A Virtual Walkthrough on Reinforced Concrete Construction Details

Mohammed E. Haque, Murtuza Aluminiumwalla, Salim Saherwala

Texas A&M University, Texas, USA

Abstract

The traditional chalkboard methods of classroom teaching are often supplemented by alternative methods, so as to enhance the understanding of the students. These alternative methods include field trips, use of 3-D drawings and physical models. Although construction site visits are the best way to expose students to actual construction technologies, they present difficulties of logistics and cost. Besides the risks involved in field trips, the site may not be at a particular stage of construction during the academic semesters, or the construction process may not be fast enough to understand multiple aspects within a short duration of field visits. Considerable pedagogical advantages can be achieved by the integration of the contemporary information technology (IT) and visualization tools in teaching engineering technology. The objective of this research was to develop 3-D animations and virtual walkthrough on reinforced concrete construction detailing. All the techniques that were used in this research employed a generic programming architecture, which was discipline independent and could be adapted to any other similar domain. These visualization techniques can be valuable aids not only in teaching in the classroom but also an effective self-directed tool for open learning via the web.

Introduction and Background

The instruction methods used in the majority of construction engineering and management curricula rely for the most part, on traditional methods such as exposing students to applied science courses. These traditional teaching methods, however, are often not fully adequate in providing students with all the skills necessary to solve the real world problems that are encountered in the construction industry. Furthermore, complex engineering knowledge is also not conveyed effectively using only traditional "chalk and talk" methods. Studies showing that students in undergraduate engineering exhibit a stronger preference for the active, sensing, visual and sequential learning styles indicate that virtual reality can potentially have a tremendous impact on engineering education (Scott, et. al, 2003). Teachers are not able to convey their ideas and explain concepts clearly through these old traditional techniques. Design concepts can be explained more clearly if they are explained using visuals and animations. By providing learning environments rich in varied learning methods, educators can provide students with more diverse means of receiving and applying knowledge and information resulting in a more engaging and interactive educational setting (Scott, et. al, 2003).

Complementing the more conventional classroom instructional tools would ideally include visits to construction sites or site training (AbouRizk and Sawhney, 1994). There are, however, various

complicating issues that make it impossible to rely on site visits. Most importantly, the instructor cannot control the availability of a project at the necessary stage of completion. In addition, visits of larger groups to construction sites may not be welcome, involve risk, and are unpractical. Finally, the high cost of site training is a further impediment to its extensive use for construction education. General computing and information technologies and simulation in particular, have the potential to act as a priceless complement to construction engineering and management education.

As technology rapidly changes, the importance of educating and training diverse populations of civil/construction engineering/science students becomes more critical. With the advances in information technology (IT) over the last decade, the traditional teaching format of having an individual lecture to an audience has been supplemented, and in some cases, replaced by the rapid development and implementation of new distance learning methods. Classroom use of IT for teaching science, engineering and technology has increased dramatically in recent years and has proved to be very effective in various situations (Haque 2001, 2003). Contemporary applications of IT allow us to develop learner-centered virtual design studios that can be reached to a large student population via the web. Enhancing World Wide Web developments, the new opportunities for interactivity and flexible access to various media format (text, sound, static illustrations, 2D and 3D dynamic illustrations, Virtual Reality worlds) challenge the traditional experience in shaping learning environments for web-based education (Klett, 2002). The student-centered distance-learning archetype should include dynamic demonstration of theoretical engineering models allowing students to manipulate, experiment, and translate theories into real-world applications (Haque 2003). Visualization is an important factor in modern education. Traditional lecture format teaching methods sometimes fall short of conveying the complex analysis and design principles that need to be mastered in reinforced concrete design course. One of the methods of reducing this short fall is to use simple animated virtual models, which demonstrate basic structural design concepts that can be used to enhance the students understanding. The interactive computer aided learning (Haque 2001) allows students to proceed at their own pace, motivated by a curiosity about "what happens" interactivity and "the need to know" the design/ analysis principles.

