

# DESKTOP VIRTUAL ENVIRONMENTS IN CONSTRUCTION EDUCATION

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## Abstract

*In construction science, classroom oriented education remains the preferred mode of teaching. Alternative methods such as field trips, use of 3D drawings, and physical models often supplement and enhance the understanding of students. In addition to the risks involved with field trips, designated sites may not be at the particular stage of construction during the academic semester, or the construction sequence may not be fast enough to demonstrate the multiple facets during field visits. Considerable pedagogical advantages can be achieved by the integration of IT and visualization tools in teaching construction engineering/technology. The objective of this research was to develop a desktop virtual environment using 3D, animations, virtual reality and walkthrough of construction processes of steel, concrete, and lightwood structures. 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.*

## 1. Introduction

With the complexities involved in large-scale construction operations, there is a continuous need for the construction industry to find a technique, which is capable of modeling, visualizing, and simulating construction operations (Naji and Najafi 1996). The traditional methods of classroom teaching are often supplemented by alternative methods, to enhance the understanding of the students. These include field trips, use of 3D drawings and physical models. Although field trips are the best way to expose students to actual construction methodologies and sequences, they present difficulties of logistics and cost. Besides, the site may not be at a particular stage of construction, or the construction may not be fast enough to explore the various aspects of the process within a short duration of time (Haque 2004a, 2004b). In addition, the risks involved in field trips may be a deterrent in arranging more site visits for the students by the educational institutions.

Building physical models is an effective way of exposing the students to different construction techniques. However, the cost and time required for making these models in large numbers, and the space required for their storage renders this exercise financially unfeasible for educational use.

Although the traditional methods of instruction are very

effective in explaining the principles of structure to students, they have limitations that often make their use for instructional purposes unviable. Haque (2001) is of the view that traditional lecture format teaching methods sometimes fall short of conveying the complex analysis and design principles that need to be mastered in structural design. 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. (Haque and Alumininumwala, 2004)

It is essential to use alternative modes of instruction to create an 'almost real' environment which enables students to better understand the construction concepts. In today's computer age, it is crucial to use multimedia as effective tools of teaching. Kuyath (2002) is of the view that if complex topics were explained through animations, multimedia, and interaction, student understanding would be greatly improved. 3D models created using software like Autodesk Viz, Architectural Desktop, and Autodesk 2005 produce life like images in the virtual world with its rendering capabilities using parameters like lighting, material, textures, etc. For the net savvy generation of today, this form of multimedia

form essential tools that can be utilized for effective teaching. 3D models created in software like AutoCAD and rendered in Autodesk Viz can produce life like images with various tools available within them. VRML's can be used in addition to regular 3D models to better explain complex construction details. Unlike conventional 3D modeling, VRML presents no problem of selecting a viewpoint to understand a model, since one can freely choose a viewpoint. In VRML it is possible to animate the objects in the scene like in traditional animation but the user can watch the animation from whatever viewpoint he wishes (Jonkers, 2000). This is a valuable resource, which can help students understand the various aspects of construction technology due to its inherent nature of being interactive and graphical.

The interface, the graphical and the interactive nature of the entire system will enable students to explore, evaluate and gather information about the various construction techniques using their own curiosity and eagerness and thereby develop their self-learning process.

## 2. Research Methodology

The purpose of the research study was to teach the students of architecture and construction management, the essentials of (1) stud frame wood construction, (2) reinforced concrete, and (3) steel frame construction using 3D models, walkthroughs and VRML. A typical home plan was developed for each case. The design was converted into 2D and 3D drawings, which were rendered using lights, materials, and textures. The rendered model was then animated to show the stepwise construction sequencing of the house. Certain details were identified in the process and their 2D drawings as well as 3D models were created which were also converted into VRML models. Finally, all this information was integrated into an interactive web based interface. A flow chart for the sequence of steps is shown in Figure 1.

- a. 2D Drawings- These included the architectural as well as structural drawings of the house. Sections, elevations, etc. of the house are also included in this section which explains the basic dimensions,

