YRKESHÖGSKOLAN
NOVIA

Measuring and extracting data from a BIM model

Oskar Lindström

Thesis for a master's degree

The Degree Program of Industrial Management & Engineering

Vasa 2022

DEGREE THESIS

Author:	Oskar Lindström
Degree Program:	The Degree Program of Industrial Management & Engineering (University of Applied Sciences), Vasa, Finland
Specialisation:	
Supervisor (s):	Juhani Hovi, Lumon Oy Mats Braskén, Novia UAS

Title: Measuring and extracting data from a BIM model

Date: 27.5.2022 Number of pages: 48 Appendices: 0

Abstract

This thesis aims to provide technical help in understanding what BIM is and how to implement this for Lumon Oy's technical support department. Furthermore, it will serve as the foundation for Lumon's transition to Building Information Modeling (BIM) and the capabilities that come with it. In this thesis, we will delve into the world of BIM and take a close look at how Autodesk Revit families work, how we can make manual measurements in Solibri, as well as how we could automate the process of extracting data from an IFC file, which is the standard file format that every design discipline shares across disciplines in the design industry.

Autodesk Revit and Solibri Model Checker are the most commonly used design applications.

Language: English Keywords: BIM, Solibri, Building design, Autodesk Revit, RAK, Lumon

---

EXAMENSARBETE

Författare:	Oskar Lindström
Utbildning och ort:	The Degree Program of Industrial Management & Engineering (University of Applied Sciences), Vasa, Finland
Inriktingsalternativ/Fördjupning:	
Handledare:	Juhani Hovi, Lumon Oy Mats Brarskén, Novia UAS

Titel: Mätning och uttagande av information från en BIM modell

---

Datum: 27.5.2022 Sidantal: 48 Bilagor: 0.

Abstrakt

Syftet med detta examensarbete är att ge teknisk hjälp till Lumon Oy:s tekniska supportavdelning. Dessutom kommer den att tjäna som grund för Lumons övergång till BIM (Building Information Modeling) och de möjligheter som följer med den. I den här avhandlingen kommer vi att dyka in i BIM-världen och titta närmare på hur Autodesk Revit-familjer fungerar, hur vi kan göra manuella mätningar i Solibri samt hur vi kan automatisera processen att extrahera data från en IFC-fil, som är det standardfilformat som varje designdisciplin delar mellan olika discipliner i byggnadsbarnchen.

Autodesk Revit och Solibri Model Checker är de vanligaste konstruktionsprogrammen.

Språk: Engelska Nyckelord: BIM, Solibri, Building design, Autodesk Revit, RAK, Lumon

---

OPINNÄYTETYÖ

Tekijä: Oskar Lindström

Koulutusohjelma ja paikkakunta: The Degree Program of Industrial Management & Engineering (University of Applied Sciences), Vasa, Finland

Suuntautumisvaihtoehto /Syventävät opinnot:

Ohjaajat: Juhani Hovi, Lumon Oy

Mats Brarsken, Novia UAS

Nimike: Mittaus ja tiedon saataminen BIM mallista.

Päivämäärä: 27.5.2022 Sivumäärä: 48 Liitteet: 0

Tiivistelmä

Tämän opinnäytetyön tarkoituksena on antaa teknistä apua Lumon Oy:n teknisen tuen osastolle. Lisäksi se toimii pohjana Lumonin siirtymiselle rakennuksen tietomallintamiseen (BIM) ja sen mukanaan tuomiin mahdollisuuksiin. Tässä opinnäytetyössä syvennytään BIM:n maailmaan ja perehdytään tarkkaan, miten Autodesk Revit -perheet toimivat, miten voimme tehdä manuaalisia mittauksia Solibri-ohjelmassa sekä miten voisimme automatisoida tietojen poimimisen IFC-tiedostosta, joka on standarditiedostomuoto, jonka kaikki suunnittelualat jakavat suunnittelualan eri tieteenalojen kesken.

Autodesk Revit ja Solibri Model Checker ovat yleisimmin käytettyjä suunnittelusovelluksia.

Kieli: English Avainsanat: BIM, Solibri, Building design, Autodesk Revit, RAK, Lumon

---

Table of contents

Abbreviations

BIM	Building Information Model
IFC-Standard	Open source standard file format
IFC-Model	Native model exported to. IFC file.
Autodesk Revit	Architect software made by Autodesk
Solibri	IFC viewed the program and material takeoff
Notepad++	Open source program to open different file formats
Presets	IFC parameters that can be custom made
ITO	Information takeoff in Solibri
YTV	Finnish BIM standard

1. Introduction

Lumon is a company that specialises in balcony glazing and railings and terraces and terrace railings and other outdoor living spaces. Moreover, Lumon sells its products worldwide, from Chile to Norway's North Cape, and the company employs over 2000 people involved in everything from installation to manufacturing to product creation and development. In order for Lumon Oy to incorporate Building Information Modelling (BIM), this thesis will serve as the foundation for such understanding.

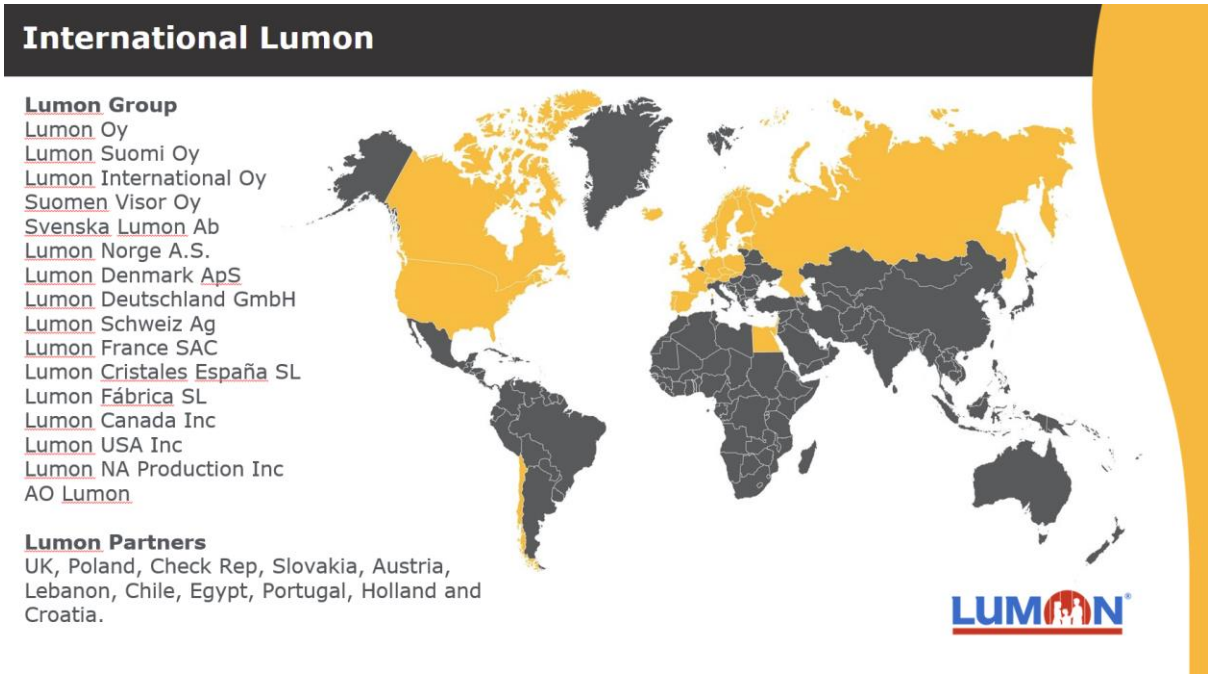


Figure 1: Lumon around the World (Lumon 2022)

1.1 Company Background

Lumon has established itself as the market leader in Finland for balcony glazing and glass railings, with a presence in other countries across the world, including North America and Europe. An essential topic to investigate while writing this thesis is how Lumon could digitalise the workflow in the field of Building Information Modelling. Unfortunately, the amount of expertise in BIM and the knowledge of what BIM is are inadequate at Lumon. However, while this thesis will aid in developing competence, it will also present a clear image of what we need to work on and where we may achieve significant benefits from the application of BIM in the construction business.

Figure 2: Lumon in numbers 2020 (Lumon 2022)

1.2 BIM at Lumon until 2022

At the very least, since 2012, when Lumon introduced BIM-Object, a service that made chosen Archicad objects available for download by end-users, BIM has been a part of the organisation since then. Although this was initially accurate, our perspective quickly shifted when we began examining what tools were currently available and how they could be improved to support better the daily tasks of an architect or engineer in their profession. There has been a lack of knowledge about Building Information Modelling (BIM) for several decades, but that has changed drastically since Lumon realised the power behind BIM. (Hovi, 2022)

Figure 3: BIM (Adobe 2022)

Figure 4: AutoCAD (Autodesk Inc 2022)

1.3 Aim of the thesis

It is essential to understand how Lumon may use the data obtained throughout the offering stage and during a support person's or a salesperson's day-to-day workflow. Therefore, it is critical to understand the premade and user-made parameters and accurately make the full use of them in both Autodesk Revit and Archicad; however, it is also critical to ensure that they are appropriate for both an overall project manager and the architect or engineer who will utilise the objects that are made available to them.

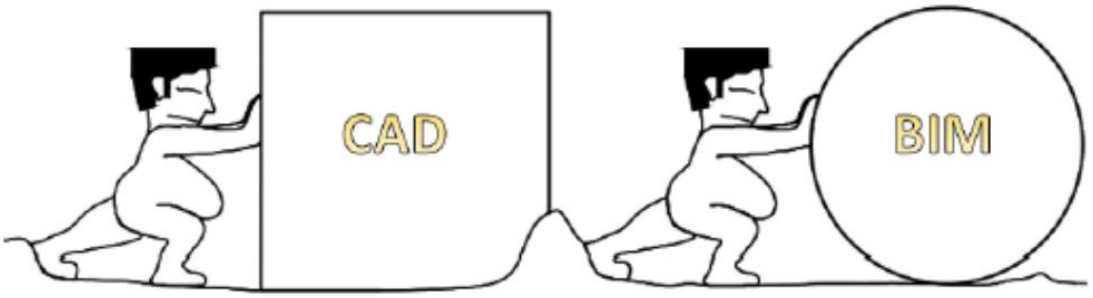


Figure 5: What we would like to achieve with BIM; the picture illustrates the workflow from CAD design to BIM design. (Fleming 2016)

2. The IFC Standard

The procedure that is followed in this thesis can be broken down into two parts, which are the following: the information takeoff with the assistance of using Solibri and the development of Revit families. However, having a firm grasp of the IFC standard is essential to amass the particular pieces of knowledge required for both the utilisation of Solibri and the production of Revit families. In addition, a few specialists in the field of building information modelling (BIM) will be asked to participate in brief interviews about the process by which Revit families are developed and utilised in the regular workflow of the software. In the following two sub-chapters, you will get an in-depth look into the IFC file format and a native model, both of which are discussed in the previous chapter and are essential to comprehending the concepts of information takeoff and family building.

2.1 IFC

IFC, or "Industry Foundation Classes," is a digital description of the built environment defined and used across industries. It includes buildings and civil infrastructure (IFC). In numerous hardware devices, software platforms, and interfaces, a widely applicable, vendor-neutral international standard (ISO 16739-1:2018) is used for a variety of different use cases. In order for building SMART International to realise its mission of promoting openBIM around the world, such specification is the essential technical deliverable they can provide. (BuildingSmart, 2022)

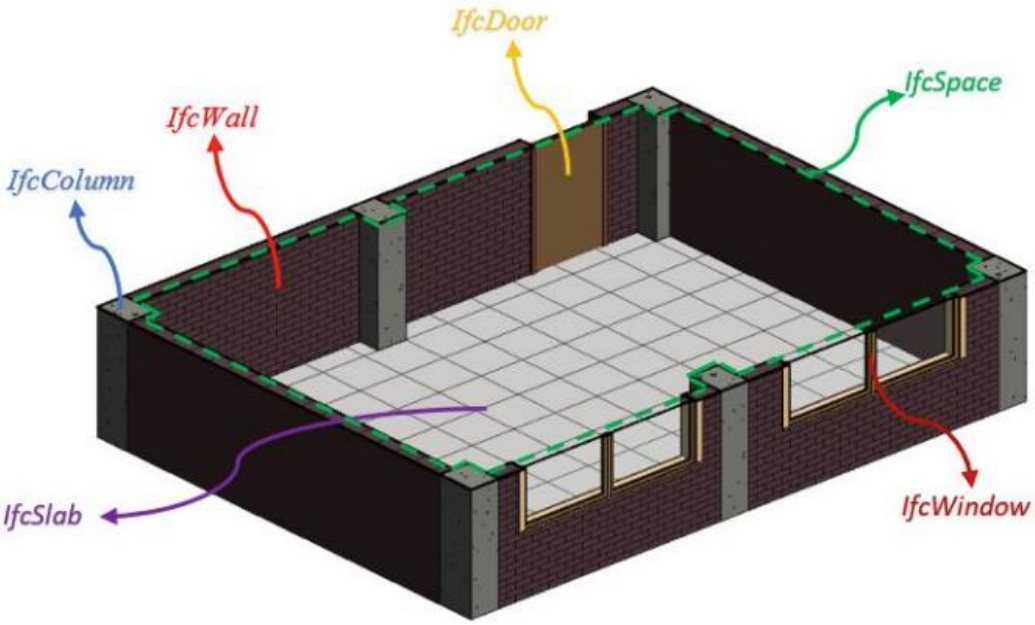


Figure 6: Example of IFC entities in an IFC export; this shows a clear picture of the entities like IfcDoor, a door in the picture. (Temel and Başağa)

According to the IFC schema, the IFC model is a defined data model which organises information according to a logical way. It is described in a few ways below:

1. Identity and semantics include name, unique machine-readable identifier, object type, or function.
2. Characteristics or attributes can be material, colour, or thermal properties.
3. Relationships that include location connections and ownership.
4. Objects such as columns, slabs, and walls.
5. Abstract concepts like performance and costing.
6. Processes such as installation and operations.
7. People that are owners, designers, contractors, etc.

The use, building, and operation of an installation can all be described in the schema description. Besides more abstract structural analysis models, IFC can specify mechanical and electrical systems, building and product components, and other related items. Additionally, IFC can break down project expenses and schedule projects.

