



Designing with Autodesk Revit

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The final work observes functionality of Revit software in comparison to the conventional AUTOCAD by modelling D3 block of Arcada. The technical drawings provided were used as an asset during designing process. The software functionality including families, simulations, rendering and applications was studied and closely observed by author himself and qualitative analysis was conducted via interviews of experienced engineers regarding this topic. Findings included designing speed, costs decrease and increase of automation of workload. The AUTOCAD overview of functionality was also made based on the author's previous experience. Once the designing was made, close comparison with AUTOCAD was done.

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1 INTRODUCTION

For engineers the main part of work before the production itself was designing and then sketching the object. It is vital that the work is done precisely since it might be a matter of peoples' lives, especially, when the object itself is a building. Until recent past, architects relied mostly on hand sketching – the first program installed on PC for them was released only at 1960 (Smith, 2013). At 1974 Computer Aided Design became the essential program for architects and this was a groundbreaking moment. Nowadays, with the computing power skyrocketed among past two decades, engineering software developed and changed dramatically. Since CAD could not offer all the needed tools for architects, new class of software developed under the name of CAAD (Computer Aided Architectural Design). Revit, being one of the newest programs (initial release: 5 April 2000, latest stable release: April 2018 (The History of Revit - The Future of Design, n.d.)). The main goal of this work is exploring and testing Revit in comparison with already known AUTOCAD.

1.1 Background

The Revit software operates in a way that architects can manipulate the whole building or a chosen part of it. When it comes to designing, user can operate with so-called “families” (walls, ceilings, furniture, etc.) or import geometries. The “families” feature is what makes Revit one of the best software to use for a civil engineer. This thesis is a final work of a student which main aim is to research of Revit software and focuses on three main objectives:

- Learning possibilities and techniques of Revit software.
- Creating D3 block of Arcada in Revit.

- Studying differences in drawing process and functionality between Revit and AUTOCAD.

1.2 Objectives

Nowadays the dominant software in architectural design is AUTOCAD with 36.84% share of the CAD software market (Companies using Autodesk Revit, n.d.). There are number of options to substitute this arguably an outdated way to create architectural drawings, one of which is Revit. While Revit has share of only 1.03% of the market the interest in it is growing (Interest over time, n.d.). The main objective of this work is to familiarize with the software, compare it with conventional AUTOCAD and define the conditions under which this software is a better choice.

1.3 Selection of Methodology

Research methods that were chosen for the final work are as follows:

- Interviewing of engineers working either with Revit and/or AUTOCAD to collect data regarding how the work is handled with mentioned software.
- Creating a D3 block model using Revit software in order to study software capabilities and difficulty.

2 LITERATURE REVIEW

2.1 Revit overview of functionality

2.1.1 Applications

After a huge success of AUTOCAD in architecting, Revit was designed as a tool which could do the work AUTOCAD did but instead using programming language, achieve a direct modification of properties of objects. This goal was scored using parametric model of references, system of “families” and elements. There were 3 different Revit versions each had unique functions:

- Revit Architecture was specifically designed to help architectures.
- Revit Structure performed tests and analysis to ensure structure’s stability and planned reinforcements if needed.
- MEP (Mechanical, Electrical and Plumbing) performed modelling of system inside the building and could do energy analysis of the building.

2.1.2 Functions

When it comes to Civil engineering, Revit is acclaimed to be one of the most powerful software on the market. User can create a sketch of the building from a scratch using Revit since it offers great amount of functions and pre-sets. Unlike AUTOCAD, Revit supports “family” features which saves great quantity of time for an architect. For example, the task to sketch a bathroom was given and engineer operates in a limited time. User do not need to draw each object of a bathroom manually (e.g. sink or bathtub) and then insert it into the program, he can either chose from pre-installed family, download it from the Internet or even import his own model. Outside of that, Revit supports parametric engine which means that every change made will be saved and held throughout the whole project automatically. The following examples of these element relationships are:
The outside of a door frame is a fixed dimension on the side from a perpendicular partition. If the partition is moved, the door remains this relationship to the partition.

Windows or pilasters are spaced equally across a given elevation. If the length of the elevation is changed, the relationship of equal spacing is maintained. In this case, the parameter is not a number but a proportional characteristic.

Inside of the project, Revit uses 3 types of elements (About Element Behavior in Revit, n.d.):

- Walls, windows, doors are referred to *model elements* – actual 3D geometry of the building
- Reference planes, grids and levels are called *Datum*
- Tags and dimensions and other elements that can be seen only in specific 2D view are called *View-Specific elements*
- Some elements can have sub-elements, see Figure 2

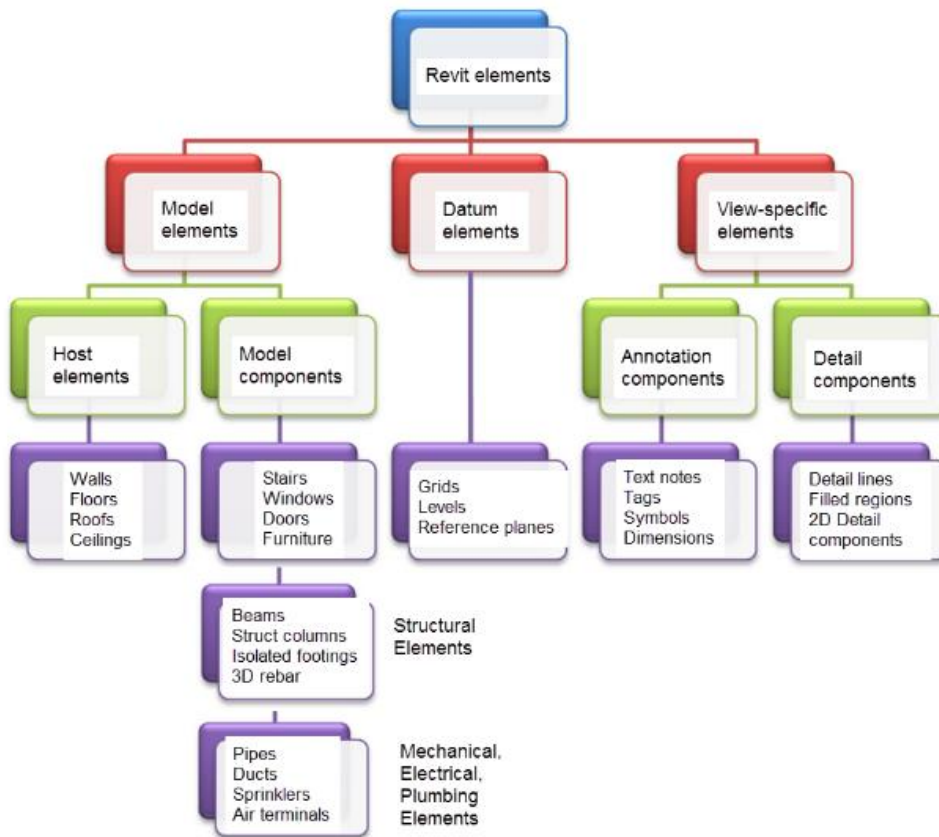


Figure 1: Revit structure (About Element Behavior in Revit, n.d.)

2.1.3 Families

One of the features Revit stands out of the other CAD software is so called families. Families are the group of objects with similar parameters, identical usage and graphical representation. Different Revit families can be found on Internet and there are some pre-installed (About Families, n.d.).

- **System families**

Those are already-made and set into programs standard families that user cannot create as separate file. The properties and visual representations are untouched. User can transfer system families between projects (e.g. floors, walls, dimensions).

- **Loadable families**

The user can load those kinds of families from templates into project, change its' properties and visual representation.

- **In-Place families**

Custom geometries with a help of which user can set relationships between objects. Those are of a limited use and cannot be duplicated as a family type to create several types.

- **Families out of the box**

Families that are available straight from the purchased program, those are updated frequently (e.g. doors were updated in 2016).

- **Creating personal family**

The family editor can be used to create personal family if suitable one was not found (About Families, n.d.).

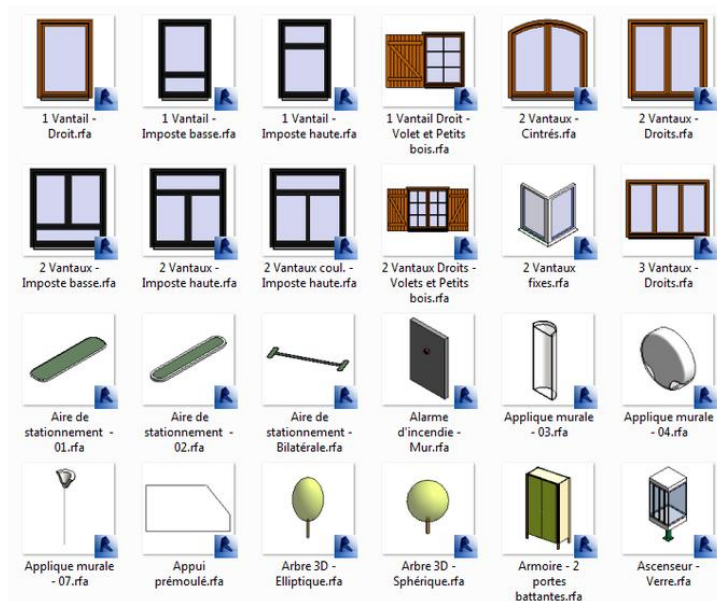


Figure 2: Revit families example (Revit families, n.d.)

Each family has different objects and each object has its own parameters. For example, the walls parameters include Analytical properties (ones related to material it is made of such as heat transfer coefficient, thermal resistance, absorbance, thermal mass and roughness), Identity data which identifies object as a product manufactured by a specific company and includes property such as manufacturer, model, price, URL of the company this object was made by etc. Constructional properties are related to width and its function (exterior or interior) while graphics parameters specify object's pattern and color.

