The Civil Engineering Resource Library: Developing A Multimedia Education Resource

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Abstract
The delivery of civil engineering projects requires civil engineers to address a broad spectrum of issues generated by both project participants and regulatory agencies. Providing tools that assist team members in addressing these issues through the use of information and knowledge from previous projects may reduce project errors by creating informed decision-makers. Recent advances in communications and computer technologies provide the opportunity to enhance student access to these resources. The Civil Engineering Resource Library research effort explores this opportunity by combining an introduction to civil engineering processes with emerging Web-based technologies. This combination is captured in an electronic library that uses case studies to illustrate emerging civil engineering practices and regulatory compliance strategies.

Introduction
The lifecycle of civil engineering projects incorporates a broad and diverse set of design and construction issues. From initial project development through construction and operations, civil engineers address a broad spectrum of requirements established by direct constituents including the owner and the design team and indirect constituents including regulatory agencies and jurisdictional governments. The combination of aesthetic, engineering, and regulatory issues creates a diverse, and often conflicting, set of demands that result in each project appearing to be a one-of-a-kind endeavor. While this diversity reduces the opportunity for civil engineers to apply previous project solutions directly, diversity increases the need to provide documentation and storage tools that enable civil engineers to learn and extrapolate from previous solutions. Specifically, tools that provide team members with information and knowledge from previous projects can assist in reducing project errors by creating informed decision-makers. For example, the consistency of external issues such as wetland regulations over extended periods of time provides an opportunity to establish information libraries that highlight project solutions and compliance strategies. This opportunity is the basis for the Civil Engineering Resource Library, an electronic case library for civil engineering students and educators.

The Resource Library research effort combines two motivating factors; (1) knowledge of emerging solutions to environmental concerns is essential as increasing emphasis is placed on environmental responsibility, and (2) computer technologies should be integrated into the classroom environment to augment traditional learning techniques. In terms of the former, as environmental awareness and responsibility moves to the forefront of design influences, civil engineers must receive education covering compliance strategies for local, state, and national environmental policies. Achieving this awareness establishes the second research motivation, the integration of computer technologies into civil engineering classrooms. Specifically, the research effort combines an introduction to civil engineering processes with emerging Web-based technologies to create an electronic library that uses case studies to illustrate emerging civil

engineering practices and regulatory compliance strategies. This paper introduces the research as it developed through classroom analysis, field studies, and an initial CD-ROM-based prototype.

Resource Library Development

The Civil Engineering Resource Library has followed a development path leading from the classroom to the professional office, and finally, to the computer lab. From the outset, the Resource Library research focused on understanding the environments where the electronic library concept would enhance learning and the production of project solutions. As such, a series of steps were established for the research effort as follows:

1) Develop a course to interactively obtain both student and educator perspectives on the information required to present civil engineering cases, processes, and solutions;
2) Establish a test program within a professional office to determine areas of professional interest and focus;
3) Perform field studies of particular cases to establish a baseline set of structured library entries on which to expand the Resource Library; and
4) Develop a technical solution for an electronic library incorporating a structured, but flexible, environment that addresses the requirements of multiple constituents.

Case Study Project Course

Creating an electronic library that assists current and future professionals in addressing emerging civil engineering issues required the research effort to examine the needs of these constituencies. As such, a case study course was introduced for civil engineering graduate students to analyze emerging topics such as design for disassembly and wetland protection through specific construction projects. The course required students to interact in a discussion format to identify the indirect and direct documents that defined, described, and influenced the civil engineering projects being studied. A discussion format was established that required students to present the indirect and direct influences on particular components of the cases each week. For example, early in the course, the emphasis was placed on examining the regulatory and permitting influences on environmentally sensitive projects such as managing tree-save and drainage areas. In response, students presented summaries of the National Environmental Policy Act (NEPA), Federal Regulations, and Corps of Engineers guidelines that directly governed these operations.

In contrast to traditional lecture formats, the case study course provided opportunities for student self-discovery. Given an introduction to a topic such as NEPA, the students utilized government documents, World Wide Web sites, and Corps of Engineers interviews to supplement traditional textbook authorities. In this way, a broad spectrum of case study data was accumulated and analyzed for each topic covered in the course. This process of self-discovery and document collection provided invaluable insight into the broad ranges of contextual information that is needed by students beyond required readings. One notable area that demonstrated this need was in the case of document interpretation. The interpretation of regulatory documents is often a difficult task for students as they wade through legal jargon, professional acronyms, and obtuse regulations. To assist students in understanding the impact of regulations and other external project impacts, a broad range of materials is required to provide an appropriate case context. The students demonstrated a need for plans, project videotape, written regulations, and third-party summaries to successfully grasp the scope of a given case. This focus on broad issues and

contextual information emphasized the need expand beyond traditional written case formats to a format that provides a breadth of information covering all aspects of the civil engineering process.

