Saimaa University of Applied Sciences
Technology, Lappeenranta
Double Degree Programme
Civil and Construction Engineering

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INVENTORY MODELING PROCESS AS A PART OF SINGLE-FAMILY HOUSE RENOVATION DESIGN

Thesis 2019

Abstract
Nikita Chertov
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The purpose of the thesis work was to create an inventory and renovation models and to implement the inventory modeling process for a single-family house. The house is situated in Estonia, Harju County. The author of the thesis and the instructor decided the modeling process to be done using Autodesk Revit 2018 software.

The thesis consists of theoretical and practical parts. In the theoretical part the author describes the main features of BIM and Autodesk Revit program. The practical part consists of modeling the single-family house, producing IFC-files, making the Tekla BIMsight package file, filling in the model description document Excel sheet and uploading all the files to the Trimble Connect service.

The client and the instructor were provided with all the files related to the project. All the renovation decisions were made in cooperation with the client and under the supervision of the instructor. The client was satisfied with the renovation project design suggested by the author of the thesis work.

Keywords: Autodesk Revit, Trimble Connect, Excel, BIM, renovation

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1 Introduction

Designing buildings using BIM is a competitive advantage not only for companies that include this direction in their strategy, but also for market participants who seek to build qualitative buildings with no extra cost, thinking through all levels.

The key advantage of BIM is the work of all project participants with one model: the designers work together on the model, seeing all the changes made to the project, and excluding spatial collisions and "intersections". Nowadays the idea is that specialists work in cooperation using different models merged together. This eliminates the need for additional work during installation of systems. The customer can monitor the progress of the project every minute, manage the design and installation processes, equipment delivery schedules and financing all phases of construction.

In case of renovation process the client will get an opportunity of evaluating the space-planning decisions with all their properties and dimensions. All the changes will automatically reflect the floor plans, facades and sections of the house. Thus, the project will be implemented within a reasonable time and all the drawings, sheets and specifications will be formed from a single model, which minimizes the risk of errors and spatial collisions.

The main purpose of the thesis is to implement inventory modeling process for the single-family house renovation design. The first practical part consists of making the inventory model of the existing house. The second practical part is producing the single-family house renovation model based on the inventory model.

2 Building Information Modeling

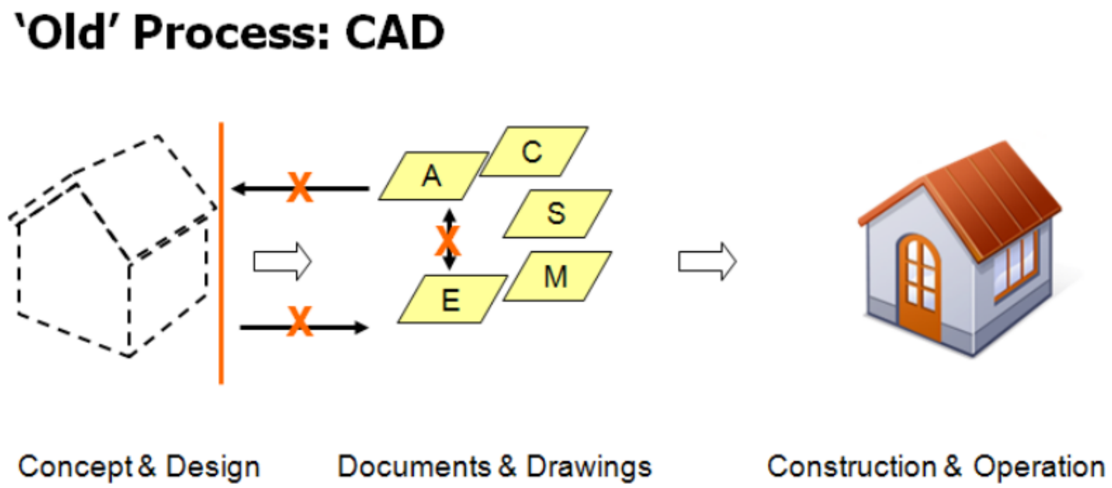
Building information modeling is an integrated process built on coordinated, reliable information about a project from design through construction and into operations. BIM is not just for architects. While it has its roots in architecture, the principles of BIM apply to everything that is built, including roads and highways, and the benefits of BIM are being experienced by civil engineers in the same way they are by architects. BIM is not just about 3D. BIM allows engineers more easily to predict the performance of projects before they are built; respond to design changes faster; optimize designs with analysis, simulation, and visualization; and deliver higher quality construction documentation. Furthermore, it enables extended teams to extract valuable data from the model to facilitate earlier decision making and more economic project delivery. (What does BIM mean for civil engineers?, 2008)

2.1 What is BIM?

Building Information Modeling (BIM) is one of the most promising developments in the Architecture, Engineering and Construction (AEC) industries. BIM simulates the construction project in a virtual environment. With BIM technology, an accurate virtual model of a building is digitally constructed (Eastman et al., 2008).

The principal difference between BIM and conventional 3D CAD is that the latter describes a building by independent 3D views such as plans, sections and elevations. Editing one of these views requires that all other views must be checked and updated, an error-prone process that is one of the major causes of poor documentation. In addition, data in these 3D drawings are graphical entities only, such as lines, arcs and circles, in contrast to the intelligent contextual semantic of BIM models, where objects are defined in terms of building elements and systems such as spaces, walls, beams and columns. A building information model carries all information related to the building, including its physical and functional characteristics and project life cycle information, in a series of “smart objects”. For example, an air conditioning unit within a BIM would also contain data about its supplier, operation and maintenance procedures, flow rates and clearance requirements (CRC Construction Innovation, 2007). The Figure 1 shows difference between the traditional CAD process and BIM.

BIM combines the use of 3D computer modelling with whole life asset and project information to improve collaboration, coordination and decision-making when delivering and operating public assets. It also addresses long over-due changes in processes from the analogue into the digital world that enable us to control and manage an unprecedented volume of digital data and information (EU BIM Task Group, 2018).



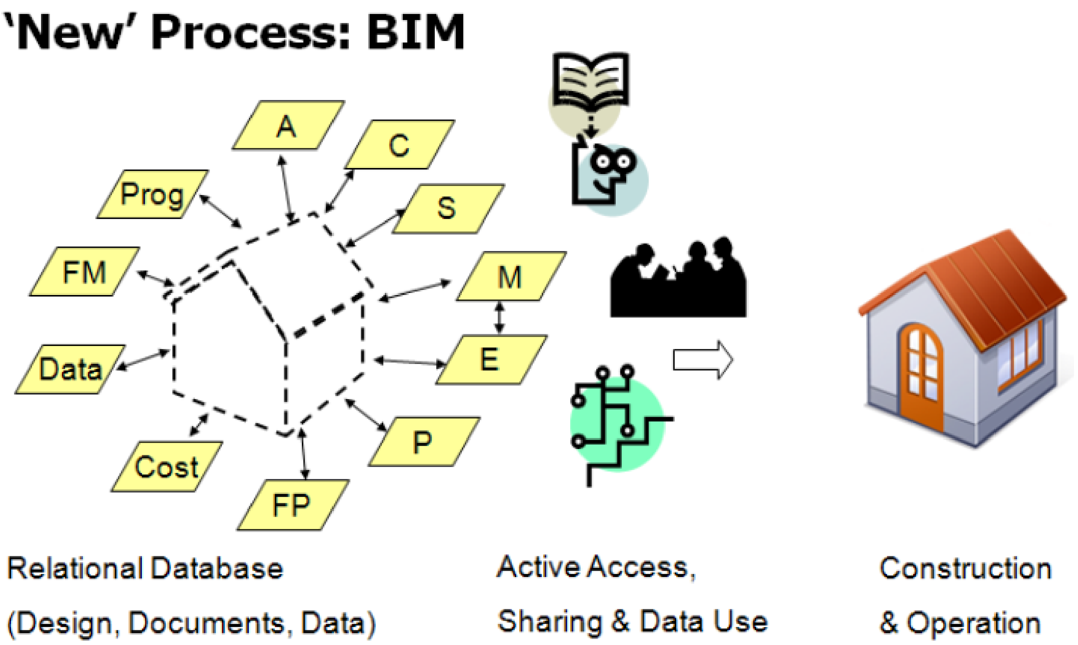


Figure 1. A Comparison between Conventional CAD and new BIM Approach (Azhar, 2008).

It is important to note that a building information model characterizes the geometry, spatial relationships, geographic information, quantities and properties of building elements, cost estimates, material inventories and project schedule. This model can be used to demonstrate the entire building life cycle (Bazjanac, 2006). As a result, quantities and shared properties of materials can be readily extracted. Scopes of work can be easily isolated and defined. Systems, assemblies, and sequences can be shown in a relative scale with the entire facility or group of facilities. The construction documents such as the drawings, procurement details, submittal processes and other specifications can be easily interrelated (Azhar, 2008). The Figure 2 shows different aspects of Building Information Modeling process.

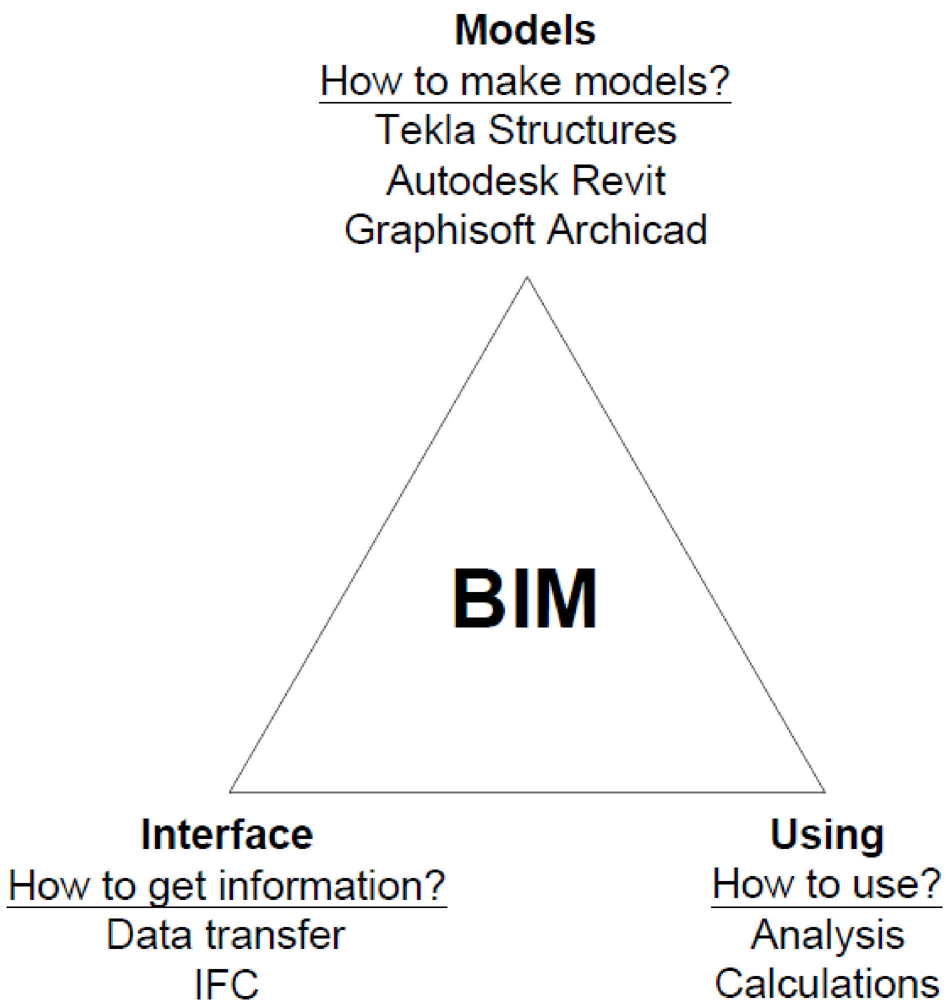


Figure 2. Different BIM aspects (Lehtoviita, 2018).

