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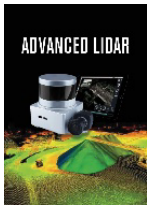

Creating Architectural Surveys of Traditional Buildings with the Help of Terrestrial Laser Scanning Method (TLS) and Orthophotos: Historical Diyarbakır Sur Mansion

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Keywords
Analytical Survey,
Cultural Heritage,
Terrestrial Laser Scanning,
Orthophoto,
Sustainability.

ABSTRACT

Manual mapping or traditional methods of architectural documentation by an expert in historical buildings are today considered time-consuming and laborious procedures. In recent years, with the development of technology, the use of digital tools to support architectural documentation activities has provided more detailed results on architectural analysis and has simplified processes which were performed manually. The Historical Sur Mansion, located in the Diyarbakır urban protected area, which is the subject of the study, is a historical building that reflects the general characteristics of traditional houses in Diyarbakır, containing its own characteristics, formed by factors such as topography, materials, climate as well as cultural elements in the immediate environment. The building has been registered as a "monumental" structure to be protected by the Council of Europe's Natural and Cultural Heritage Conservation Inventory and the General Directorate of Turkish Cultural Heritage and Museums. The decorations and inscriptions on the iwans, window and door openings of the building are examples of Diyarbakır residential architecture. The aim of the study is to obtain the analytical surveys of the historical Sur Mansion, which is a great necessity for the sustainability of the cultural heritage in the region, by using orthophotos produced by various techniques from laser scanning as a base. Researches carried out on the studied area have shown that by using the orthophotos produced from the data obtained from terrestrial laser scanning as a base, data with sufficient level of detail needed in architectural documentation can be obtained today, and this method offers an economically effective and fast solution to produce analytical surveys.

1. INTRODUCTION

Manual mapping of architectural documentation in historical buildings or detection by an expert using traditional methods are today considered time-consuming and laborious procedures (Barber et al., 2006). In recent years, with the development of technology, the use of digital tools to support architectural documentation activities has provided more detailed results on architectural analysis, thus simplifying processes which were performed manually (Del Pozo et al., 2016). In recent years, among the technologies used in architectural documentation, terrestrial laser scanning, photogrammetry and unmanned aerial vehicles called "drone" are frequently seen. In particular, surveys based on terrestrial laser scanning (TLS) tools enable to obtain very good geometric data in terms of high resolution, high accuracy and low uncertainty, and to obtain dense point clouds that are useful in architectural documentation (Comert et al., 2012; Russo, 2017).

It is emphasized that the use of laser scanning method instead of traditional methods greatly reduces the time and effort required in field studies and drawing processes, as common in the studies carried out to verify the usability of the terrestrial laser scanning method, which has proven to be a promising technique, especially in the last decade (Alptekin et al.,2019; Alyilmaz et al.,

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2010; Guldur et al.,2015; Karataş et al.,2022; Korumaza et al., 2010; Korumaz et al.,2012; Lerones et al., 2010; Ulvi et al., 2016; Şasi & Yakar, 2017; Ulvi & Yakar, 2010; Ulvi & Yakar,2014; Yakar et al.,2009; ; Yakar et al., 2015; Yakar & Mirdan, 2017; Yakar & Doğan, 2019; Yakar & Omar ,2016; Yakar, 2015; Yılmaz & Yakar, 2006; Olsen et al.,2010; Doğan & Yakar, 2018 ; Yakar et al.,2010; Yakar et al.,2014; Yakar& Doğan, 2017).

