Comparison of Autodesk Revit & Graphisoft ArchiCad in OpenBIM workflow

LAB University of Applied Sciences
Double Degree in Civil and Construction Engineering
DDCIV21
Angelina Raiman

Abstract

Author(s)	Publication type	Completion year
Angelina Raiman	Bachelor's thesis	2022
	Number of pages 35	

Title of the thesis

Comparison of architectural modeling in OpenBIM projects

Autodesk Revit & Graphisoft ArchiCad

Degree

Civil and Construction Engineering

Name, title, and organisation of the client

LAB University of Applied Sciences

Abstract

This thesis explores the Autodesk Revit and Graphisoft ArchiCad in OpenBIM workflows and compares them. Explained in the form of a guideline how to set basic coordinate points for correct IFC export from two software, considered MVD database, and as a result, there is a comparison table between the exported IFC models created in Graphisoft ArchiCad and Autodesk Revit. Explains concepts such as Building Information Modelling, OpenBIM, Model View Definition, BIM Collaboration Format, Industry Foundation Classes.

Comparing the IFC export capabilities of Revit and ArchiCad, we can conclude that ArchiCad is currently the best software for IFC Export, possibly due to the fact that Graphisoft was one of the first to develop OpenBIM, while Autodesk developers try to build their community by creating their own internal programs for different design areas. But it can not be excluded that the two companies are developing and looking for ways to communicate with the idea of OpenBIM.

Keywords

BIM, OpenBIM, ArchiCad, Revit, IFC, MVD, BIMcloud, COBie, Common BIM Requirements, Sharing workspace, Project Location, Survey Point, Project Base Point, Project North, Sea Level

Contents

1 Introduction 1
2 BIM 2
3 OpenBIM 3
3.1 Industry Foundation Classes (IFC) 4
3.2 MVD database 5
3.3 BIM Collaboration Format (BCF) 8
4 Autodesk Revit and Graphisoft ArchiCad 9
4.1 History of Autodesk Revit 9
4.2 History of Graphisoft ArchiCad 9
5 Sharing Workspace 12
5.1.1 Sharing workspace in Autodesk Revit 12
5.1.2 Sharing workspace in Graphisoft ArchiCad 14
6 Comparison of workflows in Revit and ArchiCad 16
6.1 Revit. Base Project Point, Survey Point 16
6.1.1 Survey Point. 17
6.1.2 Project Base Point. 18
6.2 ArchiCad. Project Location, Survey Point 20
6.2.1 Project Location. 20
6.2.2 Survey Point. 21
6.2.3 Project North 22
6.3 Export verification 23
7 Comparison of IFC-models 26
7.1 Revit object IFC properties 26
7.2 ArchiCad object IFC properties 27
7.3 Comparison of ArchiCad IFC-model with Revit IFC-model 29
8 Summary 30
References 31

Abbreviations

BIM – Building Information Modelling

IFC – Industry Foundation Classes

MVD – Model View Definition

BCF – BIM Collaboration Format

CDE – Common Data Environment

DXF – Drawing Exchange Format

DWG – Drawing

IFC 2x3 – the third extension of IFC 2

IFC4 – the fourth extension of IFC 2

CObie – Construction Operations Building Information Exchange

GIS – Geographic Information System

1 Introduction

Statistically, the use of ArchiCad on in Finland exceeds the use of Revit among architects. Although, in on Russian market, there is opposite case – Revit has more popularity over ArchiCad. Many may find themselves in a situation where they have to work with models from other software made by a colleague, another team or even an architectural firm. This thesis research was inspired by this problem.

This thesis will expose a theme that concerns all engineers from different fields of design: how to simplify everyone's work and make compatible programs from different developers, how to minimize data loss when transferring data from one software to another?

There is a solution, and this is the OpenBIM concept developed by the international BuildingSmart alliance. And the purpose of this research is to find most appropriate and correct usage of their technologies, find out it is capabilities and limitations.

In addition, a comparison of the differences between Revit and ArchiCad software for OpenBIM purposes will be carried out using the example of an identical building model, modelled separately in Revit and ArchiCad. The modeling was carried out in accordance with the «Common BIM Requirements Series 3: Architectural Design» (BuildingSMART Finland. 2012).

2 BIM

Building Information Modelling, BIM is a process result of which an information model of a building (structure) is formed, at the same time, for each stage there corresponds some model that displays the amount of information processed at that moment (architectural, design, technological, economic) about a building or structure to which all interested persons have access. (GRAPHISOFT, 2021.).

Preparation of architectural and construction projects in the BIM environment is a set of interrelated processes for creating an information model based on customer requirements. The technology of design, construction and operation of an object in BIM is considered in the product life cycle. The information model, being a digital analog, also experience all stages of the life cycle from the idea of creating an object to its reconstruction/demolition.

At the heart of BIM is object-oriented design. This means that all programs working in this technology assume modeling based on a large number of pre-created objects called Families, the main design operations are carried out with elements such as indivisible blocks, a kind of "components". Each element of the model carries geometry and attribute information.

A unified information model presupposes the collective work that unites specialists from all sections of the design: technologists, architects, designers, engineers of indoor and outdoor networks, etc. (Figure 1). Teamwork is carried out in the Common Data Environment (CDE) and must comply with certain rules and interactions between participants in the BIM modeling process, which are reflected in BIM Execution Plans (EN ISO 19650-1, 2018).

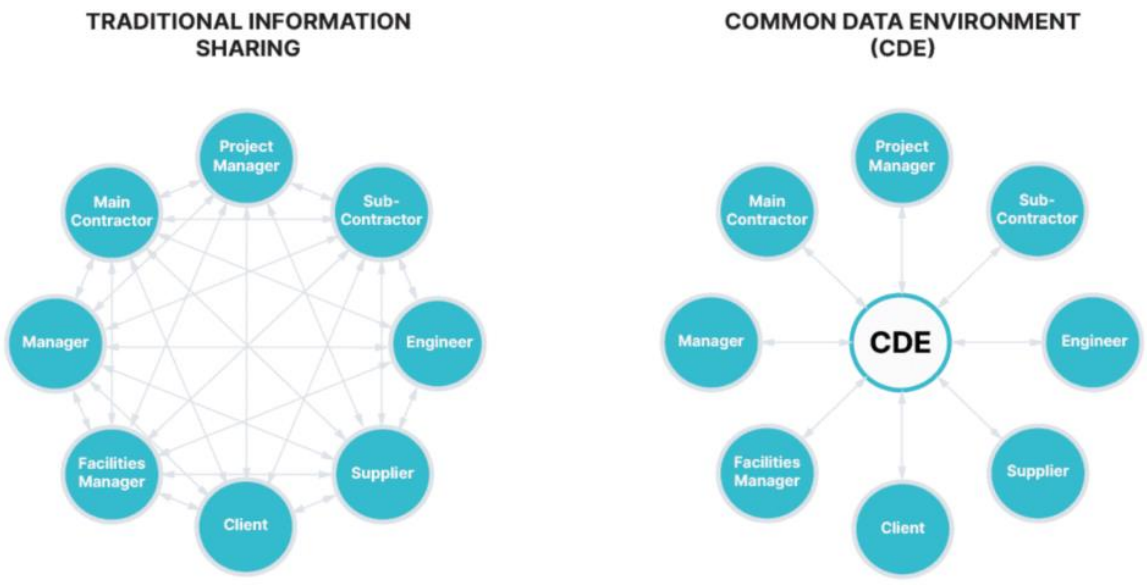


Figure 1. Common Data Environment concept (BIMSPOT, n.d.)

3 OpenBIM

The technology of building information modeling has significantly complicated interdisciplinary interaction. It is no longer enough to simply transfer a BIM model from one application to another: in various programs, complex BIM elements are often described differently. Such objects contain not only general, primitive geometric descriptions (types of 2D lines, hatching, object height, width, etc.), but also information data that another program may simply not understand: for example, the electrical characteristics of the engineering subsystem of the building will be 90% extra load in the architectural BIM model (buildingSMART, n.d.).

In general, the problem of integrating information models created within different disciplines is not only the loss of information between models. As practice shows, different BIM models have much more different than it seems at first glance. Up to the point that even the principles of model construction may differ. For example, if you impose an architectural BIM on a BIM designer that simulates the physical embodiment of a building, then the object "architectural column that permeates the entire building" will not correspond to several columns used by the design engineer; the overlap in the architectural model will lie in other spatial coordinates and have a different geometry compared to the floor slabs of the design engineer, pinched in the walls.

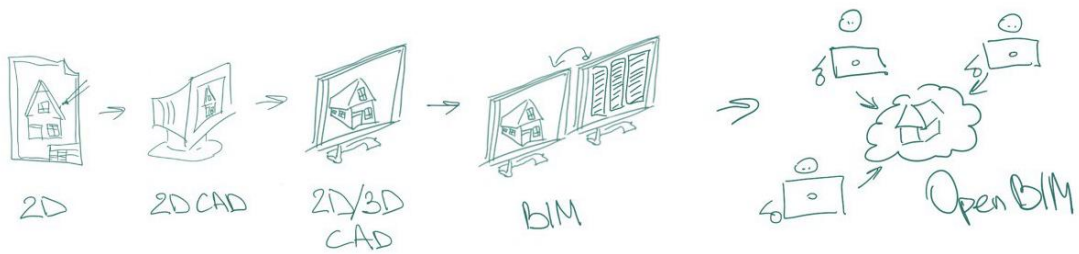


Figure 2. From 2D design to Open BIM

The members of the BuildingSmart alliance came up with a more realistic initiative: what if we leave the opportunity to create specialized BIM models developed within one-three specialties in those solutions that do it best, and then link the models together in those parts that require coordination? This idea was called reference model-based BIM workflows. (buildingSMART, n.d.). Unlike closed BIM, the following benefits are offered by the OpenBIM strategy:

- Project managers can use a unique set of tools that includes the best solutions available in their industry and best complete the project's tasks.;
- With no need to lengthen design time, project managers have complete control over all project components, including upgrading separate programs;

- Using a collection of solutions decreases the chance of data loss, compared to using a single BIM model (which brings together much expertise yet keeps the output in a single file). Of course, you can save backups of a single file, control data fusion, and give out editing powers, but all these are additional administrative resources that can fail at a critical moment;

- Project managers can give up the complex configuration of a universal BIM file, sharpened for all kinds of specialties, and use models created in independent programs and related to each other;

- As a consequence, designers receive a clear BIM that is based on open standards and that enables them to use the information throughout the whole life cycle of the building, from construction through reconstruction or demolition. (buildingSMART, n.d..)

3.1 Industry Foundation Classes (IFC)

Using OpenBIM, it's possible to exchange model data with others, working in preferred software. The language for exchanging information about the model is IFC. It is a way to exchange complete project models where DXF/DWG exchanges graphic objects such as lines, arcs, and fills. IFC is an open standard, accessible to everyone, registered as an official international standard ISO 16739:2013 (ISO 16739:2013, 2013).

IFC is a huge structure of interconnected elements and attributes that contains many classes with thousands of properties. To facilitate the export and remove the extra amount of data for a specific purpose, it is necessary to filter out unnecessary parameters from the IFC schema. This requires a Model View Definitions (MVD).

