Visualization
Using
Computer Generated 3D Models
And Their
Applications in Architectural Practice

MASTERS REPORT
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Chapter 1

1. SYNOPSIS

"As an architect who enjoys drawing, I was once skeptical of computer aided design as a representation tool for creating perspectives and 3D models: I feared it was a replacement for drawing. Only after I began to use CAD did I realize that computers can supplement familiar skills in remarkable ways.”

- Mark Lauden Crosely, A.I.A.

Computers can be used effectively to generated 3D models. Studies produced using computer generated 3D models can be helpful to the architect in visualizing his design. Architects who are aware of the usefulness of computer generated 3D models in their design process but are not using them, believe that their current visualization techniques accumulated after many years of experience are adequate. They should be warned, however, that a very dangerous trap for architects is to believe the way they have been doing something is the best way.

"The accelerated developments in personal computers and their application to architectural design visualization have raised more forcefully the question of the role of conventional representation techniques in architecture.”

- Paul Laseau

One of the aspects of architectural design process is based on a designer’s ability to visualize design solutions. Tools and media can play an important role in this process. The computer is one such tool which can be used to generate 3D
models for visual studies and will certainly have an impact on the future of the design visualization techniques. Therefore, it becomes important for us to understand how computer generated 3D models will help us in design visualization.

2. STATEMENT OF PURPOSE

The purpose of my master's report is to study the effective ways a computer created 3D model can be used to generate visual studies to provide a better understanding of architectural design.

To increase the objectivity of my research, I will evaluate the importance of visualization by using computer generated 3D models in architectural practice and the reasons for their not using it. I will make a few recommendations to help reduce the defects commonly reported by architects for their not using computer generated 3D models in visualization studies.

3. RESEARCH METHODOLOGY

The original intent of my research was to create a guidebook about the capabilities of computer generated 3D models in visualization. As work progressed however, it was revealed that if my research were to be truly useful, it would have to go beyond that and address the question whether or not computer generated 3D models are being used in architectural firms to create visual studies and if they are not, to seek the reason for their not doing so. It was also suggested that I should make recommendation on how to lessen the degree of those problems.
The early part of the research focuses on the different ways a computer generated 3D models can be used as a visualization tool. Literature reviews and knowledge gained by using different CAD software's formed a basis for this part of the report.

The latter part of the research stems from questionnaires and interviews I had with twenty-one large architectural firms* in Tucson. The questionnaires and interviews helped me identify the usefulness of computer generated 3D models as a tool to provide a better understanding of their design and some of the most frequent problems faced by practicing architects in using computer generated 3D models as a serious design visualization tool.

* List of large architectural firms was determined through the results of a survey by "Inside Tucson Business". Refer Appendix A-2, for the list.

In summary, my research report accomplishes three goals: first, it discusses the various methods of visualization using computer generated 3D models; second, it investigates if 3D visualization is important to architects and if according to them, computer generated 3D models are good design visualization tools. It identifies the most frequently faced problems by architects in the firms interviewed in using computer generated 3D models as a design visualization tool; and finally it gives recommendations on how to lessen the degree of those problems.

4. ROLE OF THE AUTHOR

My work on computer graphics has consumed many hours both educationally and professionally. The Diploma in CAD which I received in February 1992,
provided a strong spring board for future studies in computer aided design. As a student in the Masters of Architecture program, nearly one year was spent in learning and understanding the applications of computers in architecture. My work as teaching assistant in both basic and advance CAD classes provided me through knowledge and expertise to understand computer graphic programs. As an architect and computer specialist in the Department of Campus and Facilities Planning, my experience in computers translated into two years of valuable professional experience and provided an excellent opportunity to synthesize my academic and professional skills to comprehend the significant impact computers can have in our profession today.
Chapter 2

1. INTRODUCTION

"While 2D drafting is the workhorse application, Computer aided 3D models give you a chance to expand your ideas and look at them in a new light. After using 3D to help develop your design, you might find it difficult to imagine what you would do without it." 3

- George Omura

"Computer generated 3D models" is the representation of a two dimensional drawing by extruding the line or form in the third dimension. Computer aided design (CAD) programs are used to generate two dimensional floor plans. The same floor plan are used as a reference to draw up sections, elevations and construction documents. Computer generated 3D models are merely one such extension of the floor plan which is created by extruding the same floor plan, but in the third dimension that is in the Z direction (See Figure 2.1, Page 6).

4 “In a questionnaire survey conducted in the top twenty one architectural firms in Tucson, 58% of the firms were uncertain of the fact that once a 2D floor plan is drawn on the computer using CAD programs, the same drawing can be used to generate 3D models.” 4

Architectural firms are using CAD programs to create drawings that have no real advantage over the practice of manual drafting, while they could be using the same floor plan to create 3D computer models.
Figure 2.1: 3D Plan View and Plan Extended in the "Z" Direction
So, why should I learn about Computer generated 3D models:

1. Computer generated 3D models can be used to quickly study a variety of design solutions and view them from any angle - a quick way to get a good sense of the space you are creating.

5 "In a questionnaire survey conducted in the top twenty one architectural firms in Tucson, 100% of the firms agreed that studying a 3D model from different angles would be very useful since they would be able to visualize the designed space more spontaneously.”

2. Once the design is approved, the Computer generated 3D model can be used to produce floor plans, sections, elevations and construction documents for the construction phase.

6 "In a questionnaire survey conducted in the top twenty one firms in Tucson, 66% of the firms were either uncertain or not sure of the fact that floor plans, elevations and sections can be generated from the same 3D model.”

3. Client presentation: The ability to present to a client a 3D model so that they can better visualize the project. The 3D models make it easier for people who cannot understand 2D plans, elevations etc.,

7 "In a questionnaire survey conducted in the top twenty one firms in Tucson, 58% of the firms agreed that by presenting a 3D model to the client, the client would perceive the designed space better than they would from 2D representations.”
“The responses the survey conducted by A.I.A. in June 94 to help the A.I.A. Arizona committee on computer education to determine the needs of SAC members regarding computer skills were-

Q. In order of preference, which areas would you be involved in improving your knowledge of computers? -

1. Networking
2. 3D Modeling
3. IBM or comparable software
4. Hardware
5. Macintosh Software
6. Other: CADD”


This survey conducted clearly reveals that practicing architects are interested to learn more about computer generated 3D models.

"... it makes you think about your design development in a different manner. It may change the way designers think. When you are working at the computer, you begin to think relative to your medium - three dimensionally."

- PA, September 1992

2. COMPUTER APPLICATION IN 3D MODELING:

A dozen years ago, a debate ensured over whether computer technology could be effectively used in producing construction documents. Today the focus has shifted to whether computer technology can be effectively used as a tool to support design visualization.

"Computer technology is most effective and efficient when used in support of all phases of the design process and visualization. Computer aided 3D models will result in a dramatic change in the design visualization process itself”

- PA, November 1992
Computer generated three-dimensional modeling makes special representation easily accessible to designers. It generally operates on the same hardware* as drafting systems, allowing you to create multiple views of your work without having to redraw it, over and over again. (Figure 2.2, page 10; shows different views of the same model generated by changing the view points).

* With the current trend of engineering better and faster machines, both on the Mac and DOS platforms, it is possible to increase the speed of work and productivity. However, a machine only works as the fast as the person working on it can and time saved by the faster machines is usually in the regeneration time in the common CAD commands such as "zoom", "hide", "pan" etc. It is common now to think of a 16 Meg Ram, 510 Meg hard drive with a 33/66 Meg Hertz speed chip or a 40806 Simm chip on a computer. With the increasing speed of computers and increasing number of good CAD packages, it has become relatively easy to create complex CAD models.

A project could be started with organized sketches, in plan, then create volumetric massing studies, in three dimensions, develop the plan further, and then work on some specific sections and elevations. Thus, you would be transforming your floor plan into a 3D models with walls, floors and roof. You would simultaneously be locating door and window opening, and refining the shapes and surfaces of the various forms. As work progressed you would be able to view the model, in perspective, from any viewpoint, inside or out and when you are ready extract the two-dimensional representation of plans, sections and elevations, then dimension and annotate them. Any changes you make during this last phase would be reflected in the original 3D model, which can be
FIGURE 2.2: Different Views of the Model Generated by Changing the View Point
reviewed simultaneously while making these changes. Finally, the finished model is available for presentation purposes and can be used as a reference on the construction site.