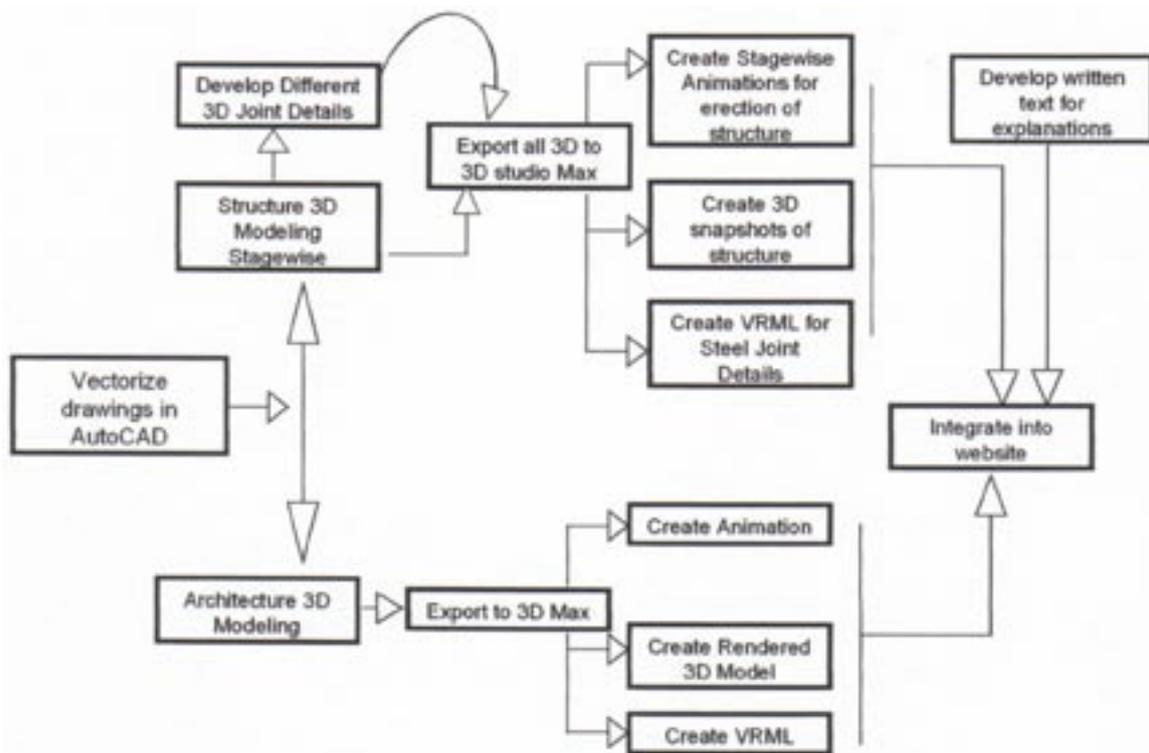


Figure 1: Flow chart.

construction methodology, material finishes, joints, connections, etc. It also displays certain key details of the construction along with brief descriptions of the materials and techniques used. The details, material specs, techniques as well as structural details were taken from relevant publications.

- b. 3D models - The 2D drawings were converted into a 3D model using AutoCAD. The model was then exported to Autodesk Viz and rendered using necessary materials, colors, lightings and textures. The 3D model of the entire house included both the structural 3D that explains the framing and the construction methodology of the house and the architectural 3D model complete with textures, materials, shadows, landscape, etc. showing the quality of the final finished product. The key details, which were identified in the previous module of 2D drawings, were also converted into 3D models

and rendered. These created 'life like' images of the details, which were labeled to explain the material, techniques, mode of construction used. The 3D model of the structural framing of the entire house was developed right from the foundation till roof framing including the internal as well as the external wall framing and the floor framing.

- c. Generation of VRML files - The 3D models of details were exported to the VRML format. The VRML files can be played using the commonly available 'Cosmo Player' or 'Cortona VRML Client', which can be easily integrated within the Internet Explorer browser. Using the same player, the user can view the detail from different viewpoints for greater understanding. Figure 2 shows a 3D image of truss joint on VRML browser.
- d. Animating the 3D models - The 3D model of the entire house showing the foundation, framing as