Developers of each software can select a list of IFC classes that support IFC import and export functions. This means that they can create their own model view definitions.

It is important to understand that virtually every IFC export function in every program is based on MVD.

Official versions of Model Representation Definitions (MVD) from BuildingSmart (buildingSMART, n.d..):

IFC Schema	MVD Name	Status	Documentation	Summary
IFC4 ADD2 TC1	IFC4Precast	Final	Full documentation (zip)	Exchange of geometric information between CAD and MES systems for automated production of precast building components.
IFC4.2	Bridge Construction View	Draft	BRie 2017.10.24	Build and maintain bridges.
IFC4 ADD2 TC1	Reference View	Final	RV 1.2 HTML RV_1-2.mvdxml	Simplified geometric and relational representation of spatial and physical components to reference model information for design coordination between architectural, structural, and building services (MEP) domains
IFC4 ADD2 TC1	Design Transfer View	Draft	DTV 1.1	Advanced geometric and relational representation of spatial and physical components to enable the transfer of model information from one tool to another. Not a "round-trip" transfer, but a higher fidelity one-way transfer of data and responsibility.
IFC4 ADD2 TC1	Quantity Takeoff View	Draft	mvdXML	Estimate and track construction materials and costs.
IFC4 ADD2 TC1	Energy Analysis View	Draft	EV	Estimate and track energy usage and costs.
IFC4 ADD2 TC1	Product Library View	Draft	LV 0.1	Manufacturer product information and configurations.

Figure 3. MVDs for IFC (buildingSMART. n.d.)

Industry Foundation Classes are divided into different schemes, the most relevant at the moment are IFC2x3 and IFC4 - a set of descriptive instructions, which specifies how a model element and its parameters must be represented when exporting to IFC (GRAPHISOFT. Model View Definitions. n.d.).

The "Industry Alliance for Interoperability" industrial consortium, made up of twelve American businesses, invested in the creation of computer code in 1994. "International Alliance for Interoperability" became the name of the alliance in 1997. BuildingSmart has been the consortium's primary means of operation since 2005 (BIMsupporters. n.d.).

BuildingSmart is the name of an organization whose current goals include enhancing information sharing across programs used in the construction sector, as well as developing standardized documentation for code creation, training, and increasing the usage of BIM.

3.2 MVD database

Model View Definition is a so-called filter for IFC, with which we can determine exactly what information should be transferred.

For example, it is necessary to provide an architectural model for energy analysis, for this purpose certain IFC export criteria are selected, the format of which is called Energy Analysis MVD. At the same time, only the necessary information is exported (the shell of the building, spaces, and u-values for external walls).

In the OpenBIM workflow, Model View Definition is an important and useful tool to help ensure the clear operation of BIM.

This chapter will review the integrated basic MVD in Graphisoft ArchiCad and Autodesk Revit.

ArchiCad offers a handy import/export menu where you can easily define the MVD (Figure 4) format you want. On the left are integrated translators optimized for specific programs, such as Revit. There is also an option to add a new MVD.

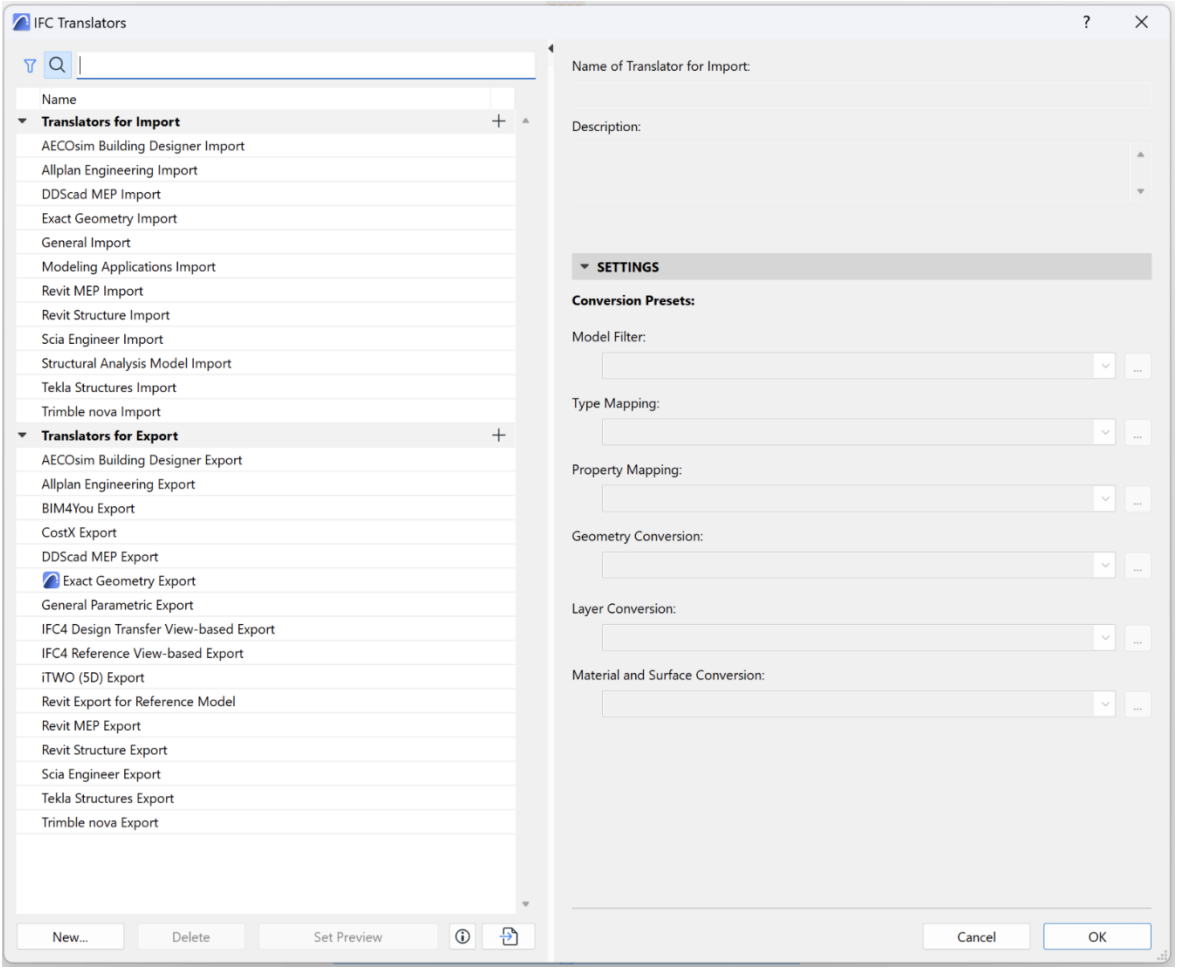


Figure 4. IFC Translators, ArchiCad

ArchiCad supports two basic IFC schemes that can be selected (Figure 5)

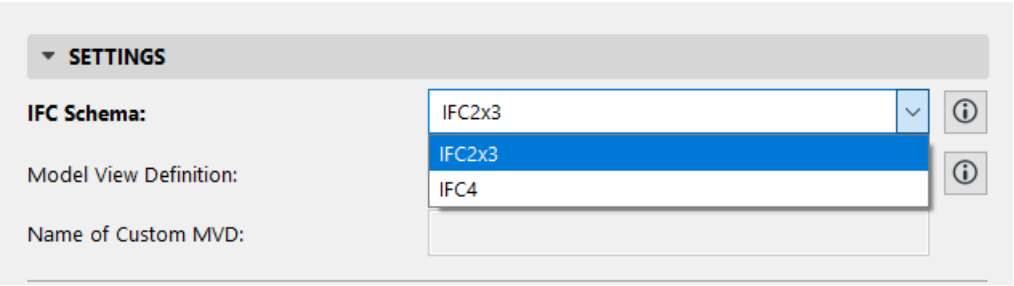


Figure 5. IFC Translators, ArchiCad

Further, additional MVD requirements can be selected, both integrated and customized (Figure 6).

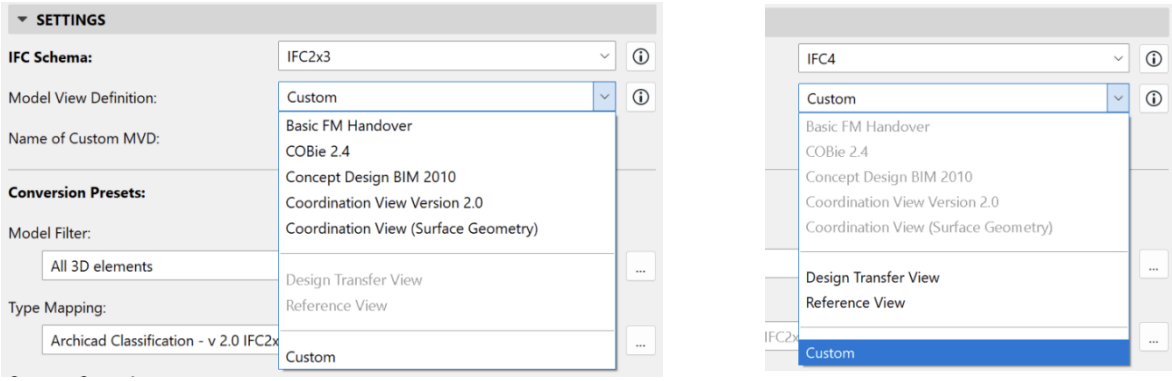


Figure 6. IFC Translators, Settings, ArchiCad

The next menu of the Translator is Conversion Presets, which includes six configurations. It is possible to select the included configurations or by clicking on the square icon next to them, to edit the information according to the requirements.

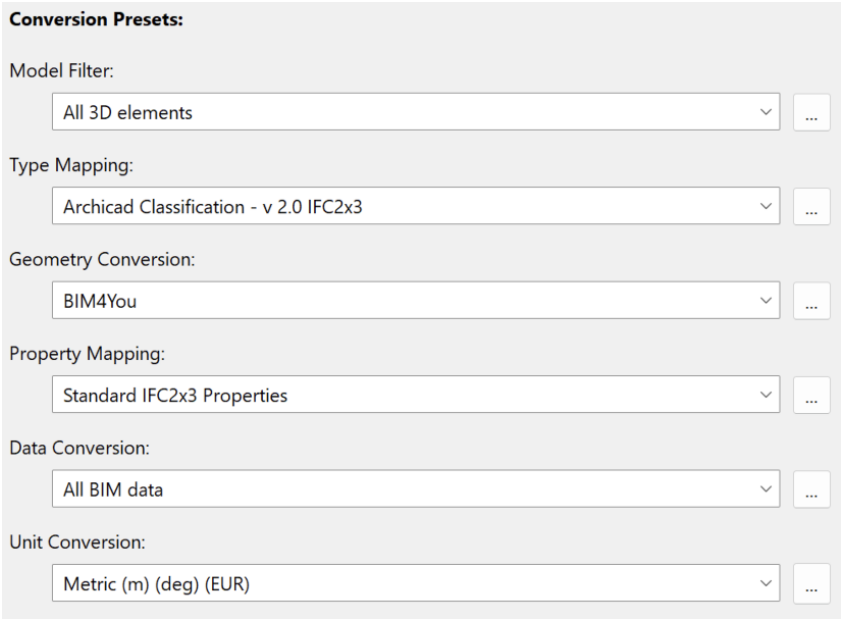


Figure 7. IFC Translators, Conversion Presets, ArchiCad

Revit also offers 2x3 and 4x4 IFC schemes with different MVD configurations this can be seen on the left side of the Modify Setup window. Any additional settings are locked and are only available for customization. It is also possible to add a new MVD (Figure 8).

