

Saimaa University of Applied Sciences  
Faculty of Technology, Lappeenranta  
Double Degree Program in Construction and Civil Engineering

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## **BIM-based design of residential apartment**

Bachelor's Thesis 2015

## **ABSTRACT**

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BIM-based design of residential apartment, 41 pages, 1 appendix

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The purpose of this thesis was to create a model of the two-level apartment with program Revit Autodesk for company NCC. The apartment is situated in the housing complex Skandi Klubb, which is being built in Saint-Petersburg.

The model was made for commercial purposes, in order to speed up the selling process of this apartment, as the most expensive one.

The second purpose was to describe basics of BIM and Revit program.

The thesis is divided into two main parts: theoretical and practical. In the theoretical part the characteristics and main functions of Revit were considered. Also this part explains the concept of BIM. For writing these parts the books as well as internet resources were analyzed.

In the practical part the main steps of creating the model were described. Also the opinion of people about this model was considered.

As the result, the main characteristics of Revit program and BIM were discovered. The model of apartment was shown to the possible customers and get good reviews.

Key words: Revit, BIM, modelling, residential apartment

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# 1 INTRODUCTION

The digital age has brought many changes, even in construction. Nowadays more and more companies begin to use BIM (Building Information Modeling) in the construction projects, because it has many advantages in comparison with CAD-drawings. BIM is a term used to describe the process used by architects, engineers, owners and contractors to coordinate drawings between disciplines in a three dimensional environment. The most valuable benefits of BIM are the following, for example:

BIM allows a team to collaborate at a level with efficiency previously unavailable in the industry;

- The drawing sets are more coordinated. You can find problems in the drawing sets prior to the construction process;
- BIM helps to reduce time and cost of the project;
- etc.

A lot of market researches, which have been made recently, show that the future of building design and construction will increasingly rely on BIM. It is no longer the future of construction and design industry, it is becoming the standard.

Revit is the Autodesk solution for Building Information Modeling. It is one of the most popular software used for BIM in the world. Revit is much more than the drafting program, it helps to make a complete model. All views, sections, schedules, material takeoffs and other important materials are generated from the model automatically.

The original purpose of the thesis is to create the model of a two-level apartment. The main purpose of this model is the visualization of this apartment, so that the customer can fully understand and imagine his future flat. Thus, this model will speed up the process of selling this apartment.

The theoretical part of the thesis shows the concept of BIM, what benefits you can get from its usage. Also the features of Revit Autodesk are shown and the way of making a model in this program.

## **2 BUILDING INFORMATION MODELING**

In the field of structural design the word "revolution" is often mentioned in connection with the use of BIM-technology. The concept of building information model assumes the work of all participants in the design of a common, actually existing in the form of an electronic database model. It is completely different from the traditional approach to design.

### **2.1 What is BIM**

BIM is a revolutionary building design and building/construction technology. It is not just a 3D model. BIM is information modeling for the built environment. It is about intelligent design, a process that lets you explore the project's physical and functional characteristics digitally before it is built. It applies to municipal, utility and building lifecycle. BIM is not just a tool but also a process that supports virtual design and construction methodologies. It points all the parties together throughout the entire design and construction process and beyond to the operation and maintenance of the building. BIM offers significant advantages throughout every stage of a building's lifecycle (Vysotsky A.E., Parfenov N.V. 2012. Tutorial Program Autodesk Revit Architecture. Basic course)

Building information models have the following goals (COBIM 2012):

- Provision of support for investment decisions by comparing the functionality, scope and costs of the solutions.

- Energy, environment and lifecycle analyses for the purpose of comparing solutions, design and objectives of facility management follow-up.
- Design visualization and analysis of construction feasibility.
- Enhancement of quality-assurance and data exchange and making the design process more effective and efficient.
- Improve team collaboration and more easily manage project data across extended teams and external partners.
- Provide a valuable digital asset to the project owner for the operations and facility management.
- Simulate multiple alternatives more quickly and accurately.
- Keep documentation accurate no matter how many times the design is changed.
- Reduce cost and time by identifying costly design conflicts virtually before construction begins.

BIM has changed the process of how a building is designed. The Autodesk Revit software is a true BIM product in that it is much more than drafting software. By creating complete models and associated views of those models, the software takes much of the tediousness out of producing a building design.

In the traditional design process, plans create the basis for the model, from which you then create sections and elevations, as shown in Figure 1. Construction Documents (CDs) can then be created. In this workflow, changes are made at the plan level and then coordinated with other documents in the set (Autodesk Revit Architecture 2013 Fundamentals).

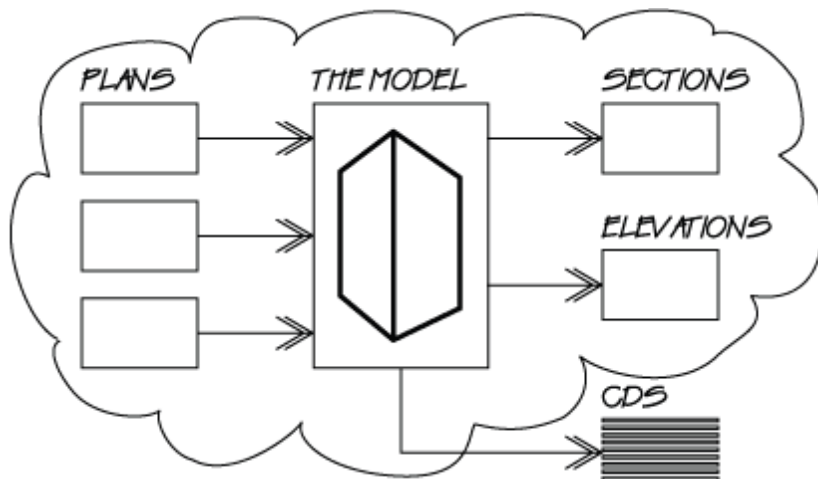


Figure 1. Traditional design process (Autodesk Revit Architecture 2013 Fundamentals)

In BIM, the model is at the center of the project, as shown in Figure 2. Plans, elevations, and sections are simply 2D versions of the 3D model. Changes made in one view automatically update in all views. Even Construction Documents update automatically with callout tags in sync with the sheet numbers. By putting the model at the center of the project, you will gain the deeper insight into the project costs, schedule and constructability (Autodesk Revit Architecture 2013 Fundamentals).

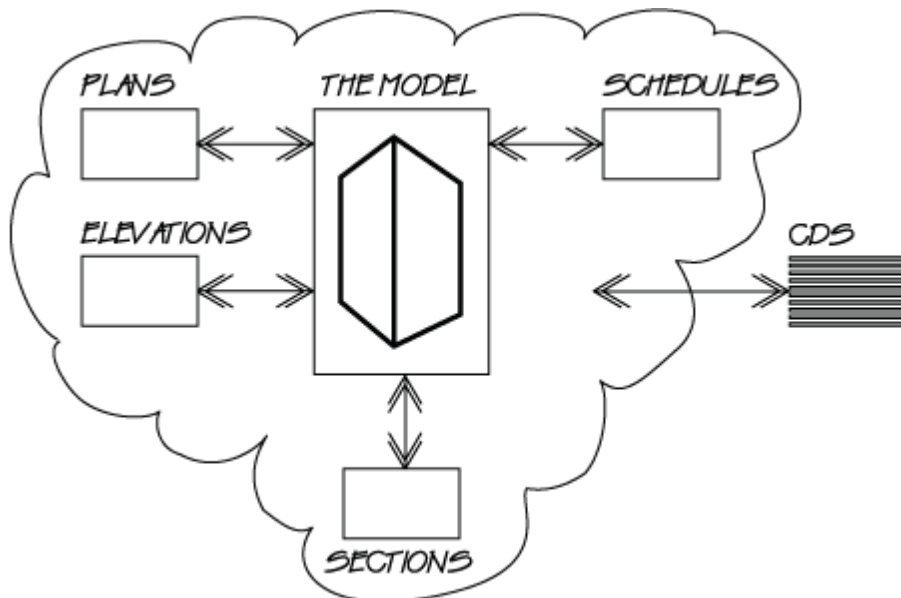


Figure 2. BIM process (Autodesk Revit Architecture 2013 Fundamentals)



Usually the parts of the model such as structural, architectural, HVAC, etc. are made by the different designers and engineers in different programs. Then the separate parts can be combined into one merged model with the help of special programs (Solibri Model Checker, Tekla BIMSIGHT etc.). (Timo Lehtoviita 2013. Better Data Management with BIM)

## **2.2 Use of BIM in different stages of the project**

BIM models are used throughout the whole construction process: from the beginning when the needs and objectives are determined till the end of construction and even after it. This chapter is based on COBIM 2012 and all information is related to the open BIM concept. Open BIM - a unique opportunity to combine projects and various representations of buildings into a single model; technology that allows participants to interact with the design, regardless of the tool used.

### **2.2.1 Assessment of needs and objectives**

During this stage alternatives are assessed and decisions concerning the operating model are made in order to attain the objectives of the project - for example new construction or renovation. The requirement model is made, which consists of:

- The net area requirements for each room and, if necessary, size and shape requirements
- The function and users of the room, the essential connections to other rooms
- The requirements for indoor air conditions, sound insulation, lighting, loads, durability, safety and quality.

- The requirements for HVAC systems, electrical systems, fixtures, fittings, equipment, spacesharing components, the interior surface structures

### **2.2.2 Design of alternatives**

At this stage the most suitable basic solution is further developed using rough spatial models for alternative designs. The Site BIM is made for a new construction. It includes a model of the construction site and its environment, yard etc. For the reconstruction project the Inventory BIM is developed, which represents the existing building and structures (COBIM 2012).

The design of alternative solutions is made with the help of the Spatial BIMs, which consist of the spaces and walls that surround them. These models are further used for different analyses, such as energy and cost analyses. After the comparison of alternatives the design solution is chosen.

### **2.2.3 Early design**

In the early design stage, the basic design solution that was selected in the previous stage is developed further. Architectural, structural and MEP preliminary building element BIMs are made. The key factor on this stage is collaboration between the different designers and engineers (COBIM 2012).

