

## A VIRTUAL TOUR OF A STEEL STRUCTURAL CONSTRUCTION

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### **Abstract**

The traditional methods of classroom teaching are often supplemented by alternative methods, so as to enhance the understanding of the students. These alternative methods include construction site visits, 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 construction site visits, the site may not be at a particular stage of construction during the academic semester, 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 modern information technology (IT) and visualization techniques in teaching engineering technology. The objective of this research was to develop 3-D animations and virtual walkthrough on steel structural construction. 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**

Construction industry in today's world is becoming enormously complex as project sizes are increasing and project duration decreasing. At the same time designers are conceptualizing ever-complex designs, which no longer can easily be comprehended by 2D drawings. With this change it has become necessary that construction education develop newer ways of teaching. Extraordinary growth in 3D graphics, web accessibility and networking presents new opportunity in education (Blais et. al., 2001). 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. Recently 3D information used for construction education has restricted themselves to finished products of 3D images. A more interactive format of presenting objects in 3D should be available to students such as a virtually real world.

Classroom education would be more effective if students have access to a tool where they can virtually handle a 3D object and have the freedom to turn the object and visualize it from any angle. Especially in case of any structural element the freedom to view the action of forces at a structural joint in a virtual 3D world would be invaluable. Kamath and Martinez (2000) are of

the view that 3D visualization of the of the construction will provide easier accessibility for the planners by graphically conveying the physical configuration of the system of interest in a very realistic but virtual format, thus allowing the user to easily and clearly comprehend the dynamic and interrelated behavior of the system model after each simulation run. The same can be applicable to the relationship between the teacher and student.

Visualization has always been an important aspect in the construction industry and construction education has always laid stress on that aspect. Design professionals and educators used drawing as a practical tool for seeing, thinking and understanding their ideas, and for communicating them to others. In education, drawing was often woven tightly into curriculums and it was expected to play a major role in developing students' visual abilities (Anderson, 2002). With the advance of technology 3D visualization has become very user friendly and objects that were restricted to drawings in paper can today be viewed in a 3D environment with ease. The Internet revolution has also changed the world of education with distance learning becoming a more convenient, accessible and lucrative.

Construction operations range from the relatively simple to the most complex. Kamat and Martinez (2000) are of the view that traditional methods used to design them prove ineffective in many cases where simulation modeling and visualization can be of substantial help. The purpose of using simulation to design construction operations is to obtain insights into alternate designs and thus help the planner make the most advantageous decisions (Kamath and Martinez, 2001).

One of the focus areas in this technologically advancing era is to provide better visualization through the Internet. Lipman and Reed (2000) are of the view that the ultimate goal is to provide three-dimensional web based technologies for managing, accessing and viewing construction project information. In their research they have tried to determine the applicability of Virtual Reality Modeling Language (VRML) in construction industry applications.

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. However when the theories are exemplified in a virtual environment with multimedia, animation, interaction, and manipulated image visualization techniques in a virtual reality environment, students' conceptual understanding are enhanced.

The objective of this research was to develop a three dimensional model of steel structures and detail out joints and place them in a virtually real world using AutoCAD, 3ds MAX and VRML. The model shows the construction sequence of a steel framed structure virtually. The model also makes it possible for viewing steel joints by rotating it or zooming into it in a real-time virtual 3D environment.

## Development Methodology

The research aims to develop a web-based model, which systematically shows animated 3-dimensional construction sequence of a framed steel structure. Hot links are embedded within the virtual 3D model of the framed steel structure at the steel joints to pop-up VRML navigation windows for real-time views of steel joints. The steps listed below are followed for the study and creation of the model. A flow chart for the sequence of steps is shown in Fig.1.