Comparing the IFC export capabilities of Revit and ArchiCad, we can conclude that in ArchiCad the built-in MVD settings are the most flexible and data structuring is intelligently understandable. This can be explained by the fact that, judging from the history of Autodesk Revit development, Autodesk developers have long tried to create their own microflora,

creating their own internal ones for different design areas. Whereas Graphisoft was one of the first to start developing OpenBIM.

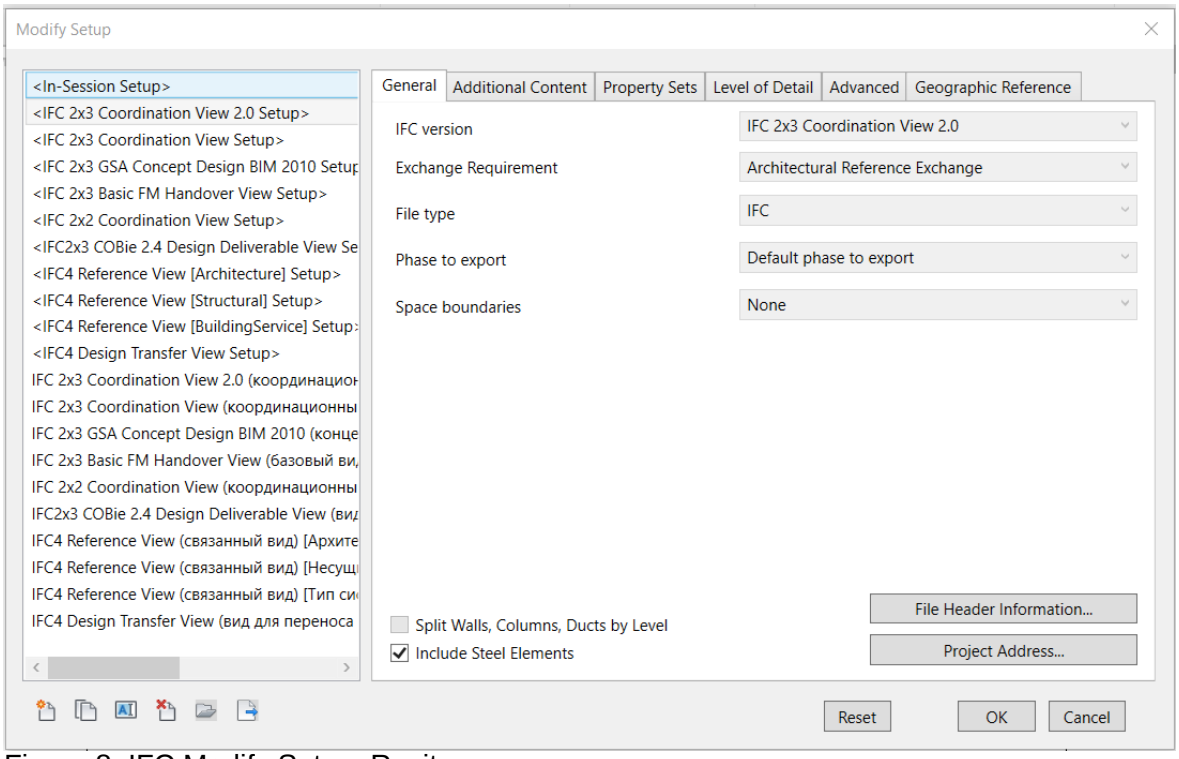


Figure 8. IFC Modify Setup, Revit

3.3 BIM Collaboration Format (BCF)

Another principle of OpenBIM interaction is the BCF format (BIM Collaboration Format) - an open file format that allows to add text comments and screenshots to IFC models to improve interaction. BCF data is integrated directly into the BIM model using the Markup tool. Problems and conflicts discovered during the design process of the project should be reported to the author of the model to solve them.

BCF is an open standard format supported by the BuildingSmart Alliance. BCF is used in many structural and engineering design applications, as well as in model validation programs, allowing you to add comments, screenshots, camera locations and 3D cross-sections to the IFC model. While the IFC contains the model itself, the BCF contains only information about the model, linking it directly to the model. (BIMcollab. About BCF. n.d..)

For example, an architect using ArchiCad sends a model to a structural engineer (in IFC format together with Markup Components in BCF format). The structural engineer looks at the model in Tekla Structures. Due to the compatibility of the BCF format, the engineer can easily and quickly detect the changed elements.

4 Autodesk Revit and Graphisoft ArchiCad

The two leading design software are Graphisoft's ArchiCad and Autodesk's Revit. Before we get to the most important part of this thesis, below is a history of the creation of these software.

4.1 History of Autodesk Revit

Autodesk Revit is building information modeling software for architects, landscape architects, structural engineers, mechanical engineers, electrical and plumbing engineers, designers, and contractors. The original software was developed by Charles River Software, founded in 1997, renamed Revit Technology Corporation in 2000, and acquired by Autodesk in 2002. The software allows users to design buildings and structures and their components in 3D, add annotations to the model with 2D drawings, elements and access building information from the building model database. (Graves, Michael. 2012). Revit is a four-dimensional building information modelling, with tools for planning and tracking the various stages of a building's life cycle, from concept to construction and subsequent maintenance and/or demolition.

On April 5, 2000, the first version of the program was released Revit 1.0.

After 2004, Autodesk released several versions of Revit. In 2005, Revit Structure was introduced, and then in 2006. - Revit MEP. After the 2006 release, Revit Building was renamed Revit Architecture.

Dynamo was released in beta form in 2011, providing the first glimpse into direct programming of the behavior of placed components using the drag-and-drop node interface.

Beginning with Revit 2013, the various disciplines were merged into one product, called simply Revit.

With Revit 2016, Autodesk dropped support for 32-bit Windows (BIM Learning4U, 2018).

Developers improve the program several times a year, evolving with the times and the needs of designers.

4.2 History of Graphisoft ArchiCad

ArchiCad is a graphic CAD software package for architects created by Graphisoft. Intended for the creation of furniture, landscape components, architectural and structural structures and solutions, etc.

The first version of the ArchiCad program was created in 1984. It worked on Apple Lisa computers and was a program for designing water pipes.

1986 ArchiCad 2.0, first version for the Macintosh, incorporating integrated 2D and 3D plug-ins, the first version called ArchiCad.

1987 ArchiCad 3.0, introducing the color image. Graphisoft presents the Virtual Building, the first integrated building information model system.

1993 Graphisoft introduces a cross-platform strategy, ArchiCad 4.16 was released for the Windows operating system.

1996 Graphisoft was one of the first companies to support the International Alliance for Interaction (IAI), founded by the leading architectural CAD companies. IAI's mission is to "define, promote and publish the Industry Foundation Classes (IFC) standard specification, as the basis for information exchange throughout the design process, globally across disciplines and technical applications".

1997 With the release of ArchiCAD 5.1, ArchiCad for TeamWork was first introduced, a revolutionary technology for collaborative design and working on a single 3D building model. ArchiCad for TeamWork uses high-level communications technology while remaining network-independent. To minimize network traffic, and while maintaining offline capabilities, ArchiCad for TeamWork does not require a permanent connection to the main project.

2001 ArchiCAD 7.0 delivers the next generation of the web-based collaborative design workflow, in the form of the integrated ProjectXChange solution. As a striking addition to the functionality of ArchiCad TeamWork, ProjectXChange introduced a unified approach to managing design workflow and fabricators over the Internet. Using the trio of ProjectXChange tools, Publisher, Reviewer, and Revision, it allows ArchiCad projects to be made available over the Internet, without the need for cumbersome file hosting or third-party applications.

2007 ArchiCad becomes certified as compliant with IFC 2×3, the International Alliance for Interoperability (IAI).

2012 г. "BIM at Your Fingertips. ArchiCad 16 features, enriched by the latest Morph tool for volumetric conceptual design, and the unique system for creating, finding, and exchanging user-defined objects (BIM components). New built-in energy analysis capabilities make ArchiCad one of the best CAD solutions in the market for creating environmental BIM projects.

2013 г. ArchiCad was the first certified CAD software to support IFC Coordination View 2.0 imports and exports.

COBie Test. Graphisoft successfully passed BuildingSmart's COBie test in the cost estimating category. ArchiCad released COBie data that was fully compliant with the equivalent COBie test drawings and calculations.

2014 r. Graphisoft introduces BIMcloud. ArchiCad 18 introduces the industry's first collaborative process when working on a BIM model, regardless of the size, location, or deployment of the design team. The BIMcloud solution goes far beyond the standard cloud storage services on the market. The end-to-end cloud collaboration solution provides the software layer needed to deploy either as a small private cloud or as a public cloud service.

Developers improve the software every year, evolving with the times and the needs of planners. (GRAPHISOFT, 2021..)

5 Sharing Workspace

Sharing Workspace is a workflow in which there is the interaction between the team members involved in the process. In the process of such work, a common task can be solved, or the result of the work of one employee can be used by another employee.

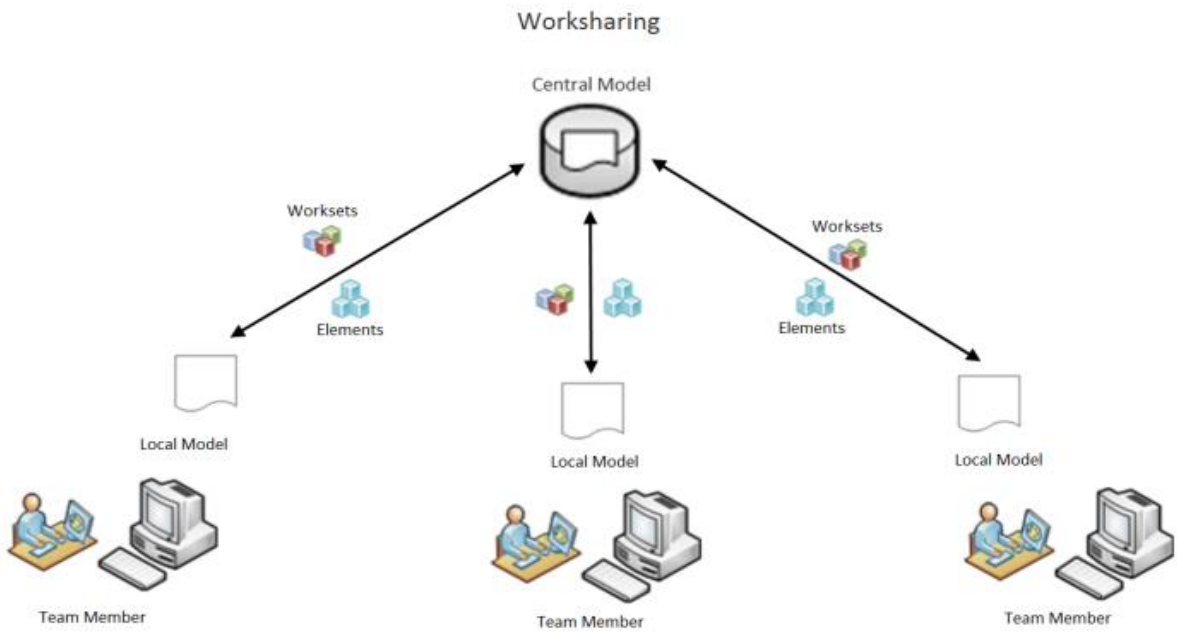


Figure 9. Worksharing concept (Autodesk. About Worksharing. 2022)

5.1.1 Sharing workspace in Autodesk Revit

It is required to create a common coordination file associated with Revit. This file will collect all the results of the employees' work and synchronize with a single Revit model. Each designer should have one local file, which are then combined into a complex coordination file.

