Modelling a building in ArchiCAD and Revit

State Office Building of Seinäjoki

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Bachelor in de bouw

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PREFACE

This final thesis is the result of our internship. We had the opportunity to go abroad and to spend our final semester in the land of Alvar Aalto and Jean Sibelius, Finland. In the small city of Seinäjoki, we had the chance to elaborate a project at the Seinäjoki University of Applied Sciences. It was a once in a lifetime experience, one which we could not have completed successfully without the support of the people around us.

First, we want to thank our external supervisor from Finland, Mr. Tapio Hellman, for all the guidance he gave us. He had a huge impact on the subjects we eventually covered in our thesis. He was always there to support us and guide us. He put us in contact with the right people, gave us lead-outs on the possible directions and above all took time for us in his busy daily schedule. This was always done with a smile, and nothing seemed too much for him. Thank you for the great cooperation! Kiitos!

We also want to thank our mentor, Ms. Katleen Van Tricht, for her help and support.

Also special thanks to the city of Seinäjoki. The city made it possible to use the State Office Building in our project. In particular, we want to thank Mr. Jaakko Peltonen for taking time for us. He provided us with all the possible information and tools he could spare, making our job a lot easier.

We are also grateful for Ms. Sofie Mols, international coordinator of Thomas More Kempen, and Mr. Tapio Pihlajaniemi, international coordinator of Seinäjoki University of Applied Sciences. Without them, we would not have had the chance to go abroad.

Above all we want to thank our parents. Giving us the chance to go to college and have this unique experience. Thank you for all your confidence, support and encouragement you gave us.

A special thanks goes to all the people who made our stay in Seinäjoki pleasant and unforgettable.

Last but not least, we want to thank all the people who supported us during this internship but are not mentioned in this foreword.

Thank you all!

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SUMMARY

In this thesis, we summarized our findings of the modelling of a building in Autodesk Revit and Graphisoft ArchiCAD. These are both BIM-software applications. BIM stands for Building Information Modelling.

The building we have been modelling is the 'State Office Building'. This building is part of Seinäjoki's famous City Centre, designed by renowned architect Alvar Aalto. To work with BIM, We had to acquaint ourselves with Finland's guidelines concerning BIM. These guidelines are written down in a series of documents, called COBIM2012. We also checked the dimensions of the building. We did some exterior measuring with a laser meter, to determine if we could use the old architectural plans of the building as a basis. We were also able to follow a group of professionals from the Finnish Geospatial Research Institute when they took laser scans from the City Centre. The approaches of both Revit and ArchiCAD appeared to be quite similar to each other. But there were also some differences. In Revit, the somewhat higher learning curve and smaller object library resulted in a lesser progressed model. However, the parts that were modeled have a great accuracy due to the flexibility and freedom of the Family Editor. In ArchiCAD on the other hand, due to the availability of the huge built-in library, we were able to get a lot of detail in the model very fast.

Although we were new to the software, we got some satisfactory results. We learned a great deal about the modelling-possibilities of both Revit and ArchiCAD. To put things into perspective, we eventually used only a fraction of the features of both software packages. We did not get, for example, into energy analysis, the making of sheets, the 2D-capabilities, cooperation possibilities, MEP and Structural analysis, etc... This was a matter of making choices. One of the reasons is because we specifically wanted to focus on the 3D modelling-part of the software. Another reason is that it is impossible to learn everything about two different software packages in 4 months. We thought it was far better to focus on a small part of the software and to pursue quality.

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LIST OF ABBREVIATIONS AND SYMBOLS

SeUAS	Seinäjoki University of Applied Sciences
BIM	Building Information Model
LOD	Level of detail
HVAC	Heating, ventilating and air conditioning
RP	Reference plane
GDL	Geometric Description Language

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INTRODUCTION

As students in the field of construction, we always need to acquaint ourselves with new ideas and principles. The last years, a new way of building has become more and more popular. This new approach is called Building Information modelling, or in short BIM. Although, the idea of BIM already exist for a long time, it really got a boost in the last decade. One of the reasons of this boost, is the upcoming popularity of BIM software packages like Autodesk Revit and Graphisoft ArchiCAD. As of this year, our university college offers the first-year students the possibility to work with BIM-software. Also great investments were made with the MoreBIM project at our school, to do research in the field of BIM, adopting it in the Belgian Construction industry. As this is very exciting, we also wanted to get to know more about working with BIM-software.

Because we were new to BIM-software and its modelling-capacities, we decided to use both Autodesk Revit and Graphisoft ArchiCAD to model the State Office Building in Seinäjoki, Finland. We used these particular software packages because they are currently the most used BIM-software in the world. Because we had no prior experience, it was interesting to research if there were big differences between both software packages. We were also interested in the differences in outcome with both Revit and ArchiCAD. Another interesting field we wanted to get to know better is how to approach the modelling of an existing building.

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1 SEINÄJOKI UNIVERSITY OF APPLIED SCIENCES

In the last part of our education, we had the ability to go to Seinäjoki University of Applied Sciences. A university in a somewhat small city in Finland called Seinäjoki. The School of Technology, which is a department of the University of Applied Sciences, is well known around Finland for its 3D research.

1.1 General information

Seinäjoki University of Applied Sciences, in short SeUAS, is a multidisciplinary university located in Seinäjoki, Finland. The university has a total of 20 Bachelor and 7 Master degree programs. One of these bachelor degrees is construction engineering. At this moment, there are around 4800 active students in the university. In addition, there are 400 staff members.

Internationalization is an important aim of the university. They have more than 200 partner universities and networks in almost 50 countries. An extra addition to the university and their international aims is that 3 bachelor degrees are fully taught in English.

Figure 1.1 – Aerial image of the Frami campus of SeUAS (source: SeAMK)

Seinäjoki UAS is mainly located on three campuses. The Frami area is the main campus of SeUAS and serves all the needs for around 3000 students. The fields of education on Frami campus include technology, culture and design, business, hospitality management, social work, elderly care and forestry. Of the other campuses, Kosmalantie campus has 600 health care students and Ilmajoki campus gives 400 students all the necessary education in the field of natural resources.

1.2 The CAVE

Our work environment and place to have meetings was mainly the Cave Automatic Virtual Environment, in short CAVE. The CAVE exists of 5 projection surfaces that are 3.0 by 2.4 meters. By projecting the virtual environment on these 5 surfaces, you get a complete sense of immersion in that environment. To experience the 3D view, you will need to wear stereo glasses and trade your shoes for slippers. The slippers prevent that the floor side of the projection-surface gets damaged.

The CAVE can help people to understand and perceive details in an easy way. In our work field, it is being used to show all kinds of 3D computer generated buildings, rooms and environments. But the CAVE is capable of doing more than that. It is not only used for construction & architectural purposes, but there is

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also an extra value on the fields of urban planning, factory site design, simulation, engineering, industrial design, medicine, geology, astronomy, culture, history and entertainment.

The CAVE is not only used for educational purposes. For example, there has been cooperation between the city of Seinäjoki and the University in multiple projects. A certain project was the design of the new library of the city. The CAVE made it possible to walk through the new designed library to ensure that all the desired characteristics were included in the final design. For example, the view from the inside of the new library towards some of Alvar Aalto's creations was tested in advance. Another concern was that the new library would cover the view from the streets towards Alvar Aalto's Centre. With placing the model in the virtual environment, they found the right place to build the library.

The virtual world is still developing rapidly. So apart from the 3D modelling in the CAVE, there are still a lot of other projects going on in the Virtual Laboratory. The Oculus Rift, Phantom Omni and Unity are some of these technologies and are followed very closely. These things are already very important in the virtual world and still have a huge potential.

The project where the most students have been working on is probably The Virtual Seinäjoki. This project started in 2005 when the Seinäjoki planning unit ordered a 3D model of some particular buildings of the city. The collaboration with the city for this project ended after a few months, but the project is still going on. A lot of students have been modelling one of the buildings here in Seinäjoki. The model is currently having around 140 models and is available for everyone to watch on Google Earth. The model is also fully viewable in the CAVE, so we have been lucky to watch and experience the virtual city in the CAVE.

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Figure 1.2 – Demonstration in the CAVE

2 STATE OFFICE BUILDING OF SEINÄJOKI

In our quest to find an interesting subject for our final thesis, we always talked about our desire to model one of Alvar Aalto's buildings. So we were very happy that the State Office Building could be part of our final thesis. This building was one of the latest buildings in the Administrative and Cultural Centre to be completed. The building consists of 4 stories and is mainly used as office building, but a few years ago the building was also used by the police and tax department. The building's ownership was transferred to the city in 2003.

2.1 The building

The building forms the Western terminus of Aalto's plan for the City Centre. His idea was to design an ending to the group of buildings. The construction period started in 1966 and ended in 1968. The building consists of 3 stories above ground level and a basement. It has a floor surface of more than 6000m². The courtroom is the most noteworthy room of the building. You can see a lot of Alvar Aalto's influences when you walk around. The door handles, lamps, furniture and finishing of the walls were all designed by Alvar Aalto himself.

The outside of the building is almost fully covered with white plastering. Since the building is almost 50 years old, you can see that the building needs a restoration. As the City Library is in restoration now, the State Office Building will be the next one in line. In that case, our model could be useful as a basis for that restoration.

Figure 2.1 – Alvar Aalto's Centre (source: Seinäjoki)

In order to model the building we received the original plans of the building from the Alvar Aalto Foundation. They take care of Alvar Aalto's material and heritage and store all this information in a museum located in Jyväskylä.

Figure 2.2 – State Office Building

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2.2 Alvar Aalto

Alvar Aalto (3 February 1898 – 11 May 1976) was a Finnish architect and designer. His work includes architecture, furniture, textiles and glassware. Aalto graduated with honours from Helsinki Polytechnic in 1921 after which he opened his own practice in Jyväskylä.

2.2.1 Alvar Aalto's Centre

The Administrative and Cultural Centre, completely designed by Alvar Aalto, is the pride of Seinäjoki. The centre consists of 6 buildings and are mainly completed between 1960 and 1968. Alvar Aalto already made his introduction to Seinäjoki in 1925 when he designed the Seinäjoki Defense Corps Building.

2.2.1.1 The "Cross of The Plains" church and the Parish Centre

So how did Alvar Aalto end up back in Seinäjoki after all those years? As a result of an architectural competition in 1951, Aalto's design was chosen to be constructed. But the construction of the church did not take place until 1957-1960 due to financial problems. The additional Parish Centre was constructed during 1965-1966. Our predecessors, Laura Peeters and Bart Vermeiren, modelled the church back in 2011.

2.2.1.2 Town Hall

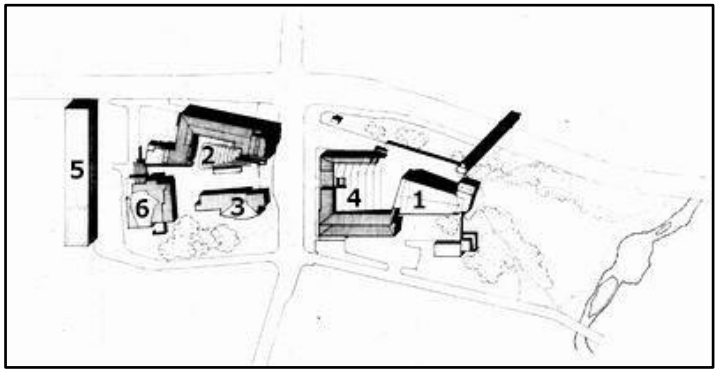
The competition for the City Centre, including the Town Hall, took place during 1958-1959. The Town Hall was constructed in 1962 and has a remarkable façade. The façade is covered with ceramic tiles, an element that is also used for the State Office Building. The ceramic tiles glitter differently according to the time of the day and the season.

2.2.1.3 City Library

Based on the design of the Town Hall, Alvar Aalto was also asked to design the library, theatre and administrative building. The City Library is constructed during 1964-1965. The library has been completely restored to its original state and is planned to be open again in the summer of 2015. They will also complete an underground connection between the old and the new library.

2.2.1.4 Seinäjoki Theatre

Alvar Aalto already drafted the preliminary design for the theatre back in 1968. These plans were updated to the more modern needs of a theatre. The theatre was finally constructed in 1987 under the lead of Alvar Aalto's wife Elissa Aalto.



1. Church	1960
2. The Town Hall	1962
3. The Library	1965
4. The Parish Centre	1966
5. Office Building	1968
6. The Theatre	1987

Figure 2-3 - Site plan of Aalto's Centre (source: Seinäjoki)

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2.2.2 Alvar Aalto's career

It is estimated that Alvar Aalto designed approximately 500 buildings during his 50-year career. Around 400 of them are built in his home country Finland. He started his career with classicistic designs, changed to modernism and ended his career with some monumental buildings.

2.2.2.1 The first steps 1920-1930

When starting his career, Aalto designed family houses in the so-called Nordic Classicism. During this period he also completed his first public buildings including several churches. The Seinäjoki Defence Corps Building is a good example of one of Aalto's designs during this phase of his career.

2.2.2.2 Modernism 1930-1960

The Viipuri Library characterizes the shift in Aalto's design, from classicism to modernism. The library went through a whole transformation. It went from an originally classical design to a complete high-modernist building. Thanks to the Paimio Sanatorium and Viipuri Library, Aalto achieved his first worldwide attention in architecture. These buildings were significant milestones on the way to modernity. It was characteristic of Aalto to treat each building as a complete work of art, including the furniture and light fittings.

2.2.2.3 Late career 1960-1976

Between 1960 and 1970 Aalto's work began to pale in colour. White plastering and ceramic tiles gave his buildings a new character. These features are easy to recognize in all the buildings that are part of the Alvar Aalto's centre in Seinäjoki. In the last decade of his life, Aalto was still an active and influential architect. One of his last famous works to draw, was Helsinki's Finlandia Hall, which he was contracted to draw in 1962. Although Alvar Aalto died almost 40 years ago, the furniture design company he established still sells many of his designs today.

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3 MEASUREMENTS

Our first job was checking the original plans. How accurate was the building constructed back in 60's? The main goal was to check the outer dimensions of the building, so we could see if the plans we used, were accurate enough. During one of our last weeks in Seinäjoki, we were able to follow a group of professionals from the Finnish Geospatial Research Institute for 2 days. They came to Seinäjoki to laser scan Alvar Aalto's Centre and the new library. The generated Point Cloud Data however, is not used. The reason for this is that we did not have enough time to properly import the data into our models. Nevertheless, it was very interesting to have been introduced to these modern techniques. In our future careers, we will certainly make use of these new technologies. We have, however, investigated how we could use the data in our models.

3.1 Checking the plans

3.1.1 Used equipment

1. Leica DISTO Plus (range of 200m) for measuring outside
2. Fluke 411D (range of 30m) for measuring inside
3. Manfrotto tripod
4. Tape ruler (length of 8m)

3.1.2 Measuring

The first laser distance meter has been invented more than 20 years ago. From that point, it became a much used and important tool in the construction field. You can measure every short and long distance in a very fast and easy way.

We decided to measure as much distances as possible. Because we had a devise that has a very long range, we tried to capture the whole length of a façade from one point. We worked from a corner of the façade. Because of this long distance, we used a tripod to have maximal control over our laser point.

An overview from the results of our measurements can be found in appendix 1. When we checked the final results of the measurement of the upper façade, we could see that the difference between the plans and the actual measurements are small. We had an average deviation of 2,33 cm and had only a deviation of 1,2 cm for the whole length of the façade.

At the bottom façade we had almost the same result with only an average deviation of 2,433 cm. We saw a deviation of 0,4 cm for the whole length of the facade. With taking the margin of error of the laser meter, human error and construction faults into account, we can conclude that we can trust on the outer dimensions that are stated on the original plans.

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Figure 3.2 – Measuring the East façade

Figure 3.1 – Leica DISTO Plus

3.2 3D Laser scanning

3.2.1 Principle

3.2.1.1 Theoretical

A 3D laser scanner will measure the environment with high speed scanning. The laser scanners that were used for the measurements are FARO Focus^{3D} X - devices, which can scan up to 976 000 points/sec and have a range of 330m. These measured points will form what is called a point cloud. The point clouds will not generate your 3D model itself, but can be used as a handy tool. The laser scanners are not yet able to scan the type and thickness of a certain building-component, but hopefully they will in the near future. You can use the point cloud from the beginning and trace over it or use it afterwards to check how accurate you have drawn your model.

But is it profitable to scan a whole building? It takes a lot of time and money to scan such a large building. We've been scanning for 2,5 hours and used 3 laser scanners. In that time, we have only been able to scan the largest parts of the hallways and the courtroom. Maybe scanning the whole building would be overkill, as the basic structure can easily be modelled without the point clouds. Scanning and using point clouds for parts of the building can be useful. Especially for complex details or for piping packages.

3.2.1.2 Practical

Setting up the laser went fast and did not take that much effort. The laser scanner has a simple and clear interface. Here you have to define the resolution and the quality. Selecting a higher resolution and quality will obviously get you a longer scanning time. In our situation, they chose for a medium resolution and quality, which got us a scanning time of 2 minutes per scan. To give an indication, picking the highest settings will get you a scanning time of approximately 30 minutes per scan.

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The last important thing that had to be set up before the actual scanning, were the target points. These points need to be in range of the laser scanners, so we are able to assemble the different scans into one point cloud. So when we moved the laser scanner to another area, the laser scanner needed at least 2 target points from the previous scan. You need to have this 'rule' in mind for every scan you do. Therefore, you have to have some sort of 'walk around'-strategy, to optimize the scanning-procedure.

Besides the scanning of the inside of the State Office Building, we have been able to see two other scanning platforms. The first one scanned the outside of the site with the laser scan material attached to an ATV/quad. The scanning devices that were used, were the same as the ones used on the inside of the building. The second one scanned the outside of the buildings with an UAV/drone. The flight plan was set up on a tablet/pc and was uploaded to the UAV right before takeoff. The UAV scanned the area based on the imported flight plan. The AUV flew on automatic pilot. The landing and taking off, however, was done manually. The technical details of the performed laser scanning in Seinäjoki can be found in appendix 2.

Figure 3.3 – Target points

Figure 3.4 – UAV laser scanner

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3.2.2 Using point clouds for modelling

3.2.2.1 ArchiCAD

ArchiCAD 18 has no integrated function that makes it possible to import point clouds. A company has developed a program, called Points4BIM, that makes it possible to work with points clouds in ArchiCAD. But it is still not possible to insert point clouds directly into ArchiCAD. You will have to run both programs and import the point cloud in Points4BIM. Points4BIM creates a connection between both programs, which makes it possible to work with the data of the point cloud in ArchiCAD.

Graphisoft has announced that ArchiCAD 19 will have point cloud support. This is one of the biggest new features, making it possible to import point clouds with the standard *.e57 or *.XYZ format.

3.2.2.2 Revit

Revit already supports point cloud import for a few years. Importing can be done in a wide range of formats. The best format to import point clouds into Revit is *.pcg. This file format is the least demanding for the system hardware. Every year, point cloud support is updated, since it is still a technology with many growing pains. We have been able to get some images of the point cloud scan of the ATV. You can see that the roof structure is missing, as well as a part of the second floor. This is because these parts are not visible from the ground floor. To also visualize this part, the UAV-data can be used.

Figure 3.5 – Point cloud from the State Office Building (source: NLS)

Figure 3.6 – Close up of point cloud from the State Office Building (source: NLS)

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4 COBIM 2012

Although the main focus of our thesis is on the 3D modeling-part, it is interesting to have a look at the practice of Building Information Modelling in Finland. First of all we should ask ourselves what this 'BIM' actually is. In a way, you can look at it as some sort of simulation of a building process. This simulation is performed using a centralized model from which eventually all data is collected to make plans, schedules, estimations, visualizations, planning, etc. From this simulation, the different building parties could learn a great deal and alter some of the initial workflow. You could say that you can learn from your mistakes before you actually make them. Also because you work with one central simulation-model from which all plans and schedules are derived, you minimalize misunderstandings during the building process. On the other hand, because all the building parties are tightly linked to each other and depend even harder on each other's work, the understanding of the process is primordial.

Because the building-process involves so many different players, you need some kind of common rules to begin with. The Common BIM Requirements 2012 or in short COBIM are a series of documents that serve as a framework for BIM-projects in Finland. The series of documents are divided in 13 general parts or series and are also available in English. You can access them for free and download them from the Finnish part of the buildingSMART website.

Part 1 of the series gives us a good insight in how the series are built up. The concept of BIM and the advantages that a BIM-workflow can have are explained. For example a BIM supports investment decisions in an early stage of a building-project. Also lifecycle analyses can be performed more easily, it aids design visualization, improves quality insurance and makes usage of the data possible for facility management later in the building process.

Further in this part there is a topic about the technical requirements for a BIM-based project. The usage of the platform-independent IFC-format for exchanging building-information is mandatory. Also the usage of a common coordinate system and the usage of the same measuring unit is stressed in this part. The usage of the proper and intended design-tools in the software is important. For example: a column should be modelled using the column tool instead of drawing a very short piece of wall. Other examples are made as well.

The role of the BIM-coordinator is also partly defined in this part. It is essential that someone overlooks the whole BIM building process and this coordinator serves as a connection point between the different parties in the BIM-process. The problems that arise in BIM-projects are often of a technical nature, so a thorough knowledge of BIM software and processes are very important.

In each of the series 2 to 13, a particular subject is covered.

In "series 2: Modeling the starting situation", we get some information on how the starting situation should be measured and modelled. This starting situation can either be a new plot or an existing building. In this series there is a part '4.1 measurement requirement, content' which informs us of the different methods of measuring and their uses. There are possible 3 levels for measuring the initial state of the building or the plot. Level 1 is the usage of a laser meter, a method we performed on the State Office Building. If you want to base your model on old drawings, like we did in our model, you should check the stated measurements on the plans by going in the field and do some control measurements. If there aren't any alarming differences, you can base yourself on the old drawings. Level 2 is the usage of a Tacheometer. Level 3 is a laser

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scanning survey. How the information in level 2 and 3 can be processed and what it is used for, you can find here as well. On the modelling part, the same rules apply as stated in the general part. You should always use the right tools for the right building components.

In series 3 to 5 respectively architectural, MEP and structural design are covered. The architectural model serves as a starting point, so it is very important that the correct modeling- methods are used. At the end of this part of the series, we can find a document called "Architecture Model Content Requirements", in which the content requirements and Level of Detail (LOD) are stated and recorded. Also for MEP and structural design in series 4 and 5, there is a similar document.

Series 6 covers the assurance of quality. This assurance can be viewed from different perspectives. Each perspective is covered in this series. From the client's point of view, it is primordial that potential issues are found and corrected as soon as possible. The content requirements have to be checked, so that they correspond with the demands in the initial design. IFC is utilized for these tasks. From the designer's point of view, it is very important to further develop his/her knowledge of the BIM-process. This way overall quality will improve, but this requires a constant adaptation and assessment of the delivered work. Finally you have the quality-improvement of the designer group. This is mainly achieved by improving communication-skills between the different parties. For each of these views, a series of tasks and 'to do's' is formulated. Further in this part of the series, the different quality assurance methods of 'checking' and 'analyzing' are covered. The BIM files that should be checked as IFC-models, and what each BIM model minimally should consist of, is stated in '6.3 BIM files to be checked'. The BIM models are respectively the Inventory BIM, Spatial BIM, Building Element BIM, System BIM and merged BIM. At the end of this part, we find how the responsibilities should be divided. There should be someone who overviews the quality of the entire project, authorized by the client. There should also be a responsible in each design-team, to follow up the internal quality of the team.

In series 7, quantity take-off is covered. A BIM-model can provide a great deal of information to measuring quantities. In this part of the series, we will not find actual instructions on how to take quantities in a BIM-model. It is more to give an idea of taking quantities in the model.

One of the important things when taking quantities of a model, is checking the consistency of the model. If a model is poorly or inconsistently made, some problems can arise. That is why all components in the building need to be modeled as agreed to in the BIM requirements document. Also arisen difficulties or certain types of decisions should be logged in the specification-document. That way, the quantity surveyor can adapt when quantifying. Another fact that should be taken into consideration is the level of detail (LOD). Throughout the project, the BIM-model and its components are modeled to a certain LOD. LOD's of components can change throughout the process, as required in the different construction- phases. This should be taken into account when quantifying. As stated before, the reason why certain building-elements should be drawn with the appropriate tools in the BIM-software is to make correct quantifications.

Series 8 is about visualization. Because BIM also includes a 3D-model, it can be used for representation purposes. In this part of the series, they make a distinction between a technical illustration and visualization. The first kind serves more as a (technical) communication tool between the different players of the BIM-team. The (photorealistic) visualization on the other hand can

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represent the designer's view project and the different design solutions. In series 9 and 10, we can read about how preliminary analysis of the building's design solutions, can aid the decision-making in a later stage. These analysis or simulations, like for example the investigation of comfort level, airflow, energy consumption, environmental impact analysis, ergonomic approaches, lighting simulation, can aid a great deal in the eventual outcome of the design.

Series 11 is goes deeper in the managing–aspect of BIM. Coordination is one of the key-aspects of a successful BIM-project. In this part, we can find some principles of information model-based project management. The process is explained, and the different roles, like the BIM-coordinator, are specified. The different stages of a BIM-project are looked at. These are stages like conceptual design, design preparation, design control, construction preparation, control of construction, commissioning/handover/takeover and the Warranty period/operation/maintenance-stage. This last phase is further explained in 'series 12: Use of models in facility management'. Finally, in Series 12, COBIM tries to give a deeper understanding on how the models should be used in construction. This is because the construction- and production -needs of the information models are specific and change, depending on the phase of the BIM-project.

Throughout the series, different principles about BIM are returning items. However, the scope is always a little bit different.

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5 3D MODELLING

After checking the dimensions of the building, our next step is to start modelling in Autodesk Revit and Graphisoft ArchiCAD. Both software companies have been investing in BIM-software for a long time. Hungarian based Graphisoft already ignited the BIM revolution with ArchiCAD in 1984. After more than 30 years of development, Graphisoft has come to the 18th version of ArchiCAD. The software is recognized as the first CAD product on a personal computer able to create both 2D drawings and parametric 3D geometry. The first version of Revit was designed in 1997 by a company called Charles River Software. In 2002, Autodesk purchased the Revit-technology. This year, version 2016 has come out, offering Architecture-, Structure-, and MEP versions. With both ArchiCAD and Revit, you can create a 3D Building Information Model, from which you can create all the necessary documentation and images automatically. For this project, we ran ArchiCAD 18 on Apple's OS X Yosemite and Revit 2016 on Microsoft's Windows 7 SP2 64-bit.

Table 5-1 - Used computer hardware

	Revit	**ArchiCAD**
Processor	Intel Centrino Duo T7500 2,2 GHz	Intel Core i7 2 GHz
Memory	4 GB DDR2	16 GB DDR3
Graphics card	AMD Radeon HD2600 256 MB	AMD Radeon HD6490M 256 MB
Hard disk	250 GB SSD	500 GB HDD

5.1 Getting started

Before we could start the actual drawing-process, we needed to get to know the software-packages first. Initially we were only going to model a building in ArchiCAD, exploring all the possibilities of the software. While we were searching for an appropriate building to model, we started by getting to know ArchiCAD by doing a lot of different tutorials. Graphisoft offers many ways to learn their software, by offering a wide selection of tutorials. They have 5 training series, beginning with some basics, applied on a very simple structure (series 1). Gradually new and more advanced topics are introduced, ending with the topic of 'teamwork' in series 5. The main free source of information for Revit is offered through their Revit Help-portal. Also on the Autodesk University website, you can find a lot of information about their software packages, including Revit.

Besides the official channels of the software vendors, there are a lot of other paid information sources you can tap into. Also Youtube proved to be very helpful, as there are a lot of users sharing their experiences.

Figure 5-1 – Overview of the training series of Graphisoft (source: Graphisoft)

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5.2 Interface and basics

5.2.1 ArchiCAD

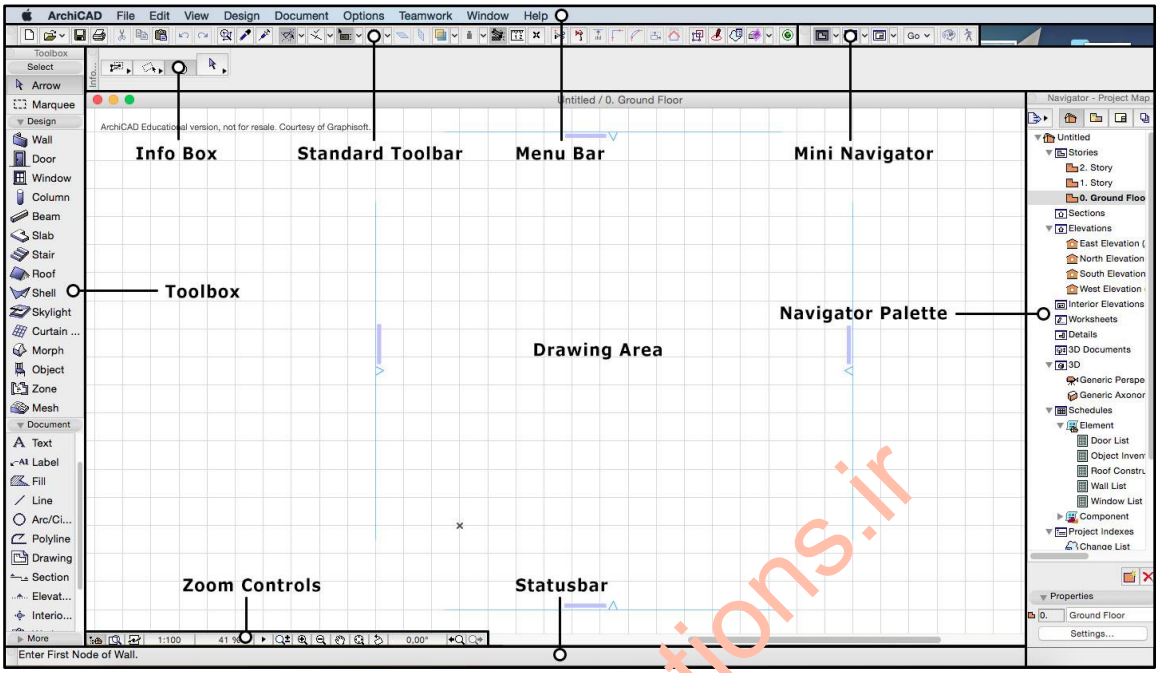

Figure 5-2 – ArchiCAD interface

5.2.1.1 Toolbox

The Toolbox shows the tools that can be used for selection, 3D construction, 2D drawing and visualization. The Toolbox is divided into 4 groups: Select, Design, Document and More.

The group Select shows 2 tools, which can be used to select elements. The Arrow Tool is the default tool that will be selected when no other tool is selected. You can select an element by left clicking on it. To select more elements at one time, you have to hold the TAB-key while clicking on the elements. With the Marquee Tool it is easier to select larger particular parts of elements.

The group 'Design' consists of all the tools, which can be used to draw an element. You can select one of the design tools by just left-clicking on them.

The group 'Document' has an amount of tools, which can be used to create, draw or edit a 2D document.

The group 'More' consists of tools, which were not able to specify in one of the previous groups. The Grid Element Tool, the Lamp Tool and the Camera Tool are the most important tools that are located in this group.

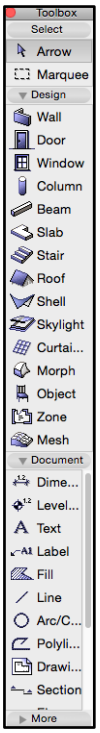

Figure 5-3 - Toolbox

5.2.1.2 Navigator Palette

The Navigator Palette is a tree structure that let you build up the entire structure of your project and navigate within it. You can create folders, then copy, drag and drop views and other project items, depending on their purpose. The Navigator Palette displays the whole project in 4 different maps. You can

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navigate through the maps by clicking on each one of them at the top of the Navigator Palette.

1. The Project Map

The Project map consists of a tree structure of the components of the model. At the top of the Project Map, the house icon represents the project and is followed by the name of the project. This map locates all kinds of views like the stories, elevations, sections, details and 3D documents. By double clicking on the views, they will pop up in the drawing area.

2. The View Map

The View Map shows the list of saved views in the project. This map consists of a variety of views from one viewpoint. When the project develops and is starting to get bigger, it is getting harder to get a clear view over the elements. The views are just viewpoints that will show you certain parts of the whole model. For example, it could be useful to only see the bearing elements or only see the floor or ceiling elements. You can set up any view that you want.

3. The Layout Book

In the Layout Book you can start organize the layouts and preparing to print the plans.

4. The Publisher Set

In the Publisher Set you set up the items you want to publish. In this map you define the publishing method and format. The most common publishing formats are PDF, DWG and IFC.

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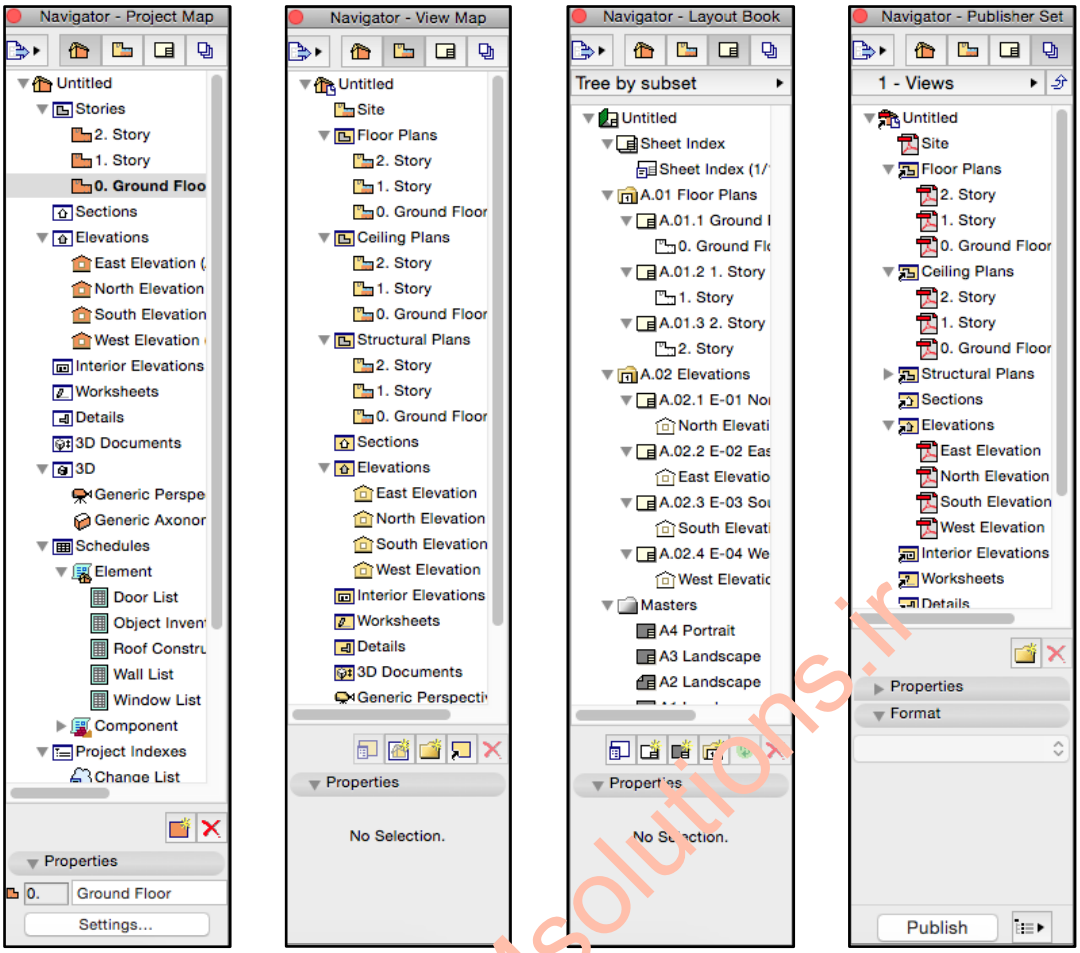

Figure 5-4 - The 4 views of the Navigator Palette

5.2.1.3 Info Box

The Info Box is available for every tool of the Toolbox. When you activate a tool or select an already existing element, the Info Box will display the current parameters of that tool/element. If several elements are selected, the Info Box displays these parameters for the last selected element.

The Info Box consists of a collection of input and parameter controls that are specific to the selected tool or element. All these controls are also available in the Tool Settings Dialog. The Info Box is a quicker and easier way to change the control, because it stays on the screen while you are working. For example, the layer, material, height and thickness of a wall are just a few of the parameters that can be edited in the Info Box.

Figure 5-5 - The Info Box when the Wall Tool is selected

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5.2.1.4 Statusbar

The Statusbar is located at the bottom left of the ArchiCAD interface. It hints what you can do next.

Figure 5-6 -The Statusbar

5.2.1.5 Standard toolbar

The Standard toolbar exists of the most frequently used actions. This toolbar provides standard actions like new file, open, save, print, undo and redo. Some of the actions we used the most will be explained in detail below.

Figure 5-7 - Standard Toolbar

1. Find & Select

We can use Find & Select to select and deselect elements based on defined criteria. This is an easy way to select a large amount of elements without having to select them all separately. We can search for elements according to the following criteria: element type, building material, layer, fill, structural function, etc.

2. Pick Up and Inject Parameters

Picking up parameters (left icon) from an already existing element can be very useful when we need to draw an element with the same or slightly other settings. When we move our cursor over an element whose parameters we want to pick up. The element will highlight with a blue colour, telling us which element we are focusing on. When we now click, for example on a wall we want to pick the parameters from, the Wall Tool will be selected automatically. This makes it possible to directly draw a wall with the parameters we have just picked up. The Pick Up command can also be selected by holding the short key 'Alt'.

When you have picked up parameters of an element, it is also possible to inject these parameters into an already existing element (right icon).

3. Trace

You can opt to display 2 different views together in every model and layout view. This is called a Trace Reference, which can be placed alongside, on top or underneath the actual drawing that you are working on. It acts as a kind of underlay, making it easy to compare multiple model views/drawings on the same screen. This was very useful when drawing columns and outer walls of the next story. This way, we could just trace, based on the story below and make sure that the elements were right on top of each other.

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4. Measure

After placing each element, we checked if they were placed on the right spot. Therefore, the Measure tool was very useful. This was a great way to get quick feedback. To use the Measure Tool, just select the icon from the Standard Toolbar, or use the shortcut 'M'.

5.2.1.6 Menu bar

At the very top, the Menu bar lists all the available commands, which are divided into different groups. As Design and Documentation are separate processes, the tools and commands supporting these processes are also located in separate menus. The Teamwork menu supports collaborative work, and the Window menu sets the visibility of the toolbars and palettes. In the Help menu, you are able to find all kinds of guides and helping documents.

Figure 5-8 - Menu Bar

5.2.1.7 Mini Navigator

With this tool, you can navigate through the stories. The first icon on the left will take you to the 2D view, the second one will open the 3D and the third icon will open the layout. When you want to specify the view that you want to open, you can click on the small arrow that is located on the right side of the icons.

The options for the 2D view are shown in the figure below [5-9]. The current selected story will be shown at the top. 'Go Up a Story' activates the story above the current floor plan. 'Go Down a Story' takes you to the story below the current one. 'The Go to Story' command opens a dialog box, allowing you to fill in the number of a story. This can be very useful when we have a large amount of stories. We can start the Orbit- and Explore Mode with the 2 remaining icons on the right.

Figure 5-9 - Mini Navigator

5.2.1.8 Zoom Controls

At the bottom of the interface, you can find the Zoom Controls. A set of icons helps you to navigate through the project and set the drawing scale and zoom factor.

Figure 5-10 - Zoom Controls

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5.2.1.9 Pet Palette

The Pet Palette is a collection of commands that pops up when you draw or edit an element. In most cases, the Pet Palette appears after you have placed an element and then select the element for further editing. Which commands appears in the Pet Palette depends on the following: the selected element, the part of the element you selected (edge, node or surface) and the active window.

You can move your cursor over the icons to read the tool tip for each one. Selecting one of the commands can be done by clicking on the icon. An easier way to navigate through the commands is by using the shortcut 'F'. The Pet Palette automatically disappears when the operation is finished.

Figure 5-11 - Pet Palette

5.2.2 Revit

In Revit there are quiet some concepts to get familiar with, and as we were quiet new to the software, they could be overwhelming at times. Nonetheless, it was important to acquaint ourselves with some of these concepts.

5.2.2.1 Working environments

There are some different working environments in Revit in which you can create 3D content. Although these are not all being used in the drawing of the State Office Building, it is interesting to distinct one from another. As we become more and more familiar with Revit in our future careers, we will certainly start to use each environment more intensely. Each environment has some different rulesets and approaches for creating 3D-content, but there are also similarities. We distinct 3 major modeling environments: the Project environment, the Family Editor environment and the Conceptual Massing environment.

1. Project environment

This is the typical environment, which displays when you start a new project. In this environment, you place system-families like walls, roofs and floors and load component-families like windows and doors. This will be the main setting of our project. There are different elements in the project-environment we can distinct. You can access this environment by starting a new project. To do this, we go to the Application Menu > New > Project. There are different elements in the project-environment we can distinct.