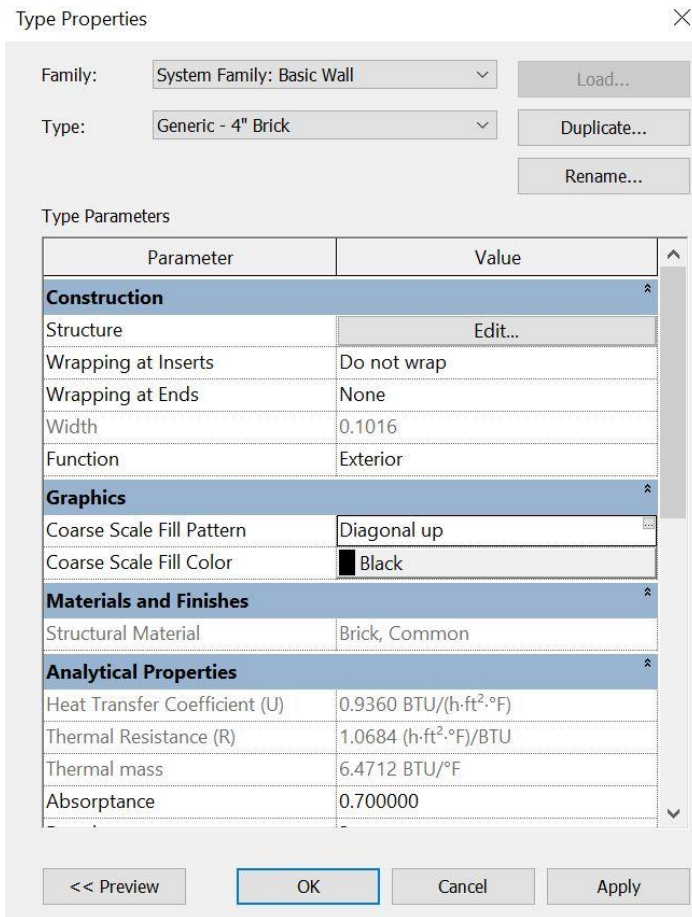


Figure 3: Basic Wall properties

Family feature offers a customization out of the box. Even if the family does not come out-of-the box, users can create their own 3D object inside family builder, download or buy them online.

2.1.4 Rendering

To achieve a better and more realistic visual look of the model, user can use rendering tools to enhance the image. Different types of rendering can be used, such as cloud-rendering, 3ds Max rendering, and other plugins. The defining factors of choosing rendering plug-ins are quality and speed of the process. However, this is limited by computing power of user's computer, so cloud-based rendering engines are recommended for low and mid-end PC. If designer operates PC with decent processor and video engine, rendering can be done with built-in tool (writer recommends uses it only on machines with 16-

core CPU, 16+ GB DDR3 RAM, video card supports DirectX 11 (System requirements for AutoCAD, n.d.)).



Figure 4: Comparison between Revit rendering tool and cloud based Neon engine (Cloud Rendering, n.d.)

2.1.5 Simulations

Revit is a powerful tool to perform various kinds of simulations including Energy analysis, Illuminance simulation and Acoustic simulation.

- Energy analysis of the building includes complex analysis of heat flow inside the building, emitting and absorbing energy. For example for giving wall with known properties Revit can calculate how much heat will pass through it, how much heat will stay inside the building and whether this given wall an optimal choice. This example included only one wall, however, Revit can do calculation for the whole building and calculate its' energy efficiency (Best Practices: Energy Analysis, n.d.).
- If the task includes designing acoustic proof room, for example music recording studio, Revit can calculate and show acoustics in the room

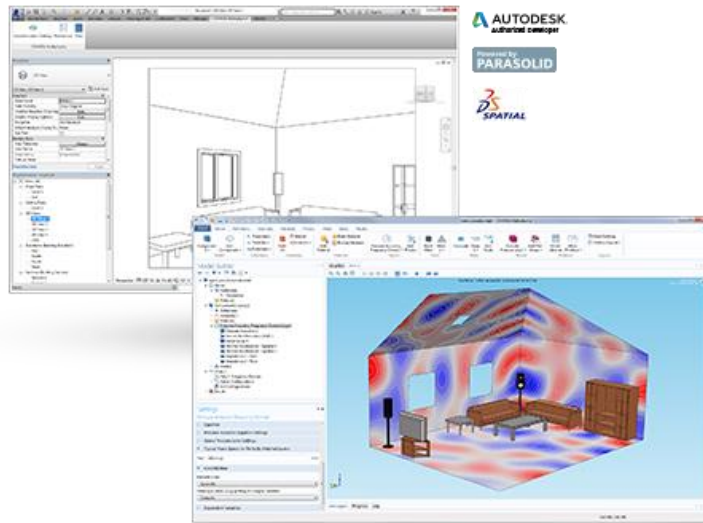


Figure 5: Acoustic simulation (LiveLink for REVIT, n.d.)

- Illuminance simulation calculates how much light is inside the room and how it is transmitted. It is crucial factor since the minimum level of 50 lux is needed to perform basic activities, however, 50 to 1000 lux is comfortable (Recommended light levels, n.d.). Revit can calculate whether it is enough, or the window should be changed or moved to achieve this level of illuminance (How Illuminance Rendering Works in Revit, n.d.).

2.1.6 Companies using Revit

The biggest companies using Revit in their work are presented below.

Company	Website	Country	Revenue	Company Size
Stantec Inc. (USA)	stantec.com	Canada	>1000M	>10000
HDR, Inc.	hdrinc.com	United States	200M-1000M	5000-10000
M.C. Dean, Inc.	mcdean.com	United States	200M-1000M	1000-5000
ARUP Laboratories	aruplab.com	United States	100M-200M	1000-5000
Atkins (company)	atkinsglobal.com	United Kingdom	>1000M	>10000

(Companies using Autodesk Revit, n.d.)

BIM in general and specifically Revit are relatively new tools in architectural design. While they offer better working environment with fast designing process and highly automotive administrative work, conventional methods still rely on AUTOCAD drawings. The biggest case in Nordics will be observed closely. Nowadays, Skanska is one of the biggest development and construction group worldwide is pursuing BIM software in their design work. Today there are 13 BIM projects listed on the official website (Bim projects, n.d.) all over the world from Finland to U.S. They reported on the significant improvement of development speed and overall increase of quality of designing process when BIM software is used.

2.2 AUTOCAD overview of functionality

2.2.1 Applications

AUTOCAD was one of the first software (first released: December 1982, last updated: March 2016) which helped engineers by replacing blueprints to a digital form. Unlike Revit, AUTOCAD does not limited only by architecting tasks, user can freely perform almost any type of design work: model an object, create a model for further 3D printing, AUTOCAD is used in fashion industry modeling new outfits. There are more than 700 training centers world-wide that teach future engineers to use the software. AUTOCAD itself is a powerful tool which can handle most of engineering tasks by itself, however, there are plenty of extensions (covered detailed in section 2.2.4) which push the boundaries of program even further.

2.2.2 Functions

AUTOCAD is a powerful tool for creating 2D images of objects. During the development of AUTOCAD the main goal was to substitute analog designing tools such as drawing board and pencils with digital solution. While when the program was first released this was a significant improvement for architects, nowadays AUTOCAD by itself lacks functionality compared to more contemporary tools. AUTOCAD is a powerful tool for creating 2D drawings of images, however, it lacks in 3D functionality when no extensions are installed.

2.2.3 Overview of existing variants

There are 5 main different versions of AUTOCAD presented on the market nowadays:

- AUTOCAD
- AUTOCAD Architecture
- AUTOCAD LT
- AUTOCAD 360
- Student version

Each one of them supports different range of functionality and offers different solutions for projects.

AUTOCAD is a standard version of software which is used by product designers, graphical designers, architects and engineers. It allows to create any kind of object or shape on a plane and supports 2D and 3D views. While users main tools are limited to lines, arcs and circles, as the project progresses, the object can be made more complex using modifying tools such as trim (trims object by a specific intersected line), fillet (makes a sharp edges into a rounded edges with a specific radius), explode (break object in a set of its components) , mirror (mirror object with a respect of a selected line) etc. AUTOCAD also supports 3D modelling however, it's main purpose is 2D modelling, thus 3D tools are lacking in its complexity.

AUTOCAD Architecture is a version of AUTOCAD suited especially for architectural works; it supports various features, such as intelligent relations between objects (walls, windows, floors, etc.). It also supports both 2D and 3D views of objects. The software automatically updates areas if some objects inside is modified or deleted and keeps all the calculations in real-time updates. AUTOCAD Architecture has all the features of AUTOCAD and also this software helps engineers to keep the work with architectural objects.

AUTOCAD LT is low-cost solution of original AUTOCAD and was firstly presented on market in 1993 and had a price of 495\$ which made it first Autodesk software priced lower than 1000\$. It supports various features, however, there some limitations directed towards customizations and network licensing. AUTOCAD LT cannot be used on different machines over a single network, it does not support 3D visualization, rendering and 3D printing of the objects, on the other hand, this version of software does support all basic functions of original CAD tools. In 2015 Autodesk introduced a rental model for a cost of 360\$ per year (Autodesk Store, n.d.).

AUTOCAD 360 offers a cloud based storage for users to share, view, edit and save CAD files. It has subscription-based model which costs 4.99\$ monthly or 49.99\$ per year. AUTOCAD 360 storage can be linked to third party cloud storages (OneDrive, Dropbox, etc.) and has various tools for online editing, has mobile applications for both Android and iPhone, supports all HTML5 browsers (Google Chrome, Firefox) and is a perfect tool to quickly download a file when the originality is not the point of interest.

Student version is a tool created by Autodesk for educational purposes and has a free 36-month renewable licensing model. All the features represented in original AUTOCAD can be used in student version, however, some limitations are still existing. For example, .DWG files are marked with internal. set and when those files are printed, print includes a stamp or banner on all the sides. In addition, objects created with student version cannot be used for commercial purposes.



Figure 6: Student version print (Autodesk Student Community, n.d.)

2.2.4 Companies using AUTOCAD

Companies using AUTOCAD are represented on the table below.

Company	Website	Country	Revenue	Company Size
Restoration Hardware	restorationhardware.com	United States	>1000M	1000-5000
HBK ENGINEERING LLC	hbkengeering.com	United States	10M-50M	200-500
Peter Kiewit Sons'	kiewit.com	United States	>1000M	>10000

Company	Website	Country	Revenue	Company Size
Atkins (company)	atkinsglobal.com	United Kingdom	>1000M	>10000
HDR, Inc.	hdrinc.com	United States	200M-1000M	5000-10000

(Companies using Autodesk AutoCAD, n.d.)

