IMAGE-BASED THREE-DIMENSIONAL MODELING OF İZMİR ÇAKALOĞLU KHAN

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by
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ABSTRACT

IMAGE-BASED THREE-DIMENSIONAL MODELING OF İZMİR ÇAKALOĞLU KHAN

Three-dimensional (3-D) documentation in historic building conservation is important in terms of demonstrating the size, shape, location within the settlement, architectural elements, spatial and volumetric features of the building. Alterations, decay in materials, structural problems and damages can be monitored and updated in image-based three-dimensional models of historic buildings. The focus of this thesis is on the image-based three-dimensional modeling of Çakaloğlu Khan, one of the urban Ottoman Khans in İzmir dating from the 19^{th} century. Çakaloğlu Khan is located in the historic Kemeraltı commercial district, to the southwest of Kızlarağası Khan close to İzmir harbor. The building distinguishes itself from other urban Ottoman Khans by its location, its middle passage plan type, its mass made up of spaces of various heights and original architectural elements. The model utilized two-dimensional documentation drawings of the building consisting of plan, elevation, sections and digital photos. Primarily, the photos were edited using the softwares Zoner Photo Studio 10, Adobe Photoshop Elements 7.0 and Inkscape, following which a solid model of the Khan was built and the photos were attached to the model surface. This model was then transferred to Google Earth, and its location on the earth was determined by entering its x, y and z coordinates. This study enabled access and sharing of the three-dimensional image of the building through satellite. The exterior mass and original architectural elements of the building were documented by using low cost digital technology in three-dimensions based on images. The prepared model not only enabled to holistically perceive a building hitherto hidden among densly located buildings, but also created data to discuss numerous alternatives for its conservation decisions.

ÖZET

İZMİR, ÇAKALOĞLU HAN'IN GÖRÜNTÜ ESASLI ÜÇ BOYUTLU MODELLEMESİ

Tarihi yapıların koruma çalışmalarında, üç boyutlu belgeleme; yapının kitlesel büyüklüğünü, şeklini, bulunduğu yerleşimdeki konumunu, yapı elemanlarını, mekânsal ve hacimsel özelliklerini anlatması açısından önemlidir. Tarihi yapıların resme dayalı üç boyutlu modeli üzerinde yapı ile ilgili değişmişlikler, malzeme bozulmaları, strüktürel problemler ve hasarlar izlenebilir ve güncellenebilir. Bu tez çalışmasında, İzmir´de 19 yy. Osmanlı şehir içi hanlarından biri olan Çakaloğlu Han'ın resme dayalı üç boyutlu modellemesi çalışılmıştır. Çakaloğlu Hanı, Tarihi Kemeraltı Ticaret Alanında Kızlarağası Hanı'nın güneybatısında, İzmir körfezine yakın bir alanda konumlanmaktadır. Yapı Osmanlı şehir içi hanları arasında, konumu, orta geçitli plan şeması, farklı mekân yüksekliklerinin oluşturduğu kitlesi ve özgün yapı elemanları ile farklılaşmaktadır. Hanın modelinde iki boyutlu plan, cephe ve kesitleri içeren rölöve çizimleri ve dijital resimler kullanılmıştır. Öncelikle, yapının dijital resimleri Zoner Photo Studio 10, Adobe Photoshop Elements 7.0 ve Inkscape programları kullanılarak düzenlenmiştir. Daha sonra Google SketchUp 8 programı kullanılarak yapının katı modeli oluşturulmuş ve düzenlenen fotoğraflar model yüzeyine uygulanmıştır. Bu model Google Earth'e aktarılarak, yapının x, y koordinatları girilerek, yerküre üzerindeki konumu belirlenebilir. Bu çalışma ile yapının uydudan üç boyutlu görüntüsüne erişilebilir ve paylaşılabilir bir olanak yaratılmıştır. Çalışma kapsamında, yapının bir bütün olarak dış kitlesi ve özgün mimari elemanları düşük maliyetli dijital teknoloji kullanılarak resme dayalı üç boyutlu belgelenmiştir. Hazırlanan model yoğun yapılaşma içinde bütünüyle algılanamayan yapının bir bütün olarak algılanmasına olanak sağlamış, ayrıca çok sayıda alternatif koruma kararlarının tartışılması için veri oluşturmuştur.

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CHAPTER 1

INTRODUCTION

Three-dimensional scaled modeling of historic buildings enables the visualization of existing physical conditions. Spaces and sections of historic buildings, historic and archaeological sites, that cannot be entered or where access is prevented, can be viewed from models. The presentation of a city or an important building in the city can be made through a model. Three-dimensional modeling can make it possible to fully or partially perceive a complex building. Visual simulation on real life in the building can be generated including information on the function of the building. Modeling creates supplementary data for conservation decisions on historic buildings and their environs. Three-dimensional modeling can be used in making conservation decisions, infrastructure works, post-disaster damage assessment, new building design around historic buildings and site-scale analysis. Restitution and post-restoration condition of a historic building can be displayed through the model**.** Three-dimensional modeling is the process of developing a mathematical and geometrical representation of any three-dimensional object (Yıldız 2011). Image-based modeling is also called photo model (Dorffner and Forkert 1998), photorealistic model (Cabrelles, et al. 2010) and textured three-dimensional model (Remondino 2011). A three-dimensional photo model is an object model where the texture information is taken from photographs or other optically working recording system (Dorffner and Forkert 1998).

The three-dimensional model used for the purpose of three-dimensional documentation, three-dimensional visualization and three-dimensional data is a significant research topic in the field of architecture and photogrammetry applications. Different techniques have been developed in the field of modeling and survey. These methods may vary depending on project requirements and the available budget (Rizzi, et al. 2007). There are three different modeling methods, which are image-based method, range-based method and the combination of image-based and range-based methods.

Image-based method (photogrammetry): This technique is widely used in three-dimensional reconstruction of building using, cameras which are metric, nonmetric and digital cameras that are SLR (single-reflex camera) camera and digital compact camera (a point and shoot cameras) with CCD (charge-coupled device) sensor for representation of significant part of building (Bonora, et al. 2003); for city model (Dikaiakou, et al. 2003, Koutsoudis, et al. 2007 and Bleisch, et al. 2009). Recently, also low cost digital cameras have been used for precise and detailed modeling of complex building (Hansen, et al. 2010).

Range-based methods (e.g laser scanning); this technique is based on active sensor that directly captures the geometric three-dimensional information of an object using artificial laser light. Using millions of three-dimensional points, the object, building or area can be correctly modeled for monumental building (Gruen, et al. 2005 and Chevrier, et al. 2009); for archeological area and building in archeological area (Remondino, et al. 2009 and Campana, et al. 2009) This technique is quite expensive and impractical for some fields.

Combination of image-based and range-based methods; since single three-dimensional modeling method is not enough, photogrammetry and active sensor are combined. The complex architectural building (El-Hakim, et al. 2005); a wide archeological area (Dylla, et al. 2010) and monumental building (Foni, et al. 2007) can be quickly and accurately modeled.

Using low cost digital technologies and methodologies like digital compact camera and free softwares is cheaper than range-based methodologies. In addition, low cost technologies are easy-accessibility, application flexibility and low cost budget in the field of digital survey and three-dimensional modeling (Styliadis, et al. 2011).

In this study, the physical condition of Çakaloğlu Khan, dated to the 19th century in İzmir, was modeled with image-based modeling method by using low cost digital technology.

1.1. Subject and Aim

Located in the historic Kemeraltı commercial district, Çakaloğlu Khan is one of the rare urban Ottoman Khan buildings where original architectural features have survived. The building, dated to the 19th century, has architectural and historic values with its middle passage plan type, original architectural elements and mass made up of spaces of various heights. Çakaloğlu Khan cannot be perceived due to densly located buildings around, however, it was deemed necessary to make its mass discernable in order to develop conservation decisions. Therefore, the aim of the three-dimensional modeling of Çakaloğlu Khan is to make the exterior perceivable as a whole so as to create realistic model, as much as, possible to document and to collect three-dimensional data for restitution, restoration and reuse. The study involved the three-dimensional modeling of the exterior mass together with original architectural elements of the building using the image-based technique. This technique is significant, in that, it enables periodical updating of alterations, which were determined through periodically taken photographs.

