

## A VIRTUAL TOUR OF A REINFORCED CONCRETE BUILDING CONSTRUCTION

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### Abstract

Visits to construction sites are ideally complementing our classroom instruction for construction engineering and management students. However, various complicating issues, such as unavailability of construction projects during the academic semesters and impracticality due to construction site risk for a large group of students make it impossible to rely on site visits. Considerable pedagogical advantages can be achieved by the integration of the contemporary information technology (IT) and visualization tools in teaching engineering technology. Although the classroom environment in Engineering and Construction Science is highly structured by the instructor, teaching students to be critical thinkers is essential in the virtual classroom of the future. The objective of this research was to develop a virtual tour of a reinforced concrete building construction using 3D animation and walkthrough. 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

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<sup>1-7</sup>. 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<sup>4</sup>. 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.

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<sup>1-3</sup> 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.

Preparing students for the challenges of managing large construction projects is an important responsibility and a difficult task <sup>8</sup>. 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 methods.

Complementing the more conventional classroom instructional tools would, ideally, include visits to construction sites or site training <sup>9</sup>. 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. Also, 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.

This paper demonstrated a virtual tour of a reinforced concrete building construction using 3D animation and walkthrough. It will help construction engineering or management students and non-technical personnel on construction sites to better visualize the sequence of operations for constructing reinforced concrete buildings. The developed 3-D computer animation model will also help students to visualize the entire construction process of a reinforced concrete building in a few minutes, which in reality on the site would take many months.

### Virtual Walkthrough Model Development Methodology

The focus of this research was to develop a web-based 3D computer animation model (Figure 1) showing systematic construction processes of a typical reinforced concrete building. The following steps were used:

1. Developing the 2-D plan of a typical three-bedroom reinforced concrete building: A 2-D plan of a typical three-bedroom reinforced concrete building was developed using AutoCAD (Figure 2). Next, the elevation and section for this building was also developed using AutoCAD.
2. Developing the 3-D model in AutoCAD: A 3-D model for the building was developed using AutoCAD.

3. Identifying the steps in constructing a reinforced concrete residential building: The important steps in constructing a reinforced concrete residential building were identified and listed. These steps were then arranged in their logical sequence of construction.

4. Developing animation clips for the important steps using 3ds max: Individual animation clips for each construction steps were developed using 3ds max. Animation and walkthrough clips for total 45-construction steps were created. Some for the animation clips are shown in Figures 3-7.

5. Writing a brief description of the important steps in the process: A brief description for the important steps in the process was written explaining its importance.

6. Developing the web page: Finally, all the separate animation clips and their brief descriptions were integrated on a web page using HTML.

3ds Max is a fascinating 3D movie making software. With 3ds Max, one can create 3D environments and characters, objects and subjects of any type. One can arrange them in settings and environments to build scenes as desired. One can animate the characters, set them in motion as required. One can then shoot movies of the whole virtual setting. Some of the important features and functions that can be controlled using 3ds Max to create a realistic 3D animation model include assigning materials to objects, providing lights, positioning cameras, animation and rendering. Some of important features in 3ds Max that were used in this research are:

- In 3ds Max material editor was used to design materials and maps to control the appearance of object surfaces. Maps were used to control the appearance of environmental effects such as lighting and background.
- Lights in 3ds Max includes the following standard light types: omni, spot, and directional lights. One can set a light to any color and even animate the color to simulate dimming or color-shifting lights. All of these lights can cast shadows, project maps, and use volumetric effects.
- Cameras in 3ds max - One can create and place cameras as desired using 3ds max. Cameras define viewpoints for rendering, and one can animate cameras to produce cinematic effects.
- Animation in 3ds max - One can animate the position, rotation, and scale of an object, and almost any parameter setting that affects an object's shape and surface. One can link objects for hierarchical animation, using both forward and inverse kinematics.
- Rendering in 3ds max - One can use the rendering features to define an environment and to produce the final output from a scene. One can render a single image by setting the 'renderer' to render a single frame of an animation. One can specify what type of image file to produce and where the program stores the file. Rendering an animation is the same as rendering a single image except that one can set the 'renderer' to render a sequence of frames. One can choose to render an animation to multiple single frame files or to popular animation formats such as .flc or .avi.

