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Use of contemporary building survey methods in documenting the renovation and conservation of heritage buildings on the example of the Church of Peace in Swidnica

Wykorzystanie współczesnych metod inwentaryzacji do wykonywania dokumentacji remontu i konserwacji obiektów zabytkowych na przykładzie Kościoła Pokoju w Świdnicy

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Abstract. Contemporary building survey technologies and methods provide key support in renovating, preparing documentation for, and carrying out works on heritage buildings. The precision level of measurements and mapping reality allows for conducting, among other things, advanced conservation work both in situ and in house. To carry out works on the Church of Peace in Świdnica, an architectural survey of its interior was used, in addition to: photogrammetry, a 3D model, a virtual tour and visualisations that depict the successive stages of the church interior's revalorisation and renovation.
Keywords: historical monument; architectural survey; digital photogrammetry; virtually walk.

Streszczenie. Współczesne technologie i metody inwentaryzacji są istotnym wsparciem podczas remontów, opracowywania dokumentacji oraz realizacji prac w obiektach zabytkowych. Stopień dokładności pomiarów i odwzorowania rzeczywistości pozwalają na prowadzenie m.in. zaawansowanych prac konserwatorskich in situ, a także w warsztacie. Na potrzeby prac prowadzonych w Kościele Pokoju w Świdnicy wykorzystano m.in. inwentaryzację architektoniczną wnętrza, a także fotogrametrię, budowę modelu 3D, wirtualny spacer i wizualizacje ukazujące kolejne etapy rewaloryzacji oraz renowacji jego wnętrza.
Słowa kluczowe: obiekt zabytkowy; inwentaryzacja architektoniczna; cyfrowa fotogrametria; wirtualny spacer.

The Holy Trinity Church of Peace of the parish of the Evangelical Church of the Augsburg Confession in Świdnica was built in the territory of the former Duchy of Silesia in the mid-17th century, and together with the Church of Peace in Jawor forms the two largest wooden Baroque religious buildings to use timber framing in Europe. Both churches became UNESCO World Heritage Sites on 13 December 2001 [1]. The Evangelical Church of Peace in Świdnica is a high-class monument of significant historical and cultural value. It was built under the terms of the Treaty of Westphalia that had ended the Thirty Years' War. The peace treaty allowed, among other things, the construction of three churches in Silesia, at the Evangelicals' own expense, in locations outside the city walls and after attaining a construction permit beforehand [2]. According to later official decrees, Protestant churches could only be made of wood and clay [3].

On 23 September 1652, the starost Baron Otto von Nostitz announced an imperial decree in the town hall, authorising the construction of the Church of Peace in front of St Peter's Gate in Świdnica. According to the decree, the plot covered 200 × 200 paces and the area for the building itself covered 100 × 50 paces [4]. Due to a lack of funds and the prohibition of outdoor services, it had been decided to build a temporary church 'God's Hut', which was replaced by a proper building in 1657 [4, 5]. Sources say the Peace Church took 10 months to build. The laying of the cornerstone took place on 23 August 1656 and the first service was held on 24 June 1657 [2, 4]. The church was built to a design by Albert Säbischa [5], a Breslau-based architect who was also the author of the other two Peace Churches. The construction was led by master carpenters Andreas Gamper and Kasper König, by and bricklayer Hans Zöller [2]. It was designed on a plan similar to a Greek cross, with a centralised plan and a three-nave basilica layout, with a three-nave transept. The central naves are covered with a gable roof, the side aisles with a pent roof. The interior of the church is surrounded by a two-storey gallery system. The main nave is 44 m long and 20 m wide, while the transept, which intersects with the nave exactly in the middle, is 30.5 m and 20 m. The entire building is supported by oak columns 40 × 50 cm thick, which, like the buttresses of the ceilings and galleries, are covered with wooden siding. The interior fittings are made of wood.

The Churches of Peace in Świdnica, Jawor and Głogów (last non-existent) were established on the basis of the previously mentioned international treaty. The churches of Silesian Protestantism have a high symbolic significance, starting with the basis of their implementation, through the imposition of their location (building outside the city walls) and construction, using specific materials (wood, straw, clay, sand) and the restrictions on specific architectural features (the churches could not have towers) [3]. Despite the use of perisha-

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ble materials, the Świdnica heritage building has survived for more than 360 years, is still in use, and hosts numerous concerts and services. Its form, multiple levels, size and the complexity of its elements constitute an outstanding work of timber-frame architecture. Together with the Jawor building, is globally unique.

