Saimaa University of Applied Sciences
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Comparison of structural modeling in Open BIM projects

Bachelor's Thesis 2017

Abstract

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Saimaa University of Applied Sciences, Lappeenranta
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The aim of this thesis was to compare structural models made in two different programs: Tekla Structures and Revit, in order to identify differences in open BIM IFC-models according to Common BIM requirements 2012 and find out benefits of modeling in each program. This topic is actual, as nowadays more customers require information models of buildings, which contain all information about the facility. So having the idea of the differences and advantages of BIM projects, made with the help of different programs, will enable designers to choose the program that is the most suitable for a certain case.

The first part of the study was to create structural models. For this purpose the student’s versions of Revit 2017 and Tekla Structures 2017 were downloaded and studied. During the process of modeling, the difference in methods of structural modeling in Tekla and Revit were analyzed.

The theoretical part of the thesis was to understand the idea of Open BIM and study Tekla Structures and Revit as open BIM structural design tools. The advantages and disadvantages of each program were also studied as tools for obtaining results. Another part of the analysis was comparison of structural IFC-models with required IFC-information according to Common BIM Requirements 2012.

In the process of writing the thesis the benefits of both programs were highlighted. During the comparison of the structural IFC-models the differences between models were highlighted and reasons of their existence were explained. All the assemblies that were possible to model were modeled in accordance with Common BIM Requirements 2012. According to the results, a suggestion was made that these programs are very similar in the purpose they are used for and problems that they solve. But comparing the methods of modeling it was considered that Tekla Structures is more accessible and easy to learn, although this program is more expensive than Revit.

Keywords: Open BIM, Tekla Structures, Revit, IFC, comparison

CONTENTS

1 Introduction

Nowadays BIM technology has become widely spoken about in the building industry. It is clear that optimization and standardization of designing processes helps to shorten the time needed for designing, improves the quality of the projects and increases the productivity of designers. Now people are trying to find the way to improve this technology.

One of the ways is a technology called Open BIM. This technology simplifies the interoperability between different software applications. So it simplifies the processes of cooperation between architects and engineers.

Now there are quite many programs that use Open BIM technology in structural design. Among them there are two that are the most popular and widely used. They are Tekla Structures and Revit. These two programs are leaders among all the variety of programs because they offer an effective solution for creating building information models.

The idea of this thesis work was to study the BIM technology, the opportunities, possibilities, advantages and disadvantages of Revit and Tekla Structures. The aim was to understand processes of modeling in these programs. The purpose of this thesis was to compare the IFC-models with the required IFC-information that is given in the Finish Common BIM Requirements 2012. To manage this, both programs were studied. This research contains the following steps:

1. Modeling in Tekla and Revit
2. Explanation of what is BIM and its benefits
3. The idea of Open BIM
4. Explanation of what is Tekla Structures
5. Explanation of what is Revit
6. Comparison of Tekla Structures and Revit
7. Comparison of IFC-models

2 BIM

2.1 What is BIM?

Nowadays BIM (Building Information Modeling) is becoming more and more popular in construction industry, but not everyone understands what BIM means actually. BIM is not just a 3D model or a type of software, as many people believe. The technology of BIM is based on the creation of three-dimensional model of building, but in this case model is not just a set of geometric elements and textures. Such a model consists of virtual representations of elements that exist in real life. Such elements possess specific physical properties and logical characteristics. That gives us an opportunity to see the idea of the building behavior in the digital environment way before the actual construction starts.

Building Information Model represents a well coordinated, coherent and interconnected digital information about the projected or existing facility. It becomes the data provider for the document system, the scheduling system, the project management system and other systems.

Figure 1 shows the information related to BIM (incoming to the model and obtained from the model)

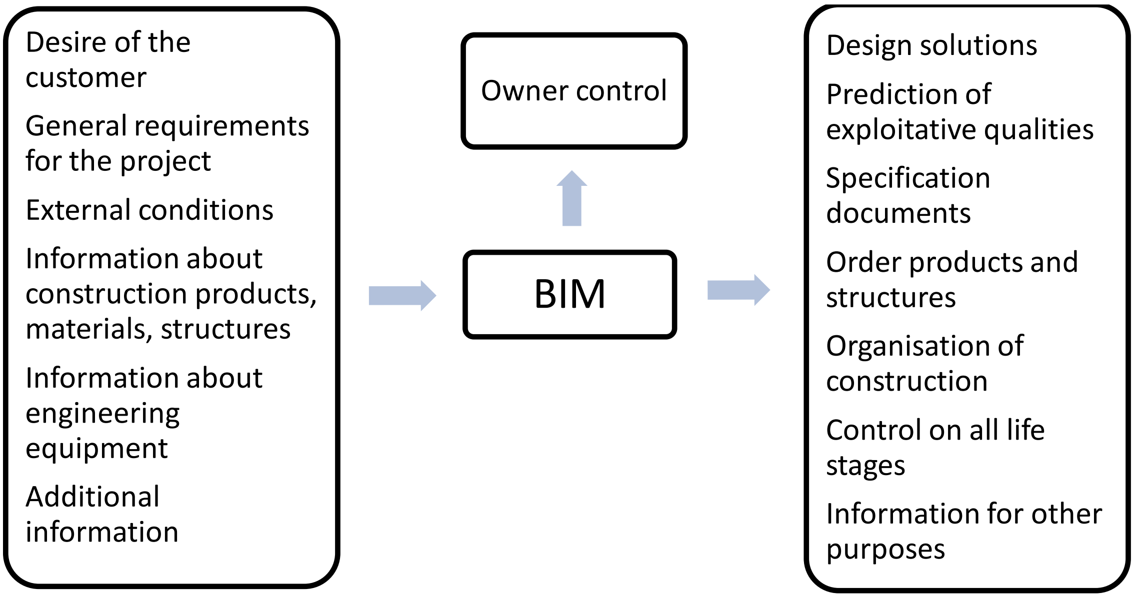


Figure 1. Basic information that have a direct relation to BIM. (1)

So BIM is a properly organized information about objects, that is used both on the design and construction stage of the building and during its operation and even demolition.

2.2 BIM benefits

The use of Building Information Models makes it much easier to work with the objects and has a lot of advantages. It allows us to assemble, link and coordinate the components and systems of the future structure created by different specialists and organizations, to check in advance their viability, functional suitability and also avoid mistakes. The Information Model exists throughout the entire life cycle of the building and even longer. The information contained in it can be changed, supplemented and replaced, reflecting the current state of the building. It is important for planning business and design, coordination of work in different sections of the project, installation works and assembly, construction.

One more benefit is centralized storage of information inside the model. That allows us to make changes easily and effectively. Changes that were made are immediately displayed in all views: on floor plans, facades and sections. This increases the speed of creating the project documentation and reduces the possibility of the mistakes.

The management of data is another benefit of BIM. Not all the information that is included into the Building Information Model can be represented graphically. That is why BIM also contains specifications that help to determine the labor cost needed for the project. Financial indicators are also available in BIM model. So the estimated cost of the project can be determined immediately after the changes have been done.

2.3 Advantages of BIM technology at each stage of the life cycle of the building

As was mentioned the Information Model exists throughout the entire life cycle of the building. There are special tasks that must be solved during each stage of the life cycle of the building and BIM technology has advantages that make the processes of solving these tasks easier.

2.3.1 Planning (Pre-project)

Before proceeding to the design of buildings, it is necessary to solve many general questions related to the clarification of the feasibility of the proposed construction, the choice of its location, the definition of the sources of financing, etc. Tasks that must be solved during this stage are as follows:

- Creation of conceptual model, that can move to the next stage without loss of data
- Placement the construction site to the existing site development
- Presenting the project to the interested persons
- Estimation of the cost of different variants

It takes a lot of time to solve these tasks but BIM technology has made this process quicker and easier because it has these advantages:

- Quick realization of the conceptual project in 3D model;
- Convenient visual assessment of proposed design solutions;
- Possibility of studying several variants and choosing the most optimal one based on project data and estimated construction cost;
- Preliminary analysis of energy efficiency;
- Preliminary analysis of shading;
- Acceleration of the design process by using the data of the pre-project stage on the next stages without loss of data. (8)

2.3.2 Designing

During this stage, a model of the future building is created and the necessary project documentation. Tasks that must be solved during this stage are as follows:

- High-quality of designing in accordance with established deadlines
- Creation of information model
- Collective work of different separated teams
- Coordination of all the sections
- Creation of specification documents
- Understanding how the data was changed and who changed it

- Avoid the appearing of duplicate data

BIM technology has advantages that make this process more convenient:

- Elimination of mistakes due to the assembly of all the parts of the project in one information space;
- Eliminating the loss of project information during the transfer of the data between the departments;
- Effective collective work;
- Increase of visualization and quality of transmitted information;
- Decrease in time of finding problem places and making the decision;
- Finding mistakes in a project before their appearance on the construction site;
- Tracking the changes in a project. (8)