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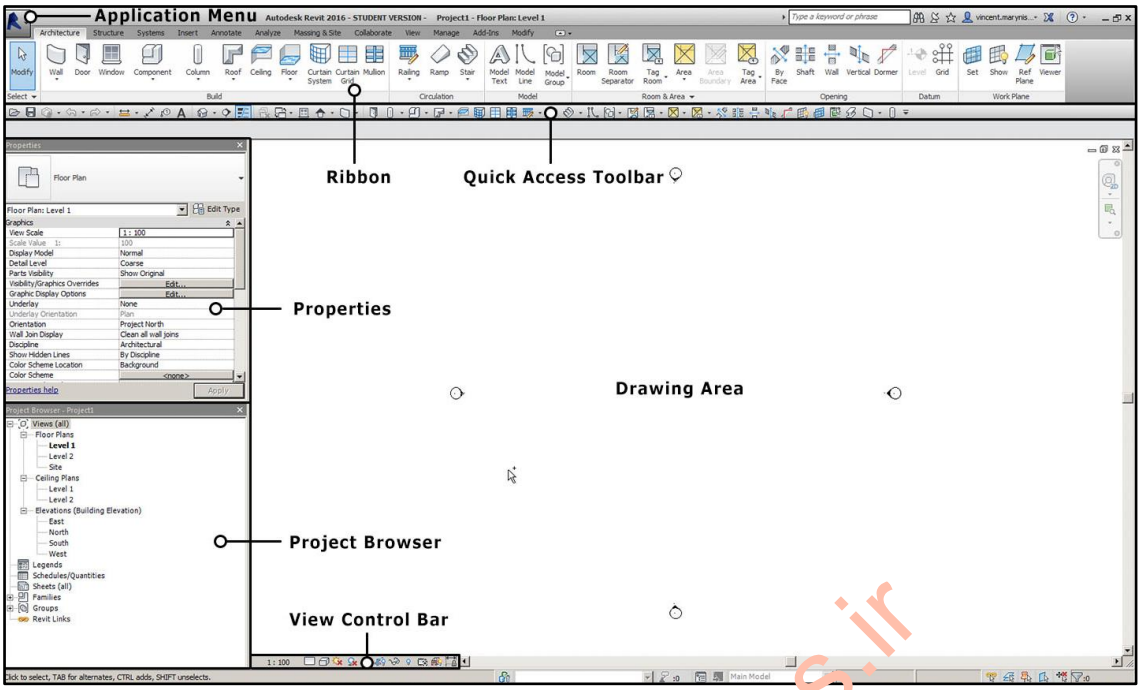

Figure 5-12 - Revit interface

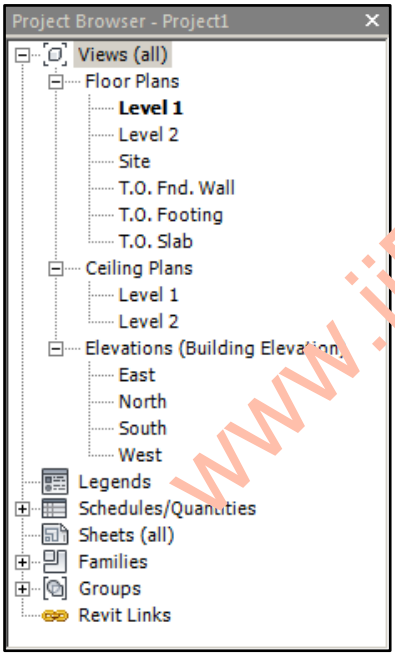

Figure 5-13 - Project Browser

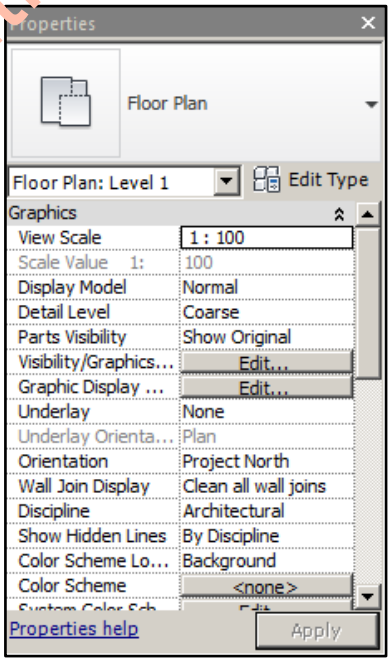

Figure 5-14 –Properties Palette

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The Project Browser displays a list of all possible views, sheets, families and parts in the project.

In the Properties Palette you can view and modify parameters of a selected element.

The Quick Access Toolbar is a customizable bar where you can add all kinds of commands, so you can gain quick access to them. This is something you can simply do by right clicking on the command, so you activate 'Add to Quick Access Toolbar'. This is something that is highly recommended to do, to speed up your work. By default, this bar is shown above the ribbon. But you can change this by right clicking on the toolbar.

Figure 5-15 - Quick Access Toolbar

To further speed up your work, you should also make use of shortcuts. In our case, we activated most commands by short key. Some short keys are predefined, others you will have to add yourself. This is something you can do by going to the Application Menu > Options > User Interface > Keyboard Shortcuts > Modify. We added some ourselves, like for example Trim/extent Single Element (TS) and Trim/extent Multiple Element (TM). We advise to use short keys as your main way of starting new commands.

The Tabs/Ribbon bar is where you find most of the commands and is highly customizable to serve your needs. Here you can cycle through the different disciplines that Revit supports, like for example Architecture, were you place walls, doors and windows. In the Structure part, you can add structural columns and beams. In the Systems-tab, you find all kids of tools to draw details MEP-systems (mechanical, electrical, and plumbing). You can only find these 3 displines together in de educational version. Autodesk separates these disciplines in the commercial versions, being Revit Architecture, Revit Structure and Revit MEP.

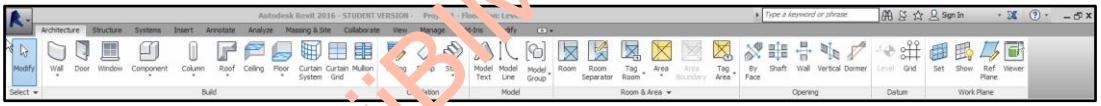

Figure 5-16 – Ribbon

The Drawing Area is where all the action takes place. In this area, the views are displayed that are listed in the project browser. By default, every time you open a new view in the project, it stacks on the previous view. This way all views are open in the background and you can quickly cycle through them.

The View Control Bar is another bar you will often use. Here you can access the view-related settings, the most important being 'Scale', 'Detail Level', 'Visual Style', 'Temporary Hide/Isolate' and 'Reveal Hidden Elements'.

Figure 5-17 - View Control Bar

By hovering over the different command-buttons, a brief explanation pops up. If it is still not clear, or if you are just interested to dig deeper, you can press F1 to go to the help portal. We found the Help-portal of Revit to be a great way to discover the different toolsets in a non-linear way.

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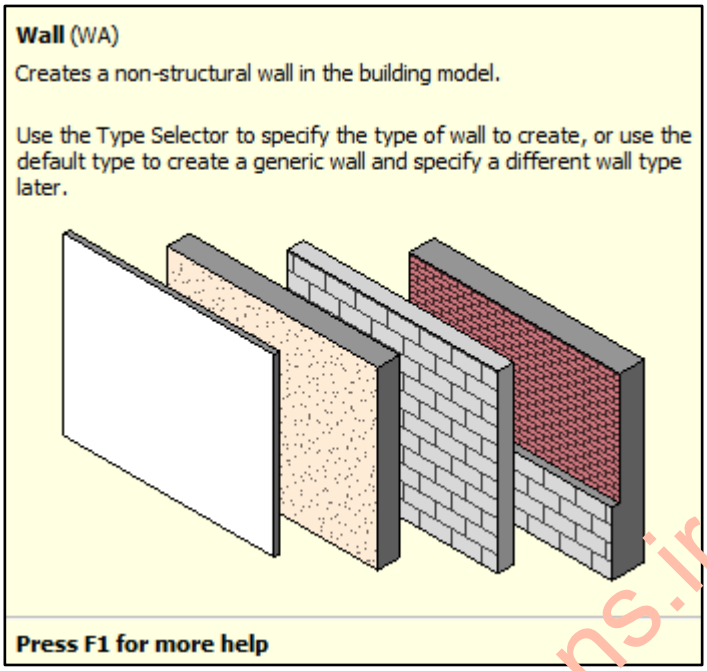

Figure 5-18 - Brief explanation of the Wall Tool

2. Family Editor Environment

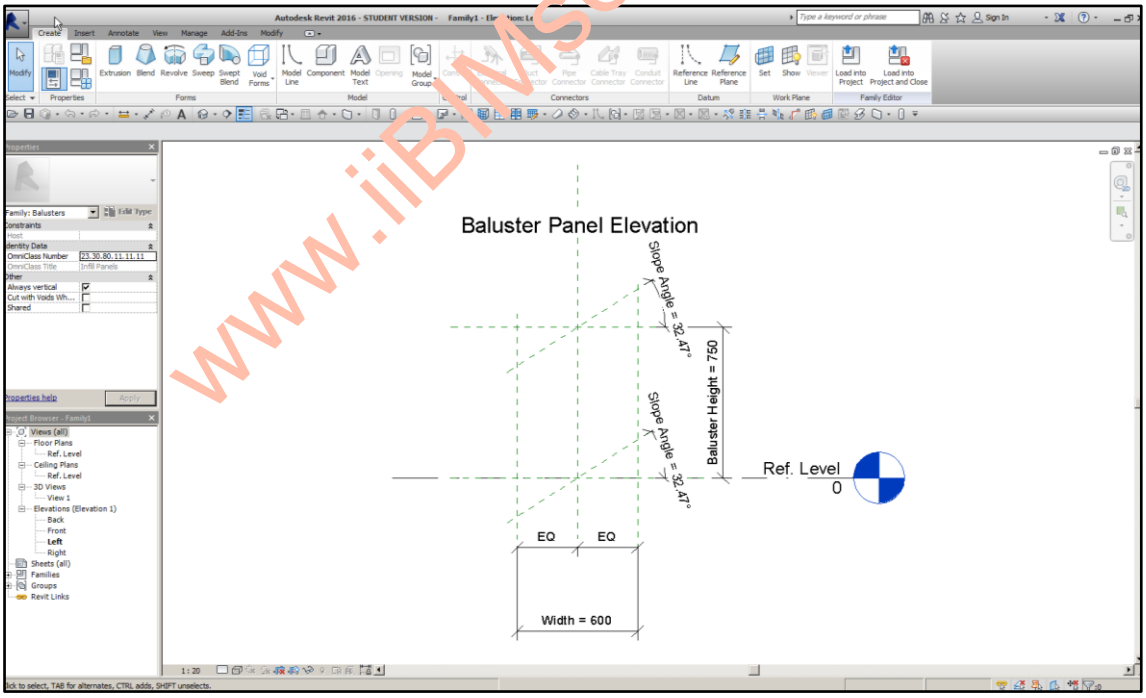

Figure 5-19 - Family Editor interface

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In the Family Editor-environment, you can make all kinds of components with the aid of family templates. Here you can make 3D geometry with some basic tools like for example 'Extrude', 'Blend', 'Revolve' and 'Sweep'. Reference Planes are used to constrain geometry and add parameters to the components. Most of 3D modelling is done using 2D views and very simple manipulation. The final product that you create in this environment can be imported back in the project environment for use in your 3D-model. This environment looks very similar to the project-environment. You also have a Ribbon, a Project-Browser and the Properties Palette. The Tabs, however, have changed. The Architecture -, Structural- and Systems Tab have been replaced by a Create Tab. This is where you will find the different kinds of manipulation tools like Extrude, Sweep and Revolve.

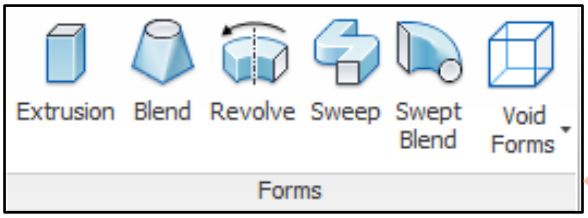

Figure 5-20 - Different kinds of basic manipulation forms

Under the properties-palette in the Ribbon we find important tools like Family Types [5-21A] and Family Category & Parameters [5-21B].

The Reference Plane and The Reference Line, both important tools for making a Component, can also be found in the Datum Panel of the Create Tab. We will go deeper into these tools when we actually make some geometry in the Family Editor (See 5.7 Revit Families).

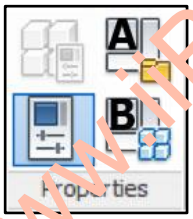

Figure 5-21 – Properties

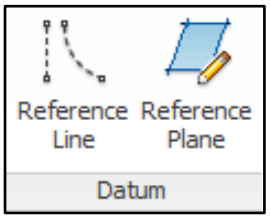

Figure 5-22 - Datum

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3. Conceptual Massing Environment

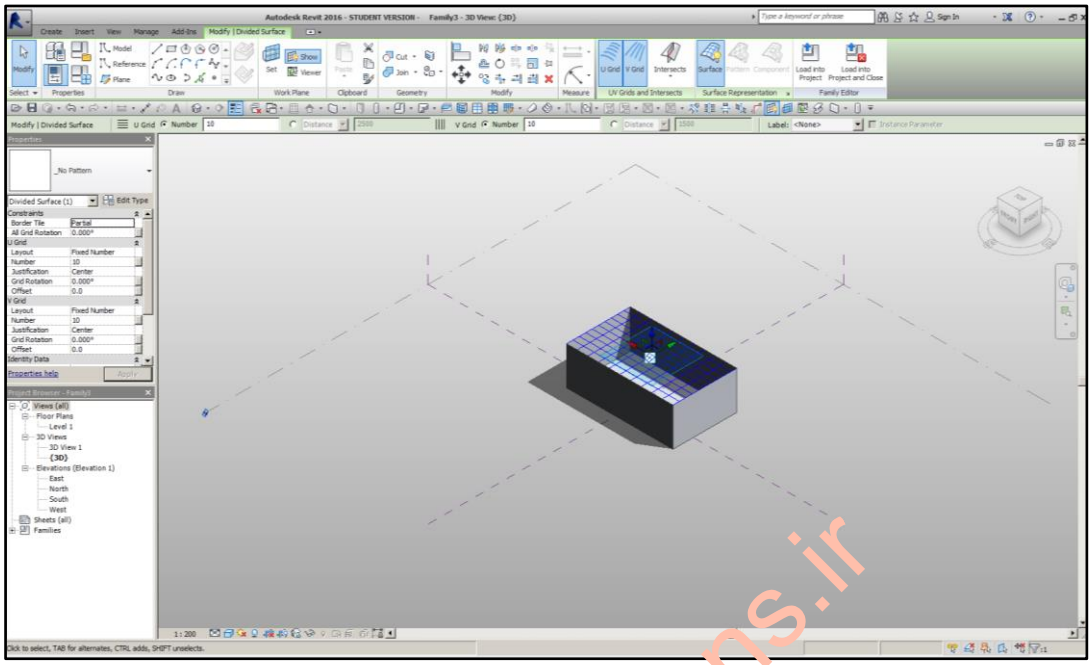

Figure 5-23 - Massing interface

You can see this as a variation of the Family Editor. This environment was first introduced in Revit 2010. You can also create 3D-forms, but the approach is different. You will mainly manipulate the object in 3D and how you do manipulations is somewhat different. One of the purposes of using this environment is to explore forms and do massing studies.

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5.2.2.2 Elements and hierarchy

There are 3 different kinds of elements in Revit we can distinguish. First, we have the model elements, and these represent all the actual 3D geometry in the building model. Walls, windows, doors, roofs, columns are great examples of model elements. Secondly, we have the Datum elements. These are elements who help to define the project context. Grids, levels and reference planes are examples of these kinds of elements. The last group are the view-specific elements. They are only displayed in the views in which you place them, hence the name. Annotations, such as tags and dimensions are examples of these kinds of elements.

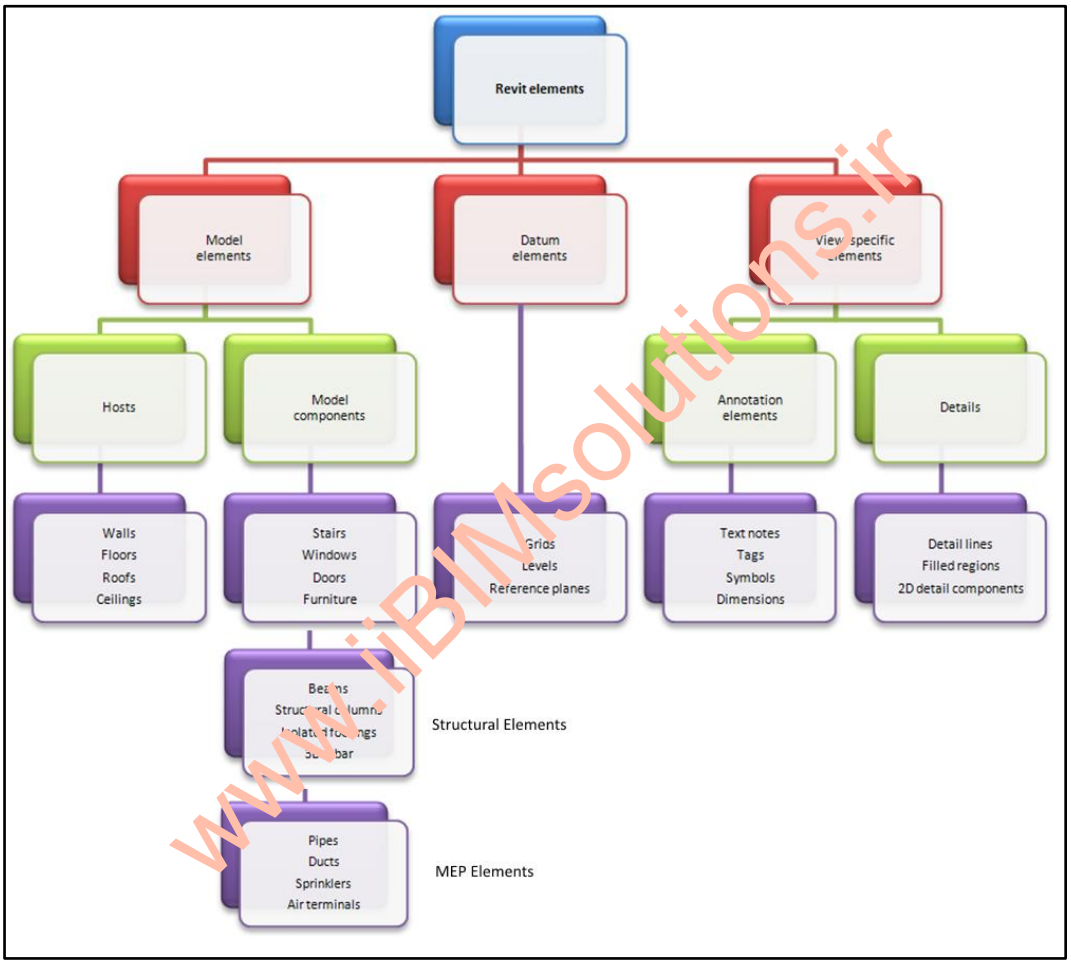

Figure 5-24 - Hierarchy overview (source: Autodesk)

All these elements answer to a certain hierarchy of Categories, Families, Types and Instances. This is best explained by an example. If we select an element in the project environment, like for example a column, we can see this hierarchy by hovering over the element. In this case, the selected column is an instance of the UC305x305x97 Type column, which is part of the UC-Universal Columns Family. This family is part of the Structural Columns Category. The power of this system is, that when you change certain properties of a type of a family, all instances of this type change accordingly in the whole project. That way you don't have to change every instance individually, which will save you a lot of time.

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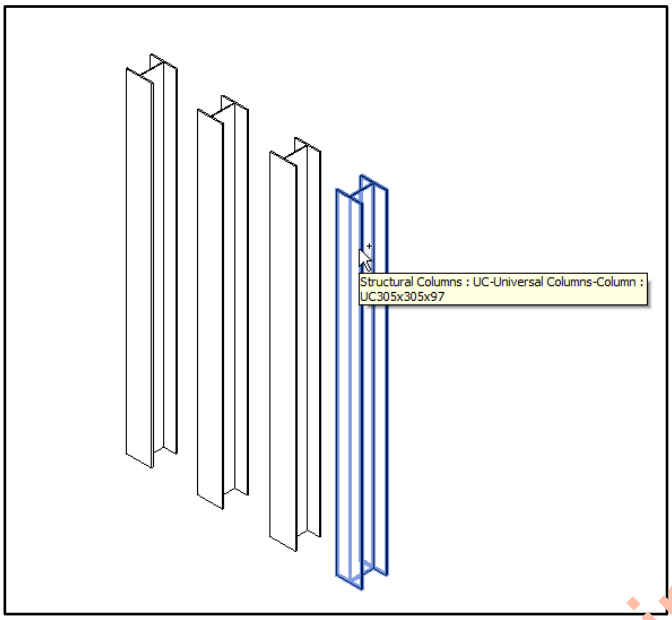

Figure 5-25 – Instance of a column

5.2.2.3 Families

The concept of a family is very important in Revit. On the Autodesk Help website we can find a good definition: "A family is a group of elements with a common set of properties, called parameters, and a related graphical representation." So everything we draw in 2D or 3D, is in some way related to this concept of families. There are 3 major kinds of families: you have the 'System Families', the 'Loadable or Component Families' and the 'In-place Families'.

1. System Families

System Families are hardwired in the project environment of Revit. You add parameters, layers, materials to a certain system family, and they are bound to certain rules which are predefined in the software. You can't load them, nor save them externally. These are typically basic elements that you assemble on the building site itself or an actual building project. Examples of a system family are for example walls, roofs and floors. These kind of families are often quantified in terms of length, surface or volume.

2. Loadable Families

Loadable Families, also sometimes called component-families, are another major kind of family. These you don't create in the project environment, but in the Family Editor environment. These are typically elements that are installed in the building, based on the carcass of the building. They are often counted as individual objects. You could see them as more self-contained and less dependent on other geometry. Doors, windows, furniture and plumbing-fixtures are great examples of loadable component families. Also 2D-components you use for making sheets, such as symbols like a north arrow or title-blocks, are loadable families. However, these are part of the Annotation Family instead of the Component Family. You can recognize Loadable Families by their *.rfa extension. When people speak about families in general in Revit, they often mean a loadable or component family.

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3. In-place Families

The last kind is an In-place Family. These are created in the project-environment itself, with many of the basic tools you find in the Revit Family Editor. The shape of an In-place Family and form are heavily based and referenced to other project geometry. This means they are almost impossible to export or copy, since they are so dependent on actual project-geometry. This kind of family you can, for example, use when you want to create a desk element that is supported by a uniquely shaped column in the project. When the column is located somewhere else or form changes, the desk will adjust accordingly.

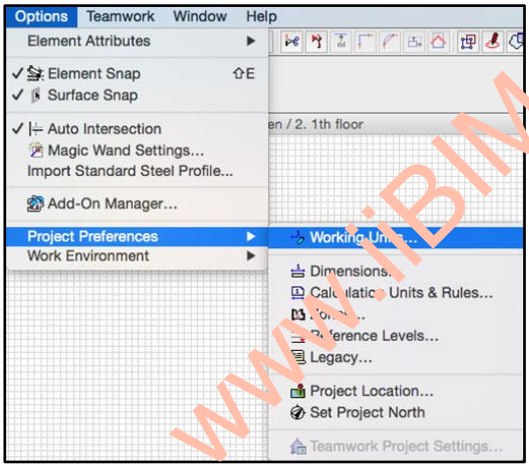
5.3 General settings

5.3.1 Working units

There are a few importing things to customize before we start drawing. As we want to draw our model following the COBIM rules as much as possible, the first task was to set our working units to millimeter.

5.3.1.1 ArchiCAD

To edit the working units in ArchiCAD, you go to the Menu Bar, select Options > Project Preferences > Working Units [5-26]. In the Working Units Settings Dialog [5-27], we select millimeter as our working unit.



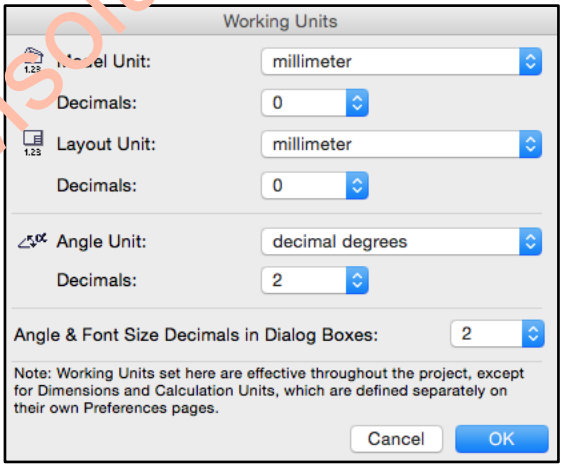


Figure 5-26 - Navigating to Working Units *Figure 5-27 - Working Units Dialog*

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5.3.1.2 Revit

To edit the working units in Revit, you go to the Manage-tab on the Ribbon > Settings Panel > Project Units and adjust the settings accordingly.

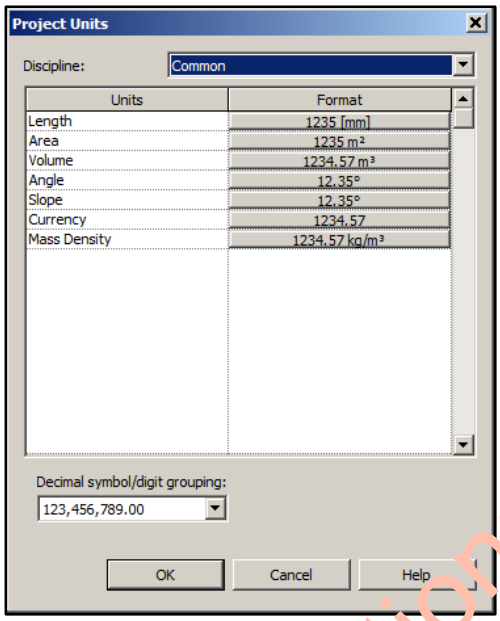

Figure 5-28 - Project Units Dialog

5.3.2 Project location

Specifying the project location and orientation is crucial to calculate the right position of the sun in our 3D-environment. The position of the sun is important in situations like 3D views, camera views, photo renderings and sun studies.

To specify the latitude and longitude of the building, the easiest way is to go to the building location on Google Maps. If you left click at the position of the building in google maps [5-31A], the exact latitude and longitude will appear on the top left [5-31B] of your screen. Also were the north is situated, can be derived from Google Maps.

5.3.2.1 ArchiCAD

To edit the location of the project, you have to go to the Menu Bar, select Options > Project Preferences > Project Location [5-29]. In the Project Location Settings Dialog [5-30], we begin by adding the Project Name and the Site Address. When clicking on the edit button [5-30A], a structured dialog will pop up so you can add the Project Name and Site Address.

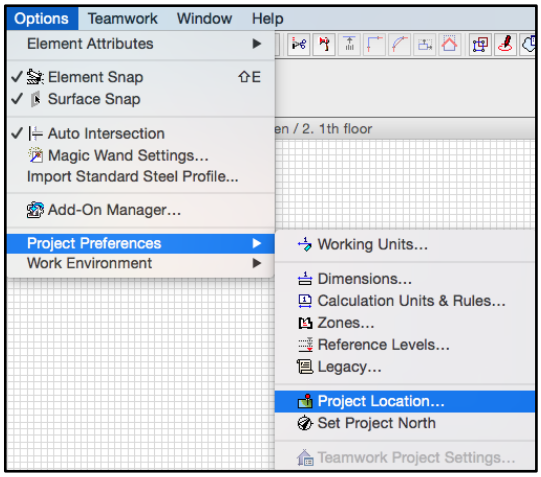

Figure 5-29 - Navigating to Project Location

You can just copy and paste the numbers you get from Google Maps into the latitude and longitude box [5-30B]. You can control the location by clicking on 'Show in Google Maps' [5-30C]. This button will direct you automatically to

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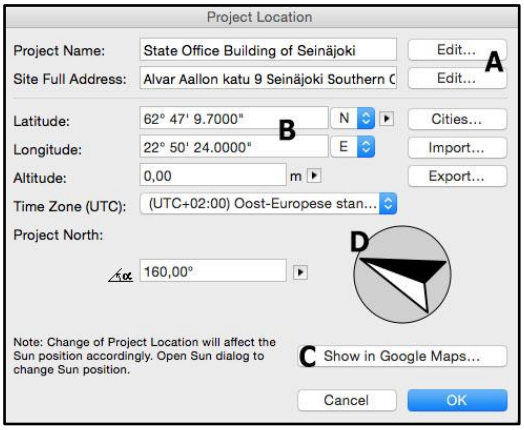
Google Maps, based on the numbers you filled in for latitude and longitude.

We can define the North in 2 ways. The first option is to fill in a specific angle. The second option is to move your mouse above the icon [5-30D] and move the pointer towards the north.



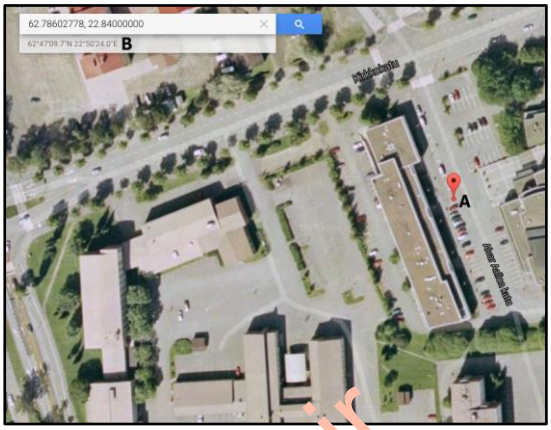


Figure 5-30 - Project Location Settings Dialog *Figure 5-31 - Location of the building*

5.3.2.2 Revit

To access the location parameters, you go to the Project Panel on the Manage Tab > Location. Like in ArchiCAD, we looked up the exact coordinates on Google Maps. To change the orientation of the building, go to the Manage Tab > Project Location panel > Position.

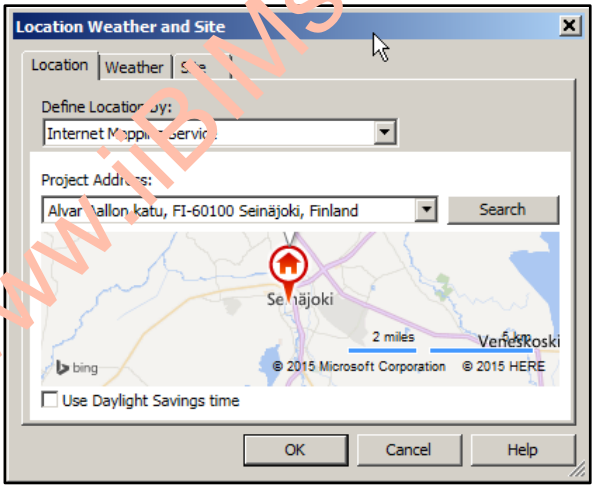


Figure 5-32 - Location Settings dialog

5.3.3 Importing the original plans

In order to be able to draw the model, we needed to have consistent plans of the building. Initially we got some AutoCAD-plans from the City of Seinäjoki. These plans were drawn for administrative purposes, to locate all the different spaces and their surface-area. However, the plans had not enough consistency to serve as a base for our project.

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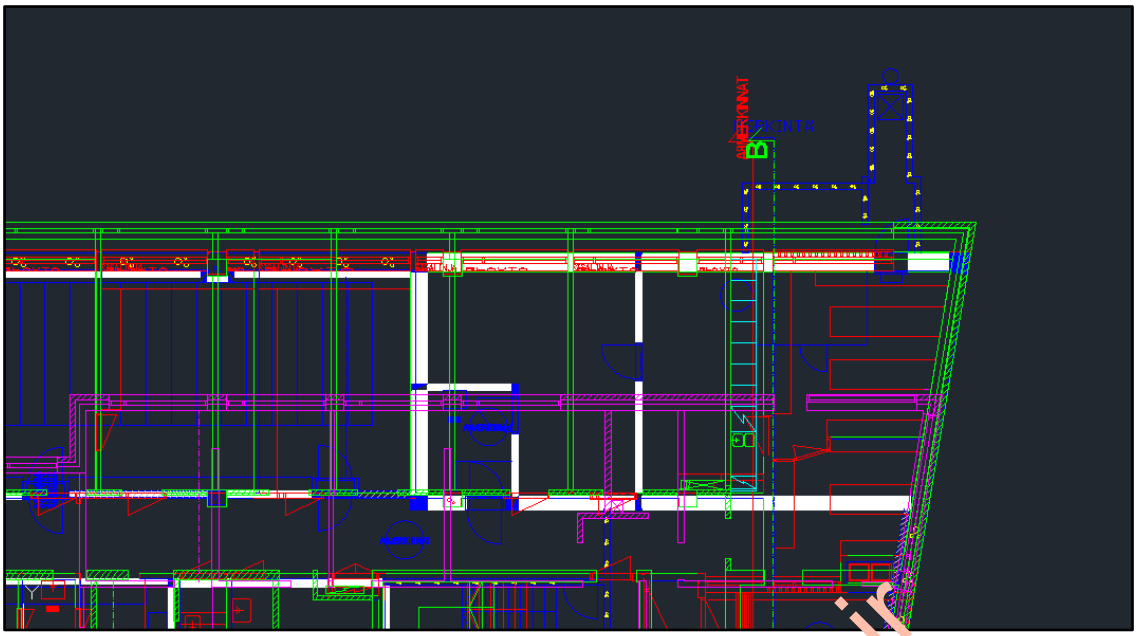

Figure 5-33 – Inconsistent AutoCAD-plans

There was also the possibility to get the original plans drawn by Alvar Aalto himself. Both the City and the Alvar Aalto Foundation were contacted, and we were able to get the scans of the original plans. The Plans of the Alvar Aalto Foundation were a little bit different from the ones from the city. Because the plans from the Alvar Aalto Foundation had very detailed written dimensions, we decided to use these as our main source of information.

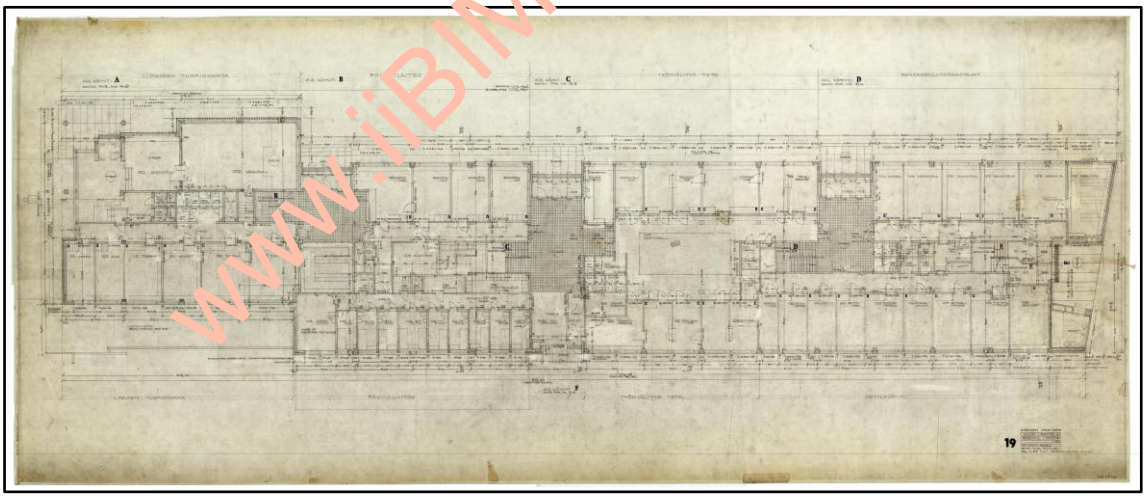

Figure 5-34 - Original plan of the ground floor

In order to be able to work fast and efficient, we decided to import the plans into the software. We used the plan as an underlay, so we didn't need to go back and forth between the software and the pictures of the plans. We also got the plans on paper, but these were too big to constantly work with. The paper plans were helpful in situations where dimensions were missing, so we could still measure the distance on the paper plans. You can find all the original plans in appendix 3.

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5.3.3.1 ArchiCAD

The easiest way to import the plans, is just to drag the file from the location you stored it [5-35A] and drop it into the ArchiCAD drawing area [5-35B].

In our case, the plans were JPG-files. But it is also possible to import all kinds of other file types. The most important formats are PDF, DWG, DXF, PNG and IFC

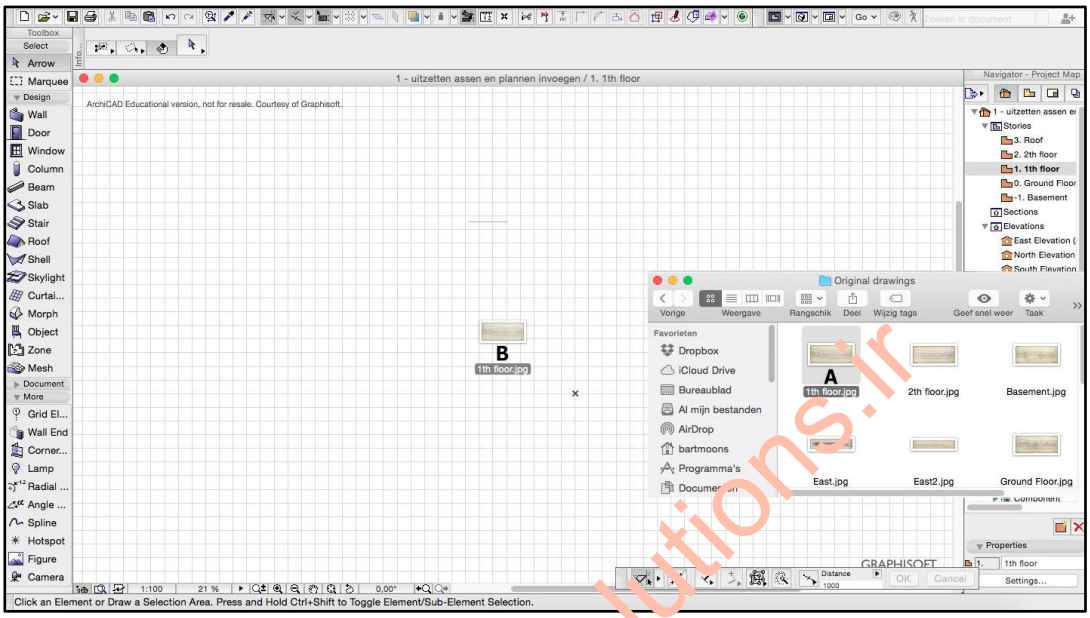

Figure 5-35 - Drag and dropping the file into the project (in ArchiCAD)

5.3.3.2 Revit

You can use the same procedure as in ArchiCAD by dragging the file into the project browser. However, in contrast with ArchiCAD, you cannot drag PDF-files directly into Revit. Although this was not an issue in our project, this is quite a handicap. There is a work-around however, by converting your PDF to an image-file with a converter. Not being able to drag PDF's directly felt strange, since this file type is a widely used format.

5.3.4 Scaling and rotating the plan

5.3.4.1 General

Once we have imported the plans into the appropriate floors (the topic of making new floors is handled later), we need to rotate and scale the plans. This way we can define the location of the walls on the plans in an exact manner. First, we searched for a long line with a known dimension on the original plan. The longer the line, the more exact the scaling is going to be. Then we can rescale the image with the scale tool. In both software packages, this is done quite similar. Rotating is also quite easy to do.

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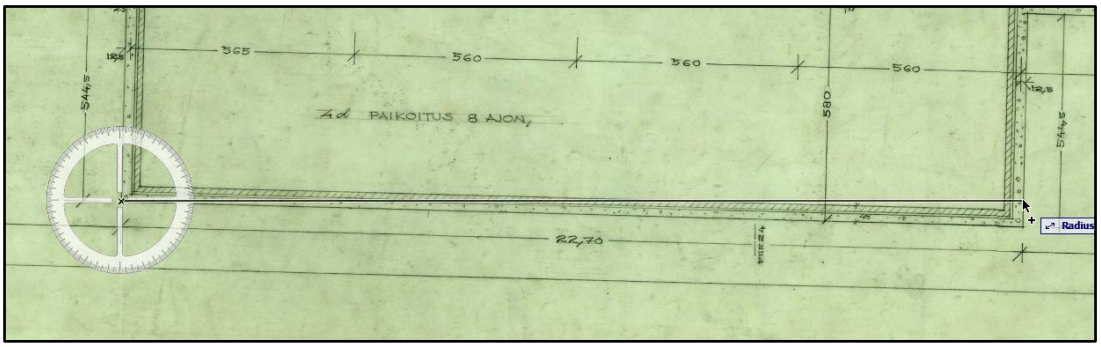

Figure 5-36 - Rotating the plans (in ArchiCAD)

Once we have decided which dimension to use as our reference, we select the image and go to Edit > Reshape > Resize [5-37]. You can resize either by giving a scale-ratio or by defining it graphically. We decided to go with the latter. You select both points of the existing line and enter the desired length. The image will then scale appropriately.

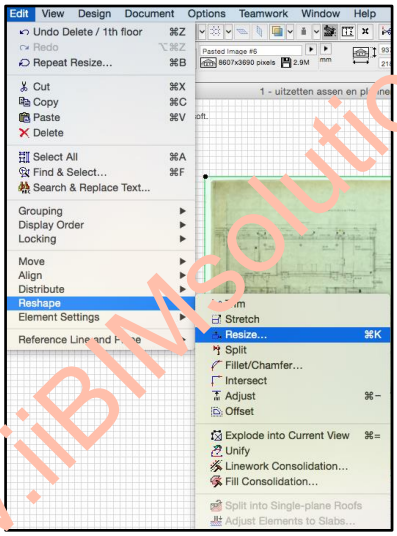

Figure 5-37 - Navigating to Resize

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Rotating is also easy to do. To rotate the file you have to go to the Menu Bar, select Edit > Move > Rotate. Another way is to just right click on the selected image and select Move > Rotate. Then you will be able to rotate the image. You can rotate the image to any angle you want, additionally the software will give hints when you are at 0, 90, 270 or 360°.

5.3.4.2 Revit

When you select the image, the modify tab will become active in the Ribbon. There you can activate the Scale (SE) and Rotate (RO) commands. Scaling is done similarly as in ArchiCAD. You pick two points of the line you want to rescale while the scale-command is activated. Then you type in the desired length and the image will scale appropriately. Also rotating is almost the same as in ArchiCAD, with the difference that you have to override point-snapping by typing 'SO' (snaps off) while you are in the rotate command. Otherwise you will always automatically snap to increments of 90° when you want to trace over the initial line on the image.

5.3.5 Setting up the grid element

5.3.5.1 General

As there was no grid drawn on any of the plans, the first step for us was figuring out a logic grid that would make drawing easier. We have to admit that this was not an easy job. Initially we based our Grid system on both the boundaries of some concrete walls as on the centerline of the columns. After some trial and error, we decided to just base our gridline on the columns of the first floor. One of the purposes of a gridline is to make the plan a little bit more logic and readable. We changed the grid at least 3 times to finally get the most efficient and best one. We decided to identify the horizontal gridlines with letters, starting from the bottom. The vertical gridlines are identified by numbers.

In ArchiCAD it is possible to the place a Grid System. This means that all the gridlines will be placed at one time. It is also possible to draw them separately if you need custom shapes, like for example a curved gridline. In our case all the gridlines are straight, so we were able to place the grid with a Grid System.

In Revit, it is not possible to place a grid system. So you have to draw each line separately, either by sketching and moving it to the right place or by offsetting it from the previous one.

5.3.5.2 ArchiCAD

In Archicad, you create your grid by going to the Menu Bar > Design > Grid System [5-39]. The Grid Element Settings Dialog will open [5-38]. All the settings are separated into 4 groups: General Settings, Grid Elements, Naming Rules and Grid Positions. The things you can define under General Settings are the geometry of the grid, which can be orthogonal or radial. It is also possible to place columns immediately together with your grid system and show dimensions between the gridlines on the 2D views. Under Grid Elements, you can define the position of the grid-tags and the point of input of the grid. In the Naming Rules-dropdown you can set up the naming of the gridlines.