This paper presents the scope of work that covered the digital documentation of the interior of the Church of Peace in Świdnica and issues related to its virtual representation, as well as the preparation of materials to assist in the implementation of a conservation programme for the decor and furnishings of its interior as part of work on a UNESCO monument.

Basis for documentation, scope of work

Between 2018 and 2020, the task of developing the 'Virtual Design of the Peace Church in Świdnica, Poland' was carried out. This action was carried out as part of the project entitled 'Conservation and restoration of a wooden UNESCO monument – the Church of Peace in Świdnica, to protect cultural heritage' funded by the European Regional Development Fund [6] carried out as part of the Operational Programme Infrastructure and Environment 2014 – 2020, Action 8.1 Protection of cultural heritage and development of cultural resources – No. POIŚ. 08.0100-00-1018/16. The conservation work for the project was done in the years 2018 – 2021 [7].

The project for the virtual tour included a building survey (drawing and measurement) of the interior of the historical building, a photographic survey of the interior, digital photogrammetry (from the photographs taken), fragmentary scans of its decor elements, 3D modelling using computer software, superimposition of textures from previously prepared and dedicated photographs, visualisation of the interior of the building, as well as specific, significant details, such as the baptismal font, epitaphs, pews, and finally the development of the virtual tour.

According to the definition found in the Little Dictionary of Monument Conservation, a building measurement survey in heritage conservation includes: drawings to scale, drawn on the basis of direct measurement, while a photographic survey includes a set of photographs taken at a specific period that give an idea of the monument as a whole (in the case of an architectural monument, also of its interior) and all its details [8].

Overview of works

The project consisted of three stages. The first stage of the work involved a building measurement survey of the interior of the Church of Peace (Fig. 1). For this purpose, archival paper versions of previous manual base survey drawings from the 1990s were used. On the basis of in situ measurements, digital vector drawings were prepared, including plans of: the ground floor (including the nave of the building and its adjoining halls, namely the Baptismal Hall, the Hall of the Dead, the Hall of Weddings, the Field Hall and the Sacristy, and pew plans), the level of the boxes in the ground floor, the first level of the galleries, the second level of the galleries, longitudinal and transverse cross-sections of both sides and drawings of selected details.

Interior details included a survey and drawing of: a wooden polychrome baptismal font dating from 1656, by Pankratius Werner of Jelenia Góra (along with a new baptismal bowl dating from 1661), which is located in the Baptismal Hall (Fig. 2); a florin, which is part of an 18th-century Baroque altar; carved wooden benches located on the ground floor of the church (Fig. 3); wooden medallions, epitaphs and inscriptions from the 17th and 18th centuries and a column located within

