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# DIGITAL SURVEY OF THE LATE 1960'S VILLA IN USTROŃ: CREATING A VIRTUAL MODEL OF A HERITAGE SITE OF POLISH POST-WAR MODERNIST ARCHITECTURE

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#### Abstract

The paper undertakes the topic of architectural heritage of post-war modernism in Poland. Beside the typical single-family housing solutions from the second half of  $20^{\text{th}}$  century (the so-called "Polish cube") it is possible to point out some examples of houses designed according to the world's leading design tendencies of that time. Those buildings were established on individual requests of the social elites including scientists, directors and government officials. One of such objects is a modernist villa from the 1960s located in Ustroń – a popular resort at the foot of the Beskid Mountains and built for General Jerzy Ziętek. There is a lack of its accurate, systematic documentation, which would become a basis for a conservation project. Here, we demonstrate a response to this problem which results in the development of a precise inventory documentation and representation of the investigated object, which is a valuable heritage of post-war modernism architecture. Methodology presented in this paper is based on combination of digital tools such as UAV photogrammetry and HBIM modelling and by adding a rich database obtained through thorough research.

Keywords: Architectural survey; Cultural heritage, HBIM, Modernist architecture, Photogrammetry, Single-family housing, UAV.

#### **1. INTRODUCTION**

The architectural heritage of the second half of 20<sup>th</sup> century has become an object of interest among researchers around the world, especially in the countries of the former Eastern Bloc. In the studies on the Polish architecture of the second half of the twentieth century an important issue is residential architecture. After analysing the literature and the research results published so far, one may notice that the researchers' interest has so far focused mainly on state and cooperative investments from 1945–1989: large-scale urban assumptions and housing complexes, both multifamily

and single-family in a compact layout. On the other hand, the issue of individual housing, built in that scope of time by private investors, has been almost completely neglected.

In the popular consciousness, single-family houses built during the communist era in Poland are not classified as original and valuable heritage. However, the preliminary field studies allowed observing that in the given period the phenomenon of single-family houses construction took on two main forms. Alongside typical, repeatable houses being built on basis of projects from catalogue sets (the so-called "Polish cube"), some single-family houses were designed according to the world's leading design tendencies of post-war modernist architecture, distinguishing themselves from the typical housing solutions. Those houses were designed and constructed on individual request of the social elites of that time like leading scientists, doctors, directors and government dignitaries.

Since the end of the 1980s, a gradual and uncontrolled process of changes has been taking place, involving alterations, changes of façade or even demolition of single-family buildings built in the time of the previous regime. The process of transformation and demolition continues, as the awareness of the value of the architectural heritage of post-war modernism is still very low. The coming years will decide whether they will disappear irretrievably or whether they will be respected as a valuable heritage providing an image of the creative potential of architects from the second half of the 20<sup>th</sup> century.

The object chosen for the following research is a modernist villa from the 1960s located in Ustroń which is a popular resort at the foot of the Beskid Mountains in Silesian Voivodeship. The representative object was built for the Silesian Voivode, General Jerzy Ziętek. It served him as both his private home and official residence until his death in 1985.

Since the late 1980s, the building has been owned by the Association of Polish Architects (pol. SARP) and now serves as the House of Creative Work. While the deteriorating technical condition of the villa over the years has necessitated discussions on possible directions for its protection and conservation, a noticeable lack of satisfactory source materials became a major problem. The collection of the data resource will provide a starting point for detailed conservation research and for the formulation of guidelines for the protection of the examined precious heritage of modernist architecture.

A survey is the most popular and at the same time most basic form of protection of architectural monuments. It is also the first step to any other further types of protection. Systematically done survey can also help with monitoring the state and the scale of any possible damages, and in case of single-family housing from the second half of 20<sup>th</sup> century can be a great preventive tool [1]. It may lead to organizing the knowledge in the extensive matter not only about current state but also help with suggestions for future restorations. Such preventive actions may be carried out in situ in the first stage of research and also virtually in the post production with the help of various computer techniques. [2].

#### 2. STATE OF ART

Before the political transformation of the country in 1989 only a few scientific publications tackling the topic of architecture of the second half of the 20<sup>th</sup> century were published. Series of monographs by Tadeusz Przemysław Szafer showing the work of Polish architects between 1966 and 1980 are one of the examples [3, 4, 5]. In the chapters about the development of residential environment and housing the author has given a few examples of individually designed single-family houses, some of them realised in Silesia.

