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Captured Construction: A Digital Media Library of Building a Construction School

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Abstract
Building construction involves multiple disciplines carrying out many varied activities. Modern information technology, especially digital multimedia and the Internet, allows construction processes and activities to be easily captured and publicized. During a two-year period, three thousand digital photographs and many hours of digital videos were captured to document the construction and management activities throughout the building process of a new state-of-the-art facility for a construction school in the United States. Faculty members in this ACCE accredited construction management degree program have developed an online digital library using these captured media to enhance teaching and learning about construction. The library helps students and educators access relevant construction knowledge about the building they occupy. With a digital collection management software program called CONTENTdm™, media in this library are selected, enhanced, cataloged and made searchable online. Finding media in the library is facilitated using keywords chosen from the common vocabulary of construction educators, students, and practitioners. Examples are materials: concrete and rebar, labor: carpenter and mason, equipment: backhoe and crane, tools: hammer and total station. This paper explains the implementation of this digital media library and introduces examples of its application as a relevant visual resource for teaching and learning about construction. Feedback from students and faculty for using and improving this library is also discussed in this paper.

Keywords
Digital media library, Online digital collection, CONTENTdm, Construction education, Building construction

1. Introduction

When planning started for a new building to house the McWhorter School of Building Science at Auburn University, faculty members envisioned the building process itself providing learning opportunities for many years into the future. The 30,000 sqft (2787m^2) three story steel, concrete, brick and glass building would house on any given day over 200 students and 20 faculty and staff, while conducting classes, meetings, interviews, computer and lab projects. The school has long been involved in exploring multimedia to enhance learning of construction for its students (Liu & Hein, 2008). As construction began faculty members were determined to capture as many construction activities as possible using digital images, video, and documents with the intention of making them readily available to the school's faculty and students. Over a period of two years, construction meetings, concrete pours, steel erection, truss bracing, temporary structures, finishes, construction documents and many other construction events were recorded digitally. The result was a large amount of data, including approximately 3,000 digital images, more than 30 hours of videotape, and more than 100 scanned images of plans, specifications and other relevant documents. The task of storing, organizing, editing, enhancing, and cataloging this large amount

of information was challenging, requiring much more time and effort than the media capture itself. The project team selected a commonly used cataloging software platform named CONTENTdm™ to manage the media nightmare and make the media available to all who wished to learn from the construction project. This paper describes the project that resulted in a robust digital media library, used by faculty and students to learn about construction in the context of the building that houses them.

2. Implementation of the Online Digital Media Library

2.1 Construction Media

Before groundbreaking of its new facility, faculty members of this construction management program made plans to document the construction process using photos and videos. The main purpose was to use the new building and its construction documentation as a teaching environment in many courses in the curriculum. A graduate student with construction experience and adequate photography skills was assigned the task of daily visits to the project site to capture major construction processes and activities using a digital camera and camcorder, and then uploading the digital media onto the school's file server.

From the groundbreaking in early 2005 to the grand opening ceremony in October 2006, approximately 3,000 construction photos and about 30 hours of video documenting the construction of the building were captured and stored. While most of the photos were taken by the student, others were captured by faculty members from their teaching perspectives, e.g. structures, mechanical systems, safety, etc. These photos and videos captured most of the building construction activities, including site work, excavation, foundation, steel, masonry, mechanical, etc. With so many digital files, a logical file naming convention was developed. Every original digital image file was named by construction activity it captured and saved in a folder named after the date it was uploaded. For instance, an image file named "*steel erection photos 013*" stored in a subfolder named "*Steel Erection 102505*" in the "*October*" folder explains that this photo was the thirteenth of a set of photos taken on October 25th 2005 at a steel erection activity.

Initially the digital collection of construction photos and videos stored in the school's file server was accessed by only a few faculty members and students. It had been realized that the search process in the collection was tedious since the simple folder structure lacked sophisticated cataloging, filtering, and search features. In most cases, users had to spend significant time browsing image thumbnails in many folders and opening a number of files before locating the desired image. Faculty and students were unable to search through the large volume, using useful search criteria. Also, a comprehensive index of these media had not been created. It became clear that reorganization of the digital media files into a more accessible collection would be essential for the school to fully realize the potential of this unique learning resource.