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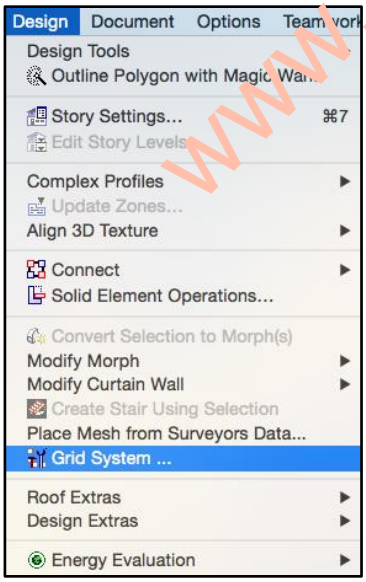

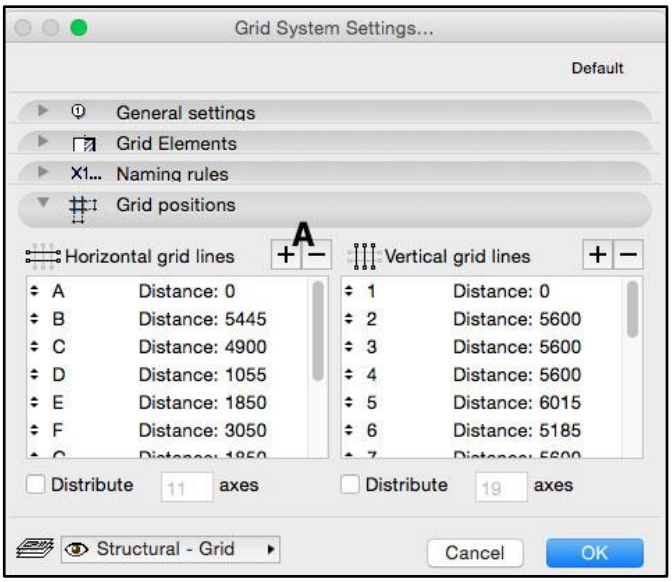

Figure 5-39 - Navigating to Grid System *Figure 5-38 - Grid System Settings Dialog*

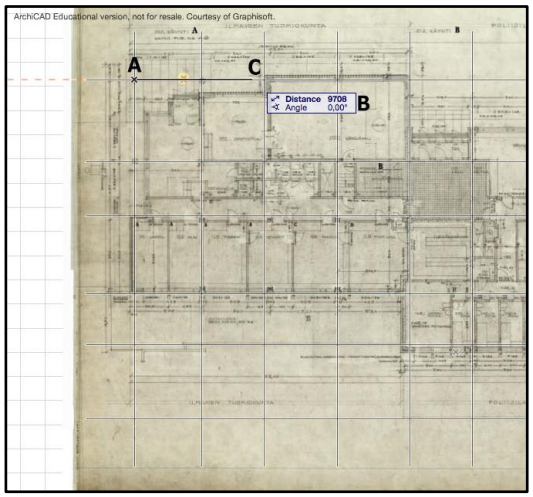

Figure 5-40 - Placing the grid

However, the 'Grid positions' is the most important setting [5-38]. You can add or remove grid lines by clicking on the plus and minus signs [5-38A]. When you have added the required gridlines, the next thing to do is defining the distances between the gridlines. You will have to fill in the distance between the selected gridline and the previous one, not the distance relative to the starting/first gridline.

A 'ghost' grid system will show up and now we can place the grid system by left clicking in the drawing area [5-40A]. ArchiCAD will now ask to click a second time to define the final position. This second click will determine the rotation of the grid system. In our case, the angle is 0°, so we can just enter this in the 'distance and angle box' that pops up [5-40B] or drag our cursor horizontal to the right [5-40C] and click on a random distance.

5.3.5.3 Revit

In Revit you have to draw each Grid Line individually. This can be done in different ways. When in plan view, activate the Grid command by going to the Datum-panel in the Architecture tab and select the Grid-command. Alternatively, you can use the short-key 'GR'. The first grid is drawn on-screen in the Drawing Area. We place the next grid by using an offset from the first gridline, with the 'pick lines' command in the Draw-panel. You will see that Revit numbers the grids automatically. When we start drawing the horizontal gridlines, we don't need numbers anymore but letters. You just have to adjust the number to a letter, to A in our case, and Revit will automatically number the rest of our horizontal grids to B, C, D, etc., while you draw them.

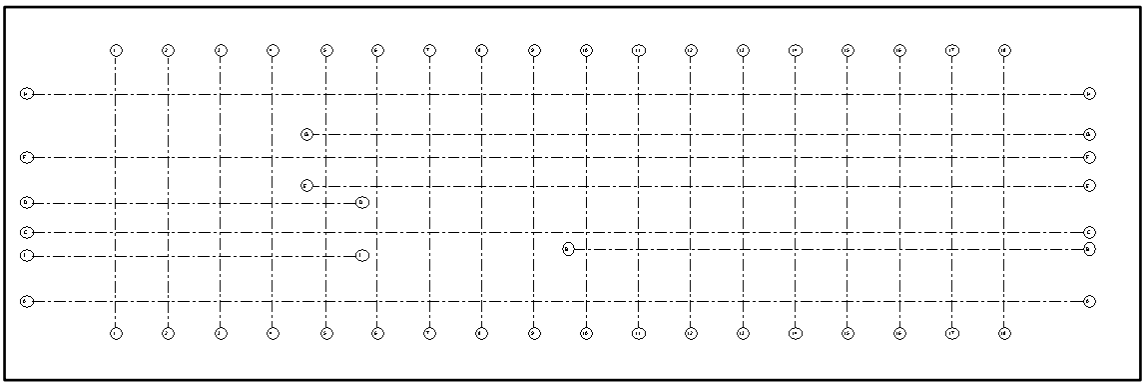

Figure 5-41 - Finalized grid for the State Office Building (Revit)

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5.3.6 Stories

5.3.6.1 General

The building has 3 stories above ground level and 1 story beneath ground level. However, we will need to create 5 stories because we also need a story for the roof. This is for example necessary to place the skylight domes.

The story levels on the old plans are shown relative to the sea level (e.g. +45,000). We also wanted to do this in our model because it would be easier for us to work with. We changed the elevation-values to millimeter, since everything in our project is in this unit.

5.3.6.2 ArchiCAD

In ArchiCAD, all the stories are displayed in the Navigator's Project Map. You can open a story by double clicking on them. You can also open and switch between the stories by using the Mini Navigator, which we already explained earlier (see 5.2.1.7).

ArchiCAD automatically creates 3 stories in every new project. So we could use these stories and add 2 extra. To edit the stories settings, you have to go to the Menu Bar, select Design > Story Settings [5-43]. Another option is to right click at one of the stories in the Navigator Project Map and select Story Settings. When the Story Settings dialog opens, you add 2 extra stories by clicking on the 'insert below' or 'insert above' button [5-42A].

1. Trial and error

The first time we created stories, we just imported the (high) values of the original plans. After defining the names of the stories, we started to fill in the elevation of the floors. But while doing this, it was not possible to give the basement with numbering -1 a positive elevation. This was a problem. Later in the project, we realized that we did not use the proper manner for importing these numbers. In the next paragraph, we will explain how we should have done it. Back in the beginning, we fixed this issue by deleting the story with numbering -1 and we numbered the basement 0 instead [5-42B]. 'The Height to Next' will automatically update by filling in the 'Elevation' and it does the same when we do it the other way around.

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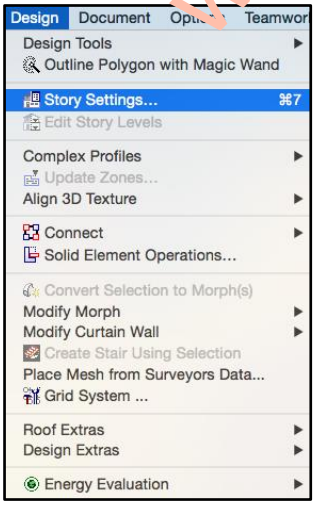

Figure 5-43 - Navigating to Story Settings

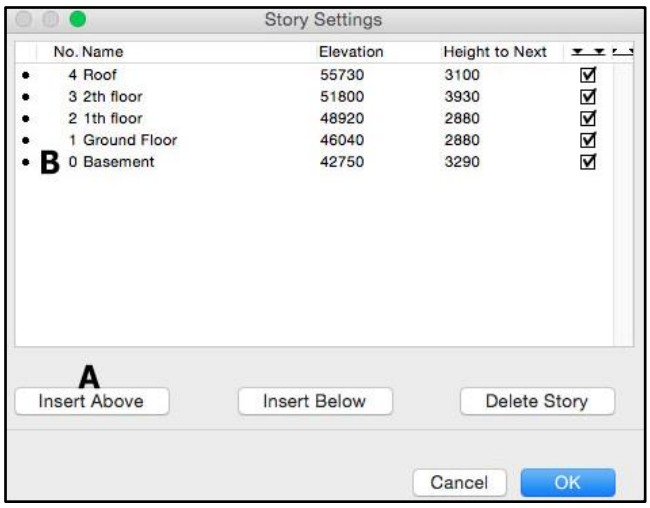

Figure 5-42 - Story Settings Dialog

2. How we should have done it

The previous way is not the proper manner for importing these numbers. In ArchiCAD, your ground floor elevation should be 0. It is also more logic if the basement has -1 as number. When the model was almost finished, we found the right way to do this. We changed the numbering of the basement to -1. The next thing we did, was editing the elevation-values. The ground floor starts with an elevation of 0 and the elevations of the other stories should be related to the ground floor and not to the sea level. After this, the settings are like shown in the figure below [5-46].

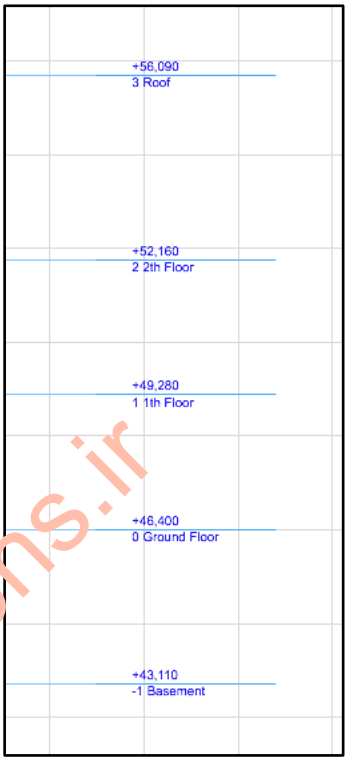

Figure 5-44 - Final elevation settings

The next thing we did, was defining the altitude between the ground floor and sea level, which is in our case is 46,4 meter. We defined this in the Project Location Settings (see 5.3.2.1). The Altitude box is located under the latitude and longitude settings. The last thing we did is navigating to one of our elevations or sections. When the elevation or section is opened, you right click at a blank space in the area and select Section Settings. The Section Settings Dialog will now open and we opened the group Story Levels [5-45A]. Now we can change the reference level from project zero to sea level [5-45B]. When clicking OK, the Level Points will automatic change [5-45C]. You will have to do this in every section and elevation as the settings will only be changed for the opened view.

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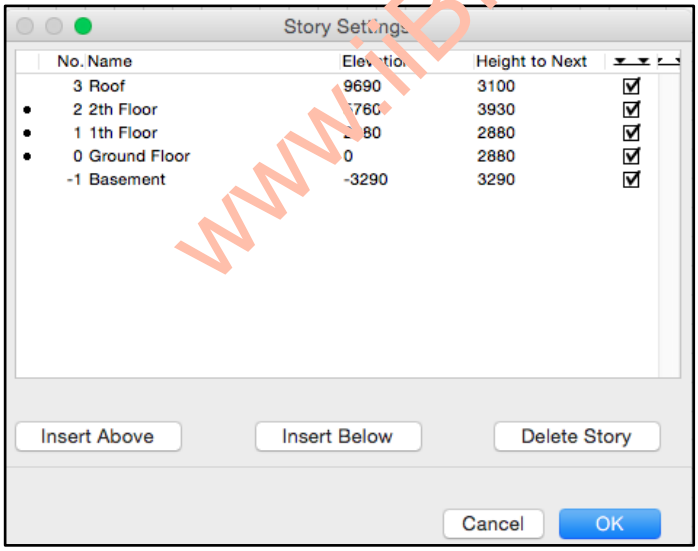

Figure 5-46 - The right story settings

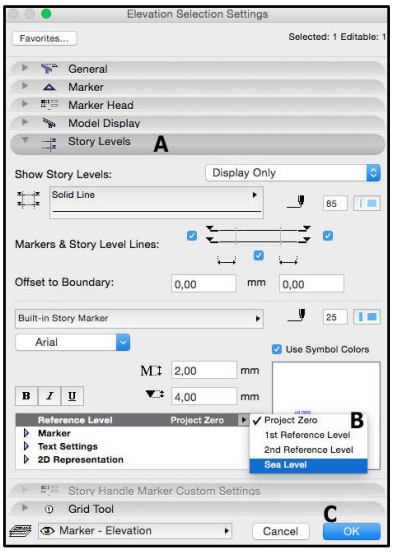

Figure 5-45 - Changing the reference level

5.3.6.3 Revit

In Revit, you add floors by going to an elevation view in the Project Browser. Once in an elevation view, you are able to add Levels. So when in elevation view, go to the Architecture Tab > Datum panel > Level. The standard short key is [LL]. Then you can just start sketching a Level. Once placed, you can change the name and elevation-height. Again, you can use the 'pick lines' –command and enter an offset for the other elevations. Later on, when the project progresses, it is easy to add additional elevations. We added 5 main Elevations, being Basement, Ground floor, First Floor, Second floor and Roof. Besides our main floors, we have added additional sub levels on the basement and ground floor. On these floors, there are alterations in the elevation of the floor slabs. By adding these extra elevations, we could just draw our floors in these elevations, preventing many offsets.

When you select a specific level in Elevation view, tick-boxes on both sides will appear. These tick-boxes control the visibility of the text-tags. It can be convenient to be selective in the text you want to display. This way you can keep things organized.

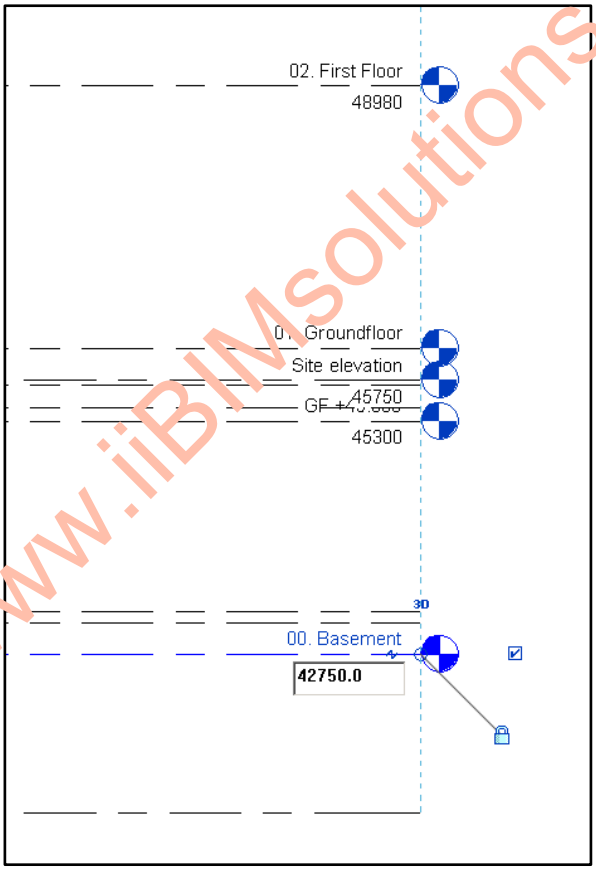

Figure 5-47 - Main levels and Sub levels

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5.4 Setting up the materials

5.4.1 Building materials

5.4.1.1 General

By default ArchiCAD and Revit already have a large amount of basic building materials in their libraries. However, these materials may not be enough or they need adjustments. Editing and making new material will be explained below. In both software packages, you can start with a full blank dialog or start from an already existing material. This can be useful when the new building material you want to create only needs a few adjustments compared to an existing material. How the material appears into section, floor plan and as a rendered image are examples of the changes you can apply. In addition, the physical properties, something that can be used to do simulations on the building, is adjustable in both Revit and ArchiCAD.

5.4.1.2 ArchiCAD

The Building Material Settings Dialog can be opened by going to the Menu Bar, selecting Options > Element Attributes > Building Materials. At the bottom of the dialog, you can create a new building material [5-48A] or delete one [5-48B].

When selecting a material on the left side of the Building Material Dialog, you can see the settings of the selected material on the right side. We can edit the name of the material at the top [5-48C]. The next thing we come across, is the 'fill' of the material [5-48D]. The fill will define how the material is displayed in the 2D views. When clicking on the fill button a screen will pop-up. Here you can choose one of the fill types. It is also possible to create a new fill, when the one you require cannot be found in the library. Straight under the fill settings, we can define the surface of the material [5-48E]. This will define how the material will look in 3D view and in photo renderings. You can also create your own surface.

The Intersection Priority [5-48F] is one of the most important things to set up for a building material. We will explain this more in detail later on in this chapter (see 5.4.3.2).

Finally, we have the Tags and Categories group [5-48G], where details of the material can be filled in. Things like the thermal conductivity, density and heat capacity of the material can be added here. We could not define any of these, as we knew almost nothing about the used materials.

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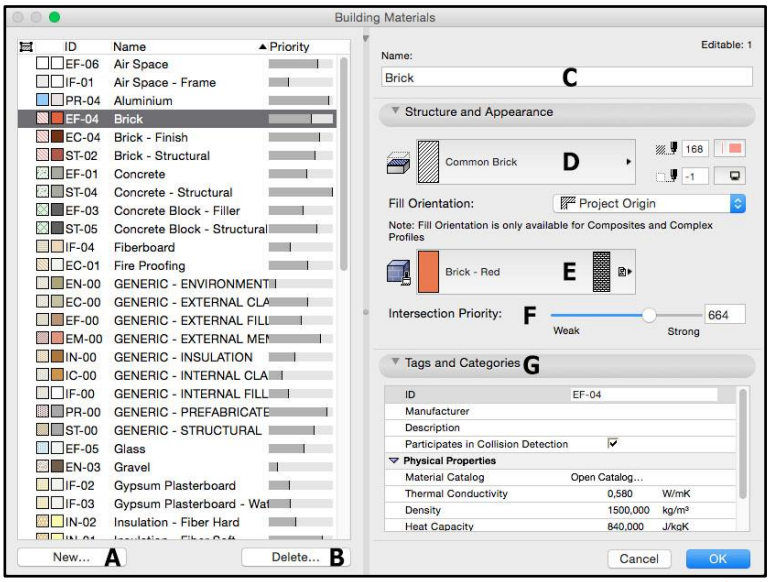

Figure 5-48 - Building Materials Settings Dialog

5.4.1.3 Revit

In Revit, you have a Material Browser [5-49] where you can add materials to the current project. You can find the browser on the Manage tab > Material Browser. Out of the box, Revit already offers many standard materials. These have certain properties, which are defined in the right pane, called the Material Editor [5-49A]. Here we find 5 tabs:

- Identity: Here you add descriptions and product information.
- Graphics: This controls the appearance of the materials in non-rendered views.
- Appearance: This controls the appearance of the materials in rendered views and realistic views.
- Physical: These are the properties used for analyzing structural properties.
- Thermal: These are the properties used for energy-analysis.

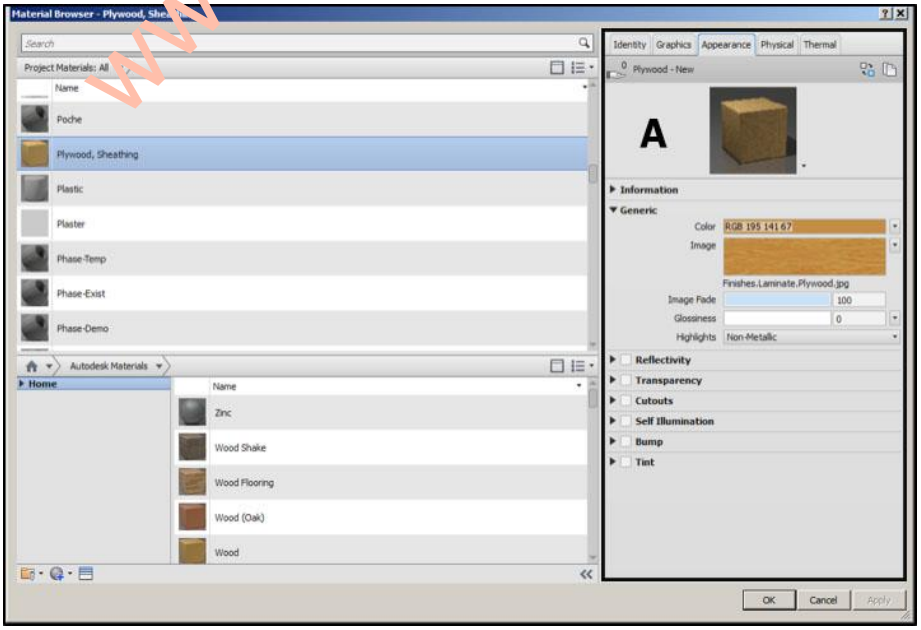

Figure 5-49 - Material Browser

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5.4.2 Composite or compound structures

5.4.2.1 General

We will need more then only basic concrete or brick walls. Most of the time, walls consists of more than one layer. Drawing every different material of the wall separately can mean a lot of work. Therefore we need to create Composite (ArchiCAD) or Compound (Revit) Structures, where all the needed materials are combined into one wall. To explain the creating of a composite or compound structure, we will create one for the outer walls of the State Offices Building as an example. This wall consists of a concrete structure, with insulation and a brick/plaster finish.

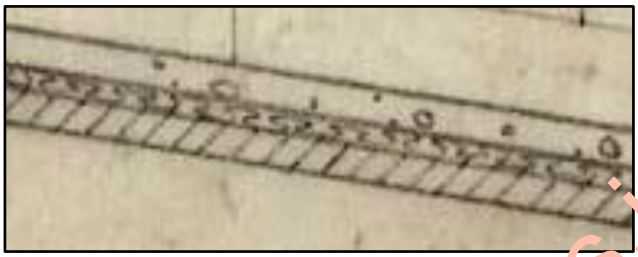

Figure 5-50 - Outer wall on ground floor level

We decided to use a naming structure for our composites to keep things organized. The thickness of the wall-components is defined in millimeters and the naming starts with the exterior material. In this case the full name of the composite is therefore "GROUND 15-130-110-170" [5-51B]. Just as with the Building Materials, duplicating an already existing structure can be very convenient when only a few things need to be edited. This is also possible in both software packages.

5.4.2.2 ArchiCAD

We start by creating a new composite structure [5-51A]. A screen will pop up where we have to define the name of our structure. By default, the new created composite structure consists of a brick wall with a thickness of 100mm [5-51]. We will start by inserting 3 extra 'skins' [5-51C]. All the added skins are brick walls with a thickness of 100mm, so we will need to adjust the material and thickness. When you click on the current selected material [5-51D], a screen will pop up with all the available building materials. We will define the top listed material as the exterior side and the bottom listed as the inner side.

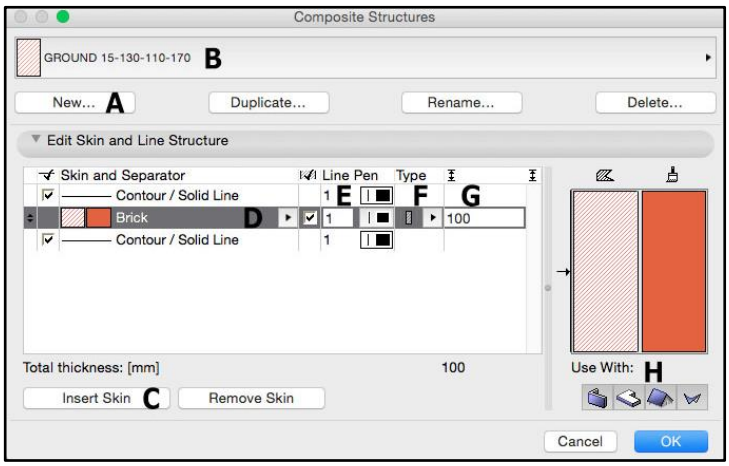

Figure 5-51 - Composite Structures Dialog

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The next thing you can define, is the linetype and the colour of the skins. We will just keep these on the default settings [5-51E]. The following thing to do, is defining the type of the material, which can be Core, Finish and Other [5-51F]. This is an important setting when we finally start drawing the wall. This will be explained together with the Wall Tool (see 5.5.3.2). Another function, when you defined the type of material correctly, lies in the 3D-view. You can choose to only display the core structures for example. We will set the concrete as Core, the insulation and brick as Other and the plaster as Finish.

Finally we can define the thickness of every material [5-51G] and at the right bottom of the dialog we can define in which tool this composite structure can be used. The 4 options are the Wall Tool, Slab Tool, Roof Tool and Shell Tool [5-51H]. In the figure below, you can see the final result [5-52].

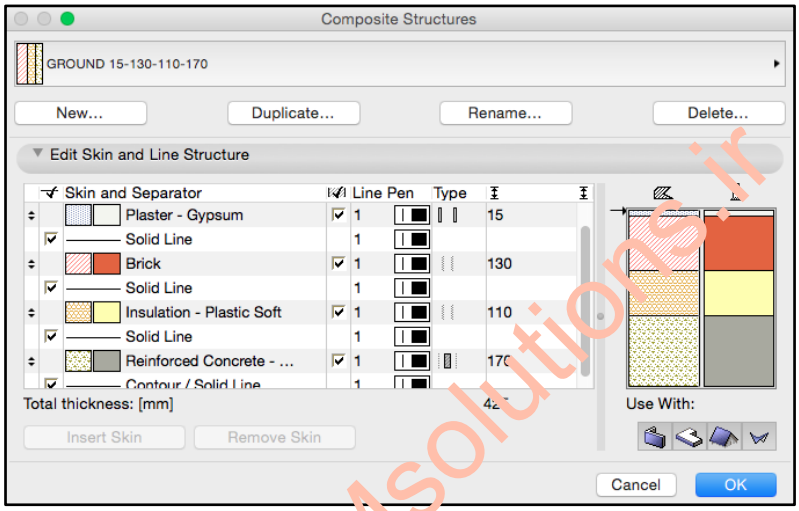

Figure 5-52 - Final result of the created Composite Structure

5.4.2.3 Revit

When you activate the wall command on the architecture Tab, the properties-palette will become active and you can click on 'Edit Type'. This will bring up the Type Properties Dialog Box. Under construction, you can click on the Edit structure button. This brings up the Edit Assembly box. The floor and roof-assemblies are changed in a similar way.

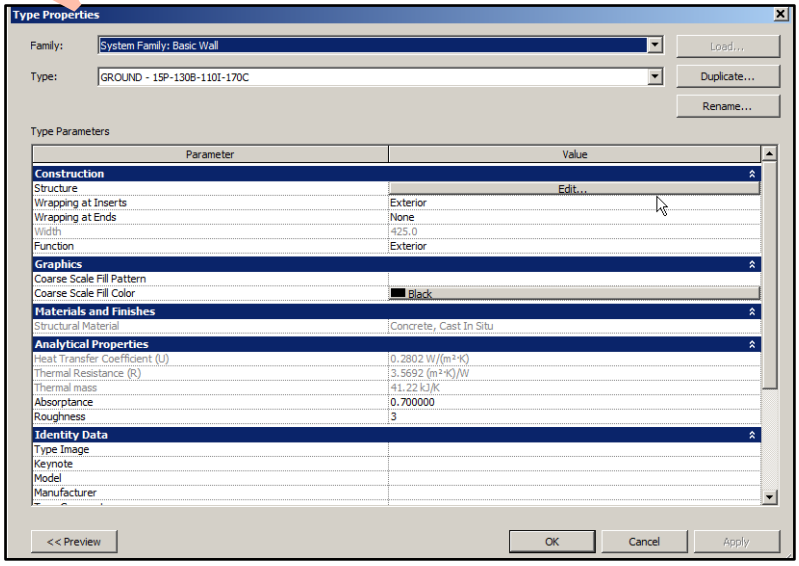

Figure 5-53 - Type Properties

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You can insert layers by pressing 'Insert' [5-54A], and then organizing them with the 'Up and Down' buttons [5-54B]. A Material [5-54C] and Thickness [5-54D] can be set for each layer by clicking on them. When appointing a new material, Revit will bring up the Material Browser, where all your materials are stored. Layer 1 is located near the Exterior side [5-54F], and the next layers go inwards. The Function [5-54E] of the materials and or if they are located in the Core Boundary [5-54G], are also important features. This will be explained in the next paragraph (see 5.4.3).

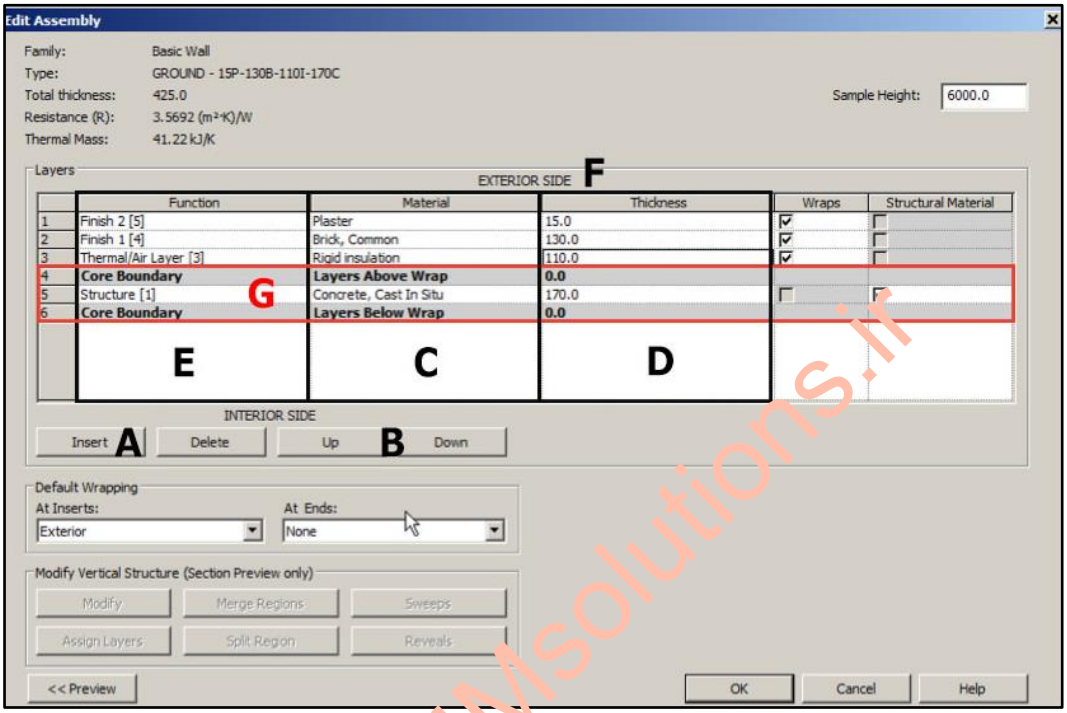

Figure 5-54 - Edit Assembly

In the 'Default Wrapping' section of the Edit Assembly dialog, you can choose if the wall has to wrap at either the end or/and at intersections (for example windows). For example, in wall A, the wrapping at inserts and ends is turned off. In wall B, the plasterwork wraps inwards at the windows and there is also a wrap at the end of the wall.

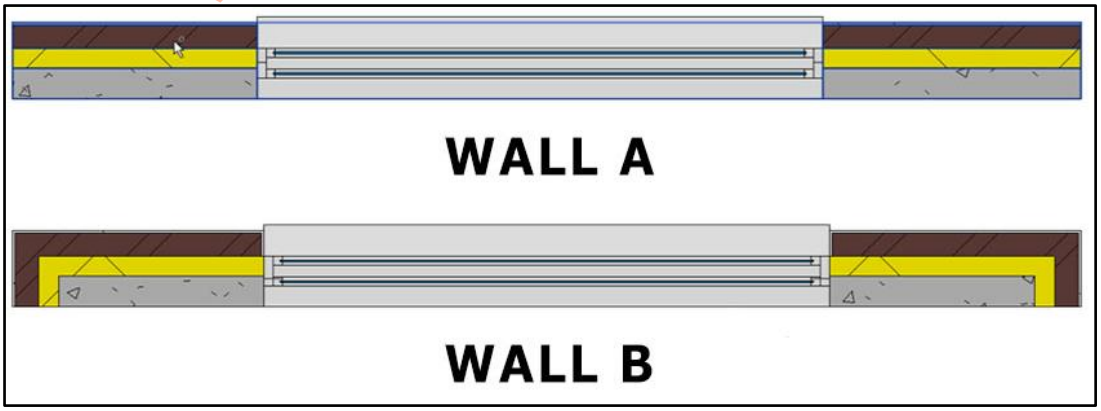

Figure 5-55 – Different wrapping behavior

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5.4.3 Intersection principles

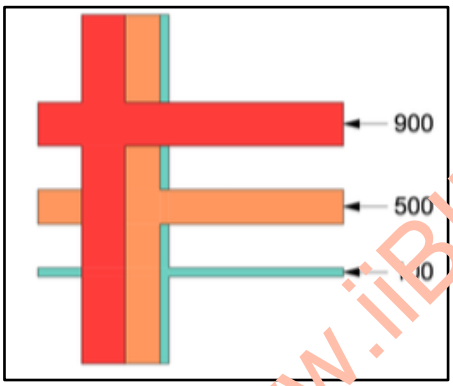
5.4.3.1 General

How the different materials of the building components interact with each other, is in both software packages very important. The joints between different building components, like for example a wall and a floor, need to intersect and join as logical as possible. Although this is not a completely automated process, Revit and ArchiCAD provide some tools to make this process easier.

In ArchiCAD, the intersection principle is based on the 'Priority Settings' of the material. Revit works with 5 functions you can assign to layers. There is also a 'Core Boundary' in each wall, which has some additional properties.

5.4.3.2 ArchiCAD

In ArchiCAD, connections between all kinds of structural elements are based on the priority of the building material. The principle of the intersection of building materials based on priority is shown in the figure below [5-56]. You can change the priority of a building material by opening the Building Material Dialog (see 5.4.1.2). The priority of a material can be any number between 0 and 999, starting from 0 as the weakest priority. There are 2 ways to change the priority of the selected material. You can use the slider or fill in a number to adjust the priority [5-57].



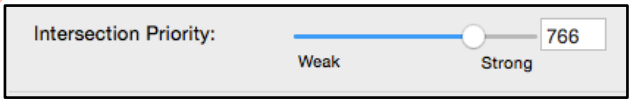


Figure 5-56 - Intersection Principle

Figure 5-57 - Intersection Priority

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However, not all structures will intersect based on the priority settings of the building materials. The table below gives a clear view on which intersection-principles are used on different elements.

Table 5-2 - Intersection-principles of the elements

	Wall	Beam	Column	Slab	Roof	Shell	Morph
Wall							
Beam							
Column							
Slab							
Roof							
Shell							
Morph							

	Automatic intersection based on the priority of the building material
	Intersection based on the priority of the building material but requires trim/merge
	No priority support

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5.4.3.3 Revit

Joins and intersections of materials are determined by some specific principles. Like mentioned previously, you have to assign a 'function' to each layer of the compound wall. Which function is assigned to your layer, will determine how it will behave in relation with other layers. You have 6 possible Functions. Structure [1] has the highest priority, while Finish 2 [5] has the lowest.

- Structure [1]: This is the layer that supports walls, floors and roofs.
- Substrate [2]: Material that serves as an underlay/basis for another material, such as for example plywood.
- Thermal/Air Layer [3]: Air and Insulation-materials are typically assigned to this layer.
- Membrane Layer: A material that serves as a barrier for Vapour/water infiltration. This layer has to have a thickness of zero.
- Finish 1 [4]: Finish material, typically on the exterior part.
- Finish 2 [5]: Finish material, typically on the interior part.

Layers with the same function will try to connect. And if these layers have the same material assigned to them, they will merge together. If they have different materials, a line will be used as graphical separation. When trying to connect, layers with a higher priority-function (meaning lower number) will cut through layers with a lower-priority function.

In every compound element, you have a section that is called 'Core'. You can assign layers to this core, and they will have extra intersection properties. For example, the cores of 2 different compound structures will automatically join. In addition, layers with a low priority inside of a core can cut through high priority layers that are outside of a core. In Revit, you always have to have a layer inside your core-boundary.

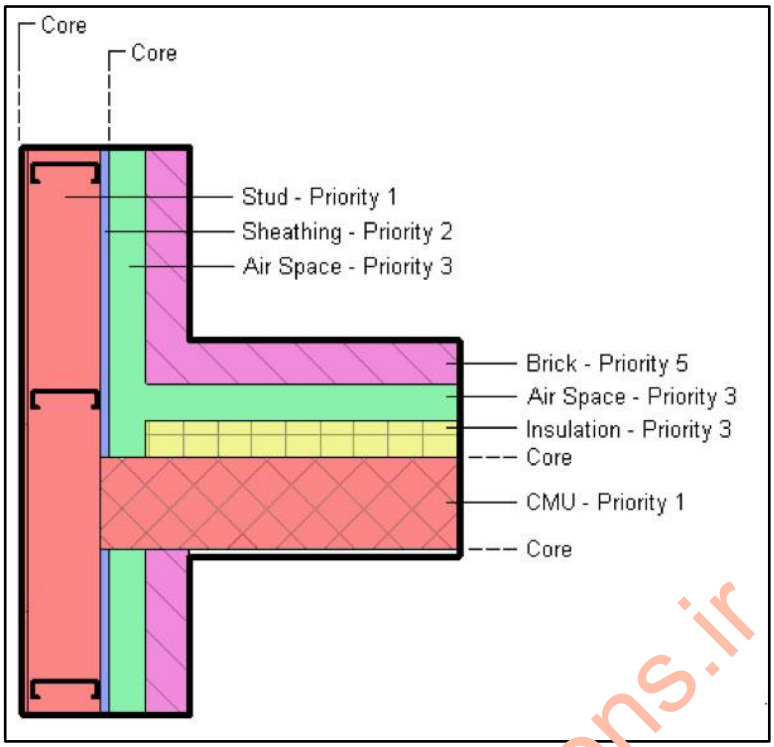

Figure 5-58 - Priority and intersection (source: Autodesk)

5.5 Carcass

5.5.1 Columns

5.5.1.1 General

The placement of the columns was quite important, because most of the time the positioning of the walls was determined by the edges or the centerline of those columns [5-59]. When we first examined the old plans, we were quite confused. No dimensions of the columns were given. Also the shape of the columns could vary a lot. Sometimes we were able to derive the dimensions by adding up different dimensions of different floor plans. But most of the time, even this was not possible. Then there was another problem. When we measured the columns on the plans, they would not correspond with the actual dimensions on site. Also the shapes and sizes of columns, that logically supposed to be the same, differed once in a while. Trial and error was our part, and it took quite a long time to have some kind of column-system in place.

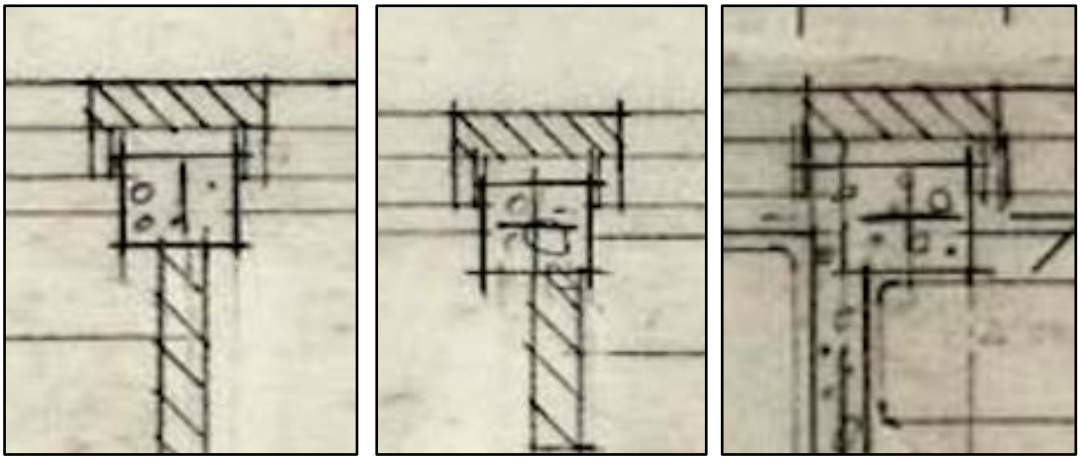

Figure 5-59 - Wall-column relation

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5.5.1.2 ArchiCAD

We start by selecting the Column Tool from the Toolbox. You can adjust the settings from the Settings Dialog as well as from the Info Box. However, the Info Box is most used and helpful when you edit some small settings like the material or height from an element. Defining a large amount of settings is easier and faster from the Settings Dialog. We can open the Column Settings Dialog by double clicking on the Columns Tool in the Toolbox [5-60A]. The Column Setting Dialog can also be accessed by clicking on the column symbol located at the left side of the Info Box [5-60B]. These 2 ways of opening the Settings Dialog is the same for all the other tools as well.

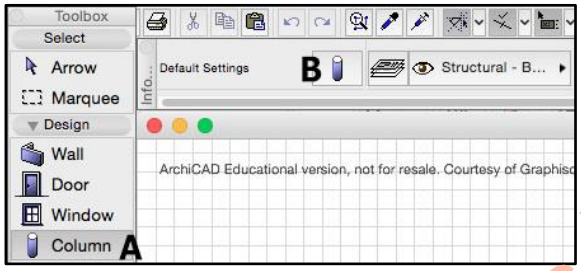

Figure 5-60 - Opening a Settings Dialog

When opening the Settings Dialog, you can see that it is divided into 5 groups [5-61]. We will focus on the Geometry and Positioning group, as this is the most important one.

You can link the bottom and top of the column to the stories you created [5-61A]. It is not mandatory to link it to a story, it is also possible to define the height of the column by yourself [5-61B]. Optionally, you can define an offset for the column [5-61C]. This can only be done when the column is linked to a story. The offset can be positive, negative or just zero. Another possibility to locate the home story of the column is also available in this group [5.61-D]. With this tool, it is possible to define the distance relative to project zero, sea level, current story or other reference levels.

On the right side of the Settings Dialog, you can define the measurements and shape of the column. It is possible to select a rectangular, circular or complex shaped column [5-61E]. With the 'complex profile'-tool, it is possible to draw any form of column that you want. In this project, we used all 3 shapes of columns. The use of complex profiles will be explained further on (see 5.8). The next thing we can define is the length and width of the column [5-61F]. When we activate the link icon on the right, we say that the length and width of the column are the same. Right under this tool, you find the option to choose the material of the column [5-61G]. When clicking on this window, a screen will open where you can choose one of the building materials from the library.

With the 'veneer' option, the column can be surrounded by another material [5-61H]. You can choose the material and thickness of the veneer. You can also choose your column to be vertical or slanted [5-61I]. We can fill in the angle when a slanted columns needs to be drawn. In this project, we only need vertical columns. The wrapping method can be selected, should the columns intersect with a composite wall [5-61J]. Next to this setting, you can define the positioning angle of our column [5-61K]. The rotation of the column can be defined before placing, but it is also possible to rotate the column after placement. The last setting we can define, is the anchor point of our column [5-

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61L]. Most of the time, we selected the middle point of the column as the anchor point, as most of the gridlines intersect the columns in the middle. Once a column is placed, you can move it by dragging one of the many other available anchor points.