(BuildingSmart, 2022)

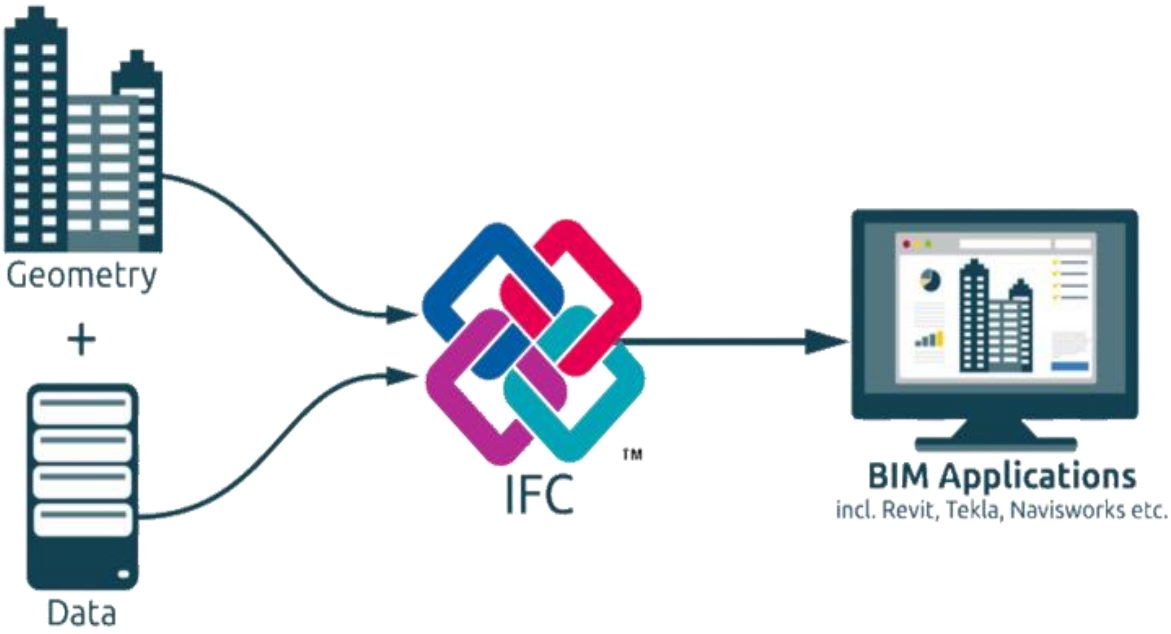


Figure 7: What is IFC? BuildingSmart 2022

2.1.1 How is IFC used, and who uses IFC?

IFC is a defined format for storing project information that the International Federation of Construction has developed. Currently, IFC is the most often utilised protocol for transferring information from one party to another to perform a "business" transaction in terms of data between the two parties. Using an example, a designer might submit a model of a new facility design to an owner, who might then send that model to a contractor for bid solicitation. The contractor might then deliver an as-built model that includes specifics about the installed equipment and manufacturer information to the owner. Additionally, IFC can keep project information so that the user can manipulate it and develop it throughout the design, procurement, and construction stages or as an "as-built" collection of information for long-term preservation and operations. For IFC data, various encoding options are available to choose from. We can transfer this information over the Internet or import and export it across databases using XML, JSON, or STEP files. Users of building information modelling tools will export

and import data in some IFC format from the software vendors who provide these tools and examine and analyse their models. It is entirely up to the individual user to share the data from a tool through the IFC. There are hundreds of different software applications that can send and receive IFC data, and numerous parties taking part in the process use them. Since 1997, it has been tried and tested, and it has earned general acceptance as a delivery mechanism for projects worldwide, including in the United States and Europe. (BuildingSmart, 2022)

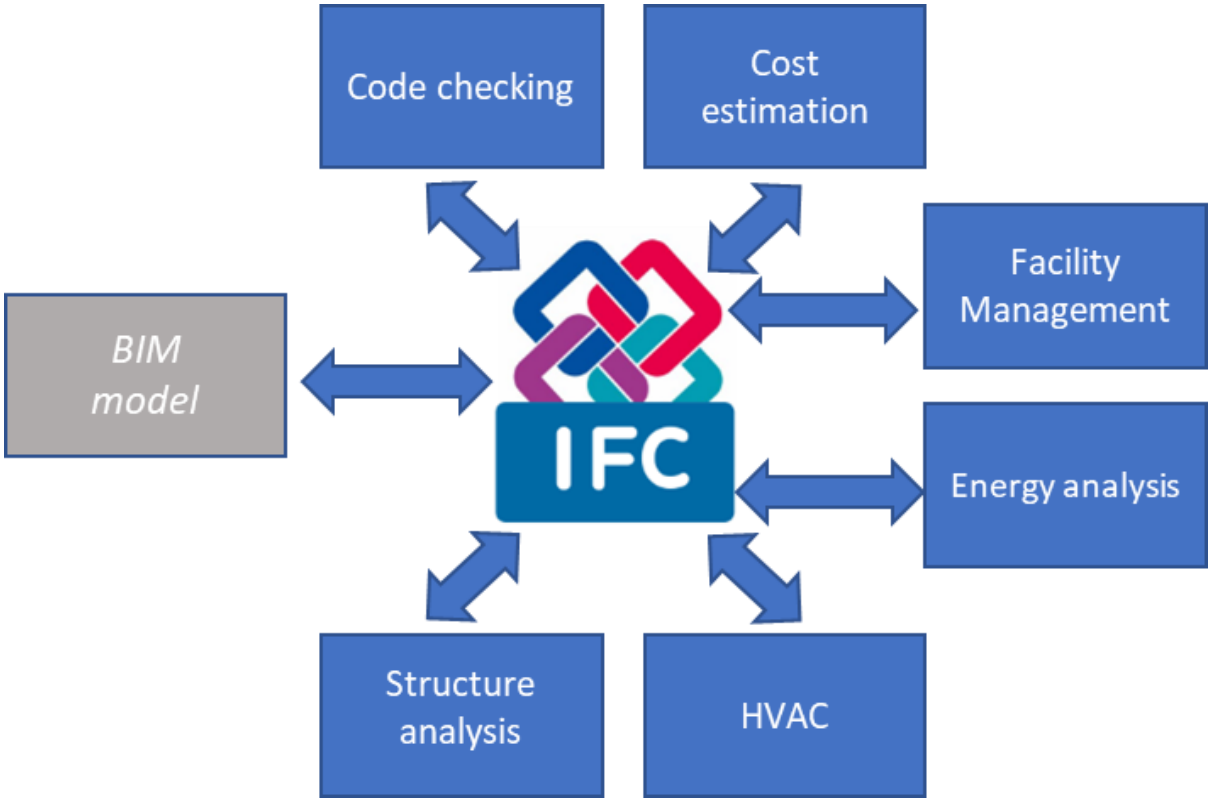


Figure 8: Example of interoperability benefits with the IFC schema (BuildingSmart)

2.2 Native model

The native model results from the program used to do the design and the modelling part. A native model described in the chapter above results from using vendor software to do the main design of a building or other parts. Software such as Autodesk Revit or Archicad are examples of this type. Typically, an architect or engineer will design the building within the programme, including all the project's drawings and details and any other design disciplines that have provided models used in the project. Working in a native model allows every discipline to operate within the same programme and precise model, which is a significant benefit if the program can do so. For example, Revit is capable of doing so. Such teamwork could help

reduce design flaws, and the partnership would operate in a dream way without problems. (Vikki, 2022)

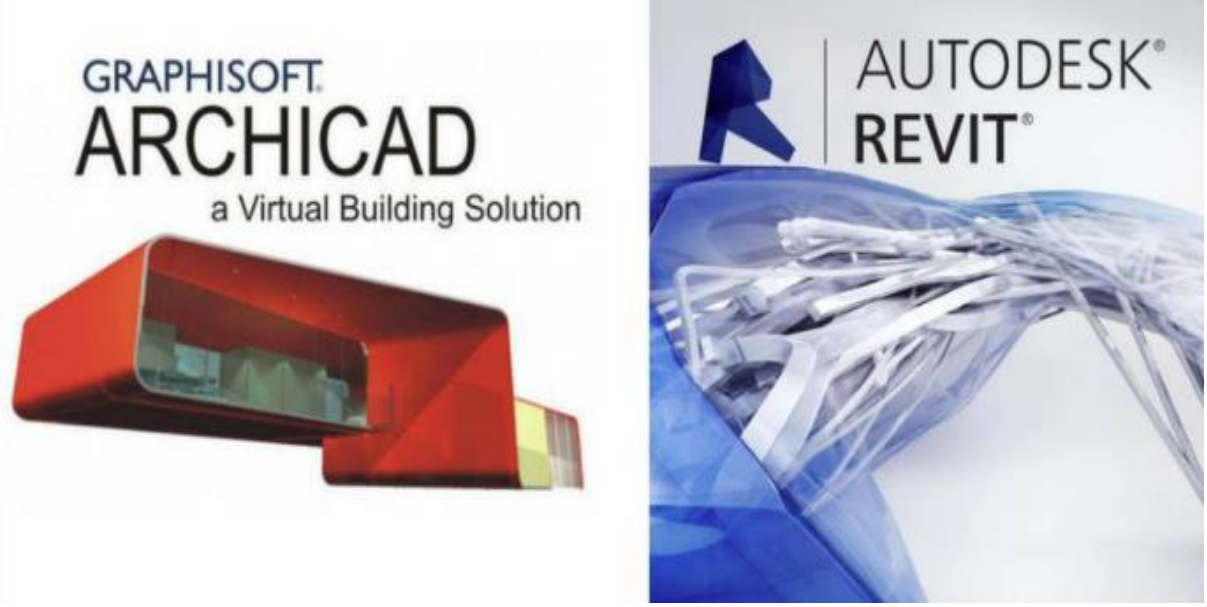


Figure 9: Archicad & Autodesk Revit (Tesla CAD UK 2018)

3. What is BIM?

BIM (Building Information Modeling) is a cutting-edge construction technology with much promise for the future. BIM can be defined as using a building's information model to plan, design, implement and maintain the building during its entire life cycle. BIM and IFCs are bridged together where BIM is the information part, and IFC is the database where everything is structured in a specific hierarchy.

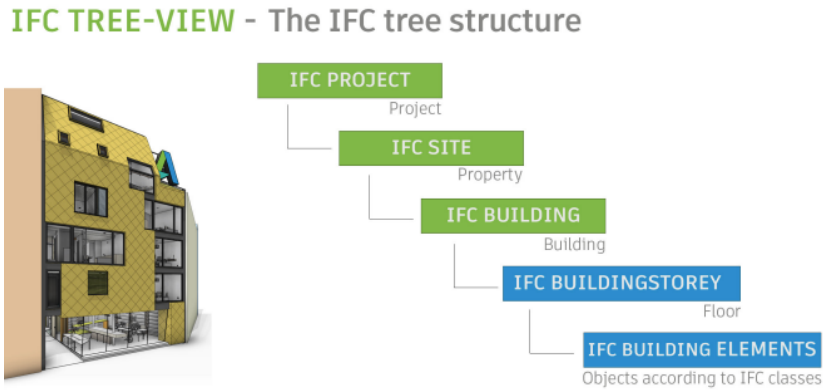


Figure 10 Example view of the IFC hierarchy (Revit IFC manual)

There are numerous advantages to using BIM in building projects, including reducing errors, rework, and waste. Additionally, the use of BIM in building projects allows for

multidisciplinary collaboration across different project teams, the attainment of project objectives, and an increase in the overall productivity of the building construction process. Visualisation, clash detection and code checking, communication, cooperation, monitoring, and time and cost management are a few things building information modelling (BIM) applications use in a construction project. Furthermore, with the potential to give extra information and interoperability opportunities over traditional computer-aided design (CAD), BIM represents a significant technological advancement over traditional computer-aided design (CAD). Because of this, BIM is frequently referred to as the industry's technical forerunner. Furthermore, because structures have a high monetary value and significantly impact the environment and people's overall quality of life, the construction industry can be one of the most critical long-term growth drivers. Therefore, it is a healthy development when the repercussions of a construction project on the environment, economy, and society are effectively handled, which is meant by sustainable construction.

(Bilal Manzoor, 2021)

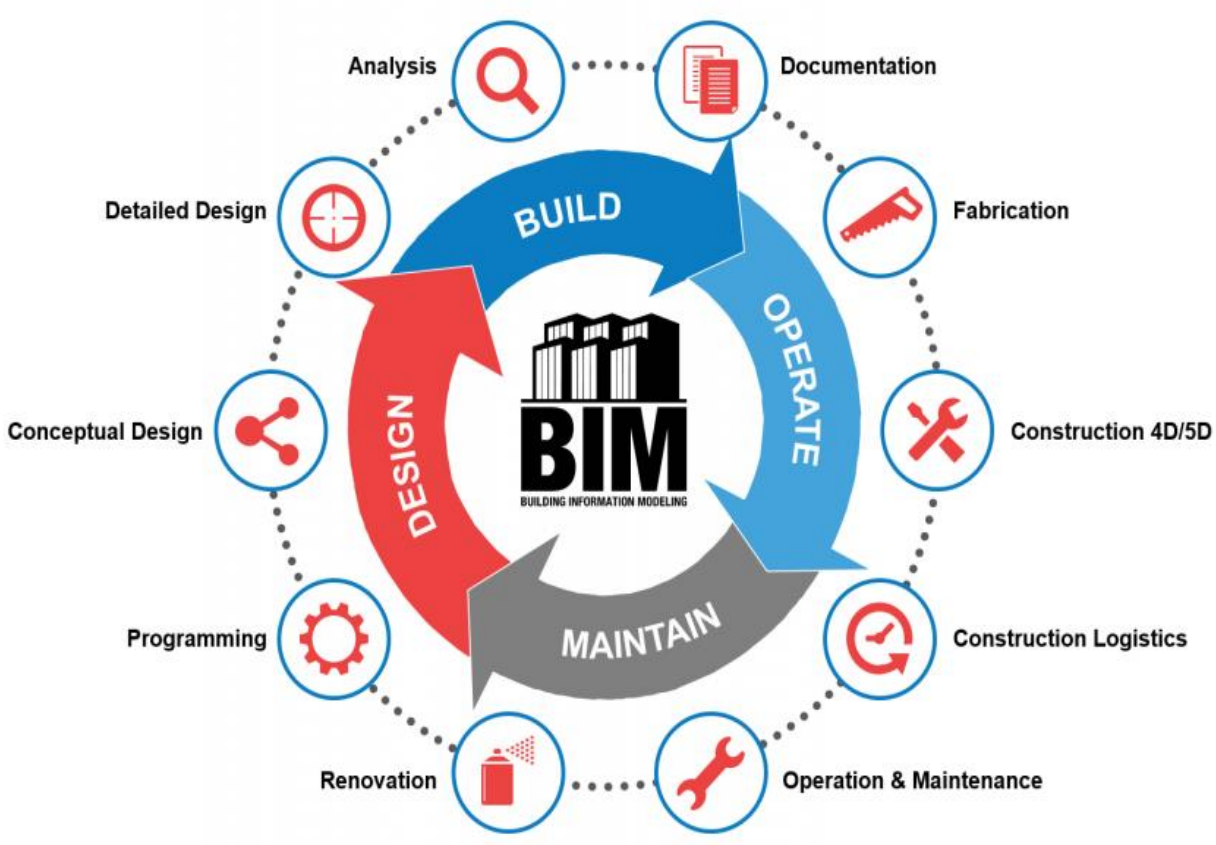


Figure 11: The cycle of BIM (Daniel Maiman)

3.1 Why BIM?

The fact that the industry is developing at such a rapid rate causes the participation of companies like Lumon in the transition that is currently underway. Using BIM is excellent for gathering the data and visible parts of the building. Failing to take advantage of this opportunity would be fatal to the business if we cannot compete with the market. Alternatively, it may compel us to go out of business because of a lack of capacity to fulfil the demand for 3D models and support our built-in tools in the worst-case scenario. In order to satisfy the expected demand, Lumon hired a BIM-Specialist for their team last year, who started to work in 2021. In addition, when projects are first formed, we usually visualise what the finished product will look like in some software. This is another advantage of employing BIM technology. That assists all disciplines in identifying and resolving problems as they arise and minimises errors that may occur on the construction site while the project is being designed. Details of the BIM advantages are shown in Figure 12 on the next page.

