A Virtual Tour of Energy Conscious Architecture

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Abstract

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. It is increasingly becoming important to develop a web based 3-D visualization and animation to explain the various environmental conscious concepts and elements. The objective of this research was to develop a virtual tour of an energy conscious building showing the various concepts, elements and technical aspects of the building. The tech savvy youth of today will find it more interesting to work on such a real time virtual model, as it would make learning fun. 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

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, 2004). 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.

McManus, and Segner (1991), are of the view that visualization will take many forms in the construction industry. The generation and manipulation of three dimensional models of a proposed project using sophisticated three dimensional modeling techniques to hypothetically build and test a facility while it is still in the design development stage is one of the important uses of visualization. Senior designers, construction managers, and client specialists use the model to "visualize" both the construction and operation of the facility. Critical interferences are prevented; inefficiencies are minimized; errors are corrected in magnetic memory rather than in steel; and client decision makers are duly impressed. Superintendents can even finish a job with single digit revision numbers on their drawings.

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).

Nicholson, L, (2004) is of the view many construction contracts nowadays are of design built nature which requires the construction company to be involved in creating a design that includes construction expertise, often of the green building nature. Thus the design built company is strongly placed to suggest and argue for inclusions green building technologies and design elements with an initial increased cost but in the along reduce the environmental impact and improve the quality of the built environment thus benefiting all. This advantage of in favor of the construction company can bring in more work from the same client. He further believes that the growing awareness of about green buildings and the increased implementations of green technology make it absolutely necessary for students to be familiar with the green building movement. Students will be expected to implant environmental conscious features into the building design and construction, as this would greatly benefit the end user, society and nature as a whole. Thus he feels that it is the responsibility of educators to seek out information and include it in the coursework.

Riley, D., Workman, E. (2003) are of the view that increased importance is being placed on the design and construction of buildings that are healthier for the occupants and have minimal negative impact on the environment as buildings and their construction processes are significant contributors to environmental degradation. Thus the need to minimize the effects of buildings on the environment becomes increasingly relevant. Worldwide efforts have resulted in the acceleration in the development of new “green” building technologies, which are constantly challenging AEC professionals and students to explore unfamiliar building alternatives. Firstly, this makes it imperative to develop evaluative skills that will allow the assessment and test the appropriateness of these unfamiliar technologies. Secondly emerging professionals must be equipped with the necessary knowledge and skills required to design the most energy conscious building.

Hence, it is increasingly becoming important to develop a web based 3-D visualization and animation to explain the various environmental conscious concepts and elements. The objective

of this research was to develop a virtual tour of an energy conscious building showing the various concepts, elements and technical aspects of the building.

Development Methodology

The main thrust of the research was the development of a 3D computer generated animation model showing and describing in detail the various elements of an energy conscious architectural design. The following steps outlines the methods used to achieve the above stated purpose. Figure 1 shows the work flow diagram

1. Design and Development: The first step was to design and develop a typical single-family three-bedroom house. Energy consciousness was the prime-governing factor for the design and development of the house. .