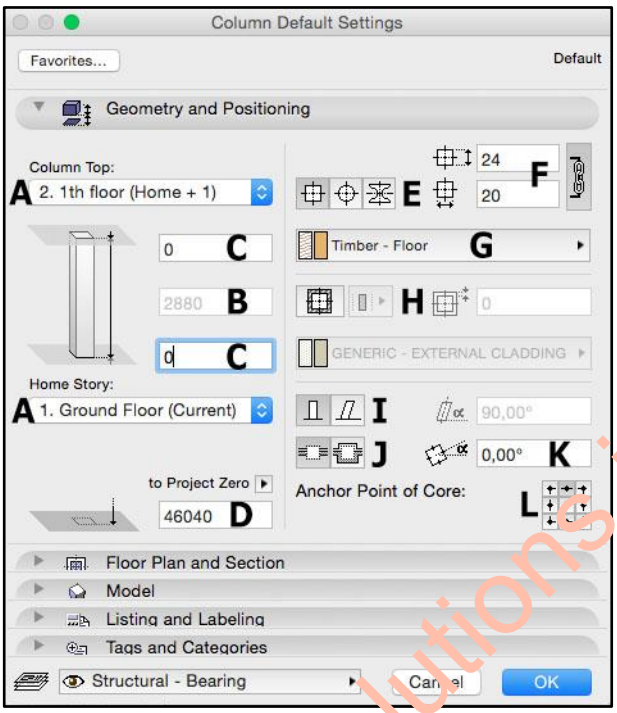

Figure 5-61 - Column Settings Dialog

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5.5.1.3 Revit

1. Architectural vs Structural Column

There are 2 kinds of columns you can use in Revit. First we have the architectural column, which is situated under the Architecture tab > Column. The other kind is the structural column, which you can find both in the Architecture as Structure part of Revit. The first kind is a purely esthetic component due to its properties. You can place this kind of column if you just want non-bearing esthetic pillar. You can also use it to 'cover up' the actual load-bearing structural columns. The architectural column is able to inherit the materials to which they are joined. Moreover, compound layers of neighboring elements can wrap around this kind of column. The other kind, is the structural column. The structural column is the one we have used for our State Offices Building. The reason why we used this one, is because a beam-structure only can 'connect' to structural columns, not the architectural ones. Structural columns can for example be used to perform load-bearing calculations by the engineer. The intended workflow for using these two kinds of columns would be as follows: The architect designs a building and ads architectural columns to his project. Then the project is handed over to the structural engineer, who can place structural columns 'inside' the existing architectural ones. Then he/she can start adding the structural framing, and use these to do his/her calculations.

2. Placing the columns

For placing structural columns, we need to go to the Structure Tab > Columns. The first time you activate this command, a steel profile column will be loaded. For our project, we need rectangular and round concrete columns.

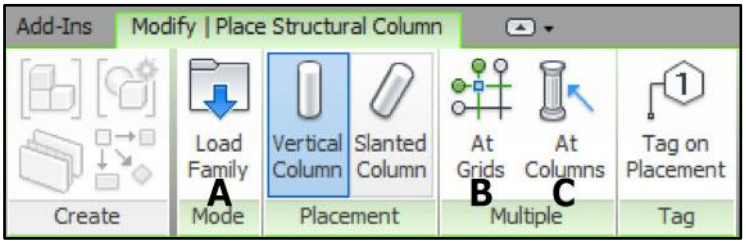

Figure 5-62 – Columns

When you click on load family [5-62A], the Revit Family's Library opens. Be sure to go to structural columns, and not just columns. It can be confusing because 'columns' are actually the architectural columns. We're not sure why Autodesk didn't just name them 'architectural' columns.

When you have loaded the appropriate column-family, you can start making types. When a new type is made, you can start to place the columns in the drawing area on the appropriate floor. Every column drawn with this type of column, is an instance of this column. When you change the properties of this specific type, all the instances of this type will be modified accordingly. This principle of instance/type is used throughout the Revit-software and is applicable on any kind of family. For making a new family-type, go to the properties palette [5-63] > edit type [5-63A] > duplicate. After you have duplicated the column and have given it an appropriate name (e.g. 400x400), you have to adjust the width and the depth of the column. Only naming it 400x400 doesn't do the trick. Be sure to adjust the dimensions in the Dimensions-parameter section.

You can place columns in a different amount of ways. You can for example select 'At Grids' [5-62B] in the 'Multiple'-panel of the modify-tab. With this method, a column will be placed at the intersection of 2 selected-gridlines. If you already have architectural columns in place, you can simply add structural ones by clicking on the 'At Columns' [5-62C] button. You can also add columns in 3D if you want. But the Grid will not be shown in 3D-mode in Revit, so we couldn't use this method.

We have drawn the columns one by one, so we could get maximal control over the placement. You just 'click' were you want them, for example at an intersection of gridlines. The anchor point is typically in the middle of the column.

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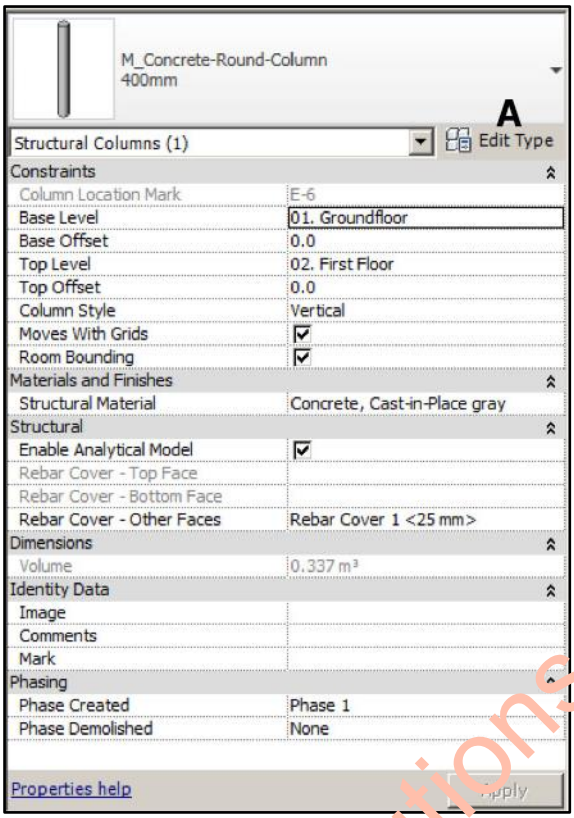

Figure 5-63 - Properties palette of a Concrete Round Column

By default, structural columns will be drawn downwards from the floor you are working on. This can be changed, so the column will go upwards [5-64A]. The 'Base Level' is typically the floor you are drawing in, while the 'Top Level' is the floor above. Offsetting can be done in the Properties Palette as well.

Figure 5-64 – Place Structural Column

5.5.2 Beams

5.5.2.1 General

We had the same problems with the beams as with the columns. No dimensions were mentioned. What made it even harder, was that none of the beams were displayed on the original floor plans, because these are architectural drawings. Because of this, we had to base ourselves on the 6 cross-sections we had. Taking measurements by ourselves on site was in most cases not possible, as most of the beams were covered by a false ceiling. What made things worse, was that we didn't have a longitudinal section. So we had no clue of the longitudinal beams. So we had to do some improvisations there as well, placing beams as logical as possible.

5.5.2.2 ArchiCAD

You begin with selecting the Beam Tool from the Toolbox. When the Settings Dialog is opened, you can see that it is divided into 6 groups [5-65]. We will focus again on the Geometry and Positioning group.

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First, you can define the height of the beam [5-65A]. Next, you can define the offset of the top of the beam to the selected Home Story [5-65B]. By default, the Home Story will be the story that you're currently working on. The offset can be positive as well as negative. As home story you can select one of the stories we created earlier [5-65C]. Another possibility to locate the Home Story of the beam is also available in this group [5-65D]. In this tool, it is possible to the define the distance relative to project zero, sea level, current story or other reference levels.

On the right side of the Settings Dialog, you can define the thickness and shape of the beam. It is possible to select a rectangular or complex shaped beam [5-65-E]. Next to the defining the shape, you can fill in the width of the beam [5-65F]. The next option is choosing the material of the column [5-65G]. A screen will pop up, where you can choose one of the building materials from the library. The next thing we can define, is if our beam has to be horizontal or inclined [5-65H]. An inclined beam will have an offset between the starting- and ending point of the beam. You can define the angle of the inclined beam right next to these 2 icons. The last setting of this group is defining the reference axis [5-65I]. By default the reference axis will be located at the middle of the beam. In some cases, it can be useful to use another reference axis.

Just like with the Column Tool, the most important things that can be set up in the other 5 groups are the ways of displaying of the beams in 2D and 3D. However, the Beam Tool has an extra group. You can create holes in the beams [5-65J], which can be useful if HVAC is also part of your model. It is possible to create rectangular and circular shaped holes.

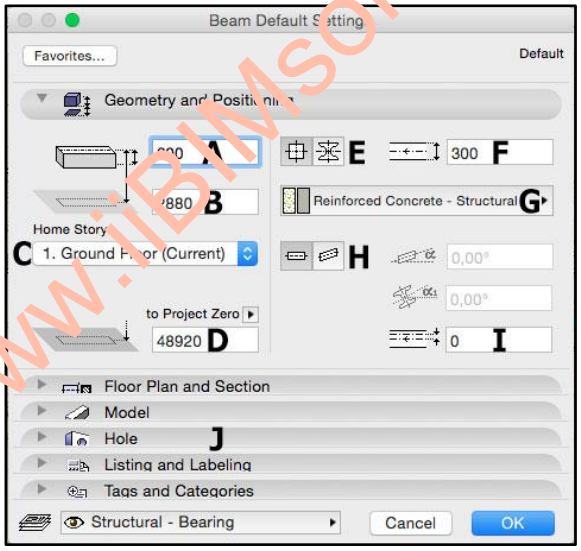

Figure 5-65 - Beam Settings Dialog

When clicking the OK button, you can start placing the beams. In the Info Box you can select one of the geometry methods [5-66A]. We can define 4 methods. Starting from the left we have the Single Beam. The name says it all, you just draw a beam by defining the start- and ending point with 2 clicks. Next to the Single Beam, we have the Chained Method. With this method you can draw a sequence of connected beams. The 3th option is the Rectangle Beam. With this tool you will be able to draw 4 beams with coincident nodes. Finally, you have the Curved Beam, which will make it possible to create curved beams. In our model we only used the Single Beam Method.

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Figure 5-66 - Info Box of the Beam Tool

5.5.2.3 Revit

Placing beams in Revit proved to be quite a challenge. When you first load a new beam-family under the Structure-tab, you will have to go into the 'structural framing' map of the library section. This proved to be a little bit confusing, because there was no mentioning of 'beams' in the map. So while you specifically start the command by pressing the 'beam' command, Autodesk suddenly stops mentioning it in the actual Library-map, naming it 'structural framing'.

Another thing that was a little bit confusing at first, is the way we are taught in school to look at beams on the plan. Normally, we look up from the floor we are standing on, to see the framework above our heads. So when we see a plan and there are beams drawn, we automatically assume they are above our heads.

First of all, beams are (just like structural columns) drawn 'downwards', and are placed on the level below the view you are working in. This means, if you want to represent the beam-work in the basement for example (beams above your head in the basement), you draw by default on the ground floor. This can be changed by picking another placement plane [5-67A], before the actual drawing.

Figure 5-67 – Option bar beam

Also, when we first drew a beam, the beam was nowhere to be seen [5-68]. This was because we were apparently drawing in an architectural drawing-template.

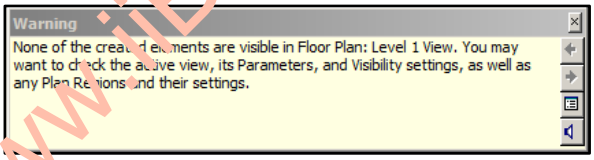

Figure 5-68 – Warning when we tried to draw a beam in Revit

So we had to play with the settings of our View-Range (properties for the cutting plane and 'how far' your eye can see). First, you have the Primary range. In this part we distinct Top [5-70A], Cut Plane [5-70B] and Bottom [5-70C]. The region that is cut by the Cut Plane, will be represented in the 'cut' linotype. The Cut plane height can be changed by offsetting it relative to the floor plan you are in. The elements that are in the top-range (above the cutting plane) and bottom-range (below the cutting plane) will be displayed in the 'projection' line type. The view depth is the zone beyond the bottom (if you are looking down, so in floor plan view) or beyond the top (if you are looking up, so in ceiling plan-view) of the primary range. Everything that's in the view depth range, will be shown in 'beyond'-line style. To access the View-Range Dialog, you go to the properties-palette [5-69] >Extents View Range > Edit.

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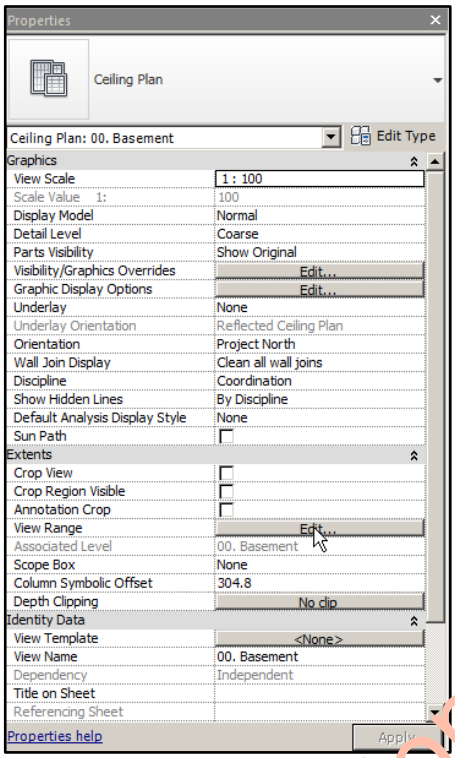
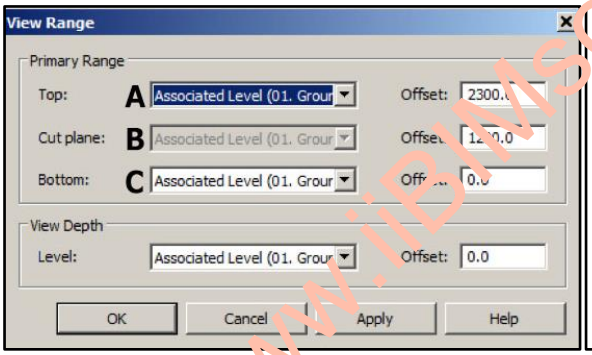


Figure 5-69 – Properties of the ceiling plan



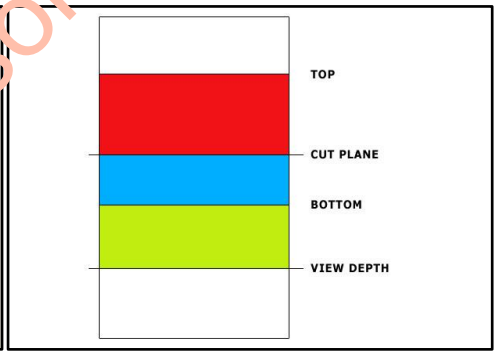


Figure 5-70 - View Range Box *Figure 5-71 - Representation of the View Ranges*

It was frustrating at the beginning, because there was no way we could see our beams in the floor plans. And it appeared we were not the only ones having this problem with representing beams in our floor plans. In the end, we used the ceiling-plan views to draw up our beams. While in a floorplan, a cut is made at a certain height, and you look down, in a ceiling plan a cut is made and you are looking up. This proofed to be ideal to place our structural framing. The approach of drawing beams is the same as with columns. You load in a family (Structural Framing > Concrete > Rectangular Beam). Then you make types of your beam-family and place them appropriately.

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5.5.3 Walls

5.5.3.1 General

Something that made our work harder and slower is shown in the figure on the right [5-72]. In this image, both walls are drawn with the same thickness, but have different dimensions. We decided to base the dimensions of our model as much as possible on the dimensions that are shown on the plans. This is how the actual builders back in the '60 would have used the plans. But a lot of dimensions were not shown on the plan, so would measuring elements be accurate enough if a wall of 20 cm is drawn with the same thickness as one of 15 cm? As much as these irregularities made our work slower and harder, we have to admit that these plans, all fully drawn by hand, have some kind of charm and made us realize how much work was put into the plans back into the days. A wall that was drawn in the wrong way was not editable in 10 seconds, like we are now used to do. Before the first line of a wall was drawn, everything needed to be thought off in advance.

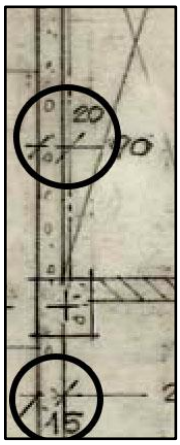

Figure 5-72 - Scale error

Another concern was that not every dimension was displayed on the floor plans, so sometimes we had to search hard and add/subtract a lot of dimensions to define the place of a wall. In some cases it was not possible to identify the right place of a wall at all, so in that case we had to rely ourselves on the underlay to position the wall as accurate as possible.

5.5.3.2 ArchiCAD

We start by selecting the Wall Tool from the Toolbox. When the settings dialog is opened, you can see that it is divided into 5 groups [5-73]. Again, we will focus on the Geometry and Positioning group.

To start, you can link the bottom and top of the wall to the stories you created [5-73A]. It is not mandatory to link it to a story, it is also possible to define the height of the wall yourself [5-73B]. Optionally you can define an offset for the wall [5-73C]. This can only be done when the wall is linked to a story. The offset can be positive, negative or just zero. Another possibility to locate the home story of the wall is also available in this group [5-73D]. In this tool, it's possible the define the distance relative to project zero, sea level, current story or other reference levels.

On the right side of the Settings Dialog, you can define the structure of the wall [5-73E]. The first option is a Basic Wall, which exists of one material. The second option is a Composite Wall. In that case, you can choose to draw one of your earlier created composite structures. The last option is a Complex Profile, which we will use to detail our model. We'll explain the functions and usage of this tool later on (see 5.8).

After you have chosen the structure of the wall, you can select which building material, composite structure or complex profile you want your wall to be [5-73F]. When clicking on this, a screen will pop up with all the available options. Next, we can define our wall to be straight, trapezoid or polygonal [5-73G]. In our model we only used a straight wall. Next to these options, we can define the thickness of our wall. When selecting a composite wall, it is not possible to define the thickness yourself. The thickness will be defined by the composite structure you created.

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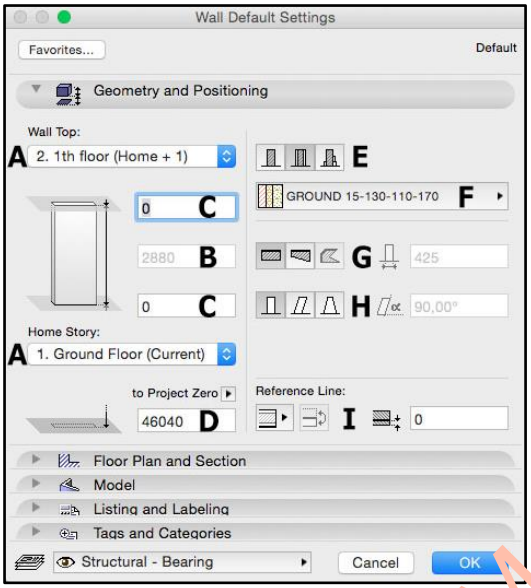
We can also define the complexity of the wall, which can be straight, slanted or double slanted [5-73H]. Most of the time we used straight wall. Only when we needed to draw the structure for the skylights, we used a slanted wall.

Just like with the Beam Tool, the last thing to set up is the reference line of our element [5-73I]. ArchiCAD has 6 different reference lines: Outside, Inside, Center, Core outside, Core Inside and Core center [5-74]. A wall existing of only one material has only the first 3 possibilities. The figure below gives a clear view on the principle of the reference lines. This shows up why it was important to set up the type of the material (Core, Finish, Other) when you create a Composite Structure.



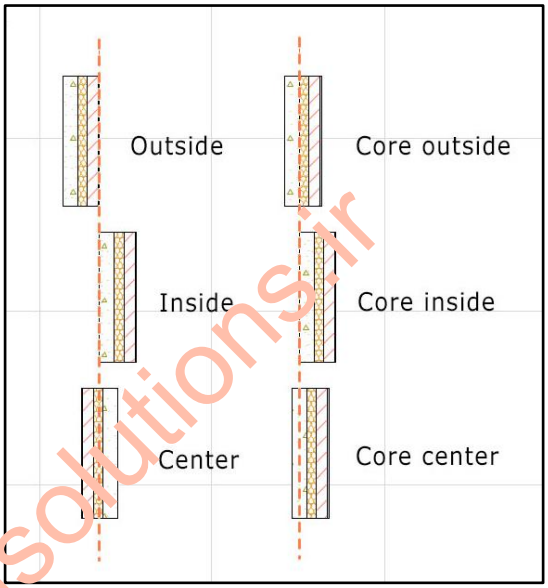


Figure 5-73 - Wall Settings Dialog

Figure 5-74 - Wall reference lines

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When clicking the OK button, we can start placing our walls. In the Info Box we can select one of the Geometry Methods. We have 4 methods. Starting from the left we have the Straight Wall. The Straight Wall has another 4 options to choose from, which are the Single, Chained, Rectangular and Rotated Rectangular. They all work with the same principle as the ones from the Beam Tool. The 3 other Geometry Methods that can be selected are Curved, Trapezoid and Polygonal. Most of the time, we use the Single Straight geometry method.

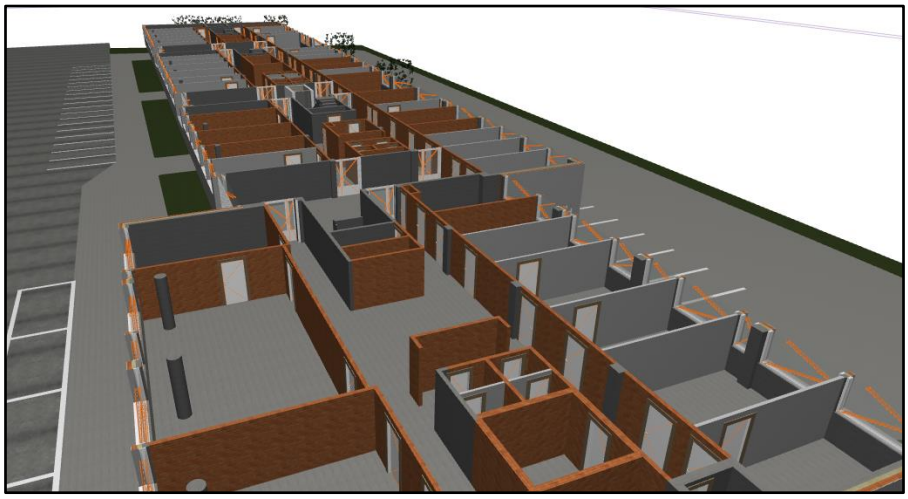

Figure 5-75 - Walls of the ground floor

5.5.3.3 Basics of positioning in ArchiCAD

In this part we'll explain the options to draw the wall in a situation like shown in the picture below [5-77]. We can draw and define the position of the wall in different ways. During the project, we used all the 4 ways that are explained below. None of them can be defined as the best one. They all have advantages in different kinds of situations. To start, we will need the Control Box to be displayed. This can be done by going to the Menu Bar, selecting Window > Palettes > Control Box.

Figure 5-76 - Control Box

1. Using Guide Lines

First you need to select the Guide Line Segment from the Control Box [5-76A]. Next, you define the starting point [5-77A] and ending point [5-77B] of the Guide Line. You can define the end point on an exact distance by pressing the TAB-button on your keyboard and then fill in the desired distance, which is in this case 1500mm. The ending point of the Guide Line will be the starting point of our wall [5-77B]. After you select the Wall Tool and define the starting point, you can drag your cursor down and easily define the ending point of our wall [5-77C]. The wall will automatically snap in a straight angle when you are holding it close to the 90 degrees point. Another option, to be sure that the wall is drawn straight, is holding down the SHIFT-button on your keyboard while defining the ending point. The wall will automatically snap onto the 0°-, 90°-, 180°- or 270°-points. The Guide Line, which is an orange dashed line, will disappear automatic after you have drawn the wall.

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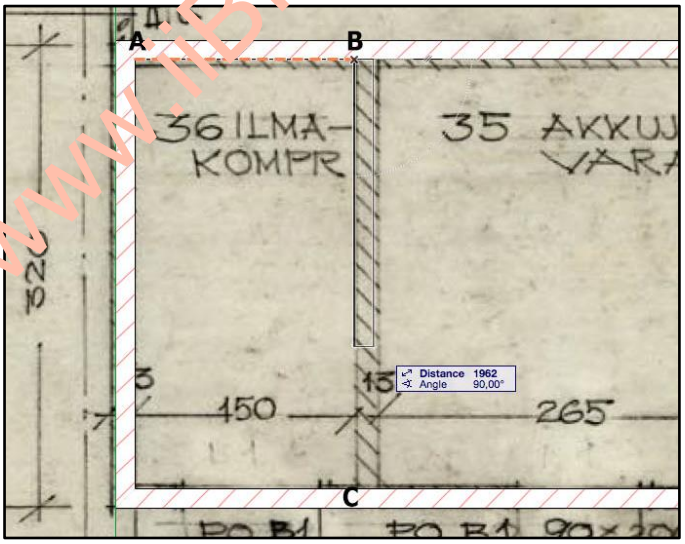

Figure 5-77 - Placing wall using Guide Lines

2. Offset Constraint

Another way to move your wall is by using the Offset Constraint. First, you have to click and hold the Relative Construction Methods icon from the Control Box [5-76B]. A small screen will pop up with 7 icons. Now you need to select the Offset Constraint icon, which is the fourth icon starting from the left. The next step is selecting the Wall Tool from the Tool Box. The first thing we need to do is drawing our wall by defining the starting- [5-78A] and ending point [5-78B]. The place where the wall is drawn will function as reference line, so it is the easiest to draw the wall on the already existing wall. When we defined the ending point of our wall, a slight dashed line will appear [5-78C]. We can drag this line to the left or to the right. In our case we will need to drag it to the right and define the offset that the wall needs by pressing the TAB-button and filling in 1630mm [5-78D]. The only thing left to do is pressing the ENTER-button on your keyboard and the wall will be drawn on the right place.

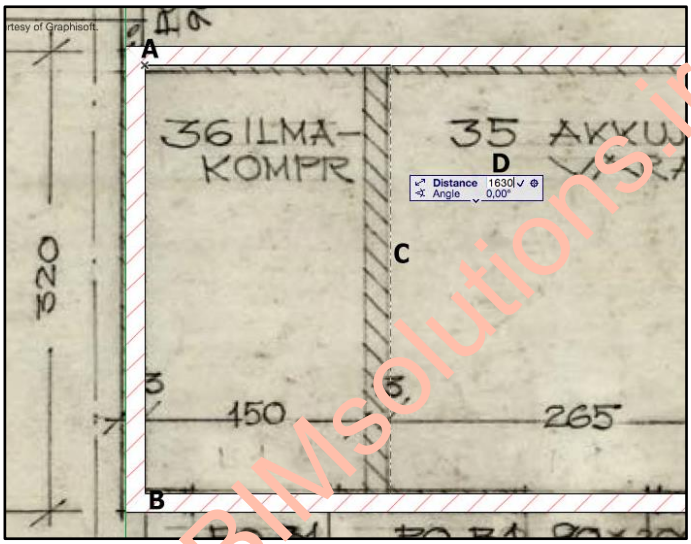

Figure 5-78 Placing wall using Offset Constraint

3. Move

In this case, you need to select the Wall Tool from the Toolbox from the start. We will draw the wall on the already existing wall just like we did when we used the Offset Constraint. Next, you have to select the wall you have just drawn by left clicking on it. Now you can select the reference line of that wall, which is, in this situation, located on the left [5-79A]. By clicking on the reference line, the Pet Palette will pop up. You need to choose the Move icon, which is the first one starting from the left [5-79B]. Now you have to drag your cursor to the right in a horizontal line. The last thing that has to be done, is defining how far the wall needs to be moved, which is in this case (again) 1630mm [5-79C]. End with a hit on the ENTER-button of your keyboard and the wall will be moved to the correct place.

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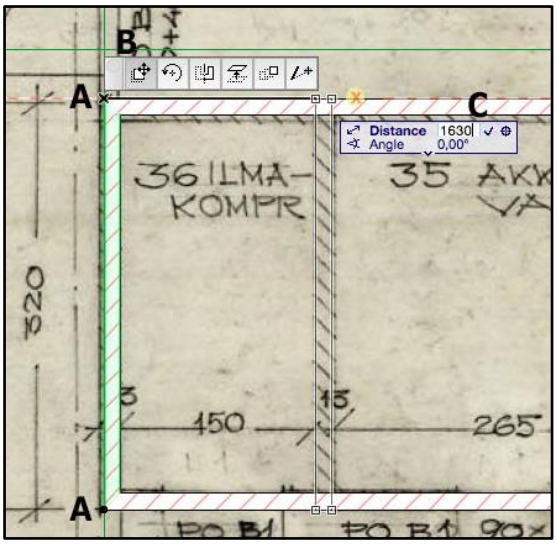

Figure 5-79 - Placing wall using Move

4. Special Snap Point

First we need to activate and set up the Special Snap Points, which is located in the Standard Bar [5-80]. We can edit the settings by clicking on the small arrow next to the icon. If you then select 'Set Special Snap Values', you can define the settings that are needed in this situation [5-80D].

There are three possible settings. The first one is 'Divisions'. If you enter a value of '3' for example, the snap points will pop up that will split the wall into three equal parts. The second option is Percent. Entering a value of 20 will result in dividing the wall into 5 equal parts. Finally, we have Distance. By filling in a value of 500, a pop up snapping point will appear every 500mm. The last thing we have to do before drawing the wall is selecting the 'Distance' [5-80B]. Also 'Between Intersection Points' [5-80C] has to be ticked. You can make these alterations in the 'Special Snap Points Menu'. The 'Between Intersection Points'- option controls if division starts from the inside [5-81A] or from the outside [5-81B] of the wall.

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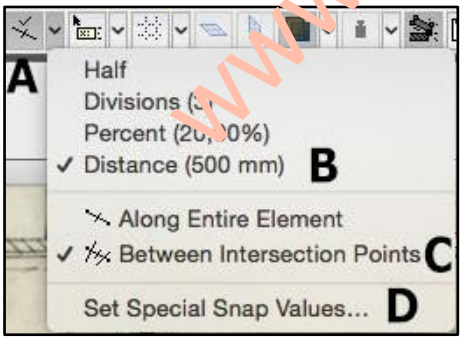

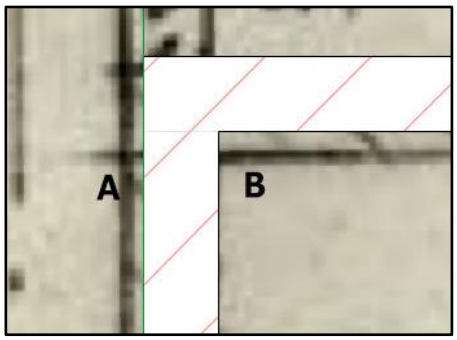

Figure 5-80 - Special Snap Point Options

Figure 5-81 - Between Intersection Points

First we have to select the Wall Tool and then we can start drawing our wall. You should start with moving your cursor on the wall where the starting point will be located. With moving your cursor over the wall, the snap points will pop up showing a point every 500mm [5-82A]. Now we can select the starting point of our wall. In our case it is the third snapping point, since our wall is located 1500mm from the reference wall [5-82B]. The last thing to do is defining our ending point at the bottom just like we did before [5-82C].

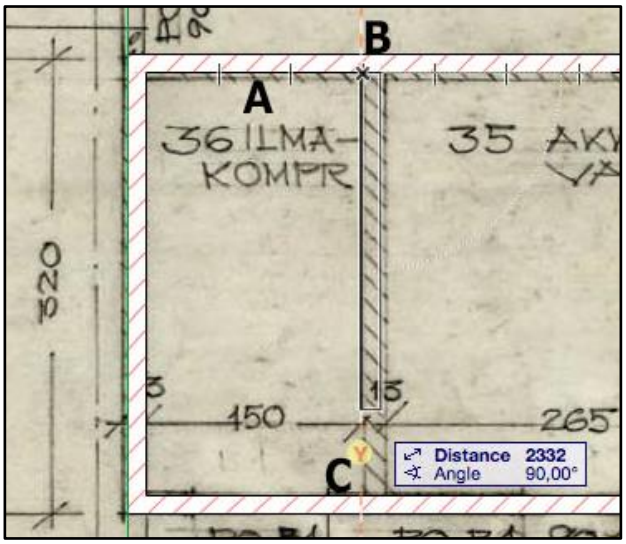

Figure 5-82 - Placing wall using Special Snap Points

5.5.3.4 Revit

The Placement of the walls starts with the activation of the Wall-tool in the Revit-tab of the ribbon. On the dropdown of the Wall-icon, you have 3 possibilities. You can either make an Architectural wall, a Structural Wall or a Wall by face. Again, the difference between non-structural (architectural) and structural, are the extra properties for the structural part. You can use structural for bearing walls, and architectural for non-bearing (filling) walls. The choice of structural or architectural is non–definitive, as you can change it afterward by ticking it on/off in the properties panel. For the wall by face command, you first need a mass object created in the massing environment. Massing-object are not utilized in this project.

For the architectural and structural walls, you can choose between a basic wall [5-83C], a stacked wall [5-83A] and a curtain wall [5-83B]. Basic walls can either consist of a single layer or multiple layers (=compound wall). A curtain wall is part of the exterior wall system but doesn't have any load-bearing properties. They often have mullions, to separate and support glass or covering elements. Finally, a stacked wall is a wall that consists of separate vertical wall components.

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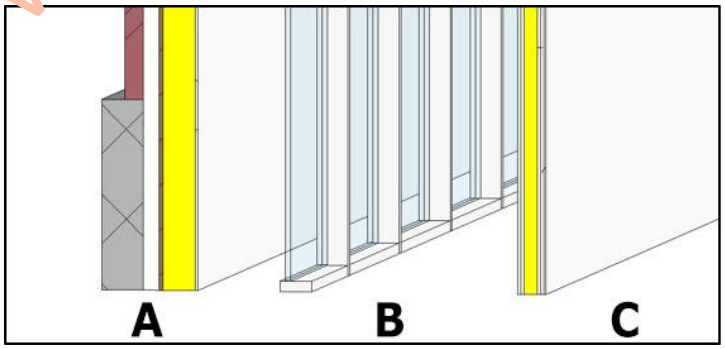

Figure 5-83 - Possible walls

For our purposes, we only need a basic wall. So we start duplicating an existing basic wall, so we can make a new type and edit the assembly [see 5-54]. We add layers to the wall, ad a function, adjust thickness and appoint materials. Our next step is to actually place the walls.

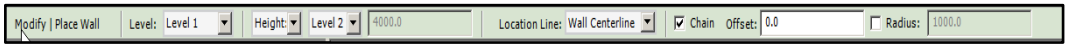

Figure 5-84 – Options bar wall

When the Wall command is activated, you can select the Base Constraint and Top Constraint in the option bar [5-84]. After placing the wall, you can adjust these settings in the Properties Palette. Here you can also change the offset values (Base and Top Offset). You also have to decide where your location line will be. This way you can control the point of input of your compound element. The possible location lines are identical to the Reference lines of ArchiCAD, but they just have a different name. The possible location lines are: Wall Centerline [5-85E], Core Centerline [5-85C], Core Face:Exterior [5-85D], Core Face:Interior [5-85B], Finish Face:Exterior [5-85F] and Finish Face: Interior [5-85A].

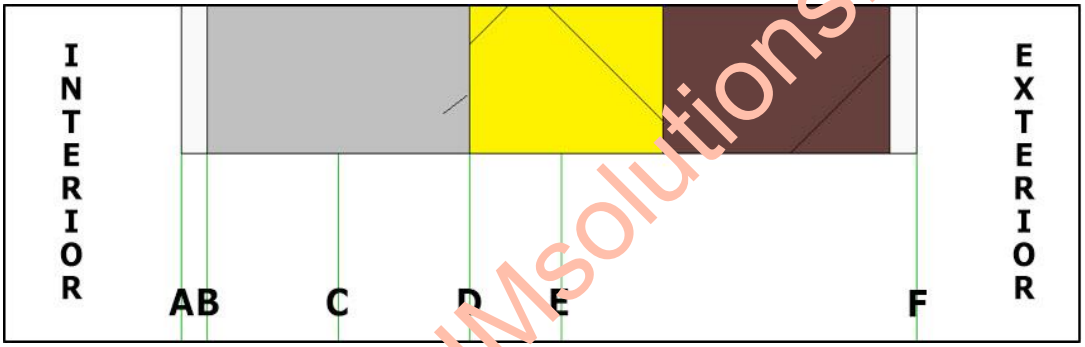

Figure 5-85 - Reference Lines

You can draw a single wall or a series of chained walls, with the possibility of offsetting them. You can add an offset value in the Options Bar. You can also draw walls in a certain geometrical relation to each other, for example a rectangle, a circle, polygons or by spline [5-86] [5-87]. Another possibility is to first sketch a form with lines, and then appoint walls to those lines with the 'Pick Lines' tool [5-86A] in the Draw panel of the Modify-palette.

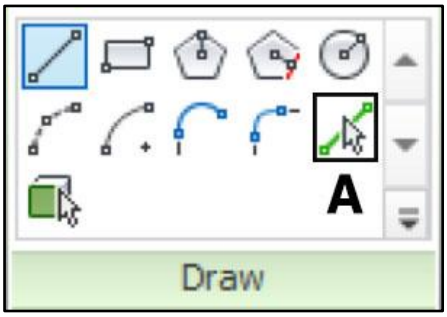

Figure 5-86 – Pick Lines Tool

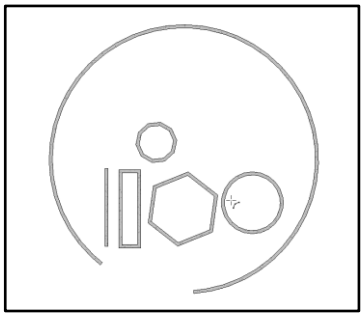

Figure 5-87 – Different Wall forms

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In Revit, you don't have to draw your element (e.g. a wall) immediately on the right spot (we even advise against it). You first sketch you element approximately in the right place and then you adjust. You have some powerful tools to move your wall to the appropriate location. When we had our underlay raster-image in place, we could simply start by tracing over with the appropriate wall-types. Then we used tools like Dimension, Align and Trim-extent to modify our wall-location.

1. Dimension

To activate the Aligned Dimension tool, you go to the Modify-tab > Measure Panel > Aligned Dimension. You can also access the command by using the shortkey 'DI'. You simply place a dimension between two elements. The next step is to select the element you want to move. When you do, the dimension you just placed will become active. Then you can specify your displacement value, and the element will move accordingly [5-88]. You always select the element you want to move, the other one will stay on its original place. We literally used this command a thousand times, and we found it a joy to work with [5-89].

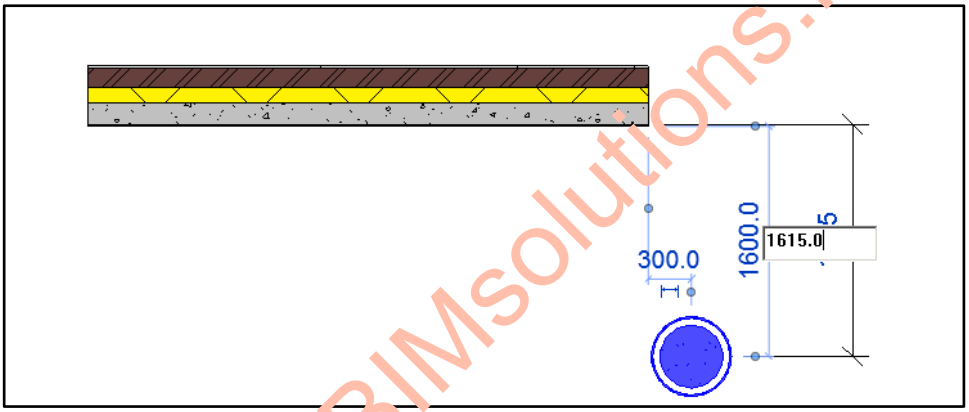

Figure 5-88 - Moving a column using the Aligned Dimension tool

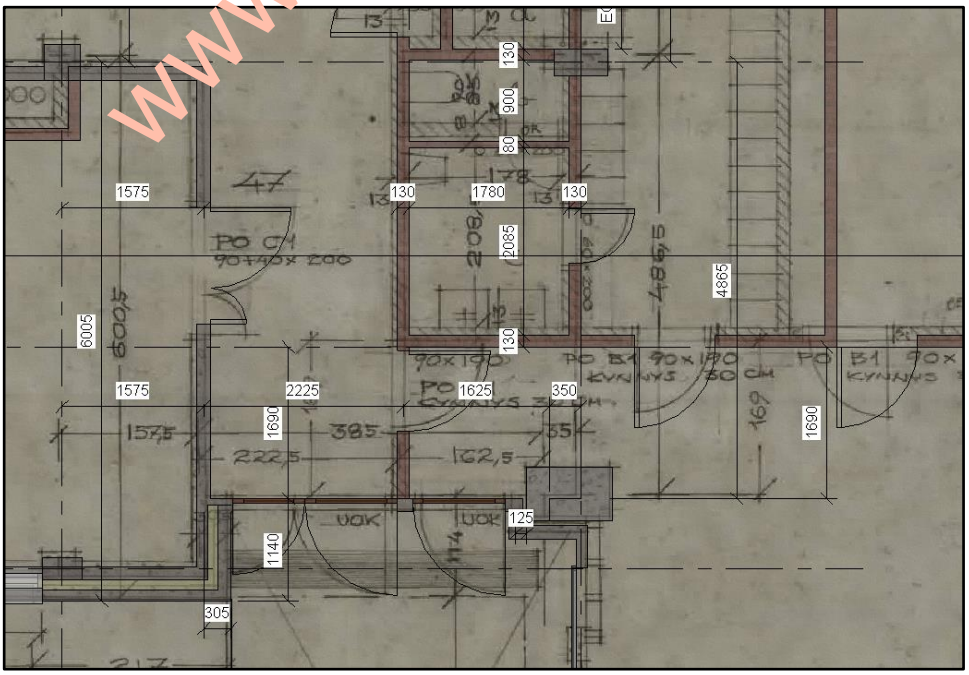

Figure 5-89 - Using the Aligned Dimension tool in the State Office Building

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2. Align

The Align tool was probably the most used tool in our project. It will be familiar when you are used to the AutoCAD-software. You activate it by going to the modify tab. We always used the short key, typing AL. After starting the align-command, you pick the face, line or point you want to align with, and then you pick the face, line or point to align. Selecting a particular point, line or face on a component is done with the TAB-key. Most of the times, multiple lines will be drawn over each other, and then it can be hard to instantly pick the one you want. You can just 'cycle' though all elements that are near your mouse-cursor by pressing the TAB-key.

3. Trim Extent

Another great feature we used extensively are the Trim Extent-tools in Revit. You can trim/extent to a corner (shortkey TR), trim extent to single (we appointed TS as short key) and trim extent to multiple (we appointed TM as short key).

