Evaluating Structural Damage Using Multimedia Technology

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15. Supplementary Notes

A CD-ROM and a web site (http://coeweb.eb.uah.edu/cee/ALDOT/login.htm) were developed. To access the web site both a username and a password are required.

16. Abstract

This project focused on providing guidelines for conducting timber bridge inspections for the Alabama Department of Transportation (ALDOT), and evaluating and understanding the various maintenance procedures available for this purpose. A self-training tool was developed in the form of a multimedia website and a CD-ROM. This website is intended to provide the inspector with an understanding of the general characteristics of deterioration and the concepts related to inspection procedures. This tool can be very valuable to ALDOT and county engineers because it describes procedures for inspecting timber bridges, and it has step-by-step instructions, accompanied by photographic illustrations for the various maintenance procedures utilized by ALDOT.

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Executive Summary

The advent of multimedia technology provides an excellent opportunity for the development of tools to train engineers on the various practices used by the Alabama Department of Transportation (ALDOT) for assessing and repairing structures. Multimedia training tools can also provide easy access to the guidelines for evaluating structural damage, and step-by-step instructions for the remedial processes that are used by ALDOT. Multimedia technology is advantageous because it can be easily modified to accommodate future changes in inspection and repair procedures exercised by ALDOT.

Timber bridge inspectors have the difficult task of accurately assessing the condition of an existing structure. They must understand the biotic and physical factors associated with wood deterioration as well as the relative rate at which these processes occur in a given environment. Timber inspection is a “learned process” that requires some knowledge of wood pathology, wood technology, and timber engineering. Familiarity with the fundamentals of timber bridge inspection for decay and deterioration along with the ability to identify the agents of deterioration are crucial when inspecting timber bridges.

This project focused on providing guidelines for conducting timber bridge inspections for ALDOT, and evaluating and understanding the various maintenance procedures available for this purpose. A self-training tool was developed in the form of a multimedia CD-ROM/web site, intended to provide inspectors with an understanding of the general characteristics of deterioration and the concepts related to inspection procedures. This tool can be very valuable to ALDOT and county engineers because it describes procedures for inspecting timber bridges. It also has step-by-step instructions, accompanied by photographic illustrations, for the various maintenance procedures utilized by ALDOT.

The developed website will be maintained in the Civil and Environmental Engineering Department at The University of Alabama in Huntsville, where it will be periodically updated by the Principal Investigator.

1.0 Introduction

The national age distribution of bridges indicates increasing deterioration of structures constructed in the 1930s and earlier, and a parallel need for improvement of bridges built, during the Interstate period. According to Xanthakos (1996), of the nations 577,000 bridges about 40 percent are structurally deficient or functionally obsolete. A deficiency occurs when a performance element is at or below a specified minimum level, generally established from a consensus of technical expertise within the engineering discipline. Deficiencies in the bridge system are categorized as a variety of physical and operating problems such as high level of congestion or riding discomfort, inadequate load capacity, compromised safety or other related conditions.

Wood used for timber bridges is subject to deterioration by a variety of agents (Ritter 1992). Damage ranges from relatively minor discolorations caused by fungi or chemicals to more serious decay and insect attack. Maintenance operations can be undertaken to correct situations that could otherwise lead to the difficult task of accurately assessing the condition of an existing structure. Inspectors must understand the biotic and physical factors associated with wood deterioration as well as the relative rate at which these processes occur in a given environment. Timber inspection is a learned process that requires some knowledge of wood pathology, wood technology, and timber engineering.

The advent of multimedia technology provides an excellent opportunity to train engineers in the design, inspection and repair practices used in civil engineering. In addition to the accessibility of this self-guided tool, multimedia technology is easily adaptable and extensible to future changes. The objective of this research project was to create a multimedia product to assist the Alabama Department of Transportation (ALDOT) in evaluating the damage to timber bridges and estimating costs associated with remedial procedures. This self guided tool covers the fundamentals of timber bridge inspection for decay and deterioration. It also identifies the agents of deterioration and describes inspection and maintenance methods.

The long-term objective of this type of research is to develop modules for all aspects of structural damage repair conducted by ALDOT and county engineers. The goal of this particular project was to develop two of these modules, namely: steel reinforced/ prestressed concrete and timber bridges. The goal of this one-year project was to develop the first module for timber bridges. The deliverable product for this module was a website and a CD-ROM based training tool that details and describes the current methodologies of inspection and repair of Alabama timber bridges.

2.0 Methodology

The groundwork for this project started with a literature review, which helped the Principal Investigator understand the different techniques available for the assessment of timber bridges. To make the process of timber bridge evaluation and repair manageable the project was divided into three parts: inspection, maintenance and repair. ALDOT engineers recommended that the focus be on creating a multimedia tool that would help maintenance employees interpret the various methods and tools required for inspection and maintenance of timber bridges.

The maintenance and repair sections of the project provide engineers with tools that outline step-by-step details for bridge maintenance and structural repair. ALDOT personnel also suggested making field visits with ALDOT maintenance employees as repairs were being made. During this process, a project assistant took pictures of several timber bridges in Alabama for illustrational purposes.

The Principal Investigator of the project met with managers of the ALDOT Maintenance Bureau on a regular basis. Bridge maintenance personnel frequently reviewed and commented on the materials as they were developed during this project. Their comments and recommendations were addressed and incorporated in the final multimedia resource package.

3.0 Website/CD-ROM Description

The multimedia resource included the following links: Main Homepage, Inspection, Defects, Maintenance, Glossary, Repairs, and Gallery. A description of each of these links is given below.

3.1 Main Homepage

This section of the module includes a welcome greeting and a short description of the information that is available on the website (see Figure 3-1).

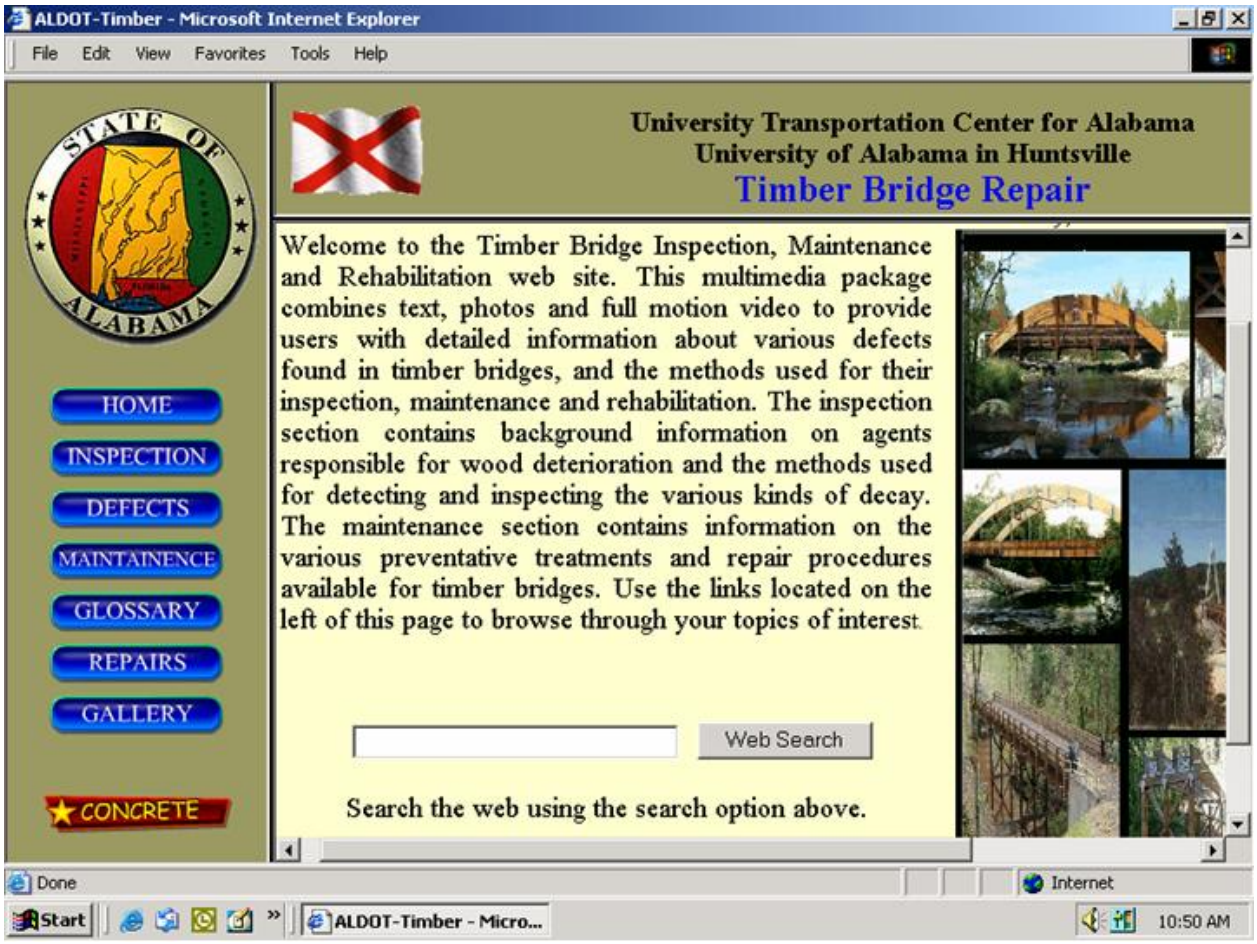

Figure 3-1: Home page of the ALDOT timber bridge repair website

3.2 Inspection

Bridge inspection may be visual or it may require the use of special equipment. The inspector examines each component of the bridge and assigns a condition rating during every routine inspection. Timber bridge inspectors have the difficult task of accurately assessing the condition of an existing structure. They must understand the biotic and physical factors associated with

wood deterioration as well as the relative rate at which these processes occur in a given environment. Timber inspection is a learned process that requires some knowledge of wood pathology, wood technology, and timber engineering.