Many studies in the literature show that terrestrial laser scanning method provides great convenience in architectural documentation when used in integration with photogrammetry method (Mohammed at all., 2016; Ulvi at all., 2014; Uysal at all., 2013; Kocaman & Yakar, 2017; Kanun at all., 2017) (Kaya, Y. at all 2021) (Yılmaz,.& Yakar, M. 2000) (Mirdan, O., at all. (2017)(Yilmaz, I at all 2004) (Pulat, F at all 2022). Especially for the documentation of stone structures in the field of cultural heritage, there are various studies that have concluded that by creating orthophotos with various software on the structures obtained by using terrestrial laser scanning, they can obtain the data that will be the base for the facade, plan and section drawings required for the relief plans (Comert et al.,2012; Gabriele et al.,2010; Georgopoulos et al.,2004; Koska & Křemen, 2013; Meroño et al.,2015; Mol et al., 2020; Stober et al., 2018; Yılmaz & Yakar, 2006). Koska & Křemen (2013) used a combination of terrestrial laser scanning and photogrammetry and confirmed that the resulting scaled orthophotos can be used to create building plans, 2D drawing documents of facades St. Nicholas Baroque Church. Gabriele et al. (2010) performed the internal and external scanning of the Italian Carignano Vallinotto temple and created the 3D model and orthophoto images of this temple, and obtained the data that will be the base for the orthophoto images and the relief plans for the facade, plan and section drawings. Comert et al. (2012)(Ulvi, A. At all 2019) scanned the former military office building in the Seyitgazi district of Eskişehir with the terrestrial laser scanning method and obtained a 3D model, and stated that orthophoto images, drawings of the facades and plans produced from this model could be produced. He stated that orthophoto images bring great convenience to architectural facade drawings, and orthophoto images obtained from point cloud allow architectural plans and facades to be drawn with millimeter precision since they contain many details. Georgopoulos et al. (2004) shows in a case study of a 15th century Byzantine church that orthophotos produced from laser scanning can be used as a base for architectural documentation, even in precision drawings. He explains that in this way it is possible to eliminate the necessary control data to be obtained using standard measurement techniques, thus reducing the time of field and office work.

As stated in the literature, with the development of technology in recent years, the use of terrestrial laser scanning and orthophotos to support architectural documentation activities has provided more detailed results on architectural analyzes, thus simplifying manual operations. The Historical Sur Mansion, located in the Diyarbakır urban protected area, which is the subject of the study, is a historical building that reflects the general characteristics of traditional houses in Diyarbakır, containing its own characteristics, formed by factors such as topography, materials, climate as well as cultural elements in the immediate environment. The building has been registered as a "monumental" structure to be protected by the Council of Europe's Natural and Cultural Heritage Conservation Inventory and the General Directorate of Turkish Cultural Heritage and Museums. Sur Mansion, which is located in the urban protected area in Diyarbakır, has been in existence for years despite being exposed to many environmental effects. The building, which was built of basalt and limestone, was able to preserve its originality to a large extent. The decorations and inscriptions on the iwans, window and door openings of the building are examples of Diyarbakır residential architecture. The aim of the study is to obtain the analytical surveys of the historical Sur Mansion, which is a great necessity for the sustainability of the cultural heritage in the region, by using orthophotos produced by various techniques from laser scanning as a base.

In line with the determined purpose, within the scope of the article, first of all, a source research on the structure and an observational analysis on the structure were made. In the next stage, the systematic of the stages to be followed in order to create the analytical surveys of the building is presented, and the findings about the floor plans and facades are obtained. In the discussion section, the results of the study are discussed and in the conclusion section, conservation suggestions are made to ensure the sustainability of the building.

2. STUDY AREA

The building is located in Diyarbakır Province Sur County, Savaş District, Ali Emiri Street No: 9-11. According to the land registry records; Located on Block 382, parcel no. 47 (Figure 1).

The building has been registered as a "monumental" structure to be protected by the Council of Europe's Natural and Cultural Heritage Conservation Inventory and the General Directorate of Turkish Cultural Heritage and Museums (Figure 2). There is no information about the construction date of the building in the sources. The inscriptions in the building do not contain information about the history of the building. On the inscriptions on the eastern wall of iwan 1 and the western wall of iwan 3, "El Baki El Hallak" is written in Arabic thuluth calligraphy. Considering the plan of the house, the materials used, the construction form and the construction date of similar example houses, it is estimated that the building was built in the XIX or XX century. It is known that the house numbered 382 47 was used as a school for the deaf in the 1950s. In our research, the building served as a school for 10 years and then moved to its new location. Only written and oral sources could be reached, and no visual data could be found about the period when the building was used as a school. The oldest document belonging to the building is the measurement sketch dated 1952 taken from the archive of the cadastral directorate. There is also the Savings sketch of the building drawn in 1953. It is stated that the building shown in plot no. 27 on the savings sketch is a masonry house and it is owned by Marton Pedros Velesi

Şemu Ef Foundation. Another document is the aerial photograph published by the Diyarbakir Promotion, Culture and Solidarity Foundation in 1966. In addition, photographs taken from the Diyarbakır Cultural Inventory show the state of the building before it was destroyed (Figure 3).