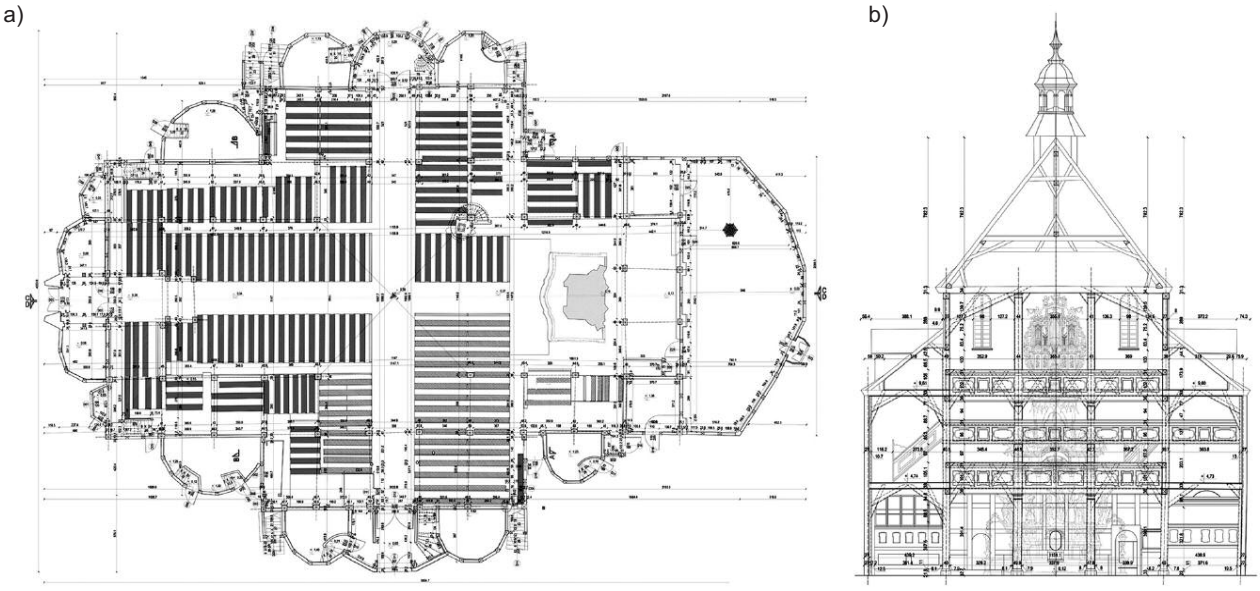

Fig. 1. Measurement survey of the interior of the Church of Peace in Świdnica: a) ground floor plan; b) transverse cross-section

Fig. A. Dobrzyńska-Jarosz, M. Jarosz, K. Wójtowicz

Rys. 1. Inwentaryzacja rysunkowo-pomiarowa wnętrza Kościoła Pokoju w Świdnicy: a) rzut przyziemia; b) przekrój poprzeczny

Rys. A. Dobrzyńska-Jarosz, M. Jarosz, K. Wójtowicz

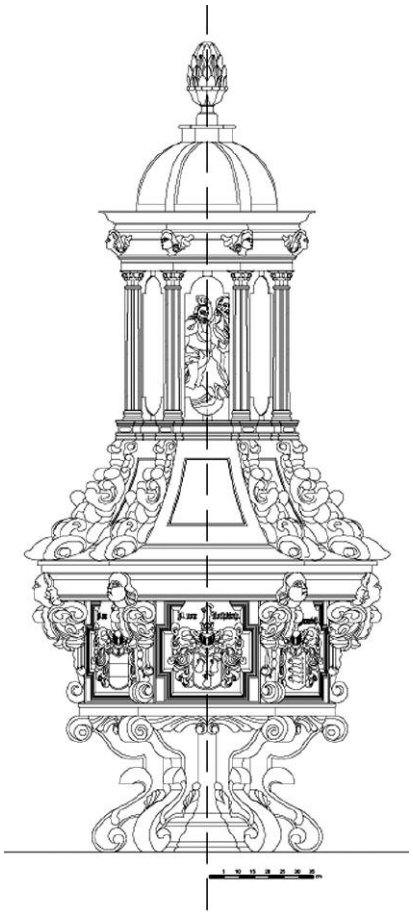

Fig. 2. Measurement survey of the Baptismal font, located in the Baptism Hall (originally the Sacristy) *Fig. A. Dobrzyńska-Jarosz*
Rys. 2. Rysunek pomiarowo-inwentaryzacyjny Chrzcielnicy zlokalizowanej w Hali Chrztów (oryg. Zakrystii)
Rys. A. Dobrzyńska-Jarosz

the first level of the galleries, one of two wooden atlases that decorate the large, Baroque organ prospect, which was created in 1666–69 by Christoph Klose, an organ builder from Brzeg. The drawings were supplemented by the floor plan of the Baptismal Hall (the original Sacristy).

A comprehensive survey of the building's interior was done in the first quarter of 2018. It took about six months of work to collect the material. The team consisted of six people. The survey was done mostly traditionally, using tape measures and laser rangefinders. The photographic survey was done with digital cameras: A Nikon D810 DSLR with FX sensor format, 35.9 × 24 mm and a resolution of 36.3 million pixels with an AF-P Nikkor 70-300 mm lens, and a Nikon D5100 DSLR with DX sensor format 23.6 × 15.6 mm and 16.2 million pixels with an 18–105 mm VR lens.

