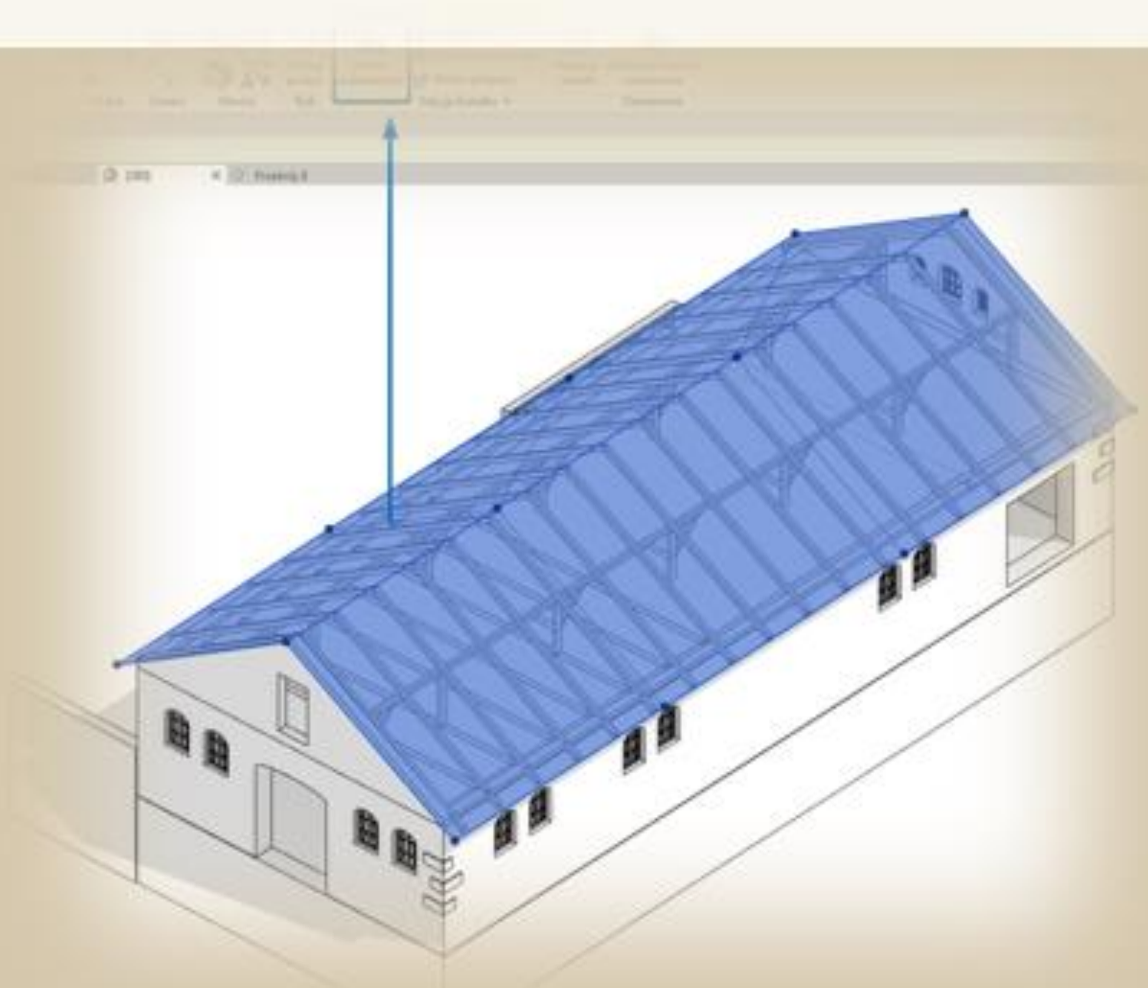
DIDACTIC MATERIAL - INVENTORY PATTERNS OF SELECTED TYPES OF MONUMENTS

Universal survey of historic object, supporting H-BIM modelling



Publication developed within the project *Heritage BIM -*

- enhancing digital competences of students of Architecture

by the consortium:

- **Politechnika Lubelska, Poland**
- **Politecnico di Milano, Italy**
- **Vysoke Uceni Technicke v Brne, Czech Republic**
- **BOSCO studio, Poland**
- **Harpaceas, Italy**
- **Allplan Česko, Czech Republic**

Lublin, 2022

Co-funded by the Erasmus+ Programme of the European Union

Key Action 2: Strategic Partnership

1. INTRODUCTION

This comprehensive manual serves as an indispensable resource for students embarking on their journey into the world of Heritage BIM (Building Information Modeling). Heritage BIM uniquely sits at the crossroads of historical preservation, cutting-edge technology, and innovative architectural practices, making it an essential subject for those who aim to bridge the past and future.

The diversity within the realm of Heritage BIM is vast, encompassing a rich tapestry of historic structures and architectural wonders, each with its distinct characteristics and historical significance. To truly encapsulate the essence of heritage preservation, students need the adaptability to work proficiently within various software environments. With this goal in mind, this manual has been meticulously designed to facilitate learning across multiple software platforms, with a primary focus on Allplan and Revit.

The selection of these software platforms is not arbitrary; it is driven by a commitment to versatility. Allplan offers robust architectural planning tools, while Revit is celebrated for its prowess in Building Information Modeling. By comprehensively covering both platforms, we ensure that our students are well-prepared to navigate the diverse software landscapes they may encounter in their professional journeys.

A pivotal theme explored within this manual revolves around the seamless integration of previously gathered data into BIM models. This process is not just about digitization; it's a transformative journey that bridges the temporal gap between history and the present. We will explore the techniques and methodologies outlined in this manual to unlock the true potential of Heritage BIM. Through this, students will gain the ability not only to create accurate digital models but also to infuse them with invaluable data retrieved from the past.

Heritage BIM's power lies in its universality. This manual demonstrates that by offering examples of creating various elements within models of diverse objects, from historic townhouses and industrial structures to objects in a state of ruin. Heritage BIM transcends architectural diversity, highlighting its adaptability and utility in preserving and documenting heritage structures of all types.

As we delve into these examples, we will learn how to capture the unique essence of each structure, regardless of its historical or architectural significance. The principles and techniques provided in this manual are universally applicable, ensuring that students are equipped to confidently and expertly tackle a wide spectrum of heritage BIM projects.

In the following sections, we will embark on a journey of discovery, delving into the intricacies of Heritage BIM. We will acquire the skills to capture the essence of historic structures, navigate diverse software environments with confidence, and harmoniously merge the richness of historical data with the precision of BIM technology.

Heritage BIM is not just an academic subject; it is a testament to our commitment to honoring our heritage while embracing the limitless potential of technology. As we navigate this educational voyage with this manual as our trusted guide, we will unlock the world of Heritage BIM and pave the way for a future where history and innovation coexist harmoniously.

2. CASE STUDY - Allplan

The Colonia Elioterapica (Heliotherapic Colony) is located in Legnano, a city of about 60.000 people northwest of Milan.

In the Lombard industrial context, it was conceived in 1936 for the children of the workers of the Cantoni cotton mill in Legnano and financed by Swiss engineer Carlo Jucker, a company executive and a man sensitive to the social and humanitarian aspects of its employees as well as to the cultural and artistic aspects of the time, in line with both the philanthropic and paternalistic lines of the late 19th century and the hygienic and pedagogical principles, not unmindful of the fascist period.

The building was constructed between 1937 and 1938 at the highest point of the city, on the hill of Ronchi Park, from which it is possible to glimpse the entire town. It was capable of accommodating 800 children (400 females and 400 males) during daylight hours and in the summertime. It was designed for summer and daytime operation only actually remained in operation for only 2-3 years. Completed in 1938, it stopped functioning when Italy entered the war in 1940. It resumed, however, after the war, starting in 1946, but with a different function.

The inauguration took place on June 24, 1938. The project was carried out by the BBPR studio, a group of Milanese architects formed in 1932 and consisting of Gian Luigi Banfi (1910 - 1945), Lodovico Barbiano di Belgiojoso (1909 - 2004), Enrico Peressutti (1908 - 1976), and Ernesto Nathan Rogers (1909 - 1969), authors of important architecture such as, for example, the Torre Velasca in Milan and the restoration, with adaptation of the rooms into a museum, of the Castello Sforzesco, also in Milan.

The design of the Colonia respects the formal and functional characters of the Modern Movement: spaces are studied in the smallest detail considering their functions and mutual relations, interior-exterior, interior-interior, exterior-exterior.

In fact, the floor plan consists of the juxtaposition of two bodies, connected by a pair of covered passageways, the whole articulated in the open space into four rooms: the main building, the shed in the lawn for siesta, the circular pavilion with services, and the outdoor facilities. The entrance building housed the management, two waiting rooms, a consultation cabinet, a medical examination room and related facilities, the changing rooms, divided according to the sex of the children.

The kitchen was a vast hall 15m wide by 10m long. It was equipped with a charcoal oven, two sinks and built-in furniture. The special feature of this room lay in its roof: a sloping ceiling with vents at the top, which, because of its shape, acted like a large hood. The walls, on the other hand, were covered with an enamel paint in the lower part, so that they could be cleaned more easily. In addition, the kitchen overlooked a basement room, reached by two external staircases, which housed pantries and storerooms. However, the kitchen, which was located in the refectory room, was divided from the latter by three portico passages.

The refectory, consisting of a U-shaped plan with an area of 5240 m3, could accommodate up to 800 children and took light from a series of high windows, and a sequence of picture windows, placed at child height, both located along the two wings of the building. The south façade, thanks to the setback of the pillars presented a continuous, openable glazing, so as to provide both ventilation and shelter. In addition, the glazing also featured paired two-by-two inward-opening doors. Today, the glazed wall is still present, albeit largely degraded. The central interior wall of the refectory was then covered in red polished stucco, while the pillars in white, as were the other walls, which, however, had a lime plaster covering. Even the interior furnishings, from the kitchens to the locker rooms to the refectory, were conceived and designed by BBPR themselves, a symptom of the strong attention to functional details of the modern movement.

The solarium made of larch wood, painted bottle green like the window frames, of which no trace remains today, ran along the south front and allowed not only shelter from the sun of the windowed front by a series of curtains, but was also able to provide an appropriate and supervised place for the heliotherapeutic care of the children. Its dimensions were 2.40m wide, 6.75m high and a length of 40.10m equal to that of the glazed wall.

Within the Ronchi Park, BBPR designed both the green space and the secondary volumes by placing, on an axis orthogonal to the facade, two circular pavilions about 10m in diameter, intended for showers, washbasins, and lavatories, also divided according to the sex of the children. These were specially designed, with a natural system suitable for warming the water intended for the showers.

Parallel to the main building there was also a large thatch-covered shed to house the children in bad weather, for shade breaks and for sheltering equipment. The structure consisted mainly of brick with reinforced concrete pillars and concrete-slab floors.

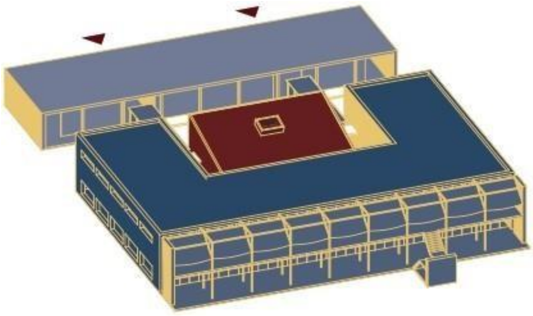


Figure 1 Colonia Elioterapica by BBPR, 1938[1].
Source: F.Biccheri, M.Delmedico, G. Garcìa Sànchez, M. Martìnez-Artero Peñalvernomi, Laboratoy of Restoration 2019/2020, Master Degree of Architettura – Ambiente Costruito – Interni, Politecnico di Milano.

The Colonia Elioterapica was closed in August 1942, occupied by German troops and turned into an ammunition depot. After the war ended, it became the headquarters of the Italian Partisans Association and was later turned over to the Legnano Hospital.

In 1954, the hospital administration decided to transform the former Colonia into a center for the reeducation to work of those handicapped by injury due to the economic-social problems born of the industrial revolution between the 19th and 20th centuries, in fact constituting the first center of its kind in Italy. It became more and more necessary, in fact, to rescue, care and re-educate to work those workers who, stricken by work injury found themselves impaired in their ability to work. The new reeducation center for motulesi from work injury began operations in the summer of 1955.

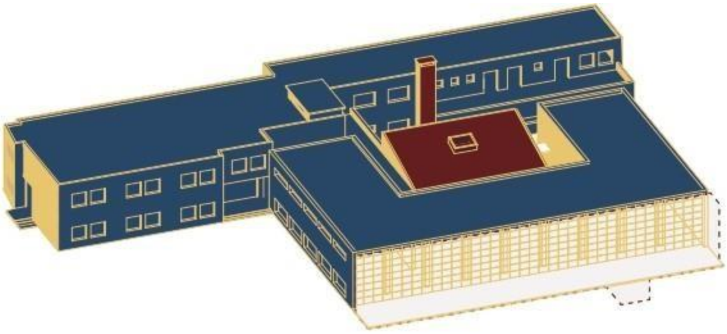


Figure 2 Colonia Elioterapica from 1956 to 1982[2].
Source: F.Biccheri, M.Delmedico, G. Garcìa Sànchez, M. Martìnez-Artero Peñalvernomi, Laboratoy of Restoration 2019/2020, Master Degree of Architettura – Ambiente Costruito – Interni, Politecnico di Milano.

The original 1938 Colonia complex was partially demolished and then rebuilt: of the original group of buildings only one building survived, the one that once housed the refectory and solarium, now dilapidated. In fact, the shed and the front body were also demolished, replaced by a two-story building. The refectory was divided into three parts: refectory and conference hall, gymnasium (left wing) and swimming pool (right wing), while the kitchen retained its purpose. The new building housed the inpatient rooms, the medical

[1] The triangles symbolize the two separate accesses to the building. The rectangular shaped body is the entrance building and it is connected to the U-shaped building, the refectory, and to the kitchen, the red body in the middle, by to covered corridors. The solarium is visible in front of the main side of the refectory.

[2] Of the original complex, only the body of the previous refectory and the kitchen survive. The original entrance building, the two covered corridors and the solarium are demolished and a new body takes place.

room, while the Colonia was adapted to the physical activity of the motulans. As can still be seen today, a gymnasium for rehabilitation exercises, a pool for underwater physiotherapy and various outpatient clinics were provided inside. Attached to the facility was later built a church, inaugurated and consecrated by Archbishop Giovanni Battista Montini of Milan in 1961, which still stands within the area today.

The Legnano center was taken as a model both in Italy and abroad, but it was closed in November 1982 andthe department transferred to the Traumatology Pavilion of the Legnano hospital citadel. Since that time, the remaining spaces of the Colonia have been unused, now severely degraded due to neglect and heavily damaged by at least two arson fires.

Since August 1, 1990, the area of the former Colonia Elioterapica has become the site of the psycho-social center, which reports to the psychiatric department of the Legnano Civil Hospital.

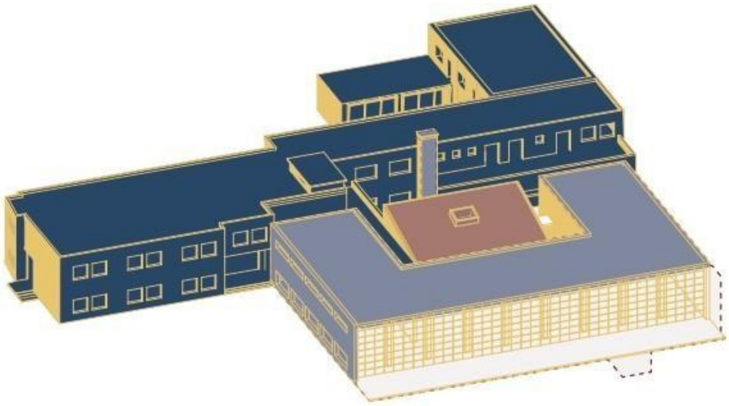


Figure 3 Colonia Elioterapica from 1998 to nowadays[3].
Source: F.Biccheri, M.Delmedico, G. Garcìa Sànchez, M. Martìnez-Artero Peñalvernomi, Laboratoy of Restoration 2019/2020, Master Degree of Architettura – Ambiente Costruito – Interni, Politecnico diMilano.

[3] To the complex of the 50s – 80s other bodies were added, but the spaces of the original kitchen and refectory have been abandoned.

1.1. Photo narrative

Figure 4 Colonia Elioterapica in 1938: view of the solarium.

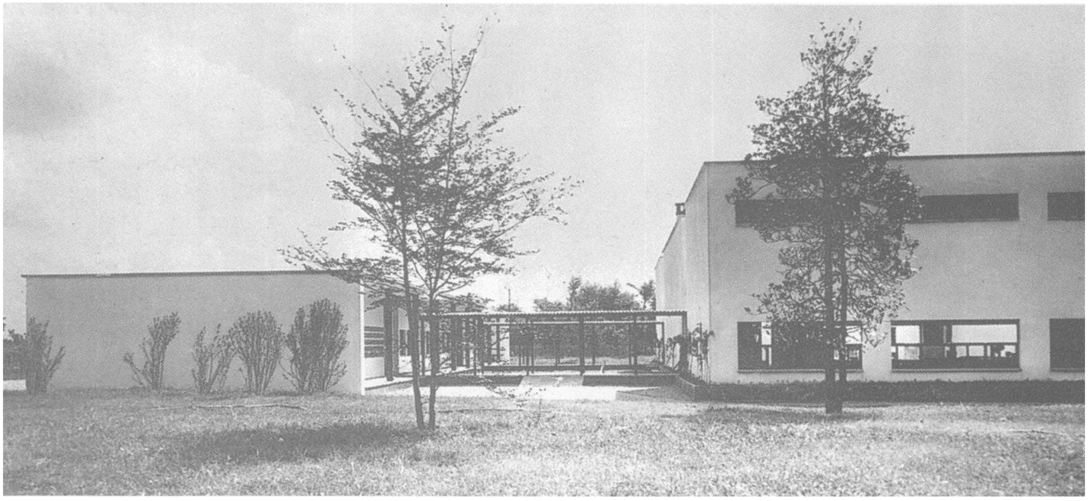


Figure 5 Colonia Elioterapica in 1938: view of the two bodies and the covered corridors.

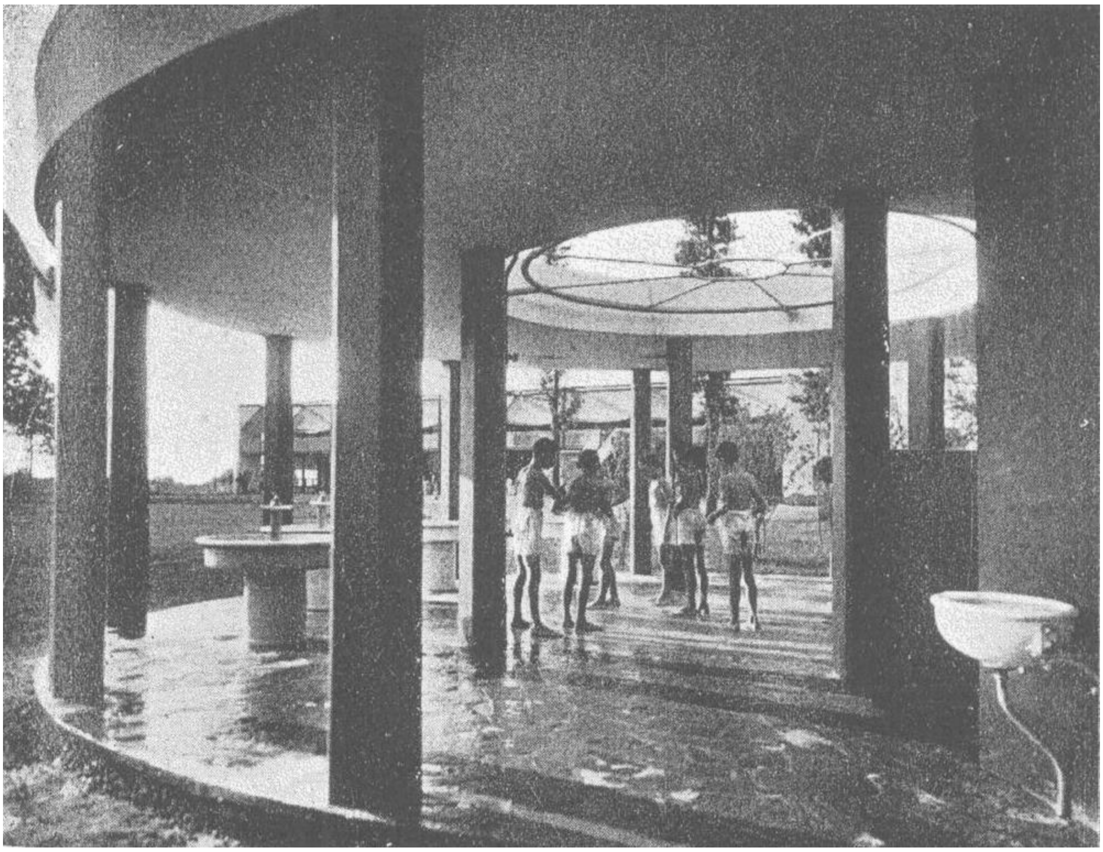


Figure 6 Colonia Elioterapica in 1938: view of one of the two the circular pavilions for showers.

Figure 7 Colonia Elioterapica in 1955: view of the ex - refectory.

Figure 8 Colonia Elioterapica in 1955: view of the continuous facade.

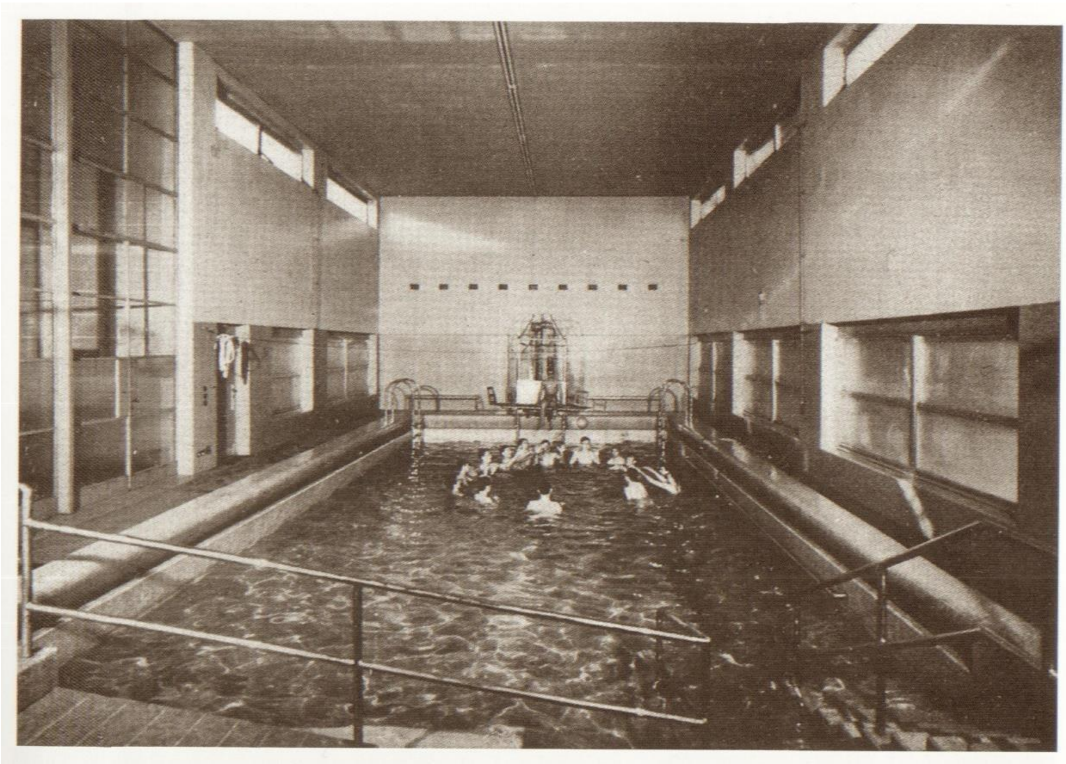


Figure 9 Colonia Elioterapica in 1955: view of the new swimming pool.

Figure 10 Colonia Elioterapica in 1988: view of the ex – solarium and the new body.

Figure 11 Colonia Elioterapica in 1988: view of the new access to the complex.

Figure 12 Colonia Elioterapica in 1988: view of the abandoned kitchen.

Figure 13 Colonia Elioterapica in 2011: view of the continuous facade.

Figure 14 Colonia Elioterapica in 2011: view of the abandoned showers' pavilion.

Figure 15 Colonia Elioterapica in 2011: view of the abandoned kitchen.

2.1. Survey

The following will be a schematic illustration of the procedure adopted for the survey of the Heliotherapy Colony. It should be noted that the following method is aimed at finding the necessary material for the realization of a project proposal, which has as its goal the preservation of the historical artifact, which is recognized and listed as a monument.

2.1.1. Conduction

Preliminary survey

Even before the on-site survey, a cognitive investigation of the area and the artifact was carried out aimed at finding as many elements as possible, in order to obtain a complete picture of the state of affairs and the historical evolution of the building. This preliminary analysis is essential to understand the object that is going to be surveyed and to plan and design an accurate survey that can return as much information as possible. Information that will be pivotal points for the realization of an appropriate conservation proposal.

Eidotype

Upon arriving at the Colonia, an inspection was carried out, allowing for an understanding of how to proceed with the laser scanner survey. In this regard, the eidotype is used to design the location of the targets (appropriately numbered) within the artifact and consequently the station points of the laser scanner. Each station point was strategically placed in order to allow as many points as possible to be acquired. In addition, at least 3 targets must be clearly acquired from each station point for proper subsequent point cloud alignment.

Laser scanner survey

Having drafted the eidotype, we proceed with the positioning of the laser scanner, on a suitable tripod,at the previously established points.

Stationing

Having drafted the eidotype, we proceed with the positioning of the laser scanner, on a special tripod, at the previously established points.

Tolerance setting

Among the various settings that can be selected before starting the laser scanner, the quality of data acquisition is also prente. This is translated into the number of points that are "beaten" by the laser and the distance between them. This tolerance must be varied according to the scale at which the survey is returned and considering that the scatter of the points increases as the distance itself increases.

Starting the scanner

The scan is then started, taking care that no obstacle accidentally comes between the scanner and the object to be surveyed.

Photogrammetric survey

To enrich the information obtained by laser scanner, a panoramic camera is used, placed on the same tripod as the station, so as to obtain a 360° photo of the previously surveyed object.

Repetition of previous points

We proceed with the survey at the next station point, repeating the previous steps.

Photographic support

At the indirect survey by laser scanner, it is also useful to take some significant photographs to elements that require attention. By also affixing a measure, such as a meter, to serve as a reference system, you will have a complete and detailed picture of what you have surveyed. This will be useful in the restitution phase and as support for the material obtained.

Decay and materials survey

By means of appropriate analysis sheets, photographic support, direct measurements, etc., a complete analysis of the degradation of the architectural object is carried out, thus obtaining a complete picture of the state of affairs and the general condition of the structure. This phase is essential for evaluating the best conservation procedures to be adopted.

2.1.2. Pointcloud

Prior to any data return operation, it is necessary to process the data obtained using the proprietary laser scanner software. At this stage, the point clouds obtained for each scan are aligned and an initial cleaning of elements not needed for the purposes of the survey is carried out. Once these steps are completed, the file is exported to the desired target format.

Proprietary software

Before any data-return operation, it is necessary to process the data obtained using the laser scanner's proprietary software. At this stage, the point clouds obtained for each scan are aligned and an initial cleaning of elements not needed for the purposes of the survey is carried out. Once these steps are completed, you export the file to the desired target format.

Recap

Use of the Recap software is useful for immediate analysis of the point cloud. Direct measurements of the fabbricate and additional file cleanup can be performed.

Autocad / Revit

Once the point cloud is obtained, it is imported (as needed) into Autocad or Revit; then performing a file return operation and obtaining the survey the predetermined technical drawings.

2.1.3. CAD restitution

Return of the drawings

Once the previous operations are finished, we proceed with the graphic restitution at a scale of 1¬50 (decided already during the survey phase); Plans, sections and elevations of the building are then reported, adequately dimensioned and sufficiently rich in information, including: details at larger scales; photographs and mapping of degradations.

2.2. Examples of data collecting sheets

Name of the surveyer: ………….MARTA ROTA……………..

Date of the survey: 01/02/22
Date of update: ……………….

Code of the building/ensamble of buildings
001

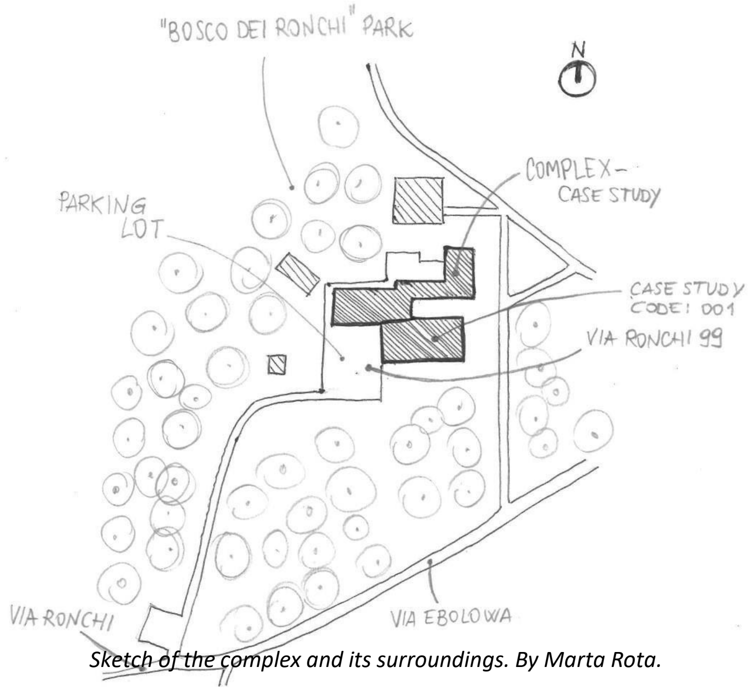
Single building n.: ………1…….. Portion ………1……..
Single building n.: ……………….. Portion ………………..
Single building n.: ……………….. Portion ………………..
Single building n.: ……………….. Portion ………………..
Single building n.: ……………….. Portion ………………..
Single building n.: ……………….. Portion ………………..

Arranging of a list of the data concerning the building and its neighborhood (block, historical center)

Typology of data

- ● Collection of archive material
- ● Collection of bibliographical material
- ● Cartographic collection
- ○ Collection of cadastral plans
- ● Collection of geometric surveys
- ○ Collection of permissions of construction

* **It is necessary to verify the presence of fixed or mobile furniture of value**
* **It is necessary to check for the presence of valuable architectural elements (decorative stucco, painted plasters, painted ceilings, valuable floors)**



Sketch of the complex and its surroundings. By Marta Rota.

MASER DATA

Name of the surveyer: ....MARTA ROTA.................

Date of the survey: 01/02/22
Date of update: ....

Code of the single building:
001

Administrative position:

Country ....ITALY.................................
Region ....LOMBARDIA...........................
Municipality ....LEGNANO...........................
Province ....MILANO...........................

Location

- ○ Historical center
- ● Surroundings
- ○ Isolated
- ● Non-isolated

Address: ....VIA RONCHI,99 (20025)..

Name of the building ....CPS LEGNANO.............................

Property:
- ● Public
- ○ Private

Date of construction: ....1938, ENLARGEMENT IN THE 50s......................
Designer/Author: ....BBPR GROUP................................

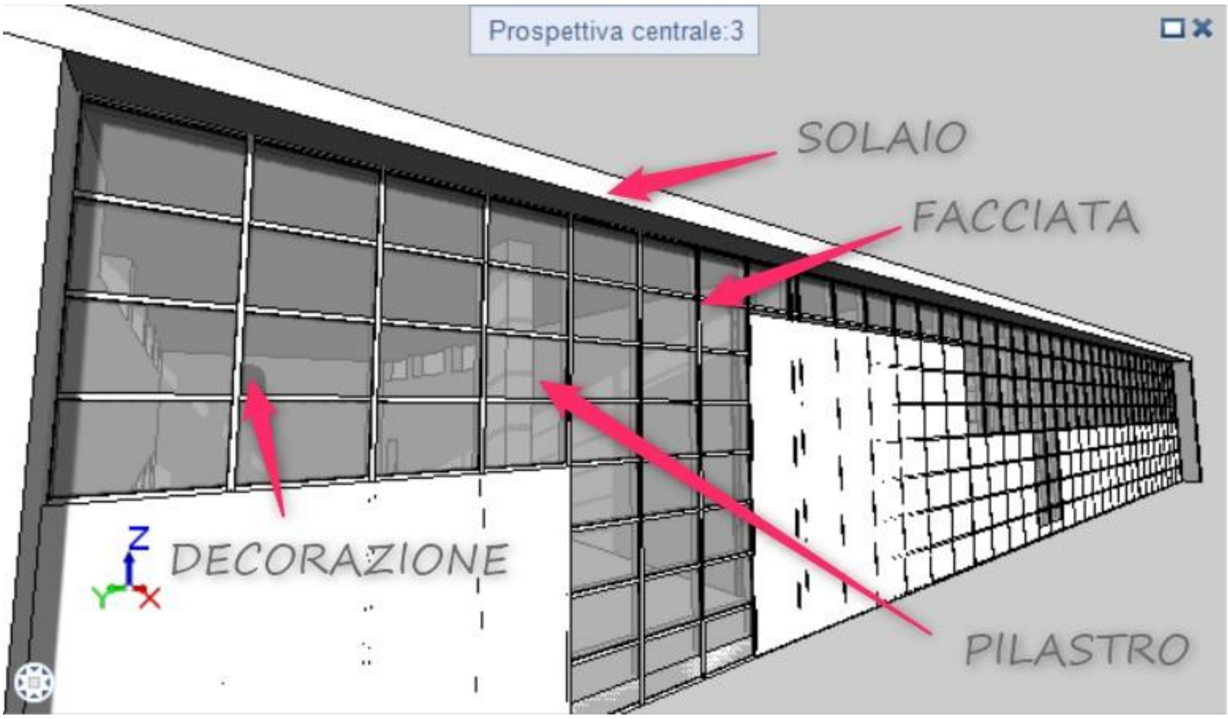
Intended use

U/G ....NU2.................
G/F ....NU2.................
F. 1 ..../......................
F. 2 ..../......................
F. 3 ..../......................
F. 4 ..../......................
F. 5 ..../......................
F. 6 ..../......................
................../......................
................../......................
................../......................
................../......................

R = Residential
D = Directional
AA = Agricultural activities
M = Warehouses and deposits
NC = Unkwown
NU1 = Not used for less than 5 years
NU2 = Not used for more than 5 years
C = Commercial
S = Services
LC = Place of worship
K = Church
A = Artisanal
I = Industrial
B = Box
X = ...