### **2.2.4 Detailed design**

This stage is quite similar to the previous one, but the level of accuracy for the BIMs is raised. Architectural, structural and MEP building element BIMs are made. BIM Coordinator combines the separate models into one merged model for visualizing the designs and assessing their compatibility (COBIM 2012).

### **2.2.5 Contract tendering stage**

At this stage the BIMs, bills of quantities and other important documents extracted from the Model are handed over to the contractor. All this information obtained from the Model helps the contractor to get familiar with the design and structure of the Model and to understand, can he implement this project or not (COBIM 2012).

### **2.2.6 Construction**

BIM is also very useful during the construction phase. BIM simplifies calculation tasks, enhances value engineering, identifies conflicts, facilitates communication, and reduces change orders.

3D visualization of the Model helps to study the design and structure of the object, thus it helps to organize the installation process, for example the installation of prefab and in-situ cast structures, and to coordinate the work.

### **2.2.7 Takeover**

At the final stage As-Built BIM is made. This model represents the final model with all the changes that have been made during construction. As-built model can be used further for the maintenance and facility management (COBIM 2012).

### **3 REVIT REVIEW**

The platform Revit is a system for making design and preparing construction and design documents, including constructive idea, drawings and specifications, which are necessary for the building project. Building information model transmits the structure of the designed object, its dimensions, and stages of design and quantity rates.

In Revit Architecture two key principles are used. The first principle is the tracking of relationships during the project. The second principle is distribution of changes in the buildings. As a result, we get the program that follows the designer's thoughts (Vysotsky A.E., Parfenov N.V. 2012. Tutorial Program Autodesk Revit Architecture. Basic course).

#### **3.1 History**

This chapter is based on the article "A Brief History of BIM", written by Vanessa Quirk.

Parametric Technology Corporation (PTC) was founded in 1985 and released the first version of Pro/ENGINEER in 1988. This is a mechanical CAD program that utilizes a constraint based parametric modeling engine. Equipped with the knowledge of working on Pro/ENGINEER, Irwin Jungreis and Leonid Raiz split from PTC and started their own software company called Charles River Software in Cambridge, MA.

The two wanted to create an architectural version of the software that could handle more complex projects than ArchiCAD. They hired David Conant as their first employee, who is a trained architect and designed the initial interface which lasted for nine releases. By 2000 the company had developed a program called 'Revit', a made up word that is meant to imply revision and speed, which was written in C++ and utilized a parametric change engine, made possible through object oriented programming. In 2002, Autodesk purchased the company and

began to heavily promote the software in competition with its own object-based software Architectural Desktop.

Revit revolutionized the world of Building Information Modeling by creating a platform that utilized a visual programming environment for creating parametric families and allowing for a time attribute to be added to a component to allow a «fourth-dimension» of time to be associated with the building model. This enables contractors to generate construction schedules based on the BIM models and simulate the construction process.

Autodesk (the developers of AutoCAD) purchased the Massachusetts-based Revit Technology Corporation for US\$133 million in 2002. The purchase allowed more research, development and improvement of the software. Autodesk has released several versions of Revit since 2004. In 2005 Revit Structure was introduced, then in 2006 Revit MEP. After the 2006 release Revit Building was renamed Revit Architecture.

Since Revit 2013 the different disciplines have been combined into one product, simply called Revit.

In 2012 Revit LT became the newest version of Revit on the market. It is a light version of Revit with a number of features such as rendering and multi user environments crippled.

With their Revit platform, Autodesk is a significant player in the BIM market together with Nemetschek, and Gehry Technologies with CATIA based Digital Project.

### **3.2 Main functions**

Revit is a basic program for creating a building model by adding architectural elements, structural elements, and MEP systems. Also you can add design options and custom components (Revit families).

To start working with a new project in Revit, you should create a project file. You can choose whether to use a template for a new file or not, as shown in Figure 3. A project template provides a starting point for a new project, including view templates, loaded families, defined settings (such as units, fill patterns, line styles, line weights, view scales, and more), and geometry, if desired.

As installed, Revit provides several templates for different disciplines and types of building projects.

You can also create custom templates to address specific needs or to ensure adherence to office standards.

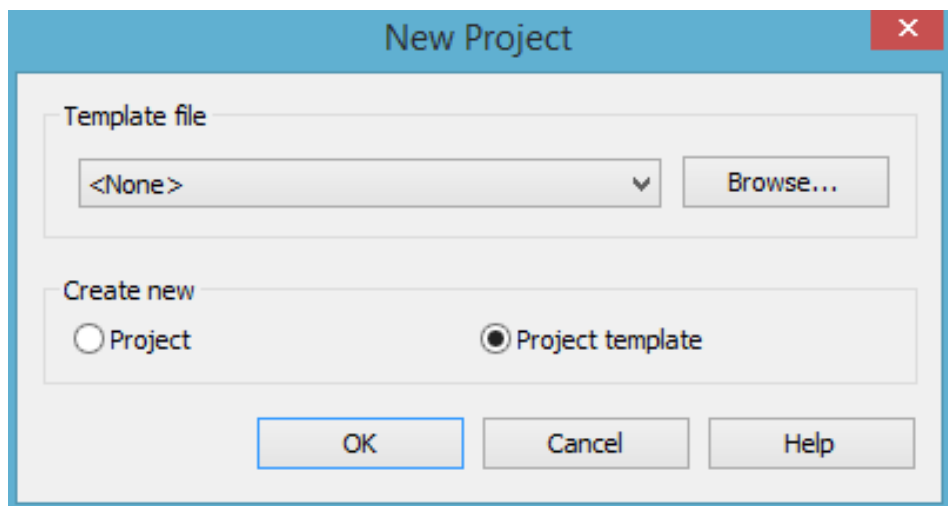


Figure 3. The New project dialog

Then move on to the Project Settings. Firstly, project parameters are set. Project parameters are parameters which are defined by the user, and then assigned to multiple categories of elements in the project. Secondly, with the command "Project Units" the format of display of different values in the project is set. Also you can choose the style of the object (color of line, lineweight, materials for the different categories / sub-categories of model objects).

The Autodesk Revit interface is designed for intuitive and efficient access to commands and views. It includes the Ribbon, Quick Access Toolbar, Application Menu, and Status. The interface is shown in Figure 4.

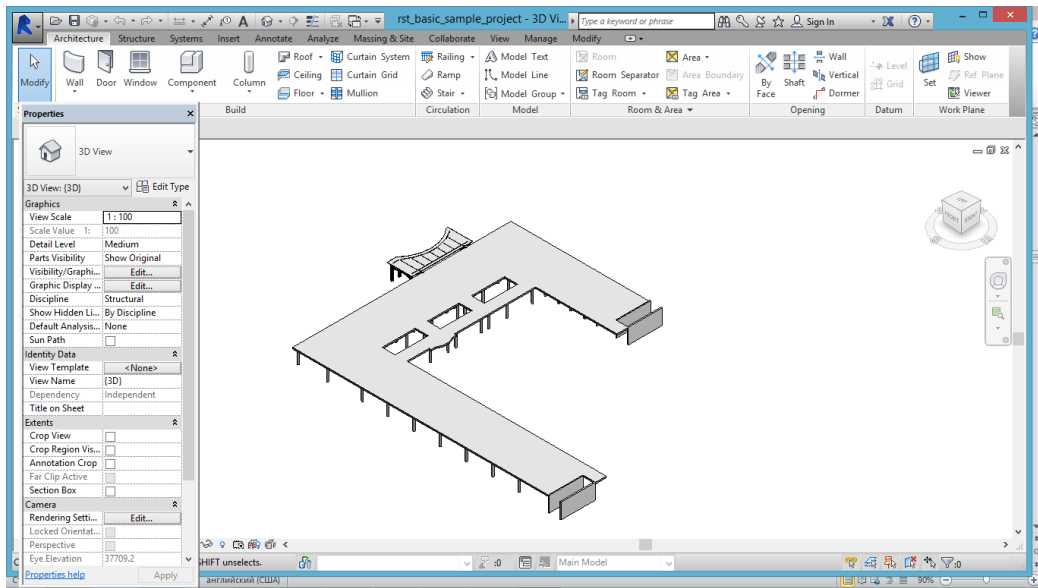


Figure 4. Autodesk Revit interface

To establish context and guidelines for the project, you should create levels and grids. The Level tool is used to define a vertical height or story within a building. You create a level for each known story or other needed reference of the building (for example, first floor, top of wall, or bottom of foundation). The Grid tool is used to place column grid lines in the building design. You can then add columns along the column grid lines. It will look like figure 5.

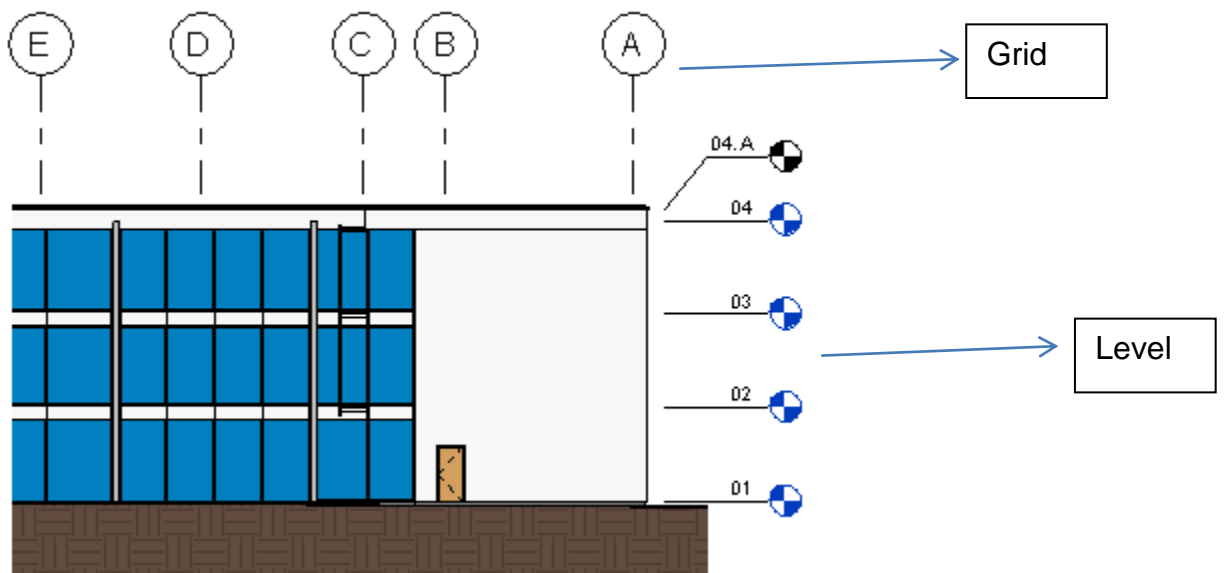


Figure 5. Grid line (Autodesk Website)

All of the elements that you add to your Revit projects are created with families. By using predefined families and creating new ones in Revit, you can add both standard and custom elements to your building models. Families also provide a level of control over elements that are similar in use and behavior, allowing you to easily make design changes and manage your projects more efficiently.

