Multimedia Package for LRFD Concrete Bridge Design

By

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15. Supplementary Notes A CD-ROM was developed in this project and can be obtained by contacting the PI, Dr. H. Toutanji.				
16. Abstract This Project developed a Load and Resistance Factor Design (LRFD) multimedia package to provide a practical introduction and an in-depth understanding of the technological advances in the design of concrete bridges. This package can be used to train engineers, architects, designers, and personnel who are in charge of the design, construction, maintenance, and rehabilitation of bridges. The complete package includes instructions of how to design a concrete bridge with AASHTO load and resistance factor design recommendations and specifications. The package includes six practical examples to provide a generic overview of the design concept and process.				
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Executive Summary

Multimedia technology is an essential instrument in the development of graduate engineers. This multimedia package provides an exclusive background and an in-depth understanding of the new technological advances in the design of concrete bridges. It gives guidelines and step-by-step instructions for the design of different concrete bridges using the LRFD specifications. One of the advantages of the package is that it can be conveniently updated and modified to add future changes and procedures necessary for today's structural demand.

The LRFD specifications were created with a conservative point of view, applying almost exclusively the limit states of strength. It is consistent with other major bridge codes adopted or being adopted in many other countries such as Canada and the European countries. Because of this many states throughout the United States have changed their specifications and are currently implementing LRFD. It incorporates deep analysis and design methods with different kinds of loads and resistance factors, which are based on the known variability of applied loads and the material properties. This multimedia package includes the basis in which an engineer can design a concrete bridge using LRFD specifications. It includes some PDF documents containing explanatory examples and an overview of the strategic development of this structural code.

This project has a main focus to be a self-training tool for inexperienced engineers who are interested in learning about the implementation of LRFD specifications in the design of concrete bridges. It is a valuable tool because it contains procedures and specifications for each possible situation together with detailed examples and illustrations. This package is a time saving, user-friendly, reliable way of learning.

The CD multimedia package will be periodically updated by the principal investigator.

1.0 Introduction

The main goal of the LRFD multimedia package is to provide a practical introduction and an in-depth understanding of the new technological advances in the designing of concrete bridges. This package can be used to train engineers, architects, designers, and personnel who are in charge of the design, construction, maintenance, and reconstruction of bridges because it is a self-training, time-saving tool. The complete package includes instructions of how to design a concrete bridge with AASHTO load and resistance factor design recommendations and specifications and six examples from which the user can have a generic overview of the design process.

Load and Resistance Factor Design (LRFD) specifications is a method of proportioning structures such that no applicable limit state is exceeded when the structure is subjected to all appropriate design load combinations. The LRFD specifications, like all other structural specifications, treat almost exclusively the limit states of strength because of the overriding considerations of public safety for people and property. LRFD specifications are among the many publications developed and maintained by the American Concrete Institute (ACI). Since the first edition of LRFD was published in 1994, many states have been diligently developing plans and taking steps to fully implement LRFD. The Federal Highway Administration (FHWA) has established a goal that the LRFD standards shall be used in all new bridge designs in the United States (US) after 2007.

The CD package will offer a tutorial that employs a wide range of multimedia, including hyperlinks and high-resolution graphics. To ensure the use of this multimedia package, it will be machine adaptable and design to run on different operating systems. The advantage of this package is that it can be accessible for updating and adding information whenever necessary. It is a self-training and time-saving tool.

2.0 Methodology

An extensive review of the existing literature and information available on LRFD was done. Since LRFD is an upcoming topic, step-by-step procedures were included in the package for better understanding.

The package is divided into twelve chapters accompanied with six design examples and various technical definitions. Each chapter contains specific equations, tables, and diagrams of relevance. To utilize the benefits of a multimedia product to the fullest, hyperlinks were created in all the chapters as well as the design examples to quickly access the required details. There is also display boxes that provide the instantaneous definitions to technical terms, a feature designed for a new engineer. This package was created with the Macromedia Dreamweaver MX software for creating dynamic HTML pages.

For further updates of the multimedia package according to the LRFD specifications including any recommendation by ALDOT (Alabama Department of Transportation), the contact information of the principal investigator is included in the package.

3.0 Description of Website and CD-ROM

This multimedia package includes a homepage together with twelve chapters and some basic theory concepts. It also provides the user with five concrete bridge design examples and several other helpful links for designing concrete bridges. It also includes a link providing some concept definitions. The following is a description of these sections.

Home Page

The home page is a welcoming page explaining the goal and advantage of the package. This page also provides an overview of its contents. This multimedia package is a self-training tool providing information on LRFD specifications. (See Figure 3-1.)

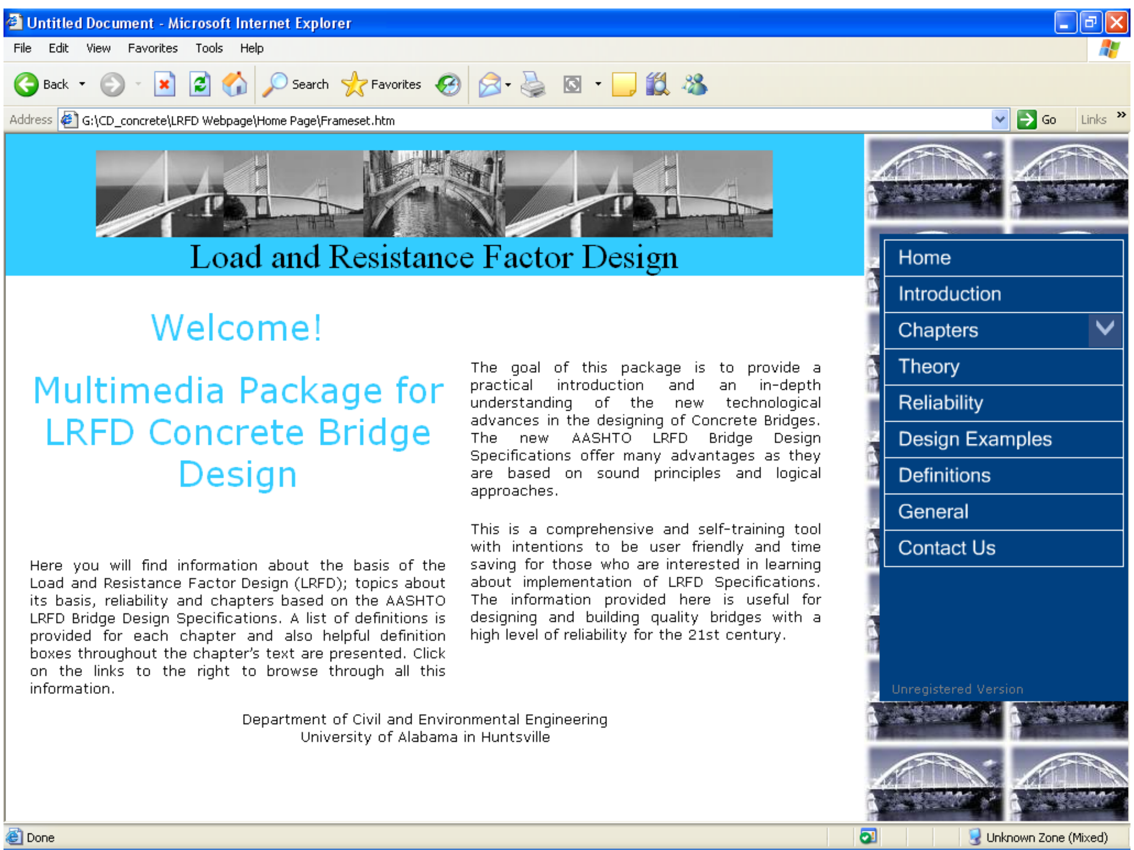


Figure 3-1. Home page of the multimedia package for LRFD concrete bridge design.

Introduction

The introduction page provides the user a brief description of LRFD specifications. This page explains why these specifications are needed and are better for bridge design. It introduces the user to the benefits of LRFD. This page projects the idea of LRFD being implemented for all bridge designs in the United States. (See Figure 3-2.)

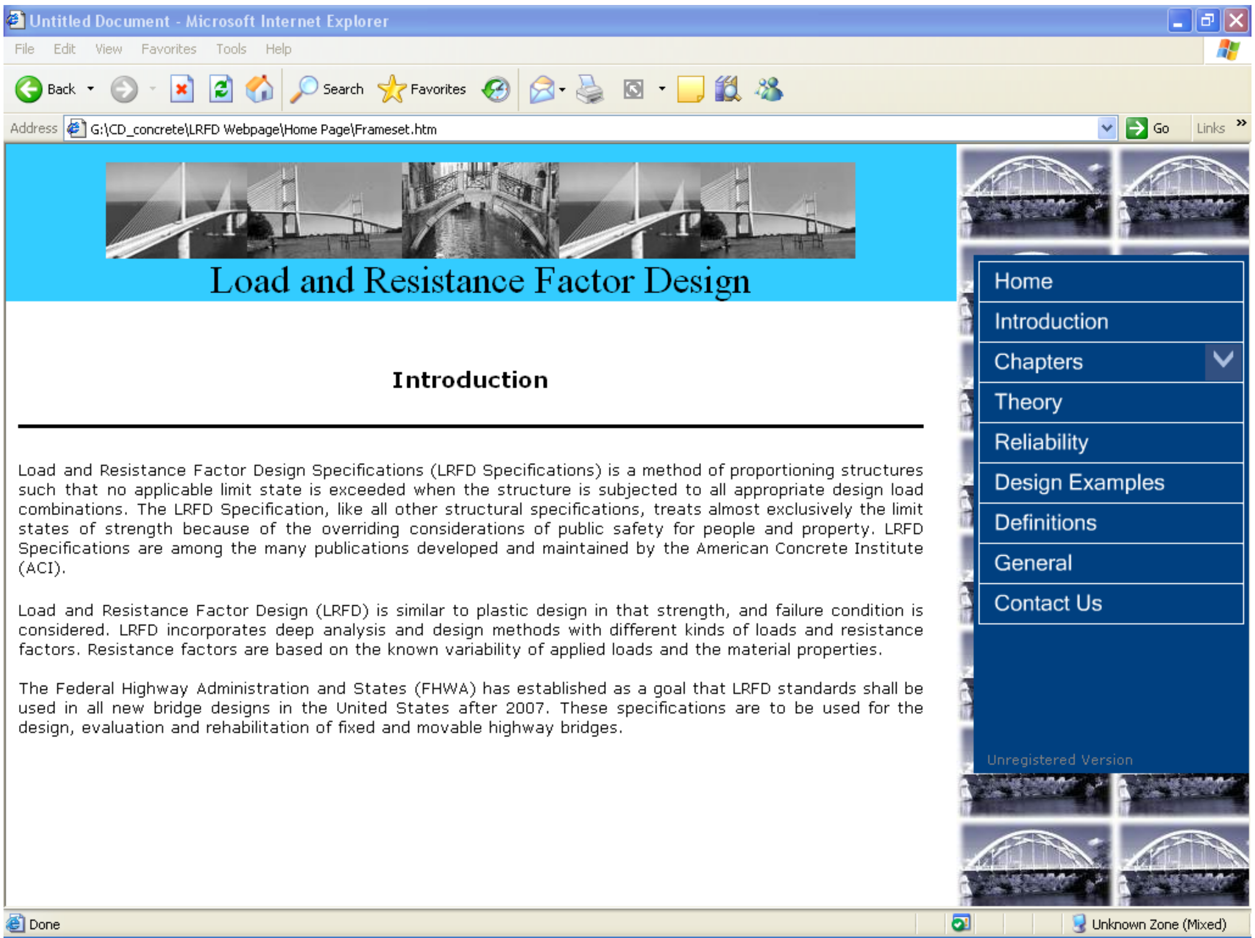


Figure 3-2. Introduction page explains what LRFD specifications are.

Description of Chapters

The following twelve chapters and their descriptions are from the AASHTO LRFD Specification Manual-Interim Revision 2005.

Chapter 1: Introduction

Chapter 1 introduces the concept of limit states and load modifiers that are required in the design specifications of Load and Resistance Factor Design (LRFD). (See Figure 3.3.)

According to LRFD design philosophy, bridges are designed for specific limit states that fulfill the security, service, aesthetic, economy, and constructability objectives. The following limit states are considered:

- Service Limit State – It is taken as restrictions on stress, deformations and crack width under the regular service conditions.

- Fatigue and Fracture Limit State – It is intended to limit the crack growth under repetitive loads in order to prevent fracture under the design life of the bridge.

- Strength Limit State – It is used to ensure that the bridge receives the statistically significant load combinations without affecting its stability and strength in a local and global form. Structural integrity is expected to be always maintained.

- Extreme Event Limit State – It is used to ensure structural survival of the bridge under extreme conditions like earthquakes, floods, vehicle collision, tidal waves, etc.

The following are the three load modifiers considered in LRFD specifications:

- Ductility – At strength and extreme event limit states, the structure system of the bridge will undergo significant and visible inelastic deformations before failure.

- Redundancy – Main elements and components whose failure is expected to cause a collapse of a bridge shall be designated as failure critical and the associated structural system as non-redundant.

- Operational Importance – The owner may declare a bridge or any structural component and connection to be of operational importance.