1.2. Content and Method

The 1/50 scale architectural documentation drawings of the Khan were acquired from the digital archive of the Architectural Restoration Department at İzmir Institute of Technology (IZTECH). These drawings were prepared within the scope of RES 502 Design in Architectural Restoration II Course in 2005-2006[1] and 2009-2010 academic years [2]. The hardware included a computer and a camera, while AutoCAD 2011, Google

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[1] Akbaylar, İ. Irgat, B. Akbulut, Ö. Kibar, A. 2006. "Conservation Project of Çakaloğlu Khan in Kemeraltı, İzmir", Studio Course: RES 502 Design in Architectural Restoration II, Supervisors: Prof. Dr. B. İpekoğlu, Assoc. Prof. Dr. S. S. Tunçoku, Assistants: E. Uğurlu, K. Şerifaki, S Eğercioğlu in the graduate program of Architectural Restoration, İzmir Institute of Technology, İzmir, Türkiye.

[2] Palaoğlu, Ü. 2010. "Revision of Conservation Project of Çakaloğlu Khan in Kemeraltı, İzmir", Studio Course: RES 502 Design in Architectural Restoration II, Supervisor: Prof.Dr. Başak İpekoğlu in the graduate program of Architectural Restoration, İzmir Institute of Technology, İzmir, Türkiye.

SketchUp 7, Zoner Photo Studio 10, Adobe Photoshop Elements 7.0 and Inkscape were used for creating three-dimensional model. The combination of these softwares was previously proposed by Prof. Dr. Gunter Pomaska for the study of three-dimensional modeling of Schloss Ovelgoenne, Bad Oeynhausen, Nordrhein-Westfalen Germany[3]. In three-dimensional modeling of the Çakaloğlu Khan, the same combination was utilized.

The selected digital camera should not to be small pixel and have good lens for high resolution to provide better image quality. That is, digital SLR (single-reflex camera) cameras with changeable lenses or full format frames and digital compact cameras (a point and shoot cameras) with CCD (charge-coupled device) sensor are recommended for images sufficient enough for the purpose (Pomaska 2001). For this reason, Panasonic Lumix FS 30 is used in the photographic documentation of the Khan.

The Khan was photographically documented on 1-26 February 2011 to create a digital photo archive to be used for the three-dimensional modeling. Specifications of the camera are given in Table 1.

Table 1. Technical specification of digital compact camera used for the thesis study (Source: Dpreview 2012)

Camera	Panasonic Lumix FS 30 
Sensor size, Type	1/2. 33" (6.08 x 4.56); CCD sensor
Effective pixel	14.0 megapixel
Focal length	F=28 – 224 mm
Max Resolution	4320 x 3240
Aspect Ratio	4:3 / 3:2 / 16:9
ISO Sensitivity	ISO / 80 / 100 / 200 / 400 / 800 / 1600 High Sensitivity (1600-1900)

[3] Palaoğlu, Ü. 2010: "3D Model of Schloss Ovelgoenne. Bad Oeynhausen, Nordrhein-Westfalen Germany", Studies on Digital Media Applied to Architectural Restoration, WS 2010/2011, Supervisor: Prof. Dr. Gunter Pomaska, Department of Architecture and Civil Engineering, Bielefeld University of Applied Science, Germany.

The 248 facade photographs were taken to create a digital photograph archive. However, only 92 photographs were used to cover the three-dimensional model. Densly located costructions around the khan caused to lack of sufficient distance to take the whole view of each facade with single shots. Therefore, each portion was documented separately.Between 2 and 5 photographs were taken for each shop facade. Photographs were taken considering the principles of single image rectification. Four control points are enough to rectify a scaled image (Turan 2003). Each photo was taken parallel to the building facade. Attention was paid to photographic documentation in cloudy weather and refrain from shaking and the camera. Shadows, reflections, and backlights or burned photographs should be averted (Arias, et al. 2007).

The scale and maximum shooting distance of the photographs were determined according to focal length of camera. Maximum shooting distance was selected as 28 m during photographic documentation. The distance range was calculated by the following formula (Swallow, et al. 2004):

$$\text{Negative Scale} = \frac{\text{Focal length}}{\text{Distance}} \qquad (1.1)$$

There are two scales involved as negative scale and output scale. Output scale is the enlargement of negative scale four or five times. Table 2 is illustrated in order to explain the relation between these scales (Swallow, et al. 2004). Maximum shooting is defined as 28m for negative scale 1/1000 and output scale 1/200.

Table 2. Scales for rectified photography
(Source: Swallow, et al. 2004)

Output Scale	**Negative Scale, range**
1:50	1:150 to 1:250
1:200	1:80 to 1:1000

$$\frac{\text{Focal length}}{\text{Distance}} \approx 1{:}1000 \text{ for } 1{:}200 \text{ scale} \tag{1.2}$$

$$\frac{28 \text{ mm}}{\approx x \text{ meters}} \approx \frac{1}{1000} \rightarrow x \approx 28000 \text{ mm} \rightarrow x \approx 28 \text{ meters} \tag{1.3}$$

The methodology for the three-dimensional modeling of the Khan is shown in Figure 1. The image-based modeling study can be examined in three parts as; data acquisition, digital image processing and three-dimensional visualization and evaluation. First, in data acquisition process, facade and architectural element photographs of Çakaloğlu Khan were taken and existing two-dimensional CAD drawings were used. Second, in the digital image processing, the photographs were edited by Zoner Photo Studio, Adobe Photoshop Elements 7.0 and Inkscape Software. Thus, the photographs were made ready for three-dimensional visualization and evaluation. Third, in three-dimensional visualization and evaluation process, two-dimensional CAD drawings were used for creating solid model in Google SketchUp 7 Software. The photographs were attached to the related facade in the solid model with texture mapping tools in SketchUp. Thus, a reality image-based mass model of the Khan was created by adjusting render on illumination settings (see 3.3.4 in Chapter 3).

The acquired photographs were edited with the software Zoner Photo Studio 10. This software was used for lens distortion correction, rectification and resampling to produce texture maps. Perspectives in the photographs resulting from angled shots were rectified and optical distortions were corrected. As the building is rectangular in plan, it was important for the photographs to display horizontal and vertical sides and four corners of facades. Once the photograph file was opened in Zoner Photo Studio 10, the four corners of the facade were overlapped with the rectangle on screen to eliminate perspective view in the photograph and remedy optical distortions. The photograph file was saved with a different name to create a digital archive to be used for the image-based modeling of the Khan (see 3.2.1).