3. CONSTRUCTION METHODS OF COMPUTER GENERATED 3D MODELS:

There are three basic* methods for creating 3D models on a computer. Each method has its own unique characteristics, but they all enable you to construct forms in space that can be translated into two-dimensional drawings and be viewed from different angles.

* Most CAD programs do not support all the three methods of modeling. If an architect is interested in buying a CAD software for 3D modeling purposes, it is important to study all the literature available on the software program application and make sure that software does fulfill the requirements. Also, it would be very useful to try out the software by buying a promotional copy of the software before making an investment. Most software companies provide this facility to their potential customers. Also, most CAD software companies provide promotional footage on their products either on CD Rom discs or video tapes. For further reading on this topic refer to "One Firms' Search for CAD" Julie M. Telstad, PA, June 1992.

A. METHOD A:

Drafting software builds drawings that are based on two-dimensional lines and shapes. These elements may be given a height coordinate, a dimension along the Z axis, which allows them to be projected or "extruded" into space.

Lines are the basic element in two-dimensional drawing. However in order to create a 3D computer model you need to create opaque planes or objects from
these lines. This means that to draw a cube, you would first draw a square, then extrude the square by giving the lines that make it up a thickness (See Figure 2.3, Page 13). This thickness is a value given as a Z coordinate. Imagine that the screen's drawing area is the drawing surface. A '0' Z coordinate is on that surface. The two-dimensional cube is drawn on this surface by entering coordinate values or relative dimensions in X and Y directions of the plane. The cube is extruded or provided with a thickness by entering a value for the Z coordinate.

This method is very efficient if a two-dimensional drawing already exists. All two-dimensional drawings consist of lines of different shapes (curved surfaces like arcs and circles are also made up of smaller units of lines). All these lines have their own unique properties (every 2D or 3D entity drawn in CAD has unique individual properties). These properties include their length, position and the dimensional value of the X, Y and Z coordinates. All two dimensional drawings will have these properties, but will have '0' Z coordinate value.

In order to generate a 3D model from this two dimensional CAD drawing, you will have to change the property of the lines. Most CAD programs* provide the editing

*A good CAD software package is usually determined on the strength of its "Command" support or "Command Menu". With the increasing number of CAD software programs in the market, the manufacturers of CAD application are trying to make CAD applications user friendly. For example, AutoCAD Release 11 and AutoCAD Release 12 have "Single Keyboard" commands (type L to activate the line command, Z for the zoom command, etc.). CAD packages must also support customization of CAD menus. Customization of the menu help in harnessing the software to ones' use. For example, an interior design firm can create a standard library of chairs and link the chair to a particular letter on the keyboard.
Figure 2.3: Square Drawn with Lines and Extruded to Form Cube
On pressing that particular key, that particular chair appears on the screen for insertion into the drawing. This customization helps to make using computers time efficient. For further reading refer to "3D Common Market" -Terrance Schilling PA, November 1992.

process by allowing the selection of each of the two-dimensional lines and entering a Z coordinate value, which would result in giving the line a thickness. Since a 3D model consists of walls of varying heights, corresponding lines can be given different thickness by changing the property of the line to match the wall height. This process is extremely quick and easy and also effective since the lines can be individually edited*.

* Popular CAD packages which support this method of 3D modeling are AutoCAD, ArchiCAD, MiniCAD, Microstation V5, Form Z, Auto Architect. Popular CAD packages are based on the survey conducted by PA, based on the number of offices using CAD presently. AutoCAD was found to be the most prevalent CAD software. For further reading refer to "Integrate Software" PA, April 1993. Also refer to the software manuals which are with the software package, "Mastering AutoCAD" by George Omura, Sybex Inc., "3D Tips and Tricks" - A compilation of Common 3D commands Sybex Inc., Also, to obtain a quick hands-on experience, follow the CD ROM guides which are available in the market, or ask for the promotional CD ROM discs from the Software manufacturer.

when you draw an object with thickness, you do not see this thickness until you view that drawing from a different angle. This is because normally your viewing angle is perpendicular to the imagined drawing surface. At that angle, you cannot see the thickness of an object because it projects toward you, just as a sheet of paper looks like a line when viewed from one end. To view an object's thickness you must change the angle at which you view your drawing.
The basic steps to be followed, assuming that a two dimensional drawing already exists and the 3D model would have at least two different wall heights, would be:

- Open the drawing
- Change the viewpoint, to be able to view the drawing three dimensionally
- Select all lines that have 10'-0" height
- From edit/modify menu select change property command.
- Enter 10'-0"
- Select all lines that have 3'-0" height
- From edit/modify menu select change property command.
- Enter 3'-0"

Let us consider the line with 3'-0" is a lintel. You would then select this extruded line and move it up by 10'-0", to match with the top of the rest of the wall height, leaving a 7'-0" opening from the base to the bottom of the lintel. A door can now be drawn, by constructing another line in the doorway opening and extruding the line 7'-0", by following the same method. The simple 3D model is ready. This model can be now viewed and studied from different angles and positions (See Figure 2.4, Page 16)

"We chose CAD for one primary reason: Its ability to convert instantly from 2D to 3D makes it a very powerful design tool" 11
- P A, November 1992
Plan View

Plan Rotated to Obtain 3D View

Walls Extruded by 10'-0"

Finished Model

Figure 2.4: Method A
B. METHOD B:

Most designs start with a diagrammatic organizational scheme. Instead of moving from diagrams into a plan design, a 3D model may created to study the \textit{volumetric} implications of early design decisions. Interior spaces can be thought of as three dimensional volumes that they really are, rather than flat outlines. Schematic designs can be sketched three dimensionally. You may actually draw in a three-dimensional mode with most CAD programs. When you draw a line it will appear as a plane, a rectangle as a box and a circle as a cylinder. This method* is very efficient if the necessity for a computer generated 3D model is predetermined.

* Popular CAD packages which support this method of 3D modeling are AutoCAD, Versa CAD, ArchiCAD, Architron, MiniCAD, Microstation V5, Form Z, Auto Architect. Popular CAD packages were determined by the survey conducted by PA, based on the number of offices using CAD presently. AutoCAD was found to be the most prevalent CAD software. For further reading refer to "Integrated Software" PA, April 1993. Also refer to Software manuals which are mailed with the software package, "Mastering AutoCAD" by George Omura, Sybex Inc., "3D Tips and Tricks"- A compilation of common 3D Commands Sybex Inc.,

Typically, you can choose a bottom or base elevation for an element, so that you can specify both its position and size in space. As you draw a plan, you may specify a "default" base elevation and height for everything you draw, and when you want to draw, for example, a half-height wall, you can specify a new \textit{Z}, coordinate. However, in practice, you may find it easier to draw everything at the default values, then, go back and change the special cases. You can also assign specific \textit{Z} values to symbols and other blocks, so that you can insert a window, it will be positioned at its proper height.
Although you are restricted to drawing along only one plane, the model can be viewed and worked in from any point, in that plane, and through you can work from a single, two-dimensional view by arranging Z coordinates as you draw in plan or elevation, it is helpful to look at several "flat" views at once, such as plan and two elevations and preferably, a three dimensional view as well, using multiple view ports. When you add an object to one view, it simultaneously appears in all the other views; likewise changes are revolved and displayed in all views. In essence, you are viewing the model through different windows.

Though you may visualize a design in 3D, you will often start sketching it in 2D and later generate 3D views. If you know right from the start what the thickness and height of an object are to be, you can set these values so that you do not have to extrude the object later. If you use the same thickness and elevation often, you can even create a template file with these settings so that they are readily available when you start your drawing.