Professional Test Program

The development of an electronic information tool for civil engineers requires input from a professional setting as well as an academic setting. In response to this need, the Resource Library research effort included the implementation of a case documentation program for an Atlanta-based construction management company[1]. This effort had one specific goal: obtain insights into the types of information that office and field personnel identify as central to the successful completion of civil engineering projects. With the assistance of company executives, a lessons-learned program was announced to the company employees that encouraged personnel to submit suggestions for cases that could serve as exemplars for either general or specific construction operations.

The program was left open-ended as to the types of lessons that could be submitted to allow company employees the flexibility to submit a broad range of materials. However, the lessons that were ultimately submitted followed a common pattern. The lessons deemed critical by the employees focused on common construction processes that were encountered in unusual circumstances on individual projects. The suggestions stressed solutions to these unusual variations as they are encountered during the completion of specific projects. For example, a common theme focused on cast-in-place concrete placement and the techniques that could be used to reduce air gaps and wasted formwork. In contrast to the broad, project-level concerns of the students, these suggestions focused on understanding solutions to task-oriented procedures that directly result in reducing project costs.

Field Study

The third component of the research focused upon obtaining actual case study data through field investigations. The classroom and professional studies described previously provided the criteria for selecting appropriate Resource Library cases. First, the cases must contain a unique element that piques the interest of the user. Second, the cases must contain a broad range of contextual information that allows students and educators to discuss the full scope of the project. Third, the cases must include examples of common construction processes to provide professionals with a selection of examples that may assist in solving a previously unforeseen circumstance. Finally, the cases must illustrate the diverse input of internal and external project constituents.

After reviewing several options for the selection of a baseline case study, the Wolf Creek Shooting Complex in Atlanta, Georgia was selected as a representative case from which to develop the Resource Library structure. The Wolf Creek site contains several unique elements that make it conducive to an educational field analysis. First, the Wolf Creek site hosted the 1996 Summer Olympics shooting events. This high visibility event ensured that both a significant amount of documentation would be available to compile illustrative materials and that a unique element surrounded the case. Second, the site included several types of wetlands and endangered plants to illustrate the concepts of wetlands and environmentally sensitive

construction. And, finally, the site incorporated several topological features that provided the opportunity to examine mitigation alternatives to the adopted design.

The emphasis of the Wolf Creek study was to compile a broad range of documentation that described the context, evolution, and individual processes of the project. Based on the classroom and professional studies, this documentation was divided into three primary categories: pre-design documents, design documents, and construction videotape. Pre-design documents included examples of compliance procedures for developing the environmentally sensitive Wolf Creek site including Corps of Engineers' permitting documents, city and county correspondence, and design inquiries. Design documents focused on the drawings and specifications that outlined the proposed project solution. These documents emphasized the undulating topography at the site including granite outcroppings and creek beds that created a challenge for the design and construction team. Finally, the construction videotape focused on the use of videotape to capture the construction process from beginning to end and transform the abstract documents into physical entities. Over the course of 15 months, videotape was collected at the Wolf Creek site and edited into approximately 40 10-second vignettes covering both project progress and individual processes. The combination of these vignettes with the previous categories of information provided the foundation for the selection, structure, and implementation of the remaining cases in the prototype Resource Library.

Prototype Development

The final phase of the Resource Library research effort focused on establishing an approach that would result in a viable prototype that included the diversity of identified information categories. In approaching this prototype effort, two requirements guided the overall concept; (1) the solution must provide an easy to use supplement to the classroom and professional environments, and (2) the solution must be generic and robust to allow additional case studies to be added on a constant basis. The first requirement specifies two important concepts, ease of use and a focus on supplementary information. In terms of ease-of-use, it must be acknowledged that if it takes longer to determine how to retrieve information from an electronic system than it takes to retrieve the information by manual means, then the value of the system must be questioned. In terms of a supplementary focus, the Resource Library is intended to supplement, not replace teachers in the classroom. Thus, providing examples and explanations that build upon first principles are more important than attempting to electronically explain fundamental engineering concepts. The second guiding requirement specifies that the system be extensible in terms of content and examples. While the Wolf Creek case study provides a strong foundation for understanding environmental issues, it represents only one project. Given