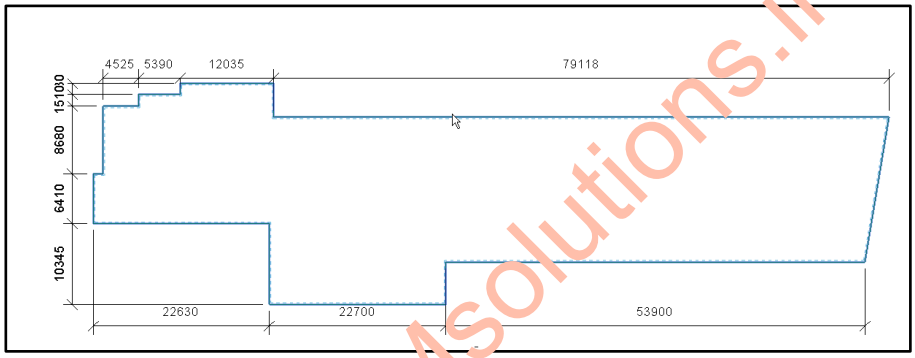

Figure 5-90 – Drawing walls with Pick Lines tool

To give you a good example of how we tried to use the tools in Revit in the best way, we will show how we have drawn the basement wall. We first started with drawing the outlines of the basement-wall with model lines (Architecture-tab > Model panel > Model Line). We added dimensions, to control the drawn measurements and we adjusted if needed. Then we activated the wall-command and used the Pick Lines tool. We made sure our Location Line of the wall was set to 'Finish face: Exterior' (or Core Face Exterior, since it is just a one-layered wall). Then we could select the whole chain of lines by cycling with TAB. Then we just had to click, and our basement-walls were born.

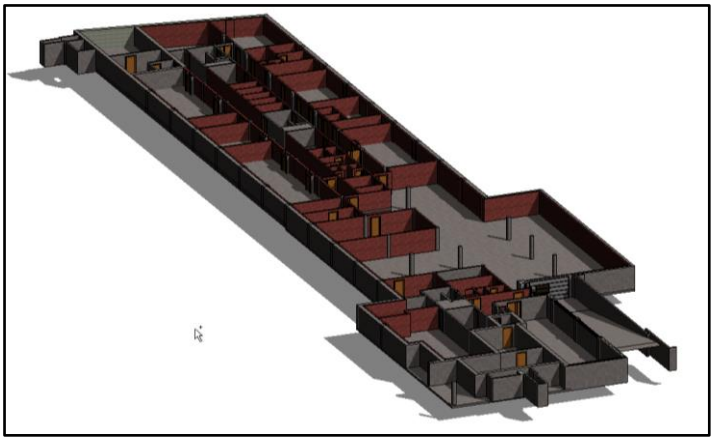

Figure 5-91 - Walls of the basement

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5.5.4 Slabs

5.5.4.1 General

The slabs would have been an easy and fast job if every floor only had one story level. Obviously, this was not the case. The State Office Building has different elevation levels in both basement and ground floor. The thickness of the concrete is also varying. For example, the bomb shelter ceiling has a thickness of 60cm. We also needed to draw ramps, to overcome these floor-variations. There are 2 smaller ramps in the basement and there is one bigger ramp on the outside. The big on makes it possible to drive a vehicle into the basement.

5.5.4.2 ArchiCAD

You start by selecting the Slab Tool from the Toolbox. In the settings dialog, you see 5 groups [5-92].

First, you can define the thickness of the slab [5-92A]. Right under this setting, you can define the offset of the slab relative to the Home Story [5-92B]. The offset can be positive, negative or just zero. Next, you can define the Home Story of the slab [5-92C]. Another possibility to locate the home story of the slab is also available in this group [5-92D]. In this tool, it is possible to define the distance relative to project zero, sea level, current story or other reference levels.

On the right side of the Settings Dialog, you can define the structure of the slab. This can be a Basic Slab, existing out of one material or a Composite Structure [5-92E]. Right under this setting, you can define the kind of Building Material or Composite Structure of the slab [5-92F].

You can also give an angle to your slab. The slab is perpendicular by default, but you can give the slab an angle. To do this, you click on the right icon and fill in the angle [5-92G].

The last setting defines the reference plane of the slab. Here you can set which reference functions as "zero" plane. When you define an offset, the offset will be given from that plane. When you select a Basic Slab you have 2 options, being top and bottom. When you select a Composite Structure, you have 4 options. These options are top, bottom, core top and core bottom. When selecting one of the 2 last reference planes, it is important to set the right materials as Core when you create the Composite Structure.

Just like with the previous tools, the most important things that can be set up in the other 4 groups are the ways of displaying of the slab in 2D and 3D.

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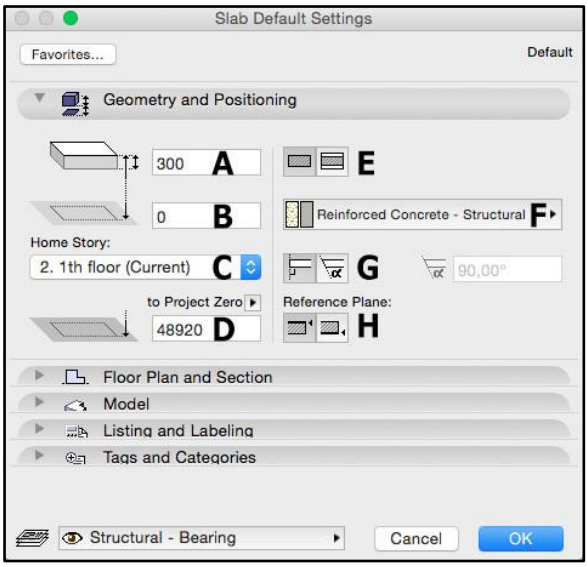

Figure 5-92 - Slab Settings Dialog

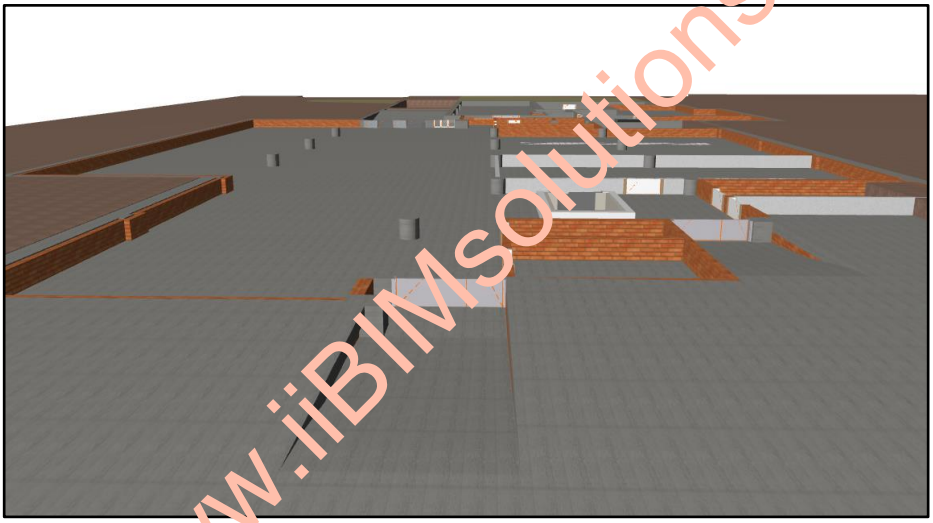

Figure 5-93 - Slab of the basement (with ramps)

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Now you can start placing the slab. In the Info Box you can select one of the Geometry Methods [5-94A]. We can define 3 methods. Starting from the left we have Polygonal. This one we used the most because you can define any shape of slab you want. The other two possible Geometry Methods are Rectangle and Rotated Rectangle.

Figure 5-94 - Info Box of the Slab Tool

In some cases it will be necessary to create an opening in the slab. For example were a stair is coming through the floor. First you need to select the slab in which you want to create the opening. Then you select the Slab Tool and start drawing the opening you want to have. ArchiCAD will interpret the new contour as a hole in the slab.

5.5.4.3 Revit

You have 2 kinds of slabs or floors in Revit, which are the structural and the architectural floors. Like with beams, columns and walls, the structural walls have some extra properties and parameters. These parameters can be used for analyzing strength-properties and for calculating reinforcing bars.

We will draw a floor by going to the Architecture tab > Floor. In the Floor command-dropdown, we select structural. Typically, the slabs are drawn downwards, just like structural columns and beams. When you first start the command, you will have to make a new type. The procedure of making floor-types is very similar to that of making wall-types. You duplicate [5-95A] an existing type by going to the Edit Type Button [5-95B] on the properties palette. Then you can edit your assembly by adding layers, functions, materials and thickness [5-96].

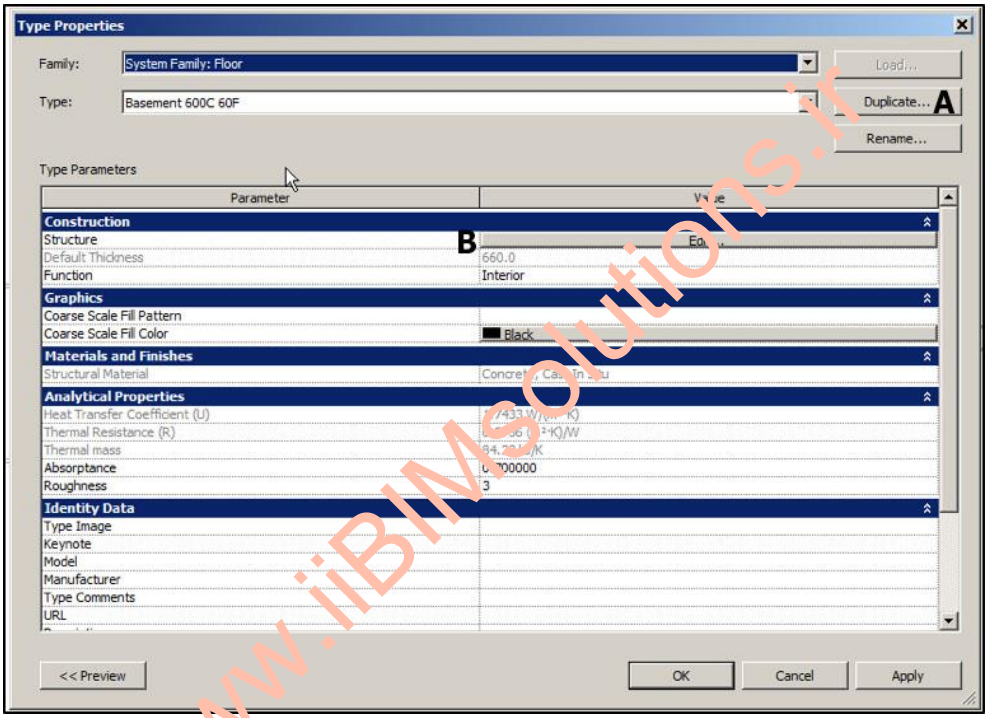

Figure 5-95 - Type Properties of a floor

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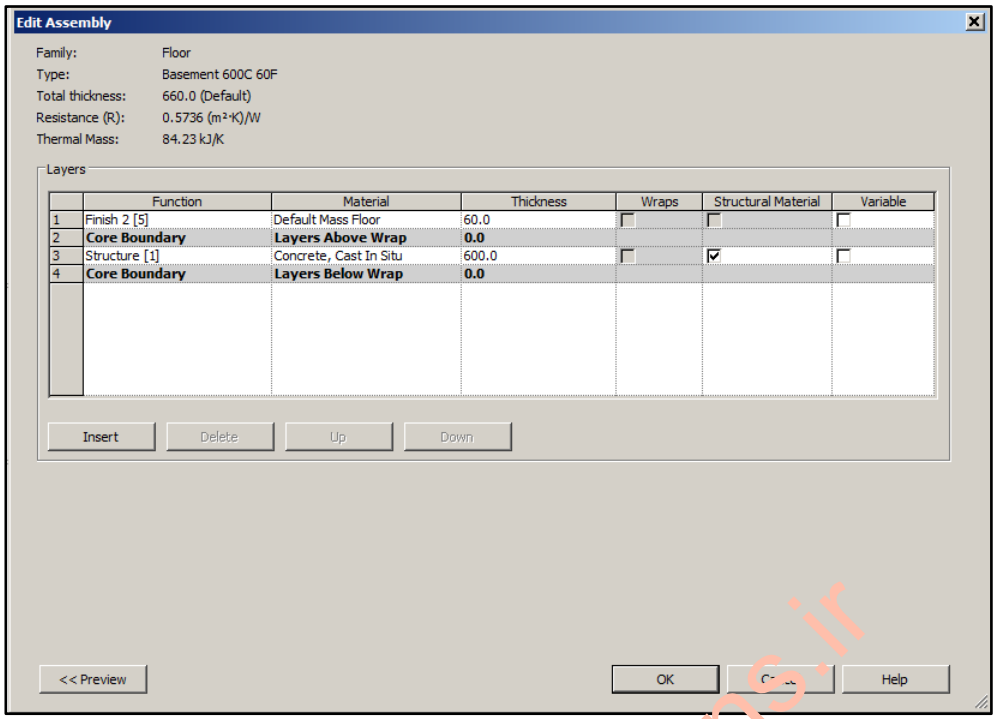

Figure 5-96 - Edit Assembly

When you assembled your floor, you can start defining the boundaries. This can be done in different ways. We can use all the utilities of the Draw panel in the Modify Tab. You can just start sketching the lines, or pick individual lines of a wall. You also have the ability to pick walls. For an irregular form like our building, we used a combination of picking lines, picking walls and drawing individual lines.

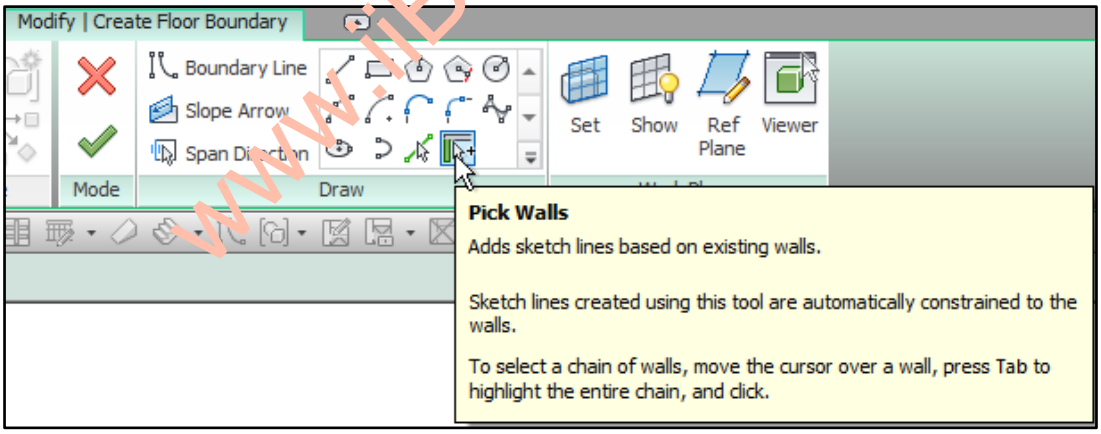

Figure 5-97 – Pick Walls

In the end, you should have a closed loop, and no overlapping lines. Your sketch boundary will appear in pink.

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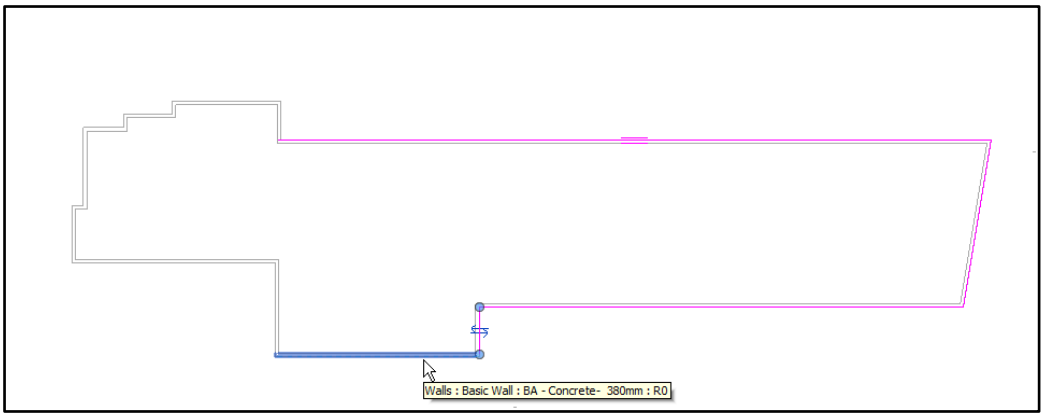
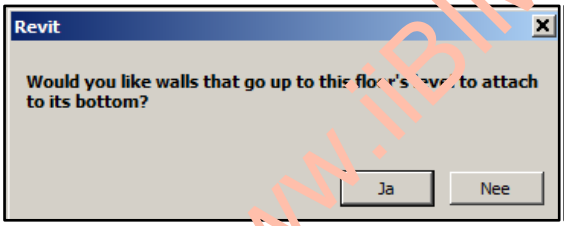


Figure 5-98 – Setting the boundary of the floor

You can use Trim/Extent to clean all your intersecting lines. When you use the 'Pick Walls'- tool, an extra setting will be available in the Options bar. You can choose to extent your floor to your core of your wall [5-99]. When working with a compound wall, this is a very simple tool to get your floor into the core of your walls and to join both structures.

Figure 5-99 – Offset

When you click 'Finish Edit Mode', sometimes you will be prompted with some extra questions:



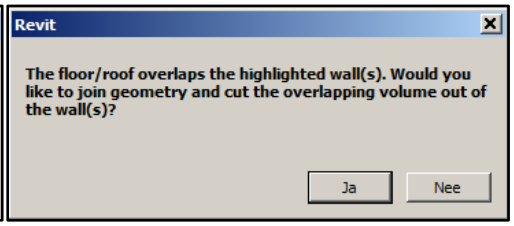


Figure 5-100 – Attach walls to floor

Figure 5-101 – Cut/join overlap

The first question will be about lowering your walls to the underside of your floor [5-100]. If you pick no, everything will stay on its place, so your walls will overlap with your floor. Initially, this is not really a problem. You can manually attach your walls to floors later on, but this can be time-consuming. You can also join floor and wall with the 'Join tool', so one of the 2 materials will be cut according to priority-level of the materials. If you pick yes, all the walls on the floor level will lower to the underside of the ceiling. This poses no problem for your interior walls. But also the outside walls will lower, leaving a gap in your façades [5-103]. To solve this, you have to pick the outer walls and activate the Detach Top/Base command [5-102] in the Modify tab. Now the walls will go back to their original position. The second question will be about joining overlapping volumes [5-101]. This question will be prompted when you extended your floors into the core of the walls. You can either click yes and join/cut automatically, or you can click no and do it manually later on.

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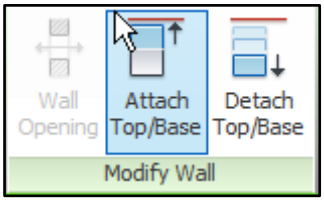

Figure 5-102 - Modify Wall

Figure 5-103 - Gap in the facade

Some floor-areas in the State Office Building differ in height. To draw these floors, we created extra elevation levels [5-104], so we could use them as work planes.

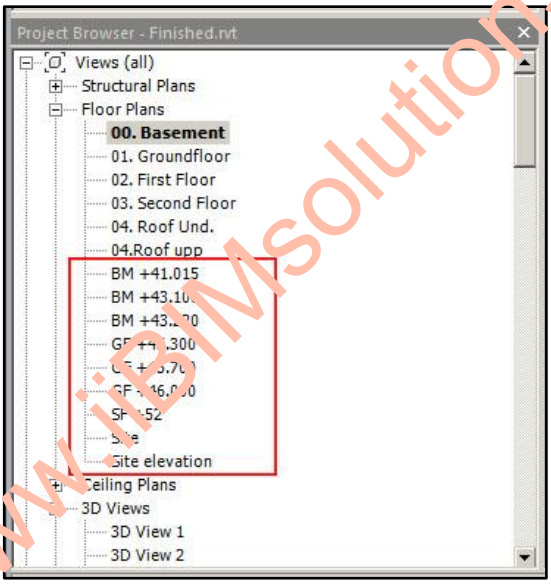

Figure 5-104 - Extra elevation levels in the Project Browser

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5.5.5 Stairs

5.5.5.1 General

The last missing part of our carcass, are the stairs. The building has four staircases. All four staircases will give you the possibility to go to the ground floor and first floor. Only three of them will lead to the basement and second floor. The staircases are made out of concrete.

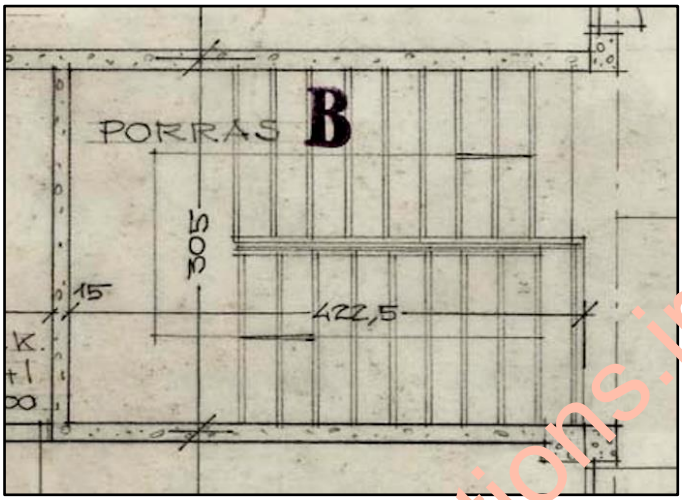

Figure 5-105 - Stair on the floor plan

5.5.5.2 ArchiCAD

You start with selecting the Stair Tool from the Toolbox. This time you can only define a small part of the settings from the Info Box and Settings Dialog. Settings like the offset, home story, placing point, angle and mirroring still have to be done from the Settings Dialog. Just like with the previous tools, the most important things that can be set up in the other 5 groups, are the ways of displaying the stair in 2D and 3D. In this case you need to set up most of settings in the StairMaker. StairMaker makes it possible to create a fully new type of stair. The library already has a few stairs [5-106A], but in our case, we will need to create a total new one.

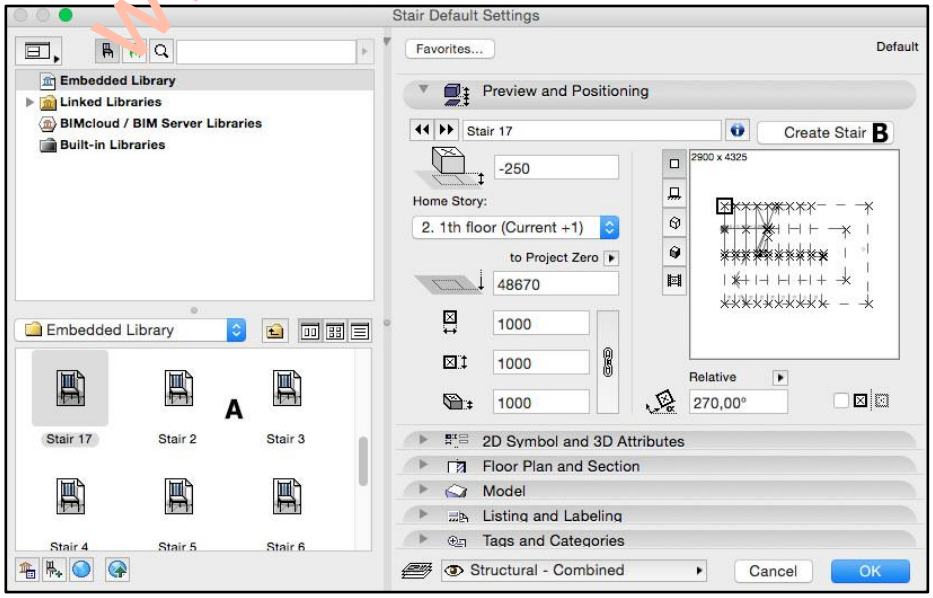

Figure 5-106 - Stair Settings Dialog

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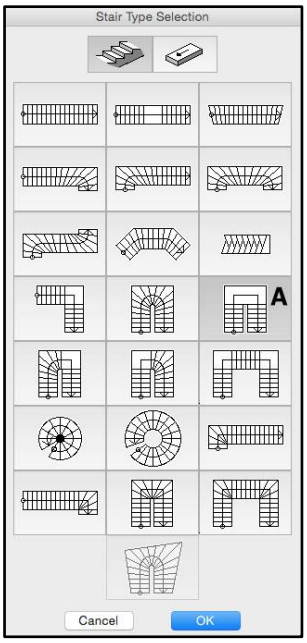
When you open the Settings Dialog, you can see that it is divided into 6 groups [5-106]. You have to select Create Stair from the Geometry and Positioning group [5-106B]. A screen will pop up where you need to define the type of stair you want to create [5-107]. In this project, we will need the U-return with landing [5-107A].



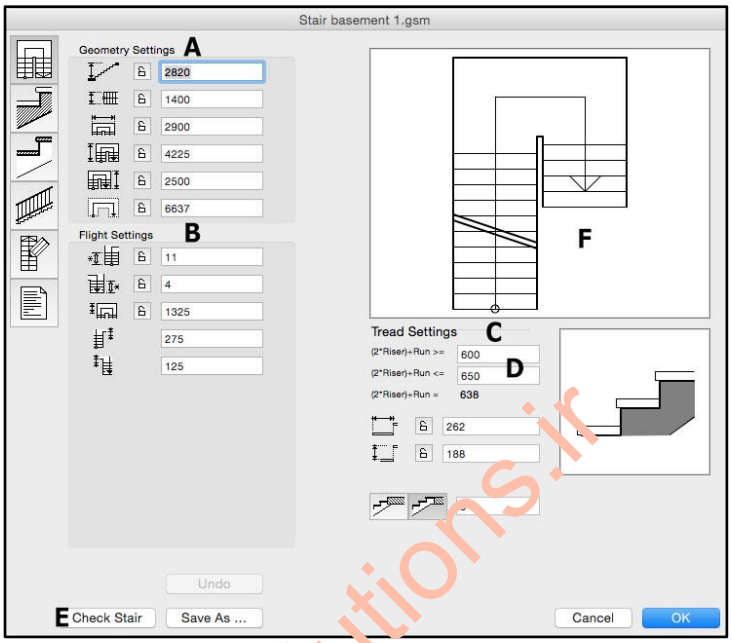


Figure 5-107 - Stair Type *Figure 5-108 – StairMaker*

After this, another screen will pop up where you have to define all the settings of the stair. You will define most of the dimensions of the stair in the Geometry and Flight Settings group, which is the first group. Most of the parameters in this group can be locked by clicking the lock icon next to it. If you do not lock a parameter, adjustments of other parameters can cause StairMaker to automatically edit the unlocked values. If parameters need changing, StairMaker will skip locked parameters and look for the next value in the hierarchy.

The first group is divided into 3 parts: Geometry Settings, Flight Settings and Tread Settings. In the part of Geometry Settings, you have to define the rise height, flight width, stair width, lower part length, upper part length and the length of the walking line [5-108A]. In the part of Flight Settings, you have to define the number of risers on the lower and upper side, width of the landing and the lower and upper offset of the landing [5-108B]. In the last part, you define the tread depth and height [5-108C]. When we would design a stair for a future building, we could define the riser geometry settings [5-108D]. It is easier and more comfortable to climb a stair when the sum of twice the riser and the run (2*riser + run) is within the range of 60 to 65 cm. We can define this in the settings and check if the stair meets these settings by clicking on Check Stair at the left bottom of the dialog [5-108E]. At the right top of the dialog, a 2D view of the stairs will show with the settings you just set up [5-108F].

In the second group of the dialog you can define the structure type, thickness of the stair and the used material [5-109]. In the third group you can define more specific settings of the treads like the thickness, possible offset and material of the treads [5-110]. In the fourth group you can define the settings for the railing. In the last 2 groups you can define the symbol settings and listing settings.

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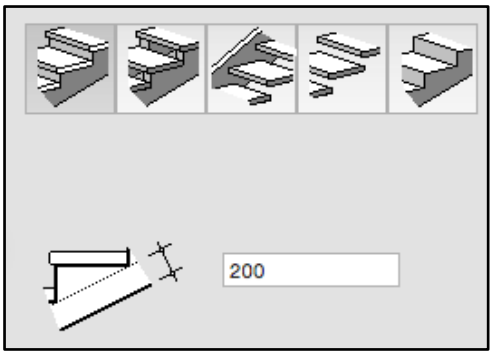

Figure 5-109 - Structure Type

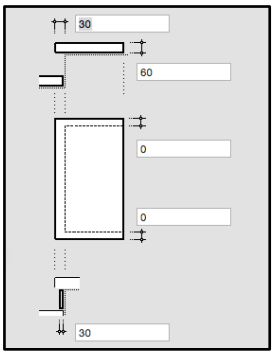

Figure 5-110 - Tread Settings

When all the settings are filled in correctly, you can save the stair by clicking Save Stair at the bottom left of the dialog. This can be useful when you need the same stair again in this or another project. It is not mandatory to save the stair, so it is also possible to just close the StairMaker, by clicking the OK button at the bottom right, and place the stair.

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Figure 5-111 - 3D view of a staircase

5.5.5.3 Revit

1. Creating openings in the floor plate

Before we can actually draw the stairs in between our floors, we have to make openings in these floors. A way to do this is by editing the floor and sketch an opening. When you draw a rectangle in the floor boundary, Revit will interpret this as an opening. Another way to make openings is with the Shaft tool. This tool you find on the Architecture Tab > Opening Panel > Shaft. With this command, you create a negative space that 'eats' away the floors, ceilings and roofs in between a certain pre-defined height, width and depth. For the width

and height, we sketch a rectangle on the appropriate spot in plan view. In the properties palette we adjust the height of the box by selecting begin and end level. We had to use both methods in the State Offices Building, because the openings of certain staircases vary on each floor.

2. Stair tool

Under the Architecture Tab > Circulation panel, you can find the Stair Tool. With this tool, you can draw a stair-element. This can be done with a pre-defined path, using the 'stair by component' tool (Straight Path, Full Step Spiral, Center-Ends Spiral, L-shaped Winder and U-Shaped Winder). Another way to make stairs is by sketching your own path in Sketch-mode. For our purposes we will use the stair by component with straight path. The drawing of the stairs proved to be quite straightforward, although many little tweaks were necessary.

When you activate the stair by components-command, you first have to load an appropriate stair from the Family Library. The family we used is the 'Cast-In-Place-Stair, Monolithic Stair'. We selected straight run. In the properties palette, you can add the Base Level [5-113A] and Top Level [5-113B]. Then we counted the amount of risers/steps on our floor plans. For some stairs, we had to go on site to count the actual amount of steps. You can add the 'Desired Number of Risers' [5-113C] in the Properties palette.

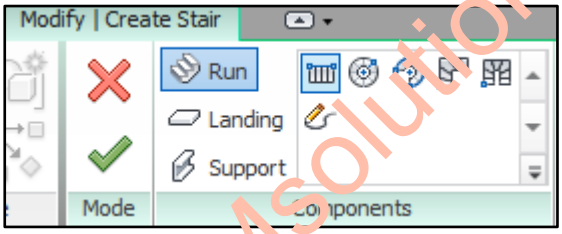

Figure 5-112 Create a stair in Revit

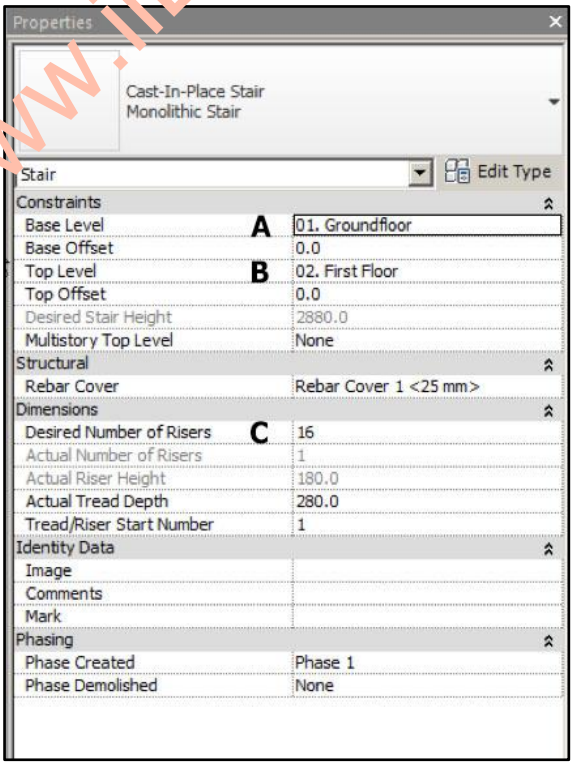

Figure 5-113 - Stair Properties

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Then we started to draw. The stairs make a turn of 180°, with a landing in between. Revit handles this very well. You just have to draw your first part and second part of your stairs, and Revit will automatically make a landing in between these two stair-parts.

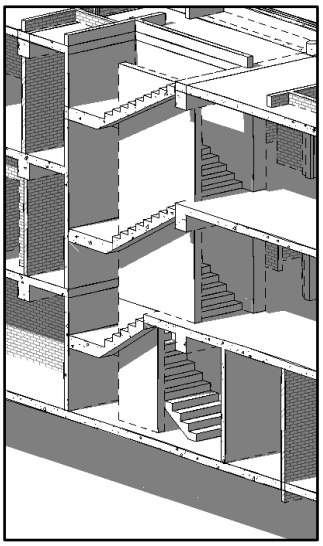

Figure 5-114 - Stairs in 3D

5.6 Windows and doors

5.6.1.1 General

Now that the carcass is completed, we can start placing our windows and doors. The windows in Finland are nothing like the ones in Belgium. The climate can be very harsh in winter with temperatures well below the freezing point. Because of this, the buildings need to be isolated very well. This attention to isolation can also be seen in the windows. All over Finland we find these double-sash windows [5-115] with in between an airspace of several centimeters. We still see this kind of double profiled windows everywhere, in old buildings but also in new ones. We combine the windows and doors into one part as creating and placing both is based on the same principle for both software packages. In total, there are over 150 window-parts and over 350 doors installed in the building.

Figure 5-115 – Double-sash window of the State Office Building

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5.6.1.2 ArchiCAD

In ArchiCAD we can relate on an extensive library. We've been able to find this type of window under the name of Inside-Outside Historic Window.

We start with selecting the Window/Door Tool from the Toolbox. Just as with the previous tools, you can define the settings from the Info Box and Settings Dialog.

When the Settings Dialog is opened, you can see that the dialog is divided in a left and a right side. On the left side you can browse through the library and search for the type of window/door you need [5-116A]. All the possible settings for the window/door will appear on the right side of the dialog [5-116B].

Just like with the previous tools, the Settings Dialog is separated into groups. The first 2 are the most important groups. In the remaining groups, things like the view options in 2D and 3D can be adjusted. We decided to keep these settings on default values.

To start, you can define the width [5-116C] and height [5-116D] of the window/door. The next thing to do, is to define the height of the window/door from the chosen reference point [5-116E]. Most of the time, the reference point will be from the bottom of the story you are working on. However, also the top and bottom of the host wall can be selected as reference point.

The following setting is the depth of the window/door reveal [5-116F]. The final setting is the anchor point of the window/door [5-116G]. In this part, you have to define if you rather want to have your input anchor point on the left, right or center of the window. For example, when windows are placed against a columns, you need a left or a right anchoring point. A preview of the window/door will be shown at the top right of the Settings Dialog [5-116H].

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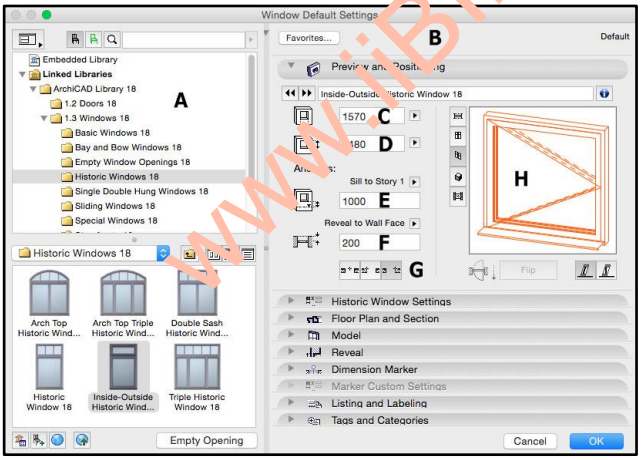

Figure 5-116 - Window Settings Dialog

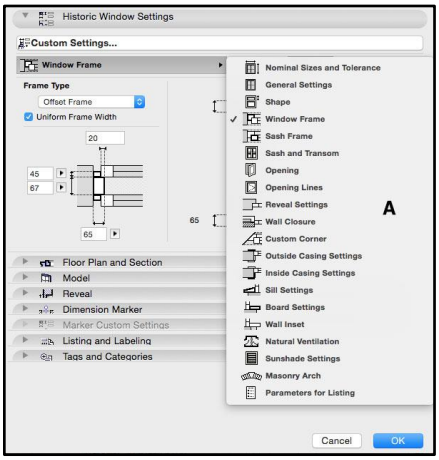

Figure 5-117 - Parameter options

Now we'll proceed to the more detailed settings of the window/door [5-117]. ArchiCAD has a large range of settings. You can see all the editable parameters in the picture above [5-117A]. All these parameters can be specified in detail. As our knowledge on the windows/doors was rather small, we could not define a lot of parameters. The frame and sill settings were the most important things to set up.

After you assigned the parameters, you can start placing the window/door. As you move the cursor over a wall, a preview of the opening will appear. The sun icon and thick line represents the outside of the window/door, so we always need to move our cursor towards the outside of the building. When we click, the window/door will be placed and you are not able anymore to move the window/door. The only thing left to do is defining the opening side of the window/door. This can be either left or right towards the inside or outside of the wall.

Figure 5-118 - 3D view of a created window

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5.6.1.3 Revit

The biggest part of windows and doors in Revit, is selecting the ones you want to use. If you have some very custom shaped windows for example, the best method is to make them yourself in the Family Editor. The editing or creating is the time-consuming part. Once you have a good and appropriate window family, the rest is straightforward. The actual making of the windows will be explained in the chapter of the family editor (see 5.7.3).

There are 2 main window-families we had to create, being the double windows with glass [5-120] and the 'cover'-parts [5-121] in between the windows. The covers are covering those parts where beams and walls are in front of the window. The covers are placed, so these walls and columns are not visible from the outside.

Figure 5-119 - Window on site

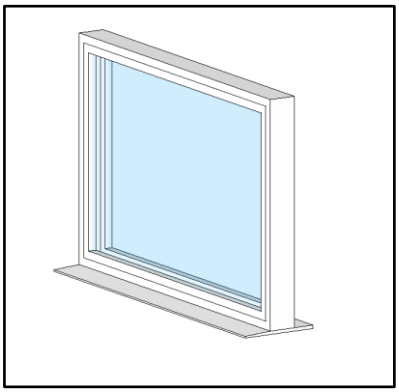

Figure 5-120 – Finished window

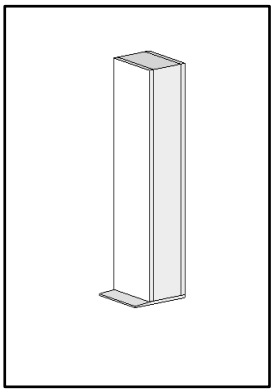

Figure 5-121 – Finished cover

So once we have loaded the 2 window families into our project, we can start making types. In total, we had to make 50 types of windows, which was quite a job. All sizes were mentioned on the plans, so we could use them perfectly as underlay. Once we had made our types, we could simply place them into the host wall. We used the align tool to align windows against columns and covers. In the properties palette, we adjusted the sillheights [5-123A] to to the appropriate dimension. We could derive these heights from the different cross-section-plans. Doors are done with the exact same principle.

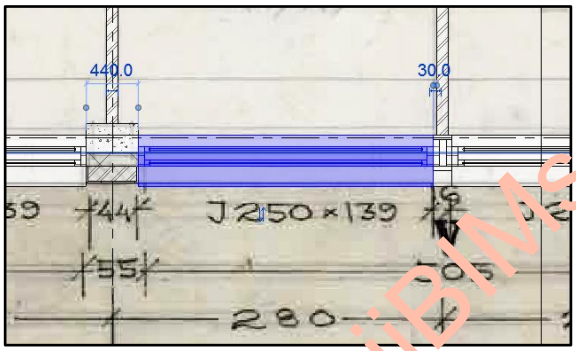

Figure 5-122 - Adding windows in floor plan

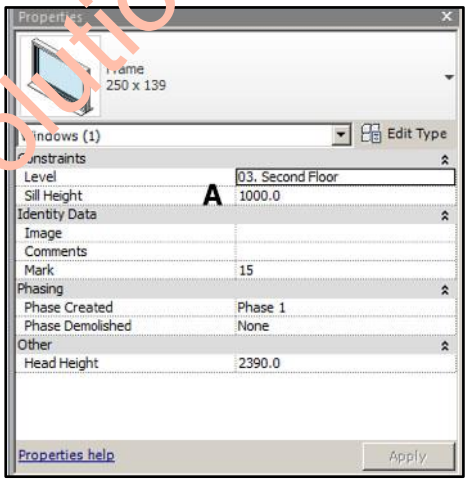

Figure 5-123 - Properties palette window

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5.7 Revit Families

5.7.1 General

The concept of a family is very important in Autodesk Revit. On the Autodesk Help website we can find a good definition: "A family is a group of elements with a common set of properties, called parameters, and a related graphical representation." So everything we draw in 2D or 3D, is in some way related to this concept of families. There are different kinds of families, and we will go further into detail below.

5.7.2 Kinds of families

There are 3 major kinds of families: you have the system families, the loadable or component families and the in-place families.

5.7.2.1 System Families

System families are hardwired in the project environment of Revit. You add parameters, layers, materials to a certain system family, and they are bound to certain rules which are predefined in the software. You cannot load them nor save them externally. These are typically basic elements, which you assemble on the building site itself. Examples of a system family are for example a walls, roofs and floors. These kinds of families are often quantified in terms of length, surface or volume.

5.7.2.2 Loadable families

Loadable families, also sometimes called component-families, are another major kind of family. These you do not create in the project environment, but in the Family editor environment. These are typically elements that are installed in the building, based on the carcass of the building and are often counted as individual objects. You could see them as more self-contained and less dependent on other geometry. Doors, windows, furniture and plumbing-fixtures are great examples of loadable component families. But also 2D-components you use for making sheets, such as symbols are loadable families. A north arrow or title-blocks are examples of these loadable families, but these are part of the annotation families instead of the component family. You can recognize loadable families by their *.rfa extension. When people speak about families in general in Revit, they often mean a loadable or component family.

5.7.2.3 In-place family

The last kind is an in-place family. These are created in the project-environment itself, with many of the basic tools you find in the Revit Family Editor. The shape of an in-place family and form are heavily based on and referenced to other project geometry. This means they are almost impossible to export or copy, since they are so dependent on actual project-geometry. This kind of family you can, for example, use when you want to create a desk element that is wrapped around a column. When the column is located somewhere else or the diameter changes, the desk will adjust accordingly.

5.7.3 Making a window with the Family Editor

5.7.3.1 General

When you need a certain loadable object for your project, before creating one from scratch, it is best to look if there is already an object in existence that meets your requirements. If so, you can just make a type that meets your requirements, and import it in your model.

For some objects in the State Office Building, like windows and the exterior doors, we decided to make a family from scratch. This ensured us that the eventual outcome would fully meet our needs. It was also a great opportunity to learn the basics of 'family-making' in the family editor. From tips and tricks, we often read that you should first make alterations to existing families before making a whole new one. But in our opinion, it is hard to make alterations to an existing family-component, if you don't know what to change in the first place.