This section covers the fundamentals of timber bridge inspection for decay and deterioration. It identifies the agents of deterioration, and summarizes inspection methods and strength loss caused by decaying of wood. By clicking on the inspection link, users are taken to a page that contains an introduction and links to information pertaining to timber bridge inspection (see Figure 3-2). The Index link takes the user to an outline that contains further links such as Agents of Wood Deterioration, Methods of Detecting Wood Deterioration, Inspection Procedures, and Strength Loss from Decay (see Figure 3-3).

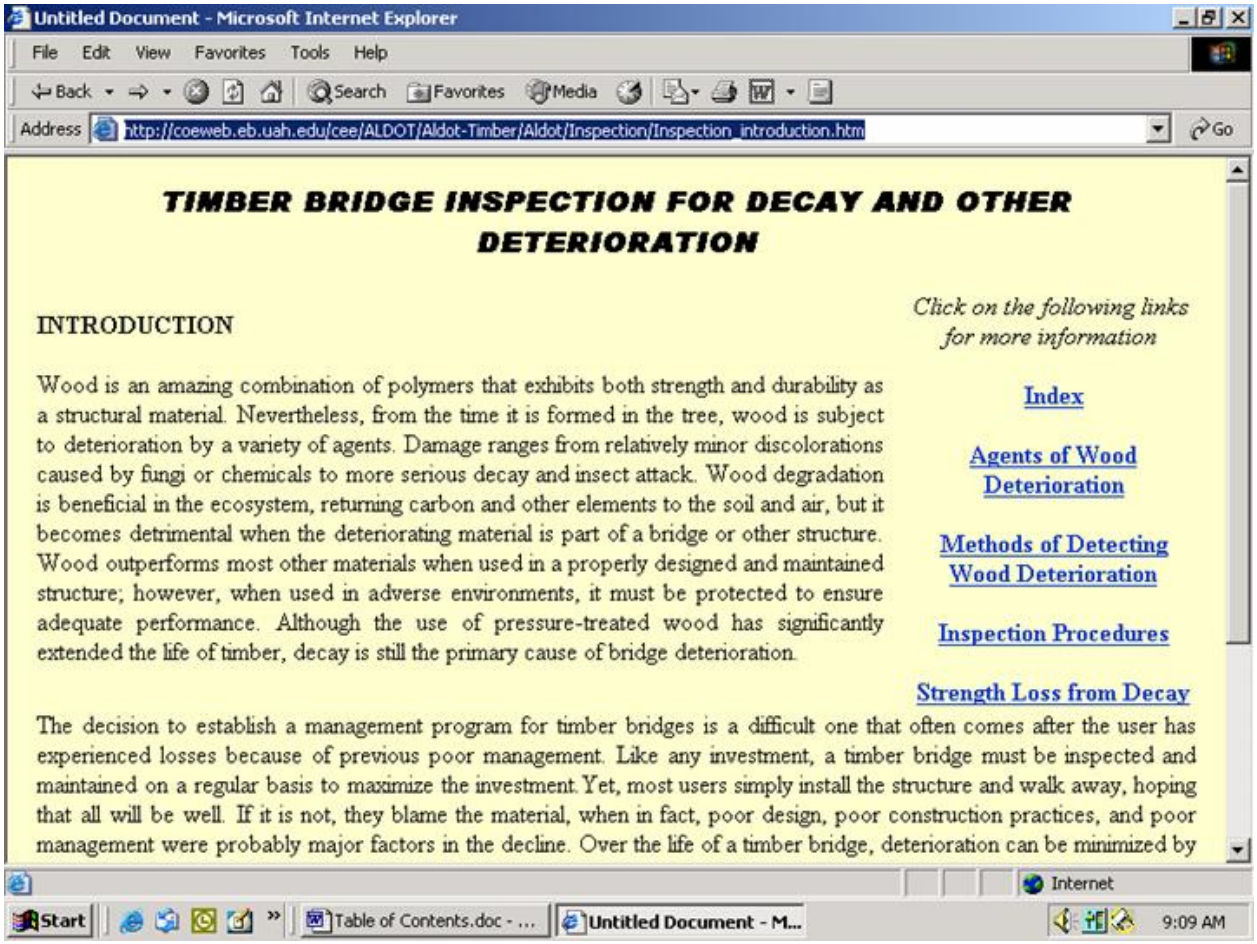

Figure 3-2: Inspection page of the ALDOT timber bridge repair website

Figure 3-3: Inspection outline accessed from index link

Agents for Wood Deterioration

This section of the module provides detailed information on the various agents of wood deterioration. These agents are classified as biotic or physical and a link to each type is included on this page (see Figure 3-4). The inspector's familiarity with the agents of deterioration is one of the most important aids in effective bridge inspection. With this knowledge, inspection can be approached with a thorough understanding of the processes involved in deterioration and the factors that favor or inhibit its development.

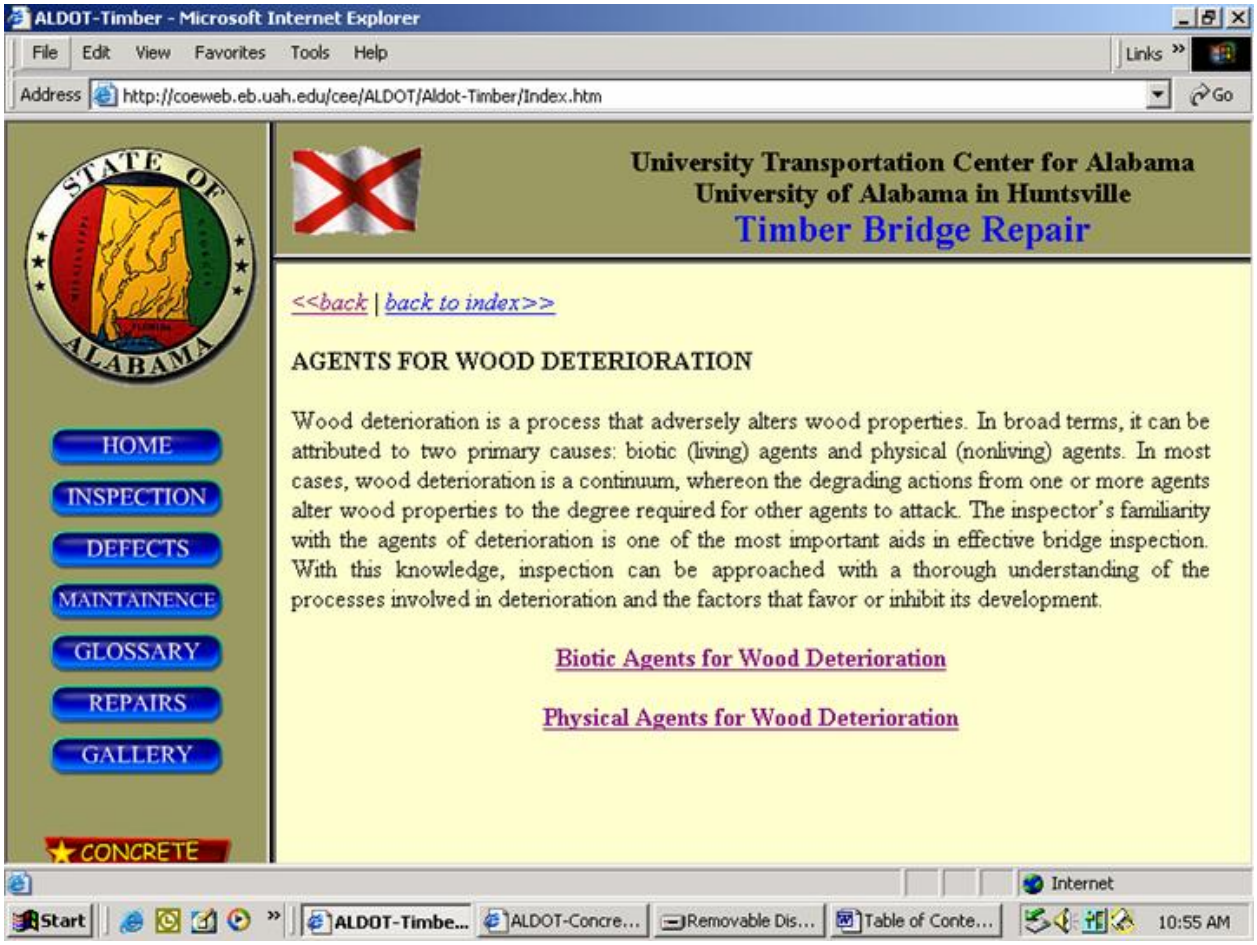

Figure 3-4: Web page displaying types of agents responsible for wood deterioration