The first years after political transformation brought practically no study interest of Polish scientists and historians in the heritage of the People's Republic of Poland (PRP). The first attempt to deal with the heritage of the past regime was made in 1994 by Adam Miłobędzki. He proposed the term of "Socialist Modernism" [6]. In 2001 Andrzej Basista published a book in which he presented a synthesis of the housing sector functioning during PRP regime [7]. In the following years a lot of local publications about post-war modernist architecture were published [8, 9, 10]. The mentioned publications constitute a great contribution to the Polish post-war modernist architecture heritage. However, the authors have concentrated mainly on the great state investments, whereas the issue of private houses designed on the individual investor's request was neglected. A limited number of post-war private single-family houses are presented in edition "Great Villas of Poland" [11].

When it comes to using digital tools in the process of protection of monuments there were many papers published about the comparison and integrations between different techniques, especially terrestrial laser scanning and digital photogrammetry [12, 13]. In 2013 Murphy and Pavia have notices that using HBIM can benefit greatly the field of conservation studies. Moreover, Oreni et al. Bruno and Roncella in 2018 presented capied out a research where they proved that it can be also very useful tool in more coordinated management and increases efficiency. Described techniques may lead to a great precision but often are highly money and time consuming and therefore there is a room for improvement [14].

The topic of modernist architecture seems to be neglected and there are very few publications treating about the protection with the use of digital tools applied to those monuments. One of the very few examples is a research on importance and treatment of Brazilian and Indian Cultural Heritage [15]. Both are representation of integration of 3D laser scanning and photographic survey with very high-quality outcome. The importance of preservation of modernist architecture is highlighted by Akin and Gursel Dino where they show the process of creating a digital twin for the Middle East Technical University Faculty of Architecture building [16]. The lack of Polish research and publications covering this issue is visible. To the contrary, during the same period of nearly thirty years, all around the world the studies that cover the issue of conservation and protection of modernist single-family houses and villas have been conducted. Today these buildings are under the risk of irreversible alteration, demolition or destruction and as a result there is an increased need for architectural conservation initiatives targeting Modernist

heritage. It is a very rare example to deal with a very good quality and state of preservation of the examples and we should embrace that opportunity. Therefore the innovation of the paper lays mostly in the choice of case study and providing a virtual model for the heritage site contributing to the initiation of conservation activities of the modernist heritage of individual single-family houses.

# **3. CASE STUDY**

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The villa of General Jerzy Ziętek in Ustroń was chosen as an example of a modernist single-family house from the second half of the 20th century to be examined with the digital tools in the following research. [Fig. 1] It was designed in 1966 by two prominent architects: Henryk Buszko (1924–2015) and Aleksander Franta (1925–2019). The villa is located in the center of the Ustroń resort and together with the neighboring villa of Edward Gierek (the former First Secretary of the Communist Party of Poland) it creates a complex of prominent single-family houses built for the dignitaries of that time, hidden in the greenery. The complex structure of the examined building consists of several cuboidal solids, with representative and private rooms arranged on three levels.

## 4. METHODS

The purpose of this research is creating a preliminary data set for an object with practical use for further conservation tasks and collection of future survey data. The research began with a literature analysis and the condition of the archival drawings of the building. The building has only one documentation made by Professor J. Pallado in 1988. Next step was to measure the site and the building.

The challenge to the in situ survey of this particular object lays in the presence of natural obstacles (mostly trees). They grow close to the building (in some parts even approximately 2 m from the elevation) being a source of shadow on the building and covering some parts completely. The low greenery is irregular and hinders access to the building. For the precise data model, we decided on combination of terrestrial and UAV photogrammetric method [Fig. 2]. Digital photogrammetry has a great advantage of the rapid survey acquisition using no too expensive instrumentation. Due to the fact that the flight was performed in an urban development in the vicinity of single-family houses, which constitute the city center, the flights were performed in accordance with the national NSTS-01 scenario. In accordance with the regulations, they were performed by a certified UAV pilot wearing a reflective vest, safety and emergency procedures, and the flights were recorded in the Droneradar application. To ensure the highest quality of the model, the flights were performed around midday. The flights were pre-planned to ensure the highest level of safety and to increase the speed and efficiency of the field work, covering an area of approximately  $47 \times 48$  meters [17].