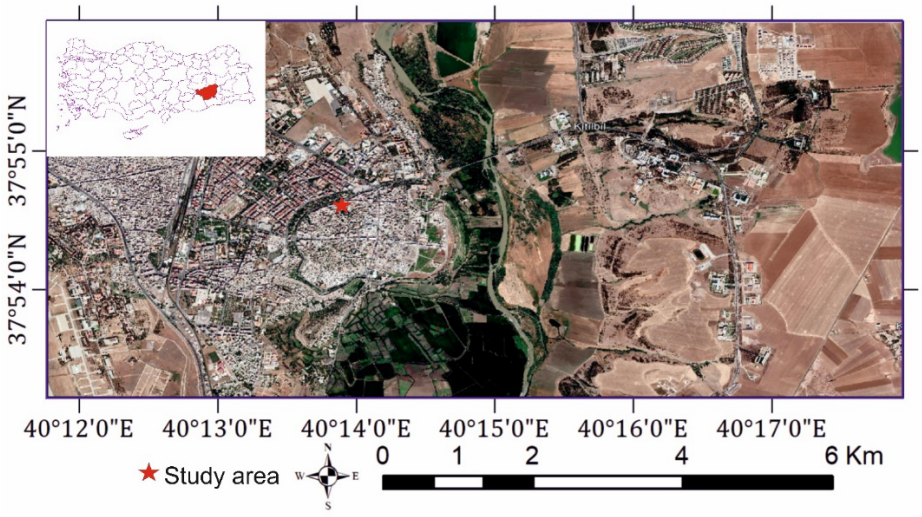

Figure 1. Location map of the study area

Figure 2. Current state of the building

Figure 3. The original state of the building

3. Method

Literature research and terrestrial laser scanning methods were used to create the architectural analytical surveys of the structure determined in the study. In the first stage of the research, general information on the historical structure where the case study will be applied was presented within the scope of an archive review and the data obtained from the Diyarbakır Metropolitan Municipality Kudeb archive.

3.1. Situation Analysis

In order to understand the relationship of the building with its environment, it is necessary to conduct research on the structure, its general structure, form, material and environment (Karkaş & Özgünler, 2021). In this context, in this first stage, all information about the historical documents about the building, its changes over time, spatial and facade features, material and construction technique and material deterioration in the current situation were collected. In the next stage of the study, a laser scanning device (Faro Focus Laser Scanner) was used in the building to obtain architectural drawings of the building and point clouds were obtained during scanning. The steps followed for the preparation of the analytical surveys of the architectural features of the building are explained systematically in this section.

3.2. The Obtaining the Point Cloud

In the next stage of the study, a laser scanning device (Faro Focus Laser Scanner) was used on some of the building facades to obtain images of the building facades and point clouds were obtained during scanning. Objects up to 330 meters can be scanned with the device used (Figure 4).