2.2.5 Extensions

There are numerous different extensions available for AUTOCAD at the moment since Autodesk offers APIs for customization and improving functionality. Those extensions used mostly for file exchange, rendering or extending functionality to the various fields. Note that some of the extensions are officially created by AUTODESK and some are created by users. Examples are:

- Different lay-outs for technical drawings
- Different standards for dimensions
- All-included plug-ins for specific tasks (e.g. Electrical)

2.2.5.1 *Raster-to-vector conversion*

AUTOCAD offers an extension which allows users to directly trace a PDF or any other Raster image into vector format. This will enable users to modify drawings without them having an initial DWG file. Students get this tool for free over the duration of 3 years, the cost of license for non-students is 840\$ per year. This is one of the most important extension for this thesis since author has only PDF files of building available.

2.3 Comparison

The table below is official statistics from manufacture of Revit and AUTOCAD which compare that two software by their price and key features.

Product		Revit	AUTOCAD
Features		<p>BIM software for architects, engineers, contractors and designers</p> <p>Create a unified model that contains real-life information</p> <p>Great for modeling, clash detection, and change management</p>	<p>Widely used commercial software for 2D & 3D CAD</p> <p>Create basic geometry that represents real life</p> <p>Great for drawing precise line work, such as elevation details</p>
Price	Monthly	\$280.00	\$195.00
	1 Year	\$2,250.00	\$1,575.00
	3 Years	\$6,750.00	\$4,725.00

(Revit vs. AUTOCAD, n.d.)

3 METHOD

3.1 Introduction

This chapter briefly describes the methodology of the thesis. The project task is to create a design of D3 block of Arcada building using BIM method with Revit software. The result of this chapter will be an analysis of the designing process in Revit and its' conventionality compared to the more widely used AUTOCAD. Appendix section shows technical drawing of D3 block of Arcada with dimensions.

3.2 Project description

The main task of the thesis is to design a D3 block of Arcada which consist of main hall, chemical lab (main room and 4 rooms inside of it), 3D printing room, teachers room (elektroniikkalab), three auditoriums (telelaboratorio and sahkomitlauslab) and a number of conference rooms. The total area of D3 block is calculated to be 584 square meters. The original technical drawings provided were used to calculate total area and the final designs are created based on them.

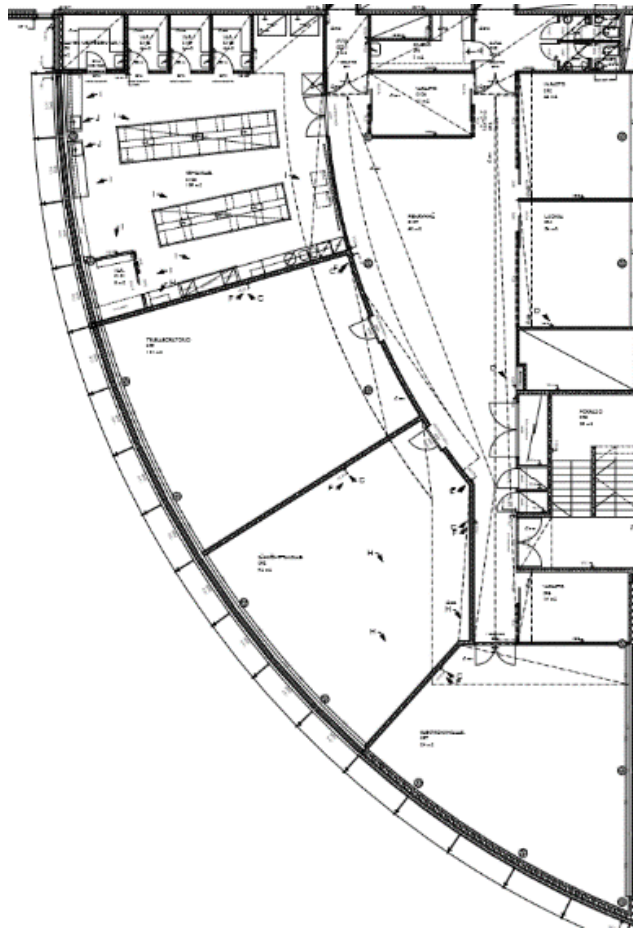


Figure 7: D3 technical drawing

3.3 Interviews

The online interview on special engineering forums among architectural engineers who are using Revit and/or AUTOCAD in their work was conducted. The interviews were conducted in Reddit forum among sub-forums of architectural engineers (r/architecture) and engineers using Revit on their work (r/Revit). 10 total participants from companies of different sizes answered the questions regarding their usage of software and how they would compare both of them. The qualitative information about engineers' experience was collected with their overall feelings of software and CAD in general. The questions were focused on the topic of usability of the software, general feeling of usage and its overall complexity.

3.4 Drawing the D3 block

3.4.1 General set-up

In order to draw the D3 block in Revit the architectural project needs to be created. Once it is done, the main working space is opened which allows users to create a basic plan and add smart objects such as walls, doors, columns and windows.

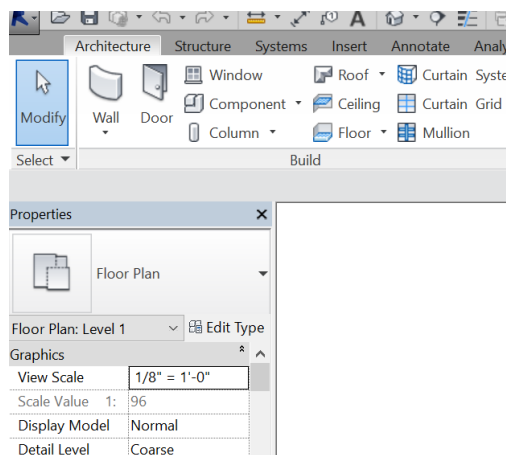


Figure 8: Revit 2016 home tab

Those smart objects are drawn as a single unit which allows architects to save time since there is no need to drawing walls or windows line by line. All those objects are selected from the libraries.

Revit allows users a possibility to trace a .jpg image into a 2D view of a building which will be a method of creating a project plan of a thesis. The technical drawing provided was used in order to snap the D3 block of it and then import it to Revit. This is a major improvement if the task of a project is redesigning an exciting architectural design.

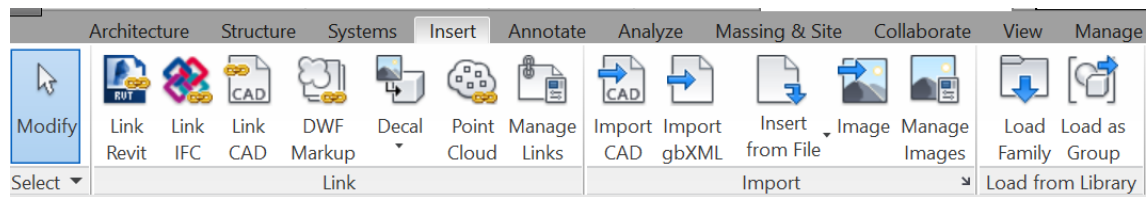


Figure 9: Inserting picture to Revit

Note that there is a possibility to insert CAD drawings, however, this is not recommended since that two software are using different development philosophies and they may conflict during the project.

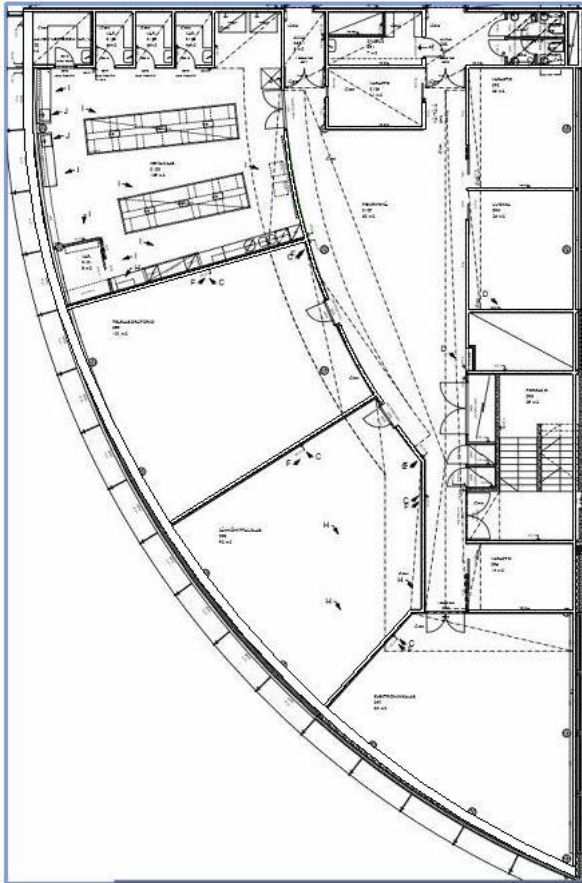


Figure 10: Imported drawing of D3 block

3.4.2 Setting-up walls and doors and chemical laboratory interior design

Once the image is imported to Revit, modelling will begin. In order to create the model, author will trace the walls and doors with original properties to ensure that the geometry of the block remains the same. The smart objects will be used to fulfill the task. Since the Revit provides only one type of the family by default (e.g. single door while the doors to classrooms are double doors), the additional families download is required. This can be done during installation of Revit if the user will check “Family download” box. After the families are downloaded, they are needed to be loaded into the current project. The figure below shows the result of creating walls (Basic family External wall for external walls and Basic walls interior for internal walls).

