SEVE - A Structural Engineering Visual Encyclopedia
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Introduction - The Problem

Civil engineers use construction (or engineering) drawings to convey to other engineers and lay people their designs for bridges, highways, buildings, etc. These drawings are often labeled "contract drawings", because they define a contract between the architect, the engineer, and the contractor as to how the finished project is to look, what materials are to be used, and how it is to be built. Therefore, it is quite important that all civil engineers be able to:

- read and interpret engineering construction drawings
- communicate their ideas by means of sketches and drawings
- visualize 3-dimensional structures from a set of 2-dimensional drawings and
- understand and properly use the terminology.

Unfortunately few graduating civil engineering seniors have had any exposure to the first three topics listed above and are, at best, weak with the last. The number of students entering civil engineering programs who have had mechanical drawing (or the equivalent) prior to entering college is decreasing and many departments have eliminated the traditional engineering graphics course from their curriculum. Instead, computer related technologies (equation solvers, geographical information systems, computer aided drawing, multi-media, internet navigation, etc.) and additional subject matter (systems analysis, engineering economics, general education depth and breath, etc.) are being added to the curriculum. At the same time, most programs are trying to incorporate these new topics and technologies without increasing the number of required credit hours or the length of stay.

Objective

The objective is to develop an interactive multi-media software package (*Civil SEVE -Structural Engineering Visual Encyclopedia*) that will address the educational "hole" that has been created by the elimination of reading and interpretation of engineering construction drawings from most civil engineering curricula. *Civil SEVE* is designed to enable a student to read and interpret engineering construction drawings, to promote the understanding of structural engineering terminology and to increase a student's three dimensional visualization of structural systems. The student will have at their fingertips a visual database of structural engineering information brought to life using 2-D and 3-D sketches, CAD drawings of typical sections and details, photographs of actual structural components and animation (video and computer generated). The format of the *Civil SEVE* package will make it useful to the faculty member as an instructional aid in the classroom and to the student as a multi-media study aid. In essence, what is being

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created is a structural engineering visual handbook or encyclopedia. The development of the program is being funded by NSF, (DUE-9555124).

Curriculum Background

Until 1969 each civil engineering student at the University of New Hampshire was required to take an engineering graphics course. Part of the course involved learning to read and interpret engineering construction drawings. In 1969, a computer programming and applications course was added to the curriculum and the number of credits for the engineering graphics course was reduced by removing the reading and interpretation of engineering drawings component. By 1975 the engineering graphics requirement was dropped entirely so that additional emphasis could be placed on engineering related computer applications.

In the past two decades UNH, like many other schools, have added courses covering systems analysis and computer applications to the curriculum while courses related to engineering graphics and engineering drawing interpretation have been eliminated. The result is that the civil engineering students at UNH have become quite proficient at using application software as engineering tools for their upper level courses and as part of their professional engineering careers. On the other hand, most students lack the ability to read, interpret and create a reasonable engineering construction drawing.

Have we done our students a disservice by removing the topics associated with engineering construction drawings from the curriculum? The answer is "no" because the engineering skills required by most of our graduates have changed over the last decade. Rarely is a civil engineer required to do any production drafting, so the need for formal training in the art of drafting (manual or computer based) has been reduced significantly. During the same period, civil engineering companies have significantly increased their use of computers and information technology. Therefore, the increased emphasis on computer applications in the undergraduate curriculum has been well received by those that employ civil engineering graduates from UNH. The answer is also "yes" we *have* done our students a disservice by eliminating the engineering drawing emphasis from the curriculum. We have overlooked the fact that a civil engineer must be able to read and interpret engineering drawings and that one uses these drawings to communicate design concepts to other engineers and technicians. Thus, in the process of advancing the civil engineering curriculum, we have created a serious void.

Approaches to Addressing the Problem

One approach is to require all students to take a CAD (computer aided drafting) course. The difficulty with this approach is that the cost of the equipment, software, space and personnel to teach a CAD course is high and difficult to come by in times of shrinking budgets. *Civil SEVE* addresses many of the educational and physical problems associated with instructing engineering students how to read and interpret engineering drawings. Even if the facilities and time were made available so that a CAD course could be required, the instructional environment offered by *Civil SEVE* would still be practical and beneficial.   *Civil SEVE* provides the instructor with a dynamic teaching tool, while providing the student with interactive, self-paced tutorial material.

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A CAD package is not able to search through a set of drawings for a particular section or detail, nor does it have an informational database (both text and graphic) embedded in the drawings to help students develop an understanding of the notation, symbols and terminology associated with engineering drawings. Thus *Civil SEVE* has it own unique set of attributes.