The measurement and photographic surveys were used as the basis for the second stage of work – building a 3D model in Blender. Blender is a freeware program for modelling, rendering and creating all kinds of computer animations (https://www.blender.org/). The base model of the body and interior of the Church of Peace was supplemented by models created from individual digital photographs taken during phase one, which were processed in Agisoft Photo-Scan (Photo 1). This software enables the generation of 3D models from photographs. At this stage, the work was based on selecting images suitable for photogrammetry from the photographic survey. Non-blurry, high-quality images were selected, showing given objects from different angles, in a combined 360-degree panorama capture (Photo 2). In the photogrammetry software, shared points had to be indicated, along with marking the angle and place from which a given photo was taken, then systematising and cleanup of the resultant point cloud by filtering data (eliminating redundant information). In the case of our measurements, filtration was done manually. Using the appropriate parameters, this process was performed several times, then by interpolating the data a numerical model was created that could then be exported and imported into the program with the overall base numerical model of the monument (Photo 3).

As of 2019, Agisoft PhotoScan has been renamed Agisoft Metashape. The new version of the software can, among other things, compute data in the cloud in a dedicated user interface, and applies modern machine learning techniques which interpret points that represent various groups, such as ground, vegetation, buildings, roads, cars and other man-made elements [9].

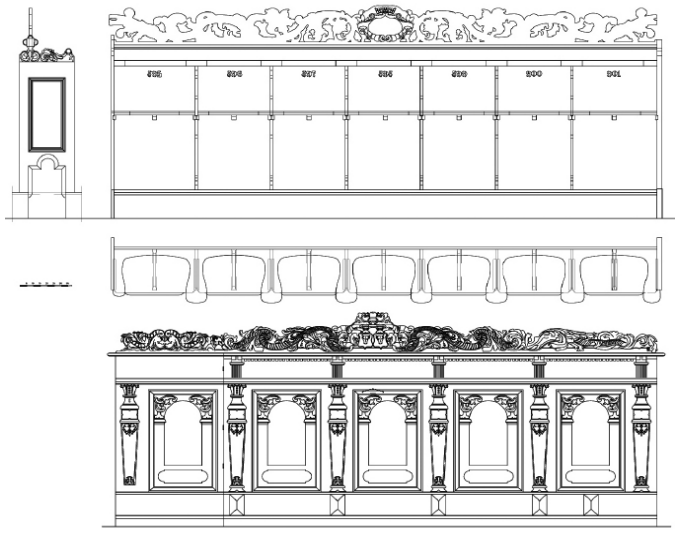

Fig. 3. 2D measurement survey of the ground floor pews in the Church of Peace in Świdnica *Fig. A. Dobrzyńska-Jarosz, K. Wójtowicz*
Rys. 3. Rysunek pomiarowo-inwentaryzacyjny 2D ławek przyziemia w Kościele Pokoju w Świdnicy
Rys. A. Dobrzyńska-Jarosz, K. Wójtowicz

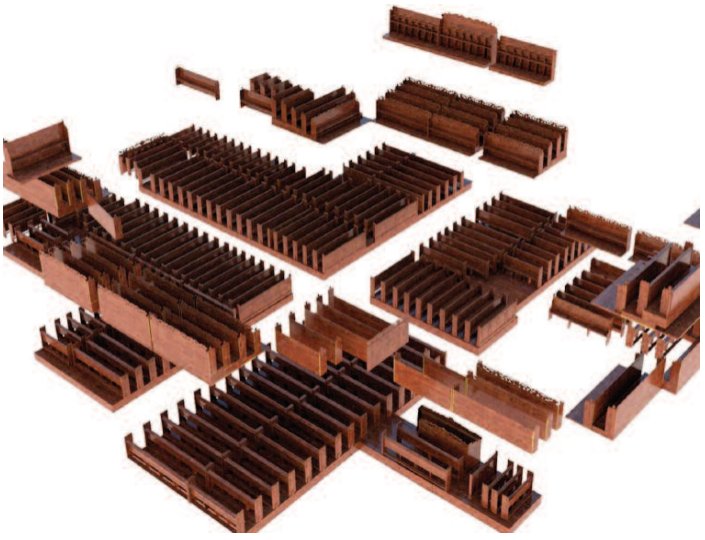

Photo 1. A three-dimensional model of the ground floor pews in the Church of Peace in Świdnica *Photo. K. Wójtowicz*
Fot. 1. Trójwymiarowy model ławek przyziemia w Kościele Pokoju w Świdnicy *Fot. K. Wójtowicz*