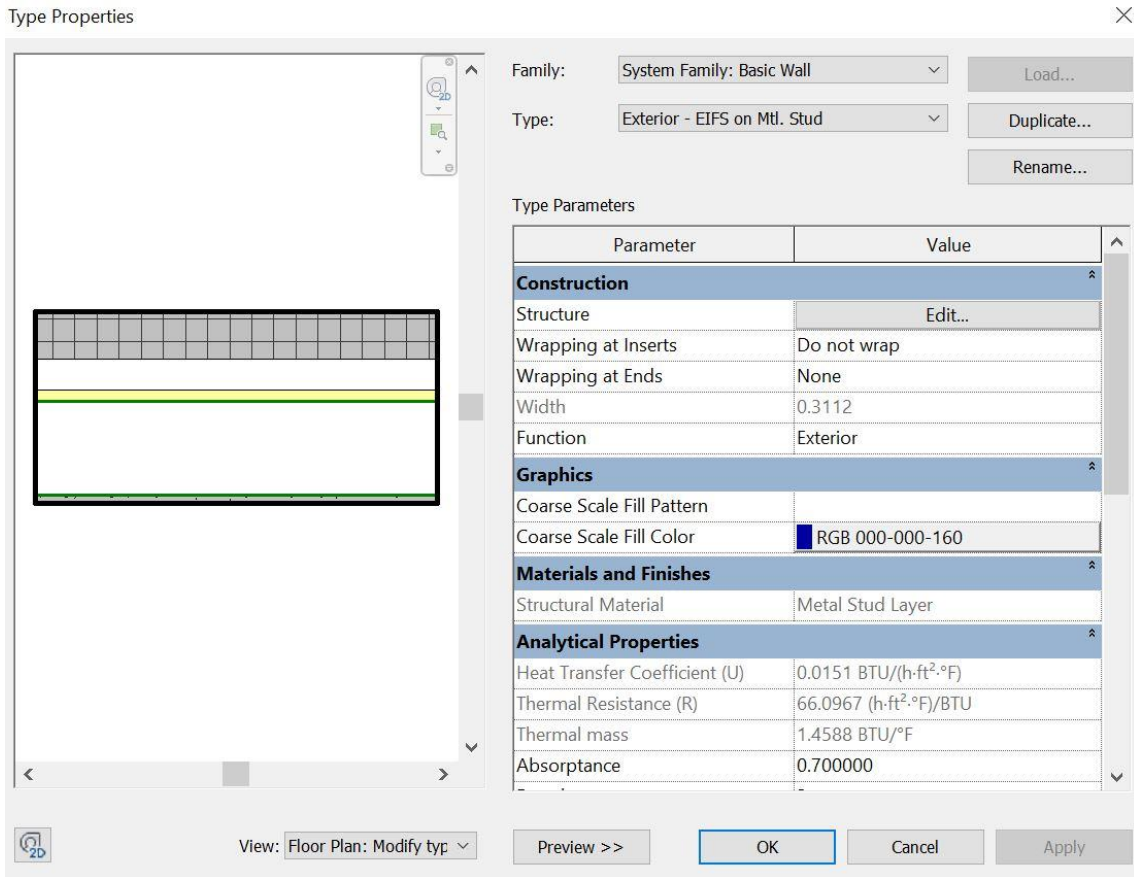


Figure 11: Exterior wall properties

Figure 11 shows properties of exterior walls used in designing D3 block of Arcada. Those walls are located on the left side of the drawing

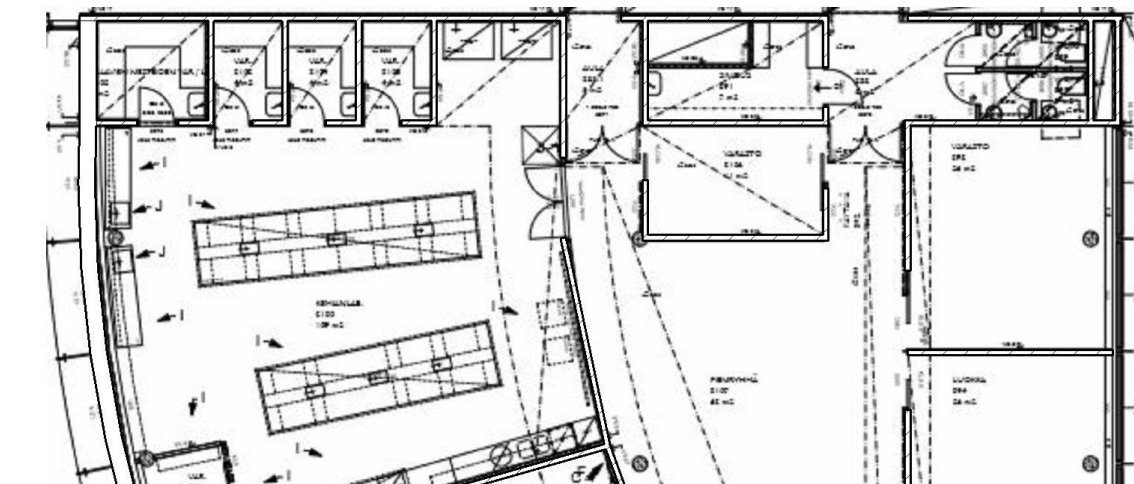


Figure 12: Walls drawn in Revit

The next step of the project is setting up doors. There are three types of doors are of interest: Single door, Double door and Slide door. All of those doors are available in default package of Revit 2016, however, the settings of the families have to be changed in order fit into the design.

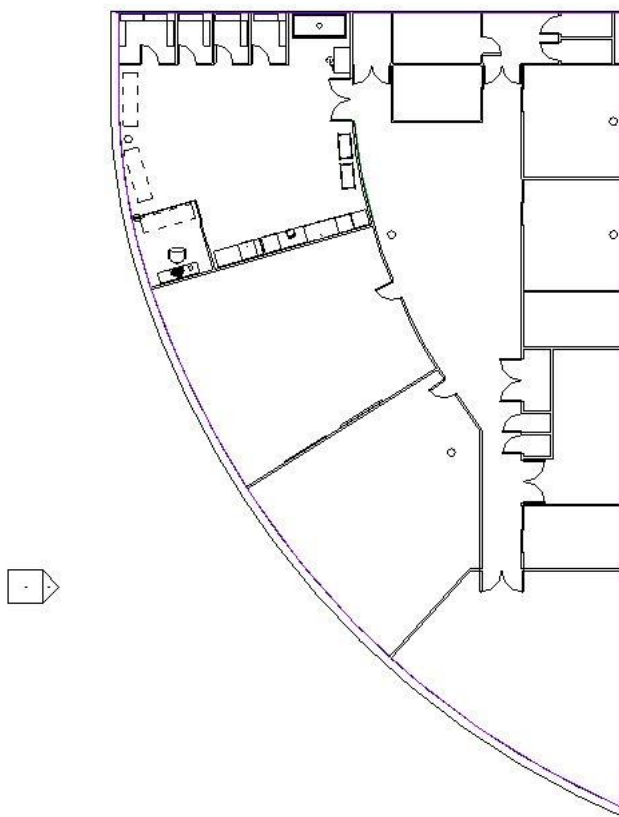


Figure 13: D3 with completed walls, doors, columns and lab equipment.

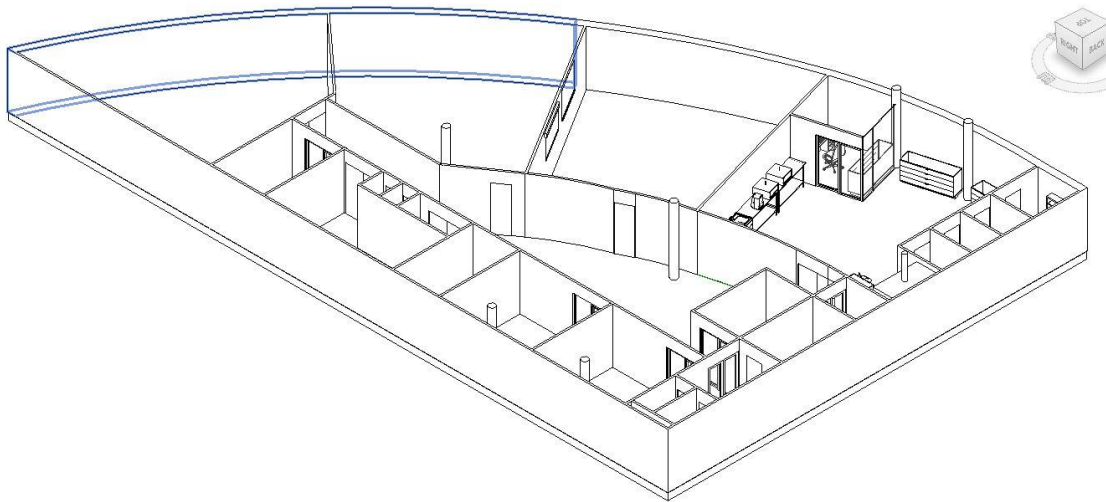


Figure 14: 3D not rendered model of D3 with walls, doors, columns and lab equipment

Figure 14 shows D3 block drawn in Revit where walls and doors are already outlined, and some equipment is placed in the chemical laboratory in 2D. Figure 14 represents not rendered 3D representation of the same design. The walls and doors were used as an out-of-box family, while some of the lab equipment was custom made. Lab equipment includes components:

- Microscope (custom)
- Washing machine (out-of-box)
- Ovens (custom)
- Fume hood (custom)
- Water system (custom)
- Computer (custom)
- Keyboard (custom)
- Shelving (out-of-box)
- Lab carts (custom)
- Whiteboard (custom)
- Safety shower (custom)

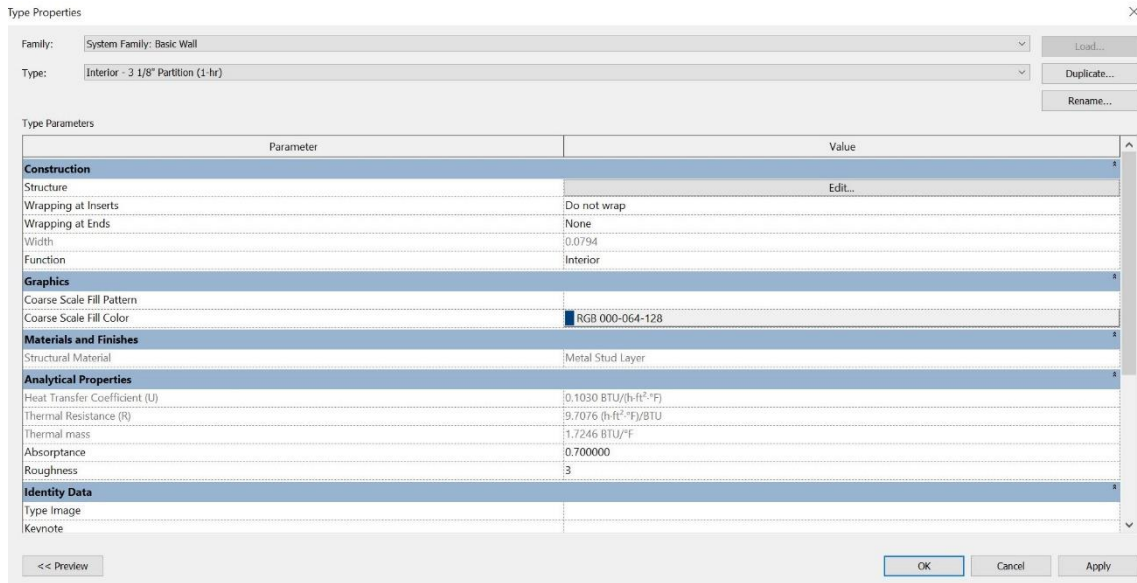


Figure 15: Interior walls family properties.