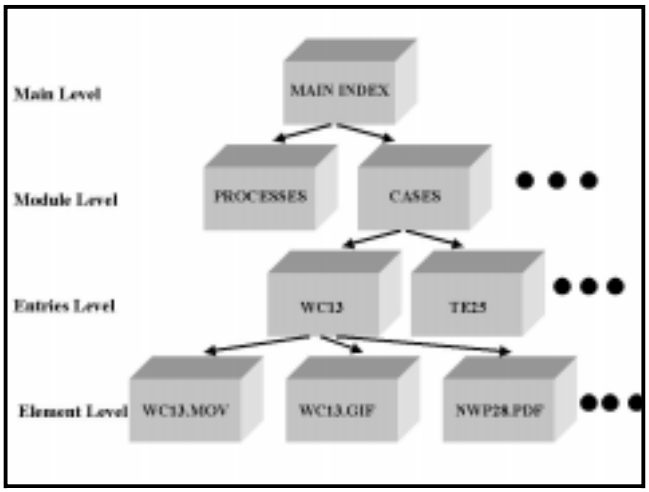

Figure 1: The Resource Library structure is based on a hierarchical concept that facilitates cross-linking within the system.

the unique attributes of each civil engineering project, a series of case studies are required to sufficiently address the diversity of issues emerging in civil engineering.

Although today's computing technologies provide a range of viable alternatives, the pervasiveness and rapid expansion of the World Wide Web set this platform apart from the remaining options and made it an obvious choice for prototype deployment. Given this selection, a modular approach was developed that emphasized a hierarchical structure with the flexibility for expansion at many levels. As illustrated in figure 1, the hierarchical structure within the Resource Library begins at the Element Level with individual elements such as documents, images, and video clips. Each of these elements is linked to a Resource Library entry at the Entries Level. Similar to traditional library catalogs, Resource Library entries provide the search and access points for the individual elements. Each entry contains a description of the linked element and a set of keywords that indicate the case from which the entry was developed, and if applicable, materials, processes, and equipment that are spotlighted in the element (Figure 2). These keywords provide the links to the central organizing component within the Resource Library, the Modules Level. Modules organize categories of case entries, equipment types, construction processes, and material examples into structured groupings (Figure 3). Through these modules, additional cases and examples can be integrated into the Resource Library with a common look-and-feel interface, but without disrupting existing entries or links. The Resource Library modules are defined as follows:

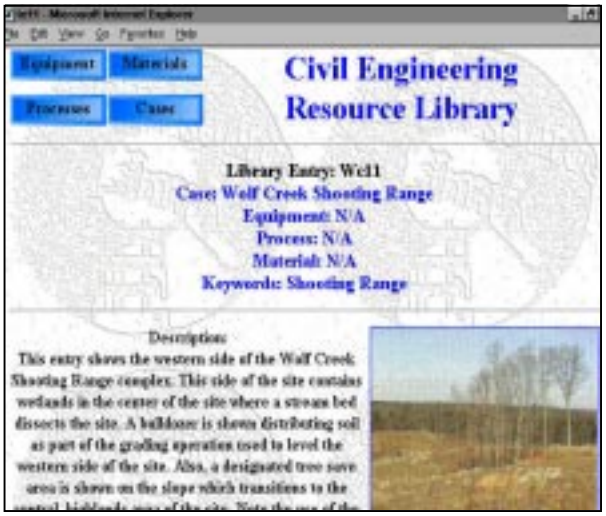

Figure 2: An individual Resource Library entry references case, process, material, and equipment

Figure 3: Resource Library modules provide a central organization structure for all entries contained within the library.

- Cases – A comprehensive collection of documents and video clips covering individual projects through the project life cycle.
- Processes - A collection of indexed entries following CSI format that illustrate the steps, applications, and variations associated with common construction processes.
- Equipment – A collection of indexed entries that illustrate common and unusual uses of construction equipment such as graders and tractors.

- Materials – A collection of indexed entries that showcase the use and installation of common construction materials including cast-in-place and pre-cast concrete.

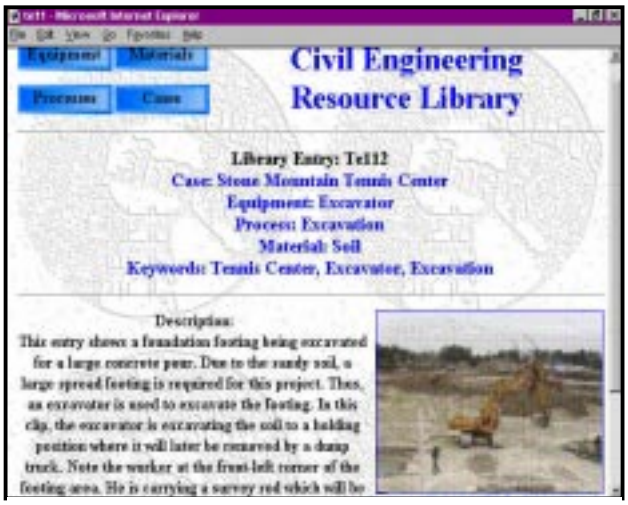

Figure 4: An individual entry chronicling the foundation excavation of a case is cross-indexed to indicate the existence of relevant excavation equipment and process information within the video