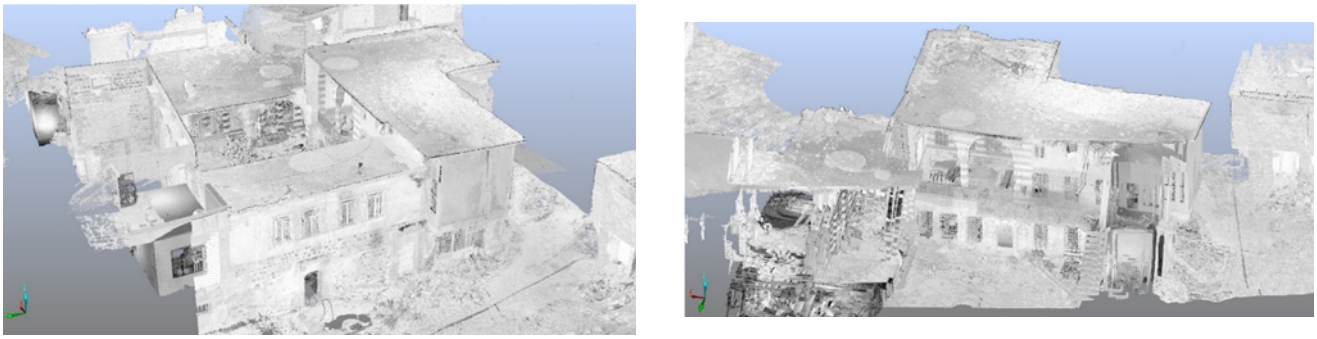

Figure 4. Obtained point cloud of the structure

3.3. Obtaining Orthophotos

At this stage, 3D images of the structure were obtained by using the point clouds obtained in the laser scanning process using the software called PointCab Origins 4.0. Using the software called PointCab Origins 4.0, sections were taken from the desired places on the 3D images of the building and scaled orthophotos of the plan and facades of the building were produced (Figure 5-8).

AutoCAD program was used in the process of creating the drawings of the facades. Before starting the drawing process, orthophoto images produced in PointCab Origins 4.0 software were transferred to the AutoCAD environment. It can be transferred to AutoCAD environment in TIF file format with .tif or .tiff extension, which is the common data format of AutoCAD software. Using the scaled orthophoto images obtained, the facade drawings of the building were obtained with the Autocad program.