Figure 15 illustrates the properties of out-of-box interior walls family where all bold properties can be edited in order to meet project requirements while faded are unchangeable. Walls family is considered to be a structural element, thus its properties mostly represent properties of materials they are made.

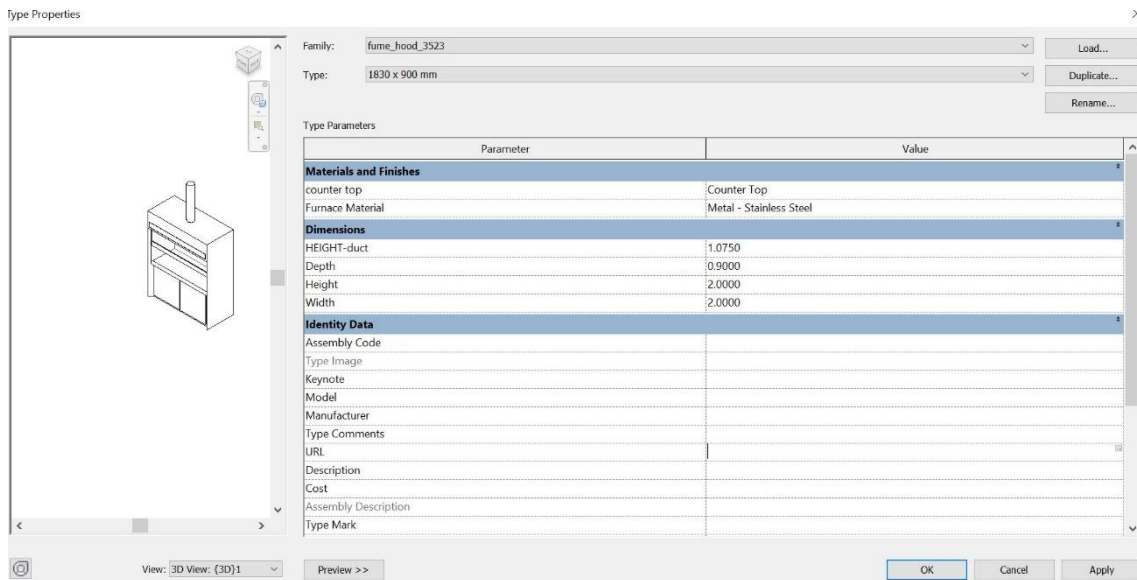


Figure 16: Fume hood.

The figure above shows the properties of Mechanical Equipment Component Fume Hood used in the chemical laboratory of Arcada to conduct odorous experiments or ones during which dangerous chemical are produced. Since this component is not structural and do not affect constructional properties of design, the information of its properties is not needed.

3.4.3 Family editor

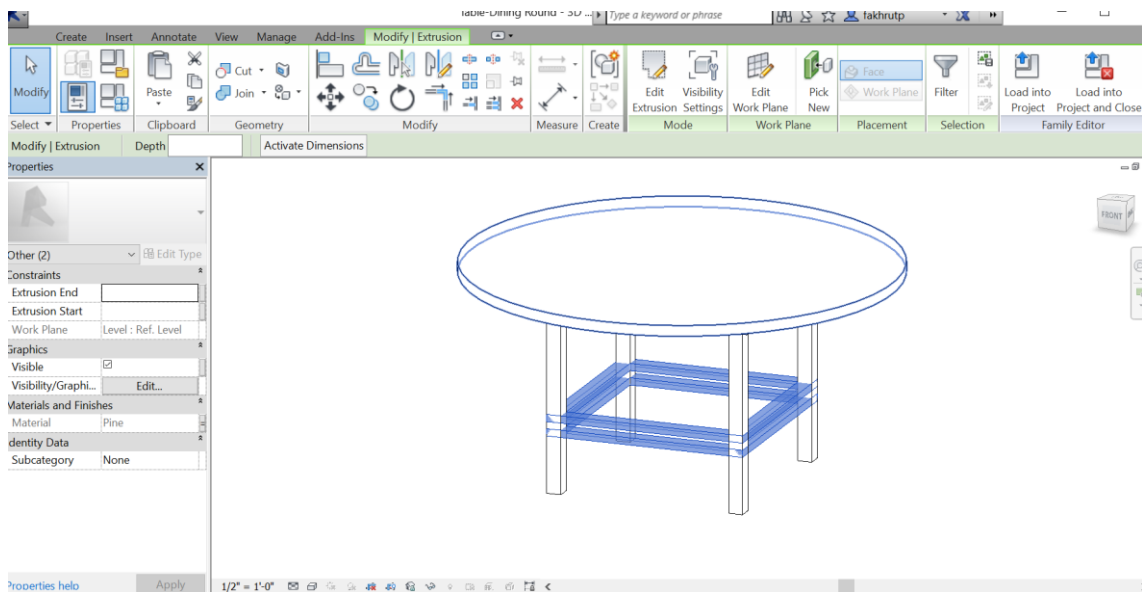


Figure 17: Family editor screen.

Figure 17 represents a family editor. Users can manipulate with existing families by adjusting dimensions of the objects or deleting/adding new parts. In order to create a table similar to the ones that a hall of D3 has, out-of-box family Dining Table Round was edited and highlighted parts were deleted. Also, extrusion level for legs, supports and for the table surface was changed to smaller levels in respect to the reference planes. The results of family edition are shown on the Figure 18. Family editor offers users not only to modify existing families but creating brand-new objects from the scratch.

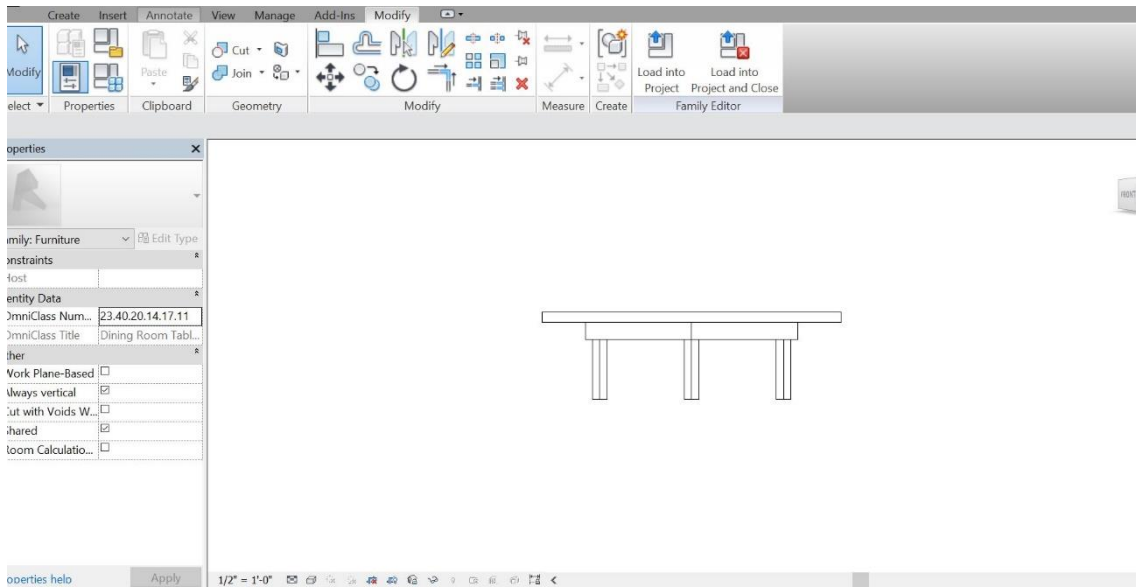


Figure 18: Dining Table Round family edited.

After adjusting tables to fit the design of ones present in D3 hall, the design of D3 shown in the Figure 19.

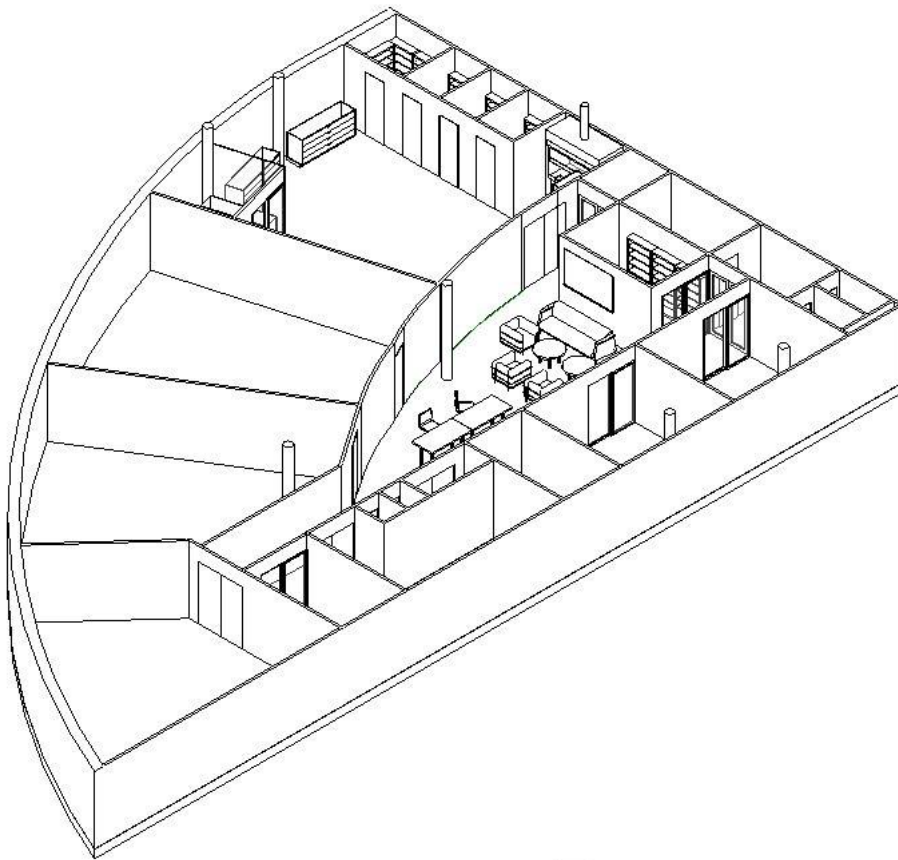


Figure 19: D3 hall design completed.

