

## **3D ANIMATION AND VIRTUAL REALITY FOR TEACHING STEEL JOINTS**

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### **Abstract**

The traditional computation-based approach to teach structures is increasingly proving to be ineffective in the classroom. Focusing on architecture students who have very different educational needs, technical capabilities it is all the more ineffective to concentrate on computations for explanations. An interesting topic in structures, which is not very easy to comprehend, is complex details of structural steel joints. These are difficult to understand in 2D drawings, and they are so minute that their failure is not visible to human eye. This creates a difficulty in understanding the phenomenon behind the joint failure, and it thus becomes difficult for teachers to make their students understand the process of design of steel joints. The classroom problem gets even more acute when it is a distance-learning program and actual contact with the instructor is minimal. A solution to all these problems is to devise a format of presenting things, which are more interactive, and real time. 3D images are popular among instructors to present processes and details in a more interesting fashion. With this study, the attempt was to make the presentations even more interactive, with students engaging the animations for enhanced understanding. Projecting 3D images in a virtual space can be an effective solution for making the study of structures more interesting and interactive. The objective of this research was to show the process of steel joints analysis considering various failure mechanisms in animated 3D virtual spaces. To make the learning process more user-friendly and easier to comprehend, the entire project was assimilated into an interactive web based format. The 3D animation and Virtual Reality based 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**

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. Structural design concept visualization in steel structure is a subject

that depends on geometric and physical perception, and every effort should be made by educators to enhance this ability<sup>1</sup>.

Although many advances have been recently made in the area of construction visualization, the main focus has been the finished product (3D CAD) or on the product as it evolves through construction (4D CAD). Very little attention has been given to visualizing the construction process that leads to the end product<sup>2</sup>.

Architecture students have very different educational needs, technical capabilities, and will apply structural design principles differently than engineering students and professional engineers. The instruction based on engineering approaches is highly quantitative, communicating even basic concepts using an advanced mathematics nomenclature. However, the mathematical disposition and skills required to understand or utilize a system based on highly mathematical models lacks in architecture students. They therefore quickly become uninterested, frustrated, or even intimidated by the structures curriculum<sup>3</sup>.

A solution to all these problems would be to devise a format of presenting things which is more interactive and real time. 3D images are popular among instructors to present processes and details in a more interesting fashion. With this study, the attempt is to make the presentations even more interactive which students can play around with to get a better understanding using animations. Bartz and Meissner (as cited in Ref. 4) in their study state that the recent advances in computer graphics has spurred interest from both academics and industries in virtual reality enabled training applications. Projecting 3D images in a virtual space can be an effective solution for making the study of construction more interesting and interactive.

This study is an attempt to develop 3D computer animations showing magnified details of steel joints and the process of their failure. These animations are made with a provision to magnify and zoom in, to closely watch the phenomenon of the failure. These animations are simultaneously linked to the joint calculations and design checks, for stepwise understanding of the complex computations.

Finally, all the information is integrated within a user-friendly web based Graphical User Interface (GUI). The final product- the website can be an effective learning tool for the students of construction science, architecture and engineering enabling them to better visualize the scenario of joint failure. This tool can also be very effective for distant learning and can eliminate the requirement of classroom teaching to a great extent.

The objective of this research was to develop a three-dimensional model of steel structures, to detail out joints, and to place them in a virtual reality world using AutoCAD, 3ds MAX and VRML. These models could then be used to virtually display the construction sequence of a steel framed structure. 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

Based on the research objectives, the methodology of the research was categorized in four phases. These phases are as follows:

- A. Graphical Interface Development
- B. Computations and Joint Failure Analysis
- C. Comprehensive Explanation Tool Development
- D. Common Web Interface in HTML.