UAV photography showing the location of the General Jerzy Ziętek's Villa in Ustroń. Source: Elaborated by the authors



Figure 2.





Diagram of the workflow for preliminary research. Source: Elaborated by the authors

The obtained models were then combined with an HBIM approach. The planned result was to get not only three dimensional model but also full conservation documentation containing plans, elevations and sections [Fig.3]. Important factor leading to HBIM choice was the possibility of defining a level of detail depending on needs and flexible workspace. We have assumed that the required LOD (Level of detail) for this object is 300 with additional data about materials. This level of knowledge should allow representing the geometry, the proper orientation of the model and together with other materials it should allow to create disciplinary diagnosis and start the advanced research. It seems to be simplified enough not to be time consuming and yet still allow showing interesting textures and unique details for such building. The model is supposed to act as a digital twin of the building which can be constantly updated according to the needs [18, 19].

For the full comprehension of the object a fusion of techniques was necessary. Chosen data acquisition methodology contains of:

- Photographic documentation of the object
- Analysis of existing drawings

- Macroscoping analysis of degradations
- UAV photography and photogrammetry
- Terrestrial photogrammetry with on point stations
- Data fusion for creating a HBIM model.

#### 5. MATERIALS [20, 21]

#### 5.1. UAV Photogrammetry and photography

To complete first part of the research we used drone photography and photogrammetric method. The model is DJI Mavic 2 Pro equipped with f/2.8-f/11 aperture and a 4K: 3840 × 2160 24/25/30p camera with colour mode Dlog-M (10bit), support HDR video (HLG 10bit). In the next step we created a photogrammetric model. We used PIX4D to collect pictures of the object with double grid mission, 80% overlap and a camera 80-degree angle combined with circular mission with 4-degree angle. In 23 min we collected 259 pictures of the object all at the altitude of 40 m. The obtained pictures were imported to Agisoft Photoscan software and automatically transformed into photogrammetric 3D model. The resulted Dense Cloud has 11 225 374 points [Fig. 4].



Figure 4.

Photogrammetric model View of Tie Points and Dense Cloud. Source: Elaborated by the authors

Because of a big amount of greenery around the object it was not possible to photograph all the details from drone but it let us see the state of roof, equipment and create a partial point cloud. Due to that fact, the quality and the completion of the model were not satisfactory. At this step we knew it was going to be necessary to expand our model by a point cloud created in another low-cost method such as photos from Ground Control Stations.

#### 5.2. Terrestrial photogrammetry and photography

Considering the low accessibility to the area an onground photography was implemented. Equipped with Nikon D5300 camera with 18-140 mm F3.5-5.6 lense we have planned Ground Control Stations around the object. The photos were taken with 70%overlap with a 90-degree angle towards the building. They were merged again in Agisoft Photoscan being a second Chunk to complete UAV photogrammetric model resulting in fully comprehended 3D representation of the villa.



UAV model and combination of UAV and terrestrial point cloud. Source: Elaborated by the authors

# **5.3.** Combination of UAV and terrestrial photogrammetry

The UAV point cloud became the base for the whole model because it had the best accuracy and represented the largest extension. The terrestrial point cloud was fitted in to this one. They were altered by manual finding of corresponding points and placing them in the software Agisoft Photoscan. The final size of this merged data set is 11 225 374 points. Unfortunately it was impossible to get the glazing in the windows due to the nature of this technique and its limitations when it comes to glass.

Table 1.
Comparison between UAV and Terrestrial Photogrammetry

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Particulars	UAV Photogrammetry	Terrestrial Photogrammetry
Data acquisition	Manual/Automatic/ Assisted	Manual
Image resolution	High	High
Ground coverage	$m^2 - km^2$	m <sup>2</sup>
Visibility	Highly positioned elements, rooftops, walls, limited when it comes to hidden objects.	Walls up to the rooftop, allows pho- tographing hidden objects, no visibility of rooftops.
Flexibility	Weather – depen- dent, cannot fly to close to the objects around, problemat- ic with too much greenery.	Applicable in hazardous areas, works in cloudy, drizzly weather.
Price and operating cost	Moderate	Low – moderate
Geo-registration possibility	High quality	Medium quality

Source: Elaborated by the authors

Those two methods combined overcome their limitations showing very good results when it comes to creating merged point clouds [Fig. 5]. Although the process in this case was mostly a manual job due to big amount of greenery around the object it was impossible to take correctly placed pictures.