2.3.3 Preparation for construction and construction

During the process of construction of the building appear a lot of organization tasks that must be solved. They are as follows:

- Interaction of the project department with the site workers
- Preparation for organization of the construction
- Schedule of works
- Cost
- Calculation of the needed materials
- Organization and management of the construction
- Monitoring the dynamics of work
- Comparison of plan and fact
- Control of deviations
- Adherence to deadlines

The advantages of BIM technology that are listed below allow to solve these tasks more quickly:

- Elimination of mistakes due to the assembly of all the parts of the project in one information space;
- Transfer the calendar schedule from planning programs to the model;

- The possibility to create an investment plan based on the concrete data;
- Access of all parties to information;
- Centralization of data;
- Traceability of equipment commissioning processes;
- Providing of a set of measures for labor protection;
- Decrease of time expenditures and avoidance of duplicate data in the system that can appear during the construction;
- Reduction of amount of mistakes and construction time. (8)

2.3.4 Usage

During the usage of the building appear such tasks as:

- Quick search for information about the building
- Reliable information
- Connection with operating systems

Advantages of BIM technology help to make the salvation of those tasks easier:

- Possibility to get and input the information about the operating facility
- Visualization
- Formation of the operation system based on the accurate information about the facility. (8)

2.4 The cost of mistakes with BIM technology and without it

If you look at the cost of the life cycle of the building from the design stage to construction and operation, then you will see that the designing accounted for the smallest part of investments (around 5%). While mistakes made by the company at the design stage will lead to significant unplanned expenses at the next stages especially at the construction stage. As a result, the cost of the project rises during the construction, and the real cost of the project is higher compared with the planned cost (the difference between the real and planned cost can be about 50%). (8)

The most common mistakes are collisions between the structure of the building and its building services systems (for example absence of temporary openings for the building services systems, incorrect calculation of the amount of the needed material). Such mistakes appear mostly because of an unproductive way of cooperation between specialists, who design different sections: architects and engineers, architects and designers, engineers and designers.

The use of BIM technology can decrease the difference between the real and planned cost of the project due to the following factors:

- On the base of Building Information Model there can be organized a collective work of all specialists that are involved in the designing process of a certain project;
- BIM technology allows us to identify the collisions automatically and make changes in the project at its early stages. This significantly improves the quality of the project documentation and specification documents;
- The use of information model allows us to plan the work on the site accurately, create correct schedules for the procurement of materials and improve all main logistic processes of construction. (8)

BIM makes it possible to shift the main amount of work on making changes to the stage of preliminary design and preparation of project documentation. (8) That significantly reduces the amount of requests for making changes in project documentation and reduces the cost of each mistake. While using the traditional design technology the main part of collisions are detected and corrected only at the stages of ready project documents and stage of construction. And making changes in ready documentation or during the process of construction takes a considerable amount of time and money.

Figure 2 shows how the cost of the collision related to the time when (on what life stage of the building) it was detected.

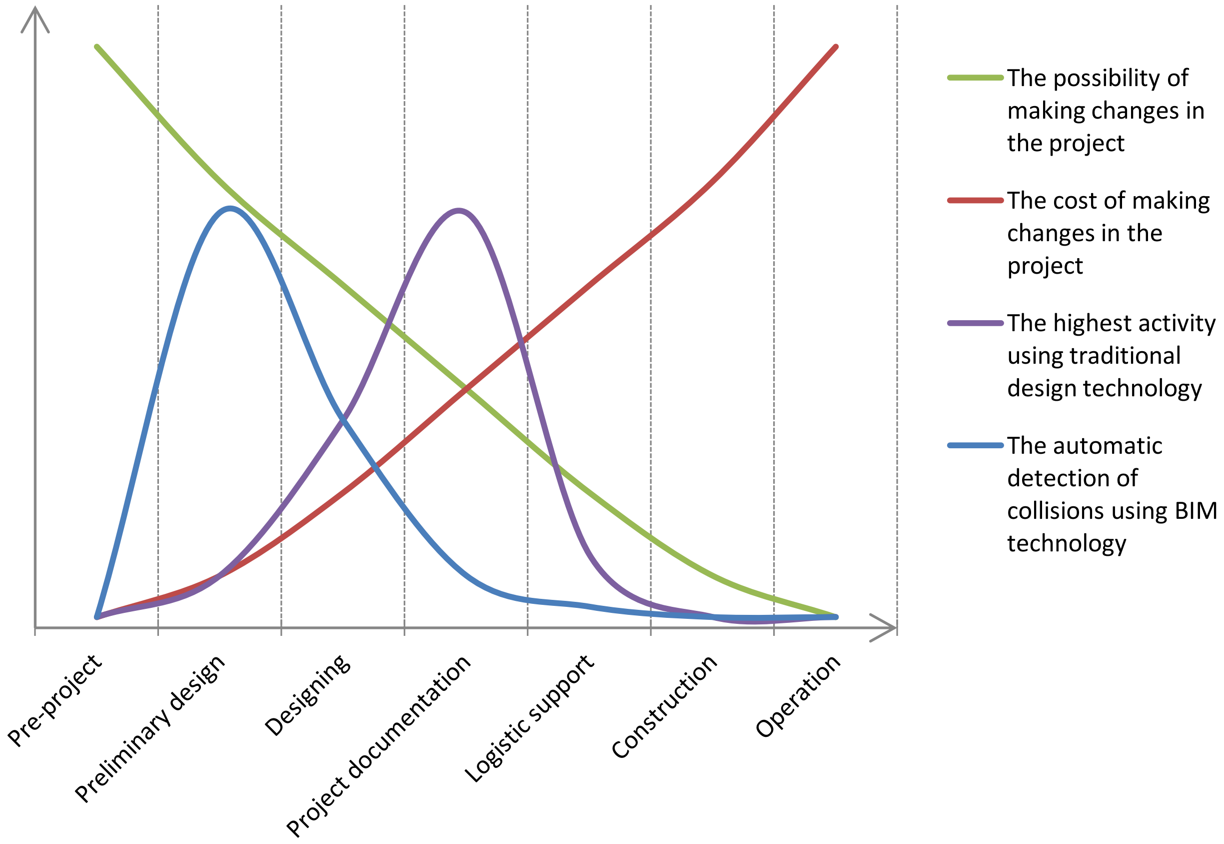


Figure 2. Relation of expenses on resources to the construction life stages of the building. (8)

BIM is a technology that makes it possible to create a three-dimensional model of the facility that will contain all the information about it. Moreover such a model is used not only for the construction, but also during the operation of the facility. That is why it is completely wrong to think that BIM is just a 3D graphic projection. The range of possibilities of this technology is very wide. Information modeling represents a completely new approach to building and managing a building, in which absolutely everything is taken into account.

BIM gives the opportunity to avoid possible changes that can appear during the designing of the building, reduces the expenses on the construction and the most important it helps to save time. BIM allows us to make right decisions at the stages of the life cycle: from investments to operation and even demolition.

Although this technology needs some financial expenses (special software is needed) but they will be compensated in the future by reducing the costs of designing and organizing the construction of the building.

2.5 Guidelines of BIM in Finland

The most known guideline of IFC is Common BIM Requirements 2012. COBIM 2012 requirements are based on the BIM Requirements published by Senate Properties in 2007. (6) The goal is to show BIM benefits for the entire life cycle of the built environment. The aim is to produce an operating culture for the use of BIM in building projects and BIM-based maintenance. Existing parts (1-9) were updated and additional four parts were added. (6) Part 14 is published but only in Finnish. The work started early 2011 and was published on the 27th of March 2012. (6) Since it is not a certified standard, it is flexible to update. COBIM is hosted by buildingSMART Finland. It can be downloaded for free from www.buildingsmart.fi (available also in English).

Series 5. Structural design is one of the parts of Common BIM Requirements 2012 and it was used during the creation of structural models in Tekla Structures and Revit needed for this thesis. This document covers structural BIM modeling and the required information content of the BIM models produced by the structural designer. (6) Modeling of structural models was made as close as possible to these requirements.

Several other Guidelines are for example as follows:

- Construction companies have released their own requirements (additions to COBIM)
- Consulting companies have their own internal guidelines
- BIM consultants who have knowledge about best practices

Also Supplementary Annexes were added to the Common BIM Requirements 2012 but these are available only in Finnish. The table that is shown in Appendix 3 was taken from the extra guideline for Structural BIM guideline and translated into English.