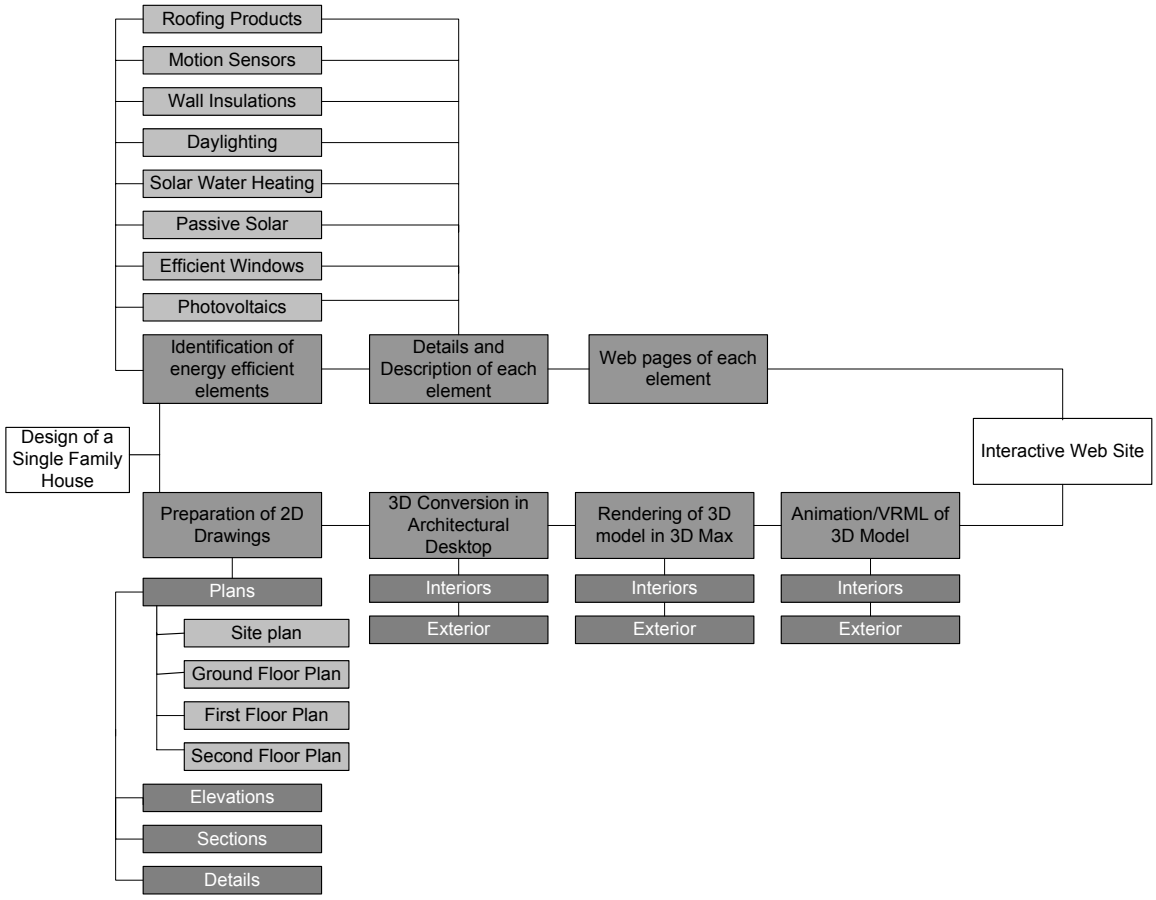

Figure 1: Work Flow Diagram

2. Development of Drawings: The various 2D architectural drawings namely plans, sections and elevations were prepared using AutoCAD® 2005 (Figure 2).

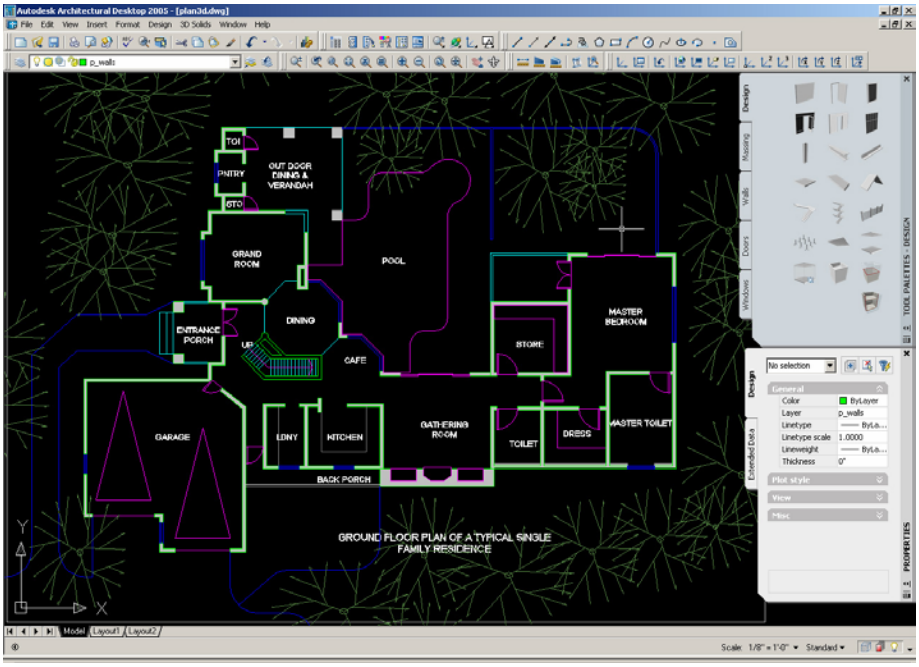

Figure 2: 2D architectural drawings using AutoCAD 2005

3. Development of a 3D Model: The next step was to develop a 3D model of the design using AutoCAD® Architectural Desktop 2005 (Figure 3).