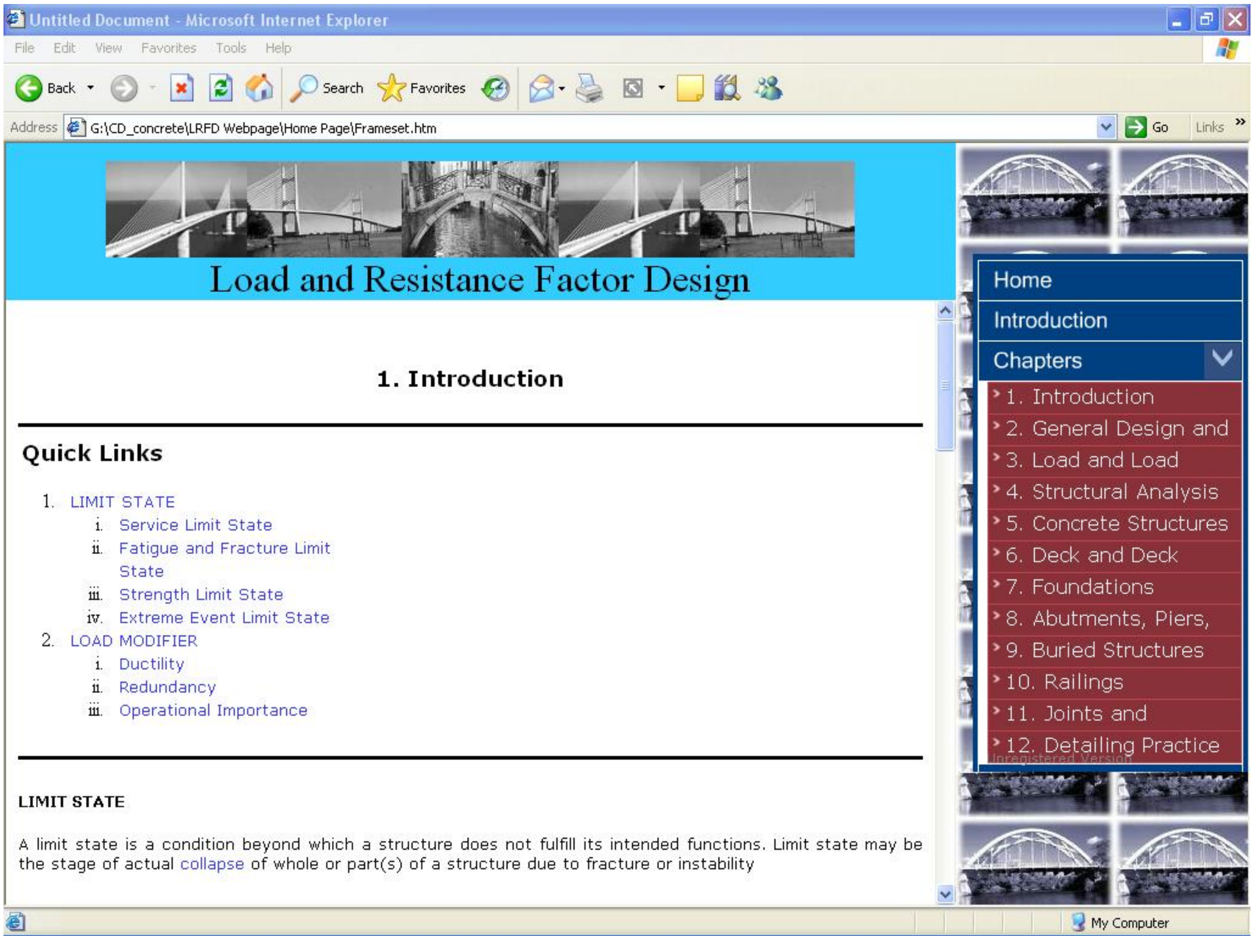


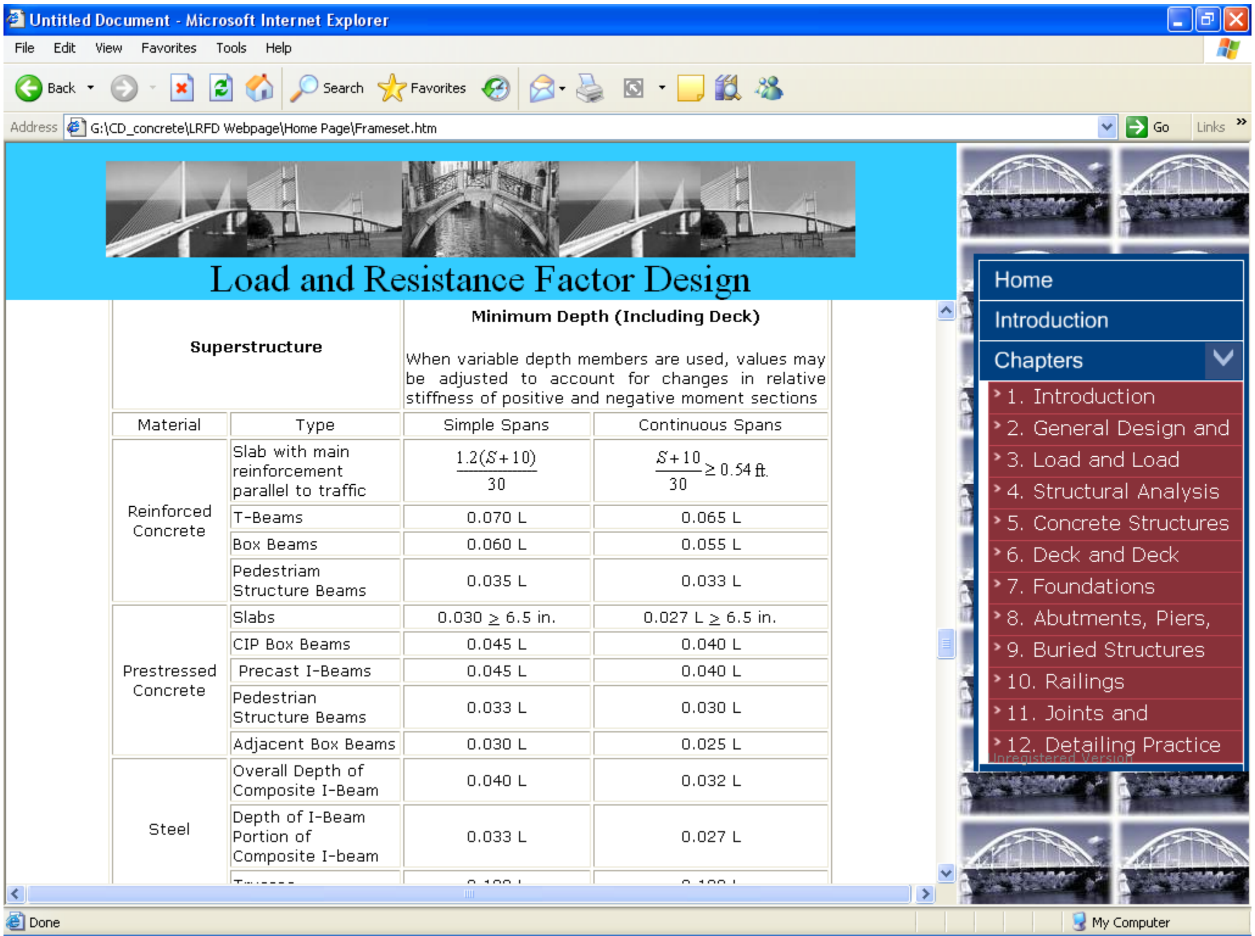
Figure 3-3. Chapter 1: introduction page explains the limit state and the load modifier.

Chapter 2: General Design and Location Features

This chapter provides minimum requirements for clearances, environmental protection, aesthetics, geological studies, economy, rideability, durability, constructability, inspectability, and maintainability. Traffic safety is also considered in this section. (See Figure 3.4.)

Chapter 2 also involves the minimum requirements for drainage facilities and self-protecting measures from ice, water, and water-borne salts. Scour, hydrology, and hydraulics that have caused bridge failure are included.

The configuration and overall dimensions of a bridge should be able to be determined from this chapter.



Superstructure		Minimum Depth (Including Deck) When variable depth members are used, values may be adjusted to account for changes in relative stiffness of positive and negative moment sections	
Material	Type	Simple Spans	Continuous Spans
Reinforced Concrete	Slab with main reinforcement parallel to traffic	$\frac{1.2(S+10)}{30}$	$\frac{S+10}{30} \geq 0.54$ ft.
	T-Beams	0.070 L	0.065 L
	Box Beams	0.060 L	0.055 L
	Pedestriam Structure Beams	0.035 L	0.033 L
Prestressed Concrete	Slabs	0.030 $\geq$ 6.5 in.	0.027 L $\geq$ 6.5 in.
	CIP Box Beams	0.045 L	0.040 L
	Precast I-Beams	0.045 L	0.040 L
	Pedestrian Structure Beams	0.033 L	0.030 L
	Adjacent Box Beams	0.030 L	0.025 L
Steel	Overall Depth of Composite I-Beam	0.040 L	0.032 L
	Depth of I-Beam Portion of Composite I-beam	0.033 L	0.027 L
	Trusses	0.100 L	0.100 L

Figure 3-4. Chapter 2: table of traditional minimum depths for constant depth superstructures.

Chapter 3: Load and Load Factors

Chapter 3 defines minimum requirements for loads and forces, the application's limits, load factors, and load combinations used for the design of new bridges. (See Figure 3-5.) The load provisions can also be used for the structural evaluation of existing bridges. This chapter also includes the force effects due to collisions, earthquakes, and settlement and distortion of the structure.

Force effects that develop during construction have a specified minimum load factor. Construction loads are not included in this section.

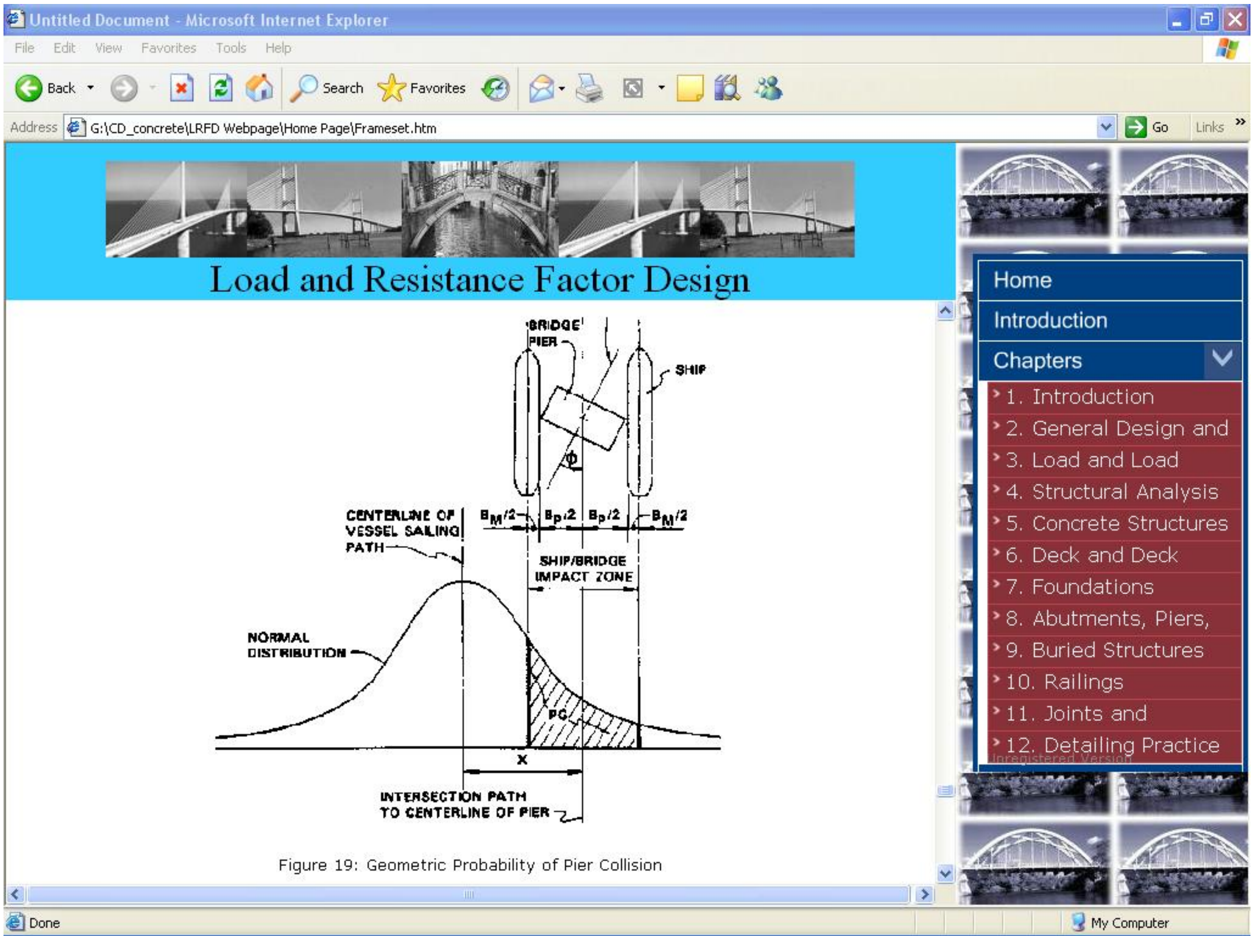


Figure 3-5. Chapter 3: geometric probability of a pier collision.

The following loads are discussed in the section:

- Permanent Loads – The weight of all components of the structure, appurtenances and utilities attached thereto, earth cover, wearing surface, future overlays, and planned widening.
- Live Loads – Forces that are variable within the bridge's normal operation cycle (Example: load exerted by a vehicle).
- Water Loads (WA) – Loads that include static pressure, buoyancy, stream pressure, and wave load.
- Wind Loads (WL and WS) – The loads in this section are horizontal wind pressure, vertical wind pressure, and aeroelastic instability.

- Earthquake Effects (EQ) – Loads that shall be taken to be horizontal force effects determined on the basis of the elastic response coefficient and the equivalent weight of the superstructure, and adjusted by the response modification factor.

- Earth Pressure (EH, ES, LS, DD) – Loads that consider compaction, presence of water in the earth, and the effect of earthquakes.

- Force Effects due to Superimposed Deformations (TU, TG, SH, CR, SE) – Internal force effects in a component due to creep and shrinkage and the effect of a temperature gradient are considered. Force effects resulting from resisting component deformation, displacement of points of load application, and support movements should also be included.

- Friction Forces (FR) – Forces due to friction shall be established on the basis of extreme values of the friction coefficient between the sliding surfaces.

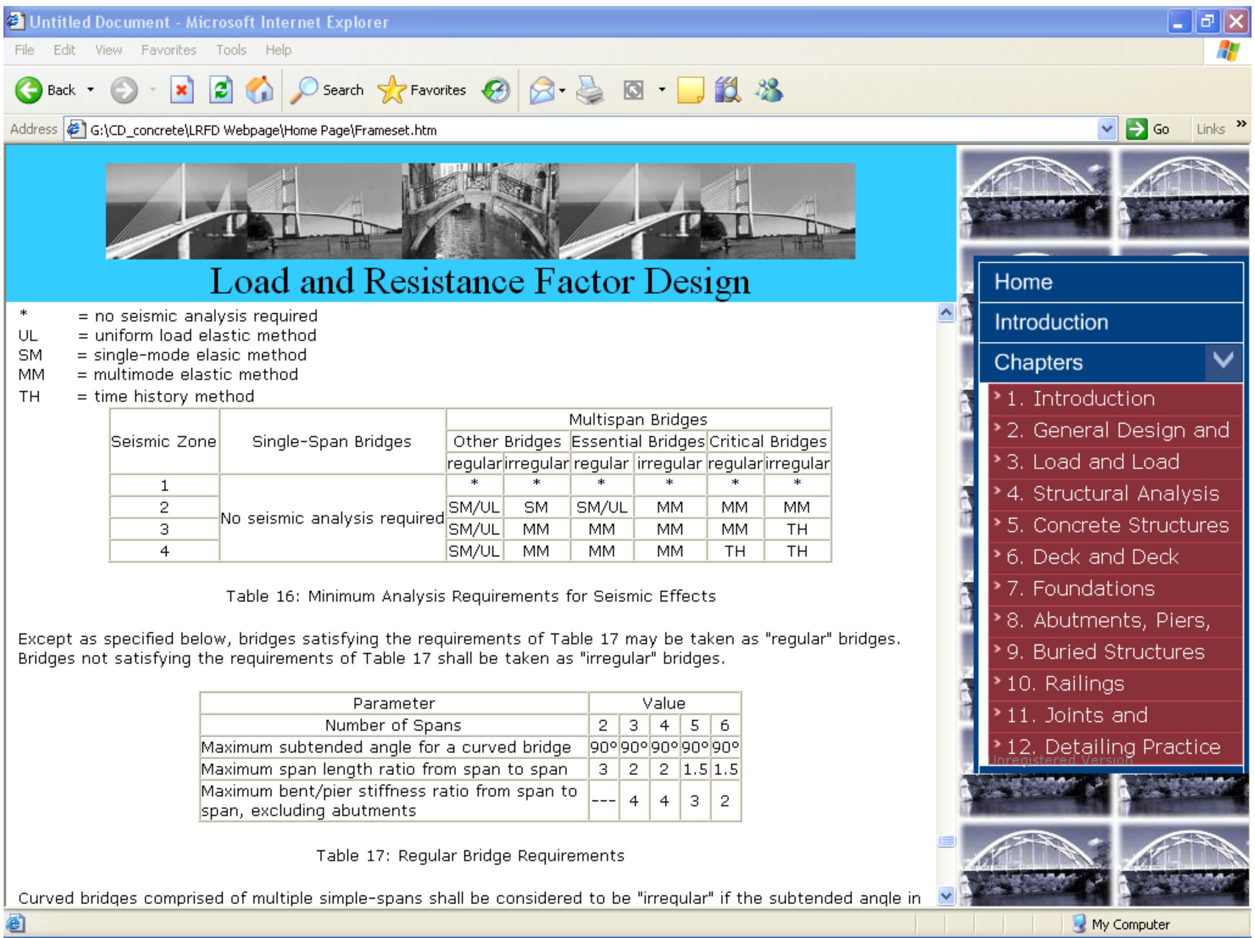
- Vessel Collision (CV) – A bridge constructed in a navigation channel is designed for a vessel collision.

Chapter 4: Structural Analysis and Evaluation

This chapter defines methods of analysis suitable for the design and evaluation of bridges and is limited to the modeling of structures and the determination of force effects. (See Figure 3.6.)

Bridge structures are to be analyzed elastically; however, this section permits the inelastic analysis or redistribution of force effects in some continuous beam superstructures. It specifies inelastic analysis for compressive members behaving inelastically and as an alternative for extreme event limit states.

The loads, load factors, and resistance factors specified throughout the specifications were developed using probabilistic principles combined with analyses based on linear material models.



* = no seismic analysis required
UL = uniform load elastic method
SM = single-mode elasic method
MM = multimode elastic method
TH = time history method

Seismic Zone	Single-Span Bridges	Multispan Bridges					
		Other Bridges		Essential Bridges		Critical Bridges	
		regular	irregular	regular	irregular	regular	irregular
1	No seismic analysis required	*	*	*	*	*	*
2		SM/UL	SM	SM/UL	MM	MM	MM
3		SM/UL	MM	MM	MM	MM	TH
4		SM/UL	MM	MM	MM	TH	TH

Table 16: Minimum Analysis Requirements for Seismic Effects

Except as specified below, bridges satisfying the requirements of Table 17 may be taken as "regular" bridges. Bridges not satisfying the requirements of Table 17 shall be taken as "irregular" bridges.

Parameter	Value				
Number of Spans	2	3	4	5	6
Maximum subtended angle for a curved bridge	90°	90°	90°	90°	90°
Maximum span length ratio from span to span	3	2	2	1.5	1.5
Maximum bent/pier stiffness ratio from span to span, excluding abutments	---	4	4	3	2

Table 17: Regular Bridge Requirements

Curved bridges comprised of multiple simple-spans shall be considered to be "irregular" if the subtended angle in

Figure 3-6. Chapter 4: tables on minimum analysis requirements for seismic effects and on regular bridge requirements.