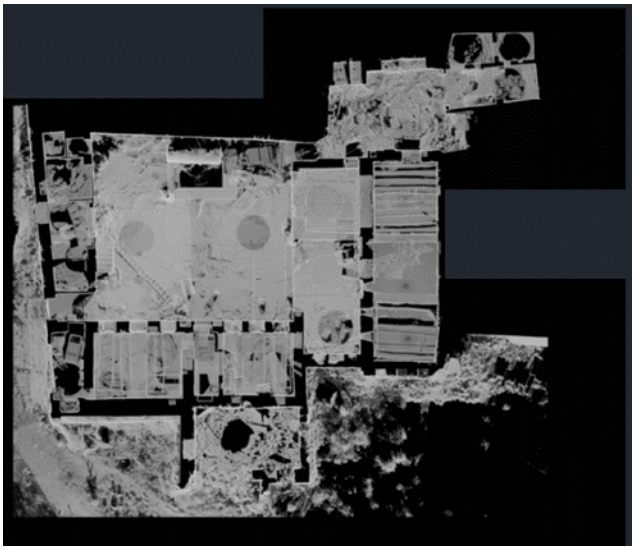

Figure 6. Orthophoto of the ground floor plan

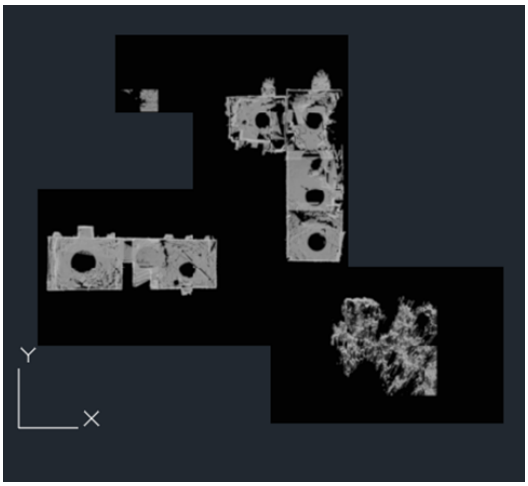

Figure 5. Orthophoto of the basement floor plan

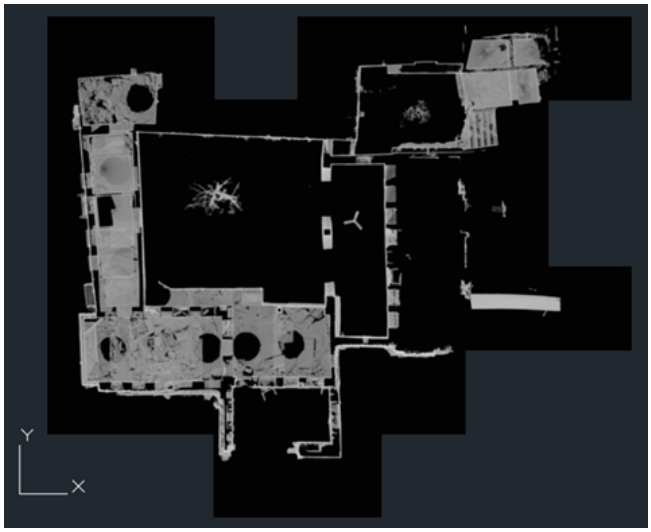

Figure 7. Orthophoto of the first floor plan

Figure 8. Orthophoto of the western façade

Figure 8. Orthophoto of the south façade

4. RESULTS

After evaluating the macro and micro visual observations made in the previous section, the current situation analysis of the building or monument and the analytical drawings obtained from the orthophotos obtained from laser scanning, the following findings have been reached.

4.1. Floor Plan Surveys

In the house, which was built in a "U" plan around the square planned courtyard, smooth cut basalt stone and limestone were used. Basalt stone is the main building block of historical artifacts in and around Diyarbakir province. The structure, consisting of east, west and south wings, was built of basalt stone. Basalt stone was used mainly on the courtyard facades. The spaces forming the south wing were built of basalt stone, and limestone stone and wooden beams were used. The same is true for the spaces that make up the east and west wings, but the rooms on the upper floor of the west wing are made of today's building materials. All rooms have basalt stone floors and wooden beams (Figure 9).

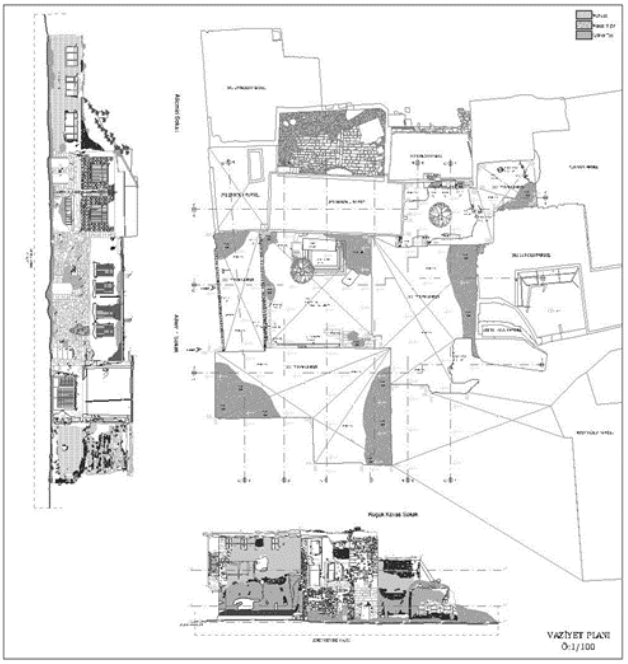

Figure 9. Building site plan survey

The building consists of south, east and west wings. East wing consists of basement and ground floor, south wing consists of basement, ground and first floor, and west wing consists of ground floor. The second courtyard is accessed from the northeast of the courtyard. On the north of this courtyard, there are two toilets, two rooms, and a woodshed in the east. The spaces in the west wing of the building are the courtyard and the WC. There are 6 rooms, 1 shop, iwan and kitchen in the south wing of the building. The spaces on the eastern wing of the building consist of 4 rooms and an iwan (Figure 10-12).

The walls of the building have been destroyed due to material loss in the rooms. In addition, deteriorations such as plaster-paint spills, cracks and surface contamination were observed on the plastered wall surfaces.