With design options, a team can develop, evaluate, and redesign building components and rooms within a single project file. Some team members can work on specific options, such as variations of a lobby, while the rest of the team continues with the main model.

Moreover, with the help of Revit you can create, annotate, and refine project documentation to communicate the design aim to team members, consultants, clients, and contractors. It is easy to make all the necessary schedules, quantities, and material takeoffs to quantify and analyze the components and materials used in a project. All schedules update automatically when you modify the project.

2D views, such as plans, elevations, sections, and callouts, can be made from building model. For example, if you want to create a Section View, you just need to Click View tab - Create panel - Section, place the cursor at the starting point of the section, and drag through the model or family, as shown on in Figure 6. To open the section view, double-click the section header, or select the section view from the Sections grouping of the Project Browser. Also you can quickly create 3D views of the model. Working in 3D views helps you visualize the project and position some of the elements correctly.

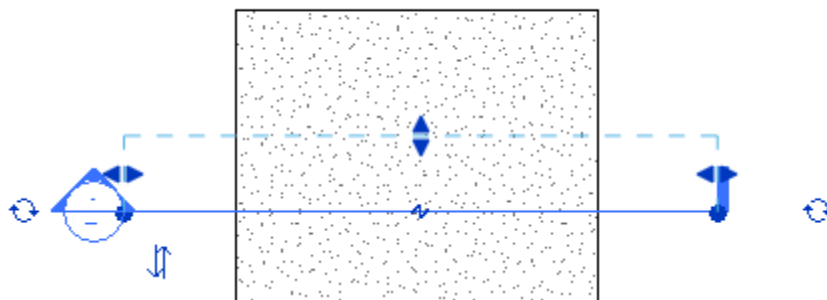


Figure 6. Creating of the section



### 3.3 Families

A family is a group of elements with a common set of properties, called parameters, and a related graphical representation.

Different elements belonging to a family may have different values for some or all of their parameters, but the set of parameters (their names and meanings) is the same. These variations within the family are called family types or types (Families Revit Architecture Manual 2010).

There are three kinds of families in Revit: system families, loadable families, and in-place families. Usually system families and loadable families are used more than in-place families. Loadable families can be combined to create nested and shared families. In-place families are used to create non-standard or custom elements (Autodesk Website).

The families used in the project of Skandi Klubb (made by LLC NCC) are considered as the example below.

The family Int\_Door is a loadable family, which was saved as rfa-file and can be loaded into the project. The family is shown in Figure 7. It includes nine family types. Each family type has a set of properties (parameters). You can change these parameters for the whole family type or just for one door in this family type (Figure 8).

In this example, for each family type you can change the following parameters:

- Construction (function, wall closure, construction type);
- Graphics (type of opening, type of fabric);
- Material and finishes;
- Dimensions (rough heights, rough height, area, height, width, thickness);
- IFC Parameters;
- Data (name, symbol);
- Identity Data (description, assembly code, type image, etc.).

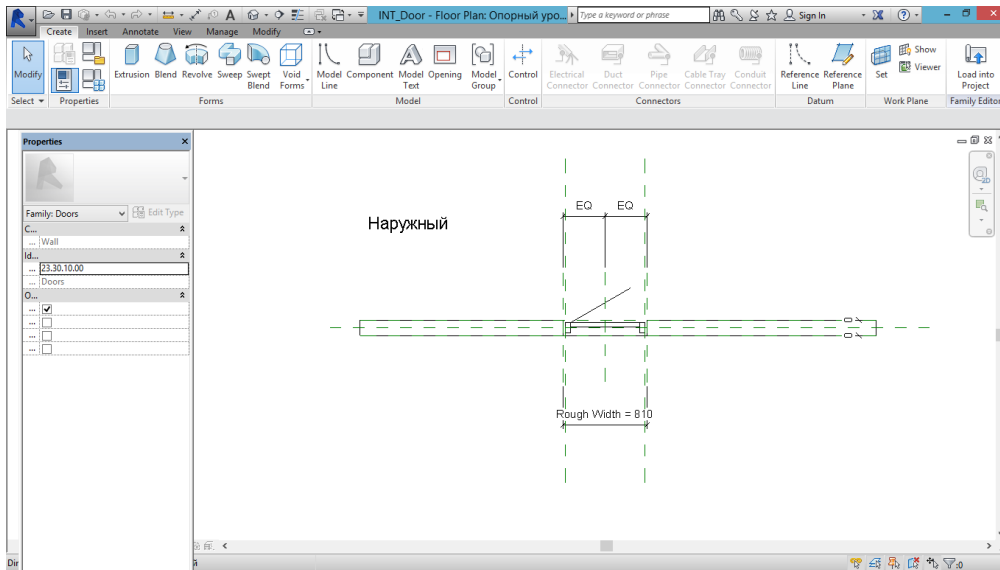


Figure 7. Family Int\_Door

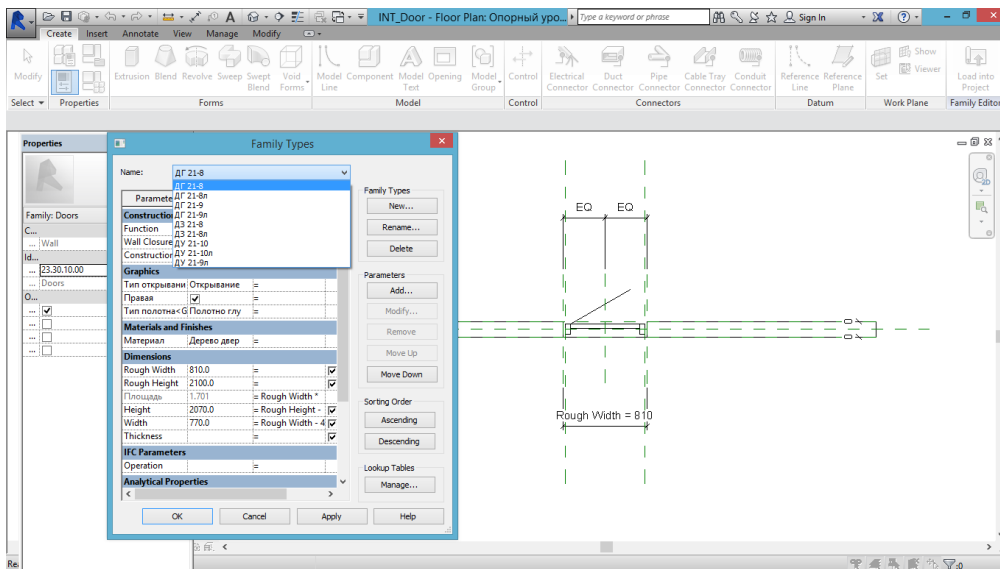


Figure 8. Family types and properties

The family Opening\_circular consists of four types (see Figure 9). For each family type you can change the following parameters:

- Construction (construction type);
- Dimensions (rough width, rough height, width, radius, area, diameter, height, height to the bottom of the hole );
- IFC Parameters;
- Identity Data (description, assembly code, type image, etc.).

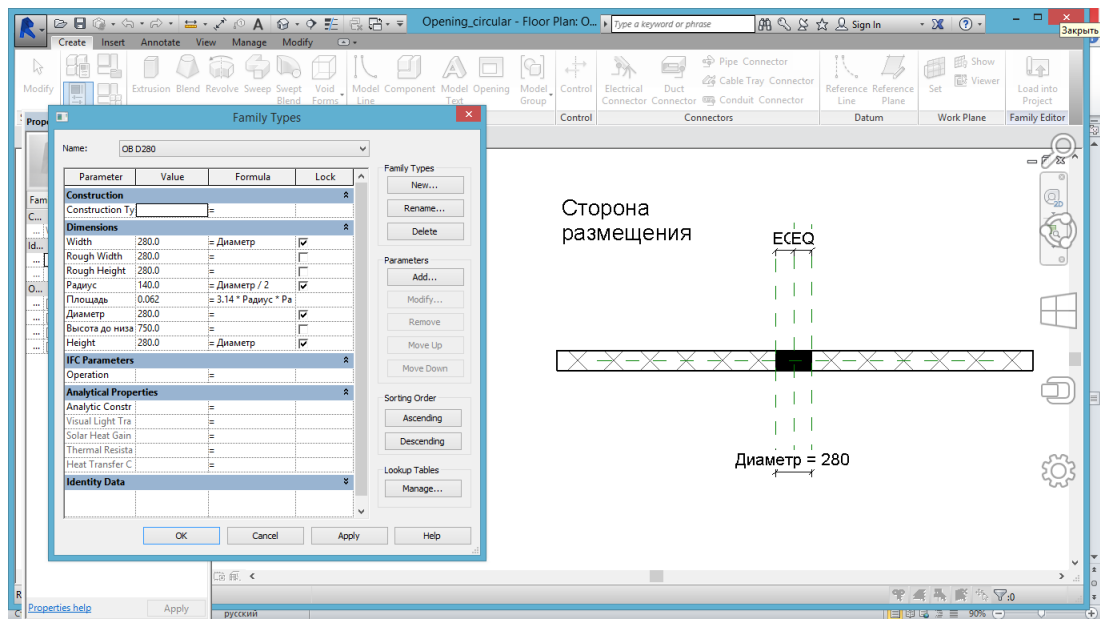


Figure 9. Family Opening\_circular

### 3.4 IFC format and Solibri program

IFC (Industry Foundation Classes) is an object-based file format, which is platform neutral and open file format specification that is not controlled by a single vendor or a group of vendors. IFC is an international file format, which allows combining models made in different programs (for example, Revit and MagiCAD) (COBIM 2012). Autodesk Revit provides IFC export and import. IFC improves communication, productivity, delivery time, and quality throughout the life cycle of a building. Also it reduces the weight of the model in ten times. However, IFC does not capture all the functionality of BIM software. It does not transmit axis and 2D elements.