Photo 2. Baptismal font from 1661, located in the Baptism Hall (originally Sacristy)
Photo. A. Dobrzyńska-Jarosz
Fot. 2. Chrzcielnica z 1661 r. zlokalizowana w Hali Chrztów (oryg. Zakrystii)
Fot. A. Dobrzyńska-Jarosz

Additionally, during the second phase of work, in addition to photogrammetry, it was decided to extend the database with laser scanning of a range of elements of details inside the Church of Peace, which were selected and approved. Laser scanners work well for verifying the vertical and horizontal curvature of objects and for more efficient acquisition of accurate dimensions. However, in the case of scanning the details of the monument's interior, due to the status of the structure and its significant historical and cultural value, gaining full access to its interior decor elements and fully illuminate of the them, or to position the benchmarks (markers), on the historical components of the church so that the readings would be correct was problematic. Numerous attempts to scan individual details, especially reflective or dark-coloured surfaces were mostly unsuccessful, therefore, with this type of complex and richly decorated historical interior, it proved simpler and more efficient to use mainly photogrammetry with minor elements of laser scanning.

Once the models of each detail had been built and integrated into the main, base model of the Church of Peace

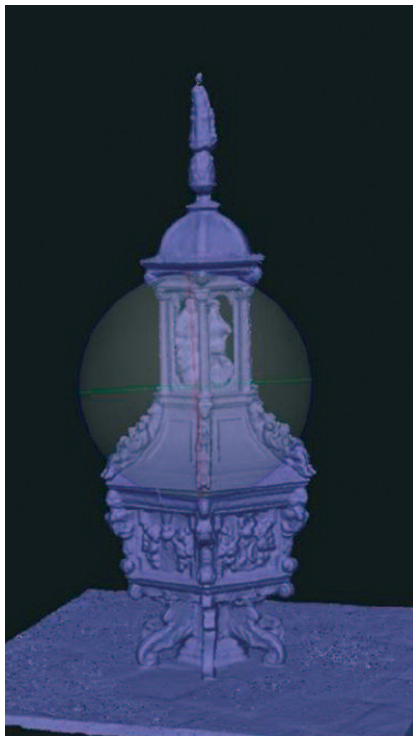

Photo 3. A three-dimensional model developed using photogrammetry (with and without textures) *Photo. K. Wójtowicz, W. Drzewiński*
Fot. 3. Trójwymiarowy model chrzcielnicy opracowany za pomocą fotogrametrii (z uwzględnieniem tekstury i bez)
Fot. K. Wójtowicz, W. Drzewiński

interior, the focus was shifted towards applying colour and material textures to the individual furnishings and finishes (Photo 1 and 3). For the purposes of conservation within the church, two finish versions were prepared: the current state and the post-renovation state (Photo 4 and 5).

The third and final stage that finalised the process was the creation of 360° spherical panoramas and a virtual interior design of the historical Church of Peace in Świdnica (Photo 5). The third phase was supported by a team of professionals from Wrocław-based companies involved in comprehensive multimedia design, application and game development in AR and VR technology (LUNE and Luminator. pl). Ultimately, an application was created showing an interactive 3D world generated from the two preceding phases of the project. A virtual environment was developed that is easily accessible and mobile through the use of VR goggles that can be used to observe virtual reality (VR), which was based on the graphics engine as an integrated graphics environment.

After being approved with representatives of the Church of Peace in Świdnica, the virtual design of the church was expanded to include tags describing selected interior elements, i.e., the baptismal font, the altar, the gallery with paintings depicting Pastors (located in the Baptismal Hall, the former sacristy), the pulpit, the large organ casing, the small organ casing, the chandelier, structural elements (pillars and galleries), boxes, inscriptions, paintings, epitaphs, coats of arms and pews. The third stage of the work featured an additional element, namely the development and creation of a tactile map of the interior of the Church of Peace, which makes it possible for people who are blind or visually impaired to perceive the interior of the building by touch.