3 Open BIM

3.1 The idea of Open BIM

Open BIM was an initiative of several leading software developers, who use the open data model of the buildingSMART. The Open BIM concept was founded by Tekla and Graphisoft companies and is supported by other organizations that use BIM technology. Open BIM movement is always ready to cooperate with any organizations of the construction industry that want to support common goals and meet certain requirements. (12)

The main idea of Open BIM is to improve BIM solutions for interoperability between different software applications. (11) So, why there was a need in Open BIM technology? There are simple reasons for this. Architects and engineers have different requirements for their BIM, that is why the modeling conventions and internal logic of the model can differ significantly. So it is important to understand that the BIM for engineers is not the same as the architectural BIM. Typically, engineering applications (for example the structural or energy design applications) are different in each country. Most engineers prefer programs that support the standards of their own country and these are usually specific local applications. An architectural program must be able to work together with hundreds of local engineering programs. There are two main conditions that must be met to achieve interoperability: support for the so-called “reference model” and support for an open-source, yet standardized data exchange format (that has quality requirements). (11) Open BIM meets both conditions. This is the implementation of the reference model on an open platform. (11)

What means reference model? Each discipline is responsible for its own work. For example, structural engineers are responsible for the load-bearing parts of the building, they calculate for the local design standards. This means that each discipline must be able to edit and modify only its own model, while using the others’ models only as a protected reference alongside their own.

As it was said, the models coming from different disciplines, even if they may seem similar at the first site, can be in fact quite different in their details. This is especially typical of the exchange between the architect and structural engineer. For example: the architects define the contour of a slab, while the engineer, doing design calculations with available building elements (for example, hollow core concrete slab panels) defines the final load-bearing structure. In the structural model, several slab elements (which might even be modeled using beams) can replace the single slab element used by the architect. So even in this simple slab example, we can see several differences between the two model types: in the element type used, in the size and in the number of elements used.

Many other examples of differences between the models used by the disciplines can be cited. For example there can be differences not only in the cross-section of the elements, but also in relative positions of the elements. An architect does not pay attention to details, the architect gives only the whole appearance of the structure and the engineer thinks about connections and other details. After all, it is engineer, who determines the final position of the load-bearing elements, as calculated using the given loads and environmental conditions.

To summarize, different responsibilities and model types among the various disciplines demand the use of the reference model concept. (11) The following basic rule must be observed: loss of information in geometry and data is not allowed. (11) The "geometry" part means that an element of the reference model must be shown in the project with its original geometry and at its original position. The "data" part does not mean that the reference model has to contain all the information that is important to the other disciplines. It must contain only the data relevant to the specific project (for example, relevant data for an architect include the exact material and profile data defined by the structural engineer in the structural model).

That is why there was a need for Open BIM technology. And Open BIM perfectly copes with its purpose. Thanks to it, programs can understand objects created in other programs.

3.2 IFC

To work properly Open BIM needs to operate with one open-code file format, which should meet several requirements. Open-code file format has various possibilities, but it also must meet a lot of requirements. Architectural and engineering programs are able to read and write many data exchange formats.

Requirements and considerations that the format for interdisciplinary collaboration must fulfill:

- It must support the 3D representation of the elements;
- It must be able to store data;

- The database must be filterable, so that each discipline can extract just the data that it considers important;
- It must fulfill the requirements of the reference model concept;
- The format code must be open to any software developer (necessary to ensure global collaboration among local programs, as well as the major ones);
- The code must have a simple scheme structure to enable fast code implementation;
- Language of the code must be English in order that it can be understandable and implemented anywhere in the world;
- It should be possible to localize the standard properties for various countries. (11)

Among the various available file formats, it is Industry Foundation Class – or IFC – which meets all of these requirements. IFC has been developed by buildingSMART (a non-profit industry-led organization) since 1994. (11) The IFC scheme contains hundreds of predefined standard properties by object type. (11) Although the IFC database can be very large, it is easily filterable with a simple user interface. As an open format, IFC does not belong to a single software vendor. It is neutral and independent of a particular vendor's plans for software development.

The IFC scheme structure is very simple. It is even possible to check the content of IFC model using a text editor. The IFC code language is in English, but some countries are translating the property names into their own language. IFC defines multiple file formats that may be used, supporting various encodings of the same underlying data. (11) Besides the most widely used IFC format, it has an XML format, which is suitable for interoperability with XML tools (for example cost estimation, facility management applications) and exchanging partial building models. Both IFC formats can be compressed into ZIP format in case of huge project models and databases.

3.3 Open BIM in practice

An IFC scheme is basically a large code. It is easy to explain the structure of the IFC's scheme on the example of a book, in which each chapter describes a particular data exchange workflow. (11)

For example: one chapter includes the specification for sharing of building information models among the disciplines of architecture, structural engineering and building services.

Another chapter defines the data requirements for facility management, for example how to describe the space containment and the base quantities of its members.

Another chapter sets the rules for sharing models for energy analysis purposes, for example how to export the relation between the spaces and the building elements that surround them.

Each of these "chapters" is called "Model View Definition". So, a Model View Definition defines a legal subset of the IFC Scheme and provides implementation guidance or agreements for all IFC concepts, classes, attributes, relationships, property sets, quantity definitions used within this subset. (11) The official names of these Model View Definitions are: Coordination View, Basic FM Handover View and Space Boundary Add-On View. (11) These Model View Definitions are the most important ones for architects and hence for an architectural application. The "Basic FM Handover" – based IFS database is the starting-point for COBie documentation standard required in many English-speaking countries. COBie stands for Construction Operations Building Information Exchange. (11) The currently most implementation IFC view is the "Coordination View", the tool for sharing building information using the reference model. One British firm tested the data exchange between programs and concluded that "IFC can and does work on the vast majority of products" and "we must all be able to use the software of our choice". (11) In other words, we have to know and learn the interoperability skills of the BIM applications we use. Thanks to the IFC open platform all disciplines are able to exchange data of the schematic design, the design development and the construction documentation phases in 3D model-based mode.

What are the requirements and the details of the structural-architectural data exchange workflow? There is a great deal of overlap between the structural engineer and the architect regarding building planning. Different structural applications have different functions, and these applications must be able to share data with architects. The data connection involves more than a simple two-way model exchange, it must be able to manage changes in the models and this is a cyclical process with many reiterations.

The main functional requirements of the data exchange:

- Create the model for each discipline;
- Assign types to elements and classify their functions, so that the other discipline will recognize model elements in its own environment;
- Filter elements and data. Filtering for export: only the data that the other discipline needs should be exported. For example, accessories such as a fence, bench or a car – these are not the part of the load-bearing structure. Structural engineer does not need a detailed window structure when the bounding box of the window will be enough. Filtering for import: in case when the received database is big, the information must be filtered for the one that is needed;
- Export the model;
- Import the model and place it as a reference model into each receiving application;
- Change management – managing the version changes in models of each discipline. (11)

It must be possible to export just the load-bearing elements to the structural engineer who uses Tekla Structures, the building model with their spaces and functions to the mechanical engineer who uses Revit and the entire project to the Manager who uses a model checker like Solibri.

So, the Open BIM program is a universal approach to the collaborative design, realization and building operation based on the open standards and workflows.

The program provides common definitions and requirements for implementing of Open BIM collaboration.

4 The main structural software applications that use open BIM

4.1 Tekla Structures

Tekla Structures is a building information modeling software, that make it possible to model structures that include different kind of building materials (steel and concrete are included). Tekla is one of the leaders among BIM-programs in the world. This program allows structural designers and engineers to design the structure of the building and its components with the help of 3D modeling, create 2D drawings and access building information. The models made in Tekla Structures can be used on every stage of the construction process: from sketches to construction, installation and management of construction works.

In Figure 3 the appearance of the Tekla Structures interface is shown.