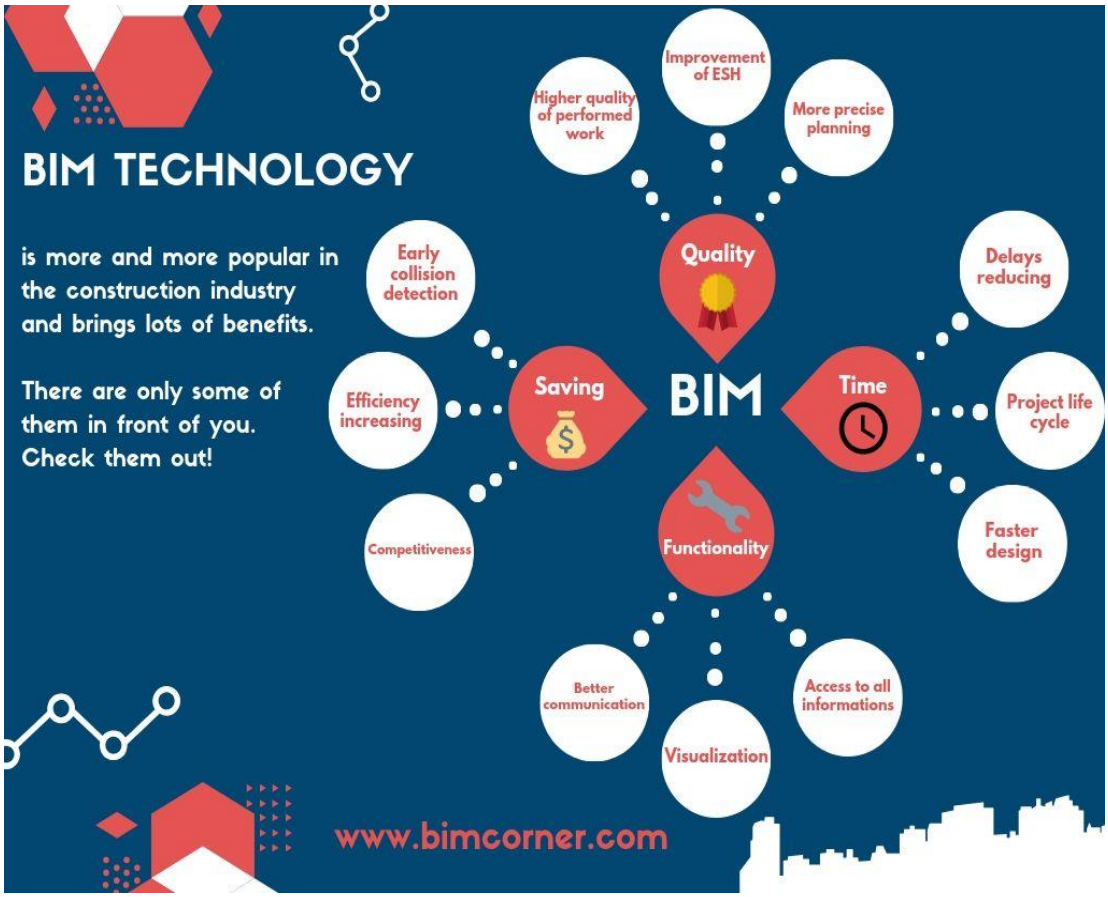


Figure 12: Why use BIM? (BIM corner)

3.2 How could this help Lumon?

Because Building Information Modelling (BIM) has been in use for approximately ten years, Lumon will try to employ it daily in the daily building projects. By making employees familiar with BIM at a basic level, we can ensure that the future process of using BIM will run smoothly and maximise user advantage from this technology. We may start by launching it for a small group of people and then gradually expanding it to include the entire group from all over the world, if necessary. Furthermore, everyone will benefit from BIM implementation, from salespeople to project managers. As BIM becomes more integrated into manufacturing processes, it may provide a clear picture of what could be missing from the offer stage or if there has been some updated architect model that has added new glazing as an example. Installers on the job site will also benefit from BIM since it will allow them to understand better the project and the location of where they are on the job site and see if everything is provided as it should be from the manufacturing line. There could be missing parts that the salesperson has not "ticked" in when the sale was made. In this case, even before going to the site, the installer could ask for the missing parts. (Hovi, 2022)

4. Measuring objects in BIM

An IFC file and an IFC reader programme are generally used in BIM to measure objects or perform other measurement operations, such as taking a reading from an IFC file. An IFC file contains many text-only data lines that can be read with a text-based programme like Notepad++. So even though IFC is a text-based code that can only be read by using an IFC viewer programme, Notepad++ may also be used to do the modelling part.

4.1 Notepad++

"Notepad++ is a text editor and source code editor under Microsoft Windows. It supports around 80 programming languages with syntax highlighting and code folding. Thanks to its tabbed editing interface, it allows working with multiple open files in a single window. Notepad++ is available under GPL and distributed as free software."

(Notepad++, 2022)

Notepad++ software can open any file format and change any of the information contained within the file. However, several precautions must be taken while working primarily with text-based programmes such as Notepad++. First, it is vital to understand how data is organised throughout the entire code to understand how it works and binds with other parts properly. Failure to understand how the data works could lead to problems when the native programme is trying to open the IFC model after coding the changes have been made manually.

Figure 13: Notepad++ Logo (Notepad++)

HEADER SECTION

```
ISO-10303-21;
HEADER;
/*********************************************************************************************
* STEP Physical File produced by: The EXPRESS Data Manager Version 5.02.0100.07 : 28 Aug 2013
* Module:                         EDMstepFileFactory/EDMstandAlone
* Creation date:                  Fri Dec 03 13:25:50 2021
* Host:                           FIN-21-04-0961
* Database:
C:\Users\oskarl\AppData\Local\Temp\25f60a26-4bbc-46d3-9440-2624d40a7201\6a98bdc5-f3ec-4481-8ccd-2597176aba29\ifc
* Database version:               5507
* Database creation date:         Fri Dec 03 13:25:50 2021
* Schema:                         IFC2X3
* Model:                          DataRepository.ifc
* Model creation date:            Fri Dec 03 13:25:50 2021
* Header model:                   DataRepository.ifc_HeaderModel
* Header model creation date:     Fri Dec 03 13:25:50 2021
* EDMuser:                        sdai-user
* EDMgroup:                       sdai-group
* License ID and type:            5605 : Permanent license. Expiry date:
* EDMstepFileFactory options:     020000
*********************************************************************************************/
FILE_DESCRIPTION(('ViewDefinition [CoordinationView_V2.0]'),'2;1');
FILE_NAME('0001','2021-12-03T13:25:50',(''),(''),'The EXPRESS Data Manager Version 5.02.0100.07 : 28 Aug
2013','21.1.40.95 - Exporter 21.4.1.0 - Alternate UI 21.4.1.0','');
FILE_SCHEMA(('IFC2X3'));
ENDSEC;

DATA;
#1= IFCORGANIZATION($,'Autodesk Revit 2021 (ENU)',$,$,$);
#5= IFCAPPLICATION(#1,'2021','Autodesk Revit 2021 (ENU)','Revit');
#6= IFCCARTESIANPOINT((0.,0.,0.));
#10= IFCCARTESIANPOINT((0.,0.));
#12= IFCDIRECTION((1.,0.,0.));
#14= IFCDIRECTION((-1.,0.,0.));
#16= IFCDIRECTION((0.,1.,0.));
#18= IFCDIRECTION((0.,-1.,0.));
#20= IFCDIRECTION((0.,0.,1.));
#22= IFCDIRECTION((0.,0.,-1.));
#24= IFCDIRECTION((1.,0.));
#26= IFCDIRECTION((-1.,0.));
#28= IFCDIRECTION((0.,1.));
#30= IFCDIRECTION((0.,-1.));
#32= IFCAXIS2PLACEMENT3D(#6,$,$);
#33= IFCLOCALPLACEMENT(#157,#32);
#36= IFCPERSON($,'','oskar.lindstromLE8LN',$,$,$,$,$);
#38= IFCORGANIZATION($,'','',$,$);
#39= IFCPERSONANDORGANIZATION(#36,#38,$);
```

BODY SECTION

```
#8623= IFCCLASSIFICATIONREFERENCE('https://www.csiresources.org/standards/uniformat','l2514','Parvekekaiteet ja
-lasitukset',#283);
#8624= IFCRELASSOCIATESCLASSIFICATION('3W6pJ1UAPCoBhOauquVc3J',#42,'Uniformat Classification','',(#8584),#8623);
#8628= IFCPROPERTYSINGLEVALUE('Name',$,IFCLABEL('Level 1'),$);
#8629= IFCPROPERTYSET('3Y3tOxUmS143Gede33WYGI',#42,'Pset_AirSideSystemInformation',$,(#8628));
#8631= IFCPROPERTYSINGLEVALUE('AboveGround',$,IFCLOGICAL(.U.),$);
#8632= IFCPROPERTYSET('0zJQ$GvJf8nhynNso36HdK',#42,'Pset_BuildingStoreyCommon',$,(#8631));
#8634= IFCPROPERTYSINGLEVALUE('Name',$,IFCLABEL('Level 1'),$);
#8635= IFCPROPERTYSINGLEVALUE('Category',$,IFCLABEL('Levels'),$);
#8636= IFCPROPERTYSET('1CewRlKMbECRBieM4yvlA4',#42,'Pset_ProductRequirements',$,(#8634,#8635));
#8638= IFCRELDEFINESBYPROPERTIES('35QiwCmv5A6hHl6lu$dfG5',#42,$,$,(#148),#8629);
#8642= IFCRELDEFINESBYPROPERTIES('1sdQmr1050MxU8nhpABeIO',#42,$,$,(#148),#8632);
#8645= IFCRELDEFINESBYPROPERTIES('3bR4yZ52v3QgpGwLKoE$jQ',#42,$,$,(#148),#8636);
#8653= IFCRELAGGREGATES('27FPNUKb958R_vgCEt6tfs',#42,$,$,#128,(#158));
#8657= IFCRELAGGREGATES('0FBu6uFvjFBAxV7$NYP5W3',#42,$,$,#158,(#139));
#8661= IFCRELAGGREGATES('27PCKGLxT4mxtV9cw6mgBW',#42,$,$,#139,(#148));
#8665= IFCPROPERTYSINGLEVALUE('NumberOfStoreys',$,IFCINTEGER(1),$);
#8666= IFCPROPERTYSINGLEVALUE('IsLandmarked',$,IFCLOGICAL(.U.),$);
#8667= IFCPROPERTYSET('0iMb8vV5EBmdorHtvcdQ65',#42,'Pset_BuildingCommon',$,(#8665,#8666));
#8669= IFCPROPERTYSINGLEVALUE('Category',$,IFCLABEL('Project Information'),$);
#8670= IFCPROPERTYSET('16Rzf0ALL7ghRFgBYqSoNh',#42,'Pset_ProductRequirements',$,(#8669));
#8672= IFCRELDEFINESBYPROPERTIES('1Zc18JVOLE5AUONKysFMg5',#42,$,$,(#139),#8667);
#8676= IFCRELDEFINESBYPROPERTIES('2rsjXZzfnCOBlYgYGqz7pT',#42,$,$,(#139),#8670);
#8679= IFCRELASSOCIATESMATERIAL('1HwgJm$cDBDurSJa0sXJlz',#42,$,$,(#207),#243);
#8682= IFCRELASSOCIATESMATERIAL('3AMd3RXU54WABSBrhiQL60',#42,$,$,(#222),#240);
ENDSEC;

END-ISO-10303-21;
```

Figure 14: Typical view in Notepad++ when opening an IFC model with visible header section and body section

The basic design of the IFC-file record is divided into two parts: the header and the body, which both supply information on the structure model. The header segment contains general information, such as the IFC form used and the date it created the entry. It is also visible that the user has chosen to go with the configuration of IFC 2x3 when exporting the model from a native program, in this case, Autodesk Revit. This is illustrated in the header section of an IFC file like in Fig. 14 when inspected. This configuration corresponds to the IFC 2x3 norm that BuildingSmart has stated. The model's body comprises information about math and the nature of the model's calculation (if there has been applied some structural loading on members or columns as an example), and the model's overall quality and accuracy when exported from a program. This section also offers information on how the connections between each model piece are given, which is beneficial in developing the model. Unless otherwise specified, each line of information in the body component of an IFC record begins with the hash key #. The hash key # is used to distinguish between the different lines of information in the database. The information lines are numbered sequentially, starting with # 1 and going down. There is an IFC element in each numbered line of the document. Every time a new building component is added to the model (such as a section, shaft, divider, floor, entryway, window, rooftop or steps), every time the material properties of the components are updated, and every time an interaction is acted on, the number of information lines in the IFC document grows. It is possible to compare each component of the structure model and each activity associated with modelling the structure in the BIM software (Revit) to a substance in the IFC information record, which is addressed as a graphical representation of the programme.

(Bayram Ali Temel, 2020)

However, it is difficult to grasp the information when everything is connected with lines, and they are not correctly aligned because of how some software, such as Autodesk Revit, generates the data. It would be simple to fill in the remaining measurements in a text editor such as Notepad++ to complete the measurements. As a result, opening the IFC in a model checker, such as the Solibri model checker, is less complicated. Furthermore, therefore, the way of doing so is presented in this thesis.

4.2 Manual measurement using Solibri

In Solibri, there is the option to measure the elements manually. The manual method validates an automatically generated measurement performed by the software. However, it can also be helpful when measuring an object that is difficult to grasp or that is problematic to measure. Solibri also enables the user to view the IFC hierarchy from an easy-to-view perspective.

To start measuring in Solibri, some actions are required. First, the user needs to open the model tab mode, choose from the dropdown menu from "info", and then press dimension, or you can get it directly by pressing the "9" key on your keyboard.

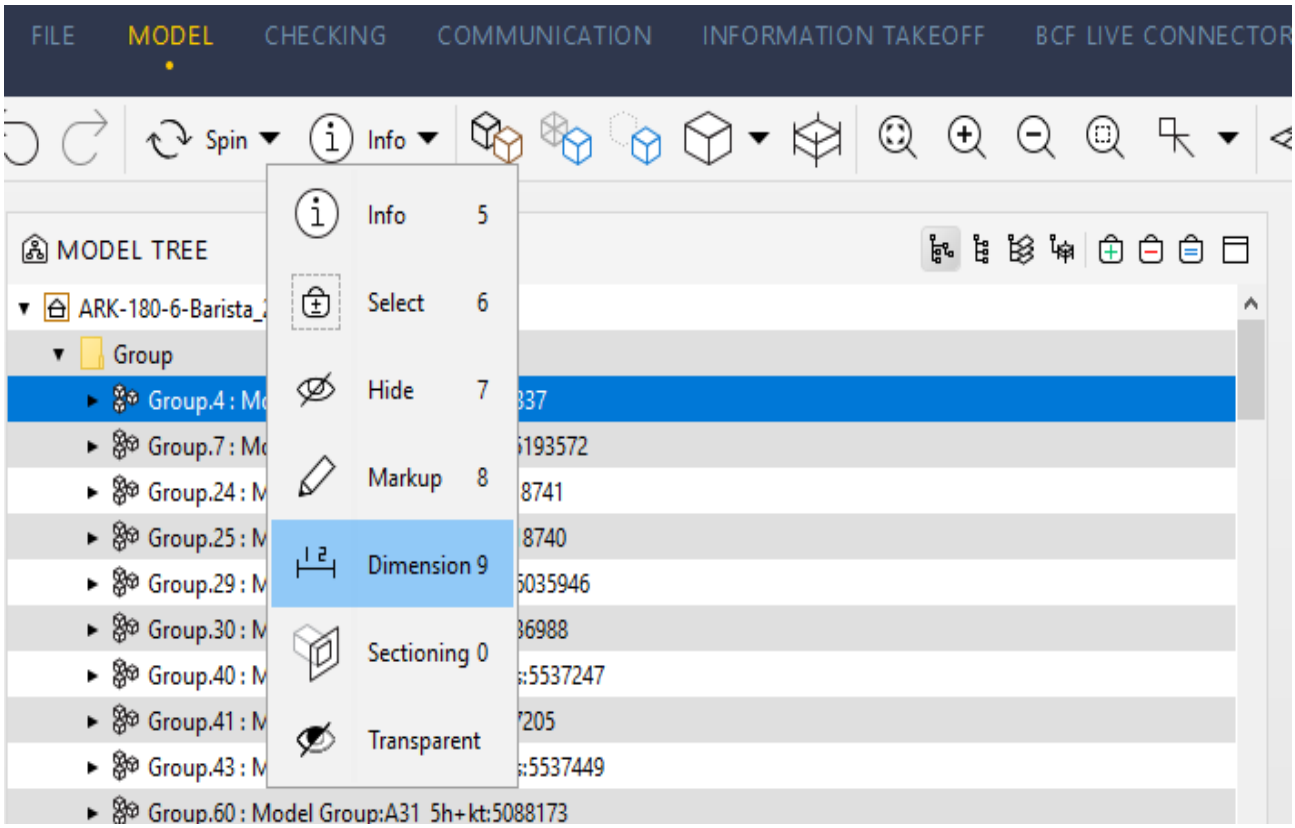


Figure 15: Manual way to measure elements in Solibri

Then, by hovering on elements and right-clicking, the user can do manual measurements. The result is visible in a purple colour and millimetres or meters, depending on how significant the distance or settings the user has made.