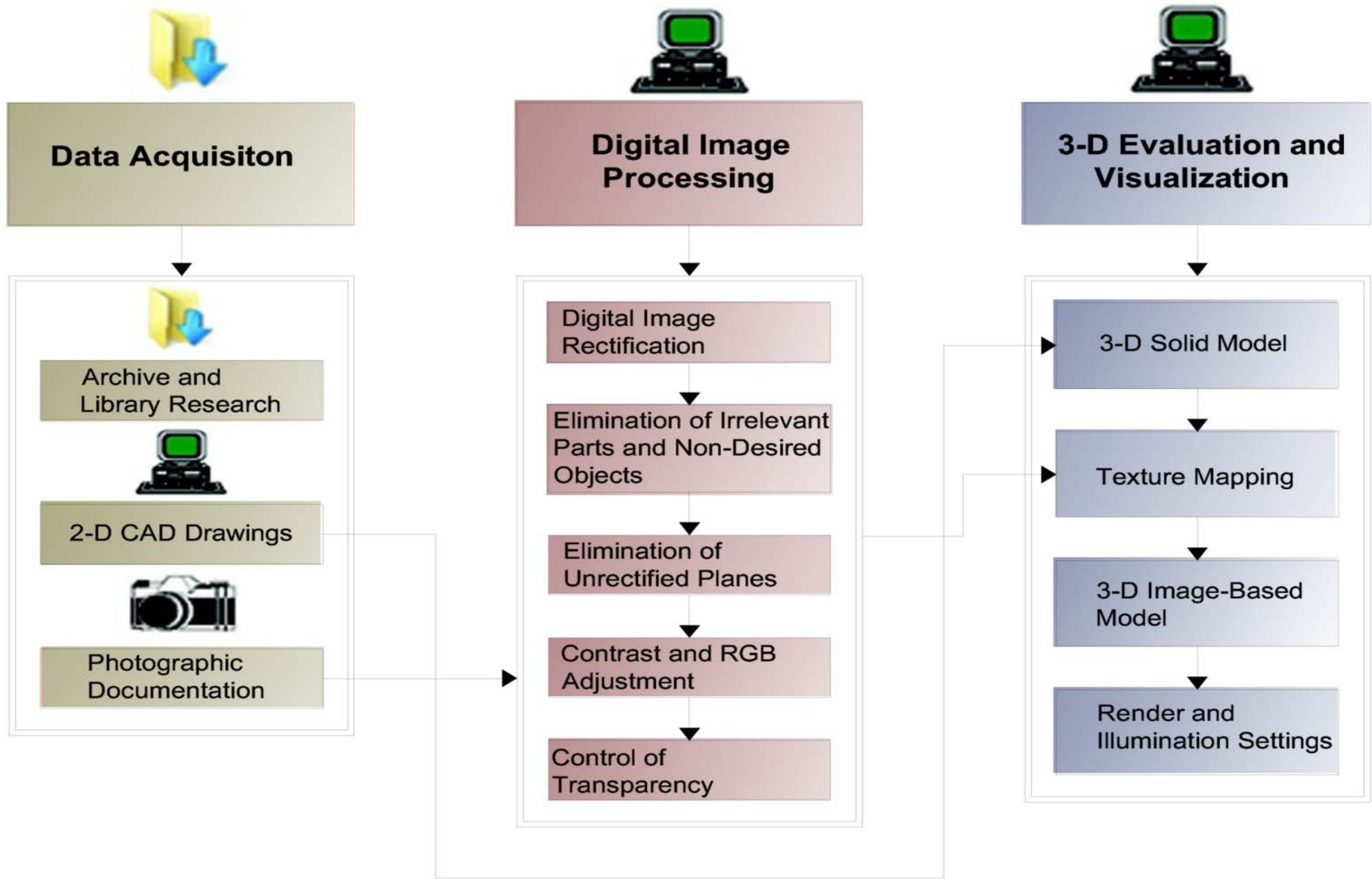


Figure 1. The flow diagram illustrating the method of the study.

After this stage, the photograph edited and saved in Zoner Photo Studio was opened in Adobe Photoshop Elements 7.0 to erase obstructing elements such as people, trees, cars etc. Protruding elements, such as panels, that were in perspective due to the angle of the shot were edited (see 3.2.2). The awnings in front of the shops on 897 Street hindered photograph shots. The facades of each shop were photographed in two stages, from the ground and the second floor of the neighbouring buildings on 897 street and 895 street. Following this phase, the photographs were combined in Adobe Photoshop Elements 7.0. Unrectified planes on photographs were edited in Adobe Photoshop Elements 7.0 (see 3.2.3). Contrast and RGB (Red, Green and Blue) adjustments were made to achieve chromatic harmony among the photographs (see 3.2.4).

Inkscape was used to derive non photorealistic - texture from photographs. Neutral surfaces were created in the photographs in order to eliminate elements behind shop windows and windows that complicated perceptions in three-dimensional modeling (see 3.2.5). The photographs were saved in Inkscape. All facade photographs were made ready for the image-based model.

Google SketchUp 7 was used for producing photorealistic model. It was preferred for its feature that enables transfer of dwg drawings, fast generation of models and ease of access through the internet. The CAD drawings in the digital archive of the IZTECH Architectural Restoration Department were used in the image-based modeling and a scaled exterior solid model was generated. An image-based mass model of the Khan was developed by attaching the related facade photographs to the solid model. The original architectural elements in the middle passage were photographed individually and attached to the solid model surface to create the image-based model. As a result, a scaled three-dimensional image-based exterior mass model of the building together with the model of original architectural elements was formed (see 3.3).

1.3. Literature Review

Publications on modeling studies concerning historical monuments and buildings (Bonora, et al. 2003; Foni, et al. 2007 and Chevrier, et al. 2009), archeological conservation areas (Gruen, et al. 2005; Remondino, et al. 2009; Campana, et al. 2009 and Dylla, et al. 2010) historic and traditional settlements (Dikaiakou, et al. 2003; Turba, et al. 2004; Koutsoudis, et al. 2007 and Bleisch, et al. 2009) can be examined under the following headings:

- Modeling of historical buildings to document their existing conditions
- Modeling for the restitutional analysis of historical buildings
- Modeling for reconstruction purposes in settlement scale
- Modeling to demonstrate historic construction techniques
- Modeling for documentation at archeological excavations
- Modeling for post-disaster damage assessment
- Modeling for the development of conservation decisions in historic and traditional settlements
- Modeling for the presentation and exhibition of cities
- Modeling to document cultural heritage in relation to topography

1.3.1. Modeling of Historical Buildings to Document their Existing Conditions

El-Hakim, et al. (2005) studied the three-dimensional modeling of Stenico Castle in Trentino, Italy using multiple types of data. The aim of this study was to accurately and completely model several of the Terantino Castles, beginning with Stenico Castle. CAD and architectural drawings, photogrammetry, automated image-based techniques and laser scanning were used for documenting the complex castle building. Measurements of the castle were used to generate both general and detailed models of the castle (Figure 2a, 2b). Photogrammetry and automated image-based technique were used in the general model. Laser scanning technique was utilized in the geometric details and parts of the castle (Figure 2b). As a result, an accurate and photorealistic model was created by using different techniques.

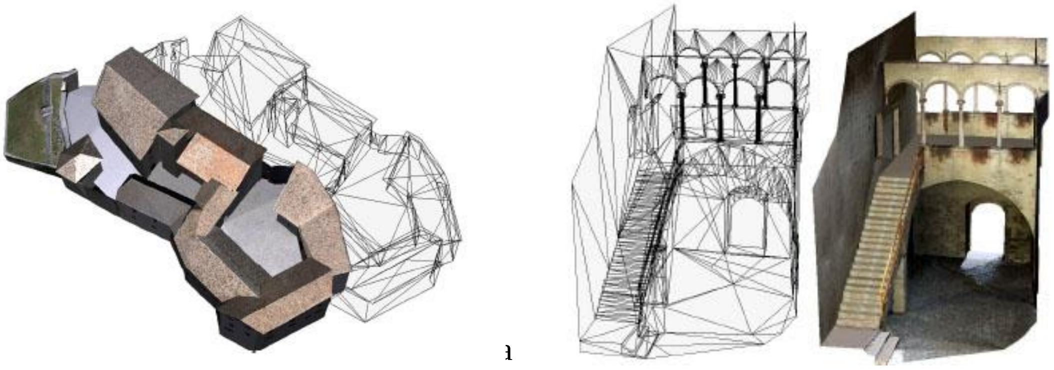


Figure 2. Three-dimensional model of Stenico Castle (a) detailed model of the Castle Loggia (b), Trentino, Italy (Source: El-Hakim, et al. 2005)

Hansen, et al. (2010) made a three-dimensional image-based model of Episkopi Church located in Greece (Figure 3). The aim was to support the CARARE (Connecting Archaeology and Architecture in Europeana) Network which includes digital archives and two-dimensional, three-dimensional virtual reality of architectural and archeological heritage. Image-based technique was used creating three-dimensional model of Middle Byzantine Church to CARARE. It is focused to be directly downloaded for use.

Figure 3. Middle Byzantine Church, 1200 A.D, Episkopi Manis, Greece (Source: Hansen, et al. 2010)

1.3.2. Modeling for the Restitutional Analysis of Historical Buildings

Foni, et al. (2007) presents three-dimensional modeling of Hagia Sophia Ottoman Mosque and Byzantine Church in İstanbul, Turkey, based on virtual life simulation and virtual restitution. This study describes techniques used to achieve real time rendering and animation of selected spaces and their characters. Wireframe detail of Hagia Sophia with polygonal modeling technique was used in order to achive three-dimensional Non-Uniform Rational Basis Spline (NURBS) model (Figure 4). Both virtual restitution of building were modeled as original Byzantine Church and as modified Ottoman Mosque. The restitution of image fresco of Byzantine Church could not be depicted because of the lack of sufficient historical and archaeological data. This study is important for three-dimensional documentation of virtual life based on restitution of Hagia Sofia redesigned from church to mosque.