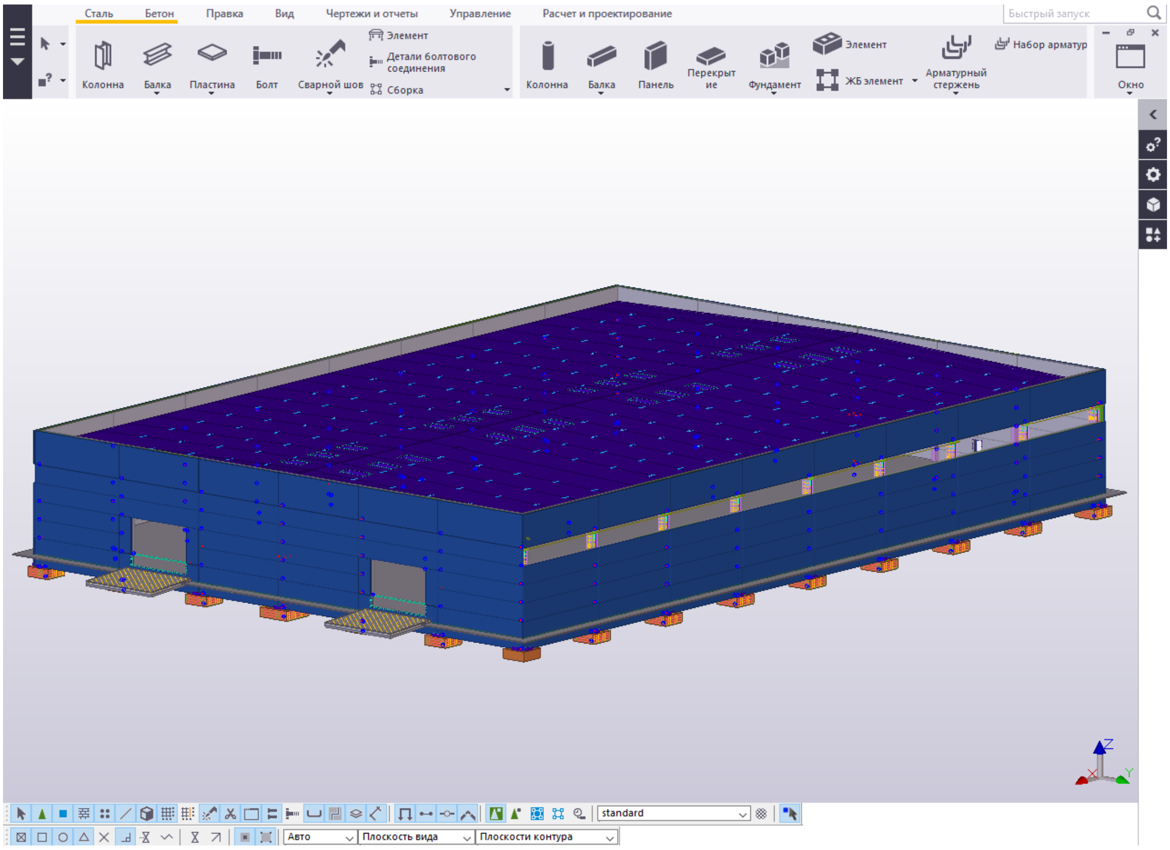


Figure 3. Tekla Structures interface view

Tekla Structures has a rather long history in construction industry. The company called Teknillinen laskenta Oy ("Technical calculations on a computer") was registered in February 1966 in Helsinki, Finland. This long name was shortened to Tekla in spring in the same year. The basic principles of Tekla's work were defined as consultations in the field of automatic data processing (ADP), computer services, training courses and software development. At the moment, Tekla Structures is used in more than 100 countries around the world and the basis of work in this program is BIM modeling. (17)

Tekla Structures represents software solutions available in several specialized configurations, so users can choose the one that is the best for their specific case. These configurations are as follows:

- Full (full detailing);
- Construction management;
- Steel Detailing (detailing only steel constructions);
- Precast Concrete Detailing (detailing of the prefabricated reinforced concrete elements)
- Reinforced Concrete Detailing (detailing of the monolithic reinforced concrete elements);
- Engineering;
- Additional project management modules. (17)

Tekla Structures Full is a universal configuration that contains modules for detailing of metal structures, prefabricated reinforced concrete elements and cast in place concrete elements. It is possible to create three-dimensional models of structures made of steel and concrete. Modules of Tekla Structures, Full allows us to carry out a variety of functions: from displaying the stages of work implementation to the automatic generation of drawings of monolithic and reinforced concrete elements. (17)

Tekla Structures for Construction Management contributes to the work of contractors who need to model, plan and manage projects, regardless of the material and its type. (17)

Tekla Structures, Steel Detailing is a configuration intended for designing of steel constructions. It is used to create detailed three-dimensional models of any metal structures and to obtain the data for manufacturing and installation.

Tekla Structures, Precast Concrete Detailing is the standard configuration that is supplemented with the functions of detailing prefabricated reinforced concrete structures. (17)

Tekla Structures, Reinforced Concrete Detailing is the standard configuration that is supplemented with the detailing functions of monolithic reinforced concrete elements. (17)

Tekla Structures, Engineering is a standard configuration that makes it possible to implement a synchronized construction. The designing of metal structures and internal engineering systems occurs within the frame of a shared model. (17)

Tekla Structures is known to support large models with several simultaneous users, but is considered relatively expensive, difficult to learn and fully use. It competes in the BIM market Autodesk Revit and others. (17)

Engineers have used Tekla Structures to model stadiums, offshore structures, plants, factories, residential buildings, bridges and skyscrapers. Tekla Structures was used in the construction for various projects around the world, including:

- Sutter Medical Center (California, USA) (15)
- Expansion, Chennai International Airport (India) (5)
- Capital Gate (Abu Dhabi, UAE) (4)
- Puuvilla Shopping Centre (Finland) (13)

Tekla Structures was used extensively for the steel design of Capital Gate at Abu Dhabi, UAE. Files exported from Tekla facilitated faster steel fabrication. One of the architects, Jeff Schofield, stated that "it was the right time in history and we had the right technology to make this happen". (4)

The Manitoba Hydro Spillway Replacement was designed using Tekla Structures to "successfully model and co-ordinate its design", a project that won the TEKLA 2012 North American BIM Award for "Best Concrete Project". (9) It was the "first hydroelectric project that has seen steel, concrete, and rebar fully detailed using Tekla Structures. (10)

Tekla Structures allows to exchange models and drawings with a number of architectural and industrial programs, one of them is Revit.

4.2 Revit

Revit is a powerful tool based on a Building Information Modeling technology. It is created for architects, structural designers and engineers of building services systems. This program allows creating three-dimensional models of the building elements and creating drawings, organizing a teamwork on the project from the concept to the release of construction documents.

In Figure 4 the appearance of the Revit interface is shown.

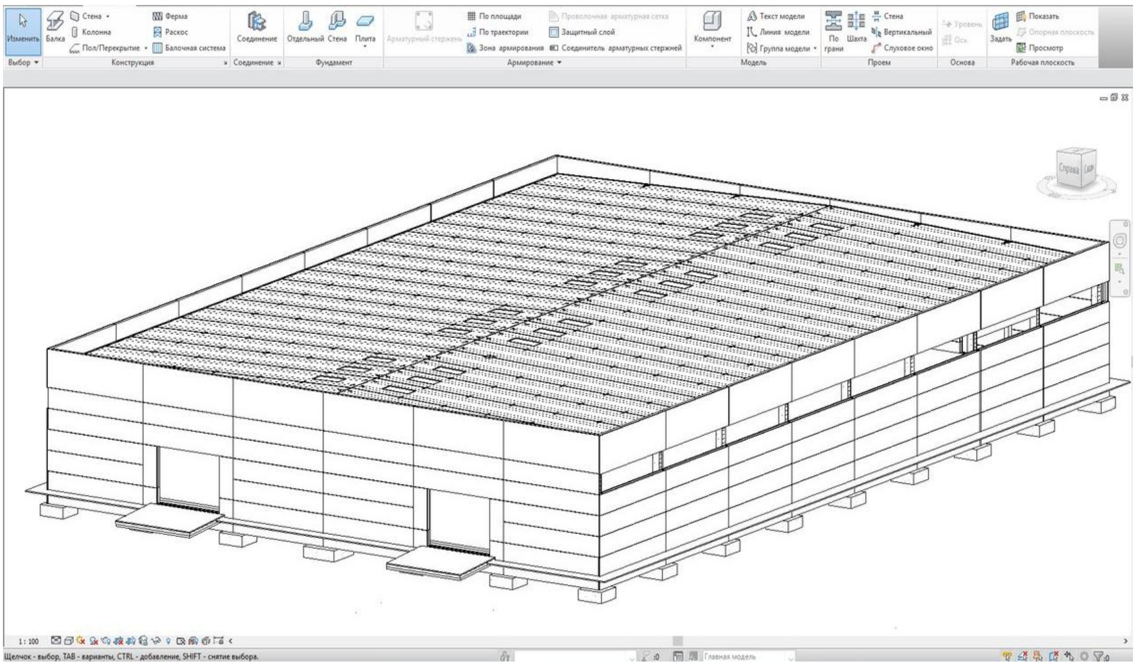


Figure 4. Revit interface view

The main features of the program are as follows:

1. Conceptual design

Convenient tools for conceptual design make it possible to create sketches of building of arbitrary shapes. The ages of this shape will be used to create walls, roofs, floor structures. Even on the stage of conceptual design, there is an opportunity to make a preliminary calculation of areas and volume of the building. (3)

2. Parametric components

These components can represent both the simplest building elements (walls, columns), and more complex - for example, furniture or various kinds of equipment. (3) Parametric components, also known as families, are the basis of the design process in Autodesk Revit. To create families, you do not need knowledge of programming. (3)

3. Specifications

They are one of the views of the model in Autodesk Revit. Any change in the model leads to an automatic change in the specification and vice versa. It is possible to associate the specification tables and also use elements such as formulas and filters in the project.

4. List of materials

The list of materials allows calculating quantitative indicators in detail. This function is very important for determining the cost of materials. Accuracy and relevance of information about materials is provided throughout the project cycle.

5. Check for intersections of elements of the model

The program provides a special function for checking the objects of the three-dimensional model for the presence of spatial intersections.(3)

6. Rendering

The rendering system allows us to achieve photorealistic visualization of completed projects. The Autodesk materials library has more than 1,200 components. (3)

7. Collaboration

The collaborative technology used in Autodesk Revit enables all team members to access the building model at the same time and also provides tools for virtual division of the model into separate parts. It is also possible to have a shared access to different parts of the project.