Let us imagine you are constructing the same drawing as in Figure 2.4 (Page 16). Now since the thickness of the wall is predetermined at 10'-0", you would now set the thickness of the lines to be drawn at 10'-0". The lines can now be constructed exactly as you would do to create a 2D drawing. The drawing also appears as a 2D drawing, but by changing the view point to view the drawing three dimensionally you will notice that all the lines drawn have a thickness of 10'-0". In order to complete this drawing, change the preset line thickness to 3'-0". Since this line which represents the lintel is to be drawn at an elevation of 10'-0", change the preset elevation height which was 0'-0" to 7'-0". On drawing a line now to represent a lintel you will notice that the line is drawn at a elevation of 7'-0" and
has a thickness of 3'-0". A door can be drawn below the lintel by changing the preset thickness to 7'-0" and elevation back to 0'-0".

The basic steps to be followed to create a 3D model with this method would be

- Preset the height and thickness you will be drawing the lines at
- Change the viewpoint, to be able to view the drawing three dimensionally
- Draw all the lines which correspond to these presets
- Change the presets to suit the consequent lines
- Draw all the lines which correspond to these presets
- Repeat this process until all the lines are drawn. (See Fig. 2.5, Page 20)
Plan View

Process of Drawing Extruded Walls

Figure 2.5: Modeling Using Method B
C. METHOD C:

This method* of creating 3D computer models, is very useful to make schematic models to study a building's interior space and to construct schematic massing models of a building. This approach to modeling is through designing forms, or solid objects, as opposed to volumes. By drawing floors, walls, and a roof, a design can be built in a realistic manner. Buildings may be assembled one object at a time.

* Popular CAD packages which support this method of 3D modeling are Form Z, Stratavision 3D, Autodesk 3D Studio, CADD Eagle Software, ArchiCAD, Microstation V5, Popular CAD packages were determined by the survey conducted by PA, based on the number of offices using CAD presently. For further reading refer to "Integrate Software" PA, April 1993. Also refer to Software manuals which are mailed along with the software package, "3D Tips and Tricks" - A compilation of common 3D commands - Sybex Inc.,

"Once you have used CAD's 3D capability, you can see how simple a process it really is. Most important, 3D can help you visualize an object without resorting to complex mathematics to input your image" 12

- George Omura

Such a form models can be constructed directly over the base of an earlier volumetric model or over a earlier existing schematic sketch on sketch paper. This process is similar to the Method B mentioned earlier, but in this case the 3D objects will be created in terms of blocks. Thus a cube will be drawn as a single entity, unlike the earlier methods were a cube has to be drawn as a series of lines. Holes or volumes can be carved or subtracted from these cubes to represent or obtain a opening. For example, to obtain an similar model as Figure 2.5 (page 16) you would first preset the object modeler height to represent that of the model which in this case, is 10'-0". Second, you would select the type of
object you need to draw, also select the *Add Form* tool from the selection menu (in this case a rectangle) and draw the rectangle of the required dimension. This rectangle has a height of 10'-0". This object has no openings yet. Reset the height of the object modeler to -7'-0", select the *Subtract Form* tool and draw another rectangular to represent the door opening. This cube subtracts the door opening from the bigger rectangular form, since it is drawn with the *negative height* and the *Subtract Form* tool. A door can now be added in the position of the opening by adding another rectangular object of 7'-0" height.

The basic steps to be followed to create a 3D model with this method would be

- Preset the height of the object modeler, select the add form tool, select the tool which represents the type of object you need to construct and draw the form.
- Change the viewpoint, to be able to view the drawing three dimensionally
- Draw all the forms which correspond to these presets
- Change the presets to suit the forms. If a form has to be subtracted, select the subtract form tool.
- Draw all the form which correspond to these presets
- Repeat this process until all the forms are drawn. (See Figure 2.6, Page 23)
Solid Rectangular Block Drawn with 10'-0" Height

Second Rectangular Block Subtracted from the First Rectangular Block

Finished Model

Figure 2.6: Method C
Chapter 3

Questionnaire

1. PART I

A questionnaire* was designed to gain responses from twenty one large architectural firms** in Tucson. All the firms considered are currently using computers in their design process, mostly in the production stages. The responses to the questionnaire tabulated by sub dividing the respondents into two groups:

- *Group A:* In the architectural firms interviewed, Principals and Project Managers who were either familiar with using or knew how computers were used to generate 2D drawings but had very little knowledge on generating or how they are generated using computers formed 66.44% of the respondents.

- *Group B:* In the architectural firms interviewed, Project Managers and CAD professionals who were either familiar with or knew how computers were used to generate 2D drawings or 3D models formed 33.34% of the respondents.

* For Questionnaire format refer Appendix A-1.

** List of large architectural firms was determined through the results of a survey by "Inside Tucson Business". Refer Appendix A-2, for the list.
The questionnaire focused on:

- The current representation methods used by architects in the design process.
- The importance of 3D visualization to architects to provide a better understanding of their design.
- The best possible method to visualize a building in three dimension.

The questionnaire also focused on finding out the most common reason that the architects provided for not using computer generated 3D models in their design process. The architects were requested to suggest solutions to the problems they were facing while using computer generated 3D models or for their not using computer generated 3D models.

A covering letter with four examples* of computer generated 3D models were attached with the questionnaire. The examples attached were:

- Hard copy of a hidden line 3D aerial view of a portion of the U of A campus.
- Hard copy of a rendered view of a building in B/W, showing isometric, building elevation, and street elevations.
- Hard copy of a rendered view of a building in color.

A brief mention on the hardware and software used to create the 3D models, with the time and purpose for creating the above examples were also made to gain the respondents reactions.

* Refer Appendix A-1 for the four examples
The following were the responses and conclusions derived from the questionnaire:

2. RESPONSES

*Group A - A*

*Group B - B*

**Question 1:**

Number of responses received as **yes** to:

1. In the design process, your design conclusions are derived from studies based on

<table>
<thead>
<tr>
<th>Yes</th>
<th>A %</th>
<th>B %</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 2D sketches of plan views</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>b. 2D sketches of plan, section, and elevation</td>
<td>21</td>
<td>100</td>
</tr>
<tr>
<td>c. Perspective sketches</td>
<td>18</td>
<td>100</td>
</tr>
<tr>
<td>d. Perspective views of the building in its surroundings</td>
<td>12</td>
<td>42.85</td>
</tr>
<tr>
<td>e. Colored perspective sketches</td>
<td>10</td>
<td>29.41</td>
</tr>
<tr>
<td>f. Computer generated 3D models</td>
<td>07</td>
<td>05.88</td>
</tr>
<tr>
<td>g. Computer generated and rendered 3D models</td>
<td>04</td>
<td>05.88</td>
</tr>
<tr>
<td>h. Paper/Cardboard models</td>
<td>05</td>
<td>29.41</td>
</tr>
</tbody>
</table>

* multiple response possible

- The most commonly used process to derive design decisions by both the groups were
  
  a. 2D sketches of plan views.
  
  b. 2D sketches of plan, section, and elevation.

- 61.90% of the interviewed respondents from the two groups considered

  b. 2D sketches of plan, section, and elevation as the most important design process to derive design conclusions.
• Only 7 (33.33%) of the 21 respondents interviewed considered Computer generated 3D models as one of the design process to derive design conclusions. Of the seven respondents 4 were from Group A (5.88% of Group A) and 5 were from Group B (42.85% of Group B). All the 7 architects, however also relied on either a, b, or c process mentioned above to derive design conclusions. Respondents who considered computer generated 3D models as one of their design decision tools were familiar with the process of creating 3D models.