Another is to add the material related to the reading and interpretation of engineering construction drawings to existing courses. *Civil SEVE* eliminates many problems associated with presenting drawing information to students by using sets of full-scale engineering drawings. The information conveyed by paper drawings is static and maneuvering through multiple drawings to view related plans, sections and details is awkward. It is easy for a student to lose sight of the concepts being discussed when he or she is having a difficult time finding the correct drawing or understanding the terminology. The idea of this project is to integrate the material into existing courses, but in an electronic form. As a teaching aid, *Civil SEVE* provides instructors and students with an interactive, graphical, hypertext based educational package that can be used effectively to teach and to learn the material related to the reading and interpretation of engineering drawings. At the University of New Hampshire, the program is being used in an introductory civil engineering course, a civil engineering applications course and a structural analysis course. It could also be quite beneficial in reinforced concrete and steel design courses.

Another important point is that many engineering students tend to be hands on or visual learners. These students have grown up in a generation of video games, video arcades, and very sophisticated visual effects in the movies. They are comfortable with the most recent advances in information technology. The suppliers of information to the general educational community (Groliers, World Book, Microsoft, Compton, etc.) have recognized this fact and are now offering many of their products on CD-ROMs. This technology can also address the needs of those students that have been identified with certain learning disabilities (such as dyslexia and information retrieval deficiency) by removing the huge hurdle they face of having to be able to spell a word exactly before they can retrieve the information. By using the computer to help with a search, one can typically find the information they desire by just being close to the correct spelling of a term. Then once the information is found, the student is able to connect the terminology with visual images, which usually enhances their ability to retain the information.

Civil SEVE **- The Program**
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In the development of *CIVIL SEVE,* construction drawings (CAD files of the plans, elevations, sections, and details) from several facilities were used as the graphical foundation. Each engineering drawing is two dimensional and contains many symbols, notations and naming conventions which are often quite confusing and unfamiliar to a student. In addition, most students have a difficult time visualizing the information in three dimensions. The drawings and text will be enhanced by sketches, photographs and animation of actual buildings and structural components.

The following is a brief description of how a student might interact with the *Civil SEVE* program. A student working with *CIVIL SEVE* would first see an introduction screen (Figure 1a.) and then the main menu screen (Figure 1b.). Using a pointing device, a student would select one of the

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eleven icons presented on the screen; ***Intro -*** an explanation of *Civil SEVE's* purpose and its major features, ***Help -*** an explanation of how to uses the different features, ***Exit -*** close the program*, **Frames -*** typical building frame components, ***Supports -*** explanation of supports for buildings, ***Terms -*** encyclopedia of the terms and notation used in a typical engineering drawing, ***Plans -*** construction drawings of an actual building enhanced with text, photographs and animation, ***Beams -*** various types of beams typically used in construction, ***Trusses -*** various types of trusses typically used in construction, ***Joints -*** various types of connections typically found in construction, and ***Columns -*** various types of columns typically used in construction.
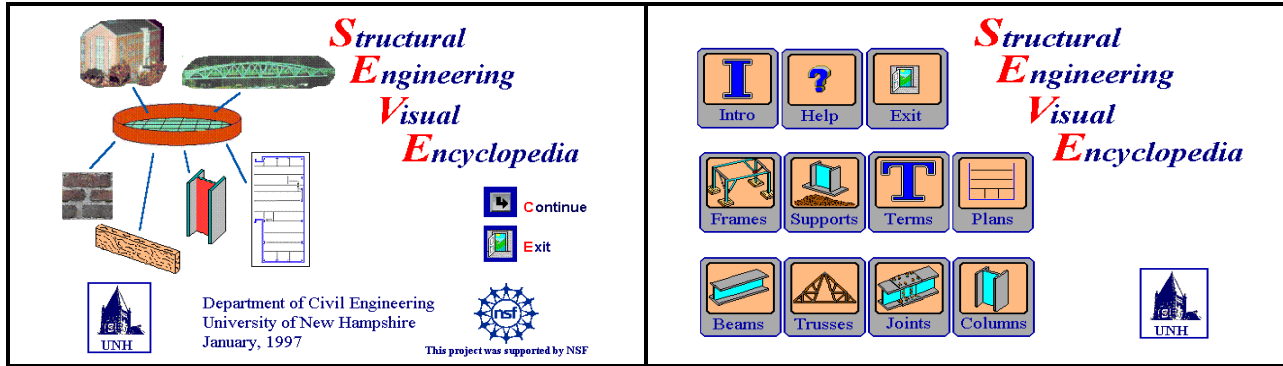
Figures 1a. & 1b. Initial Screens for *Civil SEVE*

