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Architectural visualization of a BIM-based model

3D modelling and visualization

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<p>This thesis aimed at introducing the benefits of Building Information Modelling (BIM) technology and at comparing it to Computer Aided Design (CAD). A major aim was to show the importance of architectural visualization and to illustrate how to create architectural visualizations using a three-dimensional (3D) model from a BIM programme. For the thesis, a draft model of a single-family house was created with ArchiCAD, a BIM programme.</p> <p>The final year project described the history and importance of architectural visualizations. In this thesis, the workflow of creating a 3D single-family house model in ArchiCAD and that of the visualizations with a 3D model were explained. For the thesis, ArchiCAD internal renderer, Lumion and 3Ds Max were used to create visualizations of the single-family house model.</p> <p>As a result, several architectural visualizations of a building model were created. It was established that BIM technology sped up the process of architectural visualization, removed the need for designers to spend time on remodeling, and improved the accuracy of visualizations. The thesis described the usefulness of BIM and the superiority of BIM compared to CAD in architectural visualization processes. In addition, the thesis introduced some visualization software and reviewed each visualization software by evaluating the rendering time and quality of the final products of them. The evaluation of the visualization software offers an insight of each visualization software.</p>	
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1 Introduction

Building Information Modelling (BIM) technology is widely used in Architectural, Engineering and Construction (AEC) industries nowadays. Unlike drawings made with Computer Aided Design (CAD) programmes, BIM technology makes it possible to create accurate digital models of buildings which can be interoperated in several AEC companies that use BIM programmes. Because of its various benefits, BIM has become one of the most important and promising technologies in the AEC industries. [1.]

One of the greatest benefits of BIM technology is that visualizations can be created from the building model in any phase of the project. Today, three-dimensional (3D) visualizations have an important role in almost every project since they make the concept understandable to people who would find a presentation based on traditional two-dimensional (2D) drawings difficult to understand. However, architectural visualizations have been considered expensive to create and their creation a difficult process to learn. Thanks to 3D BIM technology, designers, architects and engineers can now design buildings in a BIM programme and get realistic 3D visualizations using the 3D model without the need to master the whole traditional course of architectural visualization. [2.]

ArchiCAD is the leading BIM software programme of Graphisoft. ArchiCAD is used by AEC companies to design, create documents and cooperate on building projects. [3.] ArchiCAD is also used to create a 3D BIM model in this thesis. For the thesis, architectural visualizations from the BIM model are created with four programmes: ArchiCAD internal renderer, Cinerender, Lumion and 3Ds Max. Each visualization software is then reviewed by evaluating the rendering time and the quality of the final product.

The purpose of this thesis is to introduce BIM technology and explain why it is better than CAD, discuss the importance of architectural visualization, explain the workflow of creating a BIM model with ArchiCAD and, lastly, to create architectural visualizations from the 3D BIM model. The thesis aims at emphasising the importance of BIM technology and visualization in construction projects and showing the usefulness of BIM models for architectural visualization. In its four chapters, the thesis first introduces the BIM technology and also defines what is not BIM. Second, the history of architectural visualization is described and the importance of architectural visualization is discussed. In the following chapter, the workflow of creating a single-family house model using ArchiCAD and the creation of architectural visualization of the model are described.

2 Building Information Modelling

BIM technology has introduced a new approach to the field of construction and maintenance. [1.] To begin with, a definition of BIM technology and its benefits to construction projects are given. Then, major BIM programmes are introduced. Throughout the thesis, the term “BIM” is used to describe both an activity (building information modelling) and an object (a building information model).

2.1 What Is BIM

BIM is a new technology that enables users to create one or more precise 3D visualized digital models of a building. These digital models support the design in all phases of projects because they enable better analysis and management. The computer-generated model of a building, including accurate geometry and data needed for construction, fabrication and procurement activities, offers a better understanding of the building. BIM is not only about creating a 3D model, it also puts data in focus. [1.]

One of the most significant changes that BIM brings to construction projects is that when a 3D BIM model is designed, the digital file of a building model can be shared and cooperated on by other parties in a project. Traditionally, communication in construction projects has been based on paper drawings. Errors and omissions in drawings would initially go unchecked, and fixing them would increase costs and delay projects. These problems continued even after the implementation of 3D CAD design tools until BIM technology was introduced because BIM eliminated the need to use paper or digital drawings. [1.]

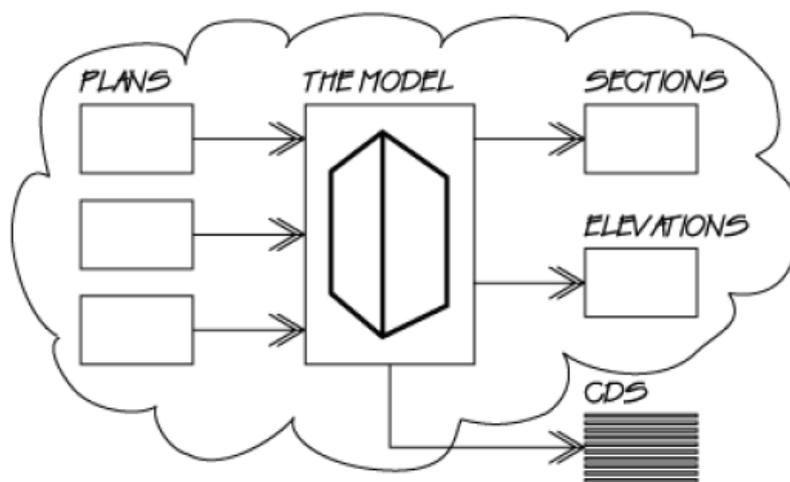


Figure 1. Traditional CAD (computer aided design) process. [5.]

To understand BIM better, it is good to check out the difference between BIM and a traditional CAD process. CAD programmes generate digital files and the final products are plotted drawings as a requirement to exchange information between different stakeholders. After the plans are designed, sections and elevation can be created, as shown in figure 1. Afterwards, Construction Documents (CDs) can be published. When changes are made in one drawing, other drawings must be updated manually. [5.]

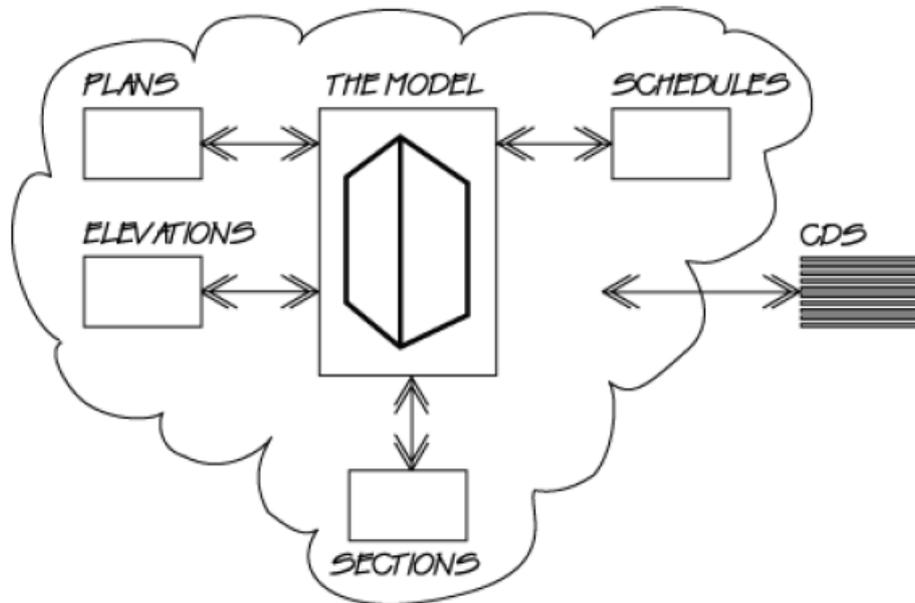


Figure 2. BIM design process. [5.]

On the other hand, a 3D model with associated data is the basis of building drawings in BIM, as shown in figure 2 above. All the plans, elevations and sections, along with building element information, can be automatically generated and retrieved from the model. In addition, every change made in one view is updated accordingly in every other view without the need of manual correction, as the documents are interlinked with the model. Ultimately, the process saves a lot of time and reduces the total costs of a construction project by reducing errors. [5.]

2.1.1 Main Objectives of BIM

BIM technology is becoming more widely used in the construction industry and it is constantly being developed further. Because of the novelty of BIM, the concept and goals of the technology can be unfamiliar to the parties involved. To create a Building Information

Model that is sufficient for all the needs of a project, objectives and priorities should be specified for the model and its application. [4.]

In Finland, due to the growing use of BIM, companies and organizations decided to develop a common rule set for the use of BIM technologies. Common BIM Requirements 2012 (COBIM) is the result of the development project of these companies and organizations in the Finnish construction industry. COBIM was published as a guideline for designers working with BIM. [4.]

The following are the main objectives of BIM stated in the 'Common BIM requirements 2012' [4.]:

- To give support for the project's decision-making processes.
 - To have the parties commit to the project objectives by means of using the building information model.
 - To visualize design solutions.
 - To assist in design and in the coordination of designs
 - To increase and secure the quality of the building process and the final product.
 - To make the processes during construction more effective.
 - To improve safety during construction and throughout the building's lifecycle.
 - To support the cost and lifecycle analyses of the project.
 - To support the transfer of project data into data management during operation.
- [4.]

2.1.2 What Is Not BIM Technology

The utilization of BIM is gradually increasing in construction industry. The term BIM is generally used by construction project participants. From time to time, the definition of what BIM technology stands for is misinterpreted and confused by people with incorrect information about BIM. To solve this kind of confusion and misleading information, it is helpful to check out modelling solutions that do not apply BIM technology. [1.]

The BIM handbook is a BIM guide book that provides in-depth understanding of BIM technology. The book describes the ways to utilize BIM for design, construction and operation of buildings. The BIM handbook gives information about the designs that do not

apply BIM technology. The followings are types of models that do not apply BIM technology [1.]:

- Models that contain only 3D data without object attributes.
 - These are models that can be merely used for 3D visualization. A 3D model creates good visualization. But, due to the lack of object information, it is not possible to create design analysis and to support data integration. For example, a Sketch up application is extraordinary for fast building plan designs, but it is not possible to get any analytics because the design does not contain other object information than geometry and image for visualization, as shown in figure 3.