2.2 Building Information Modeling benefits

The key benefit of BIM is its accurate geometrical representation of the parts of a building in an integrated data environment (CRC Construction Innovation, 2007). Other related benefits are:

- Faster and more effective processes – information is more easily shared, can be value-added and reused.
- Better design – building proposals can be rigorously analyzed, simulations can be performed quickly and performance benchmarked, enabling improved and innovative solutions.
- Controlled whole-life costs and environmental data – environmental performance is more predictable, lifecycle costs are better understood.

- Automated assembly – digital product data can be exploited in downstream processes and be used for manufacturing/assembling of structural systems.
- Better customer service – proposals are better understood through accurate visualization.
- Lifecycle data – requirements, design, construction and operational information can be used in facilities management.

Stanford University Center for Integrated Facilities Engineering (CIFE) figures based on 32 major projects using BIM indicates benefits such as (CIFE, 2007):

- Up to 40% elimination of unbudgeted change.
- Cost estimation accuracy within 3%.
- Up to 80% reduction in time taken to generate a cost estimate.
- A savings of up to 10% of the contract value through clash detections.
- Up to 7% reduction in project time (Azhar, 2008).

2.3 How to Develop a Building Information Model?

Number of different software applications related to construction using BIM are available in the market at the moment, for example:

- Tekla Structures
- Graphisoft Archicad
- Autodesk Revit

After discussion with the lecturer the author picked Autodesk Revit as a program for a practical part of the thesis work. The Revit software package includes three software applications: Revit Architecture, Revit MEP, and Revit Structure. Revit Architecture has the 2D capabilities of AutoCAD, as well as the 3D modeling design functions. AutoCAD files can be imported to produce models. For estimating functions, information can be exported to other estimating programs which have been designed to work with Revit Architecture. Revit MEP is used for the design and modeling of mechanical/electrical/plumbing systems. Revit Structure is a modeling and drafting program that can model all types of materials and structural systems. All of the Revit programs use a centralized database so all changes are updated universally (Azhar, 2008).

3 Renovation Projects

The number of renovation projects is rapidly increasing and use of BIM is becoming more common for this purpose. The challenges in renovation projects differ in many ways from those in new construction, however, from a BIM perspective, they still have a lot of similarities.

The main difference in renovation projects is, of course, the existing building and its constraints. Modern measurement techniques can provide precise information on the existing situation and as the modeling techniques and know-how evolve, inventory models will provide a good starting point for BIM-based design. However, it should be considered that the stumbling block may be the data exchange between different software. Data exchange, even between software from the same manufacturer, can be problematic. When using the IFC as an exchange method, 3D geometry may transfer rather well, but for most models and their components there is a loss of features that are needed for modification and presentation in documents. To aid in this situation, it is recommended to use an inventory BIM. Inventory BIM creation is described in section 2 – ‘Building Inventories.’

If a good inventory BIM is available, the modeling work of the architect can be decreased considerably in comparison to a new building of the same size. On the other hand, if the inventory BIM is incomplete or does not exist at all, the modeling time required for a renovation project can be many times higher than for a new building project (Common BIM Requirements 2012. Series 3: Architectural design, 2012).

3.1 Requirements in renovation projects

The reason for renovating a building is that it does not meet the user’s needs. This can depend on the aging of the building, or faults done in the design, construction, or use of the building. The aging of the building is not directly related to the age of the building but rather on the usage and the user’s needs (Helander, D. and Singh, V, 2016).

The aging can be divided into the following categories:

1. technical aging
2. functional aging
3. economical aging
4. locational aging

The faults can similarly be divided into the categories:

1. functionality faults
2. experience faults
3. technical functionality faults

Renovation projects usually face additional challenges when compared to new construction projects. Among these are:

1. physical constraints due to the current building condition, e.g., limited space or capacity limitation of systems
2. limited work area
3. uncertainty about current building condition (Mitropoulos, P. and Howell, G.A., 2002).

To reduce the impact of these problems the potential threats should be discovered as early as possible. Thus, the current condition of the building has to be known in the beginning of the design phase. Other risks in the project have to be assessed as well, such as budget and schedule constraints.

Therefore, to make the decision about what is to be done in the renovation project, information about the building is needed. If enough information is not available the decisions made in uncertain conditions may lead to added risks in the project (Helander, D. and Singh, V, 2016).

3.2 BIM in renovation projects

(Penttilä, H., Rajala, M. and Freese, S., 2007) suggest that in renovation projects inventory models are particularly useful. An inventory model is defined as "all historic, survey, measurement, etc. data, information about an existing building in an accessible and usable format" (Penttila et al., 2007). An inventory model can improve data management, planning, decision-making, and increase the profitability of renovation projects (Brilakis, I., Lourakis, M., Sacks, R., Savarese, S., Christodoulou, S., Teizer, J. and Makhmalbaf, A., 2010). This emphasises the need for keeping the building information up-to-date. Well-documented projects and a comprehensive hand-over of change information after construction projects is a prerequisite for having up-to-date information. Up-to-date information can offer several benefits such as higher leasing incomes due to shorter schedule, lower risk-premiums due to information reliability, and so on. However, to avail the potential benefits the inventory modelling requirements have to be clear and sufficient so that the model matches the needs of all stakeholders (Helander, D. and Singh, V, 2016).

Based on a previous research study conducted in Finland (Haavisto, 2013), it was recommended that if there is a plan to model the old structures without measuring the whole building (for example, based partly on old technical drawings and partly on measurement), it must be a prerequisite that the existing data should be complete and accurate, or else the structures should be modelled again from scratch. Similarly, it has been suggested that for mechanical engineering and plumbing (MEP)-design in renovation projects it is important to have a model of the old structures (Helander, D. and Singh, V, 2016). Overall, it is acknowledged that since the inventory model and the initial information almost always contain elements of uncertainty, it must be clear which parts are modelled to what level of accuracy (Gu, N., Singh, V., London, K., Brankovic, L. and Taylor, C., 2008).

3.3 Working with Inventory BIM

Ideally, the inventory BIM has been created using the same software that is used by the architect. This minimizes the problems caused by the data exchange. The end result is further improved if the model has been prepared by, or under the supervision of, the project architect. That way there is an opportunity to influence modeling methods, the naming of model objects, modeling accuracy and the phasing of the work. If the architect uses different software from that which was used to create the inventory model, the architect must be prepared to re-model part or, in the worst-case scenario, the whole model. There are both technical and content matter reasons for this. Although the model geometry transfers through the IFC data reasonably well, the more details the model has, the more likely all the parameters and ability to make modifications will not be transferred. This causes problems in the production of documents and in the modification of the existing structure (for example, the placement of a new door into an existing wall). BIM software is constantly developing and modeling skills have a great impact on compatibility. It is possible that working with inventory models becomes easier over time following improvements in software data exchange and architect fluency with BIM (Common BIM Requirements 2012. Series 3: Architectural design, 2012).

3.4 Design Coordination

If a proper inventory BIM is available in the initial planning stage, it also facilitates BIM-based design coordination. With the support of an inventory BIM, the architect can provide a BIM-based design to other disciplines at a rapid pace. The renovation of a building often means an increased amount of new HVAC and electrical installations. This stresses the importance of collaboration, in which BIM provides an effective tool for use by the entire project team. It is rarely the case that in renovation projects, the structural engineer must create a BIM for the whole building. Many times it is sufficient to model only the new structures and old structures as far as are they are changed. In practice, the architect’s model, or in fact, the inventory BIM, also serves as a structural model. If, however, the amendments are so extensive that they affect the statics of the building core, a structure model should be created for the entire building.

BIM-based collaboration in a renovation project is, of course, not without challenges, even though a good material and models are made available. The measurement of the building and the BIM model based on these measures must be made while the building is still in use. Suspended ceilings or other structures often hide ducts, pipes and beams and they cannot be properly documented. When the demolition work starts, it often reveals unknown structures and systems parts and it is difficult to prepare for these surprises in the design phase (Common BIM Requirements 2012. Series 3: Architectural design, 2012).

4 Inventory Modeling Process

The inventory modeling process part is based on the Common BIM Requirements 2012 (Series 2: Modeling of the starting situation).

4.1 Modeling of the site

The Site model has to be at least a three dimensional surface model. Otherwise, the site elements are modeled with the agreed accuracy. The plot model can also include judicially or technically significant points, such as drains or cables.

Ground surveys of the plot can also be done which produces a geotechnical model of the plot. Nearby buildings and street areas can also be included in the model of the plot in the appropriate scale.

4.2 Inventory modeling

Inventory modeling is done based on the measurements, inventories and investigations done on site. This information is implemented based on old drawings and other documents. It is also necessary to document the origin of the source data in the BIM specification.

4.3 Use of layers

The layer system used in the Inventory Model should be documented in the BIM specification. The layer requirements of CAD drawing instructions cannot be applied directly to drawings produced using Building information models.

4.4 Modeling of building elements

Building parts are modeled using the tools intended for modeling this part; the beams are modeled using beam tools, columns using column tools, etc. If this principle cannot be followed the chosen modeling principle must be documented in the BIM specification.

4.5 Classification of building elements

Building elements are classified according to the accuracy level and accuracy of the Inventory model. The names of the categories must show that this is part of an existing structure. The classification principle used shoud be documented in the BIM specification.

4.6 Coordinate system and units of measurements

A project coordinate system is defined for the project so that the datum point is situated near the building. Planning according to the municipality coordinate system is not recommended as locating the information model far from the source coordinate causes problems for most planning software.

It is recommended that the coordinate system is defined in such a way that the whole building area is in a positive coordinate system as negative coordinate system may cause problems in site surveying.

The location of the project coordinate system in relation to municipal coordinate system is documented by using at least two corresponding points. X and Y coordinates for the corresponding points are stated in the project coordinate systems and in the municipal coordinate system.

The building information models are modeled in actual elevation in the municipal elevation system. Millimetres are used as the measurement unit for building information models.

4.7 Processing storeys

The building is modeled by storey according to Series 3: “Architectural design”. Measured floor surface level is defined as the inventory model storey zero level. It is recommended that the zero level of the storey is defined at the height of the main staircase landing.

4.8 BIM specification

The BIM specification describes the source data of the inventory model, modeling principles and other issues affecting the use or the reliability of the model. The BIM specification is an irreplaceable aid in the continuing using of the model.

Points to be documented:

- measuring methods, accuracy and date/ time
- exceptions from measurement specifications
- source data origin
- software used in the model
- coordinate system, coordinate corresponding points and information on names, amount and location of stories
- naming conventions of files and building elements
- layers used in the model
- exceptions from the defined modeling practice
- Inventory model inspection form (Appendix 3)
- other material obtained in measurement (Common BIM Requirements 2012. Series 2: Modeling of the starting situation, 2012).

5 Requirements to source data

The requirements to source data part is based on the Common BIM Requirements 2012 (Series 2: Modeling of the starting situation).

5.1 Measurement requirements

Level 1 – Laser measurement and existing drawings

The measurement material is formed by the distances between the building elements manually recorded by the measurer. The measurements are not in the same coordinate system. The method is suitable for verifying the correctness of individual distances and for example, modeling based on old drawings.