Chapter 5: Concrete Structures

This chapter discusses the design of bridge structures in concrete. (See Figure 3.7.) The provisions in this section apply to the design of bridge and retaining wall components of normal weight or lightweight concrete and reinforced with steel bars, welded wire reinforcement, and/or prestressing strands, bars, or wires.

The provisions combine and unify the requirements for reinforced, prestressed, and partially prestressed concrete, including seismic design, analysis by the strut-and-tie model, and design of segmentally constructed concrete bridges and bridges from precast concrete elements.

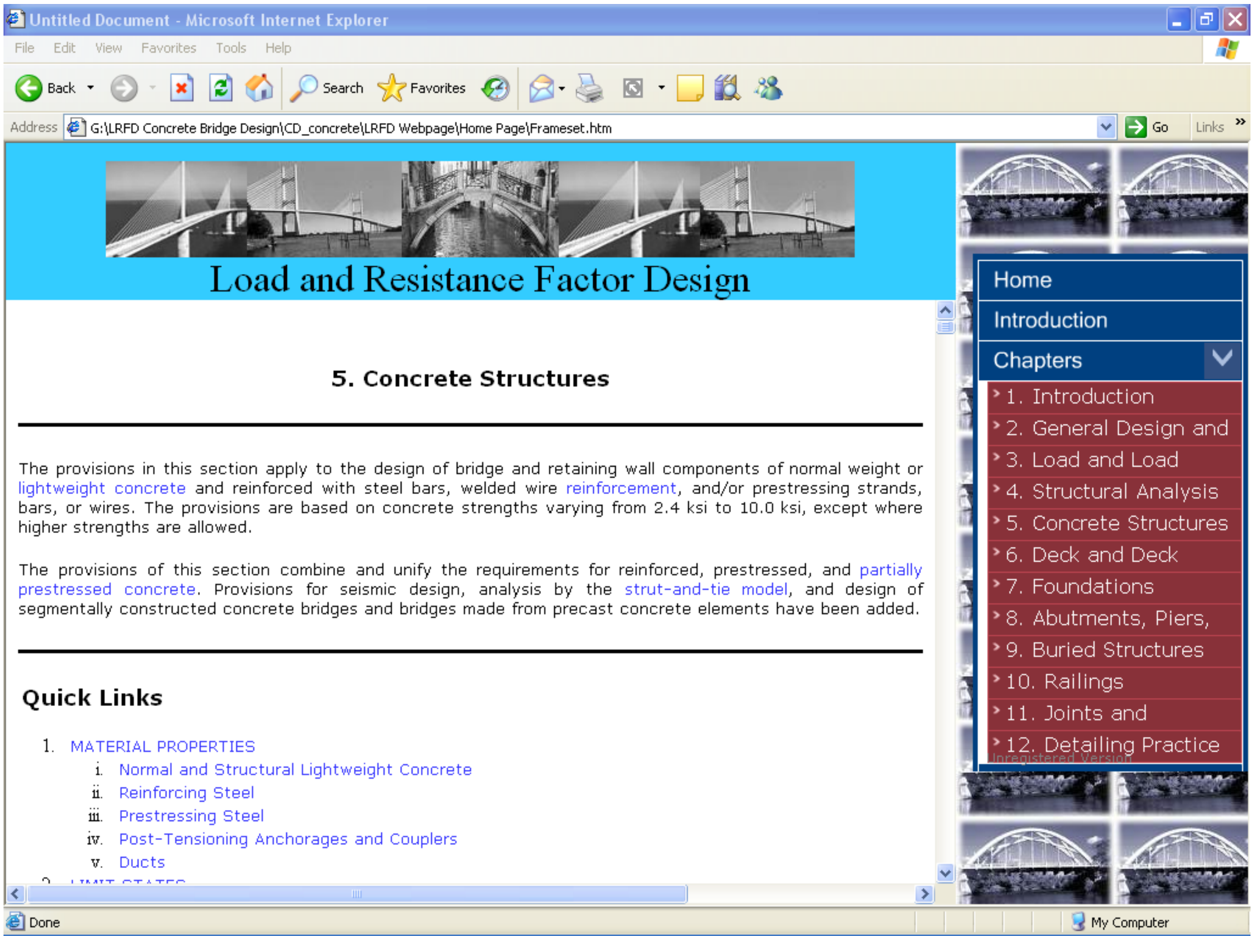


Figure 3-7. Chapter 5: concrete structures page.

Chapter 6: Decks and Deck Systems

This section contains provisions for the analysis and design of bridge decks and deck systems of concrete, metal, or their combination subjected to gravity loads. (See Figure 3.8.) Implicit is a design philosophy that prefers jointless, continuous bridge desks and desk systems to improve the weather and corrosion-resisting effects of the whole bridge, reduce inspection efforts and maintenance costs, and increase structural effectiveness and redundancy. This chapter is divided into five parts covering the following areas: the general design requirements, the limit states, the proper structural analysis, and its application to concrete deck slabs and metal slabs.

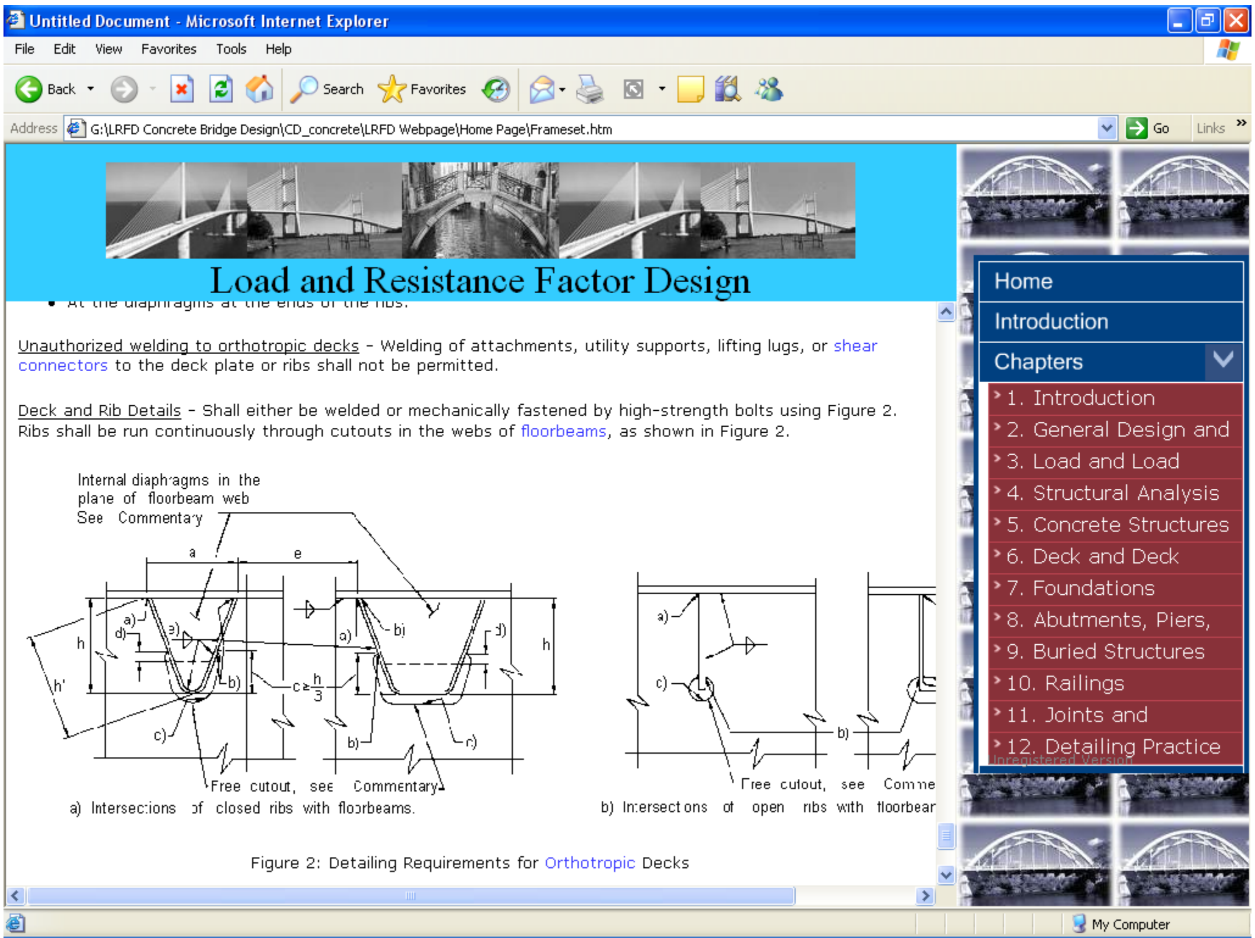


Figure 3-8. Chapter 6: detailing requirements for orthotropic decks.

Chapter 7: Foundations

This chapter provides the LRFD specifications for the design of spread footings, driven piles, and drilled shaft foundations. (See Figure 3-9.) In case of spread footings the general considerations shall apply to the design of isolated footings and, in some cases, to combined footings. Footings should be designed so that pressure under the footing is as nearly uniform as practical.

In some cases, positive anchorage should be provided between the rock and footing such as that provided by rock anchors, bolts, or dowels. In case of inclined load, failure by sliding shall be investigated for footing that supports this condition.

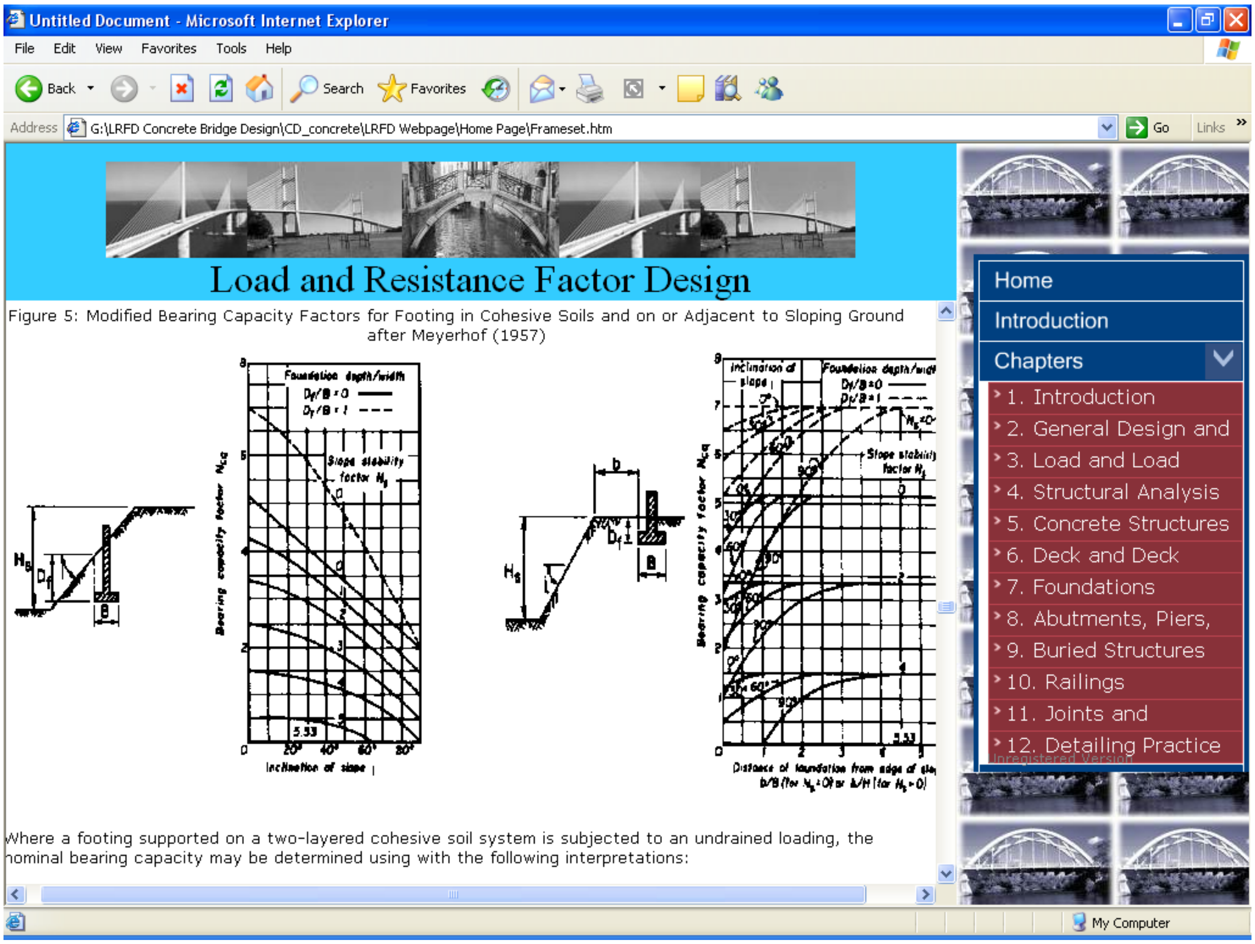


Figure 3-9. Chapter 7: modified bearing capacity factors for footing in cohesive soils.

Chapter 8: Abutments, Piers, and Walls

This chapter provides requirements on the design of abutments, piers, and walls. (See Figure 3-10.) These shall be designed to resist water pressure, the self weight of the wall, any live and dead load along with temperature and shrinkage effects.

In accordance with LRFD concrete bridge design specifications the design should be able to resist any vertical and lateral deformation or displacement. In addition this section provides the general considerations for the abutments and conventional retaining walls: loadings, wing walls, and reinforcement.

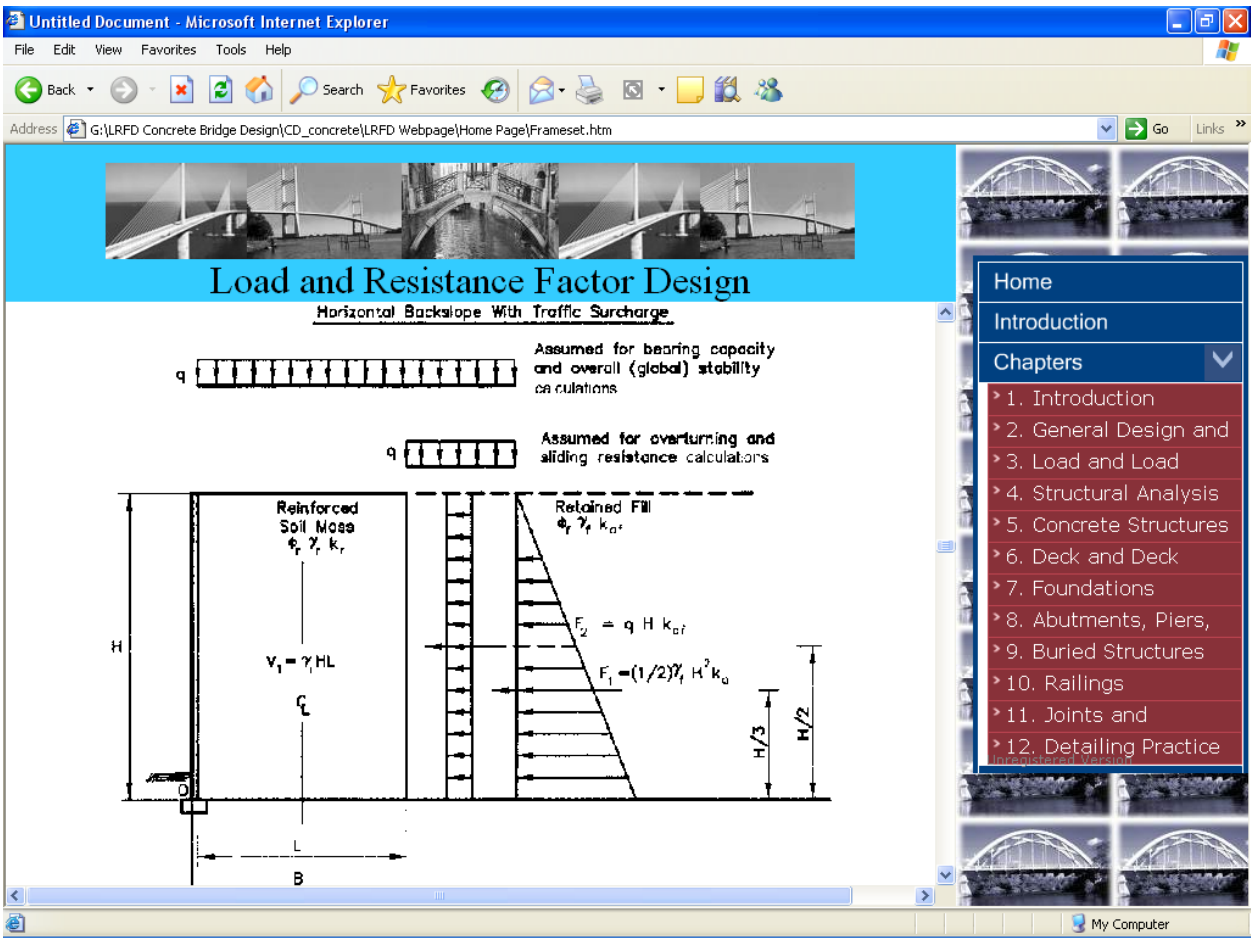


Figure 3-10. **Chapter 8: external stability for a wall with horizontal back-slope and traffic surcharge.**

Chapter 9: Buried Structures and Tunnel Lines

This chapter gives the requirements for the selection of structural properties and dimensions of buried structures such as culverts and steel plates used to support tunnel excavations in soil. (See Figure 3-11.) It discusses the terms and characteristics of buried structure systems used in the designs such as metal pipes, structure plate pipes, box and elliptic structures, long-span structural plate, structural plate box, and thermoplastics pipes.