This scheme is perfect for working with a large group of designers on a large object. For instance, a team might allocate several team members to focus on specific functional areas, including the interior structure of a building, the facades, and the placement of walls. Moreover, employees in this case may be located in different parts of the planet. In this case, it is important to register links to local employee files in the cloud. Thus, the current model will be displayed on the cloud. And then all the individual files can be assembled into a single file.

This method has positive and negative sides.

Positive aspects:

- information loss is excluded;

- synchronization;
- all participants see the same model at the same time.

The negative side: if the object is very complex, and we start uploading architecture, structures, and engineering to a single file, then in this case the model will be very heavy. Therefore, the method of working with a single shared file will be effective for small objects and a small development team.

In the case of complex objects, it is better to have several coordination files for disciplines. For example, one is for architecture, the other is for structures, and the third is for engineering.

For example, the main team (architects, designers, engineers, and project managers) works in Revit. There is a single file on the server or on the cloud, which is assembled from two auxiliary files (architecture + designs and engineering). All specialists have copies of this file on local machines, which are synchronized with the necessary auxiliary file. The project manager periodically connects to the central file to monitor the model, because he needs to see the entire model.

We can form several general principles for working with a shared Revit file:

- A shared Revit file should be in a public place and synchronized with local copies
- each designer must have his own local copy of the shared file with which he works

How to create a shared file in Revit:

1. Create a new project
2. On the "Collaboration" tab, click on the "Create working sets" button to form working sets. Working sets are layers belonging to different designers. For each working set, you need to specify the owner who must be pre-registered in the system. It is better to form the names of work sets according to the tasks of the employee.
3. Then we save the project and we have a shared file. First, let's save this file on your computer.
4. It is very important to check in the saving parameters the set checkboxes "consider the storage model after saving", "compress the file", you can set the number of backups of the project.

How to create a local file for the designer:

1. From the designer's computer, open the project on the server and check that the "create a new local" checkmark is set. Thus, a local copy of this file will be created.
2. Then you need to go to "Collaboration" and configure editable and non-editable work sets. Then you need to synchronize.

There are two types of synchronization: instant and with parameter updates. When synchronizing with parameter updates, you can compress the model, save/not save the model, and set comments.

5.1.2 Sharing workspace in Graphisoft ArchiCad

ArchiCad has a special collaborative design tool: the Teamwork function. Teamwork technology meets the requirements of creating a multi-user workspace and allows you to organize teamwork within a single project.

For example, the workflow process can be configured in such a way as to provide the ability to edit specific elements only by certain users. The rest of the participants will only be able to update the versions of the files by viewing the changes made. In addition, the system supports communication between users in the context of the project.

The server part consists of three components:

- BIMcloud Manager. An application with a browser interface for managing BIMcloud.
- BIMcloud Server. A component for storing models and data in the BIMcloud environment. Several BIMcloud Servers can be installed on one or several computers at once. Their management will be centralized through BIMcloud Manager.
- BIMcloud Delta Cache. This additional component is designed to optimize data transfer between ArchiCad clients and BIMcloud Server.

How to create a shared file in ArchiCad:

1. First you need to configure all the components mentioned above.
2. Create a local project in ArchiCad and then place it on the server. The project does not have to be new, you can open an existing one and upload it to the BIMcloud server.
3. Next, we make settings so that there is a possibility of group work. To do this, click on "Teamwork — Project — Sharing" in the tab bar.

4. Enter the credentials, the server address with the port, login and password from the user account. In our case, the first and so far only user was created, but in the future, there will be more of them with different rights. Not all of them will be able to host projects. (Graphisoft Help Center, 2021.)

How to create a local file for the designer. After all the steps are done, our colleagues who have accounts on the deployed BIMcloud server and the appropriate access rights can connect to the group project and fully work in Teamwork mode.

The principle of working with the general model is simple. Instead of opening the file on the computer, we download the project from the Teamwork server in the same file opening dialog box. During operation, you can receive or send current model changes to the server. Before completing the work, we send all the changes and close the program.

6 Comparison of workflows in Revit and ArchiCad

The comparison was made on the example of two identical architecture models created in ArchiCad and Revit. It should be clarified that was used certain versions of programs: Autodesk Revit 2023 and Graphisoft ArchiCad 25.

The modeling was carried out in accordance with the «Common BIM Requirements Series 3: Architectural Design» (BuildingSMART Finland. 2012) created by BuildingSmart. This guideline is available in English, Finnish, Spanish and Estonian languages. There is also a very important addition to the guideline «YTV2012 Täydentävä liite ARK» (BuildingSMART Finland. 2012), which is only in Finnish. For correct modeling, an English translation of this document has been done in this thesis.

In order to work with IFC correctly, it is necessary to set the basic coordinate points properly. This chapter will explain what points there are and how to place them.

Project Base Point is the starting point of the coordinate system directly in the project. All sizes and heights in the X, Y, and Z system are counted from it and can be unique in each project. Usually coincides with the first floor level, but this is optional.

Project Survey Point is a reference point with a national coordinate system that determines the actual location of the model in the real world. In other words, it is a point on the master plan with coordinates of latitude, longitude, and displacement relative to sea level. The correct configuration of the Survey Point location guarantees accurate and correct transmission of coordinates between programs and other BIM design tools. (GRAPHISOFT, 2021)

6.1 Revit. Base Project Point, Survey Point

Revit uses two coordinate systems to coordinate the model between sections and to assemble the overall model (AUTODESK. 2022):

1. Survey coordinate system (absolute). It includes:
    - Survey Point
2. Project coordinate system (relative). This includes:
    - Base Project Point
    - Internal Origin

Name	Graphic notation
Survey Point	
Base Project Point	
Internal Origin	

Table 1. Table of designations

6.1.1 Survey Point.

In Revit, the survey point defines the actual position of the model in the absolute coordinate system. That is, this is the point at which we know the coordinates.

For example, it could be:

- A point with known GIS coordinates
- A point with geodetic coordinates (reference point)
- A boundary point on the cadastral map.

To see these points, it is best to switch to the 3D view. Navigate to "Visibility/Graphics" → expand the "Site" category → check the boxes for "Project Base Point" and "Survey Point" (Figure 10).

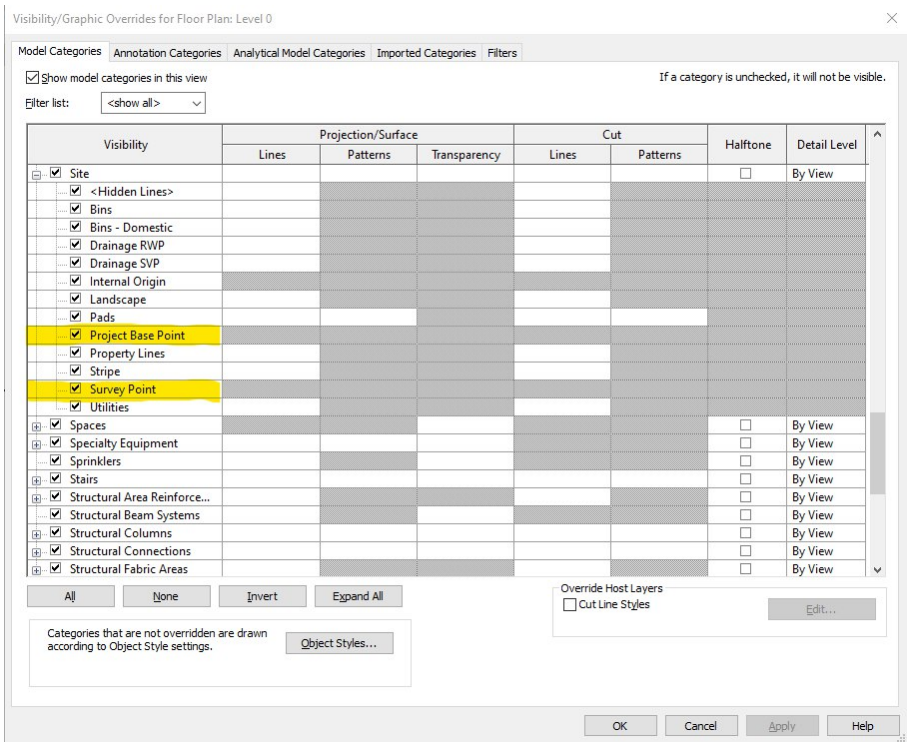


Figure 10. Visibility override window, Revit

The base point and survey point can also be seen on a plan or section, but they may not always make it into the view.

The ETRS-GK 25 N2000 coordinate system was used in the project, so it was not necessary to tie the object to a specific boundary and use a survey point. The survey point settings remain unchanged (0,0,0). (Figure 11).

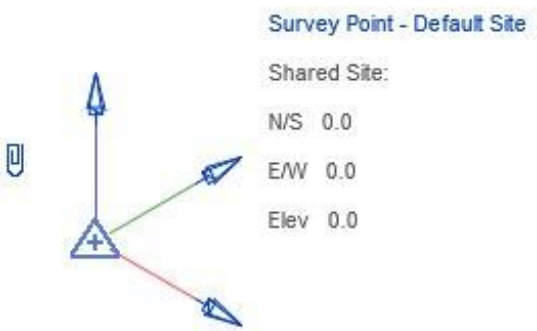


Figure 11. Survey Point and properties, Revit

You have entered the coordinates, now you have to click on the paper clip again.

The text at the top "Internal" is the name of the file site. A site is something like a location where the current coordinates and position of the file are stored. There can be several sites in one file.

6.1.2 Project Base Point.

The Base Project Point defines the origin (0,0,0) of the project coordinate system. It is used for internal model coordination to set the angle difference between True North and Project North. Navigate to Manage → Coordinates → Specify Coordinates Point (Figure 12).