Level 2 – Tacheometric surveying

The survey material consists of individual points, lines and symbols in the same coordinate system. The method is very suitable for yard surveys and complementing laser scanning surveys e.g. for floor drains. The method is suitable for establishing source data for inventory model for geometrically simple targets where the points to be measured are limited in number. The completion and refinement of the inventory model and measurement drawings requires additional measurements on site. Confirming the correctness of the inventory model and measurement drawings is difficult visually. The deviation of the defined measurement points must be less than 5 mm.

Level 3 – Laser scanning survey

The measurement material is graphic and its correctness can be confirmed visually. If necessary, the Inventory model or drawings can be supplemented and refined without additional measurements. Accuracy of laser scanning survey noise i.e. error margin max. ±10 mm resolution i.e. point density: measurement points within less than 5 mm intervals. In special cases such as historic building documentation, measurements can be done at an even greater level of accuracy where measurements points are for example in intervals of 1 mm. However, the work load related to the measurement is in this case considerably higher.

Figure 3. Excerpt of a laser scanning point cloud of a historic building (Common BIM Requirements 2012. Series 2: Modeling of the starting situation, 2012).

Laser scanning measurements in places that are awkward to measure, such as roofs, can be complemented by other survey methods such as tacheometric survey or photogrammetry. An inventory model based on the measurement material can be made reliably at 10 mm tolerance. The materials can also be used to compile detailed drawings, e.g. where material boundaries are visible. The Figure 3 is the example of the laser scanning process.

5.2 Requirements for surveys, analyses and inventories

Level 1 – Space identifiers and the general classification of building elements

Space identifiers and general classification of building elements are included in Inventory model. The building elements are classified using a general principle of classification (e.g. existing exterior wall type 1 = EEW01, existing load bearing partition wall type 1 = ELBPW01, existing intermediate floor type 1 = EIF01, etc.).

Level 2 – Room space inventory and classification of building elements

In addition to level 1 information, room space specification is included in the inventory model. The building elements are classified according to the definitions of existing plans or designers.

Level 3 – Historical and research information of the building

Inventory information on building history survey and information on task investigations such as condition and contaminants are included in the Inventory model. Information content details are defined on a project basis (Common BIM Requirements 2012. Series 2: Modeling of the starting situation, 2012).

Matters to be defined:

- What is inventoried
- What information is attached to the model
- What information is reported using other methods such as database format or table format

6 Modeling requirements

The building information model of the site to be built is called “Site model” and that of an existing building “Inventory Model”. Both a Site model and an Inventory model are required for the building renovation project. The modeling requirements part is based on the Common BIM Requirements 2012 (Series 2: Modeling of the starting situation).

6.1 Site model, Site elements

A tool appropriate to the modeling software is used for site modeling. The site elements are modeled using tools meant for modeling building elements: supporting walls are modeled as walls and stairs as stairs. Otherwise, site elements are modeled so that their geometry location and classification can be transferred in IFC format (Common BIM Requirements 2012. Series 2: Modeling of the starting situation, 2012).

6.2 Accuracy levels of Inventory model

The structures of old buildings are almost always somewhat slanted, sloping, curved or otherwise inexact in their geometry. Striving for “absolute” accuracy in the Inventory model is not appropriate.

The allowed measurement deviations for the Inventory model are:

- 10 mm on corner points of building elements
- 25 mm on surfaces, e.g. walls and floors
- 50 mm for old irregular structures such as roof structures

Level 1 – Spatial model

The spatial model and drawings are used as source data for surveys and project planning. The spatial model models the building’s outer shell without details and the spaces as space objects with space information.

Level 2 – Building element model

Level 2 is the basic level of the Inventory model. It is needed after the project planning phase and when making Schematic design level project plans where the spatial model is enough as source data.

Level 3 – Building element model

Compared to the Level 2 Inventory model, the level of detail is enhanced and modeled building elements are added (Common BIM Requirements 2012. Series 2: Modeling of the starting situation, 2012).

6.3 Modeling requirements in different project phases

Needs and objectives assessment and conceptual design

The existing building and site is measured and inventoried and agreed surveys are done in the needs analysis and project planning phase. An Inventory model, measurement drawings and reports are compiled based on the information.

Design preparation

The Inventory model compiled in the conceptual design phase and the reports based on this are used as source data as call for tender material. If required, the model is further updated and fine tuned in the building element model.

Schematic design, design development and detailed design

The Inventory model is transferred into the software used by the architect and its usability is verified.

Construction preparation

The Inventory model and the reports prepared based thereon are used in call for tenders regarding contracts as descriptive material of the existing building.

Construction

Measurements to document hidden new structures and MEP can also be done in the construction phase. For example, before installing suspended ceilings MEP installations that remain hidden are laser scanned as part of the as-built model.

Commissioning

In the commissioning phase, the as-built models together with the Inventory model are merged together to serve the needs of facility management in accordance with Series 12, “Use of models in facility management” (Common BIM Requirements 2012. Series 2: Modeling of the starting situation, 2012).

7 Inventory and renovation modeling of the single-family house

7.1 Reasons to renovate the house

The client has a need of changing the plan of the house for a higher comfort level. Several years ago the house was extended and the effective area of the house increased from 54.5 square meters to 182.9 square meters. However, the contractor made several changes to the project and the nowadays version of the house has many differences from the drawings made before extension. These deviations made valuable reflection on the building comfort quality level. What is more, the building process is not yet finished. This fact has both positive and negative sides for the house inhabitants. One side is that finishing works in several rooms have not yet been done and it is not very comfortable to live inside. On the other hand, on this stage it is still possible to make changes to the project according to deviations and mistakes made by the contractor.

7.2 Reasons of using BIM

The author of the thesis work suggested making a renovation design using Building Information Modeling software. BIM not only improves the technology itself, also changes the process of design and build. Walter claims that: “BIM enables better decisions; faster BIM reduces the abstraction and integrates the multiple disciplines, including design and documentation. And BIM integrates plans, sections, details, graphics, and data in ways not possible in 2D." Based on his argument, the period which is spent on the design can be cut by about half at half the cost. Moreover, "half time at half cost" will not just save the money, it is also reducing the time to the market. Therefore, using BIM can save the cost of design and can benefit from earlier access to the construction market (Han Yan, 2008). In this particular case, 3D model will also be a much better visualization of the renovation project for the client.

7.3 Database to start modeling

Several information and document sources will be used to make inventory and renovation models. The author of the thesis has a package of drawings made before the house extension project. The Figures 4-11 were used as a database for inventory modeling.