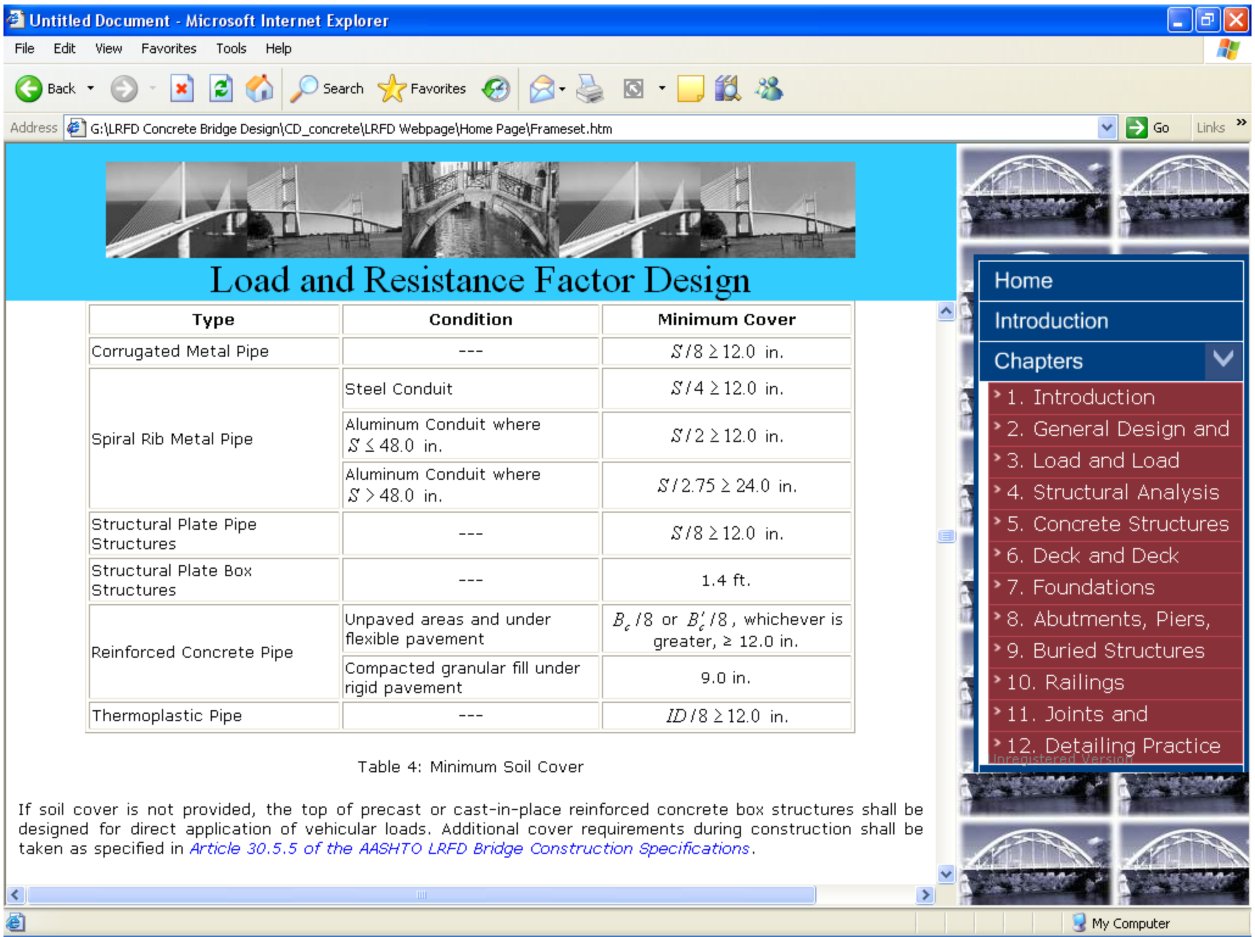


Figure 3-11. Chapter 9: minimum soil cover table depending on the different types of pipes or pipe structures.

Chapter 10: Railings

This section provides six bridge railing test levels and their associated crash test requirements. This chapter applies to railings for new bridges and for rehabilitated bridges to the extent that railing replacement is determined to be appropriate. (See Figure 3-12.) The process for the design of crash test specimens to determine their crash worthiness is described. There are three types of railings discussed in this section: traffic railings, pedestrian railings, and bicycle railings. Curbs and sidewalks are also considered in this section.

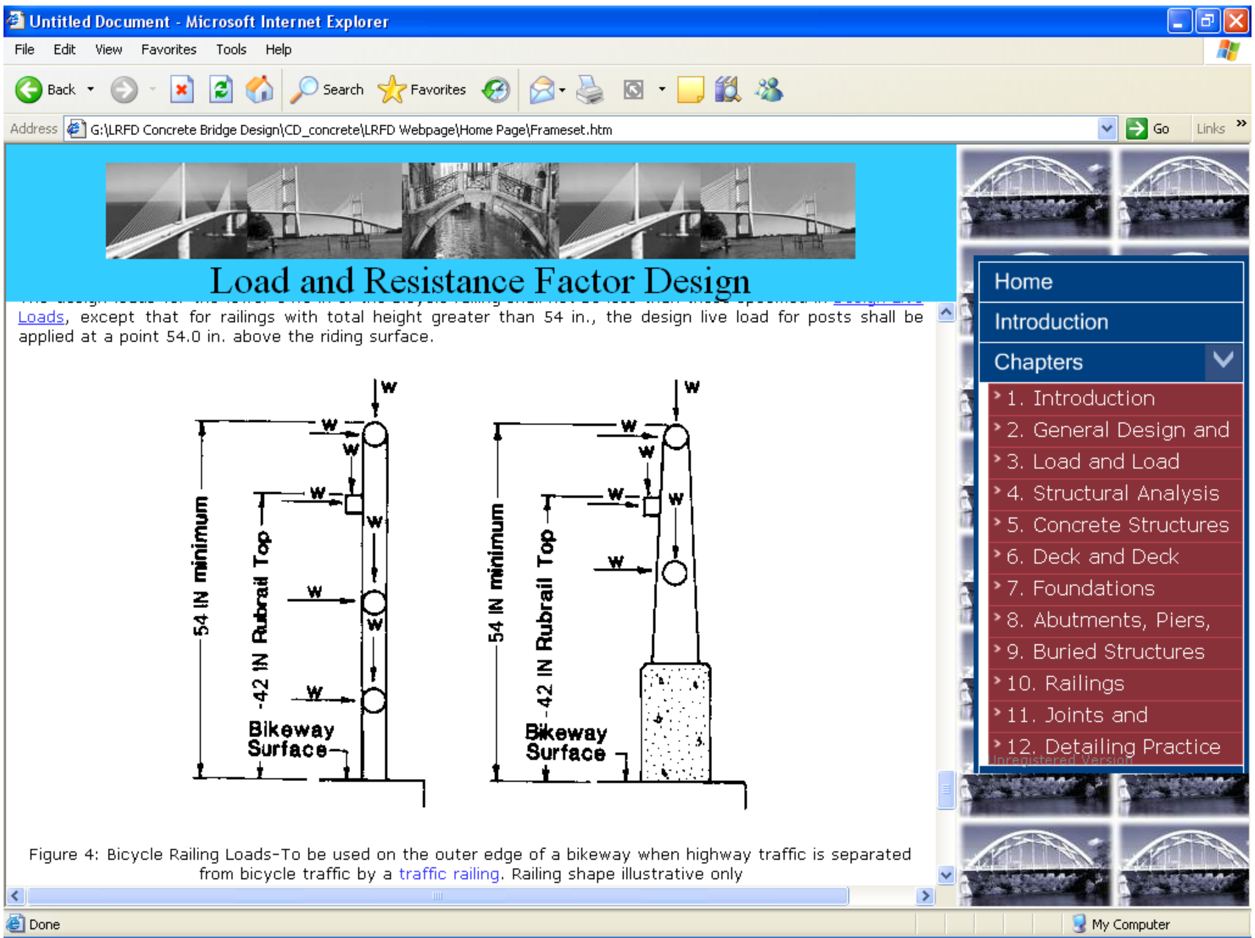


Figure 3-12. Chapter 10: bicycle railing loads.

Chapter 11: Joints and Bearings

In this section, requirements for the design and selection of structural bearings and deck joints are outlined. (See Figure 3-13.) The design specifications for joints and bearings are stated separately.

Selection and layout of joints and bearings shall allow for deformations due to temperature and other time-dependent causes and shall be consistent with the proper functioning of the bridge. Deck joints and bearings shall be designed to resist loads and accommodate movements at the service and strength limit states and to satisfy the requirements of the fatigue and fracture limit state. Design loads for joints, bearings and structural members shall be based on the stiffness of the individual elements and the tolerances achieved during fabrication and erection. At service limit state no damage due to joints or bearing movement shall be permitted. At strength limit or extreme event states no irreparable damage shall occur.

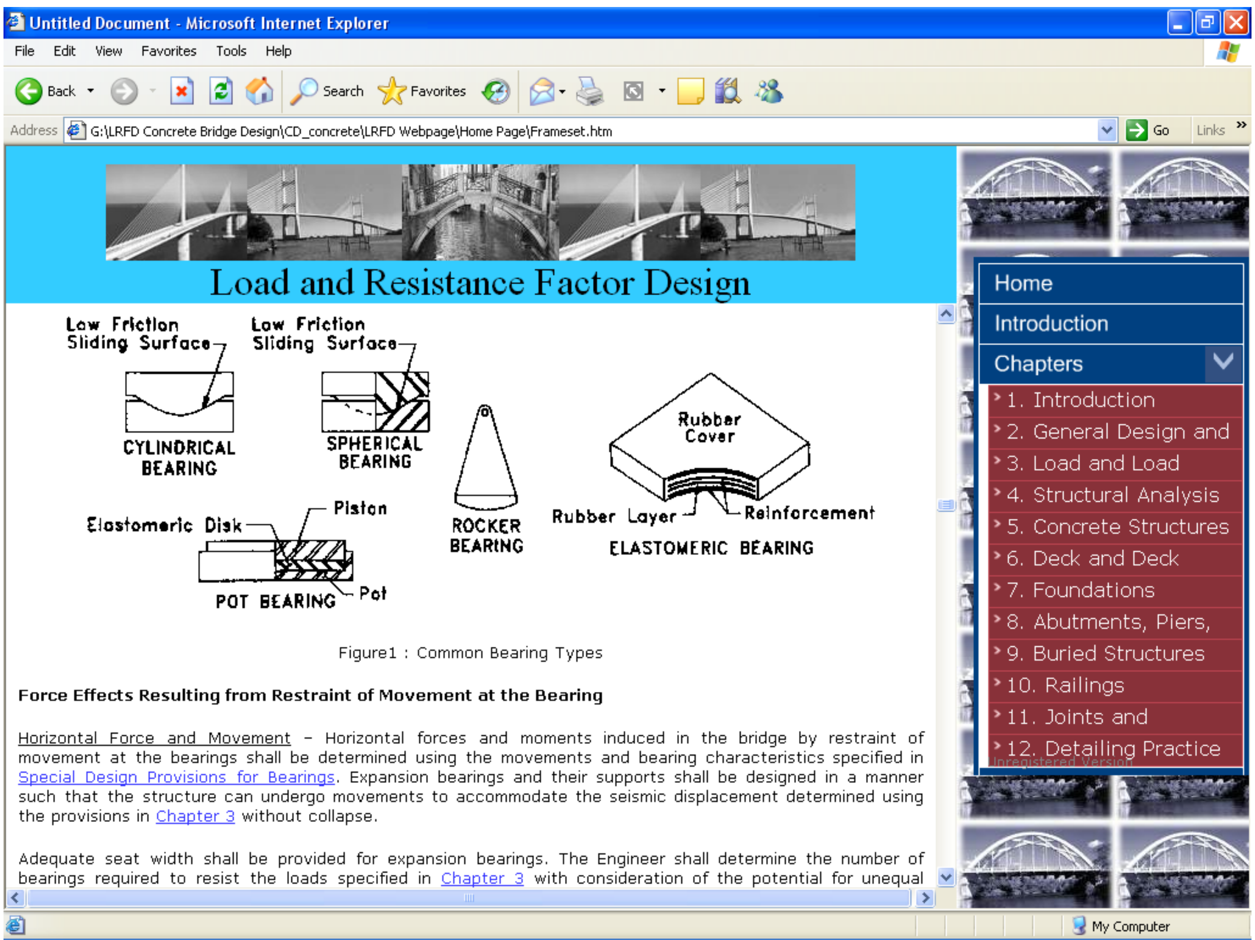
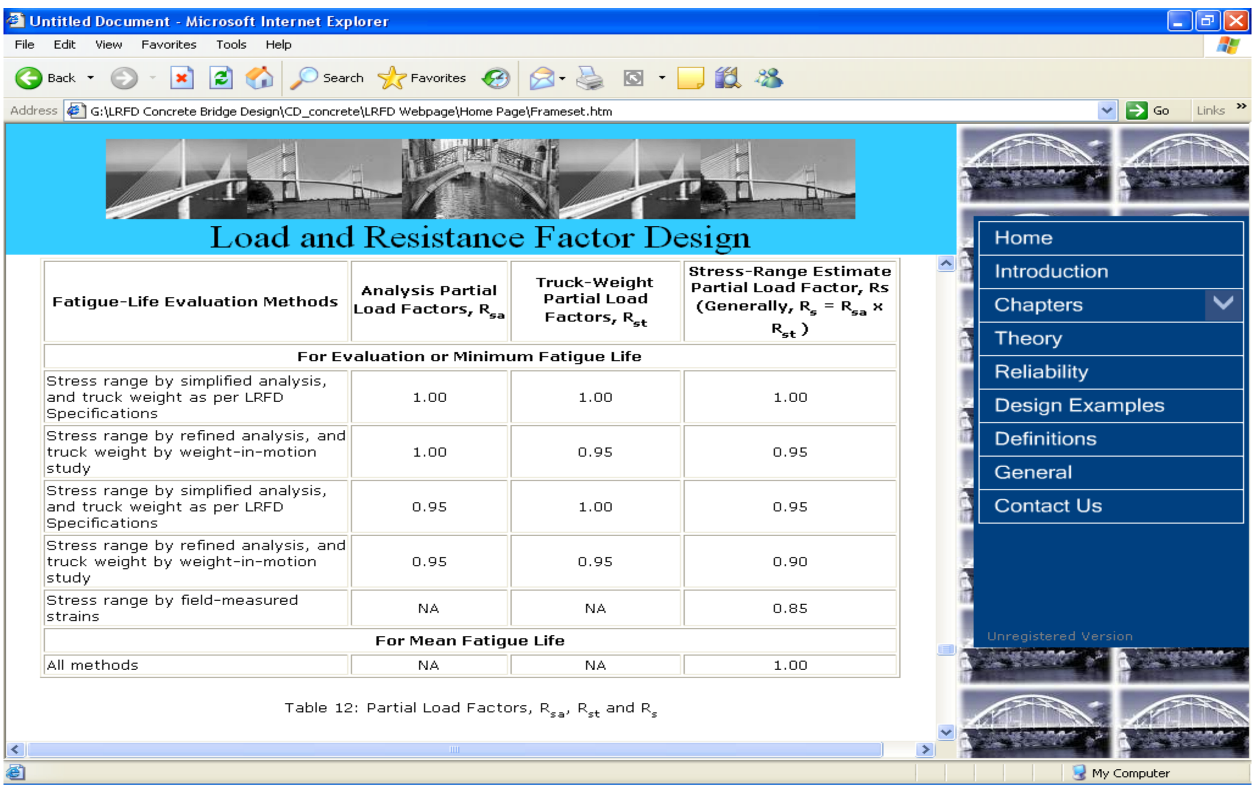


Figure 3-13. Chapter 11: common bearing types.

