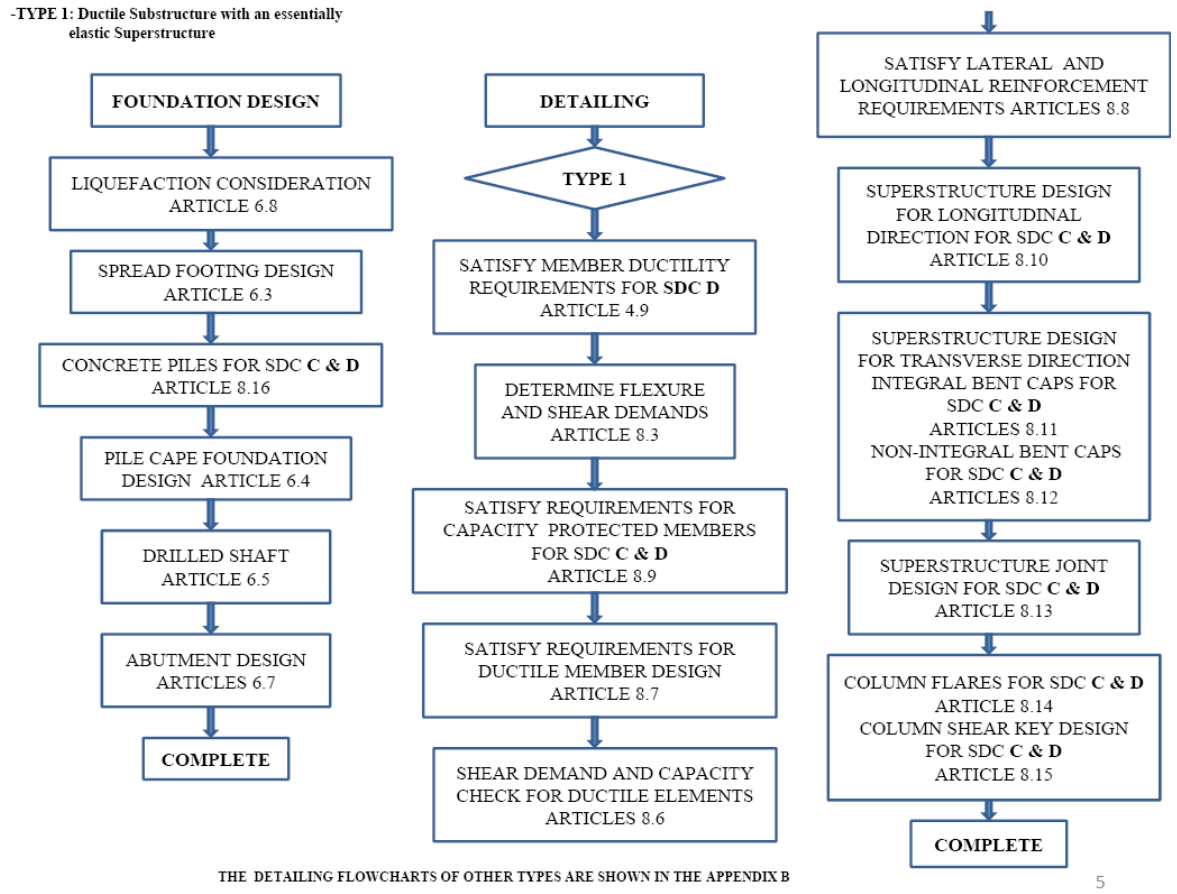

Figure 1.3-5—Foundation and Detailing Flowcharts

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Section 5: Analytical Models and Procedures

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Appendix A: Foundation-rocking Analysis

TABLE OF CONTENTS

Appendix B: Design Flowcharts

TABLE OF CONTENTS

TABLE OF CONTENTS