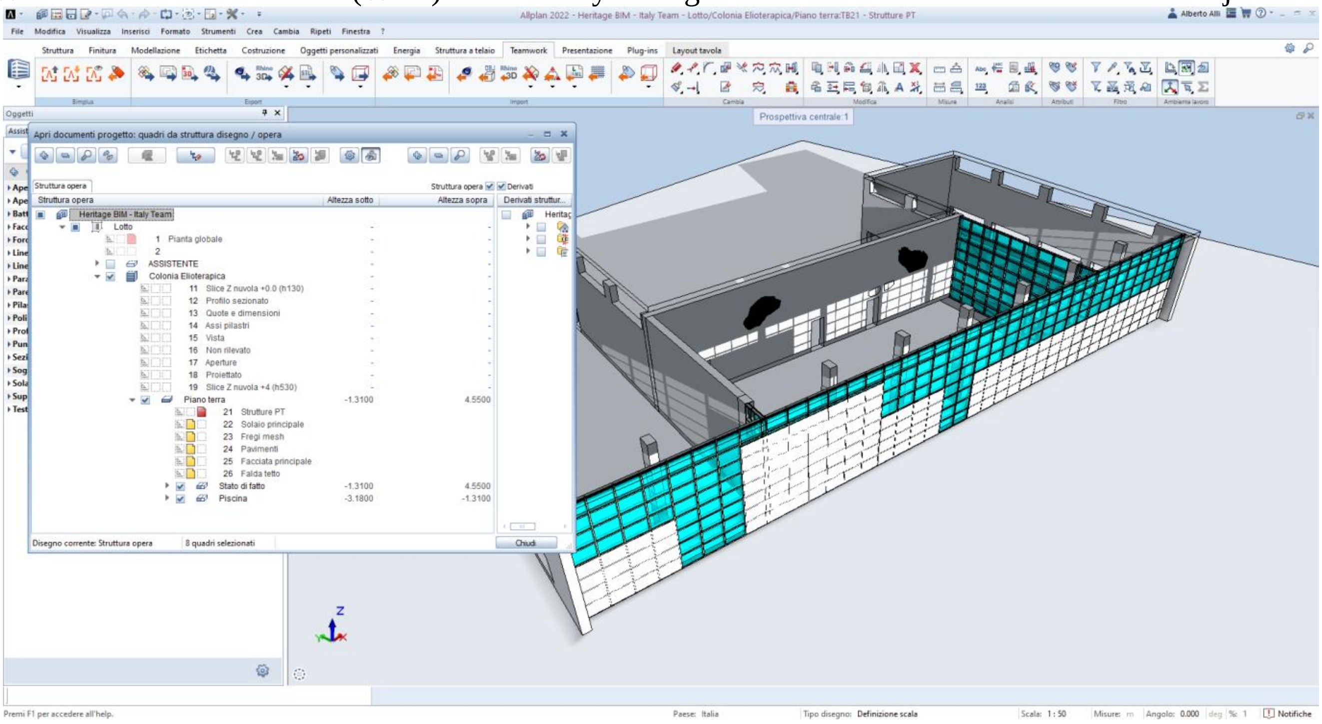
Single building			
Predominantly vertical construction		Slender	
		Not slender	
Predominantly horizontal construction	X	Vertically interspersed	
		Horizontally interspersed	
Others:		Vertically and horizontally interspersed	X

2.3. Modeling



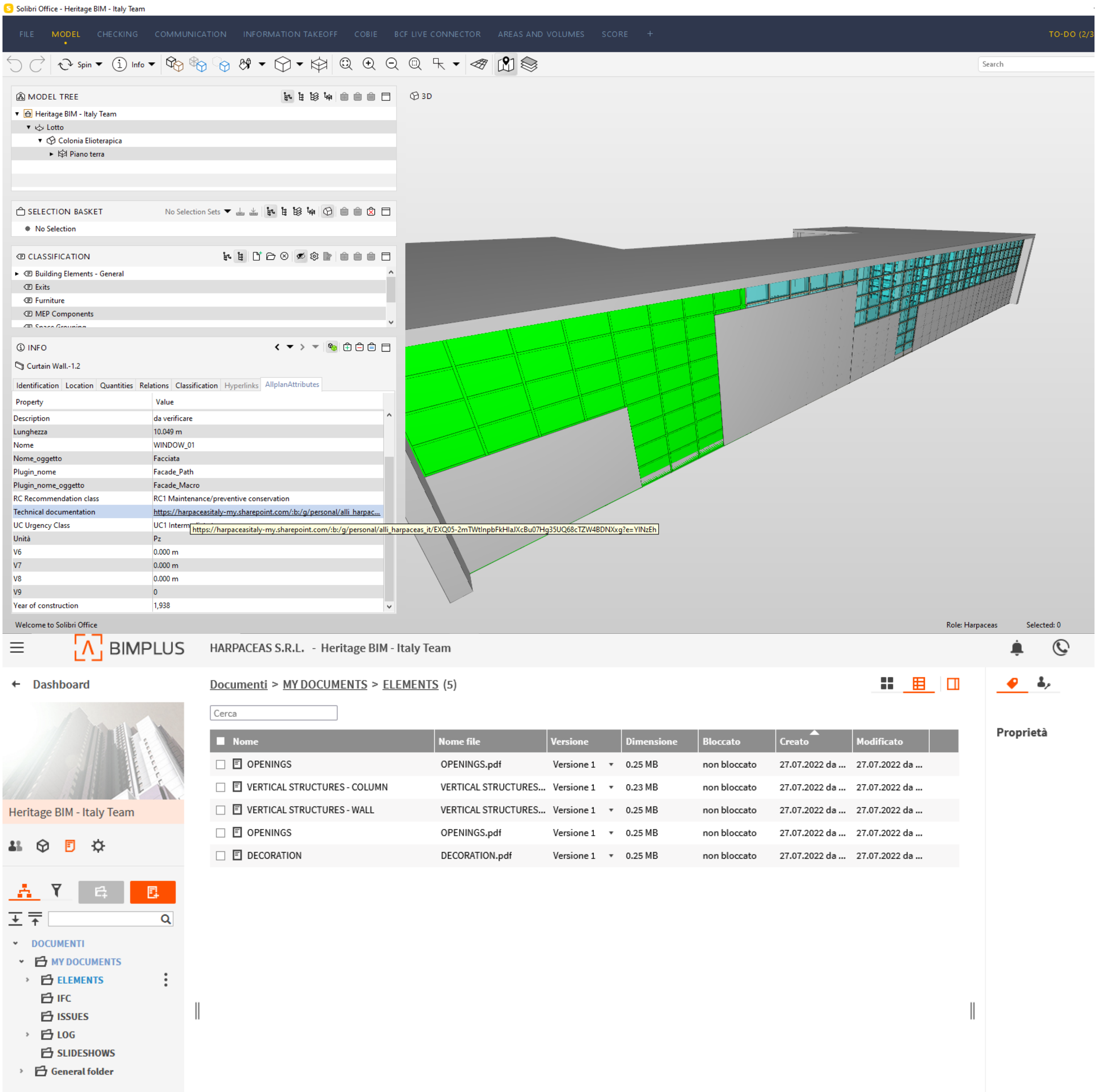
During the process of creating the BIM model, starting from the point clouds obtained, the approach to organizing the building's plans and modeling its architectural and structural elements has been based on the IFC (Industry Foundation Classes) standard.

Structuring according to the Site_Building_Floor schema allows for the generation of graphical and computational information, both point-based and structured for completed works, with a breakdown of a Work Breakdown Structure (WBS) that is easily manageable in relation to the final extraction objectives.



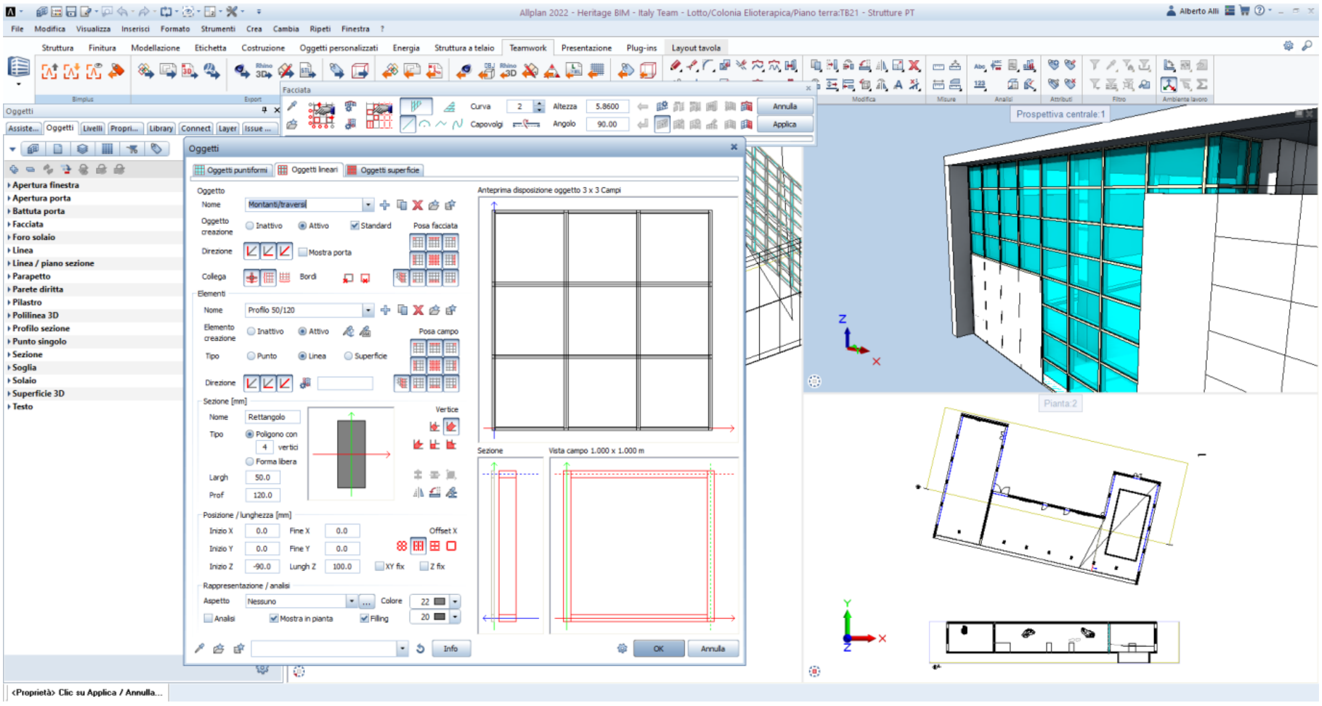
The model developed using Allplan solutions (for BIM model management) and Scalypso (for point cloud management) has been shared within the BIM+ collaboration platform. Uploading can occur directly from the native model, rather than through the upload of IFC files.

Within the platform, access is only identifiable and planned through user accounts (email addresses) corresponding, in an authorization matrix, to the representatives of individual activities and specialist models. The platform includes documents related to technical sheets of surveyed components, making them accessible through a web browser for project participants present on the platform.



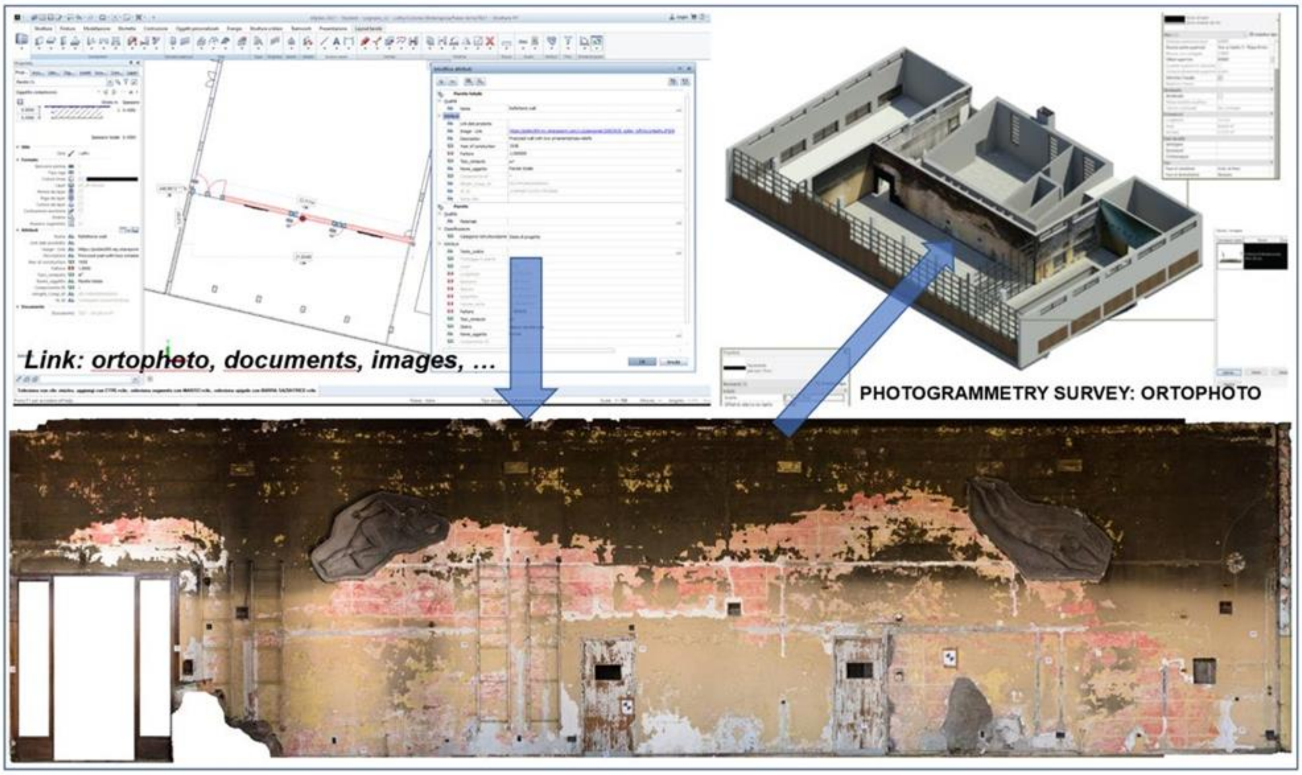
2.3.1. Window

Vertical closure elements must be reparameterized based on the complexity of the geometry to be reconstructed. However, it is possible to create each individual component of the façade/window, ensuring the ability to manage and subsequently extract information (both graphical and metric computation).



2.3.2. Wall

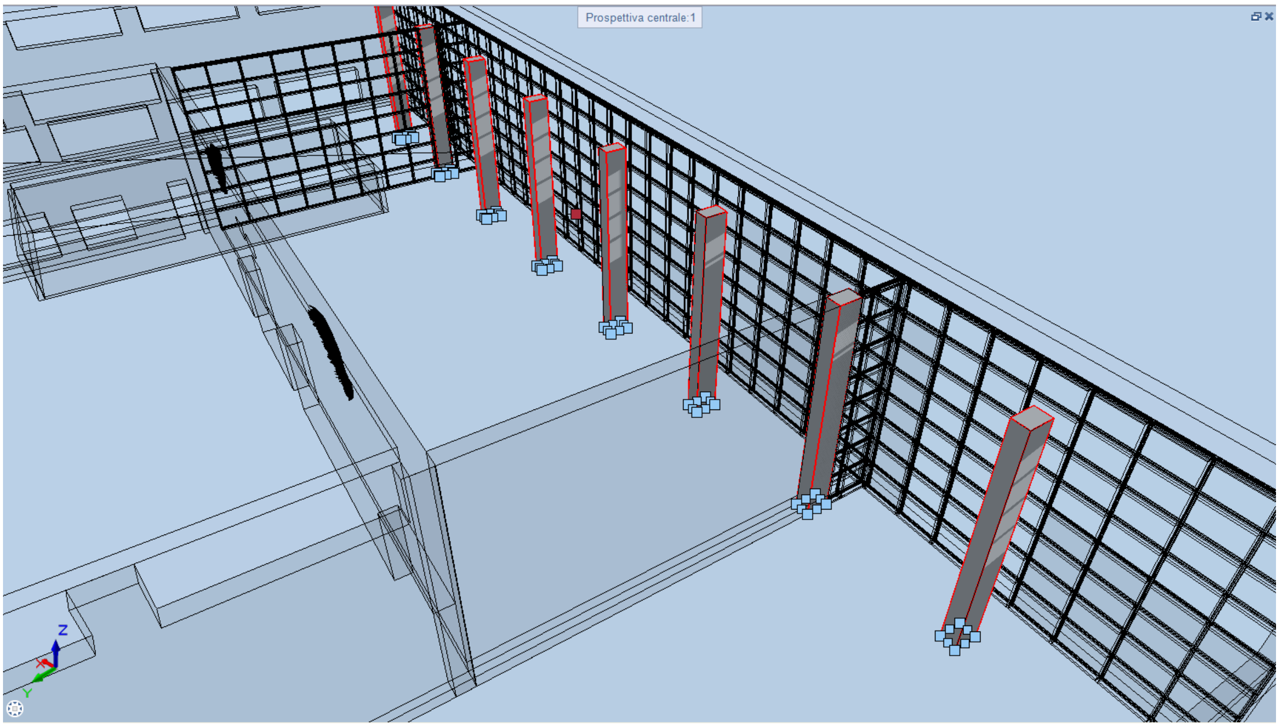
In the modeling process, the use of point clouds is crucial for capturing geometric information and reconstructing elements by reparameterizing them using functions available in BIM modeling software.



Details captured during the survey through photographs can be integrated as pixel mapping directly onto a single modeled element..

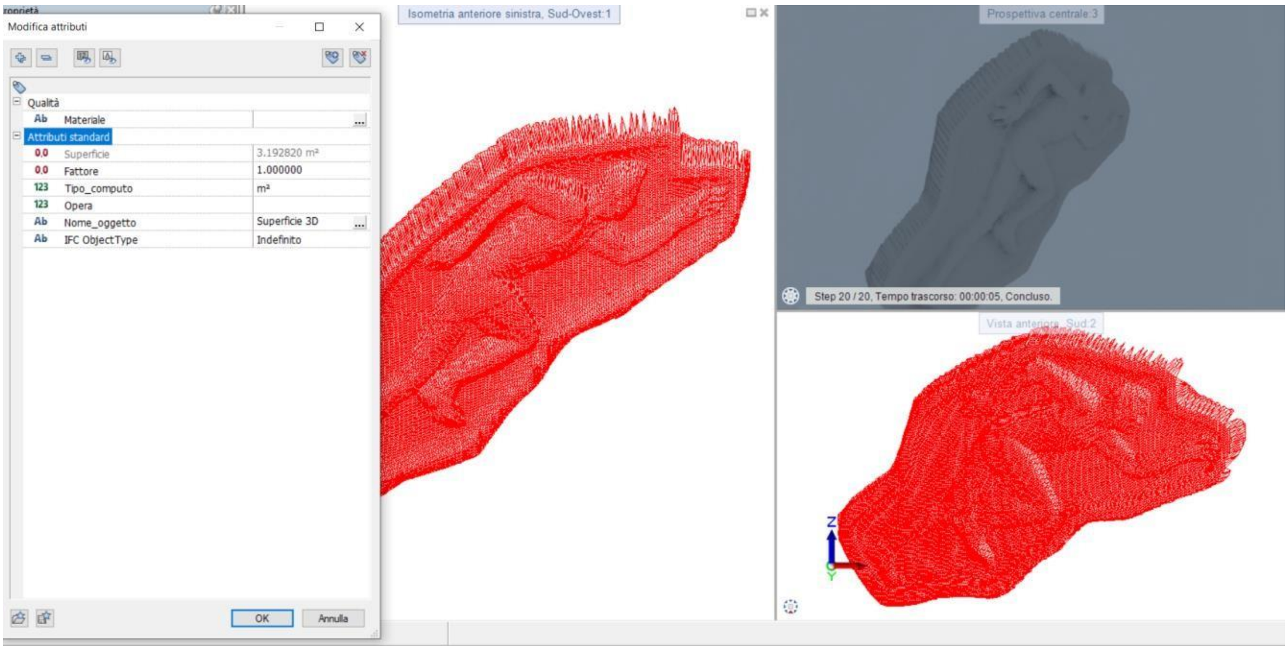
2.3.3. Column

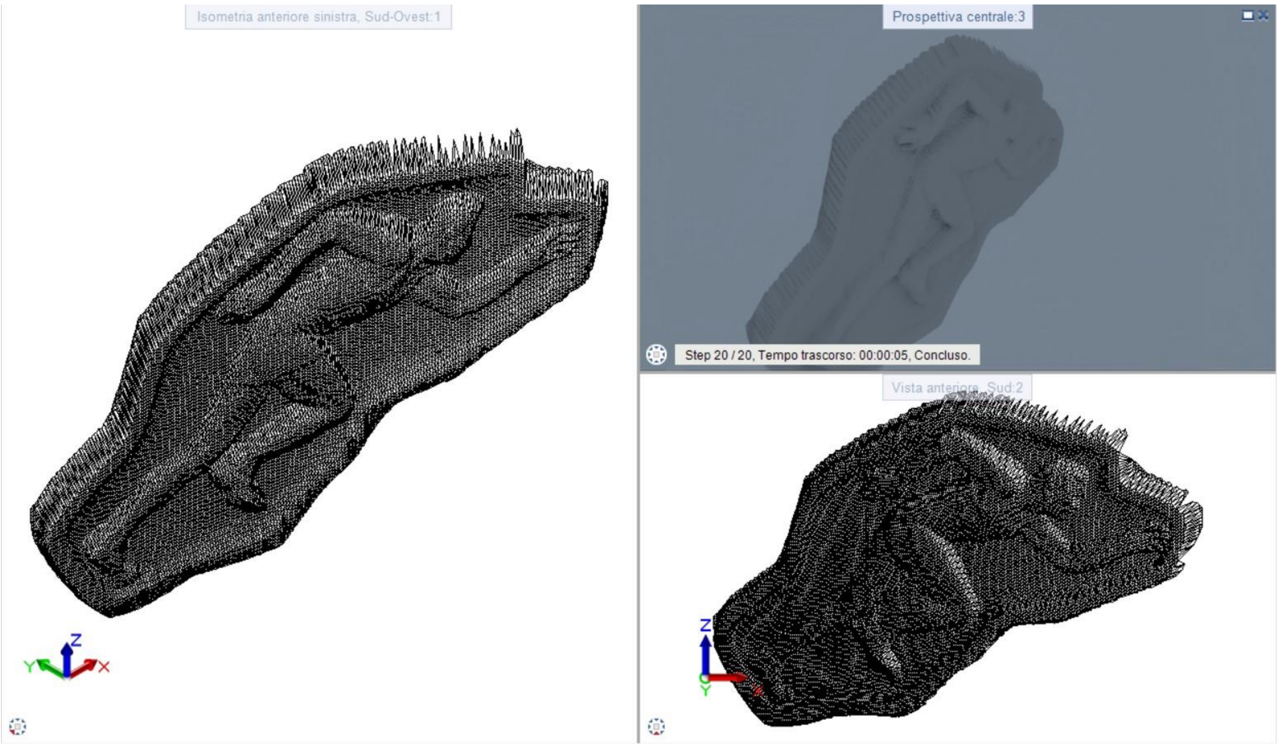
The modeling of vertical elements, such as columns, is simplified thanks to the automatic detection of closed areas within a two-dimensional floor plan



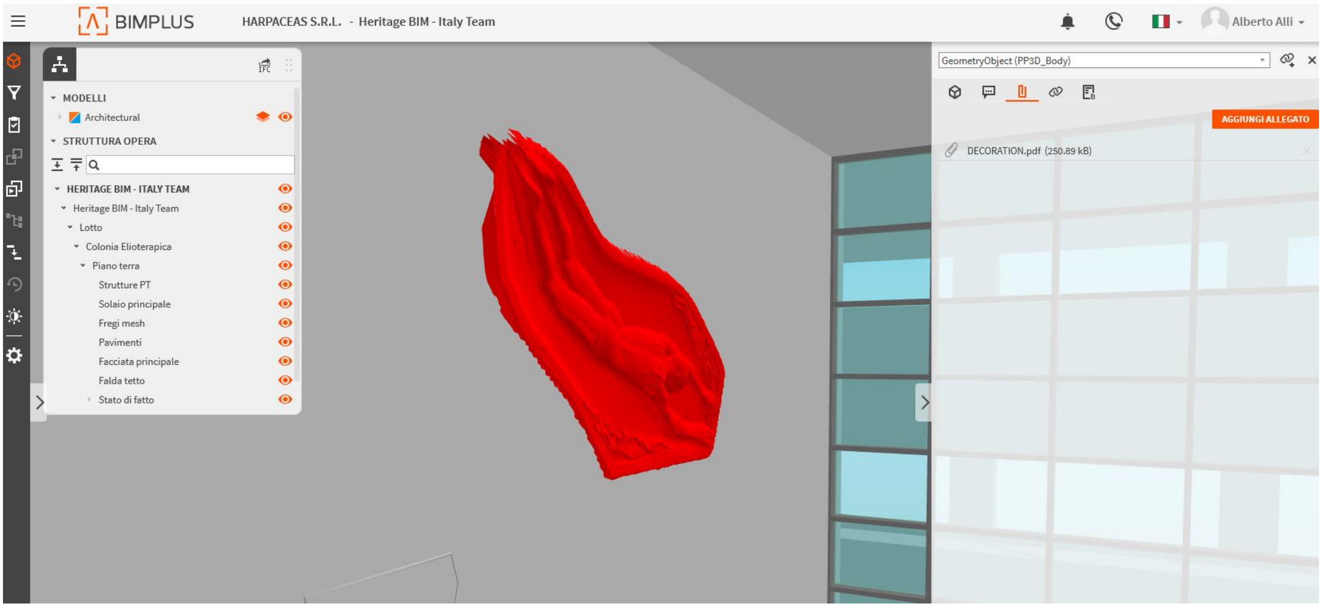
2.3.4. Bas–relief

Through the existing integration between Allplan and Scalypso, regarding specific elements such as friezes and decorations, as well as the modeling of vertical elements, it is possible to automatically recreate 3D surfaces in the BIM model with the goal of transferring certain objects that play an important artistic role in the project in a "true-to-life" manner.





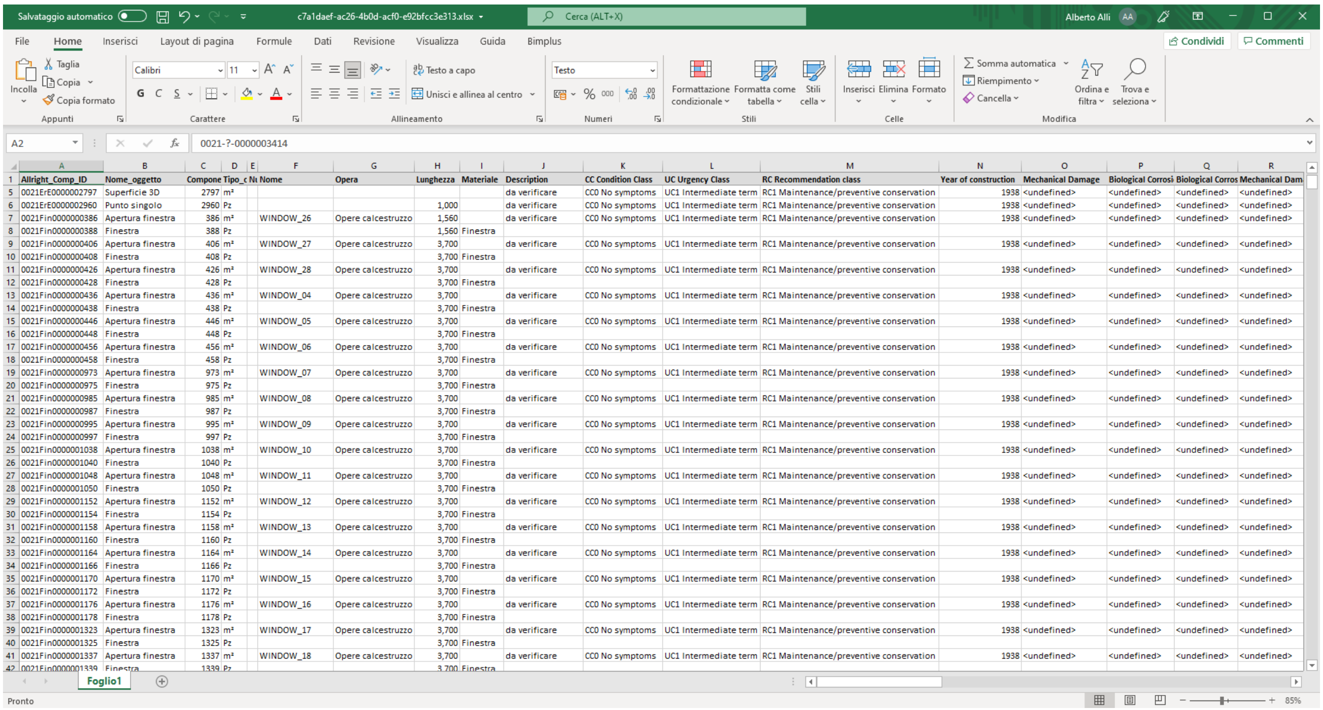
La piattaforma di condivisione BIM+ veicola verso gli utenti inseriti nel progetto, oltre agli *attribute informative* (geometrici e prestazionali) anche eventuali documenti a corredo dell'elemento, come ad esempio schede tecniche, disegni CAD, documentazioni di rilievo materico, fotografie ed altro.



2.4. Attributes - examples

The informational content of the elements is planned at the beginning of the BIM modeling process, so that useful information can be shared through the model throughout the Design, Construction, and Management/Maintenance phases of the project element.

Attributes within Allplan can also be managed through an Excel table, simplifying the addition and modification of informational content for any element in the BIM model.

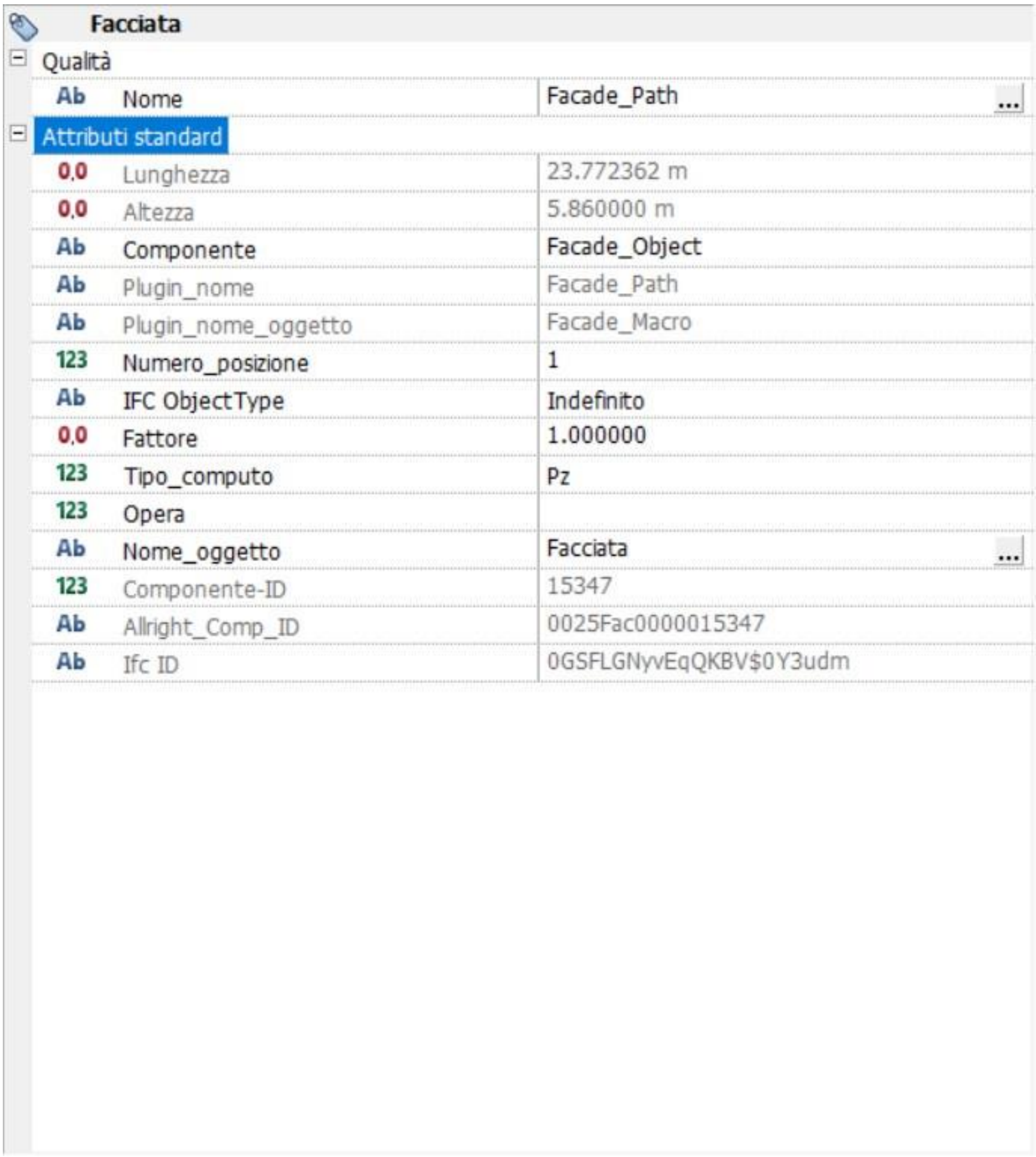


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Allright_Comp_ID	Nome_oggetto	Compone	Tipo_c	Nu	Nome	Opera	Lunghezza	Materiale	Description	CC Condition Class	UC Urgency Class	RC Recommendation class	Year of construction	Mechanical Damage	Biological Corrosi	Biological Corros	Mechanical Dam
5	0021ErE0000002797	Superficie 3D	2797	m²						da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
6	0021ErE0000002960	Punto singolo	2960	Pz				1,000		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
7	0021Fin0000000386	Apertura finestra	386	m²		WINDOW_26	Opere calcestruzzo	1,560		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
8	0021Fin0000000388	Finestra	388	Pz				1,560	Finestra									
9	0021Fin0000000406	Apertura finestra	406	m²		WINDOW_27	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
10	0021Fin0000000408	Finestra	408	Pz				3,700	Finestra									
11	0021Fin0000000426	Apertura finestra	426	m²		WINDOW_28	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
12	0021Fin0000000428	Finestra	428	Pz				3,700	Finestra									
13	0021Fin0000000436	Apertura finestra	436	m²		WINDOW_04	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
14	0021Fin0000000438	Finestra	438	Pz				3,700	Finestra									
15	0021Fin0000000446	Apertura finestra	446	m²		WINDOW_05	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
16	0021Fin0000000448	Finestra	448	Pz				3,700	Finestra									
17	0021Fin0000000456	Apertura finestra	456	m²		WINDOW_06	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
18	0021Fin0000000458	Finestra	458	Pz				3,700	Finestra									
19	0021Fin0000000973	Apertura finestra	973	m²		WINDOW_07	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
20	0021Fin0000000975	Finestra	975	Pz				3,700	Finestra									
21	0021Fin0000000985	Apertura finestra	985	m²		WINDOW_08	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
22	0021Fin0000000987	Finestra	987	Pz				3,700	Finestra									
23	0021Fin0000000995	Apertura finestra	995	m²		WINDOW_09	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
24	0021Fin0000000997	Finestra	997	Pz				3,700	Finestra									
25	0021Fin0000001038	Apertura finestra	1038	m²		WINDOW_10	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
26	0021Fin0000001040	Finestra	1040	Pz				3,700	Finestra									
27	0021Fin0000001048	Apertura finestra	1048	m²		WINDOW_11	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
28	0021Fin0000001050	Finestra	1050	Pz				3,700	Finestra									
29	0021Fin0000001152	Apertura finestra	1152	m²		WINDOW_12	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
30	0021Fin0000001154	Finestra	1154	Pz				3,700	Finestra									
31	0021Fin0000001158	Apertura finestra	1158	m²		WINDOW_13	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
32	0021Fin0000001160	Finestra	1160	Pz				3,700	Finestra									
33	0021Fin0000001164	Apertura finestra	1164	m²		WINDOW_14	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
34	0021Fin0000001166	Finestra	1166	Pz				3,700	Finestra									
35	0021Fin0000001170	Apertura finestra	1170	m²		WINDOW_15	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
36	0021Fin0000001172	Finestra	1172	Pz				3,700	Finestra									
37	0021Fin0000001176	Apertura finestra	1176	m²		WINDOW_16	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
38	0021Fin0000001178	Finestra	1178	Pz				3,700	Finestra									
39	0021Fin0000001323	Apertura finestra	1323	m²		WINDOW_17	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
40	0021Fin0000001325	Finestra	1325	Pz				3,700	Finestra									
41	0021Fin0000001337	Apertura finestra	1337	m²		WINDOW_18	Opere calcestruzzo	3,700		da verificare	CC0 No symptoms	UC1 Intermediate term	RC1 Maintenance/preventive conservation	1938	<undefined>	<undefined>	<undefined>	<undefined>
42	0021Fin0000001339	Finestra	1339	Pz				3,700	Finestra									

The Excel file remains a direct means of editing and updating information, thanks to the unique identifier (Allright_Comp_ID) that links the object in the BIM model to specific information.

Below, we provide a comparison for each analyzed element of the informational content in Allplan and after export to the IFC4 format.

