Development of Multimedia Resource and Short Courses for LRFR Rating

By

Dr. Houssam A. Toutanji
Department of Civil & Environmental Engineering
The University of Alabama in Huntsville
Huntsville, Alabama

Prepared by

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University Transportation Center for Alabama
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and The University of Alabama at Huntsville

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16. Abstract

Multimedia technology is an important instrument in the training of graduate engineers. This multimedia package provides an exclusive background and an in-depth understanding of recent technological advances in the evaluation and rating of highway bridges. It gives guidelines and step-by-step illustrative examples using either hand calculation or Virtis™ software for the rating of different types of bridges according to the first edition of *The Manual for Bridge Evaluation* (2008). One advantage of the package is that it can be conveniently updated and modified to keep it useful for today's engineers.

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Executive Summary

Multimedia technology is an important instrument in the training of graduate engineers. This multimedia package provides an exclusive background and an in-depth understanding of technological advances in the evaluation and rating of highway bridges. It gives guidelines and step-by-step illustrative examples using either hand calculations or Virtis™ software for the rating of different types of bridges according to the first edition of *The Manual for Bridge Evaluation* (2008). One advantage of the package is that it can be conveniently updated and modified to keep it useful for today's engineers.

The first edition of the *Manual for Bridge Evaluation* (MBE) was adopted by the AASHTO Highway Subcommittee on Bridges and Structures in 2005 and published in 2008. MBE combines the second edition of the *Manual for Condition Evaluation of Bridges* and the *Guide Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges* into a single standard for bridge evaluation and rating. It provides three methods—ASR, LFR, and LRFR—for bridge rating without preference, and it is consistent with other major bridge codes adopted or being adopted, such as *AASHTO Standard Specifications for Highway Bridges* and *AASHTO LRFD Bridge Design Specifications*. LRFR incorporates design analysis and rating methods with different kinds of load factors and resistance factors, which are based on material properties and the known variability of applied loads.

This multimedia package teaches the basis on which engineers can evaluate highway bridges and calculate the rating factors. It includes illustrative examples and an overview of the strategic development of the structural code. This software is intended to be a self-training tool for inexperienced engineers who are interested in learning about the bridge-evaluation and bridge-rating procedures. It contains procedures and specifications for each possible situation together with detailed examples and illustrations. It is a time-saving, user-friendly, reliable way of learning.

Section 1
Introduction

The main goal of the LRFR multimedia package is to provide a practical introduction and in-depth understanding of the rating procedures. This package can be used to train engineers, architects, designers, and personnel who are in charge of the management, evaluation, rating, maintenance, and reconstruction of bridges. It is a self-training and time-saving tool. The package includes instructions of procedures of bridge evaluation and rating based on the *Manual for Bridge Evaluation* and several examples from which the user can get an overview of the evaluation and rating process.

Load and Resistance Factor Rating (LRFR) is a rating method providing uniform reliability for load effects and structure resistances. The *Manual for Bridge Evaluation* provides not only the specifications for bridge management and evaluation but also the procedures for three bridge-rating methods: ASR, LFR, and LRFR. Load and Resistance Factor Design specifications are fully adopted nationwide as a single design method and procedure, so many states have been working to implement LRFR, which is the parallel rating method to LRFD.

For new bridges designed by LRFD after October 1, 2010, the operating rating and inventory rating are to be computed and reported to the NBI as an RF based on LRFR methods using HL-93 loading. An introduction comparing the three rating procedures (ASR, LFR, and LRFR) is included on the CD.

The CD package offers 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 designed to run on different operating systems. It is a self-training and time-saving tool. One advantage of this package is that it is easily updated.

Section 2
Methodology

An extensive review of the existing literature and information available on bridge rating was performed. Since LRFR is a new topic, step-by-step rating procedures were included in the package for better understanding.

The package is divided into four parts. The first part, LRFR Basic Knowledge, has eight sections. Each section contains specific equations, tables, and diagrams of relevance. The second part, Illustrative Examples, has five sections. These sections are composed of nine rating procedure examples using hand calculations. The third part, Virtis™ Rating Examples, consists of four rating examples using Virtis™. The fourth part, Search Engine, provides a platform for users to look up technical definitions related to LRFD and LRFR and to search for a topic included in the package. To utilize the benefits of a multimedia product to the fullest, hyperlinks were created in all the sections as well as the design examples to quickly access the required details. This package was created using Macromedia Dreamweaver MX.

For updates to the multimedia package according to the MBE, including recommendations from ALDOT (Alabama Department of Transportation), the PI's contact information is included in the package.

Section 3
CD-ROM Description

This multimedia package includes a homepage together with section pages and basic theory concepts. It also provides the user with nine manual-calculation bridge-rating examples, four Virtis™ rating examples, and several links to helpful bridge-evaluation and -rating resources. It also includes a search-engine webpage that provides many definitions. The following is a description of these sections.

3.1 Homepage

The homepage explains the goals and advantages of the software and provides an overview of the package's contents. This multimedia package is a self-training tool providing information on MBE and bridge-rating procedures (see Figure 3-1). In the left column are dropdown lists that provide links to the package contents.

Figure 3-1. The homepage

3.2 Introduction

The introduction page provides brief information about bridge rating and LRFR. This page answers several questions about bridge rating: *what are specifications and codes about load rating? what is load rating for highway bridges?* and so on. It introduces the user to general knowledge about bridge rating (see Figure 3-2).

Figure 3-2. The Introduction page answers FAQs

3.3 Terminology

The terminology page provides basic definitions about bridge rating and LRFR (see Figure 3-3). (More comprehensive terminologies and definitions about bridge design and rating are found in Section 4, Search Engine.)

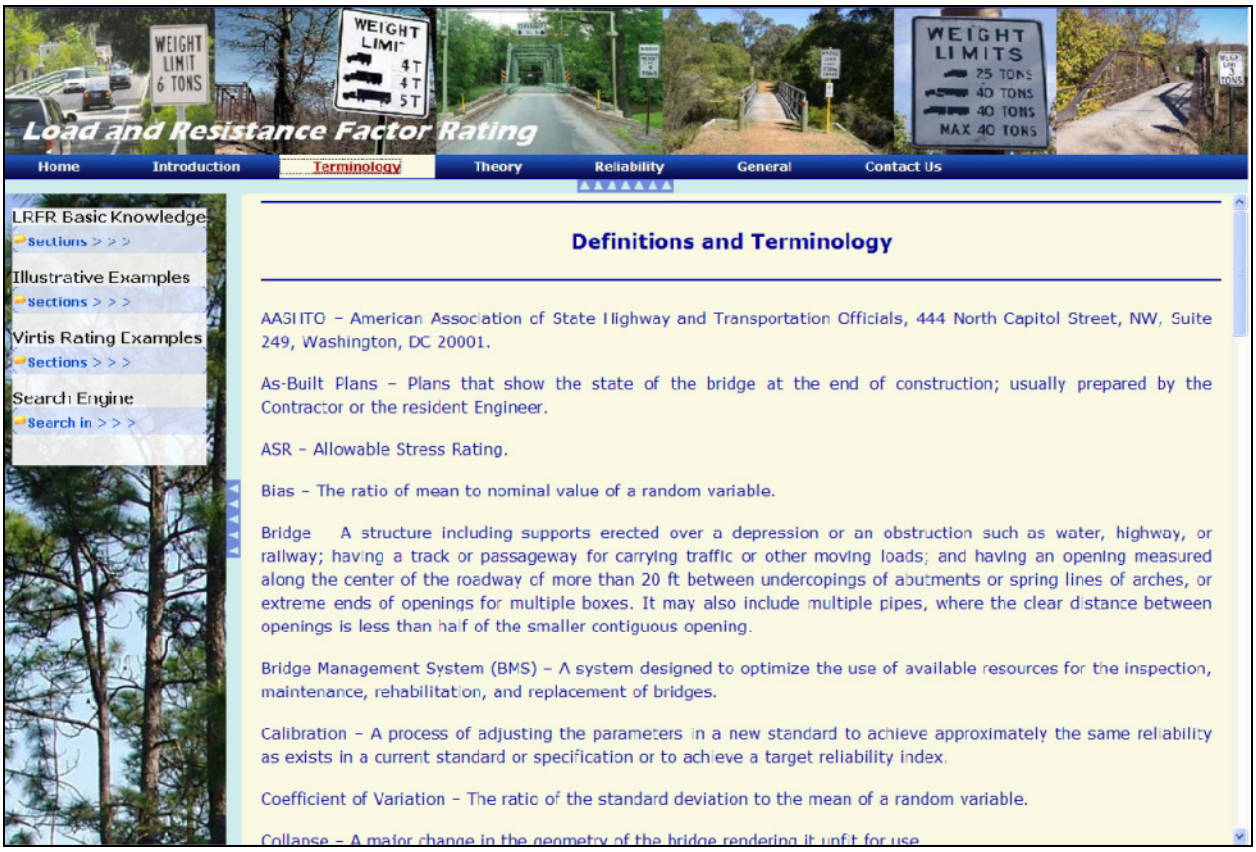


Figure 3-3. Definitions and terminologies

3.4 Theory

On the theory page, the general theory behind three rating methods—Allowable Stress Rating, Load Factor Rating, and Load and Resistance Rating—is discussed (see Figure 3-4).