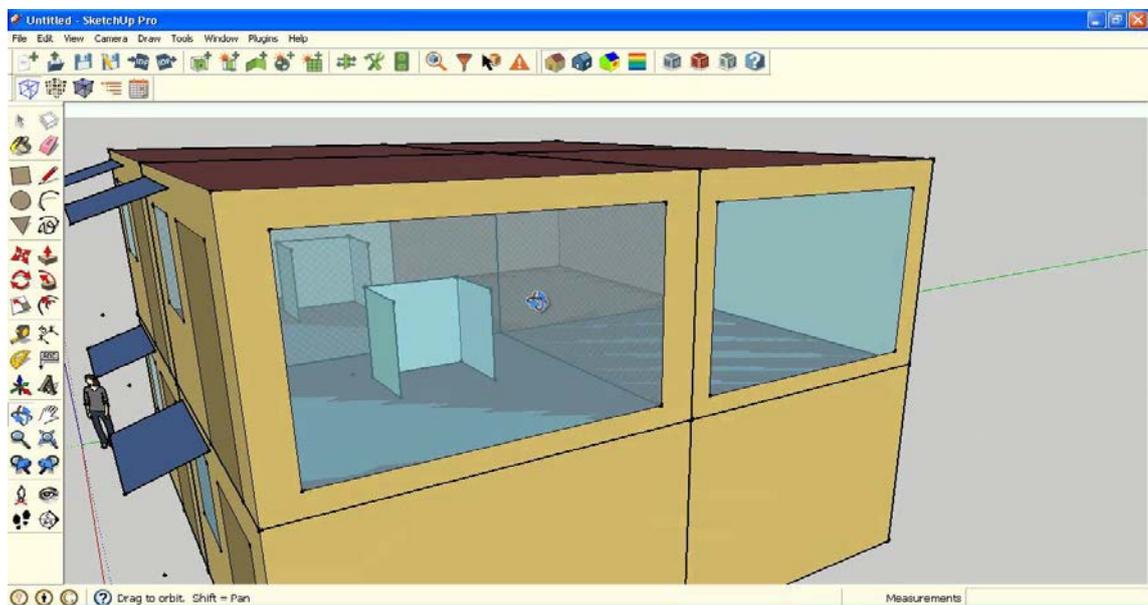


Figure 3. Sketchup interface.

- Models that are unable to move object positions.
 - The models have intelligence of objects but cannot change the position or proportion of the objects since they do not utilize a parametric system. This kind of modelling can easily lead to creating inaccurate views of model.
- Models that absolutely require 2D CAD reference files attached to define the building.
 - These are models that do not give any guarantees that a 3D model would be practical and accurate.

- Models with no automatic system that reflects the changes in dimensions from one view to any other.
 - This type of a model makes it harder to find errors in the model. [1.]

2.2 BIM Benefits

BIM is developed to support and improve the current business practices in the AEC industry. Even though BIM technology is at its early days of use, remarkable improvements have been made in practical aspects compared to CAD and traditional paper-based practices. BIM is a significant solution to the current business practices, where complex solutions need to be produced faster than ever before. Especially, BIM is at an important position to respond to the increasing pressure on construction projects. BIM can handle the increasing pressure of complexity and fast development and it can help to reduce the cost of a building, as shown in figure 4. [1.]

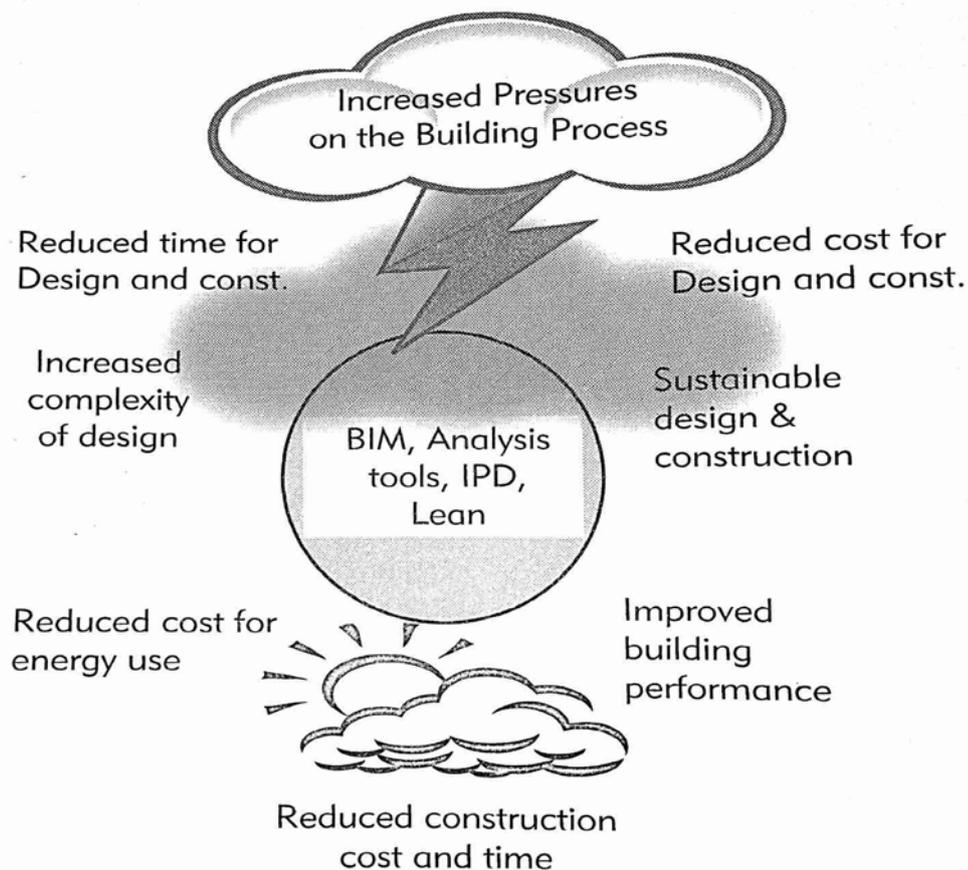


Figure 4. BIM technology and associated process that resolves increasing pressure on construction projects. [1.]

Figure 4 above illustrates the areas where BIM technology and its process can resolve the increasing pressure on construction projects. With traditional practices, it would be impossible to handle these pressures. The following sections explain how this advantage of BIM technology and its process can be accomplished. [1.]

2.2.1 Preconstruction Benefits

The one who gets the most benefits of the preconstruction stage is the owner. When an owner chooses an architect, the owner's greatest concern would be whether a building they desire can be built with the given cost in the given time. If the building can be built to satisfy the financial requirements of the owner, the owner can continue with the hope that they can get what they desire. However, there is a risk that the project might exceed the budget. With BIM technology, it is possible to have a draft building model which can be used to create cost estimations, reducing the risk of exceeding the budget. [1.]

2.2.2 Design Benefits

One of the greatest benefits that BIM can bring is the 3D visualization of both the project and the embedded information. A 3D model that is created with BIM is more precise than a model that is generated from 2D plans. A dimensionally correct 3D model can be used for visualization at any stage, even at the early stages of the process. [1.]

The creation of a building model with BIM technology is based on parametric rules, which make sure that the model is dimensionally correct. This ensures that the 3D model has less geometrical and alignment errors. When changes are made to the model, there is no need for designers to check if the alignment in every view is correct. In addition, accurate drawings can be created from any view or of any specific object in the model. Compared to traditional CAD drawing technology, this reduces the amount of time and number of errors significantly by updating changes in every view automatically, as shown in figure 5 below. [1.]

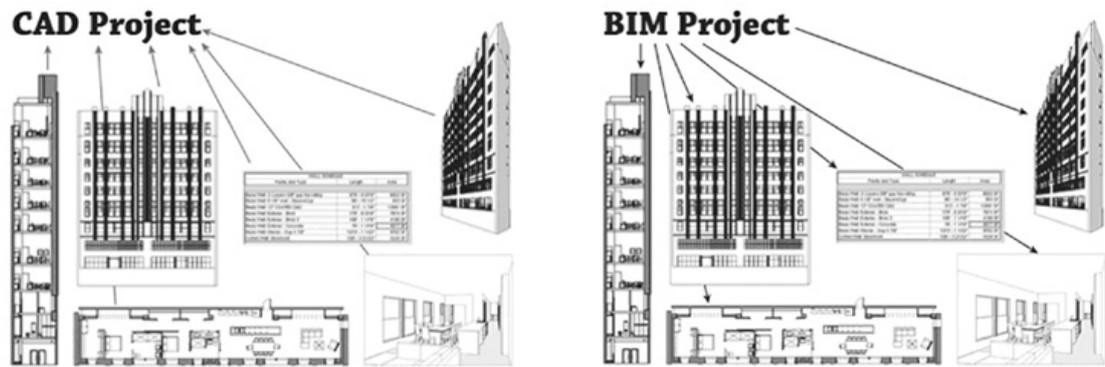


Figure 5. Difference between CAD and BIM projects.

BIM technology supports collaboration with other design programmes within the various fields of the AEC industry. When it comes to the exchange of information and management of changes and updates, it is better to collaborate using 3D models rather than sharing drawings. This way, design errors can be detected at an early stage of a project. A 3D model gives an insight to design problems in advance so that designs can be improved. This kind of early stage collaboration is very effective in terms of time and quality of design, as shown in figure 6. Also, engineering designs can be applied in advance rather than only after the decisions of major designs are made. [1.]

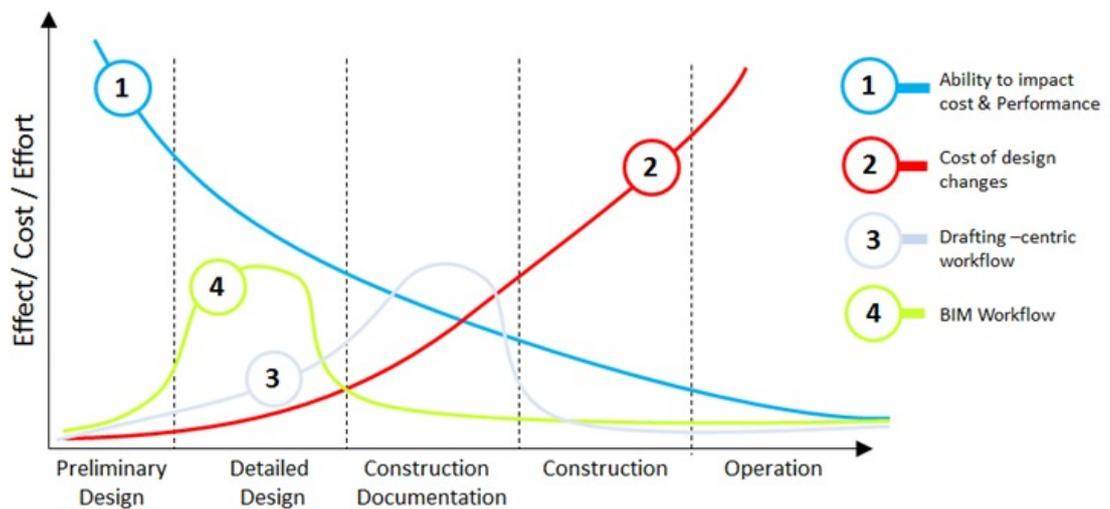


Figure 6. How BIM workflow helps in design.