Methods for Detecting Deterioration

Unfortunately, the ability to detect wood deterioration has lagged far behind the knowledge of deterioration mechanisms. As a result, inspection processes vary widely among regions, although the tools of the trade are fairly standard. There is no magic box that will accurately determine the condition of a given structure, but a number of tools used in combination can give a reasonable estimate of the amount and degree of wood deterioration present. This section of the module provides detailed information on the different methods used for detecting deterioration. These methods are divided into two categories: those for exterior deterioration and those for interior deterioration. Both of them are thoroughly covered in this component of the module.

Three methods for detecting exterior deterioration are described in the module, namely Visual Inspection, Probing and Pick Test. Each procedure is described in detail and photographs also included for illustrative purposes (see Figure 3-5).

Figure 3-5: Web page containing instructions for conducting a pick test

Inspection Procedures

Inspection procedures for timber bridges depend on variables such as the age and type of bridge and the environment in which the bridge is located. Therefore, detailed recommendations for specific procedures are somewhat impractical. In general, the inspector must thoroughly examine the bridge for decay and other deterioration and record findings in sufficient detail for an engineering appraisal. The specific procedures and methods, however, will vary substantially from bridge to bridge. Although the specific procedures in each step vary among bridges, the basic process is the same.

This section of the module contains detailed discussions to provide the inspector with an understanding of the general characteristics of deterioration and the concepts related to inspection procedures. With this understanding, specific inspection procedures can be developed that are best suited to a particular structure. Furthermore, bridge inspection can be divided into three major steps: pre-inspection evaluation, field inspection, and preparation of reports and records. All three of these major steps are covered in full detail in this section of the module (see Figure 3-6).

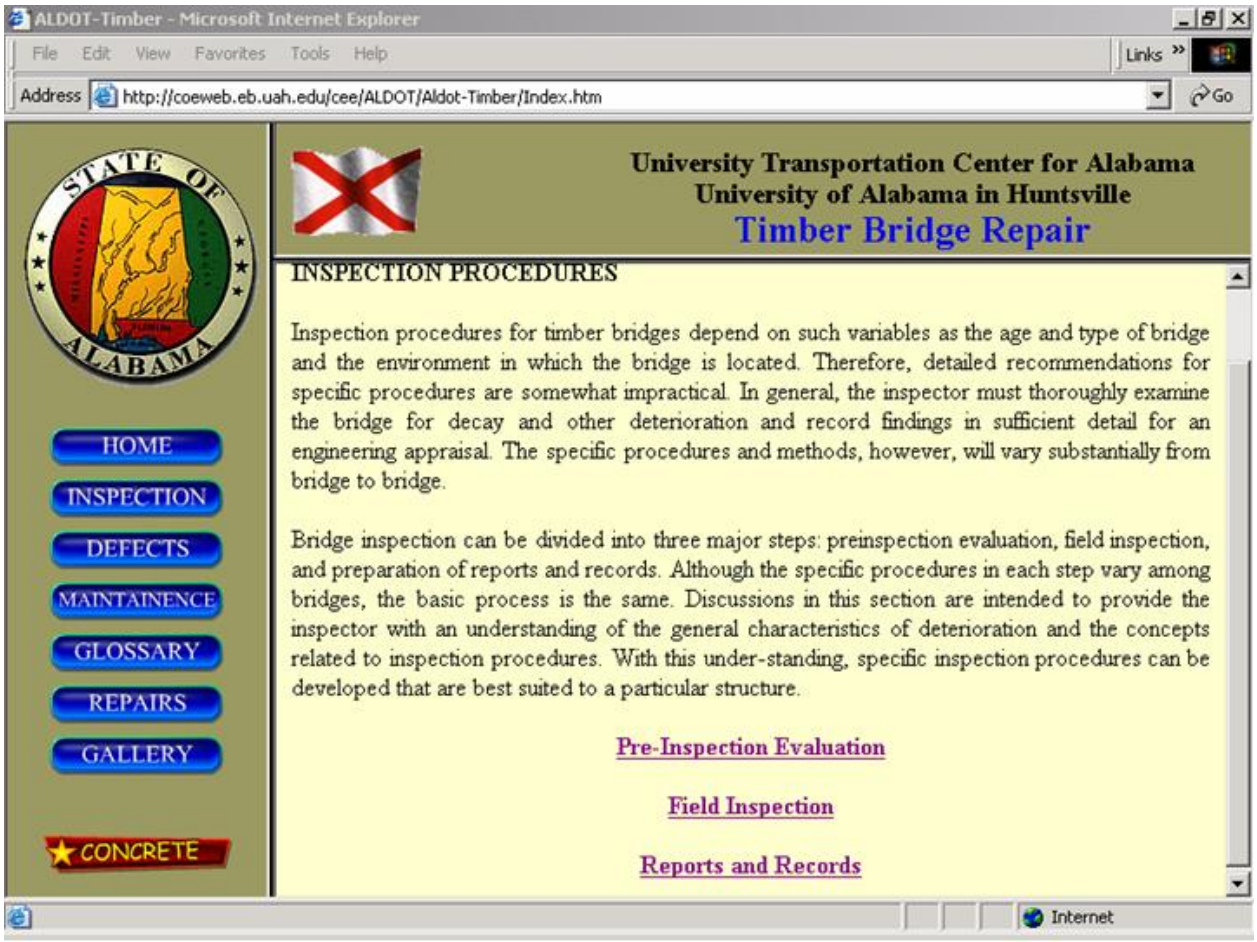

Figure 3-6: Inspection procedures web page

Strength Loss from Decay

This section of the module describes different methods that can be used to accurately assess the strength loss caused by decay of timber bridge systems in different stages: advanced, intermediate or incipient (see Figure 3-7).