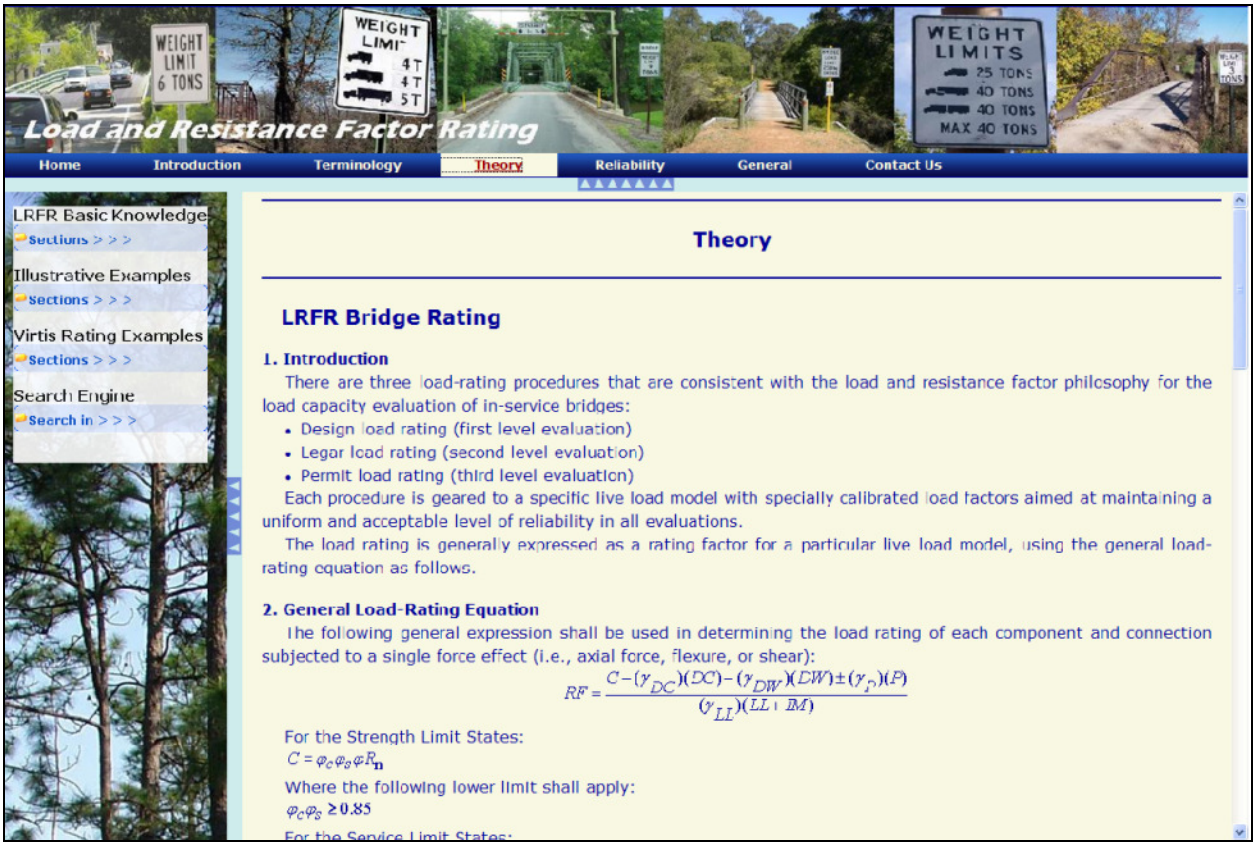


Figure 3-4. Basic theory behind rating methods

3.5 Reliability

The reliability page provides history behind bridge evaluations and the relation between reliability theory and LRFR ratings (see Figure 3-5).

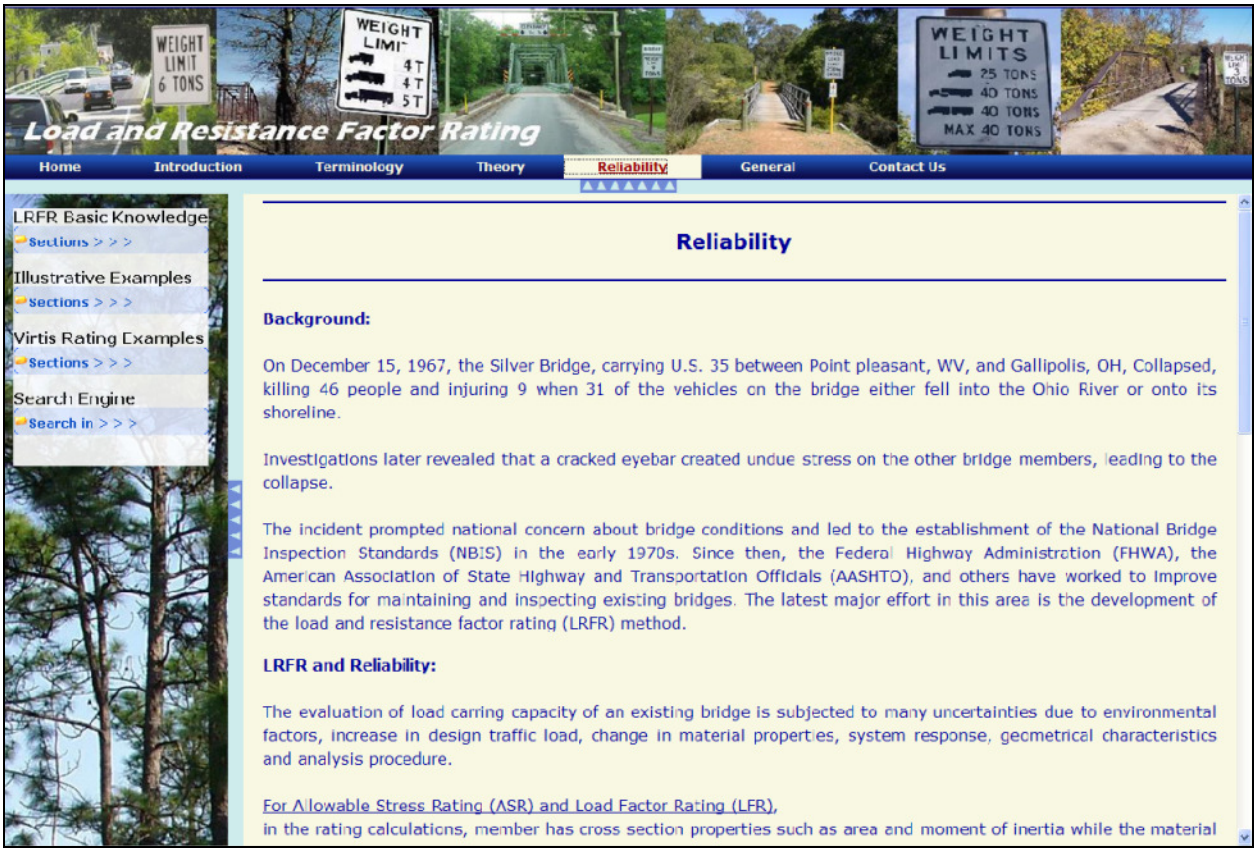


Figure 3-5. LRFR ratings and reliability theory

3.6 General

This page presents the introduction of bridge ratings and several rating methods (see Figure 3-6).

Figure 3-6. Background and comparisons

3.7 Description of Parts

3.7.1 LRFR Basic Knowledge

The following eight sections and their contents are from the first edition of the *Manual for Bridge Evaluation* (2008).

3.7.1.1 Introduction Section 1 introduces four topics: 1) the purpose of bridge evaluation and rating, 2) the scope of bridge evaluation and rating to give users a general introduction for the contents in the package, 3) applicability to inform users which kind of highway bridge is considered in this package, and 4) quality measures to emphasize the importance of quality control during bridge evaluation (see Figure 3-7).

Figure 3-7. Introduction page for Section 1

3.7.1.2 Bridge Files This section describes bridge files, inventory data, inspection data, and data collected for bridge load rating (see Figure 3-8).

The data required for condition rating and load-rating procedure are:

1. Bridge Condition Rating. Document the results of the bridge-condition inspection, including observed conditions and recommended maintenance operations or restrictions regarding the deck, superstructure, substructure, and channel.
2. Load Rating. A record should be kept of the calculations to determine the safe load capacity of a bridge and, where necessary, the load limits for posting. A general statement of the results of the analysis with notes of which members were found to be weak, and any other modifying factors that were assumed in the analysis, should be given. See Section 6 for the load-rating procedures.

Figure 3-8. Bridge files

3.7.1.3 Bridge Management Systems Section 3 provides information about bridge management systems (BMSs): 1) the objectives of BMS, 2) the components of a bridge management system, and 3) national bridge management systems (see Figure 3-9).