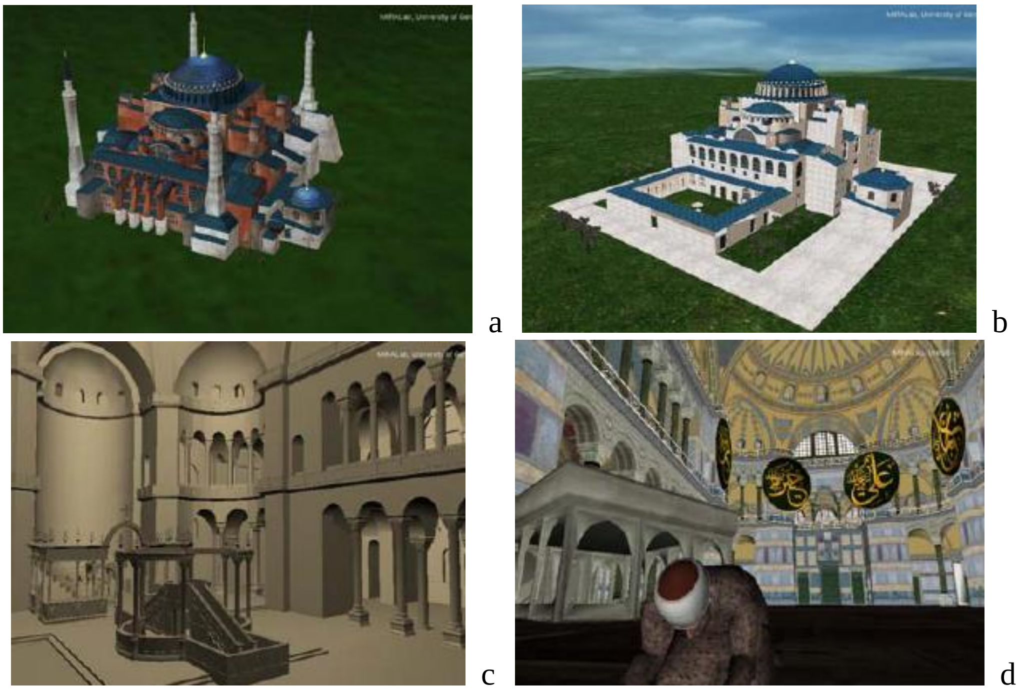


Figure 4. Three-dimensional model of Hagia Sophia, İstanbul, Turkey the exterior of Ottoman Mosque (a) the exterior of Hagia Sophia Byzantine Church (b) the interior of Hagia Sophia Byzantine Church (c) the interior of Hagia Sophia Ottoman Mosque (d) (Source: Foni, et al. 2007)

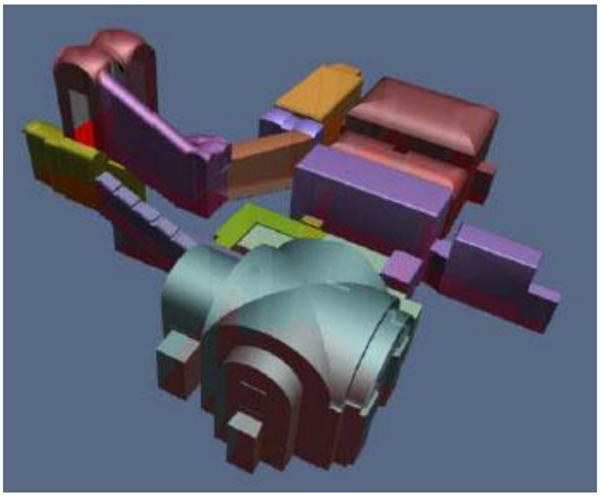
Chevrier, et al. (2009) discusses the three-dimensional modeling of Saint Abbey Church in France. They aimed to create a digital archive of three-dimensional models of many types of architectural elements such as columns, vaults, cornices, balconies, pediments, cupolas, sculptured elements and so on. Photogrammetric method was used to build the global shape of the building, but without details like column, volutes and vaults. Point clouds technique was used with pictures, two-dimensional plan and architects sketches to create three-dimensional model of architectural elements. The result is accurate, consistent and reusable model (Figure 5).


a

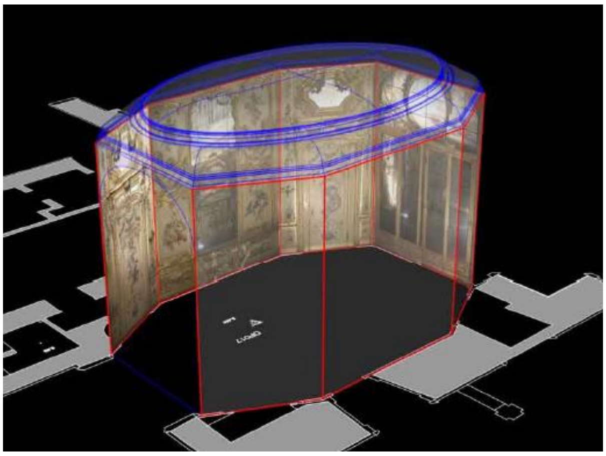
b

Figure 5. Three-dimensional model of Saint-Sauveur Abbey, Nancy, France, interior view (a) exterior view (b) (Source: Chevrier, et al. 2009)

Bonora, et al. (2003) created a three-dimensional model of Royal Palace in Turin**.** The aim of the study was to investigate and communicate how a structure is shaped and built up; this is the reason why architectural studies often use models to integrate two-dimensional representation and drawings. This study distinguishes two different three-dimensional model types. In A type model, the goal of topographic survey was to generate detailed geometric descriptions and construction character of all parts of the building spread on different levels. The geometric model was created with topographical survey (Figure 6a). In B type model, the photo realistic model of objects were ceated with texture mapping onto surfaces. Images taken from interior space were arranged for the representation of the image-based three-dimensional model (Figure 6b).



a



b

Figure 6. Royal Palace, Turin, Italy, whole solid model (a) the interior view of image-based model of Lounge “Orba” (b) (Source: Bonora, et al. 2003)

1.3.3. Modeling for Reconstruction Purposes in Settlement Scale

Using laser scanning technique, Dylla, et al. (2010) discusses the three-dimensional modeling of the entire city of ancient Rome to demonstrate the urban development of the city in 320 A. D. The project distinguishes buildings in two different parts Class I and Class II elements found in combination in the entire city of ancient Rome. Class I elements give information about identification, location and design. Class II elements give information about mass and geometry. Position of Class II elements derived from a laser scanner of the large scale model of ancient Rome. Architectural elements such as balconies, windows and doors came from photo texture. The project shows how it utilized procedural modeling techniques and parametric modeling techniques to create visually detailed models of the Class II elements in digital model of ancient Rome. Laser scanning technique and image based technique were combined (Figure 7).