2.4.1. Window's attributes – Allplan and IFC



	Facciata	
	Qualità	
Ab	Nome	Facade_Path
	Attributi standard	
0,0	Lunghezza	23.772362 m
0,0	Altezza	5.860000 m
Ab	Componente	Facade_Object
Ab	Plugin_nome	Facade_Path
Ab	Plugin_nome_oggetto	Facade_Macro
123	Numero_posizione	1
Ab	IFC ObjectType	Indefinito
0,0	Fattore	1.000000
123	Tipo_computo	Pz
123	Opera	
Ab	Nome_oggetto	Facciata
123	Componente-ID	15347
Ab	Allright_Comp_ID	0025Fac0000015347
Ab	Ifc ID	0GSFLGNyvEqQKBV$0Y3udm

INFO

Curtain Wall.-1.7

Identification | Location | Quantities | Relations | Classification | Hyperlinks | AllplanAttributes

Property	Value
Site	Lotto
Building	Colonia Elioterapica
Floor	Piano terra
Federated Floor	Piano terra
Top Elevation	5.89 m
Bottom Elevation	-25 mm
Distance to Next Floor	275 mm
Global Top Elevation	4.58 m
Global Bottom Elevation	-1.33 m
Global X	-51.45 m
Global Y	-17.55 m
Global Z	0 mm

INFO

Curtain Wall.-1.7

Identification | Location | Quantities | Relations | Classification | Hyperlinks | AllplanAttributes

Property	Value
Model	EXPORT_STANDARD_V4
Discipline	Architectural
Name	Facade_Path
Type	
Type Name	
Description	
Material	
Layer	Facciate
System	
Building Envelope	False
Geometry	
Application	Allplan
IFC Entity	IfcCurtainWall
IFC Type	
GUID	1UuFb1fRHCtgz3$kS8HopO
BATID	
Model Categories	

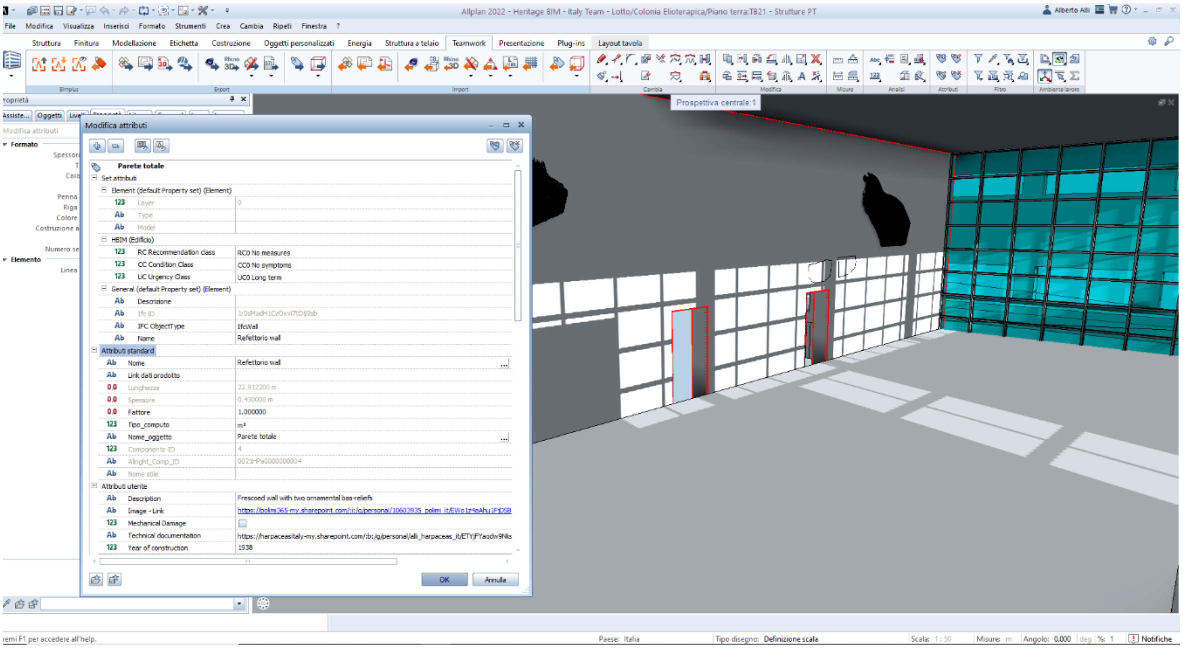
INFO

Curtain Wall.-1.7

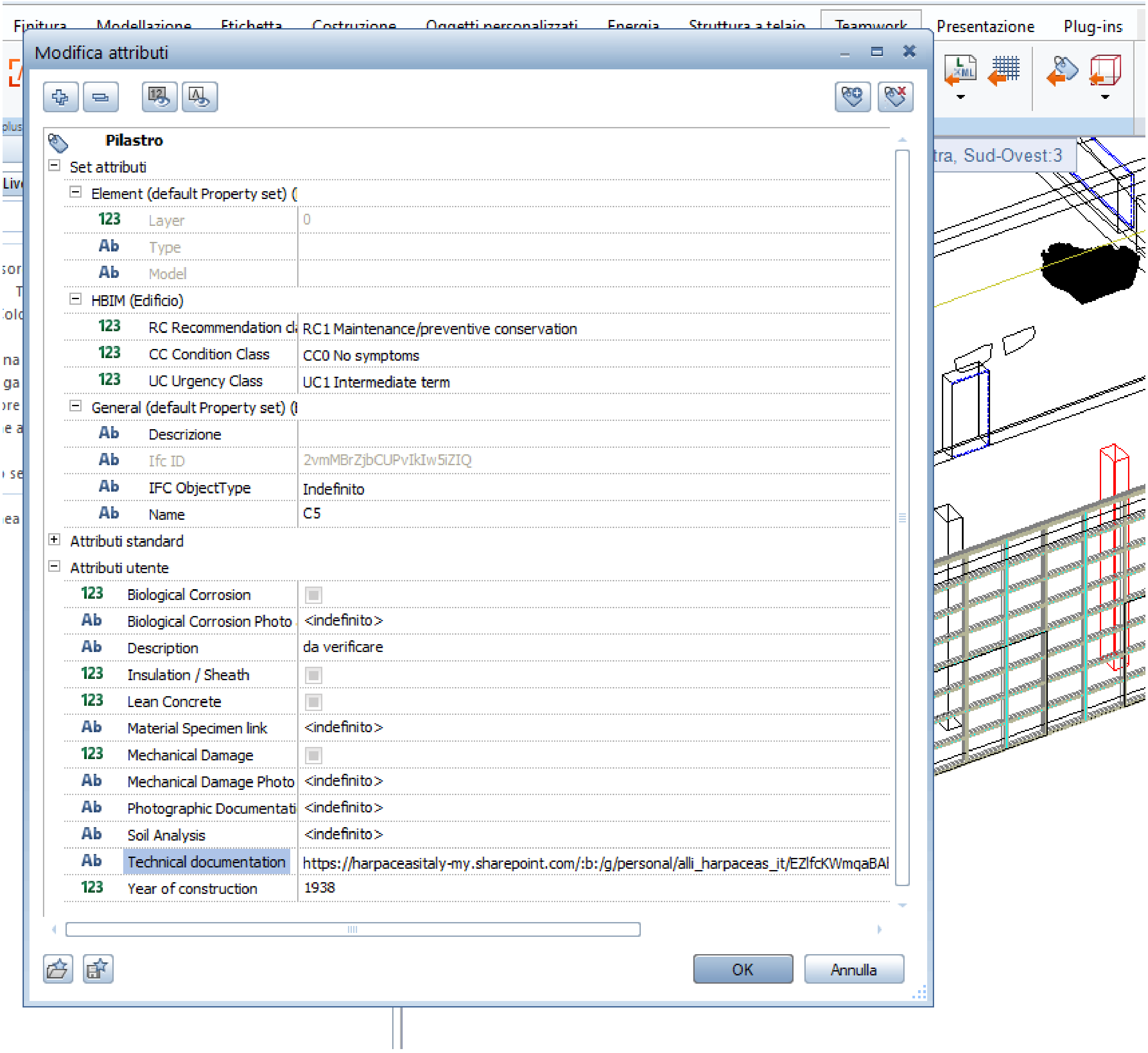
Identification | Location | Quantities | Relations | Classification | Hyperlinks | AllplanAttributes

Property	Value
Allright_Comp_ID	0025Fac0000013779
Altezza	5.86 m
Componente	Facade_Object
Lunghezza	10.05 m
Nome	Facade_Path
Nome_oggetto	Facciata
Plugin_nome	Facade_Path
Plugin_nome_oggetto	Facade_Macro
Unità	Pz
V6	0 mm
V7	0 mm
V8	0 mm
V9	0

2.4.2. Wall’s attributes



2.4.3. Column’s attributes – Allplan and IFC



Attributes with hyperlinks can direct a detailed analysis of the element, allowing the opening of technical documentation shared via the internet. In the image above, you can see the hyperlink leading to a Technical Documentation.

Column.-1.7

Relations | Classification | Hyperlinks | AllplanAttributes | Pset_ColumnCommon

Identification | **Location** | Quantities | Profile

Property	Value
Site	Lotto
Building	Colonia Elioterapica
Floor	Piano terra
Federated Floor	Piano terra
Top Elevation	5.86 m
Bottom Elevation	0 mm
Distance to Next Floor	300 mm
Global Top Elevation	4.55 m
Global Bottom Elevation	-1.31 m
Global X	-33.94 m
Global Y	-18.24 m
Global Z	-1.31 m

Column.-1.7

Identification | Location | Quantities | Profile

Relations | Classification | Hyperlinks | **AllplanAttributes** | Pset_ColumnCommon

Property	Value
Allright_Comp_ID	0021Pi 0000000077
Nome_oggetto	Pilastro
Unità	m

INFO

Column.-1.7

Relations | Classification | Hyperlinks | AllplanAttributes | Pset_ColumnCommon

Identification | Location | Quantities | Profile

Property	Value
Model	EXPORT_STANDARD_V4
Discipline	Architectural
Name	
Type	
Type Name	
Description	
Material	
Layer	Pilastri
System	
Profile Type	Rectangular
Building Envelope	False
Geometry	Extrusion
Application	Allplan
IFC Entity	IfcColumn
IFC Type	
GUID	2F59cUnfXFkujpCmlbebr5
BATID	
Model Categories	

3. CASE STUDY – Revit

Within the pages of this comprehensive chapter, we embark on a journey into the intricate world of modeling historic buildings using the powerful Revit software and the cutting-edge technology of Building Information Modeling, often referred to as BIM. Our primary focus is on the realm of heritage BIM, where the past meets the future, and where the preservation of our architectural heritage relies on the fusion of technology, knowledge, and creativity.

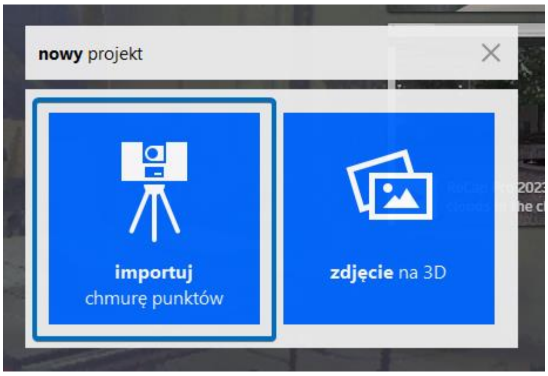
Heritage BIM stands as a beacon of hope for the preservation of our cultural treasures. Historic buildings are more than just structures; they are living remnants of our shared history and artistic expression. As these architectural gems age, they require meticulous care and documentation to ensure their legacy endures. This chapter unfolds the principles and practices essential for students and educators to navigate this intricate domain effectively.

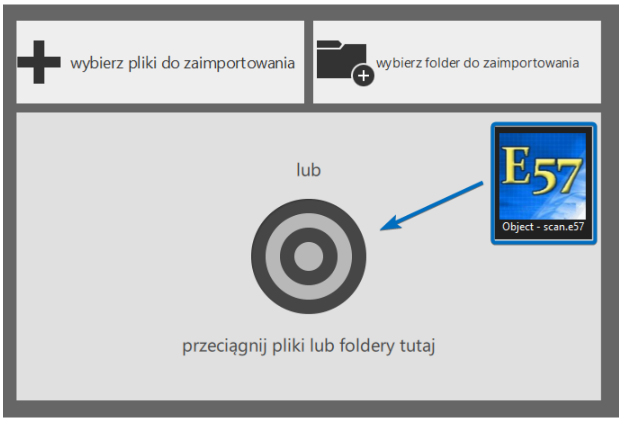
Modeling historic buildings is not without its unique challenges. These structures often defy convention with irregular shapes, varying dimensions, and intricate details. Thus, the task of capturing their essence through modeling demands a deep understanding of both technology and artistry. This chapter equips educators and students with the knowledge and techniques required to rise to these challenges gracefully.

Throughout this chapter, we explore a spectrum of elements encompassed within the domain of modeling historic buildings. From foundational concepts to advanced methodologies, students will develop a comprehensive skill set to create accurate and detailed BIM models. Key topics covered include point cloud integration, modeling walls, openings (doors and windows), and various architectural elements, parametric modeling, proper documentation and annotation, and site and context modeling. These insights and practices are designed to serve as invaluable resources for educators as they guide their students through the fascinating world of heritage BIM, ultimately contributing to the preservation of our architectural heritage for generations to come.

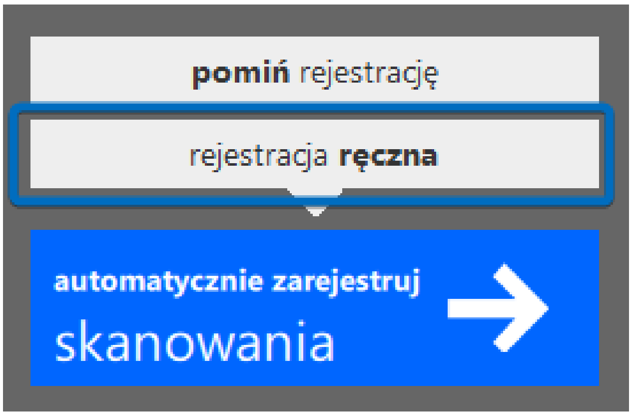
3.1. Combining and Generating Point Clouds

In this chapter, we will demonstrate how to combine and generate a point cloud created with a laser scanner. The first step is to create a new project with the "Import Scan Cloud" option in the ReCap Pro software.

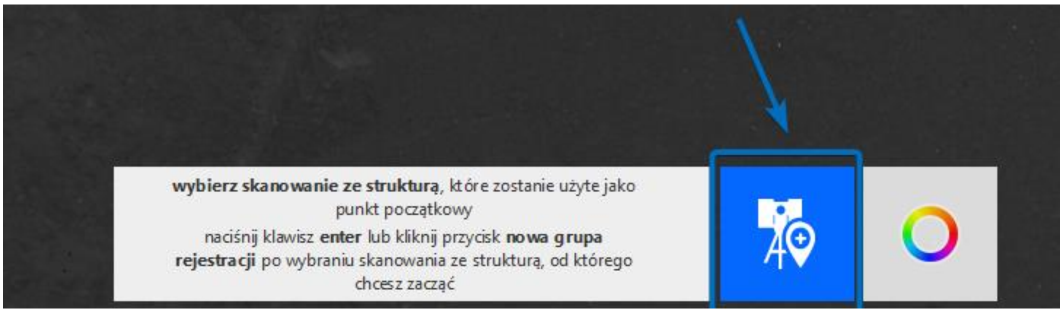




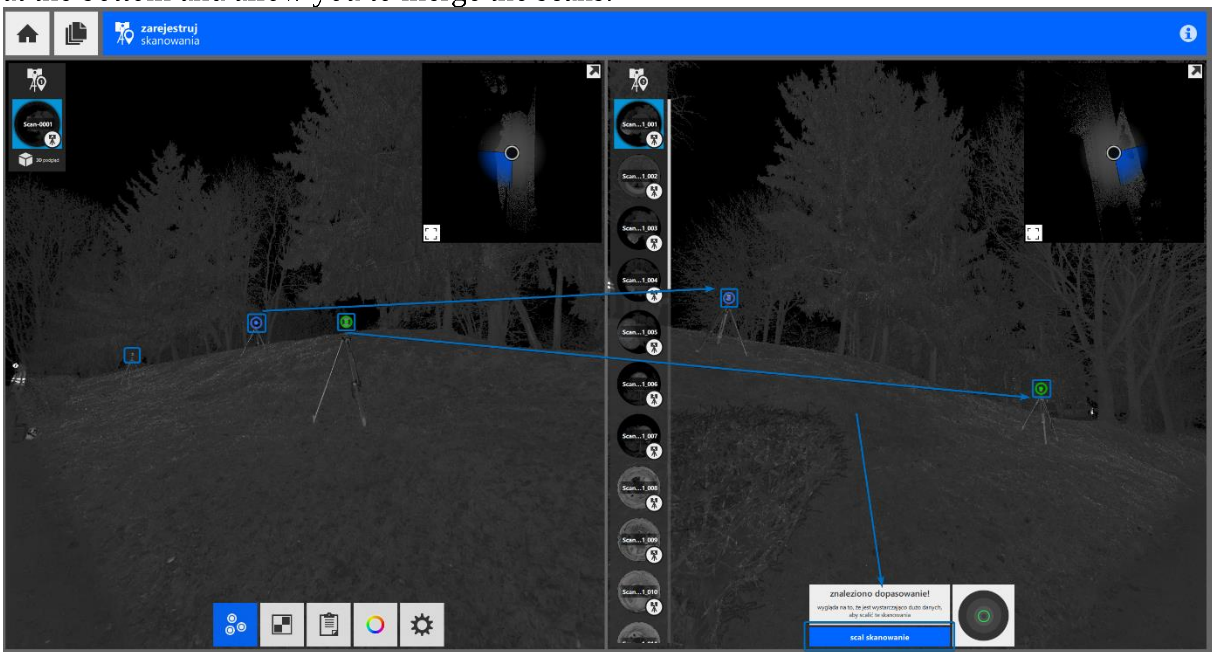
After importing the scans with default settings, you should choose the manual registration process.



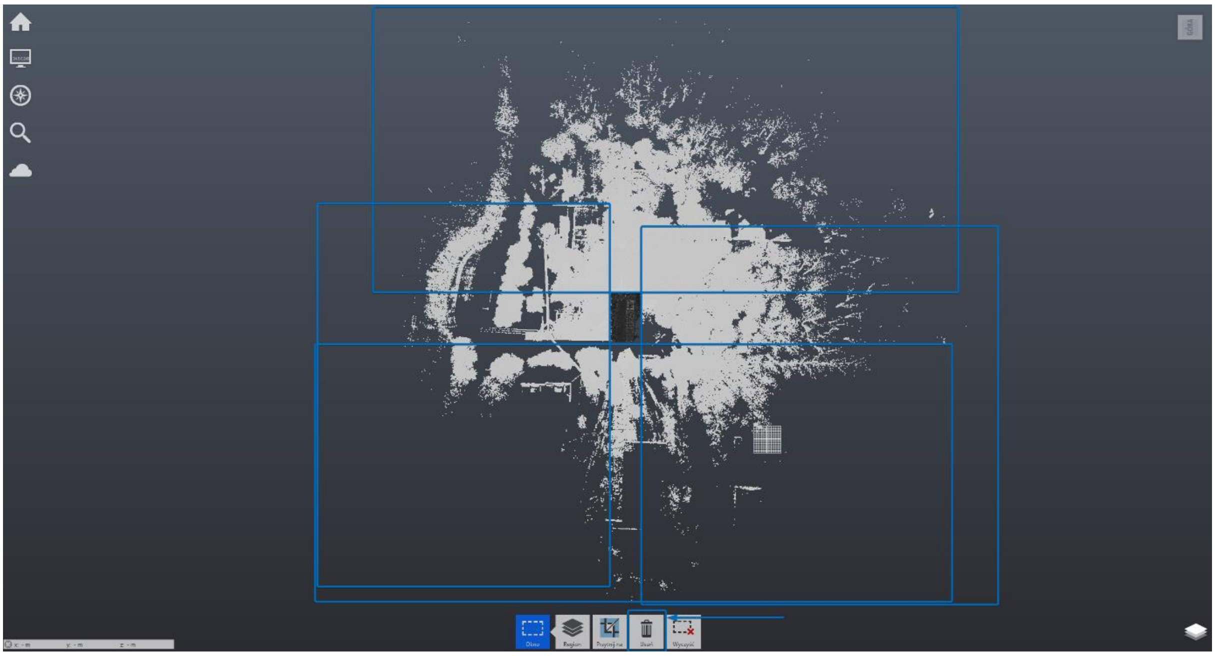
In the spherical view displayed from the first scanner position, select the icon marked to designate it as your starting point.



Next, by navigating the view to the right and left of the screen, locate corresponding targets and mark them one by one. Once the program finds similarities, it will display a message at the bottom and allow you to merge the scans.

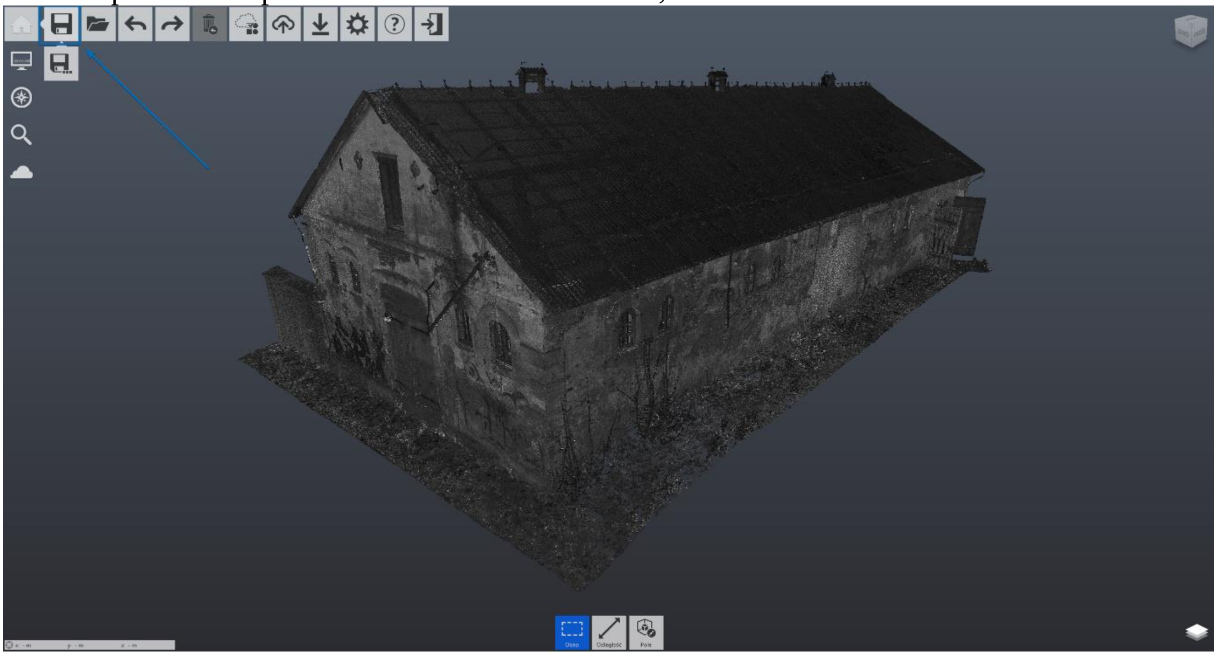


Repeat the matching process for all positions, and after completion, you will see a 3D view of the entire merged point cloud from all positions.



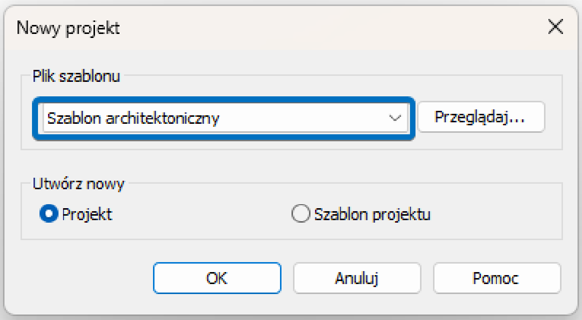
In the top view, select the entire object's surroundings, leaving approximately a 1-meter buffer around it. After marking unnecessary elements of the cloud, remove them, leaving only the object of interest within the specified range.

Below is a view of the cleaned and aligned point cloud. After performing these tasks, save it in *.rcp format to proceed with the work in Revit, as described later..



3.2. Import and Positioning of Point Clouds

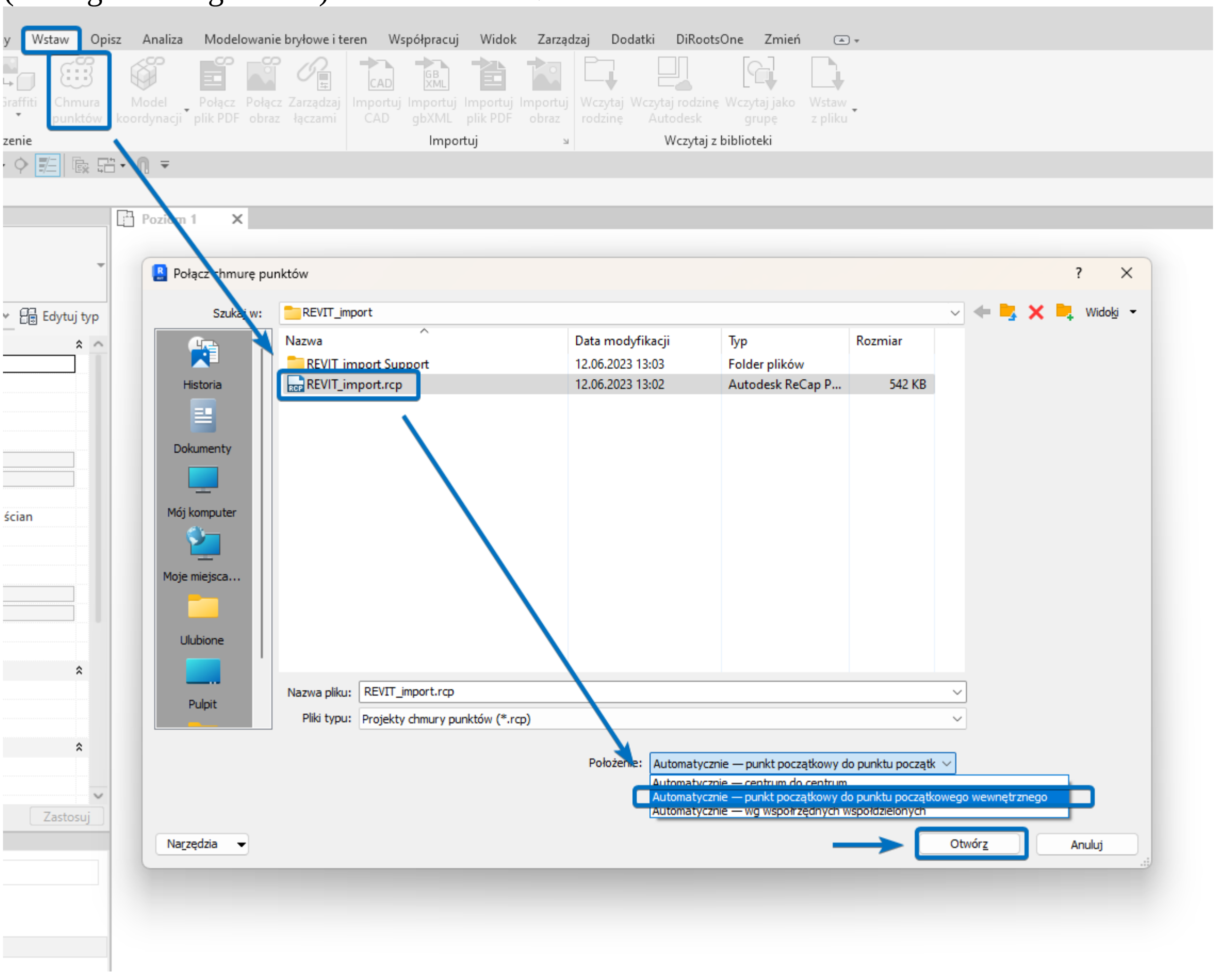
This chapter will show how to insert and position a Point Cloud in the Revit software.



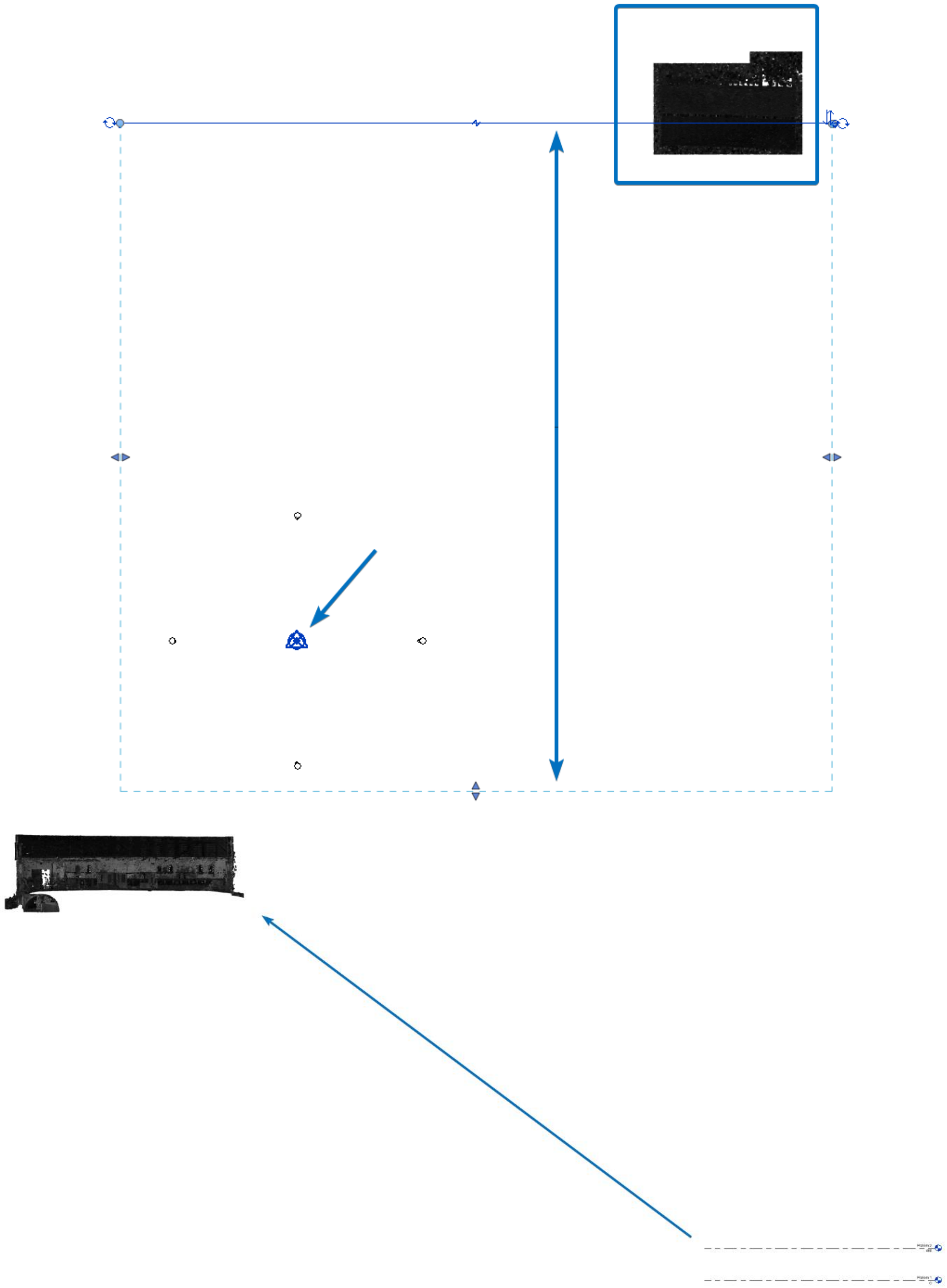
For the purpose of this exercise, it is assumed that the model will not have shared coordinates, and its survey point will be in the same location as the internal origin point.

To begin, create a new project using the Architectural Template or your custom template conforming to external standards, and change the project units to centimeters.

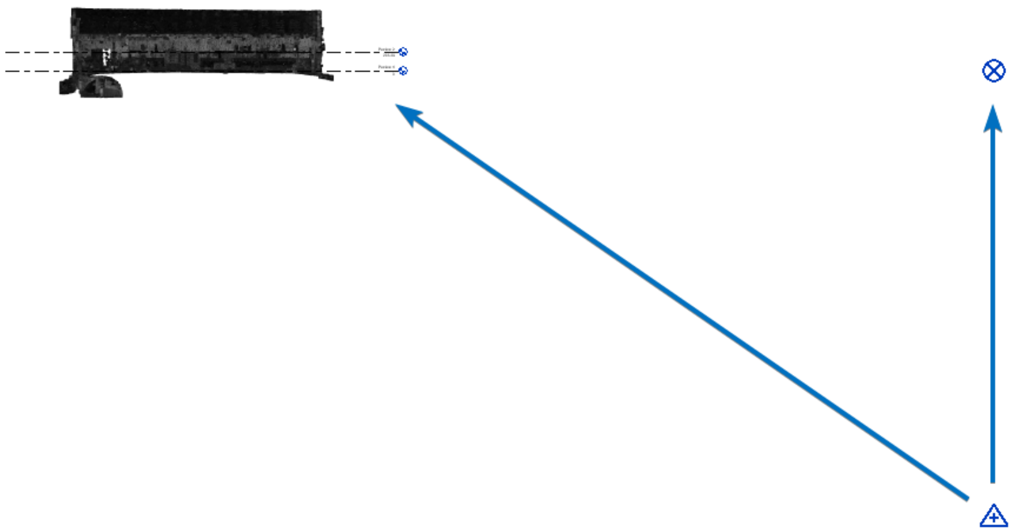
Open an empty file with basic families for BIM modeling in Revit. Insert the Point Cloud by going to the Insert tab > Point Cloud: and select the Position: Automatically - from the internal origin point to the internal origin point. By choosing this method, you ensure that the Point Cloud will always load into the same location, even if it is completely removed (Manage>Manage Links) from the model:



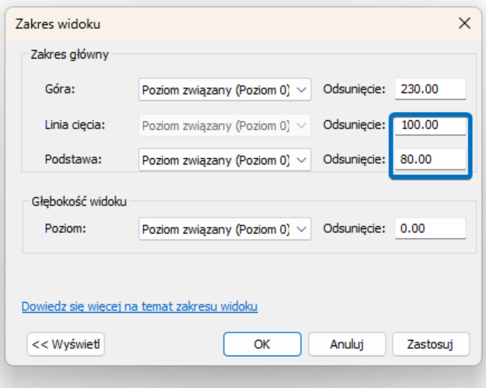
The loaded Point Cloud may be in different locations within the model. To locate it, use the Site view or 3D view. Then, after locating the Point Cloud, it's a good idea to create an approximate section through the building, which will include the Point Cloud, the level range, and the project base point and survey point in Revit:

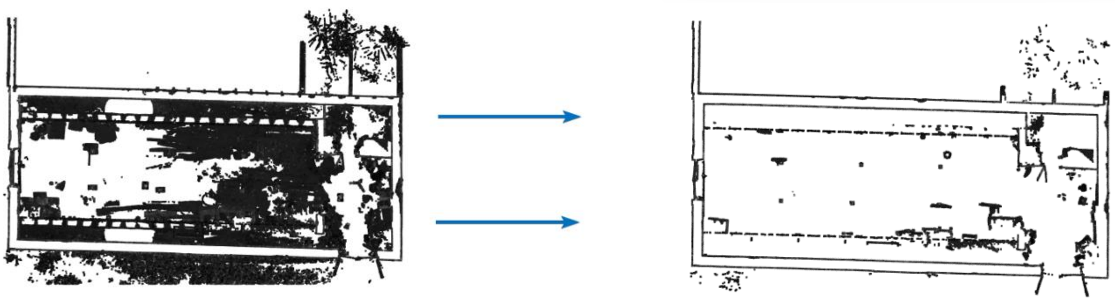


Next, adjust the levels to match the Point Cloud. Then, move the project base point to the level 0 height. Keep in mind that Level 0 is an arbitrary level. In historic buildings, floor levels may vary significantly. In such cases, it is recommended to average the placement of Level 0 or place it at the lowest point of the floor, especially if the height differences are substantial (e.g., more than 10 cm). Note that the project base point and survey point are hidden by default:

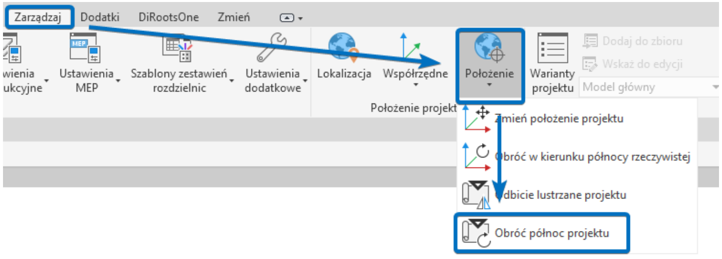


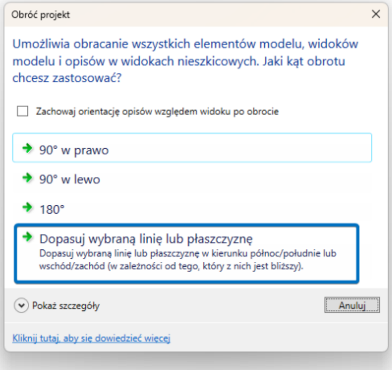
Moving on to the views, you can easily filter out unnecessary noise by adjusting the view range at different heights with a shallow depth (e.g., the section cut will be at a height of 100 cm).