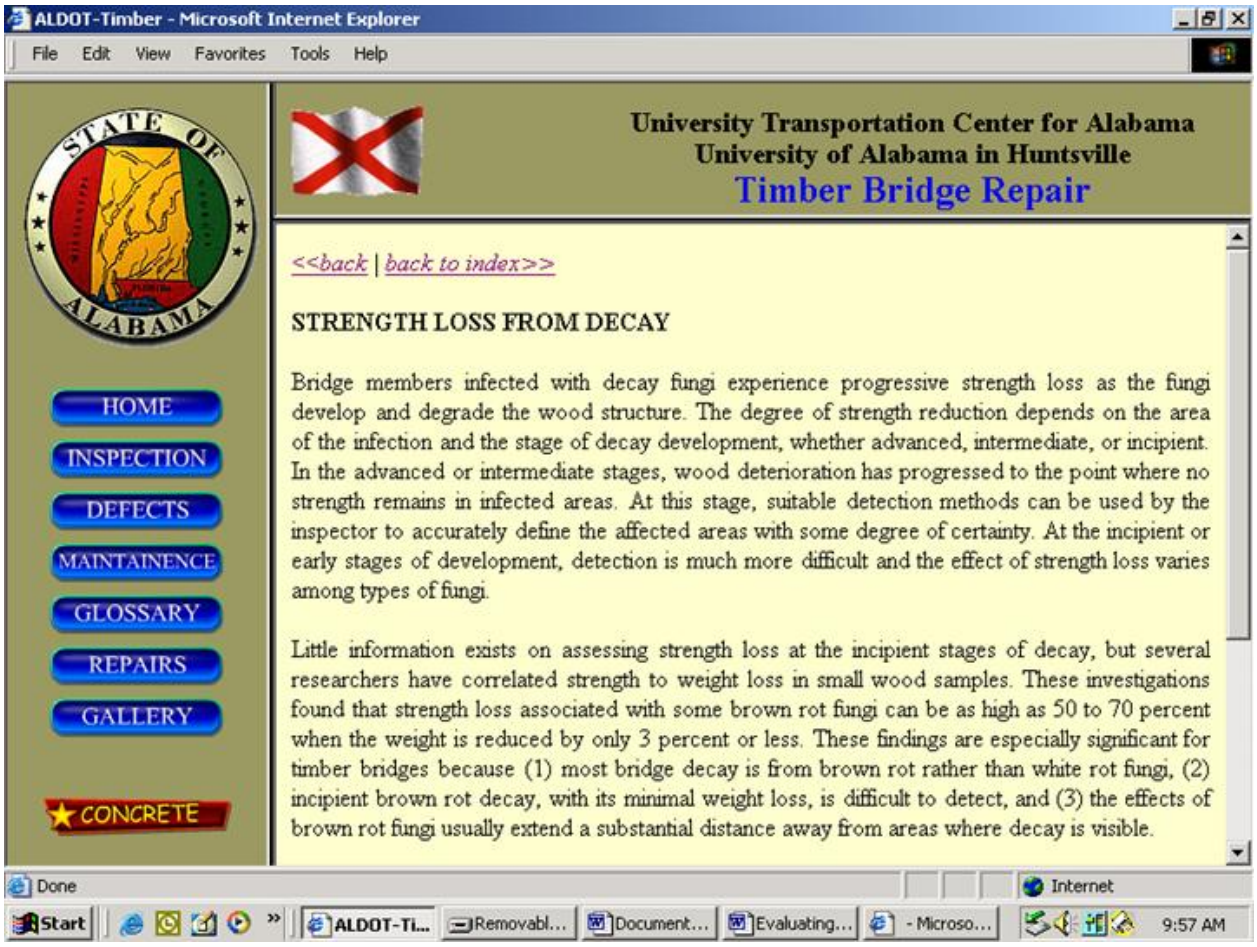

Figure 3-7: Sample of information available on strength loss from decay

3.3 Defects

The Defects section of the module provides detailed information on the various types of defects commonly found in Alabama timber bridges and the damages to which they are subjected. Some of the common defects mentioned are shakes, checks, creeps, splits, biodetoriation, fungus, insect infestation, marine borers, pine beetles and termites. The cause of each type of defect is described and photos are provided of existing defective structures. Figure 3-8 gives an illustration of how this information is presented on the web page.

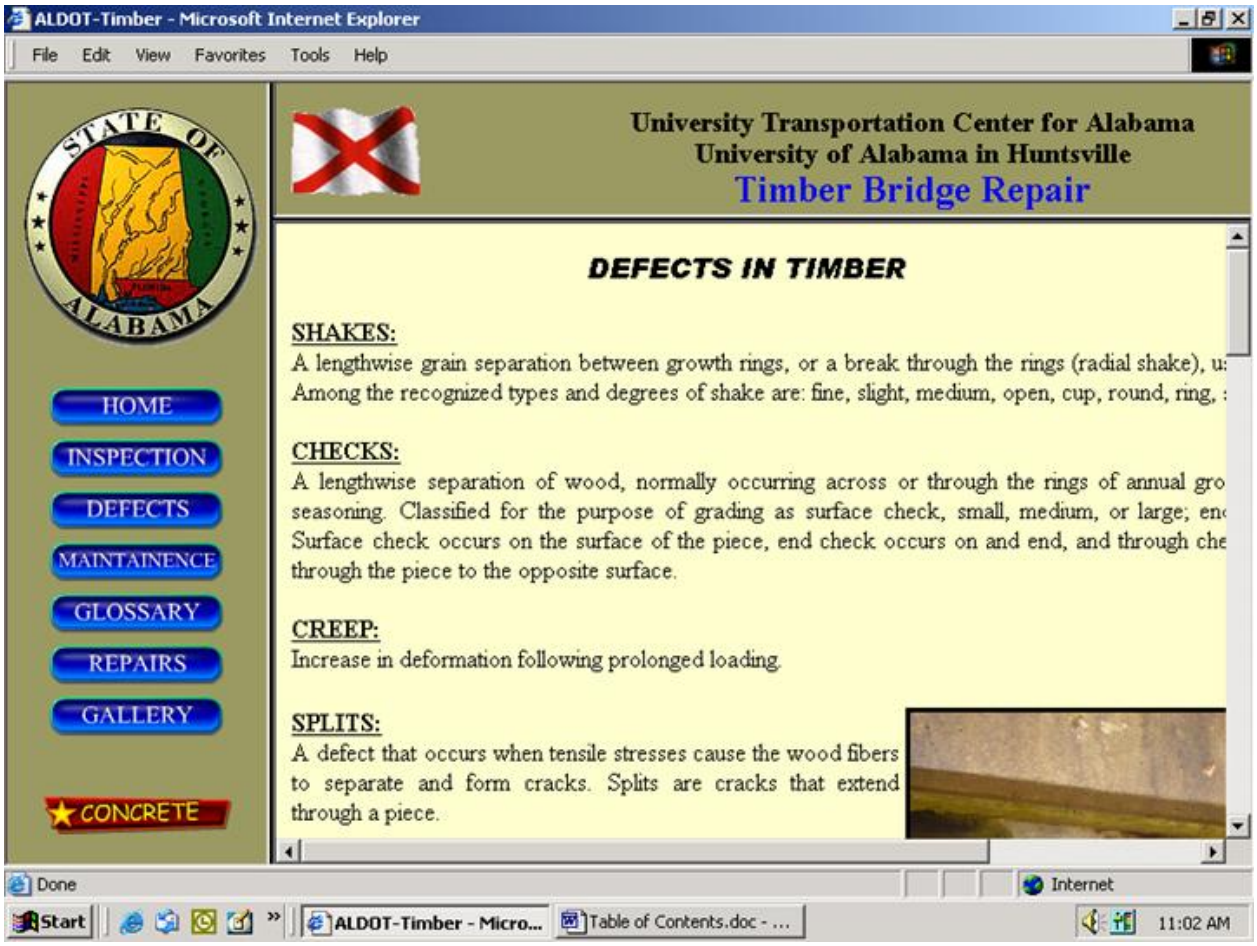

Figure 3-8: Sample of the information available on the defects web page

3.4 Maintenance

This section of the module focuses on the methods employed by ALDOT for maintaining and repairing timber bridges. It includes discussions of several maintenance and rehabilitation practices, and methods that are commonly used for timber bridges. Because deficiencies develop from a variety of causes, it is impractical to address each type of potential problem. Rather, preventative and remedial methods that can be adapted to the specific circumstances of the structure are discussed.

The maintenance page contains an introduction, and links to several maintenance procedures for timber bridges (see Figure 3-9). The Index link takes the user to an outline that contains further links to maintenance procedures such as moisture control, in-place preservative treatment, mechanical repair, epoxy repair, and component replacement (see Figure 3-10).

The website provides detailed information about each activity. When a maintenance method is selected from the maintenance web page, the process is described, including step-by-step instructions and photographs of the repair work.

