

Computer based laboratory simulations for Geotechnical Engineering

Sunil Sharma¹ and James H. Hardcastle²

Dept. of Civil Engineering, Univ. of Idaho, Moscow, ID 83844-1022, USA

¹*Tel: (+208) 885-6403, Fax: (+208) 885-6608, ssharma@uidaho.edu*

²*Tel: (+208) 885-6302, Fax: (+208) 885-6608, jimhard@uidaho.edu*

Abstract: This paper discusses a Computer Based Instruction (CBI) module which introduces the many phases of the laboratory experience associated with the direct shear test to undergraduates. This module is part of a total of ten modules that have been developed to provide experiential aspects of laboratory testing associated with the first course in geotechnical engineering. In general, these modules range in complexity from visual, manual soil classification techniques to shear strength determination using the more complex triaxial test. Each of these modules provides: (1) reference material, (2) modeling and simulation using rendered 3-D graphics and video, (3) an interactive tutorial and quiz to test the student's understanding, (4) handouts containing typical lab data, results and blank forms in Adobe PDF format, and (5) exploratory links to external World Wide Web sites. The series have been developed using ToolBook II from Asymetrix and 3D Studio Max from Kinetix. In this paper, the Direct Shear Test module is discussed to illustrate our proposed teaching concepts and the overall framework of the other nine modules. This module shows the students how to assemble the shear-box for the test, prepare the machine for shear loading and the data collection and reduction aspects. These procedures are demonstrated using video clips and animations and can be expected to provide the student with a realistic experience of the actual test before going to the laboratory.

Keywords: geotechnical, laboratory, computer, simulation, education

1. Introduction

In the Department of Civil Engineering at the University of Idaho, multiple laboratory sections are used to ensure that students receive significant hands-on training that will firstly enhance their educational experience and secondly give them an accurate insight into the general practice of engineering. In order to provide this rich experience, faculty have to expend considerable effort to ensure that the highest standards are achieved at all times.

To facilitate this learning experience, a Computer Based Learning framework has been developed to enhance the laboratory instruction. It is also hoped that this will reduce the overall demands on the faculty time for multiple laboratory sections. These tools can operate on individual workstations or over a local area network (LAN). Future modifications will allow these modules to directly operate over a local Intranet or over the more global Internet for the convenience of non-campus students.

2. Project Scope

The project will develop twelve computer-based modules to supplement the existing geotechnical laboratory sessions. The proposed 10 modules are:

1. Water content, weight-volume relationships
2. Visual manual soil classification
3. Atterberg limits
4. Grain size distribution
5. Compaction tests
6. Field density testing
7. Permeability tests
8. Consolidation testing
9. Direct shear test
10. Triaxial tests – UU, CU and CD

The modules, or courseware, have been designed to operate on a multimedia capable (i.e. one with a CD-ROM drive and sound card) IBM-PC, or compatible, with at least 16 Mb of RAM, running the Microsoft Windows-95, Windows-98 or Windows-NT operating system. Although not necessary, it is recommended that the computer have access to the Internet for downloading small files and submitting quiz results for grading by the instructor.

The courseware ranges in complexity from visual manual soil classification techniques to triaxial shear strength testing. Each module provides the following features: (1) reference material, (2) modeling and simulation using rendered 3-D graphics and video, (3) an interactive tutorial and quiz to test the student's understanding, (4) handouts containing typical lab data, results and blank forms in Adobe PDF format, and (5) exploratory links to external World Wide Web sites.. The reference material is assembled as a multimedia, hypertext document which includes graphics, video clips with audio commentary, example problems and engineering applications. This material has been assembled from HTML files using the new Microsoft "Help-file" compiler. This is much easier than the previous help file system and allows users to modify, and supplement, the provided help-files, much more easily. Of course, as the reference material is viewed using a mini-browser, the user can also "visit" other relevant sites on the WWW.