BIM supports quantity calculations at every design stage, enabling early and precise cost estimations. Cost estimations can be made automatically and easily. Especially, at the early stages of a project, it is truly beneficial to have bills of quantities and space calculations. As a project progresses, these bills of quantities get more detailed and give more

precise cost estimations. In conclusion, BIM provides a building model that contains useful information of the design and its cost estimation in the design phase. [1.]

After the design phase of a project, BIM models from all disciplines can be gathered and compared to find design errors both systematically, using clash detection, and visually. Design errors and conflicts can be detected before they are found in the construction site, saving considerable amount of time and money. Designers and construction contractors cooperate better in this way, and the construction process is accelerated and the work flow gets smoother for the project teams. [1.]

BIM models can be linked to energy analysis tools. In addition, some BIM programmes contain built-in energy analysis tools. For example, ArchiCAD has Ecodesigner for energy analysis. Others have add-ons or link to export BIM data for energy analysis. This provides the opportunity to make energy performance calculations in every phase, not only at the end of the design phase, and consequently, makes it possible to modify the design to enhance energy performance of buildings and make them more sustainable. [1.]

2.2.3 Construction and Fabrication Benefits

BIM models can be transferred to fabrication machines using CNC data, imbedded in the BIM model. Thus, building components for fabrication can be automatically counted from the model. Currently, it has become a common practice in steel and wooden element fabrication to use this method. This makes offsite fabrication easier. In addition, more precise and faster off site fabrication reduces costs and construction time. Costs are further reduced by having less labour on-site, by using less time for installation of properly fabricated elements, and by using less on-site storage space. [1.]

When the design has to be modified at the pre-construction or construction stage, the use of BIM allows the changes to be shown in the building model and updates the changes in other objects without any extra effort. If there are some clashes in the model due to the changes, those clashes would be checked in the visualization or through clash detection. Modifications in BIM can be done very quickly compared to a paper-based system since they can be estimated, shared, visualized, and solved simultaneously. [1.]

Construction planning can be visualized with BIM technology. BIM can simulate a construction process through 3D visualization. The visualization shows how the building will be built, day-by-day. A 3D visualized construction simulation gives an insight to, and for example, the potential problems and possible improvements for the site, equipment, space conflicts. [1.]

After completing a building model, it is possible to get the bills of quantities of elements and materials that are used in the design. These documents with quantities, specifications and properties can be used to procure products. Today, several manufactured products, like doors and windows, are defined and registered in BIM object libraries by the manufacturers themselves. These objects have accurate information imbedded, making the procurement process even more precise. However, there are still many manufacturers that have not developed their object library, forcing designers to use generic objects. Once the BIM object libraries are more developed, and designers can make building models using manufacturer libraries, bills of quantities and cost estimations will be a hundred percent accurate. [1.]

2.2.4 Post Construction Benefits

In a construction process, the main contractor and Mechanical, Electrical and Plumbing (MEP) contractors gather information about the building elements that are installed, and about the maintenance of the systems. This information is applied to the building model, and the information can then be handed over to the owner. It is also possible to check if all the systems in the building work as they are designed to. [1.]

The building model contains information of all systems installed in the building. Any type of analysis that is used to choose the most suitable system for the building can be given to the owner so that the owner knows how the new system can improve the functionality of the building. This information can be utilized after the building is completed as well, for checking whether all systems work properly. [1.]

A building model with accurate information about the spaces and systems in the building provides a helpful basis for managing and operating the building. BIM supports monitoring real-time control systems and remote operation management of facilities. Many of the capabilities are still being developed, but facility management with BIM has tremendous potential. [1.]

2.3 BIM Software

BIM software can be divided into two fields of design, architectural software and software used by engineers. The programmes differ in the way they are used and what they are used for. For the scope of this thesis, the architectural software is looked into in more detail, and the engineering software is just listed for readers who want to know which programmes are more widely used.

ArchiCAD

ArchiCAD is one of the leading Building Information Modelling solutions for architects, designers, engineers and constructors. From the beginning of the ArchiCAD for over 30 years ago, ArchiCAD has developed with the BIM technology. [3.]

ArchiCAD was developed in 1982 by the Hungarian company Graphisoft. ArchiCAD is renown as the first CAD software that enabled a creation of both 2D and 3D geometry on a personal computer. ArchiCAD was also the first commercial BIM software for a personal computer. ArchiCAD has been considered revolutionary for its capability to store large amounts of information in 3D objects. [7.]

Revit

Revit is a well-known and popular programme for BIM in architectural design. Revit was introduced by Autodesk in 2002 after Autodesk purchased the Revit Technology Corporation. Autodesk has released several versions of Revit since 2004, such as Revit Structure, Revit Architecture and Revit MEP. Since Revit 2013, these disciplines were merged together into one product, called Revit. [15.]

Bentley Systems

Bentley Systems is a software development company that offers a wide range of products and services for the design, construction and operation of infrastructure. Bentley is a significant player in the civil engineering and infrastructure market. [16.]

Tekla Structures

Tekla Structures is offered by Trimble (formerly by Tekla Corporation, a Finnish company founded in 1966). Tekla Structures is a BIM software that allows the user to model structures that include different types of building materials, including steel and concrete. Tekla Structures was developed for structural drafters and engineers to design a building structure and its elements. The users design structures with 3D modelling, create 2D drawings and access building information. Tekla Structures was formerly known as Xsteel. [17.]

3 Architectural Visualization and Its Importance

Architectural visualization is the language between a client and designer. With the help of architectural visualization, a client can get better understanding and insight of the architect's work. This chapter discusses the history of architectural visualization and its importance.

3.1 History of Architectural Visualization

Throughout history, architects and designers have shown their ideas and concepts using architectural visualization for better communication with clients and users. As technology has evolved, architectural visualization techniques have been gradually improved to achieve more accurate and realistic presentations. [18.]

The history of architectural visualization started with hand-drawn images. Before the invention of perspective, the subjects of drawings were expressed with height and width but not in depth. To achieve a more realistic visualization with accurate proportions and geometry, the perspective rule was developed. The invention of perspective brought architects and designers a chance to express the physical world on a two-dimensional medium with accurate proportions, scale and perspective, as shown in figure 7 below. [18.]



Figure 7. The Perspective of olio su pannello by Piero della Francesca. [18.]

The development of computer technology has changed the field of architectural visualization. Thanks to the application of CAD programmes, architects and designers have started to present their designs with the aid of computers. As computer databases developed from a two-dimensional to a three-dimensional medium, users could observe three-dimensional models with different angles of views and location. Today, this interactivity has made it possible to create computer animations and virtual reality. [18.]

The development of computer aided drafting and 3D modelling has changed the way architects visualize their design. Computers have sped up the process of making accurate 3D pictures and it is becoming less common for designers to draw by hand. Today, the BIM technology, discussed earlier, has made it possible for designers to design 3D building models that contain all the information needed for a construction project and utilize the 3D building model as a base for visualization purposes. [18.]

Computer aided visualization has made it possible to create photo-realistic renders of buildings, helping customers to get a more immersive feel for the designs at hand. The process of computer aided visualization is being taken to a new level with the advent of interactive visualization and animation technology. Architectural visualization is becoming hyper-realistic and more accurate in detail day by day. [18.]

3.2 Why Architectural Visualization Is Important

Architectural visualization is used for better communication between designers and clients. Through this communication, designers can suggest different design options and make the process of decision making easier for their clients. Better communication with the client helps the designers to develop designs in a faster way. For clients and users who find it difficult to understand professional drawings, like floor plans, sections and elevations, architectural visualization can be helpful to envision the designed space. [18.]

In projects where clients have little to no say during the design phase, visualization can be helpful in a more economical way. Architectural visualizations help designers and architects sell their designs. Realistic architectural visualizations help would-be customers to see what the final product looks like. These visualizations are crucial in building an emotional connection between customers and designs at hand. [18.]

Architectural visualization can help designers find design errors. Architects and designers can use 3D models for a visual inspection of building elements. This visual inspection helps architects detect design errors that would be harder to detect in 2D drawings. Best example of these are load bearing walls and columns that to this day tend not to overlap from story to story. This kind of a mistake is very easy to see in 3D visualization. [18.]

3.3 Interactive Visualization

With the development of BIM and 3D modelling, architectural visualization is developed further and in more interactive ways. The world of architectural visualization is changed from 3D render images to Virtual walkthrough. Virtual walkthrough is a simulation of a designed space with the help of computer software. The virtual walkthrough offers interactivity and physical immersion in the virtual world. [18.]

BIMx from Graphisoft is a software tool to interactively present a 3D model and 2D documentation of building information models created with ArchiCAD. Clients and project participants can virtually walk through the design and make measurements in the 3D model. BIMx also contains a real-time cutaway function that helps the user to detect the details of the 3D building model. BIMx is a free software that can run on computers and smartphones. [19.]



Figure 8. BIMx interface.

2D construction documents can be retrieved straight from the 3D model views to check more detailed information about the building, as shown in figure 8 above. These capabilities of BIMx enable construction project participants to exchange BIM information easily. Furthermore, the exchange of information is even possible using mobile phones and tablets on-site. It is truly beneficial that architectural visualization along with technical drawings can be delivered to mobile devices. [19.]

4 Workflow of 3D Modeling in ArchiCAD

In this section, the workflow of 3D modeling in ArchiCAD is explained. The main purpose of this thesis is to create visualizations with a 3D BIM model. Therefore, only the main tools that are used to create a 3D model are described in the section. For this thesis, a draft design was done for a single-family house. The house has two storeys, a kitchen, sauna and six rooms. The draft design is not meant to be completed.