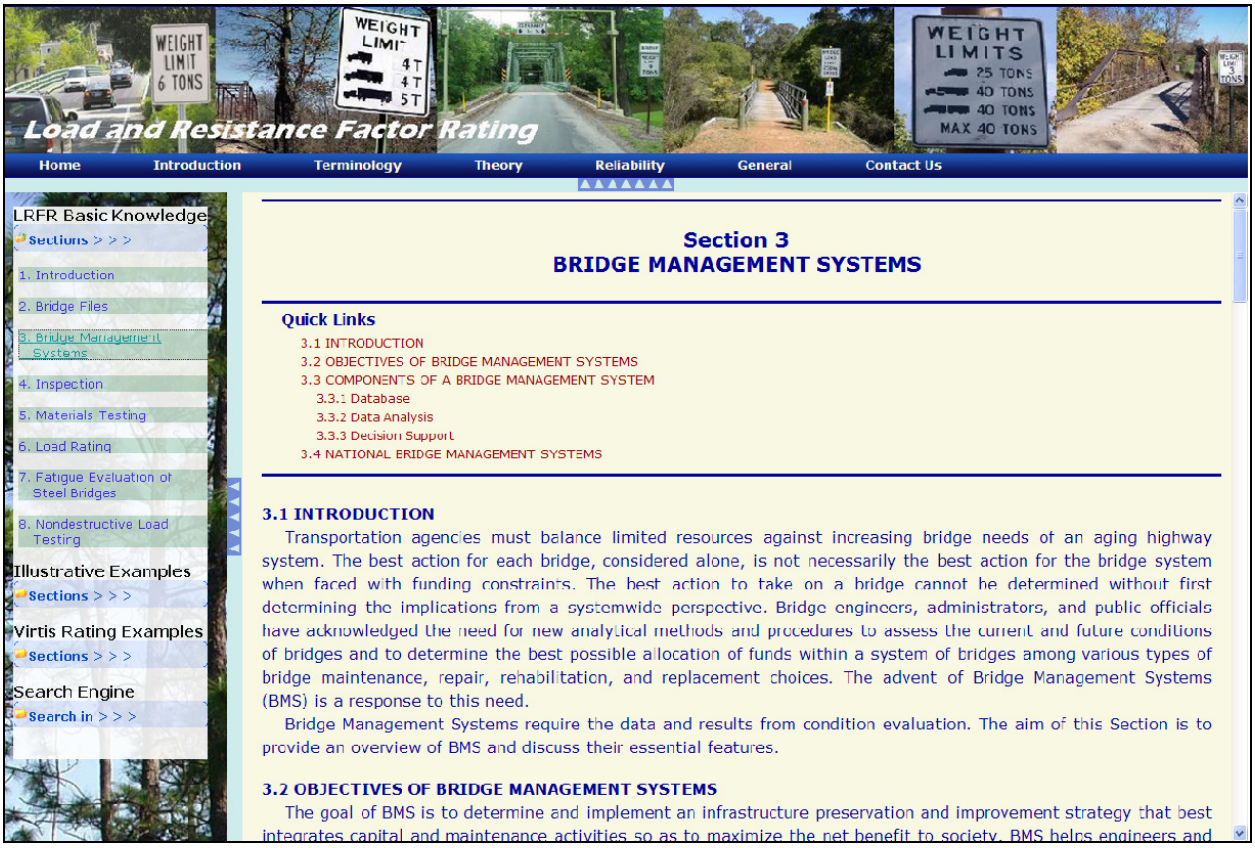


Figure 3-9. Bridge management systems

3.7.1.4 Inspection Section 4 introduces several aspects of bridge inspection: types of inspection, frequency of inspection, inspection safety, inspection procedures, and so on. Subsection 3 also provides inspection requirements for fatigue-prone members and fracture-critical members (see Figure 3-10).

In inspection-procedure specifications, the members of bridges are grouped into three types: substructure, superstructure, and decks. The MBE gives detailed procedures for inspecting each type of bridge member.

Figure 3-10. Inspection

3.7.1.5 Material Testing Section 5 provides knowledge related to material testing. It introduces field-test methods for concrete, steel, and timber bridges. It also describes field-sampling requirements and laboratory testing (see Figure 3-11).

Figure 3-11. Material testing

3.7.1.6 Load Rating This section provides the requirements and procedures of three rating methods: Allowable Stress Rating (ASR), Load Factor Rating (LFR), and Load and Resistance Factor Rating (LRFR) (see Figure 3-12).

Part 6A covers LRFR and Part 6B covers ASR/LFR. These two subsections detail requirements and procedures for all three methods.

Figure 3-12. Load rating

3.7.1.7 Fatigue of Steel Bridges This section covers a special topic: fatigue of steel bridges. It provides the inspection requirements for steel bridges and introduces a method to estimate finite fatigue life (see Figure 3-13).

Figure 3-13. Fatigue of steel bridges

3.7.1.8 Nondestructive Load Testing This section contains provisions for nondestructive load testing. Load testing is the observation and measurement of the response of a bridge subjected to controlled and predetermined loadings without causing changes in the elastic response of the structure. Load tests can be used to verify both component and system performance under a known live load and provide an alternative evaluation method to analytically computing the load rating of a bridge (see Figure 3-14).

Figure 3-14. Nondestructive load testing

3.7.2 Illustrative Examples

The following five parts illustrate bridge rating using manual calculations.

3.7.2.1 Introduction and General Information In this section several aspects about rating procedure are detailed, such as background knowledge and loads used in load rating (see Figure 3-15).

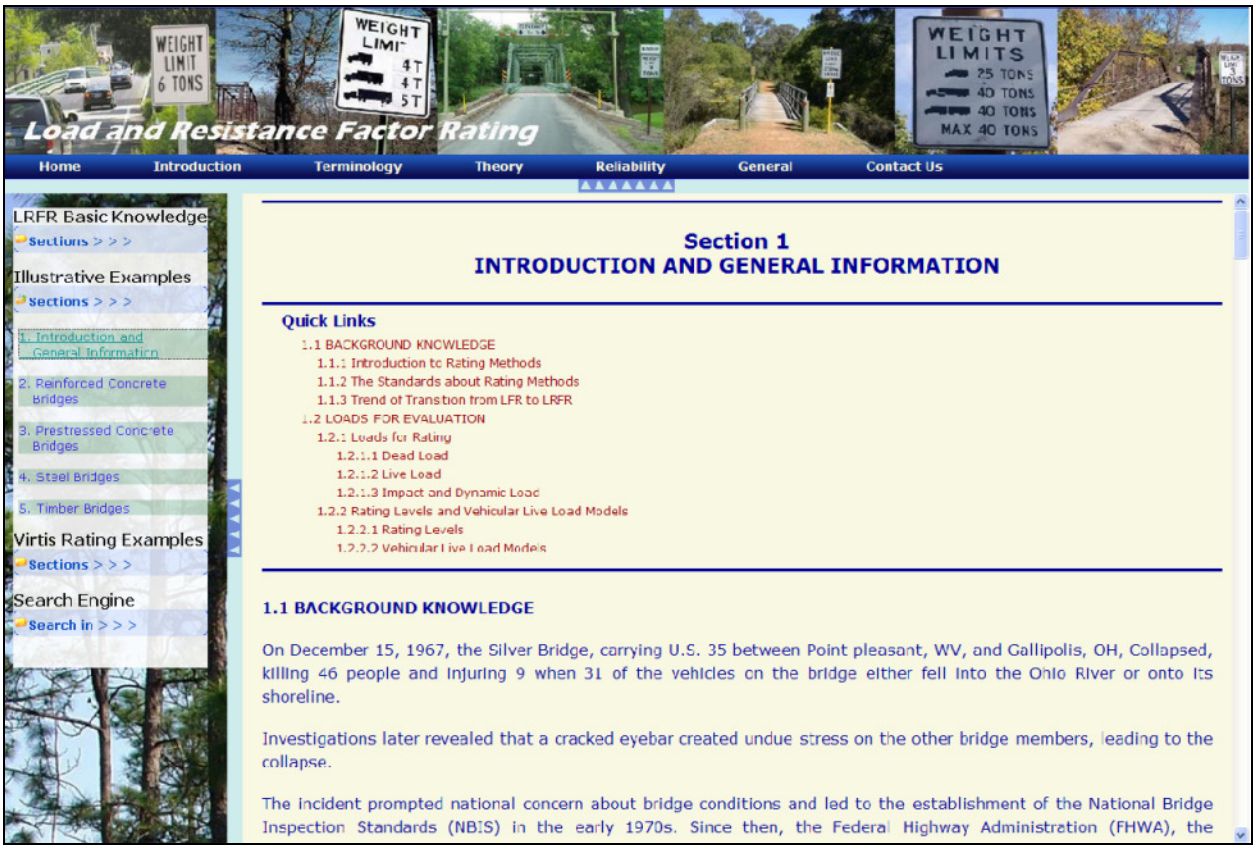


Figure 3-15. Introduction and general information about bridge rating

3.7.2.2 Reinforced-Concrete Bridge-Rating Examples This section contains two typical concrete superstructure bridge-rating examples. The first is a reinforced concrete T-beam bridge. The interior beam is rated with ASR, LFR, and LRFR respectively (see Figure 16). The second example is a general outline of the procedure (see Figure 17). The second example intended to be a generic overview of the rating process.