Overiew of results and conclusions

The project presented here was aimed at creating a virtual reality representation of the historical building of the Church of Peace in Świdnica. This included a survey of the interior's

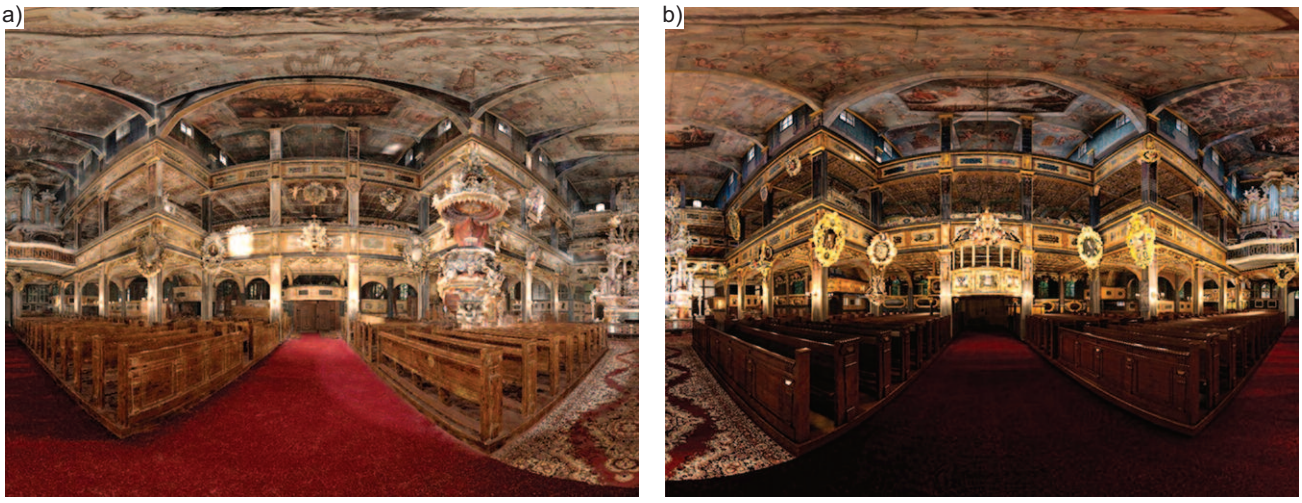

Photo 4. Interior of the Church of Peace in Świdnica – 360-degree shot: a) state during conservation works; b) final state

Photo. K.Wójtowicz, W. Drzewiński

Fot. 4. Wnętrza Kościoła Pokoju w Świdnicy z uwzględnieniem tekstur – ujęcie 360°: a) stan w trakcie prac konserwatorskich; b) stan docelowy

Fot. K.Wójtowicz, W. Drzewiński

existing state and producing a virtual design of the historical Church of Peace in Świdnica, which can, in the future, be used in further revitalisation work on the building. Through the work, the digitisation of documentation, the use of photogrammetry and the creation of a 3D model of the existing elements, as well as the imposition of textures and their updating, in accordance with conservator guidelines as to the necessary and planned repair measures, a model of the interior of the monument was produced, presenting the possible future appearance of the building after comprehensive conservation measures have been carried out. This treatment can be helpful in developing conservation plans for monuments, discussing the work, its form and scope with, among others, site managers, custodians, but most importantly with state and public administration bodies. They provide a comparative element that shows the pre and post stages in the renovation process. In addition, the creation of a digital version of the technical documentation of the current state of preservation of the building and a virtual design, based on surveys: drawing and measurement and photography, photogrammetry and a comprehensive, digital model of the interior constitute important source material in case of possible unforeseen events. In the case of high-class monuments, it is important to possess extensive documentation to enable the potential faithful restoration. The virtual design of the Church of Peace can also be used for promotional and tourism-related purposes. The final result of the work, in the form of a virtual tour that is several minutes long, can enable visitors and interested parties to see parts of the church that are not generally accessible to the public.

The currently observed progress and new requirements on the use of virtual reality have contributed to its use and conducting research on its innovative application, including in architecture and design. It should be noted that digital photogrammetry and laser scanning are complementary methods. Using only photogrammetry, we will not achieve the degree of accuracy of laser scanner measurements, but depending on the intended use of the final material, they can be sufficient for further work. Photogrammetry provides the ability to accurately model hard-to-reach, underexposed and irregularly shaped features.

The documentation created as a result of the work should also not be overlooked, as its creation allows the preservation of important information and parameters concerning the monument. In the case of the Church of Peace in Świdnica, the work presented concerning the survey of the interior and building a 3D model together with a virtual tour are the first complete digital documentation of the building, which at the same time forms the basis for conservation documentation that is kept on an ongoing basis [10]

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