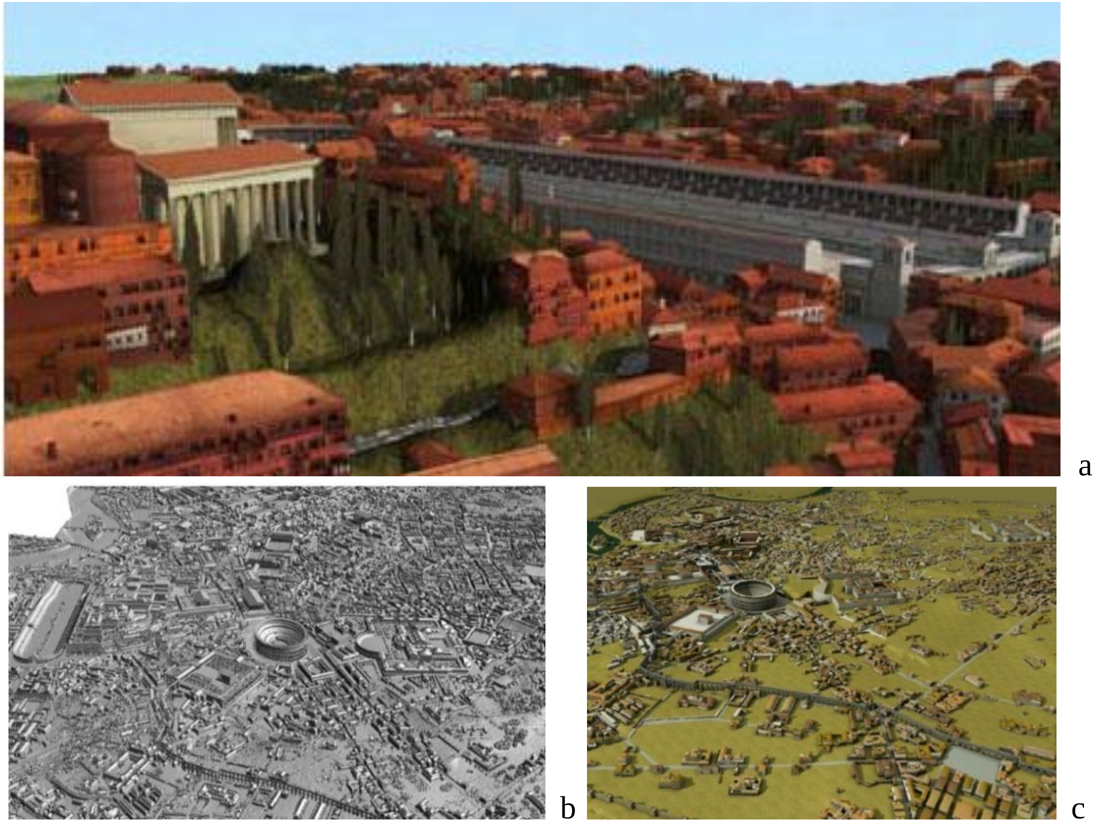
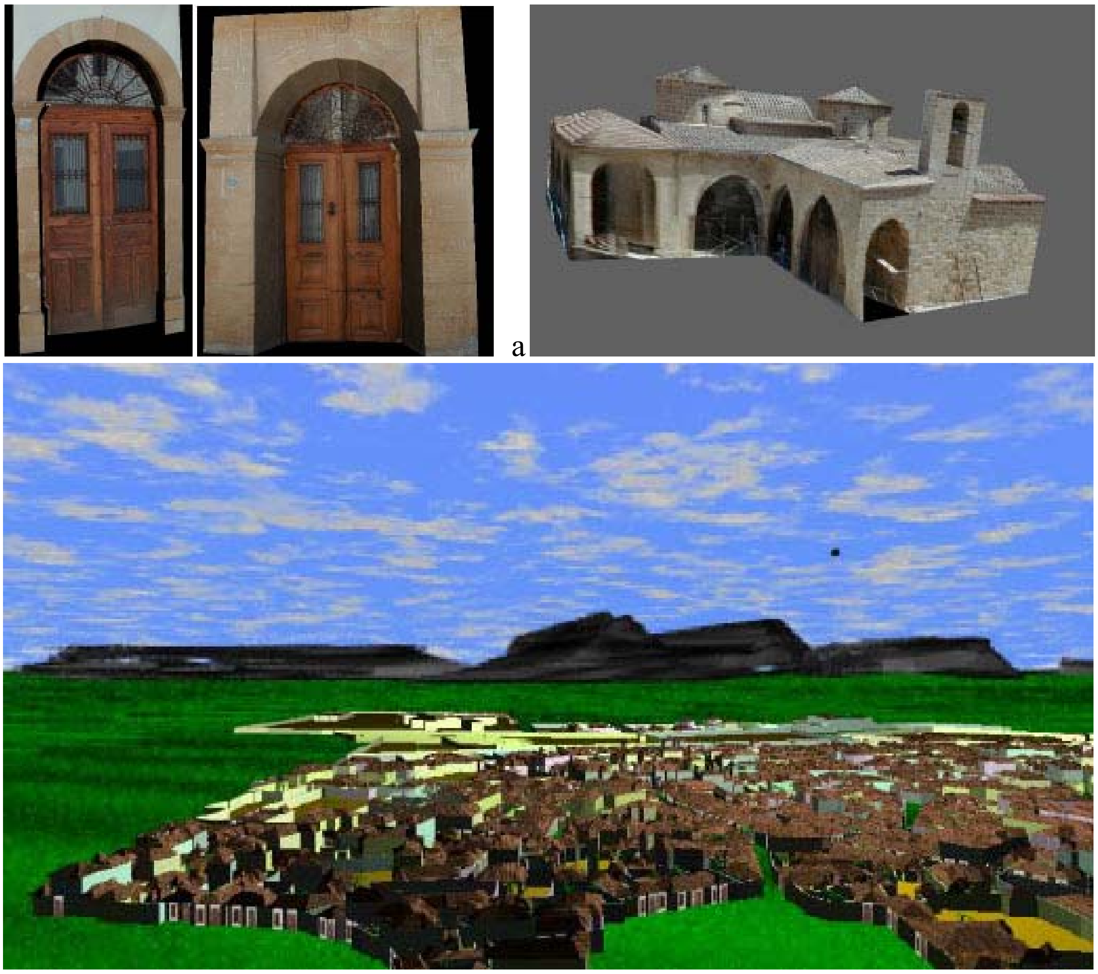


Figure 7. Rome, Italy, three-dimensional model of Rome Reborn (a) detail model of Plantico di Rome Antico by laser scanning technique (b) and the resulting massing model (c) (Source: Dylla, et al. 2010)

Dikaiakou, et al. (2003), in the model of the Walled City of Nicosia in Cyprus, aimed to create three-dimensional models of geometric and architectural styles of the buildings in the area. In this model, the traditional houses and the construction of the three-dimensional model was created with three-dimensional components from a digital library containing elements such as windows, doors and balconies (Figure 8a) and display significant buildings such as Chrysaliniotissa Church. The Church was modeled from photographs (Figure 8b). The study required numerous photographs to get textures on to the model surface. The three-dimensional digital model of the city was created with ImageModeler software. Three-dimensional building blocks were defined using two-dimensional digital data (Figure 8c).



a b c

Figure 8. Three-dimensional model of Nicosia City, Cyprus, typical doors for original courtyard houses from component library (a) the Chrysaliniotissa Church built with Image Modeler Software (b) Nicosia Walled City (c) (Source: Dikaiakou, et al. 2003)

1.3.4. Modeling to Demonstrate Historical Construction Techniques and Process

In this study, the visual model of the construction of the Great Pyramid from beginning to end in Egypt is explained. The aim of this study was to describe the construction process of the Pyramid with three-dimensional technology and real visual simulation (Figure 9).

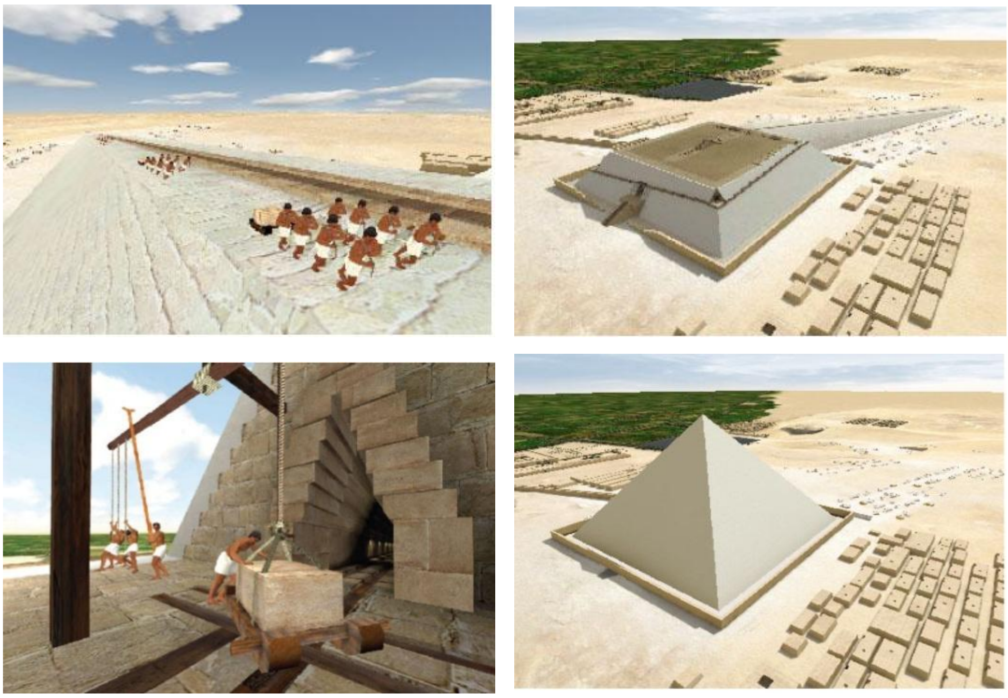


Figure 9. Three-dimensional modeling and simulation of the construction of the Great Pyramid from beginning to end, Egypt (Source: Khufu.3ds 2012)

1.3.5. Modeling for Documentation at Archeological Excavations

Remondino, et al. (2009) studied the current state of the Acropolis temple in Maya Site of Copan archaeological area. The project aims are; (i) the reality-based 3D modeling of the East Court (ca 35x40m) with its Temple 22 inside the old Acropolis of the site, (ii) the precise three-dimensional model modeling of some of the famous Copán's stelae, (iii) the virtual reconstruction of different structures (mainly pieces of architectural sculpture) located in the local museum and also in foreign museums, together with their re-integration into the reality-based three-dimensional model of the Temple 22. The three-dimensional model was created by using UAV (Unmanned Aerial Vehicles) and terrestrial images, while using TOF laser scanner to acquire better results to remedy the smoothing effect at the corners (Figure 10).