As the global community increases its utilization of new technologies in the distribution and acquisition of knowledge and information, new paradigms in engineering and management education emerge. A successful engineering and management education model must include and initiate new and diverse methods in order to effectively determine and address the current and forthcoming needs in the training of engineers and managers (Motlagh, and Shahir-Motlagh, 2002).

Hence, it is increasingly becoming important to develop a web based 3-D visualization and animation to explain the various construction processes. The objective of this research was to develop 3-D animations and virtual walkthrough on reinforced concrete construction detailing.

Visualization and Animation Techniques

The visualization techniques that are used to develop a web-based design and construction details' visualization are broadly classified under the following categories:

1. Image visualization/Animation
2. Detailing using VRML
3. 3ds Max based Design Animation and Walkthrough

The image visualization and animations are powerful tools for teaching design courses. If a student has a difficulty with an analysis and design problem, the animations of the structural response to loads and the 3-D animated free-body diagrams explicitly show the foundations of the design mechanics by showing the connectivity between cause and effect. This technique was used to show and calculate the loads distributed from plywood sheathing to studs/joists, stringers/wale, shores and lateral bracings. Figures 1-2 show some of the animated formwork construction details created using 3ds Max.

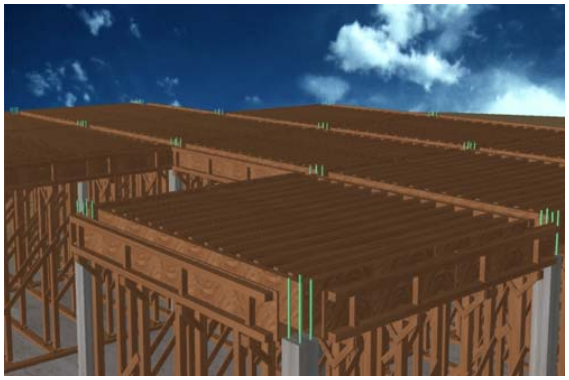

Figure 1: Animated Slab Formwork

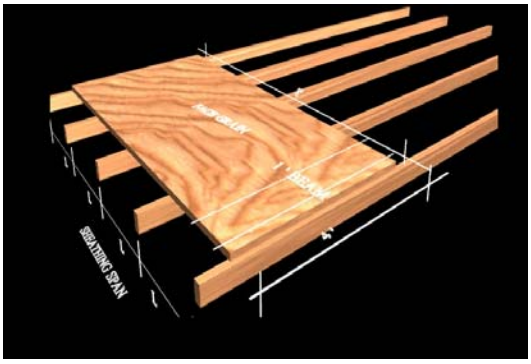

Figure 2: Animated View of Plywood Placement with Stronger Axis Bending

Several animation clips for construction processes and details for reinforced concrete structures were developed using 3ds max. Figures 3 and 4 show the animation and walkthrough details for reinforced concrete foundation and structural slab-beam reinforcement details respectively.