2.2 A Digital Multimedia Collection

To take advantage of the educational features of construction documentation media of the new facility, faculty members started a project to develop an efficient application to utilize these media in teaching. The objectives of this project, which have now concluded were: 1) to include relevant construction media including digital photos, videos, construction drawings, specifications and 3-dimensional models; 2) to review, enhance and catalog these media files; and 3) to develop a means to make them easily accessible to faculty and students, the construction industry and the general public. Through research, the project team has created an online multimedia collection that catalogs the construction media, making it searchable by media type, such as photo and PDF document; or by a vocabulary of familiar construction keywords, within categories such as building material, labor trade, equipment, tools, activity, etc. A typical work flow of adding a construction photo to the collection is shown in Figure 1.

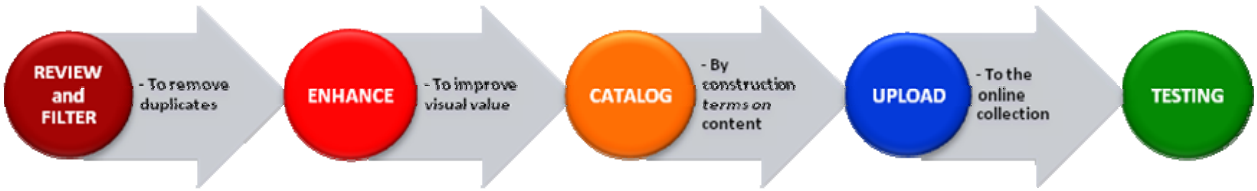

Figure 1: Work Flow of a Typical Media File in this Project

2.2.1 Review the raw digital media

The objective of this step is to eliminate the duplicated media files, keeping only the most representive ones in the collection, mainly the construction activity photos. Since digital cameras were used to capture the photos, many similar or even identical photos were often taken. Reviewing the original media files was useful in educating the project team about the raw resource, facilitating better cataloging in the later stage of the project. Digital image software programs used for this task included Windows Picture and Fax Viewer, Microsoft Office Picture Manager, and Adobe Photoshop. Raw videos were also reviewed and divided into managebale modules of construction activities. For example the original 1-hr raw video capturing a concrete slab pour was subdivided into 3-6 minute segments illustrating the distinct preparation, placing and finishing activities, such as layout, excavation, forming, depositing, strike-off, floating, edging, troweling, jointing, etc. Video modules were compressed for fast access over the web.

2.2.2 Enhance

Some of the photos were taken in poor light conditions or with incorrect camera settings, such as insufficient light, unlevel framing, poor subject position, or poor color balance. The project team used Microsoft Office Picture Manager and Adobe Photoshop to improve the visual value of these types of photos, for example: adjusting the brightness and contrast of a dark photo, using the auto-color feature to balance others. This step has been conducted simultaneously with reviewing to eliminate similar files. When working on the original photos, team members have been careful not to compromise accuracy of photographic content, such as by distorting the aspect ratio, over rotating, or cropping valuable context from an image. Video compression was done by downloading raw footage to avi format, clipping unnecessary footage and compressing to wmv (Windows Media Video) file format. This produced a medium quality video much smaller in file size than the original.

2.2.3 Catalog

There are five types of multimedia files included in this digital collection, they are: 1) digital construction photos; 2) construction drawings/plans in PDF (Portable Document Format); 3) construction specification in PDF; 4) digital construction videos; and 5) 3-dimensional models of the building in 3D PDF. The project team believes that the method of cataloging these files has been key to the success of the project. Cataloging these media files requires a thorough view and understanding of the content in each of them, which demands significant amount of time and requires appropriate construction knowledge and experience. In order to make a file searchable in the collection, keywords are assigned to it based on its content identified during the review. Since this collection is dedicated not only to serve as a teaching/training tool for construction management students and professionals, but also to provide visual experience to other related disciplines involved in building construction, selection of the keywords to be used for searching in the collection has required a great deal of attention. Team members often had to consult with their colleagues with construction expertise in areas other than their own. Through this cataloging task, each media file in the collection must be assigned one or a set of keywords that represent its significant content from different perspectives, and these keywords must also be common terms in the architectural, engineering or construction vocabulary. After thorough research and discussion, nine categories of keywords have been selected to catalog the digital files, they are: CSI (Construction Specification Institute) division of construction activity, major building material(s), construction activity,

construction labor, construction equipment, construction tool(s), primary building component(s), secondary (sub) building component, and temporary structure.

A media file can be assigned multiple keywords in each category. See Figures 2a and 2b for example.

