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Architectural documentation with terrestrial laser scanning (TLS) data: Case study of Lutfu Pasa caravanserai (Mathius Caravanserai), Izmir

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Abstract

Lutfu Pasa Caravanserai (Mathius Caravanserai), located in Yeni Mahalle, Lütfü Paşa Street, Tire district of Izmir province, is a two-story, courtyard-style, and masonry structure. The building is also known as Mathius Caravanserai, named after a former owner, a Greek businessman who operated the han during a certain period. Currently, the han is in a neglected state and privately owned. This presented paper aims to obtain survey drawings and reports regarding the historical han's current condition by utilizing observational examination and data obtained from terrestrial laser scanning, with the goal of ensuring the sustainability of the historical structure. The study intends to reveal information about the current state of the han. As a result of the study, the various stages the structure has gone through over time have been determined, and floor plan drawings and reports have been produced. Consequently, architectural drawings of the floor plan have been prepared as analytical surveys to provide information about the current state for future restoration works.

1. Introduction

Architectural documentation is a process used to preserve the design, details, and historical values of a structure. Terrestrial laser scanning is one of the most common techniques used in architectural documentation. Scanning data is utilized for measurements, geometry, material information, and documenting changes in the structure. This provides an accurate and precise foundation for restoration projects or the preservation of historical buildings, ensuring their proper conservation (Karataş, 2023a).

Analytical survey is a process used to document and record the current condition and characteristics of a structure in detail. Terrestrial laser scanning enables the creation of a complete digital replica of both the interior and exterior spaces of the building. This scanning data can be used to analyze the plans, sections, and elements of the structure in a three-dimensional format. Additionally, during the analytical survey process, it provides accurate and precise information about the measurements and geometry of the existing building (Karataş, 2023b).

The aim of the study conducted within this scope was to obtain measured drawings and survey reports of the historical han located on Lütfü Paşa Street in Yeni Mahalle, Tire district, Izmir province, using data obtained from terrestrial laser scanning. The study aimed to reveal information about the current condition of the structure. As a result of the study, the current state of the building, which has undergone various stages of transformation over time, was determined through drawings and reports.

1.1. The location, history, and significance of the structure

The caravanserai is located on Lütfü Paşa Street in Yeni Mahalle, Tire district, Izmir province. It is a one-storey, courtyard-oriented, and rubble-built structure. In some documents, the han is referred to as Mathius Caravanserai (due to its Byzantine origins), Esir Caravanserai (as it was used for buying and selling slaves), or Dellaloğlu Caravanserai. It is understood from the sources of the General Directorate of Foundations that the han was built by the foundation established by

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the Grand Vizier Lütü Pasha in Tire. The building is also known as Mathius Caravanserai, named after a Greek man who operated the han for a period of time. Currently, the han is in a neglected state and privately owned (Figure 1).



(a)



(b)

Figure 1. Lutfu Pasa Caravanserai, located in Tire, Izmir, features a captivating entrance section. a) Entrance section, b) View from a shop inside the caravanserai

2. Method

In the study, literature research, visual observation, and terrestrial laser scanning methods were used to create analytical surveys of the identified structure. The obtained information was evaluated through descriptive and systematic analysis methods. In the initial phase of the research, a situation analysis was conducted on the historical building where the case study would be applied, and general information about the structure was presented based on data obtained from an archival scan. Additionally, an observational analysis was conducted on the structure to document its material issues.

2.1. Documentation of the Architectural Features and Deteriorations of the Structure

The systematic presentation of the stages followed for documenting material deteriorations using methods derived from terrestrial laser scanning is presented in this section, following the analysis of the current condition of the structure.

2.1.1. Scanning Process and Data Processing

For the overall measurement of the structure, a 3D laser scanner of the Leica Geosystems brand, model ScanStation C10, was utilized. When examining the general technical specifications of the device, it offers wide-angle scanning and documentation capabilities, with a range of 360° horizontal and 270° vertical coverage. Additionally, it allows for focused scanning and photography of specific areas and surfaces, enabling detailed and accurate capture of these regions. The device is capable of scanning surfaces with up to 90% reflectivity at distances of up to 300 meters, with a scanning speed of 50,000 points per second. The efficient operating temperature range for the device is between 0°C and 40°C. It is unable to operate effectively below or above these temperature thresholds (Figure 2).