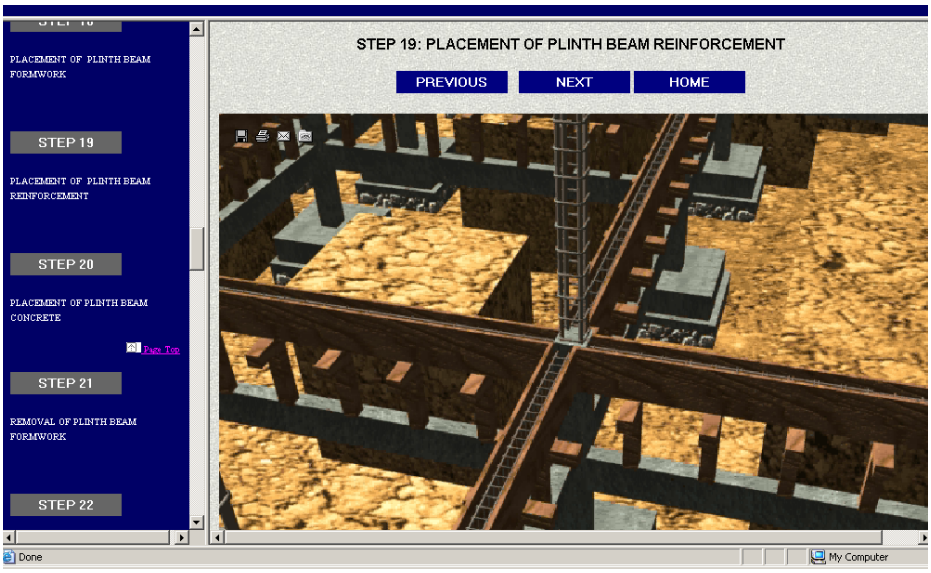

Figure 3: Animation and walkthrough of foundation details.

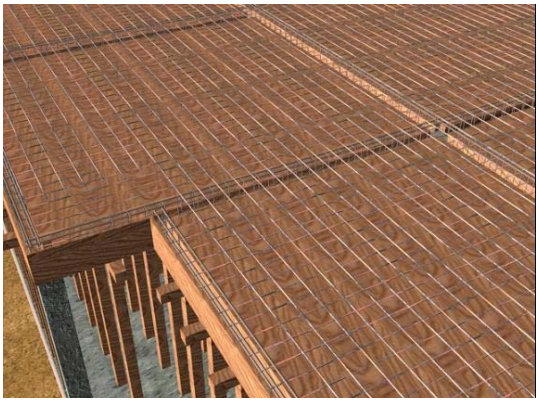

Figure 4: Slab Reinforcement Details

If the 3D objects can be presented on the Web and be interactively changed/navigated, it will be beneficial for the students' conceptual understanding. For example, the capabilities of VRML Model (Figure 5) include calculating number of reinforcement for simple structures such as rectangular beam and T-beam, generating the position of reinforcing steels, and plotting the 3-D navigational structures (Haque, 2001). Inputting beam dimensions and load information in a JavaScript based program, this generates the information in a VRML world file for view from any direction/angle and walk through the designed structure. It requires a web browser for interpreting standard html and JavaScript, such as Netscape or Internet Explorer, and a VRML browser such as Cosmo Player.

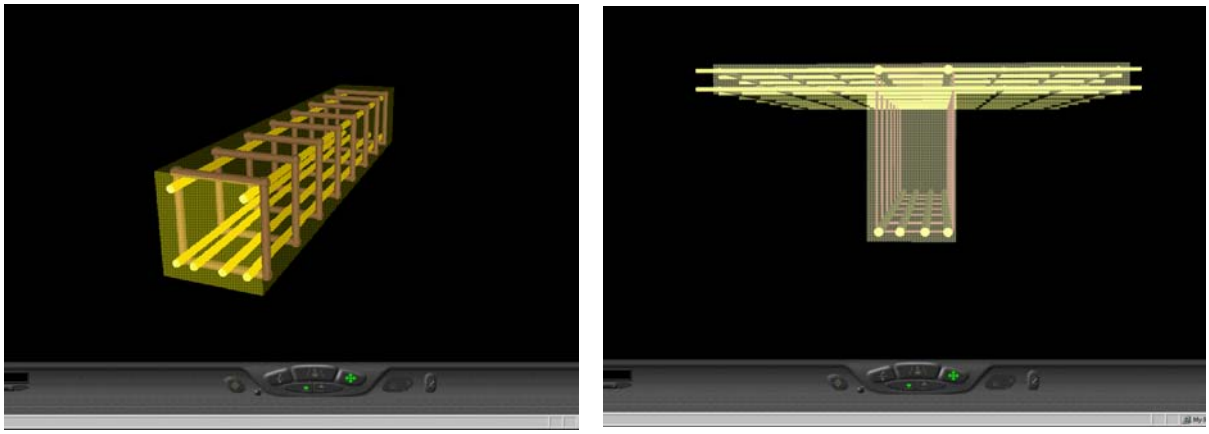

Figure 5: VRML Design Navigation of (a) Rectangular Beam, (b) T- Beam Reinforcement details.