8. Calculations of systems

Autodesk Revit allows you to:

- calculate the energy consumption of the building;
- determine loads on heating and cooling systems;
- trace systems in the building automatically or manually;
- automatically select sections of pipelines and ventilation ducts;
- determine the costs in the system and the pressure loss in the network;
- to calculate average illumination;
- calculate loads in the electric line, taking into account the utilization factor;
- determine the voltage loss in the electric line. (3)

9. Creating families

In Revit the groups of elements with the same parameters are called the families. To replenish libraries of such groups, you can use one of the following methods:

- Editing families existing in the program;
- Create new families. To create a family, it is needed to correctly describe the geometry of the object and make the necessary dependencies.
- Depending on the purpose of the object, different technical characteristics can be assigned to this object (pressure loss, local resistance coefficient,

power, etc.) and add connectors to hook up the element to the engineering networks;

10. Creation of several variants of project solutions in one file (3)

When you implement a project in Autodesk Revit, you can present the customer with several options for design solutions, systems or equipment used. All variants will be stored in one file. Powerful means of visualization and preparation of presentations for the customer is speeding up the decision-making process.

Revit was used in the construction for various projects around the world, including:

- Stadium Tyumen-Arena (Russian Federation) (8,14)
- The Freedom Tower (Manhattan) (2)

5 Comparison of modeling in Revit and Tekla Structures

The comparison was made on the example of two identical models of concrete structure created in Tekla Structures and Revit.

5.1 The modeled structure

The designed model is a model of the industrial building. In this one-story industrial building, the bearing structure is a concrete frame system. The frame in this case is a system of racks and beams. Racks are reinforced concrete columns of rectangular cross-section. The height of the columns in the extreme rows is 8,3 meters and in the middle row 8,05 meters. Columns are supported by the foundation blocks of reinforced concrete.

Figure 5 shows a column of the extreme row modeled in Revit.

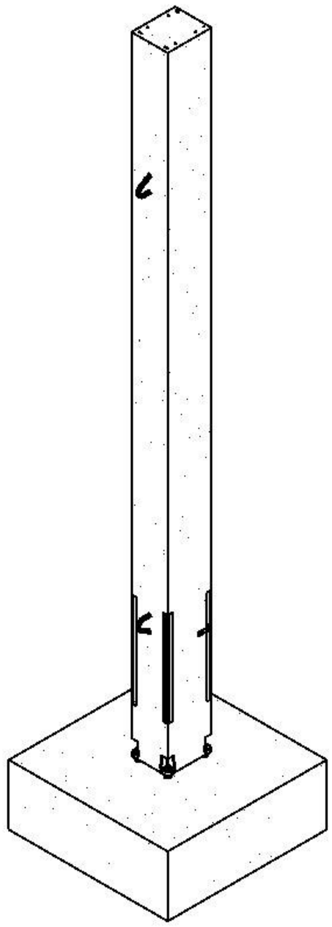


Figure 5. Column in Revit

In the designed model there are beams of two types. One type represents beams of rectangular cross-section. Such beams connect the extreme rows' columns. Another type of beams represents beams of complex cross-section. Beams of this type connect the middle row's columns.

Figure 6 shows the appearance of a beam of complex cross-section modeled in Revit.

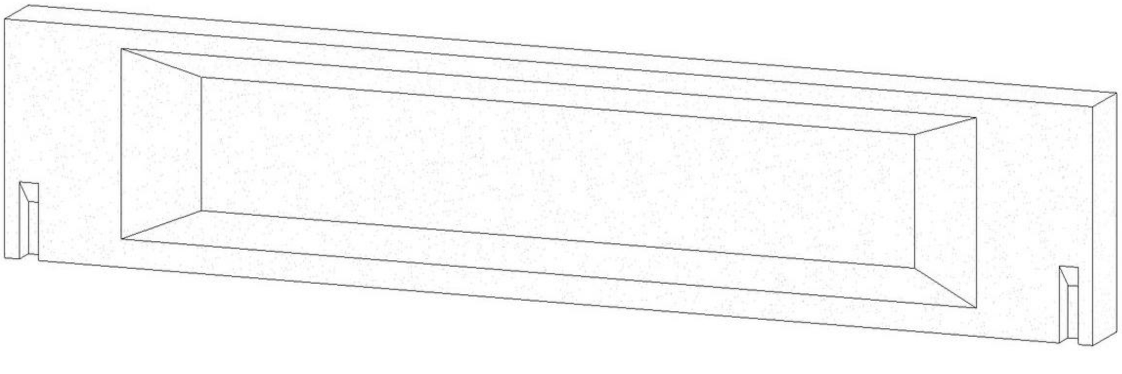


Figure 6. Beam of complex cross-section in Revit

To connect beams to columns seating connections with dowel were used. That means that beams are connected to columns with the help of anchor bolts and in some cases also with develed corbel.

The outer walls in this case are certain walls and they consist of sandwich panels. Such walls perform only enclosing functions and transfer their mass to the columns of the frame, except for the panels of the lower tier that are supported by the foundation. Roofing consists of TT-slabs that are supported by beams.

During the process of modeling some advantages and disadvantages of each program on several stages of modeling were highlighted.

5.2 Output of 3D view

Two identical models were made in Tekla and Revit. Comparing the speed of copying the model elements, it can be surely said that Tekla Structures is several times faster than Revit (especially when it is needed to copy a big part of the model). However, when the time needed for removing a big part of the model was compared, the result was the opposite. The removal speed in Tekla is lower than it is in Revit but it should be noted that the difference between removal speeds is not as big as the difference between copy speeds.

5.3 Temporary dimensions and dimensions in the models

The time sizes in both programs work quite differently. In Tekla, it is not possible to select a numerical value for the size and enter the needed value, dynamic input is disabled, the change occurs by moving the size arrow to the desired location.

The temporary dimensions in Revit work absolutely the opposite way, it is not possible to change the size of the element by moving the end of the dimension line, but you can dynamically enter a value for the size.

Dimensions in the model in Tekla are similar to the dimensions of the model in Revit, their difference is that for example the tool "measure distance" works not only in the working plane but also in the three-dimensional space of the model. If you press the right mouse button and choose "update model" all dimensions disappear.

5.4 Modeling concrete elements

In Revit there are several ways to make concrete elements:

The first way is to use special tools for each element: to make a model of a column use tool “column”, for beam - tool “beam”, etc. It is the simplest way to create concrete elements.

Another way is to create so called families. In this case to make, for example, a model of the column a special tool is used. It is called extrusion. With the help of this tool it is not difficult to create any concrete element. At first it is needed to set the dimensions of the section and then adjust the height of the column. This way is more useful and efficient when there is a need to create some specific column (for example if a column has a complex cantilever). A column is one of the simplest elements as an object for creating a family. It differs from other elements’ families in that it has a binding of the top and bottom to the levels of the model. If the layout of the levels is changed (for example, the height of the floor changes), the columns are automatically extended or shortened.

In Tekla it is easy to make concrete elements. For each element there is a tool with the help of which it is possible to make a model of this element. The column is placed in one click that defines the position of the column. Then the size of the section, height, material and other needed settings of the column are adjusted in the option “properties”.

However, during the modeling it was found that in Revit it is easier to create beams of difficult section than it is in Tekla.

5.5 Reinforcement

5.5.1 Tekla Structures

Tekla Structures allows creating reinforcement in various ways. Manually it is possible to create:

- Individual reinforcing bars;
- Rebar groups;
- Reinforcing mesh.

In addition, there are a lot of reinforcement components in Tekla Structures. It is recommended to use reinforcement components to create reinforcement, if possible. They are adaptive, attached to the concrete part and automatically updated in case, for example, changes in the size of the reinforced part. Then, additional reinforcement tools can be created with the help of other tools. In many cases, you can not get the desired reinforcement with the help of any one tool, and you need to use this or that combination of tools cops.

The rods are located in 3D due to the fact that there are parameters that are responsible for binding the reinforcement to the work plane. The tool does not allow creating every variant of the rod shape that can be imagined but there is a huge number of possible rod shapes. In order to create a group of elements, there is a separate tool. The only difference between it and the one-bar reinforcement tool is that now the "group" tab has become available in it. As a result, it is a more extensive tool and contains all the possibilities of the previous tool. The group of reinforcing bars consists of several identical or very similar reinforcing bars. The program considers these rods as a group and changes them in the same way, removes them all at once, and so on. When creating a group, it is first necessary to determine the shape of a single rod, and then the direction in which Tekla Structures will distribute the rods. Instead of determining the shape of the rod manually, it is possible to use the "Shape Catalog", where a needed shape can be chosen from the variety of shapes. It is also possible to create a reinforcing mesh consisting of two perpendicular groups of reinforcing bars. The program considers reinforcing mesh as a single object however it distinguishes between the main and transverse rods. After the reinforcement mesh is created, it is impossible to change its type. The reinforcement stack can be rectangular, polygonal or curved.