**Question 2, 3, 4, 5, 6, & 8:**

Architects response to their familiarity in generating 3D models using computers or in the process involved in making computer generated 3D models were:

<table>
<thead>
<tr>
<th>Question</th>
<th>A %</th>
<th>B %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. How familiar are you of Computer generated 3D models</td>
<td>85.71</td>
<td>100</td>
</tr>
<tr>
<td>3. How familiar are you in making a computer generate 3D model</td>
<td>07.14</td>
<td>57.14</td>
</tr>
<tr>
<td>4. How familiar are you with the different uses of computer generated 3D models</td>
<td>71.42</td>
<td>100</td>
</tr>
<tr>
<td>5. How familiar are you with the process involved in making a Computer generated 3D model</td>
<td>07.14</td>
<td>100</td>
</tr>
<tr>
<td>6. How familiar are you with the process involved in making a Computer generated 3D model and rendering it</td>
<td>00.00</td>
<td>23.80</td>
</tr>
<tr>
<td>8. How useful do you feel Computer generated 3D models can be in understanding your design better</td>
<td>92.85</td>
<td>100</td>
</tr>
</tbody>
</table>
• Among the respondents the average of the who knew how to create computer generated 3D models or knew the process involved in creating 3D models is lower than the average of the who considered computer generated 3D models will help in providing a better understanding of their design:

2. How familiar are you of Computer generated 3D models
   A %  85.71  B %  100

3. How familiar are you in making a computer generate 3D model
   A %  07.14  B %  57.14

• Among the respondents the average of who were familiar of the different uses of computer generated 3D models is higher than the average who were familiar in generating 3D models:

4. How familiar are you with the different uses of computer generated 3D models
   A %  71.42  B %  100

5. How familiar are you with the process involved in making a Computer generated 3D model
   A %  07.14  B %  100

• Among the respondents the average who were familiar with the process involved in making computer generated 3D models is higher than the average who were familiar with the process involved in generating 3D models and rendering them:

5. How familiar are you with the process involved in making a Computer generated 3D model
   A %  07.14  B %  100

6. How familiar are you with the process involved in making a Computer generated 3D model and rendering it
   A %  00.00  B %  23.80

• A highest number of respondents from both the groups considered computer generated 3D model would help them understand their design better:

8. How useful do you feel Computer generated 3D models can be in understanding your design better:
   A %  92.85  B %  100

28
**Question 7:**
Responses to the following questions were:

7. *What is your opinion on the following:*

<table>
<thead>
<tr>
<th></th>
<th>A % Agree</th>
<th>B % Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A computer generated 2D drawing can be extruded to generate a 3D model.</td>
<td>57.14</td>
<td>100</td>
</tr>
<tr>
<td>b. The same computer generated 3D model can be used to view the building from different angles.</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>c. The same computer generated 3D model can be used to produce plans, sections, and elevations.</td>
<td>78.57</td>
<td>100</td>
</tr>
<tr>
<td>d. The same computer generated 3D model can be used to produce colored renderings.</td>
<td>85.71</td>
<td>100</td>
</tr>
<tr>
<td>e. The same computer generated 3D model can be used to produce animated walk through.</td>
<td>85.71</td>
<td>100</td>
</tr>
<tr>
<td>f. The same computer generated 3D model can be inserted into photographs to study the building in its context.</td>
<td>85.71</td>
<td>100</td>
</tr>
</tbody>
</table>
The percentage of the respondents who were familiar with

b. The same computer generated 3D model can be used to view the building from different angles.

<table>
<thead>
<tr>
<th>A %</th>
<th>B %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

and

d. The same computer generated 3D model can be used to produce colored renderings.

<table>
<thead>
<tr>
<th>A %</th>
<th>B %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>85.71</td>
<td>100</td>
</tr>
</tbody>
</table>

were higher than the percentage of respondents who were familiar with

a. A computer generated 2D drawing can be extruded to generate a 3D model.

<table>
<thead>
<tr>
<th>A %</th>
<th>B %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>57.14</td>
<td>100</td>
</tr>
</tbody>
</table>

c. The same computer generated 3D model can be used to produce plans, sections, and elevations.

<table>
<thead>
<tr>
<th>A %</th>
<th>B %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>78.57</td>
<td>100</td>
</tr>
</tbody>
</table>
Question 9:
The architects response to the following question was:
9. At what stage of the design process would you use computer generated 3D models:

<table>
<thead>
<tr>
<th>Option</th>
<th>% A</th>
<th>% B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. From conceptual stage</td>
<td>64.28</td>
<td>71.42</td>
</tr>
<tr>
<td>b. After conceptual stage before finalizing design</td>
<td>35.71</td>
<td>14.28</td>
</tr>
<tr>
<td>c. After finalizing design during presentation</td>
<td>07.14</td>
<td>14.28</td>
</tr>
</tbody>
</table>

- 66.66% (64.28% from Group 1 and 71.42% from Group 2) of the respondents interviewed would use computer generated 3D models from the conceptual stage.

Question 10:
The architects response to the following question was:
10. Please provide your opinion on the following:
An architect’s ability to understand his design will be enhanced if (before the building is actually built):

<table>
<thead>
<tr>
<th>Option</th>
<th>A %</th>
<th>B %</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The building can be viewed three dimensionally from different angles</td>
<td>100</td>
<td>57.14</td>
</tr>
<tr>
<td>b. The building can be viewed with its actual colors and textures</td>
<td>100</td>
<td>71.42</td>
</tr>
<tr>
<td>c. The building can be viewed in its surroundings</td>
<td>100</td>
<td>85.71</td>
</tr>
</tbody>
</table>
Also

• 30.95 % (all were from Group 2) of the respondents interviewed considered Computer generated 3D models as the best method to achieve 10 a.

• 23.80 % (all were from Group 1) of the respondents interviewed considered Sketching as the best method to achieve 10 a.

• 35.07 % (all were from Group 2) of the respondents interviewed considered Computer generated 3D models as the best method to achieve 10 b.

• 23.77 % (all were from Group 1) of the architects interviewed considered Sketching as the best method to achieve 10 b.

• 71.42 % (57.14% from Group 1 and 100% from Group 2) of the architects interviewed considered Computer generated 3D models as the best method to achieve 10 c.

Q 11.

Architects response to the following question was

11. If you are familiar with the usefulness of Computer generated 3D Models the reason you are not using computer generated 3D models are:

<table>
<thead>
<tr>
<th>Reason</th>
<th>% A Agree</th>
<th>% B Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Time factor in learning</td>
<td>42.85</td>
<td>-</td>
</tr>
<tr>
<td>b. Time factor in making the 3D model</td>
<td>23.80</td>
<td>-</td>
</tr>
<tr>
<td>c. Cost factor</td>
<td>14.28</td>
<td>-</td>
</tr>
<tr>
<td>d. Lack of technical know how</td>
<td>14.28</td>
<td>-</td>
</tr>
<tr>
<td>e. Usefulness in the overall design scheme</td>
<td>28.57</td>
<td>-</td>
</tr>
<tr>
<td>f. No client demand</td>
<td>14.28</td>
<td>-</td>
</tr>
</tbody>
</table>
• Among the interviewed (all of which were from Group 1) the first highest percentage considered time factor involved in learning to create a computer generated 3D model as a major criteria for not using computer generated 3D models.

• Among the interviewed (all of which were from Group 1) the second highest percentage considered time factor involved in creating a computer generated 3D model as a major factor for not using computer generated 3D models.

Q 12.
The architects response to

12. What do you suggest to solve this problem?

• Marketing the 3D model approach to those in charge of budgeting the firms labor time.

• Communicating with the client on the importance of computer generated 3D models.

Q 13.
Architects response to the following question was

13. If computer generated 3D models are an important visualization tool which will help you in the design process, would you

<table>
<thead>
<tr>
<th>Option</th>
<th>% A</th>
<th>% B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Learn how to create the 3D computer model yourself</td>
<td>71.42</td>
<td>-</td>
</tr>
<tr>
<td>b. Employ a person who knows how to do it</td>
<td>57.14</td>
<td>-</td>
</tr>
<tr>
<td>c. Train your existing staff</td>
<td>28.57</td>
<td>-</td>
</tr>
<tr>
<td>d. Sign up a contract employee to as the need arises</td>
<td>35.71</td>
<td>-</td>
</tr>
<tr>
<td>e. Other -All of the Above</td>
<td>7.14</td>
<td>-</td>
</tr>
</tbody>
</table>

• 47.62 % (all of which were from Group 1) of the respondents considered learning how to create computer generated 3D models.
Q 14.