5.7.3.2 Choosing the right template

When we first made a new family, we were asked to choose a family-template, which is recognized by the *.rft extension. There are all kinds of family-

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templates in Revit and choosing the right one is a very important step in the process. It can make your modelling so much easier and some tools will only be available in certain template-environments. For a window, there is a pretty straight-forward template, called 'metric-window' or 'metric-window with trim'. However, it is possible to start with another template, and eventually ending up with the same window. It can be quiet challenging to determine what all the different properties of the templates are. Choosing a certain template can have a great impact on how your element eventually is going to behave. Besides templates that are named corresponding with the type of element you want to create, such as a window or a door, there are also templates with some extra descriptors, e.g. wall based, floor based, and so on.

If you can determine how your elements have to behave in the project environment, you can select an appropriate template more easily.

1. Host based

Wall based (e.g. windows in a wall), ceiling based (e.g. light fixtures), floor based (e.g. heating-element) and roof based (e.g. skylights) families can only be placed on the element of the corresponding host type. They can cut through the host element if desired.

2. Standalone

Standalone families don't relate to a host, and can be placed independently. Furniture is a great example of a standalone family.

3. Adaptive families

Adaptive families are used to create components that can be used for repeating systems using arrays and constraints. These families are made in the conceptual mass environment.

4. Line-based families

Line-based families create elements where the main geometry is attached to a length by specifying 2 points.

5. Face-based

A Face-based object can be placed on any surface of a model element in the project. These can also interact with other elements, for example by making complex cuts.

5.7.3.3 Start making the window

The principals of making a component in the family-editor is to make a 2D sketch-based form, on which you then can do some simple transformations like extrude, blend, revolve, sweep and a swept blend.

To make a window in the family editor, we have to shape the elements of that window and be sure they behave in a parametric way. Parametric means that we can adjust the width or the height for example. This ensures us that we can make all kinds of family-types of our window-family.

The steps to a successful family component are always the same. First we need to choose the right template and determine the hosting-behavior. After that, we

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lay out our reference planes. These Reference Planes, also referred to as RP, are the skeleton of our component. We build and lock geometry to these planes. In addition, if we want to add parametric properties to our components, we add it to our Reference Planes. Reference Planes are the actual things that move when we change for example a height or a depth. The geometry is just 'glued' to these planes, and they simply follow along.

The rough steps are as follows:

1. Choose the right Template and hosting (wall, floor, face,…)
2. Sketch our Reference planes and name them so we can get track of them
3. If necessary, add parameters and constrain our Reference planes to each other.
4. Add the actual geometry
5. Test how the component behaves if we change some parametric values. Sometimes this testing is referred to as 'flexing the component'.

Our window will consist of a frame that will contain 2 sashes. In the end, we will add a sill to complete our window.

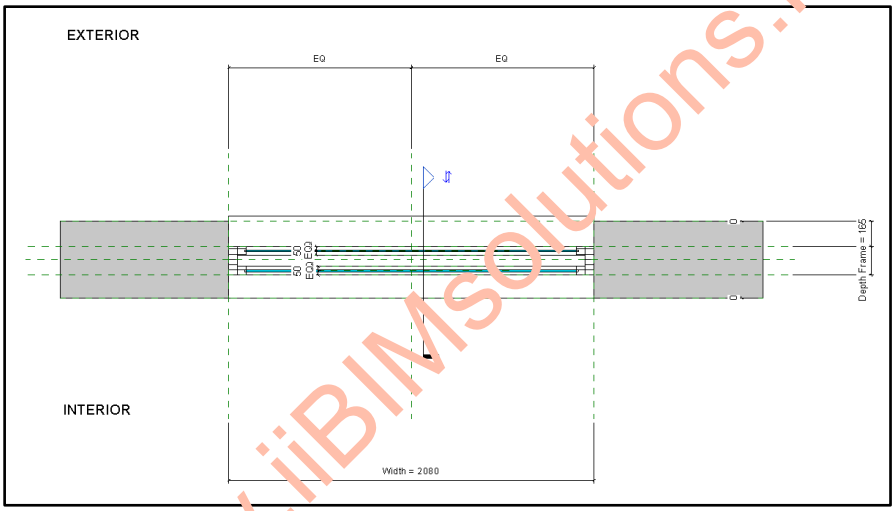

Figure 5-124 – Window in Family Editor

1. Choosing template

We will start with the metric-window.rft template [5-125]. In this template, there is already a host-wall drawn, and we also find a cutting plane that makes the opening in our wall. If we would flex this rough model now, we would see that when you adjust height or width, the cutting plane will follow. So this means the cutting plane is attached to the laid-out reference planes. We flex our model by going to the Family Types under the properties panel and change the values accordingly [5-126]

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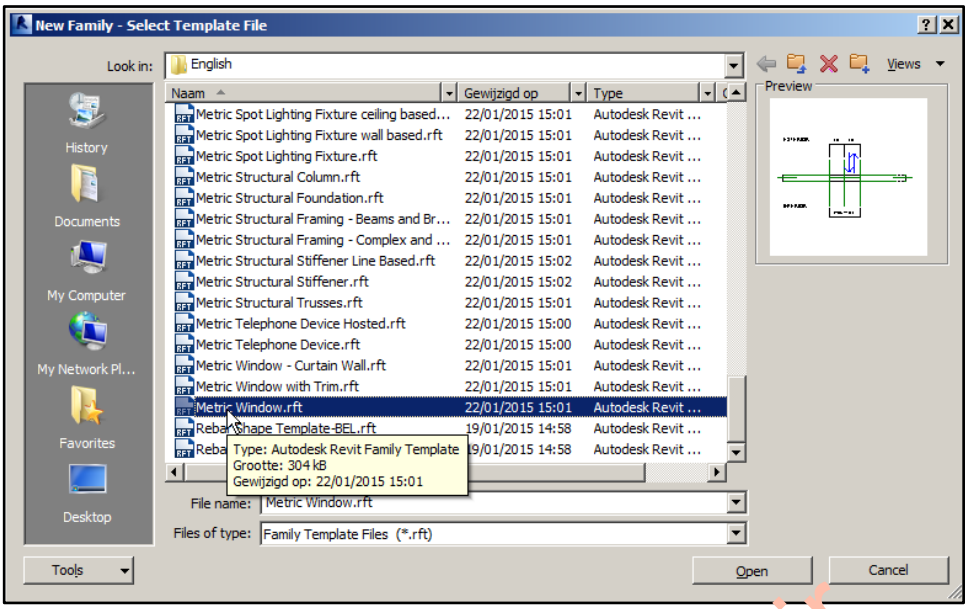

Figure 5-125 - New family with template

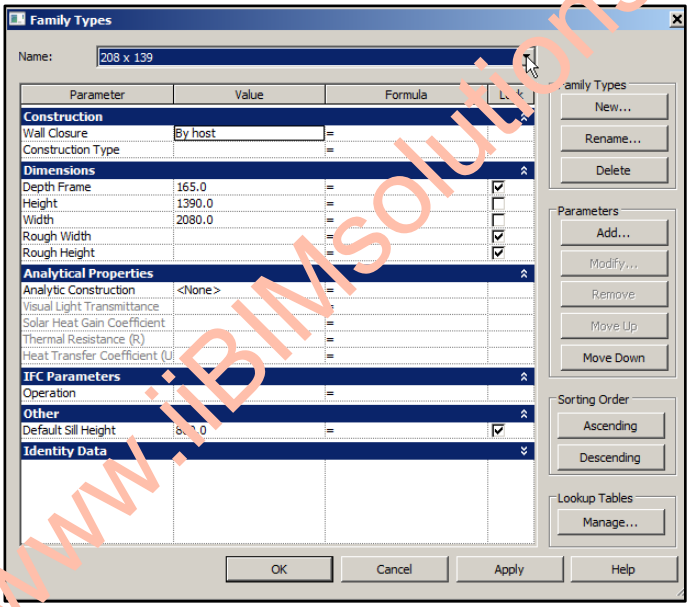

Figure 5-126 - Family Types

2. Sketching Reference Planes

The next thing we will do, is laying out some of our additional Reference Planes. The outer boundaries of the windows are already defined by the existing RP's. From a plan view, we will add a reference plane, parallel with the already existing outer one, so we can define how deep the window will be placed in the wall. Another RP will define the depth of the window frame. This RP will be named 'Depth Frame'. The actual geometry of the frame will thus be squeezed in between the 'Depth Window'- RP and the 'Depth Frame'-RP. These 2 reference planes will also be part of our boundaries for our inner and outer sash. The inner and outer sash will therefore need 2 more Reference planes, being Outer Sash and Inner Sash. The Outer Sash-RP and Depth Window-RP define the Outer Sash Width, the Inner Sash RP and Depth Frame define the Inner

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Sash Width. Naming the reference planes is important, so we don't accidentally refer to the wrong one when more reference planes are added in a later stage. You can add an identifier to a Reference Plane in the properties palette (when the RP is selected). By adding a dimension between these 2 Reference Planes with the Aligned Dimension Tool (shortkey DI), we make it possible to add a parameter to this dimension, making it adjustable [5-127]. To make a distance parametric, we select the placed distance and add a parameter to it by labeling it [5-128]. For this example we will give this parameter the same name as the reference plane "Depth Frame". A point of care when you select an object or line is to be sure you have selected the right object or line. When you make families, you will often find a lot of lines drawn over each other. To select the right line or object, you should use the Tab-key to cycle through all objects where you are currently hovering over and click your mouse when the right one is lighting up. In the left down corner of the drawing area, you will see the identification of the current selected object.

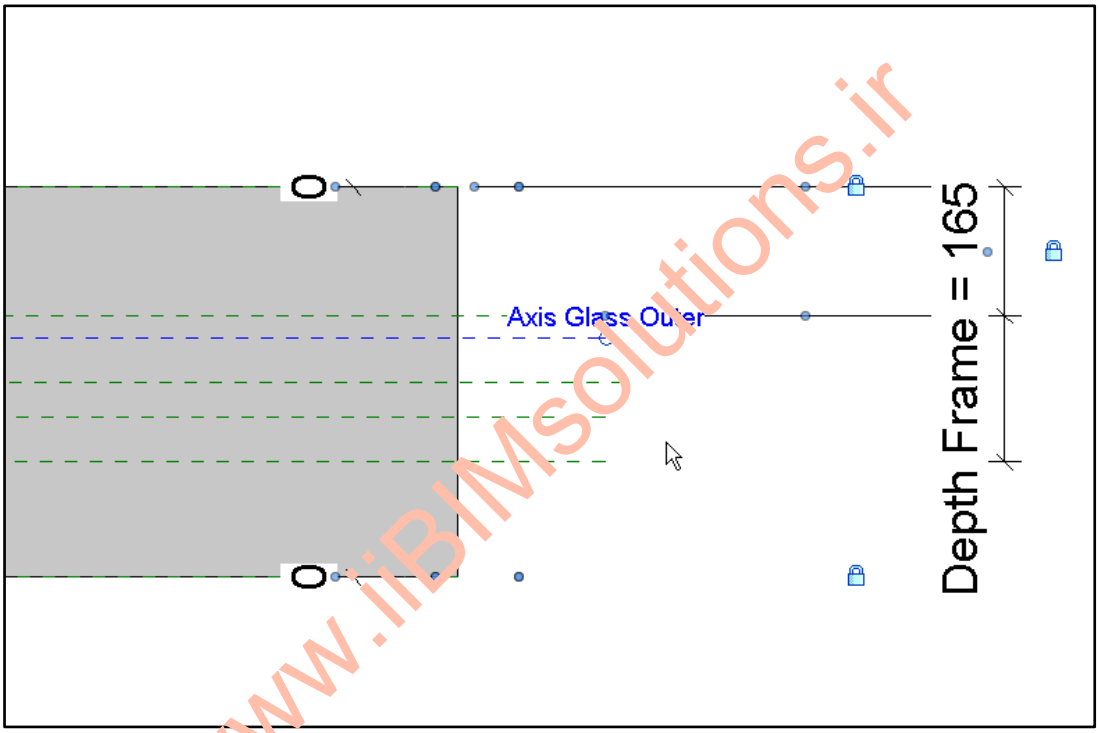

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Figure 5-127 - Depth Frame

3. Adding parameters

Distances between these Reference planes will be tagged with a parameter accordingly. Finally we need 2 more Reference planes to define where our inner and outer glass will be. These will be placed in between the Outer Sash-RP and Depth Window-RP for the outer glass, and Inner Sash RP and Depth Frame for the inner glass. The glass needs to be in de middle of the sashes, so we make sure that the distances are equal with the 'equal distance feature' of the distance command.

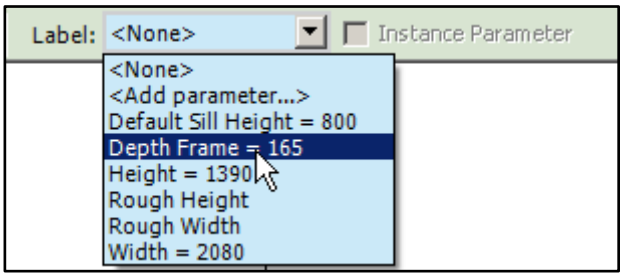

Figure 5-128 – Making the 'Depth Frame' Parametric by adding a label

4. Add the actual geometry

Now that all our Reference planes are laid out, and they have been tagged with parameters accordingly, it is time to add some geometry. All window-geometry will be drawn with the extrude tool, the sill will be defined by a sweep. The way this works in the family editor is by first sketching the shape you want to extrude, and then extruding it defining the Extrusion Start and Extrusion End value. In which view you start drawing (an elevation view or floor plan view), is also important. The extruding of a shape takes place parallel with the view you sketched your shape in. Depending on the extruding value, the extrusion goes 'into your screen' or comes 'out of it', so to speak. In other words, you will not be able to see the extrusion initially, but you have to change views, for example by going to the 3D-view.

We take the window frame for example. We start of by going to the Exterior Elevation View. In this view we draw 2 rectangles. The outer will define our height and width of the frame, and we will lock these sides to the according RP. The inner rectangle is interpreted by the sketch as an opening. We can also define the relation between the inner and outer rectangle, thus defining the mullion width of the frame.

First we need to define on which Reference plane we want to draw our geometry. In the case of the frame, we can pick the Depth Frame RP. We draw our inner and outer rectangle, and set them 50 mm apart with the Aligned Dimension tool. Then we will lock the outer sides of the rectangle to respectably Head-, Sill-, Left- and Right Refencence planes. These were already predefined in the template and determine the outer dimensions of the window. Locking is done by using the Align tool (shortkey AL). First we select the reference plane we want to align to, then the 'to align' side of the rectangle. So we want each outer line of the rectangle to align with the right reference plane. Each time an alignment takes place, a lock -icon appears. This lock should be activated, so the geometry is 'glued' to the Reference plane. When the reference plane changes its position, the geometry will follow along. Another thing to do, is to define the extrusion-value. We will leave the Extrusion start to 0; and set the extrusion End to 165. The extrusion will 'come out' of the screen with 165 mm, which is the depth of our frame. In a similar way, the other parts of the window, like the sashes and the glass, are extruded, aligned/locked and set to the appropriate Reference Plane.

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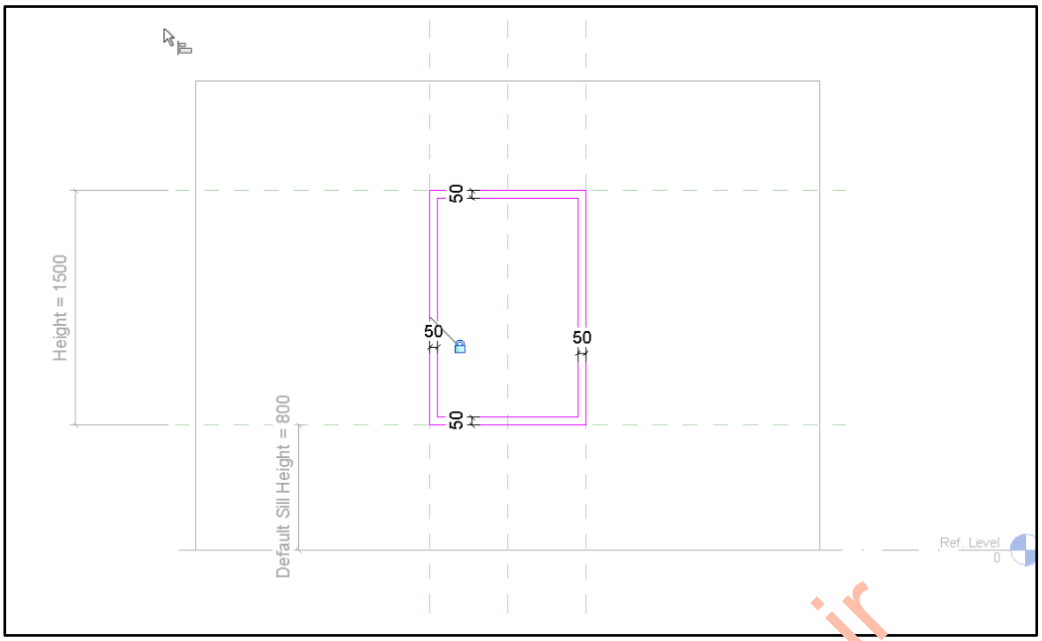

Figure 5-129 - Locking geometry to reference planes

For the sill geometry we will use a sweep form. The principle is that you appoint a path [5-130A] (which is a line in our case) along which a 2D profile [5-130B] is 'sweeped'. This profile can be a sketch-based shape or can be a predefined 2D-family shape. For our purposed we will define the shape ourselves.

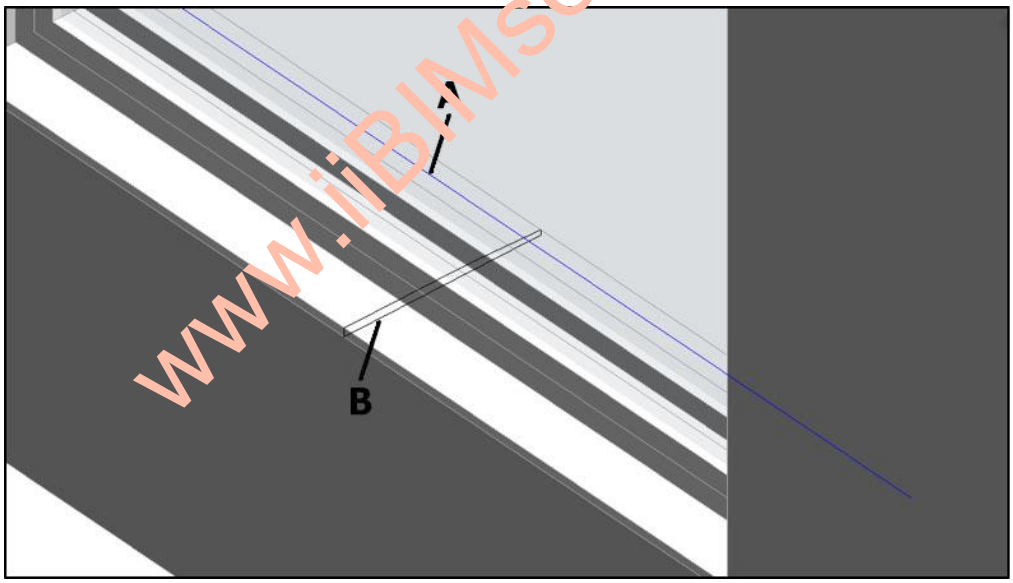

Figure 5-130 – Sweep of the sill

In the end we will have to appoint some materials to our window. In the properties palette, under 'materials and finishes' we can define the material of the drawn geometry. We will appoint a white paint color to the frame-geometry in the family editor itself. Another way to add materials to geometry, is by making the 'materials and finishes- tag' parametric. This way it is possible to change our material later on. For our purposes, we will fixate the material in our family editor itself, making it non-changeable.

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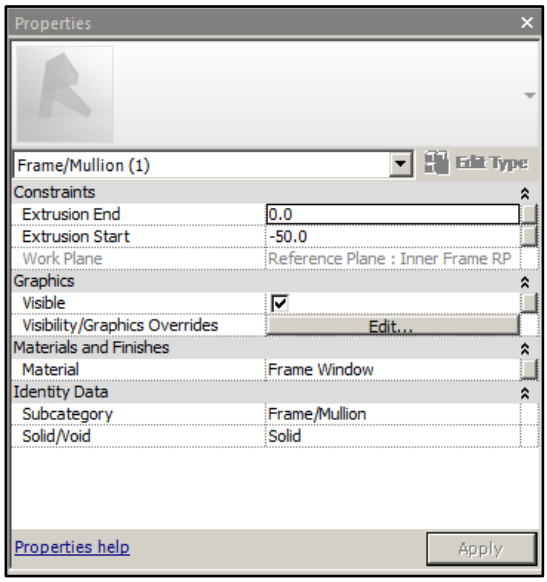

Figure 5-131 - Frame properties

5. Flexing the component

It is advised that each time you add some new geometry, you flex the model. This way, you can ensure you are still on the right track and you can adjust if needed.

Figure 5-132 - 3D result

5.7.4 Making columns in the Family Editor

There are two custom-shaped columns needed in the State Offices Building. The first one being some kind of oval shaped columns in section, which are situated on the ground floor (axis 12). These are actual round columns, which have been stretched. This is because there is a dilation joint going through them, and there are some movement joints incorporated in the columns. The

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other custom shaped columns, are located on the outside. Both columns were made in the Family Editor, using the same principles as with the making of the windows and doors.

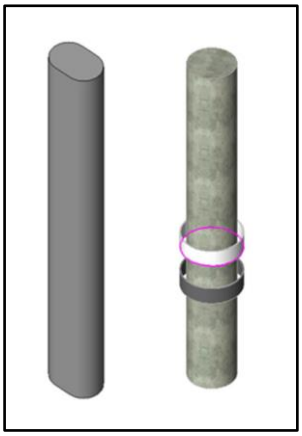

Figure 5-133 - Column result

5.7.5 Making Tiles in the family editor

Figure 5-134 - Tiles on the building

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Aalto is very famous for the use of ceramic tiles that are designed by himself. In the State Offices Building, these were used on a part of the front façade. In front of the windows, concrete stiles are used as a raster, which are tiled. The rest of the wall is also tiled. This is a very unique feature, and defines the whole outlook of the building. That is why we tried to reproduce it as exact as possible in Revit. We did some measurements on site to determine the dimensions of the tiles and the stiles. Then we created 2 'face-based' families, one for the stile and one for the tiles. The face-based properties of the family are ideal for the purpose. They will automatically orient and attach to faces they get in touch with. So after we made them in the family-editor and imported them into the project, we used arrays to put the tiles and stiles on the right place. This was a tedious job, but in the end we got a satisfactory result.

Figure 5-135 – Rendered image of the tile-façade in Revit

5.8 Complex profiles in ArchiCAD

When customizing a standard construction gets too complicated, you can create a complex profile. For example all the outer walls on the ground floor have a concrete footing. You could draw the footing and wall apart from each other, but in that case you'll need to draw an extra wall which would take a lot more time.

In ArchiCAD, we can easily create this footing as a Complex Profile.

First we need to select the wall, beam or column that we want to edit. When the element is selected we can open the Complex Profile Manager by going to the Menu Bar, selecting Design > Complex Profiles > Profile Manager [5-136]. Another way is by right clicking and selecting Edit Selected Complex Profile, but to do this, the selected element already has to be a Complex Profile.

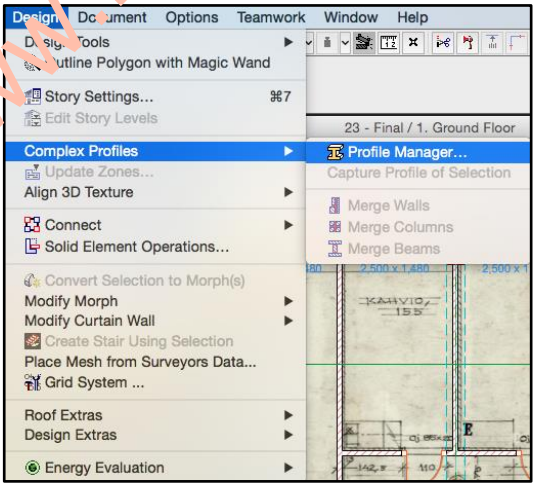

Figure 5-136 - Navigating to Profile Manager

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The Profile Manager Dialog will now open [5-137]. By clicking the Capture button you will be able to edit the selected element [45-137A]. The Profile Editor will now pop up with the structure of the selected element in it [5-138]. Now you need to draw the adjustments with the Fill Tool. So we start by selecting the Fill Tool, which is located in the Document group in the Toolbox. You can define the kind of material you want to use from the Info Box. You can also use the Pick Up Parameters function (see 5.2.1.5) when the material you need is already in the element.

As an example, we'll create the wall with the concrete footing. In this case, we can use rectangular as Geometry Method from the Info Box. Now we define our starting point for the footing [5-138A]. Next, we have to define the height and width of the footing. By pressing the TAB-button, we are able to fill in exact measurements for the fill we want to create [5-138B]. We define a height of 175mm and a width of 120mm for the footage. By pressing the ENTER-button, the footing will be created.

Now we still need to edit the bottom side of the bricks and plaster, as they still overlap the concrete footage. First we need to select the fill we want to adjust. This can be done by just clicking on a random area inside the fill [5-139A]. The selected fill will be highlighted with a green colour. Next, we select the bottom line of the material as we want this to be above the concrete footage [5-139B]. By selecting the bottom line, the Pet Palette will pop with a collection of tools that can be used to edit the fill. In this case, we will need to select the Offset Edge icon [5-139C]. The next thing we do is dragging our cursor upwards and click on the top of the footage [5-139D]. Now the brick wall will be adjusted to the top of the footage. The same needs to be done for the plaster as well.

Now that the adjustments are done, we can either choose to store the profile or/and apply it to the selected element. Storing the profile can be useful when we need to have the same Complex Profile at other walls too, which is the case for the profile we just created. So we store and give the profile a name first [5-137C] and after that we can apply the profile on the selected wall [5-137B].

But to use the Complex Profile for other walls, you'll have to take some things in mind. Both walls need to be exact the same, having the same structure/thickness and height. The wall that you want to use the Complex Profile on needs to be drawn with the same reference line as the wall that you originally created the Complex Profile from. The Reference Line from a Complex Profile cannot not edited and changed.

The end result of this complex profile in 3D is shown in the figure below. A collection of the complex profiles we created for this project can be found in appendix 4.

However, sometimes it is still better to draw 2D-details, when structures are getting to complicated to draw in 3D. Of course, 2D details will not affect the 3D geometry.

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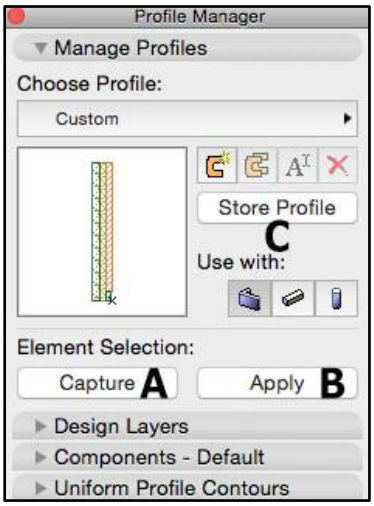

Figure 5-137 - Profile Manager Dialog

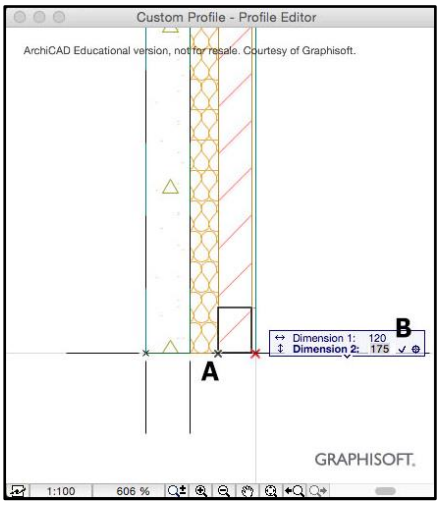

Figure 5-138 - Editing a Custom Profile

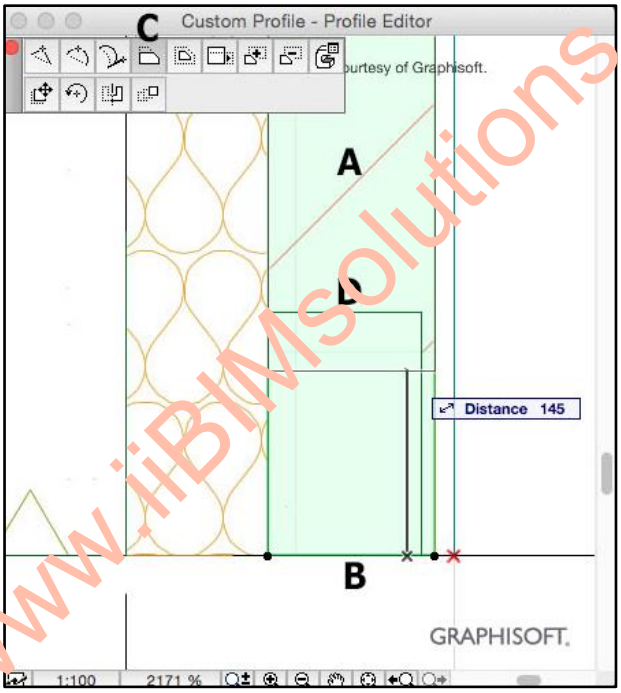

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Figure 5-139 - Editing the fill

5.9 Environment

5.9.1 General

A model always looks nicer when it is placed in an environment. Because we have been able to draw our ArchiCAD model so quickly, we still had the time to model the surroundings. We have drawn the site plan according to the original plans we had. Besides that, we were able to import the other buildings of the Alvar Aalto Centre. These are previously modelled in 3ds Max by other students from the university. These models can also be found in Google Earth and can be downloaded from the 3D Warehouse of SketchUp.

5.9.2 Ground

We need to create the surrounding grass fields and roads with the Mesh Tool, so we start with selecting the Mesh Tool from the Toolbox. Just as with the previous tools, you can define the settings from the Info Box and Settings Dialog.

When the Settings Dialog is opened, you can see that it is divided into 5 groups [5-140]. In the Geometry and Positioning map you can define the thickness of the mesh [5-140A]. In this case it doesn't really matter how thick the mesh is, as long as it gives a realistic view to the project. Next you can define the offset of the mesh, which can be positive, negative or zero [5-140B]. Defining another Home Story can be done right under the previous setting, but in almost every case it will be the easiest to define the offset from the ground floor [5-140C].

Another possibility to locate the Home Story of our mesh is also available in this group [5-140D]. In this tool, it is possible to define the distance relative to project zero, sea level, current story or other reference levels.

On the right side of the Settings Dialog, you can define the Construction Method, which can be Surface Only, Surface with Skirt or a Solid Body [5-140E]. The last thing to set up in this group is the building material [5-140F]. In every mesh of this project, we used Sand as building material.

To give the top side of the mesh another look you have to go to the Model group. In this group we can override the top, skirt and bottom surfaces. In our case, we need to override the top case by clicking on the top icon [5-140G]. Now we are able to select a top surface. We used 3 different kinds of surfaces: grass, concrete and asphalt.

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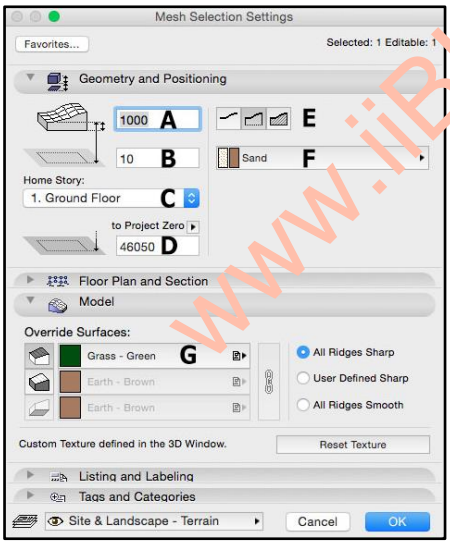

Figure 5-140 - Mesh Settings Dialog *Figure 5-141 - Result of the created Meshes*

When you are done with the settings, you can start drawing the mesh. First you need to choose one of the 4 Geometry Methods from the Info Box. The options are Polygonal, Rectangular, Rotated Rectangular and Regular Sloped. In most of the cases, we used Polygonal as geometry method because most of the meshes we need to draw are various shapes. When you define the starting point, the Pet Palette will show up where you can choose to draw straight or circular lines. To finalize the mesh you need to end up back at the starting point.

5.9.3 Buildings around the model

When you download a model, you need to save this as a SketchUp 8 or earlier version. Only these versions of SketchUp are supported in ArchiCAD. You can also download the models from the website of SketchUp, but because we had to save the files in another format, we needed to download the models in SketchUp itself. After we saved the model, we can return to ArchiCAD and import the file by going to the Menu Bar and select File > File Special > Merge. Then we search for the file that needs to be imported. After the file is imported, the last thing you need to do, is defining the position of the model with a final click.

But as we import the model, a part of the terrain from Google Maps around the building is also imported. The imported model also had photo textures on the facades, but in our case we didn't want to use them. We thought that they attracted too much attention from our actual model. To adjust these settings, you will need to select the model and open the Settings Dialog from the Info Box. We can disable the terrain from the Custom Settings [5-142A] and override the surface in the Model group. First, we have to disable the Select Object's Surfaces [5-142B] and then we can assign another material to the model [5-142C].

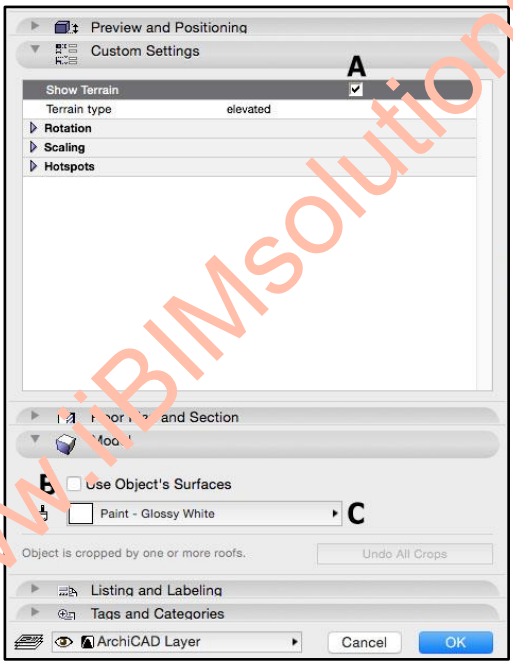

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Figure 5-142 - Settings Dialog of the imported model

Figure 5-143 - Final result with all the models imported

5.10 Objects in ArchiCAD

5.10.1 Using objects from the library

One of the big advantages of ArchiCAD is the large library. A lot of objects can be found in the library and the amount of objects is growing every year. A big part of these objects have proven to be very helpful for our project, as they are very easy to place and edit. A lot of parameters can be adjusted specifically for every kind of object. The settings of the selected object will pop up at the right side of the Setting Dialog [5-144B].

As we select the Object Tool and open the Settings Dialog, we can scroll to all the maps on the left side [5-144A]. The library is divided into 3 main parts: Basic Library, Visualization Objects and Add-On Library. The Basic Library contains all kinds of furnishing (chairs, office equipment, etc.), building structures (fences, precast column and beam, hollow core slab, etc.), special constructions (ladders, rainwater pipes, elevators etc.) and 2D elements (electric and graphic symbols). The Visualization folder contains site improvements (trees, parking places, vehicles).

Another way to search for a specific object is by typing the name of the object you want in the Search Bar at the top of the Settings Dialog [5-144C]. This way you will not only search for objects in the integrated library, but also on the BIM Components Portal. This is a portal where everyone can upload his created objects. This way, you will find more and different objects. Of course internet connection is required for this feature.

In our project, we've made use of following objects: skylight domes, ladders, ramps, elevator, parking places, 3D text and trees.

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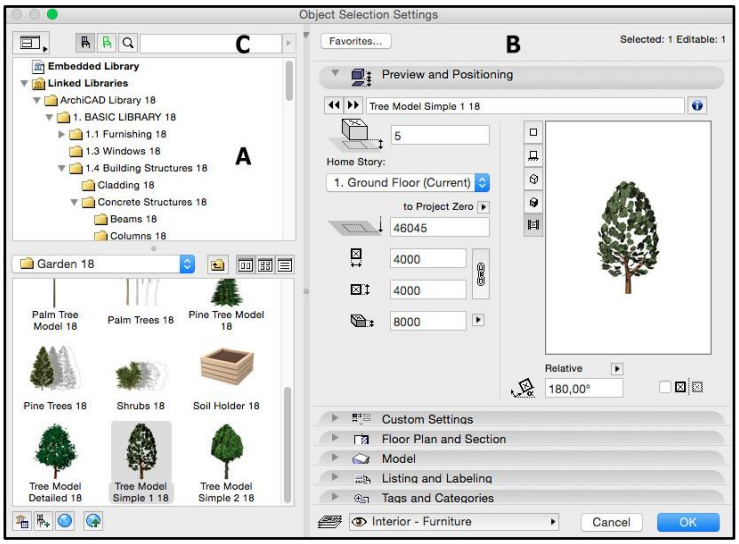

Figure 5-144 - Object Settings Dialog

5.10.2 Creating an object

As mentioned in the Revit-family chapter, a small part of the front façade is covered with ceramic tiles. In order to model these, we needed to create an object ourselves. You can start drawing an object within the current project or in a new one. As it is a rather small and easy object, we decided to draw it in the current project.

It does not really matter with which tool you create the object, you just select the tool which you think is the easiest one to draw your object with. So we decided to draw the ceramic tile with the help of the Slab Tool. After selecting the Slab Tool, we can easily create the shape of the tile with the Polygonal Geometry Method. The dimensions assigned to the slab don't really matter, as we can adjust the width, length and height of the object in the Settings Dialog later. When the shape is drawn and the slab selected [5-145A], we can save the slab as an object by going to the Menu Bar and select File > Libraries and Objects > Save Selection as > Object [5-145B]. A screen will pop up where we have to set up a name for the object.

The object can now be found in the library and we can define the dimensions and surface from the Settings Dialog of the object [5-146]. Another object we created are the rings that are situated around the columns. The result of both is shown in the figure below [5-147].

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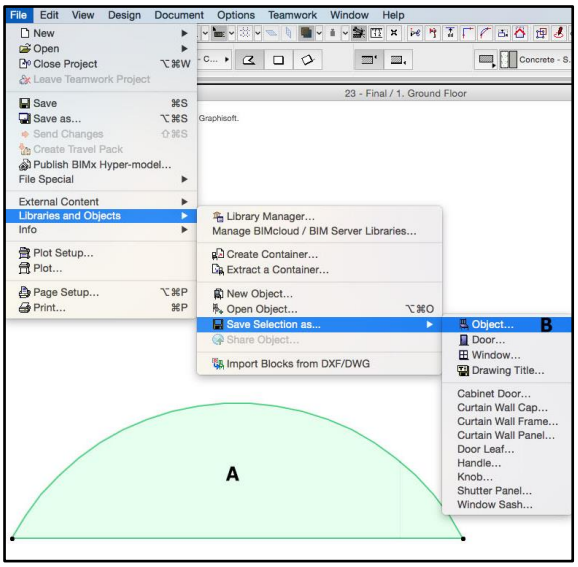

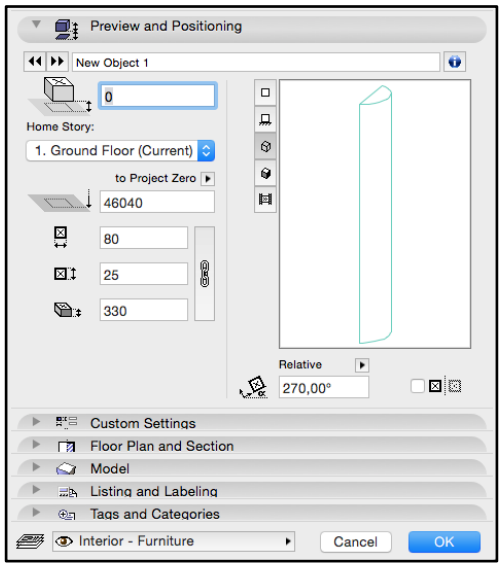

Figure 5-145 - Save as an object *Figure 5-146 - Settings Dialog of the tile*

Figure 5-147 Final result of the tiles and column objects

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5.11 View properties

5.11.1 Navigating through the model

5.11.1.1 ArchiCAD

1. Navigating in ArchiCAD in 3D

By default, ArchiCAD has two 3D projections views: Generic Perspective and Generic Axonometry. It is also possible to create new perspective views with the Camera Tool, but these are mainly used to create a fly-trough. You can navigate your way around the building with your mouse. Scrolling with the wheel will cause the action zoom in and out. By holding the scrolling wheel and Shift-button at the same time, you'll be able to turn your view and move your way around the building by moving your mouse. Another way to do this is by selecting the Orbit command from the Mini Navigator (see 5.2.1.7) or using the shortcut "O". In this case you just have to click and hold the left button of your mouse to move around.

We always worked with the Generic Perspective as this perspective has an extra feature, in comparing to the Generic Axonometry view, which we used a lot. This feature is called Explore Model. You can select this command from the Mini Navigator (see 5.2.1.7) or from the Zoom Controls (see 5.2.1.8). A perspective view needs to be opened first before you can select this command.

In Explore mode, you need to use the mouse and the arrow keys of the keyboard to navigate through the model. It is a bit the same as playing a video game. You can easily fly or walk through the model. This tool was very helpful to discover faults and errors in our model. The figure below gives you a preview of all the actions that are possible and how to use them [5-148]. You exit the Explore mode by pressing ESC or by left clicking in the 3D view.

However, it is not possible to edit an element when you are using the Orbit or Explore Model command.

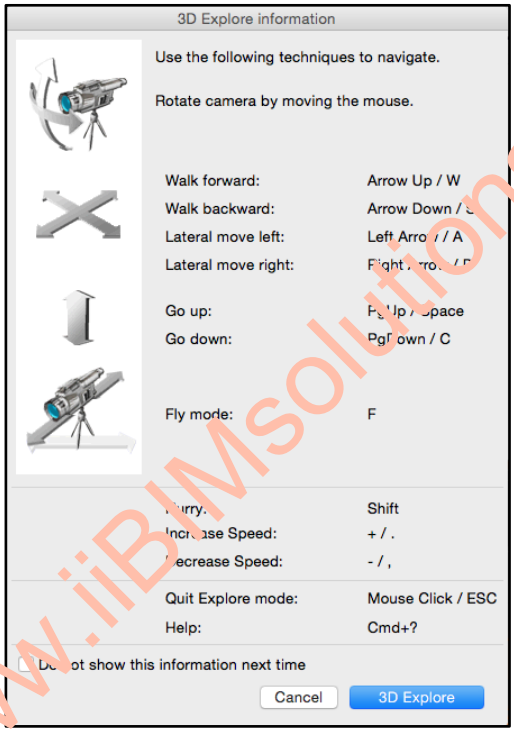

Figure 5-148 - 3D explore information

2. BIMx

In most cases, only professionals will have ArchiCAD on their computer. Therefore it can be useful that also non-ArchiCAD users can watch the model. This can for example be useful for clients. This is possible with BIMx. BIMx allows you to view models on computers, tablets and smartphones.