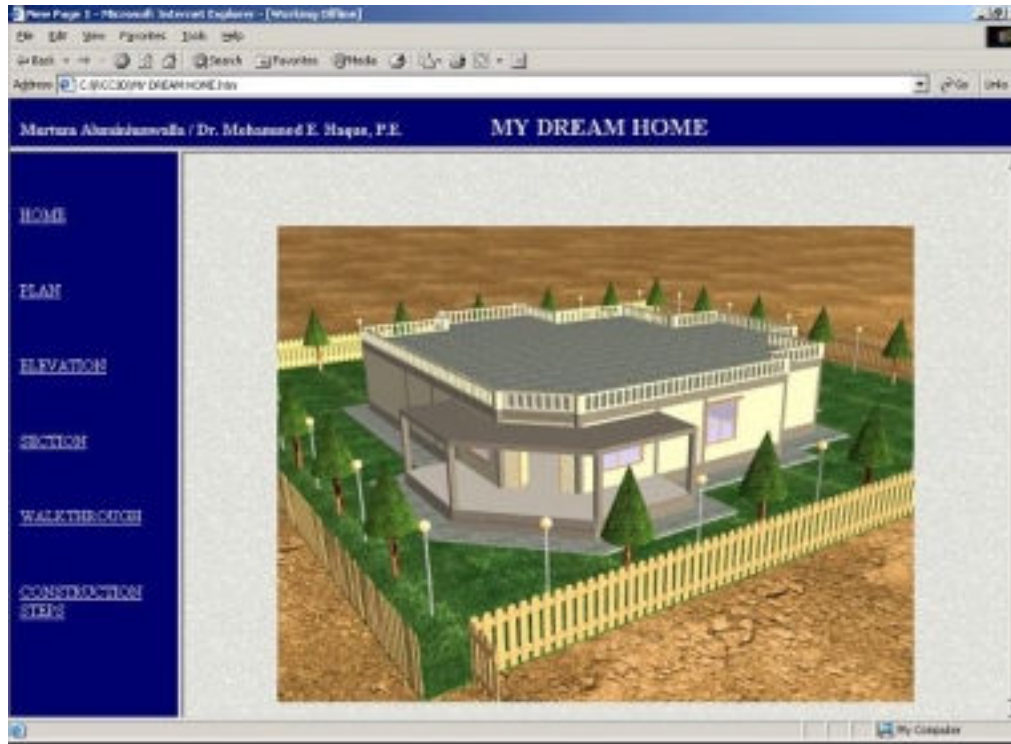


Figure 1: Computer Animation Model of a Reinforced Concrete Residential Building

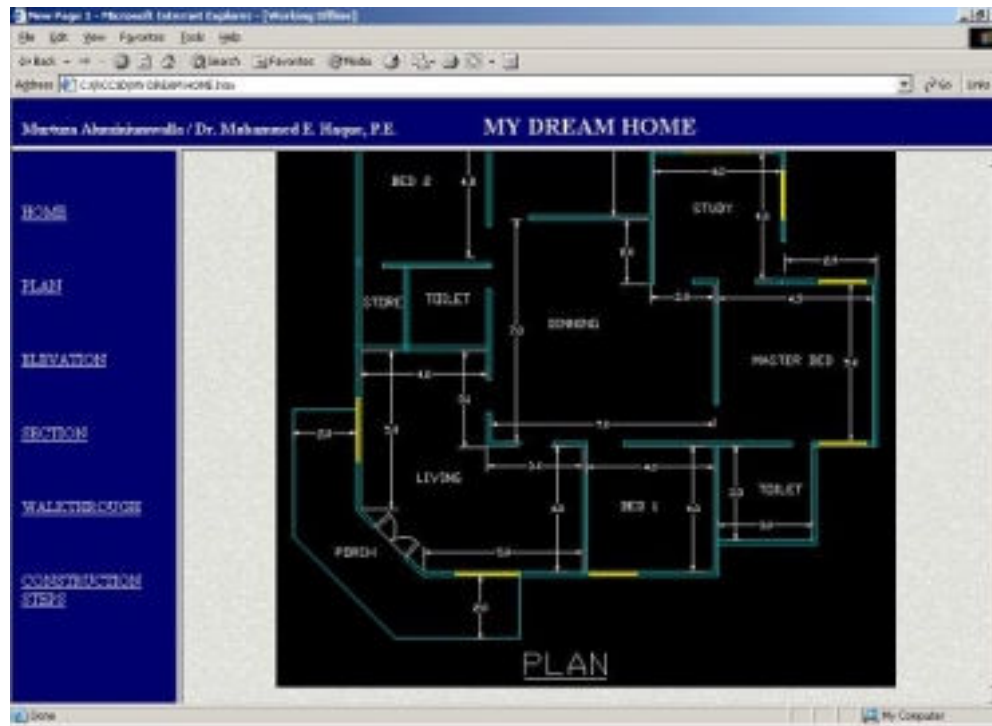


Figure 2: Plan View of the Building

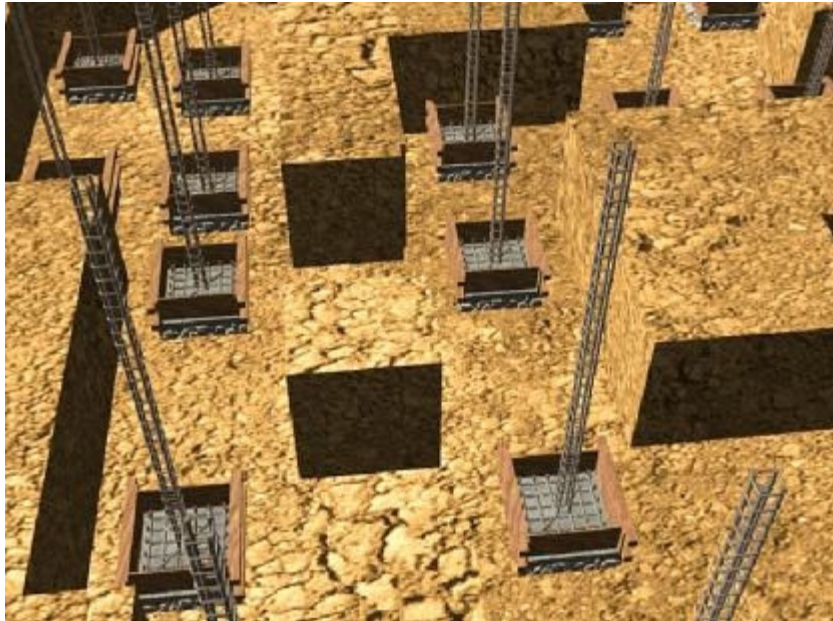


Figure 3: Footing Foundation Walkthrough Model

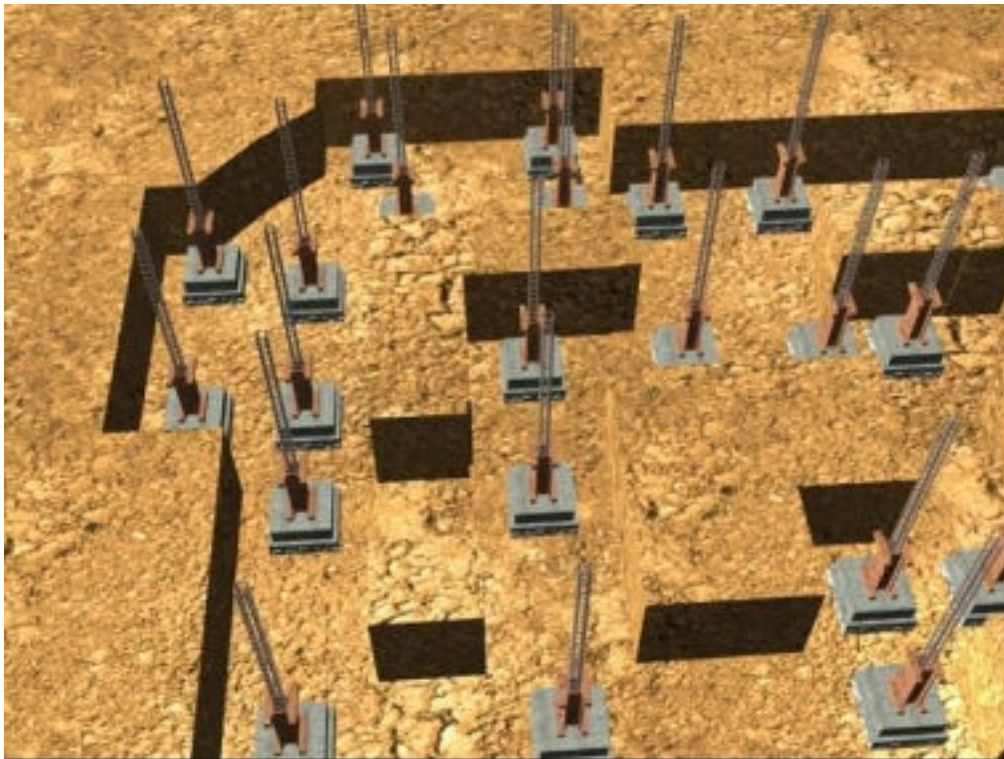


Figure 4: Placement of Column Formwork up to Tie Beam Level

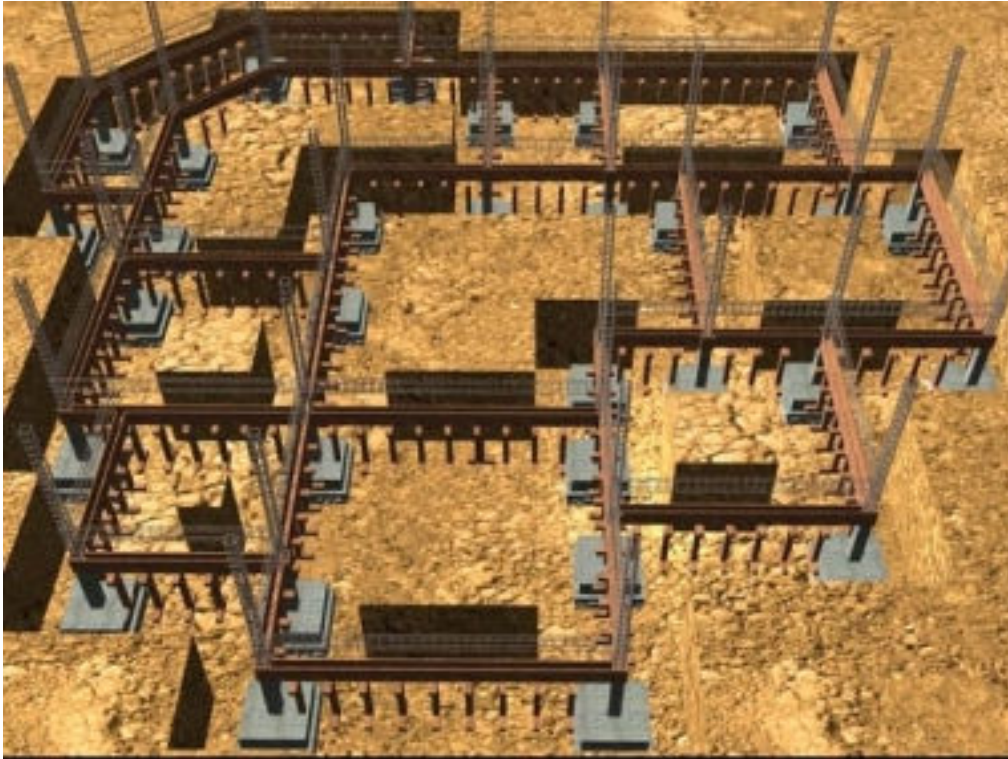


Figure 5: Placement of Tie Beam Reinforcement

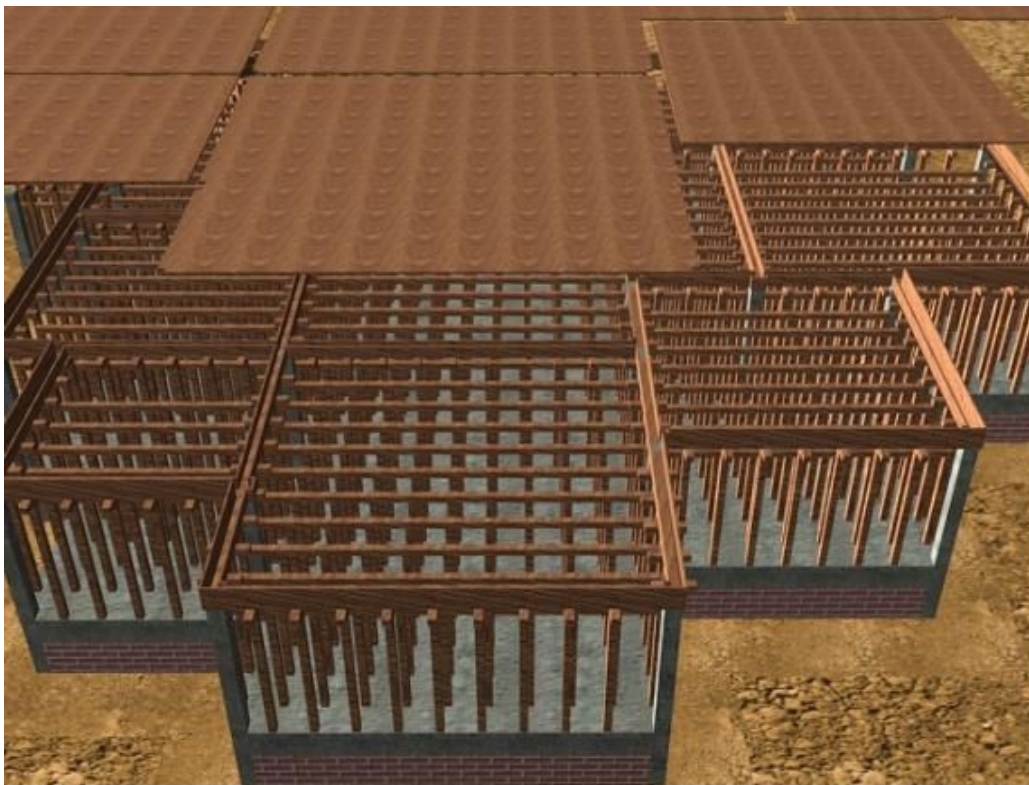


Figure 6: Slab Formwork Walkthrough Model

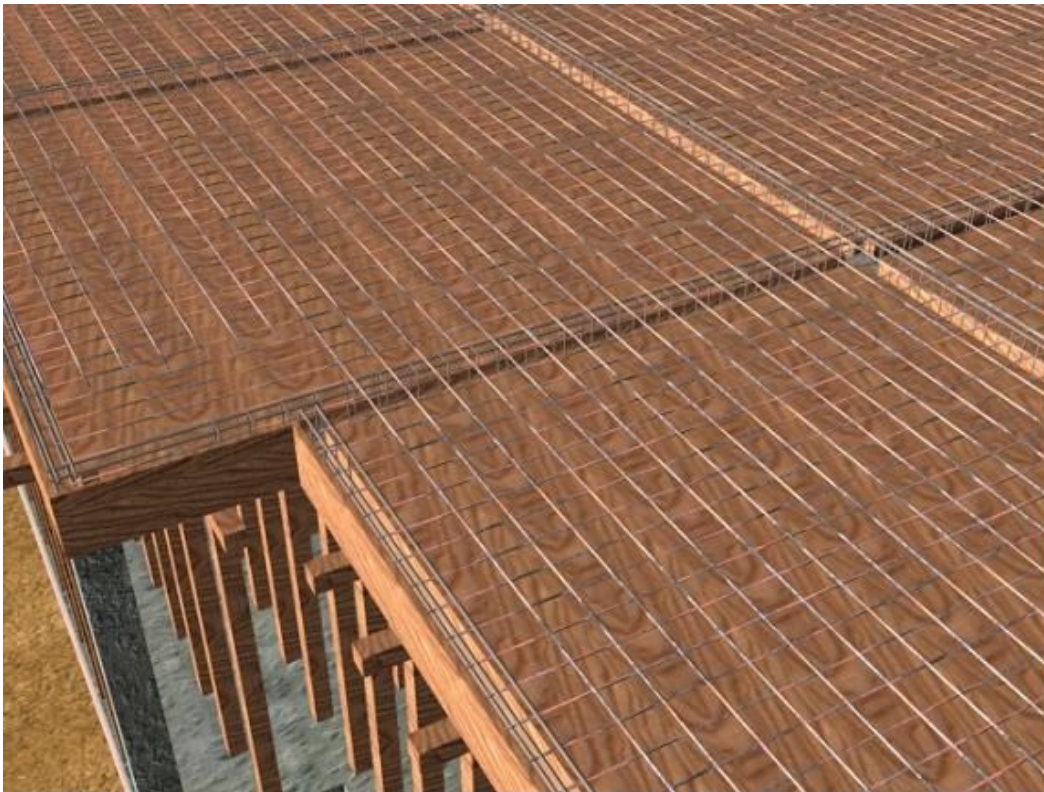


Figure 7: Slab and Beams Reinforcement Walkthrough Model



Figure 8: Reinforced Concrete Beams and Columns Frame System Walkthrough Model



Figure 9: Brickwork Walkthrough Model