The architects response to

14. What will be the greatest advantage of using Computer generated 3D models to you?
- Client presentation
- Client participation in the design process.
- Problem identification and the ability to quickly study a variety of solutions.
- A quick way to get a good sense of space you are creating.
- Data management - ability to keep all the project information in one source file
- Consistent quality in presentation drawings.
- Eliminates many surprises while constructing the building.
- Design communication with the client and the consultants is easier.

Q 15.

The architects response to

15. What will be the greatest disadvantage of using Computer generated 3D models to you?
- Production time
- Lack of humanism in architectural details.
- Switching over to a new medium of presentation, probably the way we design is not easy. We would also have to reorganize our working mechanism.
- Cost of computers and computer software is not feasible. Production will not really offset the investment.
3. PART II

Based on the responses to the first questionnaire, a second questionnaire was formed. This questionnaire would help in identifying methods which would prompt architects to use computer generated 3D models for visualization.

4. RESPONSES

Q 16

The architects response to

16. The most important factor which concerns you in using computer generated 3D model as a visualizing tool would be

Time factor in learning the process 95.23 %
(of which all were from group 1)

Q 17

The architects response to

17. The most critical factor lacking in a computer generated 3D model is

Lack of humanism (drawings look very mechanical) 85.71 %
(of which all were from group 1)

Q 18

The architects response to

18. The most important reason which would convince you to use computer generated 3D models as a visualizing tool would be

Related practices and young professionals are accustomed to computers 71.42 %
(of which all were from group 1)
5. SUMMARY:

• Among the interviewed the highest average of the respondents considered Computer generated 3D models will help in providing a better understanding of their design.

• Respondents are familiar to the fact that a 2D computer drawing can be converted to a 3D computer generated model and viewed from different angles, and rendered.

• A large percentage of the respondents were ready to use computer generated 3D models from the conceptual stages of their design.

• A high percentage of the interviewed considered computer generated 3D models as a good method to achieve multiple views of the building, viewing the building with its actual colors and textures, and to view a building in its surroundings.

• Respondents cited two major reasons for their not using computer generated 3D models.
  a. Time factor involved in learning to make computer generated 3D models.
  b. Time factor involved in making computer generated 3D models.

• Respondents realize the potential use of generating 3D computer models. They also find it necessary to learn it themselves but either do not have the time or consider creating 3D computer models as a very difficult task due to the lack of technical know-how.

• Architectural offices work in a time bound production oriented atmosphere. Within the Architectural offices the work force is structured. There is the group who
design and the people who are responsible to execute the design. Easy and clear communication between the two groups is extremely useful. Therefore, it becomes necessary to use a common language which can be understood clearly by the entire staff. At the present time, conventional drawing techniques are predominantly used, because every person who joins an architectural firm (either the design force or the production staff) is accustomed of drawing. Therefore, sketching and quick representation perspective sketches play a predominant role in visualizing and perceiving 3D views of a building, despite the fact that architects agree that computer generated 3D models can be the most effective 3D visualizing tool.

- With the emerging changes in technology and advanced Computer Aided Design application software programs, it is surprising to see that practicing architects still prefer conventional drawing techniques as the more important design conclusion deriving process. The fact that both Group A and Group B prefer conventional methods of drawing (Q.1 a, b, c) clearly indicates that CAD may still not be sufficiently developed and user friendly to suit architects. However, the lack of technical know-how among the design decision making team within offices could also be an important factor to consider and it would be interesting to study the amount of input Group B has in the design development and decision making process. It would interesting to study the influence of computers in the design process and the extent of its use in architectural firms which have the design decision making teams well acquainted with CAD and Computer generated 3D models.

- Group A which considered 3D drawings (Q.1d) as an important process for arriving at their design conclusions were not familiar with the process of creating computer generated 3D models, whereas Group B who were familiar in creating computer generated 3D models did not consider 3D drawings as an important process
for arriving at their design conclusions. It would be interesting to compare and study if architects who are familiar in creating computer generated 3D models would still prefer conventional drawing techniques over studying their design using computers.
**Chart Determining Group Responses to Questions:**

1. **In the design process, your design conclusions are derived from studies based on**
   - a. 2D sketches of plan views
   - b. 2D sketches of plan, section, and elevation
   - c. Perspective sketches
   - d. Perspective views of the building in its surroundings
   - e. Colored perspective sketches
   - f. Computer generated 3D models
   - g. Computer generated and rendered 3D models
   - h. Paper/Cardboard models

2. **How familiar are you of Computer generated 3D models**

3. **How familiar are you in making a computer generate 3D model**

4. **How familiar are you with the different uses of computer generated 3D models**

5. **How familiar are you with the process involved in making a Computer generated 3D model**

6. **How familiar are you with the process of making a Computer generated 3D model and rendering it**

7. **What is your opinion on the following:**
   - a. A computer generated 2D drawing can be extruded to generate a 3D model.
   - b. The same computer generated 3D model can be used to view the building from different angles.
   - c. The same computer generated 3D model can be used to produce plans, sections, and elevations.
   - d. The same computer generated 3D model can be used to produce colored renderings.
   - e. The same computer generated 3D model can be used to produce animated walk through.
   - f. The same computer generated 3D model can be inserted into photographs to study it in its context.

8. **How useful do you feel Computer generated 3D models can be in understanding your design better**

9. **At what stage of the design process would you use computer generated 3D models:**
   - a. From conceptual stage
   - b. After conceptual stage before finalizing design
   - c. After finalizing design during presentation

10. **An architect's ability to understand his design will be enhanced if (before the building is actually built):**
    - a. The building can be viewed 3 dimensionally from different angles
    - b. The building can be viewed with its actual colors and textures
    - c. The building can be viewed in its surroundings

---

**Percentage**

<table>
<thead>
<tr>
<th>Percentage</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
</table>

**Group A:**

**Group B:**
1. VIEWING COMPUTER GENERATED 3D MODELS:

Viewing the 3D model as work progresses or a finished 3D model can be very valuable in helping the designer understand his own work and in client presentations. Viewing a computer generated 3D model while creating them can help eliminate many unforeseen results which can occur after a building is built.

A computer generated 3D model can be viewed by several different methods. The first method is the *wire frame* (Figure 3.1, Page 40). The wire frame view is the default three dimensional view of a computer generated 3D model. The 3D model appears as an open object made of wire. The second method is the *hidden line view*. Since the overlapping lines of a wire frame can be visually confusing, the 3D computer model can be viewed as a solid object using the *hidden line view* (Figure 3.2, Page 40). Hidden line removal automatically hides lines that are behind the object. The object in the front, blocks the view of all the objects behind it. After entering the appropriate command, the software can calculate which surfaces obscure others, treating each as opaque, and generate a hidden line view. The third possible method is the *automatic surface shading*. Any surface, as defined by an extruded line or curve, is treated with a solid tone of color, giving the forms the appearance of being solid objects. This is especially important to create photo-realistic renderings (Figure 3.3, Page 41).

Photo Realistic Renderings: Bit mapped or pixel based painting software or rendering programs can be used to capture a three dimensional computer image.
Figure 3.1: Wireframe View

Figure 3.2: Hidden Line View
PROPOSED S.A.L.T. FACILITY
(View Looking Southeast)

Key to Buildings and features:

B. Education  E. Modern Languages  H. Second Street
C. Steward Observatory  F. Administration  I. Main Mall

FIGURE 3.3: 3D Model Rendered in a Paint/Rendering Based Program
The captured image is a similar to a photograph or a painting and cannot be edited any further. None of the CAD editing tools can be used on this image, but the image can be rendered or painted upon, using the painting tools the software supports. CAD 3D models can also be saved as DXF* files and imported into rendering programs. Once the model is imported into the rendering program, the objects which form the building mass can be selected individually and applied with material, textures and colors. Using these tools, it is possible to study and present more combinations of material, color and textures. Choices can be based on accurate simulations of colors as they will actually be seen in context.