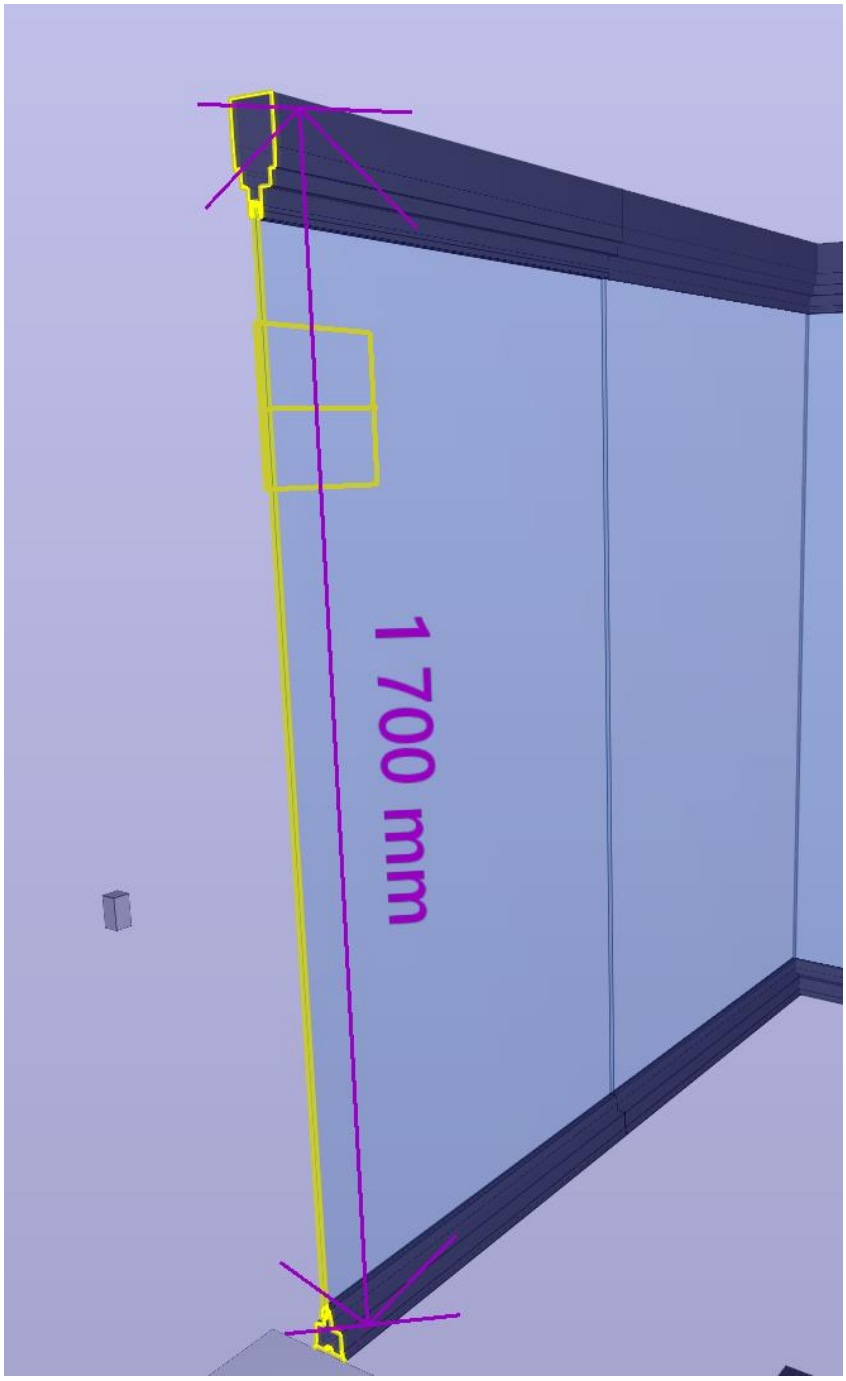


Figure 16: Manual measurement in Solibri

4.3 Automatic measurements via Solibri

In Solibri, the most intuitive way to measure items is to look at the object's parameters that have been selected as the starting point for measurement. For this demonstration, we shall use the same glazing as seen in Figure 16. Therefore, the accuracy of the parameters and their ability to be provided understandably and straightforwardly information are critical. Understanding the parameters and how to utilise them are covered in Chapter 6. In addition, using structured parameters that describe how the IFC is built makes it easier to navigate through the data and find what the user is searching for by selecting the element they want to seek in Solibri (in this case, Curtain Wall 8.8).

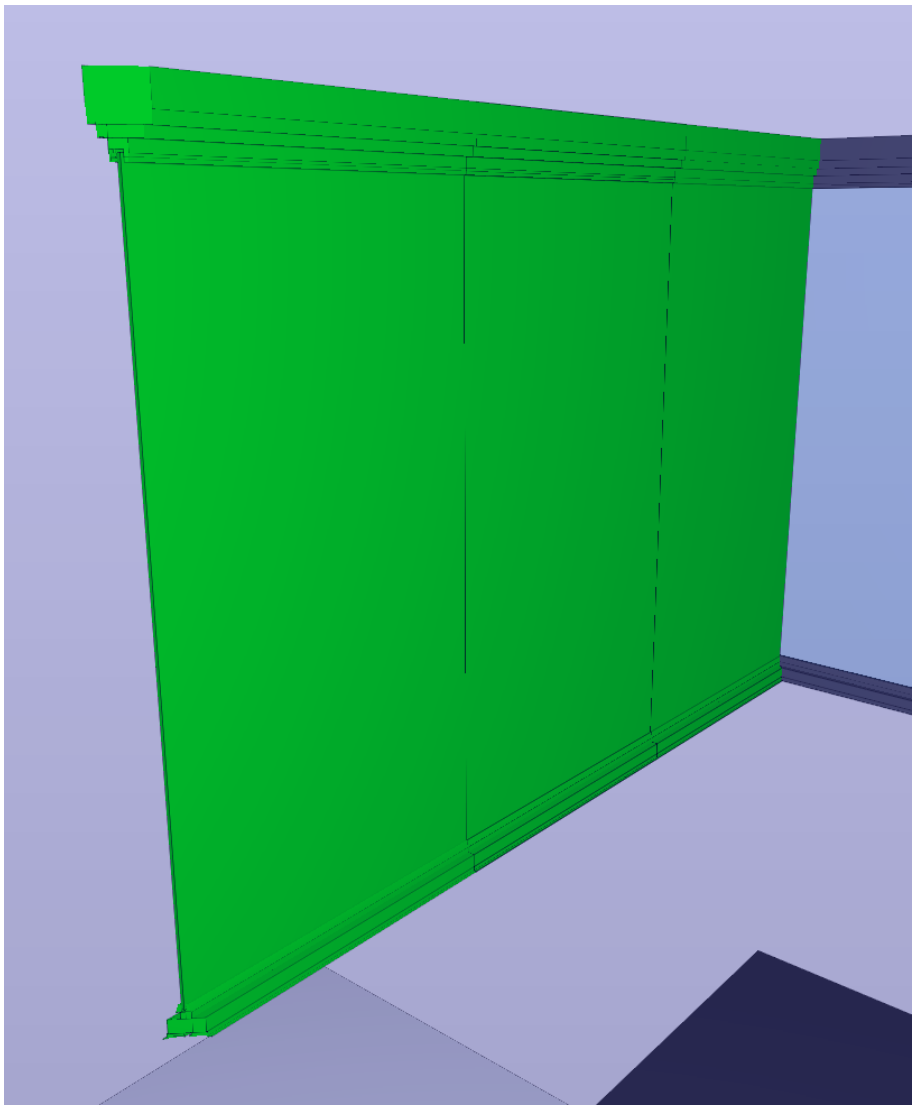
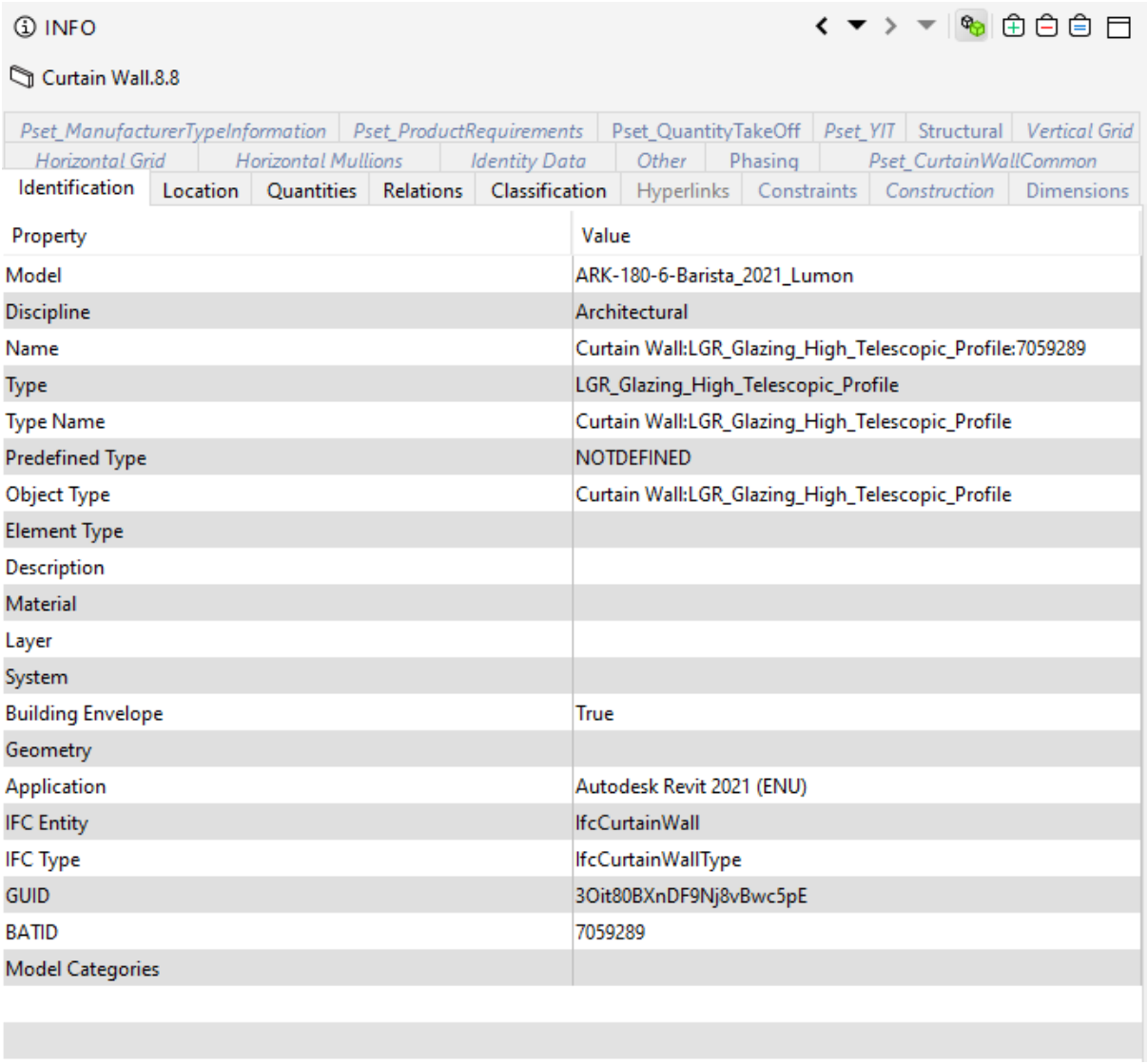


Figure 17: Curtain Wall 8.8 selected

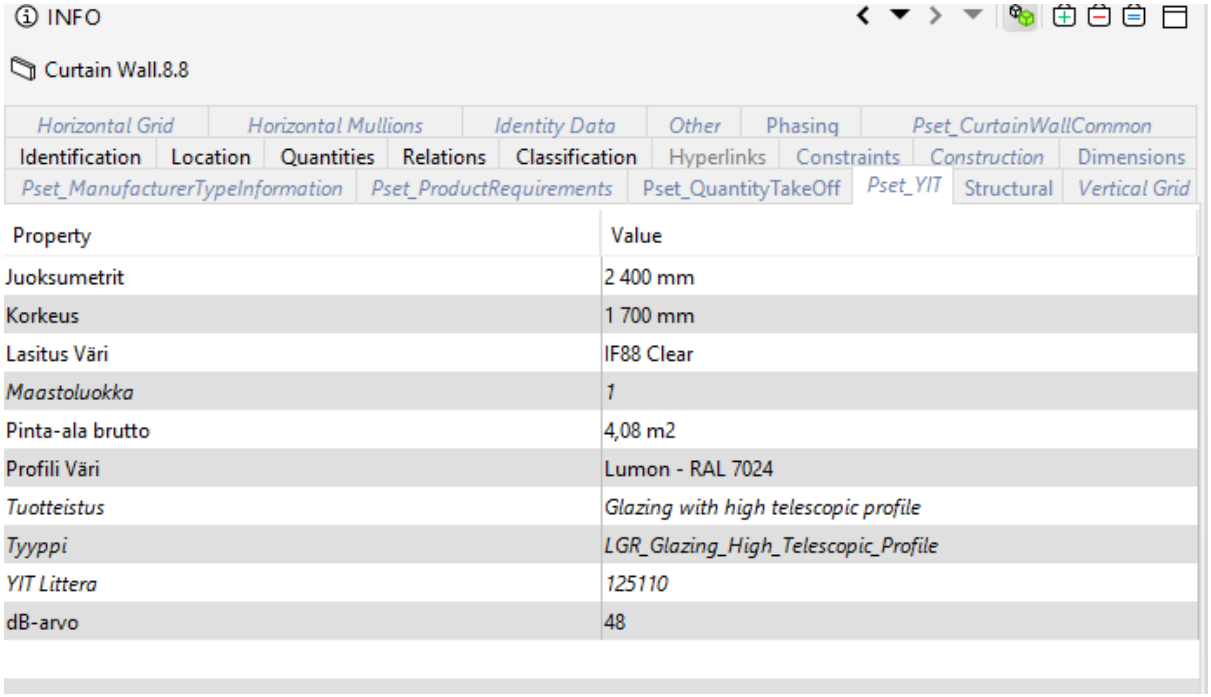
We can then access various tabs by selecting the "Info" option from the dropdown menu.



Property	Value
Model	ARK-180-6-Barista_2021_Lumon
Discipline	Architectural
Name	Curtain Wall:LGR_Glazing_High_Telescopic_Profile:7059289
Type	LGR_Glazing_High_Telescopic_Profile
Type Name	Curtain Wall:LGR_Glazing_High_Telescopic_Profile
Predefined Type	NOTDEFINED
Object Type	Curtain Wall:LGR_Glazing_High_Telescopic_Profile
Element Type	
Description	
Material	
Layer	
System	
Building Envelope	True
Geometry	
Application	Autodesk Revit 2021 (ENU)
IFC Entity	IfcCurtainWall
IFC Type	IfcCurtainWallType
GUID	3Oit80BXnDF9Nj8vBwc5pE
BATID	7059289
Model Categories	

Figure 18: Infographics of what the element holds.