If a student were to select the ***Plans*** icon the screen in Figure 2. would appear. From here a student would be able to tour through a set of floor plans for an actual building at the University of New Hampshire. The major difference between seeing a floor plan for the foundation level on paper vs. using *Civil SEVE* is what support information would be readily available.
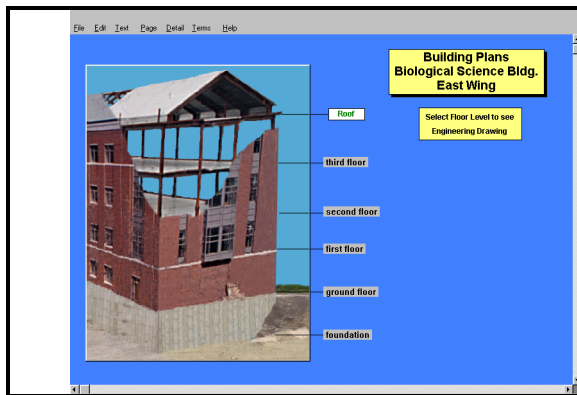
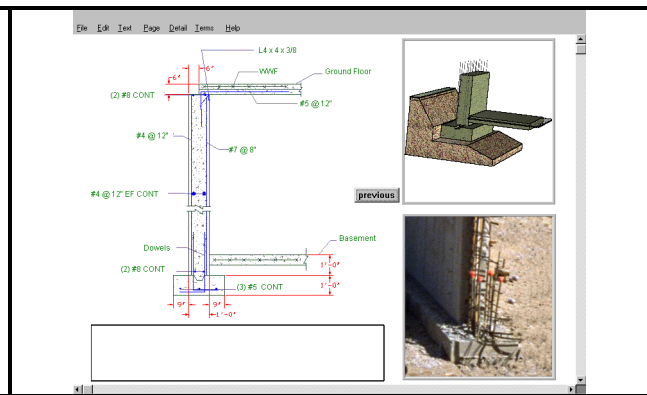

Figure 2. Plans Main Menu   Figure 3. Section Drawing Information

Example - a typical floor plan would have symbols identifying *section drawings* that are available on another drawing and provide more detail about the construction of a particular part of the foundation wall for the building. With a paper drawing, in order for a student to know that there is a section drawing they would have to recognize a section symbol, what it meant and how to locate the additional information. In *Civil SEVE* if a student did not understand a symbol or a

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word, the color of the word or symbol would indicate they could click on it and more information would be provided. In the case of the section symbol, the section drawing would appear along with a 3-D model of the section and pointers to additional information such as photographs, animation, and definitions (see Figure 3.)

Each engineering drawing includes various building components, symbols, notations, and terms that need to be identified and explained to a student. One approach is to have the item on the drawings be "active" (identified by its color) and when selected would display additional information on the screen. Another approach is to have an icon - **_Terms_** - which would present the user with a menu from which to select a term and the appropriate information would appear on the screen. Both have their advantages and each is used in _Civil SEVE_. In either case, a definition is accompanied by visual information associated with the term that would help the user better understand what the term, symbol or two dimensional drawing represents. This is an important feature of _Civil SEVE_, because many students have never been on a construction site and few have any physical feeling for the information presented in an engineering drawing. While three dimensional sketches, animations and photographs cannot replace a tour of a construction site, they can provide a student with the opportunity to develop some feeling for actual building components and how they are graphical represented.

Another major feature of _Civil SEVE_ is that information can be presented interactively in a classroom environment by utilizing a computer and a video projection system. There are many projection systems on the market, ranging from liquid crystal displays placed on an overhead projector to the more costly large screen color projection systems. Using a projection system, an instructor can respond to student questions in an effective and timely fashion. This mode of presentation stimulates student questions and encourages student participation in the classroom. The _Civil SEVE_ software is portable, so students can use it outside of the classroom in a self-paced format on their own personal computer or in public clusters.

Civil SEVE - The Development

The above is a brief description of how one mechanically might use _Civil SEVE_. It would be very difficult to fully communicate all aspects of using _Civil SEVE_ on paper due to its interactive nature and the large volume of information available in the program. Therefore, the remainder of the paper focuses on the factors and decisions that were involved in creating the "look and feel" of _Civil SEVE_. It is also the intent of this section of the paper to give the reader a feeling for how diverse the issues are that influence the development of an interactive multi-media educational package.

There are several components that need to be brought together in order to develop multi-media software like _Civil SEVE_; experience with the development of multi-media courseware, a strong multi-media courseware development platform and support services, a wide availability of computer hardware capable of handling multi-media software, and a source of non-propriety CAD files, 2-D and 3-D sketches, photographs in digital format, video clips related to structural engineering terminology and projects.