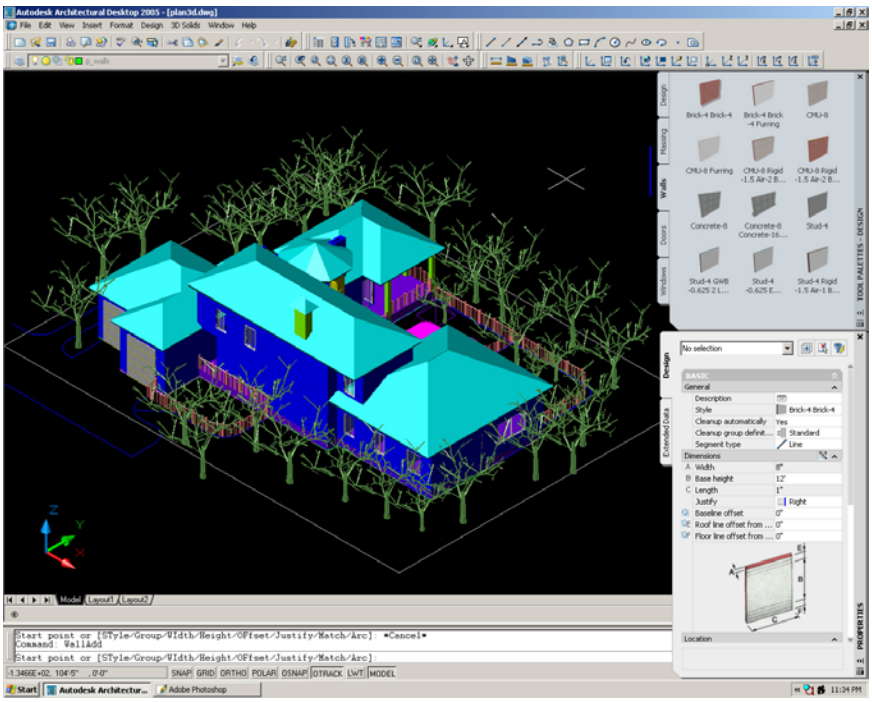

Figure 3: 3D model of the house

4. Development of an Animated Walkthrough: The next step was to develop an animated walkthrough of the house with a focus on various all the energy conscious elements of the building using 3DS MAX (Figure 4).

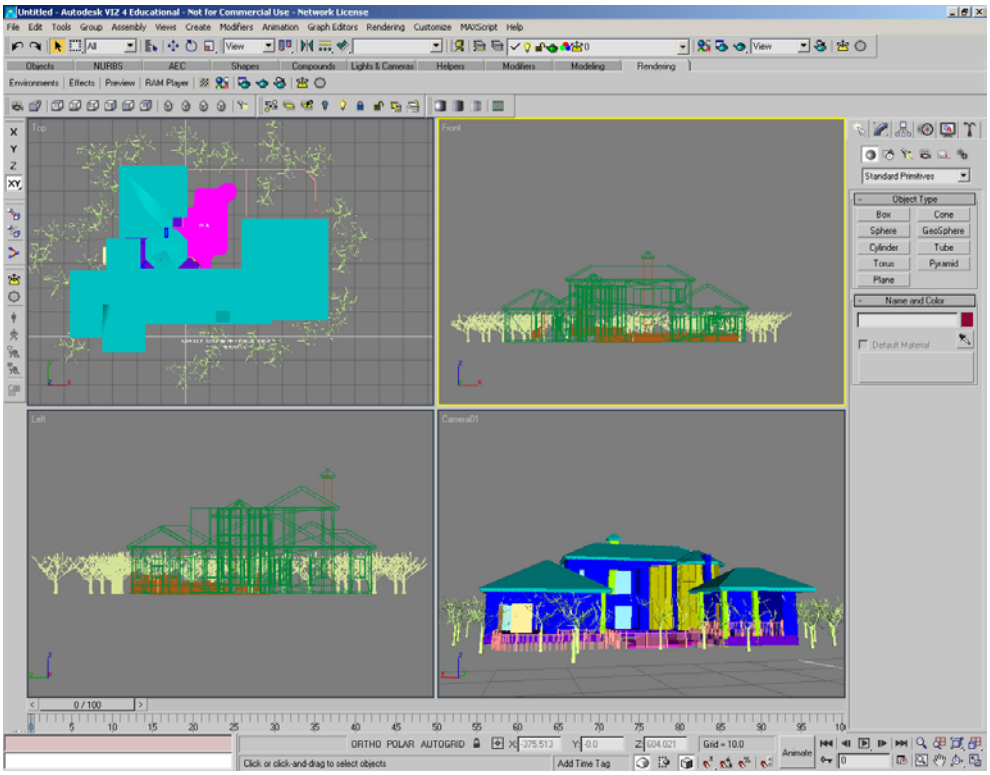

Figure 4: Development of 3D Walkthrough on 3DS MAX.