Chapter 12: Detailing Practice

This chapter states the procedure that should be done according to the standards of the Load and Resistance Rating (LRFR) manual for any design of a bridge structure. (See Figure 3-14.) It goes step-by-step on everything that should be done. The areas covered are:

- Bridge Records
- Bridge Management Systems
- Inspection
- Material Testing
- Load and Resistance Factor Ratings
- Fatigue Evaluation of Steel Bridges
- Nondestructive Load Testing
- Special Topics
    - Evaluation of Unreinforced Masonry Arches
    - Direct Safety Assessment of Bridges
    - Historic Bridges



Fatigue-Life Evaluation Methods	Analysis Partial Load Factors, R_{sa}	Truck-Weight Partial Load Factors, R_{st}	Stress-Range Estimate Partial Load Factor, Rs (Generally, $R_s = R_{sa} \times R_{st}$)
For Evaluation or Minimum Fatigue Life			
Stress range by simplified analysis, and truck weight as per LRFD Specifications	1.00	1.00	1.00
Stress range by refined analysis, and truck weight by weight-in-motion study	1.00	0.95	0.95
Stress range by simplified analysis, and truck weight as per LRFD Specifications	0.95	1.00	0.95
Stress range by refined analysis, and truck weight by weight-in-motion study	0.95	0.95	0.90
Stress range by field-measured strains	NA	NA	0.85
For Mean Fatigue Life			
All methods	NA	NA	1.00

Table 12: Partial Load Factors, R_{sa}, R_{st} and R_s

Figure 3-14. Chapter 12: partial load factors, R_{sa}, R_{st} and R_s.

Theory

This page introduces the user a basic theory of LRFD specifications, providing basic equations of its methodology and definitions. (See Figure 3-15.)

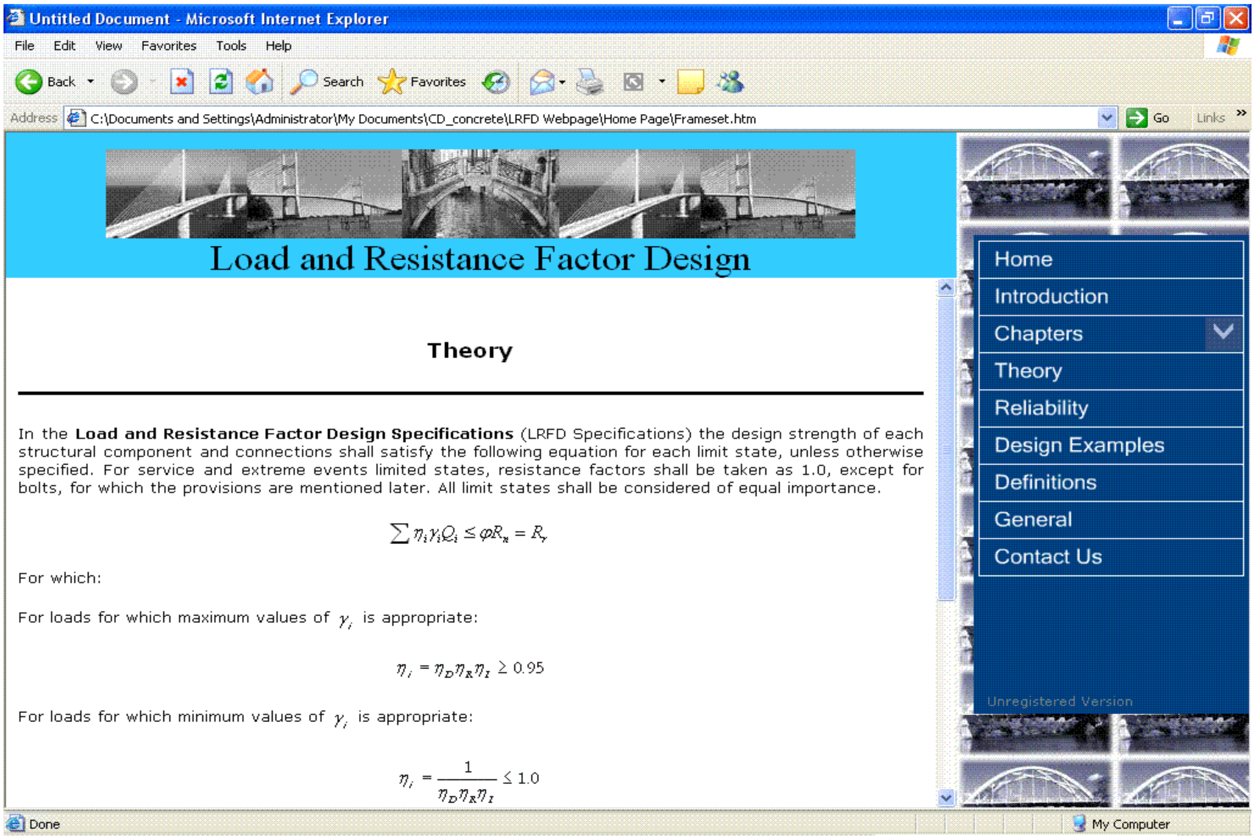


Figure 3-15. Theory page shows basic equations in LRFD.

Reliability

The main idea of this page is to give the user a background of why AASHTO adopted LRFD Specifications in 1994. There is a comparison of the three design philosophies: elastic design / working stress design (allowable stress design), plastic design, and Load and Resistance Factor Design (LRFD). (See Figure 3-16.)

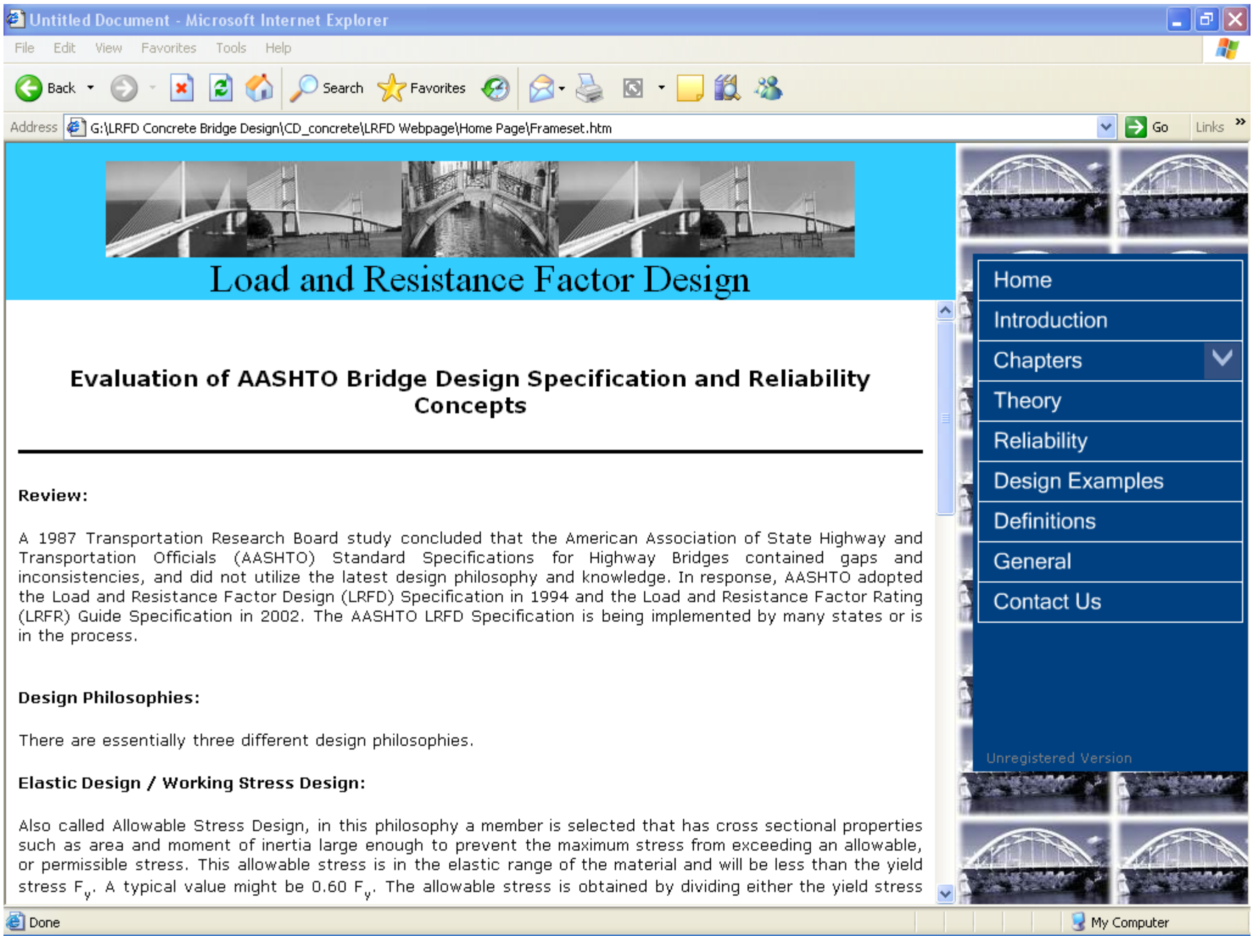


Figure 3-16. Reliability concepts page describes the three principal design philosophies.

The LRFD live load model, designated HL-93, was developed as a representation of shear and moment produced by a group of above-legal-limit vehicles routinely permitted on the highways in various states.

For a better understanding about the reliability of LRFD Specification, the following graphs show the progress of implementing LRFD. (See Figures 3-17 and 3-18.)

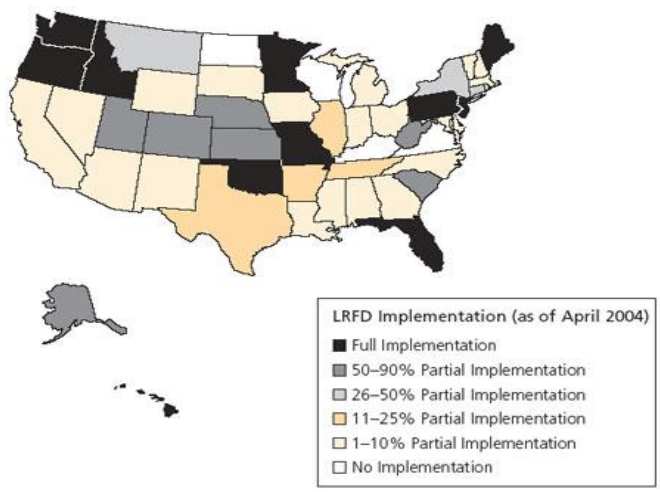


Figure 3-17. LRFD implementation by states and local governments as of April 2004.

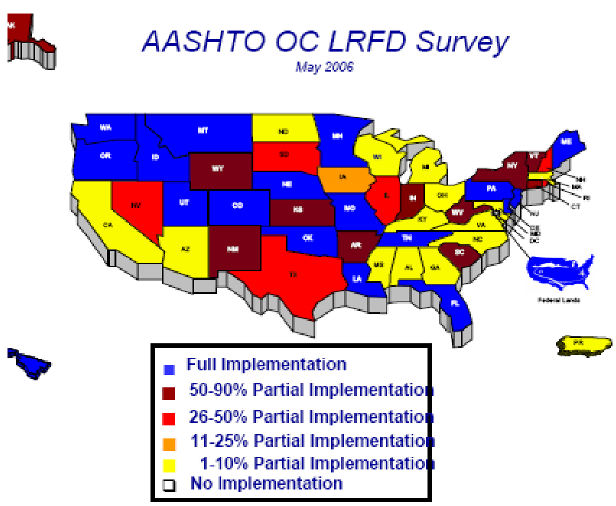


Figure 3-18. LRFD specifications implementation by states and local governments as of May 2006.

Twelve US states have fully implemented LRFD Specifications as shown in Figure 3-19. Every year more of the new bridges are being designed using LRFD because of the considerations of public safety for people and property and the goal to have the entire US implemented by 2007. (See Figures 3-20 and 3-21.)

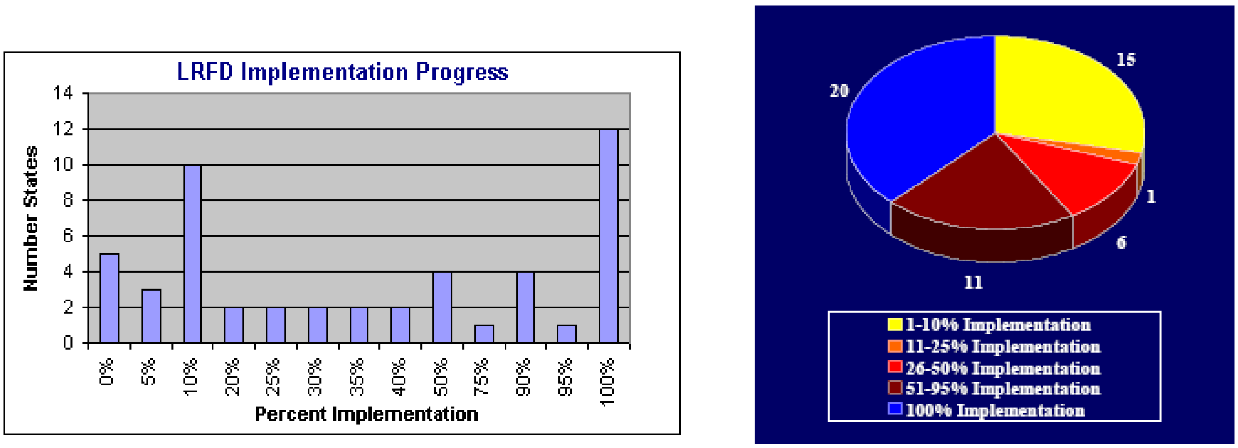


Figure 3-19. LRFD implementation progress.

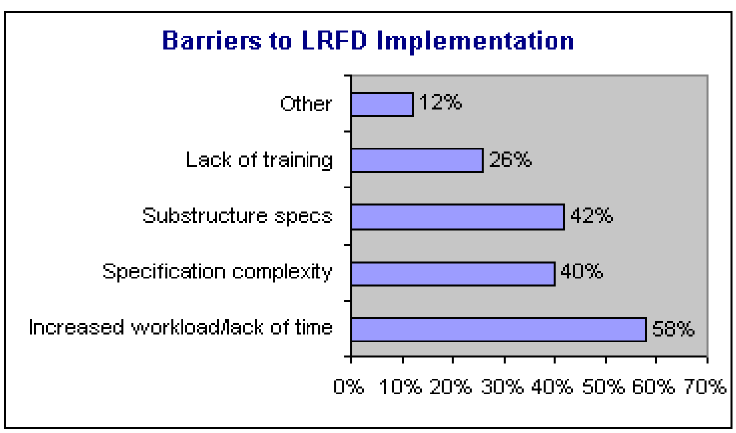


Figure 3-20. Barriers to LRFD implementation.

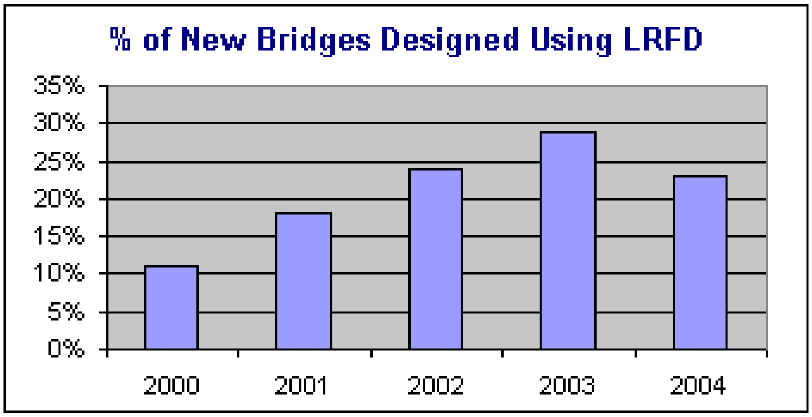


Figure 3-21. Tendency of LRFD bridges construction during recent years.

Design Examples

This section contains six typical concrete beam and girder superstructure designs. (See Figure 3-22.) The first design example is a deck of a reinforced concrete T-beam bridge. The second example is a simply supported solid slab bridge. The third example is a reinforced concrete T-beam bridge. The fourth example is a simply supported pretensioned prestressed concrete girder bridge. The fifth example is a concrete box-girder bridge. And the sixth example is a stub abutment design. For the simplification of design procedure, a general outline is also presented. It is intended to be a generic overview of the design process. It should not be regarded as fully complete, nor should it be used as a substitute for a working knowledge of the provisions.