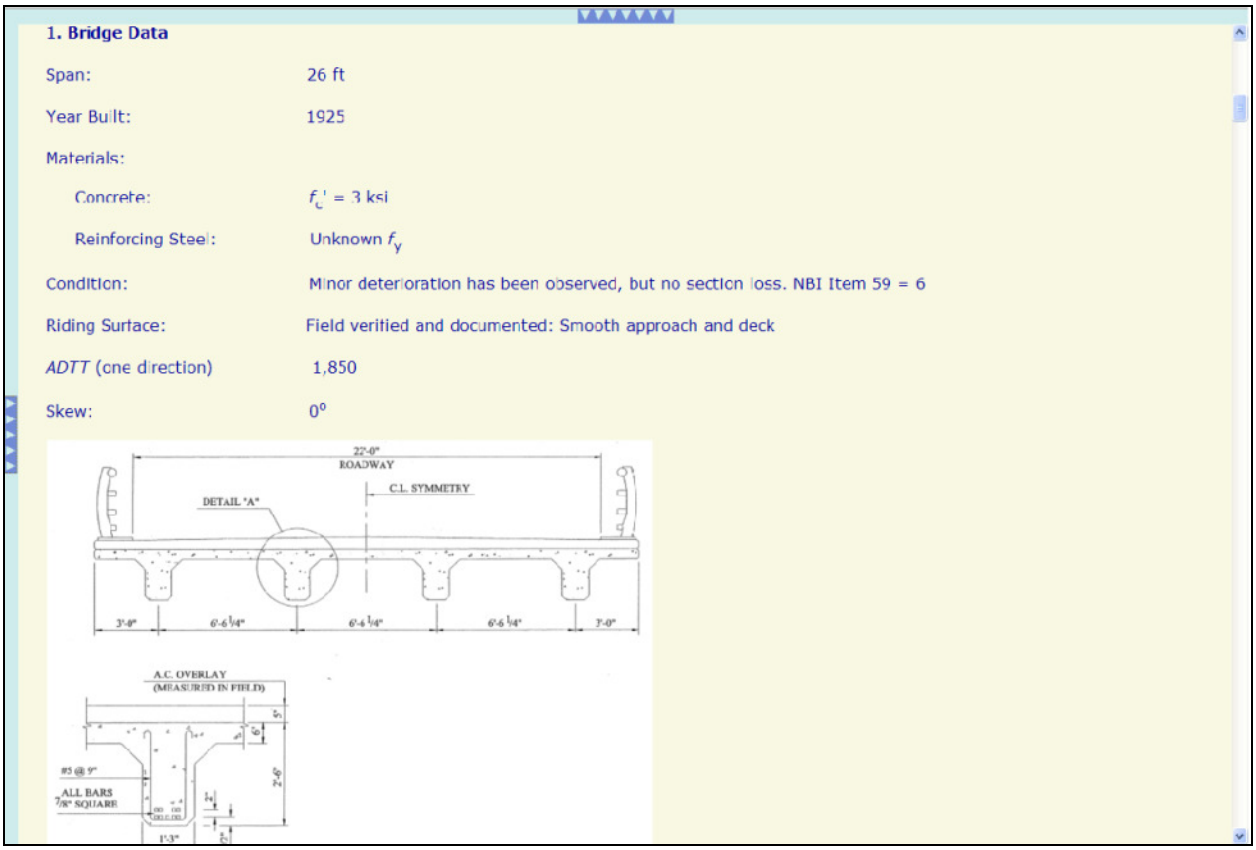


Figure 3-16. Reinforced-concrete bridge-rating example #1

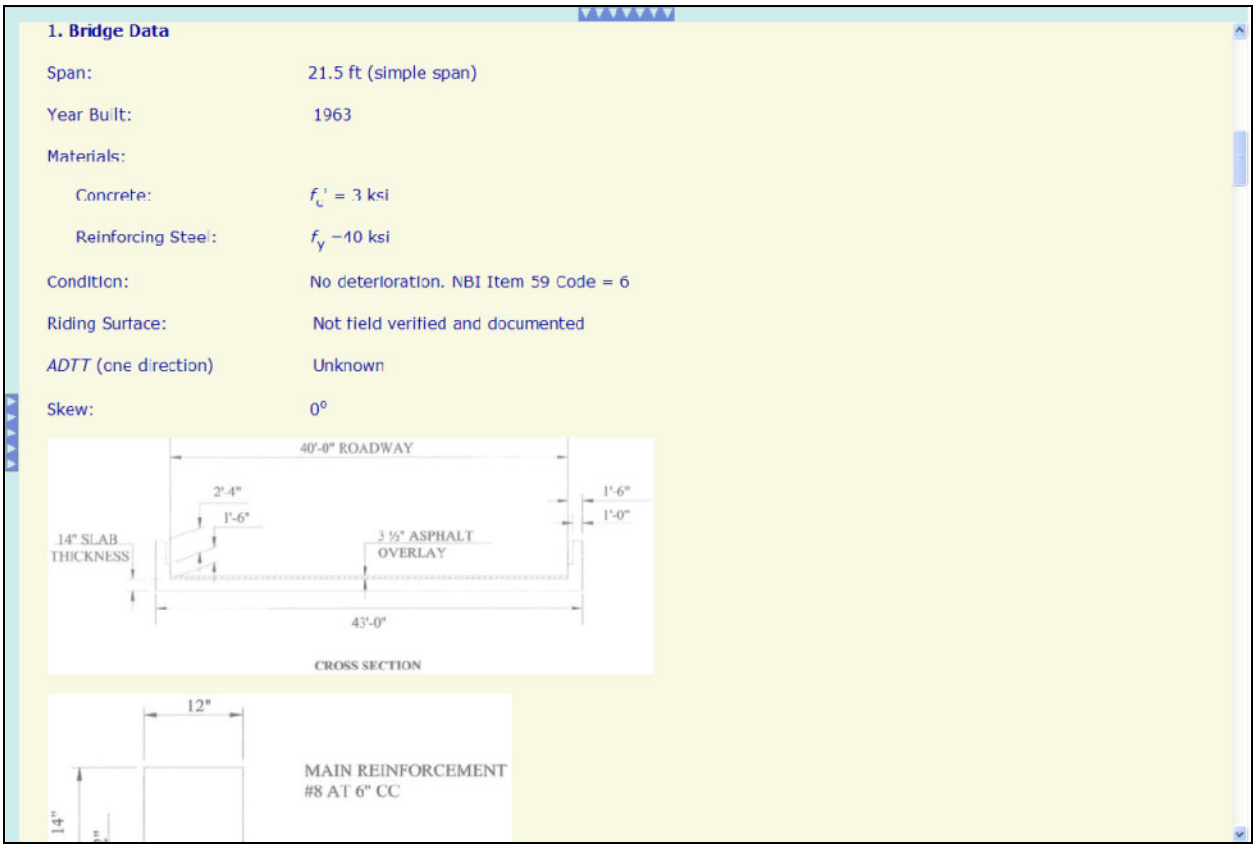


Figure 3-17. Reinforced-concrete bridge-rating example #2

3.7.2.3 Prestressed Concrete Bridge Rating Examples This section uses two prestressed-concrete bridges as rating examples. The first is a simple span prestressed-concrete I-girder bridge (see Figures 3-18). The second is a prestressed-concrete adjacent box-beam bridge (see Figures 3-19).

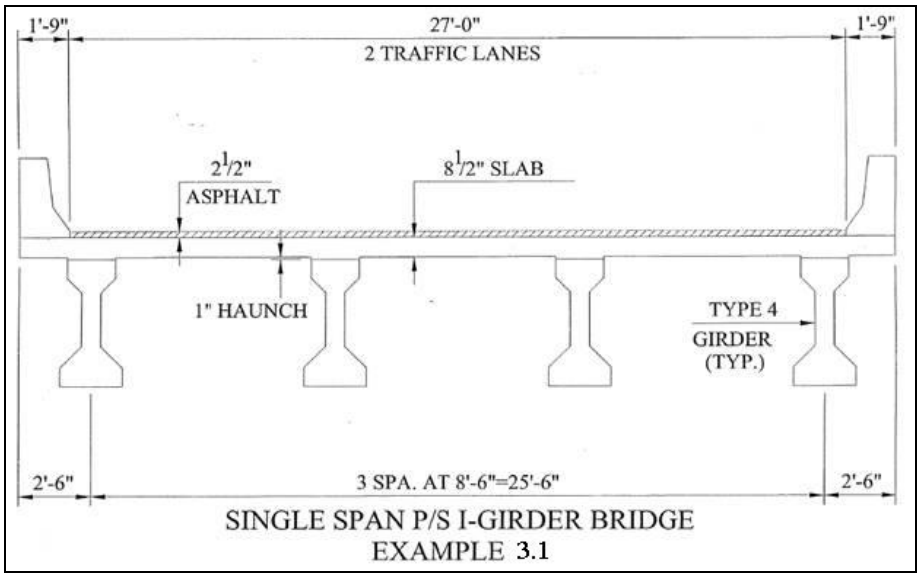


Figure 3-18a. Prestressed-concrete bridge-rating example #1 cross section

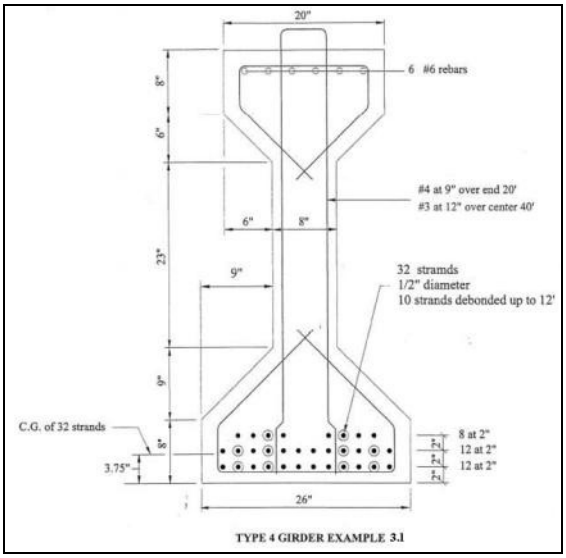


Figure 18b. Prestressed-concrete bridge-rating example #1 I-girder

1. Bridge Data

Span:	80 ft (Total Length = 81 ft)
Year Built:	1985
Materials:	
Concrete:	f_c' = 4 ksi (Deck)
	f_c' – 5 ksi (P/S Beam)
	f_{ci}' – 4 ksi (P/S Beam at transfer)
Prestressing Steel:	½ in. diameter, 270 ksi, Low-Relaxation Strands
	A_{ps} = 0.153 in.^{2} per strand
	32 prestressing strands; ten are debonded over the last 12 ft on each end
Stirrups:	#4 at 9 in. over end 20 ft
	#3 at 12 in. over center 40 ft
Compression Steel:	six #6 Grade 60
Condition:	No Deterioration, NBI Item 59 Code=6
Riding Surface:	Minor surface deviations (Field verified and documented)
ADTT (one direction)	5,000
Skew:	0°
Effective Flange Width	b_e LRFD Design 4.6.2.6.1
Minimum of:	
i)	*L*)