Figure 18 displays the many tabs available to the user. For example, the following typical tabs are present in practically every element: identification, location, amounts, relationships, and classifications, to name a few. Then there might be user-created tabs that Solibri creates by the custom made user's parameters. In this scenario, the Pset YIT tab was created, in which the user has specified the critical data to aid the user in quickly comprehending the element and other critical data, such as the element's length, height, and colour, among other things.



Property	Value
Juoksumetrit	2 400 mm
Korkeus	1 700 mm
Lasitus Väri	IF88 Clear
Maastoluokka	*1*
Pinta-ala brutto	4,08 m2
Profili Väri	Lumon - RAL 7024
Tuotteistus	*Glazing with high telescopic profile*
Tyyppi	*LGR_Glazing_High_Telescopic_Profile*
YIT Littera	*125110*
dB-arvo	48

Figure 19: Pset_YIT

Detailed instructions on extracting data from a model in Solibri into an Excel spreadsheet are described in Chapter 5, and detailed instructions on how to define parameters are provided in Chapter 6.

5. Solibri

Solibri Model Checker is a BIM quality assurance software system that evaluates Building Information Models and architectural and engineering designs for integrity, quality and physical safety. In addition, Solibri Model Checker contains capabilities for information takeout, assessing and extracting the information in BIM models. Solibri Model Checker targets zero design errors, cost savings in building projects, and more effective modelling and quality assurance. With a single mouse click, the system analyses the building information model and reveals any defects and weaknesses in the design, shows the clashing components and confirms that the model conforms to BIM regulations and the organisation's best practices. Solibri delivers out-of-the-box tools for BIM validation, compliance control, design process coordination, review, analysis, and code verification. Solibri's corporate message is to create and market quality assurance technologies that increase the quality of BIM-based design and make the entire design and construction process more efficient and cost-effective. Solibri's customers include significant building owners, construction businesses, architects and engineering firms in over 70 countries. It is part of the Nemetschek Group and is based in Helsinki, with operations in the US, UK, Germany and Spain. Solibri continues to endeavour to save time, money and the environment. (Nemetschek, 2022)

Figure 20: Solibri model checker

5.1 Problems that could occur in the software.

Some things can go wrong when a model has been exported from native software during the export stage. Another option is that our competitor's criteria differ from ours, and we will need to change our specifications. As a result, it may be essential to address this issue to get the most out of that IFC model's capabilities.

5.2 Information takeoff from Solibri

In a building project, there will be multiple instances in which a user will need to extract information from a model, such as quantities, and then report on it. For example, the user may require the information for something like one or more of the following:

- **Gross area analysis at the start of a project.**
  Architectural design imposes criteria and limitations on the amount of usable floor space (m^2) and specific needs for certain forms of activity. The most common numbers that are evaluated at the beginning of a project are the gross area compared to the requirements of the plot or contract, the net area to determine how effectively space is being used, and the space regulation requirements to meet the needs of the required services within the building.
- **Provide a list of spaces or supplies.**
  Prior to tendering, spaces and supplies are utilised extensively, particularly in interior design and the completion of spaces. Therefore, material quantities are essential when calculating and assessing the total amount of goods and expenditures.

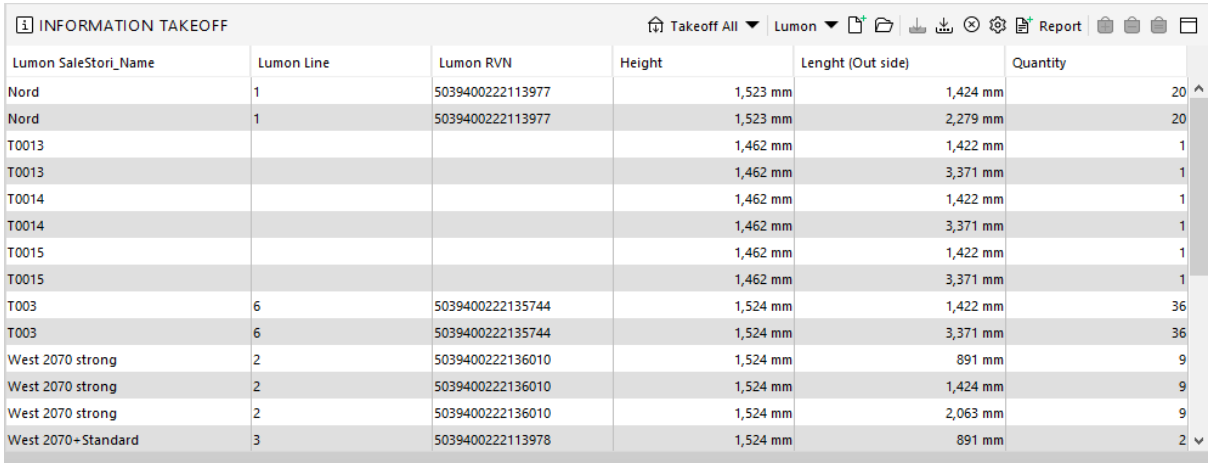
- **Quantity surveying for contract packages or tendering design.**
  The calculation of quantities to tender and differentiate contract packages directly impacts the prices of contractors and materials. Therefore, to bid on the costs of building, detailed listings of such expenditures are required. This kind of listing is also helpful for the contractor's logistics, material delivery, and installations.
- **Verifying the content of the BIM model.**
  Utilising ITO (Information takeoff) will be the quickest and easiest method for verifying the data content of a model. When the user lists the components for each row, an empty cell will represent any information lacking.

- **Coordinating quantities and masses on site.**

  It is essential to coordinate the continuous flow of materials and installations at the location where construction is currently taking place. There is not enough room for high traffic, storage, or lifting areas in some locations, so it is essential to have a scheduled delivery process. ITO reports can substantiate this claim.

(Solibri, Understanding Information Takeoff (ITO), 2022)

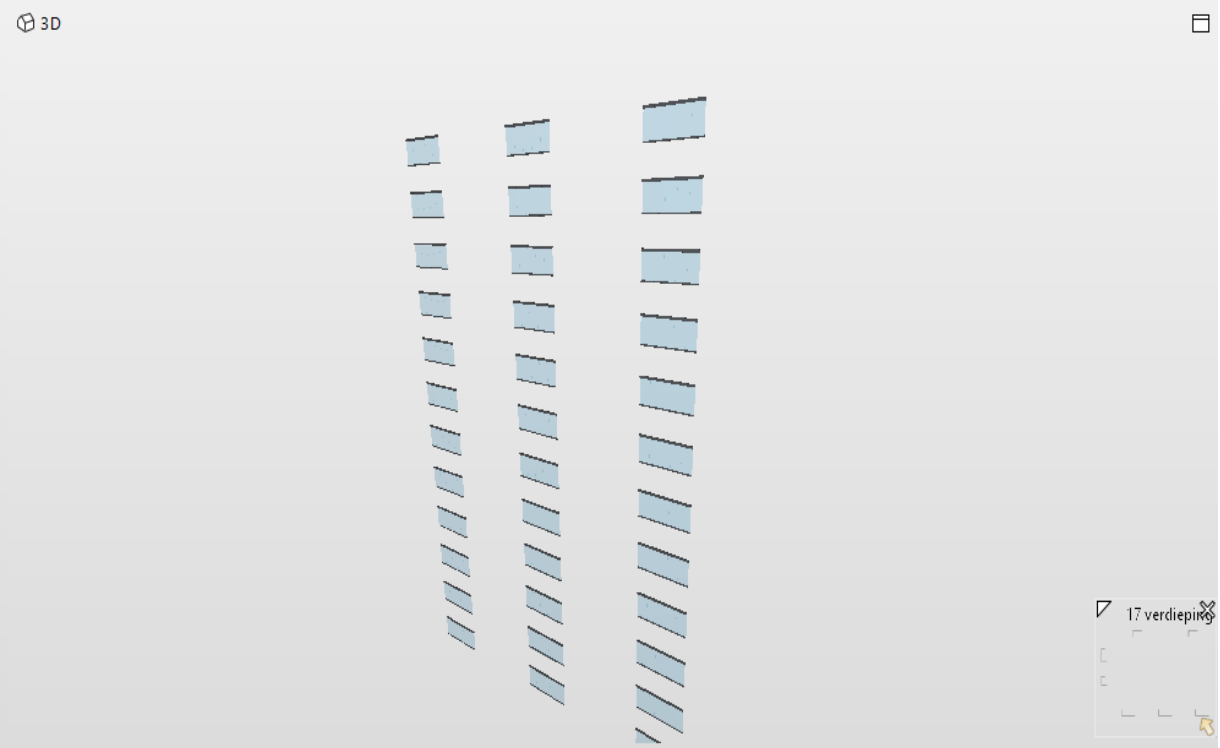
Figure 21, below the view, presents the information takeoff tab in Solibri. The view comprises a data table and tools for dealing with ITOs.



Lumon SaleStori_Name	Lumon Line	Lumon RVN	Height	Lenght (Out side)	Quantity
Nord	1	5039400222113977	1,523 mm	1,424 mm	20
Nord	1	5039400222113977	1,523 mm	2,279 mm	20
T0013			1,462 mm	1,422 mm	1
T0013			1,462 mm	3,371 mm	1
T0014			1,462 mm	1,422 mm	1
T0014			1,462 mm	3,371 mm	1
T0015			1,462 mm	1,422 mm	1
T0015			1,462 mm	3,371 mm	1
T003	6	5039400222135744	1,524 mm	1,422 mm	36
T003	6	5039400222135744	1,524 mm	3,371 mm	36
West 2070 strong	2	5039400222136010	1,524 mm	891 mm	9
West 2070 strong	2	5039400222136010	1,524 mm	1,424 mm	9
West 2070 strong	2	5039400222136010	1,524 mm	2,063 mm	9
West 2070+Standard	3	5039400222113978	1,524 mm	891 mm	2

Figure 21: Solibri information takeoff with Lumon ITO

ITO definition determines the columns visible in the ITO table, as shown in figure 22 below. The user can restructure the data in the table by moving the header of one column to a new position. Note that the returned data is connected to the information on the left side of the column. If the user clicks on a row in the ITO table, it will display the corresponding components in the 3D view, presented in figure 22:



INFORMATION TAKEOFF

Takeoff All | Lumon | Report

Lumon SaleStori_Name	Lumon Line	Lumon RVN	Height	Lenght (Out side)	Quantity
Nord	1	5039400222113977	1,523 mm	1,424 mm	20
Nord	1	5039400222113977	1,523 mm	2,279 mm	20
T0013			1,462 mm	1,422 mm	1
T0013			1,462 mm	3,371 mm	1
T0014			1,462 mm	1,422 mm	1
T0014			1,462 mm	3,371 mm	1
T0015			1,462 mm	1,422 mm	1
T0015			1,462 mm	3,371 mm	1
T003	6	5039400222135744	1,524 mm	1,422 mm	36
T003	6	5039400222135744	1,524 mm	3,371 mm	36
West 2070 strong	2	5039400222136010	1,524 mm	891 mm	9
West 2070 strong	2	5039400222136010	1,524 mm	1,424 mm	9
West 2070 strong	2	5039400222136010	1,524 mm	2,063 mm	9
West 2070+Standard	3	5039400222113978	1,524 mm	891 mm	2

Figure 22: Information takeoff using Lumon ITO

The following tools on the toolbar for the Information Takeoff view are described in a way down below:

- Options for updating the ITO table.
    - **Takeoff All:** Publishes an updated version of the Information Takeoff table, including all model components that successfully got through the definition filter.
    - **Takeoff Selected:** The Selection Basket components are added to the Information Takeoff table. First, the user must add the components to the Selection Basket by picking them from the table.
    - **Takeoff All ITOs:** Performs an update on all the Information Takeoff tables that are a part of the model using all the components that are a part of the model**.**
- **ITO definition selector:** Select the active ITO definition using the menu that drops from the top.
- **Edit ITO definition:** Change the properties of the currently active ITO definition.
- **Report:** Formulate reports based on ITO definitions using spreadsheets.
- **Selection Basket tools:** Gather the scattered components and place them in the Selection Basket.

(Solibri, Understanding Information Takeoff (ITO), 2022)

5.3 Exporting data in Excel from

Solibri includes illustrative Excel templates that can report default ITOs. ITO definitions can have over one reporting template. In addition, the user has the option to change the templates either through the Report Information Takeoff dialogue or through the resource path where the templates are stored.

The user can make two types of ITO reports: a plain Excel report and an Excel template report.

	A	B	C	D	E	F
1	Lumon SaleStori_Name	Lumon Line	Lumon RVN	Height	Lenght (Out side)	Quantity
2	Nord	1	5039400222113977	1523	1424	20
3	Nord	1	5039400222113977	1523	2279	20
4	T0013			1462	1422	1
5	T0013			1462	3371	1
6	T0014			1462	1422	1
7	T0014			1462	3371	1
8	T0015			1462	1422	1
9	T0015			1462	3371	1
10	T003	6	5039400222135744	1524	1422	36
11	T003	6	5039400222135744	1524	3371	36
12	West 2070 strong	2	5039400222136010	1524	891	9
13	West 2070 strong	2	5039400222136010	1524	1424	9
14	West 2070 strong	2	5039400222136010	1524	2063	9
15	West 2070+Standard	3	5039400222113978	1524	891	2
16	West 2070+Standard	3	5039400222113978	1524	1424	2
17	West 2070+Standard	3	5039400222113978	1524	2063	2
18	West 2830+Standard	4	5039400222135736	1524	891	2
19	West 2830+Standard	4	5039400222135736	1524	1420	2
20	West 2830+Standard	4	5039400222135736	1524	2939	2
21	West 2830+Strong	5	5039400222113980	1524	891	9
22	West 2830+Strong	5	5039400222113980	1524	1420	9
23	West 2830+Strong	5	5039400222113980	1524	2939	9
24	Zuid 3000 Strong	7	5039400222113979	1463	1417	4
25	Zuid 3000 Strong	7	5039400222113979	1463	2936	4
26	Zuid 3000+Standard+-+hoogte+1456	8	5039400222166404	1524	1417	12
27	Zuid 3000+Standard+-+hoogte+1456	8	5039400222166404	1524	2936	12

Figure 23: Plain excel report with same data as Figure 22 above

The direct Excel report includes all the columns and rows from the ITO view but lacks formatting. So, the user needs to make some slight changes to the report afterwards.

With the Excel template, it is easy to manipulate the input data that comes from Solbri, as shown below in Figure 24.