5. Analysis and Description of Elements: A brief analysis and description of each element was carried out to explain the concepts, energy benefits, technical details etc. of individual elements.

6. Development of the Website: The final step was to develop an interactive web based model integrating the 3D model, animation, and the description using a combination of Flash MX, Dreamweaver MX and HTML.

The tour would include and focus on the following aspects of an energy conscious architectural design:

a) Energy Efficient Windows: Advances in window and glass technology have resulted in greater energy efficiency, while yielding better quality of indoor environment through natural lighting. The ultraviolet light-filtering glazings have led to reduce energy demands (Figure 5).

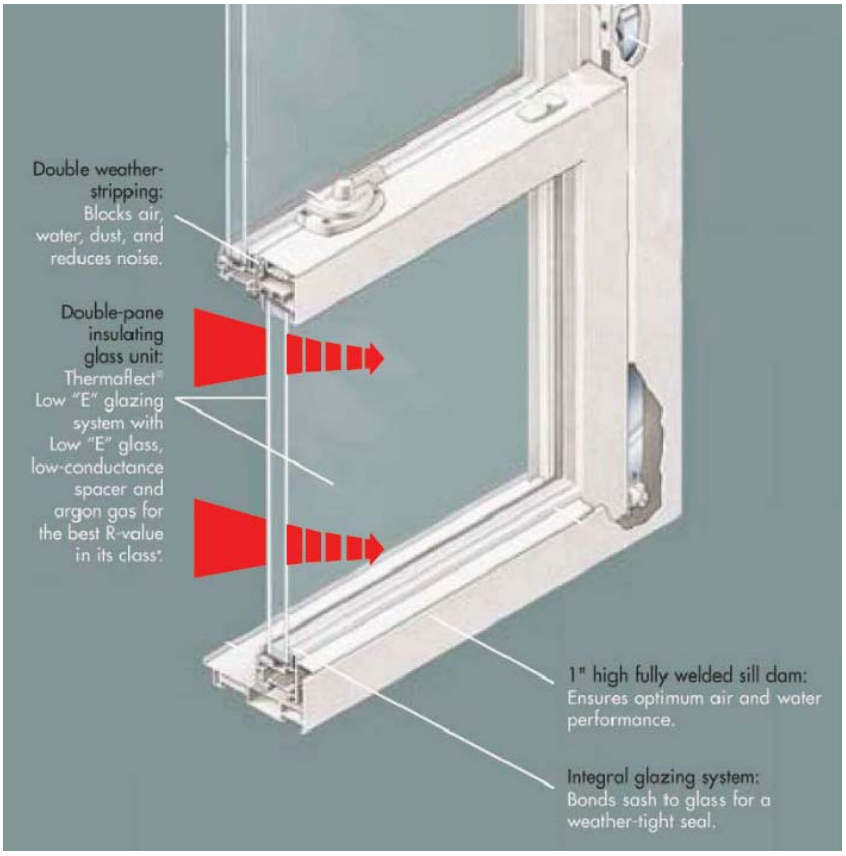

Figure 5: Double-glazed window with low solar gain

b) Passive Solar Design: Passive solar design includes a broad range of building design strategies. A passive solar building design allows sunlight, heat and air flow into building only when needed, and only in amounts necessary to raise the occupants' comfort level. A passive solar design successfully integrates and balances the use of daylighting, an efficient building envelope, and the use of energy efficient mechanical and electrical equipment to create a comfortable, healthy and energy efficient indoor environment.

c) Photovoltaic: Photovoltaic cells create electrical current from sunlight. The technology has advanced to the point where certain building components contain photovoltaic cells integrally. Photovoltaic cell integrated roofing panels can be purchased and installed in a manner similar to those made out of sheet metal, while taking benefit of the ambient sunlight to generate electricity.