Figure 18c. Page for prestressed-concrete bridge-rating example #1

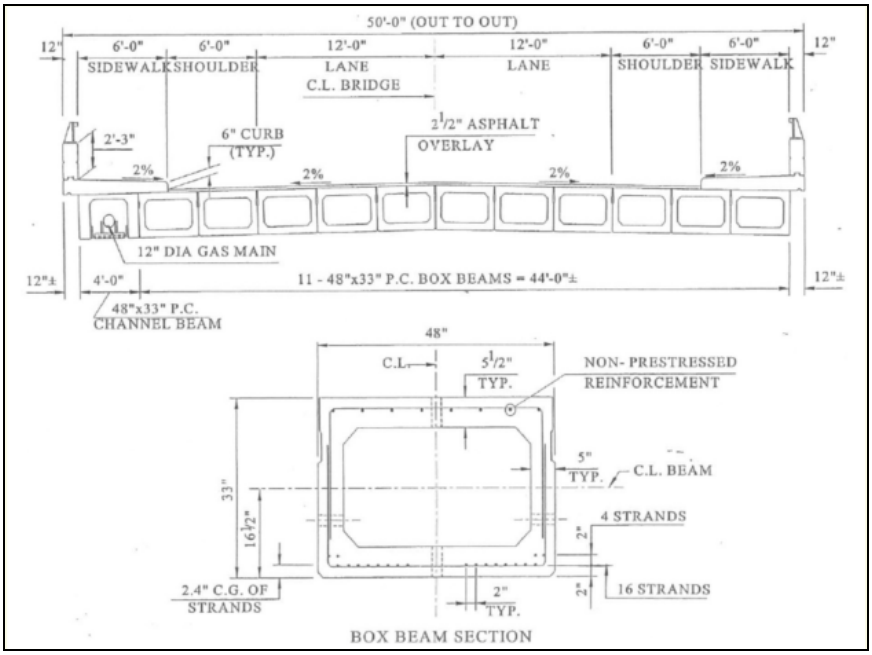
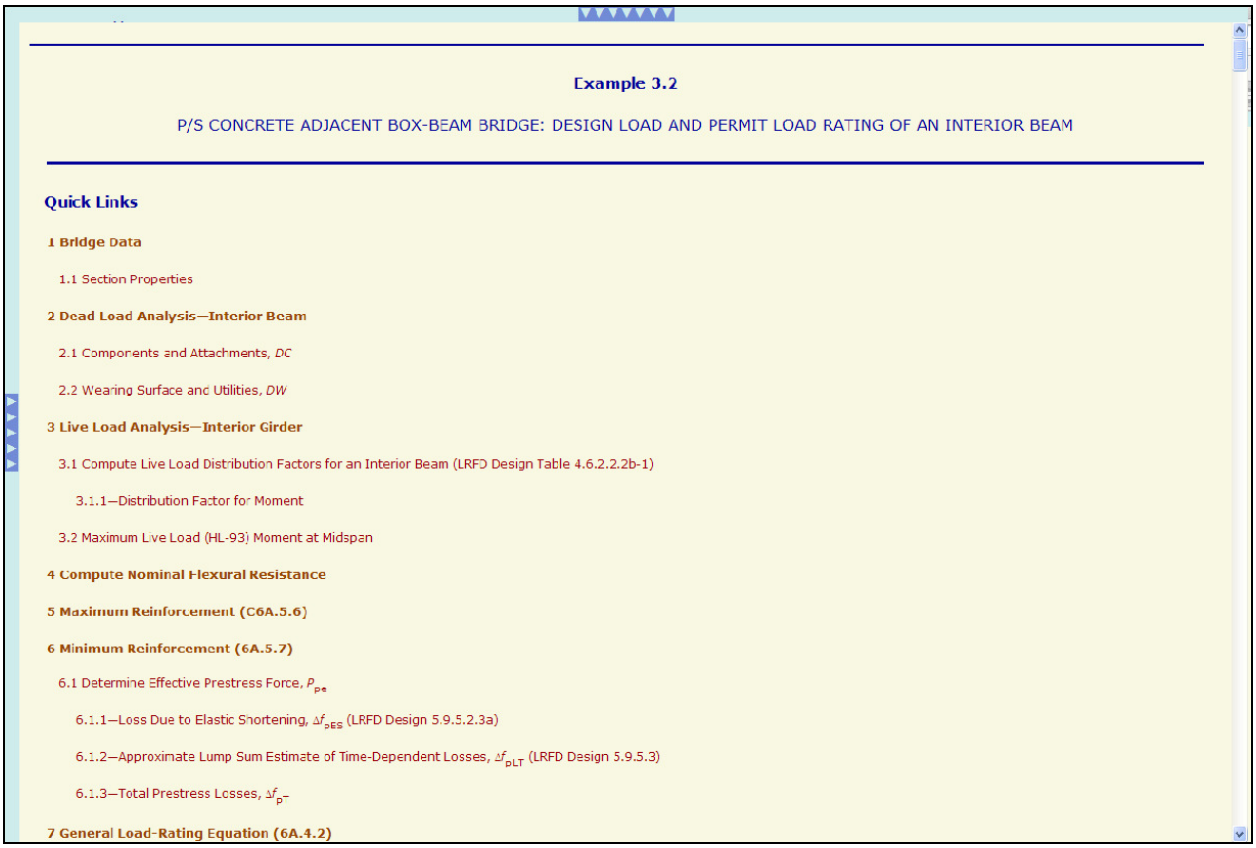


Figure 19a. Prestressed-concrete bridge-rating example #2 cross section



Example 3.2

P/S CONCRETE ADJACENT BOX-BEAM BRIDGE: DESIGN LOAD AND PERMIT LOAD RATING OF AN INTERIOR BEAM

Quick Links

Figure 19b. Page for prestressed-concrete bridge-rating example #2

3.7.2.4 Examples for Rating Steel Bridges This section contains rating examples for four typical steel bridges. The first is a simple span composite-steel stringer bridge (see Figure 3-20). The second is a four-span continuous straight welded plate girder bridge (see Figure 3-21). The third is a through Pratt truss bridge (see Figure 3-22). The fourth is a two-girder steel bridge (see Figure 3-23).