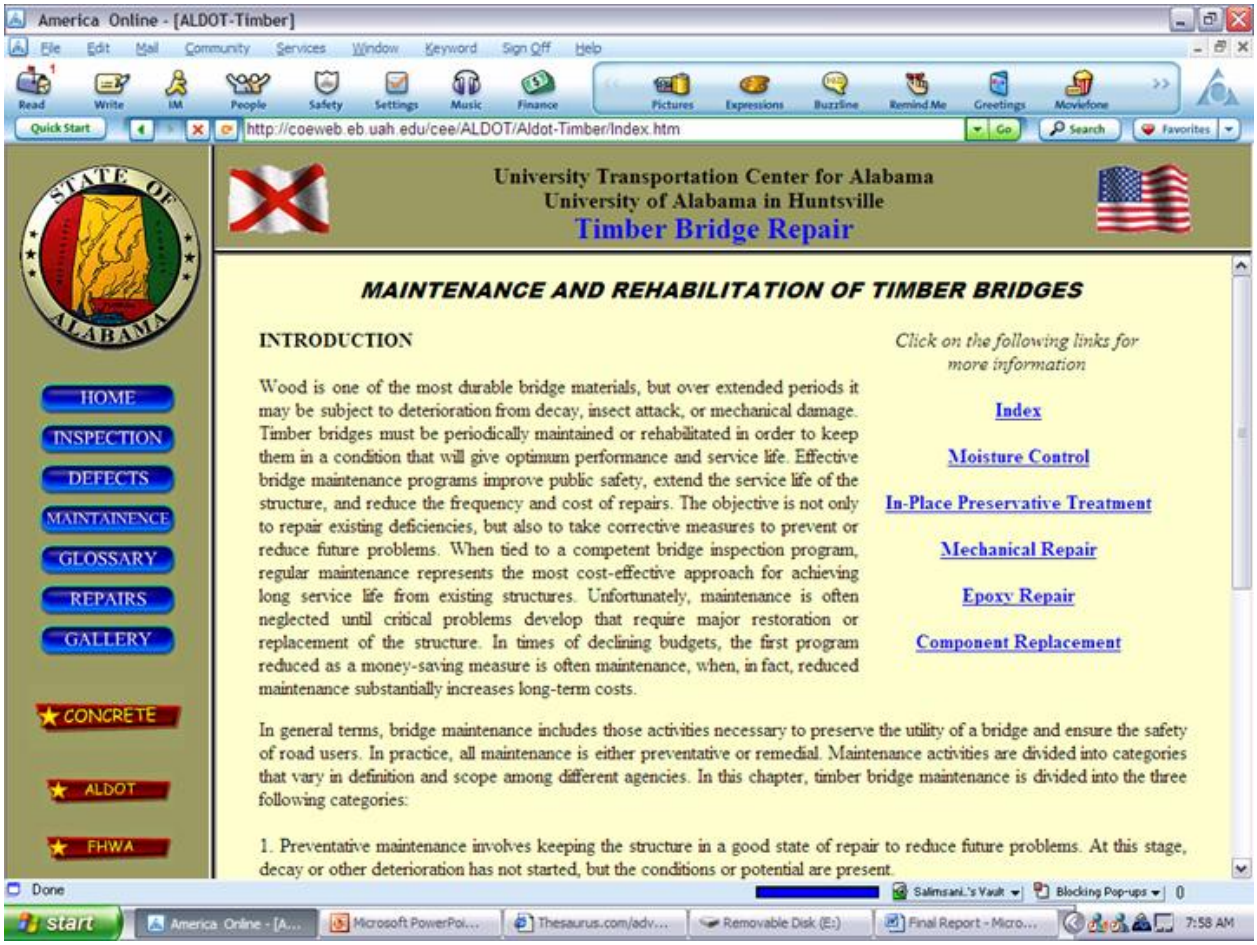

Figure 3-9: Maintenance homepage of the ALDOT timber repair website

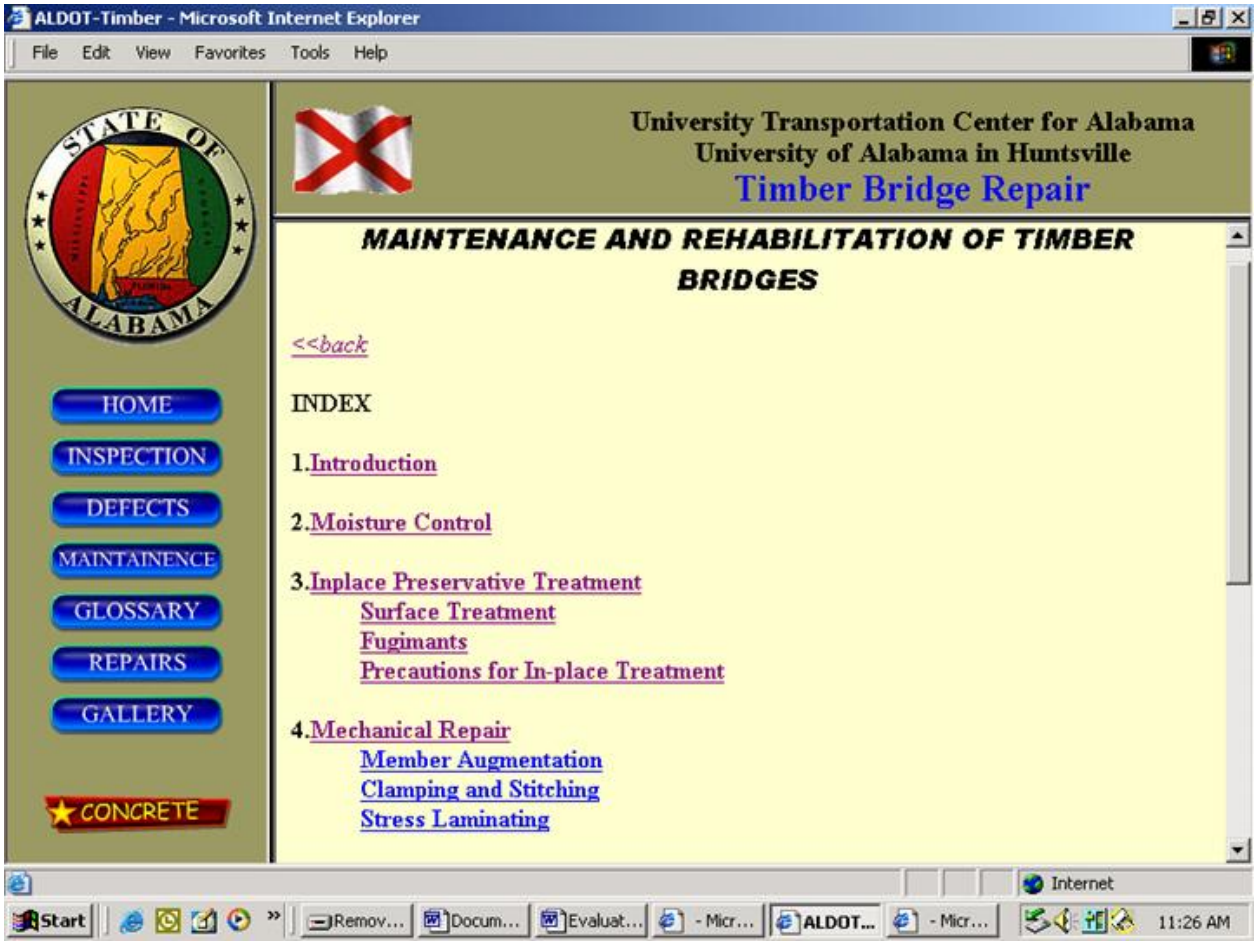

Figure 3-10: Maintenance outline accessed from index link

Moisture Control

Moisture control is the simplest, most economical method of reducing the hazard of decay in timber bridges. It can be used as an effective and practical maintenance technique to extend the service life of many existing bridges.
This section of the module describes in detail different techniques and methods employed by ALDOT to control moisture (see Figure 3-11).

In-Place Preservative Treatment

In-place treatment involves the application of preservative chemicals to prevent or arrest decay in existing structures. Two of the most common types of treatment are described in this section: surface treatments and fumigants (see Figure 3-12). Precautions for in-place treatment are also described in depth.

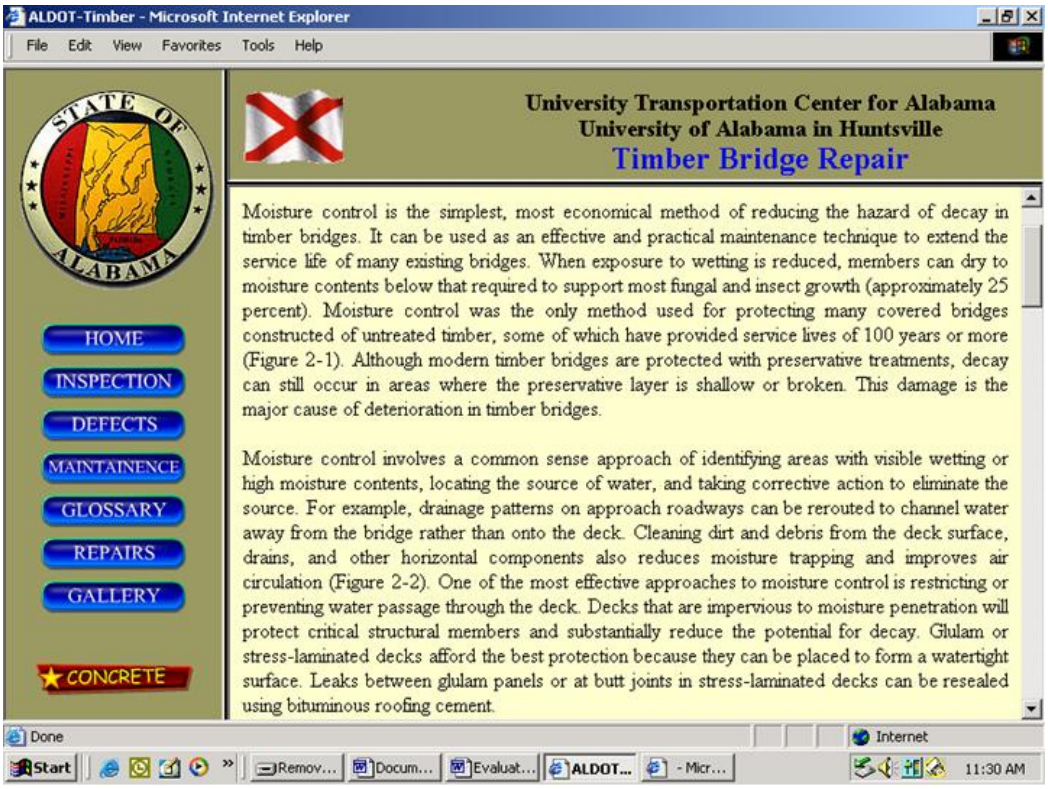

Figure 3-11: Sample of information available on moisture control web page

Figure 3-12: Sample of information available on the website for in-place preservative treatment

Mechanical Repair

Mechanical repair methods use steel fasteners and additional wood or steel components to strengthen or reinforce members. The three methods of mechanical repair discussed in this section are member augmentation, clamping and stitching, and stress laminating (see Figure 3-13).