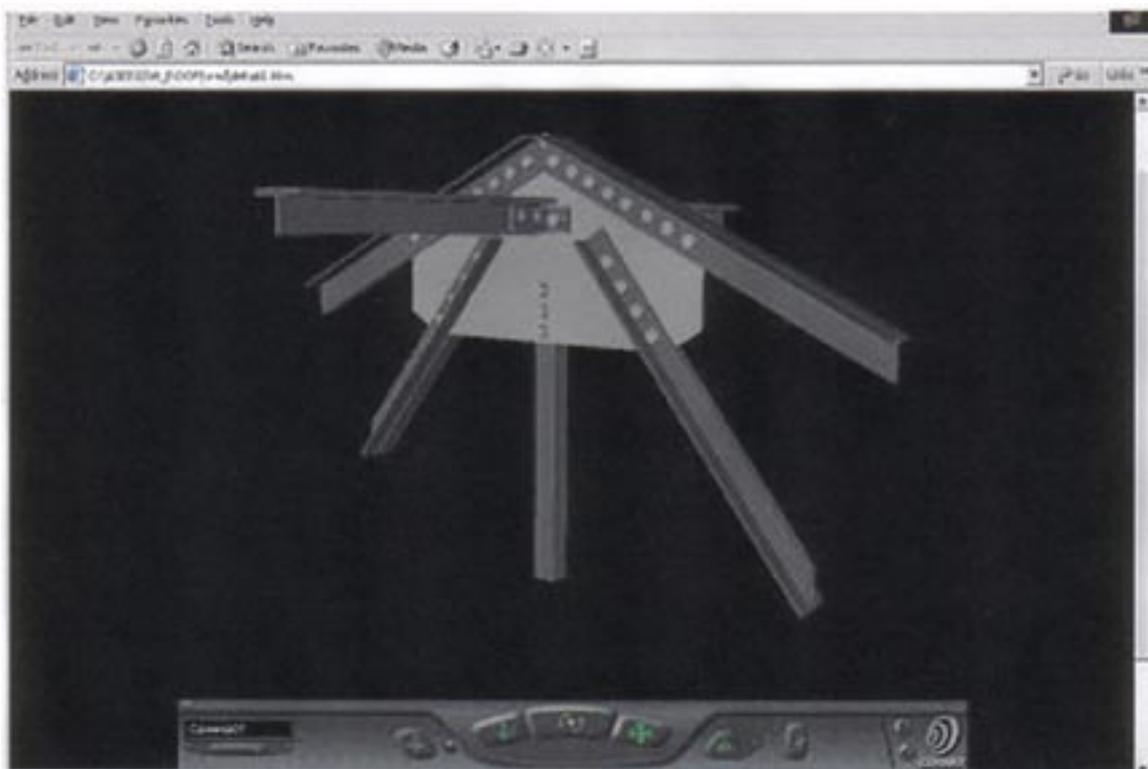


Figure 2: A truss Joint on VRML browser.

well as the finishing was then animated to create a step-by-step sequence of the entire construction process. Based upon review of related literature, the construction process was broken into 13 key steps. The animations were rendered with anywhere between 200 to 750 frames depending upon the complexity of the sequence as well as the number of components it had and also to maintain a low file size for easier retrieving (Figure3).

- e. Creating the HTML based Graphic User Interface (GUI) - Once the 3D models, the VRML animations and the animations were complete, the final step was to integrate the entire project to make it a web based, comprehensive, interactive learning tool for the students. For this purpose, all information, so far created was assimilated and integrated within a web-based interface. An HTML editor like Macromedia Dreamweaver was used for this purpose. The interface essentially provided the interactive environment that

enabled the students to navigate through the various aspects of the construction process. It has menus, which provide direct links to the various pages, each of which has a particular aspect of the tool. On the 3D model, which explains the structural layout of the building, hyperlinks or ‘hot spots’ are provided at the certain key locations which open in new windows and display the interactive VRML’s of those details (Figure 4). The student can navigate the model using the VRML model and explore it from different angles providing more information regarding the construction technique and methodology.

### 3. Conclusion

With the advances in information technology, teaching methods have undergone tremendous changes. The availability of high speed internet, faster processing computers, availability of newer software and the ever-increasing awareness of today’s youth have made it