Figure 2a: A Photo in the Collection

Title	Pour SOG 030
Description	Pour SOG 030.jpg
Date Photographed	2005-10-19
CSI Division	03 Concrete
Material	concrete wood
Activity	Installation
Labor	Cement Finisher
Equipment	Pump, Concrete
Tools	Float, Bull Come Along
Building Component	Slab On Grade Blockout
Sub Building Component	Rebar Welded Wire Mesh Vapor Barrier
Temp Structure	Form, Wood Brace
Format	JPG
Source	Pour SOG 030.jpg

Figure 2b: Multiple Keywords Assigned to this Photo

2.2.4 CONTENTdm

The project team conducted a study of completed web-based digital multimedia collections and software programs used to build them. The initial goal of this study was to locate a software application adequate to handle all types of digital media files, would be efficient and friendly to all types of users, and would also require low cost of implementation and maintenance. The project team turned to the Auburn University Library for assistance and after a productive meeting with library staff, decided to evaluate a web-based digital collection builder named CONTENTdm, which had been adopted by the University for developing multimedia collections for several academic units on campus and for the state of Alabama.

CONTENTdm is Windows-based software from OCLC designed for building digital collections with cataloging workflows. It can handle storage, management and delivery of digital collections to the Web where data and digital items are prepared in large batches. CONTENTdm can provide a Web-based search interface and customizable display templates for collections. Digital collections can be searched via the Web using standard Web browsers by any number of users. The way CONTENTdm works is: a collection resides on a CONTENTdm server; digital items can be added to this collection from anywhere using the CONTENTdm Acquisition Station software; and then the collection can be managed remotely over the Web (CONTENTdm, 2008).

CONTENTdm has been used by many academic institutes and libraries. The project team was impressed by its following software attributes: 1) robust capability for creating, managing and sharing Web-based digital collections; 2) friendly customizable user interface; 3) easy to use with pre-built templates and batch processing; 4) excellent viewing and presentation features well suited for teaching; and 5) flexibility and fully customizable, offering full control over digital resources, their descriptions, access and display (CONTENTdm, 2008).

The decision to use CONTENTdm was influenced by the considerable expertise that the university's library staff has acquired through successfully building digital collections with the software for years. Furthermore, the experienced staff were willing to help develop the new collection and to host it on their

CONTENTdm server. Consequently, it was an easy decision for the project team to use CONTENTdm as the platform for their digital collection.

With assistance provided by the library staff, the structure of the new digital collection has been established. At the time of this writing a total of 1,108 digital files, including 991 photos, 114 construction plans and 3 construction specifications have been posted, with more to come. Figure 3 is a screen shot of sample thumbnails from the digital photo collection in CONTENTdm.

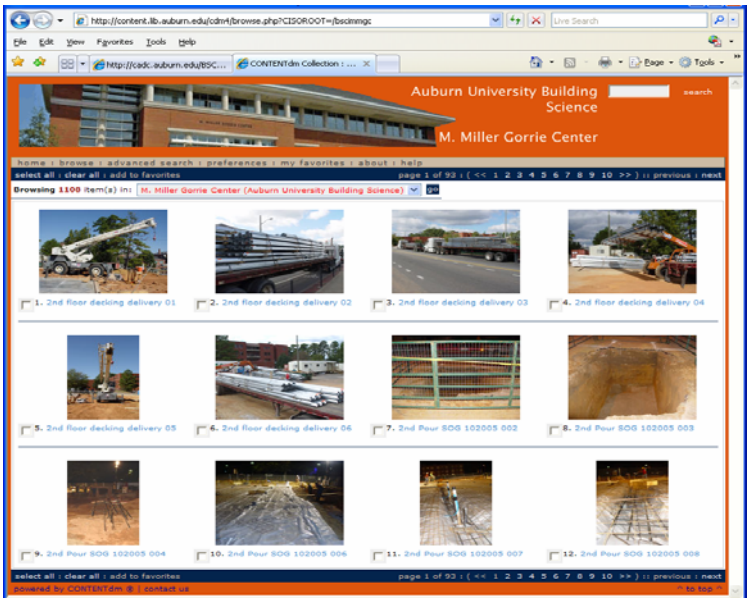

Figure 3: Interface of the CONTENTdm Digital Collection

Figure 4 shows the homepage of the digital construction media library hosted on the McWhorter School of Construction's website. This homepage has a short introduction of the collection, a quick link to the entire collection hosted on the CONTENTdm server of the university library, and some quick search features that allow users to find photos from a listing of pre-defined keywords in a desired category or to find construction drawings and specifications using the pre-defined list of document types.