### Concluding Remarks

This paper describes a virtual tour of a reinforced concrete building construction using 3D animation and walkthrough. It will help construction engineering or management students and non-technical personnel on construction sites to better visualize the sequence of operations for constructing reinforced concrete buildings, and will make them better equipped to design, manage, estimate and schedule of reinforced concrete construction projects more effectively. This approach will be especially very useful for students who have changed their major to construction science and for laborers and workers who are new to the construction industry to better visualize and understand reinforced concrete building construction process. The developed 3-D computer animation model will also help students to visualize the entire construction process of a reinforced concrete building in a few minutes, which in reality on the site would take many months.

Considering the interest of youths in computer games these days the use of a 3-D computer animation model will develop a lot of interest amongst them and will motivate them to try to better understand and retain important concepts of design and construction management of a reinforced concrete building.

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. Haque, M.E. "Web-based Visualization Techniques for Structural Design Education" American Society for Engineering Education, 2001 ASEE Annual Conference Proceedings, Section 2793 Multimedia, Albuquerque, NM, (2001).
2. Haque M.E., Vamadevan A., Duraimurugar S., and Gandlur Y. Java and VRML based Interactive Reinforced Concrete Design Course Studio. American Society for Engineering Education, ASEE 2000 Annual Conference Proceeding, Section 1315 Use of Computer Technology to Enhance CE Education, St. Louis, MO, (2000).