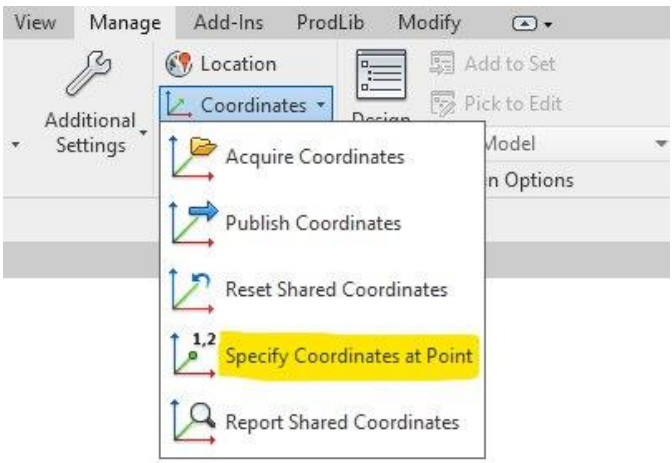


Figure 12. Expanded control menu, Revit

For example, let's choose a parking lot on the LAB University Campus. The exact coordinates are presented in Figure 13

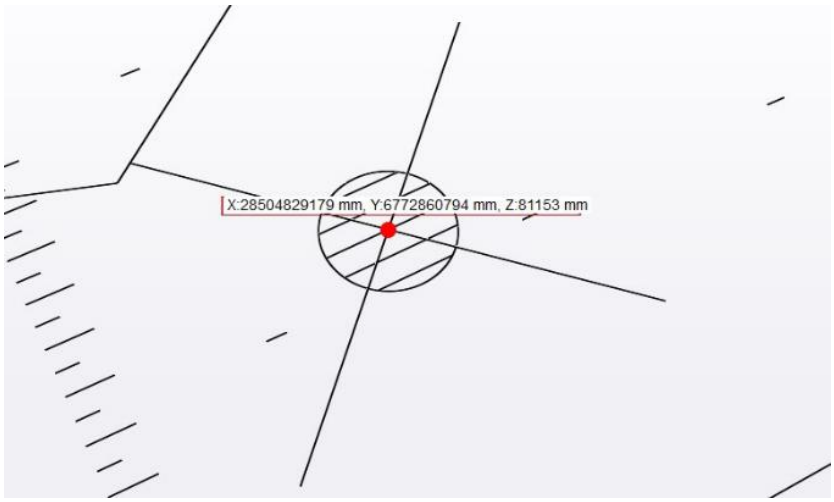


Figure 13. ETRS-GK 25 N2000 coordinate, Trimble Connect

Enter Latitude/Longitude and Sea Level (Elev) coordinates in millimeters.

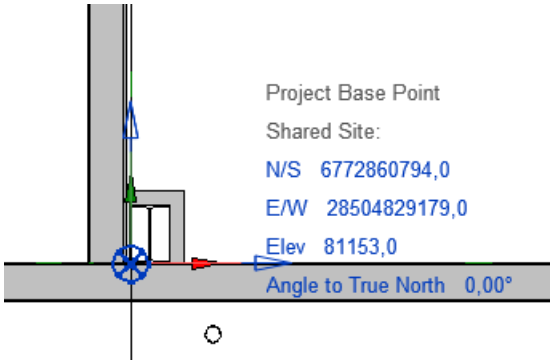


Figure 14. Base Project Point and properties, Revit

In addition to height and coordinate settings, the Base Point has an angle setting from True North. If the building on the master plan is rotated relative to the north by a sharp angle, it is inconvenient to work with such a building, so it can be rotated so that the axes are parallel to the edges of the coordinate monitor (Figure 15). True north is the actual location of the building on the master plan, and conditional north is the model rotation for convenience.

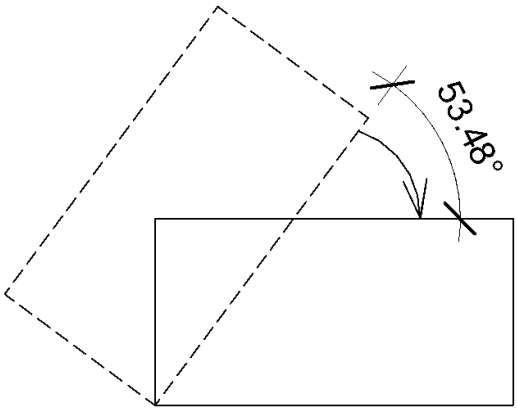


Figure 15. The True and Conditional North

6.2 ArchiCad. Project Location, Survey Point

Three coordinate systems are used in ArchiCad to coordinate the model between sections and to assemble the overall model:

- Project Location
- Survey Point
- Project North

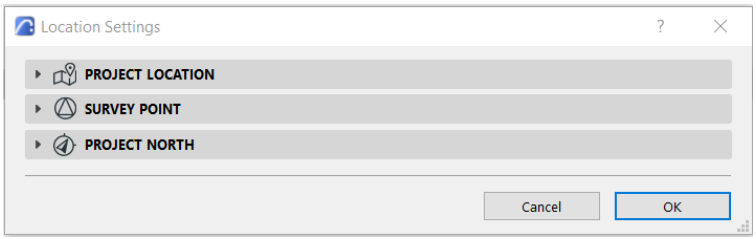


Figure 16. Location Settings, ArchiCad

The coordinate system settings can be found in Toolbar → Show Survey Point → Location Settings (Figure 17)

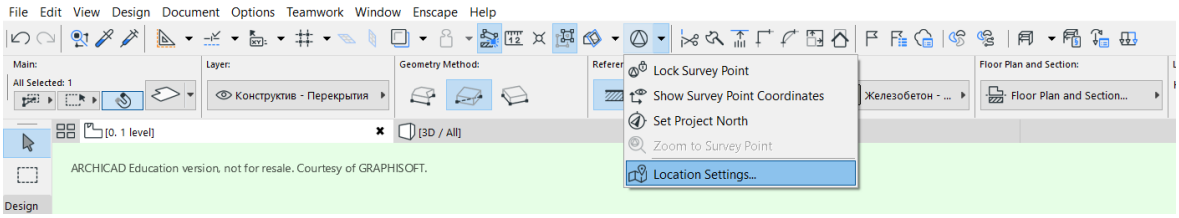


Figure 17. Toolbar, ArchiCad

6.2.1 Project Location.

In ArchiCad Project Location defines the actual position of the model in the absolute coordinate system. These location information settings are used when exchanging IFC data and are saved as IFC properties. They do not affect the position of the Reference Point in ArchiCad (GRAPHISOFT helpcenter, 2021).

- IFC 2x3 export: the data is exported as two new IFC property sets.
- Export in IFC4 format: new IFC definitions are created: IFC Map Conversion and IFC Projected CRS.

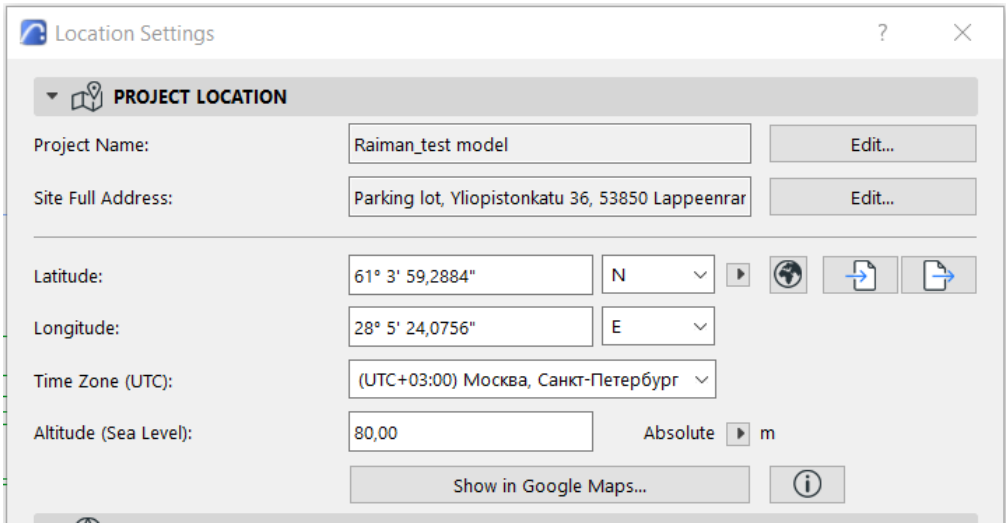


Figure 18. Project Location Settings, ArchiCad

Choose also a parking lot on the University LAB Campus with the same coordinates. Provided there is a connection to the Internet, using the button "Show in Google Maps" it can be check the location of the object according to the entered data (Figure 19).

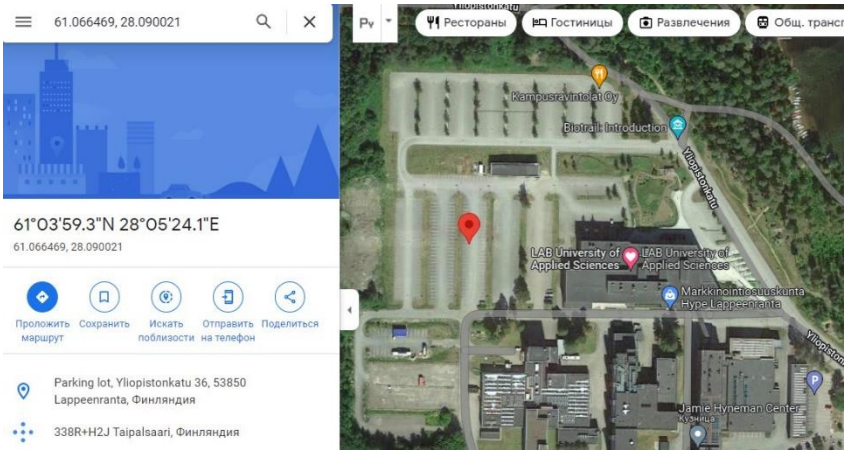


Figure 19. Google Maps

6.2.2 Survey Point.

The ArchiCad Survey Point can be used as a survey benchmark for coordinating models in various applications.

The Survey Point can also be used:

- to match the origin of the XREF coordinates (in the Join Xref dialog box)
- to match a Linked Module (in the Linkage Placement dialog box)
- to match the location of IFC Site exported IFC models (see Determine IFC Model Location by)

Reference Point is integrated with ArchiCad coordination processes with IFC, BCF, DXF, and DWG files and allows you to transfer project reference point coordinate data.

To disable and enable the display Survey Point: Toolbar → Show Survey Point → Show Survey Point Coordinates (Figure 20). It is possible to lock a Reference Point, this command prevents accidental moving or editing of the Reference Point.

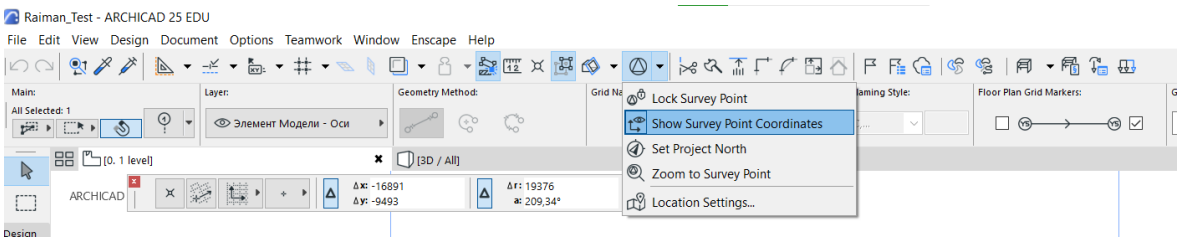


Figure 20. Toolbar, ArchiCad

In the "Position" section it is necessary to enter the Latitude/Longitude and Sea Level (Elevation) coordinates in millimeters with the sign “ - “ (Figure 21).