Before turning on the programme, even though the design of the building is a draft, the design requires some reference designs to identify the design goals in a clear way. The

main material for the design is concrete and wood. Research of wood and concrete buildings was done and a mood board for the design was created in the final year project, as shown in figure 9.

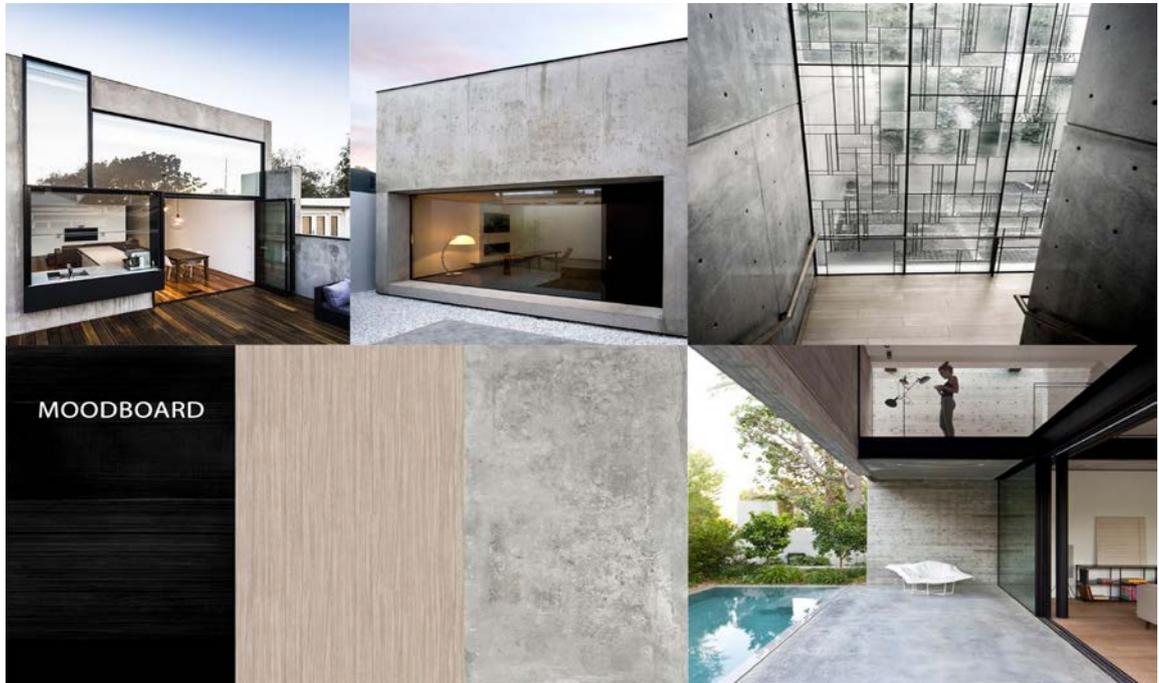


Figure 9. Moodboard for design of the single-family house.

Creating a mood board is very helpful to kick-start a design. It provides more ideas about the design to the designer. Also, the client can have a clearer view of what the building would look like after the project is done.

4.1 Beginning the Project

To begin with, when ArchiCAD is launched, a new project can be created or an existing project opened, as shown in figure 10. Each project sets a starting template or uses the latest project settings. It is recommended to have a favorite template for every project. The templates can contain a lot of information like project preferences, layouts and layer settings. Once the template is created with this information, there is no need to input the information again in the beginning of a new project. Therefore, it is a common practice for companies to have their own templates. For this project, ArchiCAD 20 template is set as the starting template.

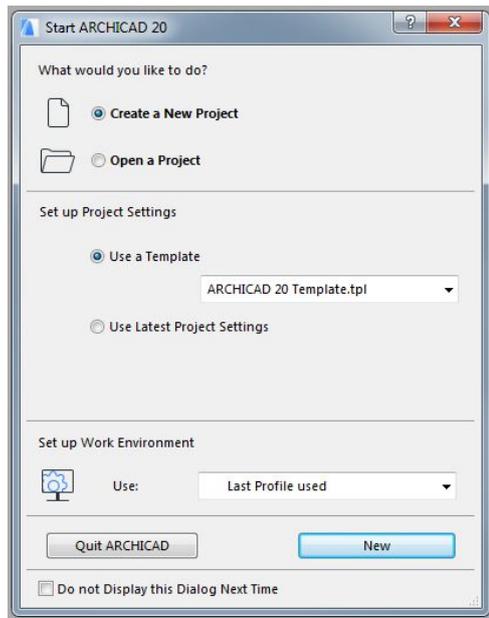


Figure 10. Starting dialog box of ArchiCAD.

Once a new project is created, the first thing to be checked is the project preferences. The project preferences contain the basic information for a project, like working units, dimension setting, and project location, as show in figure 11.

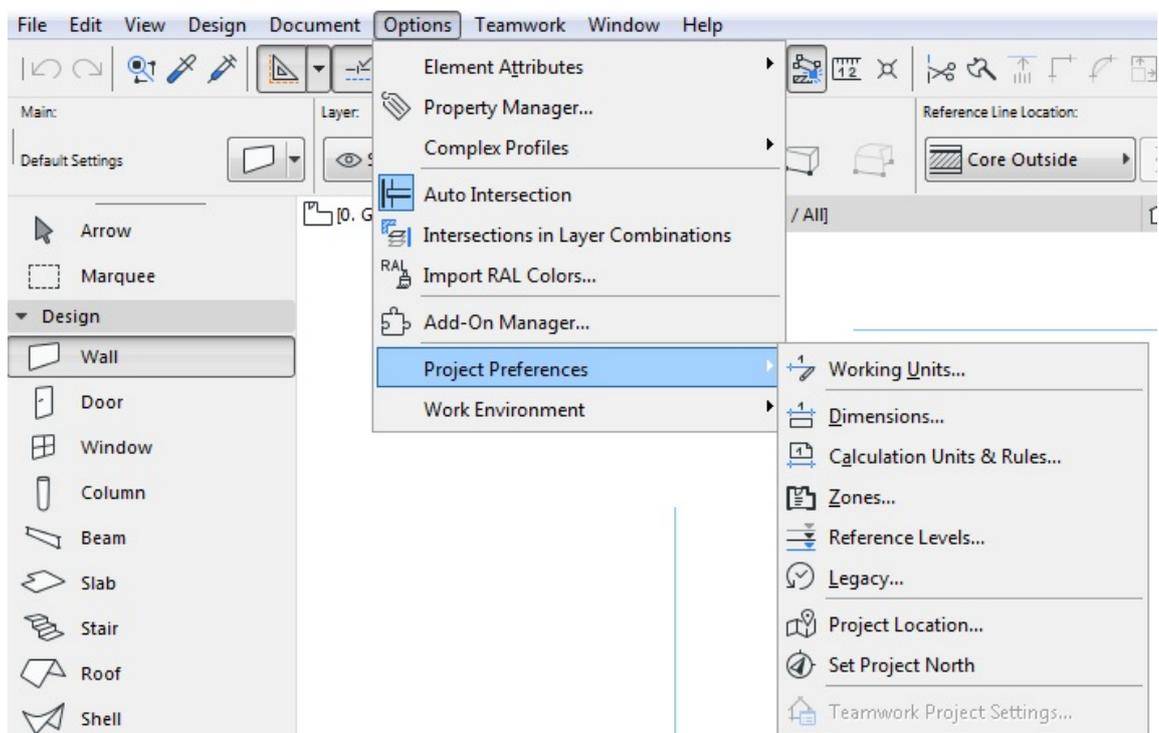


Figure 11. Project preferences settings in ArchiCAD.

After the project preferences are set, the last thing to be checked before starting to create the model is the story settings. Story settings can be opened from a project map in a pop up navigator in the upper right-hand corner of the ArchiCAD interface, or by pressing a keyboard shortcut (Ctrl+7 or cmd+7). The sample building for this thesis contains four stories: a basement, first and second floor, and a roof, as shown as figure 12. Roof is usually not a storey, but, in ArchiCAD, it is common for a roof to be placed at zero level of roof storey.

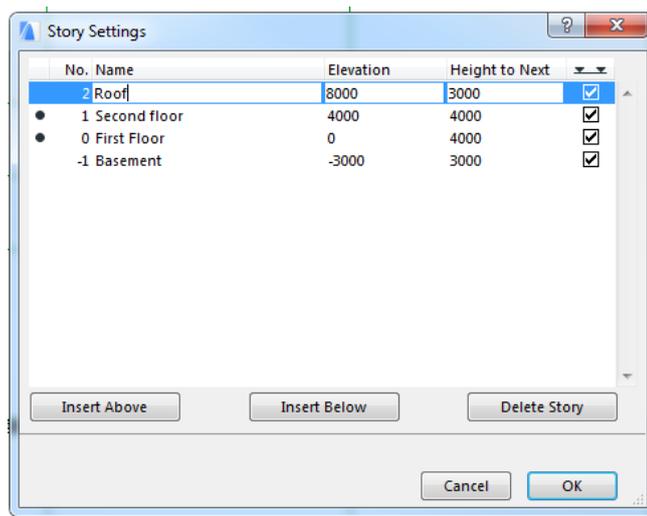


Figure 12. Story settings dialog box in ArchiCAD.

For more detailed information of the project, more project settings can be checked, for example, layer settings or composite settings, because design of the sample building is at draft stage, only a few settings are checked in advance of building modelling.

4.2 3D Modelling

To create design in ArchiCAD, appropriate modelling tools should be used for each building element. Each tool has its own settings and corresponding data definition. For each modelling tool in ArchiCAD, for example the wall tool, there are numerous options to define the wall with. The main tool palette is located on the left in the main interface by default. There are several tools to create the building model and construction documents with as shown in figure 13.