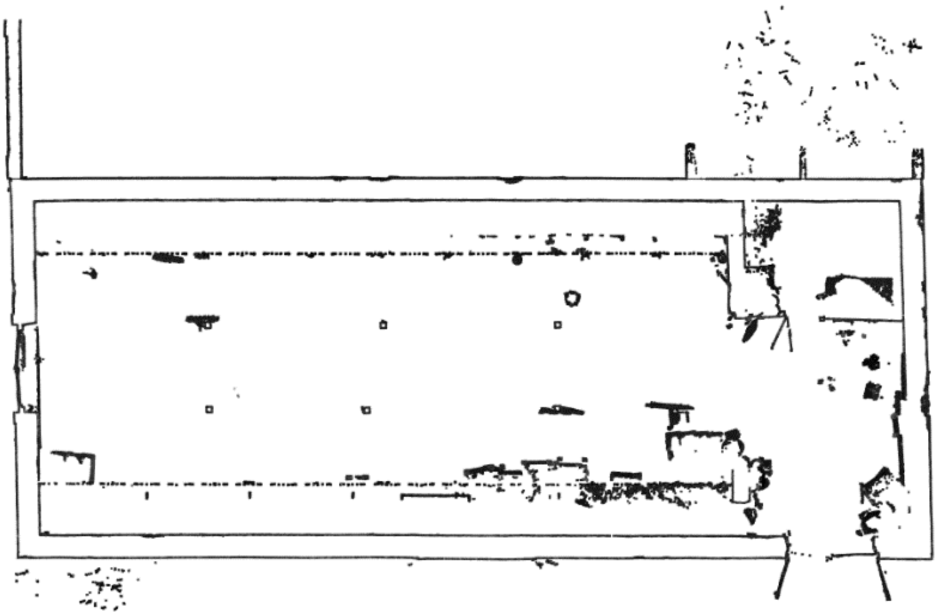
The project's north direction should typically be set parallel to the longest external wall of the building or the wall with the most walls in the same direction. To do this, it is helpful to first draw a Detail Line (DL) along the external edge of a wall, for example, and then orient the project's north direction relative to it:





Assuming the Point Cloud is correctly oriented relative to the true north. If not, it should be corrected.

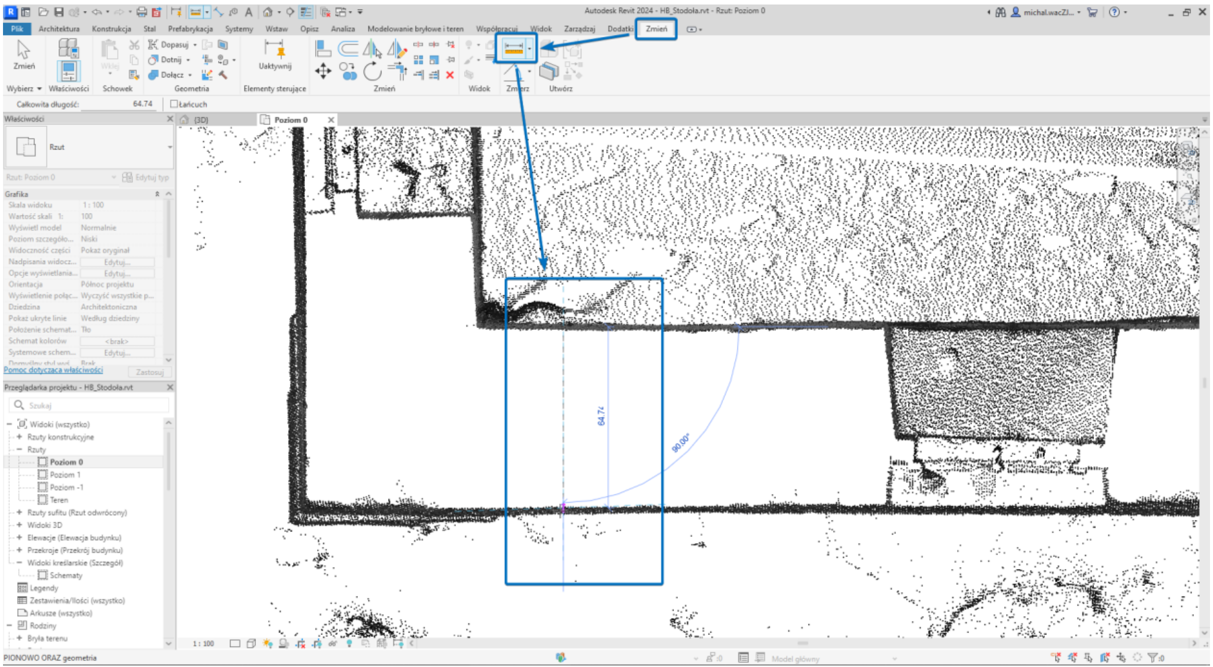
This way, the model has been adjusted and set up to begin modeling.



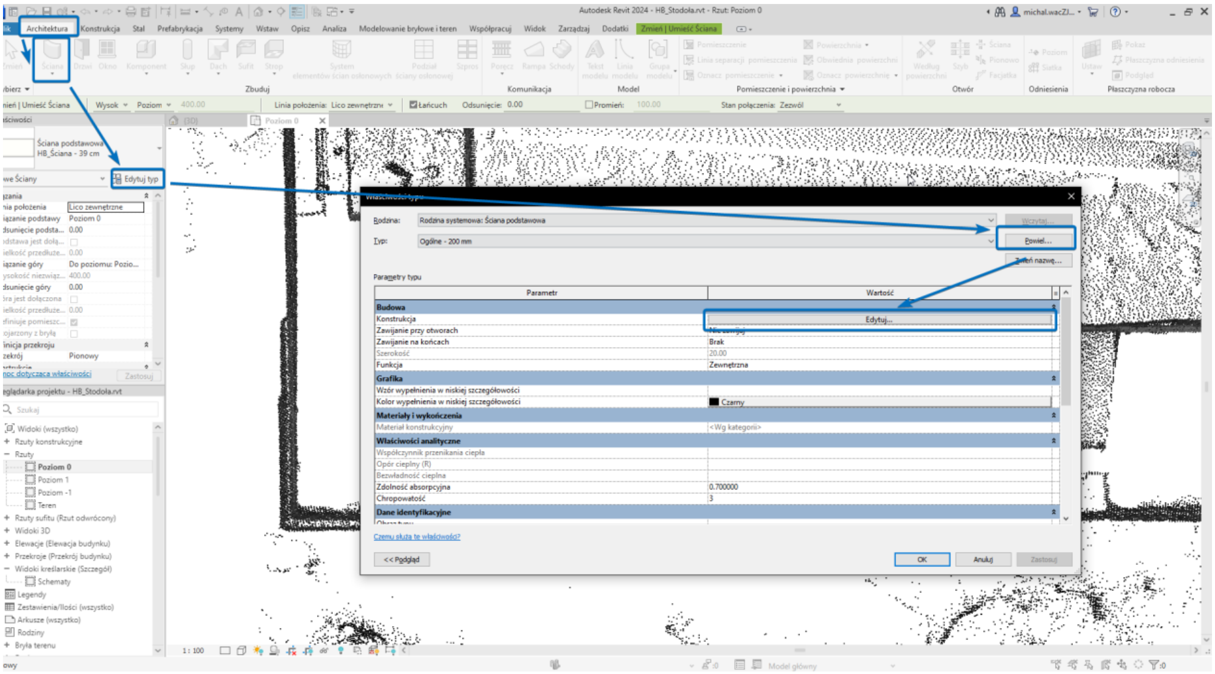
3.3. Wall Modeling

A properly generated and aligned point cloud serves as a kind of foundation used during modeling. Our task will be to populate it with models of individual elements of the object in Revit. The first element to model will be walls. To begin work related to them, switch to the Ground Floor view.

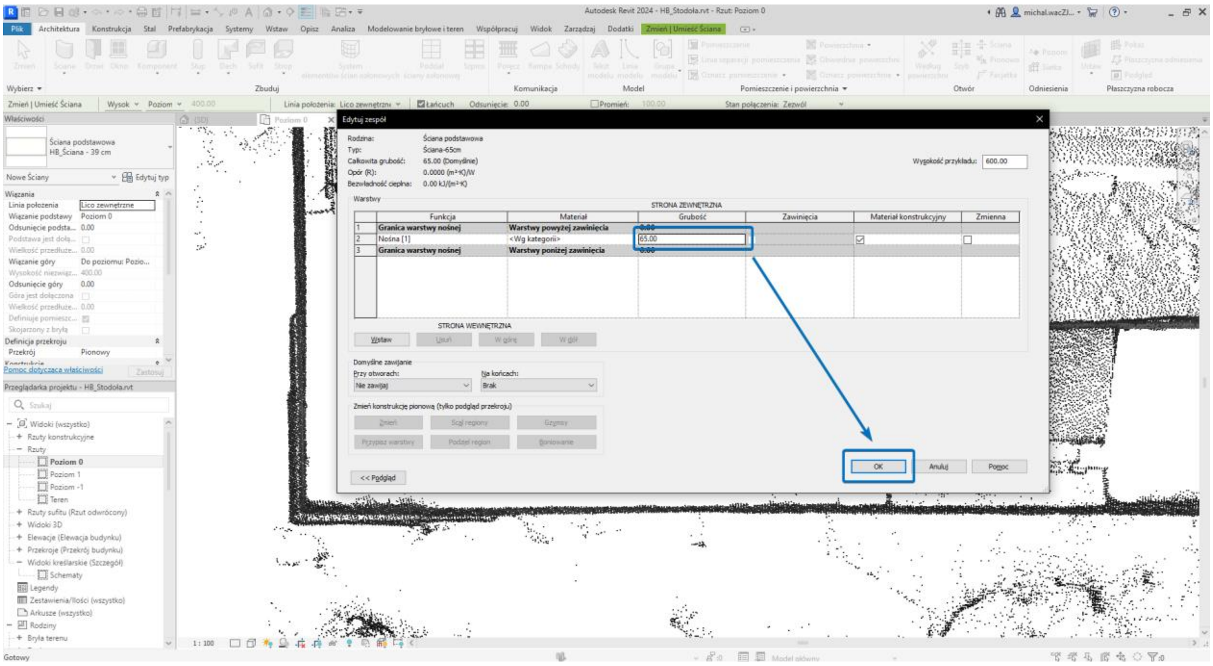
Using the Measure Between Two Reference Points tool, measure the thickness of the wall from the point cloud.



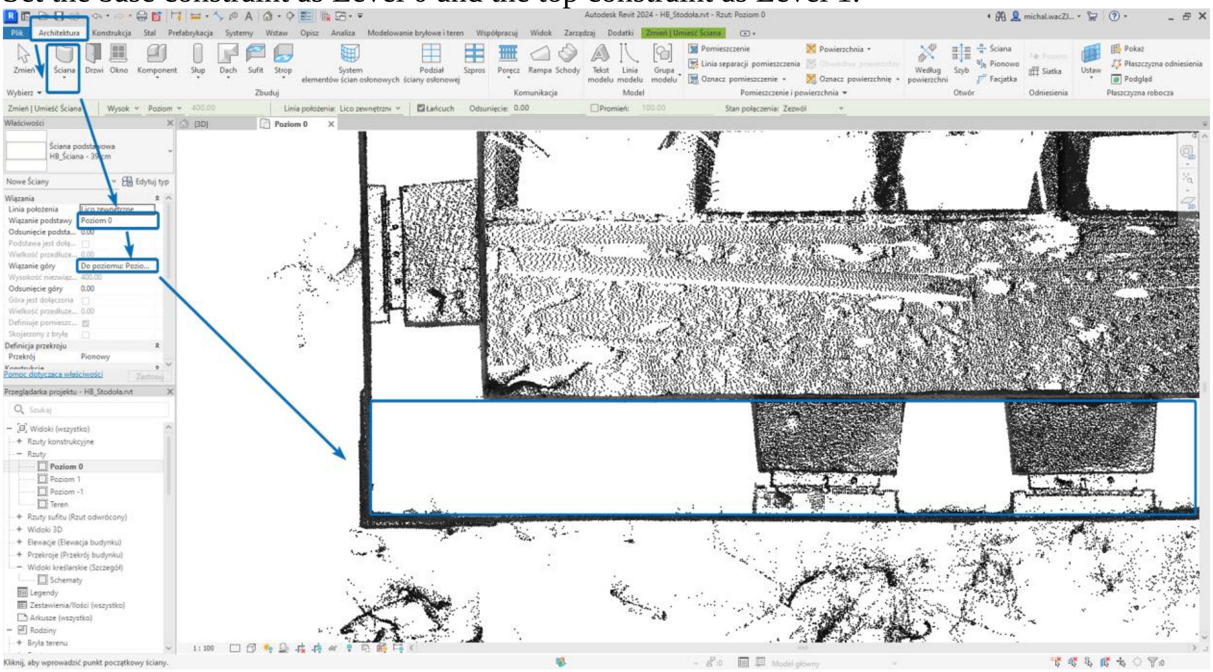
The next step is to create a new wall type based on the measured thickness. To do this, go to Architecture > Wall > Edit Type > Duplicate > "Wall-65cm" > Edit.



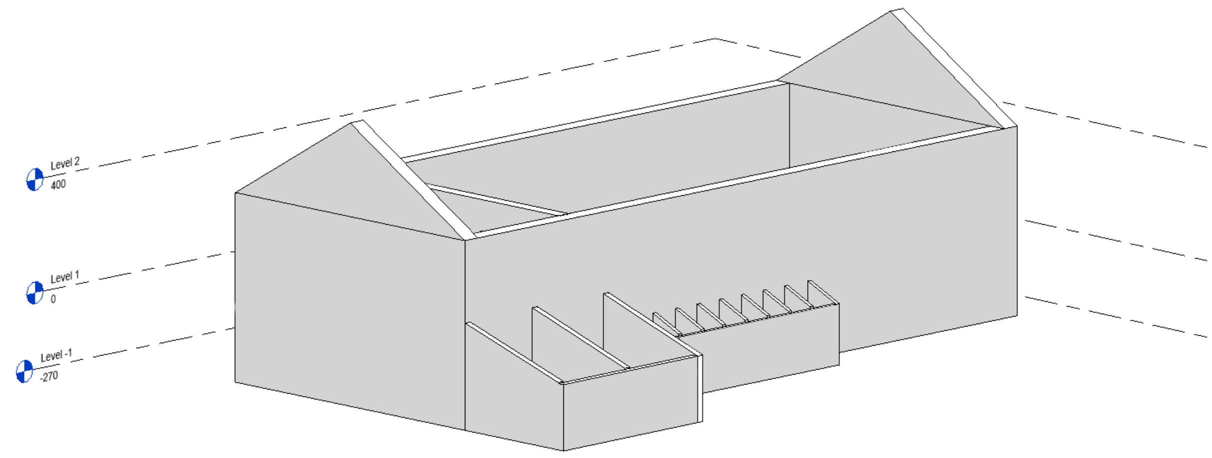
Change the layer thickness to the measured value from the foundation and confirm.



Wall modeling is done using the Architecture > Wall tool with the newly created type. Set the base constraint as Level 0 and the top constraint as Level 1.



After completing these steps, you can start modeling individual walls by adjusting their parameters and contour to achieve the desired effect one by one.

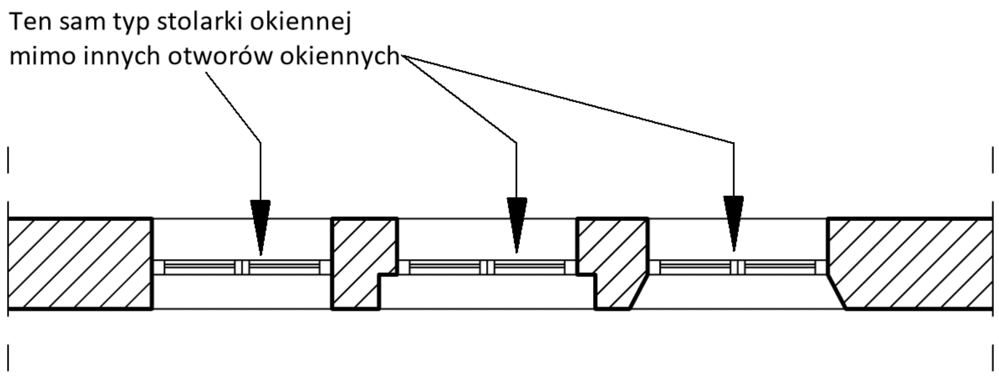


3.4. Opening modelling

In this chapter, we will discuss the principles and examples of modeling two types of opening families. For the purposes of this work, it is assumed that the opening families will be created independently of window and door families for two reasons:

Firstly, openings in historic buildings are often irregular and uneven. This means that in some cases, it will be necessary to model the opening separately using the Component > Local Model option under the Architecture tab.

Secondly, window and door openings may vary in different locations, even if they have the same window or door family. Therefore, if the opening family and the window/door family were one family, it would not be possible to accurately replicate the building, as illustrated in the diagram below:



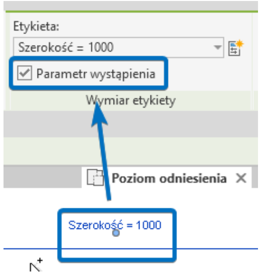
Rectangular Opening Family (for doors and windows):

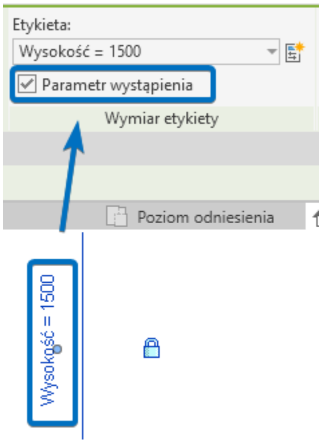
To begin creating the opening family, select File > New > Family. From the family template list, choose Window - Metric*.

If the list of family templates does not appear or appears in a limited range, make sure that the family libraries and templates are correctly installed on your computer. The default location for family templates is: C:\Program Data\Autodesk\RVT <version>\Family

Templates\Polish

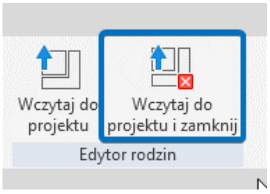
Due to the low repeatability of dimensions for openings in historic buildings, the Width and Height parameters should be set as instance parameters (element) to control each occurrence of the family independently, without the need to create dozens or even hundreds of separate types for a single family. To do this, select the Width parameter on the Reference Level and change it to an instance parameter (element).



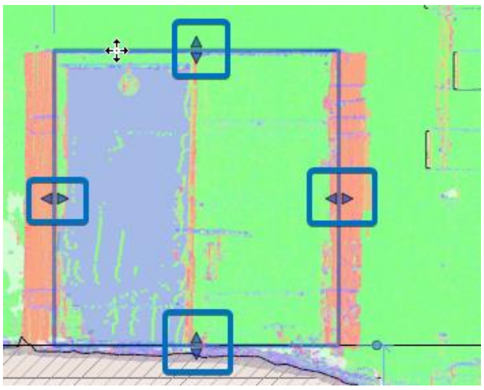


Similarly, proceed with the Height parameter on one of the elevations. Then save the family and name it according to the project's standard: File > Save As > Family > HB_Rectangular Opening.rfa.

The prepared family can be loaded into the project and closed.



Thanks to the reference planes that were implemented in the family template from the beginning, and by changing the Width and Height parameters to instance parameters, you can control the family on the elevation using arrows. This is particularly convenient when you need to model many openings with different dimensions.

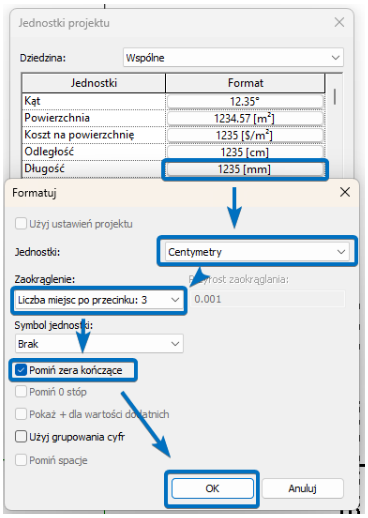


Please note that the arrows to control the family will appear only when the elevation or section view is perfectly parallel to the wall where the family is placed. If the section or elevation is not parallel, you can use the Align (AL.) option to align the elevation or section plane with the wall plane and then move it away from the wall (e.g., 20cm)..

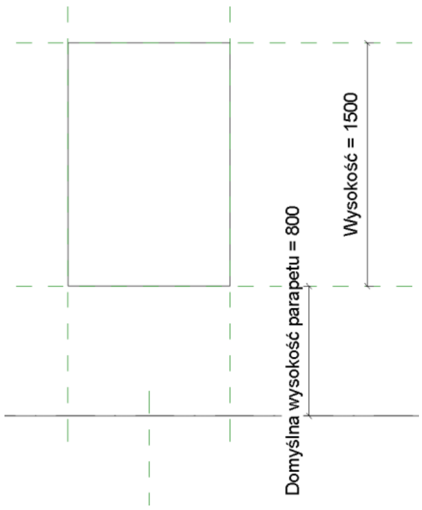
Rounded Opening Family (for doors and windows):

To start creating the family, select File > New > Family, choose Window - Metric from the family template list, and repeat the steps for creating the rectangular family. Save the family as HB_Rounded Opening.rfa

For clarity, you can also change the units to centimeters in the family: Manage > Project Units (UN).

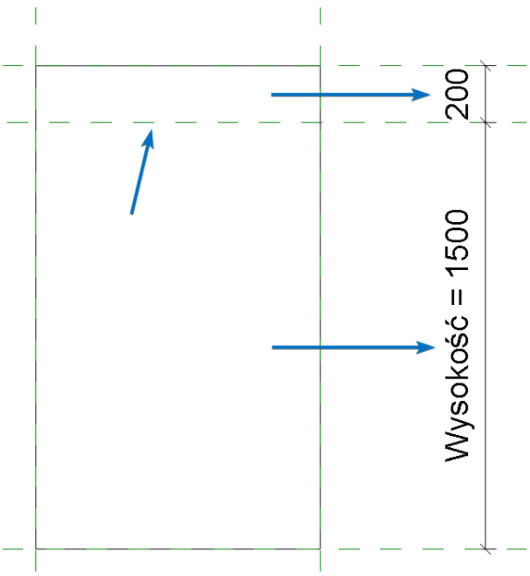


Switch to an external or internal elevation where you will begin modeling the opening:

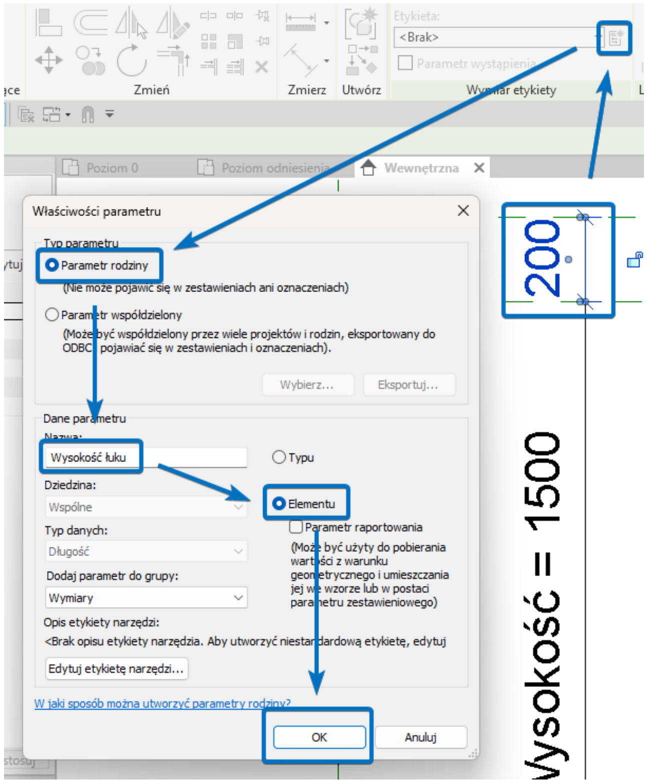


To create a family with an elliptical lintel, you need to prepare its structure in the form of reference planes first. Create Reference Plane (RP), edit the Height parameter, and edit the existing rectangular opening family to convert it into a rounded opening. An additional element parameter named "Height of the Arch" is used to control the height of the arch in the lintel.

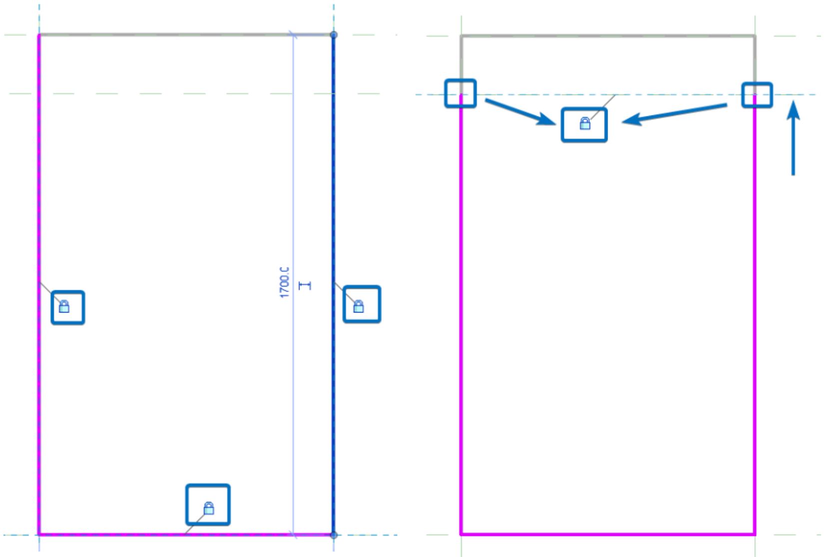
Creating the reference plane:



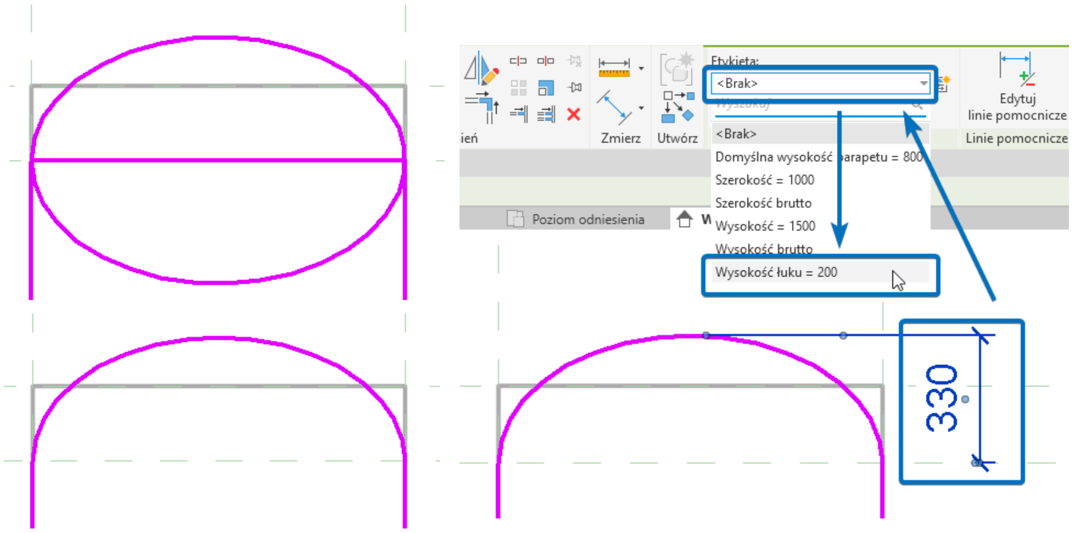
Creating the parameter:



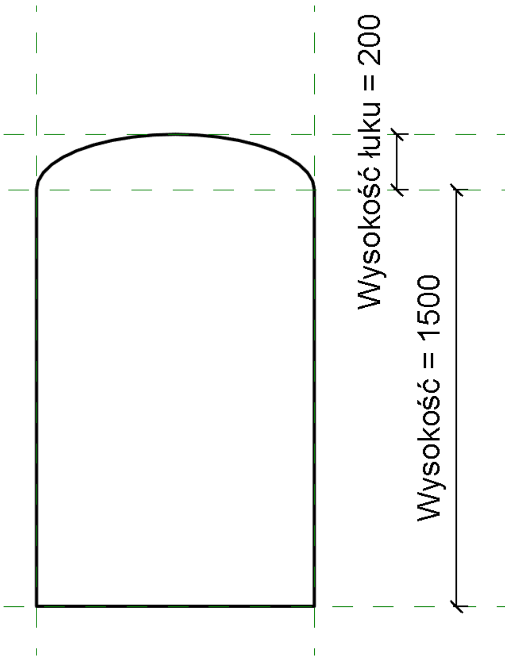
You should start editing the opening by attaching a sketch line to the reference planes and then connecting the two ends of the line to the additional reference plane created earlier: Modify > Align (AL.)



The next steps include creating lines and an ellipse, deleting lines, trimming the ellipse to the rest of the outline using the Trim tool, creating a height dimension, and changing the dimension to the previously created "Height of the Arch" parameter.



After completing these steps, the family of the rounded opening with a lintel should look like the image below:



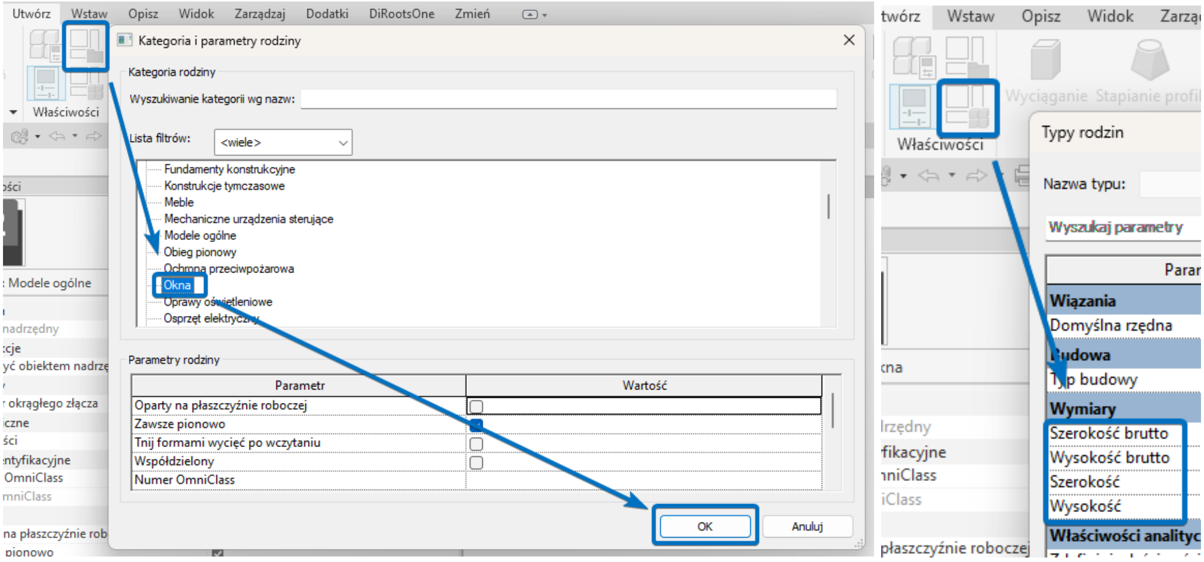
3.5. Modeling Semi-Circular Window Frames for Historic Building

In this module, we will explore the principles of modeling semi-circular window frames for historic buildings, assuming that the window frames are being modeled to fit existing openings. To maintain flexibility, the family will not be hosted, allowing it to be inserted into any location, regardless of the shape or parameters of other building components. This method is recommended for both beginners and advanced users, as it simplifies the modeling process. However, it is important to note that modeling window frames along with openings is best suited for advanced users and when dealing with a high degree of repetition, such as more than 30 instances of the same window frame.

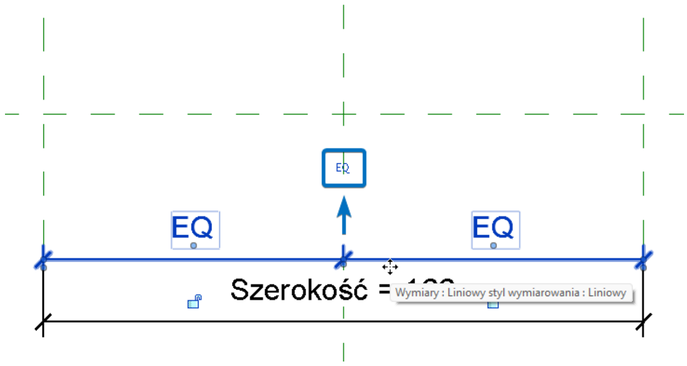
To begin, go to File > New > Family and select the Generic Model (Metric) template.

Metryczne żebro konstrukcyjne oparte na linii.rft	27.01.2021 14:25	Szablon rodziny pr...	400 KB
Metryczne żebro konstrukcyjne.rft	27.01.2021 14:25	Szablon rodziny pr...	396 KB
Model ogólny (metryczny).rft	27.01.2021 14:25	Szablon rodziny pr...	400 KB
Model ogólny adaptacyjny (metryczny).rft	27.01.2021 14:25	Szablon rodziny pr...	424 KB
Model ogólny oparty na dachu (metryczny).rft	27.01.2021 14:25	Szablon rodziny pr...	404 KB

This template is designed for various simple families like furniture, basic fixtures, handles, parking spaces, panels, and more. By default, this template falls under the "Generic Models" category. Change it to "Windows" to access system parameters specific to windows, such as Width and Height.



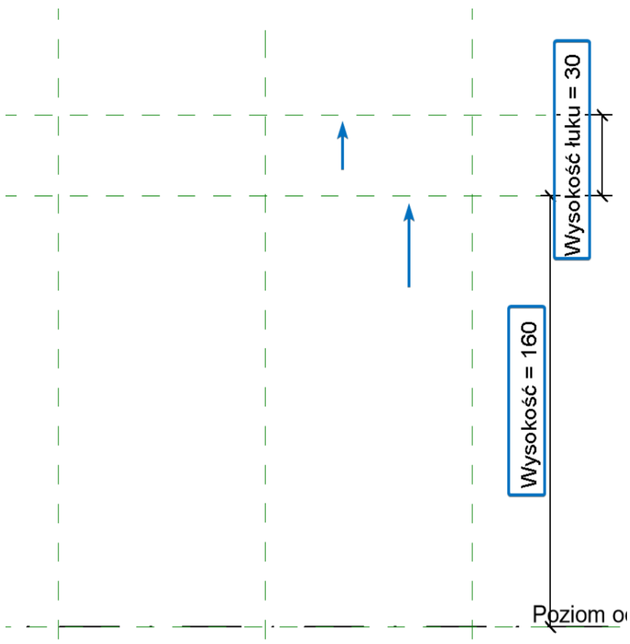
It is recommended to change the family units to centimeters. Next, create a framework composed of reference planes (RP) to resemble the template used for the circular window opening. Create a right, left, and two upper reference planes, assign parameters to them, and establish Equal constraints.