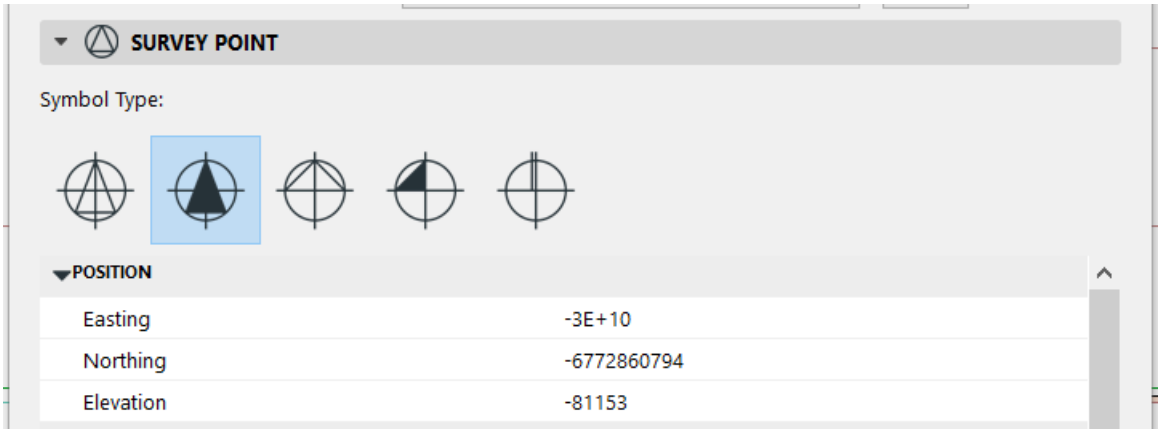


Figure 21. Survey Point Settings, ArchiCad

6.2.3 Project North

Setting up the North of the project is simple, just enter the angle if known (Figure 22).

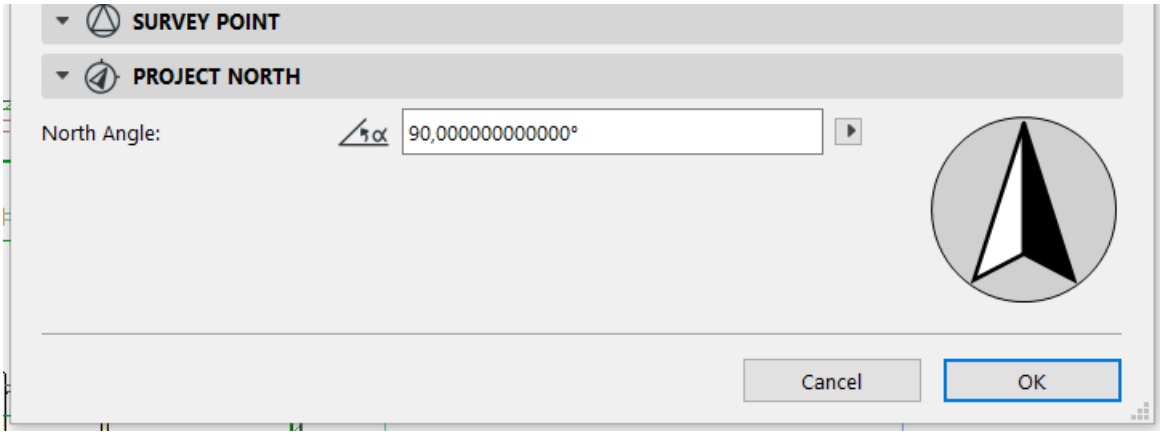


Figure 22. Project North Settings, ArchiCad

Or install it yourself with the help of: Toolbar → Show Survey Point → Set Project North (Figure 23)

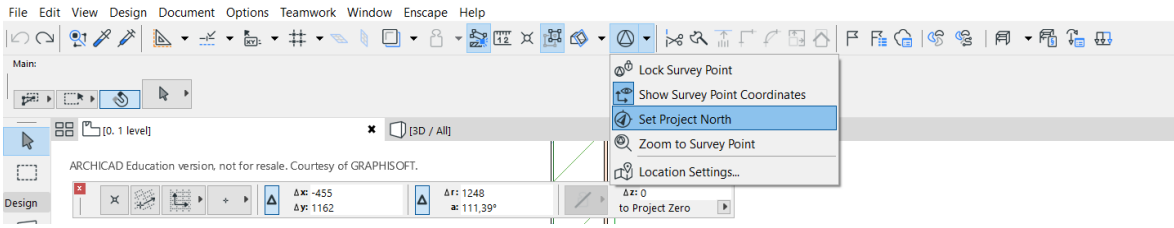


Figure 23. Toolbar, ArchiCad

Next on the Floor Plan or in the 3D window:

- Click the mouse to display the North Project sign.
- Move the cursor to set the rotation of the North arrow of the Project.

The coordinates of the angle to the north of the Survey Point will be changed accordingly.

6.3 Export verification

Verify correct export and location of models in global coordinates by using Trimble Connect software. On the master plan (Figure 24) there is a point with coordinates that have been entered in the project coordinate system parameters. Two IFC models from ArchiCad and Revit should fit correctly at this point. MVD "IFC 2x3 Coordination View" was used when exporting models.

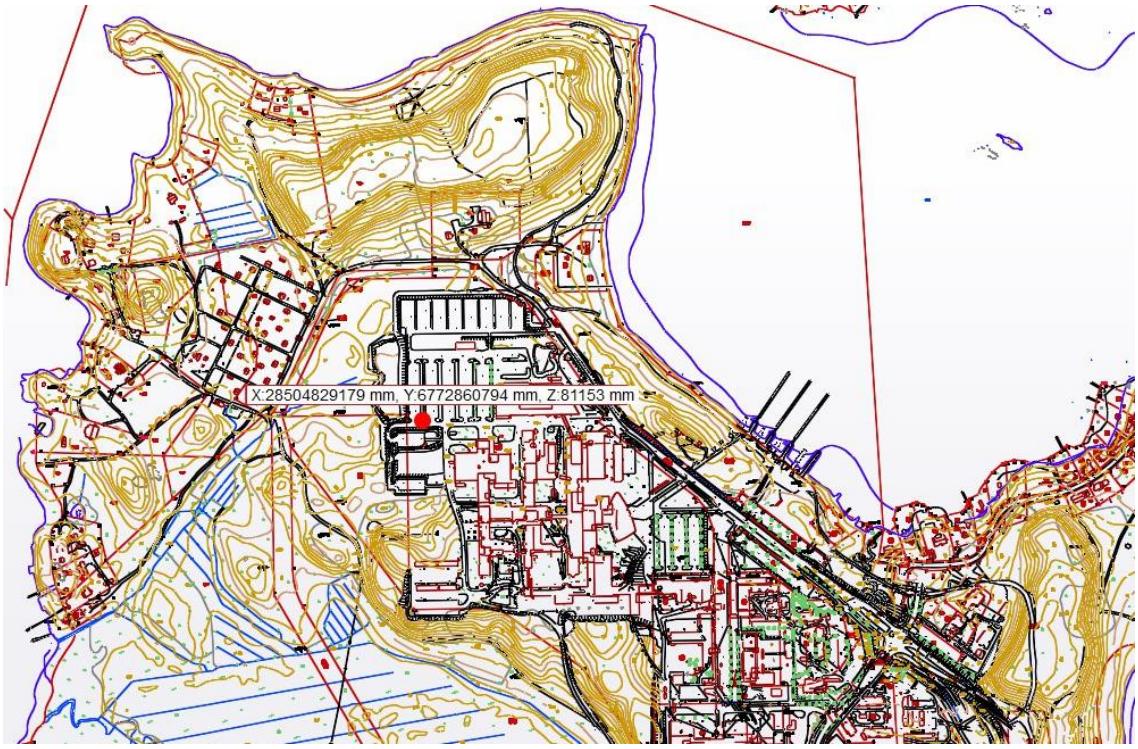


Figure 24. Master Plan, Trimble Connect

Figure 25 shows an IFC import from ArchiCad, the model has the correct insertion.

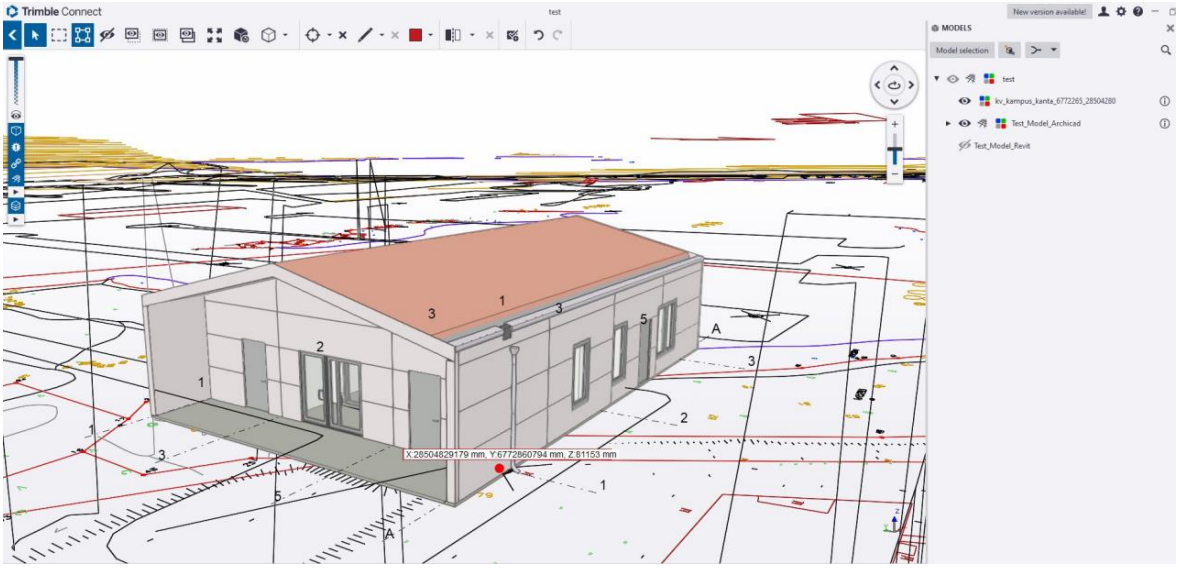


Figure 25. IFC from ArchiCad, Trimble Connect

Figure 26 inserts the IFC model from Revit. Correct.