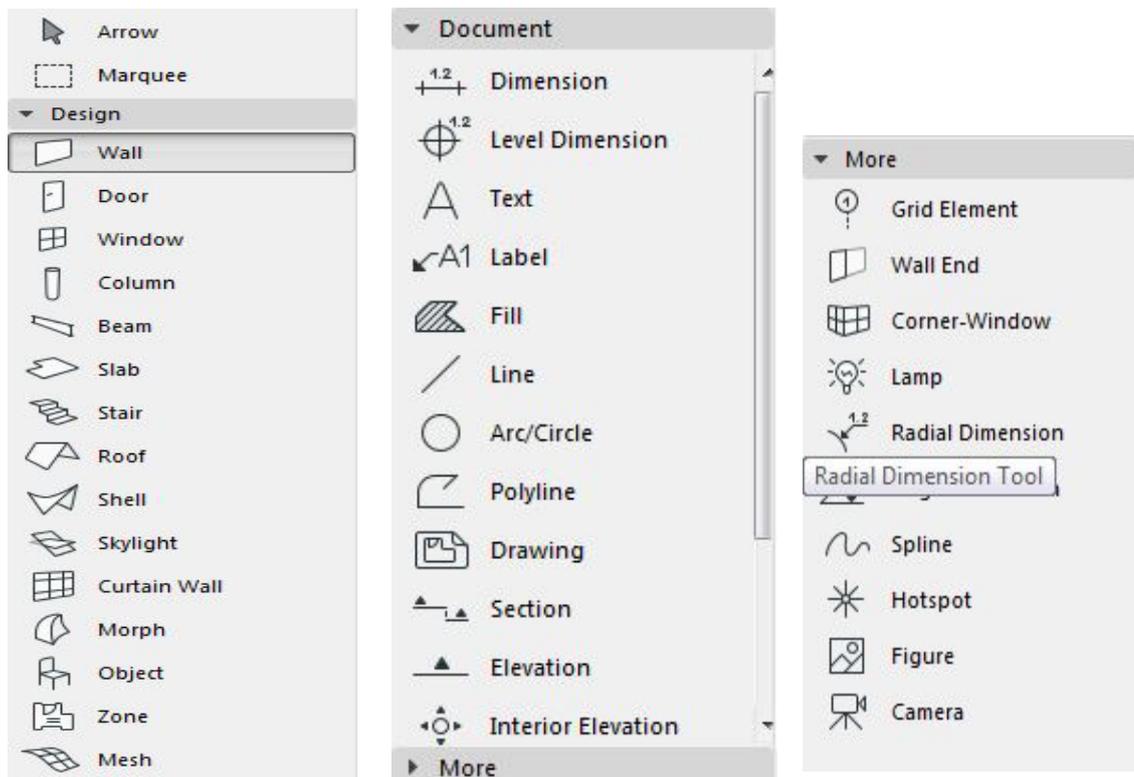


Figure 13. ArchiCAD tool palette.

By double clicking a desired tool, the tool setting is opened and correct information about the tool is input. In the tool palette, there are selection tools, design tools, document tools and other tools. The design tools are most commonly used to start the design of a building.

The design of the single-family house for the thesis started with defining the walls for the building. There were two types of walls. One type is an exterior structural load-bearing wall and the other type is an interior wall. The walls are shown in figure 10. The exterior walls are concrete walls with insulation and an air cavity. The thickness of these walls is 315 mm. The exterior walls are overridden with a concrete surface material. The layer for these walls in ArchiCAD is the Structural Bearing layer. The interior walls are gypsum plasterboard walls. The thickness of the interior walls is 120 mm. The layer of the interior walls in ArchiCAD is the Interior-Partition layer. The height of the walls is 4000 mm, defined by story settings, which were defined earlier. As shown in figure 14 below, in wall settings, the building materials, the geometry of the walls, the layers, and the surface overrides are defined.

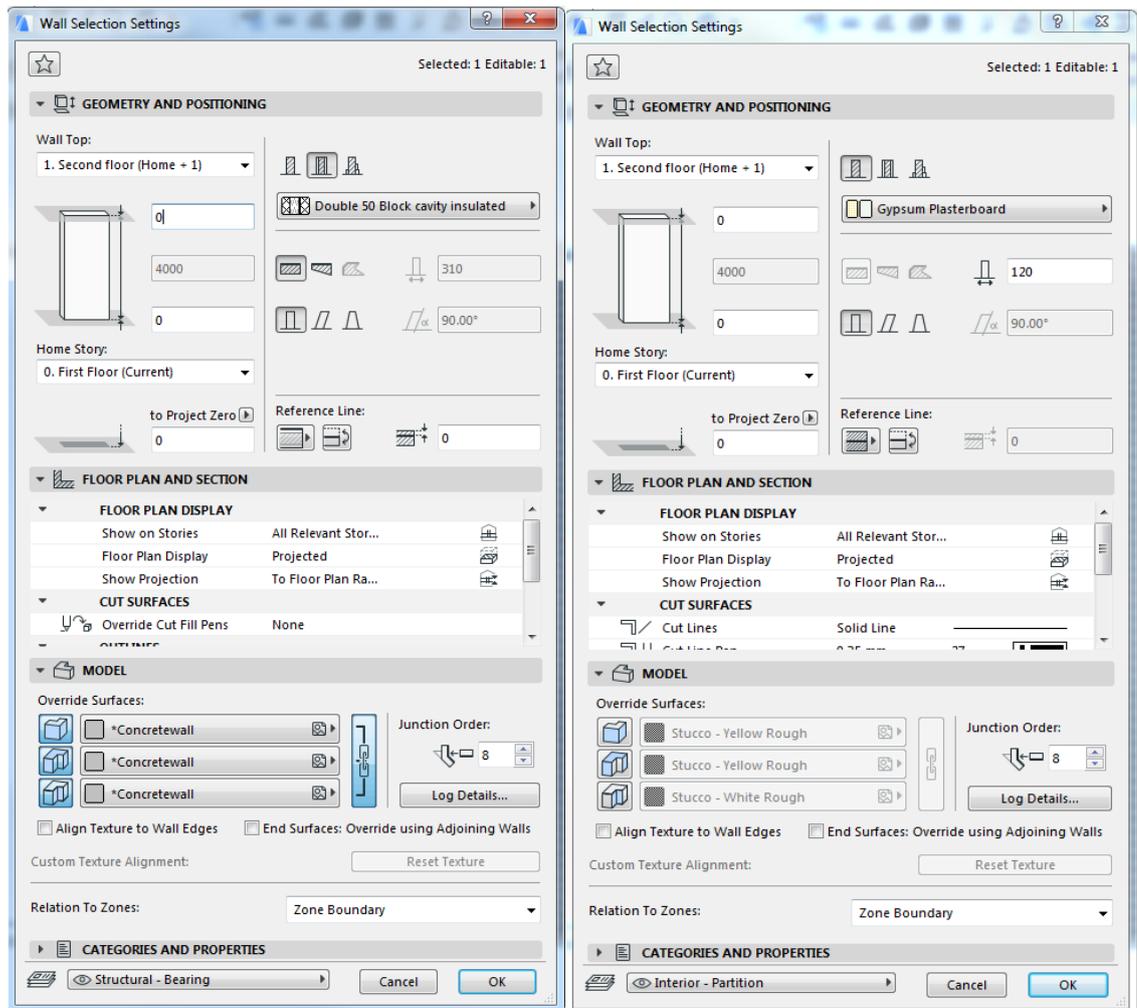


Figure 14. ArchiCAD wall settings for the exterior walls (left) and the interior walls (right) for the sample house.

After the walls are created and the spaces of the building are defined, doors and windows can be placed on the walls. The door and window models are chosen from the ArchiCAD 20 object library a built-in library of ArchiCAD. There are some manufacturing companies on the market with their own door and window object libraries for ArchiCAD. These libraries can be found online (e.g. BIMcomponents.com, BIMobjects.com) or by asking the manufacturers directly in some cases.

There are two types of doors in the single-family house model drafted for the thesis. One is an exterior glass door and the other is an interior door, as shown in figure 15. The size of the exterior glass door is 1500 mm x 2400 mm (width x height). The door has a metal frame and the door leaves are of glass. The surfaces of the door frames are overridden with ivory black paint. The exterior door is placed in the main entrance of the building. The interior doors are wooden doors 900 mm wide and 2100 mm high. The surfaces are painted white. The doors are placed for each room in the building.

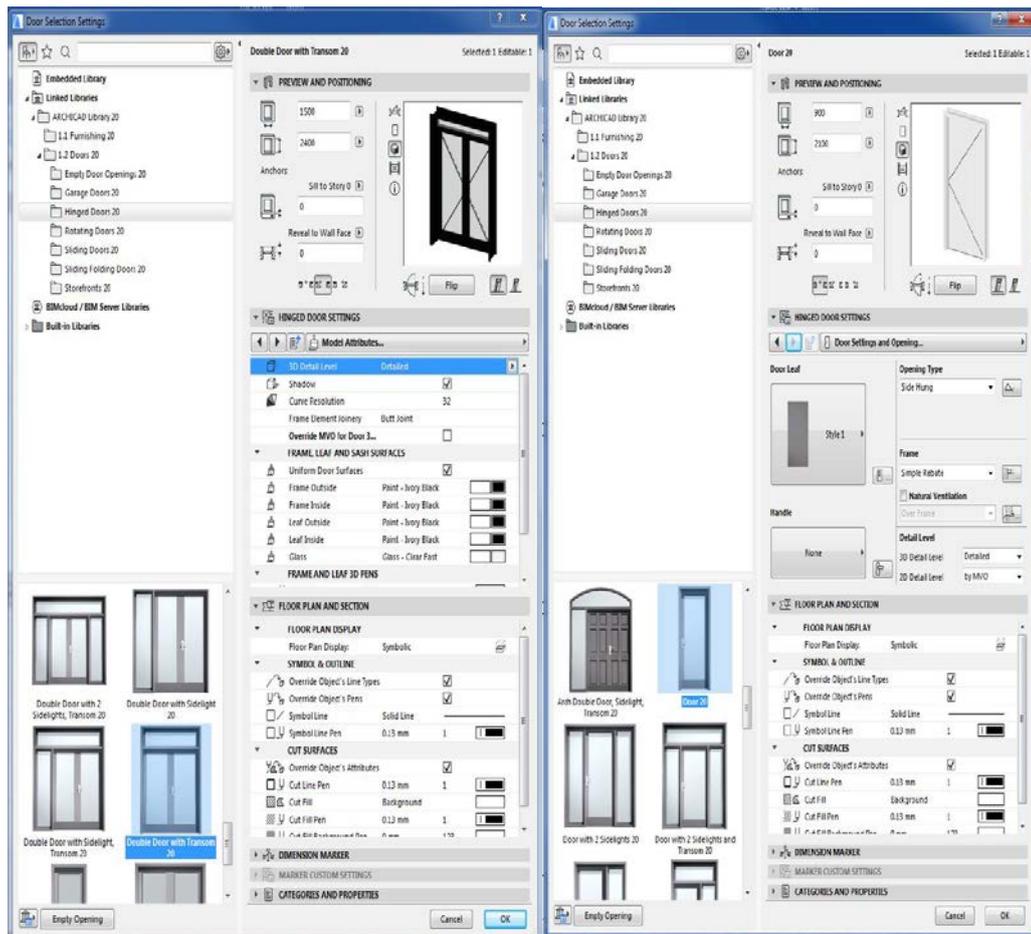


Figure 15. ArchiCAD door settings for the exterior door (left) and the interior door (right) for the sample house.