### A. Graphical Interface Development

#### 1. Developing the 2D drawing of a typical riveted/bolted steel joint using Auto CAD.

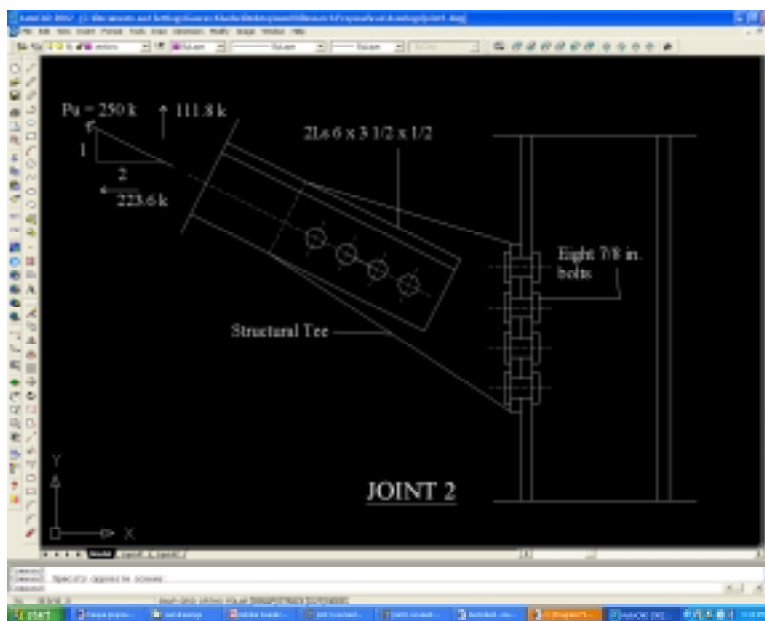


Figure 1: 2D Drawings for joint details

A simple 2D drawing for a connection was designed and a digital drawing of the same was drawn in AutoCAD. The elevation and section of the structure was developed and drawn in AutoCAD (Figure 1). AutoCAD is an interactive drawing system designed to for a user to be able to draw on a graphics screen. It is one of the leading computer-aided design software throughout the world and extensively used in the AEC industry and manufacturing industry. Since its origin as a basic 2D CAD tool, AutoCAD has evolved into a much complex tool with capability to draw in three dimensions and perform material rendering. In AutoCAD, each

drawing is stored on a disk file, and AutoCAD is only able to edit one drawing (or file) at a time. This similarity to word processors is reflected in the fact that the principal functional component of AutoCAD is known as the drawing editor.

#### 2. Developing a 3D Model in 3D Studio Max Version 6 for the same joint.

3D Studio Max was developed as a total animation package with a deep, productive feature set designed to accelerate workflow, 3D Max is the leader in 3D animation for game development, design visualization, visual effects, and education (Figure 2).