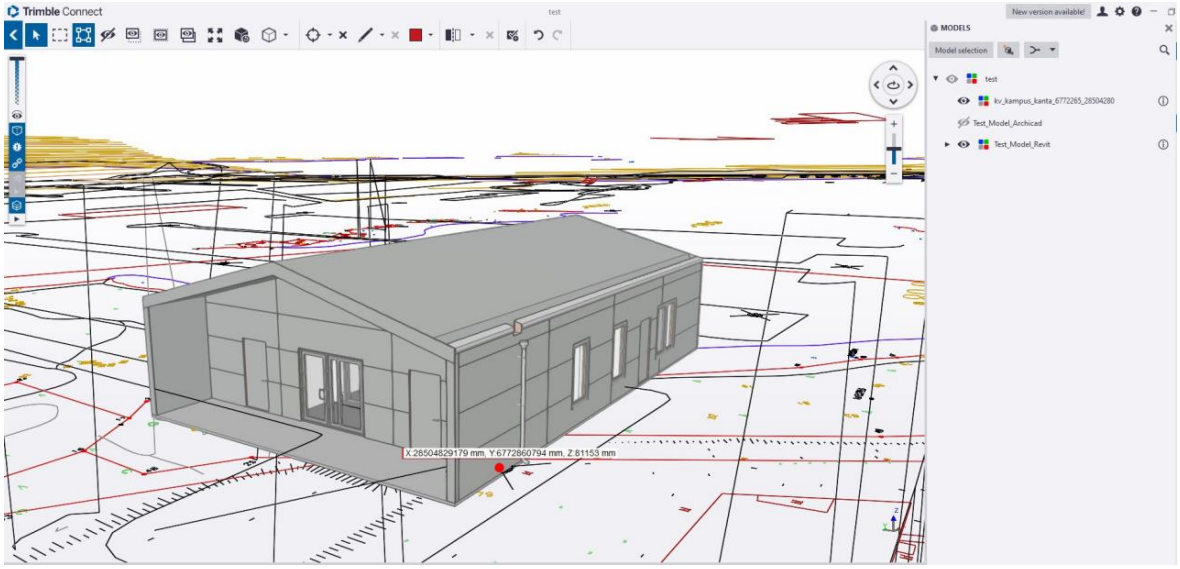


Figure 26. IFC from Revit, Trimble Connect

In Figure 27 and Figure 28 the display of both IFC models is enabled. It can be seen that the model from Revit overlapped with the model from ArchiCad without collisions. The only difference may be seen is the gutters at different positions, this is not an export error. This collision is related to the original modeling.

Accordingly, it can be concluded that the procedure for assigning coordinates (Project Location, Survey Point, Project Base Point, Project North, Sea Level) and exporting IFC models in global coordinates was correctly described.

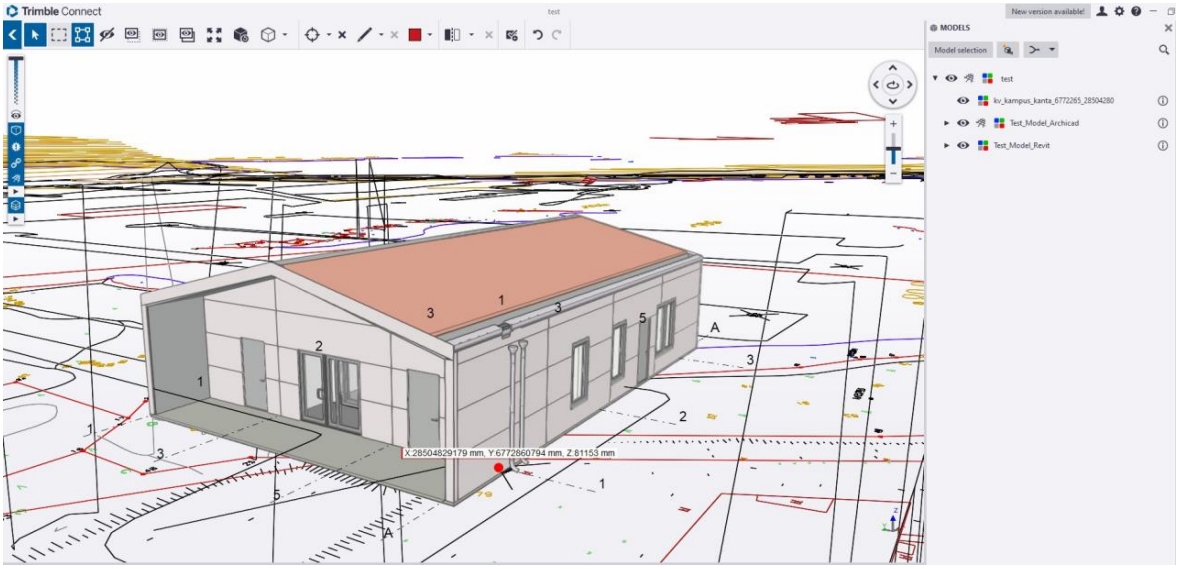


Figure 27. IFC from Revit and ArchiCad, Trimble Connect.

Figure 28. IFC from Revit and ArchiCad, Trimble Connect.

7 Comparison of IFC-models

IFC models from ArchiCad and Revit were imported to Trimble Connect to check their similarities and differences. Models have the same location and the same building geometry, so their appearance overlaps with each other. Recall that the models were exported using the MVD "IFC 2x3 Coordination View"

To look at those models more precisely, we can turn on them one by one and review each separately on the example of one window.

7.1 Revit object IFC properties

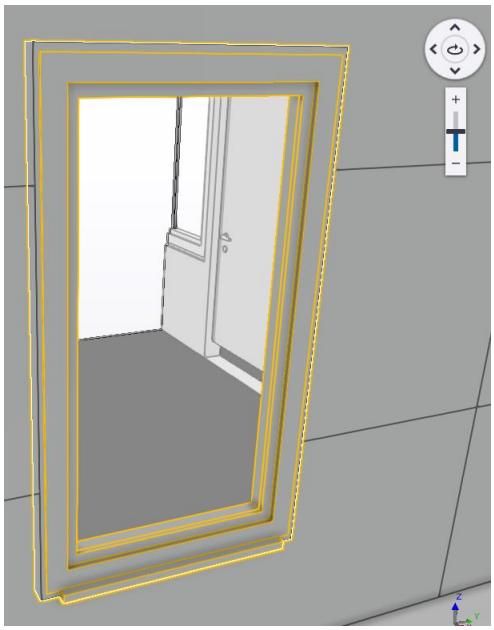
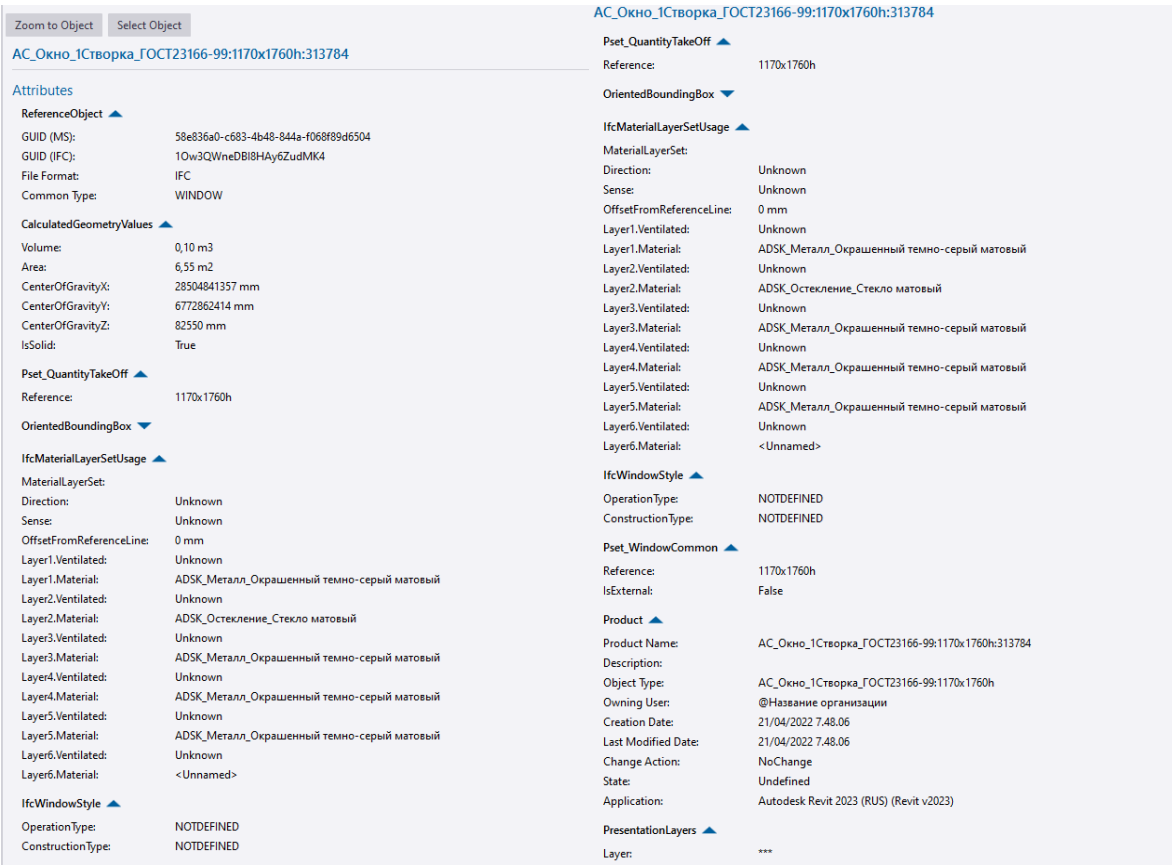


Figure 29. IFC element Revit, Trimble Connect

IFC Window object exported from Autodesk Revit contains the following information:

- CalculatedGeometryValues – Calculated by Trimble Connect geometrical information based on solid geometry;
- Pset_QuantityTakeOff – Size of window;
- IFCMaterialLayerSetUsage – Material and surface paint data;
- Product – Information about model name, producer, and date produced.