The reinforcement contains all parameters for all kinds of sheets and specifications, nothing to invent as in space is not necessary. Another feature and difference from the program is that the whole reinforcement lives by itself, it does not belong to any automatic design and can hang in the air and its copying does not need a base, more precisely.

5.5.2 Revit

There is a tool for reinforcing the columns with individual rods in Revit. But in the 3D model mode, it is not possible to place the reinforcing bar; it is needed to create a cut and only in the section it is possible to place the necessary rod. Here it is possible to place the rod in any plane of the section (orthogonal or parallel to the view). When the rod is already placed in the plane, an array of roads can be made either by setting spacing or amount of rods. It is possible to make a new sketch of the reinforcing bar, but in the end it can be forgotten about placing the bar into the list of elements or anywhere else in the specification.

There is a possibility of using IFC reinforcement. In this case it is possible to create their families of reinforcement, both independently and inside other categories of families, and they can be placed without creating a cut, that means that it is placed immediately in three-dimensional form.

A big problem is the volume of the model, which is growing strongly due to the creation of views and sheets. For this reason, making a whole large building with reinforcement and creating sheets will result in a collapse of the model. In addition, there are problems with the numbering of the rods. One element cannot be reinforced by analogy with the other as it can be done in Tekla, it is necessary to make a new reinforcement or copy each element of the reinforcement one by one. If they are not put in groups, then the reinforcement will move and the outwardly identical positions will differ by a couple of millimeters and turn into different positions.

6 Comparison of IFC-models

6.1 Comparison of Tekla Structures IFC-model with Revit IFC-model

The comparison of IFC-models was made with the help of Tekla BIMsight. Tekla BIMsight is a system for synchronized 3-dimensional viewing and testing of building models of different formats. It allowed us to open both models at the same time and see the differences between their constructions.

Visually, the models look the same, but there are some differences if a detailed check is made. The most significant difference is that the whole Tekla IFC-model is shifted relative to the Revit IFC-model. The magnitude of the shift (it is 10 mm) is not very big in comparison with the dimensions of the entire model, but it is noticeable and can be rather important when it is needed to compare small parts of the models. This problem can appear when IFC-files were created. Both models were attached to the center of coordinates during the adjustment of the IFC-file, it is most likely that one of the models was shifted relative to the center of coordinates in the beginning of the modeling, and as a result, this shift appeared when these models were opened in Tekla BIMsight.

Another difference is about beams of complex cross-section. When you try to pick out one of such beams from the Revit IFC-model, it is highlighted as a single unit. When you try to do the same with the Tekla IFC-model, you see that this beam is made up of several parts and it is possible to highlight each part only separately. This difference appears because of differences in the methods of modeling. In both programs this beam was made up of several parts, but in Revit it was made as a family. When creating a new family, you can make an element from many different parts but when the family is created, the element that was made up of several parts is recognized as a single unit. This is a special feature of modeling in Revit.

One more difference between Revit IFC-model and Tekla IFC-model is about pipes. There are no pipes in Tekla model. The reason of this difference is that Revit has a special tool for creating plumbing, and in Tekla Structures there is no such tool. That is why pipes are not modeled in Tekla Structures.

During the comparison of models it was also found out that the reinforcement in the Tekla IFC-model slightly differs from the reinforcement in the Revit IFC-model. This difference may occur due to inaccuracies in the adjustment of the parameters of the reinforcement. Such inaccuracies could be made because the methods of creating the reinforcement are completely different in Tekla Structures and Revit.

6.2 Comparison of IFC-models with required content of IFC-model

This comparison was made with the help of Solibri Model Viewer. Solibri Model Viewer is a free tool that allows to review IFC-models. This program is useful when it is needed to review IFC-format model but there is no need to perform checks.

Solibri Model Viewer can show the information about the selected element. It is possible to show elements only of one category (for example to show only walls, or only slabs, or columns). Here one thing about walls in Revit IFC-model should be explained. In this particular Revit IFC-model there is no “wall” category. It is so because walls were created as a system family. System families are families that are made inside the particular project and it is impossible to use them in another project (to have such family in another project, you will need to create it once again). For system families there is a separate list of categories that can be assigned to these families and there is no “wall” category in this list. That is why in this project category “objects” was assigned to the walls.

The results of comparison of IFC-models with the required content of IFC-model are shown in Appendix 3. The required content of IFC-files is based on the Part 5 of extra guidelines published in Common BIM Requirements 2012. According to the result of the comparison it can be said that all assemblies were modeled in accordance with Common BIM Requirements 2012.

7 Summary

Tekla Structures and Revit are two the most known programs that use Open BIM technology. They help designers to facilitate and quicken the process of modeling and to increase the quality of models.

Both these programs have their pros and cons but according to this research it can be said that Tekla Structures is easier to learn and use and is more convenient for structural modeling.

Tekla Structures allows modeling in 3D environment. It is very convenient because there is no need in using a lot of reference plans and it is possible to snap on the face of objects. In Tekla Structures it is also much easier to model the connection details and create the reinforcement.

While in Revit, the designer needs to use several plans when he/she needs to model the element. Moreover when it is needed to make an identical reinforcement (for example if columns have different sizes of sections) it is not possible in Revit. This does not mean that Revit is a useless program and it should not be used any more. Revit has many advantages (for example it is possible to create architectural elements and it is more feasible in making complex cross-sections) but if there is a need to make a detailed structural model, then modeling it in Tekla Structures will be easier.

The comparison of IFC-models showed that differences in IFC-models can be related to the inaccuracies made during the process of modeling, and also differences may occur because of the differences in methods of modeling in Tekla Structures and Revit. All of the assemblies that were possible and needed for this project were modeled according to the Common BIM Requirements 2012.

To sum up, it should be said that both Revit and Tekla Structures are very helpful in Building Information Modeling and they should be studied and implemented in a larger number of structural companies.

Figures

References

1. BIM: WHAT IS USUALLY MEANT BY THIS? http://isicad.ru/ru/articles.php?article_num=14078

2. BRIEF HISTORY OF BIM. https://www.archdaily.com/302490/a-brief-history-of-bim

3. CAD FOR ARCHITECTURE AND CONSTRUCTION / ARCHITECTURE / AUTODESK REVIT. https://cad.ru/ru/software/detail.php?ID=26900

4. CAPITAL GATE, ABU DHABI, UAE. https://books.google.ru/books?id=H67mBQAAQBAJ&pg=PA157&dq=%22Tekla+Structures&redir_esc=y#v=onepage&q=%22Tekla%20Structures&f=false

5. CHENNAI AIRPORT ERWEITERUNG. https://www.tekla.com/ae/node/4661

6. Common BIM Requirements 2012. Series 5: Structural design.

7. FROM THE PRACTICE OF INFORMATION MODELING https://damassets.autodesk.net/content/dam/autodesk/www/campaigns/BTT-RU/Sportbuild.pdf

8. INFORMATION MODELING OF INDUSTRIAL AND CIVIL CONSTRUCTION OBJECTS. https://damassets.autodesk.net/content/dam/autodesk/www/campaigns/BTT-RU/BIM%20for%20buildings_Autodesk.pdf

9. KGS GROUP TEKLA NORTH AMERICAN BIM AWARD. http://www.kgsgroup.com/awards_tekla.html

10. MANITOBA PROJECTS WIN IN NORTH AMERICAN BIM AWARDS. https://www.constructioncanada.net/manitoba-projects-win-in-north-american-bim-awards/

11. OPEN BIM. http://www.graphisoft.com

12. OPEN BIM. http://isicad.ru/ru/articles.php?article_num=18524

13. SHOPPING CENTER PUUVILA. https://group.skanska.com/projects/57816/Shopping-Center-Puuvila

14. STADIUM TYUMEN-ARENA: THE EVOLUTION OF FORM AND DESIGN TECHNOLOGY. http://www.forma.spb.ru/archiblog/2014/11/15/arena-revit/