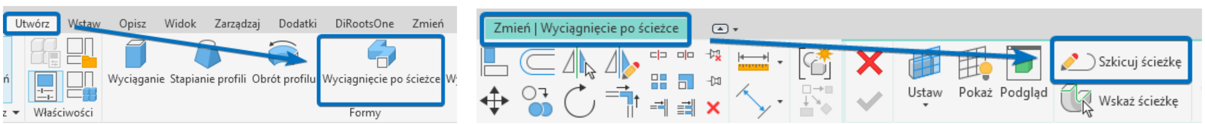
Use elevation "Front" in the model to parameterize the Height and Arch Height, similar to the HB_Semi-Circular Window.rfa family. Both parameters should be instance parameters

It is recommended to change the family units to centimeters. Next, create a framework composed of reference planes (RP) to resemble the template used for the circular window opening. Create a right, left, and two upper reference planes, assign parameters to them, and establish Equal constraints.

Use elevation "Front" in the model to parameterize the Height and Arch Height, similar to the HB_Semi-Circular Window.rfa family. Both parameters should be instance parameters:.

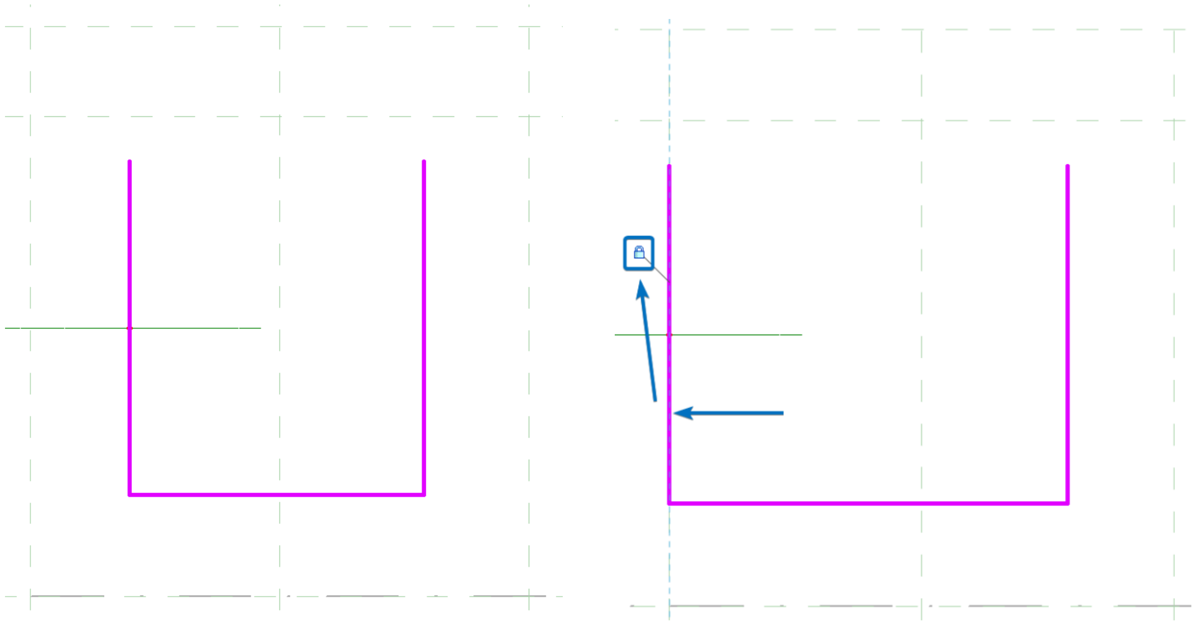


The next step is to create the outer frame profile. In this exercise, we will create a fixed

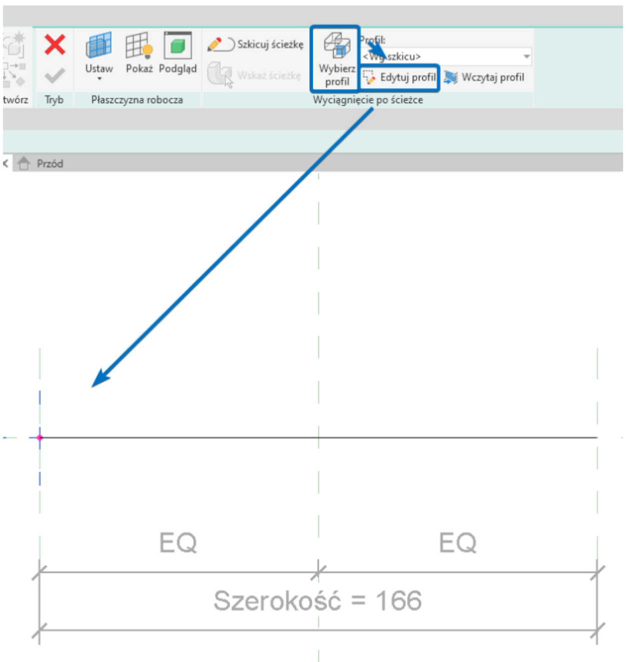


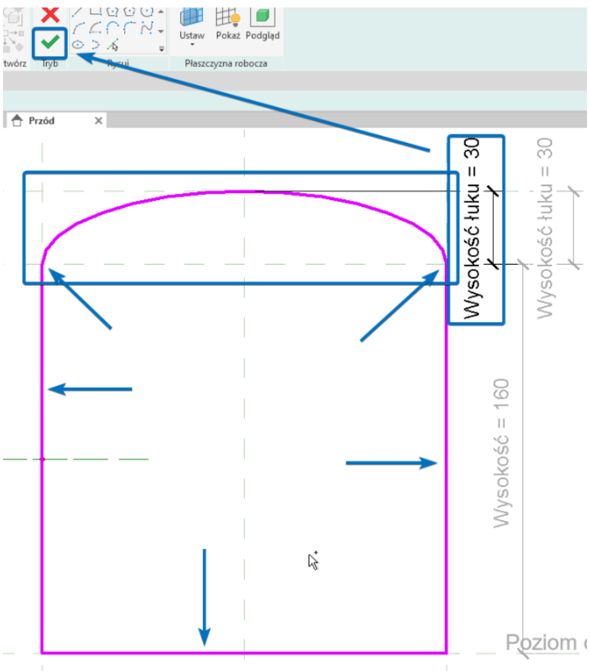
window with a constant frame. To model an operable window, a more parameterized family consisting of both a frame and a sash is recommended. Select Create > Extrusion along Path and sketch the path, similar to the family opening.

It is a good practice to first draw sketches "in the air" and then use the Align (AL) option to attach them precisely to a reference plane. When a family needs to be parametric, and a line needs to follow a reference plane, be sure to pin the line to the plane right after using the Align (AL) option.

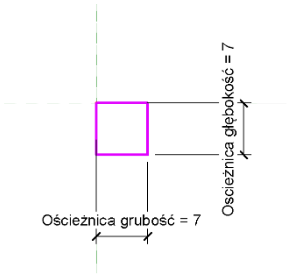


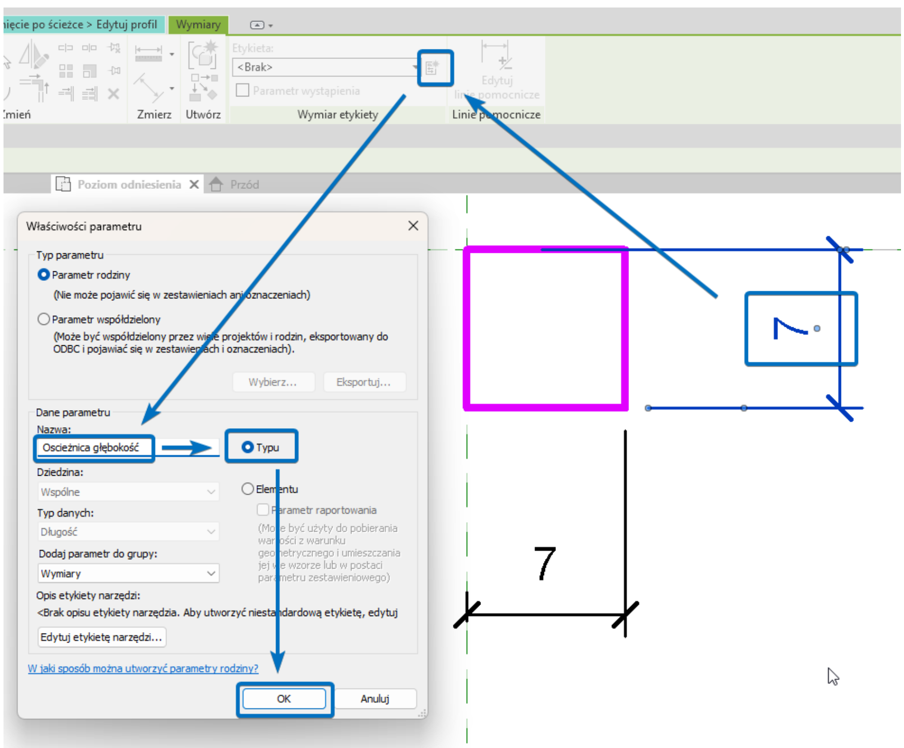
After creating a complete sketch (while pinning both ends of the line) and assigning a parameter for Frame Depth and Frame Thickness, finish editing mode by clicking the Finish Edit Mode button (only once). Then switch to the reference level to sketch the profile.

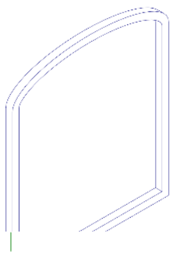




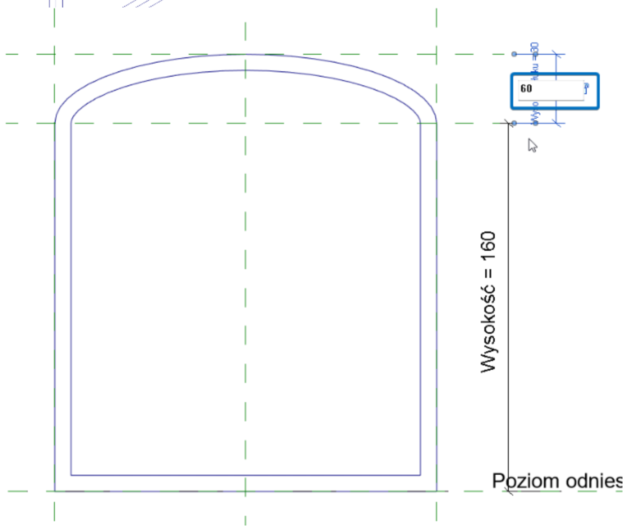
When drawing smaller elements, it is advisable to change the view scale from 1:20 to, for example, 1:5. Start sketching the profile by drawing a rectangle, which, when extruded, will form the frame. After creating the rectangle, parameterize its thickness and depth. These parameters should be type parameters since window profile sizes are often standardized, even for historic windows.

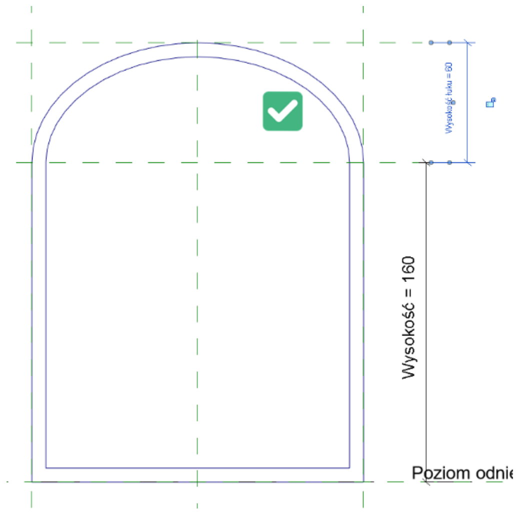


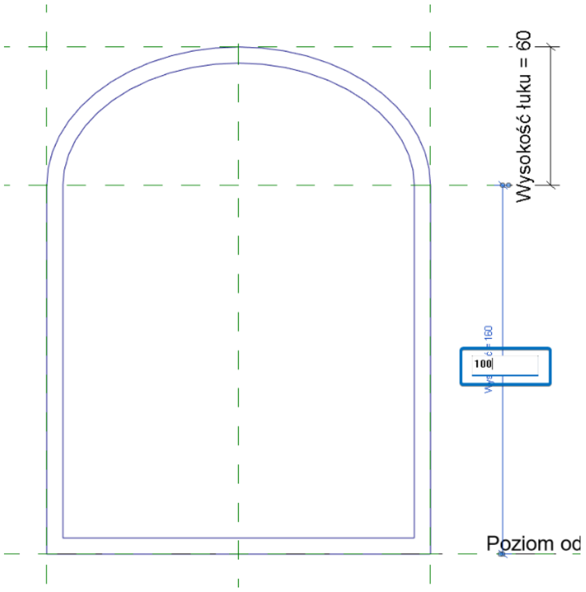




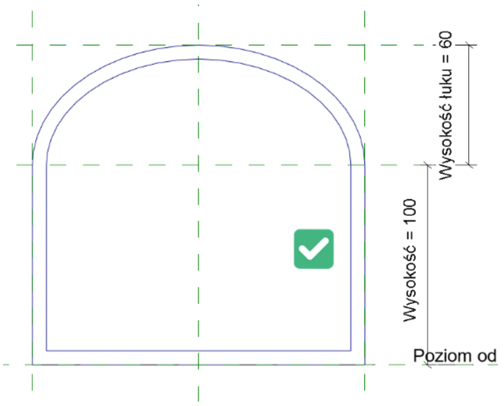
After approval, the modeled frame should be visible in the 3D view and Front Elevation. To ensure the model's accuracy, change the values of the following parameters one by one: Width, Height, Arch Height, Frame Depth, and Frame Thickness.



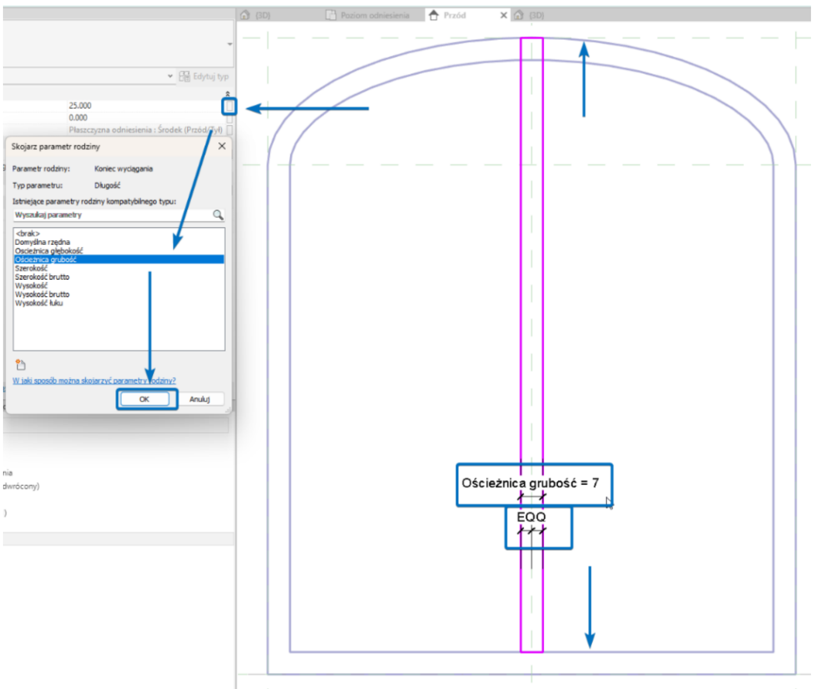




Conducting a short test to assess the family's behavior (by altering its parameters) after creating each element is crucial for proper parameterization and understanding the family's functionality:

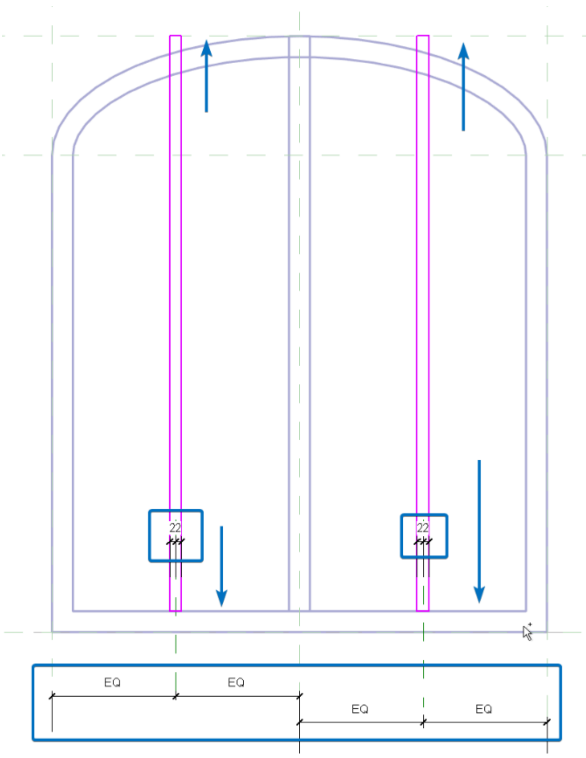


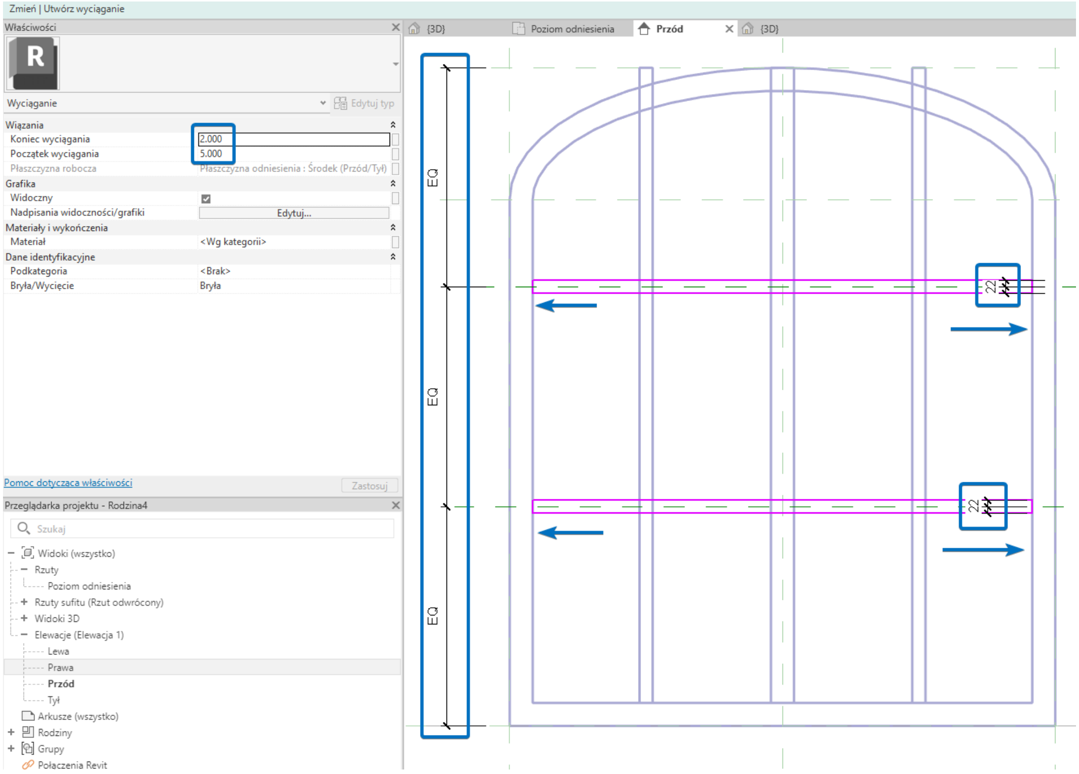
The next step is to create internal muntins within the window, including one thicker muntin (matching the frame's thickness) and additional muntins (with a constant thickness, e.g., 4cm). In the Front view, extrusions symbolizing muntins will be created, and their thickness and depth will be parameterized.



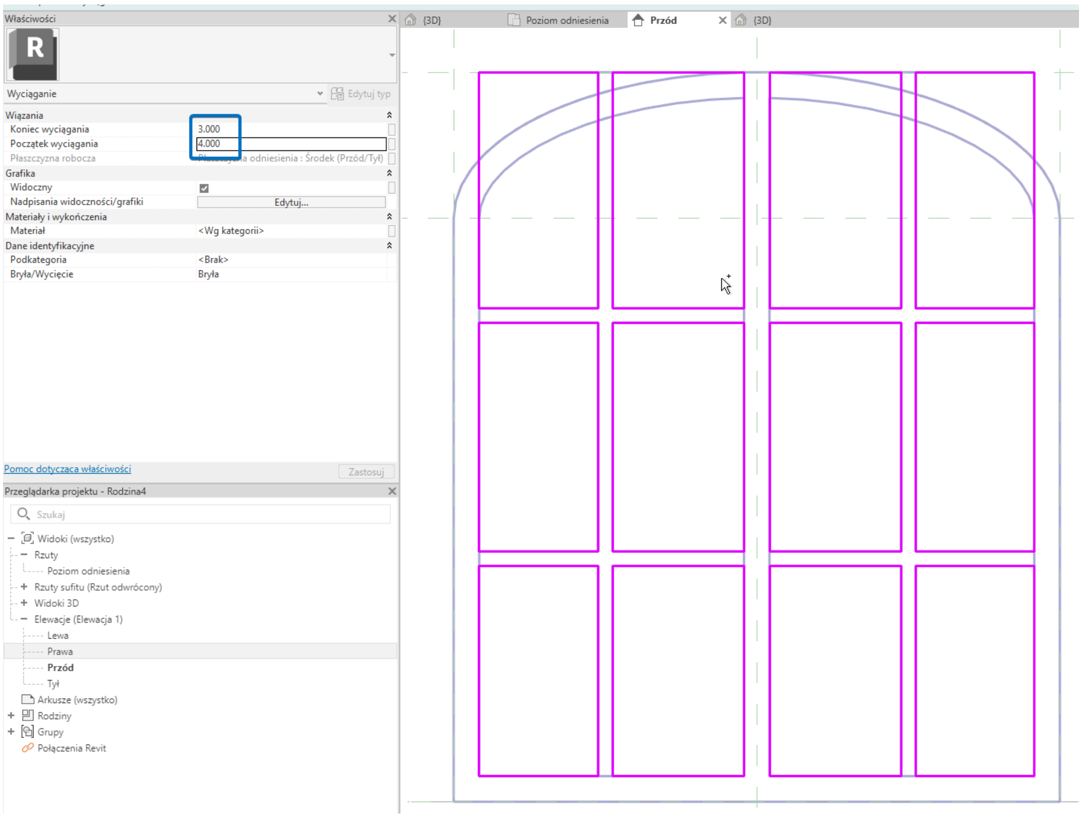
Creating geometry in families should be approached with a sense of balance. The more parameters a family has, the more time-consuming it is to create, and the greater the complexity during project editing.

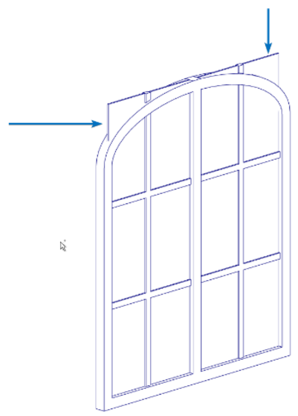
For horizontal muntins, additional reference planes (RP) for muntins with a thickness of 4cm will be utilized. In family parameterization, maintaining a reasonable balance is crucial. The most versatile family has all dimensions parameterized, but an excessive number of parameters can lead to a lack of transparency and longer editing times in the project.





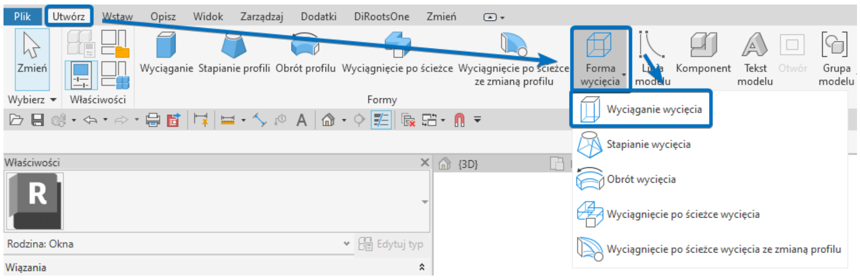
Creating rectangular prisms symbolizing window panes works similarly. The approximate thickness of the glass is assumed to be 1cm:



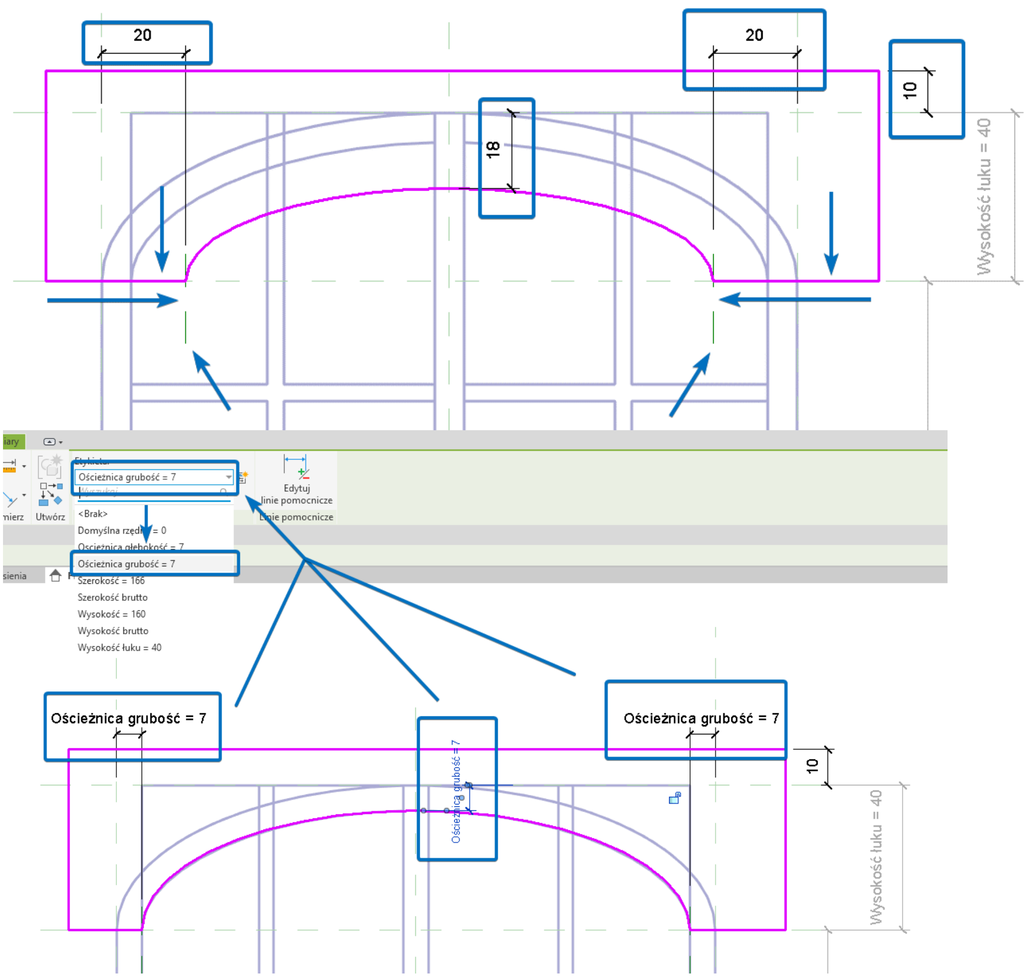


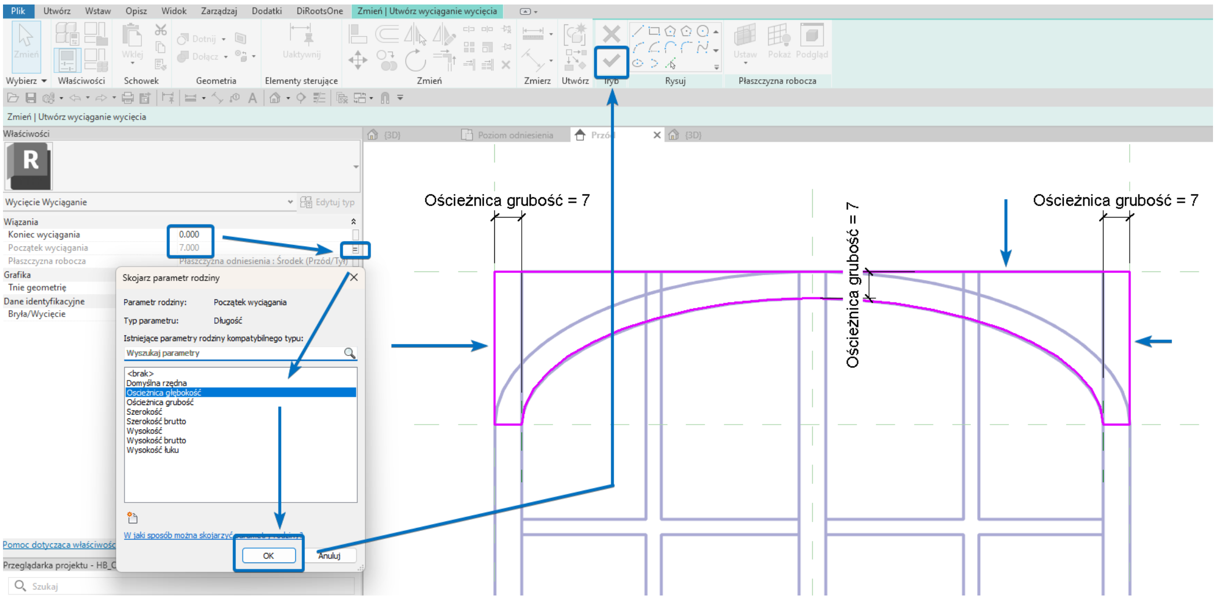
The final step in creating the geometry is to create extrusions that will trim the protruding rectangular prisms of the glass and muntins.

Create > Form > Extrusion by FaceThe final step in creating the geometry is to create extrusions that will trim the protruding rectangular prisms of the glass and muntins.
Create > Form > Extrusion by Face:

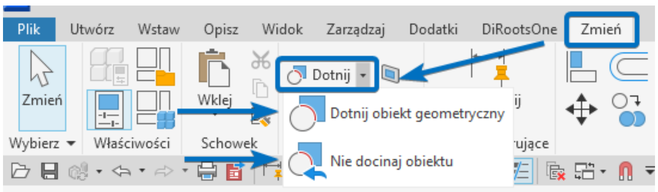


Binding lines to planes should be done with exceptional precision. A single improperly attached constraint can disrupt the functioning of the entire family. In this sketch, internal reference planes were also used, and lines as well as their endpoints were aligned to them:



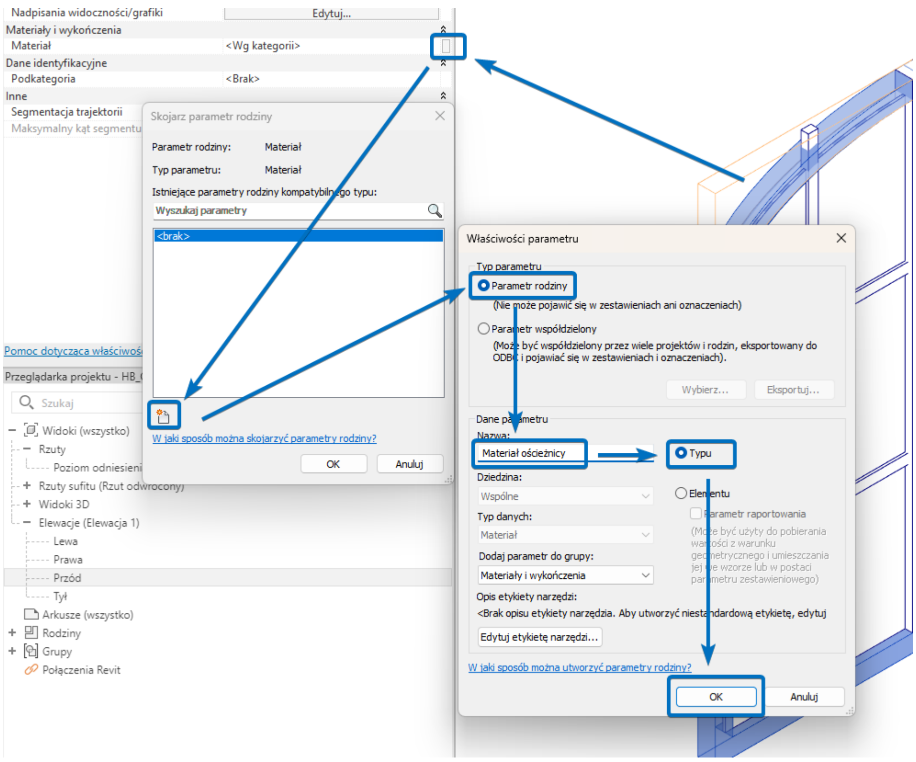


Using the options Create > Cut Geometry or Don't Cut Geometry, trim the protruding muntins and glass without cutting the main frame:



To parameterize the material of the muntins and glass, create two material parameters:

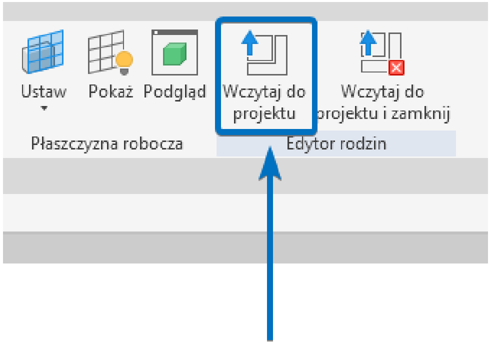
- Frame Material
- Glass Materia

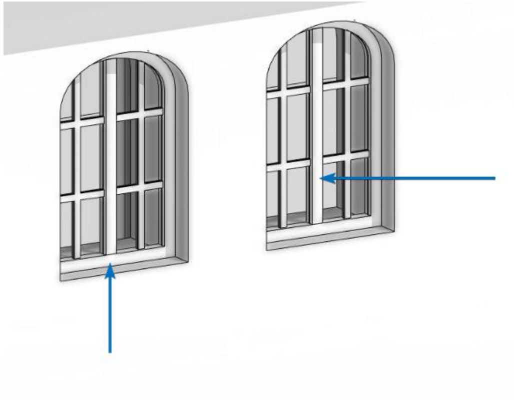


This allows you to select specific materials for the family you create in the project.

After completing all the steps, the family is ready to be loaded into the project.