The modeling and simulation builds on the reference material and adds animation effects to introduce the students to the actual sequence of the recommended laboratory procedures. The most important feature of the courseware is the tutorial, which provides interactivity through an elaborate "branching" structure which uses drill and practice concepts to reinforce and test the student's understanding of fundamental principles

3. Example Module

The modules have been prepared such that a student can complete the simulation within 30-40 minutes. It is generally recommended (... by educational psychologists) that such exercises be limited to only thirty minutes as students usually lose interest if they are too long or overly complicated. One has to remember that the user will typically only complete a module once (or possibly twice) before proceeding to the next laboratory module. In view of these constraints, we have prepared all modules within a consistent and intuitive framework. To illustrate our approach, the "Direct Shear" (DS) module will be presented as an example.

Figure 1 presents the opening screen for the DS module. From this screen, the user can review the objective of the direct shear test, which is just one short paragraph to allow for easy comprehension. Selection of the "Background" option takes the user to a HTML-Help file (Figure 2). This is similar to the material that one finds in a text-book, but can be supplemented with new interactive material, video-clips and hyperlinks to other sections and WWW sites. The "Direct Shear Test" and the "Practice Test" selections take the user to the interactive material.

As with all laboratory sessions, a set of brief notes, blank data forms and a set of example data are provided for printing. This printable material has been prepared in Adobe's "Portable Document Format" (PDF) as it offers the most convenient approach. A typical file is provided for use, but if the instructor wishes to change these notes, a modified PDF file can be substituted accordingly. To complete the material content, a "References" selection will guide the student to more information that may be made available by the instructor. Upon selection of the "Direct Shear Test" option, the user is taken to the screen shown in Figure 3. This is the main screen for the interactive module.

From this screen, the user can press one of the topical buttons on the left to view a list of related items that are shown on the right. In this figure, the "Equipment" option has been selected and offers the student an opportunity to view the laboratory equipment that will be used for a typical direct shear test. In exploring this figure, the student is presented with different views of the various parts of the shear-box (Figure 4) or the actual direct shear testing machine. This allows the student to get familiar with the terminology. In Figure 4, for example, the "Porous Stone" is identified by the current location of the cursor. We find that if the student can become familiar with the terminology *before* attending the actual laboratory session, unnecessary questions and repetitive explanations can be avoided and more time can be dedicated to the actual test. Other options from the screen shown in Figure 3 will take the user to other screens that illustrate sample preparation, assembly and the test process using animation.

One of the most important parts of the laboratory test is the data collection and reduction phases. To illustrate this, the "Data Collection" option shows the user typical raw and computed data, as well as graphical versions. The steps necessary to convert the raw data to the final data are all explained via an external RTF file. These explanations are kept in a separate external file as it allows the instructor to make appropriate changes using a conventional wordprocessor rather than modifying the ToolBook file itself.



Fig. 1. Main screen of the Direct Shear module.