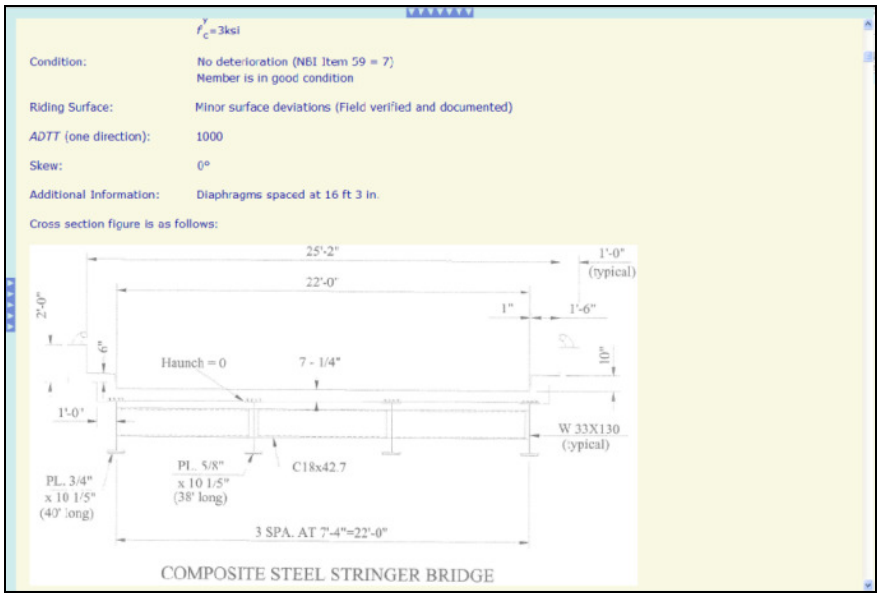


Figure 3-20. Example #1 for rating steel bridges

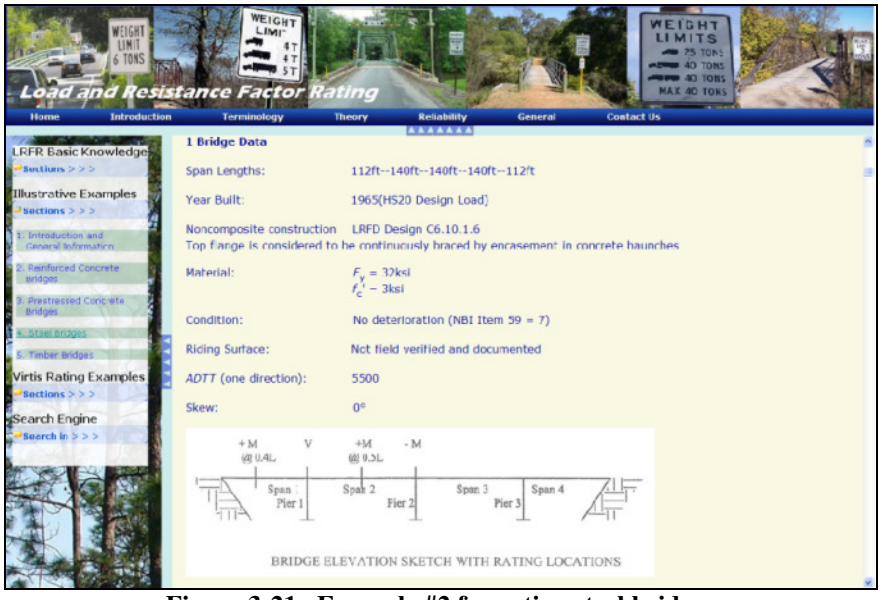


Figure 3-21. Example #2 for rating steel bridges

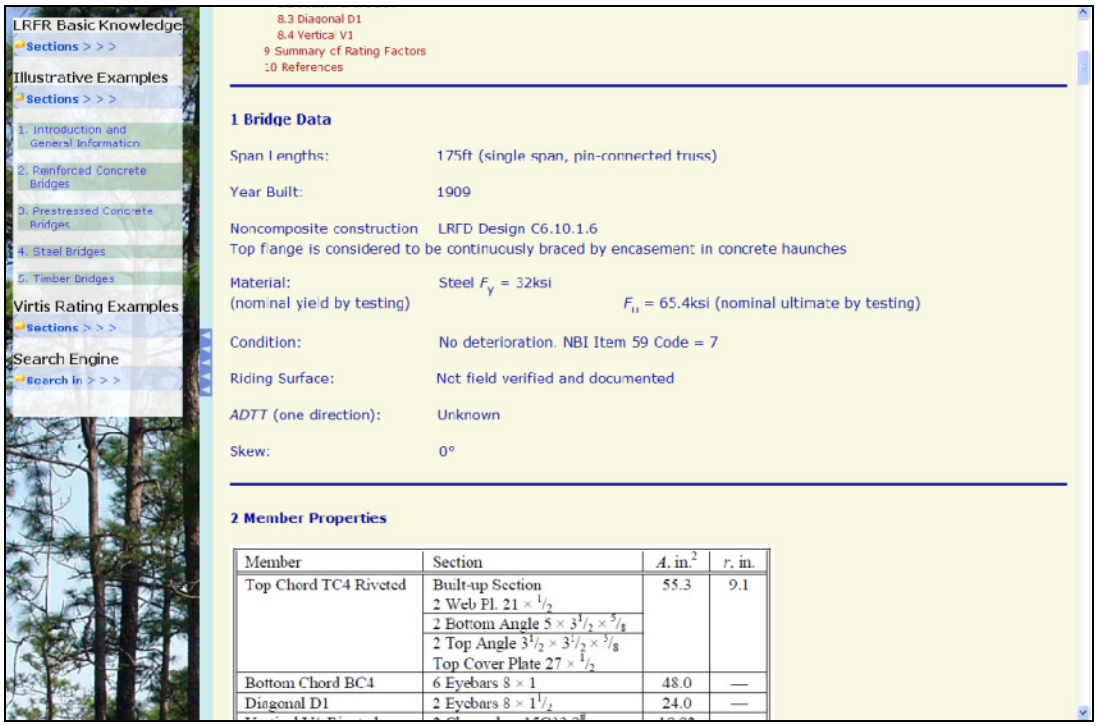


Figure 3-22. Example #3 for rating steel bridges

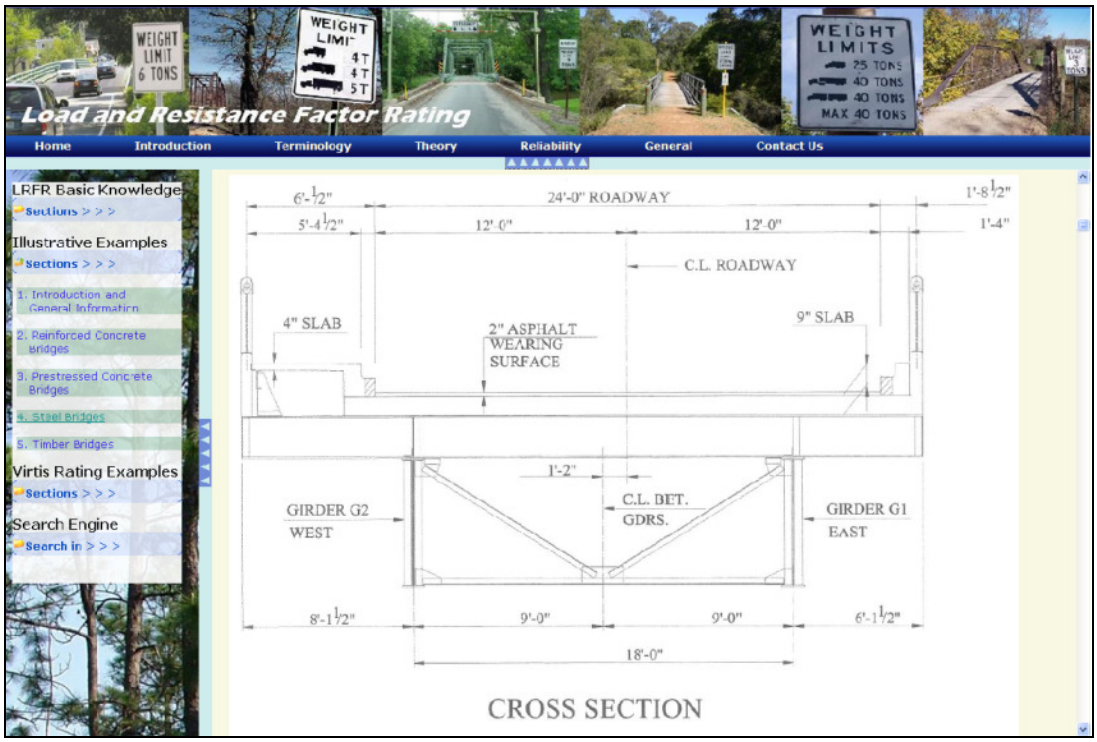


Figure 3-23. Example #4 for rating steel bridges

3.7.2.5 An Example for Rating Timber Bridges This section contains an example for rating a timber bridge with ASR/LFR and LRFR methods (see Figure 3-24). The rating process is presented procedurally. The outline and summary of the rating procedure is also shown in the example. The users of this section may get a thorough and clear understanding of the rating process for timber bridges.

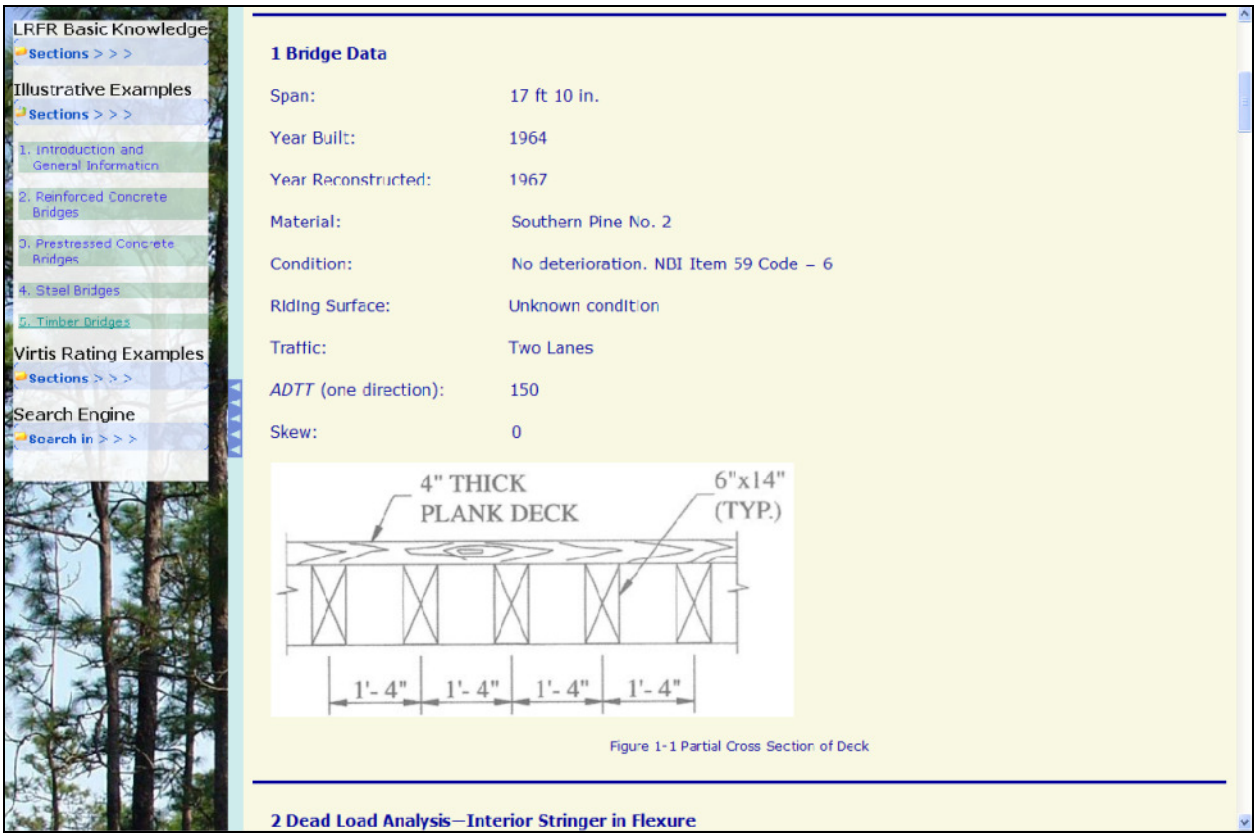


Figure 3-24. Example for rating a timber bridge

3.7.3 Virtis™ Rating Examples

This part contains four sections. The first section is introduction to Virtis™. The other three are Virtis™ bridge-rating examples.