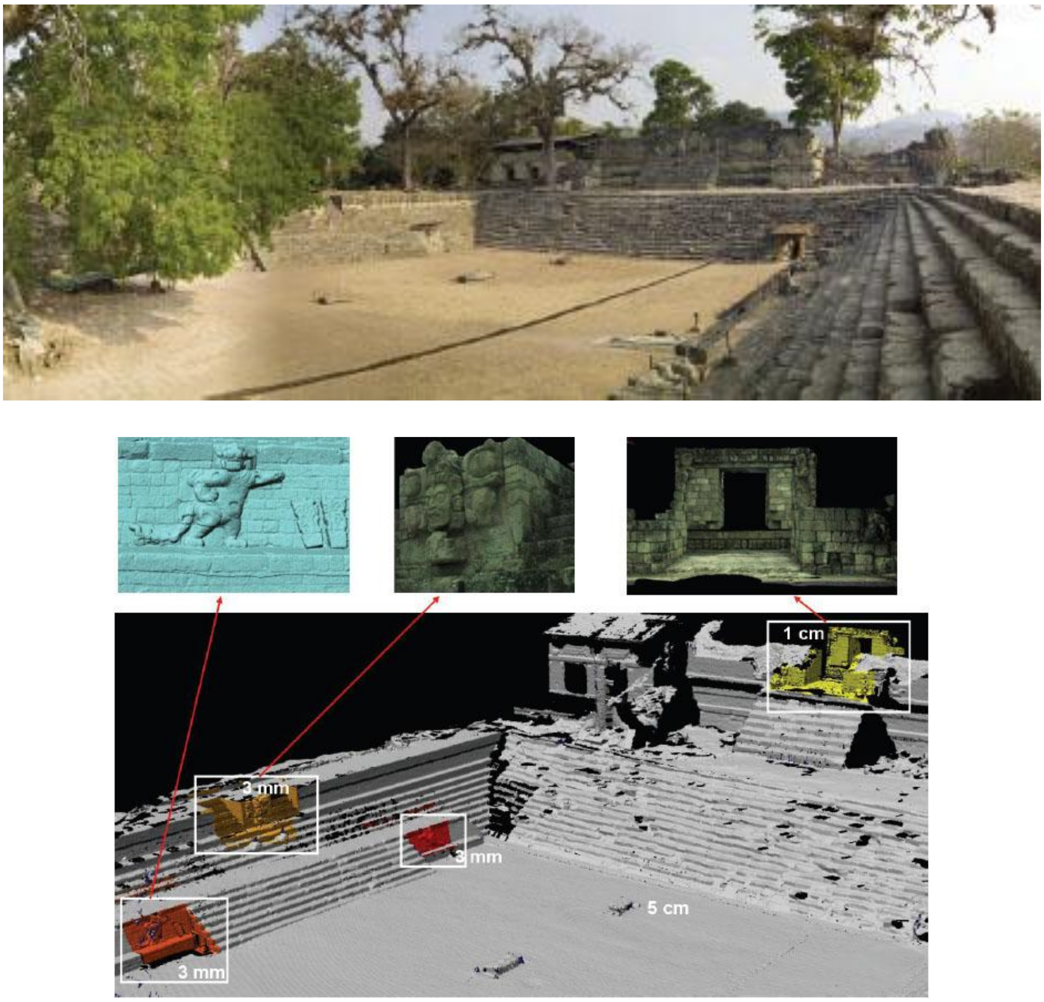


Figure 10. Maya, Copan, panoromic view of the excavation field, UAV (Unmanned Aerial Vehicles) image taken from the east courtyard and temple 22 (Source: Remondino, et al. 2009)

Campana, et al. (2009) focused on the excavation of a late antiquity-early medieval church at Pava in the province of Siena, Italy. It was aimed to require fast but precise and detailed digital documentation of archaeological excavations. They describe the advantages and features of utilizing three-dimensional technology at archaeological excavations. DSM (Dense Surface Model) of excavation produced by using laser scanning technique. Approximately 5 million points were obtained in ca 3 hours of work. Image-based technique was used for color-shaded, shaded and texture models of the Church in the excavation area and were generated by taking three close-range photographs from a simple camera. Due to a pretty detailed DSM, the church wall could be easily modeled using few points and geometric entities (Figure 11).

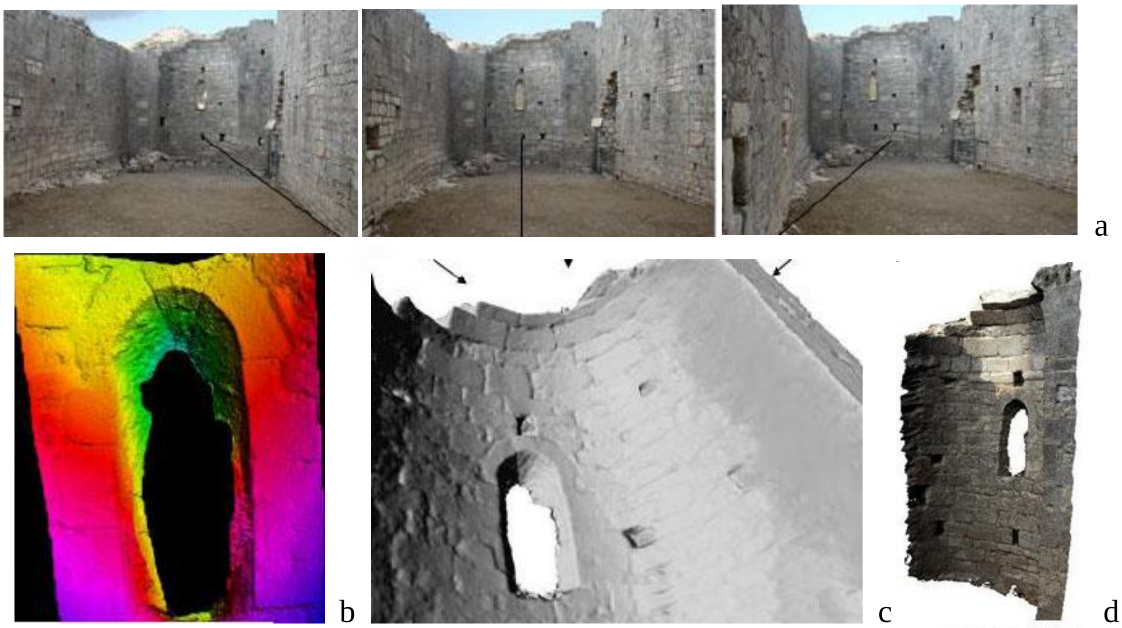


Figure 11. Three-dimensional model of the Church in the excavation area, Siena, Italy, three original images taken from inside the church (a) color shaded model of the church interior (b) shaded model (c) textured model (d) (Source: Campana, et al. 2009)

1.3.6. Modeling for Post-disaster Damage Assessment

Turba, et al. (2004) a three-dimensional model of Prague was prepared by the city development authorities in the Prague Municipality Strategical Planning Department for areas estimated to be damaged by flooding (Figure 12). This model was supplied to evaluate water level at culmination and the damage estimation of buildings. The post-disaster damage estimation was made on a city model.

Figure 12. Post-disaster damage identification in Prague (Source: City Development Authority Prague, Strategic Planning Department, 2004)

1.3.7. Modeling for the Development of Conservation Decisions in Historic and Traditional Settlements

Prague Castle in Czechoslovakia image-based modeling has been developed by the LIDAR Software based on aerial and terrestrial images (Figure 13). Three-dimensional modeling provides new opportunities for planning and visualization of decisions on new building design and building reconstruction.

a

b

Figure 13. Three-dimensional model of historic Prague Castle, Prague, Czechoslovakia, based on aerial and terrestrial images (a) the documentation of Prague Castle based on terrestrial and air image (b) (Source: ISPRS 2007)

In the study of Koutsoudis, et al. (2007) a three-dimensional modeling study to document part of the traditional residential area of the city of Xanthi in Greece was made (Figure 14a). The study aimed to create three-dimensional modeling of low-infrastructure investments such as walking paths (Figure 14b). The model, generated by image-based technique and photogrammetry, was made more realistic through the use of models and video.

Figure 14. Image-based modeling of the city of Xanthi, Greece, facades (a) perspective views from the three-dimensional model (b) (Source: Koutsoudis, et al. 2007)

1.3.8. Modeling for the Presentation and Exhibition of Cities

In the study, Bleisch, et al. (2009) a three-dimensional model of Solothurn City in 1820 was produced with image-based modeling technique using an architectural model of the city showing its state in 1820 (Figure 15). The project aimed at digitally documenting, visualizing, displaying and presenting the architectural model. The digital model contains data of the city, its buildings and their residents in the 1820s. Also, this model is important to document as digital and three-dimensional modeling of city in 1820.

Figure 15. Three-dimensional model of the city of Solothurn, Switzerland, using image-based modeling technique (Source: Bleisch, et al. 2009)

1.3.9. Modeling to Document Cultural Heritage in Relation to Topography

In their project, Gruen, et al. (2005) created a three-dimensional model of Bamiyan (Afghanistan), which is a UNESCO World Heritage Site, by multi-resolution and multi-temporal images. Satellite images, digital aerial camera, radar and hyperspectral sensors, gps/ins positioning systems, aerial and terrestrial laser scanners, terrestrial style video, video and panoramic cameras were used as tools for modeling of the site. The purpose of this study was the documentation of the Great Buddha statues situated in the Bamiyan Cliff that were intentionally dynamited and destroyed by the Taliban in March 2001 which were inscribed into the World Heritage List, by using three-dimensional modeling technique (Figure 16).