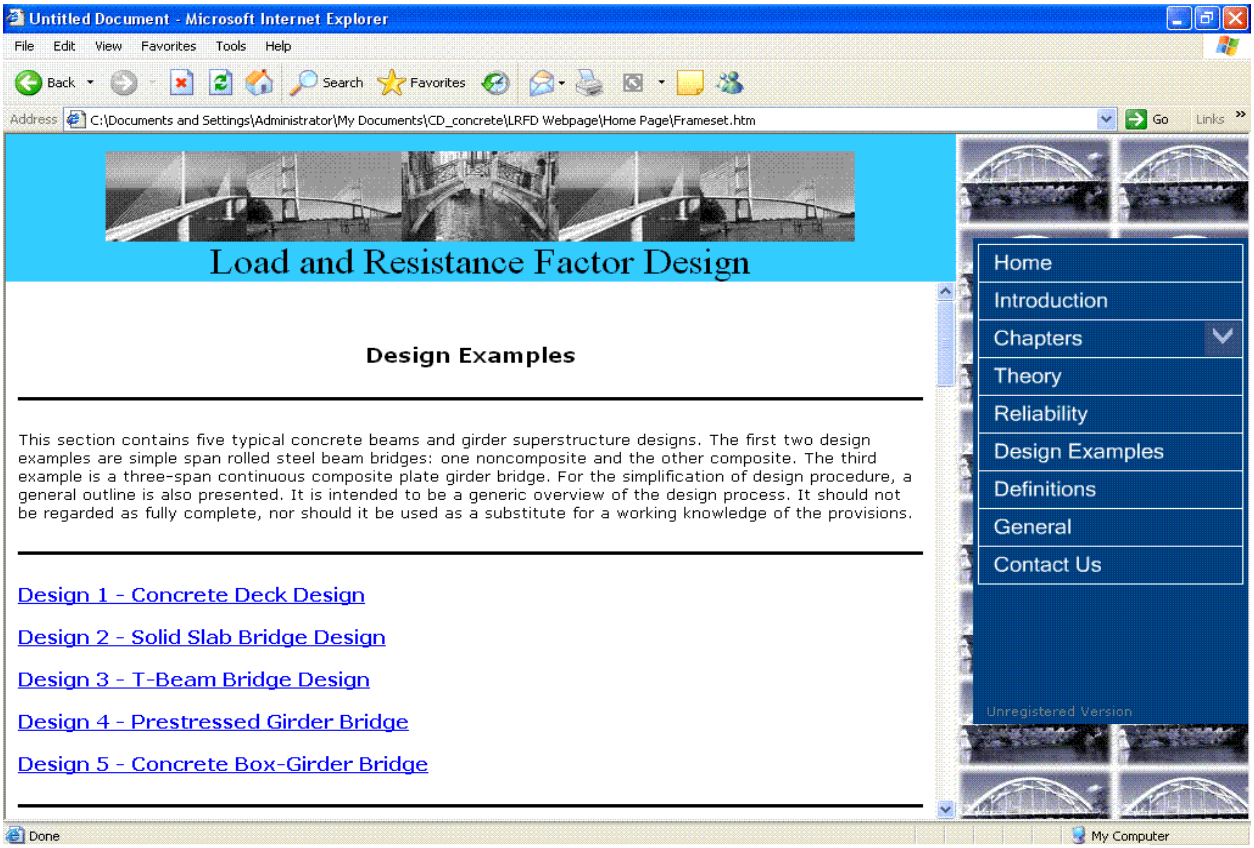


Figure 3-22. Design examples page show six different examples step-by-step.

Design Example #1

Use the approximate method of analysis to design the deck of the reinforced concrete T-beam bridge section of Figure E7.1-1 (Figure 3-23) for a HL-93 live load and a PL-2 performance level concrete barrier. (See Figure 3-24.) The T-beams supporting the deck are 96 in. on centers and have a stem width of 14 in. The deck overhangs the exterior T-beams by 39 in. The concrete density is 0.150 kcf. Allow for a wearing future wearing surface of 3 in. thick bituminous overlay. Use $f'_c = 4.5$ ksi and $f'_c = 60$ ksi.

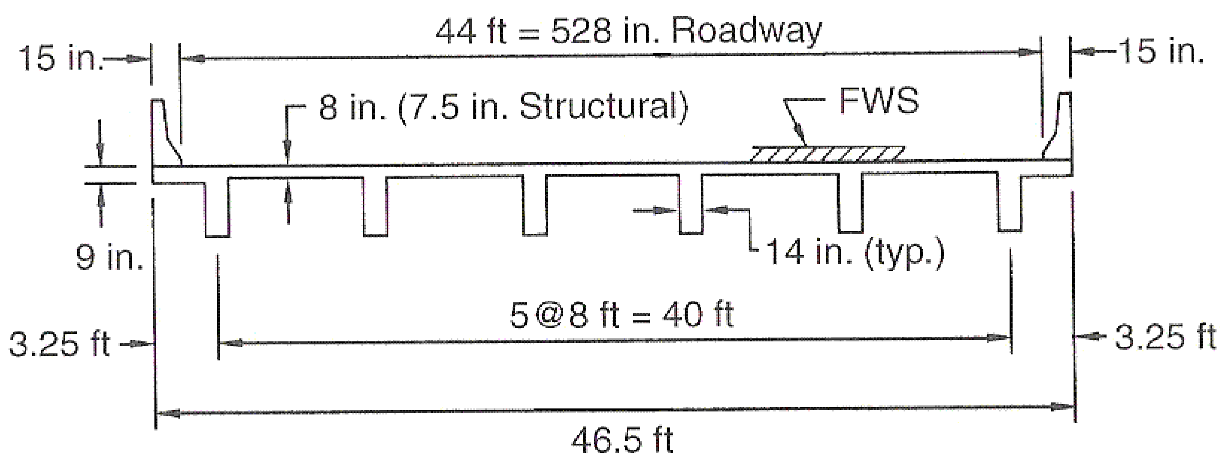
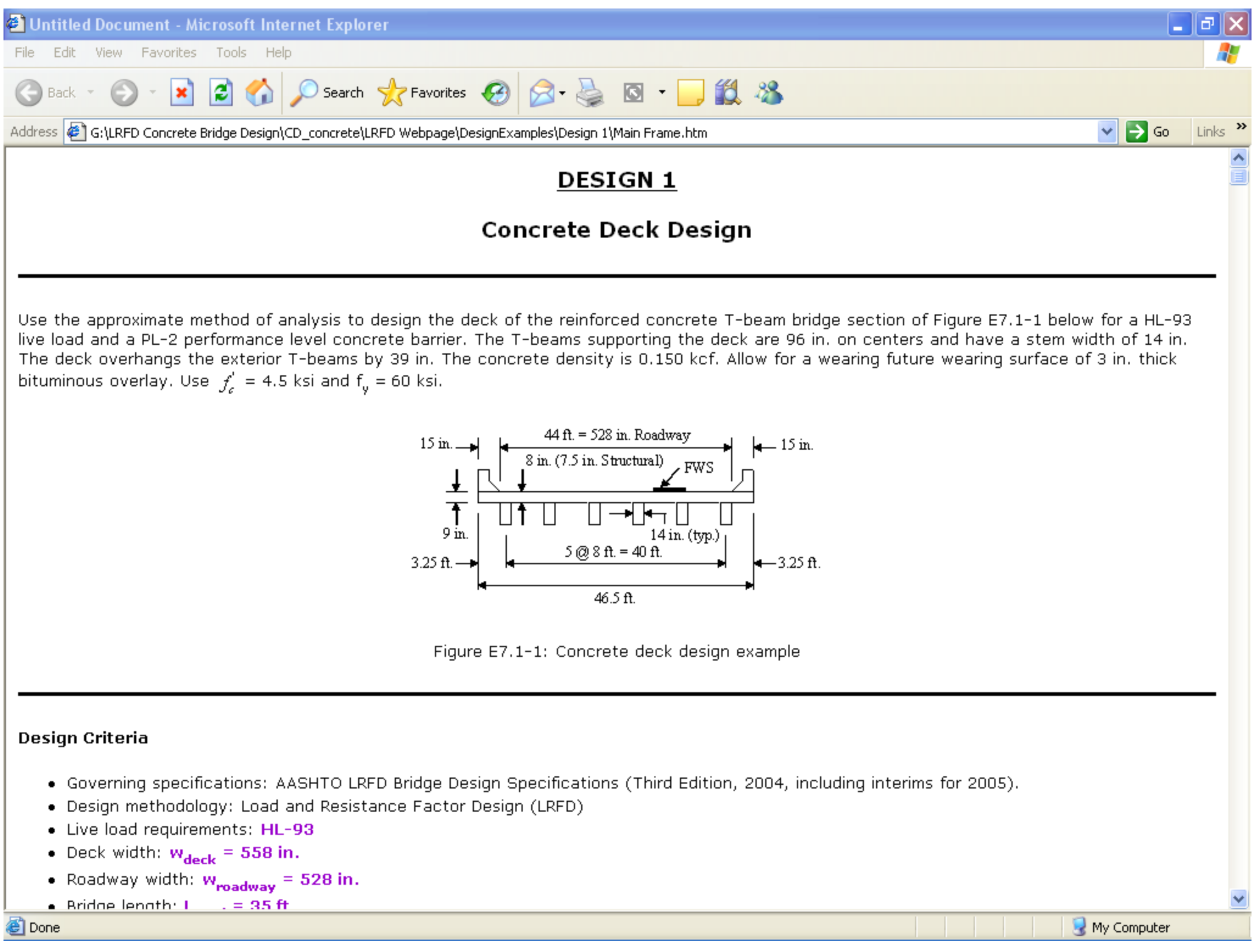


Figure 3-23. Beam for design example #1.



DESIGN 1

Concrete Deck Design

Use the approximate method of analysis to design the deck of the reinforced concrete T-beam bridge section of Figure E7.1-1 below for a HL-93 live load and a PL-2 performance level concrete barrier. The T-beams supporting the deck are 96 in. on centers and have a stem width of 14 in. The deck overhangs the exterior T-beams by 39 in. The concrete density is 0.150 kcf. Allow for a wearing future wearing surface of 3 in. thick bituminous overlay. Use f'_c = 4.5 ksi and f_y = 60 ksi.

Figure E7.1-1: Concrete deck design example

Design Criteria

- Governing specifications: AASHTO LRFD Bridge Design Specifications (Third Edition, 2004, including interims for 2005).
- Design methodology: Load and Resistance Factor Design (LRFD)
- Live load requirements: HL-93
- Deck width: w_{deck} = 558 in.
- Roadway width: $w_{roadway}$ = 528 in.
- Bridge length: L = 35 ft

Figure 3-24. Page for design example #1.

Design Example #2

Design the simply supported solid slab bridge of Figure 1 (Figure 3-25) with a span length of 35 ft. center to center of bearings for a HL-93 live load. (See Figure 3-26.) The roadway width is 528 in. curb to curb. Allow for a future-wearing surface of 3 in. thick bituminous overlay. A 15-in.-wide barrier weighing 0.32 k/ft. is assumed to be carried by the edge strip. Use $f'_c = 4.5$ ksi and $f_y = 60$ ksi. Use exposure class 2 for crack control.

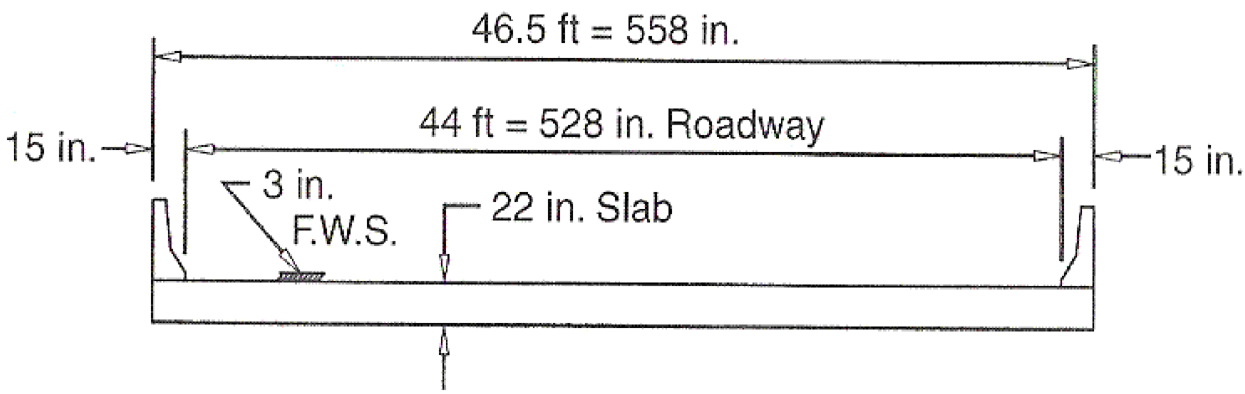


Figure 3-25. Concrete deck preliminary details for design example #2.

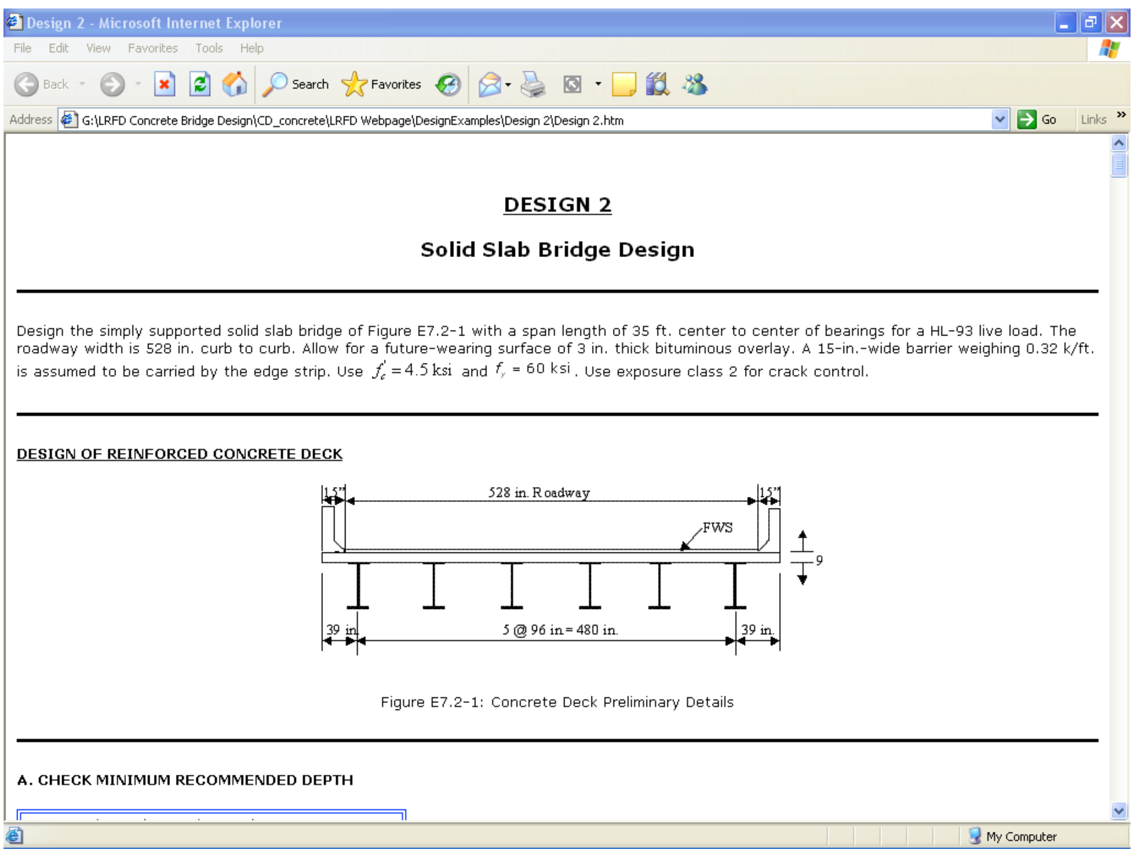


Figure 3-26. Page for design example #2.

Design Example #3

Design a reinforced concrete T-beam bridge for a 44-ft. wide roadway and three-spans of 35 ft.-42 ft.-35ft. with skew of 30° as shown in Figure 1 (Figure 3-27). (See Figure 3-28.) Use the concrete deck of Design Example #1 previously designed for an HL-93 live load, a bituminous overlay, and an 8 ft. spacing of girders in Design Example #1. Use $f'_c = 4.5$ ksi and $F_y = 60$ ksi.