The most popular programs to work with IFC-models are Solibri Model Viewer or Solibri Model Checker (Figure 10). Solibri Model Viewer allows you just to view the model and leave the comments. It has a limited set of functions. There are not so many tools: info tool, dimension tool, select tool, hide tool, markup tool, sectioning tool, transparent tool. You can save the model in SMC format. A model saved in the native SMC format ('smc' file extension) contains all model data, rule set information, presentations, and checking results from a previous

Solibri Model Checker checking session. When you open an SMC model file your workspace will be restored to the state it was in when the checking session was saved.

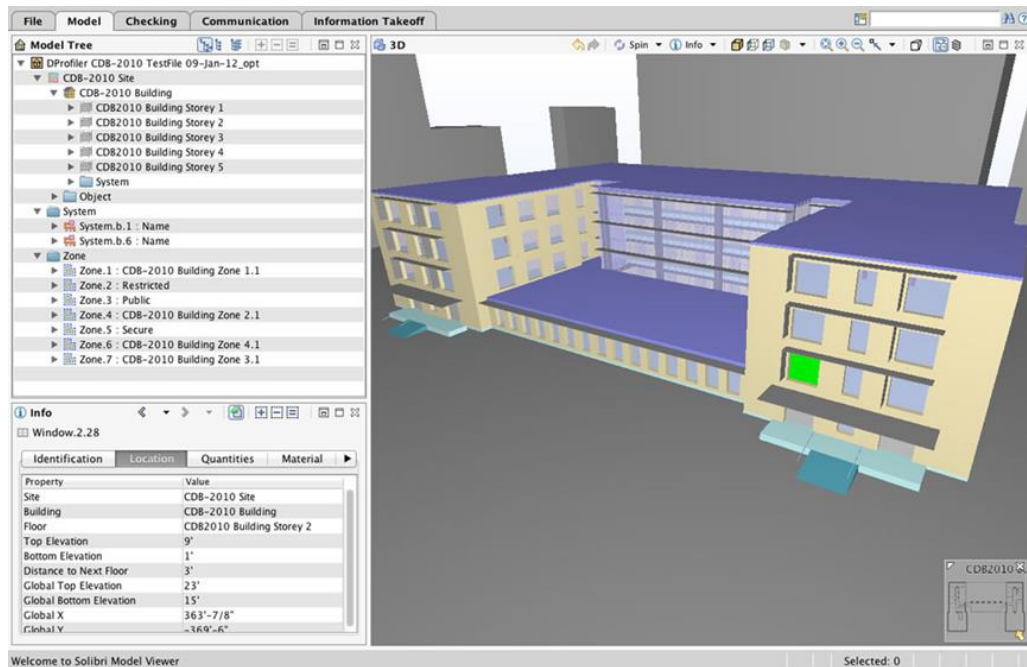


Figure 10. Interface of Solibri Model Viewer and Solibri Model Checker

Solibri Model Checker allows making a merged model. It helps you to find and visualize issues and problems before and during construction. It can merge several building models (ifc-files) from different design disciplines. It automatically analyzes and groups clashes according to severity. You can find relevant problems quickly and easily investigate the quality of your BIM files.

### 3.5 Use of Revit in the world and Russian Federation

The most innovative Russian companies started to use BIM and have already felt the benefits of using the technology.

Barnaulgrazhdanproekt is one of the largest design organizations of the Altai Territory. The main activity of the company is the design of the large-panel buildings series KPD-330E (see Figure 11). In 2012, the company decided to introduce Autodesk Revit. The work with large-panel houses entailed a number

of difficulties. The main problem was the need to develop a large number of items - panels of which the house will be built. To resolve this problem the company considered two basic options of the concept of work in Revit. The most suitable solution was to create the models for each project – structural and architectural (Customer Success story Autodesk 2014).



Figure 11. Large-panel buildings series KPD-330E (Customer Success story Autodesk 2014)

An important objective of the project was to create families in Autodesk Revit. All in all, more than 600 families were created, including families of reinforced concrete elements, hinges and embedded parts etc. The example of a family you can see in Figure 12.

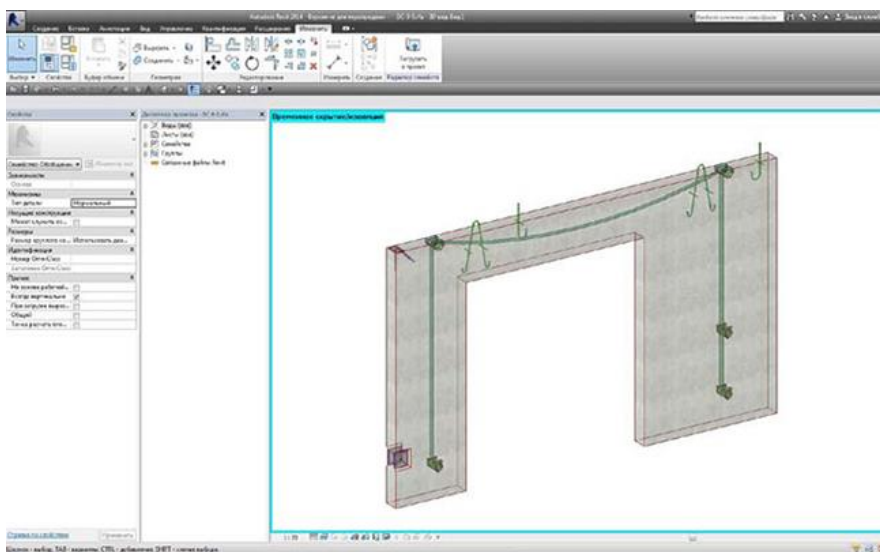


Figure 12. Internal wall panel family (Customer Success story Autodesk 2014)

After creating the database of the elements a typical section was assembled and then - two-section residential building.

In the end, the company was satisfied with the results of the use of Revit. A lot of benefits of using Revit instead of AutoCAD were discovered, such as:

- Any changes in the plan are made five time faster
- Visualization of the model
- Less number of mistakes

The other example of the successful usage of BIM technology is the construction of the National Air and Space Museum in Moscow – the biggest air and space museum in the world (Figure 13). The project was made by the Moscow Research and Design Institute for Culture, Leisure, Sports and Health (mosproekt-4).

The project of the Aerospace Museum is the first project, in which experts Mosproekt-4 use the technology of Building Information Modeling. The conceptual design was made in AutoCAD, as it is more familiar to architects. After that the data was exported to Revit Architecture and the digital model of the complex was created.

Finally, the main advantages of using Autodesk products (Autodesk Revit Architecture, Autodesk Revit Structure, Autodesk Revit MEP) were identified, such as (Customer Success story Autodesk 2011):

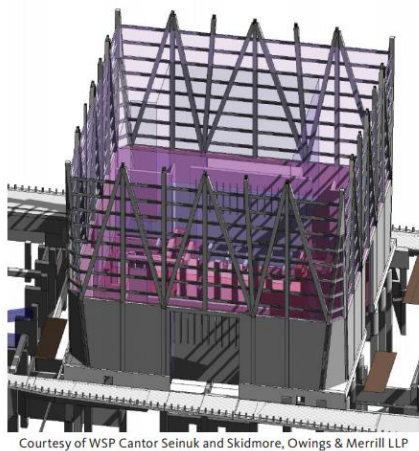
- Reduction of the designing time
- Improvement of the quality of the project documentation
- Unlimited opportunities to work with architectural elements, complex surfaces and structures
- The possibility of collaboration work



Figure 13. The architectural view of Aerospace Museum (Customer Success story Autodesk 2001).

BIM technology and in particular Autodesk Revit are widely used all over the world. There are some examples below.

The project of One World Trade Center: The Freedom Tower, New York, that was held by Skidmore, Owings & Merrill LLP (SOM) firm, is one of the examples of the use of BIM technology in the USA (Figure 14).



Courtesy of WSP Cantor Seinuk and Skidmore, Owings & Merrill LLP



Figure 14. Model of One World Trade Center (Customer Success story Autodesk 2007)

Autodesk and its expertise in design software, project collaboration, and consulting services was a significant factor in helping SOM and its engineering partners reach this point. The Revit platform helps us visualize projects as they will really be constructed, says SOM Partner Carl Galimoto, FAIA. That means we can design better buildings - buildings that are more efficient, are higher performing, and, consequently, that also help us meet our sustainable design goals. It's nothing short of a revolution (Customer Success story Autodesk 2007).

The project of the CET mixed-use development in Budapest, Hungary, made by the ONL firm is an example of nonstandard art and architecture (Figure 15) (Customer Success story Autodesk 2009).



Figure 15. The architectural view of the CET (Customer Success story Autodesk 2009)

ONL adopted Autodesk Revit Architecture building information modeling (BIM) software in 2004. ONL also integrates Autodesk 3ds Max software into its BIM workflow for conceptual design and visualization.



## 4 IMPLEMENTATION OF BIM

### 4.1 3D printing

3D printing is a new revolutionary technology that helps you to bring your design to life. 3D printing is an additive manufacturing technology which makes it possible to turn 3D modeled designs into custom solid objects on demand. The examples of 3D printed objects you can see in Figure 18.



Figure 18. Model House printed at 1:100, 1:200, 1:500 and 1:1000 scales (3D printer Website)

Many of the most successful design, engineering and construction firms have adopted 3D printing as a critical part of their design development and project delivery process to (3DSystems website):

- Increase innovation
- Improve communication
- Speed project approval process
- Reduce costs and time on model making
- Win business

The typical acceptable file formats are STL, FBX, OBJ, WRL, BLD etc.