BIMx for computers can be downloaded from the Graphisoft website for free (www.graphisoft.com/downloads/bimx/bimx_desktop.html). A small guide of how to use this program, can be found in appendix 6.

Graphisoft has recently updated the BIMx application. It is for example also available on the App Store and Google Play. This makes it possible to use a smartphone or a tablet to explore your model. The BIMx app is divided into 2 versions. The first BIMx version is free and is recommended for clients. With this app, you are able to watch 3D models that are shared with you. The BIMx PRO

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version will cost you €49,99 and can display 2D views, as well as 3D views. Therefore you have access to all your plans wherever you are. Graphisoft wants to bring BIM into practice with this app. However, sharing and uploading a model onto the app is not free. For every model you want to share, you'll have to pay €49,99. However, sharing models to view in the BIMx Desktop Viewer is free.

5.11.1.2 Revit

You can go into 3D view by clicking on the little house, located in the Quick Access Toolbar. The first time you open a 3D view in a project, a 3D-view dropdown will be added in your Project Browser. From now on, you can just click on this view in the Project Browser. If you add new 3D views, they will be added in this section. You can add and name as much new 3D views as you want. This you do by going to the 3D-viewcube. When you right click on this viewcube, you can make new views with a specific orientation. You can orient a view to for example a floor plan/elevation/section (making floor plan/elevation/section visible in 3D) or orient to a direction. You can safe and name these specific views, and they will be added to the 3D-views in the Project Browser [5-149]. We made a 3D view for each floor level and saved it to the list, because this is the only decent way to properly get into the building.

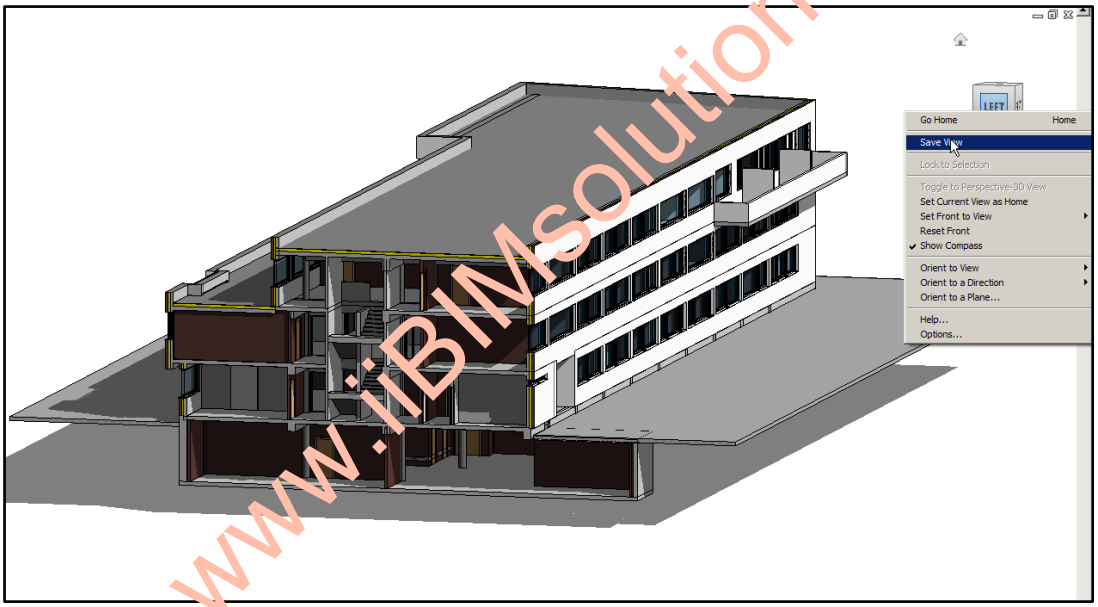

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Figure 5-149 – Save view

To walk around in Revit, you have to create a Perspective View by placing a camera in the project. You go to the View tab > Create Panel > 3D view > Camera. You have to place the view in a 2D floorplan. Once placed, you go into the perspective view. This view will be added to de 3D-view section of the Project Browser. You can rename this view if you want, to keep things organized. You can walk around in this perspective view, by using the Full Navigation Wheel. This can be accessed by typing "Shift+W". There are different tools in the Full Navigation Wheel, like walk and look. You just click the tool you want and keep your mouse key pressed in [5-150].

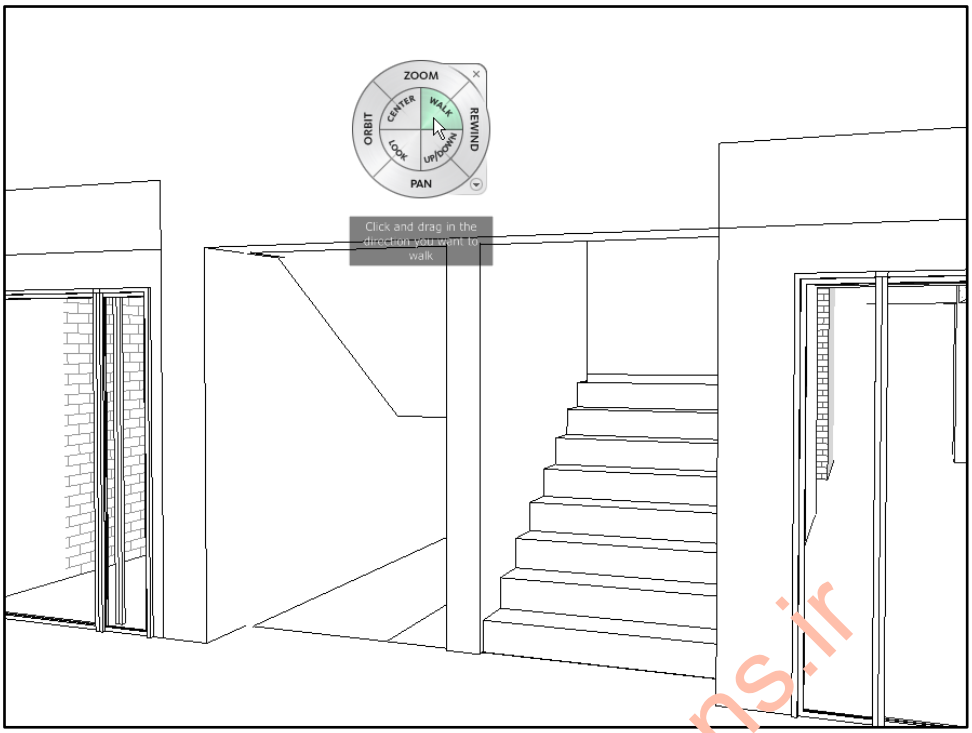

Figure 5-150 - Walk around in Revit

5.11.2 Sections

5.11.2.1 General

Sections are an important part of the plans, as no building can be constructed without sections. The advantages of these software packages come forward as creating sections is just as easy as dragging a line. Another advantage is that you are able to make 3D sections. 3D section can be very useful to edit particular parts of the building. It is also a nice tool to visualize details or particular parts of the building.

5.11.2.2 ArchiCAD

1. 2D section

We start with selecting the Section Tool from the Toolbar, which is located in the group Document. We can create single and staggered sections. Now you just need to draw a Section line through the building by defining the starting and ending point of the Section line. After this, you only have to define the viewing way of the section. This can be left or right for crosswise sections, and up or down for longitudinal sections. Each newly created Section is listed in the Navigator Project Map, in the Sections part. By default, the created section will be linked and updated according to the floor plans, but it is also possible to create sections that are not linked to the floor plans.

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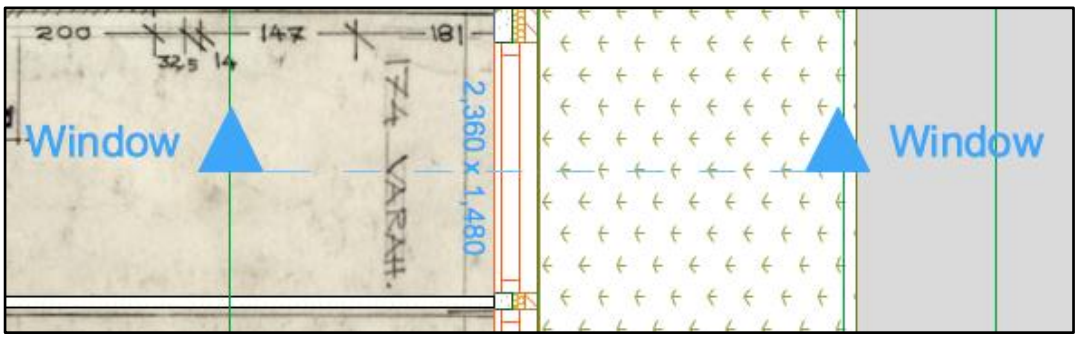

Figure 5-151 - Created section on the floor plan

2. 3D section

To start, you need to activate the Cutaway tool from the Standard Toolbar. This will cause the displaying of the Cutting Planes handles on all four sides of the screens [5-152A]. Now you can drag and hold one of the handles to the desired position. There will be a palette, in the drawing area, where you can finalize or cancel the cutaway. It is possible to save a cutaway after which you are able to open it from the Navigator's Project Map at any given moment. Cutaways can be both created on the floor plans as in the 3D view. An overview of rendered 3D sections can be found in appendix 5.

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Figure 5-152 - Making a 3D Cutaway

5.11.2.3 Revit

You can find the Section and elevation tool under the View tab > Create Panel > Section/Elevation. You add your sections and elevations to your floor plans. The view direction depends on the order in which you pick your start- and endpoint. Once a section or elevation is added, it will appear in the project browser under 'Sections' or 'Elevations'. You can rename them, so things can stay organized. By double clicking on the arrows of the section or elevation, you go to section/elevation-view. You can simply make a 3D section of 2D sections by going to the 3D viewcube. This is explained in the previous paragraph.

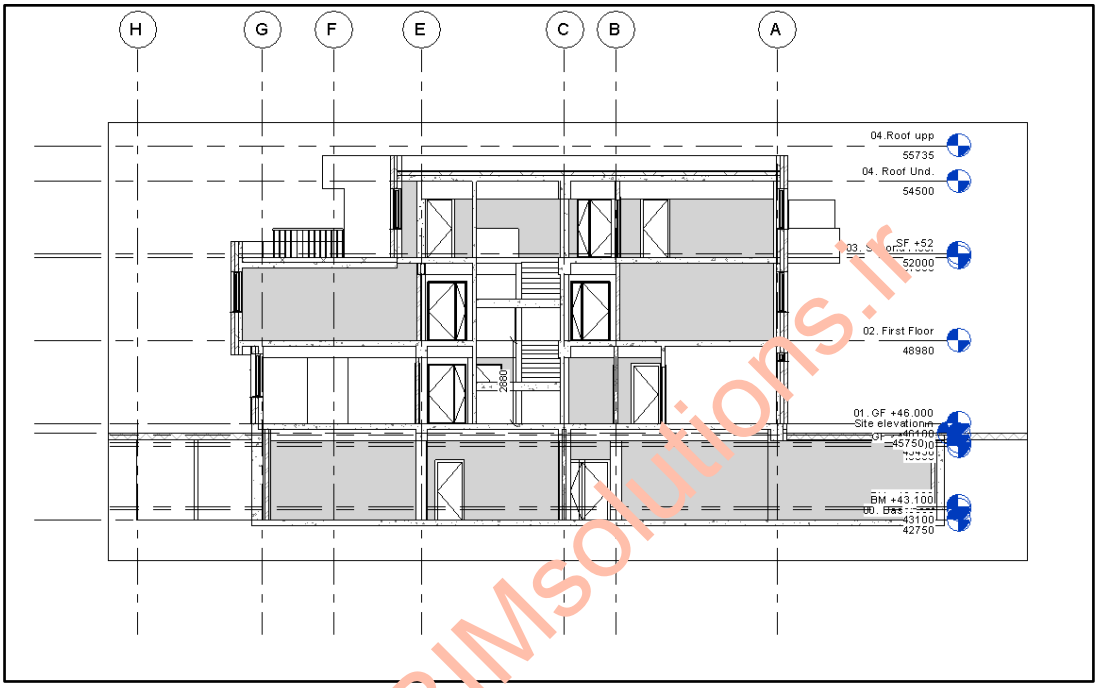

Figure 5-153 - Cross-section of the State Office Building in Revit

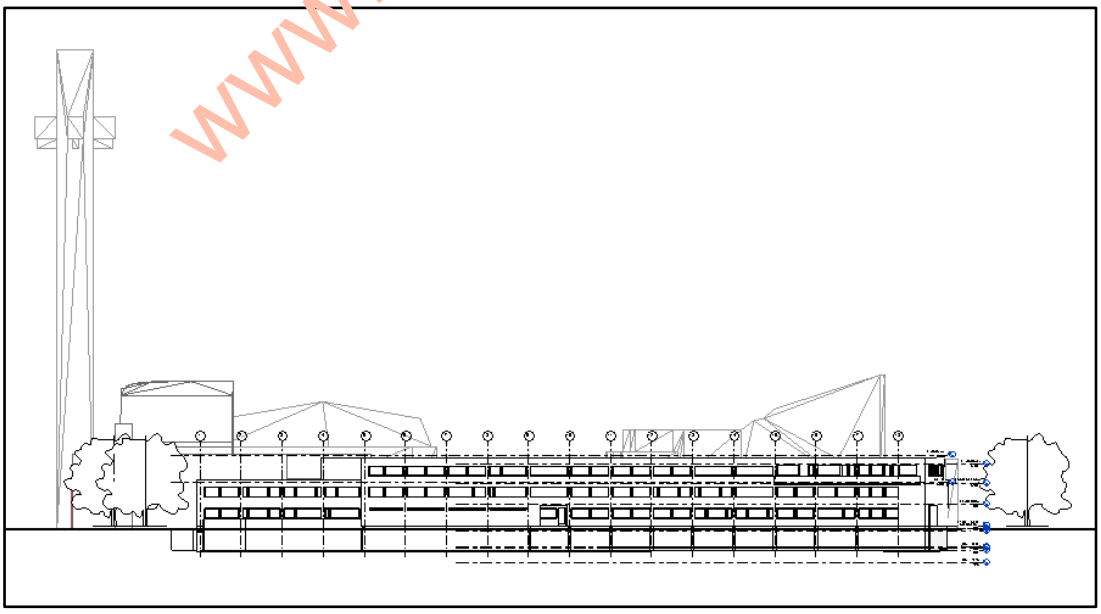

Figure 5-154 - West-elevation of the State Office Building in Revit

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6 REVIT OR ARCHICAD?

Comparing 2 products is always a tricky business and when we searched for user-experiences, we had the impression that the comparisons were always quite biased. It often resulted in very subjective opinions. It is true, if you are a long-time user of one brand of software, adaptation to another brand can feel strange. Most of the times, preference is also quite a personal matter. Because we were both new to the software-packages, we think we started less biased and maybe could be a little bit more objective. Nonetheless, we want to be careful with big statements. The reason for this is because we probably don't know half the things of what ArchiCAD and Revit can do. There were however some things we really liked and some things we thought that could improve. Furthermore, we should say we only made use of certain features of both Revit and ArchiCAD, and these features are mostly related to 3D modelling. So this is only a fraction of what we eventually will learn and discover, but it is just impossible to learn everything in such a short amount of time.

We have both installed ArchiCAD and Revit on our systems, so we could both see how the software-packages behaved. Although this is maybe very subjective, and our systems are not very state of the art, we saw some clear differences in performance. Revit seemed to be much heavier on our computers, while ArchiCAD appeared very light. Although as soon as our projects files became bigger, and both systems started to suffer, the performance change was still visible. For example, we imported the same raster image-plans for our underlay both in Revit and ArchiCAD. In ArchiCAD, panning around on both computer-systems went fluently, while in Revit it was really lagging. These were the same files, the same size, the same quality... strange!

ArchiCAD is available both for Microsoft Windows and Apple iOS, while Revit can only be installed on the Windows-platform. This can be seen as a handicap, since firms with iOS as their main operation system can't choose for Revit.

The approach on how objects are added to the models is also quite different. You could say that making walls, floors, columns, beams and roofs is quite similar. But the rest is quite different. ArchiCAD has a vast object-library installed inside the software. Adding and changing the look and properties of an object is very easy and straightforward. In contrast, Revit has a very basic object library. This is because of the use of the families. You have to go into the family editor to change and make objects. There are also a lot of websites and communities where you can find *.rfa files of objects. But we had the impression that the quality of these objects is not always guaranteed. As a Revit user, you have much more flexibility to make your own objects in the Family-Editor. But before you can make high-level objects, you have to build up experience. Moreover, learning how to make new families is quite tricky and theoretical, and in our case, it was sometimes quite frustrating. On the other hand, in ArchiCAD you are limited to the object library. If you want to make custom-objects, you have to know how to program in 'GDL'. You could say that 'GDL' is the counterpart of the family in Revit. GDL requires programming-knowledge, and is not for everyone. ArchiCAD is very user friendly for building up your model, but cannot handle creating or editing objects very well. In Revit it is a little bit vice versa, you can very flexibly build new objects, but building up a model with those objects can be tricky (because in the beginning your library will be empty).

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So in ArchiCAD you can boast results very quickly, since it is so easy to import and adjust objects from the built-in library. It felt very rewarding to be able to get in so much detail so fast. In Revit, because of the learning curve with the Family-editor, results came slower. Because of this, we were able to get much more detail in the ArchiCAD-model. We had to leave the Revit-model in a much more primitive state, which was somewhat frustrating.

Nevertheless, we really appreciated how Revit handles the drawing of new elements. The principle of first 'sketching' it approximately on the right place, and then using the aligned distance and align tools, really pleased us. In our eyes, this is one of the strong points of Revit.

The principle of making types of a family and how they behave, is another thing we really liked about Revit. Changing a certain instance of a type results in changing all of the instances of that type. In ArchiCAD, it is also possible to make changes on multiple objects simultaneously, by using 'Find & Select'. So both Revit and ArchiCAD have done a good job.

On the other hand, we felt that Revit has too many dialogs all over the place, and you go from one dialog to another. We liked the ArchiCAD approach better, keeping everything nice and clean in a central window. This clearly had an impact on how we had to refer to certain principles in this thesis. The ArchiCAD pictures are always very comprehendible and clean, while in Revit we had to take screenshots all over the place, making things look more disorganized.

For moving around in 3D, we have to make a clear distinction between 'working' and 'walking around' in 3D mode. We liked the 3D possibilities of ArchiCAD very much. In Revit you have to work in a 3D-axonometric view, and you can only activate a perspective view if you go through some steps. You have to add a camera on the floor plan by going to the View tab > 3D view > Camera. In addition, this perspective view is not intended to be used as your main working area, since the possible actions you can perform are close to none. In Revit 2016, Autodesk made it possible to Align, Move, Pin and Unpin in Perspective View. Although, this is a good start, this is still very disappointing. In ArchiCAD, every single manipulation can be done in Perspective and Axonometric view, and switching goes with a click of a mouse button. Revit can still learn quite some things from ArchiCAD on this part.

Also the exploring of your model is done in different way. Also on this part, ArchiCAD has done a great job. You can just activate the 'Explore Model'-Mode, and then you can just start running around like if you are in a videogame, using mouse and your keys ZQSD (Azerty-layout). In Revit, you first have to be in perspective view, so you first have to make a view by going to the View-tab >3D view > Camera. Then you can access the 'Full Navigation Wheel' and using your mouse to go over the different navigation actions. So all navigation has to be done with your mouse, and no keys are involved. This way, you can only do one action at a time, which feels very unnatural. It also happened more than one time, that if we were a little bit to brusque, we ended up in some place of the model we did not want to be. Sometimes we were even lost, and had to exit this mode, only to start a new view back from where we started. We had the impression you have to purchase a 3D-mouse to fully harness the use of the3D perspective-navigation in Revit. So in ArchiCAD, it is a joy to walk around in your model, doing adaptations and controlling your work. In Revit it is rather stressful and not practical at all. This results in a very different working approach.

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CONCLUSION

In this thesis, we learned a great deal about the different features that both Autodesk Revit and Graphisoft ArchiCAD have. We started with doing some measurements, to know if the old architectural plans were reliable to base our model on. We also learned more about point cloud data and how it is collected on site. The modelling in both software packages boasted some great results.

Although both ArchiCAD and Revit have some very similar features and tools, there are also some differences. In Revit, we saw that the learning curve was a little bit higher due to the use of the somewhat technical Family Editor. Also because we had to make a lot of custom objects in Revit, we had to spend much more time on certain objects than in ArchiCAD. On the other hand, the Family Editor gives you a lot of flexibility and freedom. We can imagine that, once fully mastered, the possibilities of the Family Editor are endless. The fast buildup of the ArchiCAD model is partly due to the vast object library inside the software. It was very easy to specify all kinds of details on windows and doors. Also importing objects like skylights, trees and ladders, was very straightforward. We also learned that Revit was a little bit heavier on our hardware than ArchiCAD. Furthermore, both ArchiCAD and Revit handle the actual drawing and positioning of new objects pretty well. However, Revit did a particularly good job. The Aligned Dimension and Align-tool in Revit are really of great value. Also the different approaches on exploring and working in 3D were interesting to see. We saw that ArchiCAD has done a marvelous job on this part. Being able to run around in your model, as if it is a videogame, gives you a lot of power. In Revit, the 3D-navigation seemed a little bit more primitive. Also the lack of editing in perspective view surprised us. In the end, we learned a great deal about the different modelling techniques in Revit and ArchiCAD.

Being able to spend so much time with ArchiCAD and Revit, resulted in gaining a lot of experience in 3D-modelling and BIM. We hope this knowledge and experience are a starting point in our further careers as BIM modellers or in a BIM-related job.

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APPENDICES

Appendix 1: *results of the measurements*

Upper side					
Point A	Point B	Distance	Distance on the plan	Difference	Adjusted difference
A	1	5,016	5,022	-0,006	-0,006
A	2	6,461	6,462	-0,001	-0,005
A	3	7,014	7,012	0,002	-0,003
A	4	12,055	12,062	-0,007	-0,009
A	5	12,619	12,612	0,007	-0,014
A	6	17,645	17,662	-0,017	0,024
A	7	18,212	18,212	0	-0,01
A	8	23,118	23,122	-0,004	0,004
A	9	23,985	23,952	0,033	-0,037
A	10	28,704	28,722	-0,018	0,051
A	11	29,546	29,552	-0,006	-0,012
A	12	34,437	34,462	-0,025	0,019
A	13	35,022	35,012	0,01	-0,035
A	14	40,052	40,062	-0,01	0,02
A	15	40,635	40,612	0,023	-0,033
A	16	45,662	45,662	0	0,023
A	17	46,228	46,212	0,016	-0,016
A	18	51,123	51,122	0,001	0,015
A	19	51,975	51,952	0,023	-0,022
A	20	56,715	56,722	-0,007	0,03
A	21	57,566	57,552	0,014	-0,021
A	22	62,451	62,462	-0,011	0,025
A	23	63,04	63,012	0,028	-0,039
A	24	68,064	68,062	0,002	0,026
A	25	68,643	68,612	0,031	-0,029
A	26	73,525	73,522	0,003	0,028
A	27	74,349	74,352	-0,003	0,006
A	28	78,913	78,962	-0,049	0,046
A	29	79,134	79,122	0,012	-0,061
					Average 2,33cm
Distances are in meter					

Bottom side					
Point A	Point B	Distance	Distance on the plan	Difference	Adjusted difference
C	1	3,609	3,63	-0,021	-0,021
C	2	8,946	8,96	-0,014	-0,007
C	3	9,501	9,51	-0,009	-0,005
C	4	14,547	14,56	-0,013	0,004
C	5	15,11	15,11	0	-0,013
C	6	20,142	20,16	-0,018	0,018
C	7	20,69	20,71	-0,02	0,002
C	8	25,74	25,76	-0,02	0
C	9	26,302	26,31	-0,008	-0,012
C	10	31,339	31,36	-0,021	0,013
C	11	31,891	31,91	-0,019	-0,002
C	12	36,95	36,96	-0,01	-0,009
C	13	37,501	37,51	-0,009	-0,001
C	14	42,534	42,56	-0,026	0,017
C	15	43,086	43,11	-0,024	-0,002
C	16	48,124	48,16	-0,036	0,012
C	17	48,825	48,85	-0,025	-0,011
C	18	52,564	52,64	-0,076	0,051
C	19	59,287	59,36	-0,073	-0,003
C	20	59,887	59,91	-0,023	-0,05
C	21	64,907	64,96	-0,053	0,03
C	22	65,503	65,51	-0,007	-0,046
C	23	70,521	70,56	-0,039	0,032
C	24	71,106	71,11	-0,004	-0,035
					Average 2,43cm

Left side				
Point A	Point B	Distance	Distance on the plan	Difference
D	E	6,47	6,43	0,31
E	F	1,469	1,26	0,209

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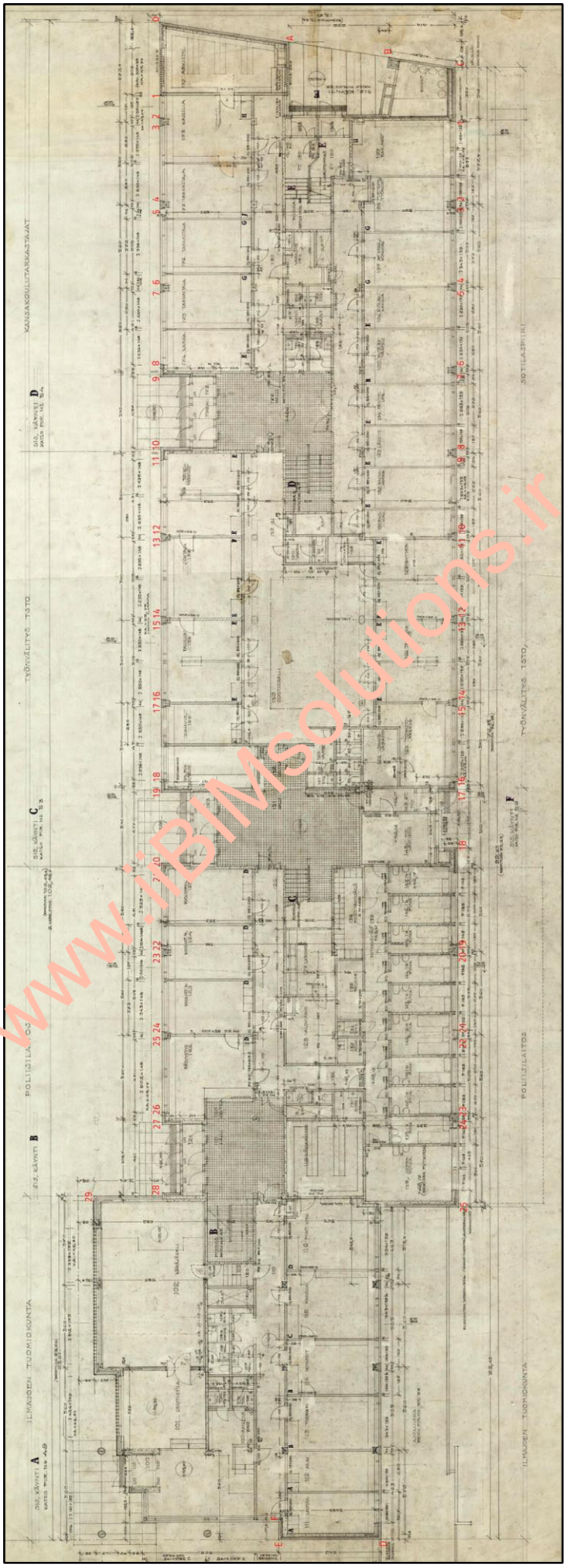

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Appendix 2*: technical details of laser scanning system*

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Antero.Kukko@nls.fi

Technical details for AkhkaR2 Personal Laser Scanning (PLS) system

The data for Seinäjoki project was collected using AkhkaR2 system that is a backpack application of mobile laser scanning (MLS). To make kinematic data collection possible the system needs to have a positioning system coupled with the data collection instrumentation.

The AkhkaR2 system uses GNSS-IMU (Global Navigation Satellite System-Inertial Measurement Unit) positioning to track the platform movement during the survey. Positioning data is post-processed with correction data from virtual GNSS base station service for accurate system trajectory with precise attitude at 200 Hz frequency. The Trajectory data contains the position (Easting, Northing, and Elevation) and attitude (Roll, Pitch, and Heading) of the platform as a function of time. The trajectory data is timed in essence by the GPS time, and timing of the laser data is carried out by TTL level signal sent by the scanner for each of the profile and recorded by the GNSS receiver event logging.

The laser scanner mounted on the system for this project was FARO Focus 3D X330 (Figure 1). In MLS the laser scanner operates in so called helical scan mode, which in effect means it senses the surroundings with cross-track profiles at 95 Hz scan frequency. The point measurement rate used was 488 kHz, giving 1.2 mrad angular resolution, i.e., 30 mm point spacing at 25 m distance from the scanner. In addition to 3D coordinates, the scanner also records the intensity of the returned laser signal. In a typical case the point precision is a few millimetres, seen clearly from the point cloud illustrations in Figures 2-4, the positional accuracy being typically about 20 mm.

Figure 1. Backpack mounted AkhkaR2 PLS system comprises GNSS-IMU positioning system and laser scanner to capture detailed and accurate 3D data for virtual modeling and mapping. (Photo M. Matilainen 2013)

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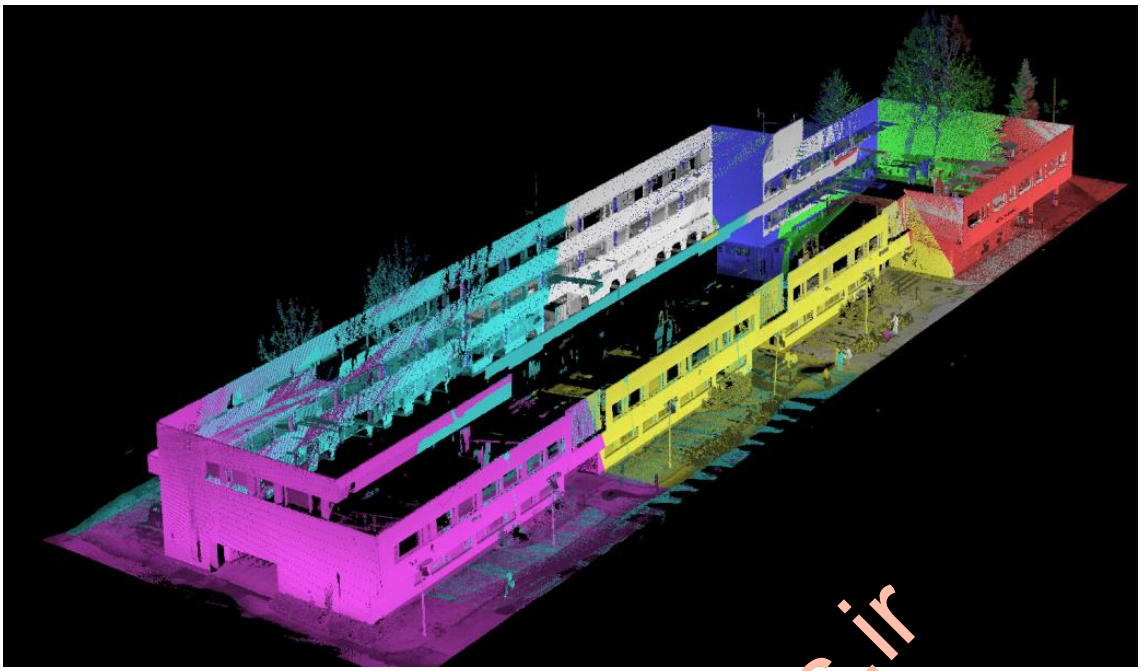

Figure 2. Valtion virastotalo measured with AkhkaR2 personal laser scanning system 11. 5.2015. The point cloud represents the geometry of the building precisely and captures the prominent features well. The points are colored by the laser intensity and data file number (data is split in to files containing 3000 profiles each) to illustrate the progress of the data collection. Data collection took about 4 minutes. (Image A. Kukko, 2015)

Figure 3. Point cloud colored by laser intensity in grey scale. What could be seen in this figure is that as the data collection was carried out from the street level the wall of the third floor is only partially captured due to the shape of the front façade of the building. Such data caps could be captured by collecting data from the roof as well. (Image A. Kukko, 2015)

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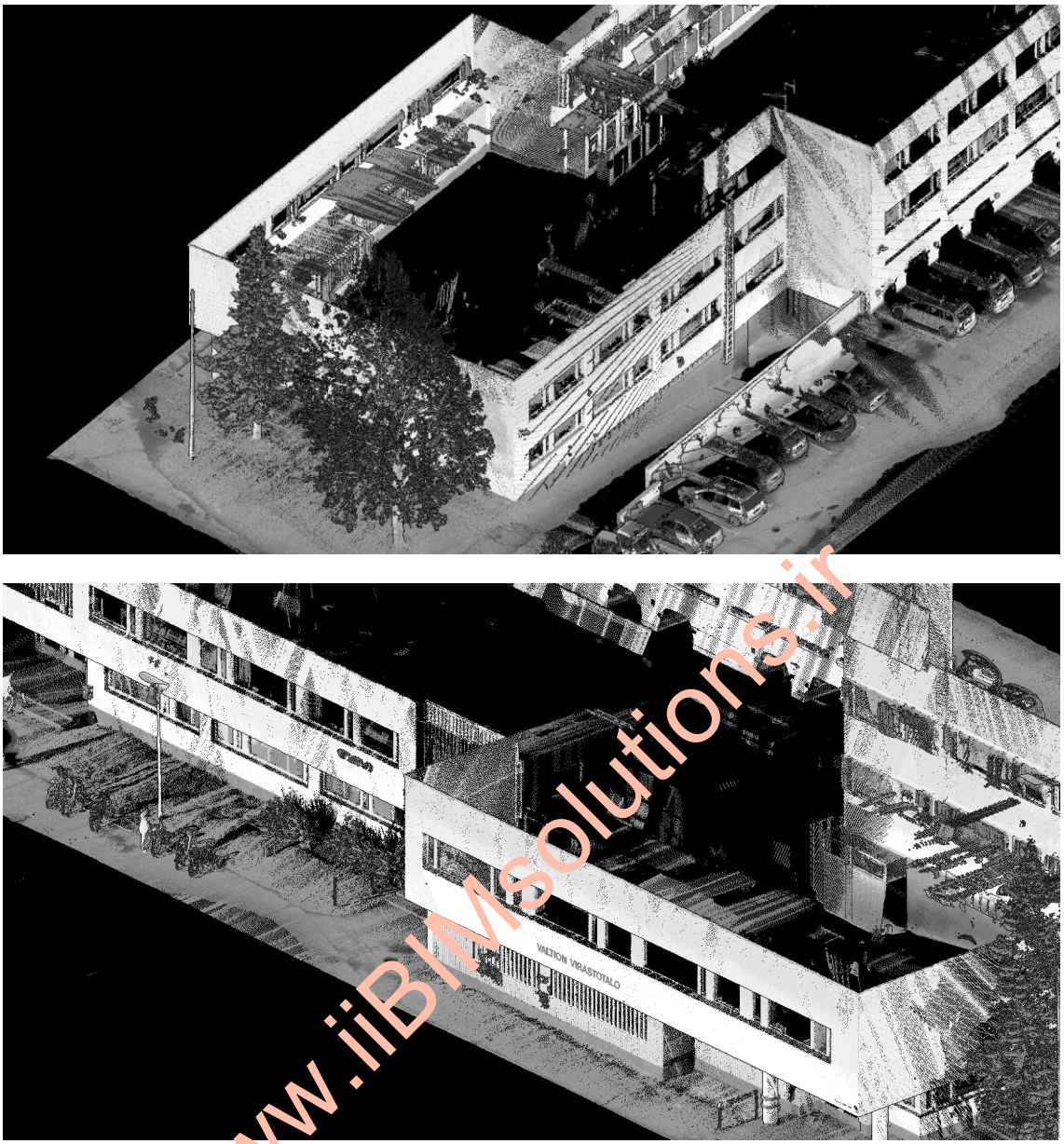

Figure 4. Some details of the building illustrating the system capability to capture three dimensional features. (Image A. Kukko, 2015)

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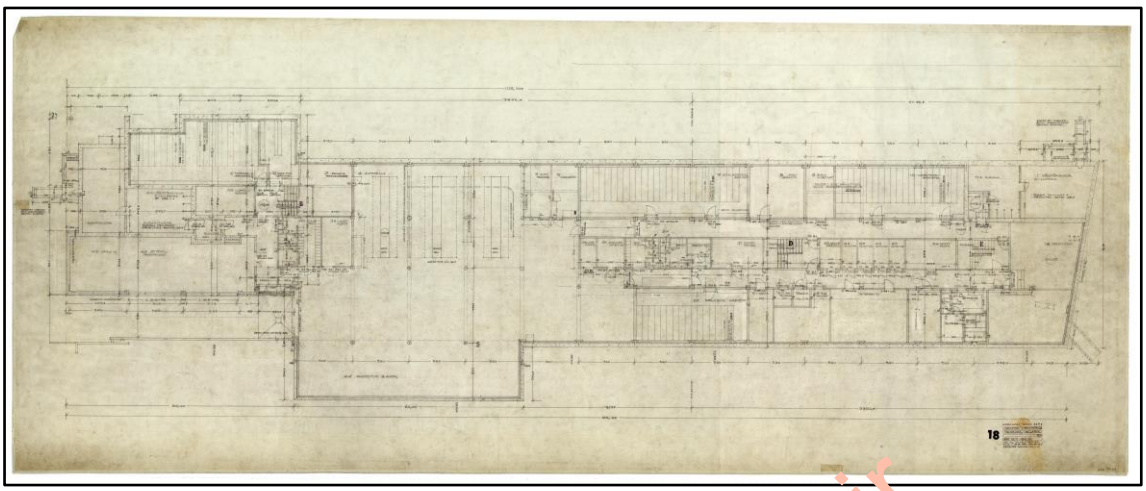
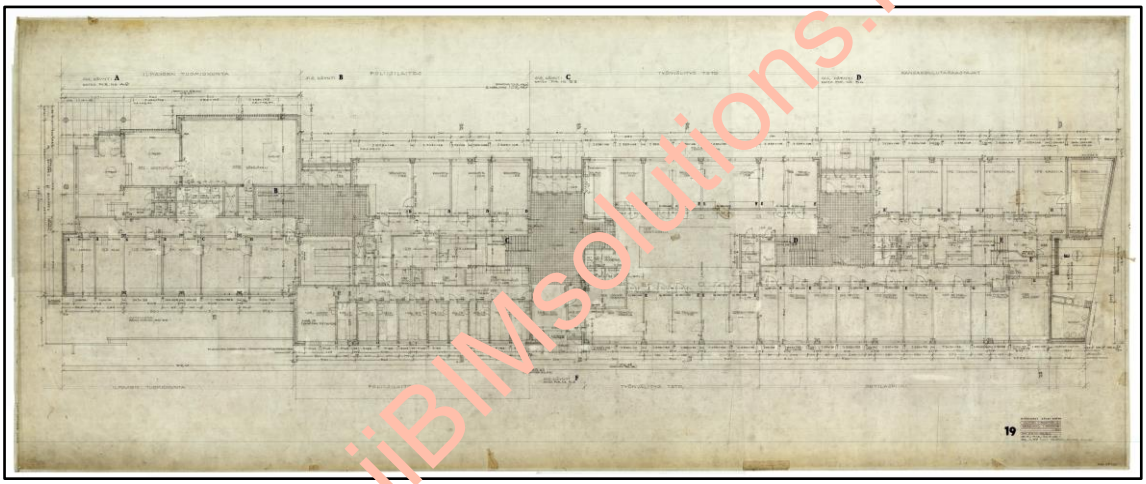
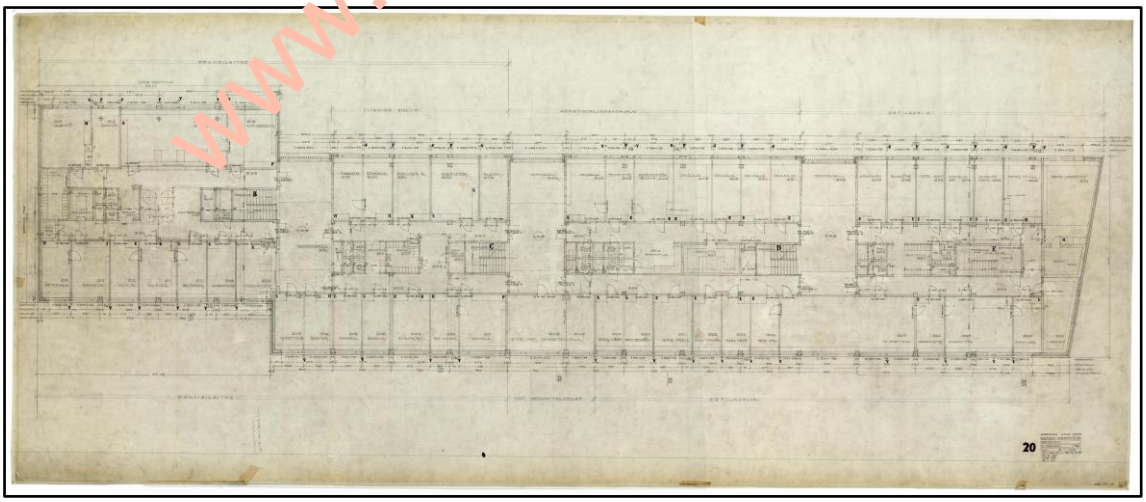
Appendix 3: original *plans from Alvar Aalto Foundation*