3.4.4 Classrooms

After placing furniture in the hall of block D3, classrooms have to be designed. Since both classrooms have relatively same design, only one of them will be shown in detail. In the classrooms the components that have to be used are as follows:

- Tables (out-of-box)
- Chairs (out-of-box)
- Computers (custom)
- Projector (custom)
- Whiteboard (custom)
- Projector screen (custom)

After loading those families into the Revit design the result is shown in the Figure 20 and 21 below.

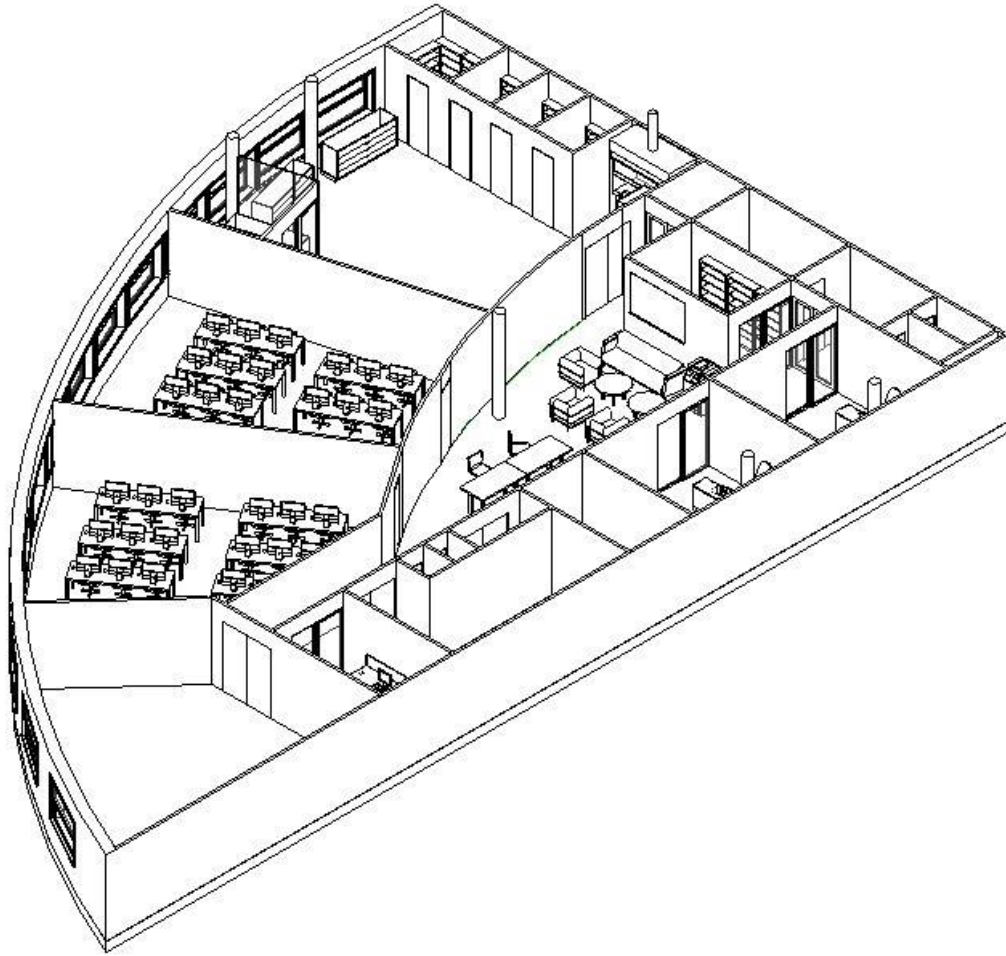


Figure 20: D3 block design with classrooms (1)

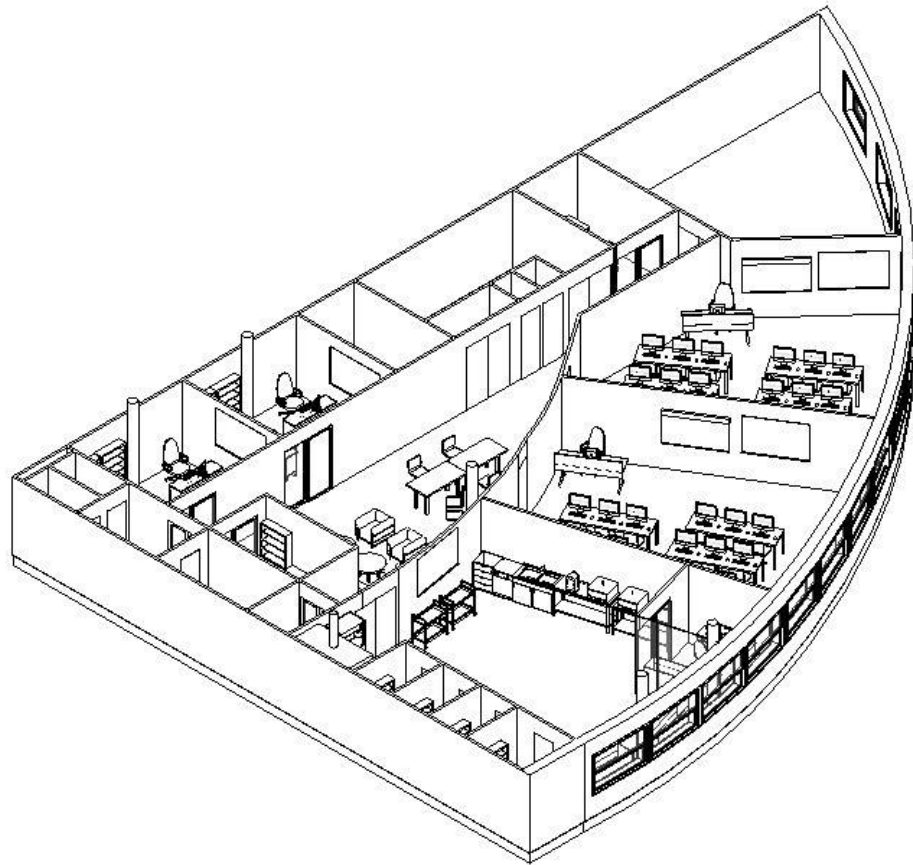
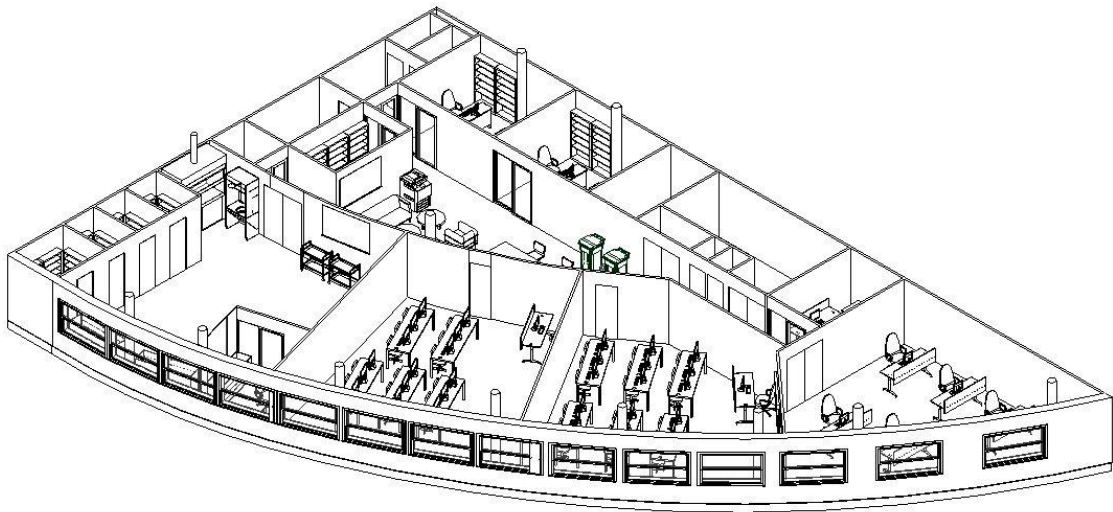
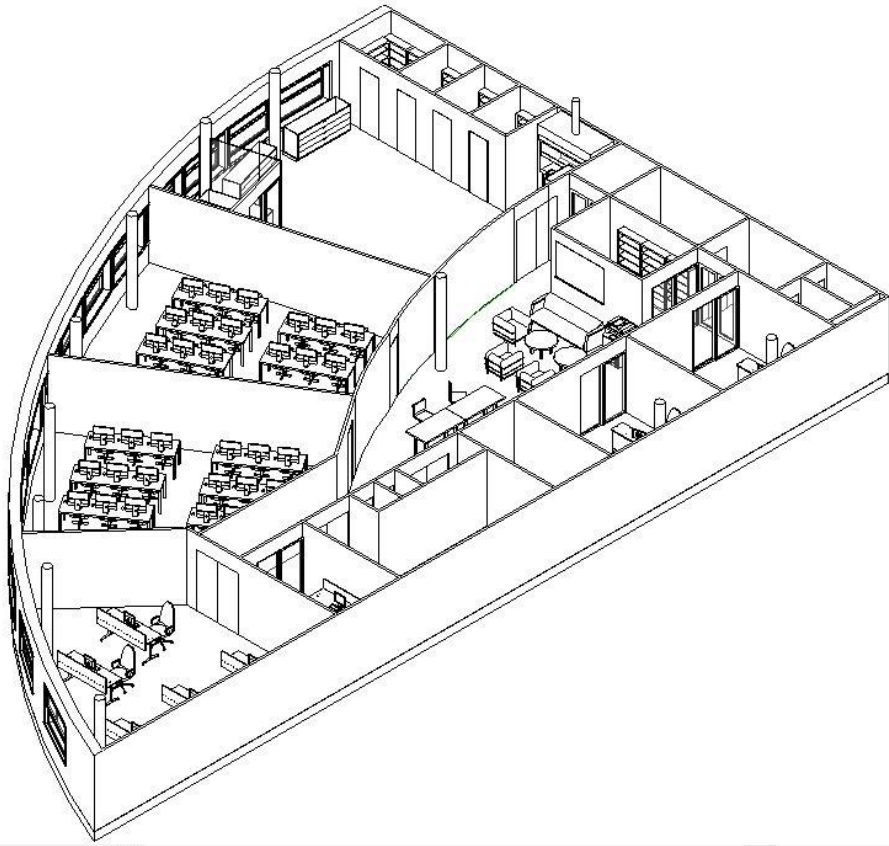


Figure 21: D3 block design with classrooms (2)

3.4.5 Ready design of D3 block

After setting up teachers' room with families which were used before, the final design is presented of the Figures below.