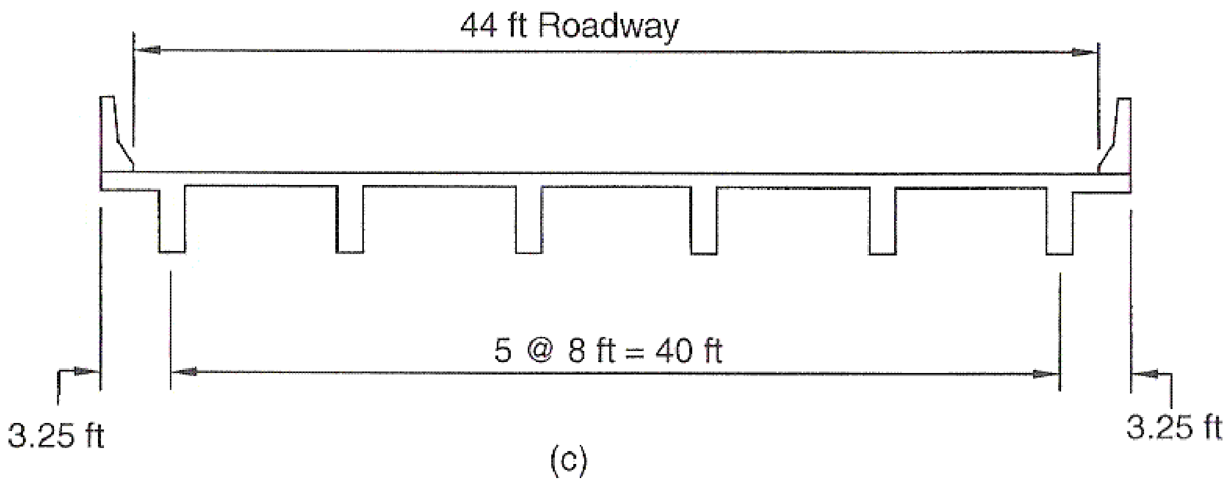


Figure 3-27. T-beam bridge section for design example #3.

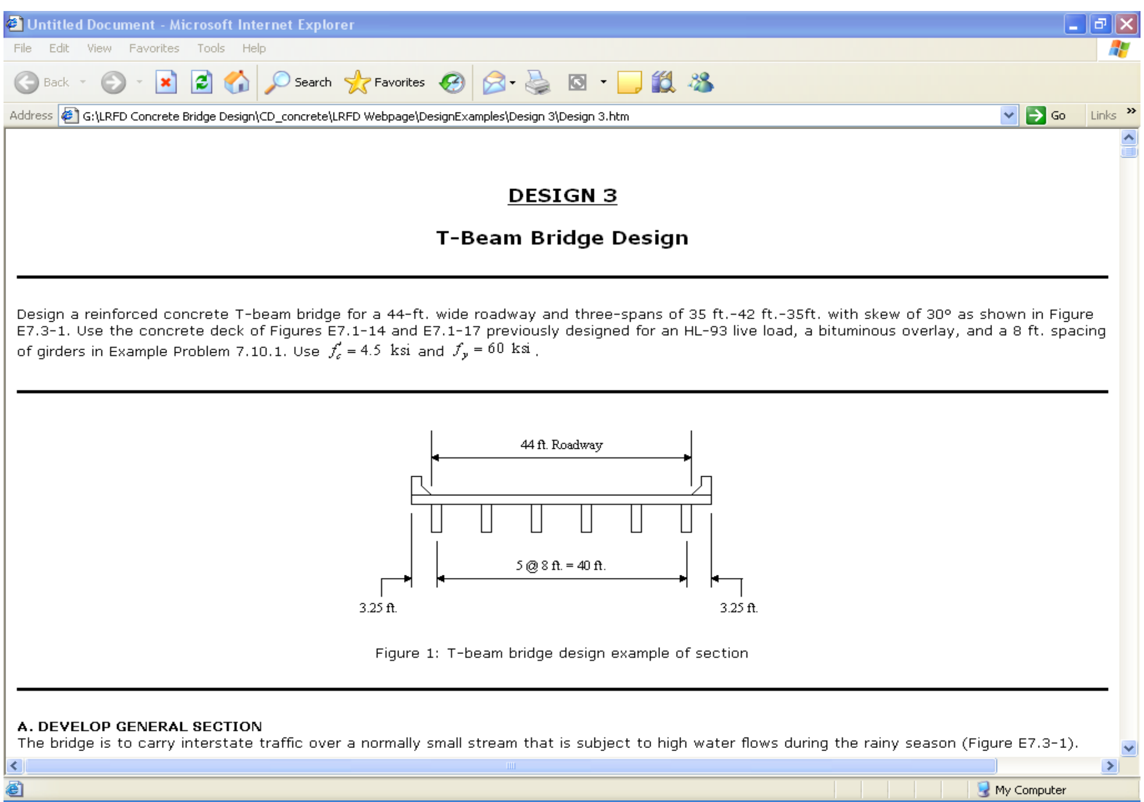


Figure 3-28. Page for design example #3.

Design Example #4

Design the simply supported pretensioned prestressed concrete girder bridge of Figure 1 (Figure 3-29) with a span length of 100 ft. center to center of bearings for a HL–93 live load. (See Figure 3-30.) The roadway width is 44 ft. curb to curb. Allow for a future wearing surface of 3-in. thick bituminous overlay and use the concrete deck design of Design Example #1 (f'_c = 4.5 ksi). Follow the beam and girder bridge outline of the AASHTO (2004) LRFD Bridge Specifications. Use f'_c = 8 ksi. Use f'_{ci} = 6 ksi, f_y = 60 ksi, and 270 ksi, low-relaxation 0.5 in., seven wire stands. The barrier is 15 in. wide and weighs 0.32 kips/ft. The owner requires this load to be assigned to the exterior girder.

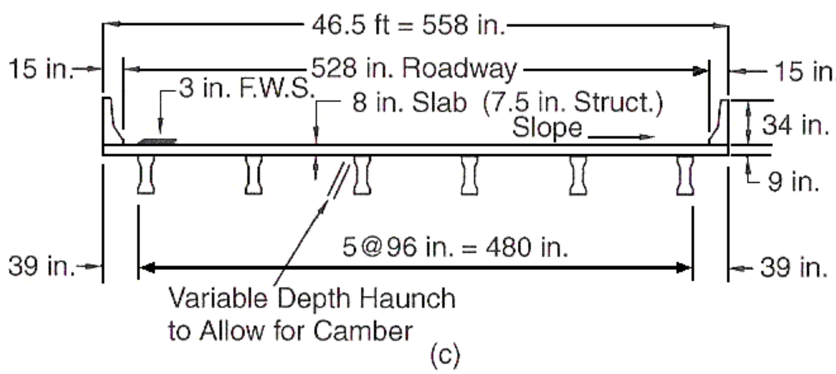


Figure 3-29. Prestressed concrete girder bridge section for design example #4.

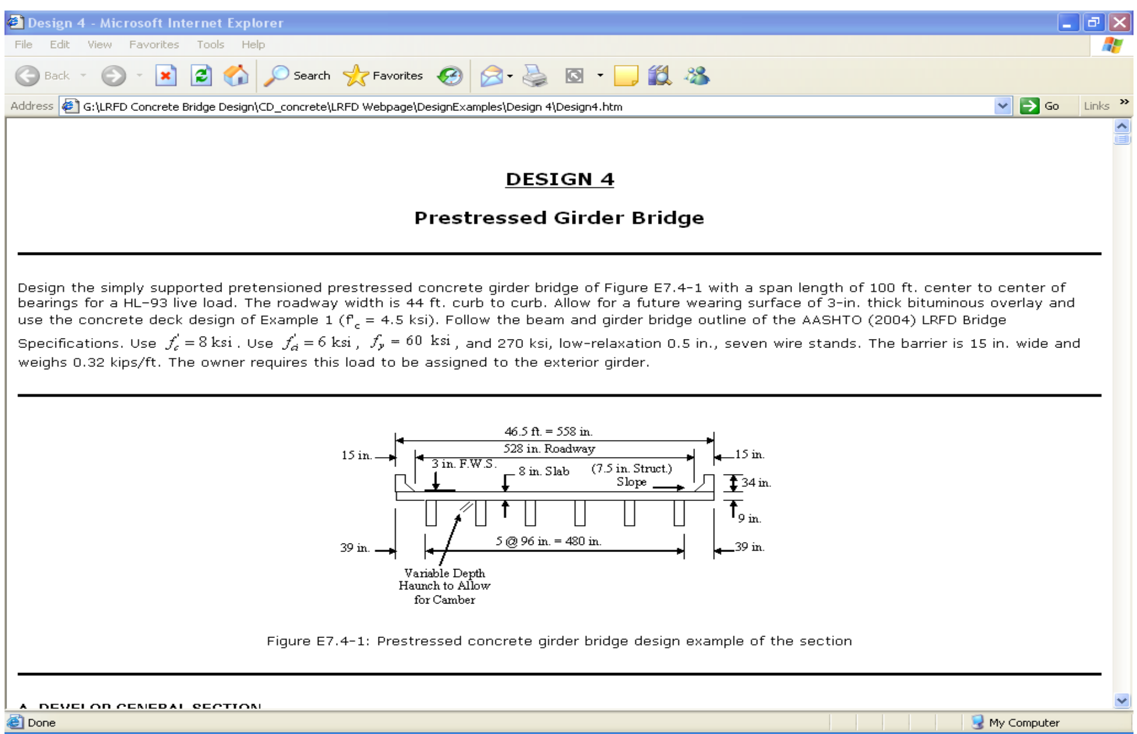
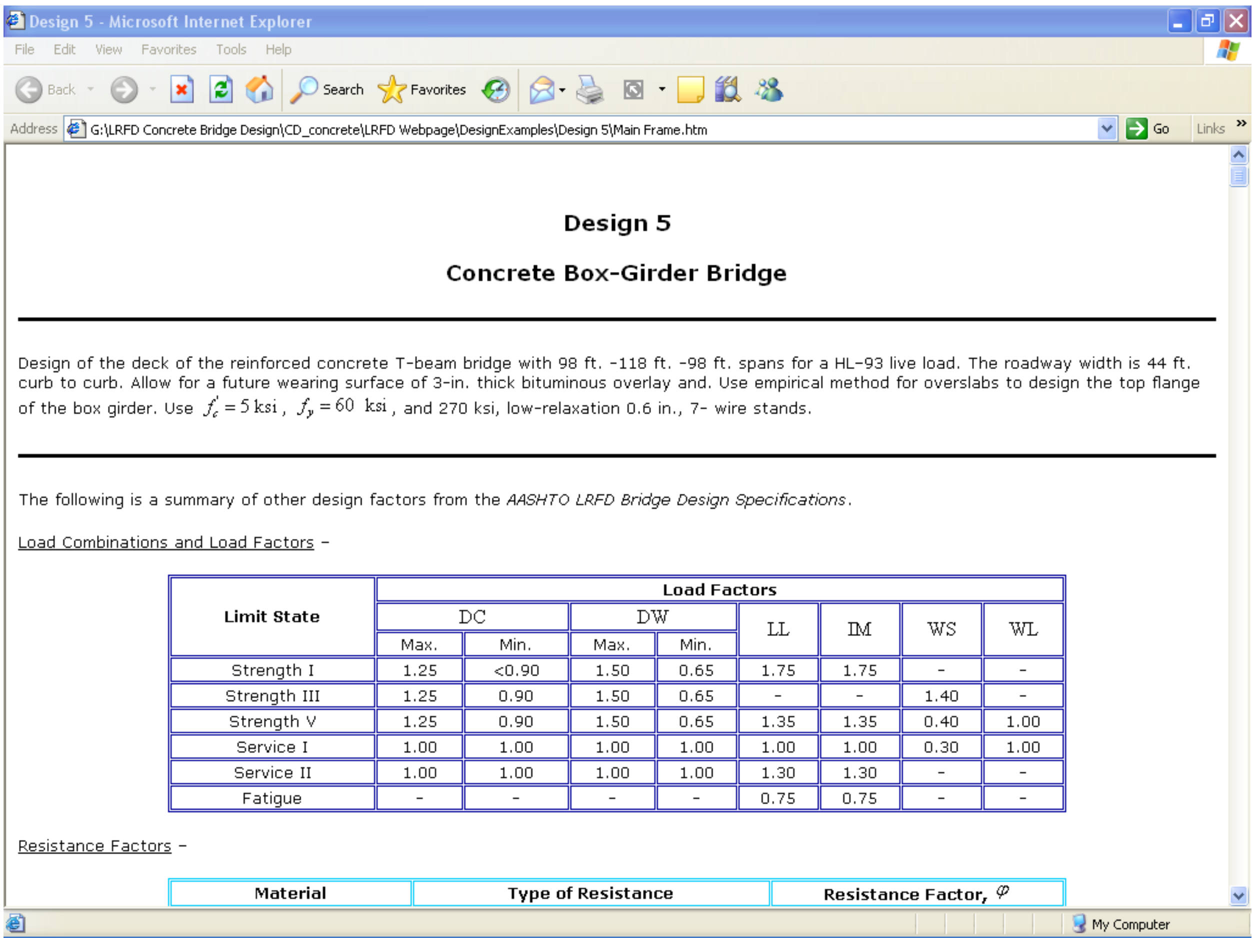


Figure 3-30. Page for design example #4.

Design Example #5

Design of the deck of the reinforced concrete T-beam bridge with 98 ft. -118 ft. -98 ft. spans for a HL–93 live load. (See Figure 3-31.) The roadway width is 44 ft. curb to curb. Allow for a future wearing surface of 3-in. thick bituminous overlay and. Use empirical method for overslabs to design the top flange of the box girder. Use $f'_c = 5$ ksi, $f_y = 60$ ksi, and 270 ksi, low-relaxation 0.6 in., 7- wire stands.



Design 5

Concrete Box-Girder Bridge

Design of the deck of the reinforced concrete T-beam bridge with 98 ft. -118 ft. -98 ft. spans for a HL-93 live load. The roadway width is 44 ft. curb to curb. Allow for a future wearing surface of 3-in. thick bituminous overlay and. Use empirical method for overslabs to design the top flange of the box girder. Use $f'_c = 5$ ksi, $f_y = 60$ ksi, and 270 ksi, low-relaxation 0.6 in., 7- wire stands.

The following is a summary of other design factors from the *AASHTO LRFD Bridge Design Specifications*.

Load Combinations and Load Factors –

Limit State	Load Factors							
	DC		DW		LL	IM	WS	WL
	Max.	Min.	Max.	Min.				
Strength I	1.25	<0.90	1.50	0.65	1.75	1.75	-	-
Strength III	1.25	0.90	1.50	0.65	-	-	1.40	-
Strength V	1.25	0.90	1.50	0.65	1.35	1.35	0.40	1.00
Service I	1.00	1.00	1.00	1.00	1.00	1.00	0.30	1.00
Service II	1.00	1.00	1.00	1.00	1.30	1.30	-	-
Fatigue	-	-	-	-	0.75	0.75	-	-

Resistance Factors –

Material	Type of Resistance	Resistance Factor, φ

Figure 3-31. Page for design example #5.

Design Example #6

Design a stub abutment to accommodate the given reactions from a composite steel superstructure. (See Figure 3-32.)