The most frequently used geometry creation software is Revit, 3DMax, Maya etc. All geometry to be 3D printed must be in three-dimensions. Any two-dimensional geometry cannot be processed by the machines software or interpreted by the 3D printer. All three-dimensional geometry must consist of closed volumes.

STL format is the most commonly used. STL file format does not contain any BIM data or file history, it contains only an X,Y and Z coordinate for each point that makes up the individual triangles. The points are based on the universal world coordinate system.

Moreover, today we can print not only models, but real concrete elements and even houses. For example, in China, a company named Winsun has managed to 3D print an entire apartment building, consisting of 6 stories (Figure 18.a)



Figure 18.a. A 6-story tall building which has been 3D printed by Winsun (3D print Website)

## 4.2 Visualization

Visualization is one of the most important goals of the BIM. Visualization by means of BIMs supports the work of the designers and project management, improving the communication between the design team, project parties and end-users of the facilities. The principal benefits of visualization include quality

optimization, more convenient comparison of alternatives, increased interaction between different parties, and support of the real estate development and marketing process (Revit and Visualization Autodesk 2008).

There are two types of visualization (Revit and Visualization Autodesk 2008):

- Technical illustration is used as a communication tool between designers, project manager and client;
- Visualization is photo-realistic illustration of designer's solution, view.

The most commonly used platforms for visualization are Revit and Autodesk 3ds Max. The Revit platform contains an internal render for quick visualizations. However, it is not so realistic. 3ds Max is used to achieve the most realistic picture. On the high level of modeling, it is difficult to distinguish the model from photos. You can see the differences in visualizations in Revit and 3ds Max in Figure 19.

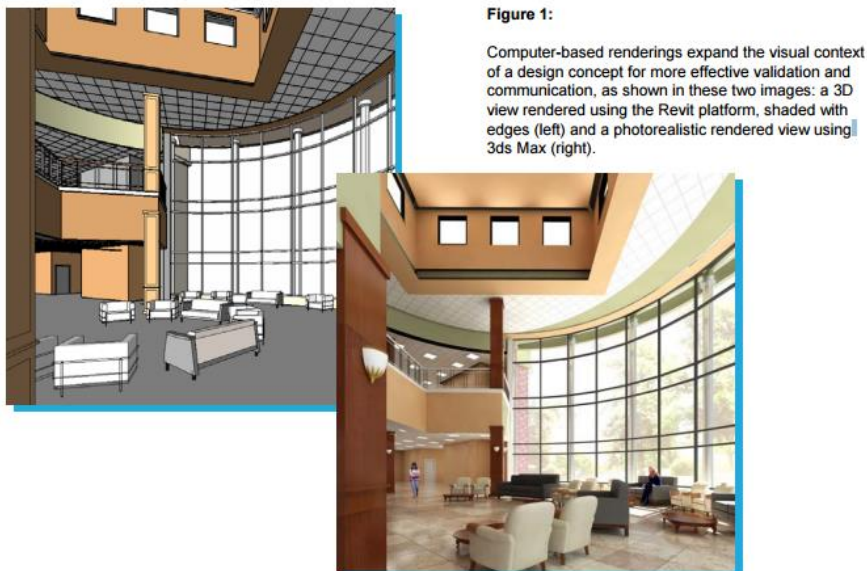


Figure 19. The differences in visualization with Revit (left picture) and 3Dds Max (right picture) (BIM and Visualization Autodesk 2008)

The BIM data can be easily exported from Revit to 3ds Max in DWG format.

### 4.3 Automatic generation of Material Takeoffs

Revit allows you to create material takeoffs easily. Material quantity takeoff allows you to make detailed material quantities directly from the BIM.

Firstly, you select for which structure you would like to get the material takeoff (Figure 20).

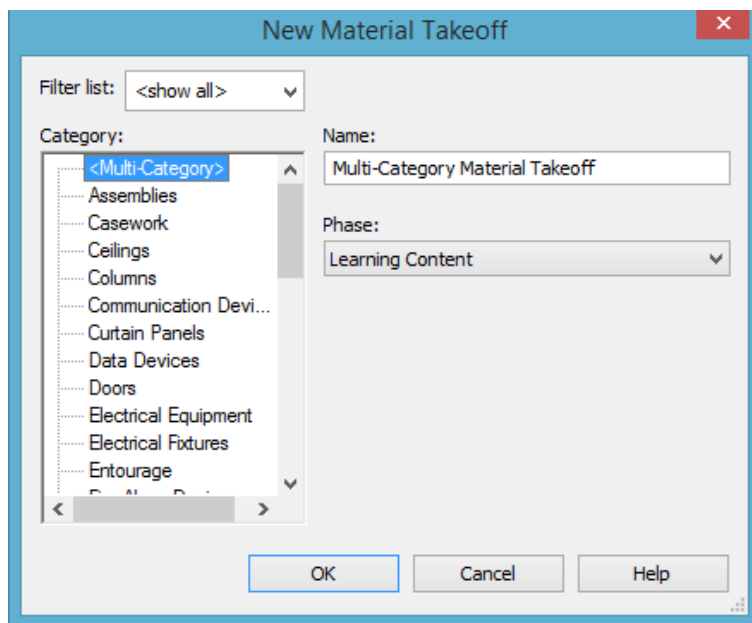


Figure 20. Creation of new material takeoff

Secondly, you select material takeoff properties that you need (Figure 21).

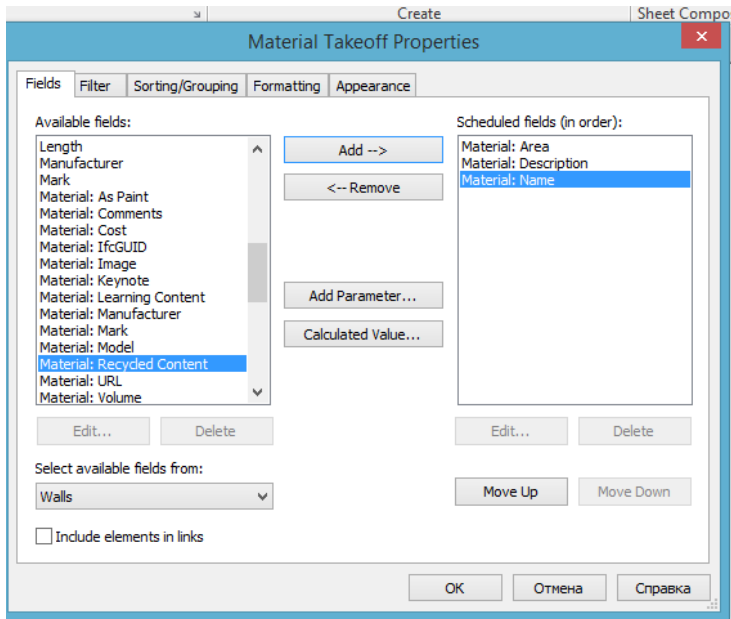


Figure 21. Selection of the material takeoff properties

Finally, Revit automatically generates the material takeoff table. It will be automatically updated if any change is made in the model (Figure 22).

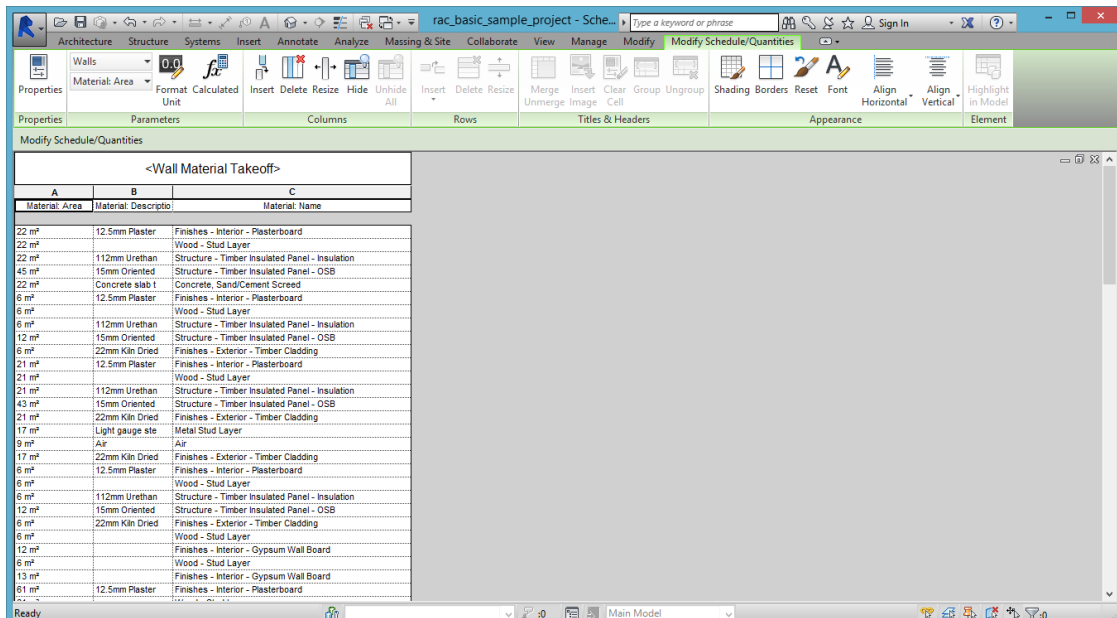


Figure 22. The ready material takeoff

#### **4.4 Scale models and mock ups**

Scale models and mock ups are the miniature copy of the object, for example, building. The main purpose of it is advertising. Many construction and real estate companies use mock ups to attract customers. Scale models are also able to attract a profitable investor and are served as illustrative example of the professionalism of the construction company (Flintco Website)

By utilizing a BIM virtual mock-up the entire team was better able to define the owner's expectations. In addition to providing a virtual model that streamlines decision making during design, early BIM virtual mock-ups serve as platforms to study the transitions between dissimilar material types and thermal conductivity from exterior to interior spaces. Developing virtual mock-ups in BIM during the early design phase helped produce a constructible design solution that exceeded the owner's expectations (Flintco Website).