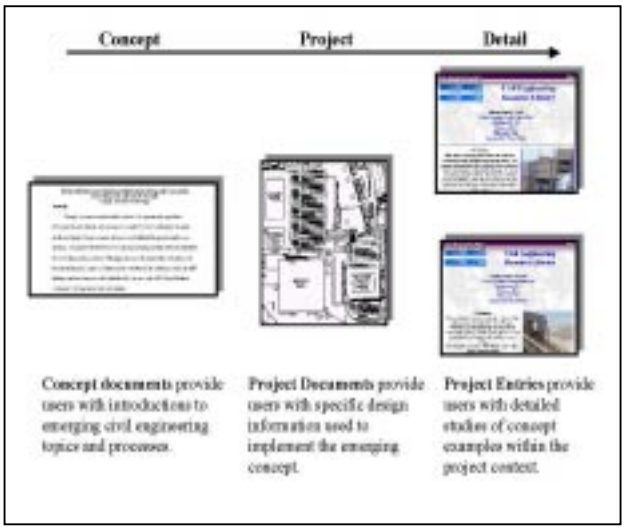

Figure 5: The delayering concept within the Resource Library provides users with a general-to-specific introduction to topics included within the system.

The Resource Library Modules
Based on the premise that an electronic library should complement, and not replace, classroom or professional education, the Resource Library modules are designed to serve multiple constituencies. For students, the modules provide supplementary course information at either general or detailed levels depending on the course focus. For example, in a course focusing on construction operations, the Processes module may be used to highlight individual operations that are being covered in specific lectures without the requirement for extensive project context to accompany the illustrations. Similarly, in a course focusing on a specific topic such as environmentally conscious design and construction, the Cases module may be used during a series of lectures to provide students with a continuous, in-depth example of how a specific project addressed the course topic.

For professionals, the Resource Library modules serve as both lessons learned and resource materials. In terms of lessons learned, each of the modules provides insights into methods and operations that have proven to be both positive and negative solutions during project completion. At a broad level, the Cases module provides overall project strategies that have been employed to address situations such as wetland development, design for disassembly, and infrastructure rehabilitation. Similarly, at a detailed level, the Equipment and Processes modules provide a set of detailed examples of standard and non-standard solutions to commonly encountered construction operations. For example, the Processes module contains several examples of solutions to drainage problems during construction operations. However, rather than singularly focusing on successful solutions, unsuccessful solutions are also included that show erosion and silt problems resulting from incorrect drainage procedures. In this manner, the Resource Library builds upon case study

research that documents that multiple types of case studies are essential components of the learning and assimilation process[2].

The decision to include these diverse constituency requirements presented the potential problem that addressing these constituencies could significantly increase the number of entries required within the library. To address this problem, a design approach was adopted that emphasizes case studies as the core of the repository. Based on the field study approach adopted early in the research effort, combined with the large body of evidence stating that case histories are a valuable addition to the learning environment[3,4] , case studies were established as the organizing structure for all stored materials. Specifically, all Resource Library entries are initially developed as part of a chronological description of a specific case. After creating this chronological history, individual video clips are evaluated for possible cross-indexing in the remaining Resource Library modules. For example, the entry illustrated in Figure 4 focuses upon the excavation of a foundation footing at the Stone Mountain Tennis Center. While this entry was initially selected to be an entry within the Stone Mountain case study, it was subsequently cross-listed in the Processes module as an example of an excavation operation and in the Equipment module as an example of an excavator. In a similar manner, each of the 5 case studies initially selected from the 1996 Olympic Games development effort were analyzed for potential use in multiple modules. Through this cross-listing approach, the Resource Library maximizes the use of entries while addressing the need for both contextual viewing of multiple entries and directed viewing of individual entries.

Conclusion

The development of the Civil Engineering Resource Library prototype follows a methodology that emphasizes the transformation of classroom, professional office, and field study knowledge into a multimedia repository of case study information. The case study basis of the Resource Library provides the flexibility to address the diverse requirements of students, educators, and professionals. Currently, the Resource Library prototype is being released to a selected group of educators for testing through a CD-ROM format. The feedback and results from this initial testing will be used to enhance and advance the Resource Library concept. Through a series of evolutionary steps, the Resource Library will continue to progress from the current CD-ROM stage to an on-line repository, and finally, to an intelligent project assistant. However, throughout this evolutionary process, the thread of continuity that will remain is the belief that the Resource Library is a knowledge supplement, not a knowledge substitute. The focus of the Resource Library will remain on complementing the acquisition of information and knowledge by students.

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