Figure 2. Leica ScanStation C10

The structure was scanned using a terrestrial laser scanning device (Leica Geosystems brand, ScanStation C10 model, 3D laser scanner) (Figure 3). Point clouds were obtained during the scanning process.



Figure 3. Lutfu Pasa Hami during laser scanning of the inner courtyard

2.1.2. Plans and elevation drawings were derived from orthophoto images.

In this section, the steps followed for creating orthophotos using the point cloud data are presented in detail. The point cloud data obtained from the laser scanning process was processed using the software PointCab Origins 4.0 to generate 3D visualizations of the structure (Figure 3). In the next stage, using PointCab

Origins 4.0, cross-sections were taken from desired locations on the 3D visualizations of the structure to produce orthophotos (Figure 4).

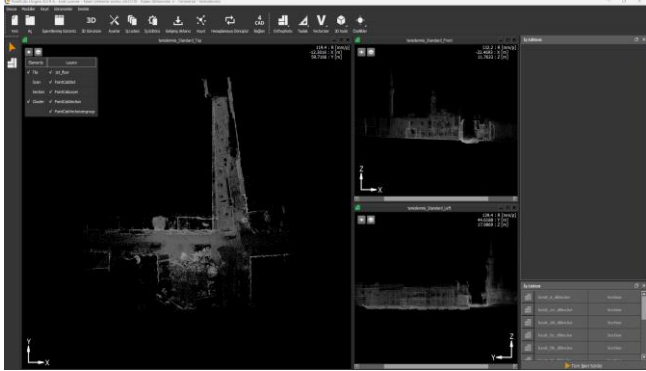
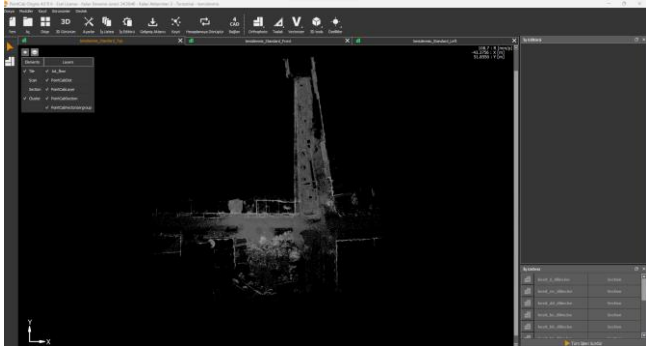
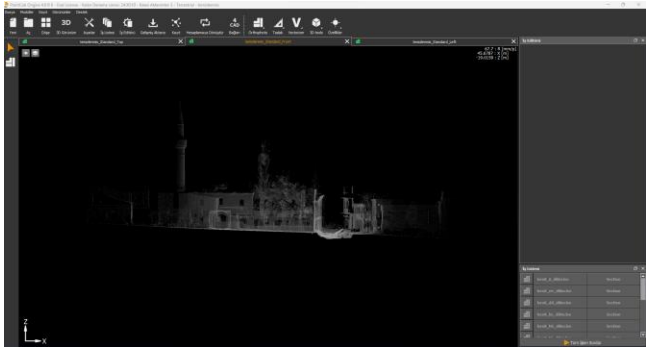


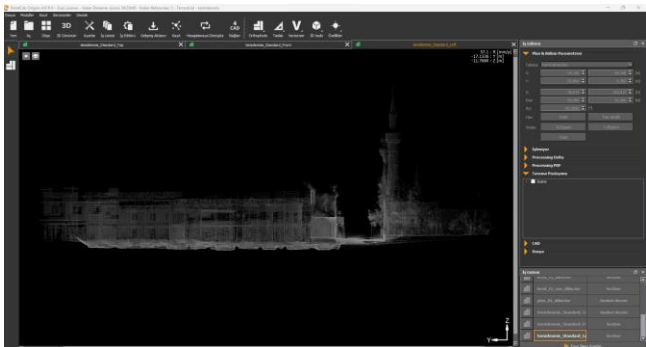
Figure 3. An example scene from PointCab Origins 4.0 program where scaled orthophotos of the structure are obtained