Floor plans







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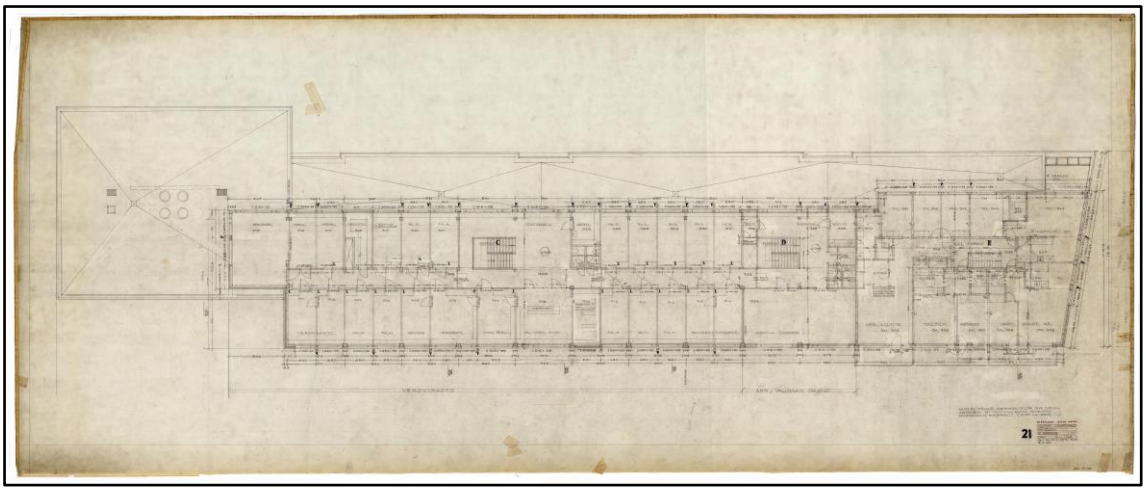
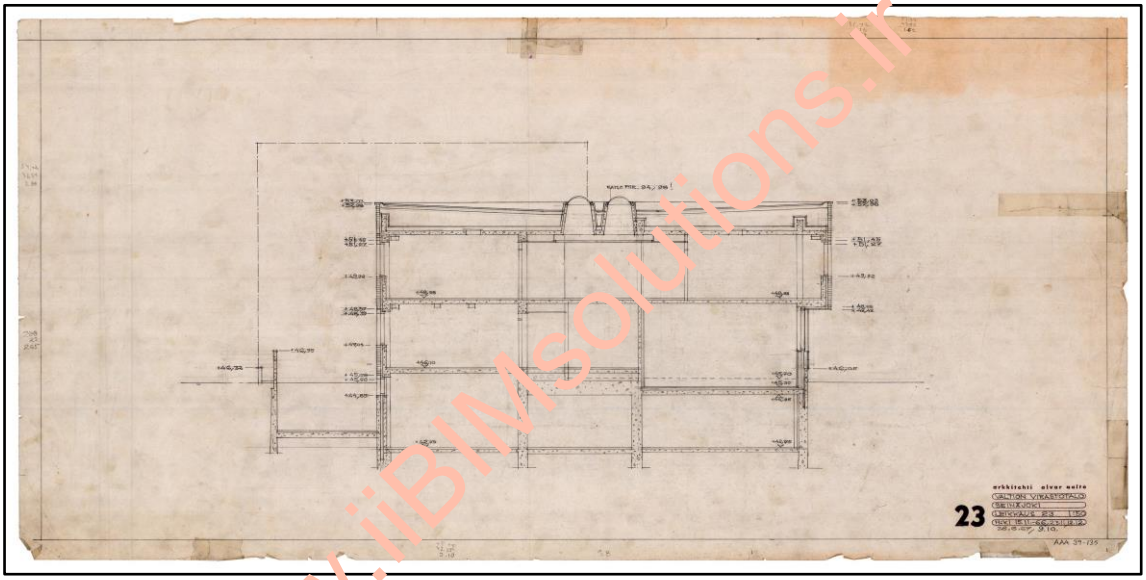
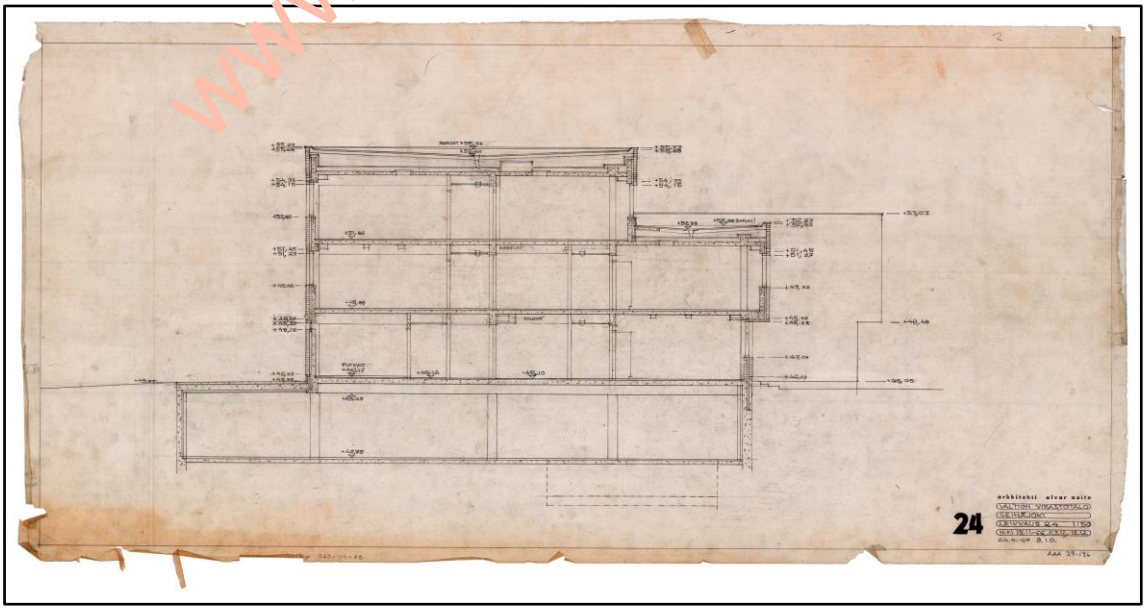


Sections





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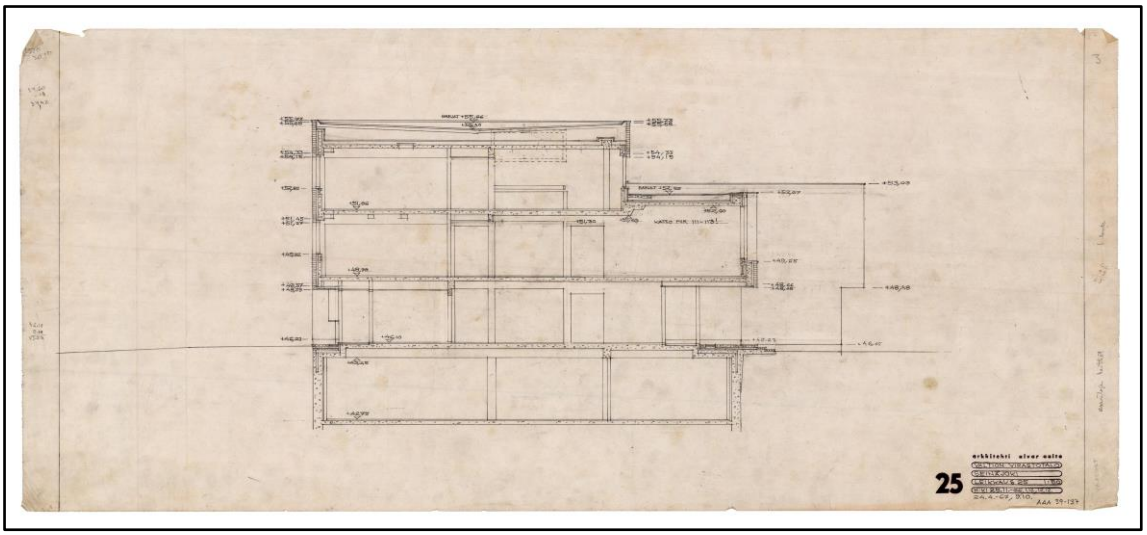

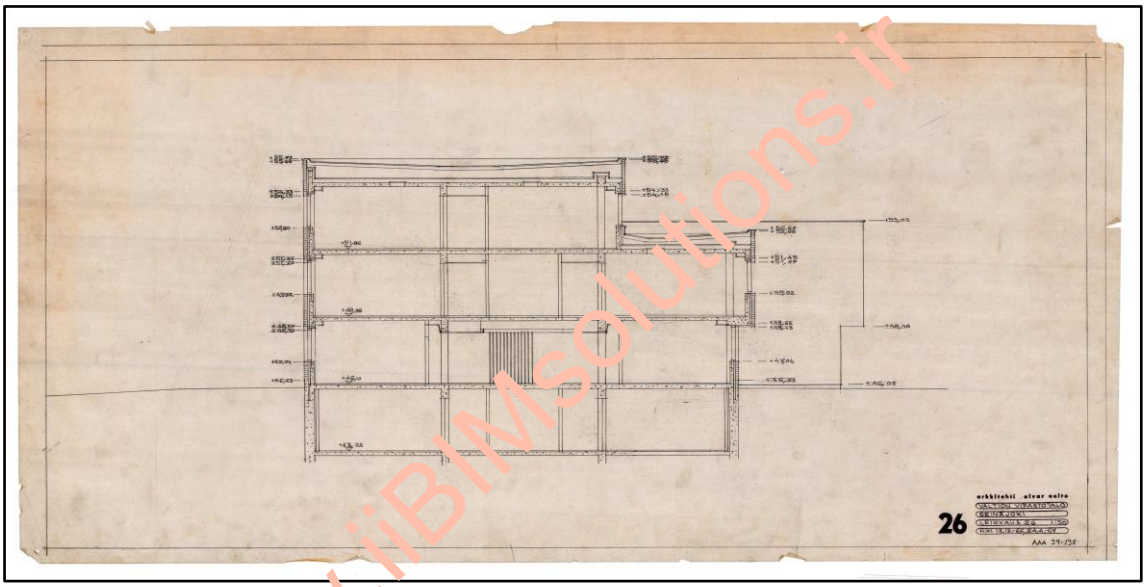

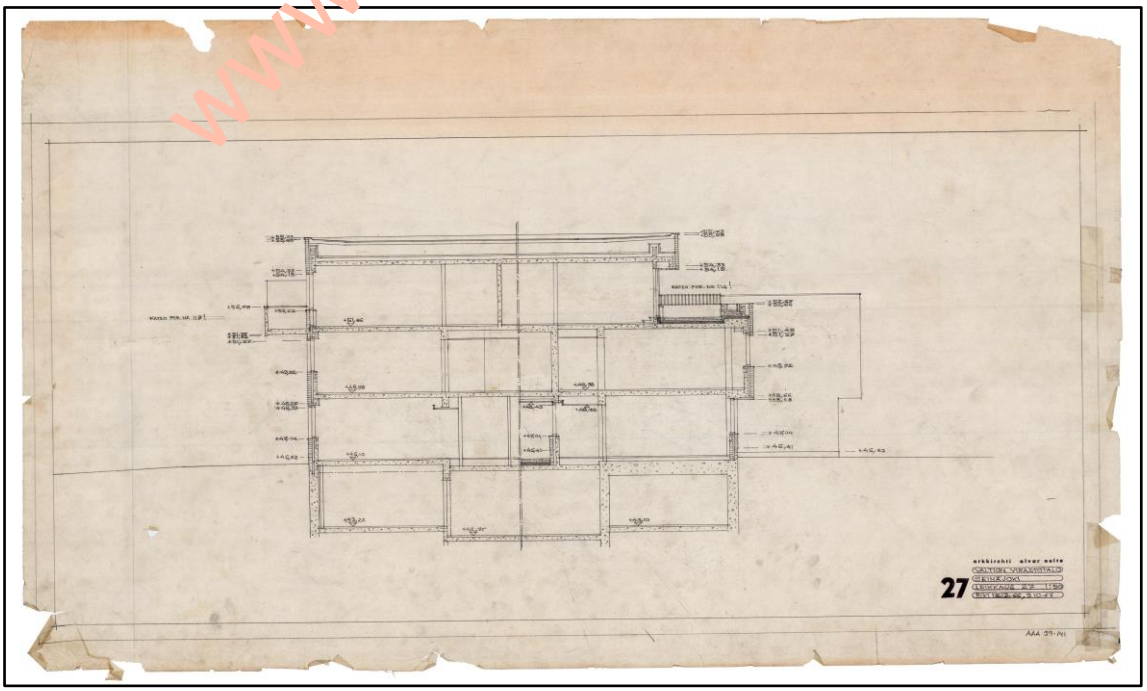

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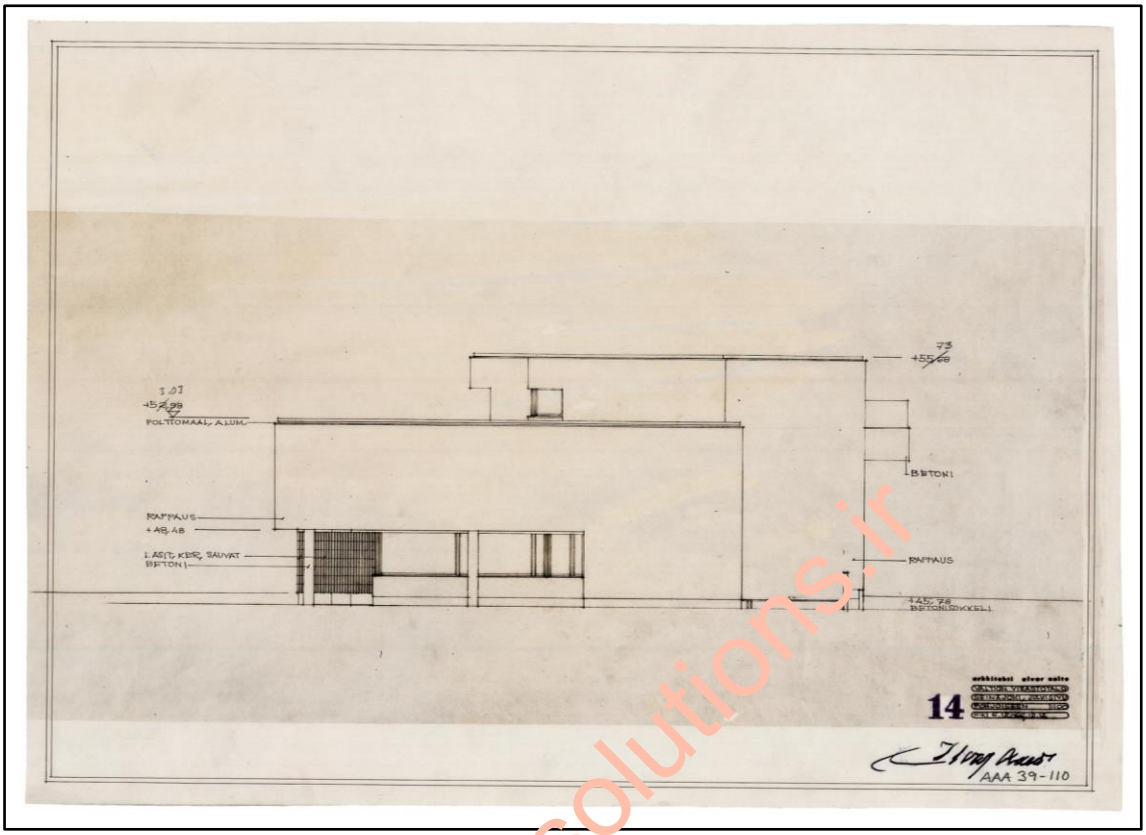
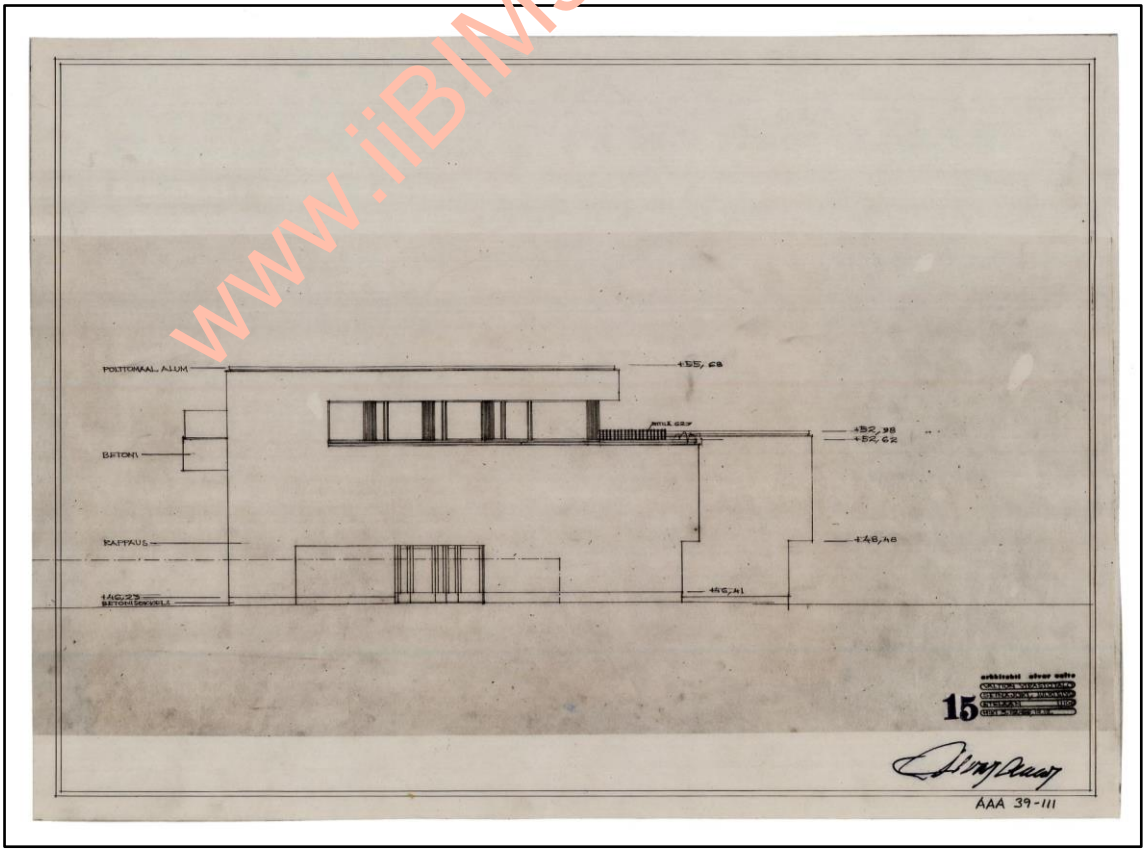
Elevations





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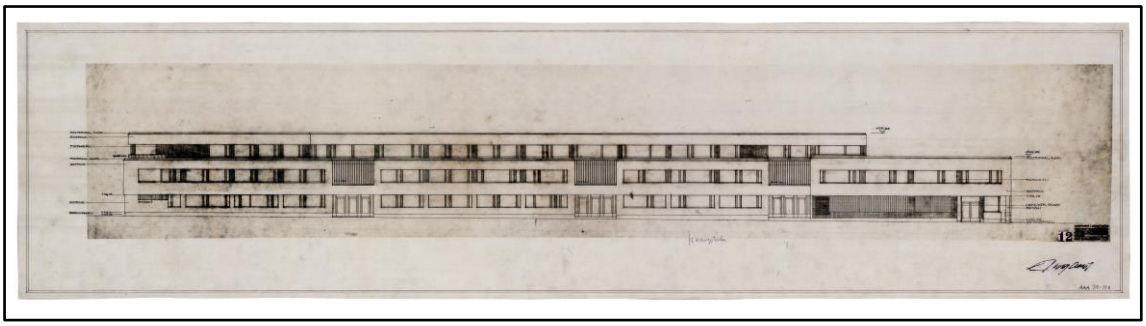
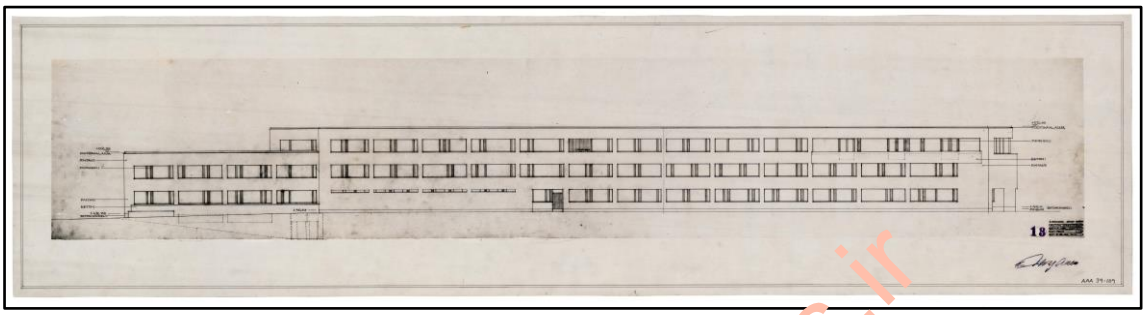
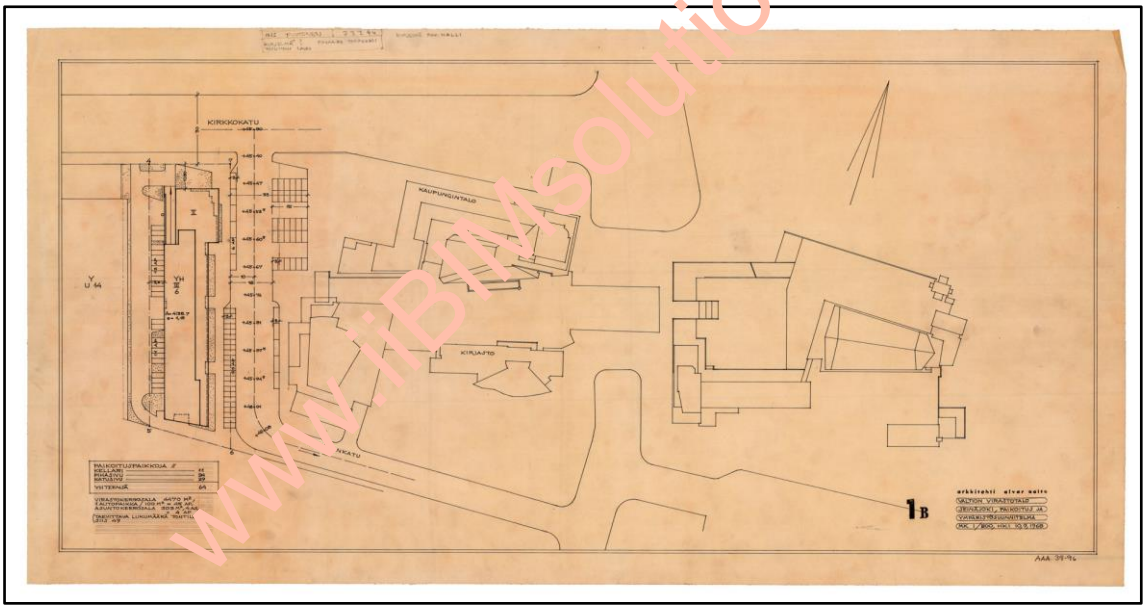




Site plan



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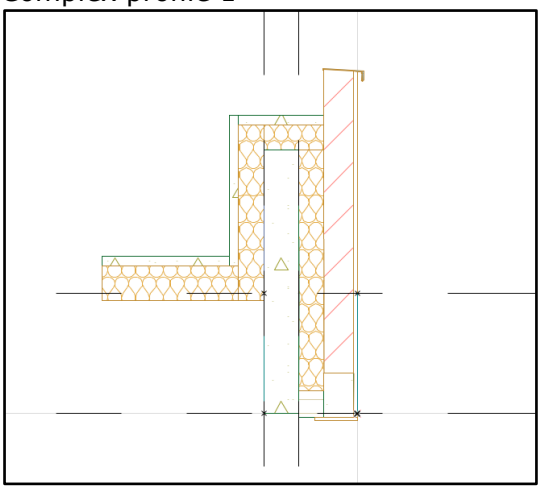
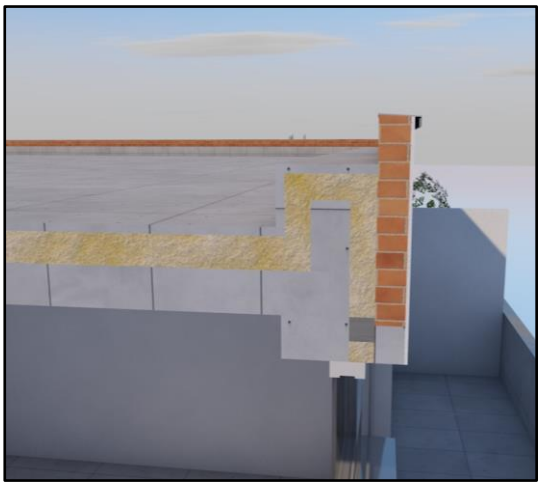
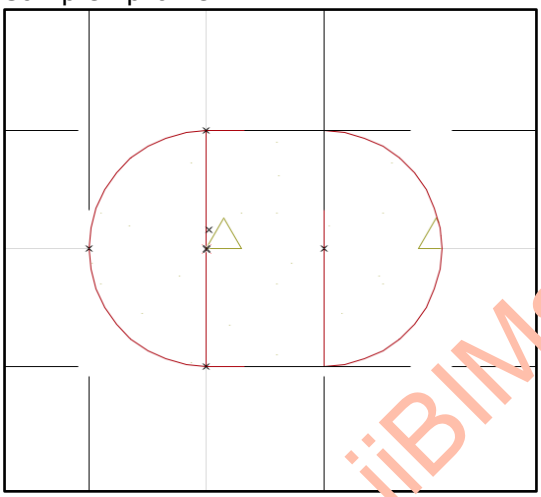
Appendix 4*: overview of complex profiles*

Complex profile 1





Complex profile 2



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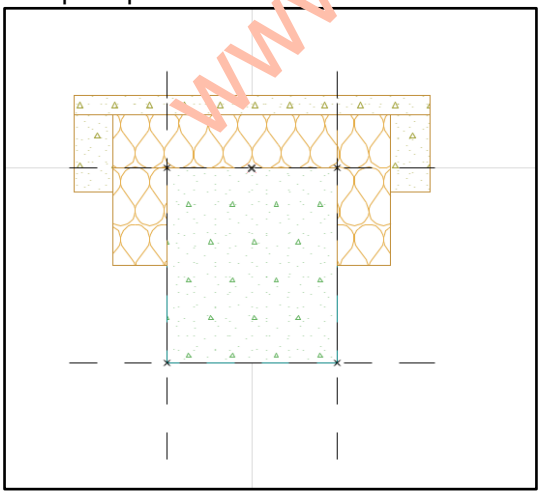
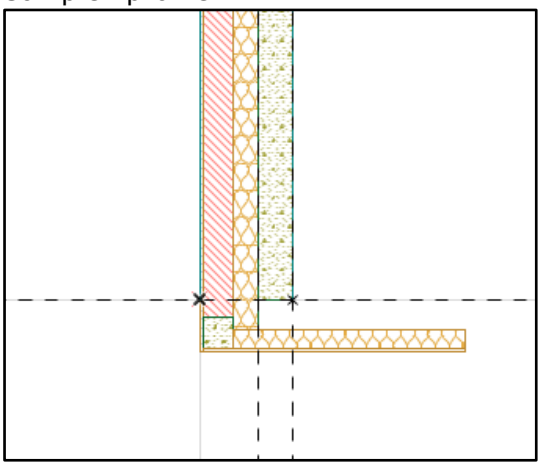
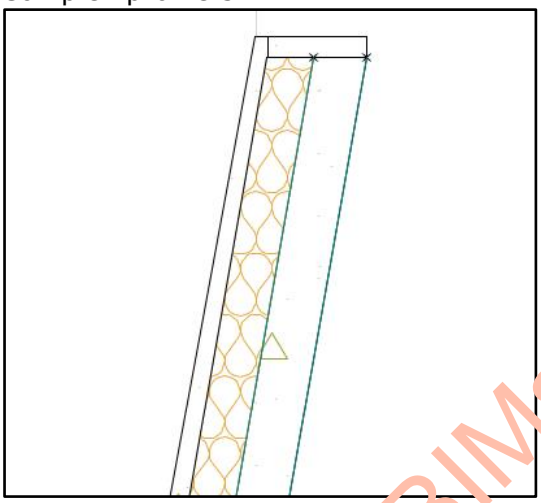
Complex profile 3



Complex profile 4



Complex profile 5



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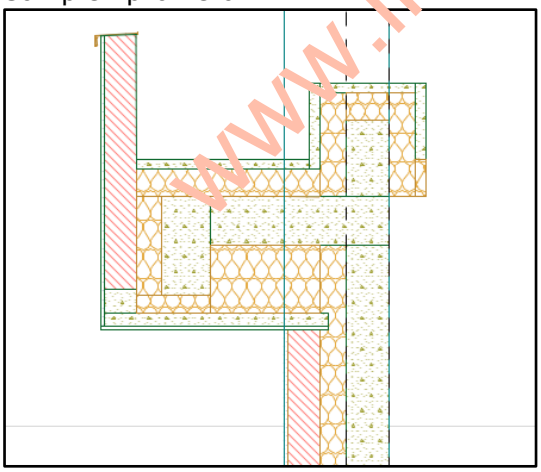
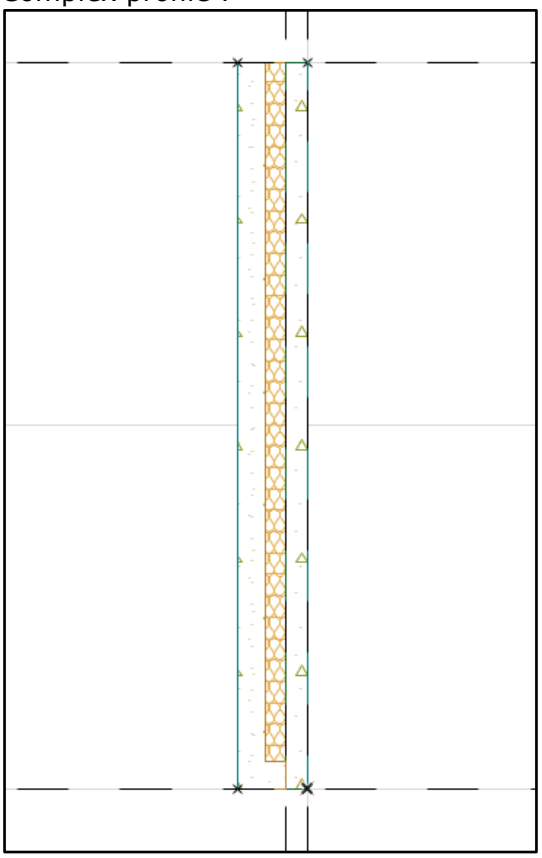
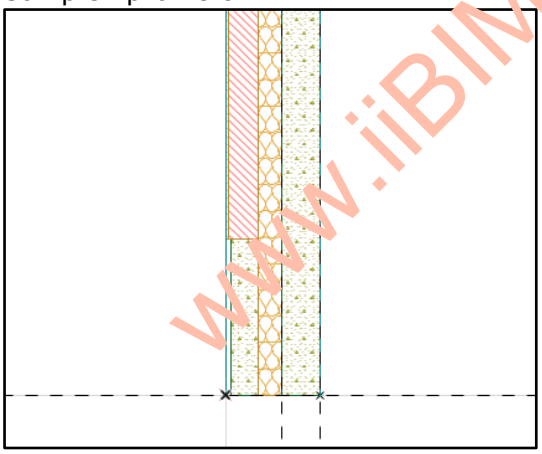
Complex profile 6

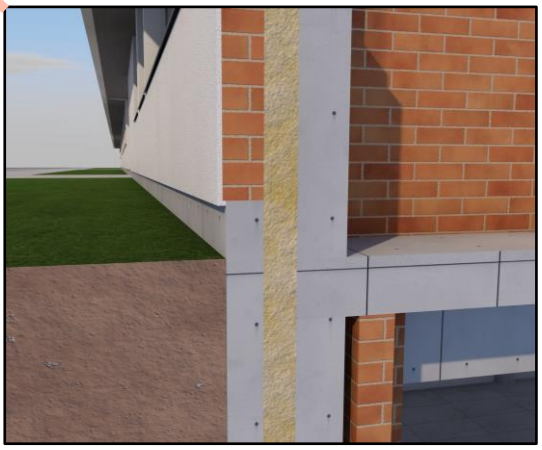


Complex profile 7



Complex profile 8





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Appendix 5: renders of the final result

Outside of the building in ArchiCAD

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Cutaways in ArchiCAD

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Outside of the building in Revit

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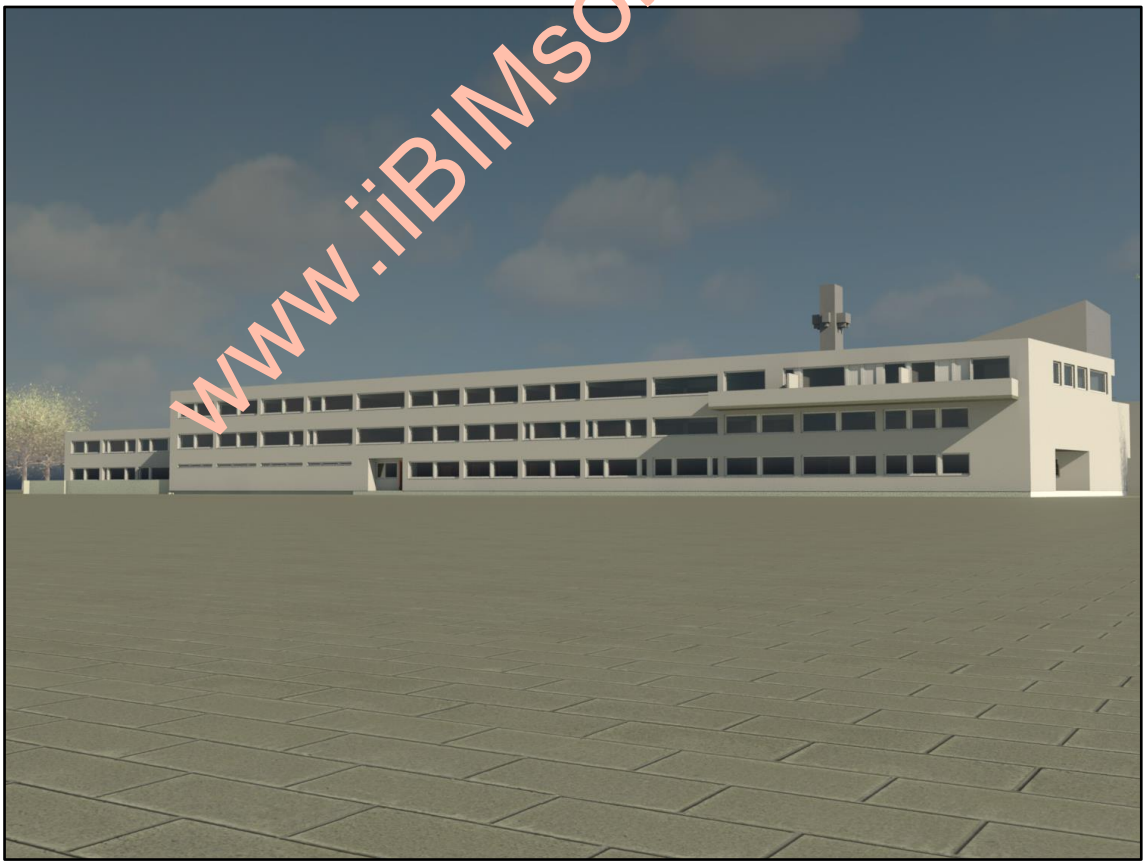

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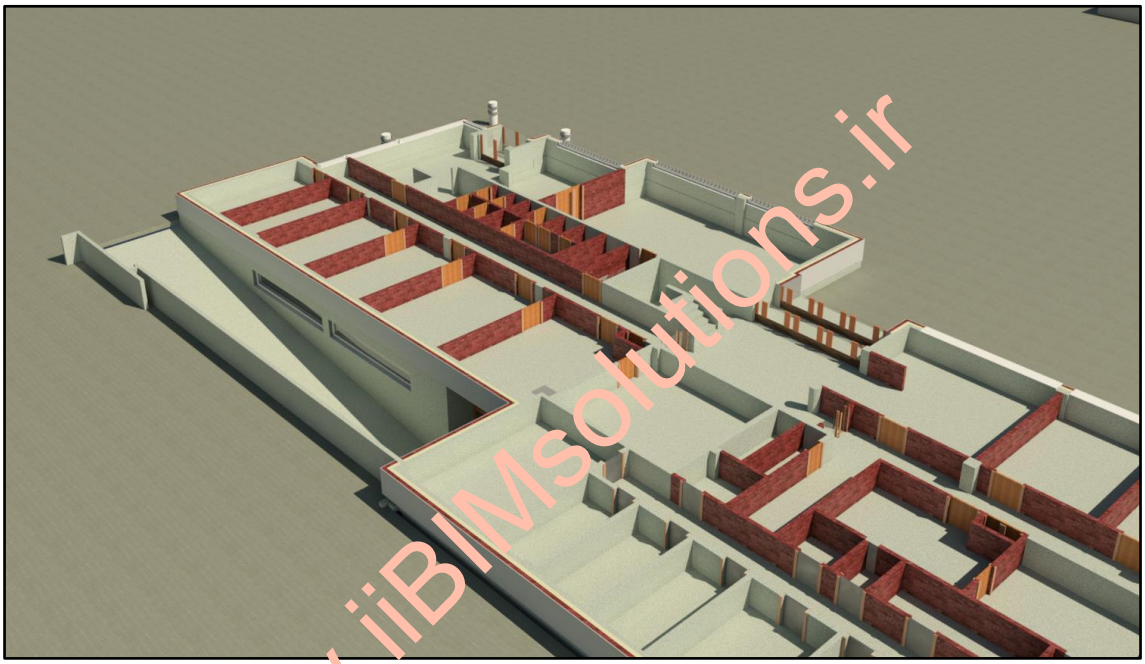
Cutaways in Revit



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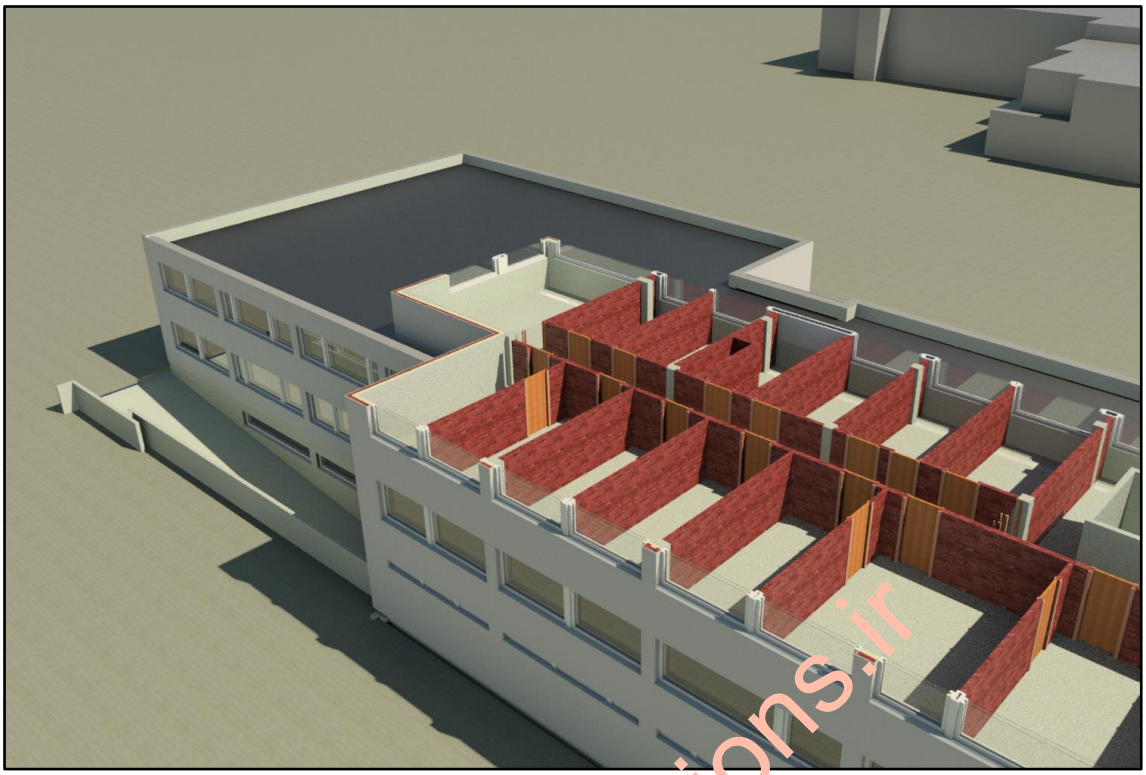

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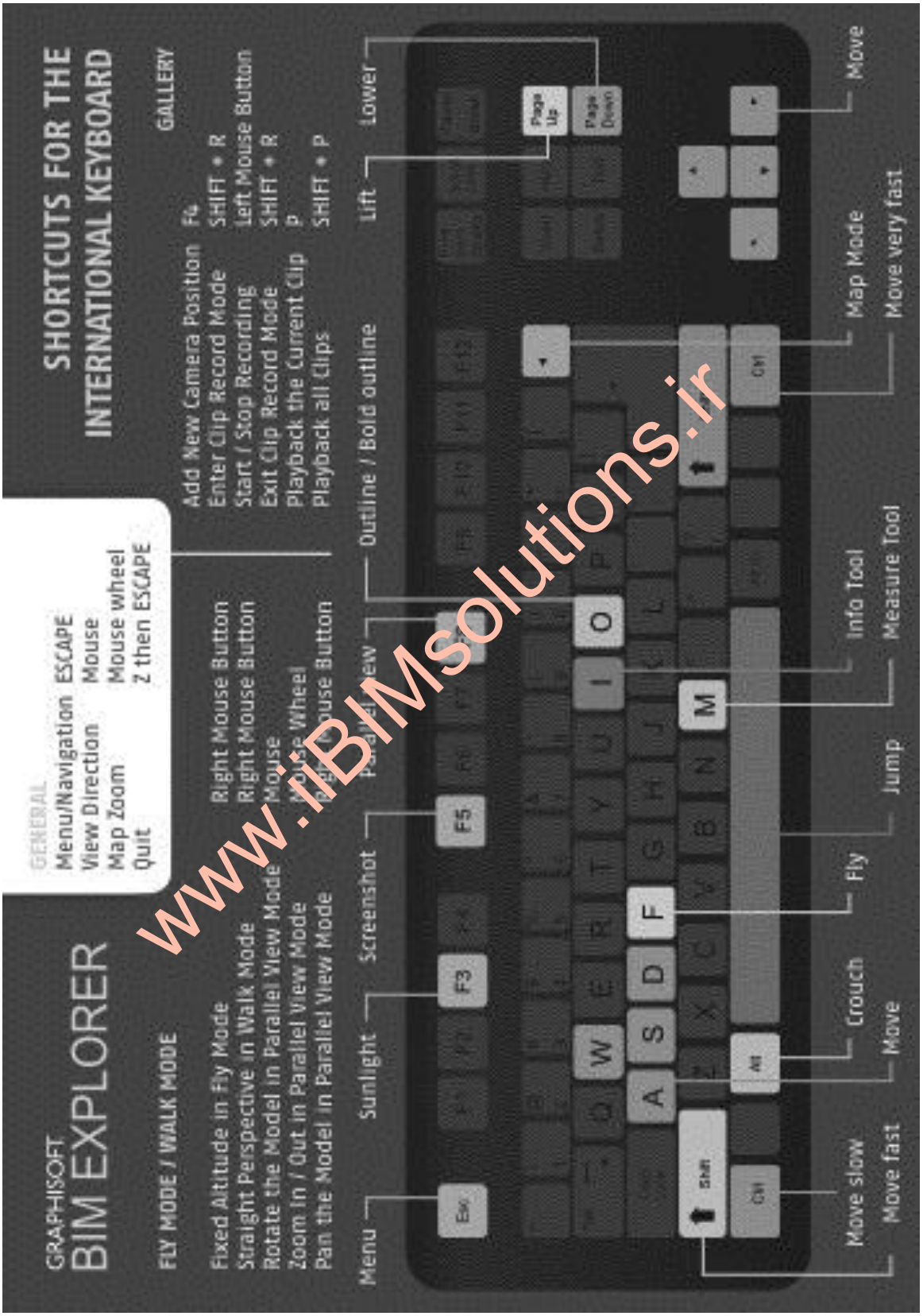
Appendix 6: Using guide for BIMx



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Appendix 7: CD-ROM with Revit- and ArchiCAD-files

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