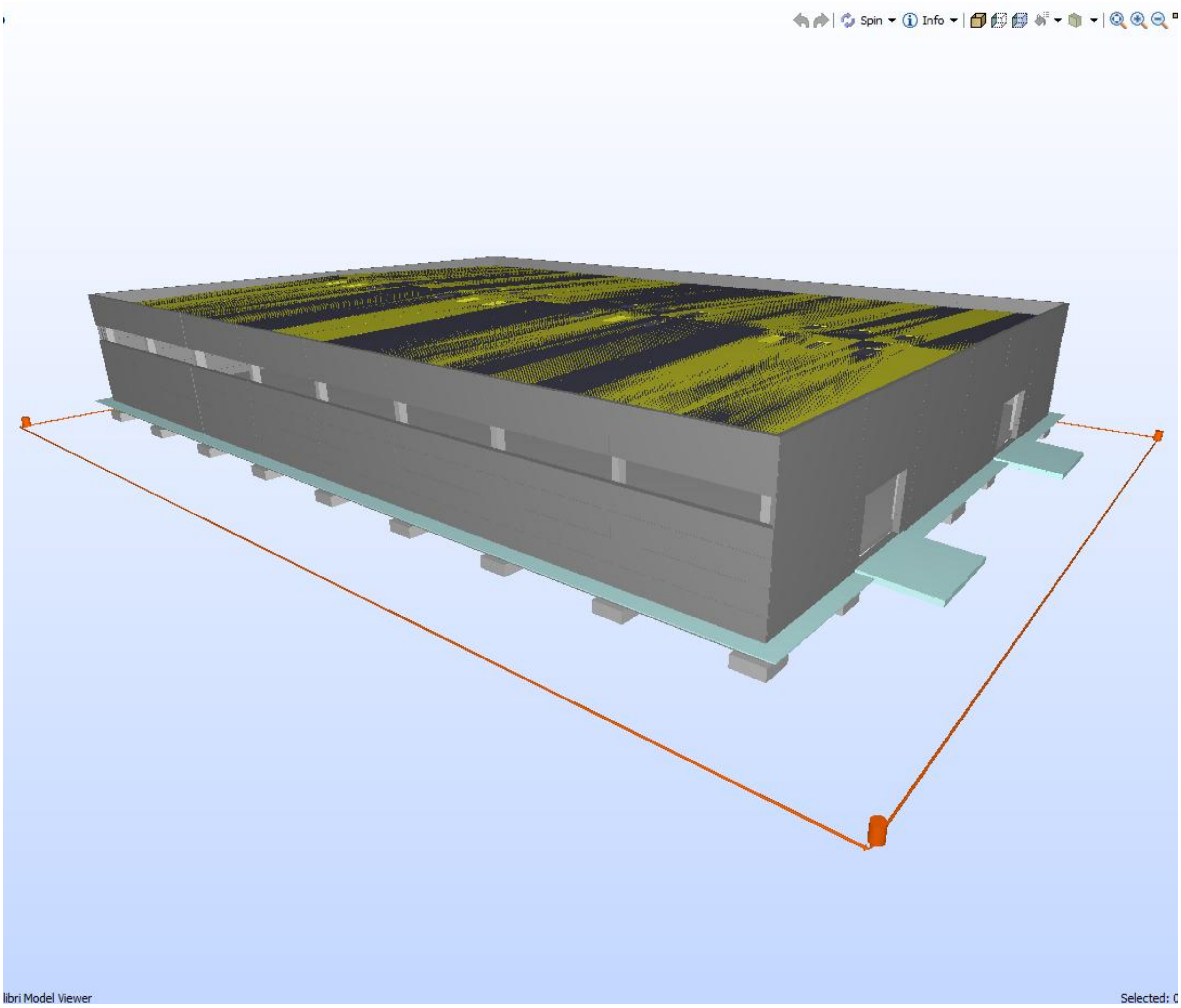
15. SUTTER MEDICAL CENTRE CASTRO VALLEY. https://www.tekla.com/ae/node/5000

16. Supplementary Annexes. Part 5. Structural Planning. Subscriber's Guide. Modeling accuracy. https://buildingsmart.fi/yleiset-tietomallivaatimukset-ytv/

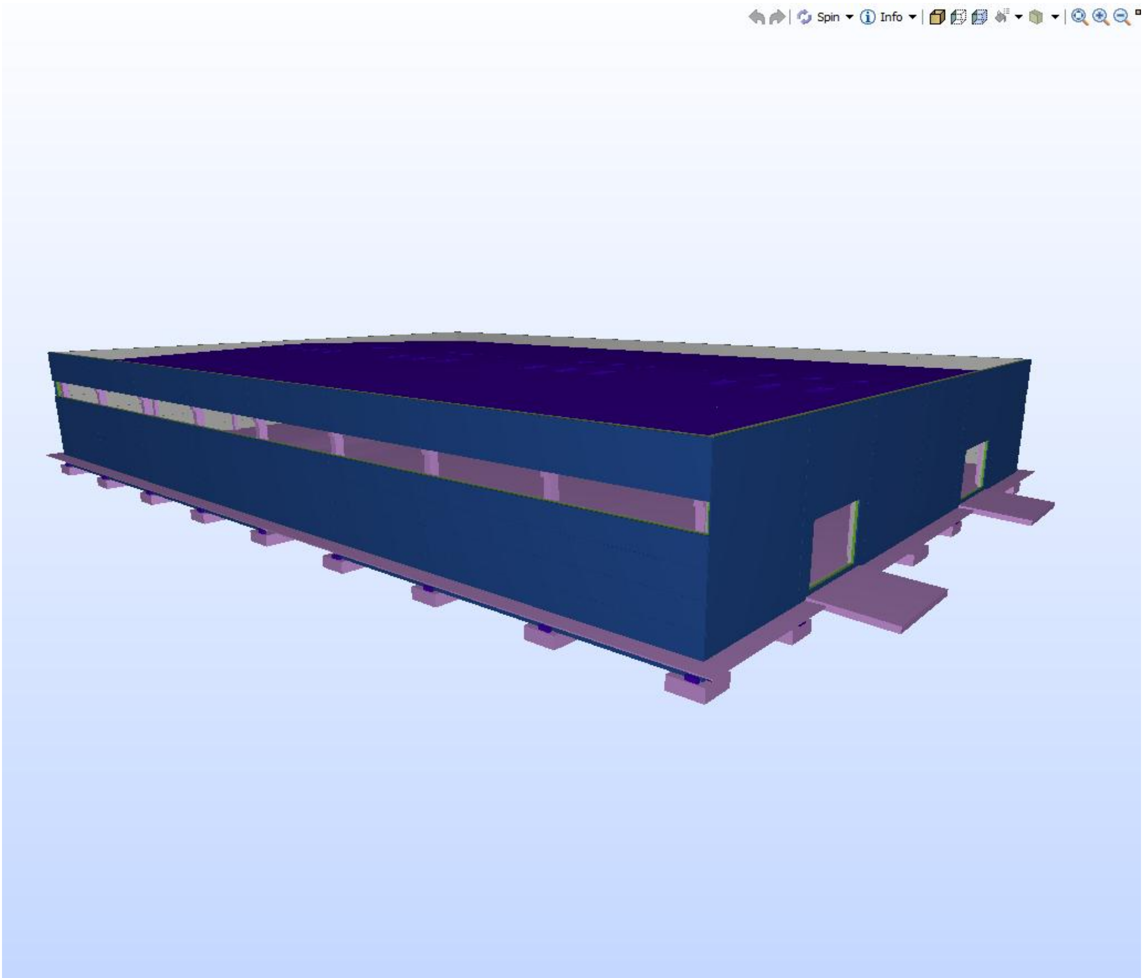
17. TEKLA STRUCTURES IS INNOVATION OF STRUCTURES' MODELING. http://unistroy.spbstu.ru/index_2013_11/3_baranovskij_tarasov_11.pdf

Appendix 1. Models opened in Solibri Model Viewer

Revit model opened in Solibri Model Viewer

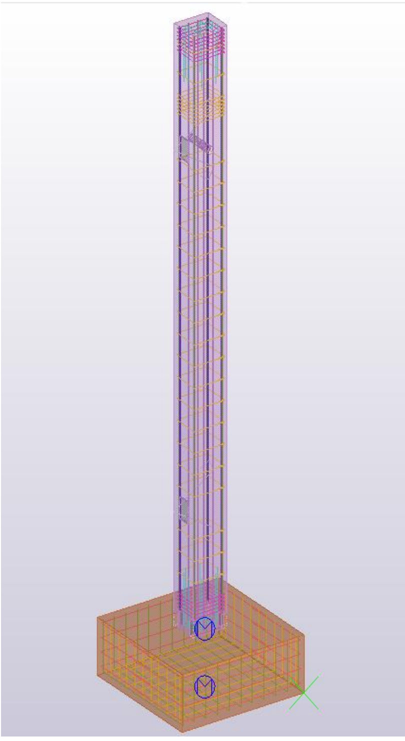
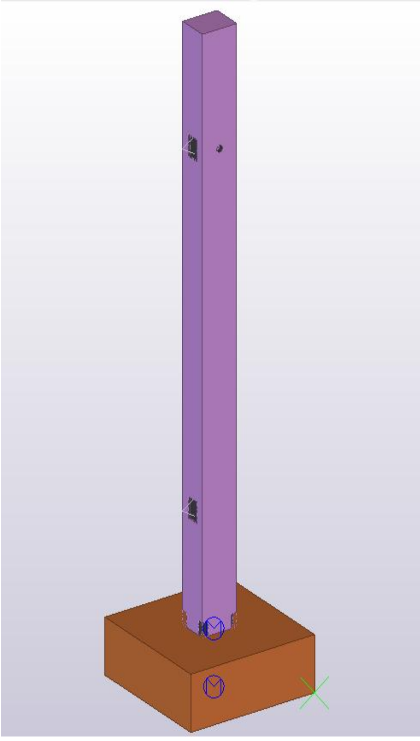