Zoom to Object | Select Object

AC_Окно_1Створка_ГОСТ23166-99:1170x1760h:313784

Attributes

ReferenceObject

GUID (MS):	58e836a0-c683-4b48-844a-f068f89d6504
GUID (IFC):	1Ow3QWneDBI8HAy6ZudMK4
File Format:	IFC
Common Type:	WINDOW

CalculatedGeometryValues

Volume:	0,10 m3
Area:	6,55 m2
CenterOfGravityX:	28504841357 mm
CenterOfGravityY:	6772862414 mm
CenterOfGravityZ:	82550 mm
IsSolid:	True

Pset_QuantityTakeOff

Reference:	1170x1760h

OrientedBoundingBox

IfcMaterialLayerSetUsage

MaterialLayerSet:	
Direction:	Unknown
Sense:	Unknown
OffsetFromReferenceLine:	0 mm
Layer1.Ventilated:	Unknown
Layer1.Material:	ADSK_Металл_Окрашенный темно-серый матовый
Layer2.Ventilated:	Unknown
Layer2.Material:	ADSK_Остекление_Стекло матовый
Layer3.Ventilated:	Unknown
Layer3.Material:	ADSK_Металл_Окрашенный темно-серый матовый
Layer4.Ventilated:	Unknown
Layer4.Material:	ADSK_Металл_Окрашенный темно-серый матовый
Layer5.Ventilated:	Unknown
Layer5.Material:	ADSK_Металл_Окрашенный темно-серый матовый
Layer6.Ventilated:	Unknown
Layer6.Material:	<Unnamed>

IfcWindowStyle

OperationType:	NOTDEFINED
ConstructionType:	NOTDEFINED

AC_Окно_1Створка_ГОСТ23166-99:1170x1760h:313784

Pset_QuantityTakeOff

Reference:	1170x1760h

OrientedBoundingBox

IfcMaterialLayerSetUsage

MaterialLayerSet:	
Direction:	Unknown
Sense:	Unknown
OffsetFromReferenceLine:	0 mm
Layer1.Ventilated:	Unknown
Layer1.Material:	ADSK_Металл_Окрашенный темно-серый матовый
Layer2.Ventilated:	Unknown
Layer2.Material:	ADSK_Остекление_Стекло матовый
Layer3.Ventilated:	Unknown
Layer3.Material:	ADSK_Металл_Окрашенный темно-серый матовый
Layer4.Ventilated:	Unknown
Layer4.Material:	ADSK_Металл_Окрашенный темно-серый матовый
Layer5.Ventilated:	Unknown
Layer5.Material:	ADSK_Металл_Окрашенный темно-серый матовый
Layer6.Ventilated:	Unknown
Layer6.Material:	<Unnamed>

IfcWindowStyle

OperationType:	NOTDEFINED
ConstructionType:	NOTDEFINED

Pset_WindowCommon

Reference:	1170x1760h
IsExternal:	False

Product

Product Name:	AC_Окно_1Створка_ГОСТ23166-99:1170x1760h:313784
Description:	
Object Type:	AC_Окно_1Створка_ГОСТ23166-99:1170x1760h
Owning User:	@Название организации
Creation Date:	21/04/2022 7.48.06
Last Modified Date:	21/04/2022 7.48.06
Change Action:	NoChange
State:	Undefined
Application:	Autodesk Revit 2023 (RUS) (Revit v2023)

PresentationLayers

Layer:	***

Figure 30. Properties IFC element Revit, Trimble Connect

7.2 ArchiCad object IFC properties

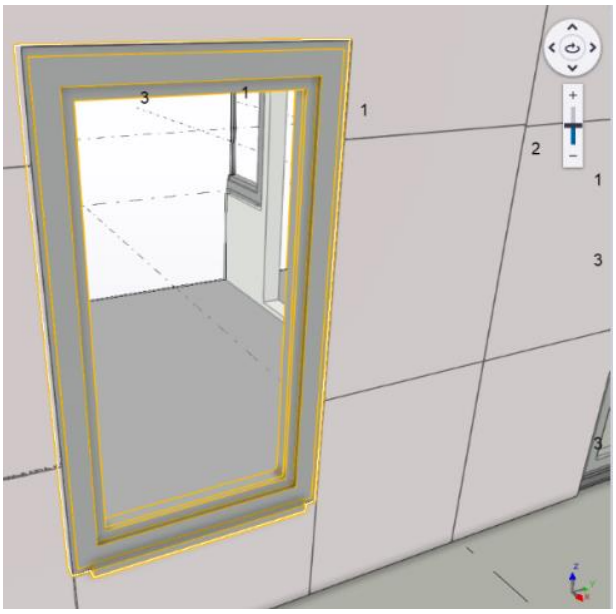


Figure 31. IFC element ArchiCad, Trimble Connect

IFC Window object exported from ArchiCad contains the following information:

- CalculatedGeometryValues – Calculated by Trimble Connect geometrical information based on solid geometry;

- IFCMaterial – Material data;
- AC_Pset_RenovationAndPhasing – Information about the phase of construction;
- IfcClassificationReference – Information about the source of model and its number;
- Pset_QuantityTakeOff – Size of window;
- ArchiCADProperties – set of Archicad element ID, name, type, layer, positioning, material, and surface paint information;
- ArchiCadQuantities – Calculated by ArchiCAD geometrical information such as Area, Height, Volume, Top and Bottom Elevations relative to the ground surface and sea level and survey coordinates;
- Pset_WindowCommon – Fire, Acoustic, and Safety rating;
- AC_Pset_Separate_Window_IFC3 – Surface material names and their graphical representation;
- Product – Information about model name, producer, and date produced.

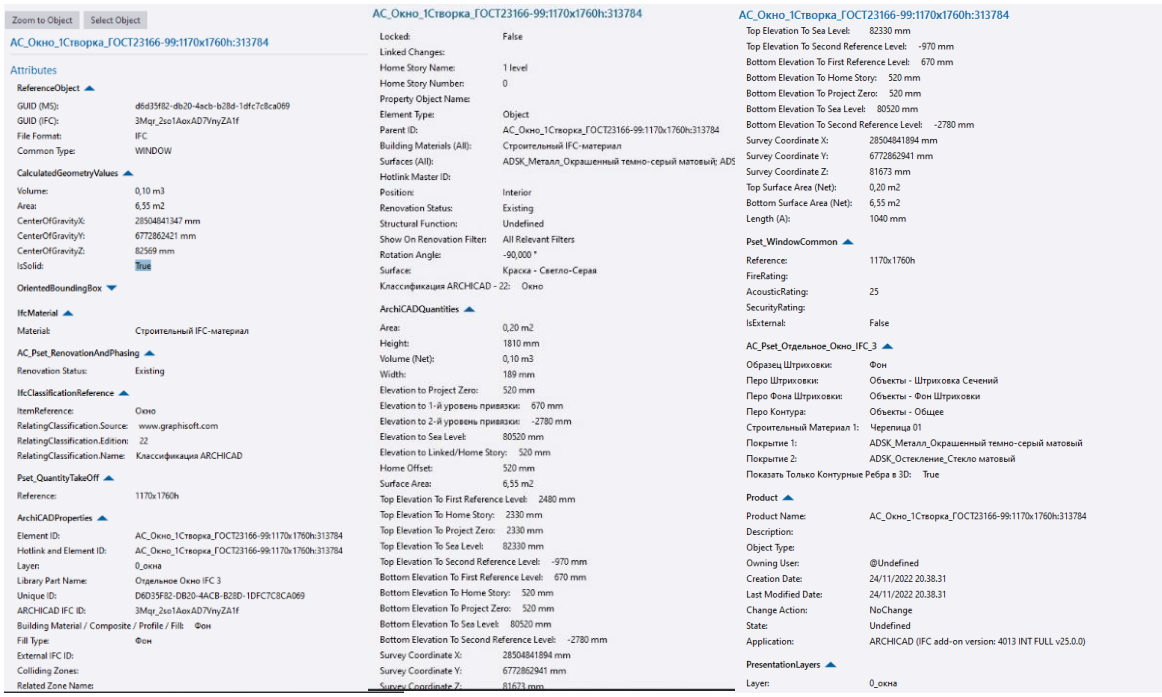


Figure 32. Properties IFC element ArchiCad, Trimble Connect

7.3 Comparison of ArchiCad IFC-model with Revit IFC-model

By reviewing the window element in both models, we can see that the ArchiCad IFC model contains more information than the Revit IFC model, mostly about materials, more detailed geometry description, and some special graphs such as Fire, Acoustic, Safety rating, and phase of construction. However, not all of this information is generated automatically. A lot of unique information graphs remain empty or have no relevant information if this information was not written manually in ArchiCad.

For the Revit model, there is a bit less information available to see, but nevertheless, it's still possible manually add custom IFC parameters to elements in Revit, and they will appear in any IFC viewer. So, it's also possible to add needed information to the element.

In a comparison of information in elements, the conclusion can be made that geometry and material data are being automatically generated from both models without a problem. But talking about other more specific information in our model, it should be written manually while creating a BIM model in the original software. Not all ArchiCad libraries and Revit families contain all needed specific in-build object information. Depending on the purpose of our BIM model, keeping in mind how it is going to be used in the future and why – the information contained in future exported IFC should be created and controlled during the stage of creating the BIM model.

Below, there is a comparison table (Table 2) between ArchiCad and Revit-produced IFC models:

Parameter	ArchiCad	Revit
Size of IFC model	10.3 MB	3 MB
Geometry information	+++	+
Material information	+	+
Possibility to create custom IFC parameter	+	+
Element type	+	+
Construction stage info	+	-
Special information	Has to be filled manually	-
Product data	+	+

Table 2. Comparison table between ArchiCad and Revit produced IFC models

8 Summary

The aim of the work was to investigate the capabilities of Autodesk Revit and Graphisoft ArchiCad in OpenBIM workflows and to compare them. In the process of comparison, it can be concluded that the design tools in both software are equally strong, and certainly have weaknesses in one or the other. But on the given comparisons, for example the adjustment of coordination points is easier and more intuitive in Archicad, as all settings are in one dialog box, as well as with the settings of MVD.

To summarize, we can conclude that both considered software programs tend to develop in OpenBIM direction, and approaches to help designers to minimize collisions.

OpenBIM is a unique opportunity to combine projects and different representations of buildings into a collaborative model, a technology that allows design participants to interact regardless of the tool used. The concept is still evolving, and thanks to the BuildingSmart community, we can use standards that help us work correctly with OpenBIM.

References

BIM: What does this mean? BIMLAB. [Online] https://bimlab.ru/faq-bim3d.html.

What is openBIM®? buildingSMART. [Online] https://www.buildingsmart.org/about/openbim/openbim-definition/.

Database, MVD. buildingSMART. [Online] https://technical.buildingsmart.org/standards/ifc/mvd/mvd-database/.

About BCF. BIMcollab. [Online] https://www.bimcollab.com/en/resources/openbim/about-bcf.

Common BIM Requirements 2012. BuildingSMART Finland. [Online] https://buildingsmart.fi/en/common-bim-requirements-2012/.

Yleiset tietomallivaatimukset YTV2012. BuildingSMART Finland. [Online] https://buildingsmart.fi/yleiset-tietomallivaatimukset-ytv/.

Graves, Michael. Architecture and the Lost Art of Drawing. The New York Times. [Online] https://www.nytimes.com/2012/09/02/opinion/sunday/architecture-and-the-lost-art-of-drawing.html.

Revit. wikipedia.org. [Online] https://ru.wikipedia.org/wiki/Revit.

A Brief History of ArchiCAD. Scan2CAD. [Online] https://www.scan2cad.com/blog/cad/archicad-brief-history/.

Native Archicad Survey Point. GRAPHISOFT. [Online] https://community.graphisoft.com/t5/Data-Exchange-articles/Native-Archicad-Survey-Point/ta-p/304147.

Knowledge Network. AUTODESK. [Online] https://knowledge.autodesk.com/support/revit/learn-explore/caas/CloudHelp/cloudhelp/2018/ENU/Revit-Model/files/GUID-68611F67-ED48-4659-9C3B-59C5024CE5F2-htm.html.

Project Location and Project North. GRAPHISOFT help center. [Online] https://community.graphisoft.com/t5/Data-Exchange-articles/Native-Archicad-Survey-Point/ta-p/304147.

BIMcloud User Guide. Graphisoft Help Center. [Online] https://helpcenter.graphisoft.com/.

Coordinates converter. [Online] https://coordinates-converter.com/en/decimal/61.064555,28.087728?karte=OpenStreetMap&zoom=16.

History of Revit || BIM Learning4U. [Online] https://www.youtube.com/watch?v=QU75aO-Hl4