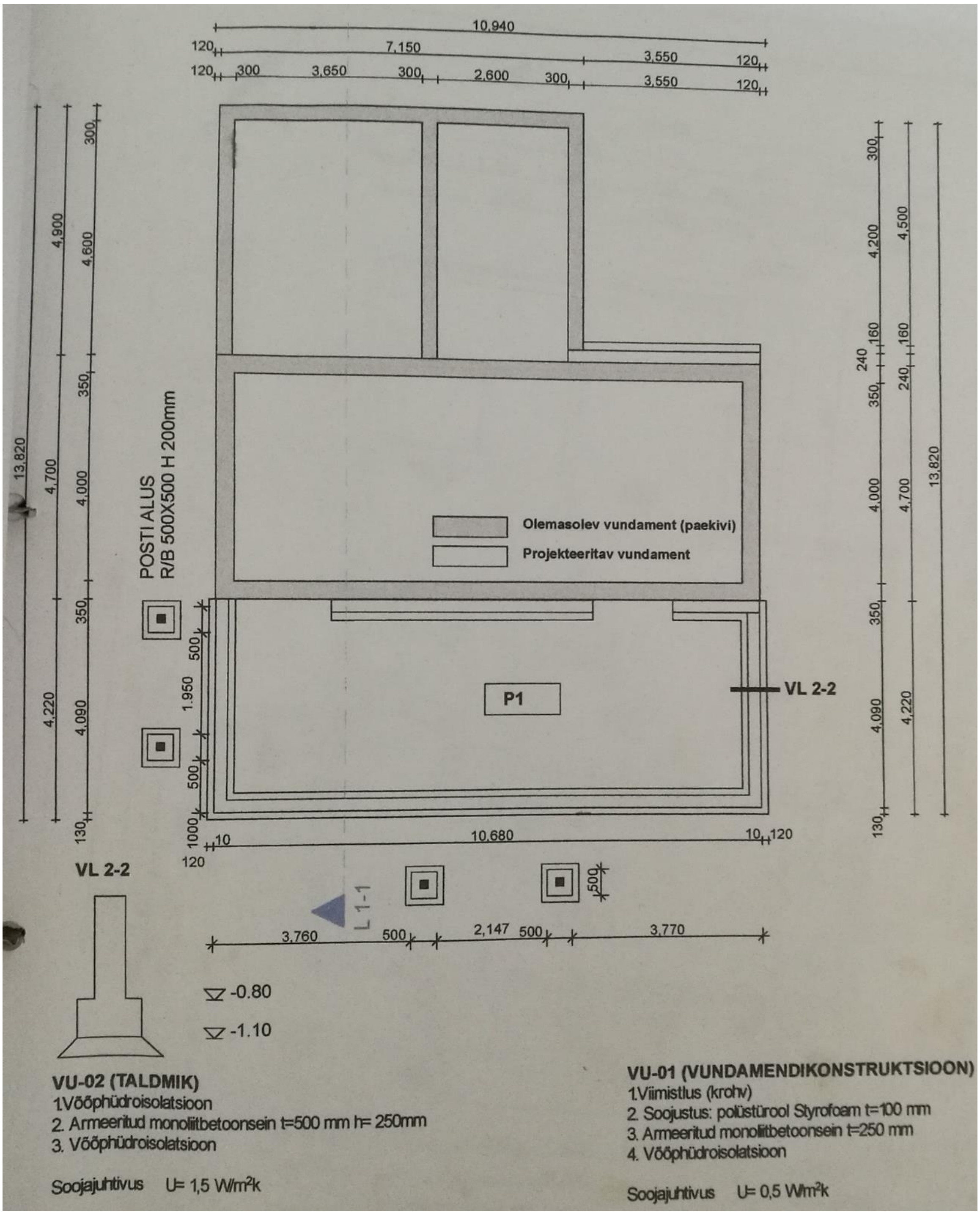


Figure 4. Existing Drawing. Foundation Plan

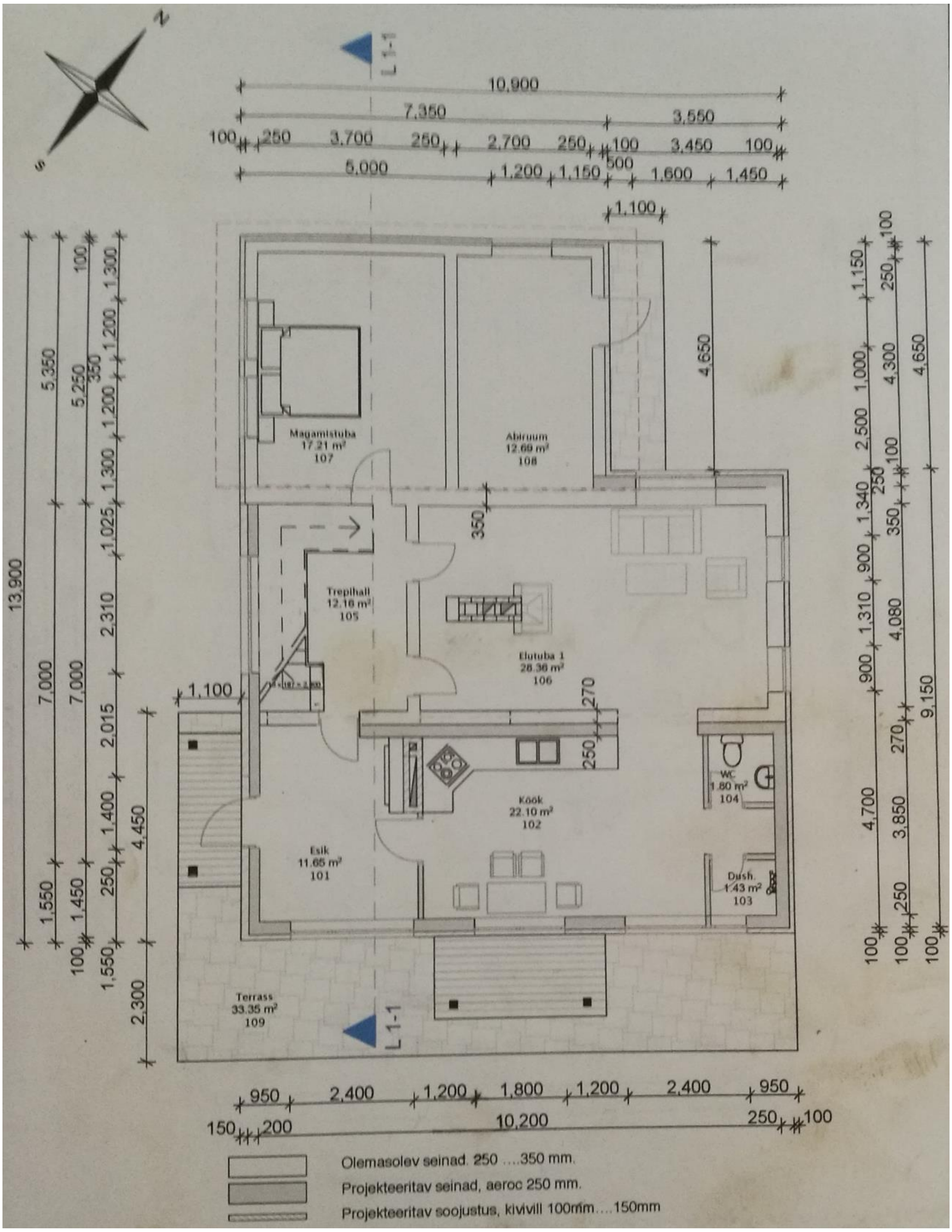


Figure 5. Existing Drawing. 1 Floor Plan

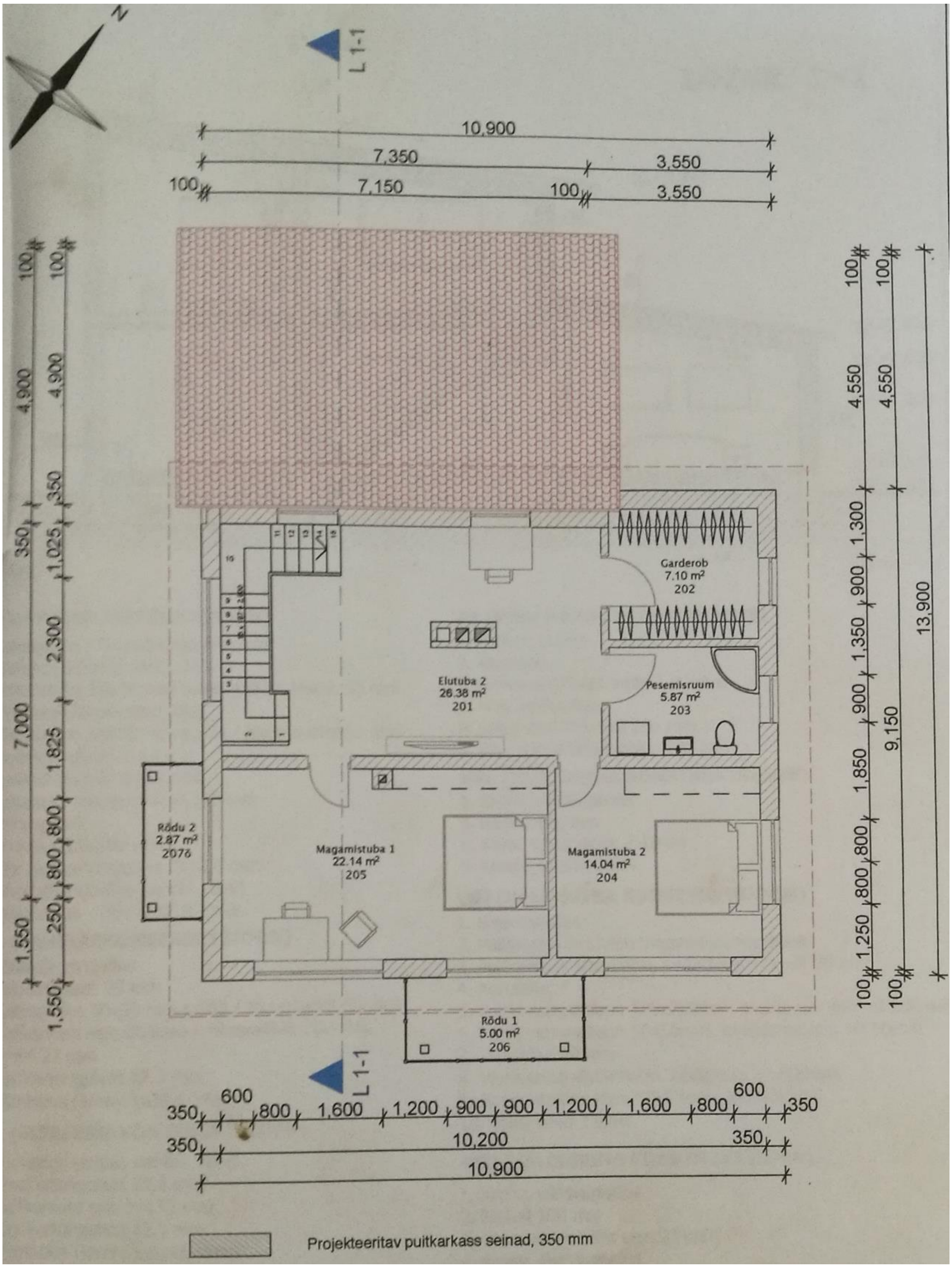


Figure 6. Existing Drawing. 2 Floor Plan

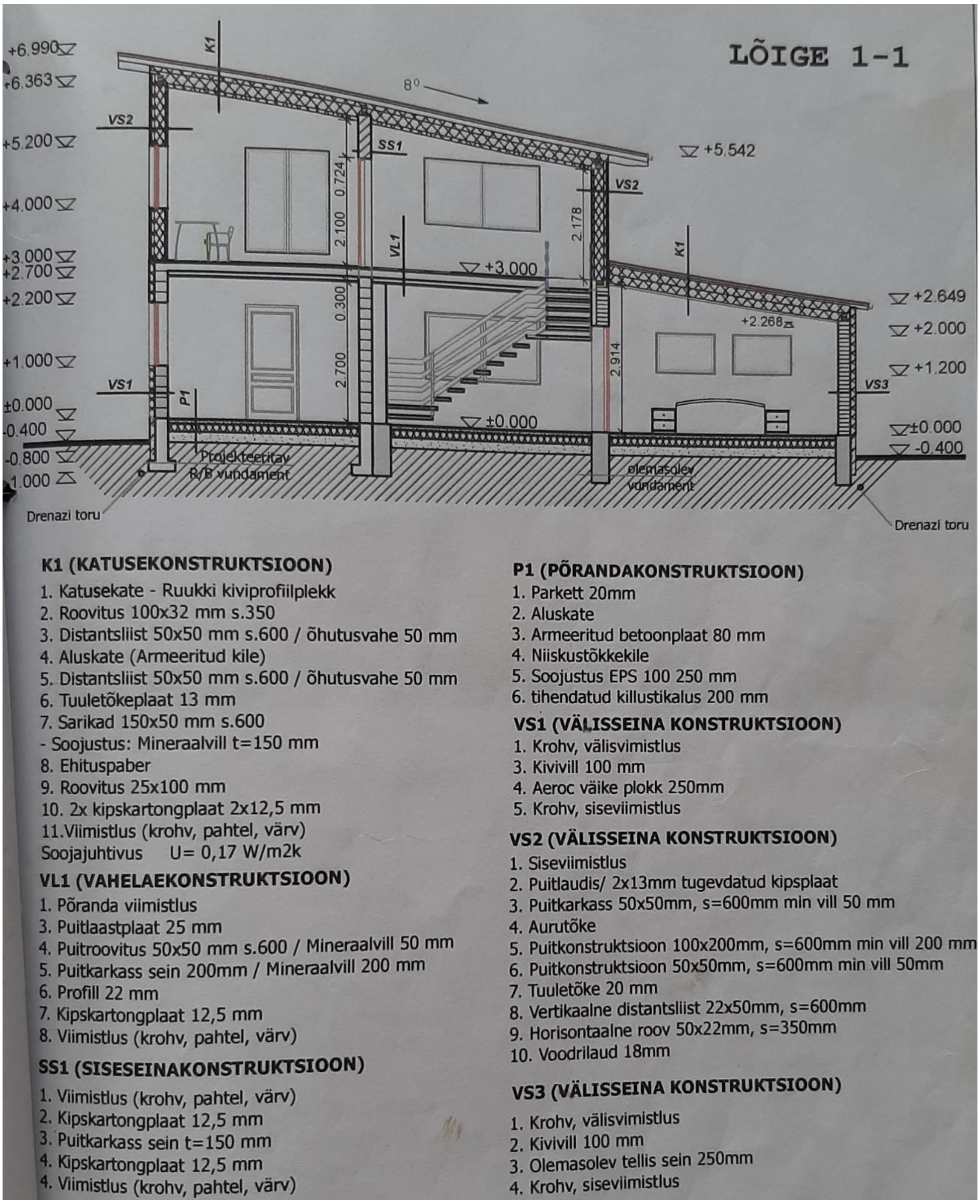


Figure 7. Existing Drawing. Section 1-1

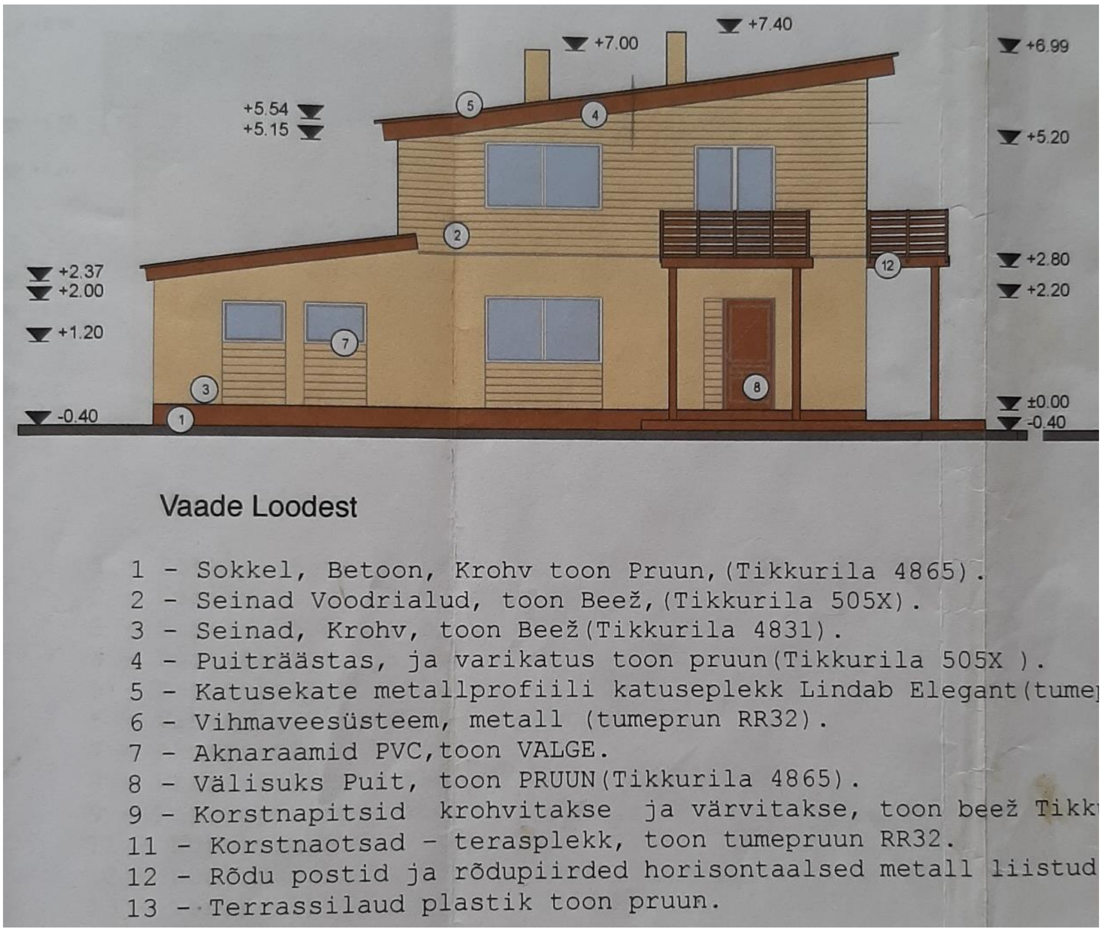


Figure 8. Existing Drawing. Facade 1

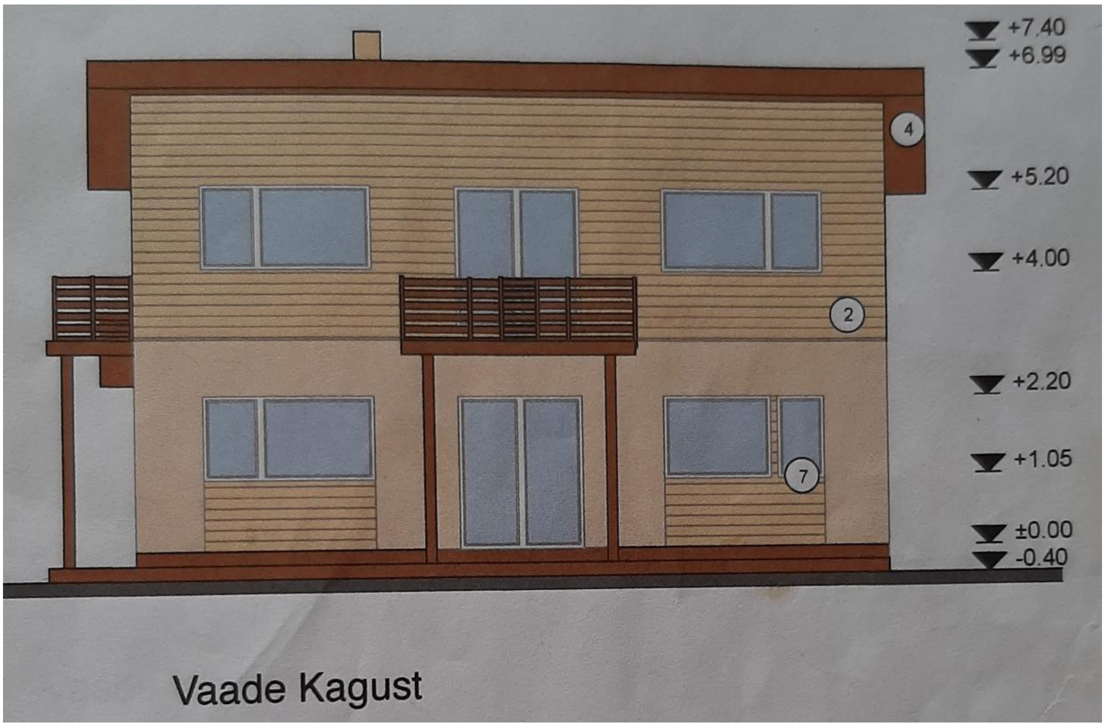


Figure 9. Existing Drawing. Facade 2