* DXF : DXF file is a DOS text file containing all the information needed to reconstruct a drawing. It is often used to exchange drawings created with different programs. Many micro-CAD programs, including some 3D perspective programs, can generate or read files in DXF format. You may want to use a 3D program to view your drawing in a perspective view, or you may just have a consultant who uses a different CAD program that accepts DXF files. There are many 3D rendering programs that read DXF files on both the IBM PC and compatibles and on Apple Macintosh computers.

2. COMPUTER GENERATED 3D MODELS AND THEIR APPLICATION TO ARCHITECTURAL PRACTICE:

Based on the responses to the questionnaire, the conclusive evidence showed that there were three main factors or areas the respondents were interested to learn more about before using Computer Generated 3D models in their design process. Through the following Case Studies, an attempt has been made to explain the three factors by using examples with similar situations.
A. CASE STUDY I:

Computer generated 3D models can be used to quickly study a variety of design solutions and view them from any angle - a quick way to get a good sense of the space you are creating.

13 "In a questionnaire survey conducted in the top twenty one architectural firms in Tucson, 100% of the firms agreed that studying a 3D model from different angles would be very useful since they would be able to visualize the designed space more spontaneously." 13

14 "Computer technology provides tools that allow architects to process and evaluate design through 3D models by manipulating information for reviewing "what if?" scenarios" 14

- PA, August 1993

Project: National Optical Astronomy Observatory - “The Department of Campus and Facility Planning” at “The University of Arizona” was entrusted with the responsibility of studying the feasibility of a new 12,000 Square feet “N.O.A.O” building as part of the “Campus Development Plan”. The proposed building required to three separate blocks connected internally through corridors and a parking garage for 150 cars. The site was located at the busy vehicular and pedestrian intersection of Cherry Avenue and Mabel street. The project was interesting and complex because the designers, in conjunction to studying the visual impact of the proposed building on its surroundings, had to also study the visual impact the proposed building had on an earlier proposed ring road for the same street intersection.
After quick preliminary visual analysis and conceptual design sketches using conventional drawing techniques, the decision to use Computer Generated 3D Model to make further visual studies was decided upon since the project required merging two proposed additions—first, the building itself and secondly, the ring road. The necessity to study, separately and together, the visual impact of the two proposals—the building and the ring road had on its surroundings was important. Creating a 3D computer model was considered as probably the best way to generate accurate views from crucial view points.

15 “3D models have been effective visual representation tools. From the designers’ point of view, the biggest advantage of this computer technology is that it enables them to see and test a designed object in context almost as it were actually built.” 15

-PA, August 1993

The Computer Generated 3D model was created using Method 1, described in Chapter 2. A existing 2D plan (drawn earlier using AutoCAD) was used as a reference plan to generate the 3D model. The section of the campus under study was extracted as a Wblock* from the existing plan. A new drawing then was created by inserting this Wblock. This new drawing consisted of 2D site lines, existing roads and streets, and also the foot prints of the surrounding building.

*Wblock: Saves portions of a file to disk. Generally used to write a block to a file, Wblock can be used to save portions of a drawing.

The next step was to create the 3D model on the existing 2D drawing A schematic plan, with an approximate area of 12,000 square feet was drawn in and then extruded. Since, this was a conceptual study, the 3D model was
generated to meet the basic requirements- a three block structure, with internal connecting corridors. Then each line which represented the existing building plans (mostly residential) was extruded to match their actual height. The parking garage ring road were added. The project could now be visualized in its entirety or from different view points on the 3D model, to study the feasibility of the project (Figure 3.4, 3.5 Pages 46, 47)

16 "We have found that the simple and accessible 3D form making functions of the computer have become an important and irreplaceable tool for our staff, mainly because they allow designers to be more creative and productive” 16

- PA, August 1993

Computer generated 3D models helped uniquely in this project because, the building mass could be analyzed and tested in relation to the existing buildings and the proposed ring road. The building plan could be easily modified to match the designers decisions and these changes were reflected directly on the 3D model. The modified 3D model could be viewed from the same viewpoints used to view earlier model. This helped the designers decide the appropriateness of the size and the height of the building.

The drawing is of the proposed ring road also helped solve problems such as encroachment of the road into private property and in creating more interesting views for the pedestrians on the street. Once, a problem was identified the ring road layout was altered quickly, for further investigation.
Plan View of the N.O.A.O Project Area

View of the N.O.A.O Project Area

Figure 3.4: N.O.A.O From Different View Points
B. CASE STUDY II:

Client presentation: The ability to present to a client a 3D model so that they can better visualize the project. The 3D models make it easier for people who cannot understand 2D plans, elevations etc.,

17 "In a questionnaire survey conducted in the top twenty one firms in Tucson, 58% of the firms agreed that by presenting a 3D model to the client, the client would perceive the designed space better than they would from 2D representations." 17

Project: "Northwest Professional Plaza" - A medical facility for northwest Tucson: Recognizing the growing demand for quality medical offices in the northwest part of Tucson, "The Northwest Medical Associates", commissioned the design and construction of "Northwest Professional Plaza" a state of the art medical facility. The design was 25,000 square feet in area, equally divided on two floors. The site, located on northwest corner of LaCholla and Orange Grove Road, had steep contours, with one end of the site being twelve feet in height from the lowest diagonally opposite corner of the site. The decision to design a the hospital with multi-level entry to suit the site contours, evolved as the design progressed. The schematic design studies were made using two dimensional sketches, perspective sketches and elaborate drawings. Finally, the hospital was designed with four entrances all at different levels. The northeast corner being the highest point had the entrance at 12'-0" above ground level. The northwest corner of the building had the entry at mid level or 6'-0" height above ground level. The third entry to the building, the southwest corner was at 3'-0" height above ground level and the southeast part of the building could be entered at
ground level. The lowest and the highest levels were connected by means of an external stair.

"Besides providing a designer with a new way to create and evaluate design, three dimensional drawings and models can give clients and future users an unprecedented way to evaluate a project before construction." 18

- Mark Lauden Crosely, A.I.A

The design was very functional with the site conditions well utilized. The architect had visualized the project in its entirety, but the design had to be presented to a group of doctors, who would eventually have their office space in the building. After repeated meetings and presentations between the architect and the doctors using two dimensional drawings and a few perspective sketches, the doctors were still uncertain about the accessibility to the lower floor of the building. The multi-level entry concept was not clearly comprehended by the doctors and almost all of them did not accept a office space in the lower floor of the building (Figure 3.6, 3.7 Pages 51, 52).

The architect had tried hard to explain to the doctors, but even through elaborate sketches and perspective views but the doctors could not visualize the building three-dimensionally to understand the relation between the building and its site. The architect finally decide to approach this problem differently. He decided to generate a 3D model of the building using his computer to simulate the site condition and show the building in its actual context. The 3D model of the site and the hospital was created using Method 2 described in Chapter 2 using AutoCAD. A series of sequential three-dimensional views of the computer generated 3D model were created using specific view points around the building
marked on the floor plan which and presented to the doctors. The doctors were thus provided with the opportunity to see what they would actually see when the building was built. The doctors were now able to clearly understand and visualize the designed building.

19 "A spatial model allows you to see as many sides of a form, a building or a city as you want; to see, theoretically, every viewpoint that future users will see. With this ability, there is no real reason for architectural "surprises" to happen." 19

- Mark Lauden Crosely, A.I.A.
C. CASE STUDY III:

Once the design is approved, the Computer generated 3D model can be used to produce floor plans, sections, elevations and construction documents for the construction phase.

"In a questionnaire survey conducted in the top twenty one firms in Tucson, 66% of the firms were either uncertain or not sure of the fact that once a floor plans, elevations and sections can be generated from the same 3D model." 20

Project: "Northwest Professional Plaza": A computer generated 3D model completed model can be used to develop two-dimensional drawings for presentation and construction documents. Any good 3D modeling software creates a two-dimensional data base while producing the 3D model. A project may be designed and documented in a single data file, with the 3D model containing all the information to describe the appearance of a finished building and whenever required the floor plan, section or elevation can be extracted.