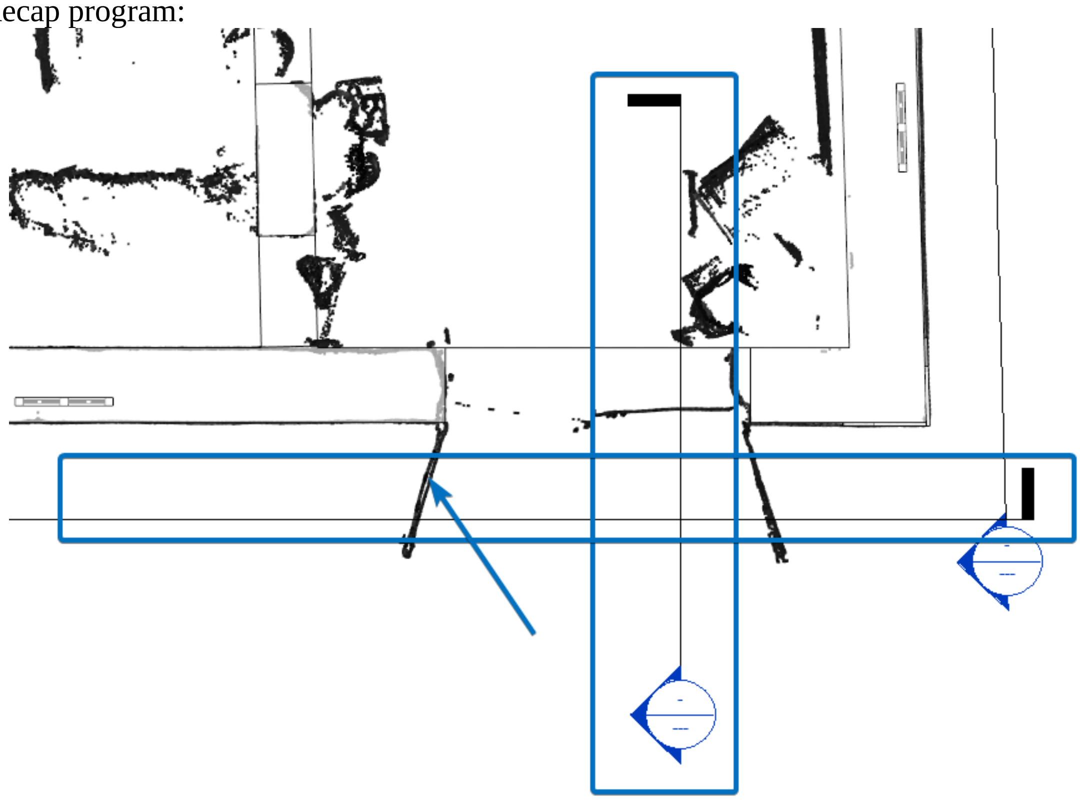
The family is ready for loading into the project and insertion into previously modeled openings:



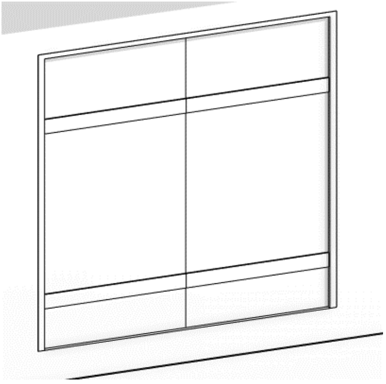


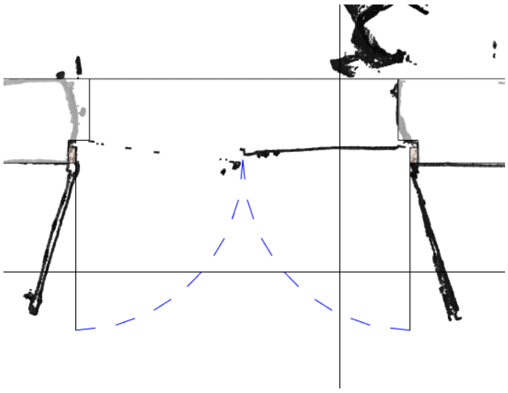
For modeling door joinery in historic buildings, it is suggested to use the generic model tool directly within the model. Often, specific doors appear only once in a building, so creating parametric families for non-repetitive elements may not be efficient.

To create door elements (e.g., gates), the best approach is to create a section, elevation, and plan at the location of the joinery and visualize the geometry of the elements parallelly in the Recap program:

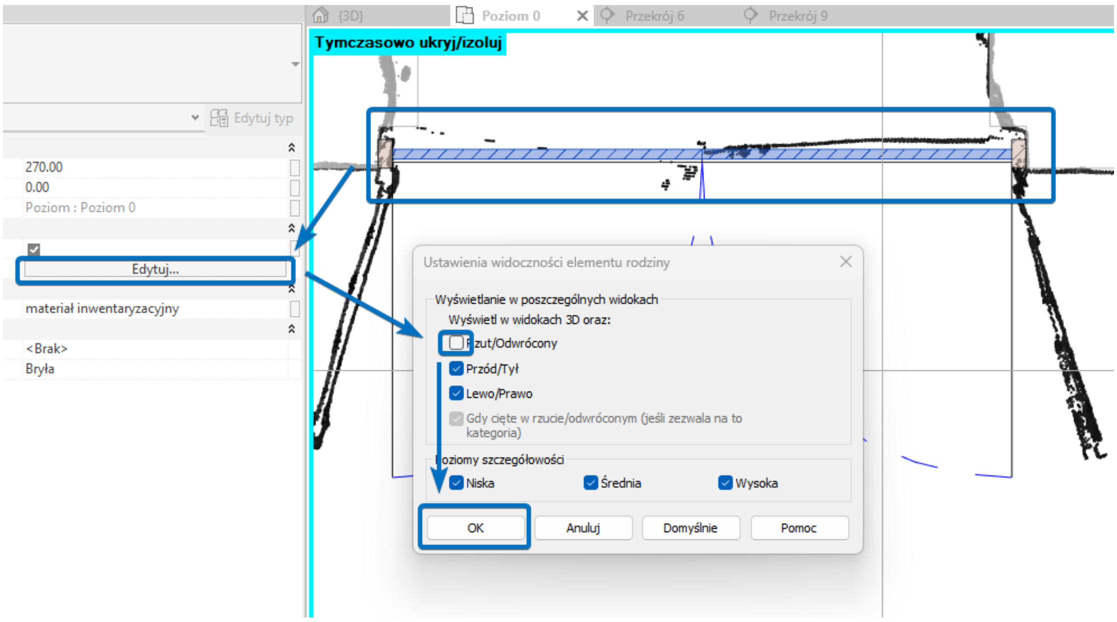


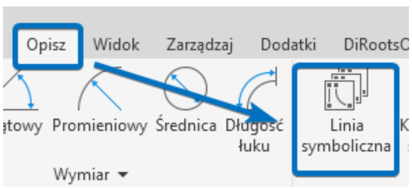
Next, by going to Architecture > Component > Local Model and selecting the Door Category, you should use modeling tools (similar to modeling a family) to create the door joinery as desired. Each case will be unique.

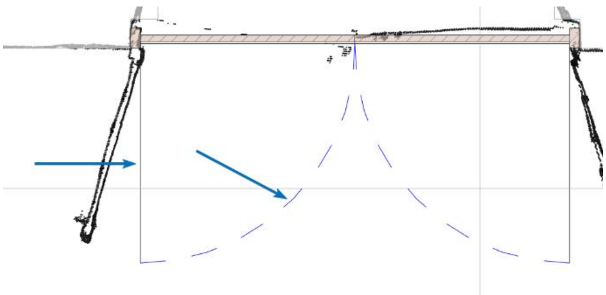




To hide the door leaf in the plan view, select the modeled element in the Generic Model and go to Properties. Choose Overrides for Visibility/Graphics and uncheck the Projection/Section box. This way, the geometry won't be displayed in the plan view, and the door leaf's operability should be symbolically represented with Detail Lines: Annotate > Symbolic Line.



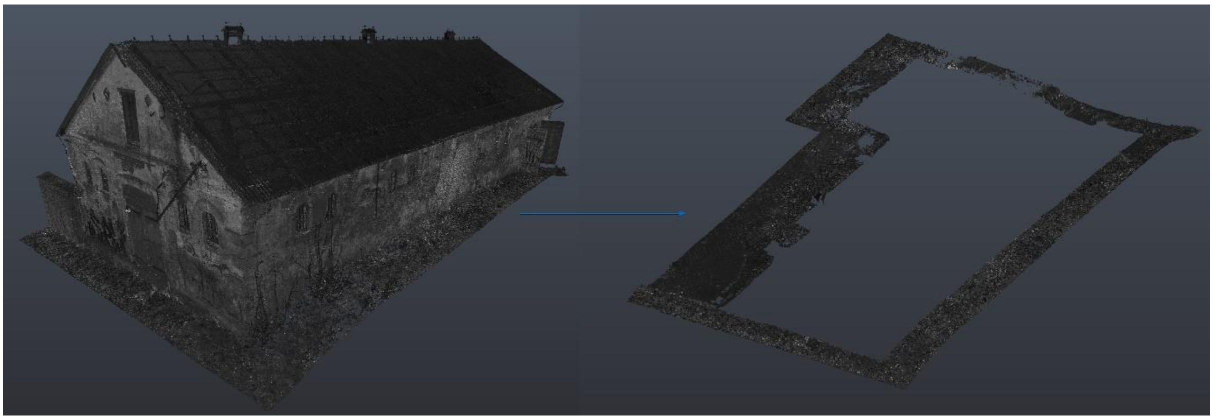




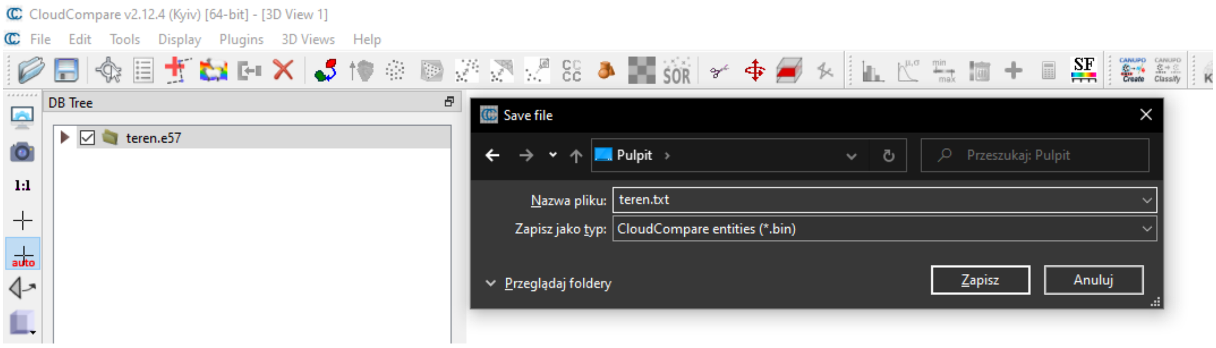
3.6. Terrain Modeling

Method I - Modeling Based on Point Clouds

To begin terrain modeling based on point clouds in Revit, you should create a copy of your *.rcp file along with its library. Next, open it, and by manipulating the 3D view, mark and remove one by one all building elements and unwanted terrain elements. The final result should be a cleaned point cloud representing the terrain around the building.

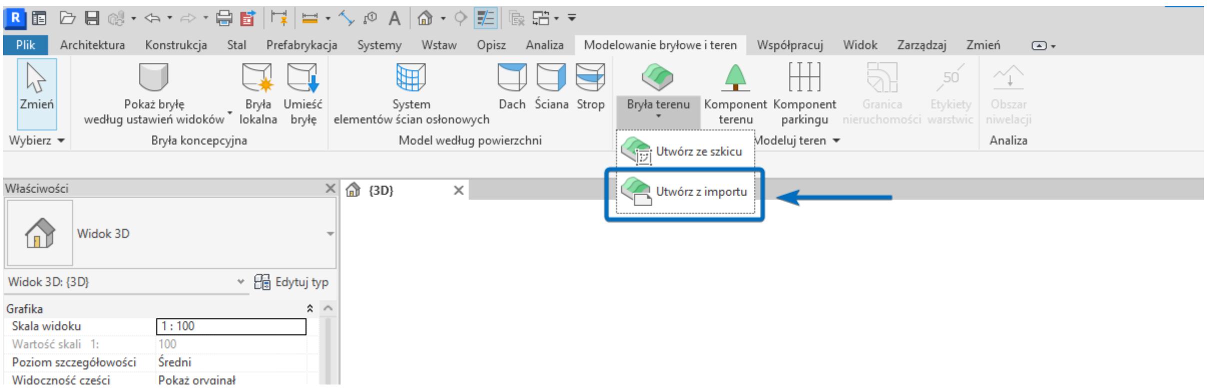


Once the terrain is cleaned, export it to the *.e57 format. Import the exported file into the CloudCompare software, select and save it as a *.txt file.

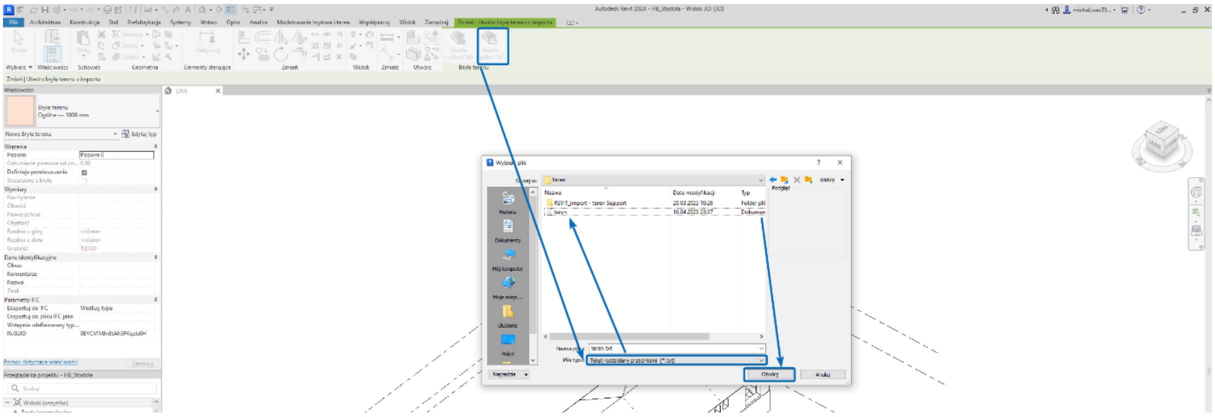


Afterward, in Revit, use the tool:

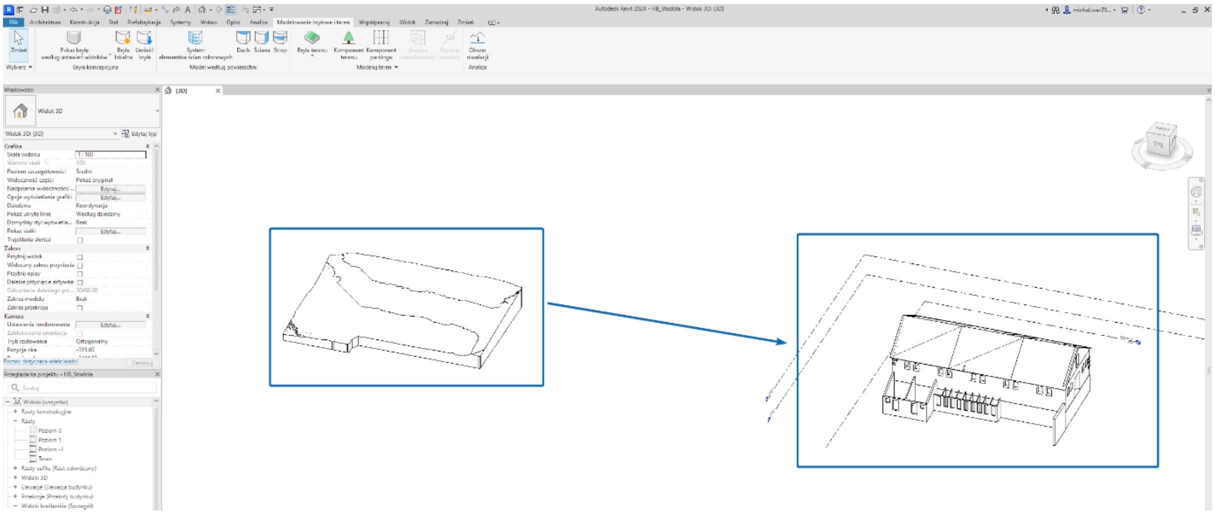
Massing & Site > Toposurface > Create from Import.



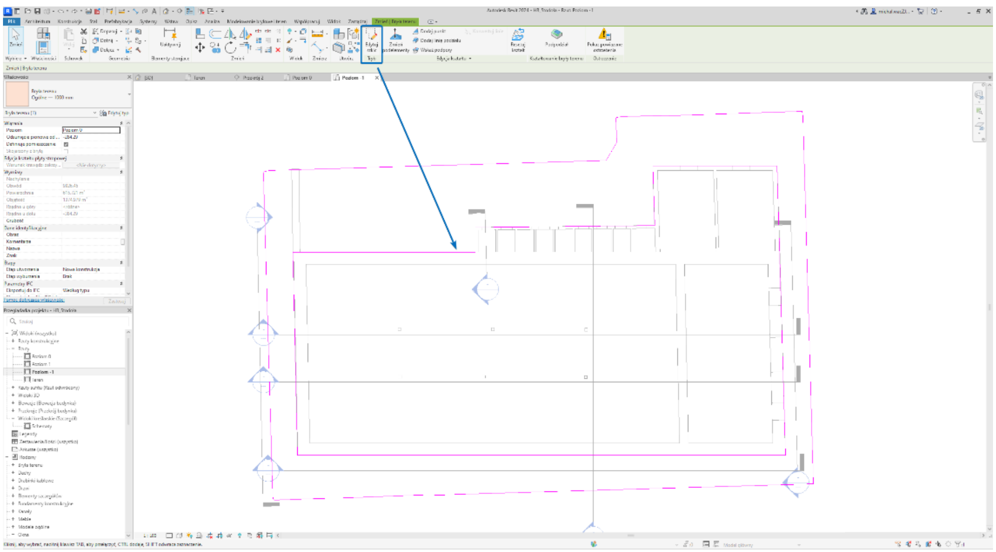
Then select Create from File CSV, change the format to *.txt, and choose the created file. Set the unit to meters.



The next step is to align the imported topography mass to the existing model using Rotate and Move tools.



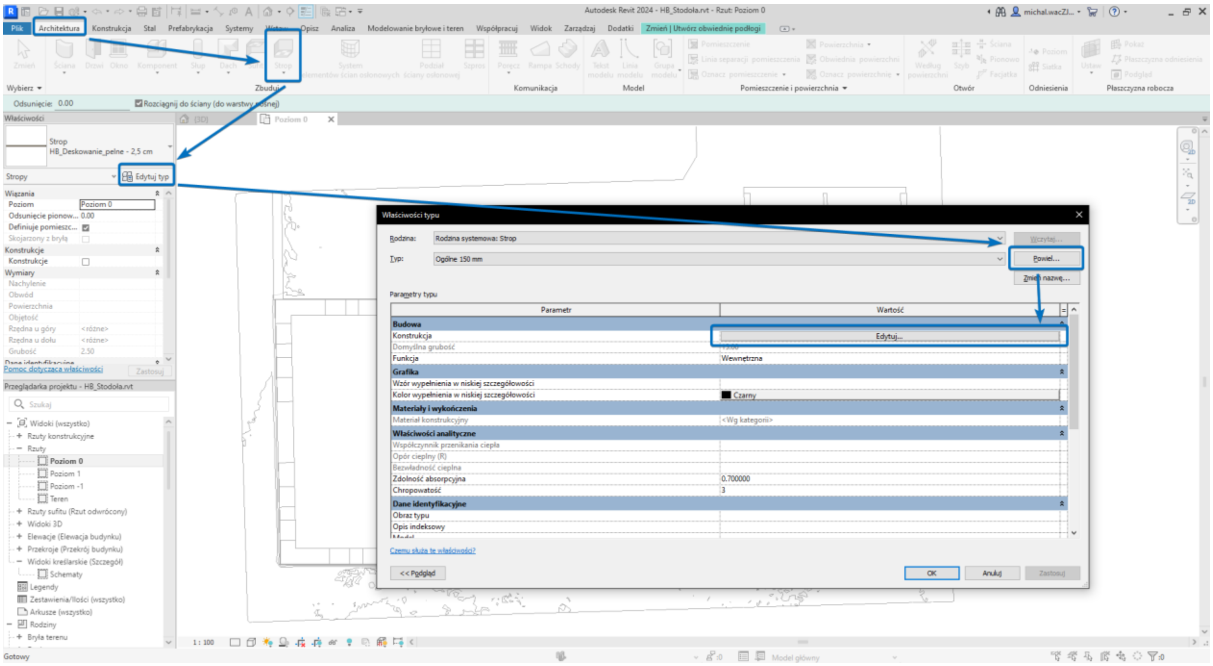
After aligning the topography mass, select it and choose the Edit Sketch option. Then, on the Level -1 plan, create an outline along the outer edge of the object and confirm the edit. Remove the inner part of the topography mass.



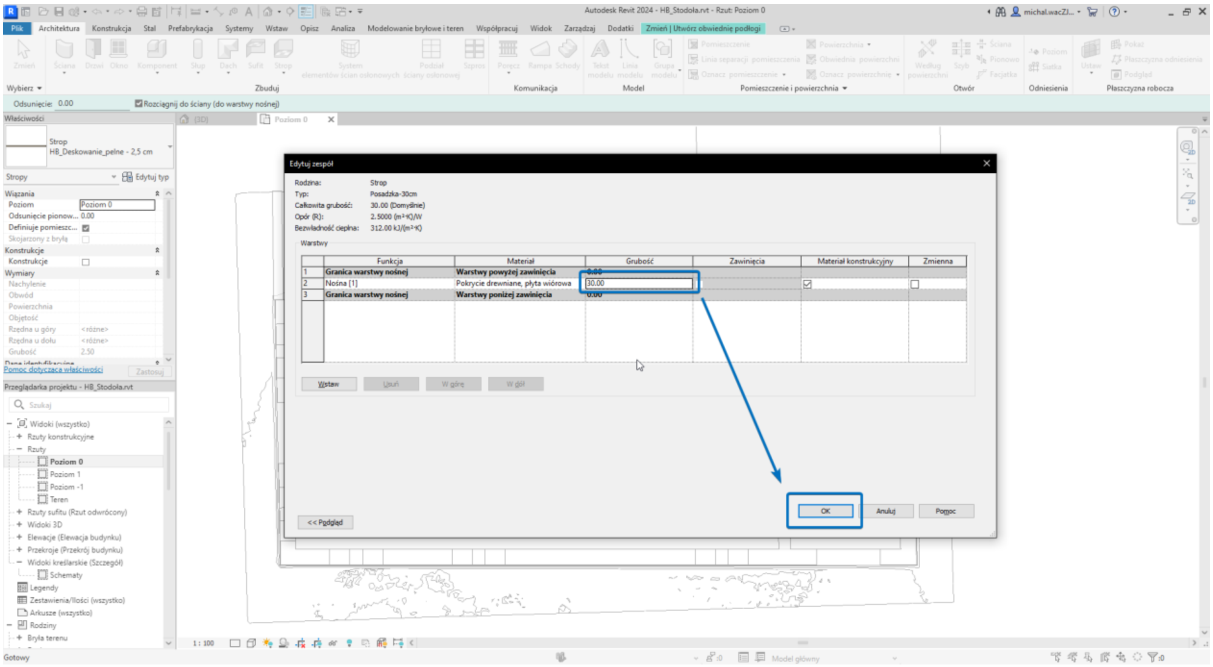
3.7. Floor Modeling and Cornice Component Modeling

We will model the floor using the Architectural Floor tool, and then customize its type with appropriate parameters and a name.

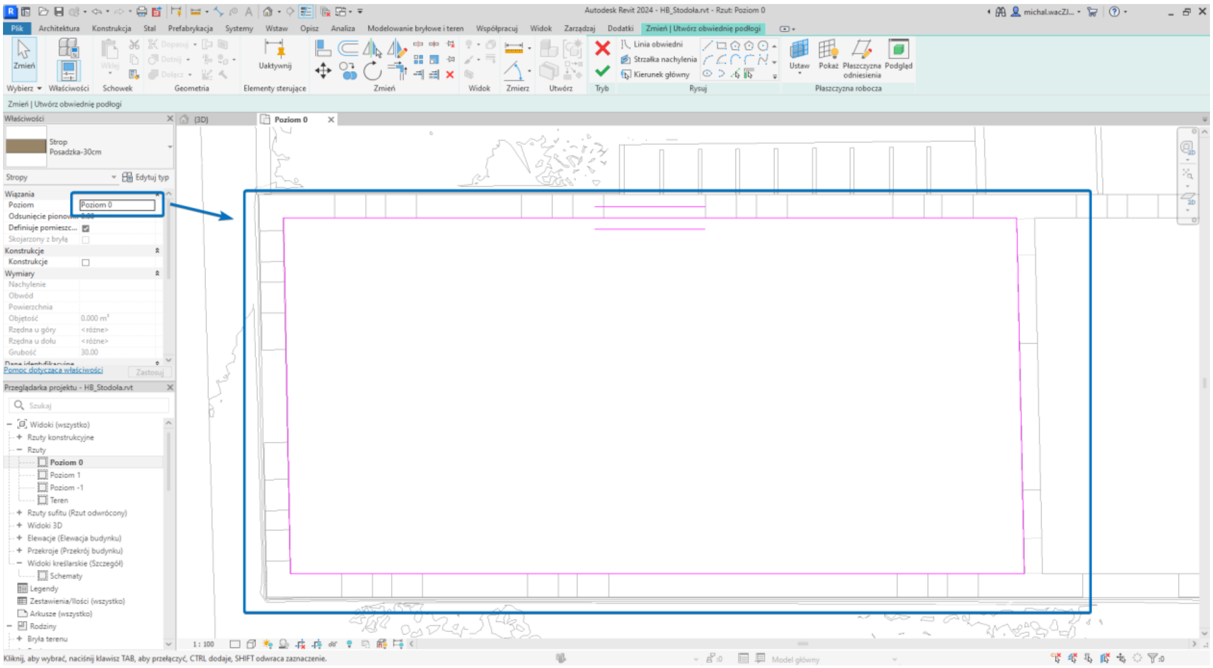
Architecture > Architectural Floor > Edit Type > Duplicate > "Floor-30cm" > Edit



Change the thickness of the layer to the desired value and confirm the edit.

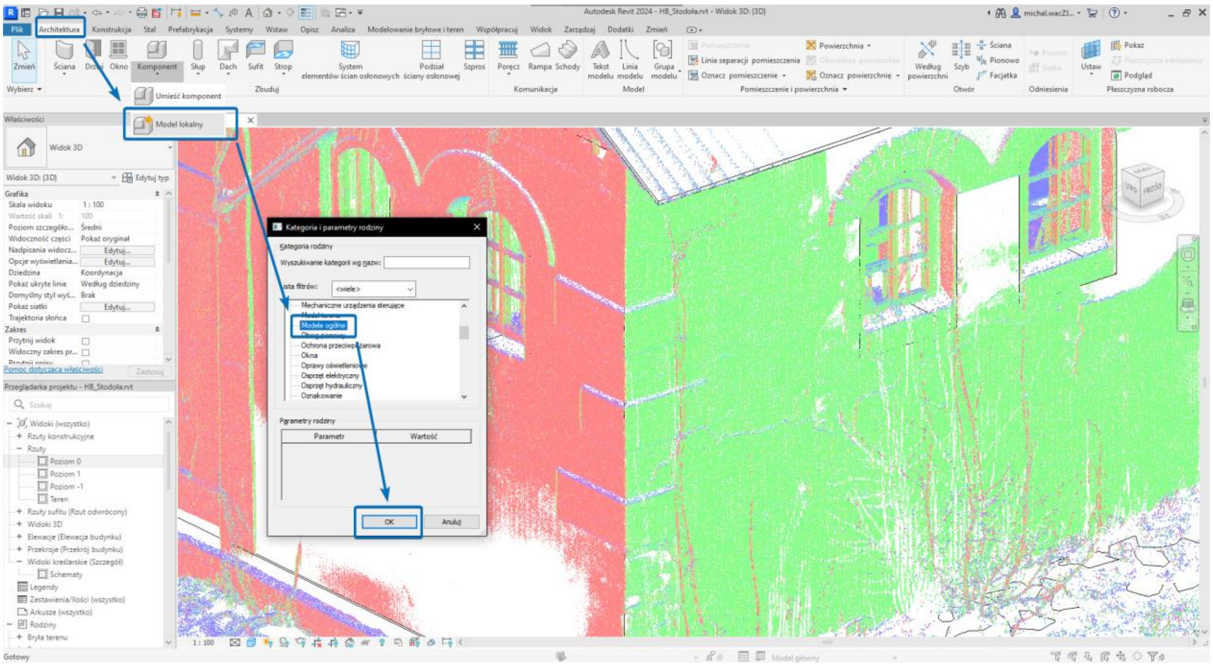


After creating a new type, outline the outer contour of the modeled floor on the ground floor plan, ensuring the correct elevation settings in the parameters.



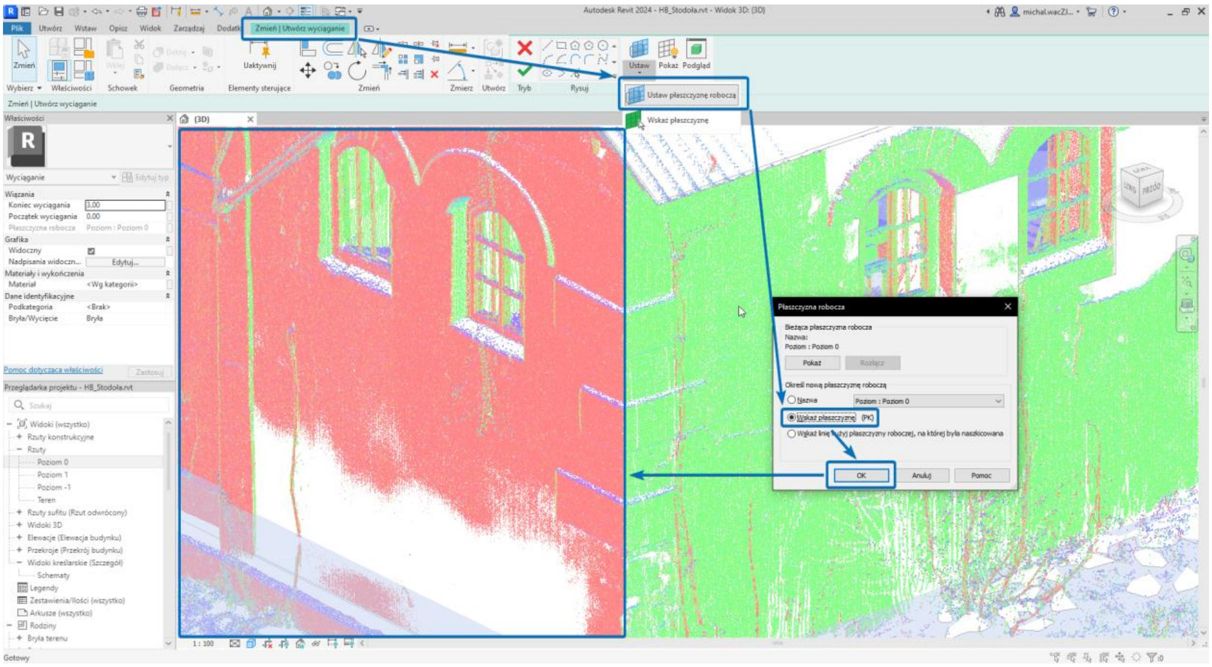
To model the cornice component, start by selecting the appropriate 3D view of the element. Then choose:

Architecture > Model In-Place > Generic Models > OK > "Cornice"

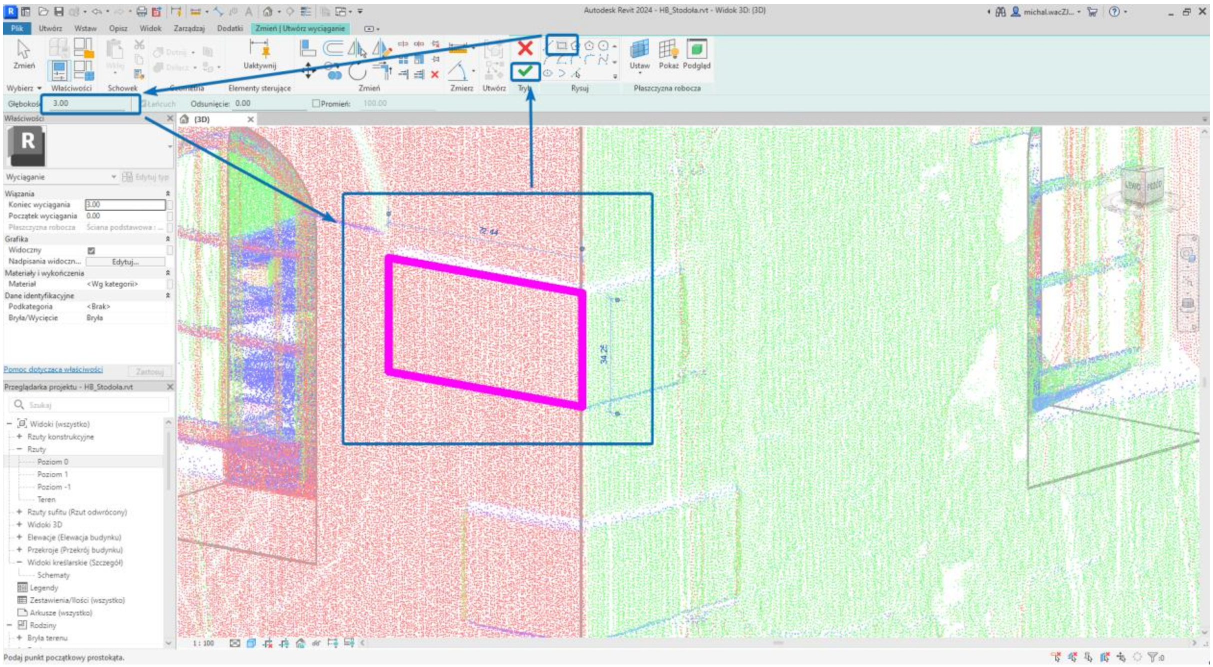


The next step is to use the Extrusion tool and select a work plane using:

Modify > Set Work Plane > Pick a Plane > OK > "Select the wall plane"

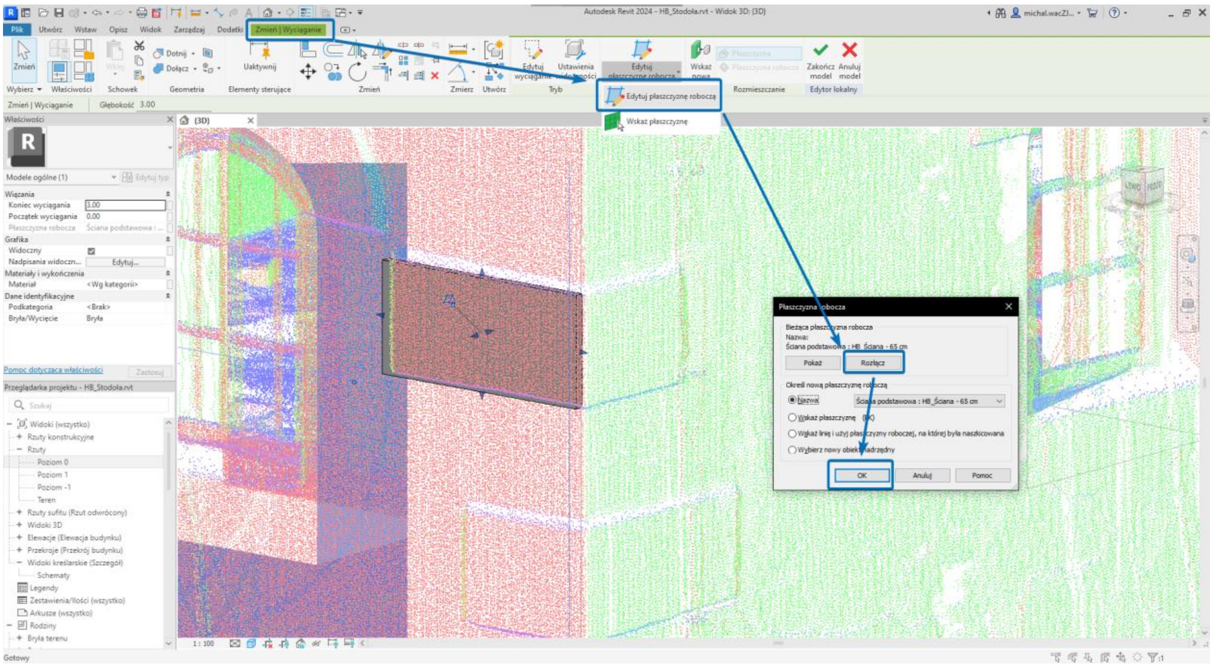


Use the Rectangle tool to draw the outline of the cornice with the required thickness and confirm.