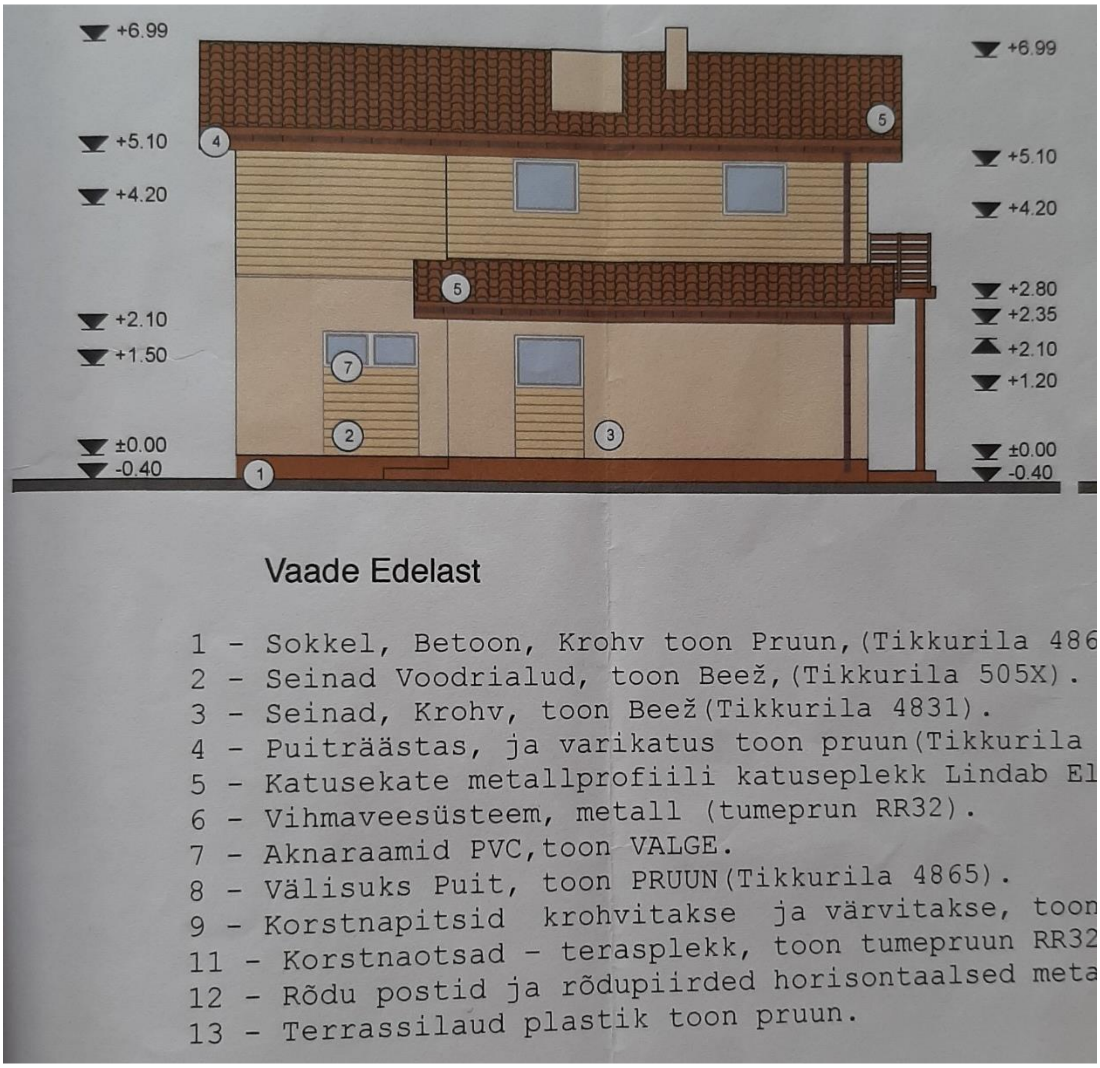


Figure 10. Existing Drawing. Facade 3

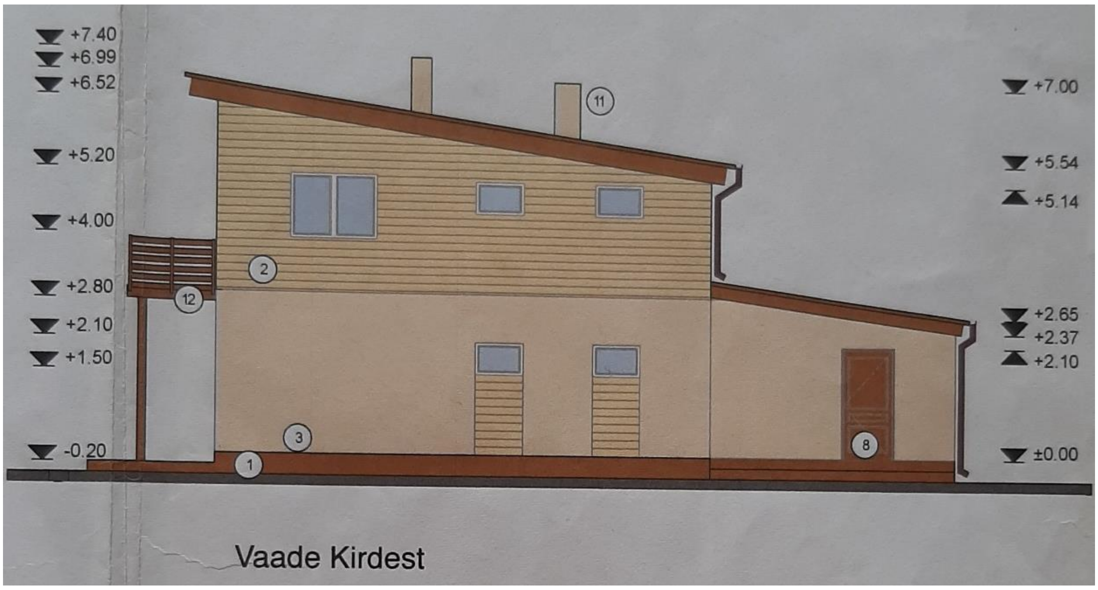


Figure 11. Existing Drawing. Facade 4

The information and numbers got from these drawings are reliable and accurate, but due to some deviations made by the contractor there are some differences between these drawings and the actual situation on site. Due to these deviations the author of the thesis made a decision to make some measurements and observations on site to have a better idea about the current situation.