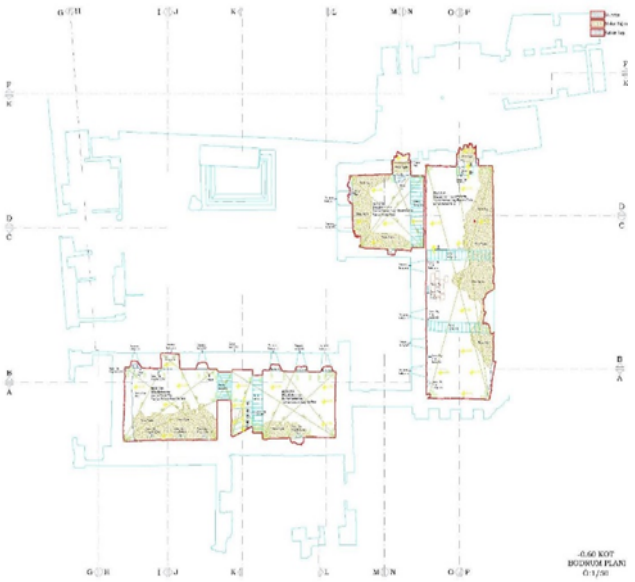

Figure 10. The basement floor survey of the building

Figure 11. The ground floor survey of the building

Figure 12. First floor survey of the building

4.2. Facade Surveys

The south façade wall consists of adobe, rubble stone, blend brick, basalt stone and plastered wall surfaces. The south façade wall consists of the south wing of the building and the south wall of the west wing. The façade wall is more clearly observed by the demolition of the building on the neighboring parcel. Intense deterioration is observed on the facade wall. Intense plaster-paint spills, especially destructions and material loss on the wall surface, and surface contamination on stone surfaces were observed. The upper level of the façade is formed by a reinforced concrete flat roof (Figure 13).

The west façade wall consists of rubble stone, basalt stone and plastered wall surfaces. The facade wall consists of door and window openings and a bay window. The façade wall was built with rubble stone up to +3.62 elevation. There are two entrance doors in the area covered with rubble stone. The entrance gates built with basalt stone have a basalt stone arch measuring 1.85x0.98 m. There is also a basalt eaves resting on two basalt stone pendentives. The wooden heeled door in one of these door openings opening to the courtyard entrance hall has managed to preserve its originality. Four rectangular PVC window openings on the upper elevation of the wall have metal railings. A 2.80x2.12 m opening belonging to the shop is seen on the east of the façade wall. Above this area is a bay window. The door openings, basalt stone pendentive, eaves and wooden heeled door on the façade wall have managed to preserve their originality. Interventions were made with cement-added mortar on the stone wall surfaces of the façade. However, it has been determined that structural deteriorations, especially surface pollution, occur on stone surfaces. The upper level of the façade is formed by a reinforced concrete flat roof (Figure 14).

Figure 13. Analytical survey of the south façade of the building

Figure 14. Analytical survey of the western façade of the building

The south façade of the building in the courtyard consists of three floors. There is a door opening on the middle axis of the ground floor main wall that provides the entrance to the building. In the eastern part of the entrance door, there are three rectangular-planned three window spaces with iron bars in front, two rectangular-planned window spaces with iron railings in front, and a staircase that provides access to the upper floors of the building. On the first floor of the building, there are two iwans with a height of 6 meters on the right side of the central axis of the main wall, and three window spaces in two rows, with a rectangular plan in front of them, on the left side. There is a section supported by buttresses on the part connecting the ground floor and the first floor on the façade (Figure 15).

The west façade facing the courtyard consists of two floors, and two closed iwans are visible on the ground floor (Figure 16).

The east façade, facing the courtyard, consists of two floors, and two iwans with pointed arches forming large openings can be seen on the façade (Figure 17).