## **5 STUDY CASE**

The practical part of the thesis was to design the model of the two-level apartment (K27-40) of housing complex Skandi Klubb.

The main purpose of creating the model of a one separate flat was to stimulate the process of selling this apartment. This two-level apartment is the most expensive apartment in the whole building, so it is hard to sell it.

The company NCC has never had the experience of making a model of a separate apartment for the attraction of customers. The model will help customers not only to see the picture of their future flat in 3D, but also to walk

through it and to see the possible design of the apartment with the help of visualization.

## 5.1 Housing complex Skandi Klubb

The new complex will be built in the historical center of Saint-Petersburg on Aptekarskiy prospect. You can see the location and the façade of the complex in Figures 16. Skandi Klubb is a complex of seven buildings of different height from 5 to 10 floors, which will be built in four stages. The residential complex includes one, two, three and four-room apartments and comfortable studio apartments.



Figure 16. Master plan (NCC Website)

In Figure 17 you can see the façade of the building.



Figure 17. View from Aptekarskiy prospect (NCC Website)

The basic characteristics (NCC Website):

- Area - 3.8 hectares
- Apartments - 1213 (348 in Phase I)
- The total area of 78,000 square meters of apartments
- Parking underground - 525 spaces for cars and 43 places for bicycles / moto
- Pantry - 953 (251 in Phase I)
- Commercial premises – 3200 m<sup>2</sup>
- Supermarket - 1300 m (in Phase I)
- Green Zones - 11,500 square meters (30%)
- Private kindergarten - 100 seats in two sections (II, IV line)
- Completion of construction - III quarter of 2018

## 5.2 Requirements of the customer to the project

Before the project is begun, the customer should provide his requirements to the project. Good and detailed requirements make the process of projecting faster and easier. The customer defines objectives for different fields of the project such as scope, time, budget, etc. Below you can see a set of



requirements for virtual design. The list of requirements based on the documents, provided by NCC.

#### **5.2.1 General requirements are:**

- Implement design process in software system for BIM designing: Autodesk Revit, building services in MagiCAD which is connected to Revit and other software compliant to Revit.
- Building plans, sections, facades, specifications of materials and equipment are taken directly from the 3D model, all changes in the model are shown in all drawings automatically.
- Automatic calculation of project volumes (total area, sold area, number of flats, number of flats according to their categories).
- Automatic generation of specifications and tables with project characteristics (areas, volumes), specifications of equipment and materials according to the provided typical forms.

#### **5.2.2 Master plan**

The requirements for master plan are:

- Master plan of the land plot should be made in AUTOCAD
- Take from model all materials and elements, which are used in the model including: automatic calculation of dredge and fill balance, automatic creating and renewal of cut-outs, sections of the networks inside the land plot, architectural landscape elements, green plants and others.

#### **5.2.3 Architectural solutions**

Visualization of the approved decisions in real-time mode and all changes in the project should be immediately implemented into the model with automatic renewal of the related sections of the project.

#### **5.2.4 Framework solutions**

The requirements for framework are:

- The model should ensure imaging of concrete forms, reinforcing, mortgage elements and other key elements in 3D and in 2D
- Bearing and non-bearing panels, internal and external panels, pedimental and copestone panels, other one layer and three layer panels are created separately

#### **5.2.5 Building services**

The requirements for building services are:

- The amount of sanitary installations, design flow rates and pressure drops should be set into the project
- Automatic selection of diameters of pipes and ducts Families
- All systems should be shown in 3D taking into account real diameters (of ducts, pipes and insulation), dimensions and characteristics of equipment, designed flow rates and loadings.
- Architectural, structural solutions and building services should be combined together in one document to see all inconsistencies of networks, to check the rightness of holes positions, to see route locations of networks taking into account all networks and structural elements.

## 5.3 CREATION OF THE MODEL IN REVIT

Drawings, which were given as initial assignment, are presented in appendix 1. The flat is situated on the 7<sup>th</sup> and 8<sup>th</sup> floors. The upper floor is presented in a volume, marked by a red line.

The model was made in Autodesk Revit 2015.

### 5.3.1 First version of the model

The first step was to make a grid for the future flat. It consists of five horizontal and nine vertical axes (figure 18). After that the levels were assigned. The height of the floor was 3 meters.

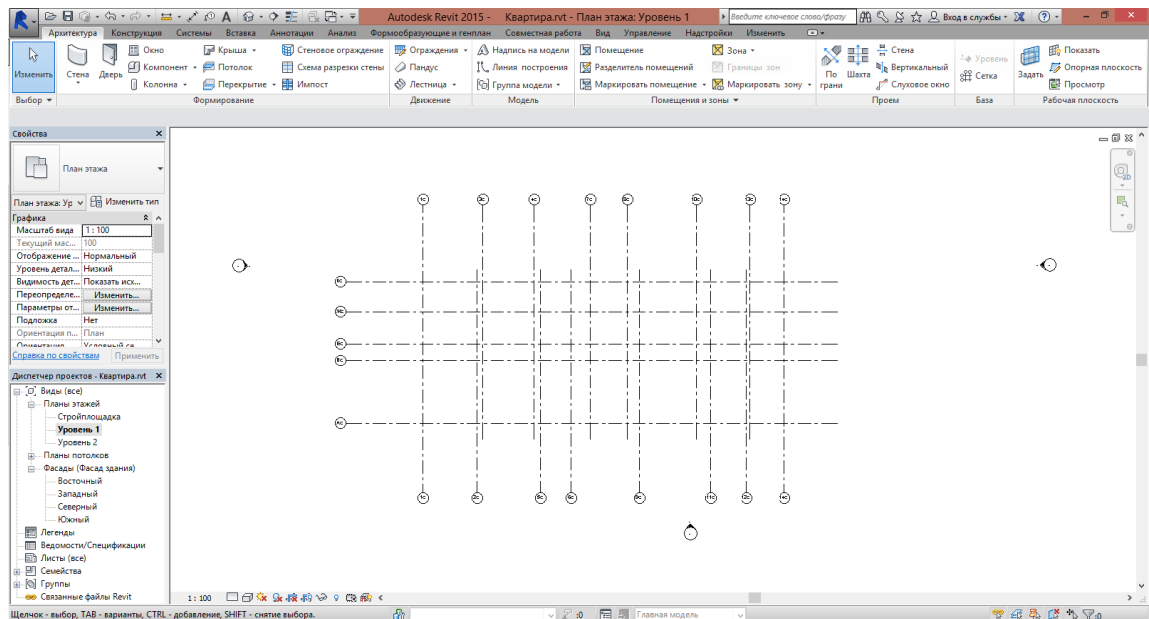


Figure 18. The grid

The second step was to draw the walls (figure 19). They are divided into two groups: internal walls and external walls. In addition, internal walls can be bearing or non-bearing. For each type of walls the families were created. Structure for each type of walls was made according to the initial drawings (appendix 1).

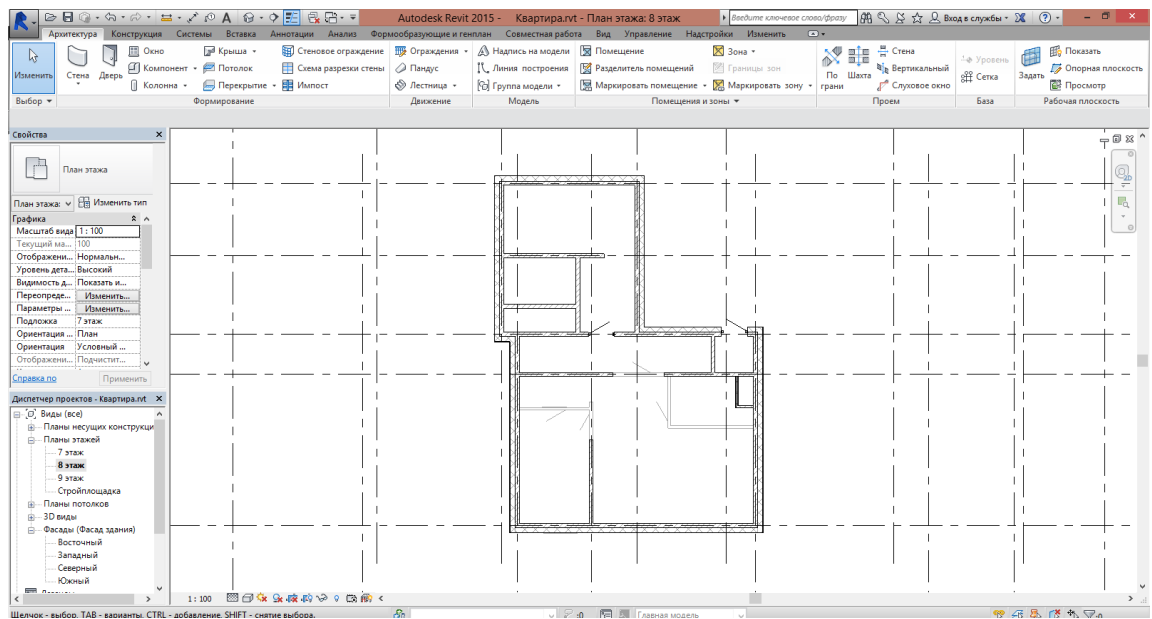


Figure 19. Walls on the first level of flat

Then the floors and the roof structure were made. The halls for the ventilation shafts were made on the roof.

The first floor was connected with the second floor by the means of stairs in the apartment. In addition, there is a staircase and two lifts outside the flat.

After that, the openings in the walls were made. They include doors (4 types) and windows (3 types).

At the end, the roof structure with fencing was created.

Then the most important part began. The model of the apartment should look very attractive and realistic. Materials for all structures were assigned. For example, for the floor of the apartment the parquet was used, the walls were painted in light colors.