Once the desired file has been located through a search, it can be viewed in a new Web browser window. File information such as, file name, short description, keywords in each category, file type and other related information is also displayed in the same browser window. Figure 5 shows the sample view of an image file in the collection and Figure 6 shows the view of a PDF structural plan.

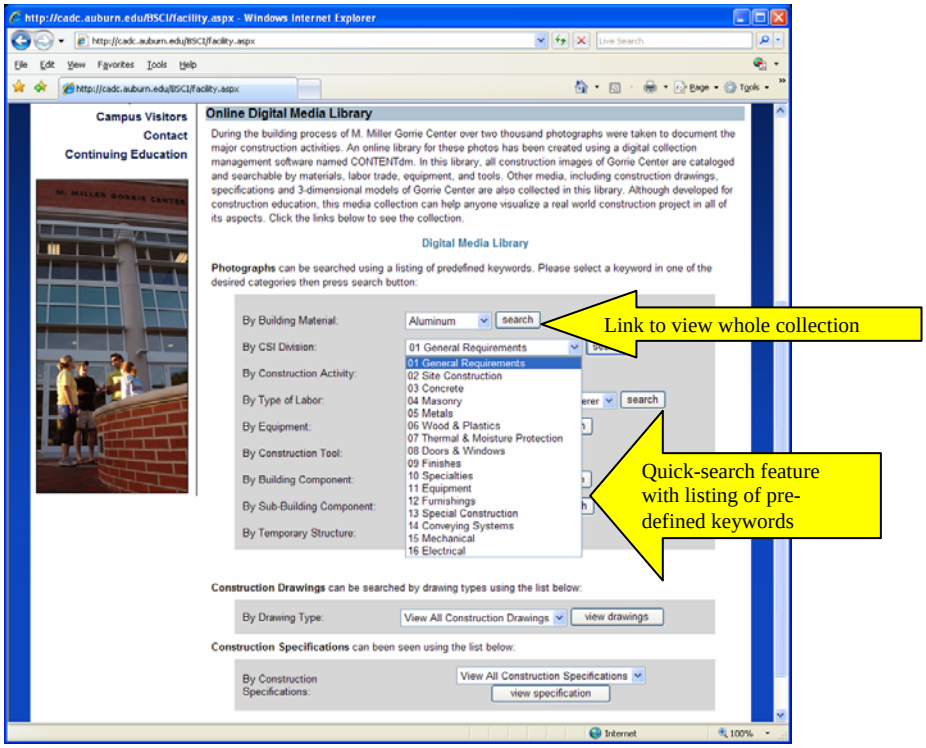

Figure 4: Homepage of this Media Library of Building Construction

Figure 5: A Single Image View

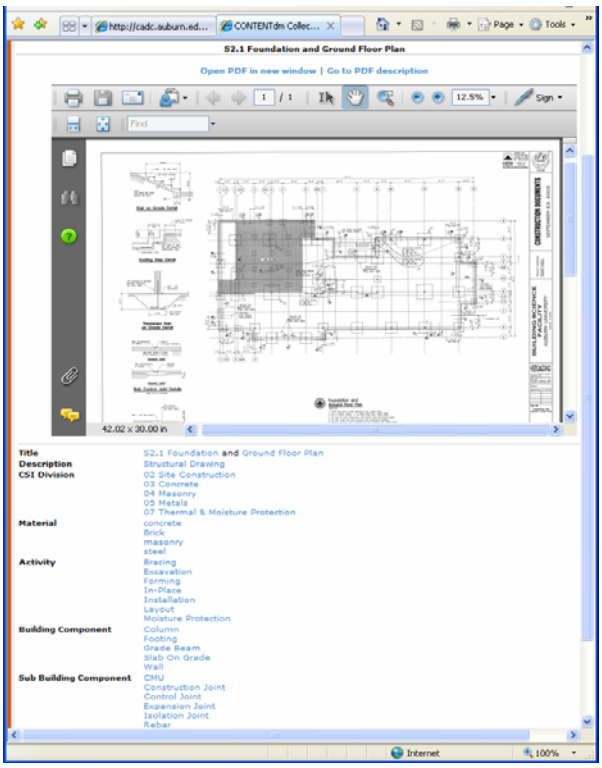

Figure 6: A Single PDF Structural Plan View

3. Use in the Curriculum and Feedback

This digital media library of building construction features many outstanding functions for teaching, such as advanced search and sort, download of selected media files to use in other software applications, side-by-side comparison of media, slideshow viewing of selected images, generation of and sharing a list of selected items, and download and import of selected images with desired data directly to Microsoft Office PowerPoint. This collection has been introduced to faculty and students in the program through presentations, training sessions and class demonstrations.