	A	B	C	D	E	F
1	SOLIBRI	Lumon				
2						
3	Mallin nimi	Lumon_Binnendok_2021_test Versio: 9.9				
4	Tarkastaja	oskar.lindstrom@lumon.fi				
5	Organisaatio	Lumon Oy				
6	Aika	12.5.2022				
7	Lumon_Binnendok_2021_t	Pvm: 2021-12-17 15:18:59 Sovellus: Autodesk Revit 2021 (ENU) IFC: IFC2X3				
8						
9						
10						
11	**Lumon SaleStori_Name**	**Lumon Line**	**Lumon RVN**	**Height**	**Lenght (Out side)**	**Quantity**
12	Nord	1	503940022211397	1523	1424	20
13	Nord	1	503940022211397	1523	2279	20
14	T0013			1462	1422	1
15	T0013			1462	3371	1
16	T0014			1462	1422	1
17	T0014			1462	3371	1
18	T0015			1462	1422	1
19	T0015			1462	3371	1
20	T003	6	503940022213574	1524	1422	36
21	T003	6	503940022213574	1524	3371	36
22	West 2070 strong	2	503940022213601	1524	891	9
23	West 2070 strong	2	503940022213601	1524	1424	9
24	West 2070 strong	2	503940022213601	1524	2063	9
25	West 2070+Standard	3	503940022211397	1524	891	2
26	West 2070+Standard	3	503940022211397	1524	1424	2
27	West 2070+Standard	3	503940022211397	1524	2063	2
28	West 2830+Standard	4	503940022213573	1524	891	2
29	West 2830+Standard	4	503940022213573	1524	1420	2
30	West 2830+Standard	4	503940022213573	1524	2939	2
31	West 2830+Strong	5	503940022211398	1524	891	9
32	West 2830+Strong	5	503940022211398	1524	1420	9
33	West 2830+Strong	5	503940022211398	1524	2939	9
34	Zuid 3000 Strong	7	503940022211397	1463	1417	4
35	Zuid 3000 Strong	7	503940022211397	1463	2936	4
36	Zuid 3000+Standard+-+hoog	8	503940022216640	1524	1417	12
37	Zuid 3000+Standard+-+hoog	8	503940022216640	1524	2936	12

Figure 24: Example of a custom-made template

It would be simple to implement one's template if one were to make use of the processes that are currently accessible. However, if something cannot be exported from Solibri in its current state, the user can manipulate the template to include a variety of Excel functions and equations that can be user change. For example, an area calculation is a good illustration of a custom equation.

(Solibri, Creating Reports from ITO Results, 2021)

5.4 Interview with Sweco

This interview was performed with members of Sweco Finland's BIM group; they have world-class experience working with Solibri and BIM and knowledge of how IFCs function in various programmes. Sweco uses BIM in its day-to-day operations and has done so since before it became the industry standard in architectural design and building design. Using Solibri in Sweco, the engineers use the programme in their daily work as engineers, architects, BIM managers, BIM coordinators, and in the design and construction business. In addition, as a task force member responsible for defining new BIM requirements (Tietomalli vaatimukset), Sweco can assist clients with new and more accessible modelling needs for diverse projects. (Tuori, 2022)

6. Autodesk Revit

Revit is widely recognised as one of the most powerful software packages today for civil engineering. Revit users can create a building's blueprint from the ground up, thanks to the software's numerous features and presets. In contrast to AutoCAD, Revit provides "family" characteristics, allowing architects to save time. For example, sketching a bathroom could be assigned, and the architect must complete the task in a limited amount of time. There is no need for the user to sketch each object in a bathroom manually and then insert them into the programme; instead, the user may choose from a pre-installed family, download a model from the Internet, or even integrate his model into the application. Furthermore, Revit is equipped with a parametric engine, which implies that any changes will be preserved and kept throughout the project without human intervention.

There is a predetermined measurement on the other side of a perpendicular wall from where the door's centre is located. Even if the partition is moved, the door's relationship stays unchanged.

(Fakhrutdinov, 2018)

Revit uses three elements during a project: model elements, datum elements, and view-specific elements. Families are another term used to refer to elements in Revit. The family contains the geometric definition of the element and the parameters used by the element. The family defines and controls each instance of an element.

Model elements represent the actual 3D geometry of the building. They display relevant views of the model. Examples:

- Walls, windows, doors, and roofs
- Structural walls, slabs, and ramps
- Sinks, boilers, ducts, sprinklers, and electrical panels

(Autodesk, About Element Behavior in Revit, 2021)

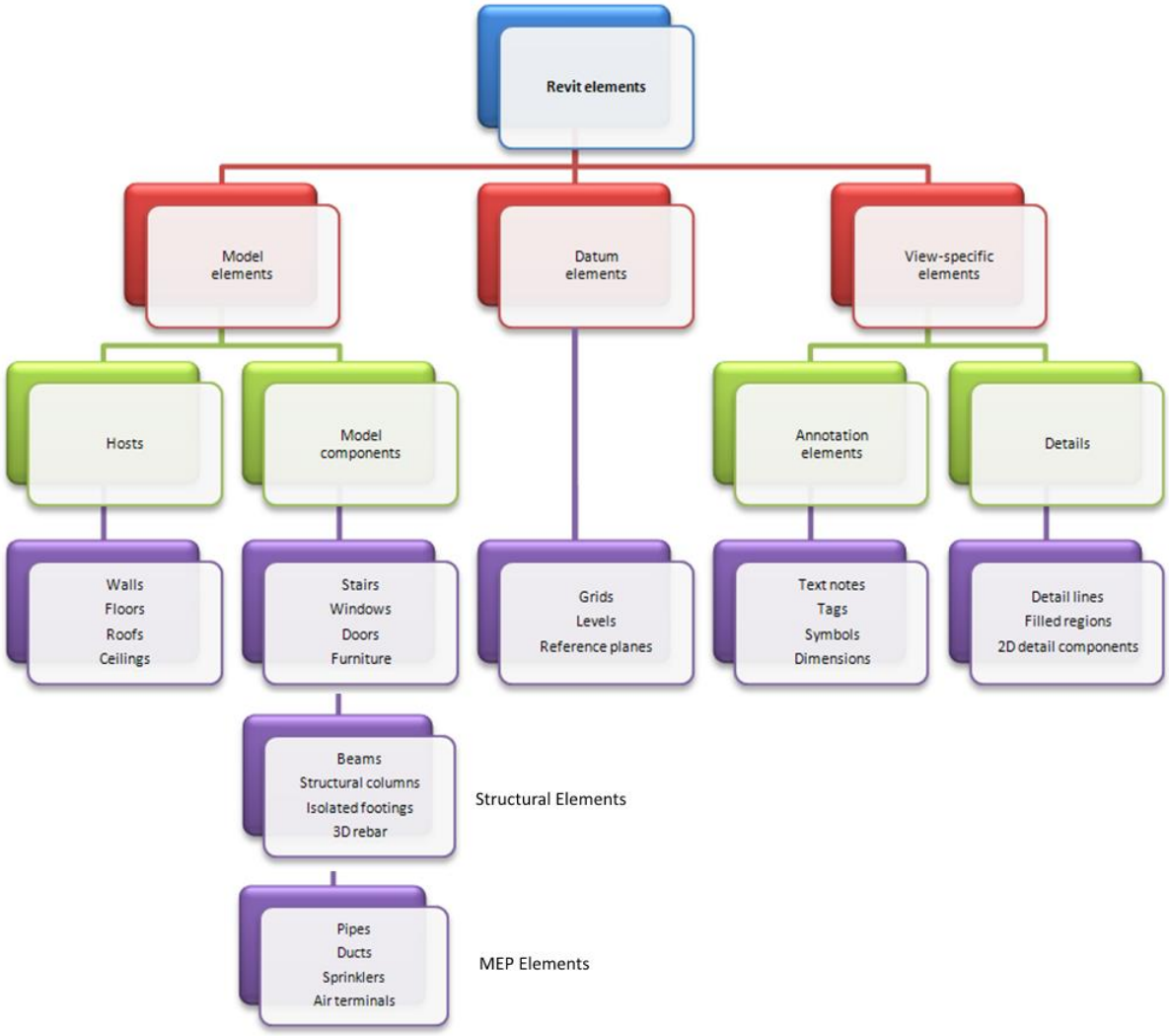


Figure 25: How the Revit structure is made (Autodesk 2021)

6.1 Revit families

A family is a collection of elements that share a standard set of properties, referred to as parameters, and a common graphical representation. It is possible for various elements belonging to the same family to have different values for some or all of their parameters, yet the set of parameters (as well as their names and meanings) remains constant. We refer to these variations within a family as family kinds or types of families. Some examples of family groups are:

- Various furniture, including desks, chairs, and cupboards, can be found in the Furniture category. As a result, the furniture category includes all different kinds of families.

- The Structural Column category contains families and family types that can construct a variety of broad flanged, precast concrete, angle, and other types of structural columns.
- The user can utilise the Sprinkler category to design various dry and wet sprinkler systems by selecting from the various families and family kinds available.

Although these families perform distinct functions and are constructed of disparate materials, they share a standard function. Therefore, each type in the family has a corresponding graphical representation and an identical set of parameters, referred to as the family type parameters.

Create an instance of an element in a project when the user creates an element that belongs to a specified family and family type. There are a set of attributes for each element instance, in which the user can change some element parameters that are not dependent on the family type parameters. These modifications only apply to the element's instance, the single element in the project. If the user makes any modifications to the family type parameters, those changes will apply to all element instances generated with that type of family.

(Autodesk, About Families, 2018)

System families, loadable families and in-place families are the three types created in Revit. Most of the elements that the user generates in the projects are system families or loadable families. Family members can be nested and shared to form a more extensive, loadable family. In-place families are used to producing elements that are not standard or customised.

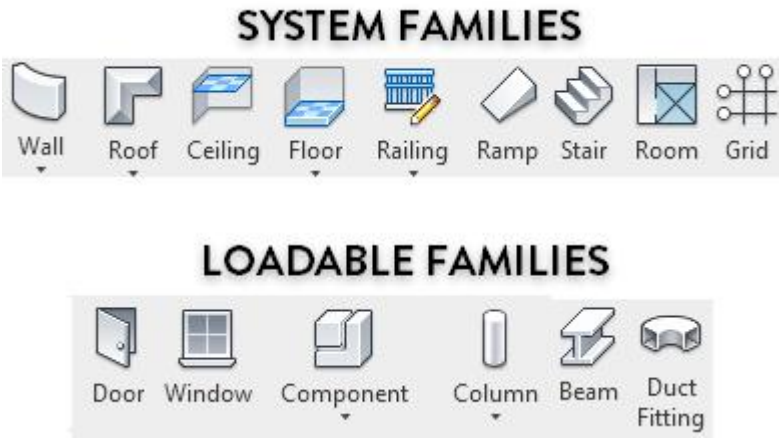


Figure 26: Identification of system families and loadable families in the Revit ribbon system (Revit Pure)

6.1.1 System Families

System families establish the fundamental pieces assembled on a building site. Examples are.

- Walls, roofs, floors
- Ducts, pipes

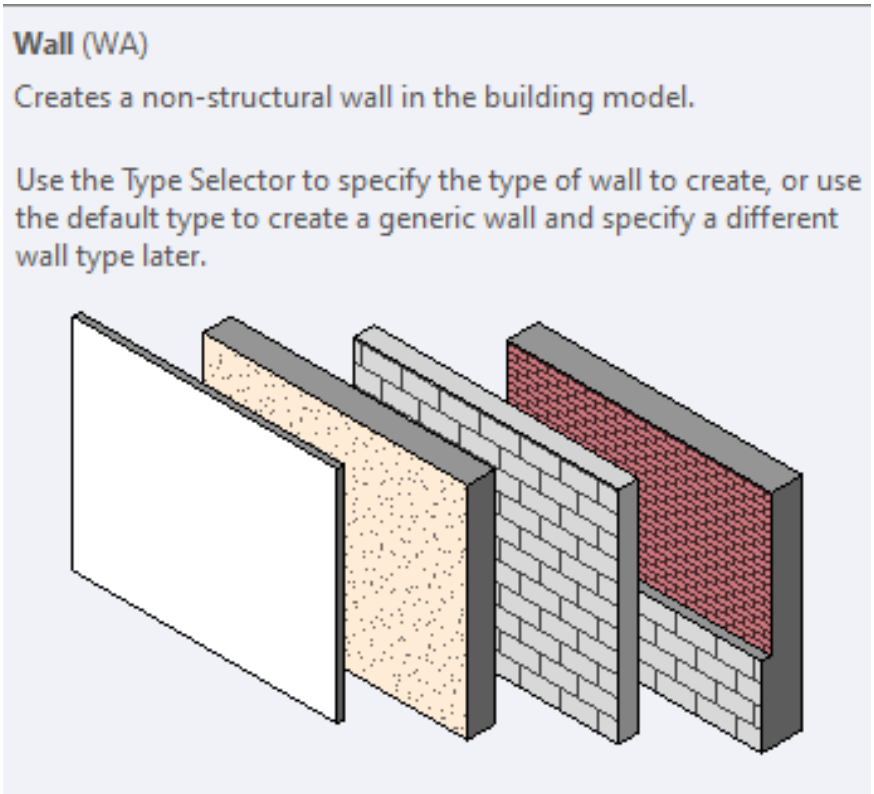


Figure 27: Example description of system wall family

System settings, which impact the project environment and include levels, grids, drawing sheets, and viewports, are grouped as system families. System families also contain different types of other system families. Although in Revit, system families have already been specified, they cannot be imported from external files, nor can they be saved in locations other than the project's current location.

(Autodesk, About the Different Kinds of Families, 2018)

6.1.2 Loadable Families

Loadable Families are the families that are utilised to construct the following.

- Typical building components commonly purchased and delivered to a building's interior and exteriors, such as windows and doors, casework, fixtures and furniture, and landscaping, are excluded.
- Boiled water heaters, air handlers, and plumbing fixtures are system components typically purchased from a retailer and brought to a building for installation.
- Annotation elements, such as symbols and title blocks, are frequently customised.

Because of their ability to be fully customised, loadable families are the most frequently created and changed in Revit. In contrast to system families, loadable families are developed in external RFA files and imported or loaded into the projects when needed. In addition, type catalogues, which allow the user to load only the required types for a project, can be created and used for loadable families that contain many types.

(Autodesk, About the Different Kinds of Families, 2018)

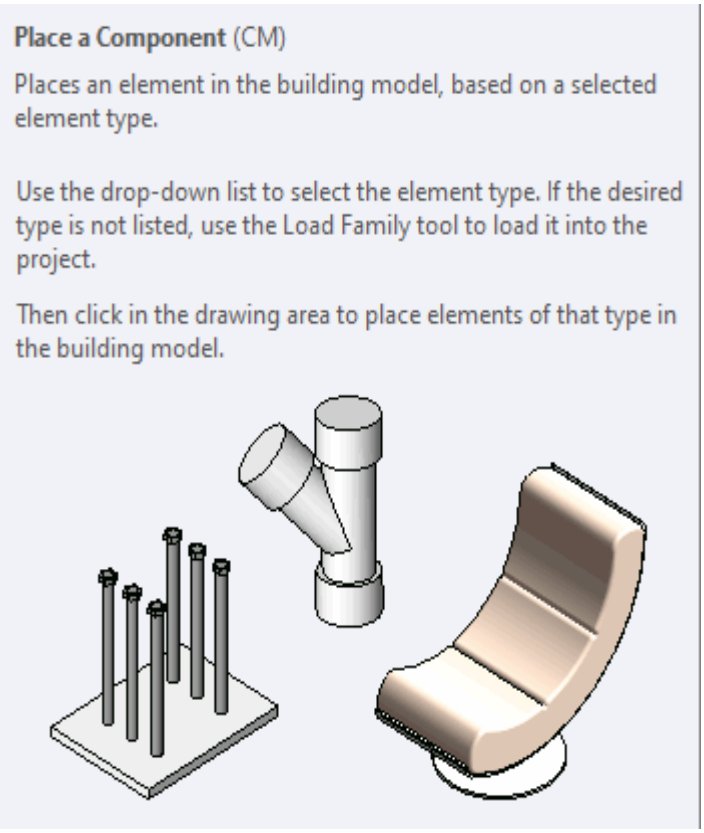


Figure 28: Example of component families that are under the loadable families category

6.1.3 In-place Families

Creating in-place elements is useful when the user needs to construct a unique component that is particular to the current project and cannot be replicated elsewhere in the code. The geometry generated in place can reference other project geometry, scaling or changing as necessary as the referenced geometry changes. Each time an in-place element is added to a project, Revit creates a new family for the in-place element, which contains a single-family type. Creating an in-place element uses many of the same Family Editor tools as creating a loadable element.