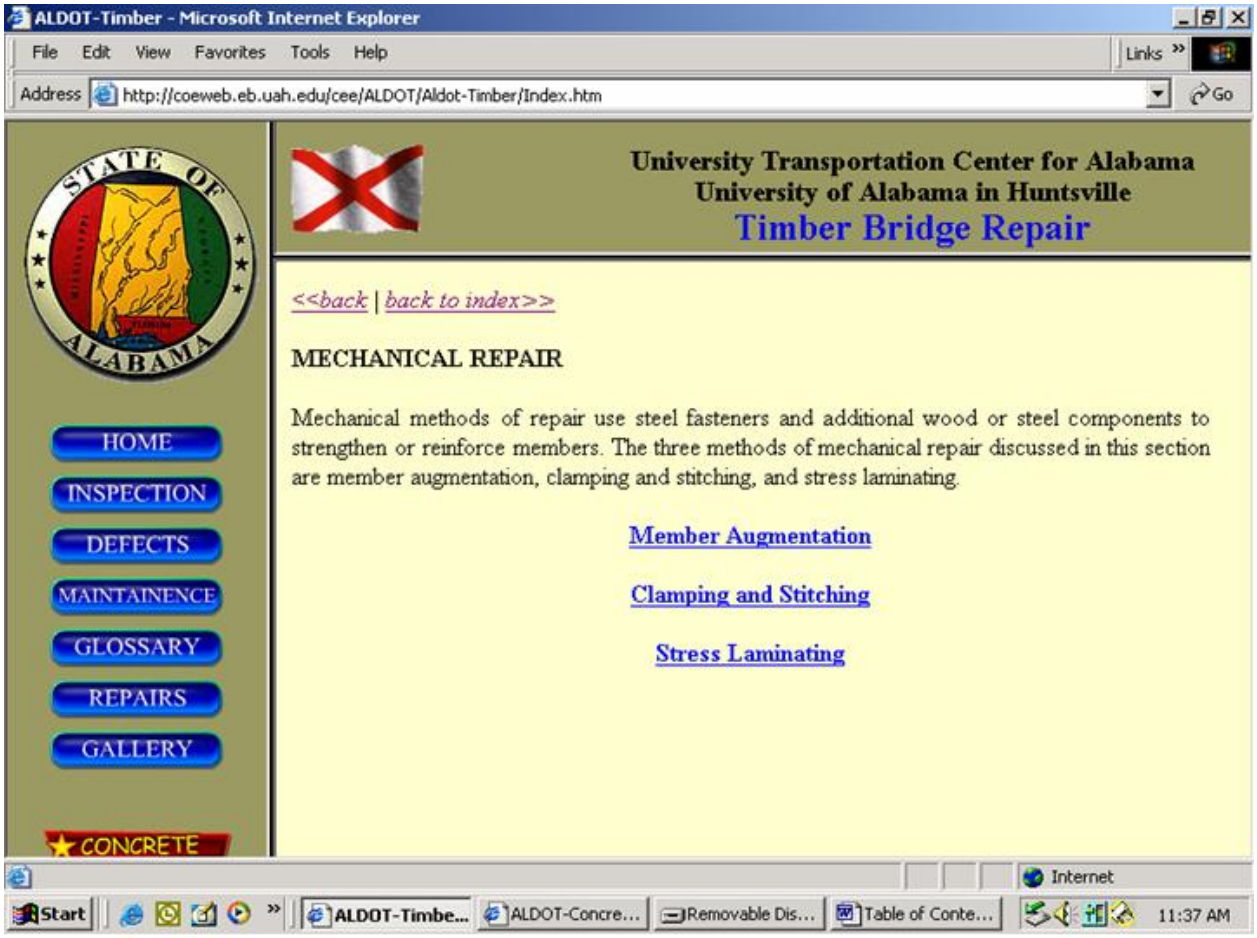

Figure 3-13:
Sample of information available on the website for mechanical repair treatment employed by ALDOT

Epoxy Repair

Epoxies consist of basic resins and resin-hardening agents that are blended in a liquid or gel (putty) form. When mixed, the epoxy compounds harden to form a solid, durable material that provides a high degree of adhesion to most clean surfaces.
This section of the module provides a comprehensive discussion of different types of epoxy repairs that are exercised by ALDOT and county engineers, and the general procedures required for these epoxy repairs (see Figure 3-14).

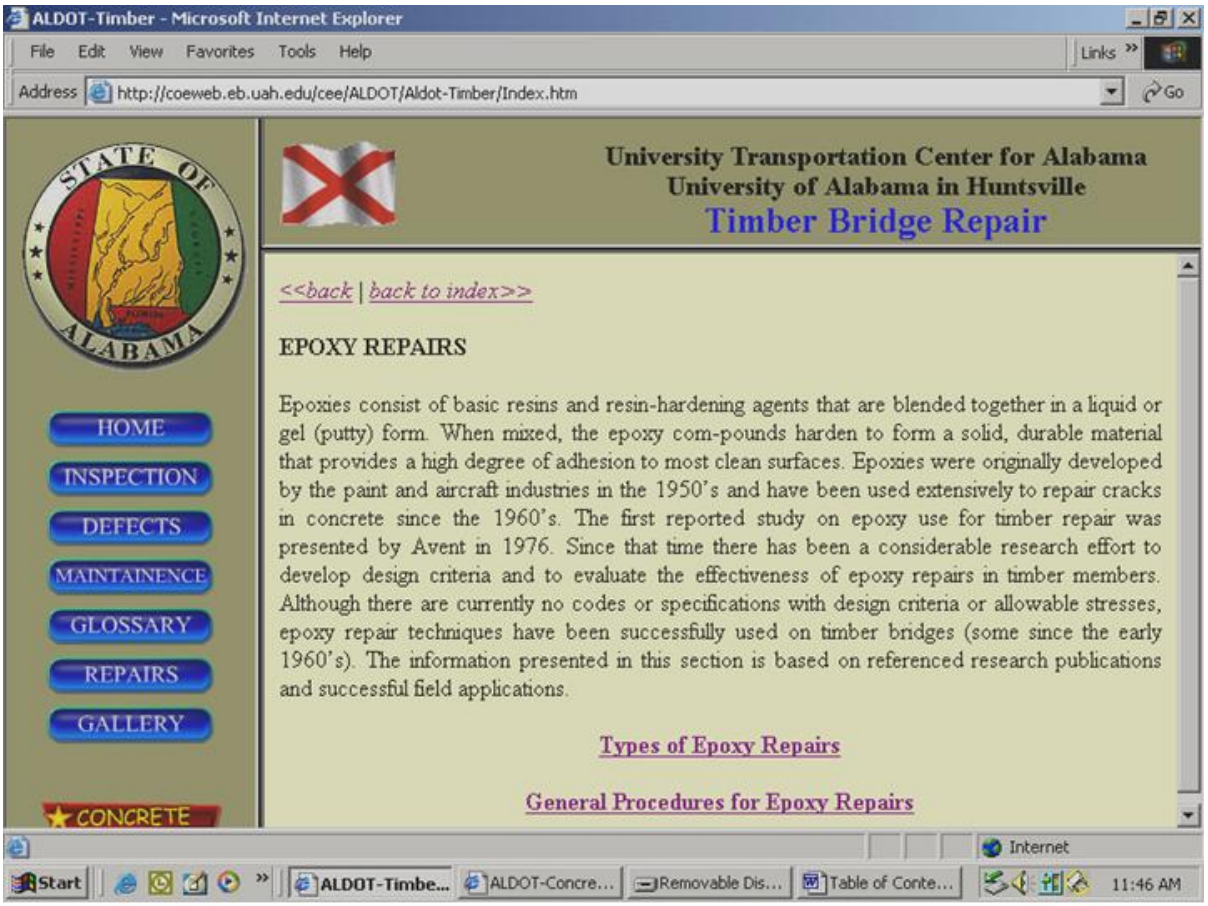

Figure 3-14: Sample of information available on the website for epoxy repair utilized by ALDOT

Component Replacement

There are situations where a lack of maintenance or other causes leads to deterioration so severe that replacement of the member is the only economically viable alternative. In these cases, the structure must be temporarily supported (when required), the old member removed, and a new one installed in its place.