Each room has windows. A storefront window from the window library of ArchiCAD was used. The size of the windows depends on the room type. The frame is painted with black paint.

The next step is to create slabs and the roof for the building. The building material for the slabs is concrete, the same as the exterior walls, and the top surface of the slabs is wood. The thickness of the slabs is 250 mm. The roof settings are similar to the slab settings, as shown in figure 16. The difference between the roof and a slab is that the roof can have pitch angles. A flat roof can also be created in ArchiCAD by defining a zero-degree pitch angle. A flat roof is used for the sample building. The thickness of the roof is 300 mm.

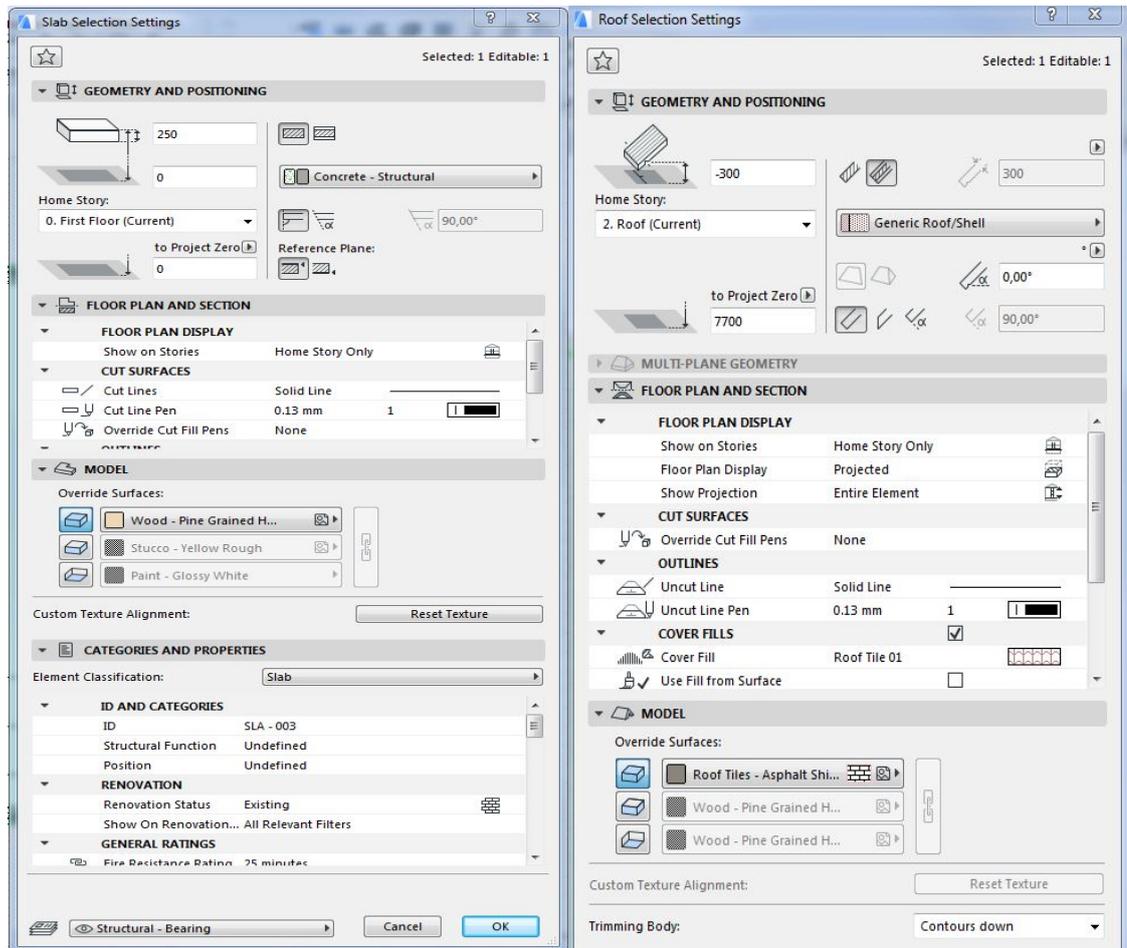


Figure 16. Slab (Left) and roof (right) settings for the draft house.

After the slabs and the roof are created, the eventual holes to fit stairs, shaft, elevators and so on are created. To create a hole in an existing slab or a roof, the slab or roof is selected and the correct tool in the tool palette is activated. A new slab or roof is drawn on top of the selected slab or roof. This tells ArchiCAD to create an opening in the pre-selected slab or roof.

To connect the first and second floor, a staircase is created in the model. The staircase is placed on the first-floor, where the first stair lands. A straight wood staircase is used in the model. The height of the staircase is 4000 mm, as shown in figure 17. Once the stairs are placed, a hole is created in the second-floor slab with the same method.

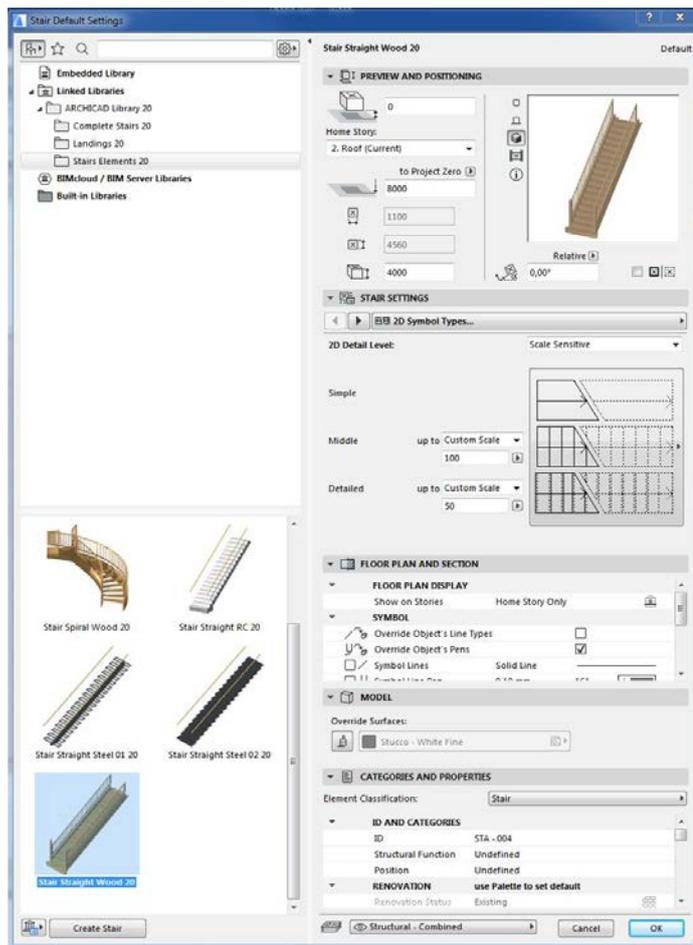


Figure 17. Stair settings for the sample house.

Once all the building elements described so far are created, all the spaces in the building are defined. To further refine the design of the building, objects can be placed in rooms to better define the spaces. All objects used in the design of the sample house are from the ArchiCAD 20 library.

The ArchiCAD 20 object library contains various types of objects, as shown in figure 18. Each object has different custom settings. Most of the objects in ArchiCAD 20 are not real products that are on the market. However, they show what kind of an object is used for each space and how many of them are used.

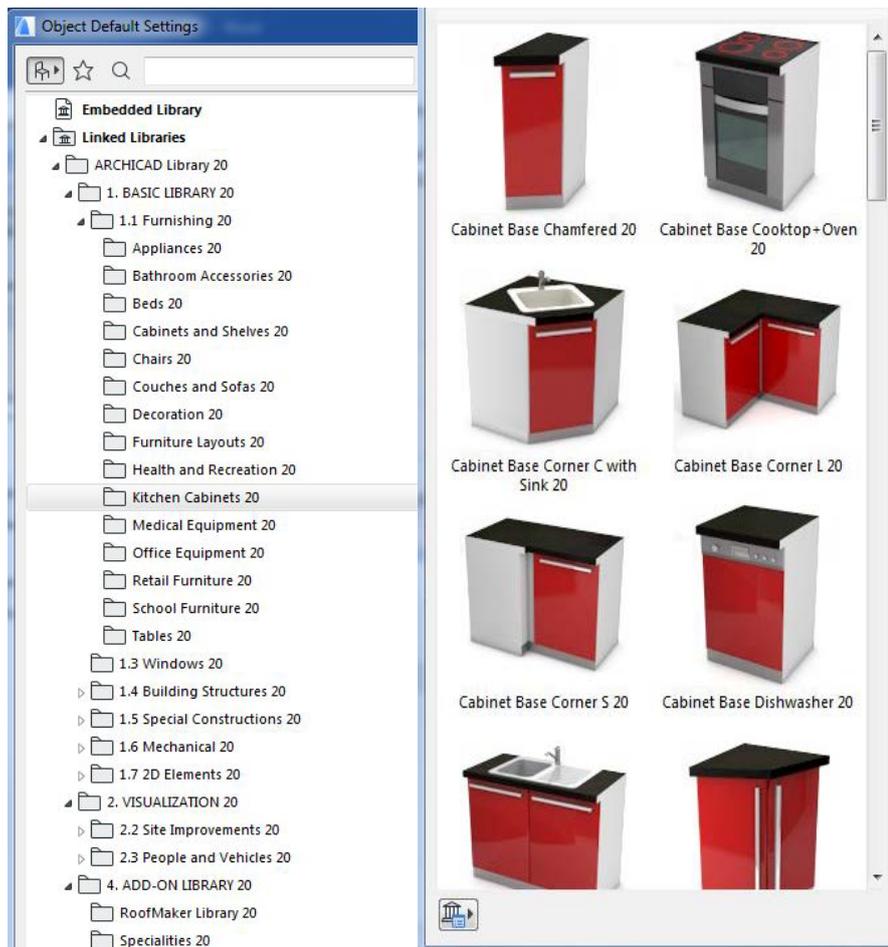


Figure 18. ArchiCAD 20 object library for kitchen in the sample house.