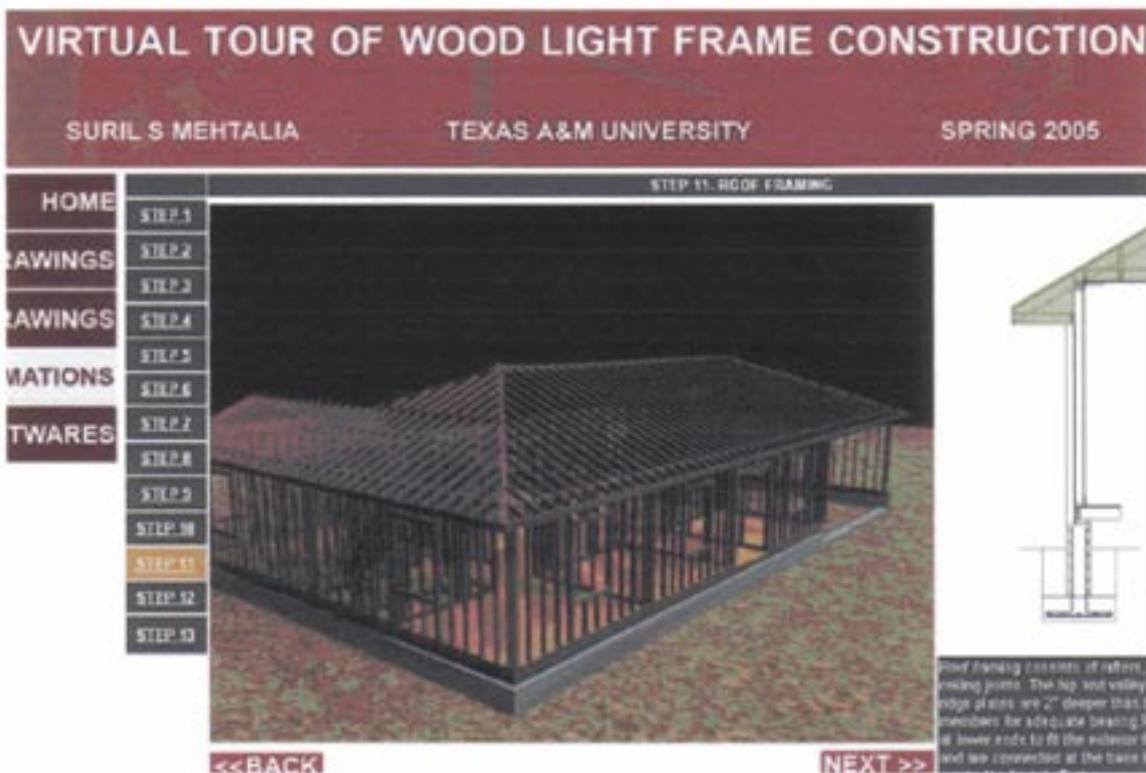


Figure 3: Stepwise construction animation sequence

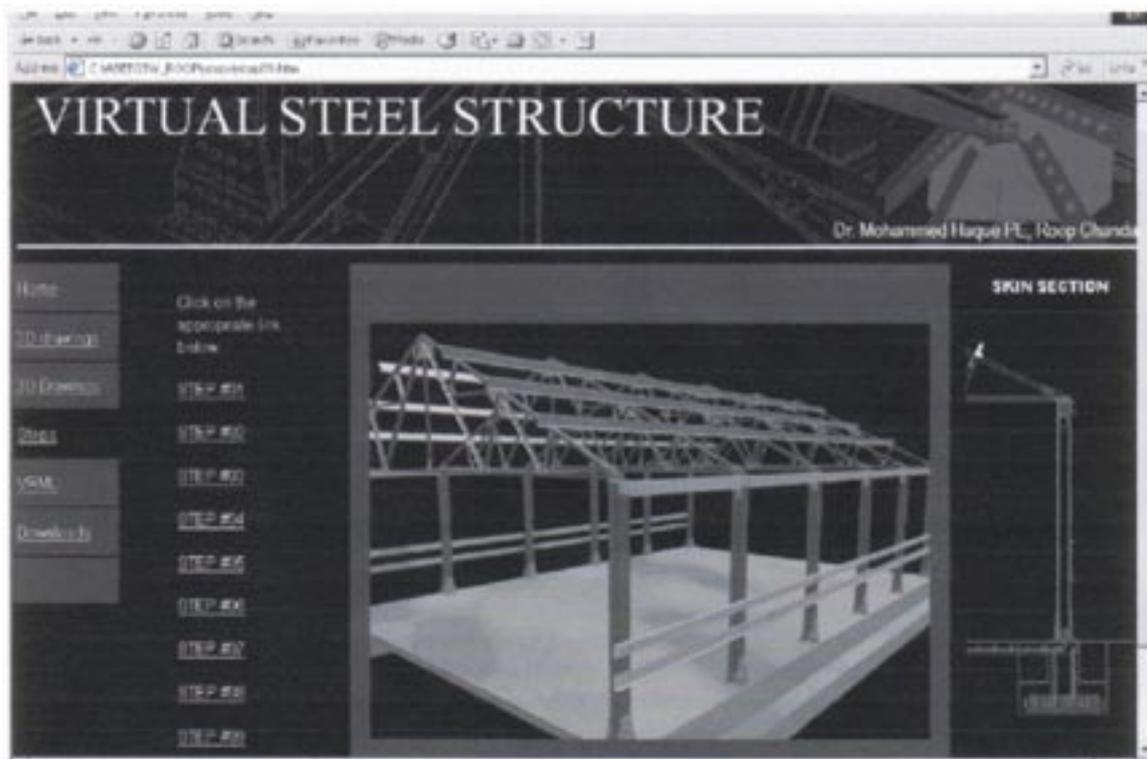


Figure 4: Virtual steel frame structure

inevitable to introduce computer and more specifically web based teaching in today's curriculum. This paper describes a 3-D animation and walkthrough integrated virtual construction site to teach (1) wooden frame construction, (2) reinforced concrete, and (3) steel framed construction. Several 3-D animations, walkthrough and VRML design details were developed. The main purpose was to create virtual environments to simulate real life situations in order to mitigate the negative effects of traditional teaching methods - especially in the field of construction technology.

The virtual construction site will help construction engineering or management students and non-technical personnel on construction sites to better visualize the sequence of operations, and design details, 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 the building structures,

design details, and construction processes. 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.

## Acknowledgements

This paper is based on graduate research projects of the author's students, Roop Chanda, Suril Mehtalia and Murtuza Aluminumwala. The author sincerely thanks his graduate students for their research works.

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