Figure 16. Three-dimensional documentation, modeling and visualization of Buddha Sculpture in Bamiyan, Afgahanistan (Source: Gruen, et al. 2005)

CHAPTER 2

HISTORICAL AND ARCHITECTURAL INFORMATION CONCERNING WITH ÇAKALOĞLU KHAN

Çakaloğlu Khan, dated to the 19th century, has architectural and historic values. The building distinguishes itself from other urban Ottoman Khans by its middle passage plan type, its mass made up of spaces of various heights and original architectural elements. It is located in the historic Kemeraltı commercial district.

2.1. Development of Trade in İzmir

Trade in İzmir came under Ottoman rule in the 16th century and developed, when the Genoan-ruled Chios Island conquered by Ottoman naval forces in 1566. After this date, İzmir harbor acquired the role of island as the bridge between eastern and western trade (Çelik 2000). İzmir became the last stop of long distance caravan trade routes that originated in the Far and Middle East and ran through Anatolia (Göregenli 2009). In this way, merchandise coming from Anatolia could be distributed from the wide and sheltered harbor of the city to the West (Figure 17). In the 17th century, İzmir collected goods from western Anatolia and exported them to other countries, primarily Europe (Yeğin 2009). Until the 18th century, İzmir sold goods brought to the city by long distance caravans, while after this period, once the export ban on local goods was lifted, the city turned into a harbor from which goods obtained from the productive lands of the Aegean were exported (Göregenli 2009). In the 18th century, the locals were engaged in retail trade, and the trade of textile products was fairly developed. In this period, Büyük and Küçük Vezir Khan (17th century), Fazlıoğlu Khan (17th century), Büyük and Küçük Karaosmanoğlu Khan (18th century), Küçük Demir Khan (17th century), Mirkelamoğlu Khan (18th century), Derviş Khan (18th century) and Kızlarağası Khan (18th century) were areas where commercial activities took place (Atay 1992) (Figure 18, 19 and 20). The investments of non-Muslims (Jews, Armenians, Levantines and Greeks) and Ottoman military class helped to develop commercial life in İzmir (Çelik 2000).

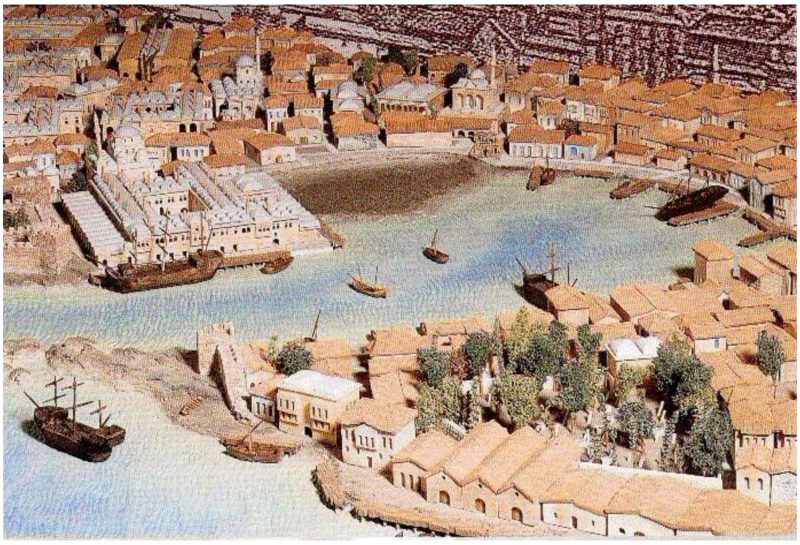


Figure 17. Inner harbor of Kemeraltı in the 17th century
(Source: Göregenli 2009)

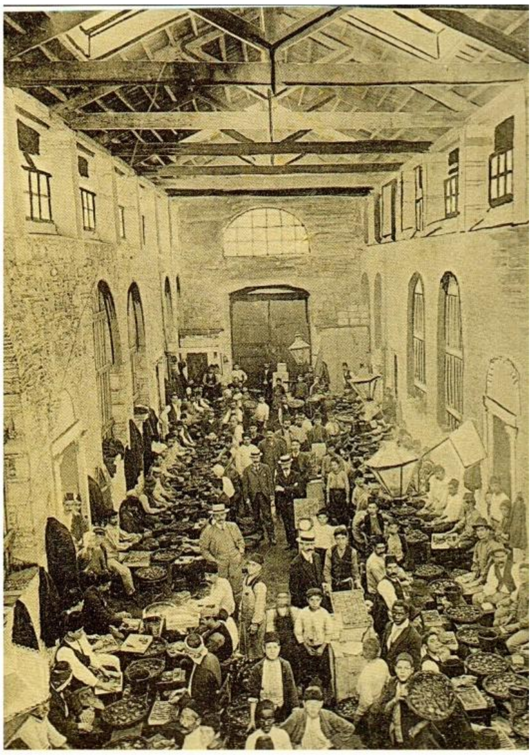


Figure 18. Fig processing, a Khan
(Source: Yeğin 2009)

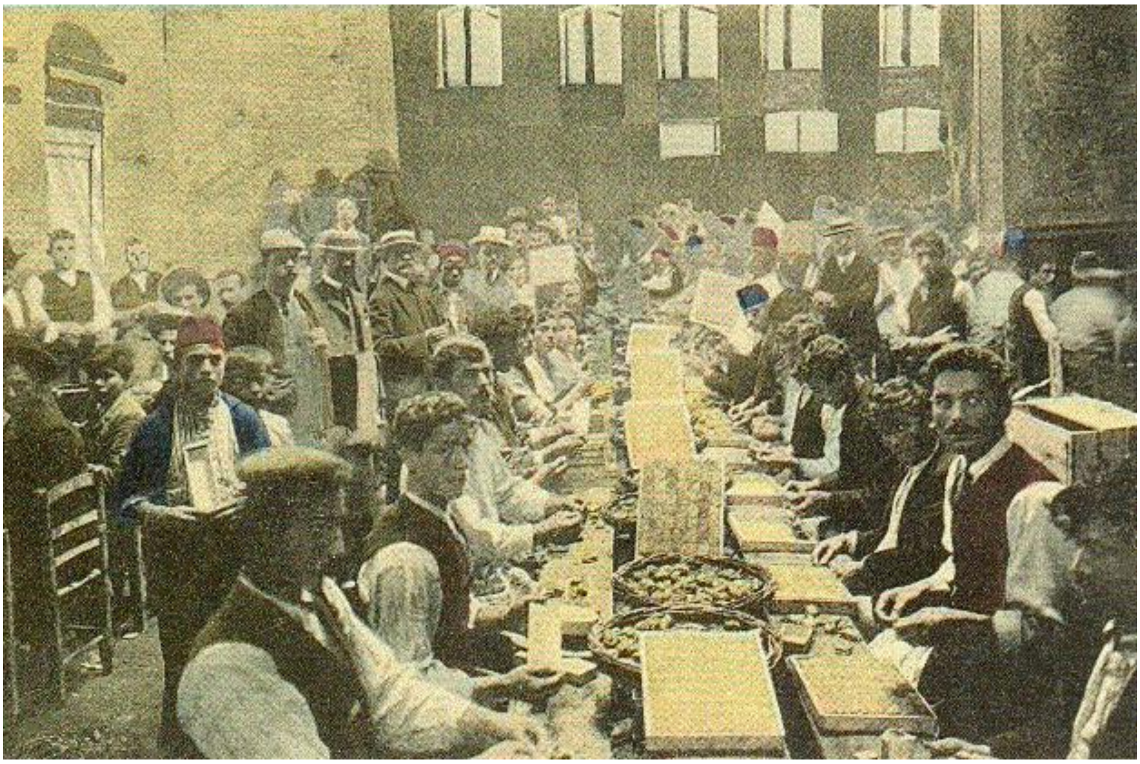


Figure 19. Filling boxes with figs
(Source: Yeğin 2009)

Figure 20. Classification of figs
(Source: Yeğin 2009)

As commercial activities and the number of consulates in İzmir increased from the end of the 18th century onwards, large Ottaman khans in Kemeraltı were divided into offices. These buildings were used as offices of Armenian, Greek, Levantine, Jewish Ottoman subjects working as intermediaries following the businesses of European tradesmen (Atay 1998). While traditional urban Ottoman khans changed their function in this way, the amount of goods arriving to İzmir continued to increase. This resulted in the need for storage spaces to keep the goods until they were exported (Atay 2003). At the beginning of the 19th century, İzmir was the sole export harbor of the Ottoman State in Anatolia. The inner harbor was filled as a result of developing commerce and new khans and storage buildings were constructed in this area. As the arrival of goods intensified, new storage buildings were constructed instead of traditional khans (Atay 1992). Accommodation spaces of old khan buildings started to be used as offices of business trackers and brokers. The inner harbor in İzmir bay was filled up during the second half of the 18th century and following the construction of a new embankment, new buildings were built on the filled area. As one of these buildings, Çakaloğlu Khan is situated in Halim Ağa Çarşısı, what used to be known as the Kasap Hızır District (Figure 21).