7.4 Inventory Modeling Process

The modeling process is made using Autodesk Revit with the help of Autodesk Autocad (making grid lines). The inventory model was made with the use of the existing drawings and the measurements on site. The measurement accuracy corresponds to level 1. Each structural element was named according to its properties, material and thickness, e.g. “existing brick wall 350 mm”, “new block wall 350 mm”, “new timber studs wall 350 mm” etc. The surveys, analyses and inventories accuracy corresponds to level 1. The author of thesis has made a model with both the spaces and the main structural elements. The level of accuracy of the Inventory model corresponds to the basic level of the inventory model – level 2. The Figure 12 represents the spaces in the inventory model. The Figures 13-16 represent the inventory model put into the Trimble Connect service. The Figures 17-18 is the house planning from the inventory model.

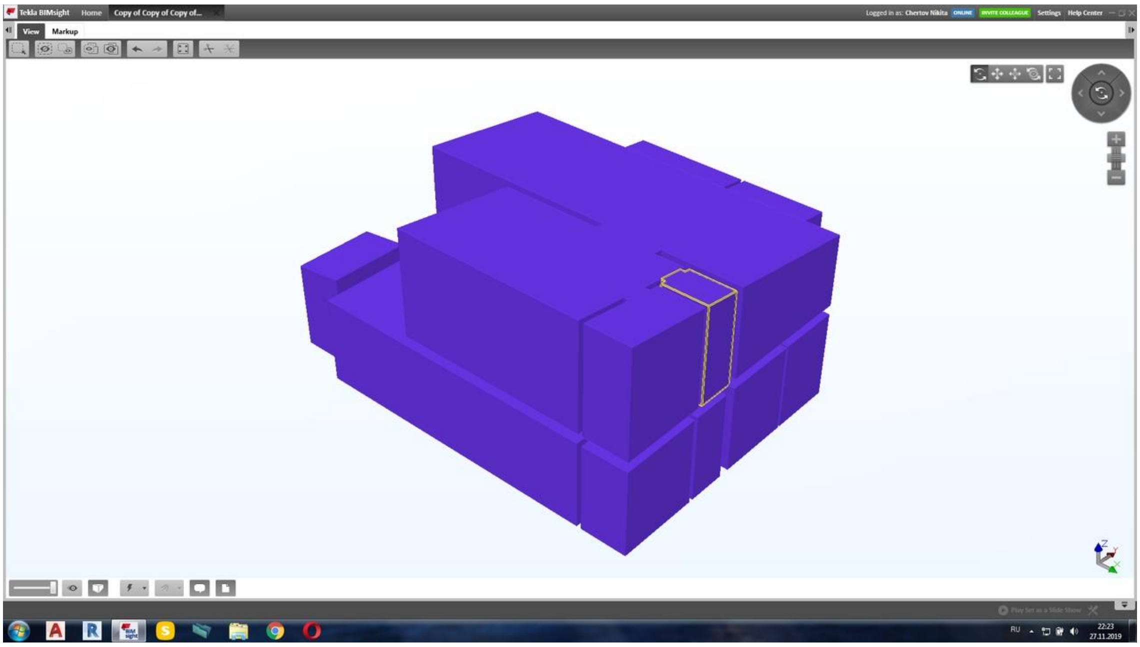