3.7.3.1 Introduction to Virtis™ An introduction to AASHTO's Virtis™ software for bridge rating is presented in this section (see Figure 3-25). This section describes several features of this rating software.

Figure 3-25. Introduction to Virtis™

3.7.3.2 Virtis™ Reinforced Concrete Bridge Rating Example This section includes one rating example for a typical reinforced-concrete bridge using Virtis™ (see Figure 3-26). The rating process is presented procedurally with detailed pictures of Virtis™ operations. The outline and summary of the rating procedure is also shown. The users of this section may get a general understanding of the rating process for reinforced-concrete bridges using Virtis™.

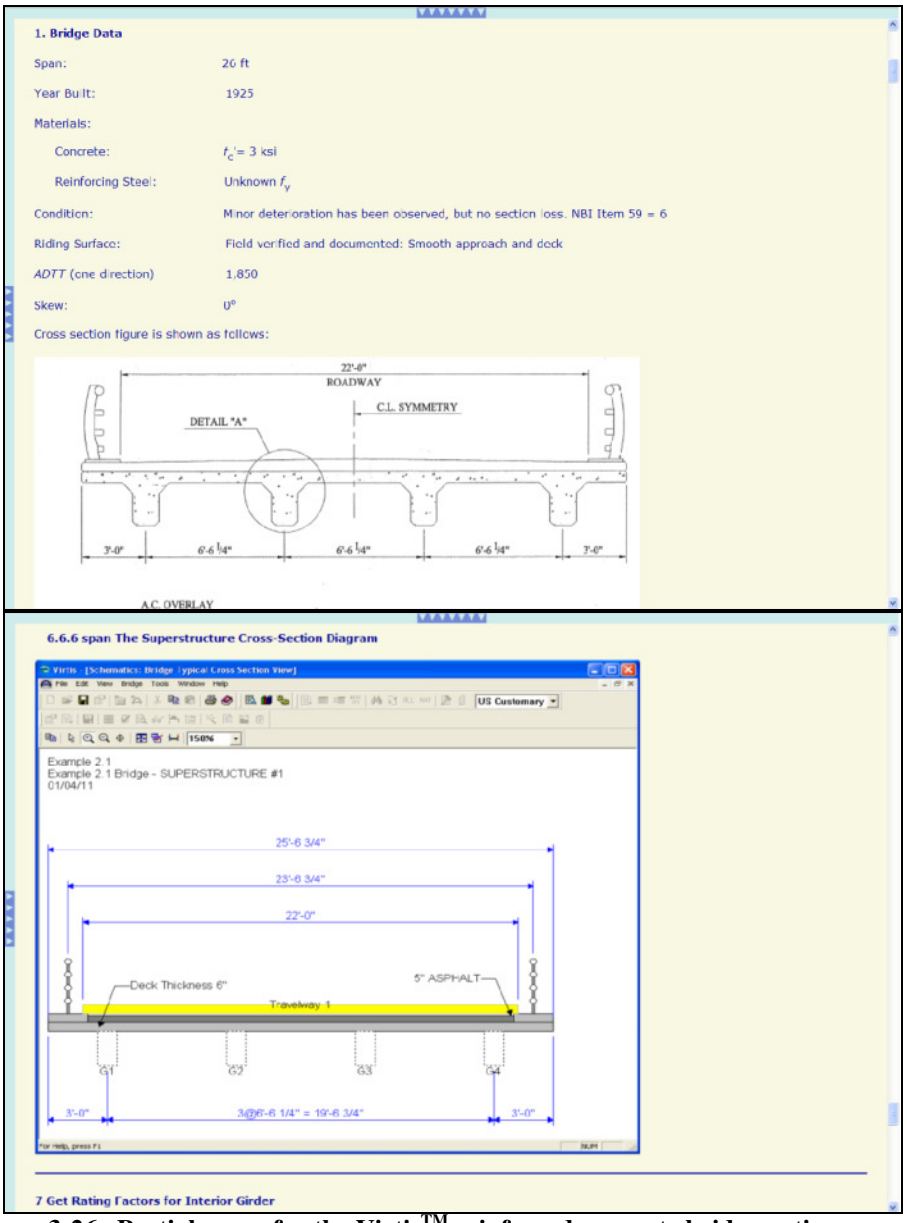


Figure 3-26. Partial pages for the Virtis™ reinforced-concrete bridge-rating example

3.7.3.3 Virtis™ Rating Example for Prestressed-Concrete Bridge This section contains a rating example for a typical prestressed-concrete bridge using Virtis™ (see Figure 3-27).

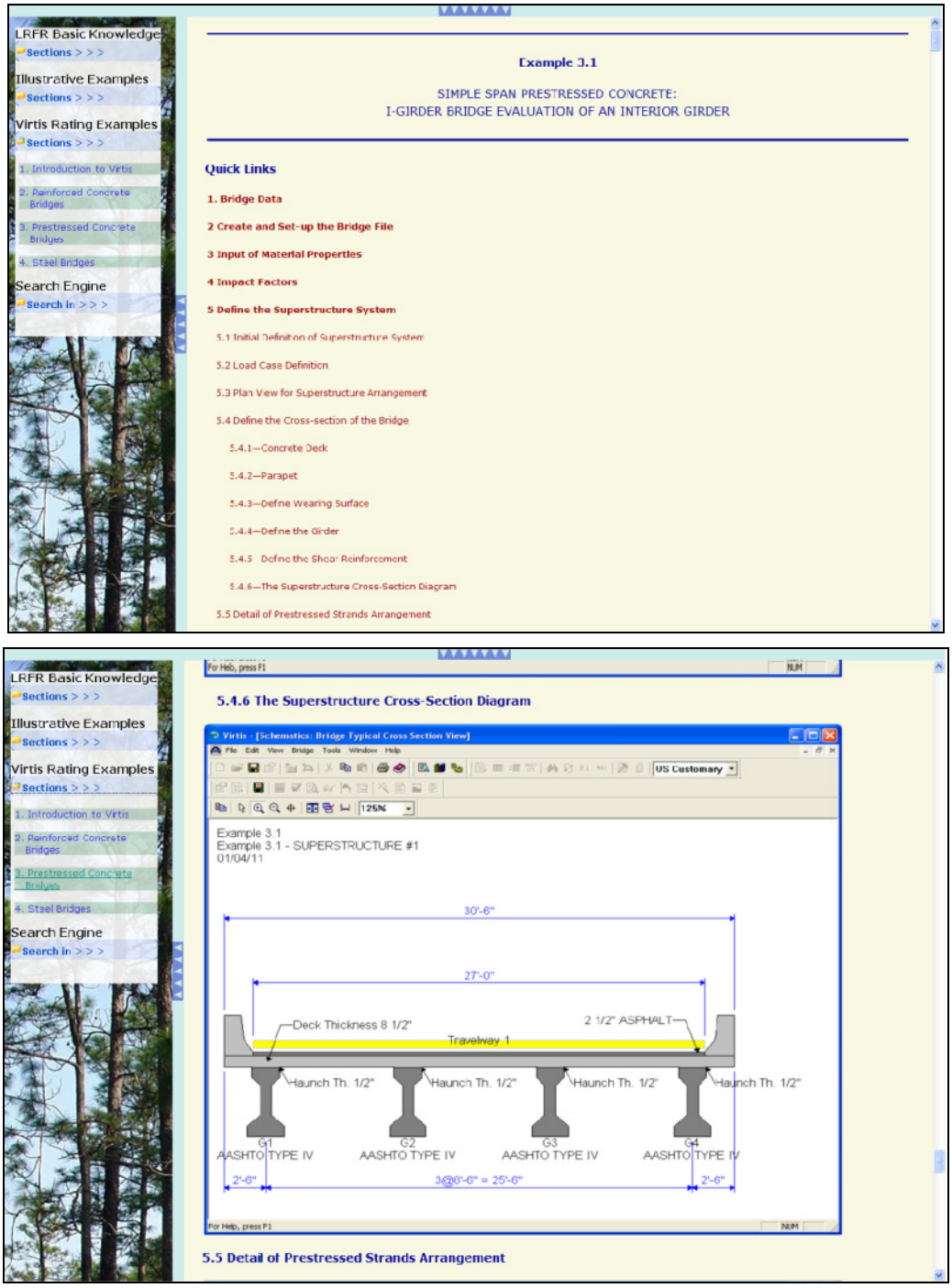


Figure 3-27. Partial pages for the Virtis™ prestressed-concrete bridge-rating example

3.7.3.4 Virtis™ Rating Example for a Steel Bridge This section presents a rating example for a typical steel-girder bridge using Virtis™ (see Figure 3-28). Key pictures show the step-by-step process in Virtis™. The users of this section may get a general understanding of the rating procedure for steel bridges using Virtis™.