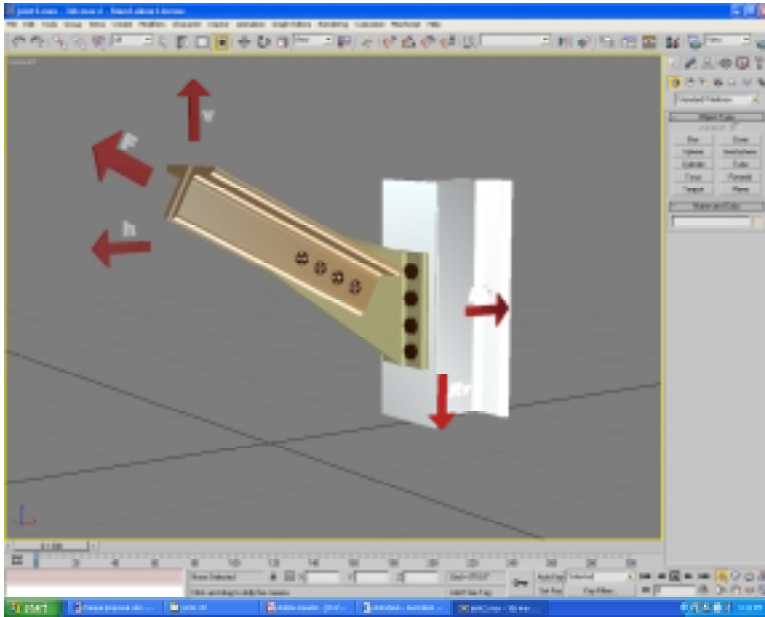


Figure 2: 3D Model of joint geometry

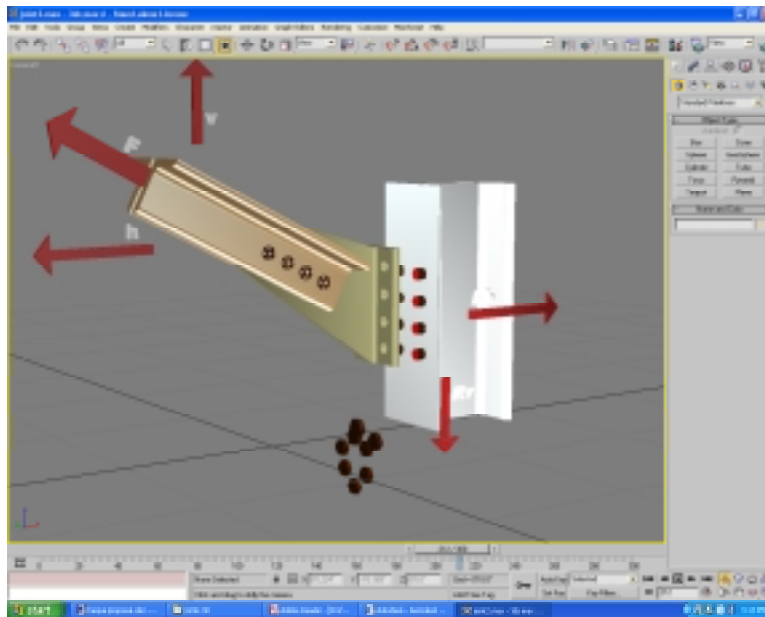


Figure 3: 3D Model after setting frames to generate animations

3. After developing the 3D model setting up frames to create 3D animations:

Animations were made visualizing failure movements in frames and depicting them in each frame using 3D Studio Max Version 6 (Figure3). The 3D model was then rendered and saved in \*.avi file format to create movies that show animated connection failure as the forces increase.

4. Export 3D model in Macromedia Director for real time 3D environment.

Macromedia Director MX enables to create real-time 3D environments to demonstrate a variety of scientific concepts. The Macromedia W3D exporter allows the artwork in 3D Studio Max and easily exports the files into a format that works well with Director. The models and the animations were exported separately (Figure 4).

## B. Computations and Joint Failure Analysis

1. Development of Excel Sheets for complex calculations and formula generation.

All calculations were first computed in excel sheets. These excel sheets were then converted into HTML format to open them in common web interface.

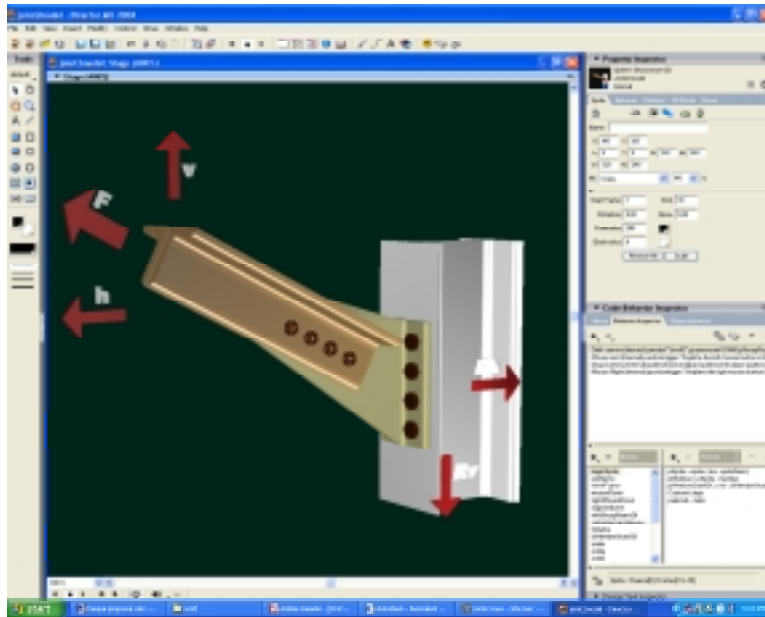


Figure 4: 3D models when exported to Macromedia Director

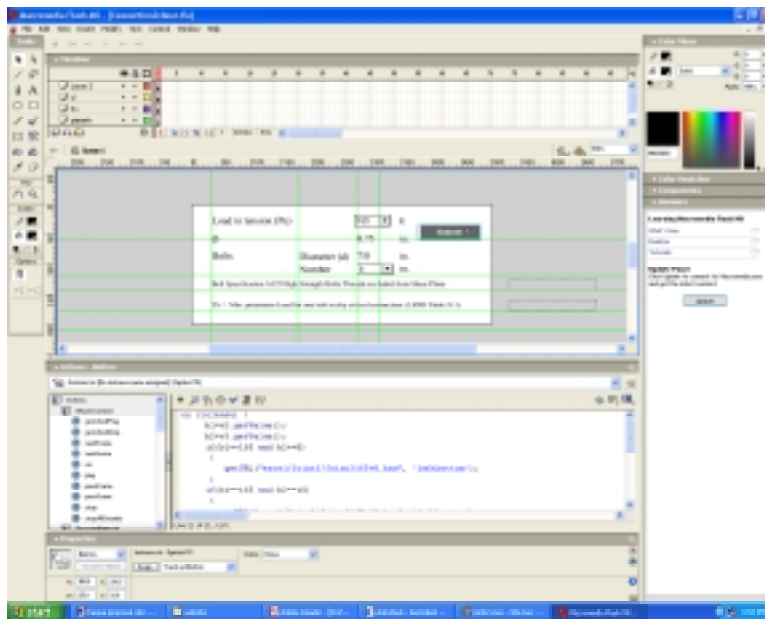


Figure 5: Drop Down menus in Macromedia Flash

development and hosts all files from MS Excel, MS Power Point, Macromedia Director, Macromedia Flash and all other software used in developing this tool (Refer Figure 8).