(Autodesk, About the Different Kinds of Families, 2018)

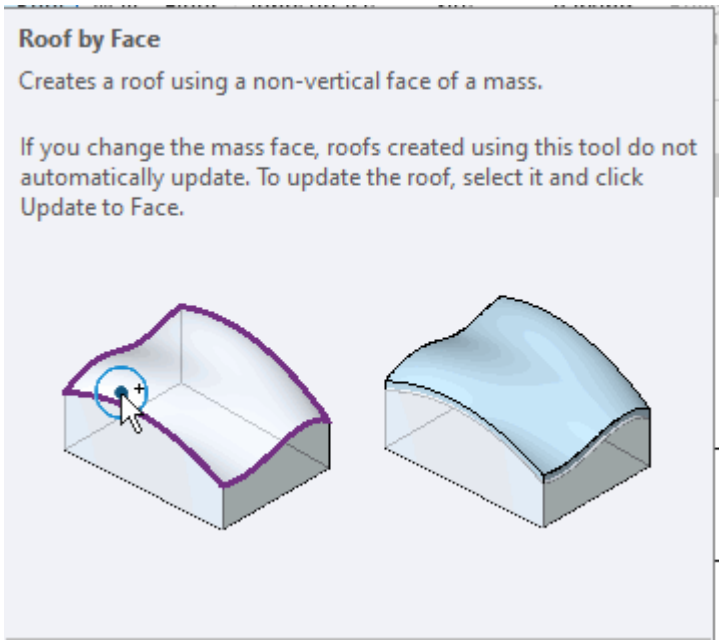


Figure 29: Example of creating in place elements, massing the roof by face.

6.2 Importing model to Revit

There are two ways to use IFC models in Autodesk Revit they are following:

- **Open:** Using the IFC data as a starting point, open (import) the IFC file into Revit to generate a new model based on it. Modifications made to the original IFC file after the model was created are not reflected in the Revit model.

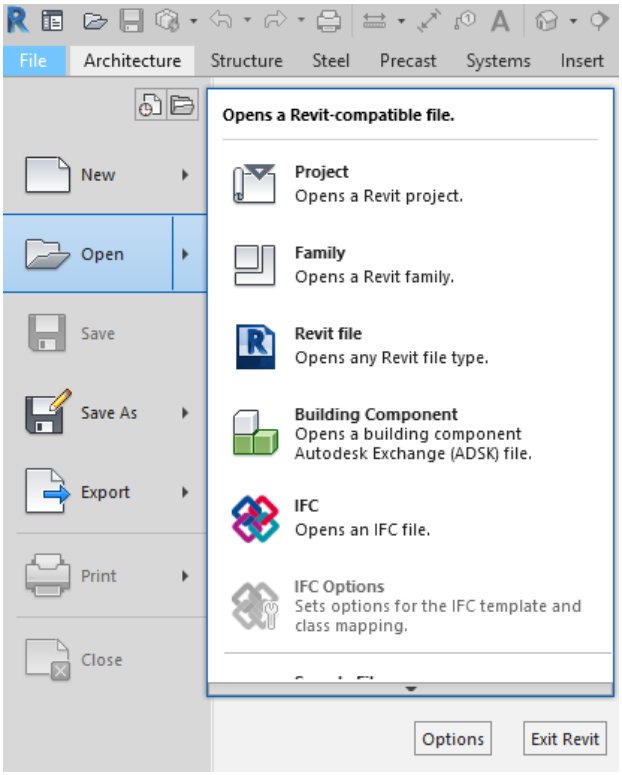


Figure 30: Opening IFC model into Revit by Open option

- **Link:** Connect the IFC file to an existing Revit model to use its information for future design work. It is possible to update the model to reflect the source IFC file changes.

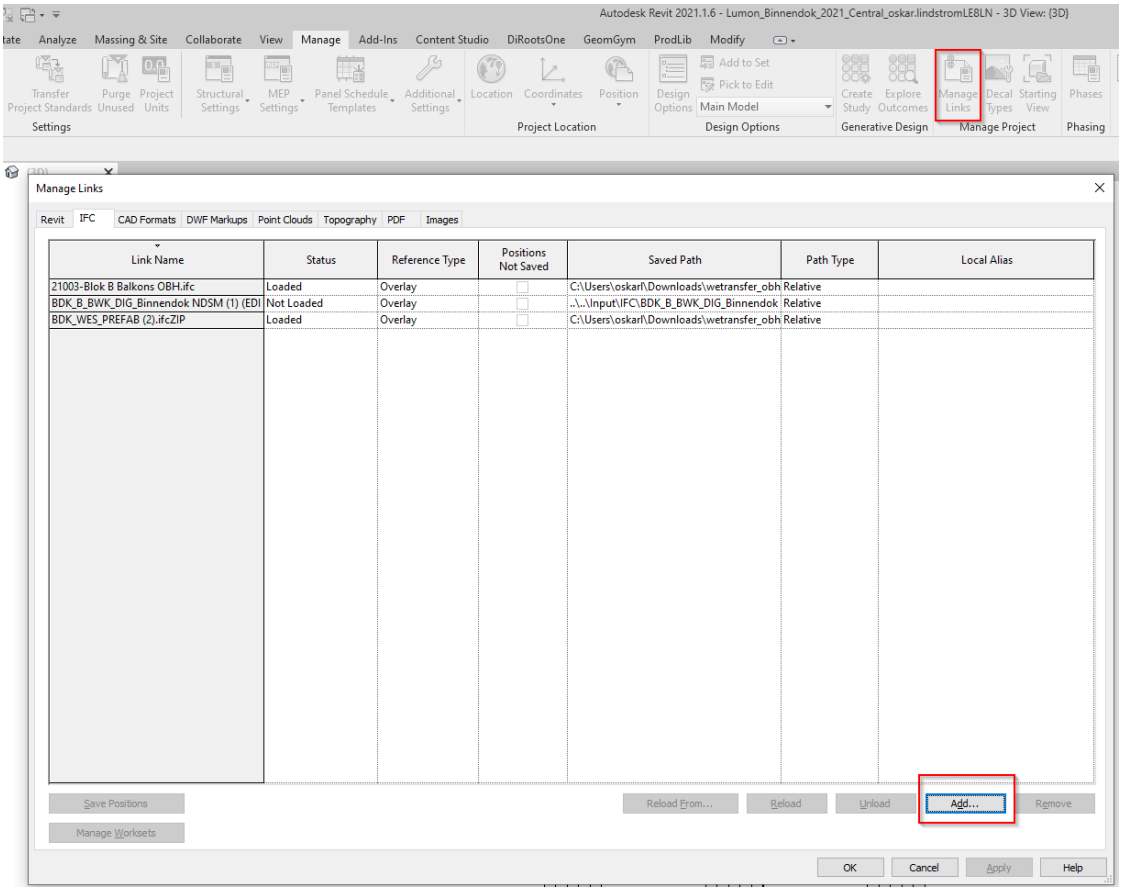


Figure 31: Example of linking IFCs into Revit by Link option

Importing IFC files is based on the following International Alliance for Interoperability (IAI) Revit supports data interchange standards: IFC4, IFC2x3, IFC2x2, and IFC2x. It is possible to select the template before opening or connecting an IFC file. The user may also load a file that maps IFC classes to Revit categories and manually changes Revit categories for IFC classes. (Autodesk, Using IFC Files, 2022)

Each element in the IFC file is converted into a native Revit object by Revit's transformation algorithm. As a result, importing huge models can be time-consuming and inconvenient. Furthermore, the import quality depends highly on the quality of the export (export parameters) and the content (IFC version).

(Autodesk, Revit IFC Manual, 2018)

6.3 Exporting data from Revit

If the parameters are supplied in the settings tab of the IFC export procedure, exporting an IFC from Revit is simple. However, numerous setups must be made before correct data can be gathered. Users often use the default settings when working with the IFC 2x3 Coordination View 2.0, and Revit's current selection arrangement is also the default.

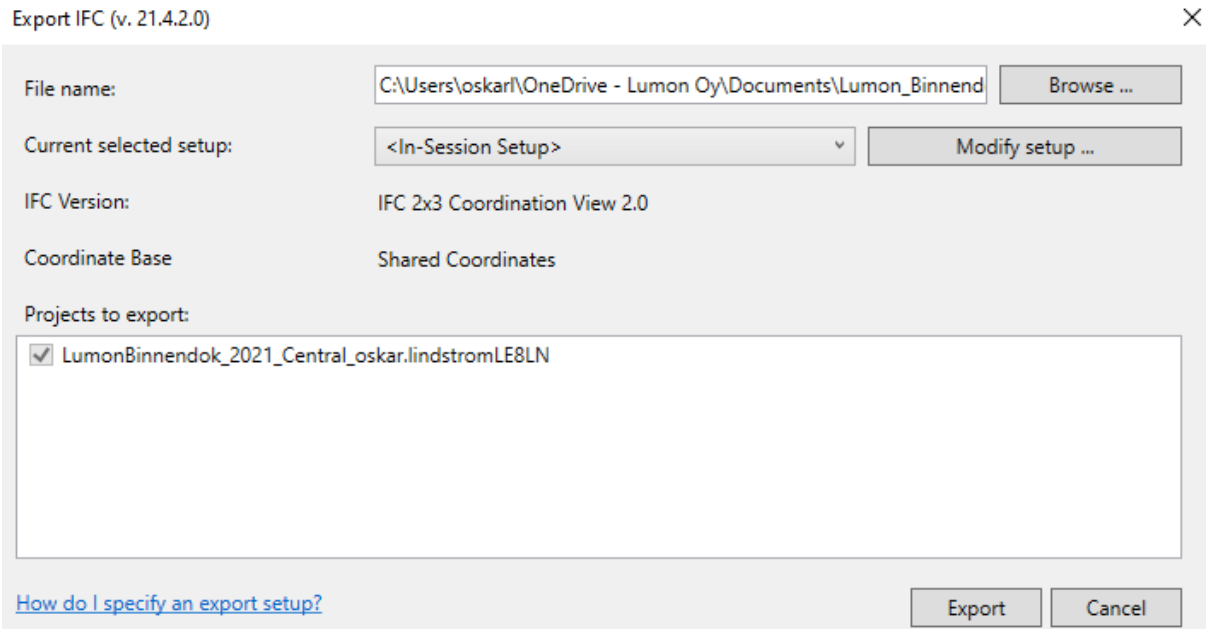


Figure 32: Default settings when exporting IFC from Revit

It is possible that someone will not correctly export the data if we leave the default parameters unchanged and that it will leave some data out of the IFC. When using the default settings, the following is what Solibri displays in Figure 33.

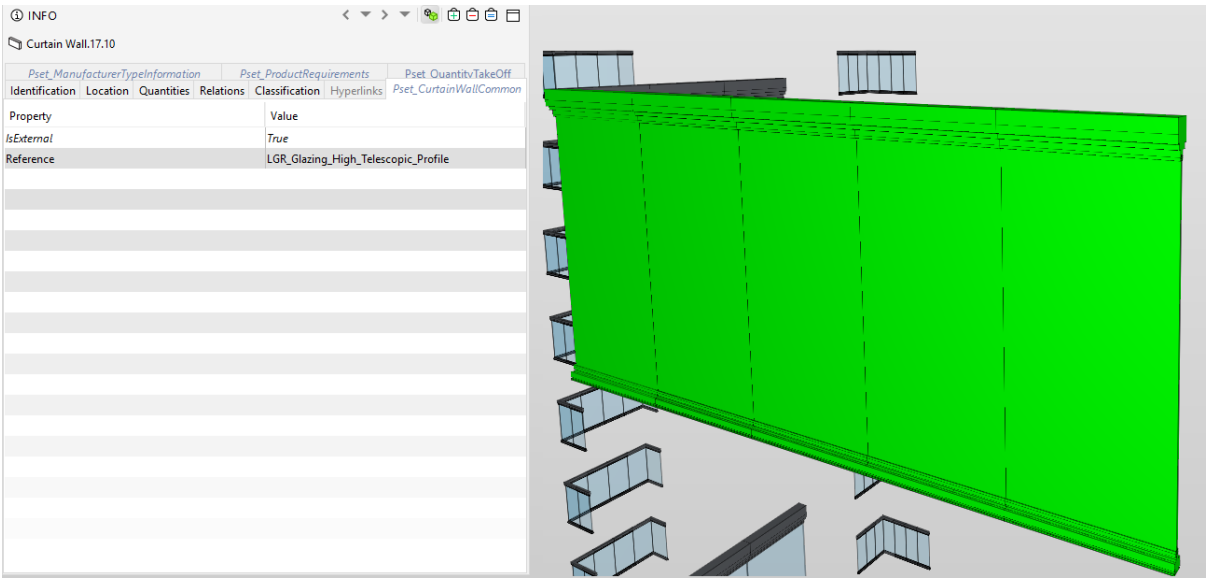


Figure 33: Property sets are missing when exporting a model with default settings

By altering the parameters of the property sets, it is possible to make them visible to the exporter. The revised configuration is as follows: Figure 30 shows the IFC 2x3 Coordination View.

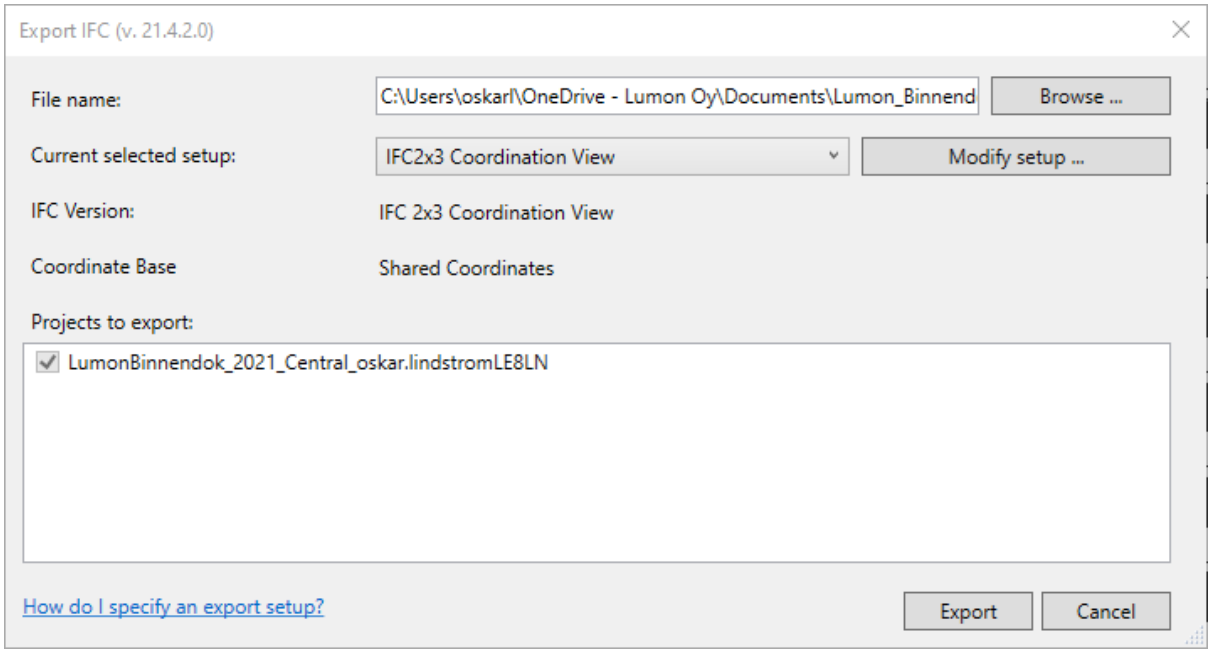


Figure 34: Updated IFC export settings.