One example of the library's early implementation can be illustrated by an assignment from a course in reinforced concrete. Course instructors created a homework assignment that required students to search the library for visual evidence to support their answers to questions about construction of the building's ground floor slab. After a brief demonstration of library use, the students were given a ten-question homework assignment. Following is the assignment in brief, one of the ten questions, and one of the student's answers to that question (Figure 7).

Assignment: *"Visit the Digital Library Collection of images documenting the building of M. Miller Gorrie Center. Using the library software search features, select three images that support your answer to each of the following questions about the slab-on-grade pour of the ground floor concrete in the building. Compose a formal memo to your instructor, answering each question with brief text supported by your images."*

Question 6: *"Find one major error or failure the contractor made during the pour. How successful was the contractor in fixing the failure?"*
Student Answer: *"The frame blew-out. The contractor reacted quickly and pushed the frame back vertical using a backhoe. The machines held the frame work in place while the concrete dried and set. The slab turned out fine, but it was not the best way to pour a slab."*

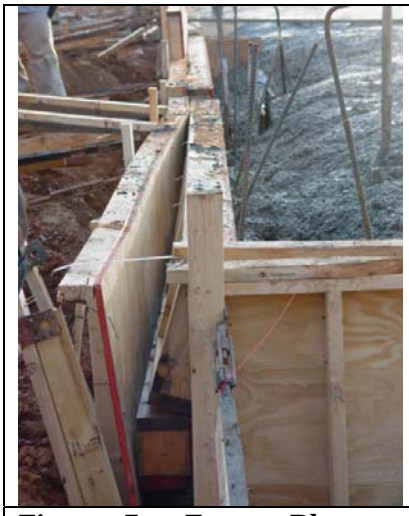

Figure 7a: Frame Blew-out during Pour

Figure 7b: Backhoe-loader pushed Frame Back Vertical to Hold Concrete

Figure 7c: Vehicles Held Frame up while Concrete Set

With only a little instruction students were able to use the keyword vocabulary to locate relevant images, and copy and paste them into their answer tables. Following this exercise students were asked what they thought of providing visual images as answers to technical questions. The consensus was that it was a much better way to communicate complex detailed construction issues. In browsing related images

students agreed that they learned something about the construction process from the images they did not select as well as from the ones that best answered the questions.

Meanwhile, other faculty members in the school have started using the digital multimedia library. One professor has used the library when covering structural and architectural components of commercial buildings in his Construction Materials and Methods course. He has used images found through keyword search that showed the respective component or system being covered in his lecture. According to his comments on using the digital library, he has noticed that the results of the keyword search were accurate with a few insignificant exceptions, and the interface was easy to use and manage. This faculty member also plans to use the library to enhance his lectures in a construction project controls course that covers planning and scheduling of commercial building projects. Part of teaching planning and scheduling is discussing construction sequencing, which is generally difficult to teach just with a set of drawings. Since the images in the library are date stamped and the date field is searchable, he plans to use the images to create a timeline of the construction process for Gorrie Center. One of the comments he made was "….having all the construction images from a single building that the students already live and learn in is far better than a collection of random images showing construction processes."

4. Conclusion

Through research, planning and many hours of media editing, faculty members of the McWhorter School of Building Science at Auburn University in the USA, have created a useful learning resource for school faculty members, students, alumni and the general public. The digital media library provides a unique and penetrating record of the construction of the new M. Miller Gorrie Center, the first gold LEED school building in the state of Alabama. Through a user friendly web interface and powerful tools provided in the CONTENTdm software, access to all of the construction activities of the facility have been made available. The process of capturing the construction began with a plan to visually document all phases of the construction activities as the building was built and will end with a complete searchable digital media library of the captured construction. The tedious chore of sorting through and organizing and cataloging media continues to date with additional files being added two years after the completion of construction. An increasing number of faculty and students are using the library to learn about construction of the building that houses their activities. Faculty in this program believe that this digital multimedia library will be a useful teaching aid for construction education in the years to come. To join this growing group of learners visit the M. Miller Gorrie Center digital media library collection at http://www.cadc.auburn.edu/BSCI/facility.aspx

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