Figure 12. Inventory Model. Spaces

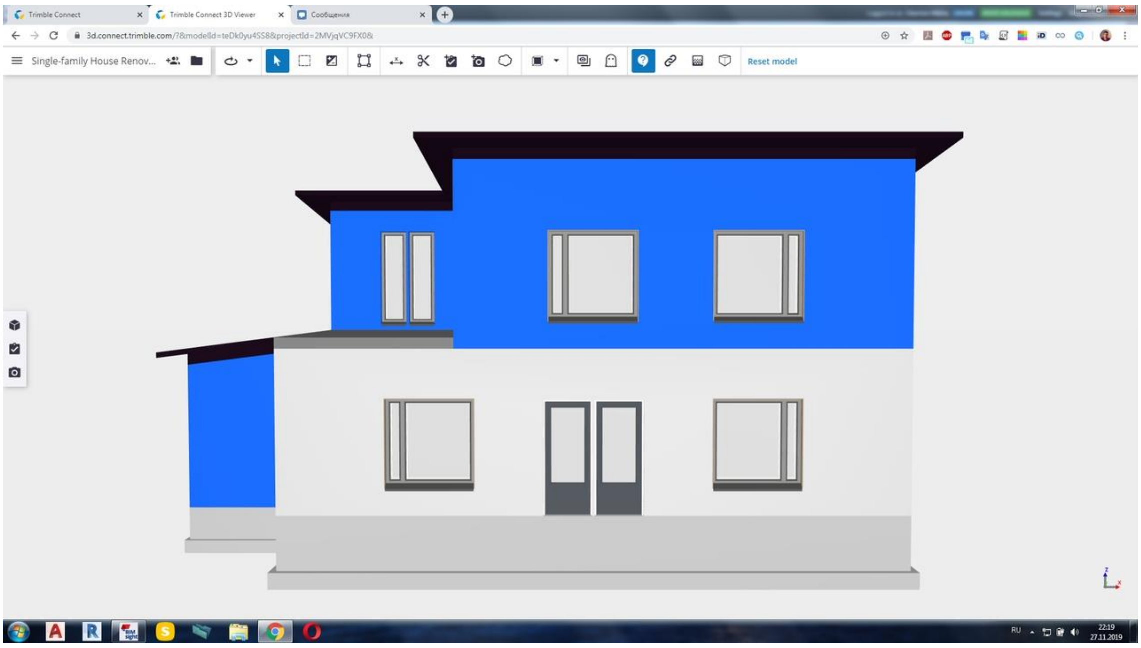


Figure 13. Inventory Model. Facade 1

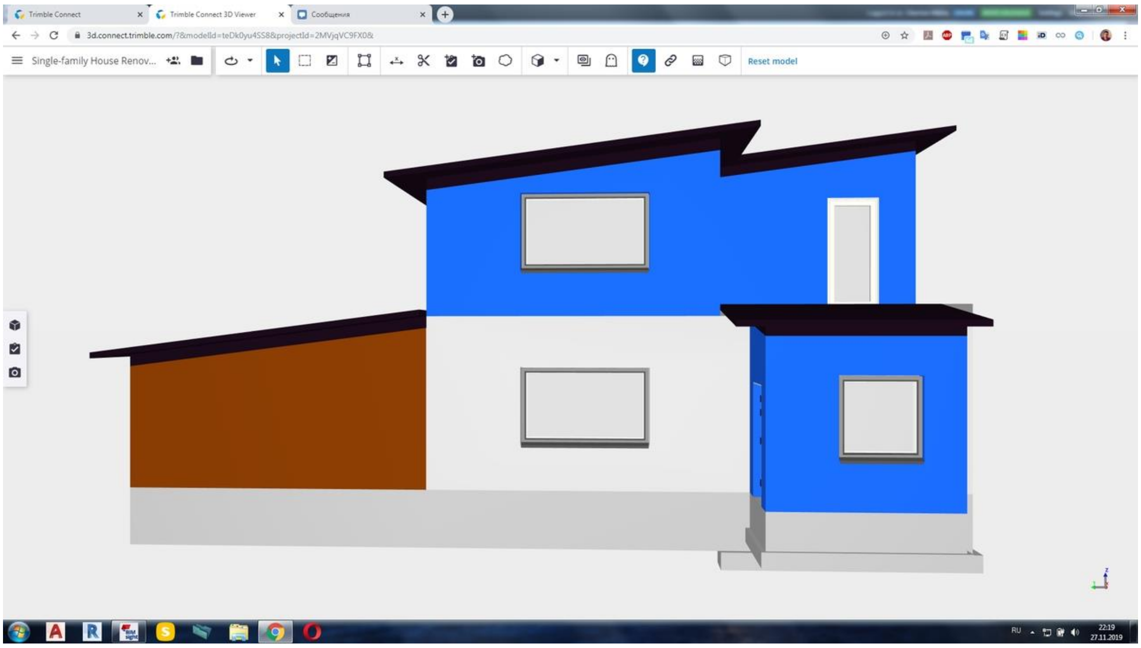


Figure 14. Inventory Model. Facade 2

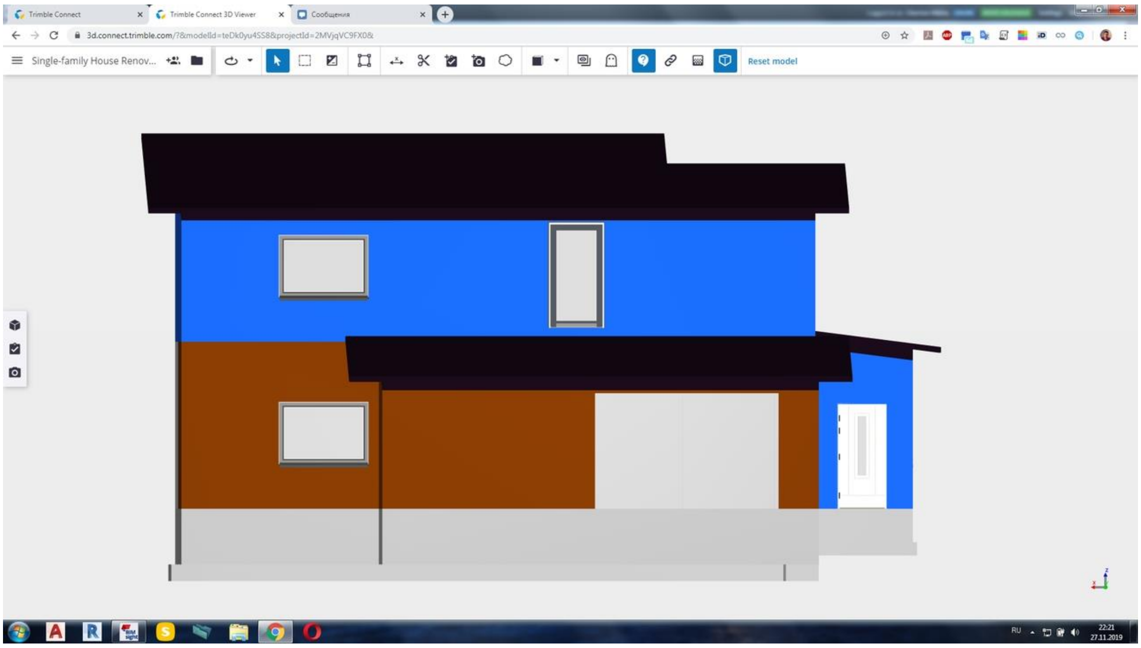


Figure 15. Inventory Model. Facade 3

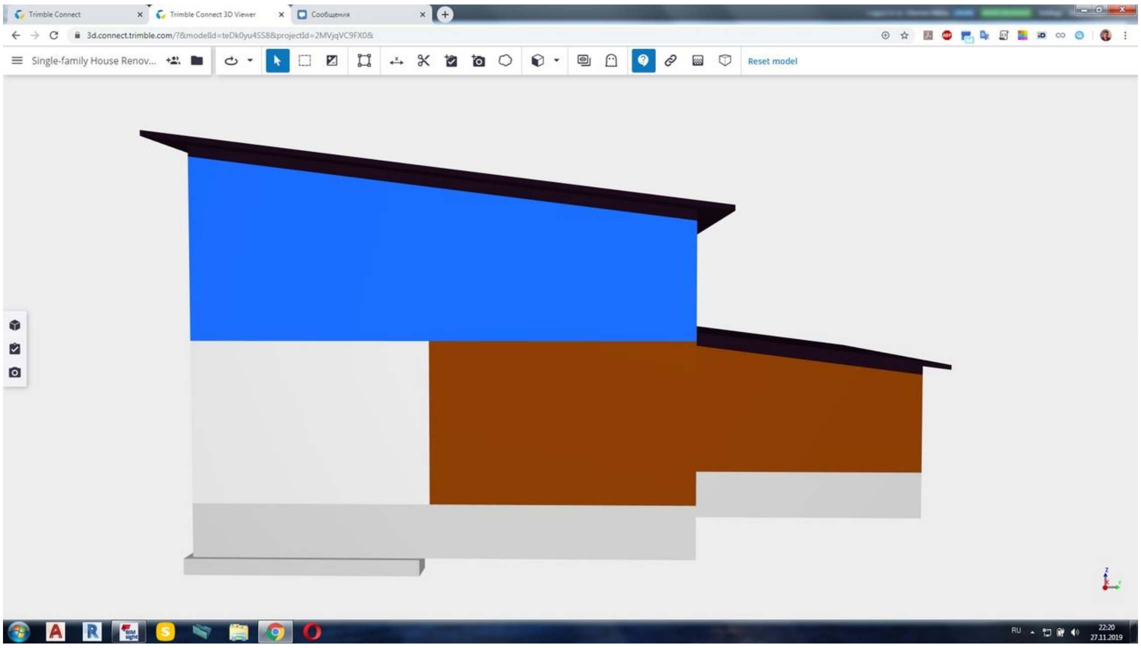


Figure 16. Inventory Model. Facade 4

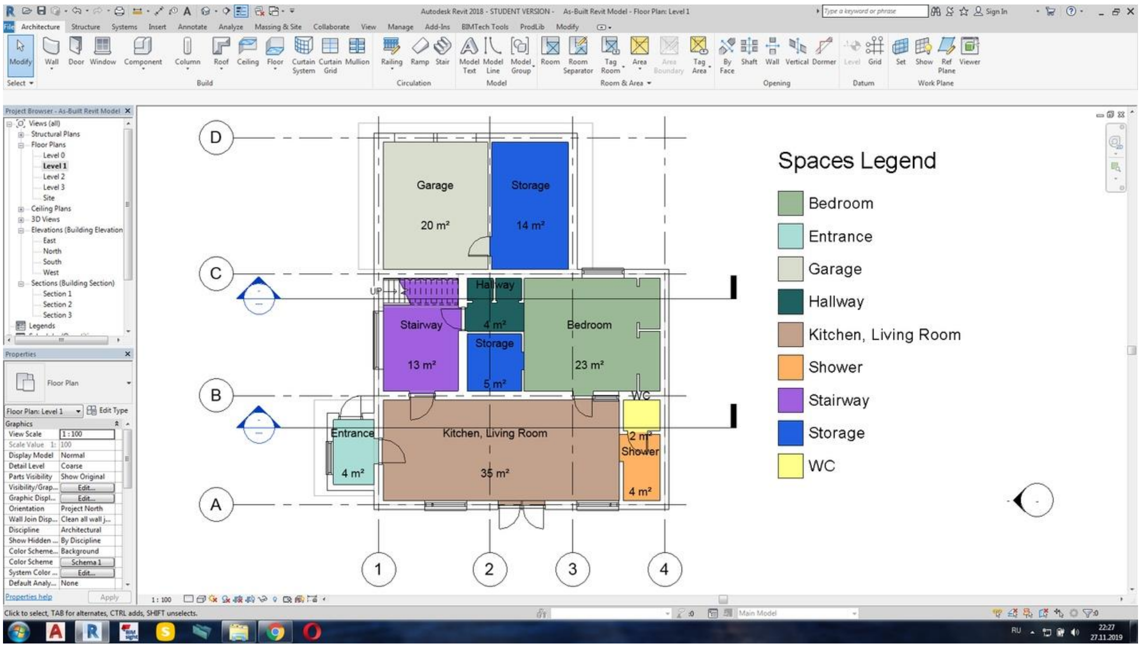


Figure 17. Inventory Model. 1 Floor Plan

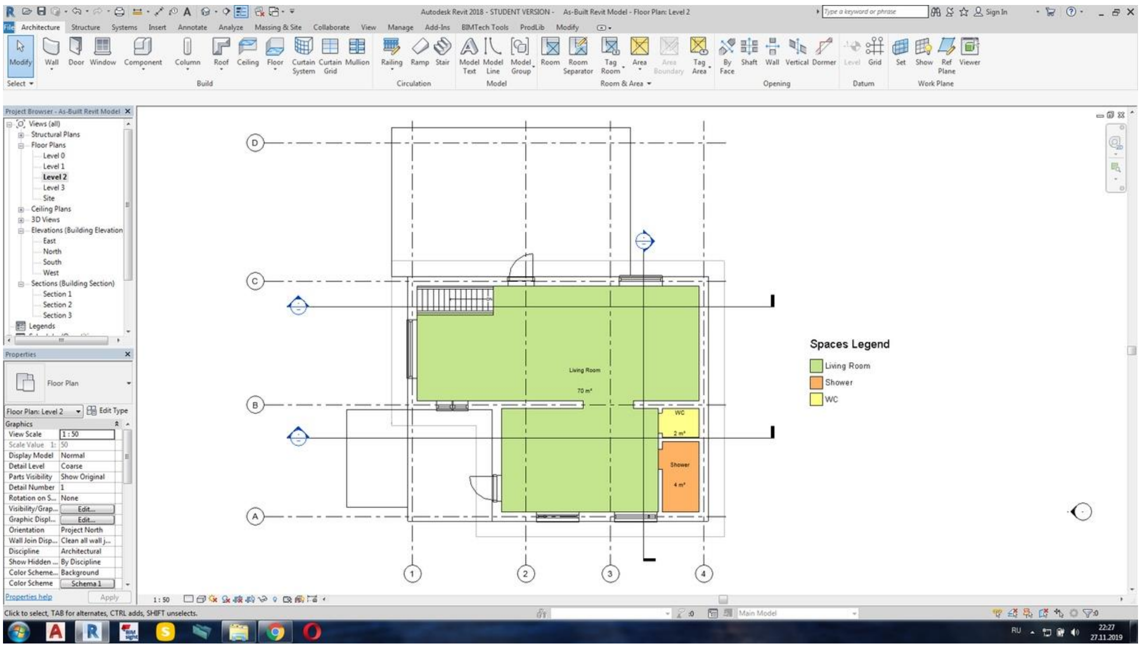


Figure 18. Inventory Model. 2 Floor Plan

7.5 Renovation Modeling Process

The renovation model was produced on the basis of the inventory model. The author applied several structural, planning and visual changes to the house in accordance with the suggestion of the client. The Figures 19-22 represent the renovation model made on the basis of the inventory model and put into the

Trimble Connect service. The Figures 23-24 is the house planning from the renovation model.