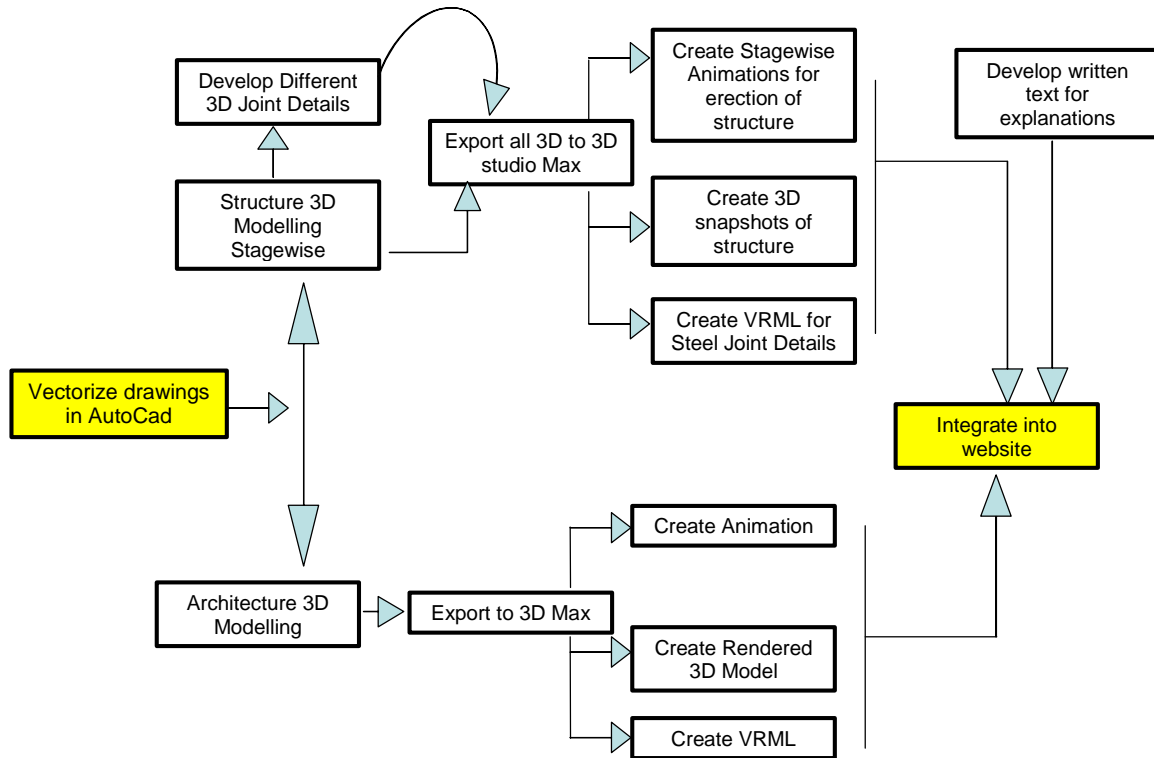


Fig 1: Flow chart

1. The first step involved the development of 2D drawings for a steel framed structure. All further 3D models in developing the models are based on these drawings. The drawing is that of a storage shed with a trussed roof. The drawings are developed using AutoCAD. Further 2D drawings of steel joints in the structure were also developed. These drawings are used for developing the 3D models of the steel joints.

- The second step involved the identifying of steps in the construction of a steel framed structure. The steps are chronologically listed such that the animations of the construction sequences in the model are in the same order. Steel joints in the framed construction are also identified in the same process (Figs. 2 and 3).