Some companies produce their own 3D BIM objects for ArchiCAD. Using the exact object for the design allows the creation of realistic visualizations. It is even possible to easily get a bills of quantities for exact objects and materials used in the design once the building model is completed. Creating objects that give information like quantities, specification and properties can be useful to procure products.

Lastly, once a building model is complete, the landscape around the building can be created with a mesh tool. The mesh can have elevated points, so it is possible to show hills or pits in the mesh. For this thesis, a simple flat mesh is used.

The sample building model is complete and construction documents like floor plans, and elevations can be derived from the model. Two floor plans are created after the completion of building modelling as shown in figure 19.

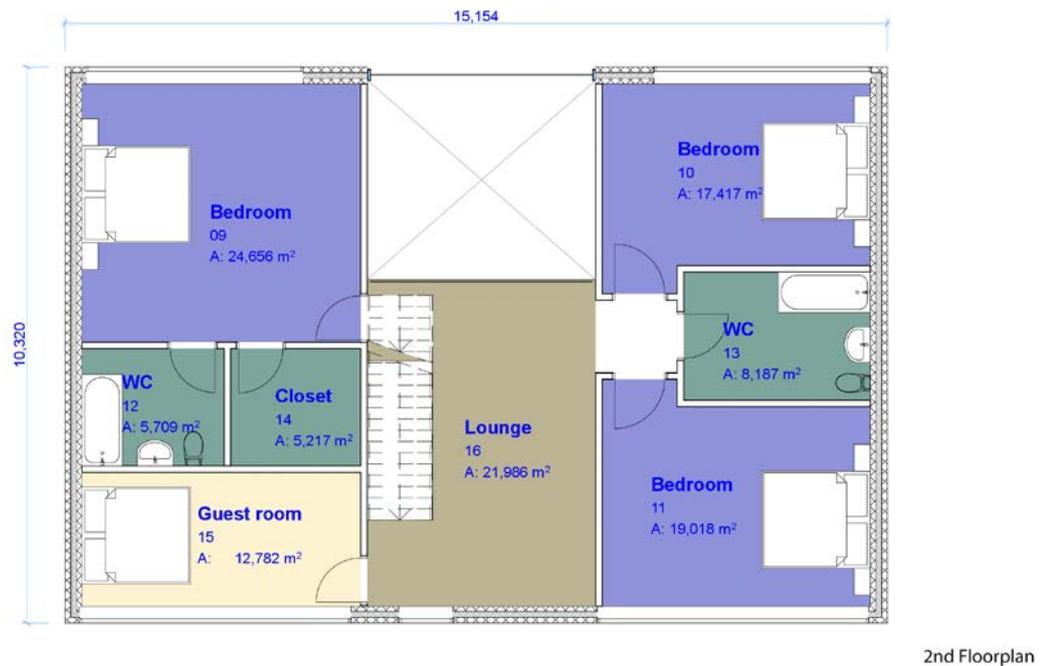
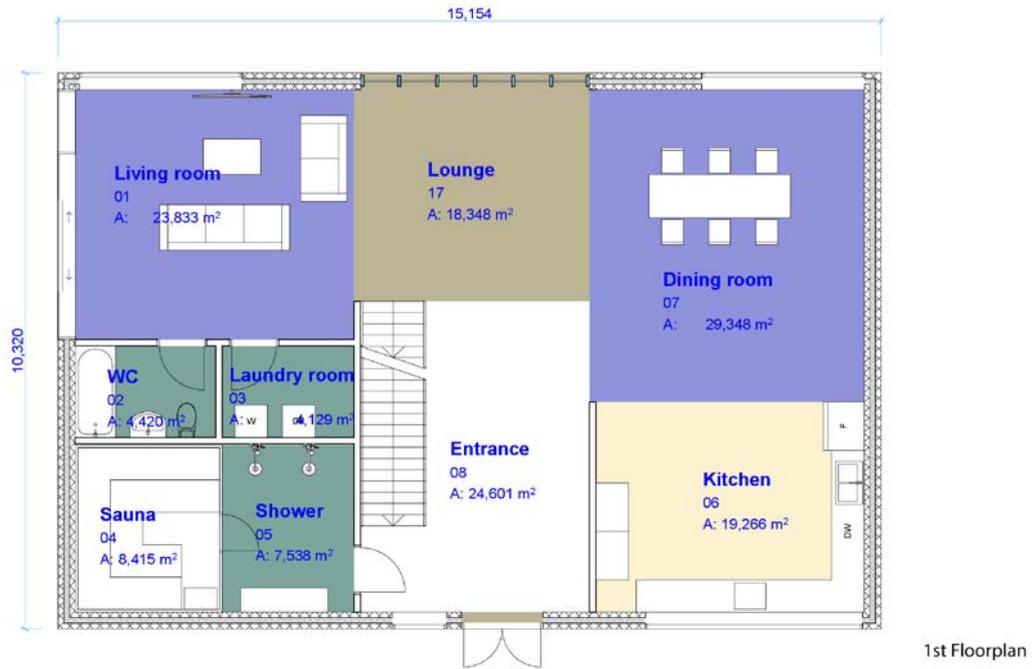


Figure 19. Floor plans of the sample house.

Once the building design is done, the 3D building model is directly ready for visualization without a need for creating a 3D model from 2D drawings, as is done in a traditional design process.

5 Visualization

After a BIM model is created, it is possible to create a 3D visualization with the model. There are multiple ways to create architectural visualizations with the BIM model. This chapter introduces how realistic architectural visualizations are created from the BIM model using ArchiCAD internal renderer, Cinerender, Lumion and 3Ds Max. The workflows of each software are also described.

5.1 ArchiCAD Internal Renderer

ArchiCAD has its own renderer software in the programme. Creating an image with the internal renderer is one of the fastest ways to get a visualization of a model. An image is created through a path: Document tab > Creative imaging > Photo render setting, as shown in figure 20.

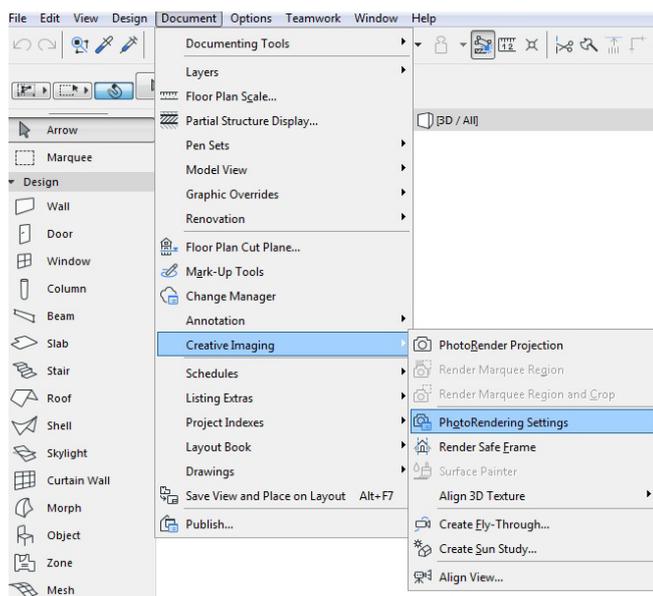


Figure 20. Create an image in ArchiCAD.

After opening the render settings, the image can be adjusted in various ways. The final product of ArchiCAD internal renderer is shown as figure 21.



Figure 21. Final product of ArchiCAD internal renderer.

The strength of the internal renderer is that creating an image takes little to no time. Thus, when there are changes in the design, it can be modified fast. However, the surfaces of the model are rendered in low quality and there are only few options to improve them.

5.2 CineRender

CineRender is the second and more powerful built-in rendering software in ArchiCAD. CineRender is developed by MAXON Computer in Germany [11]. CineRender was introduced by Graphisoft with the release of ArchiCAD 18. CineRender enables high-quality rendering to create realistic visualization. CineRender is connected to a high-end render engine of Cinema 4D. It enables ArchiCAD users to create an image fast and easily. CineRender offers high quality visualizations from ArchiCAD. [12.]

To create an image with CineRender, the same procedure as with the internal render is used. In Photo Rendering Settings, CineRender can be selected as a render engine, as shown in figure 22.

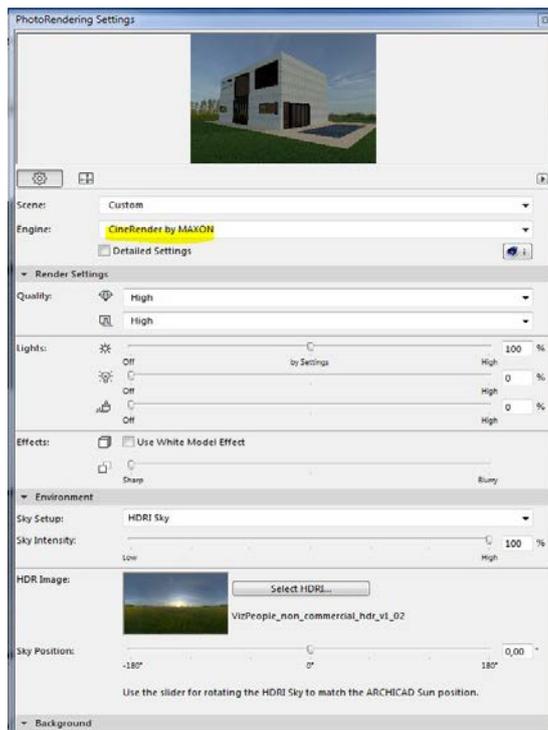


Figure 22. CineRender setting in ArchiCAD.

There are more options for improving an image and the surfaces in CineRender than in the internal renderer. Thus, the final product by CineRender is much more realistic and contains more details, as shown in figure 23. It is also possible to insert an environment picture to the image.



Figure 23. Final product of CineRender.

The strength of the CineRender is that the final products contain more precise surfaces and environments than those done with the internal renderer. However, the rendering time is significantly longer compared to the internal renderer. In addition, it takes more time to define surfaces and for the overall work

5.3 Lumion

Lumion is visualization software developed by Act-3D in the Netherlands [13]. Lumion enables anyone to create videos, images and online 360 presentation from 3D CAD designs. Lumion is easy to learn and useful not only for 3D experts but also for anyone who wants to create realistic visualizations. [14.]