3. Haque, M.E. "3-D Visualization and Animation Techniques in Structural Design Education," the International Conference on IT in Construction in Africa – Construction Information Technology, CIB W78 Conference Proceedings, pp. 2.1 – 2.9, Mpumalanga, South Africa, (2001).
4. Klett, F. "Designing a virtual learning space with 3D real-time presentation and advanced navigation" the 32<sup>nd</sup> ASEE/IEEE Frontiers in Education Conference Proceedings, session S2E, Boston, MA, (2002)
5. Jain K. and Noble, D. An interactive Web-based teaching tool for simplified 3D analysis of solar rhythms. Elsevier, Automation in Construction, pp. 181-194, 8(1998).
6. Haque, M.E. "Interactive animation and visualization in a virtual soil mechanics laboratory" the 31<sup>st</sup> ASEE/IEEE Frontiers in Education Conference Proceedings, session T1C, Reno, NV, (2001)
7. Kocijancic, S. and O'Sullivan, C. "Integrating virtual and true laboratory in science and technology education" the 32<sup>nd</sup> ASEE/IEEE Frontiers in Education Conference Proceedings, session T2E, Boston, MA, (2002)
8. Tatum, C. B. Balancing engineering and management in construction education. Journal of Construction Engineering and Management, 113, 10-17 (1987).
9. AbouRizk, S. M., & Sawhney, A. Simulation and gaming in construction engineering education. Paper presented at the American Society for Engineering Education conference. (1994) Retrieved Aug 1, 2003, from [www.informs-cs.org/wsc98papers/179.PDF](http://www.informs-cs.org/wsc98papers/179.PDF)

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