This section of the module focuses on removal of old members and their replacement with new ones (see Figure 3-15).

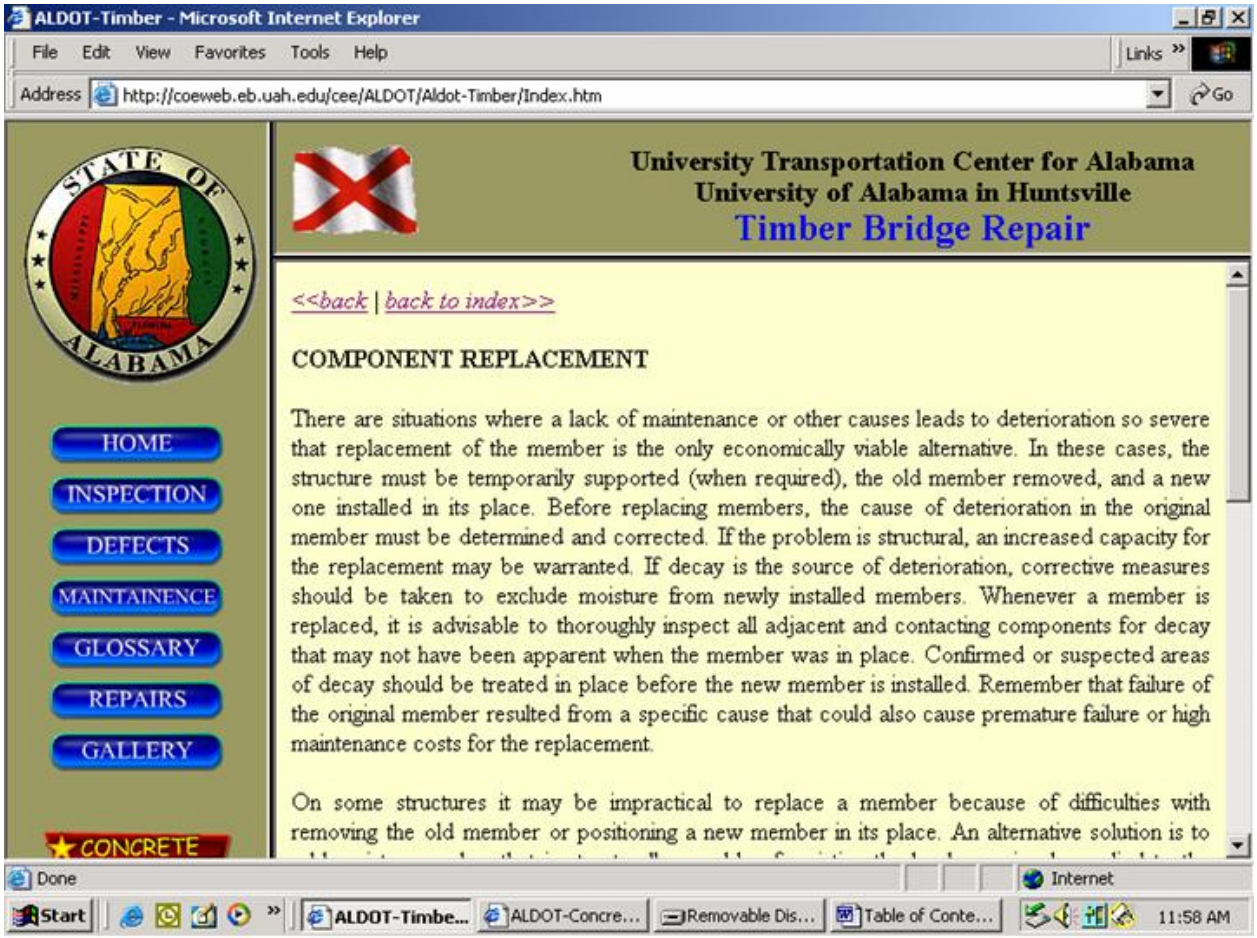

Figure 3-15: Sample of information available on the website for component replacement

3.5 Glossary

This section is a very useful tool that provides a list of key words cited on the website, and words that are relevant to this project along with their detailed definitions (see Figure 3-16).

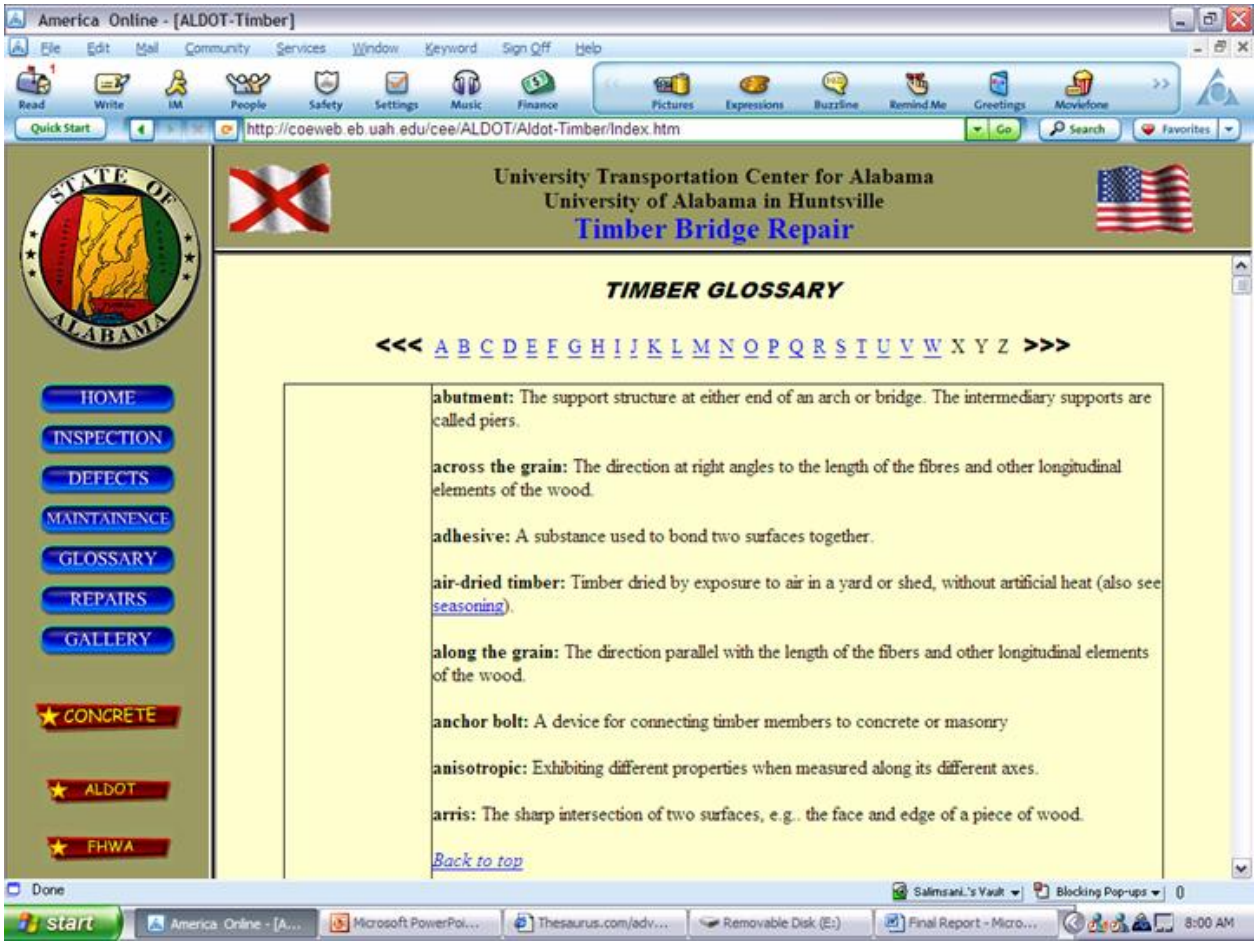

Figure 3-16: Glossary page of the ALDOT timber bridge repair web site

3.6 Repairs

This section of the module provides thorough information on some of the bridges in Alabama that have been inspected and repaired by ALDOT and county engineers (see figure 3-17). This module should be especially helpful to new employees who are in the learning process as bridge inspectors or maintenance/repair personnel.