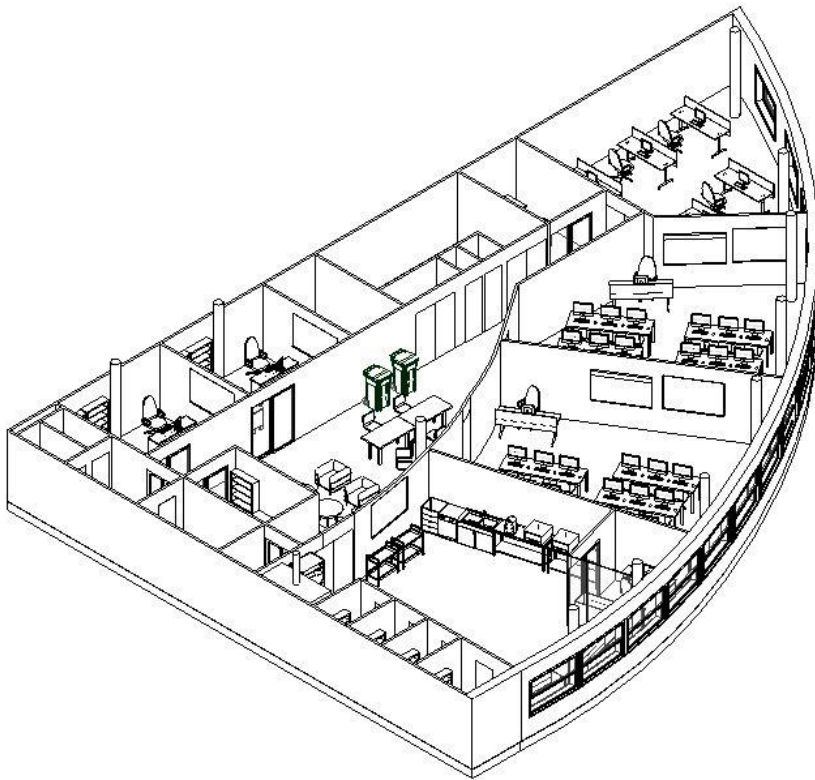
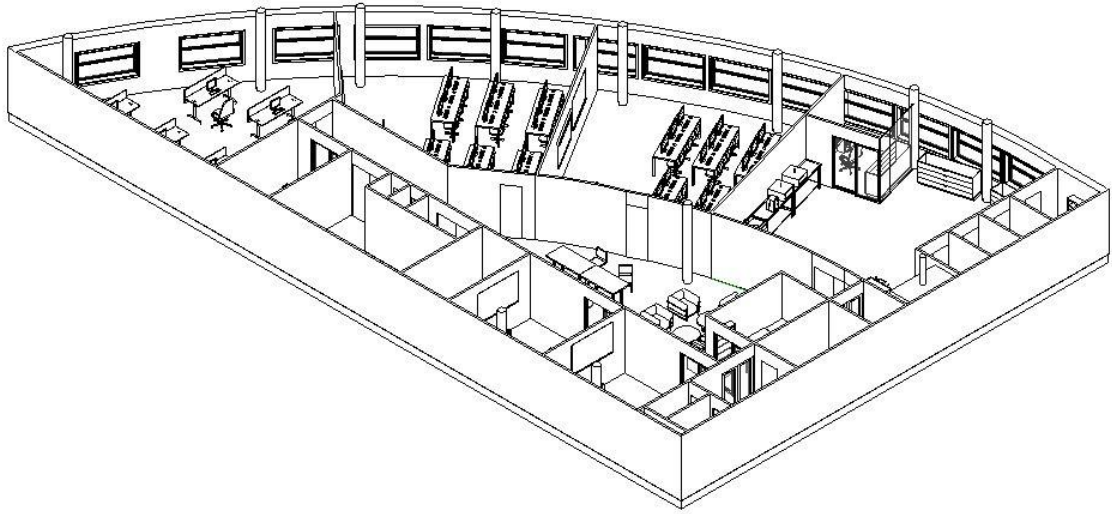


Figure 22: Ready design of D3

3.4.6 Rendering

Revit offers users to render their designs either in cloud or on the working station itself. While it is a major advantage over AUTOCAD which requires additional software to create a 3D model of the design, there are still a number of things to consider. Firstly, cloud rendering is free only for the lowest quality. Second, if the architect wants to render it on his/her machine, the system requirements are relatively high to achieve good quality. This sets up limitations for hobbyists or firms with low budget which can not afford either of those choices. Author rendered the model on own working station which considered to be middle to high-end class laptop, however, quality is low. The results are represented on the picture below. Some colors are offset, and the pixilation is disruptive. Some objects are not shown correctly, such as glass wall in the microscope room in the lab or glass doors, those are not visible at all. This could be solved by cloud rendering.



Figure 23: Rendered design

3.4.7 Walkthrough

One of the key advantages of Revit is its' capability to create animated walkthroughs of the designs made. This allows customers to have a better experience of the design even before it was built. The walkthroughs are built in Revit feature and does not need any additional tools. It is done via setting plans of the cameras and adjusting them on the key-frames in order to get a better picture.

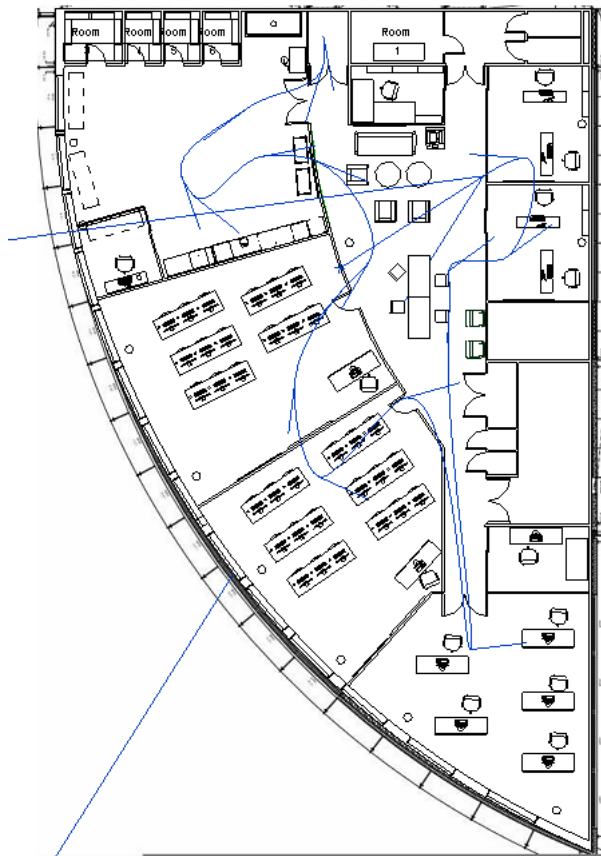


Figure 24: Walkthrough pathing

After the pathing was created, one need to adjust camera views by frames. This is achieved by picking up one of the side views and setting cameras on it.

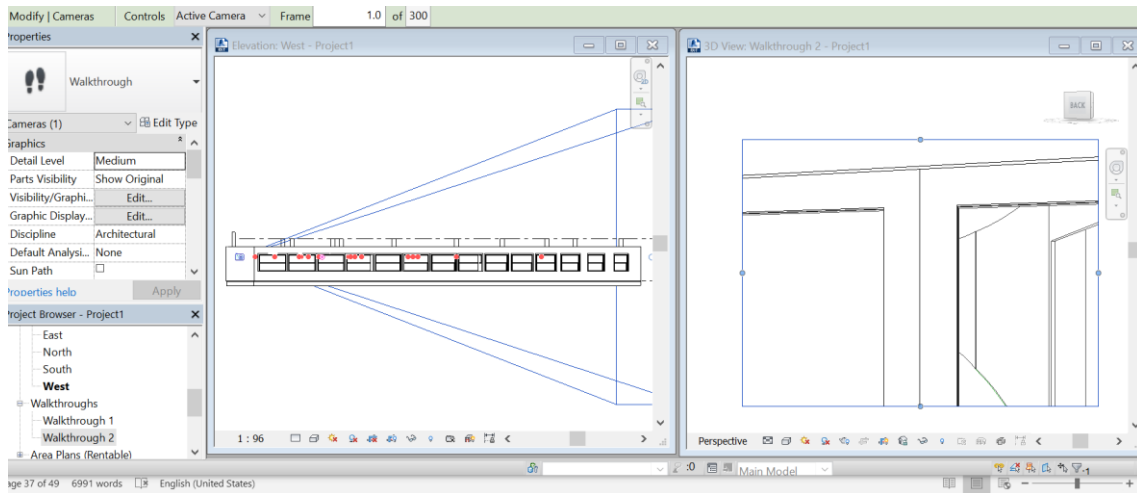


Figure 25: Walkthrough with West side view

On Figure 25 1st frame out of 300 is shown on the right part of the screen, while red dots on the left correspond to the camera views which need to be adjusted to have a better picture. This also can be done frame-by-frame. To adjust the speed, the frames per second must be changed to a lower value.

4 RESULTS

4.1 Interview results

The table below showcases the most relevant answers on the question of “How do you use Revit on your daily work and how would you compare it to AUTOCAD”. Note, grammar and punctuation are represented as original.