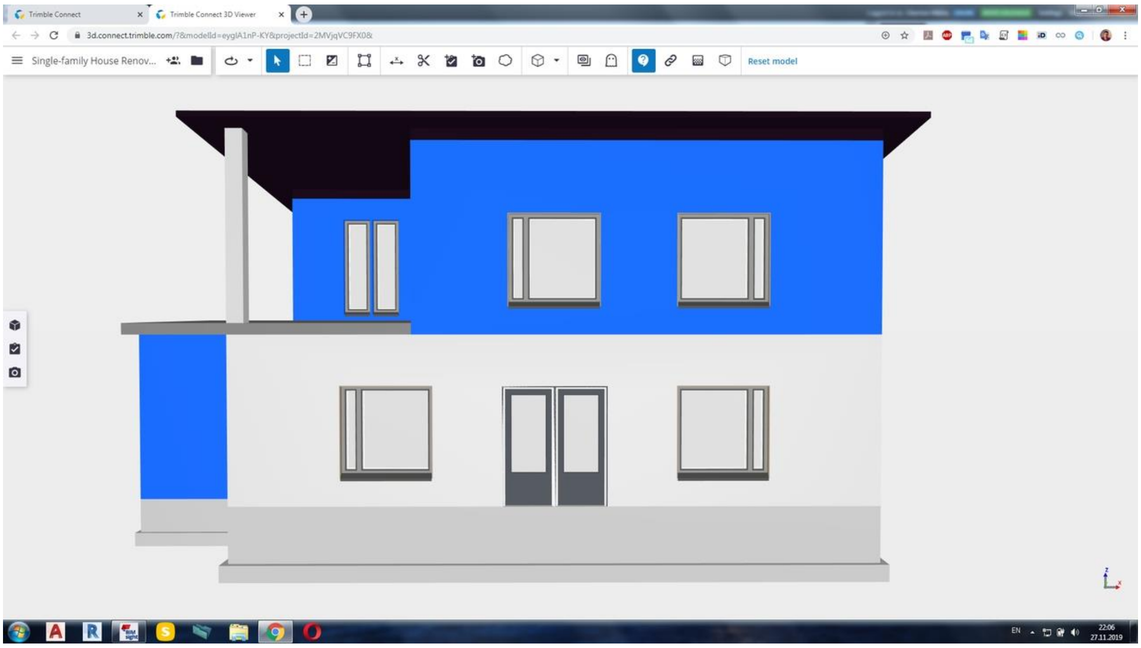


Figure 19. Renovation Model. Facade 1

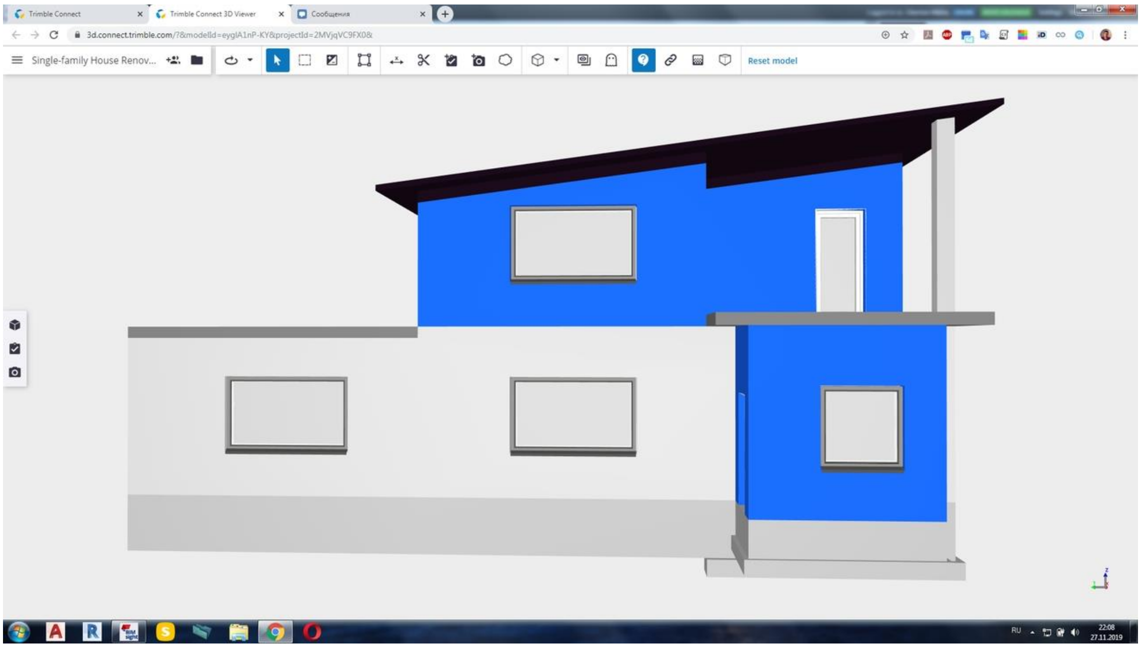


Figure 20. Renovation Model. Facade 2

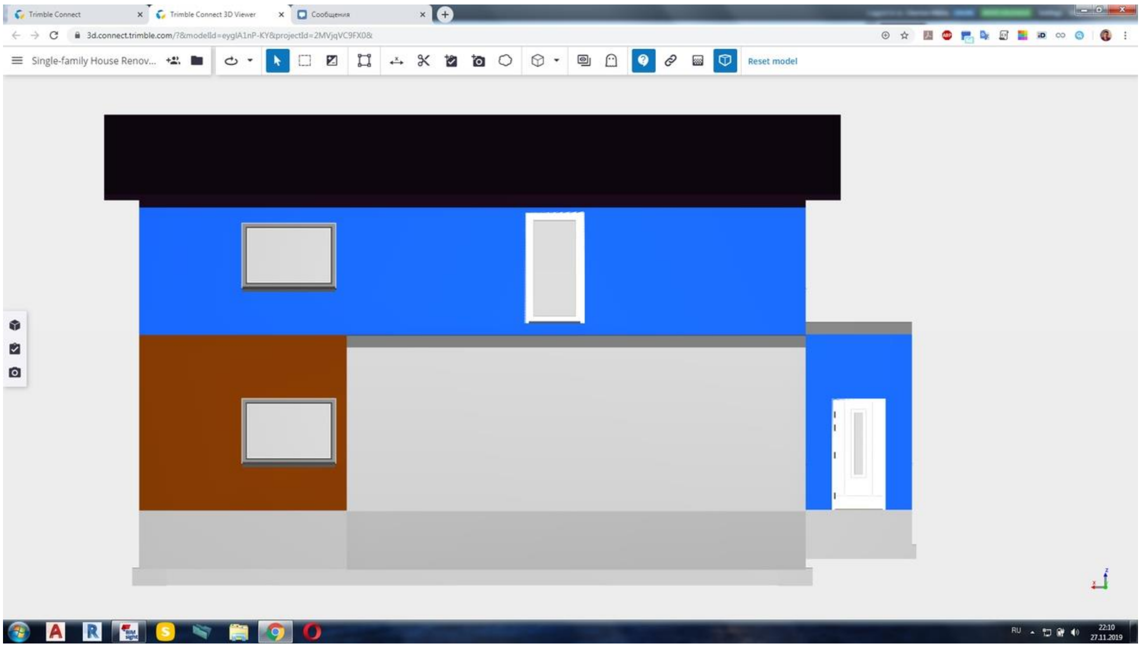


Figure 21. Renovation Model. Facade 3

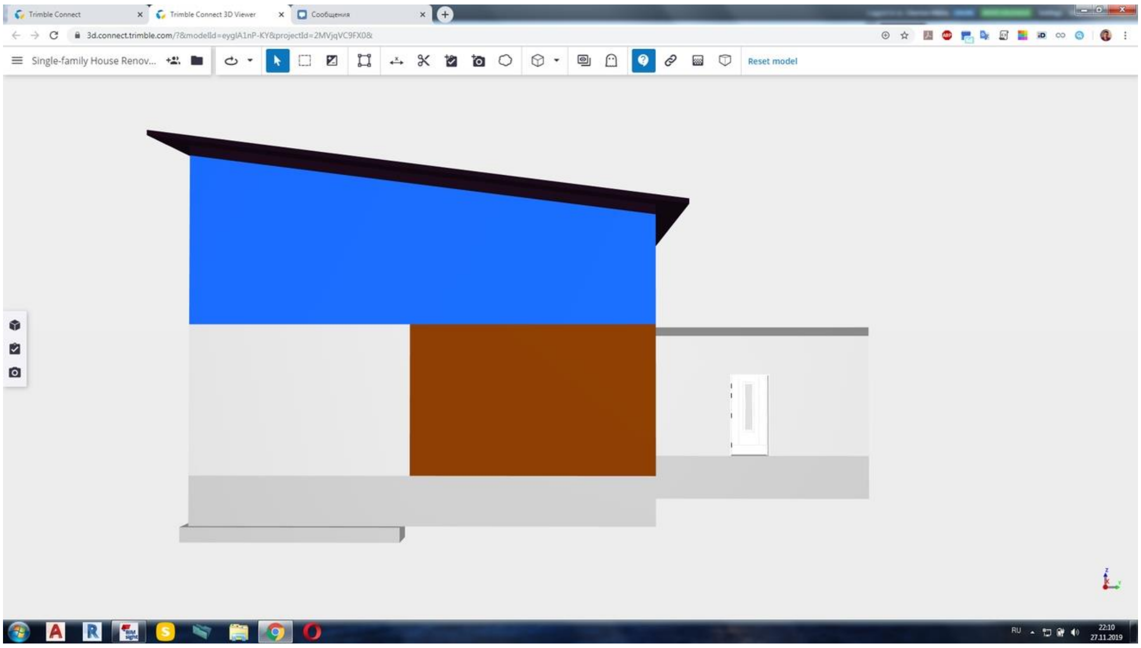


Figure 22. Renovation Model. Facade 4

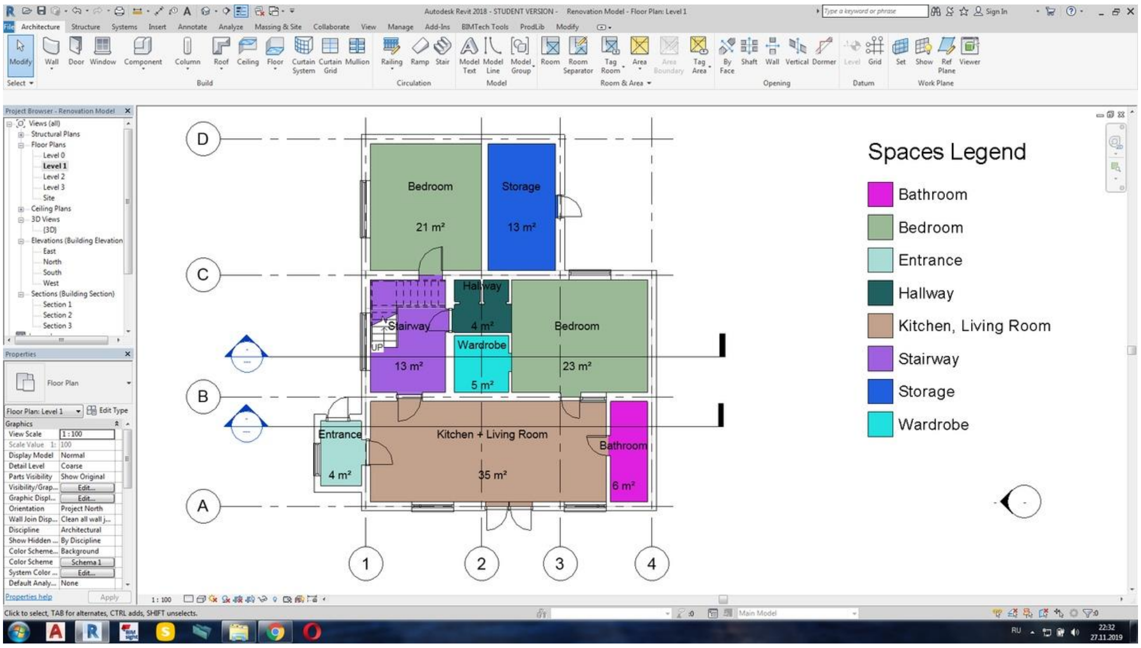


Figure 23. Renovation Model. 1 Floor Plan

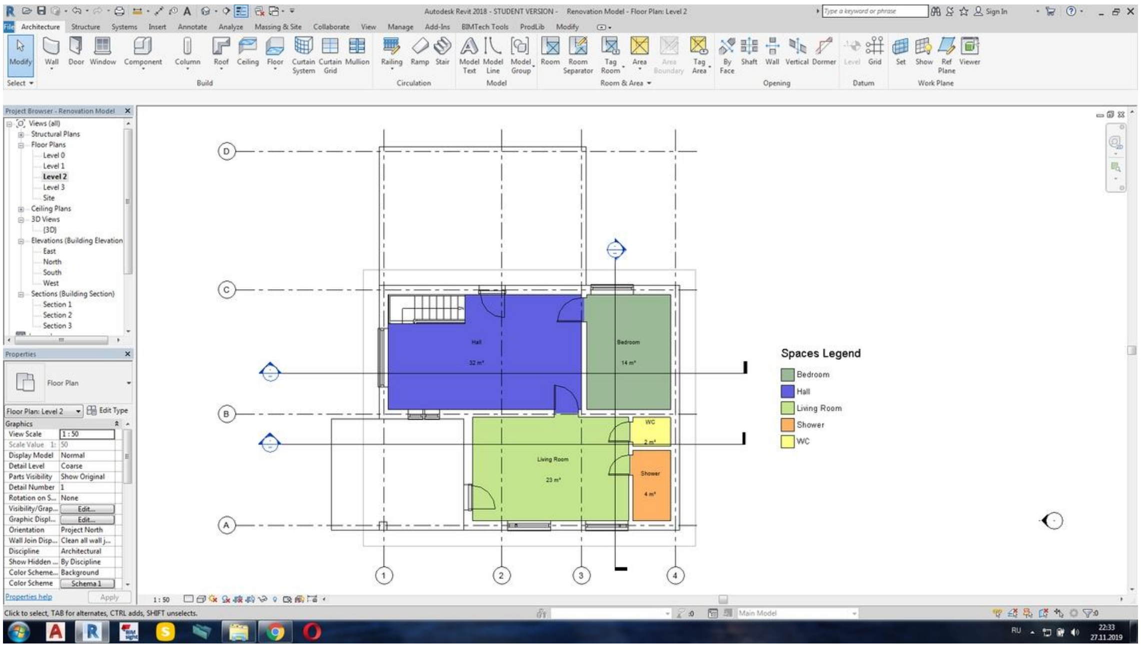


Figure 24. Renovation Model. 2 Floor Plan

7.6 Cloud services and other software used

At the beginning of the project the author and the instructor set several goals to be achieved by the end of the thesis:

- Inventory model (both Revit file and an IFC)
- Renovation model (both Revit file and an IFC)

- Tbp-package (made using Tekla BIMsight)
- Microsoft Excel sheet describing the model detailing level
- Using Trimble Connect service (all the data related to the thesis is in the cloud, so all the members of the project have access to the files)

By the end of the thesis work all the goals were achieved and all the data was uploaded to the above-mentioned cloud-services. The excel sheet shows the detailing level of the model. The parts marked green were modeled, the parts marked red were not modeled and the parts marked orange were not modeled, because they do not exist on site at all. The client got the opportunity to evaluate the current situation about the house and the way it can be renovated. During the project the author of the thesis showed the clients the intermediate results to get the feedback. Together with the clients and the instructor the author of the thesis made a house renovation project that affected both the internal and external appearance of the house and its planning. The clients are satisfied with the results of the project.

8 Conclusions

During the project the author had to get familiar with different BIM programs. The most challenging part of the thesis work consisted of a modelling process using Autodesk Revit software. Some particular details were studied out with the help of tutorials in the Internet and instructions from more experienced Autodesk Revit users.

Using Building Information Modeling for the single-family house renovation cases gives the client much better idea about the situation on site. Three-dimensional model of the house is a much better visualisation for a non-specialist than the two-dimensional plans and drawings. Cloud servises such as Trimble Connect allow the client to supervise the process, make notes and suggestions and send them directly to the designer. Using these services makes the cooperation easier and the final result better for the client.

List of Figures

List of References

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