#### 6. RESULTS

#### 6.1. Generating HBIM model

The last step was implementation of all the gathered data into a HBIM model with the use of REVIT Autodesk platform. It was used to assign the geometry of individual architectural components associated to a database obtained by direct survey, based on previous documents, metric assessment, determination of materials and damages. The transition from the general volumetric model to the detailed 3D parameter model has required the reproduction on HBIM of each single structural part.

The object did not undergo any structural changes or conservation works in the past. The only challenge was to stay consistent with the point cloud so the model could be as reliable as possible. The obtained point cloud was very important support in creating the model because the scanned documentation was not meeting in measurements with reality. Thanks to flexibility of the software, it is possible to extend the model in the future which was also an important aspect in this research. As support, point cloud, photos, and archival material were used in the modeling. The archival documentation compared to the photogrammetric model showed slight inaccuracies, especially within the garage section. Due to losses in the point cloud caused by trees, the model was completed based on the acquired documents and photo documentation with the dimensions suggested by the acquired model [Fig. 6].

The structural and architectural components have



#### Figure 6.

HBIM model obtained on the basis of point cloud and archival documentation



Wall family example

been modeled with geometrical and material characteristics. All the above information have been included in the parametric model. A library of corresponding parameterized components was established. Point cloud data provide accurate geometric data for the "family" models of the building components. Single family houses from that period have a very individual parameters ex. unusual sizes of windows or doors. Separate families were established for partitions, windows and doors, taking into account the large number of elevation and finish materials used in the building [Fig. 7, 8]. The technical data included in the model is based on archival documentation.

In the HBIM model, it is not always necessary to

model with a high level of detail. The level of detail should be determined taking into account the intended use and purpose of the model. European standards take into account LOG Level of Geometry and LOD Level of Development. LOG represents the graphical side of the object and LOI represents the information assigned to it. The model has three levels of detail to streamline the work showing generic object, defined object and detailed object [Fig. 9].

ARCHITECTUR



Figure 8.

Richness of exterior surfaces. Source for Fig. 6-8: Elaborated by the authors



The three levels of graphic detail: generic, defined and detailed level. Source: Elaborated by the authors

Average accuracy (1 cm) was used according to the purpose of the survey. Main purposes were:

- Structural analysis

- Mapping of degradation
- Metric calculations
- Restoration and reconstruction
- Sharing of Cultural Heritage.

The model has technical information on construction and finishes, all dimensions, and full architectural, photographic, and archival documentation. Parts that were not included in the point cloud and were completed on the basis of the remaining documentation are marked in the pink color on the model. The whole is made on the existing phase with planned changes in the design phase [Fig. 10].



HBIM model of the villa with color marking of modelling assumptions. Source: Elaborated by the authors

## 7. CONCLUSIONS

The modernist villa from the late sixties which has become a case study and a cause of this research is not classified as original and valuable heritage in the popular consciousness. However, as stated in the Introduction section, its history and value for Poland and post-war modernism architecture play a key role. The collection of the data recourse can be a starting point for necessary conservation process but also it may raise awareness and can be a beginning of a great cooperation seeking protection of our architectural heritage. This research has several results:

**Application result** is full documentation along with rich database which can be used for future renovations of the villa and educational purposes. When it comes to applying low cost photogrammetry method the least efficient aspect seems to be dealing with natural obstacles which causes many mistakes in collecting the pictures for the point cloud.

**Conservational outcome** is a proposition of integrated and low cost procedure for modernist heritage conservation. This procedure may be very effective in monitoring and analyzing objects in danger.

**Scientific outcome** of this research is literature and archival analysis of the structure, its history and also another addition to the knowledge about post – war architecture of single – family houses.

This survey should have a continuation in order to come up with conservation guidelines for the object and possibly improving the photogrammetric merging methods and data collection process.

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