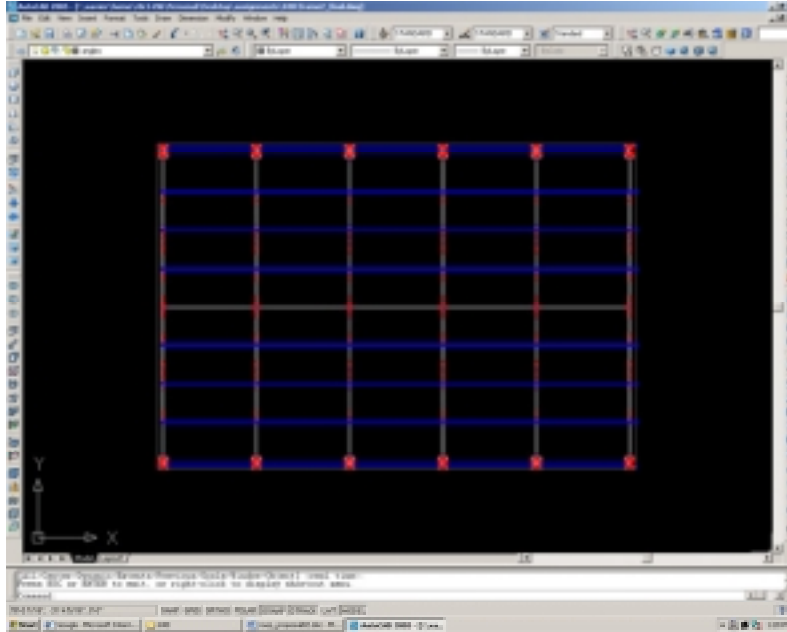


Fig.2: 2D Architectural drawings - Plan

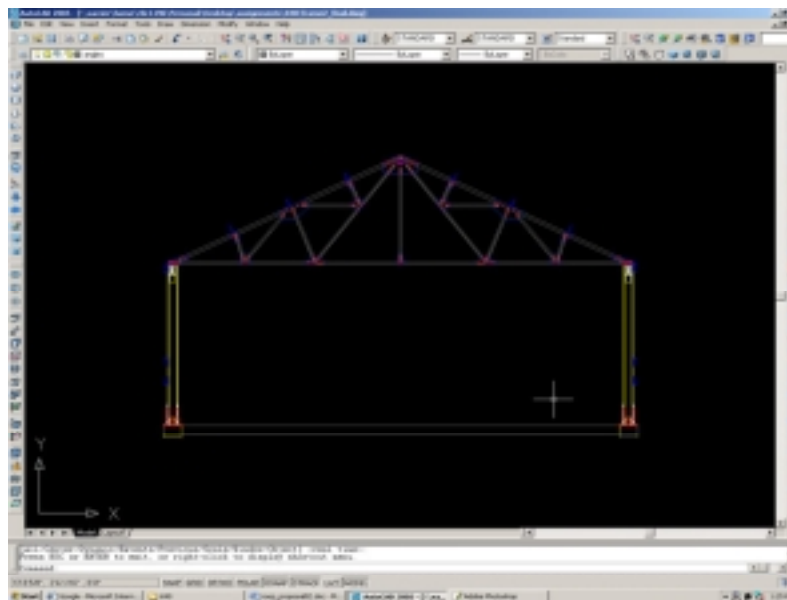


Fig. 3: 2D Architectural drawings - Elevation

3. 3D models of each step are developed in AutoCAD. 3D models of steel joints in each step of construction are developed in AutoCAD. All these 3D models are exported to 3ds max for rendering and other finishing work (Figs. 4 and 5).

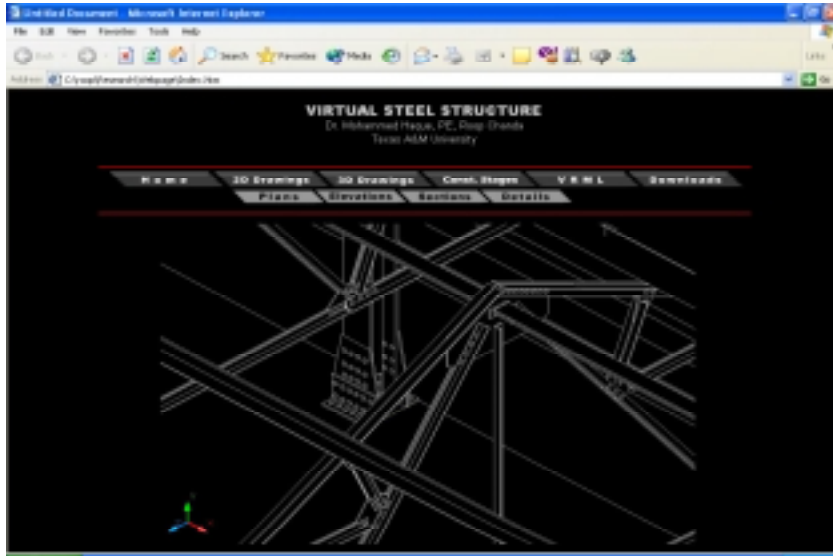


Fig. 4: 3D AutoCAD model of steel joints

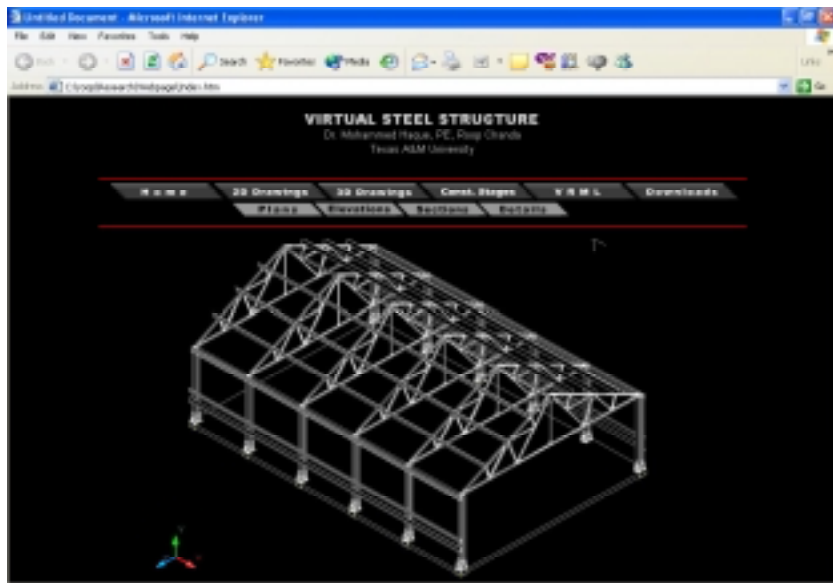


Fig. 5: 3D AutoCAD model of structure

- Individual steps in the sequence of construction of the structure are animated using 3dsMAX. Animation and walk through for all the steps are completed (Figs. 6 and 7).