Concluding Remarks

This paper describes a 3-D animation and walkthrough integrated virtual construction site to teach reinforced concrete structure construction. Several 3-D animation, walkthrough and VRML design details for reinforced concrete structure were developed. These will help construction engineering or management students and non-technical personnel on construction sites to better visualize the sequence of operations, and design details of reinforced concrete buildings, and will make them better equipped to design, manage, estimate and schedule more effectively. This approach will be especially very useful for students who have changed their major to construction engineering/science to better visualize and understand reinforced concrete building construction details and process. All the techniques that were used in this research employed a generic programming architecture, which was discipline independent and could be adapted to

any other similar domain. These visualization techniques can be valuable aids not only in teaching in the classroom but also an effective self-directed tool for open learning via the web.

Bibliography

1. AbouRizk, S. M., & Sawhney, A. (1994). Simulation and gaming in construction engineering education. Paper presented at the American Society for Engineering Education conference. Retrieved Aug 1, 2003, from www.informs-cs.org/wsc98papers/179.PDF
2. Haque, M.E. (2003). Visualization Techniques for Structural Design Education, Proceedings of the American Society for Engineering Education, 2003 ASEE Annual Conference, Session 2158, Nashville, TN.
3. Haque, M.E. (2001). Web-based Visualization Techniques for Structural Design Education, American Society for Engineering Education, 2001 ASEE Annual Conference Proceedings, Section 2793 Multimedia, Albuquerque, NM. Retrieved from http://www.asee.org/conferences/search/01143_2001.PDF
4. Klett, F. (2002), Designing a virtual learning space with 3D real-time presentation and advanced navigation, the 32nd ASEE/IEEE Frontiers in Education Conference Proceedings, session S2E, Boston, MA.
5. Motlagh, B., & Shahir-Motlagh, M. (2002). Redefining Traditional Methods in Engineering Education in the New Millennium. Paper presented at the American Society for Engineering Education conference. Retrieved Aug 1, 2003, from http://www.asee.org/conferences/caps/document2/2002-757_Paper.pdf
6. Scott, C., Ladeji-Osias, J., Capers, T., and Nyarko, K. "The Development and Implementation of EM-Viz, 3D Undergraduate Electromagnetic Engineering Visualization Application, with an Assessment of its Relative Efficacy for Minority Visual Literacy and Achievement". Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition, (2003).

MOHAMMED E. HAQUE, Ph.D., P.E.

Dr. Mohammed E. Haque is the holder of Cecil O. Windsor, Jr. Endowed Professorship in Construction Science at Texas A&M University at College Station, Texas. He has over fifteen years of professional experience in analysis, design, and investigation of building, bridges and tunnel structural projects of various city and state governments and private sectors. Dr. Haque is a registered Professional Engineer in the states of New York, Pennsylvania and Michigan, and members of ASEE, ASCE, and ACI. Dr. Haque received a BSCE from Bangladesh University of Engineering and Technology, a MSCE and a Ph.D. in Civil/Structural Engineering from New Jersey Institute of Technology, Newark, New Jersey. His research interests include fracture mechanics of engineering materials, composite materials and advanced construction materials, computer applications in structural analysis and design, artificial neural network applications, knowledge based expert system developments, application based software developments, and buildings/ infrastructure/ bridges/tunnels inspection and database management systems.

SALIM SAHERWALA

Mr. Salim Saherwala was a graduate student of the Department of Construction Science, Texas A&M University.

MURTUZA ALUMINIUMWALLA

Mr. Salim Saherwala was a graduate student of the Department of Construction Science, Texas A&M University.