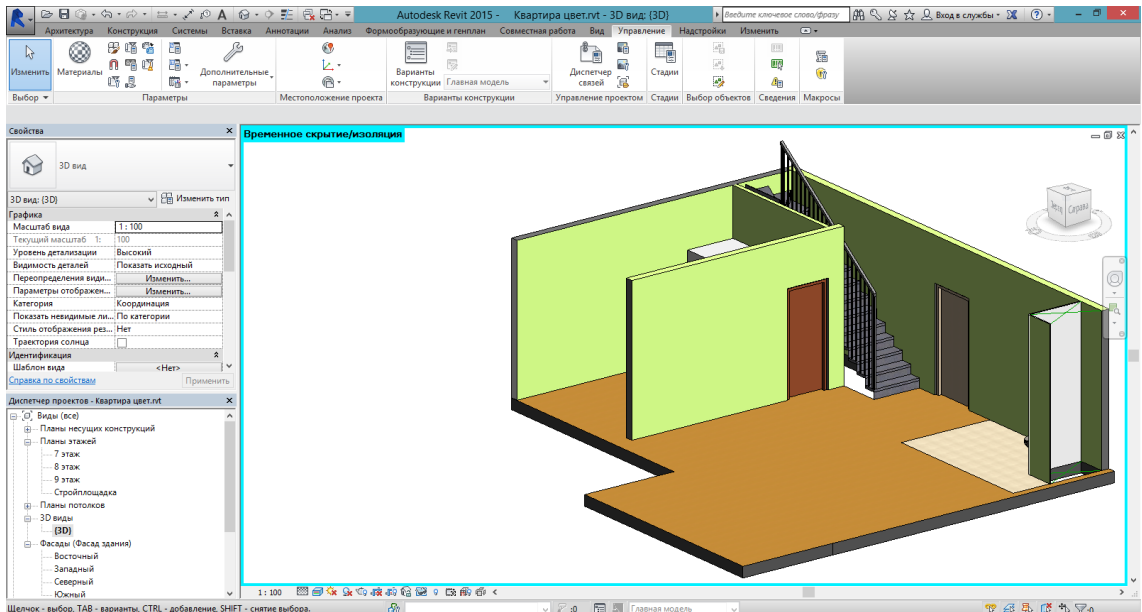


Figure 20. Finishing of the walls and floor

The furniture was placed, so that the customer could better imagine his future flat, to make the apartment look more realistic and to have a homely atmosphere.

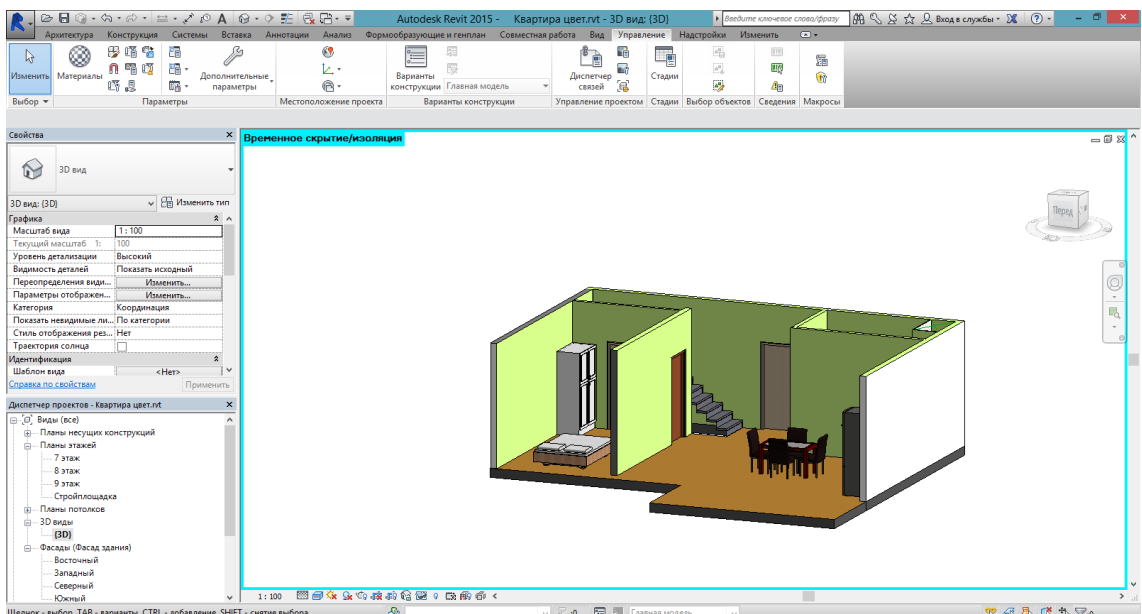


Figure 21. Furniture arrangement

At the end, when the first version of the model was completed, the model was shown to some people not connected to construction. It was important to find out their opinions about this model: what they think about this model, do they like it or not and why, would they like to buy it etc.

As the result, after the interviews were finished, the following conclusion can be made:

- 60% of people said that the model was nice, but too simple;
- 50% of people said that they would like to buy this apartment;
- 30% of people said that they would like to see more detailed and interesting design of the apartment.

### 5.3.2 Second version of the model

According to the opinion of people, a more complex interior of the apartment was made. More furniture was added, the finishing of the rooms became more fascinating. After the second opinion poll, which was made, most of the respondents said that the apartment looked more expensive and fashionable after changes that had been made. The results can be seen in Figures 22, 23, 24.

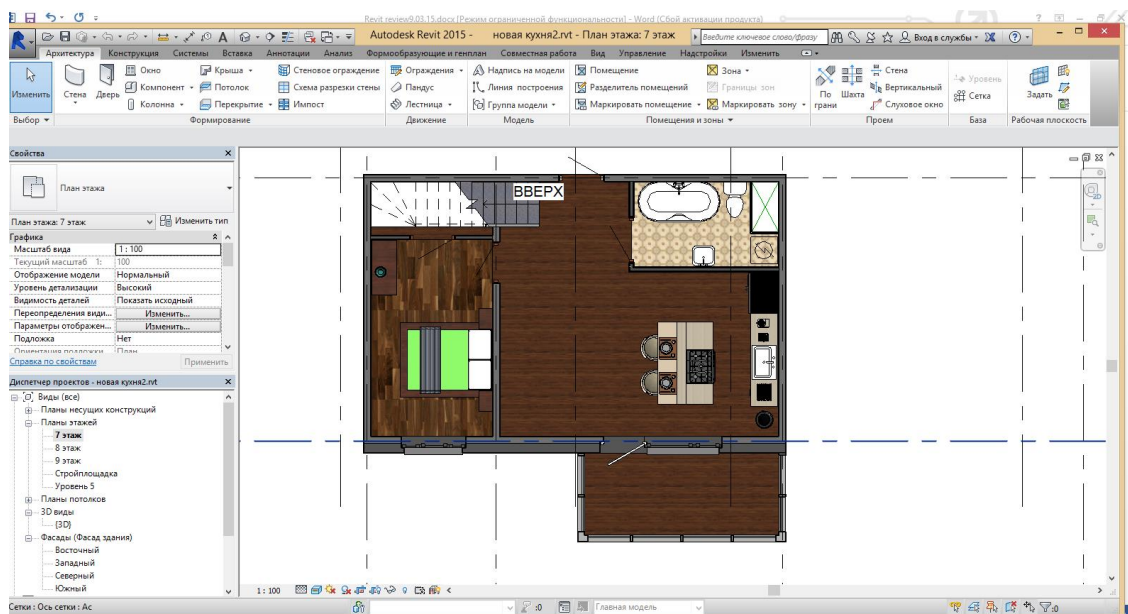


Figure 22. New plan of the 1<sup>st</sup> floor

To attract customers the fashionable furniture was placed (Figure 23).

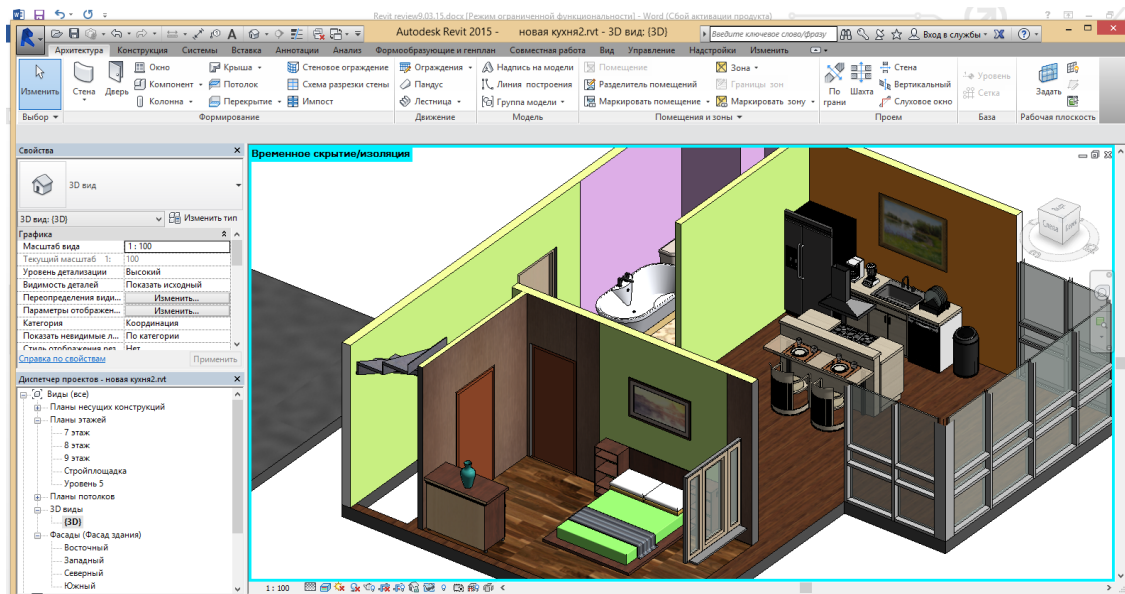


Figure 23. New furniture arrangement

On the second floor a big terrace is located, which is covered with a green grass (Figure 24).