Projects in architectural firms are time and cost bound. When design and drawing are integrated it increases productivity, to help reduce the overall time spent on the project, to make it cost effective. Computer generated 3D models integrates design and drawing. Initially, a computer generated 3D model can be used effectively to study the building from the initial stages of the project to help arrive at design decisions. Secondly, it can be used as a tool for presentation to the clients and finally, once created it can be used to extract two-dimensional floor plans, sections, and elevations to generate construction documents.
The above mentioned "Northwest Professional Plaza" medical facility had to be completed in a constrained time frame to suit the investors and clients needs and the architect had to spend more time than he had anticipated in the preliminary stages of the project. But since the architect had created a 3D computer model of the building to help him in his client presentations he had to spend relatively less time on generating two-dimensional floor plans, sections, and elevations. The two-dimensional drawings were extracted from the 3D model and were ready too be dimensioned and annotated. The base drawings for the construction documents were also generated simultaneously from the floor plan and the project was finished well before the estimated time (Figure 3.8, Page 55).

The command sequence or AutoCAD users to generate 2D computer drawings from 3D computer models would be:

1. Use File: Configure to add a PostScript plotter to the configuration list. You can have more than one PostScript configuration if you already have one set up.
2. While configuring the PostScript plotter, set the resolution to 1250 dpi.
3. Save this configuration, by typing in a name.
4. Open the 3D drawing and set up your 3D view, then start the Plot Command
5. Change the plotter configuration to the earlier saved configuration name, in the plot dialogue box. Also check the remove hidden line.
6. Use the Optimization dialog box to avoid overlapping lines.
7. After you have plotted the drawing, open anew file to receive the plot.
8. Use the File: Import: PostScript In: option to import the plot.

The 2D drawing is generated on the screen. This 2D drawing can be edited, annotated and dimensioned to generate construction documents.
Figure 3.8: N.W.P.P. - Plan, Elevation and Section Extracted from 3D Computer Model
Chapter 5

1. CONCLUSIONS

Computer generated 3D models are capable of showing a view of a building in perspective, the way we see real environments with impression of depth, as viewed from a particular position or viewpoint. The unique advantage of a computer designed 3D model is that it places objects into a clear three dimensional relationship with other objects and with the surrounding context constitutes the visual environment or landscape that we could see. Visualizing using computer generated 3D models help us in showing planned projects, planned projects in their future setting and they help us visualize future landscapes.

*Visualizing using computer generated 3D models can be critical because -*

- The very act of preparing preliminary 3D studies using computer generated 3D models such may lead the designer to discover unforeseen design complexities that he or she can then resolve. It is not at all uncommon for project designers to be surprised by the appearance of their own creations. This can be avoided by using the visualization process to communicate with one's self.
- The principal designer can more fully convey the essence of his or her idea to others on the design team.
- The design can be checked for potential aesthetic problems which, unless dealt with early in the process, could later cause harder problems.
- The relative merits of alternative design prototypes can be displayed.
Designers find it necessary to know how to create a computer 3D model themselves in order to incorporate it in their design decision making process. Despite the fact that they consider computer generated 3D models as one of the most important visualizing tool, they have not been able to devote time to learn the process. The time involved in learning how a computer 3D models is created depends mainly on the effort and practice devoted by the individual towards the process. This process has now been greatly reduced by interactive videos and CD Rom disks which accompany the 3D software programs.

The three main concerns (Ref. - Part II, Chapter 3, Page 35) the architects ave in using computer generated 3D models can be greatly reduced by

- Architectural offices must have 3D cad software program promoters to provide in house demonstration of how a 3D model of a building is created by using one of the firms design project as an example. Beginners may find it easier to learn when they are able to relate themselves to a specific project. Also the learning within the office atmosphere can help professionals to learn without inhibition.

- Once a designer is familiar it will be easy for him to decide on the projects that will be benefited by using computer generated 3D models and use them accordingly. All projects may not need visualization studies, but a computer generated 3D model can be significant in assisting conventional methods of drawing. A wire frame 3D model can be used as a reference to generate perspectives for presentation. The same model can be used to generate plans, sections and elevations thus saving valuable time. This would also satisfy the designers need to add humanism (softness of lines) to their drawings.
• The cost involved to set up the office to use 3D models would be nominal. The results of the survey showed that all firms are currently using their computers to generate 2D drawings for their construction document. Most of the time, it is possible that the same CAD program supports 3D modeling as well. But even if it does not, there is a 3D CAD software designed for that machine. The investment would therefore amount to simply buying the software.

• Most respondents from Group A (Ref. - Part I, Page 29, Chapter 3) were not aware that a 2D computer generated 3D drawing can be extruded to generate 3D models (Q.7a) - which is the most important step to be aware of to create a computer generated 3D model. It is necessary to make aware to all design decision making teams in architectural offices of the process of creating computer generated 3D models as they do consider studying buildings three dimensionally important (Q10.a,b,c) to provide a better understanding of their design (Ref. - Part I, Page 29, Chapter 3). This can be achieved probably through creating a committee of computer specialists (with a back ground in Architecture) to organize and conduct seminars on a regular basis providing important up to date information on computers and their application to architectural design process. Regularly published newsletters providing up to date information, tips and tricks, and answering the frequently faced problems by architects while buying and using computers, will be very useful.

• Developing a school curriculum which provides the students hands on experience to design using computers from the preliminary design stage, involving creating and studying computer generated 3D models, would be helpful to make the next generation of architects more familiar and accustomed to computers. This would also probably make computers the pencil of the future.
2. THE FUTURE OF TECHNOLOGY IN ARCHITECTURE:

21 "CAD software, the mainstay of design technology, will offer more facile methods of manipulating 3D models. Voice recognition, pen-based input devices, and expert systems will augment CAD interfaces. A movement toward custom environments will make it possible for designers with diverse working styles and methods to apply CAD. Ultimately, virtual design environments will transform the architect into an artisan who interacts literally with a full-scale computer model, proposing sweeping design changes with a single gesture.

Information about materials and construction will be incorporated into the model database. Solids modeling, available on many platforms, will grow in significance. Architects and clients will experience synthesized spatial proposals with a high degree of realism through computer visualization and stereo viewing technology. Rendering and animation of 3D models will take us into visualization territory, as we apply digital video editing, virtual reality, and interactive presentation techniques. The medium of exchange will be high-resolution video instead of air brushed."

- PA, April 1993
APPENDIX A-I

QUESTIONNAIRE

The following survey is being conducted to assess the awareness of architects on the usefulness of Computer generated 3D models. The survey will aid my Masters project report entitled "Visual Simulation using Computer Generated 3d Models." The survey is being conducted in an anonymous manner. All details are collective in nature. Thank you for your time in assisting with this project.

Please study the Graphics package attached before answering the questionnaire.

1. In the design process, your design conclusions are derived from studies based on

YES NO

a. 2d sketches of plan views O O
b. 2d sketches of plan, section, and elevation O O
c. Perspective sketches O O
d. Perspective views of the building in its surroundings O O
e. Colored perspective sketches O O
f. Computer generated 3d models O O
g. Computer generated and rendered 3d models O O
h. Other ____________________________

Please go back through the categories and mark an X on the line before that one criterion that is most important to you.