- A 3 span (29'-63'-29') essential bridge crossing a highway
- 1'-0" diameter concrete piles – 40 ft long. Capacity = 30 tons
- 18 pairs of piles at 6'-8" center-to-center along length of footer
- Concrete strength f_c' = 3,000 psi
- Grade reinforcement f_s = 24,000 psi
- Total reaction from all stringers R = 315 k
- Deck Weight = 21.74 k/ft.
- Geographic area has acceleration coefficient: A = 0.19
- Soil tests indicate stiff clay with angle of friction: ϕ = 30°

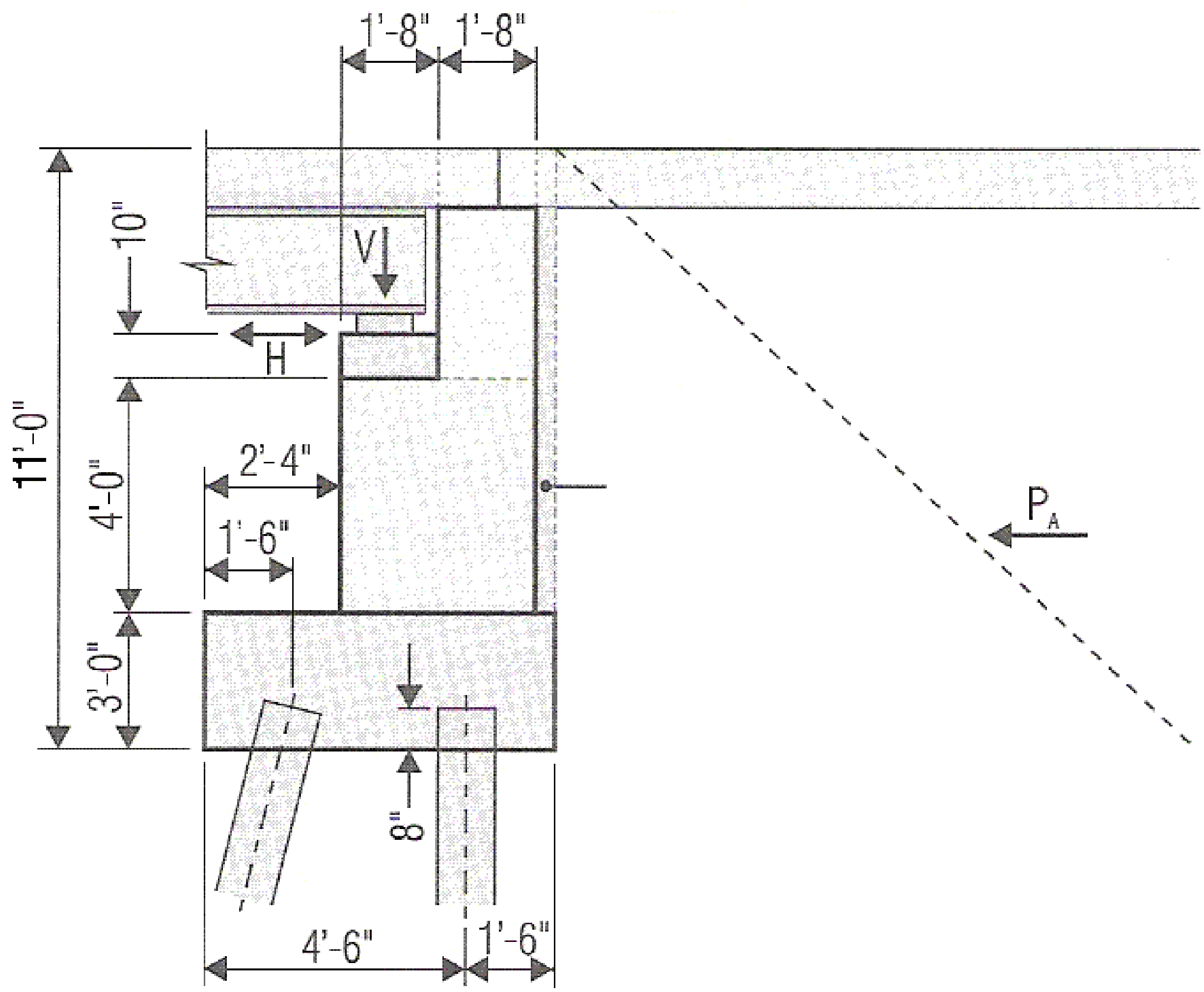


Figure 3-32. Stub abutment for design example #6.

Definitions

Alphabetized list of definitions is provided in this page and it is grouped according to chapters. See Figure 3-33.)

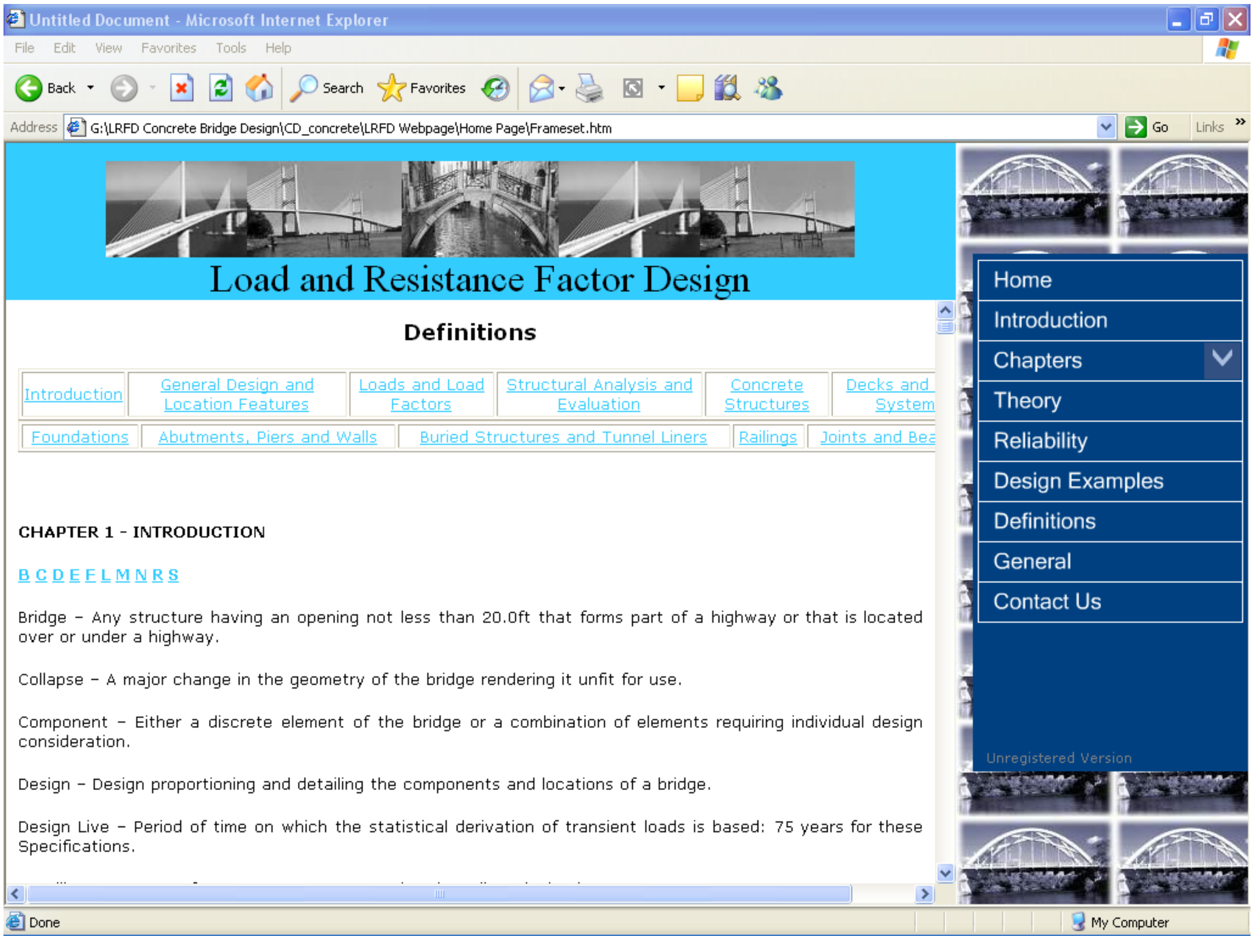


Figure 3-33. The definitions page defines some of the hardest words used in the lecture.

General

The general page provides information about the origin and the background of LRFD Specifications. (See Figure 3-34.) This section also shows the progress of states adopting and implementing the specifications through diagrams.

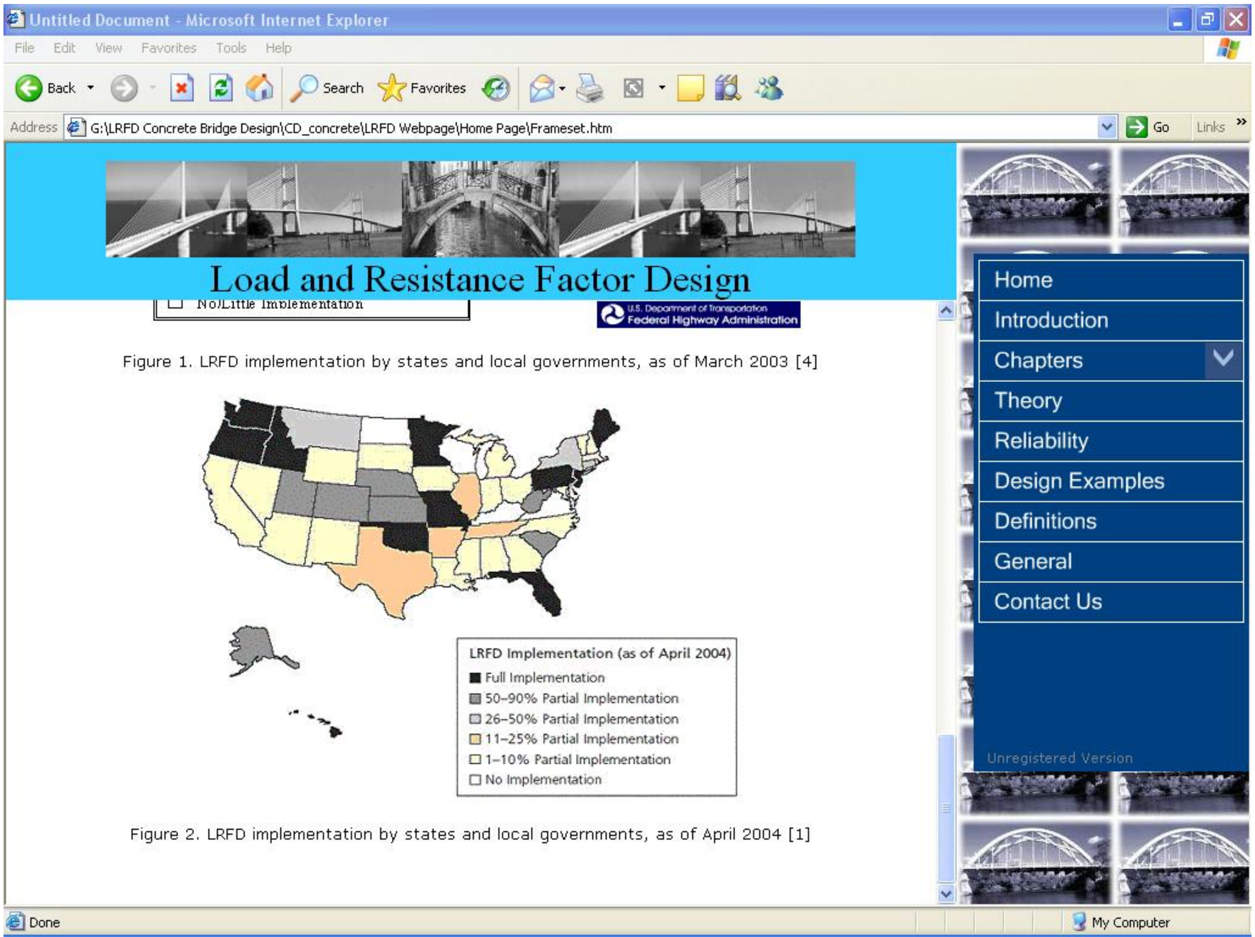


Figure 3-34. General page contains basic information about LRFD specifications.

Contact Us

This page provides the contact information of the principal investigator of the multimedia package. (See Figure 3-35.)

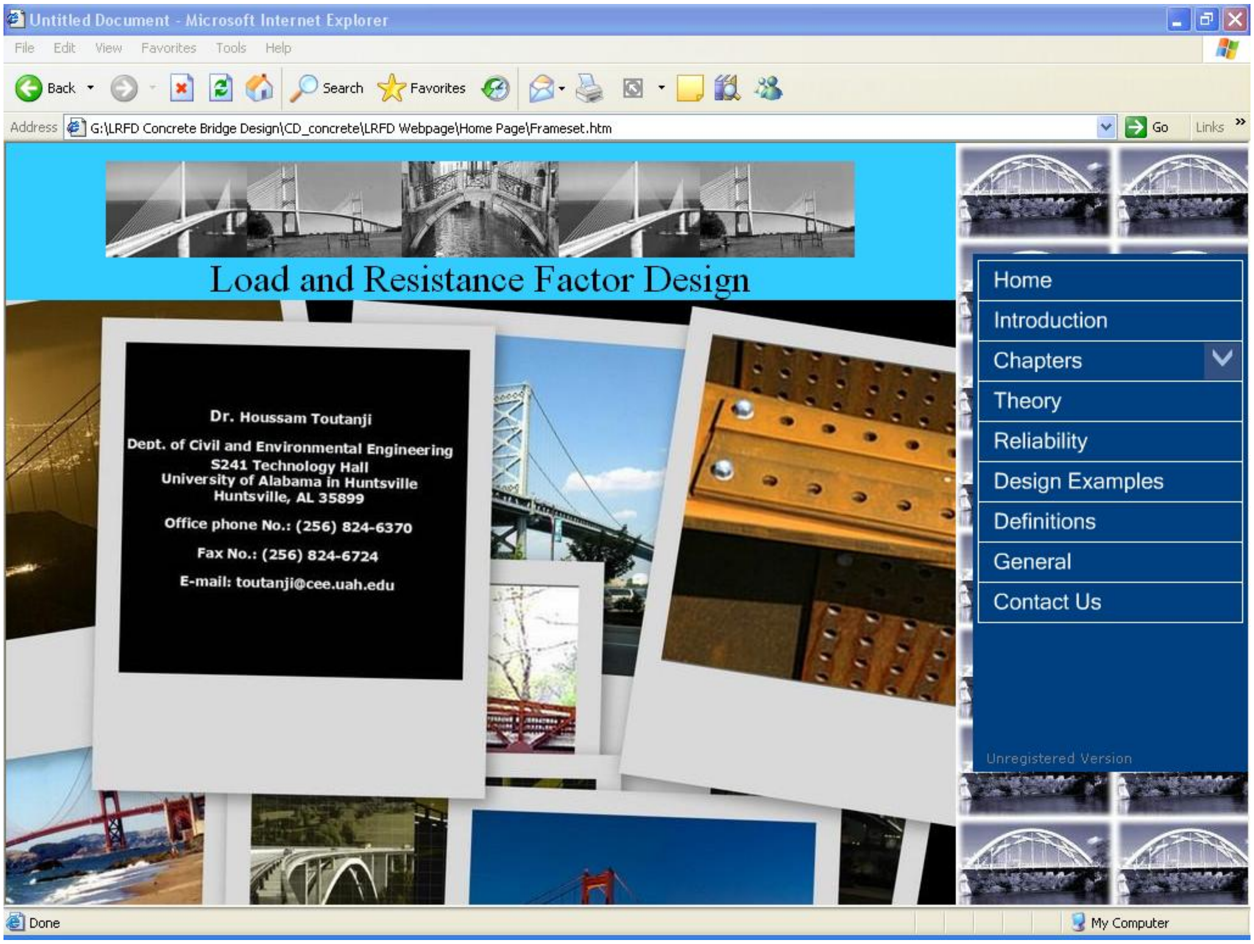


Figure 3-35. Contact page containing Dr. Toutanji's information.

4.0 Conclusions

The purpose of this project was to create a user-friendly CD-ROM with an attractive aesthetic for the viewer. The multimedia package brings the user full information about LRFD specifications. This tool can be used as a trainer for the study of the LRFD specifications that today's engineers and designers are using in the United States, and it can be updated to maintain the quality of its service to the highest level.

The multimedia technology is an advantage in many ways: step-by-step details are presented using diagrams, equations, examples, tables, definition, and theory. This multimedia package can be used like a reference tool for people trying to learn the complicated language of LRFD specifications. Another advantage is that the information can be modified whenever it is desired, able for updating the new requisites, and for including more examples.

This complete package will be available in the Department of Civil and Environmental Engineering at The University of Alabama in Huntsville. Its main purpose is to facilitate the labor to many inexperienced designers and engineers in the innovative field of LRFD specifications for bridge designs. The investigators or professors are responsible for updating it periodically or when it is necessary.

5.0 Suggested Reading

AASHTO Guide Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges, 1st ed. with 2005 Interim Revisions.

AASHTO LRFD Bridge Design Specifications: Customary U.S. Units, 4th ed.

Barker, R., and J. Pucket. *Design of Highway Bridges: An LRFD Approach, 2nd ed.* John Wiley and Sons, Inc., Hoboken, NJ, 2007.

http://obr.gcnpublishing.com/articles/brnov00b.htm

http://training.bossintl.com/html/highway-bridge-design.html

http://www.enm.bris.ac.uk/research/nonlinear/tacoma/tacoma.html

http://www.lrfd.com/Implementation_Status.htm

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http://www.normas.com/AISC/PAGES/325-01.html

http://www.personal.umich.edu/~nowak/Papers/Mertz,%20abs1,%204-19-02.pdf

http://www.tfhrc.gov/focus/july04/01.htm

http://www.transportation.org/sites/bridges/docs/concrete%20examle%20us.pdf

http://www.pupr.edu/pdf/civilpusp06.pdf

http://www4.trb.org/trb/crp.nsf/0/6306c417bc81d2758525674800561ad4?

https://txspace.tamu.edu//bitstream/1969.1/3096/1/etd-tamu-2005C-CVEN-Adnan.pdf

https://txspace.tamu.edu/bitstream/1969.1/4841/1/etd-tamu-2005C-CVEN-Mohammed.pdf