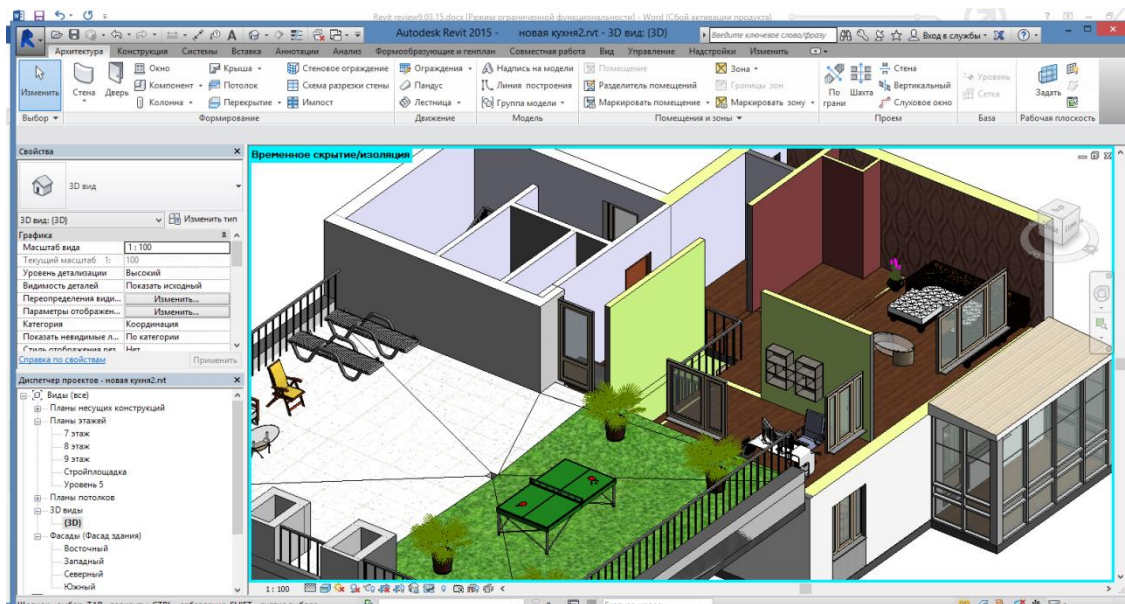


Figure 24. 3D view of the 2<sup>nd</sup> floor

In addition, the visualization of the apartment was made with a help of Revit. After the visualization the model looks more realistic. The realistic view of the apartment is shown in the Figure 25.

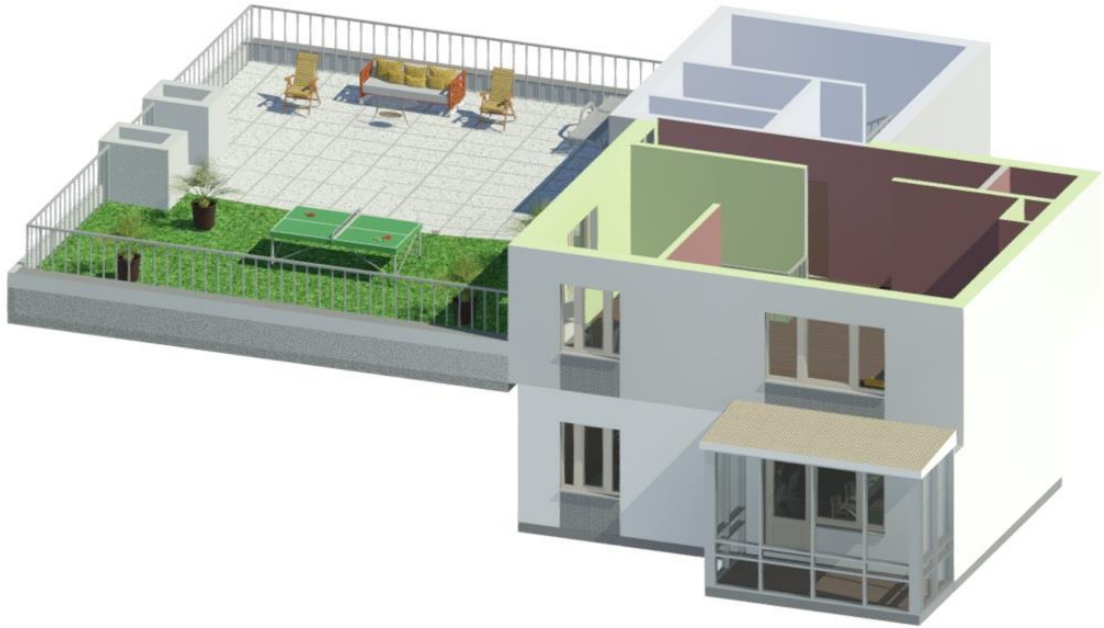


Figure 25. The realistic view of the model

The Realistic visual style displays realistic materials and textures within Revit in real-time. In Figure 26 you can see a photorealistic image of the kitchen.



Figure 26. The realistic view of the kitchen

More pictures are attached in appendix 2.

To sum up, the creation of a model of a residential apartment is a good way to attract new customers. It helps them to visualize the flat with the possible interior and even to walk through this flat.



## 6 CONCLUSIONS

The most valuable and important result of this thesis is the model of the two-level apartment in the program Revit Autodesk, which is ready to be presented for the future customers. This model can be used in NCC Company in the sales department. The purpose of this model was to attract the customer, and this purpose is achieved on the basis of an opinion poll, which was made. The majority of respondents said that they would like to buy this apartment and they like the way it looks and is designed. This model can be used not only for sale purposes, but also in advertising of the whole housing complex Skandi Klubb. Due to rendering function in Revit, it is easy to get beautiful and very realistic pictures of the apartment for advertising.

Moreover, not only the pictures of the model can be used, but the whole model can be shown to customers in Solibri Model Viewer, so they can see all the details of the apartment.

In the theoretical part of this thesis the following topics were discovered:

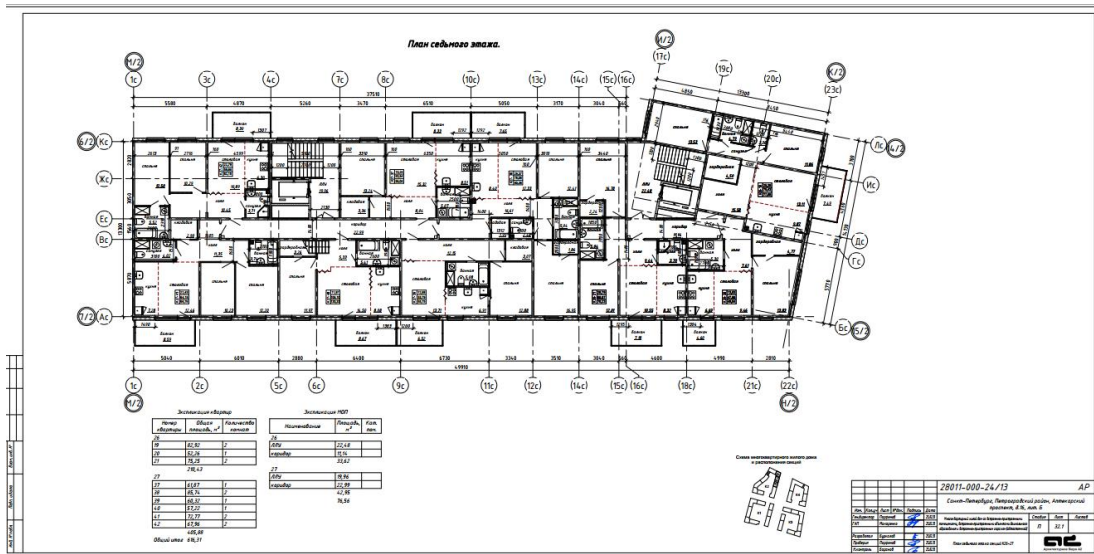
- The concept of BIM and the usage of BIM model throughout the whole life cycle of the project;
- The history of program Revit Autodesk, its main functions and characteristics;
- The main ways of implementation of BIM models.

Finally, I would like to say that it was a great experience for me. I did not work in Revit before writing this thesis, so I made the whole way from the beginner to the medium level user of the Revit while I was creating the model. I learned a lot of useful things and tools, which help me to grow as a professional engineer and I believe these new skills will be needed for my future job.

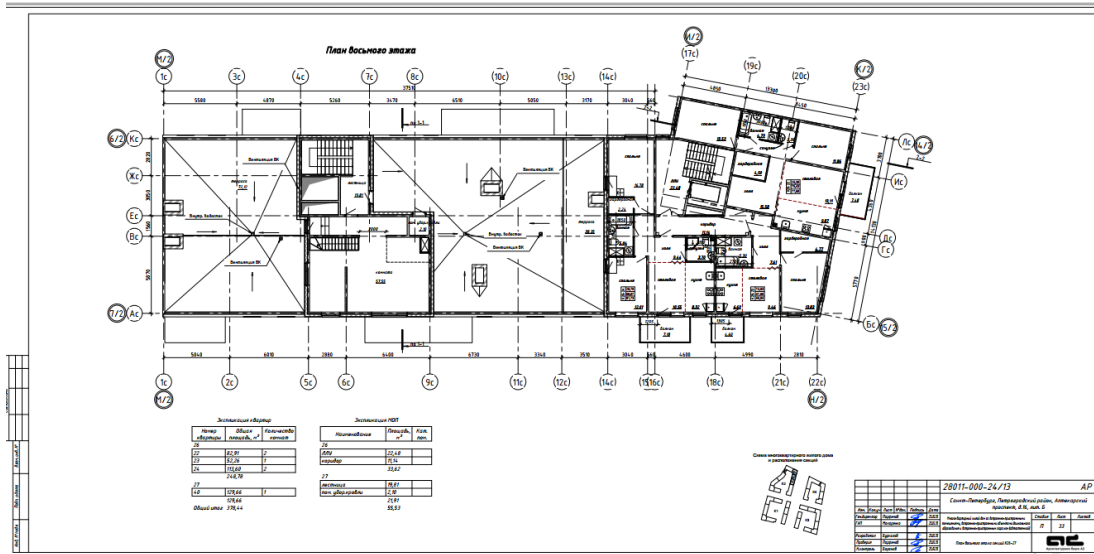
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# APPENDIX 1



Plan of the 7<sup>th</sup> floor



Plan of the 8<sup>th</sup> floor

## APPENDIX 2



The rendered image of the second floor



The rendered image of the office



The rendered image of the bedroom