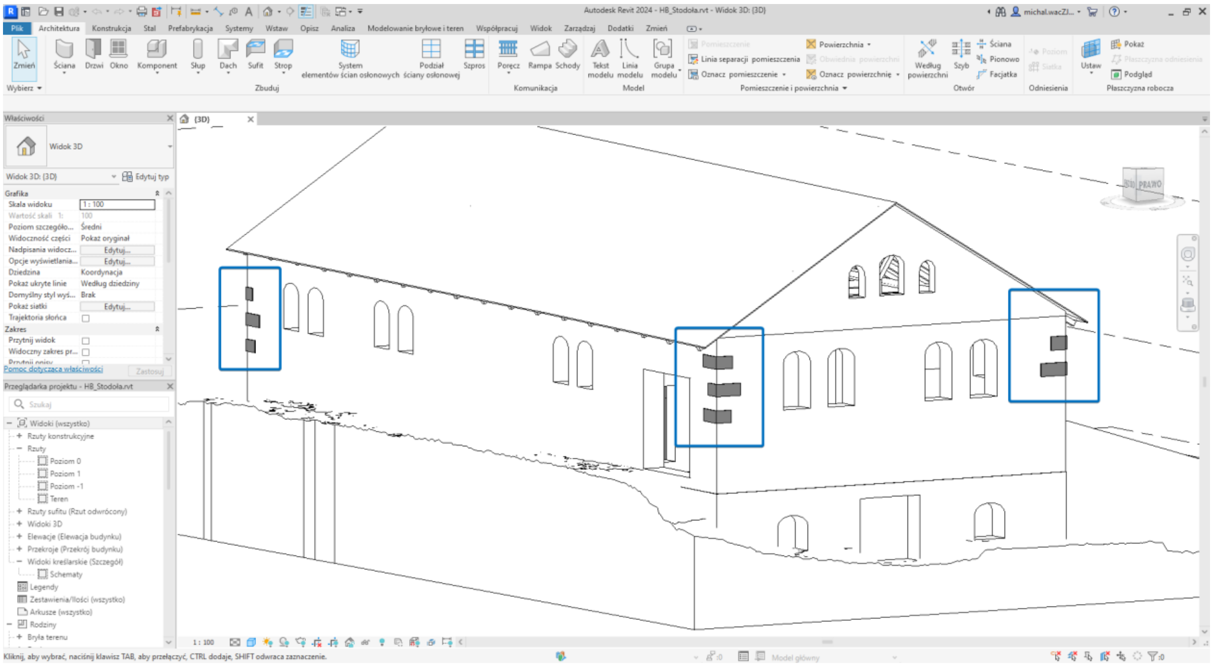


Before completing the modeling, detach the work plane from the model using:

Modify > Edit Work Plane > Detach > OK



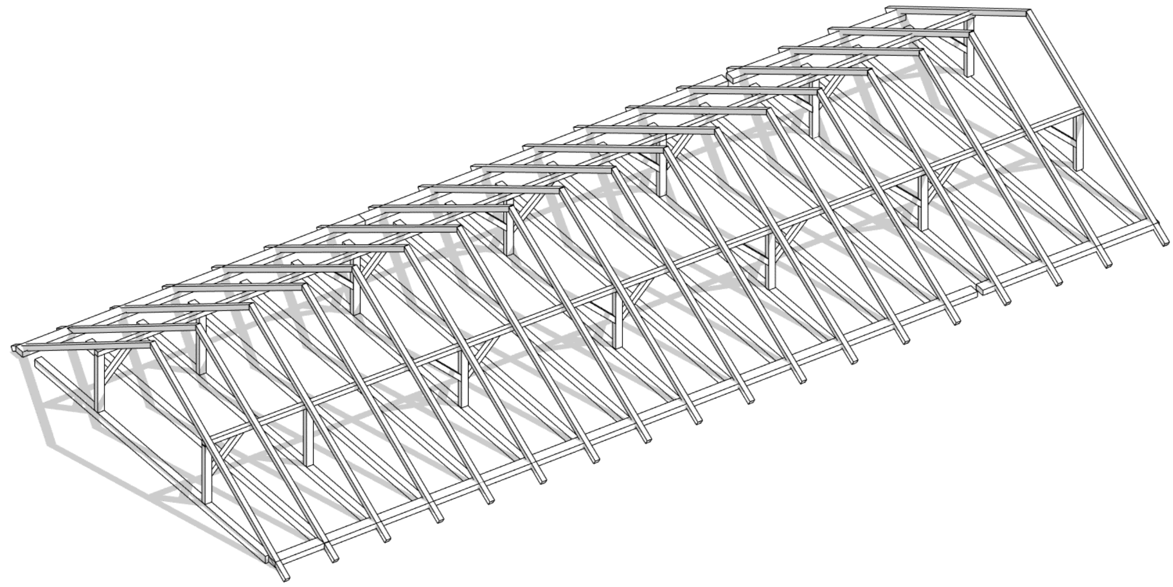
Repeat this process for all cornice elements until you achieve the desired effect and confirm the Finish Model.

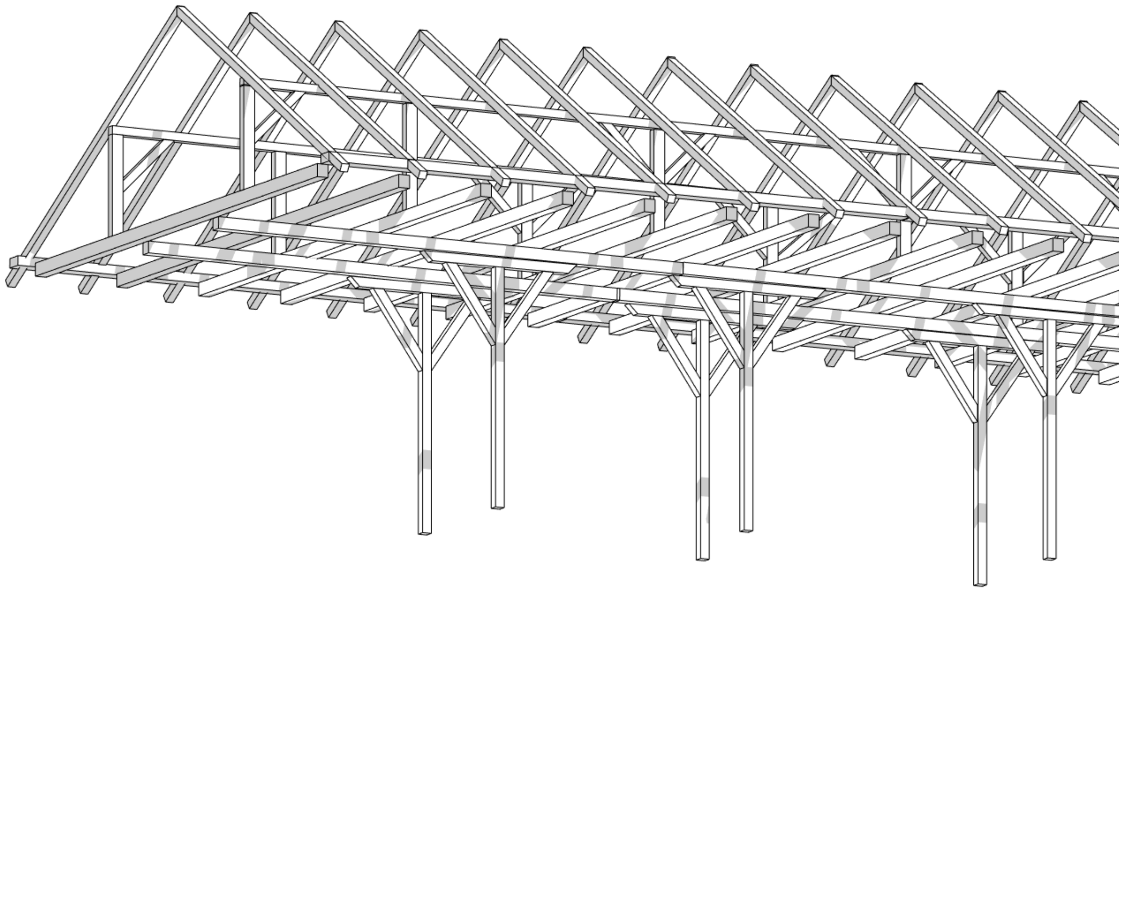


3.8. Modeling a Beam Family

Practical design work in Revit shows that it's worthwhile to create universal component families that can be used in multiple instances while maintaining their full functionality and parametric capabilities. It's important to note that a wooden structural beam can serve as a beam, column, rafter, purlin, brace, beam end, and many other wooden structural elements.

To ensure an optimal model (i.e., not containing too many families), it's advisable to create a family that is as universal as possible. In this exercise, a universal beam will be created for modeling roof trusses, structural beams, and columns:





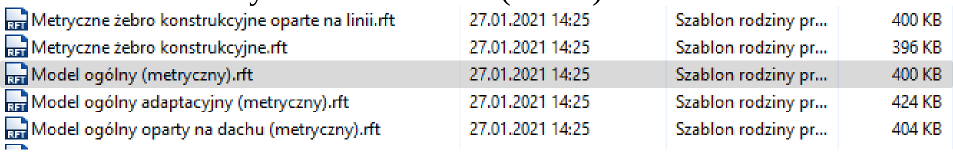
The "HB_Beam.rfa" family will consist of two families.

The first family (parent/base family) will serve as a pivot/platform capable of rotating 360 degrees.

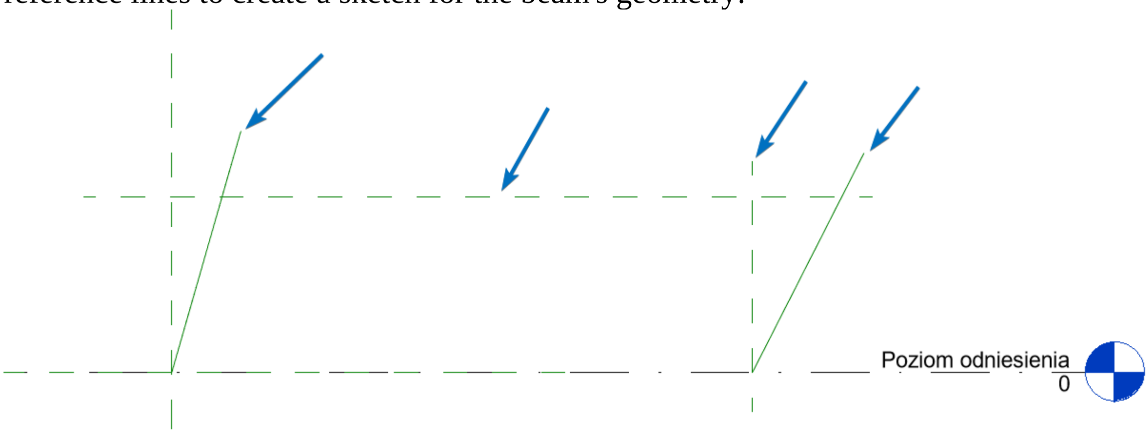
The second family (nested) will serve as the beam's geometry, capable of assuming different end profile angles and will be loaded into the parent family.

Creating the beam starts with creating the second (nested) family.

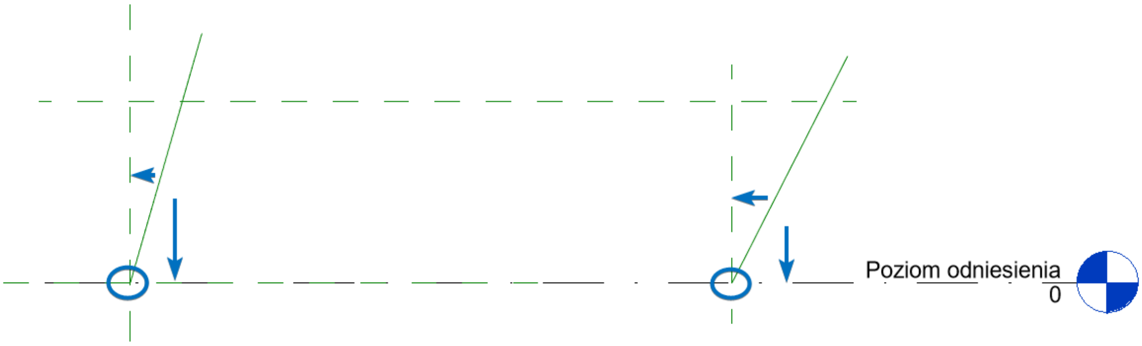
To begin, create a new family using the Generic Model (metric) template:
File > New > Family > Generic Model (metric).rfa



In the blank family, switch to the Right Elevation view and for clarity, change the view scale to 1:10, and switch the family units (UN) to centimeters. Use reference planes (RP) and reference lines to create a sketch for the beam's geometry:

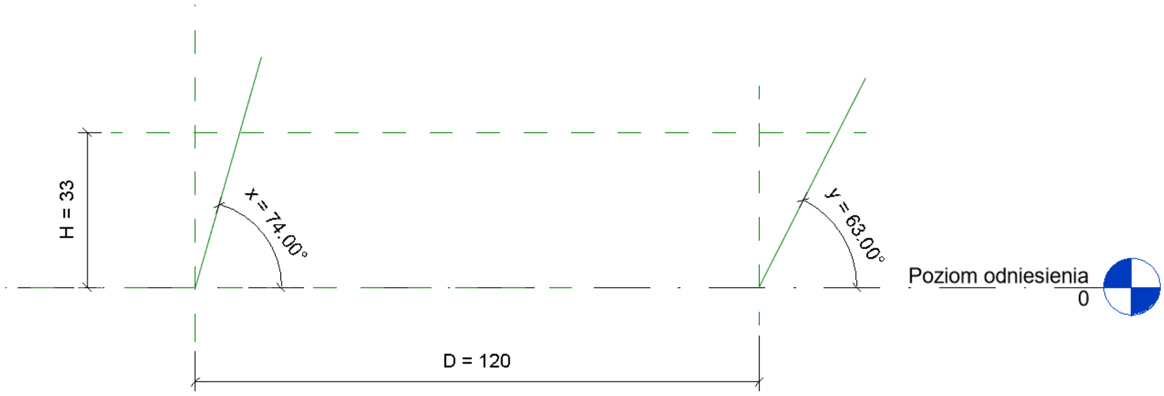


Reference lines will define the start and end of the beam. The start and end points can be set at different angles depending on the situation in the model. It's essential to align the reference lines with both reference planes using the Align (AL) tool:

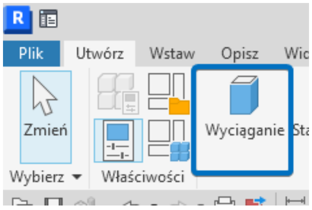


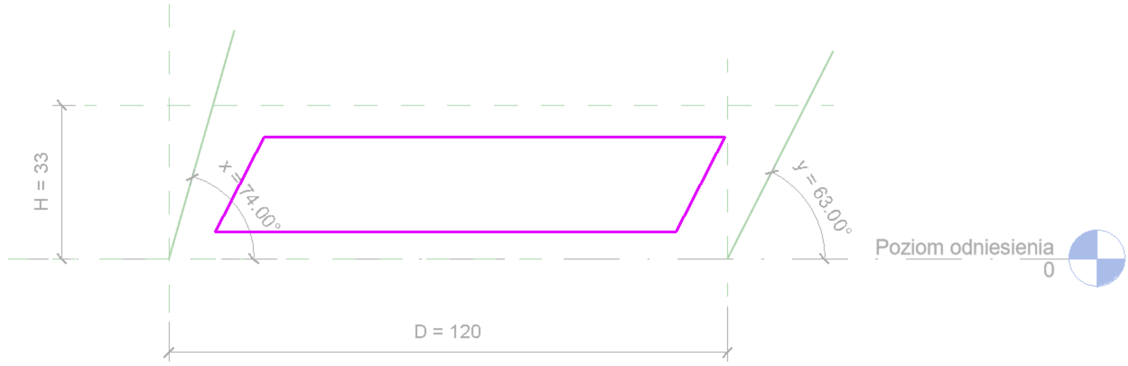
Next, you'll parametrize the family:

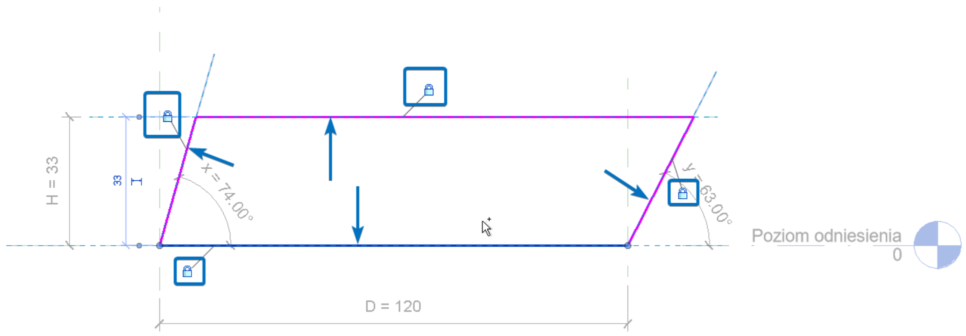
- Parameter D will control the length of the beam (excluding cuts).
- Parameter H will control the height of the beam profile.
- Parameter x will control the angle between the horizontal plane and the cutting plane at the start of the beam.
- Parameter y will control the angle between the horizontal plane and the cutting plane at the end of the beam:



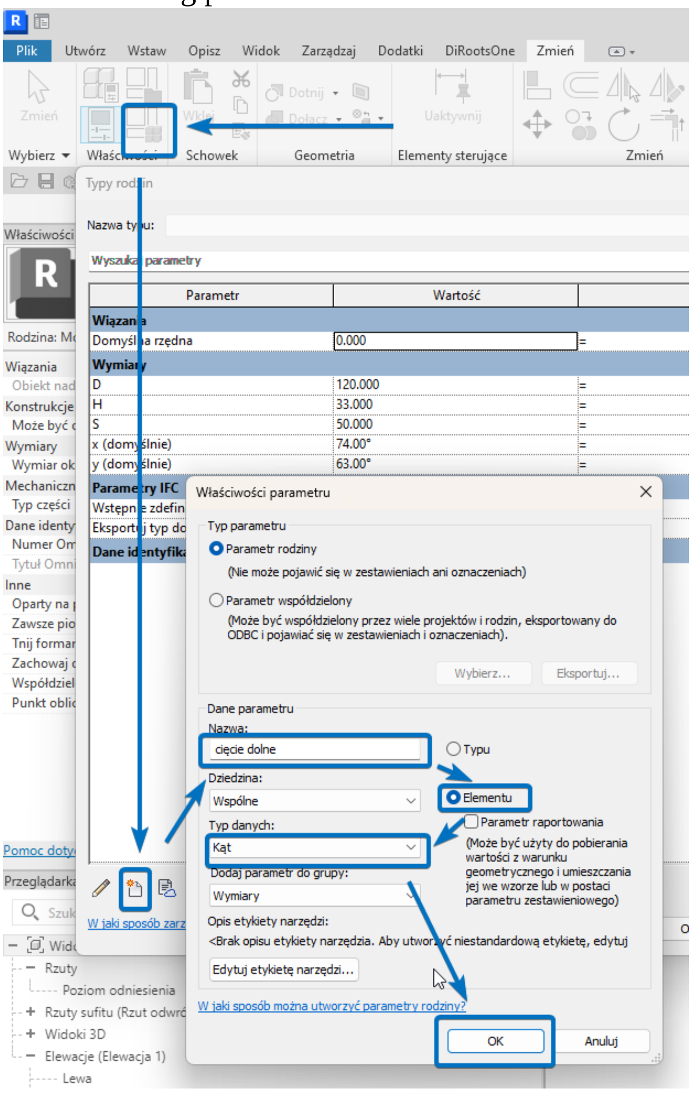
Use the Create > Extrusion tool to create a quadrilateral that matches the side view of the beam. Attach each edge to the movable reference planes and reference lines::







In the Family Types panel, add two additional controlling parameters that will reflect the actual angle of the beam's cut at its end and beginning. The parameters "x" and "y" will be controlled by controlling parameters. The controlling parameters (those used in the model during modeling) will be named "Lower Cut" and "Upper Cut.

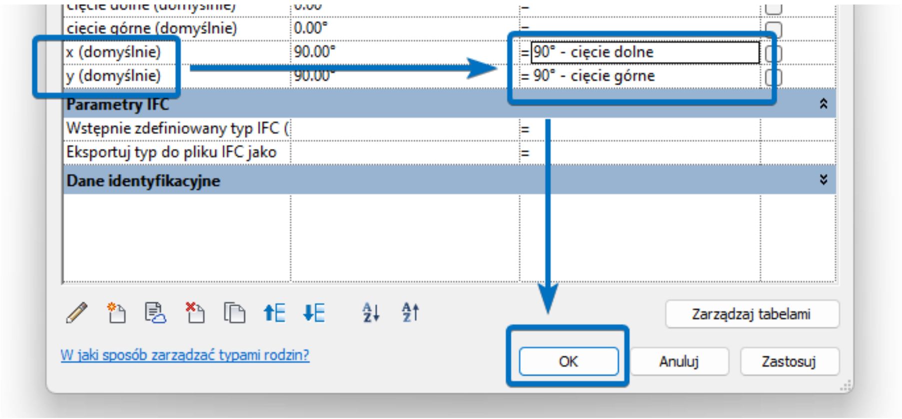


These parameters will remain in the appropriate relationships to control the actual angle of the beam cut.

The "Lower Cut" parameter will control the "x" parameter.

The "Upper Cut" parameter will control the "y" parameter.

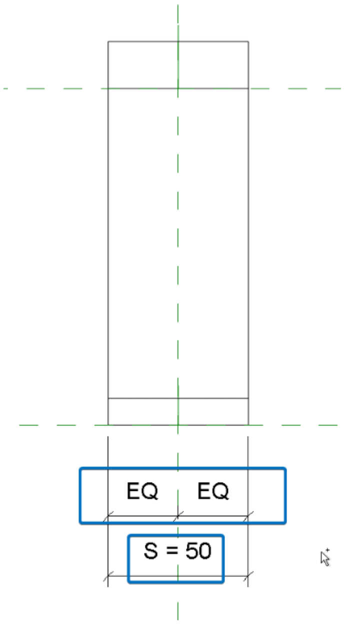
This approach will allow the cut parameters to take negative values (i.e., be cut in the opposite direction):



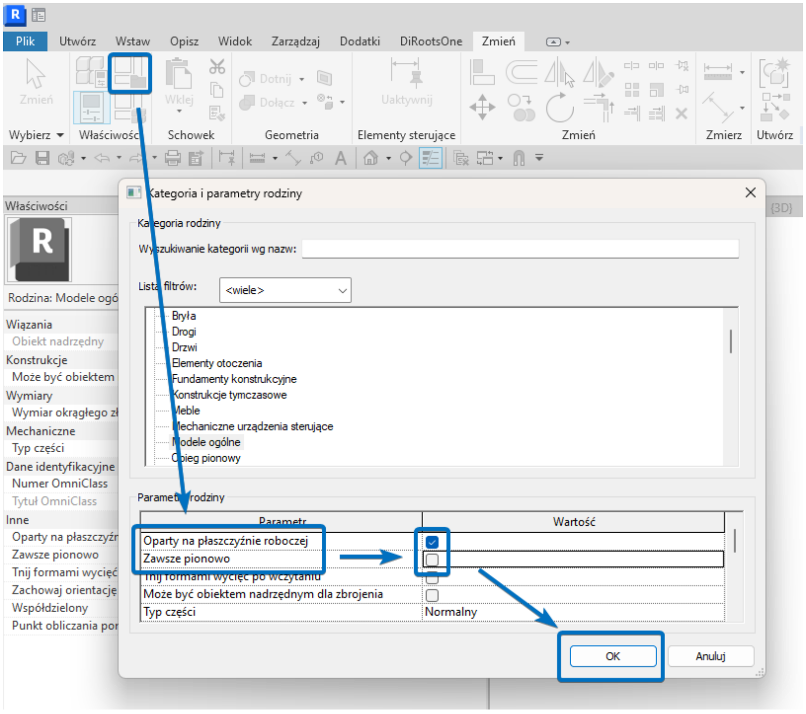
The "D," "H," and "S" parameters should be type parameters, while the rest of the parameters should be instance parameters.

Add a "Material" parameter for the beam and associate it with the beam's geometry.

Next, switch to the Reference Level view and execute the familiar Equal binding scheme, parametrize the profile symmetrically, and assign it a width "S":

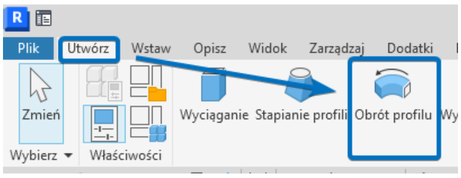


To ensure the correct behavior of the nested family within the parent family, select "Based on Work Plane" and uncheck the "Always Vertical" option in the Family Category and Parameters panel:

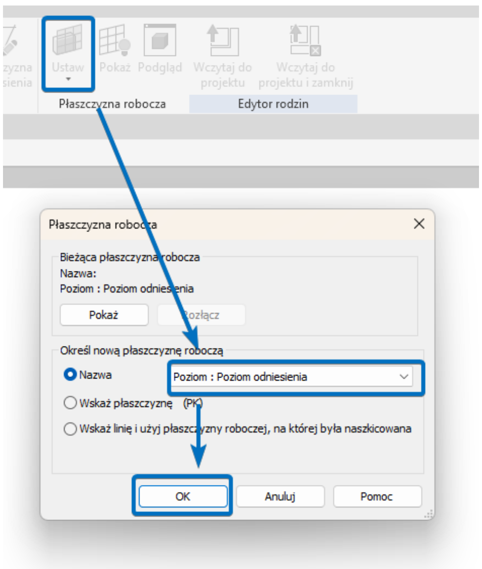


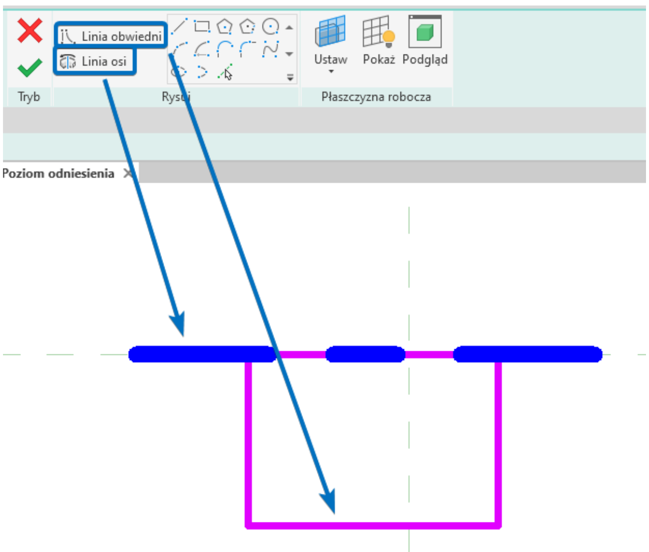
This way, the family of beam geometry with cuts is ready to be inserted into the parent family. Save the current family as "HB_Beam Geometry.rfa" and proceed to create the parent family. To do this, create a new family again using the Generic Model template.

A highly recommended practice for creating families that need to rotate 360 degrees is to use a Profile Rotation as the host. This provides a full range of rotation, which can be challenging to achieve using lines, planes, angles, extrusions, and other tools available in Revit.



It is essential to ensure that the Work Plane is set to the Reference Level. Then, to create a rotating host, simply draw any rectangle, where one side will be drawn on the horizontal Reference Plane, and the Axis Line will coincide with this side. This indicates that the rectangle is to be a profile that will rotate around the Axis Line:

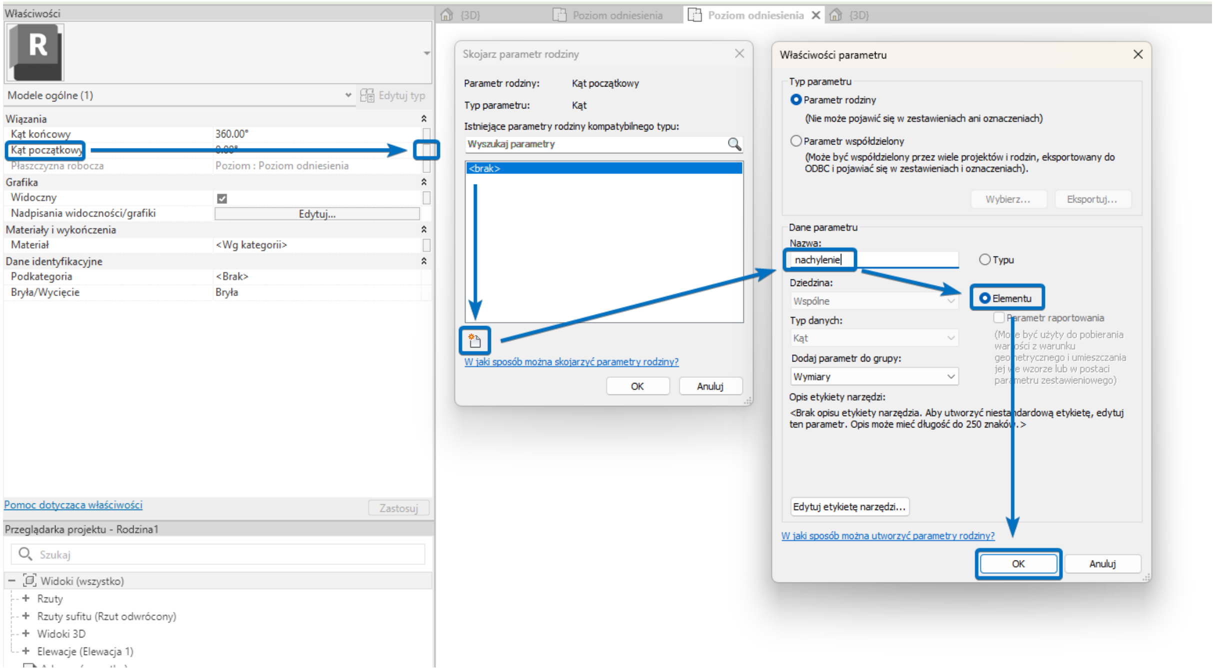




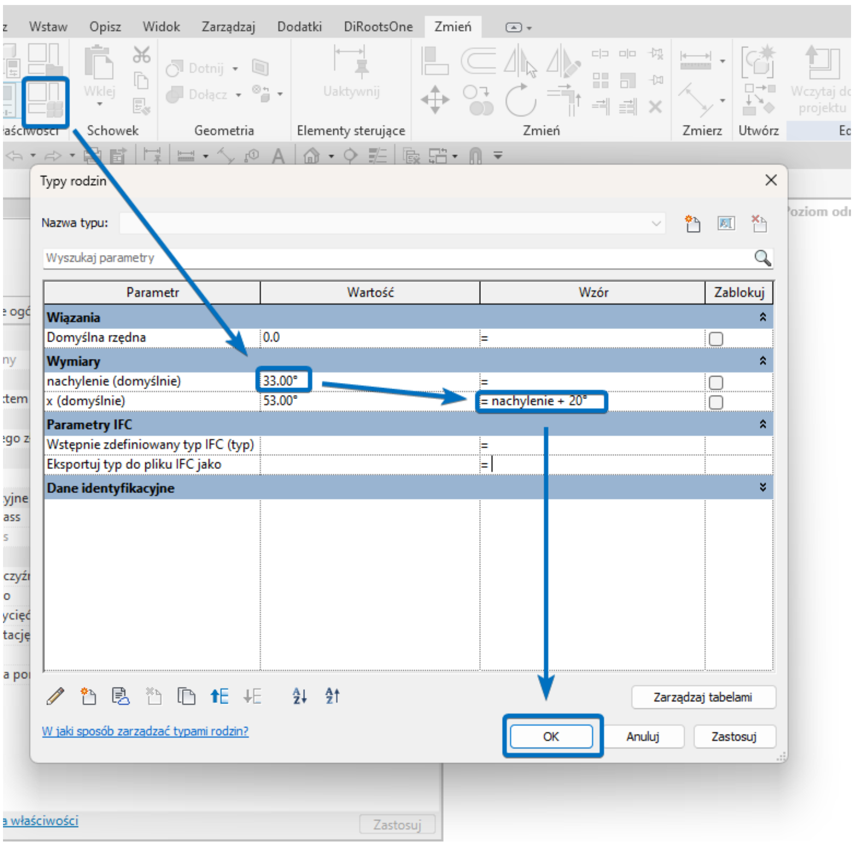
Next,

parametrize the Initial Rotation Angle and Final Rotation Angle and create parameters:

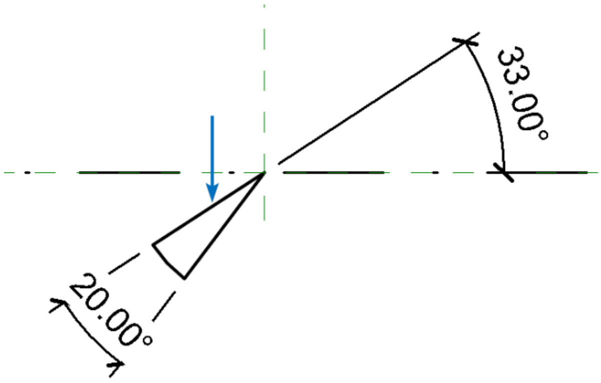
- Final Rotation Angle – will be linked to the "x" parameter,
- Initial Rotation Angle – will be linked to the "slope" parameter:



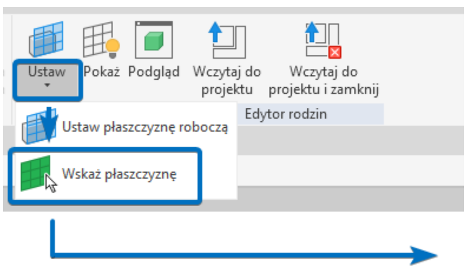
Moving to the "Change" > "Family Types" field, you should make the "x" parameter dependent on the "slope" parameter. To do this, in the Formula column for the "x" parameter, enter "slope + 20°.". It's a good practice to set the "slope" parameter to any value in the range from 1° to 89° (e.g., 33°):

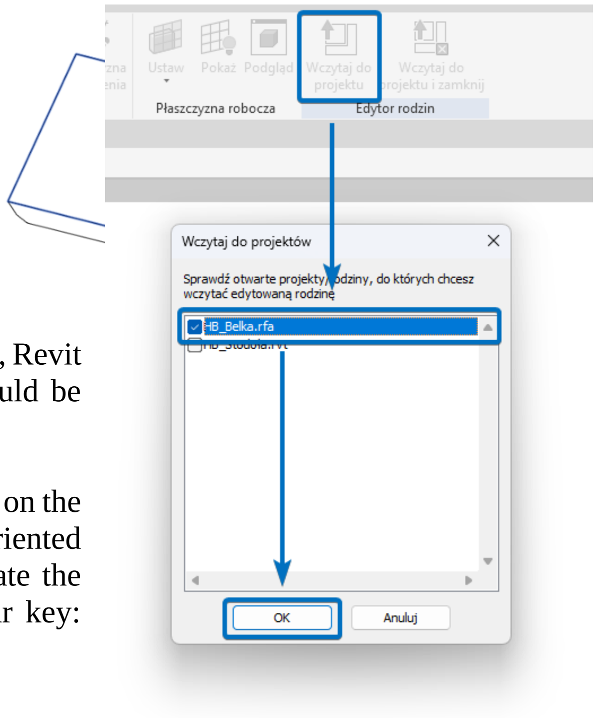


Switching to the Right Elevation view, you can observe that a kind of incomplete cylinder has been created, whose angles are controlled by the parameters. One of the cylinder's surfaces serves as a Reference Plane for rotating the beam by 360 degrees. Thanks to this, one family of beams can serve as a beam, column, sword, or rafter.