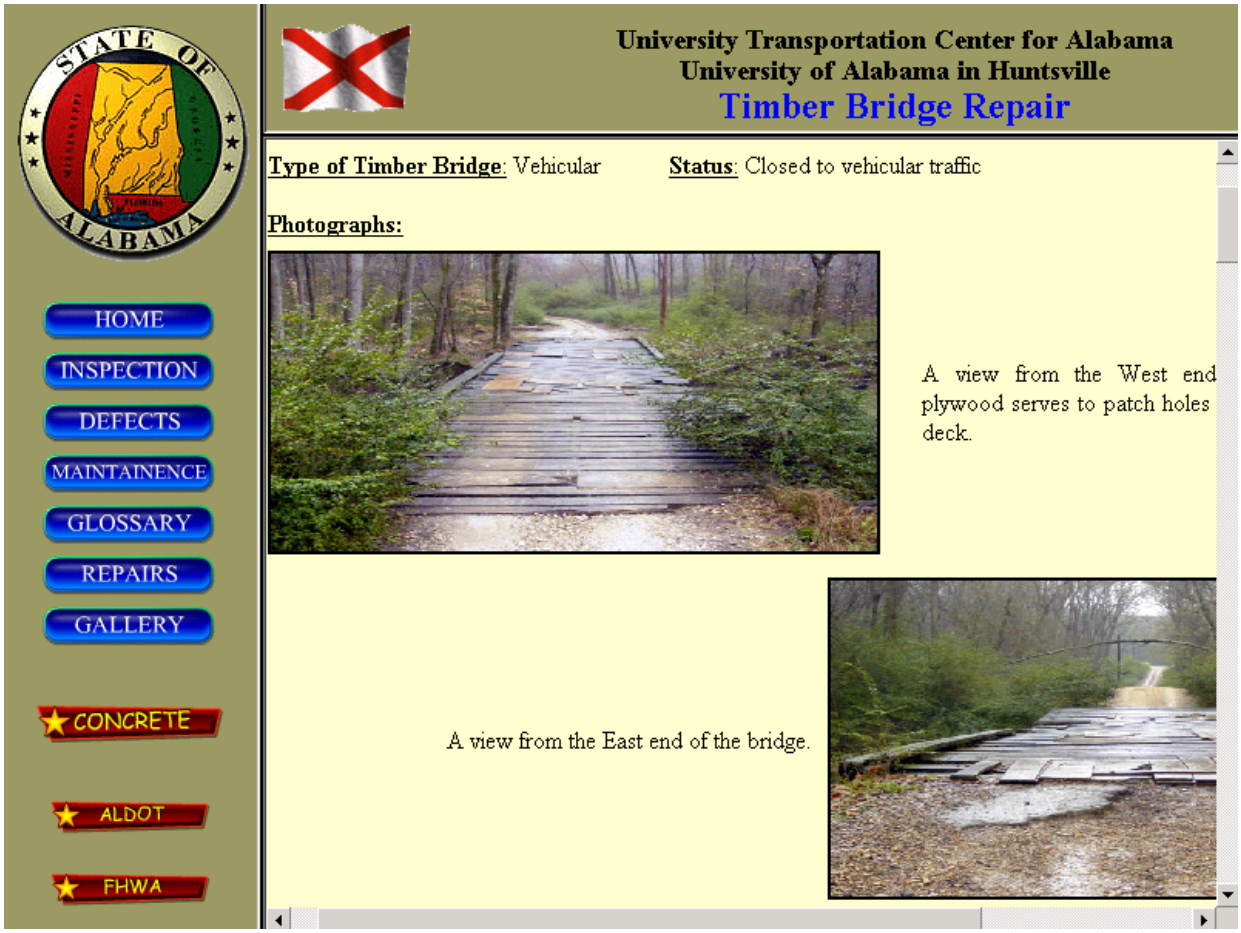

Figure 3-17: Repair web page

3.7 Gallery

The gallery section contains pictures of the various kinds of timber bridges situated across the United States. It also provides detailed pictures of the various defects and repairs on timber bridges. This section also includes timber bridges across the state of Alabama, and work done on these bridges by ALDOT and county engineers (see Figure 3-18).

Figure 3-18: Web page displaying timber bridges in Alabama

3.8 Links to External Sites

Figures 3-19 and 3-20 illustrate how the embedded links connect to the Alabama Department of Transportation website and the Federal Highway Administration website.

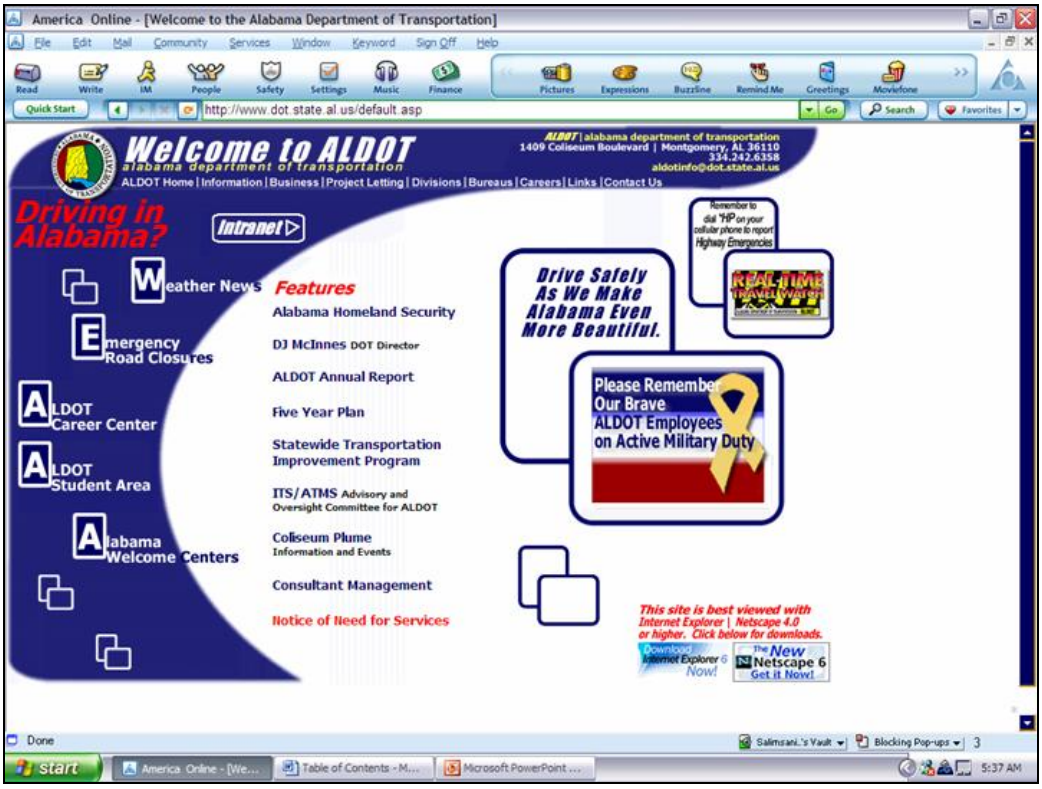

Figure 3-19: ALDOT link to home page of the Alabama Department of Transportation

Figure 3-20: FWHA link opens the home page of the Federal Highway Administration

4.0 Conclusions

The objective of this project was achieved and a web site and a CD-ROM were developed using a wide range of multimedia resources. This module provides quick access to detailed information on the assessment and repair procedures currently used by the Alabama Department of Transportation. This module contains two main sections namely inspection and maintenance. The inspection part of the module provides information that is necessary to conduct a timber bridge inspection for ALDOT. The maintenance part of the module gives comprehensive information about timber bridge repair procedures used by ALDOT.

The multimedia technology that was developed in this study is advantageous in many ways. Step-by-step details accompanied by photographic illustrations are crucial to providing users with a wealth of information that is easy to understand. Also this type of technology is easily adaptable and extensible to future changes and can therefore be easily updated whenever procedures and practices are modified. These advantages make the module an ideal training tool for engineers.

The multimedia web site will be maintained in the Civil & Environmental Engineering Department at The University of Alabama in Huntsville, where the Principal Investigator will periodically update it.

5.0 Recommendations

Three of the nine divisions of ALDOT are responsible for bridge maintenance work throughout the State. It is costly for ALDOT to undertake work on a site far away from these three divisions. This tool can be implemented to provide ALDOT and county engineers of all divisions with training on the various remedial procedures, enabling them to undertake simple repair work on sites located within close proximity of their division or county. Once this tool is completed and handed over to ALDOT, maintaining and updating the web site and the CD-ROM in response to future changes in their inspection and maintenance procedures will be ALDOT's responsibility.

6.0 References

Xanthakos, P., “Bridge Strengthening and Rehabilitation,” Prentice Hall, 1996.

Ritter, A. M., “Timber Bridges: Design, Construction, Inspection, and Maintenance”, USDA Forest Service, FPL, 1992.