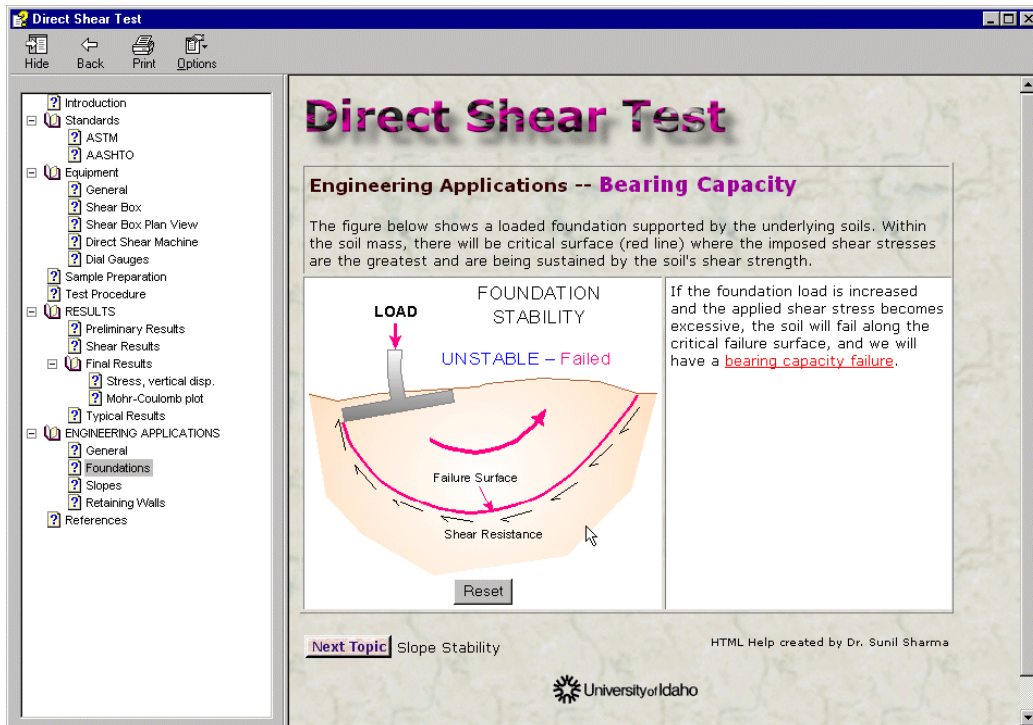


Fig. 2. Reference material presented in HTML help format.

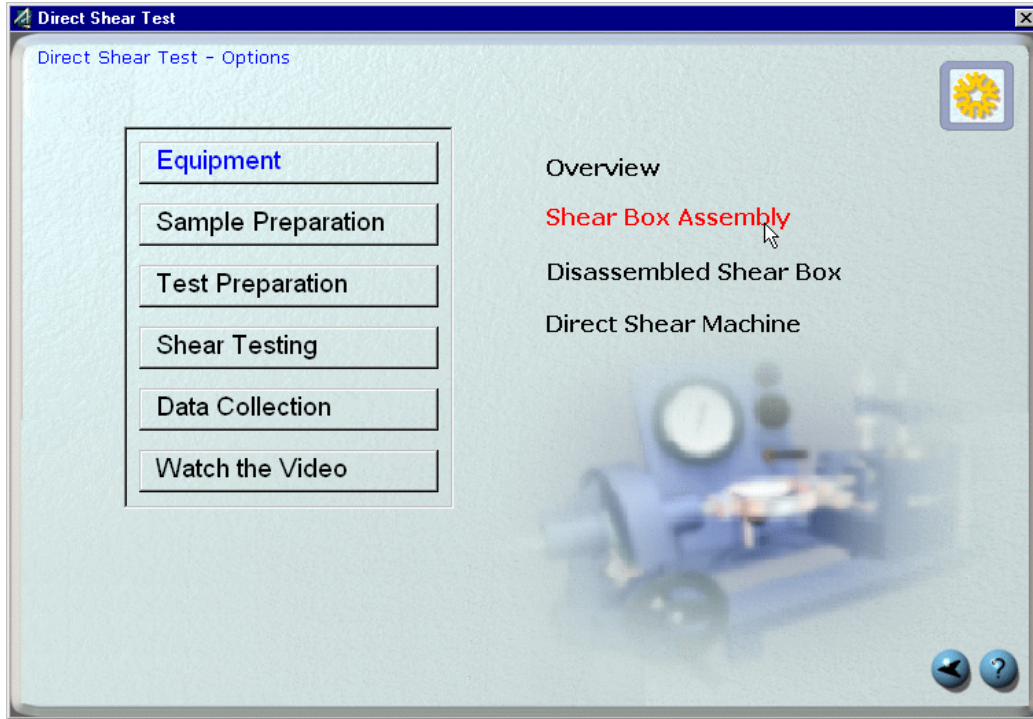


Fig. 3. The Direct Shear test content screen



Fig. 4. Exploring the equipment used for the Direct Shear test

Once the student has become familiar with the details of the test, it is possible to actually perform a test using a "drag-and-drop" approach. The "practice-test" is accessed from the main screen shown in Figure 1. After completing all the sequences, the student is now left with the final item – the QUIZ! This is a multiple choice quiz that presents the student with five questions that have been randomly selected out of a total of ten that have been programmed into a separate application. This separation of the quiz and lab module is intentional as it allows instructors to change the questions without getting involved with the main application. The results of this test can be reported to the student immediately, or alternatively, can be emailed to the instructor.