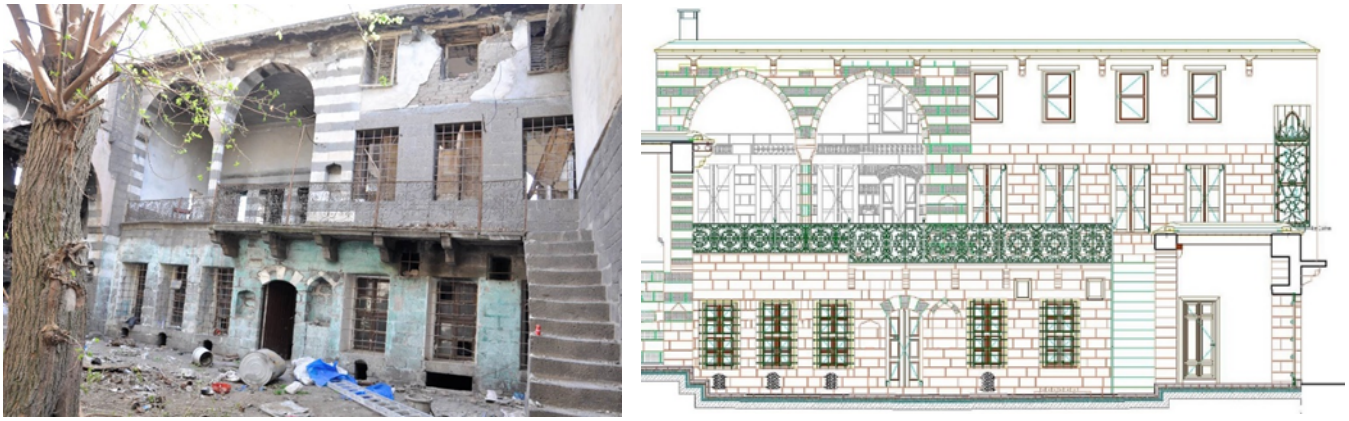

Figure 15. Analytical survey of the south façade of the building facing the courtyard

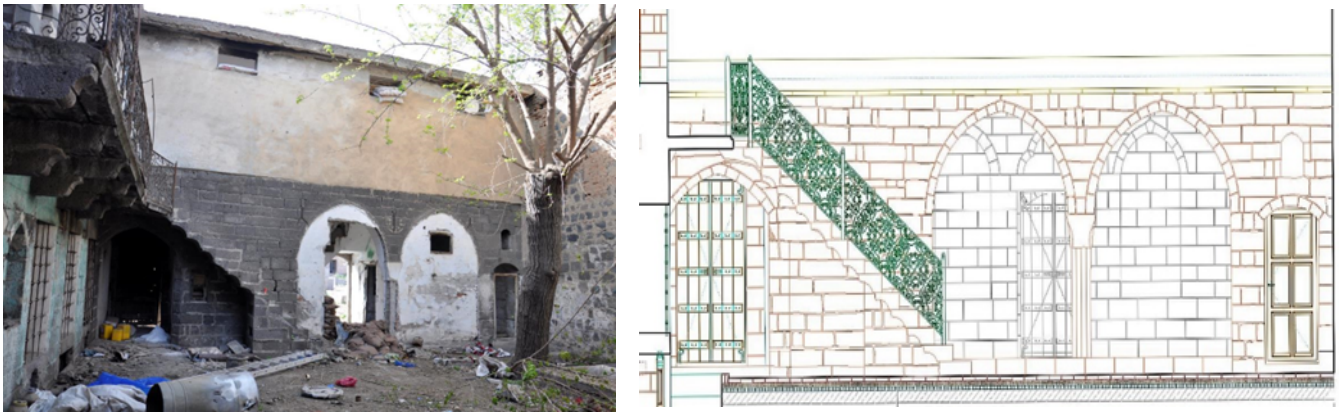

Figure 16. Analytical survey of the western façade of the building facing the courtyard

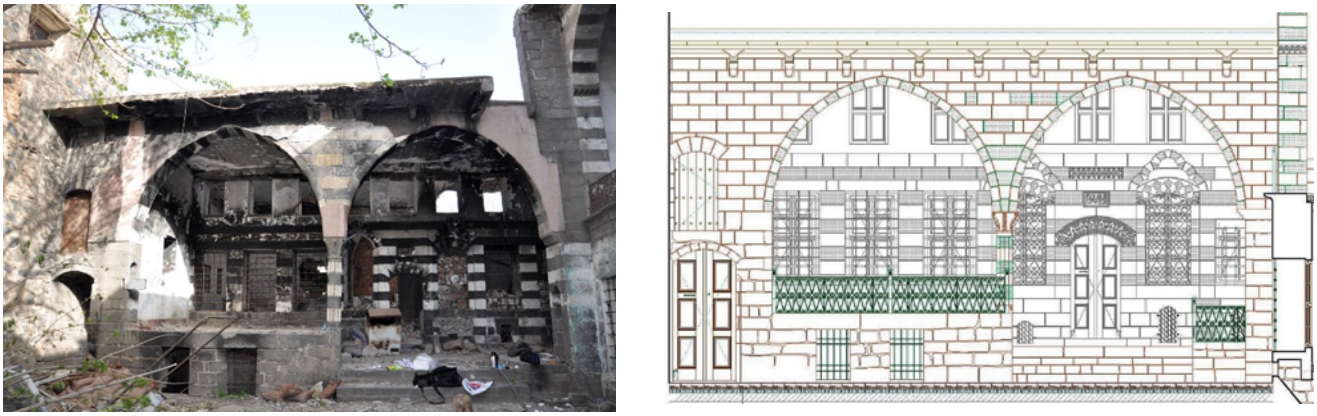

Figure 17. Analytical survey of the east façade of the building facing the courtyard