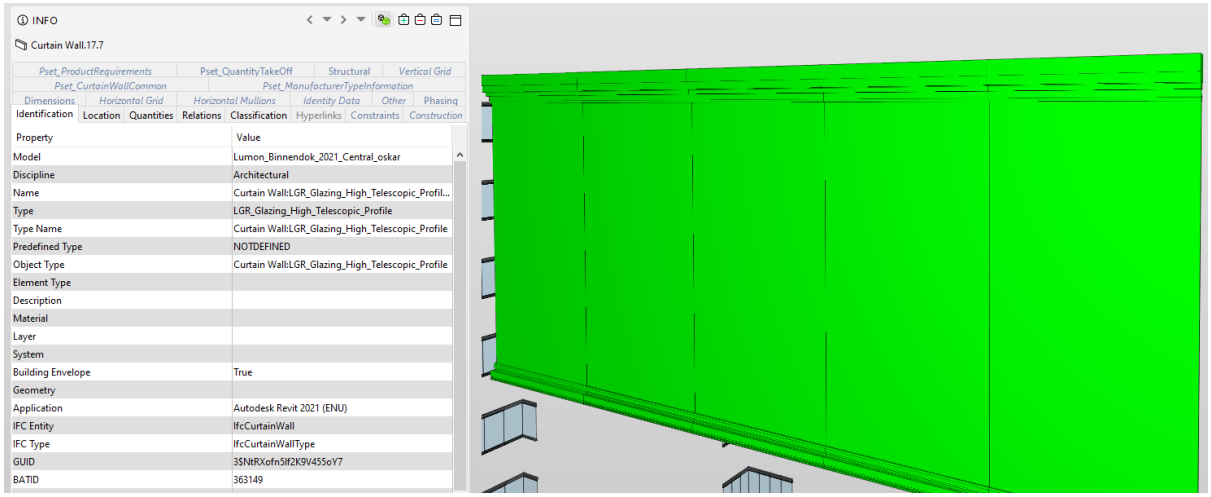


Figure 35: Updated view in Solbri now shows more property sets.

Custom IFC exporter settings are preferred if we create the family with data extraction. It was necessary to set up Lumon IFC so that our procedures could run smoothly. IFC exporter customisation is preferred if we plan on extracting specific data from the family. With Lumon IFC, the precise data needed for our procedures were obtained.

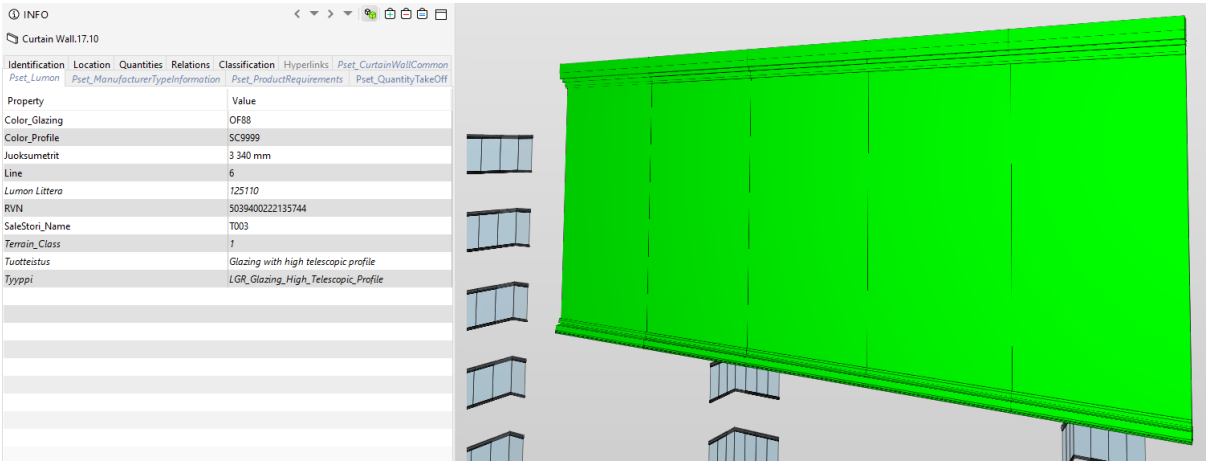


Figure 36: Pset_Lumon extracted from Revit in the way Lumon processes need it.

6.4 Interview with Kim Vikki and Nitai Bhuin

I conducted this interview with my old colleagues in Ramboll, Finland, because they have the most Revit experience in the area inside the company. Kim Vikki has been working with Autodesk Revit for the past ten years and is an expert in software. Over the years, he has worked with Ramboll to build template files for different families, and they considered him one of Finland's number one experts on how Revit works and how to develop different sets of template files. Nitai Bhuin, a former coworker with approximately ten years of experience working with Autodesk Revit, provided the following insight: Understanding how Revit works and how to create distinct families that can be utilised within Revit are critical components of the learning process to understand how Revit works. We should teach these concepts in schools from college to the university level the building design to have a more efficient workflow, be more accurate in their work, and reduce the number of errors that can arise during the design phase of a project. Lagging in Revit could be caused by many things, such as computer power, and video power could be an issue. The way to work in Revit is often to start from the model in the plan view and not in the 3D view because Revit works in a way that requires much input via the plan view option. Revit is heavily used in the refurbishment construction business in Finland because it can read point clouds. With the point cloud, it is possible to replicate the actual building using the points in Revit.

7. Model Challenges

When developing the tools that is needed to the design it is important to keep in mind how the object behaves in the model but also in the IFC model. There for the steps that has been described above is essential to provide a fully working model and get the parameters to work efficiently. It is essential to set some ground rules for new projects regarding modelling and BIM use. Depending on the type of item and whether additional actions will be added to it in the future (for example, a precast wall with embedded actions), it might be as simple as deciding which way you want your mouse to move when modelling (from left to right or right to left). Using an incorrect model could cause the embed macro to behave incorrectly. YTV (Yleiset tietomalli vaatimukset), which has been in place in Finland since 2012 but is being upgraded when this thesis is written, has stricter requirements. In YTV, each discipline has a specific list of items that must be modelled and the required accuracy. YTV could also be designed to have rules that the project adheres to throughout the entire project. People should pay more attention to how things are done and not just do things the old way, something Kim Vikki mentions in his interview. There could be a shift in how things are modelled or stricter standards in the future.

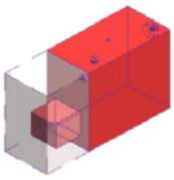
LOD 100 Conceptual	**LOD 200** Approximate geometry	**LOD 300** Precise geometry	**LOD 400** Fabrication	**LOD 500** As-built
				
The Model Element **may be** graphically represented in the Model with a **symbol or other generic representation**, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e. cost per square metre, etc.) can be derived from other Model Elements.	The Model Element **is** graphically represented in the Model as a **generic** system, object, or assembly with **approximate** quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.	The Model Element **is** graphically represented in the Model as a **specific** system, object, or assembly **accurate** in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.	The Model Element **is** graphically represented in the Model as a **specific** system, object, or assembly that is **accurate** in terms of quantity, size, shape, location, and orientation with **detailing, fabrication, assembly, and installation information**. Non-graphic information may also be attached to the Model Element.	The Model Element **is** a **field verified** representation **accurate** in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Element.

Figure 37: Lod level detail that is like YTV 2012 that we use in Finland (engbim)

7.1 As-built Challenges

When a building rises from foundations up to the last level, there could be some difficulties or challenges to tackle when the project moves forward. From manufacturing issues or issues on site that could cost some delay or even, in the worst case, severe injuries to building workers. Some issues that have accrued in the past have been:

Precast concrete column bolt/shoe connection was mixed with different manufactories, resulting in the accurate site installation. However, this was solved with the help of both embed factories (Anstar Oy and Peikko Oy).

Precast wall bolt/shoe in the wrong place. Incorrect installation of bolts in the foundation caused the issue, which was solved by injecting new anchors in the foundation.

Figure 38: Concrete column installed on top of a Peikko Deltabeam

They cast a precast panel the wrong way (mirrored view) from the factory. It could not solve this at the site or at the engineering table. The only way to solve this issue was for the factory to cast a new wall panel and deliver it to the site. This then caused some slight delay in the installation face.

The facts shown above are the result of my own professional experience; with the use of BIM, this situation may have been averted. After this, some actions were taken, and the precast factory also took some actions to prevent this from happening in the future. For example, they began reading the precast element from the model in order to obtain the appropriate components to cast with.

8. Results

The following is an example of how the thesis might be summed up: The findings were consistent with what was anticipated, and a plan has been devised to take subsequent actions, such as adding next level Revit families to the list. In the future, both Solibri and Revit will be integrated into the Lumon manner to help architects and salespeople create tenders more quickly. It is feasible to accomplish this objective with the assistance of Solibri, which is one of the essential concerns that must be addressed. However, to accomplish this objective, you will also need to acquire some knowledge about how to use Solibri.

To wrap up the result of this thesis, BIM is here to stay at Lumon. However, the question is whether we can implement it for the end-user at the company. This thesis was also a foundation for creating parameters and reflecting the necessary presets that we eventually will need. At the last minute of writing this thesis, we got exciting cooperation with Sweco to investigate the things even future how this could be implemented from manufacturing processes down to the installation phase but also the service phase in the future.

8.1 What is technically possible today?

From this thesis, many things have been available already for a decade to be used in Lumon in terms of BIM, but it has not been adopted efficiently before. However, some new things could be implemented. For example, implementing strict rule sets in Solibri makes it possible to get an excellent exact measurement on a balcony glazing or railing. However, some tolerances could be challenging to tackle for an as-built building. For example, installation tolerances and prefabricated element tolerances when installing a balcony slab. However, if the tolerances could be made smaller, we could see an innovative approach to utilise a model and run it through our sales program to get a price and run it through the manufacturing process and out to the customer.

8.2 How does it look 2-3 years from now?

In 2-3 years, the industry will adopt new changes and regulations. For example, new building regulations in Finland will force other parties to digitalise their work and force building companies to search for a building permit through a BIM model. There is also a movement in the building industries towards parametric and algorithmic design that could revolutionise the industry in terms of intuitive design. This could also have an enormous impact on the manufacturing industries and the building sites worldwide.

8.2.1 What should we think about in the future?

The data that we gather should be processed so that it is possible to re-use it in the future in terms of efficiency. So, whether it is rule sets for Solibri or algorithmic or parameters, that is always a way forward. However, one key point today is what the building industry is causing in terms of environmental impact. So, there are many aspects where a clever design made with BIM could help the environment. For example, it could be for noise reduction in buildings, CO2 reduction in the panels or railings themself, and running building efficiency tests through computer analysis to design the buildings with less carbon footprint.

8.3 What happens with the information that I have gathered?

The information I have gathered in this thesis is mostly from different projects and sources, but it is not a secret that the steps made could be replicated in any way possible for the competition to take advantage of. However, some of the information found in the study phase of this thesis is critical for our own business. Therefore, some findings will be company secrets and will not be written.

8.4 Are there some existing projects where this could have been deployed already?

Many of the ongoing projects that have been done could have utilised BIM in such a way that it would have helped the sales team gather the information in a quick way to get the tender out in no time. However, in terms of model checking, this could have helped reduce human errors by looking at the model in a 3D view and checking the critical steps necessary for our salesperson to get a tender. It is easy to see the errors that could have come out compared to a 2D drawing. Most of the big project projects that are out there are already have a BIM model available, but somehow, we have not used the full potential of the BIM model, but with the help of this master thesis, it will be in the future possible to extract out the data necessary for a tender or maybe in the future also for a building permit.

8.5 Is there potential to take this even further?

The potential here to take this step further is for a company like Lumon to answer the demand in the market, but we must also adapt to the world's ongoing changes and digitalisation. For example, when we search for a building permit, it would be necessary to know BIM when the government asks us some questions about the models. So we must also develop and deploy a model to meet their demand at the government level. If we cannot meet this demand, maybe we will lose customers, and the company could run out of business if we do not follow the change.

9. Discussion and Conclusions

Having established that BIM is becoming another process, we can state that it is highly valued. We can start reading BIM models with a speedy and correct approach to bring out offers to consumers. This has also created the potential for further cooperation between Lumon and Sweco to tie down specific procedures that will benefit both Lumon and the engineer or architect or the installation on site. Building permits that will employ BIM in the future are other significant reasons Lumon has elected to engage extensively in BIM research. The work set down in this thesis will also be the foundation for Lumon to continue forward with it. It will be interesting to see what the future holds but in my point of view, we as a firm are on the right road and going forward as a leader in balcony glazing and railing and to show also that we are ready for new challenges from the government to adopt BIM.

10. References

Autodesk. (2018, May 17). *About Families*. Retrieved from Knowledge Networks: https://knowledge.autodesk.com/support/revit/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/Revit-Model/files/GUID-6DDC1D52-E847-4835-8F9A-466531E5FD29-htm.html

Autodesk. (2018, May 17). *About the Different Kinds of Families*. Retrieved from Knowledge Network: https://knowledge.autodesk.com/support/revit/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/Revit-Model/files/GUID-403FFEAE-BFF6-464D-BAC2-85BF3DAB3BA2-htm.html

Autodesk. (2018). *Revit IFC Manual.* Chicago: Autodesk. Retrieved from https://damassets.autodesk.net/content/dam/autodesk/draftr/2528/180213_IFC_Handbuch.pdf

Autodesk. (2021, March 23). *About Element Behavior in Revit*. Retrieved from Knowledge Autodesk: https://knowledge.autodesk.com/support/revit/getting-started/caas/CloudHelp/cloudhelp/2018/ENU/Revit-GetStarted/files/GUID-5BFA499A-5ACA-4069-852C-9B60C9DE6708-htm.html

Autodesk. (2022, February 25). *Using IFC Files*. Retrieved from Knowledge Network: https://knowledge.autodesk.com/support/revit/learn-explore/caas/CloudHelp/cloudhelp/2020/ENU/Revit-Model/files/GUID-C61C2E42-0561-48C9-8459-3EAC10EC8E16-htm.html

Bayram Ali Temel, H. B. (2020). Investigation of IFC file format for BIM based automated code compliance. *Investigation of IFC file format for BIM based automated code compliance*, 114-126. Retrieved from https://doi.org/10.31462/jcemi.2020.02113130

Bilal Manzoor, I. O. (2021). BIM-Based Research Framework for Sustainable Building Projects. *A Strategy for Mitigating BIM Implementation Barriers*, 1-2.

BuildingSmart. (2022). *Industry Foundation Classes (IFC) - An Introduction.* Retrieved from BuildingSmart: https://technical.buildingsmart.org/standards/ifc/

Fakhrutdinov, P. (2018). *Designing with Autodesk Revit.* Helsinki: Theseus. Retrieved from https://www.theseus.fi/bitstream/handle/10024/147816/thesis.pdf

Hovi, J. (2022, April 1). Solution Manager at Lumon. (O. Lindström, Interviewer)

Nemetschek. (2022, May 10). *Solibri*. Retrieved from Nemetschek Group: https://www.nemetschek.com/en/brand/solibri

Notepad++. (2022, April 11). *Getting started*. Retrieved from Notepad++ User Manual: https://npp-user-manual.org/docs/getting-started/

Solibri. (2021, May 5). *Creating Reports from ITO Results*. Retrieved from Solibri Help Center: https://help.solibri.com/hc/en-us/articles/1500004672262-Creating-Reports-from-ITO-Results

Solibri. (2022, March 14). *Understanding Information Takeoff (ITO)*. Retrieved from Solibri Help Center : https://help.solibri.com/hc/en-us/articles/1500004203942-Understanding-Information-Takeoff-ITO-

Tuori, J. (2022, March 22). Technology Manager at Sweco. (O. Lindström, Interviewer)

Vikki, K. (2022, April 13). BIM-Department manager at Ramboll. (O. Lindström, Interviewer)

11. Table of figures