Lumion is compatible with most 3D design software programmes. It is possible to import an ArchiCAD model into Lumion after installing an ArchiCAD to Lumion bridge [14]. After the installation of the ArchiCAD-Lumion bridge, which is available on the Lumion website, an ArchiCAD model can be imported to Lumion. From the 3D view in ArchiCAD, the 3D model can be saved as a Lumion collada (dae) file, as shown in figure 24.

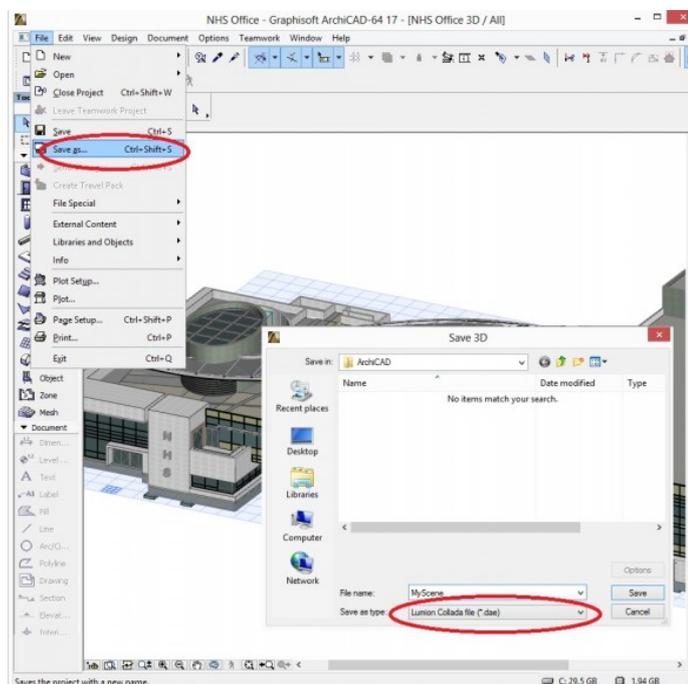


Figure 24. Saving a 3D model as Lumion collada file.

Once an ArchiCAD file is saved as a Lumion-collada file, it is possible to import the Lumion collada file to Lumion. Once the building model is imported to Lumion, there are

several steps that need to be taken to create an image. Also, when the model is imported to Lumion, some surface materials of the model, for example glass surface materials, are different than they are supposed to be. However, material surface editing is possible in Lumion. Lumion contains multitudes of different surfaces in its material library. Several surfaces in the model of the sample house, like glasses and water surfaces, were modified in Lumion. [14.]

Lumion enables the adjustment of the environments of a building such as the sky, plants, trees and landscape. Lumion contains landscape editors and a very large object library. These enable an immediate addition of trees, people and other content to bring life to the model. [14.]

When the adjustment of surfaces and environment is finished, a preparation for publishing an image is done. Rendering in Lumion is somewhat faster than in traditional 3D visualization rendering programmes. In addition, there are many artistic effects that can be adopted right before creating an image. For instance, some effects can even change the weather and the sun height. [14.]

Several images of the sample house model were created with the help of Joonas Jöeveer who has expert knowledge of Lumion from his work experience from JLL Finland Oy. The final product of Lumion contains highly defined material surfaces and a realistic environment as shown in figure 25. [14]



Figure 25. The sample house final product of Lumion.

The strength of Lumion is that it is easy to learn and use. Rendering is very fast compared to the quality of render result. In addition, it is possible to create impressive videos with Lumion. However, the quality of the image is not as good as that of traditional architectural visualization programmes and their renderers, for example 3Dsmax and V-ray.

5.4 3Ds Max

3Ds Max is a 3D computer graphic software programme developed by Autodesk Media and Entertainment. 3Ds Max is renowned for creating animations, images, models and games. It is commonly used in architectural visualization studios. [10.]

Before the BIM technology, it was a common practice to create building models for visualization in 3Ds Max from 2D CAD drawings. Nowadays, BIM models can be imported to 3Ds Max and used for creating impressive visualizations much faster than the traditional way.

To import an ArchiCAD model to 3Ds Max, the ArchiCAD model should be saved as a 3Ds studio file (.3Ds) from the 3D view of ArchiCAD. There are several ways to convert an ArchiCAD model into 3Ds Max. The choice depends on the types of information to be transferred. Creating visualizations with 3Ds Max was done with the guidance of Dmitri Kvitko who has professional knowledge of 3Ds Max from his work experience from JLL Finland Oy.

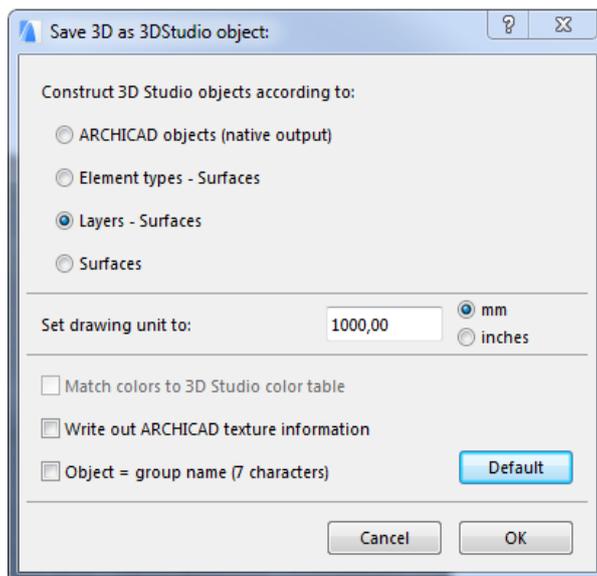


Figure 26. 3Ds saving options in ArchiCAD.

As can be seen in figure 26, there are four ways to export 3Ds objects from ArchiCAD. The choice affects the information setup in 3Ds Max. The alternative “Construct 3D studio objects according to ArchiCAD objects (native output)” is not to be recommended, because it separates composite elements according to their part. For example, the layer of a sandwich wall would be saved as separate objects. For the model building, the “Layer-Surfaces” alternative is chosen. This way the building elements with several materials were grouped according to their layer. Since this is also the case in ArchiCAD, every element ends up in the correct layer.

After the building model is saved as a 3Ds file, the file is opened in 3Ds Max. The building model imported from ArchiCAD contains not only the building elements, but also the sunlight element and the camera object are imported. For the thesis, the sunlight element and camera object from ArchiCAD are deleted and the 3Ds Max light elements and a camera added to the scene.

The strength of 3Ds Max is that the surfaces of elements can be high defined. The surfaces imported from the ArchiCAD building model are fixed and updated in the material editor of 3Ds Max to enhance the quality of the final product. To define a realistic building surface material, professional knowledge is needed. However, some surface materials can be found online. For a beginner, importing ready-to-use surface-materials from an online source is a good way to learn how the surface material settings are done for different materials.

Adjusting and adding the environment of the building with 3Ds Max is more detail work than with Lumion. There are several plug-ins available for 3Ds Max to adjust environments of building models. Some plug-ins are used to create vegetation and roads around the building model. In addition, there are multiple 3D objects online that can be used for creating a realistic environment for a building model. For the thesis, several 3D objects

are added to the environments of the building model. After a few configurations, the final image is created, as shown in figure 27.



Figure 27. Final product of 3Dsmax.

Of the four final images done with different render programmes, the final product of 3Dsmax was the best. The image generated with 3Ds max contained the highest resolution and the most realistic surface materials. However, creating visualizations with 3Ds max took a relatively long time compared to the other programmes. Defining the surface materials and the configuration of the imported 3D model demanded expert knowledge and experience.

6 Discussion

The use of a 3D building model derived from BIM programmes was truly beneficial in the creation of an architectural visualization. It was certain that a 3D BIM model can be used in architectural visualization and this utilization of a 3D BIM model shortens the work process of architectural visualization. In addition, it was much easier to produce architectural visualizations with a BIM model than in the traditional way where 3D modelling process of the building was needed in architecture visualization.

Processing the visualizations took a different time in each of the programmes. Time is a resource and designers have to know what approach to take in visualization of the project according to the project needs. In terms of time, using the internal renderer and CineR-render from ArchiCAD were the fastest ways to create a quick visualization. The process of creating the visualization was easy because there was no need for exporting and importing the 3D building model or for redefining the surface materials of building elements. However, the quality of the visualizations from the internal render software was relatively low compared to that of the other visualization software because the render software had limits in defining details in surface materials and in lighting. Therefore, the internal render is best used for creating quick and low quality visualizations.

On the other hand, using Lumion to create a visualization was fairly easy and the quality of the final product was relatively high compared to that of the internal render. However, once the building model is imported, the building model can no longer be edited in Lumion, and the model must be imported again when the design changes. Using Lumion would be beneficial for architects who need good-quality architectural visualizations and animations of a building in a short time. Therefore, it is one of the most suitable ways for a construction project because of its quality and short processing time.

3Ds max offered the best quality of visualization among the final products. 3Ds max contained a full control of the surface materials on demand. However, creating a visualization with 3Ds max took the longest time, and required professional knowledge about surface materials and 3D modelling. Therefore, 3Ds max can be operated by 3D professionals and used when there is a need for hyper-realistic renders and enough time for the project.

For designers, it would be wise to choose BIM technology over CAD because there are many benefits that BIM can bring especially in architectural visualization, as discussed above. Depending on what the client wants of the visualization, designers should choose a corresponding visualization programme, considering the estimated time for creating a visualization and the quality of the visualization.

7 Conclusion

The goal of this thesis was to create architectural visualizations from a BIM model and to emphasize the usefulness of BIM models for architectural visualizations. After several visualizations were made with different visualization programmes, it became clear that the BIM technology has a profound impact on the whole process. The workflow of architectural visualization was improved and made smoother because the 3D building model was already done in BIM. This removed the need for designers to spend time on remodelling, and improved the accuracy of visualizations.

This study was carried out to illustrate how to create photo-realistic images out of a BIM model, as an example of architectural visualization. However, the architectural visualization is developing and changing to be more interactive. There are several ways to create more interactive and immersive visualizations out of BIM models, for example virtual walkthroughs and animations. In the future, studies on interactive visualization of a BIM model would be valuable.

Throughout the thesis, I have learnt various ways to create architectural visualization using the BIM models. There are many possibilities to create impressive architectural visualizations as one of the greatest benefits of using BIM technology. In addition, BIM technology will speed up the process of architectural visualizations.

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