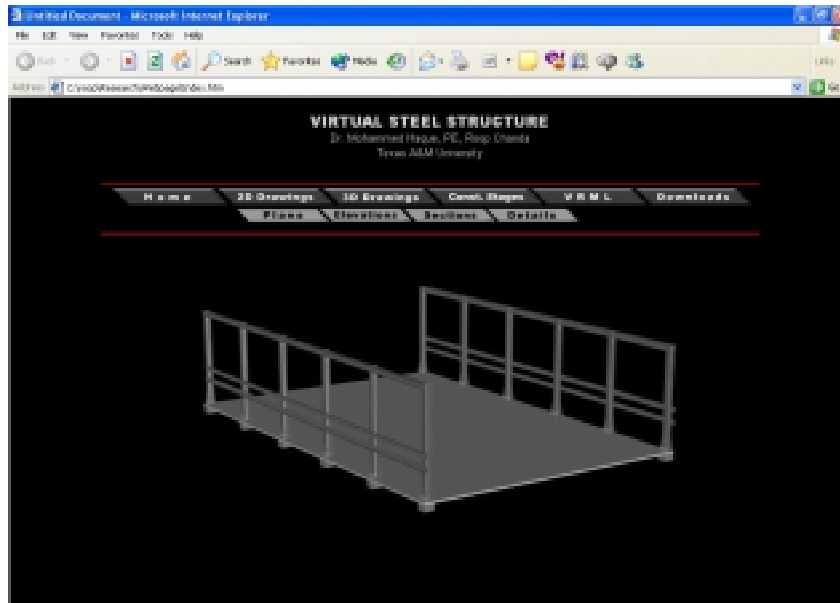


Fig. 6: 3D Model of Construction sequence



Fig. 7: 3D Model of Construction sequence

5. Rendered models of the steel joints are also exported to the VRML format for compatibility with the VRML browser. Similar steps are followed for all joints for every sequence of construction (Figs. 8 and 9).

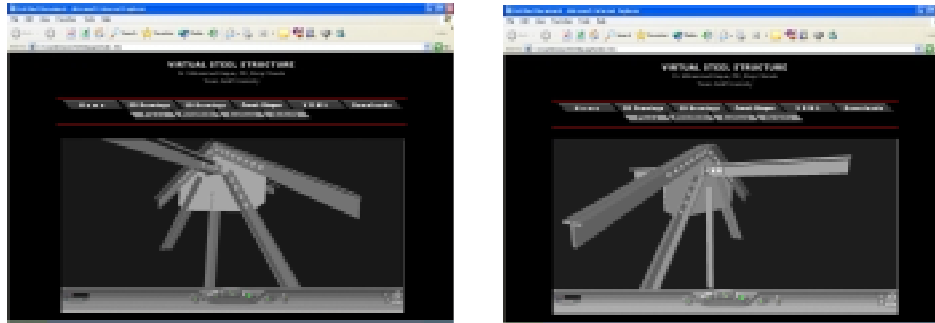


Fig. 8: 3D images of truss joints on VRML browser from different angles

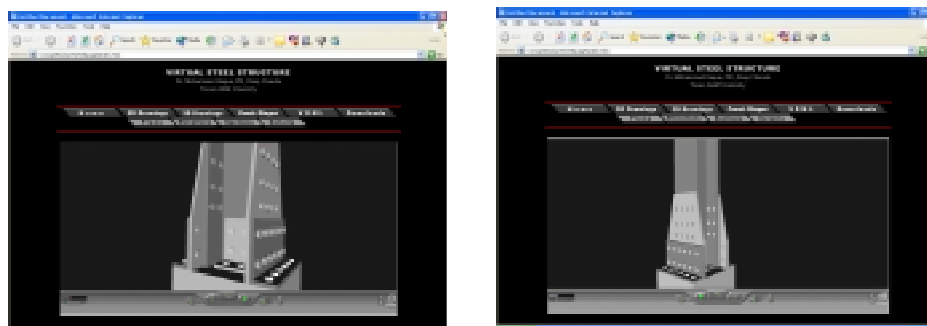


Fig. 9: 3D images of foundation joints on VRML browser from different angles

6. Details of each step in the sequence of construction are written which can be displayed on the front end of the model. Details for the steel joints are also similarly written to be displayed in the front end.
7. The final step is to develop front end user interface (UI). This was done by developing a web page using HTML. The Hierarchy of the website is shown in Fig. 10.