No.	Result
1	I've found Revit is hugely important for coordinating in the design phase as well as providing a platform for providing consistency in drawings. We not only do our drafting in Revit but use it as (or in conjunction with) analytical tools.
2	I use Revit everyday at my architecture firm and will never go back to CAD. I use it to make both construction documents and renderings
3	Revit does require the user to have a higher understanding of the way the program works than cad does - with cad you can jump on and pretty much start drawing whatever. But on Revit, you need a decent family library and a fairly good understanding of how these interact in the model environment.
4	CAD is, at worst, digitally drawing lines like you would doing drafting by hand. It gets the job done. Revit is BIM. It's a great tool but requires significantly more knowledge of construction, in my opinion, to be used effectively. I don't prefer it for design phases, but for documentation it offers incredible value for systems integration, and making sure your skin wraps the required structure.
5	If I had consultants that were at the same level, technically speaking with Revit, I'd be more inclined to introduce it earlier in the process. I'd also need to get all the technical/production staff up to speed on it.
6	Revit does require the user to have a higher understanding of the way the program works than cad does - with cad you can jump on and pretty much start drawing

whatever. But on revit, you need a decent family library and a fairly good understanding of how these interact in the model environment.
--

Figure 26: Interview answers.

The results of online interview were unanimous among those who are using Revit that they would unlikely come back to AUTOCAD if they had a choice to do so. The answers included numbers of reasonings which are as follows:

- Revit offers higher level of coordination and detail in an early stage which results in having more focusing on design tasks as opposed to technical and administrative tasks.
- Using Revit for documentation and system integration.
- Using Revit in conjunction with analytical tools and as a platform providing consistency of drawings.
- Revit is more economical to use in larger projects as it offers higher speed of design.

While feedback on sole usage of Revit was positive, the administrative part of a project work in a company where engineers using this software was mixed. It was stated that while project managers who involved into design process are comfortable navigating model in Revit, there are still problems on the contractor level. Respondents stated that most of the staff on the MEP department is more inclined to use AUTOCAD in their work, thus demanding engineers to make it look as AUTOCAD drawings. One of the respondents said that he spent countless hours creating tag and annotation families that look exactly like CAD standards they use inside the company.

Some respondents noted a steep learning curve of Revit compared to a straight-forward aspect of learning AUTOCAD while noting that with no prior knowledge in designing software Revit is easier to grasp than if one already has experience in different software.

To conclude an interview, some participants had given tips in learning Revit which are as follows:

- Customizing shortcuts on the keyboard to achieve maximum designing speed and better navigation within a model

- Creating a set of templates and standard details in order to fasten setting project up process
- Building a decent family library to reuse them in different projects

4.2 Revit software capabilities and limitations

In this chapter results of the project discussed in Chapter 3 Method are as analyzed and explained. Revit offers unique method of designing buildings and interiors using 3D modelling which allows architects to better visualize and understand a final product. Building Information Modelling paradigm is the one Revit software helps to achieve making designer's work more automotive and computable.

It is often misunderstood that Revit equals BIM. While Revit is using a BIM paradigm and helps to achieve it, those two terms are not two different things. Building Information Modelling is a step further from traditional methods used in past such as hand drawing or AUTOCAD. BIM not only saves hundreds of hours of work but offers a one-step solution for different tasks that were used to have a specific program and professional behind it in the past. Further the Revit software is explained, however, what is relevant to Revit might be relevant to other BIM programs.

Revit offers wide range of tools and functions to ease designing work and speed the process. While AUTOCAD file is a composition of lines, Revit designer works with real objects presented in real life. This makes a designing process more visual therefore, enhances quality of work and almost eliminating the risk of misunderstanding between team members regarding the purpose of the lines. They have modifying parameters and intuitively understandable.

Revit offers collaborative functions to work with a single file for a team consisting of number of members thus helps communication and cease misunderstanding of drafts. A number of team members can work on the same project real-time. While author did not tested this feature, the impact of collaboration and discussion happening in real-time is not to be misjudged.

One of the final task of the architecture is creating bill of materials, specifications of the tools used in the design (power sockets, wires etc.) in order to estimate the costs of the

project which was used to be created by hand. Revit makes all those documents automatically saving hundreds of working hours. Revit hierarchy of the objects offers to easily manipulate the properties of all same objects using during the project regardless of the it number thus helping to adjust into the final draft after contractor had some changes before building.

One of the most important yet difficult to master features is using plug-ins one of them is Dynamo. It is open source plug-in meaning that users are the main developers of it and everyone can contribute to its development. Dynamo can be used both as a standalone application and as a tool embedded into Revit. Dynamo plug-in offers a graphical interface for the command line in order to perform actions with different objects. For example, user can select all the walls by category and then rotate by a certain degree. It also helps to adjust properties of different object within one large file consisting of numerous objects. Before Dynamo was available users had to use specific commands to perform those actions making it very difficult solution for designers that did not know how to program.

As it was told earlier, Revit can create a 3D visualization of the design made in it. While the possibility to render model inside the computer exists, author found it to very resource demanding for the render of a good quality, thus, those actions were performed in cloud. Even though, AUTODESK cloud rendering is free in its basic form, if the designer need to create a better quality, more detailed and better visualized image, the credits used within AUTODESK platform have to be used. For the industrial firms and professional engineering companies this might not be an issue, author found it to be discouraging for the users who have mediocre designing machines and do not want to spend additional money apart from purchasing the software itself.

Revit also offers a vast database of user-created library of components and families created by users and available both for free and acquired by purchasing. A number of companies are producing high-quality, customizable and reliable components which can be bought in packages by designing companies. By this, Revit sophisticatedly creates more working places for engineers proficient both in 3D modelling and Revit itself. The community which continuously creates and updates a library of components and families is what makes Revit a desirable choice for engineering enthusiasts and small businesses focusing on interior design. Since those components made by community could be

acquired either for free or purchased for as little as 5\$, it almost eliminates the need of creating a new families by designers thus speeding up the work flow immensely. The only exception for this rule might be found in designs that require specific piece that was not massively produced before thus not having an image and a model online. Usually those considered as either piece of art designs and are costly thus the costs of time of development and creating a 3D component is covered by order itself.

5 DISCUSSION

The main purpose of the research was to test Revit compared to well-known AUTOCAD software for interior design and architecture purposes. The key points of using Revit are shown in the Chapter 4 Results while this chapter will focus on the close comparison between software.

5.1 Using AUTOCAD in architectural design.

While AUTOCAD statistically is the number one solution for the architectural design and is widely used around the world in number of companies, the main philosophy of the software is already outdated. AUTOCAD was created as a digital drawing tool which was used for decades by architectures. While AUTOCAD is an easy tool to pick up since all the skills were already known and all adjustments is changing a paper to digital screen and pen to the mouse, AUTOCAD suffers same drawbacks as classical pen and paper drawings. Architectural process by nature involves number of approval steps during which the draft needs to be changed. Usually that means that before creating the final clean drawings, architects are forced to make numbers of adjustments on the same file which might cause a misunderstanding because the drawing is already not clear with number of marks. Experienced architectures are stating that sometimes during large projects they were not able to see the working plane because of large number of marks that overlay the whole draft (Why Revit is better than Autocad, б.д.). This creates a space for a mistake and another failed approval process. Also, while using AUTOCAD is easy for already experienced person who is working in industry for decades and is familiar with classical mechanical drawing methods by using pen and paper, AUTOCAD file is just a composure of lines. While it has an advantage of being lightweight, it creates a difficulty distinguishing whether particular line belongs to an interior object or a constructional component. This might lead to defects during building process. Also, AUTOCAD requires a big team because of philosophy it follows. Usually, an engineering company using AUTOCAD should have following departments:

- AUTOCAD engineers to create an actual drawing

- 3D graphical specialist to transform 2D file from AUTOCAD into a 3D model
- Billing specialist to estimate costs and compose a bill of materials needed during construction

Which artificially enlarges the company and making architectural design more expensive. Also, if one of the engineers made a mistake during drawing process, the whole team must do the job once again since all of those files are not linked in any way and created separately using different programs.

While all of those mentioned above is true for a general engineer using AUTOCAD, professional users can write extensions to automate their everyday work in the program. Those plug-ins are available through the internet and can be downloaded freely but they are targeted intermediate level users as well making usage of them difficult for those who are not proficient with programming. Those extensions are not targeted in this discussion since they are not widely used in the industry.

5.2 Using Revit in architectural design.

Revit is not as widely used in industry in AUTOCAD due to several reasons:

- The software is relevantly new in a scope of established construction industry
- Revit uses a different designing philosophy compared to the one architectures are used to
- Revit is relatively hard to switch to after using AUTOCAD making, in theory rewarding change, a relatively slow process

While the reasons stated above are true, this discussion is focusing on positive sides of software that have been observed throughout this project.

In the Chapter 5.1 main drawbacks of AUTOCAD have been discussed. Revit, a young software, were made with those in mind to help organize, structure and automate designing process.

Revit offers an environment where most of the job is automated by a computer leaving a designer the most time to focus on the architectural process.

Revit is BIM software which means that the object created inside have its own parameters and functions and logically connected to each other. This method allows to shorten development time and enhance quality of the design by minimizing error possibilities. Below is the list of Revit improvements over traditional AUTOCAD.

Revit creates bill of materials automatically. The software extracts available data from the file such as number of specific components (e.g. power sockets), its parameters, cost, etc. which drastically decreases the workload of the team. This also minimizes a human factor of mistake making it more accurate. Moreover, the data is created for the component once and all the copies of the object have the same parameters, so it is easier to have all the data extracted and store it in one place.

Revit's working philosophy is centered around smart objects, so-called Families and Components. Both of those terms have their own properties and represent real-life objects. Components are used to model building elements that are installed on site, example is furniture while Families are a group of objects that have common features and related graphical representation. Those objects are easier to manipulate since they are represented on the drawing as particular representation related to this object compared to a set of lines that is used in AUTOCAD. While it has a drawback of a larger final file, the ease of drafting is not to be overlooked.

6 CONCLUSION

It is important to use up-to-date techniques in such quality demanding industry as architecture. While previous methods that have been used for decades are still working, digitalization and automation is taking more workload every day. That was the reason of introduction of AUTOCAD and now same reasonings apply to Revit. BIM offers more reliable and highly automotive methods of architectural design and switch must be made to secure further development of software. BIM is technology allowing better quality of work and lesser staff to operate. While switch from conventional methods might be costly and time consuming, in the long run the effort pays off by increase of overall quality and reduction of project time.

This work covered most cases of usage and observed main advantages and disadvantages of Revit compared to AUTOCAD. The next step to continue would be creating multi-level design with plumbing system; rendering has a room for improvement as well which would be accessible with external support.

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8 APPENDIX