d) Solar Water Heating: Solar water heating is another passive solar design that uses available sunlight to increase a building's energy efficiency. Solar water heaters use the sun's energy to heat water for building occupants' use. Solar water heaters are most often installed on roofs of buildings. They are used in line with electric or gas water heaters. The basic design intent is to pre-heat water, before it enters the electric or gas hot water heater. Water is drawn from the solar hot water heater into the gas or electric hot water heater to replenish the water drawn by building

occupants. The system reduces energy consumption by making the utility powered hot water heater in essence a storage facility for hot water heated by the solar system.

e) Roofing Products: The biggest recent advance in roofing products technology came with the advent of the radiant barrier. This physical layer in the roofing system acts to reflect sunlight back out of the roofing system before the light can be trapped and converted into heat inside the building envelope. The systems are simple to install, and only add slightly to initial building costs.

f) Motion Sensors: There has been a leaning towards the installation of motion sensors that would detect the presence of people. The development of these intelligent motion sensors would switch on and off the lights depending upon the occupancy. Thus theses equipments can offer sizeable energy savings over the life cycle of the building even though their initial installation costs are higher.

g) Wall Insulations: Advancement in material technologies has made it possible to install new insulating materials in the walls that have high R values and are more environmentally friendly.

h) Daylighting: Daylighting is the architectural or building design feature that allows natural light to be brought into interior spaces, and distributed adequately within the interior space. Successful daylighting of interior spaces reduces the need for electrical light sources, reducing energy demands and costs, while also reducing the heat generated by electrical light sources. This reduction in heat generation can allow for smaller air conditioning systems, saving further energy consumption costs. Numerous design features can be included in the interior of the building to allow for natural daylight illumination. The most common feature is fenestration, or window apertures, properly spaced and located within the exterior walls to avoid direct sunlight, while allowing indirect illumination. A common feature used to distribute indirect sunlight is the light shelf. This passive architectural device is actually a shelf structure, placed well above eye level, but below a glazed opening in a wall, and is used to reflect light above the height of the eye up onto the ceiling of the room, allowing natural light to penetrate deeper into the interior space.

Brief Description of the Software used

The following is a brief description of software used in the research:

AutoDesk® Architectural Desktop 2005: is built on AutoDesk® 2005 software platform with a similar interface as AutoCAD® 2005. AutoDesk® Architectural Desktop 2005 combines the productivity of automated documentation, the efficiency of intelligent architectural objects, and the flexibility of file-based collaboration. It has extensive 3D modeling capabilities as it integrates architectural object into the design and creates a 3D model with ease. Moreover these objects can be customized according to need making the software extremely flexible. It has an extensive library containing thousands of detail components and automated drawing routines that simplifies the process of creating construction details and drawings.

3DS Max 6: is a state of the art 3D modeling and animation software ideal for creating realistic architectural walkthroughs and still images of architectural designs giving an impression of how the building is going to look when it is built. With 3DS Max 6 it is possible to create virtually any environment, characters, structure etc that the mind can conceive. 3DS Max 6 has the capability of generating photo realistic virtual walkthroughs and animations by creating interplay of materials, lights, backgrounds, environments, cameras and rendering. It creates an animation usually by rendering each frame of the sequence and then combining the entire set of images into a standard movie format of *.avi or *.mpg, which are compatible with most media players and web browsers.

Macromedia Dreamweaver MX: is the professional choice for building web sites and applications. It provides a powerful combination of visual layout tools, application development features, and code editing support. It is software based on visual platform rather than a code based platform. With features for Cascading Style Sheets CSS-based design and integration, Dreamweaver MX enables web designers and developers to easily create and manage any website. Its friendly user interface helps people with no coding experience to create professional looking websites. Dreamweaver MX has in built capabilities for the integration of animations, sounds images and movies which is helpful in creating an extremely interactive website to give the viewers a truly multimedia experience.

Concluding Remarks

The effort of this research paper was to showcase the energy saving elements used in an energy conscious architectural design using 3D models and animations. 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 aspects of energy conscious in architectural design. This would also help to generate awareness among common people about energy conscious design, as the web interface is easily accessible and user friendly. The models and animations can act as an excellent teaching tool to explain the various concepts integral to an energy conscious design, as the instructor would present the entire scheme in a virtual world so that the students can understand the concepts with more clarity and ease.

The research has implications in the business world too as the model could be an effective tool to explain potential clients the benefits of an energy conscious design. The model could help to convince potential client/user to increase their initial expenditure outlay in return for future savings on recurring energy costs, thus benefiting the user and the environment in the long run.

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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