2. Development for Dropdown menus using Macromedia Flash Excel sheets cannot be opened in HTML with excel interface with the ability to enter data and develop calculations. This drawback was overcome by developing dropdown menu with multiple value entry in Macromedia Flash (Figure 5).

### C. Comprehensive Explanation Tool Development

A comprehensive explanation tool was developed to tie all the windows together and develop a set of direction for a sequential approach for the study. This tool helps the student to know how to interact with the interface and achieve best results and maximum understanding. This tool was developed using Microsoft Power Point. The slideshows were then converted in HTML format to enable them to operate in HTML environment (Figure 6).

### D. Common Web Interface in HTML

All the files are then comprehensively clubbed and brought together in a common web interface. This was done using Macromedia Dream weaver. This software helps in web page



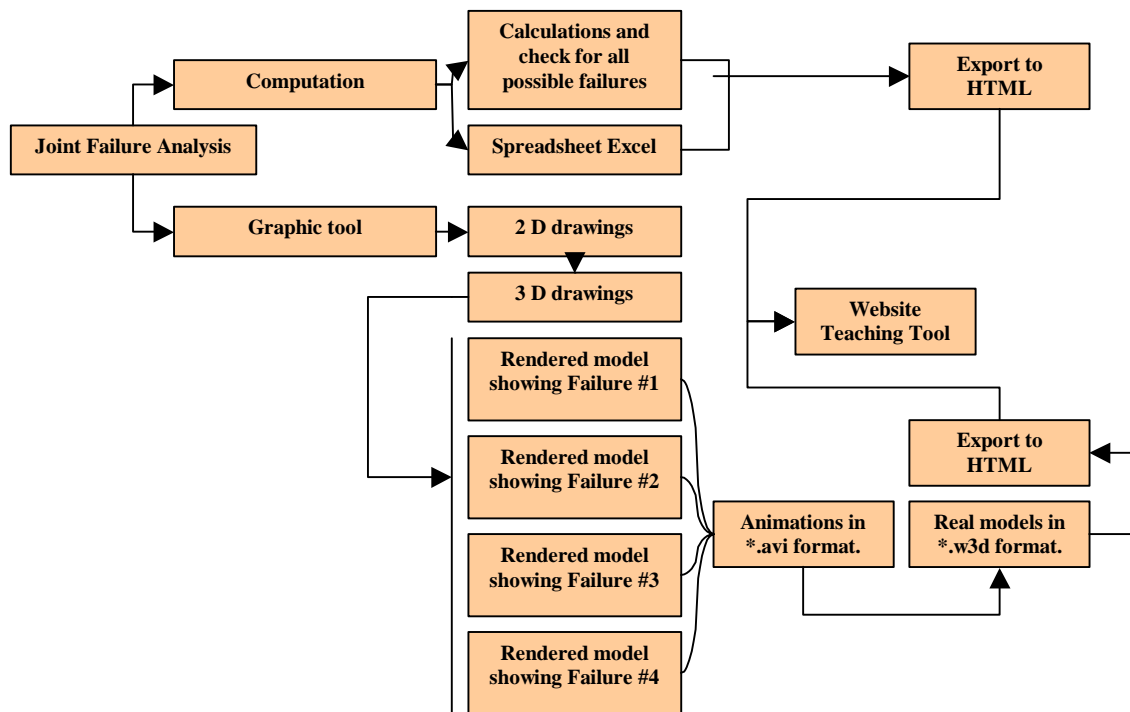


Figure 10: Proposed Methodology to develop the Teaching Tool

## Concluding Remarks

Conclusively, this tool presents many of the required concepts of architecture in a more interactive and real-time fashion. As 3D images have often been popular among instructors in presenting processes and details in a more interesting fashion, these newer models enhance the appeal of the 3D images with more interactive utility. Relying on the curiosity always attached to computer-animations, this study attempted to provide students with wider control and understanding using that animation. Projecting 3D images in a virtual space can be an effective solution for making the study of structures more interesting and interactive. This paper has attempted to show the process of steel joint analysis in a 3D virtual space. It will make the learning process more users - friendly and easier to comprehend. The model also makes it possible for viewing steel joints by rotating or zooming into it in a real-time virtual three-dimensional environment. Considering their never-ending attraction to hand-held games and computers, the use of 3D computer animation provides students with one more toy to tinker with - that of a 3D steel structure to come. By finally bringing their natural attraction to animation and education together, 3D computer animation models will develop students' interests and motivate

their understanding and retention of concepts, necessary in the design and construction of a steel structure. 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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