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One would think that if you have a strong conceptual plan that the rest would be easy, but this is not true. A simple example might be the selection of images to help a student visualize a typical foundation section drawing.   The first step is to determine what type (or format) of information will be used; a 3-D sketch, a 3-D computer generated model, an actual photograph, a computer generated 3-D animation, or a video of an actual foundation wall and footing. It might be decided to use a combination of formats. If one decides on using a photograph, one must obtain a photograph that is similar to the section drawing or one must redraw the section drawing to meet the details of the photograph. Getting just the right photograph is not always easy. You need to find an existing photograph that does not have a copyright or an actual construction site with the foundations at the appropriate stage(s) of construction. You need to get permission to have access to the site and have the weather cooperate.

Once the photograph has been obtained, it will need to be scanned, saved in a digital format and manipulated in to is final form. Some questions that need to be answered are; "What digital format (gif, tif, jpg, etc.)?", "What bit size (number of colors)?" and "What is the size of the window in which it will be presented?". All this work is necessary for just one image. To finally get the photograph into its final form can take several steps, each using a different software package. Before the actual software development for this project began, over 500 photographs were taken during the construction of several buildings on campus and only a few will actually be used in the final product.. It would have been better to develop the basic structure of the multi-media package, identify the images that were needed and then obtain those images. The problem is that one has to gather the data when it presents itself and hope that you get what you need. As the program developed and the opportunities arose, it was necessary to take additional photographs to obtain the desired angles and details.

Another time consuming aspect of developing a multi-media product is the creation of a "look and feel" that is right for the target audience. One must remember that the people using this product are trying to learn the topics presented in the program. Developers of this type of software product should be constantly asking questions similar to; "Will this make sense to the user?", "Is the program presenting the information in a consistent manner at the appropriate level?", "How will the user respond to this question or page format?" and "Does the program meet its objectives?". In the development of *Civil SEVE*, a small, but typical portion of the program was developed completely before the work any other portions began. This enabled the different aspects ("look and feel", appropriate data format, required support software, navigational aids, reworking product to meet the needs of the user, etc.) of the development of *Civil SEVE* to be thoroughly tested in order to reduce the development time associated with the rest of the program. This was found to be extremely educational and often frustrating.

A note of caution. The development time for the first version of an educational multi-media software product will be significant. This is such an exciting and fast moving area of software development that it is a guarantee that the capabilities of the programs being used to create the product will increase significantly during the development of the first version. One will be sorely tempted to incorporate the latest features into their product. A new software feature should only be added if it is essential to the goals and objectives of the project. If the new feature is not

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essential, then do not add it, merely focus on getting the project completed and out to the users. The latest software bells and whistles can be incorporated into new versions at a later date.

The items mentioned above are just a few examples of what factors go into the development of a multi-media educational package. The following is a list of some other key considerations and concerns:

> Determine the educational level and needs of the target audience.
> Determine the purpose of the educational software relative to the target audience. Is it material for classroom presentation and/or for student use outside of the classroom?
> Identify a plan of how the software package could be integrated into the course curriculum.
> Determine the format and look of the software; screen layout, types of navigational aids, (drop-down menus vs. buttons), minimize "clicks" and reduce needless page "flipping", maintain consistency of presentation, keep the amount of information presented on a page to an appropriate level.
> Navigation through the program should be kept as simple as possible with the help and exit commands readily available.
> Development of the help documentation; on-line help, instructor's guide(s), user's guide(s).
> Determine the distribution and presentation media format of the finished product; cd-rom, hard drive, via the WEB.
> Need to be mindful of the impact that hardware configuration could have on the use of the software by the user; desktop, laptop, memory, size of screen, color levels, availability of a cd-rom and sound card.

Development of a multi-media educational program is both exciting and challenging. The excitement often comes from seeing what one can do with some extremely powerful screen manipulations.. Many of these "neat tricks" provide no real value in meeting the goal of the project which is to enhance a student's ability to learn a particular topic. But they are eye catching to a user. The challenge is to find the proper mix of software tools, data (words, images, sounds and animations) and presentation style (layout, navigational aids and documentation). A good program requires imagination, creative mind(s), trial and error, and a lot of luck.

Dissemination and Distribution

A copy of *Civil SEVE,* when completed, will be made available for evaluation to any civil engineering related department at no cost. If a faculty member or department decides to adapt the software for the use by their students, the right to reproduce a limited number will be made available or they can obtain additional copies from UNH for a small fee to cover the costs of duplication, shipping and handling. It is anticipated that it will cost less than $15 per. The final version of the software will be ready for distribution during the spring of 1998.

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Biographical Information

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