5. DISCUSSION

The study aims to document the architectural features of the historical Sur Mansion, which is a great necessity for the sustainability of the cultural heritage, by obtaining analytical surveys. In the study, architectural analytical relief drawings of the historical building were created by using orthophotos produced by various techniques from laser scanning as a base. Research carried out on the studied area has shown that by using orthophotos produced from data obtained from terrestrial laser scanning as a base, it can offer an effective and fast solution to produce analytical surveys in an economical and with sufficient level of detail needed in architectural documentation today. This result supports the fact that the use of laser scanning method instead of traditional methods in documentation studies, which is emphasized in many studies to verify the usability of terrestrial laser scanning method in architectural documentation, greatly reduces the time and effort needed in field studies and drawing processes (Alptekin et al. al.,2019; Alyilmaz,2010; Guldur et al.,2015; Karataş et al.,2022;Korzaza et al., 2010; Lerones et al., 2010; Ulvi et al., 2016; Şasi & Yakar, 2017; Ulvi & Yakar, 2010; Yakar et al.,2009; ; Yakar et al., 2015; Yakar & Mirdan, 2017; Yakar & Doğan, 2019; Yakar & Omar ,2016; Yakar, 2015; Yılmaz & Yakar, 2006; Olsen et al.,2010) .

In the study, it is seen that by creating orthophotos with various software on the 3D point clouds of the structures obtained by using terrestrial laser scanning, we can obtain the data that will be the base for the facade, plan and section drawings required for the relief plans. This finding supports the studies that determined that sufficient data can be obtained for architectural documentation by using orthophotos as a base (Comert et al.,2012; Gabriele et al.,2010; Georgopoulos et al.,2004; Koska & Křemen, 2013; Meroño et al. ,2015; Mol et al., 2020; Stober et al., 2018; Yılmaz & Yakar, 2006).

In addition, all the necessary details can be drawn from the data obtained as a result of the study, even for the details on the facades, Comert et al. (2012) and Russo (2017) support the fact that terrestrial laser scanning (TLS) tools do not provide to obtain very good geometric data in terms of high resolution, high accuracy and low uncertainty and to obtain all the details useful in architectural documentation.

6. CONCLUSION

The Historical Sur Mansion, located in the Diyarbakır urban protected area, is a historical building that reflects the general characteristics of traditional houses in Diyarbakır, containing its own characteristics, formed by factors such as topography, materials, climate as well as cultural elements in the immediate environment. The decorations and inscriptions on the iwans, window and door openings of the building are examples of Diyarbakır residential architecture. Research carried out on the studied area has shown that by using orthophotos produced from data obtained from terrestrial laser scanning as a base, it can offer an effective and fast solution to produce analytical surveys in an economical and with sufficient level of detail needed in architectural documentation today.

The architectural documents obtained as a result of the study show that the building has been exposed to material damage to a large extent. Intense deterioration is observed on the facade wall. Intense plaster-paint spills, especially destructions and material loss on the wall surface, and surface contamination on stone surfaces were observed. Interventions were made with cement-added mortar on the stone wall surfaces of the façade. However, it has been determined that structural deteriorations, especially surface pollution, occur on stone surfaces.

In this context, it is necessary to apply various protection interventions to the building in order to ensure the sustainability of the building. Necessary measures should be taken against the deterioration caused by rain water in the house. Since the construction of the top cover with cement-based material in its current state damages the structure, precautions should be taken for the natural conditions that will damage the structure in the first place, and the deformed roof cover should be replaced. The basalt stone roof, which has lost its feature, should be removed and rebuilt in accordance with the original. After the concrete top cover is removed, it is recommended to build a clay soil roof based on the stages specified in accordance with the project.

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Author contributions

Lale Karataş; Methodology, data collection, writing **Aydın Alptekin;** Writing, Control. **Murat Yakar:** Editing the manuscript

Conflicts of interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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