(a)



(b)



(c)

Figure 4. In PointCab Origins 4.0 program, scaled orthophotos of the structure's floor plans can be obtained. a) Floor plan orthophoto; b) Section orthophoto; c) Elevation orthophoto

In the next stage, the AutoCAD software was used to generate architectural drawings. Before the drawing process, the orthophoto images produced in PointCab Origins 4.0 software were transferred to the AutoCAD environment (Karataş et al., 2022a,b,c; Karataş et al., 2023a,b,c; Karataş & Alptekin, 2022). The AutoCAD software supports the common data format of .tif or .tiff files, which allowed for the transfer of orthophoto images to the AutoCAD environment (Karataş & Mentese, 2022). Using the obtained scaled orthophoto images, elevation drawings of the structure were created using the AutoCAD program.

3. Results

The caravanserai located in Yeni Mahalle, Lütfü Paşa Street, Tire district of Izmir province is a two-story, courtyard-centered structure consisting of a ground floor and a single upper floor. The ground floor is devoid of arcades, while the upper floor features arcaded galleries. The han complex is comprised of 24 shops on the ground floor and 37 shops on the first floor, totaling 61 shops. The complex originally had 22 shops facing outward, but the external shops have been demolished. The shops on the other facades are currently being used with unqualified additions.

The entrance to the han is located on the eastern facade. The entrances to the rooms on the ground floor are arched, while those on the upper floor are lintel-shaped. The arcades in the courtyard have been completely demolished except for the western facade. The ground floor portion of the western facade has survived to the present day, but the upper floor section has mostly collapsed, except for the arches and supporting columns.

The caravanserai structure, measuring 40m x 43m, is constructed with rubble stone and brick. While a significant portion of the structure has been preserved to this day, unqualified additions have been made to the open shop area. The approximately 3.6m x 4m-sized shops have been altered with plaster, paint, and new joinery.

Overall, the caravanserai exhibits a traditional architectural style with its courtyard layout and arcaded galleries. Although some parts have suffered damage and alterations over time, the remaining elements provide valuable insights into the historical significance and construction techniques of the han.

The caravanserai structure features a rectangular courtyard in its interior, with a square gallery on the western facade. However, all the galleries on the other facades have collapsed on both floors. The caravanserai consists of rooms on both the lower and upper floors. The vaulted ceilings on the lower floor of the western facade remain original, while the ceiling system on the upper floor has completely collapsed. The arches and piers of the gallery are still intact.

The caravanserai has an entrance on the eastern side, and it comprises thirty-seven rooms on the upper floor and twenty-four rooms and stable compartments on the lower floor. The entrance door and corridor on the eastern facade retain their originality. The doors of the rooms on the ground floor have arches, while those on

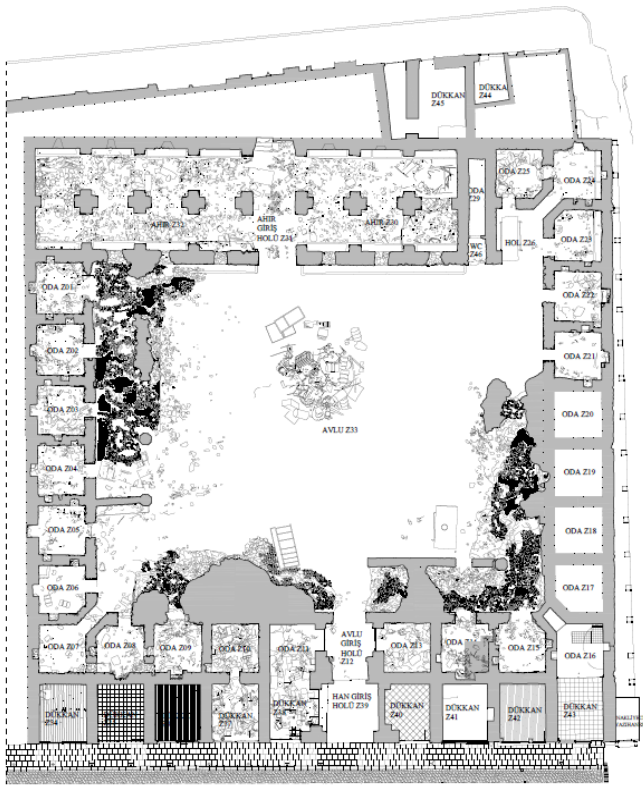
the upper floor have lintels. Out of the twenty-two shops located on the exterior of the caravanserai, the ones facing north on the outer facade have been demolished to provide road width.