Finally, as geotechnical laboratory tests are never as clean or precise as indicated by the animations, we elected to include a video-clip of the actual laboratory test. For the DS module, this clip is rendered in a 320x240 pixel window, as shown in Figure 5. At this time this particular clip uses a compressed 70Mb AVI file for the 3 minute long presentation, but with new compression technologies, the clip can be further compressed to less than 5 Mb without any noticeable degradation in the quality.

4. Summary

In this short paper, we have introduced the multimedia approach being used to enhance the learning experience of civil engineering students enrolled in their first course in Geotechnical Engineering. The computer assisted approach should improve the capability of the students in performing the actual test, and hopefully, increase their overall awareness to the difficulties associated with the testing of soils.

5. Acknowledgements

We wish to acknowledge the work of Rob Barnes (currently at the Open University, UK) who helped create the animations, video-clips and figures. Of course, none of this would have been possible without the support and foresight of the Idaho State Board of Education that funded this project under their "Technology Incentive Grant" program. Travel funds to attend this conference were provided by The National Science Foundation and the University of Idaho.

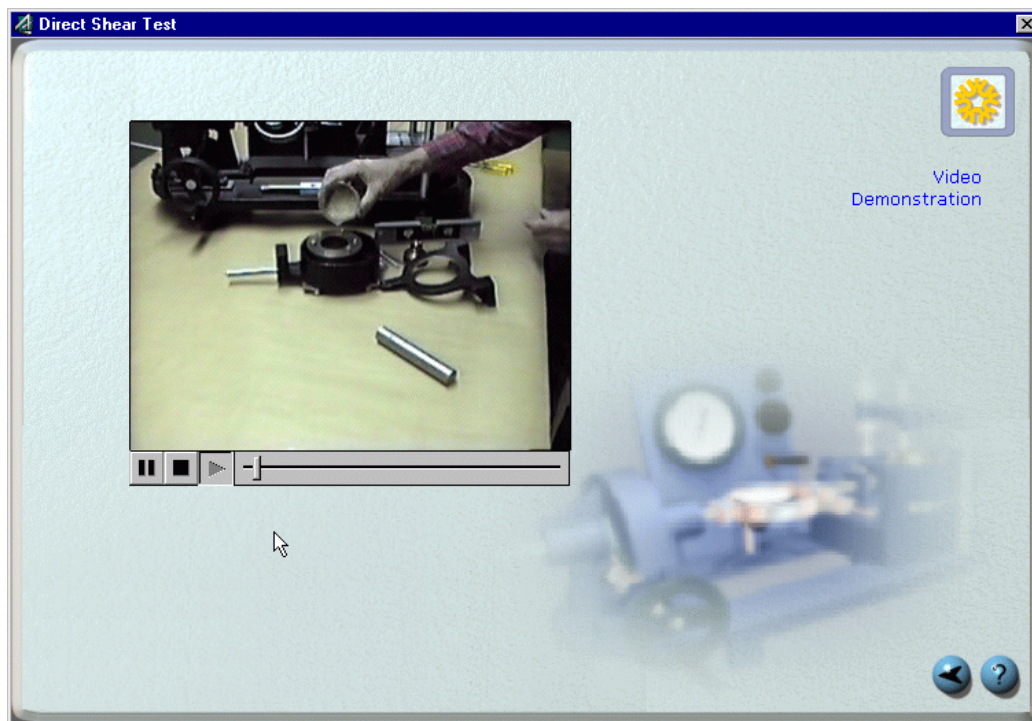


Fig. 5. Video clip of the Direct Shear test