Tekla model opened in Solibri Model Viewer

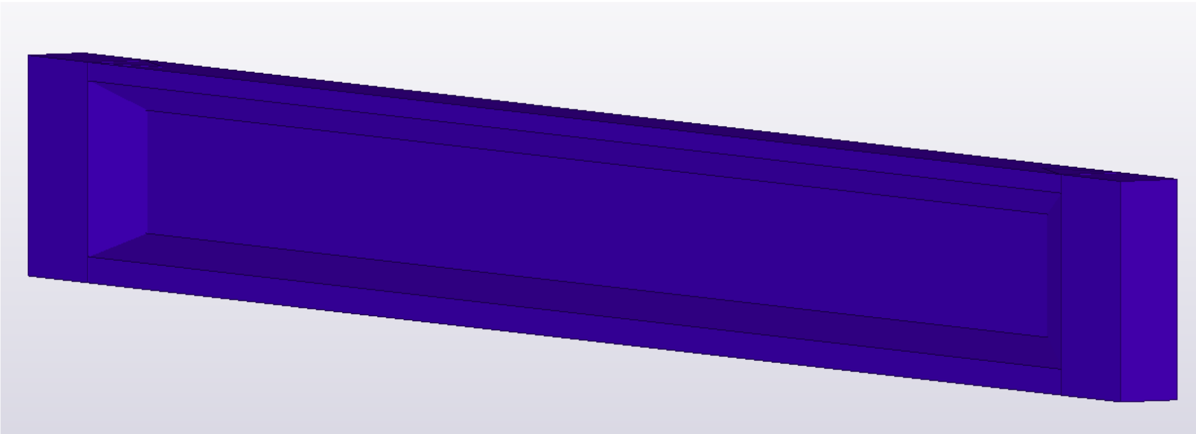


Appendix 2. View of elements in Tekla Structures

Column in Tekla Structures

Beam of complex cross-section in Tekla Structures



Appendix 3. Required level of modeling accuracy and required information content of IFC-model (16)

Symbol	Meaning
R/T	Assembly is modeled both in Tekla Structures and Revit/ information of the IFC model included both in Tekla Structures and Revit models
R	Assembly is modeled only in Revit/ information of the IFC model included only in Revit model
T	Information of the IFC model included only in Tekla Structures model
⊗	Assembly was not modeled
◯	There was no need in this assembly in this project
*	The required information of the IFC model paragraph

Modeling accuracy	Description of the modeling level
1	Modeled correctly for basic geometry and location.
2	For the basic geometry, model it correctly so that the total number of structures can be derived from the model. Structures are elemented.
3	Modeling of the elemental elements and type placement curves in terms of geometry and location, right with joints, loops and valves. The steel configurations are made with the concrete elements corresponding to the model configurations with their joints (also in alloy poles including reinforcements). Other parts are correctly modeled for geometry and location with joins and valves.
4	Model the elements and spot casts for geometry and location correctly, with their joints, braces and valves. Steel assemblies are modeled on the machine shop floor (including alloys with reinforcements). Pallet brackets are moved to the model and piles are modeled with the actual.

Models to be modeled and the accuracy of modeling				The information content of the IFC model paragraphs																					
№	Assemblies	Modeling accuracy	Comments	Name	Profile	Floor	Material	Marking	Status information	Section	Launch number (ACN)	Precast/Cast in place	Classification (class)	Top elevation	Lowest elevation	Top global cork.	Lowest global cork.	Area (brutto)	Area (netto)	Length	Width	Height / thickness	Volume	Volume of concrete parts	Weight
111	Land																								
⊗	Excavations	(2)	Agreed on each project	*	*	*		*	*	*			*	*	*	*	*	*	*	*	*	*			
R	Drainage parts	2	Drainage system	* R	* R	* R	*	* R	* R	* R		* R	*	* R	* R	* R	* R			* R	R	R	*		
R	Special land parts	2	Radon pipes	* R	* R	* R	*	* R	* R	* R		* R	*	* R	* R	* R	* R			* R	R	R	*		
112	Support and confirmation																								
○	Pile	3	Pile numbering	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Strengthening of supports	(2)	Agreed on each project	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
115	Area Structures																								
○	Yard stocks	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Garden canopies	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*

○	Fences and supporting walls	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Area of stairs, ramps and terraces	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
121	Foundations																								
R/T	Notch	3	The name is PILARIANTURA, JATKUVA MAANVARAINEN ANTURA, JATKUVA PAALUANTURA etc	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T		* R/T	*	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	*
○	base walls, cast in place	3		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Basic columns, cast in place	3		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Basic beams	3		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Basic elements	3		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Thermal insulation	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		
122	Base floor																								
○	Ground cast slab	3	Poured	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Element of slab	3		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

R/T	Ground slabs	2	Poured	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Thermal insulation	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		
○	Base canals	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Special base (ramps and swimming pool construction)	3		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
123	Frame																								
	Air-raid shelters	3		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
R/T	Supporting walls	3		* R/T	* R/T	* R/T	* T	* R/T	* R/T	* R/T	*	* R/T	*	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	*
R/T	Columns	3		* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	*	* R/T	*	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	*
R/T	beams	3		* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	*	* R/T	*	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	*
○	intermediate floors	3		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Intermediate materials, castings	3	The point foundry fields are divided into production areas defined by production areas	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
R/T	Roof, load-bearing structure	3	Modeled like floorboards, skylights are modeled	* R/T	* R/T	* R/T	* T	* R/T	* R/T	* R/T	*	* R/T	*	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	*

○	Roof, trusses	3		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
R/T	Sound, heat and fire insulation	2	Modeling of all compact building products, the size and location of which are relevant to other designers	* T	* R/T	* R/T	* T	* R/T	* R/T	* R/T		* R/T	*	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* T	* R/T	T	
○	Frame of the stairs	3		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Elements of stairs	3		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Special frameworks	(3)	Agreed on each project	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*		*
124	Facades																								
R/T	Exterior walls, concrete elements	3	The non-integral surfaces structure of the outer wall elements is modeled separately	* T	* R/T	* R/T	* T	* R/T	* R/T	* R/T	*	* R/T	*	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* T	* R/T	* T	*
○	Exterior walls: thermoset, wood, steel	2	The identifier that is used is the type of object to be	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*			

			constructed																						
R/T	Exterior wall coverings. (brickwork, plaster)	2		* T	* R/T	* R/T	* T	* R/T	* R/T	* R/T		* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* T	* R/T	T	
○	Steel frame for lightweight facades and glass facades	3		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		*
125	Outer layers																								
○	Balconies (roof tiles, fences, railings)	3		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Canopies	3		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Special exteriors (exteriors, roof terraces)	3	Concrete shielding tiles with tilting, thermal insulation and wells are modeled	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
126	roofs																								
○	Roofing structure	2	Concrete shielding beams, roof rails, heat insulation and equipment parts are	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*

			modeled																						
			The wooden grills over the bearing structure are modeled on the geometry correctly	*	*	*	*	*	*	*		*	*	*	*	*	*				*	*			
○	eaves	3	Steel support structures are modeled, such as steel structures in general	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Glass roofing	3	Steel support structures are modeled, such as steel structures in general	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		*
○	Skylights, hatches	2	The hatches for maintenance are modeled, steel / composite doors / covers of overhead decks are modeled and designed	*	*	*	*	*		*		*		*	*	*	*								
131	Space sharing																								

	sections																								
○	Non-load-bearing concrete partition walls	3	Modeled like elemental constructions in general	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Brick partitions	(2)	Modeling the required support structures (agreed on a project basis)	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Wooden partition walls	2	The identifier information is the type of object being used	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Glass partitions	2	Modeling the required support structures (agreed on a project basis)	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Staircase (concrete, steel)	3	As the frame of the stairs	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
132	Status surfaces																								
R/T	Floor surface structures	2	Surface coatings of floors	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T		* R/T	*	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	* R/T	*
134	Other items																								

⊗	Safety equipment and walking structures	3		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
○	Fireplaces and chimneys	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		
135	The status element																								
○	Bathroom elements	2	Modeled in the right space, the KPH code, the name of the bathroom items	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		
○	Cold room panels	2	reserving space	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		
○	sauna elements	2	reserving space	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		
○	Building elements of building technology	2	Reserving space. If it is made of steel and implemented according to the plans of the subscriber, it is modeled as other steel structures	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		

○	The flue elements	2	Element supplier ID	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		
000	Correction destinations																								
○	building parts to be dismantled	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		
○	Preservable building blocks	2		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		
009	Occupational Safety and Health																								
○	Safety fasteners	2		*	*	*	*	*		*		*		*	*	*	*								
○	vemot	2		*	*	*	*	*		*		*		*	*	*	*								
○	Anchoring points for safety harnesses	2		*		*	*	*		*		*		*	*	*	*								
	reservations																								
○	reservations	(2)	Provisions for load-bearing structures are modeled according to the approved IFC orders of civil engineers (agreed on the basis of the project)	*			*							*	*	*	*								