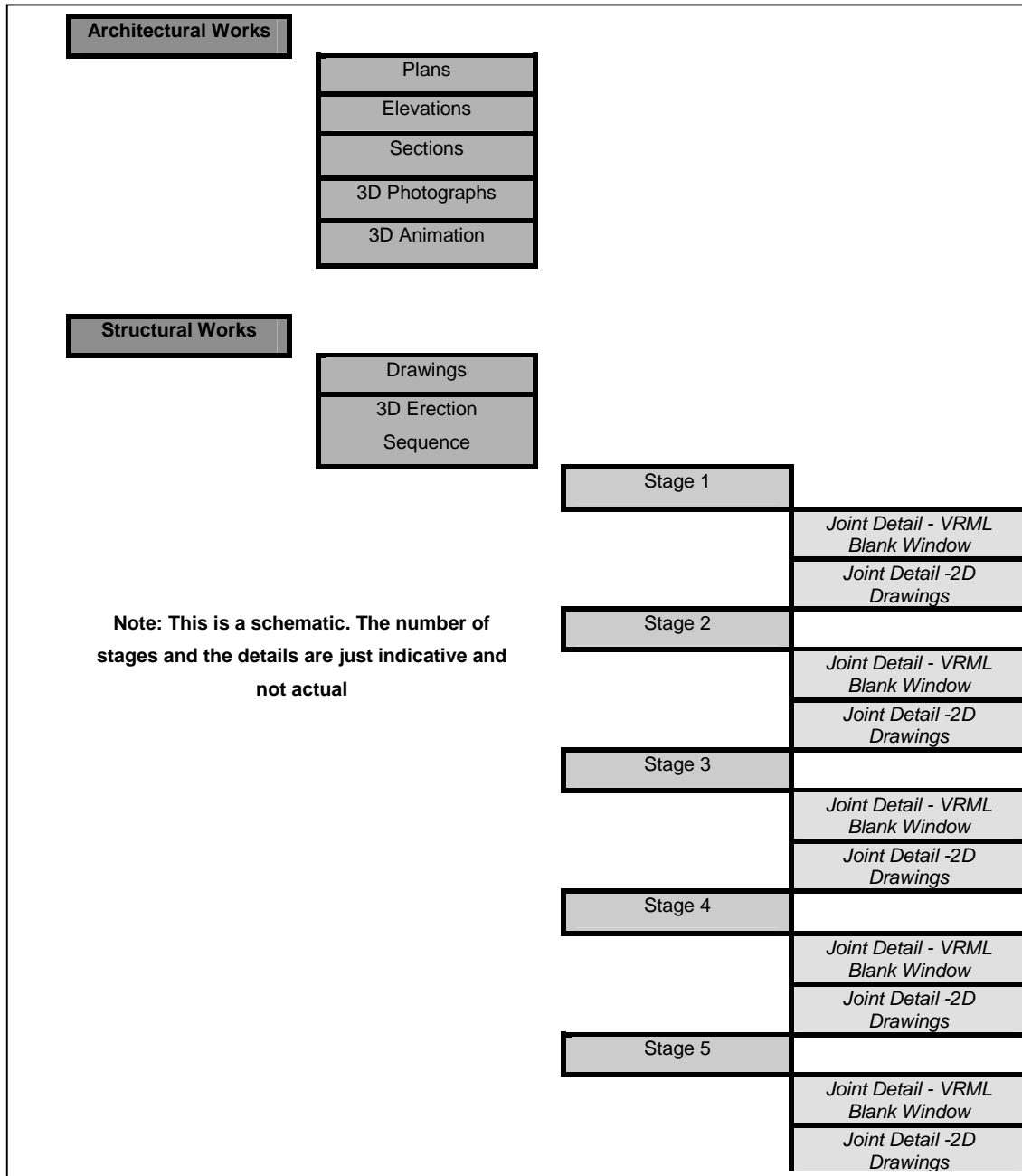


Fig. 10: Hierarchy of website used as UI

### Concluding Remarks

This paper describes a 3D model of steel structure and details, and place them in a virtual world using AutoCAD, 3ds MAX and VRML. The model shows the construction sequence of a steel



framed structure virtually. The model also makes it possible for viewing steel joints by rotating it or zooming into it in a real-time virtual three-dimensional environment. 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 of steel structure.

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.

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