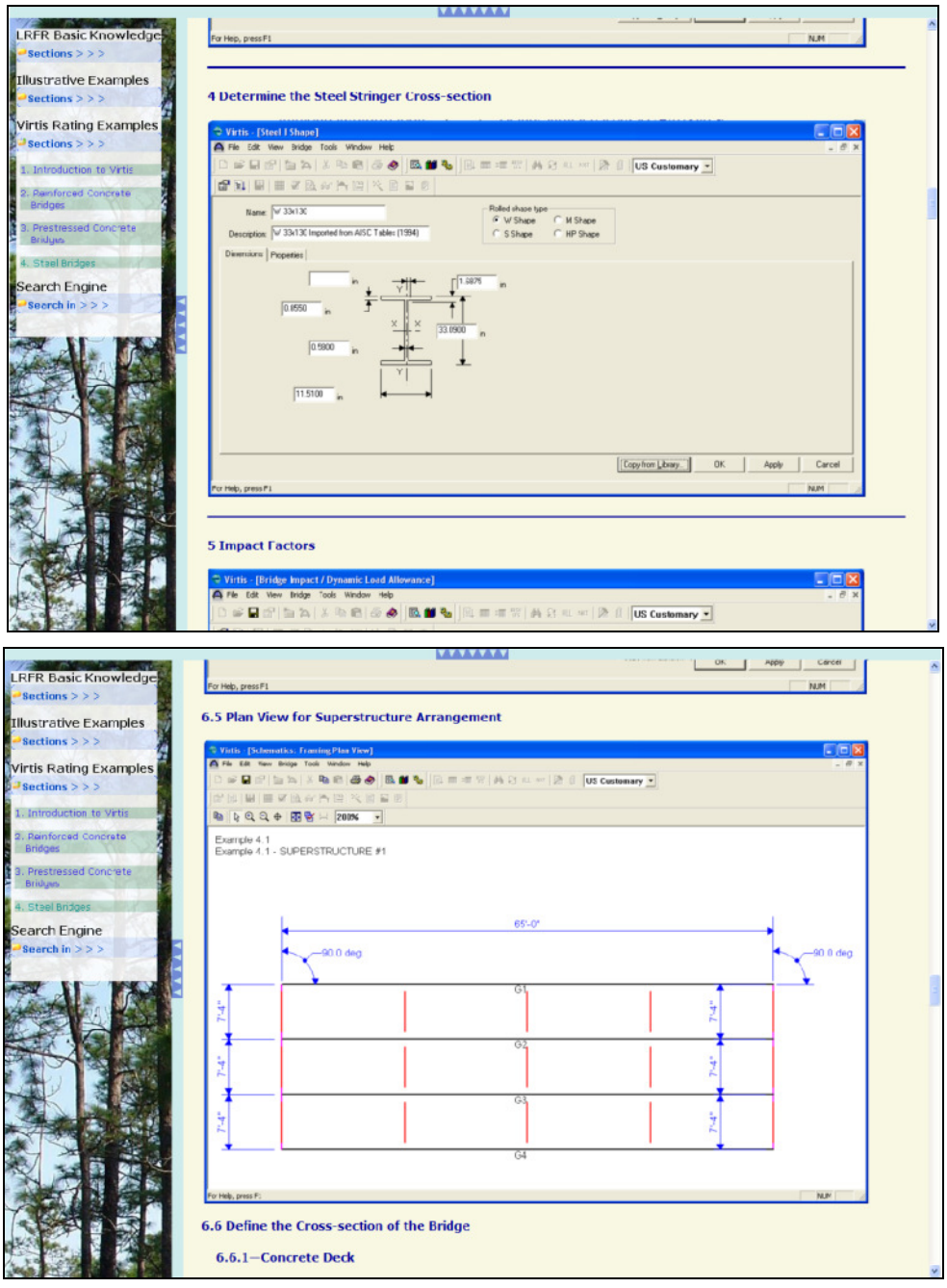


Figure 3-28. Partial pages for Virtis™ rating example for a steel bridge

3.8 Search Options

A search engine is included for conveniently looking up definitions related to bridge design and bridge rating and for locating keywords in the package. Figures 3-29 and 3-30 show examples of a keyword search in the dictionary and in the package respectively.

3.8.1 Search

Figure 3-29. Page showing results for a keyword search in the dictionary

3.8.2 Package Search

Figure 3-30. Page showing results for a keyword search in the software package

3.9 Contact Page

This page provides contact information for the PI (see Figure 3-31).

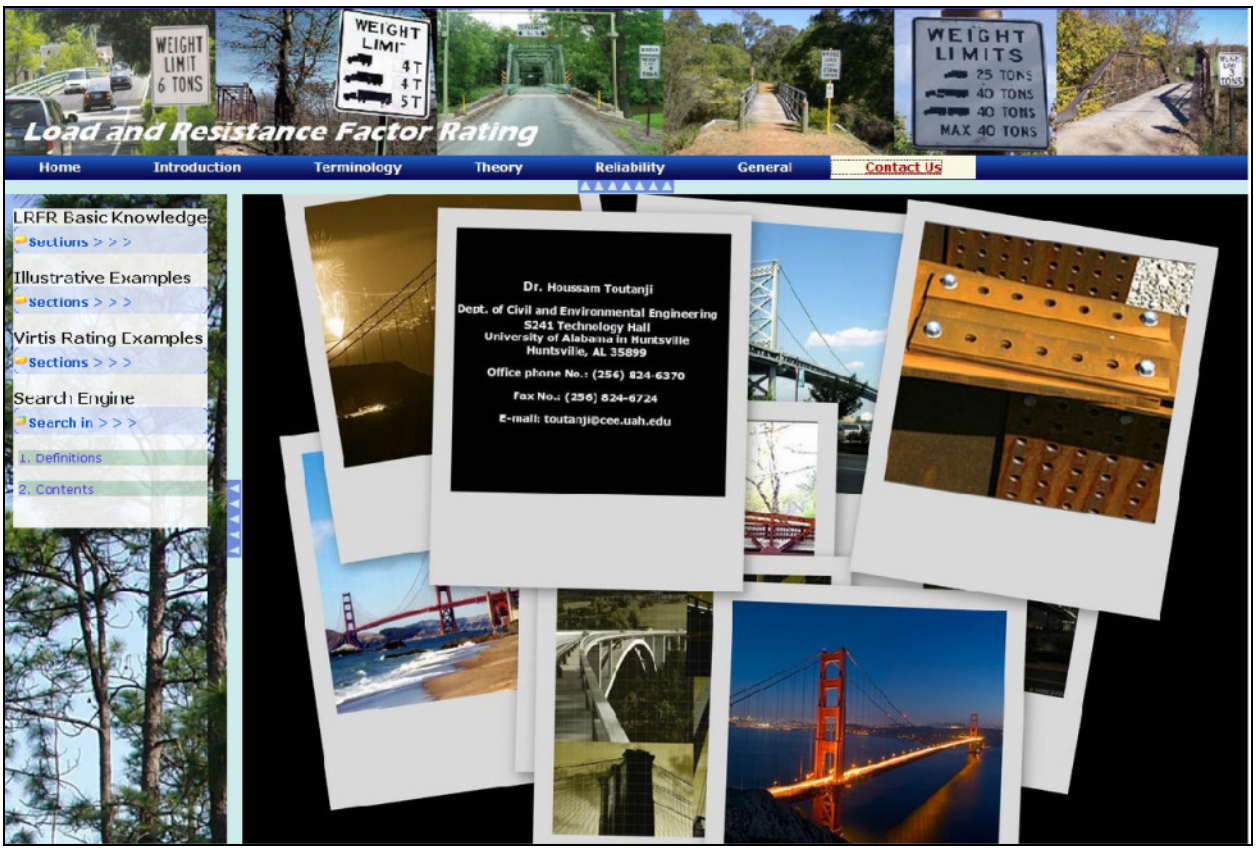


Figure 3-31. Page showing Dr. Toutanji's contact information

3.10 Conclusion

The purpose of this project was to create a user-friendly, aesthetically pleasing software package that teaches Virtis™ software and rating methods and procedures. Users can use the software to get acquainted with LRFR rating procedures and operations. This multimedia package can be updated at any time to reflect today's technology and theory.

Multimedia technology provides many advantages: step-by-step details are presented using diagrams, equations, examples, tables, definitions, and theories. This multimedia package can be used like a reference tool for people trying to learn the specifications, methods, and procedures of bridge evaluation and bridge load rating. Another advantage is that the information can be modified whenever desired, including changing requisites and including more examples.

This complete package is available in the Department of Civil and Environmental Engineering at the University of Alabama in Huntsville.

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http://www.nabro.unl.edu/events/fall1998/index.asp.
http://www.normas.com/AISC/PAGES/325-01.html
http://www4.trb.org/trb/crp.nsf/0/6306c417bc81d2758525674800561ad4?
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http://lrfd.aashtoware.org/?siteid=34&pageid=229
http://www.transportation.org/sites/bridges/docs/concrete%20examle%20us.pdf
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http://www-personal.umich.edu/~nowak/Papers/Mertz,%20abs1,%204-19-02.pdf
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