2. How familiar are you of Computer generated 3d models:

Very Familiar O O O O O Not at all Familiar

3. How familiar are you in making a computer generate 3D model:

Very Familiar O O O O O Not at all Familiar

4. How familiar are you with the different uses (as shown in the examples) of computer generated 3d models:

Very Familiar O O O O O Not at all Familiar

5. How familiar are you with the process involved in making a Computer generated 3d model:

Very Familiar O O O O O Not at all Familiar

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6. How familiar are you with the process involved in making a Computer generated 3d model and rendering it

Very Familiar       O   O   O   O   O   Not at all Familiar

7. What is your opinion on the following:

a. A computer generated 2d drawing can be extruded to generate a 3d model

O Strongly Agree       O Not Sure       O Strongly Disagree

b. The same computer generated 3d model can be used to view the building from different angles

O Strongly Agree       O Not Sure       O Strongly Disagree

c. The same computer generated 3d model can be used to produce plans, sections, and elevations

O Strongly Agree       O Not Sure       O Strongly Disagree

d. The same computer generated 3d model can be used to produce colored renderings

O Strongly Agree       O Not Sure       O Strongly Disagree

e. The same computer generated 3d model can be used to produce animated walk through

O Strongly Agree       O Not Sure       O Strongly Disagree

f. The same computer generated 3d model can be inserted into photographs to study the building in context

O Strongly Agree       O Not Sure       O Strongly Disagree

8. How useful do you feel Computer generated 3d models can be in understanding your design better

Very Useful       O   O   O   O   O   Not at all Useful
9. At what stage of the design process would you use computer generated 3D models:
   ____ From conceptual stage
   ____ After conceptual stage before finalizing design
   ____ After finalizing design during presentation
   other ________________________________________________________

10. Please provide your opinion on the following:
    An architect’s ability to understand his design will be enhanced if (before the building is actually built):
        a. The building can be viewed 3 dimensionally from different angles simultaneously

            Strongly Agree O O O O O O O Strongly Disagree

            The best way to achieve the above point would be through (Please rate 1, 2, 3 etc.,):
            ____ Sketches
            ____ Painting
            ____ Drafting
            ____ Model Building
            ____ Computer generated 3D Model
            ____ Other
            ____ Other

        b. The building can be viewed with its actual colors and textures

            Strongly Agree O O O O O O O Strongly Disagree

            The best way to achieve the above point would be through (Please rate 1, 2, 3 etc.,):
            ____ Sketches
            ____ Painting
            ____ Drafting
            ____ Model Building
            ____ Computer generated 3D Model
            ____ Other
            ____ Other

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c. The building can be viewed in its surroundings:

Strongly Agree O O O O O O Strongly Disagree

The best way to achieve the above point would be through (Please rate 1, 2, 3 etc.,):

___ Sketches
___ Painting
___ Drafting
___ Making a model
___ Computer generated 3d Model
___ Other
___ Other

11. If you are familiar with the usefulness of Computer generated 3d Models the reason you are not using computer generated 3d models are:

___ Time factor in learning
___ Time factor in making the 3D model
___ Cost factor
___ Lack of technical know how
___ Usefulness in the overall design scheme
___ No client demand
___ Other

Please go back through the categories and mark an X on the line before that one criterion that is most important to you.

12. What do you suggest to solve this problem?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
13. If computer generated 3D models are an important visualization tool which will help you in the design process, would you: (please mark an X on the appropriate answer)

a. Learn how to create the 3D computer model yourself
b. Employ a person who already knows how to do it
c. Train your existing staff
d. Sign up a contract employee to create the 3D model as and when the need arises
e. Other ____________________________
f. None of the Above

14. What will be the greatest advantage of using Computer generated 3d models to you?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

15. What will be the greatest disadvantage of using Computer generated 3d models to you?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
View:
View of the NOAO complex from North east.
E.N.R. Building

The Department of
Campus and Facilities
Planning

University of Arizona
Tucson Arizona
Appendix A-II

List of firms interviewed: The firms mentioned below were determined as "large firms" by the magazine - "Inside Tucson Business" (1994 Annual Issue).

Anderson DeBartolo Pan
2480, N. Arcadia Ave
Tucson, Arizona 85712

Seaver Franks Architects
2552 N. Alvernon
Tucson, Arizona 85712

Architecture One Ltd.
6303 E. Tanque Verde
Tucson, Arizona 85715

Roberts/Dinsmore Associates
450 W. Paseo Redondo, #130
Tucson, Arizona 85701

Burlini/Silberschlag Ltd.
4400 E. Broadway, #400
Tucson, Arizona 85711

James Merry Associates Inc.
8230 E. Broadway, E-10
Tucson, Arizona 85710

Albanese/Brooks/Mackey
2552 N. Alvernon, #A
Tucson, Arizona 85712

Earl Kai Chann Associates Ltd.
3050 N. Country Club
Tucson, Arizona 85716

Harrington & Associates, Architects
2201 N. Camino Principal
Tucson, Arizona 85715

Line & Space
627 E. Speedway
Tucson, Arizona 85705

Swaim Associates Ltd.
3936 E. Ft. Lowell, #202
Tucson, Arizona 85712

NBBJ
620 N. Country Club
Tucson, Arizona 85716

CDG Architects
345 E. Toole, #202
Tucson, Arizona 85701

Burns and Wald-Hopkins
2940 N. Swan
Tucson, Arizona 85712

Barg Meeks Barnes Inc.
1840 E. River, #300
Tucson, Arizona 85718

GLHN Architects & Engineers Inc.
2980 N. Campbell, #130
Tucson, Arizona 85719

Acorn Associates Ltd.
4400 E. Broadway, #505
Tucson, Arizona 85711

The Architecture Company
2625 N. Silverbell Road
Tucson, Arizona 85745

Eglin/Cohen & Dennehy
2921 E. Ft. Lowell, #203
Tucson, Arizona 85716

John R. Kulseth Associates Ltd.
475 S. Stone Ave
Tucson, Arizona 85701

M3 Engineering and Technology
2440 W. Ruthrauff, #170
Tucson, Arizona 85705
Bibliography

Books:

Architects & Firms
Blau, Judith - The MIT Press, Mass., 1984

Computer Applications in Architecture

Creative Imagery

Digital Design Media

Expert Systems
Landsdown, John - Royal Institute of British Architects, London, 1982

Graphic Thinking for Architects and Designers

Mastering AutoCAD
Omura, George - Sybex Inc. California., 1992

Microcomputer Aided Design

Mind Over Media

Mindstorms

Model Based Computer Vision

The Architects Guide to Computer Aided Design
Crosley, Mark Lauden - Van Nostrand Reinhold, New York., 1985

The One Minute CAD Manager
Reker, Dan - Publishers West, Albuquerque, 1991

Visual Simulation

User Manuals:

AutoCAD, Stratavision 3D, Form Z, Macromind Director, Adobe Photoshop, 3D Studio
(The above software application names are registered trademarks of their respective manufacturers.)
Magazine Articles:

"Presentation Software"

"3D Common Market"
Schilling Terrence, Progressive Architecture, November 1992

"One Firms Search for CAD"
Trelstadt M. Julie, Progressive Architecture, June 1992

"CAD Practice and Education"
Neeley Dennis, Progressive Architecture, September 1991
References

1. The Architects Guide to Computer Aided Design
   Crosley, Mark Lauden - Van Nostrand Reinhold, New York., 1985

2. Paul Laseau in conversation with Jason Howard, Graduate Student, University of Arizona, at the "Design Communication Seminar" class, November 1993.

3. Mastering AutoCAD
   Omura, George - Sybex Inc. California., 1992

4. Results of Questionnaire Survey
   Refer Appendix I and Chapter 3.

5. Results of Questionnaire Survey
   Refer Appendix I and Chapter 3.

6. Results of Questionnaire Survey
   Refer Appendix I and Chapter 3.

7. Results of Questionnaire Survey
   Refer Appendix I and Chapter 3.

8. Survey on CAD practice in Architectural Offices
   conducted by A.I.A. (Tucson Chapter). Results were published in July 1994.

9. "Tools of the Stars"
   Barhydt, Matthew - Progressive Architecture., September 1992

10. "3D Common Market"
    Schilling Terrence, Progressive Architecture., November 1992

11. "3D Common Market"
    Schilling, Terrence - Progressive Architecture., November 1992

12. Mastering AutoCAD
    Omura George, Sybex Inc. California., 1992

13. Results of Questionnaire Survey
    Refer Appendix I and Chapter 3.

14. "3D CAD for Urban Design"
    Jackunski, Fester - Progressive Architecture, August 1992

15. "3D CAD for Urban Design"
    Jackunski, Fester - Progressive Architecture, August 1992

16. "3D CAD for Urban Design"
    Jackunski, Fester - Progressive Architecture., August 1992

17. Results of Questionnaire Survey
    Refer Appendix I and Chapter 3.

    Crosley, Mark Lauden - Van Nostrand Reinhold, New York., 1985
   Crosley, Mark Lauden - Van Nostrand Reinhold, New York., 1985

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21. "Integrated Software"
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