After conducting macro and micro visual observations in the previous section, a comparative evaluation was made between the current condition analysis of the structure or monument and the analytical survey drawings obtained from laser scanning and orthophotos. Based on this evaluation, the following findings were obtained regarding the architectural features of the structure (Figure 5):

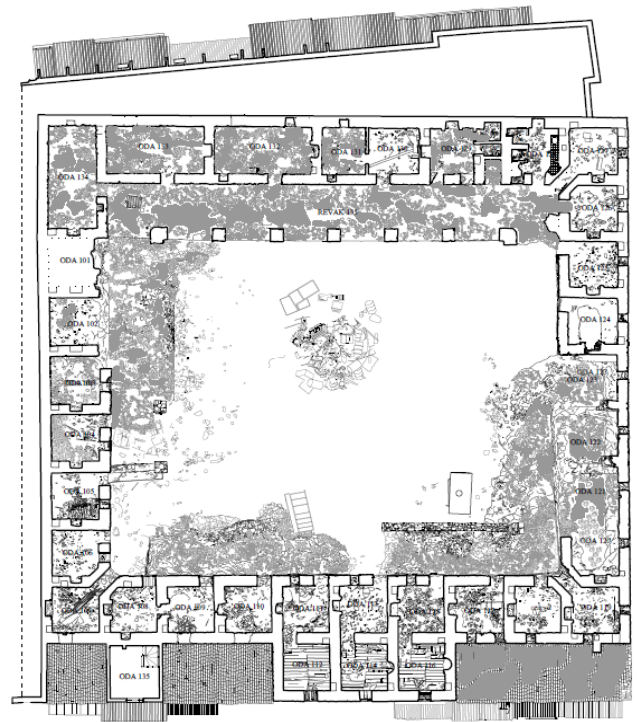
1. **General Layout and Form:** The structure exhibits a compact layout with a ground floor and single-storey height. It has a rectangular plan and is characterized by its courtyard design.
2. **Construction Materials:** The structure is predominantly constructed using traditional masonry techniques, with locally sourced stone as the primary building material. The walls display a

robust and solid construction, showcasing the durability of the materials used.

3. **Architectural Style:** The architectural style of the structure reflects the characteristics of the historical period it belongs to. It exhibits elements of Byzantine and Ottoman architectural styles, blending influences from different periods.
4. **Ornamental Details:** The structure features decorative elements such as carved stone reliefs, ornate arches, and decorative motifs. These details contribute to the aesthetic appeal of the building and provide insights into the craftsmanship of the era.
5. **Preservation Issues:** The comparative analysis reveals various preservation issues, including deterioration of the masonry, weathering of surfaces, and structural instability in certain areas. These findings highlight the need for restoration and conservation measures to ensure the long-term preservation of the structure.



(a)



(b)

Figure 5. Analytical survey drawings: a) Ground floor plan b) First floor plan

4. Conclusion

The conducted study focuses on the documentation of material deteriorations in the historical structure by combining the data obtained through terrestrial laser scanning with on-site observations, aiming to analyze the current condition and architectural features of the historical building. The study exemplifies the methods of transforming the data obtained from laser scanning into orthophotos, which serve as a foundation for

documentation, systematically illustrating the necessary stages of documenting the architectural features and current condition of historical structures.

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