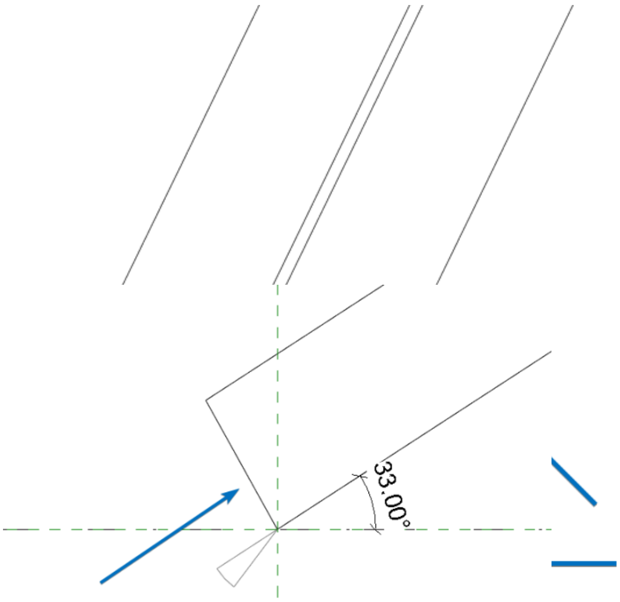
To correctly insert the "HB_Beam Geometry.rfa" family into the parent family, you must first change the Work Plane to the cylinder's surface. To do this, use the 3D view:



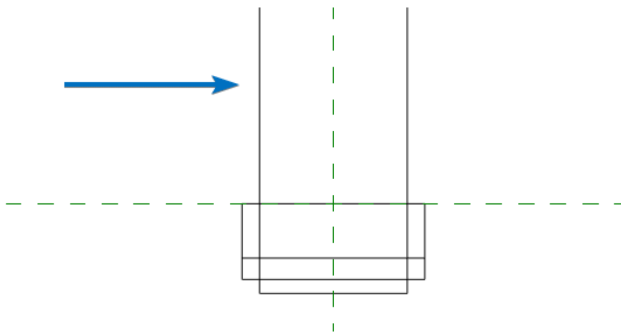


Then, by going to the "HB_Beam Geometry.rfa" family and loading it (as a nested family), Revit will prompt you to specify which file the family should be loaded into. "Create" > "Load into Project."

Next, place the "HB_Beam Geometry.rfa" family on the top surface of the cylinder in such a way that it is oriented upwards. Before clicking on the surface, you can rotate the beam 90 degrees in each direction using the spacebar key:

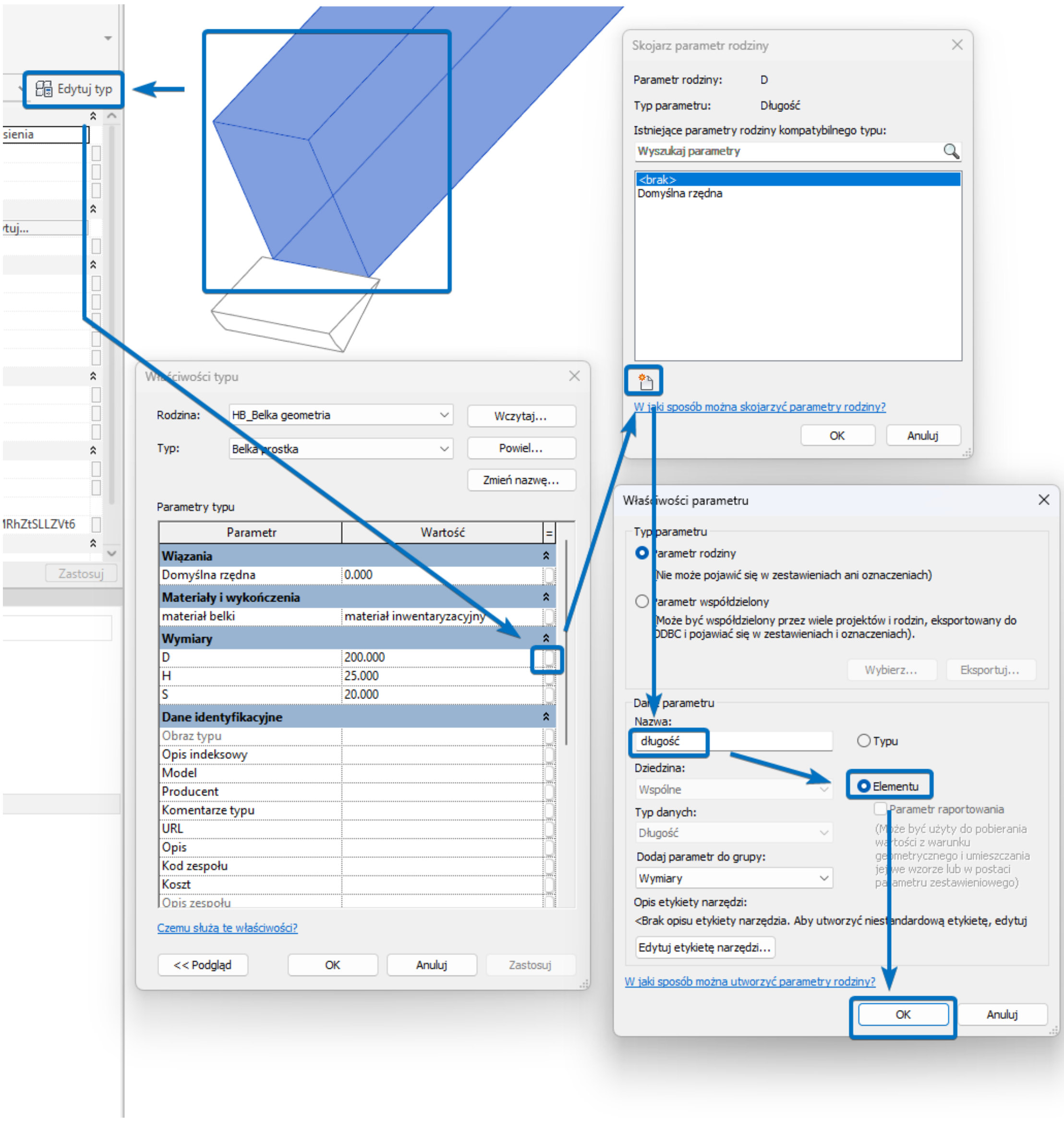


Then, in flat views (Reference Level and Elevation), align the position of the beam so that its geometry starts at the intersection of all major planes in the family. The Align (AL) tool can be used for this operation:

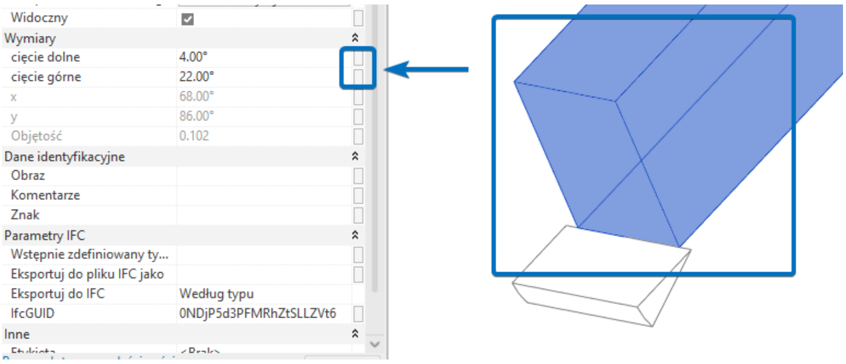


The final step in creating the beam is to assign parameters from the "HB_Beam.rfa" family to the nested family "HB_Beam Geometry.rfa." To do this, within the "HB_Beam.rfa" family, select the "HB_Beam Geometry.rfa" family, then choose "Edit Type" and assign each parameter its counterpart in the "HB_Beam.rfa" family:

- For parameter "D," create a "length" parameter - this will be the length of the beam (set it as an element parameter).
- For parameter "H," create an "H" parameter - this will be the height of the beam profile (set it as a type parameter).
- For parameter "S," create an "S" parameter - this will be the width of the beam profile (set it as a type parameter).

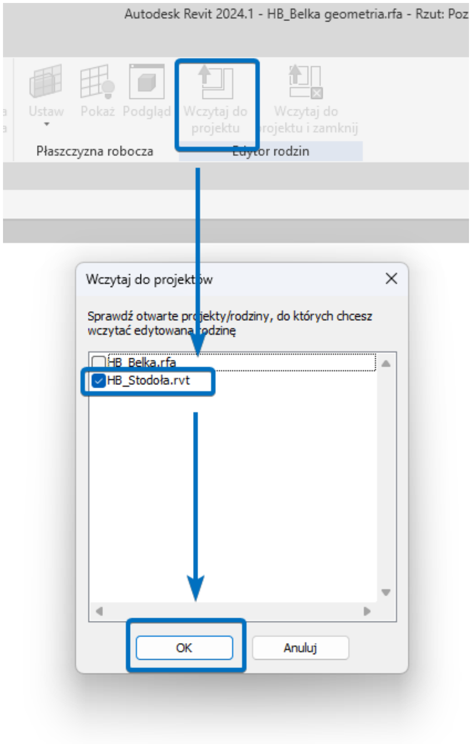


Similarly, proceed with the element parameters in the nested family "HB_Beam Geometry.rfa":



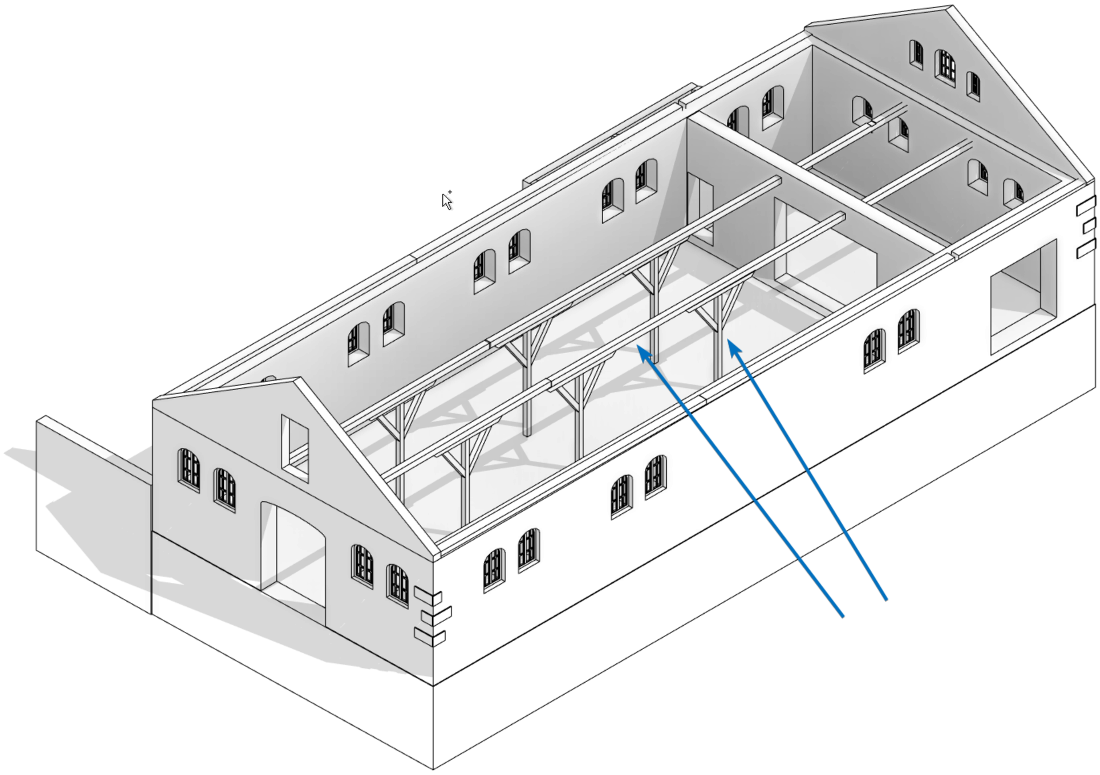
For the "Lower Cut" parameter, create a "Lower Cut" parameter - this will be the angle of the bottom cut of the beam (set it as an element parameter).
For the "Upper Cut" parameter, create an "Upper Cut" parameter - this will be the angle of the top cut of the beam (set it as an element parameter).

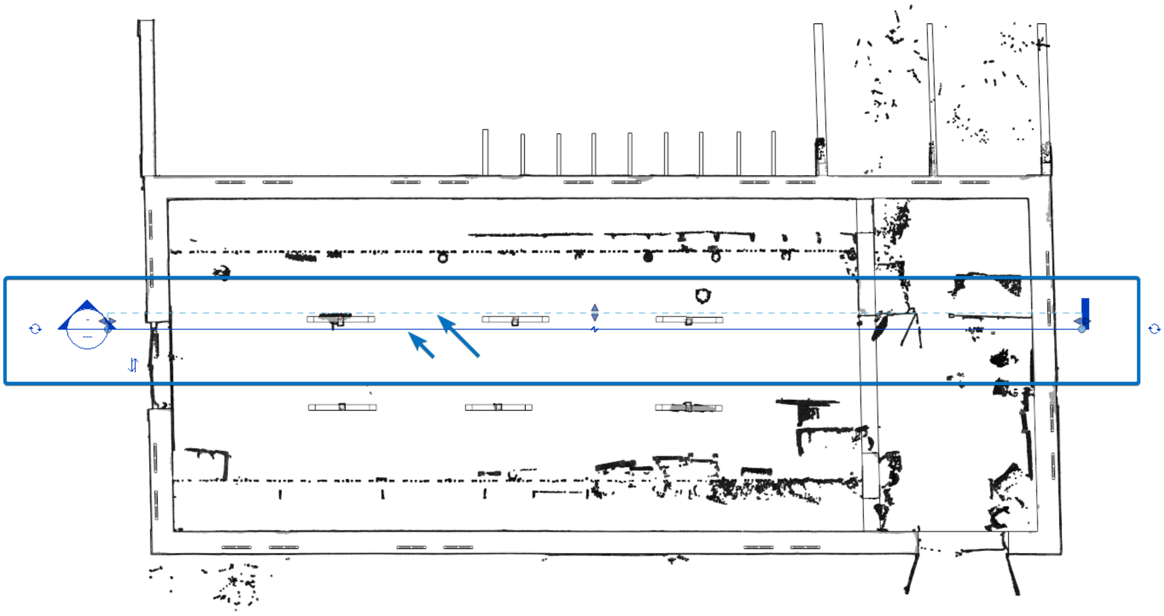
The family is now ready for loading and modeling in the Point Cloud in the "HB_Tenement" file.



3.9. Modeling Roof Trusses, Beams, and Columns

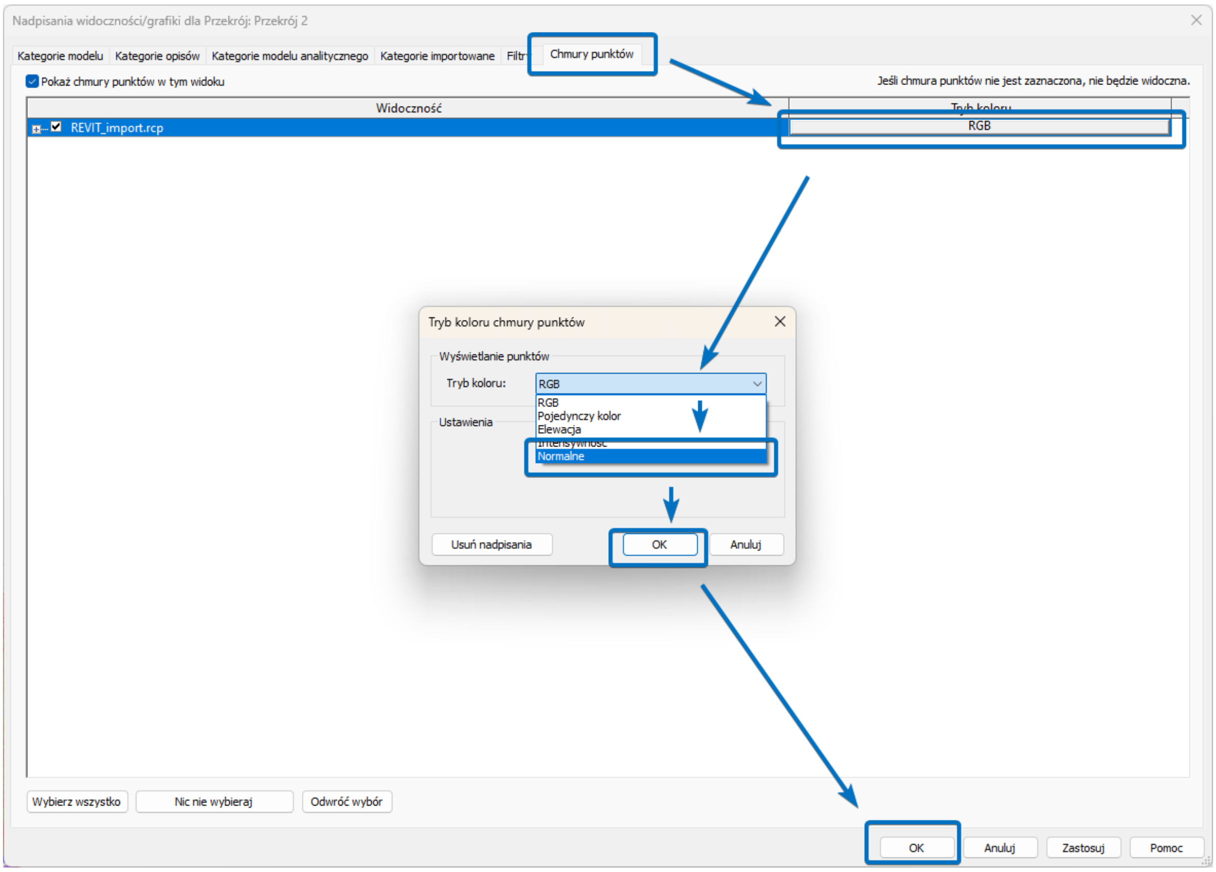
This chapter will outline the principles of modeling roof trusses, beams, and columns using the previously created family "HB_Beam.rfa." To begin, model rows of columns, beams, and swords on Level 0. It is best to use multiple sections and a 3D view simultaneously. On Level 0, create a section that shows one of the trusses, and then model it using the "HB_Beam.rfa" family, using its parameters:



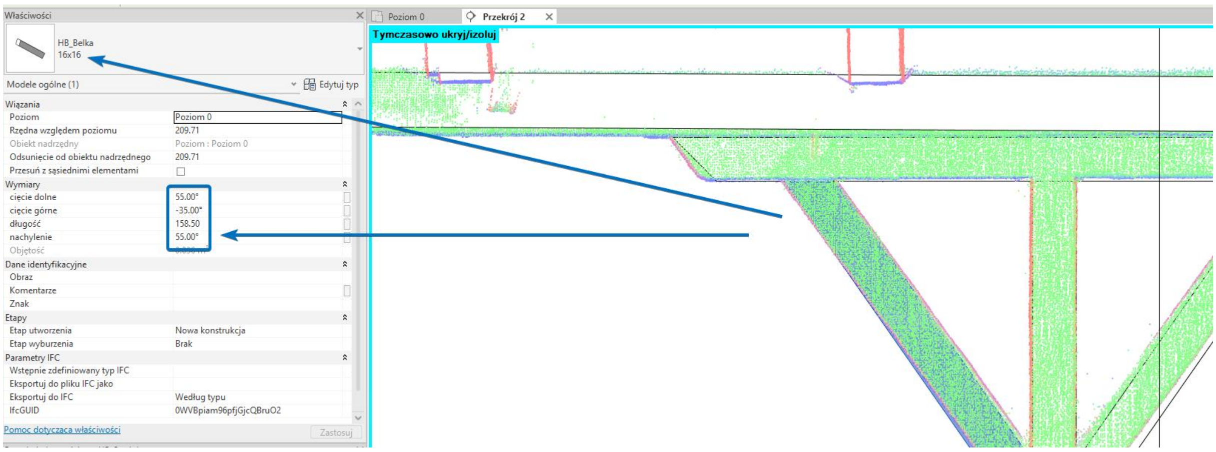


Next, in the section view, change the display mode of the Point Cloud from RGB to Normal. This improves the clarity of the Point Cloud.

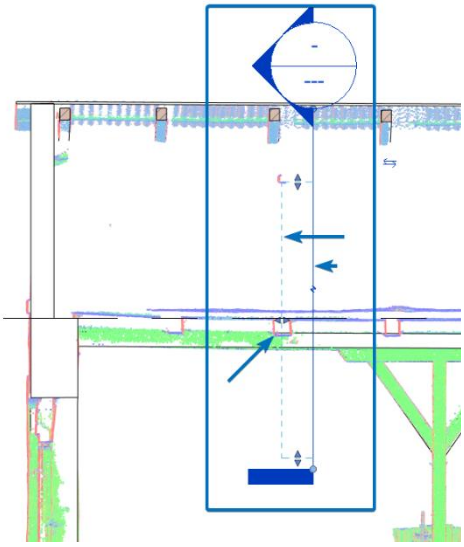
Override Graphics (VG) > Point Clouds > RGB > Normal:



It is a good practice to insert the loaded "HB_Beam.rfa" family on the plan view (Level 0) and then modify its position and parameters in the section. To insert the previously loaded family categorized as "Generic Models," go to Architecture > Component and select the "HB_Beam.rfa" family from the properties list. Then examine the profile of the modeled column/beam/sword and create a new Family Type that reflects the real cross-section profile (e.g., the sword profile is approximately 16x16 cm). For each different beam dimension, create a separate family type and name it correctly. Then, using the element parameters of the "HB_Beam.rfa" family, adjust it to match the Point Cloud:

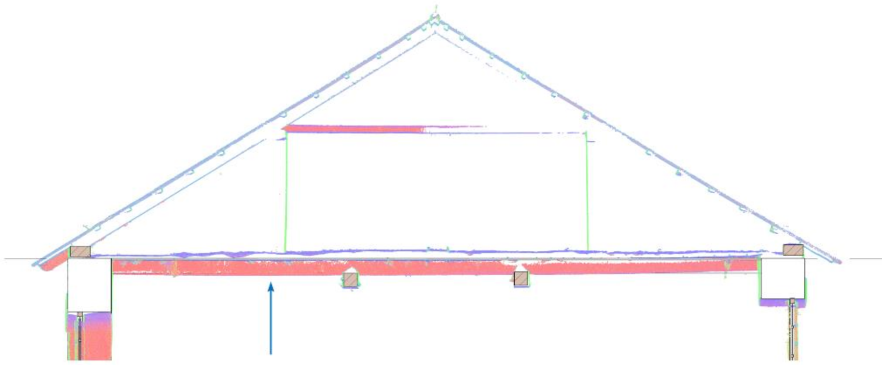


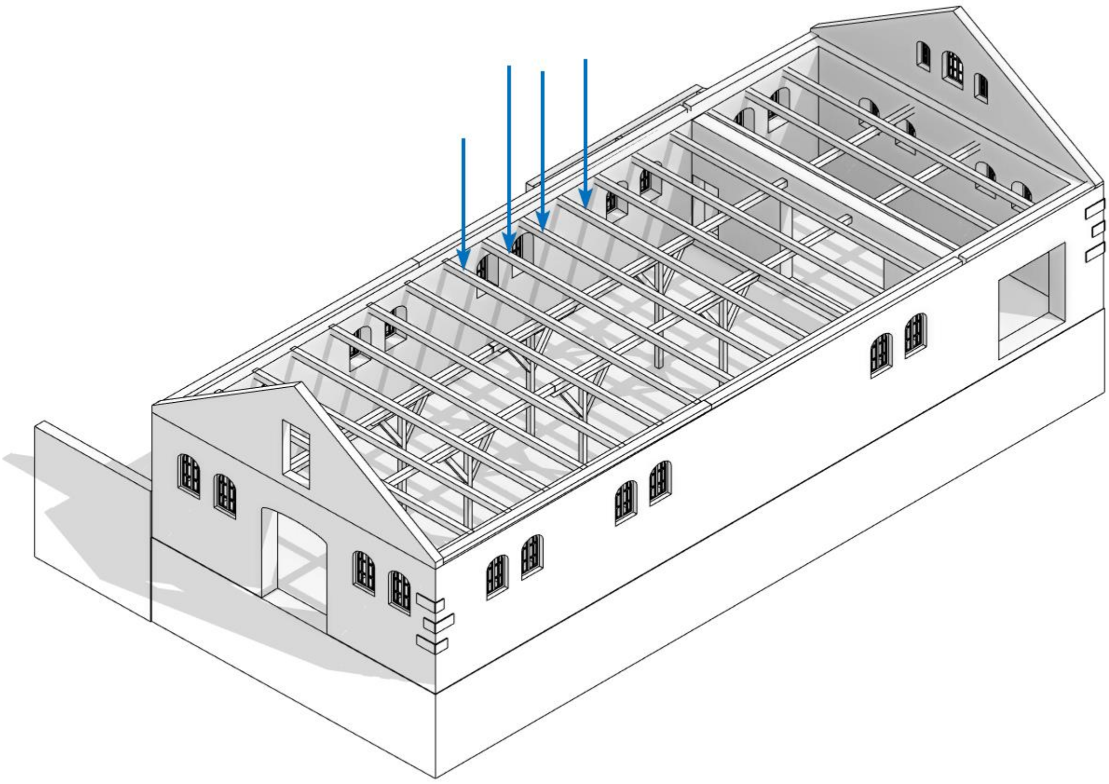
Similarly, you should proceed with modeling the floor beams. For this purpose, it's best to use a cross-section of the building.



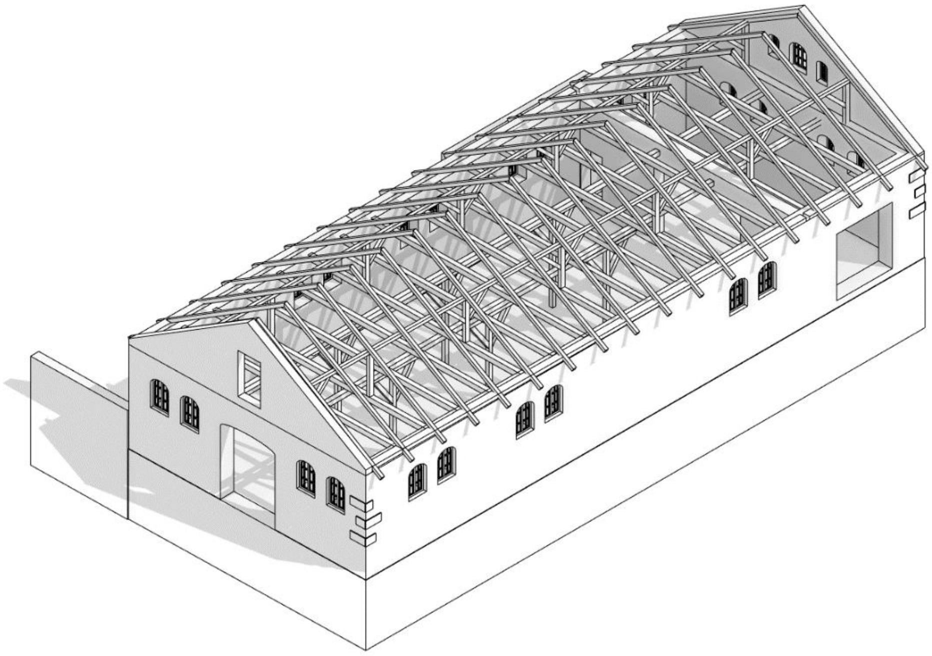
During the modeling of each element, special attention should be paid to the fact that in historic buildings, in most cases, elements are neither orthogonal nor parallel to each other. Therefore, during modeling in the cross-section, it may turn out that a beam is in its position in one direction but not in the other.

While modeling, it's often necessary to change views, from plan to cross-section, from cross-section to perpendicular cross-section, adjust the view range in the plan, and frequently switch to a 3D view to ensure that each modeled element is in accordance with reality.

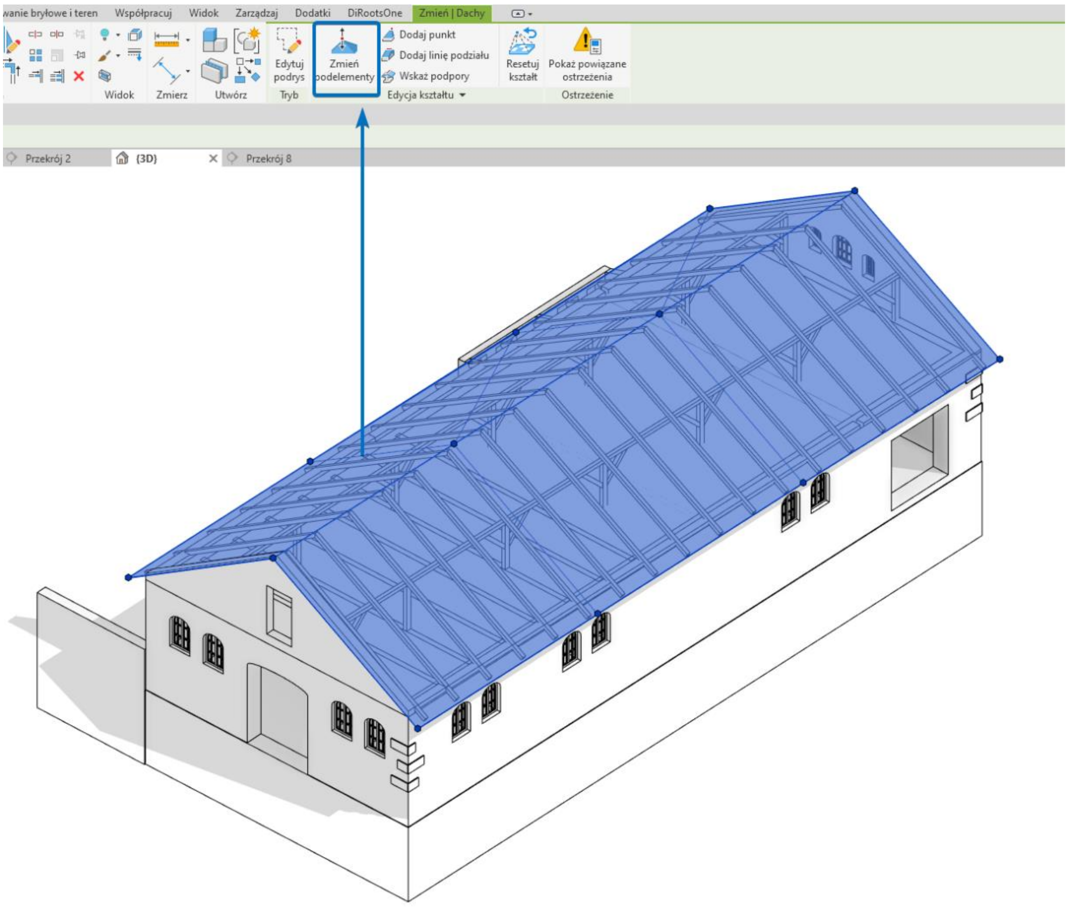




When modeling the layout of roof trusses along with the attachment points and swords, the same rules apply as in the case of modeling columns and beams.



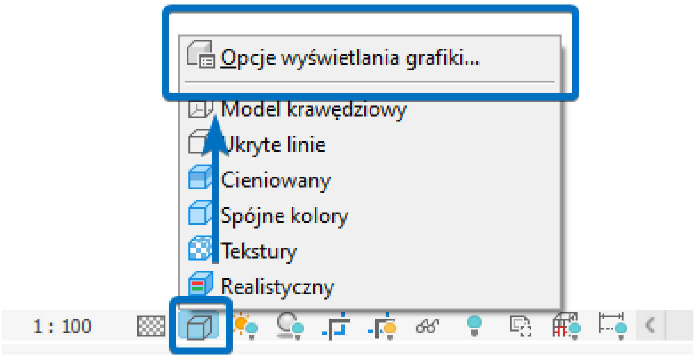
To model the roof, use the Roof tool but operate it as you would with the Floor tool (i.e., use the Change Subelements option) to adjust the roof's curvature to match the Point Cloud



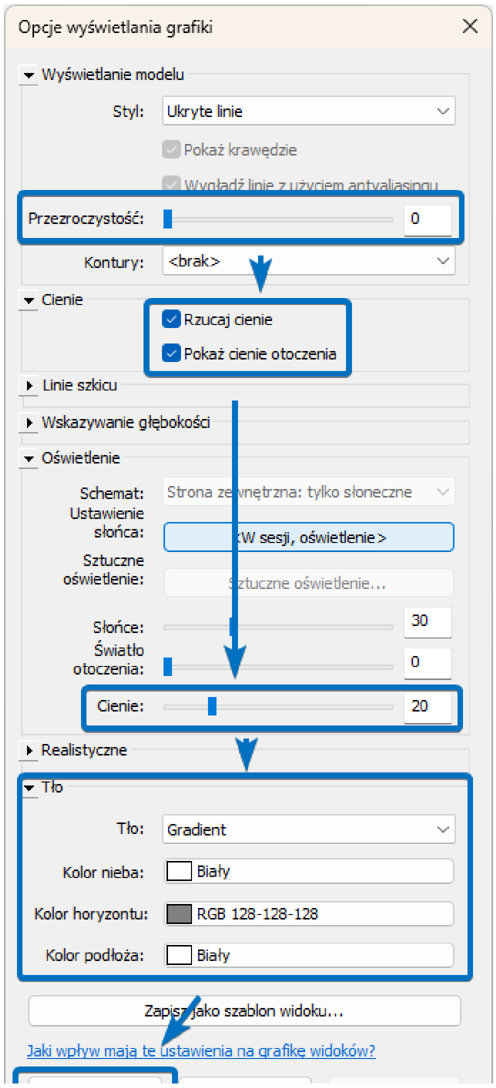
3.10. Creating an Example Sheet

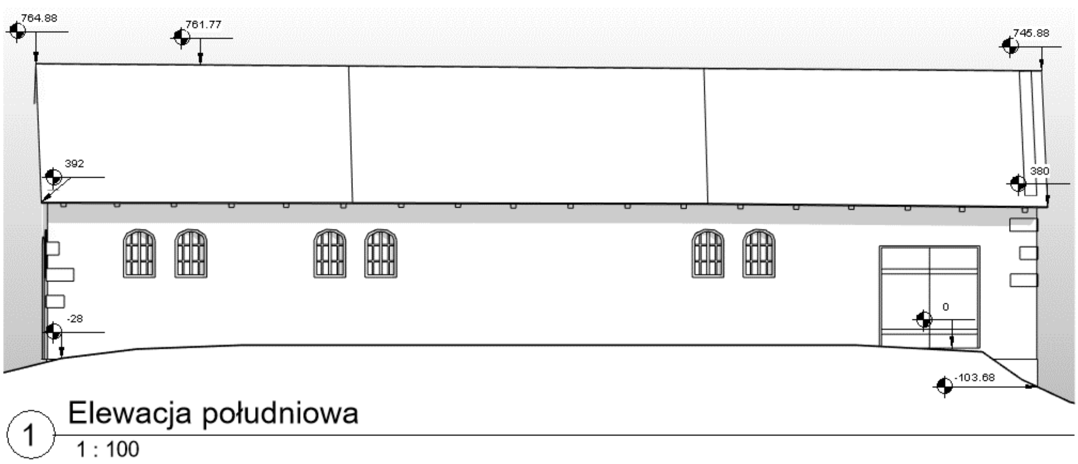
In this exercise, we will create a South Elevation Sheet. To begin creating the sheet, navigate to Project Browser > Sheets > New Sheet and choose Metric A1 or another sheet size prepared by you or compliant with institutional standards.

To ensure that the view on the sheet looks aesthetically pleasing, you should:



- Turn off model transparency if it was previously enabled for modeling purposes.
- Enable shadows, ambient shadows, and set the brightness to a lower value than the default (e.g., 15-20).
- Set a gradient background with appropriate colors.
- Disable the Thin Lines (TL) option.
- Outline the Ground Line with a <Wide Lines> detail line, then edit the view's crop region to align with the ground line.
- Hide the Sections and Levels category.
- Add system or custom elevation markers.
- Include necessary elevation descriptions.





Didactic material - inventory patterns of selected types of monuments

Developed within project

Heritage BIM - enhancing digital competences of students of Architecture

Co-funded by the Erasmus+ Programme of the European Union

Key Action 2: Strategic Partnership Projects

Contract nº 2020-1-PL01-KA203-081942