2.2. History and Location of Çakaloğlu Khan

Çakaloğlu Khan does not have a inscription panel. Although its precise construction date is not known, judging from its location and architectural features, it can be suggested to be from the 19th century.

A 19th century Ottoman urban khan, Çakaloğlu Khan is located between 895 and 861 streets in what was the Kasap Hızır District, which is known today as Halim Ağa Çarşısı (Figure 22). At present, the khan, together with other surrounding khan buildings, lies in the Kemeraltı Historical Commercial District (Figure 23). It is located to the southeast of Konak Pier, which used to be the Old Fish Market, and to the southwest of the Kızlarağası Khan, close to İzmir bay (Figure 24). Spread over a northwest-southeast direction, the Khan has a rectangular plan with a middle passage, which connects 895 and 861 streets (Figure 25, 26, 27 and 28). The Khan is entered through the gates on two ends of the middle passage. Both these streets are open to traffic, while 897 Street, facing the northeast facade of the Khan, is a pedestrian road.

Çakaloğlu Khan is one of middle passage plan type khans in İzmir that has fully or partially survived. Other middle passage khans are Abdurrahman Khan, Cambaz Khan, Esir Khan and Musevit Khan (Ersoy 1998).

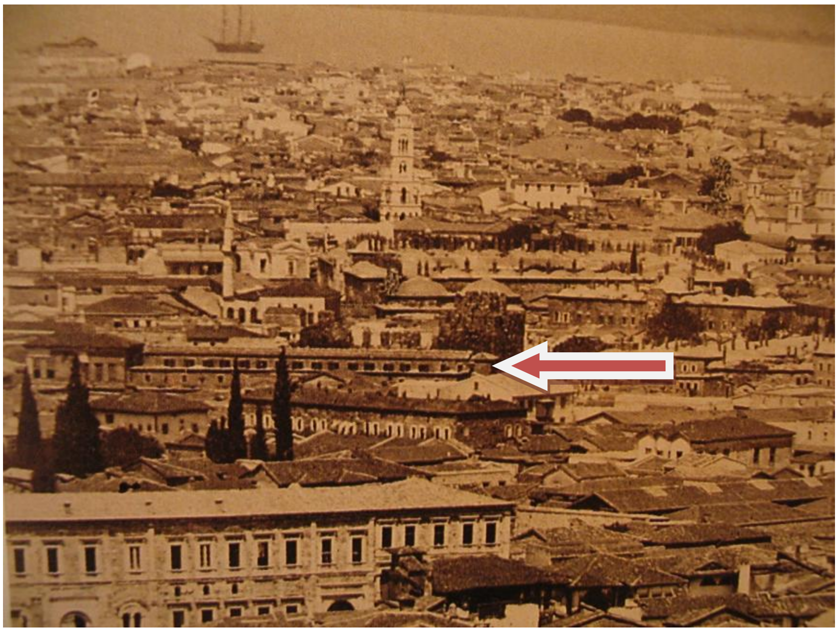
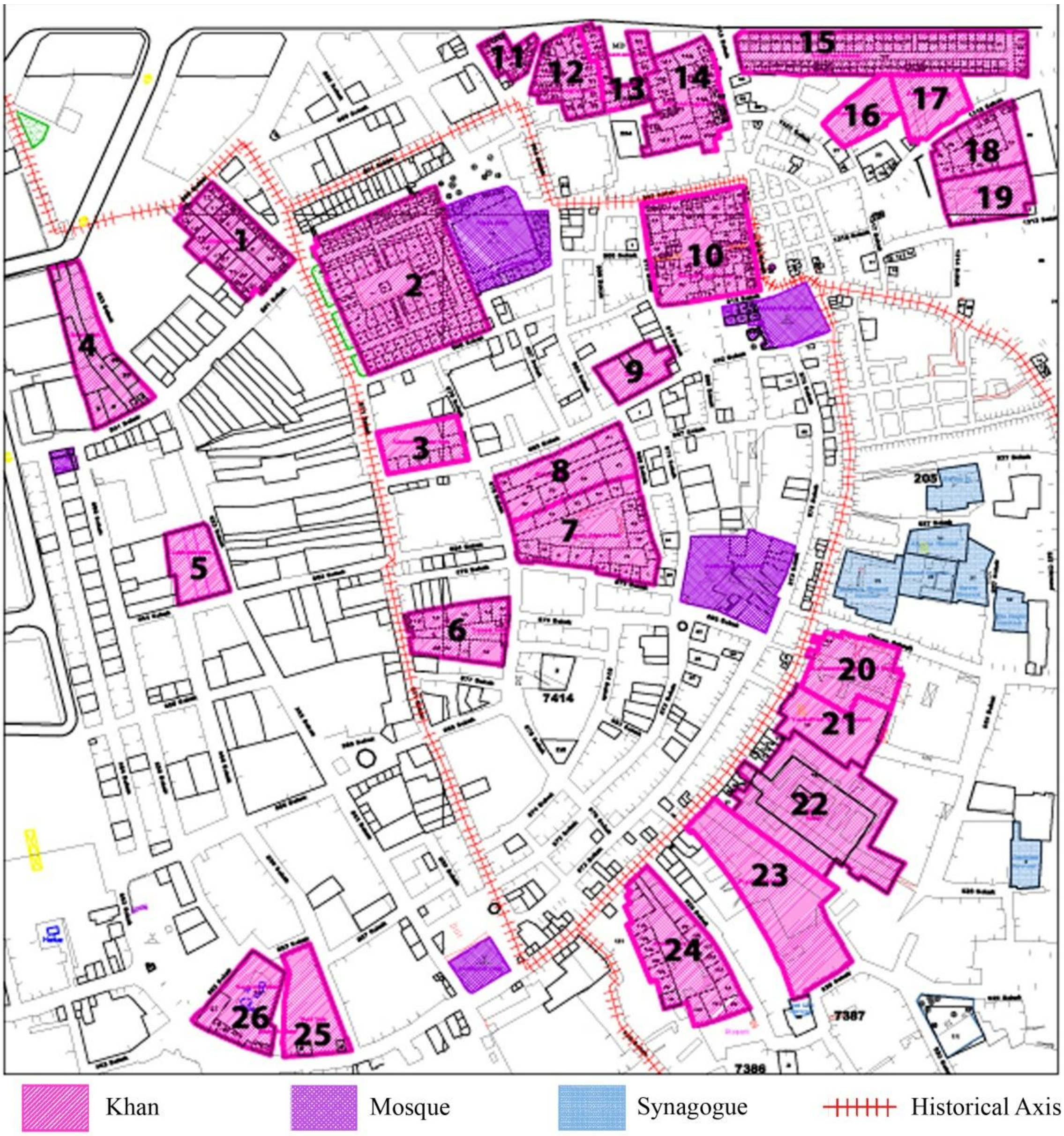


Figure 21. 19th century postcard of the Çakaloğlu Khan
(Source: Atay 1997)

Figure 22. Satellite image of İzmir Kemeraltı Commercial District
(Source: Google Earth)



1. Çakaloğlu Khan 2. Kızlarağası Khan 3. Abdurrahman Khan 4. Uzun Khan 5. Cambaz Khan 6. Tabak Khan 7. Büyük Demir Khan 8. Keten Khan 9. Ésir Khan 10. Küçük Demir Khan 11. Selvili Khan 12. Mirkelamoğlu Khan 13.Karaosmananoglu Khan 14. Manisalıoğlu Khan 15. Kavaflar Bazaar 16. Kantarcıoğlu Khan 17. Fazlıoğlu Khan 18. Yeni Khan 19. Sulu Khan 20. Küçük Karaosmanoğlu Khan 21. Yeşildirek Khan 22. Arap Khan 23. Piyaleoğlu Khan 24.Abacıoğlu Khan 25. Bey Khan 26. Kemahlı Khan

Figure 23. View of Çakaloğlu Khan with other surrounding Khans
(Source: IZTECH, Department of Architectural Restoration – Digital Archive)

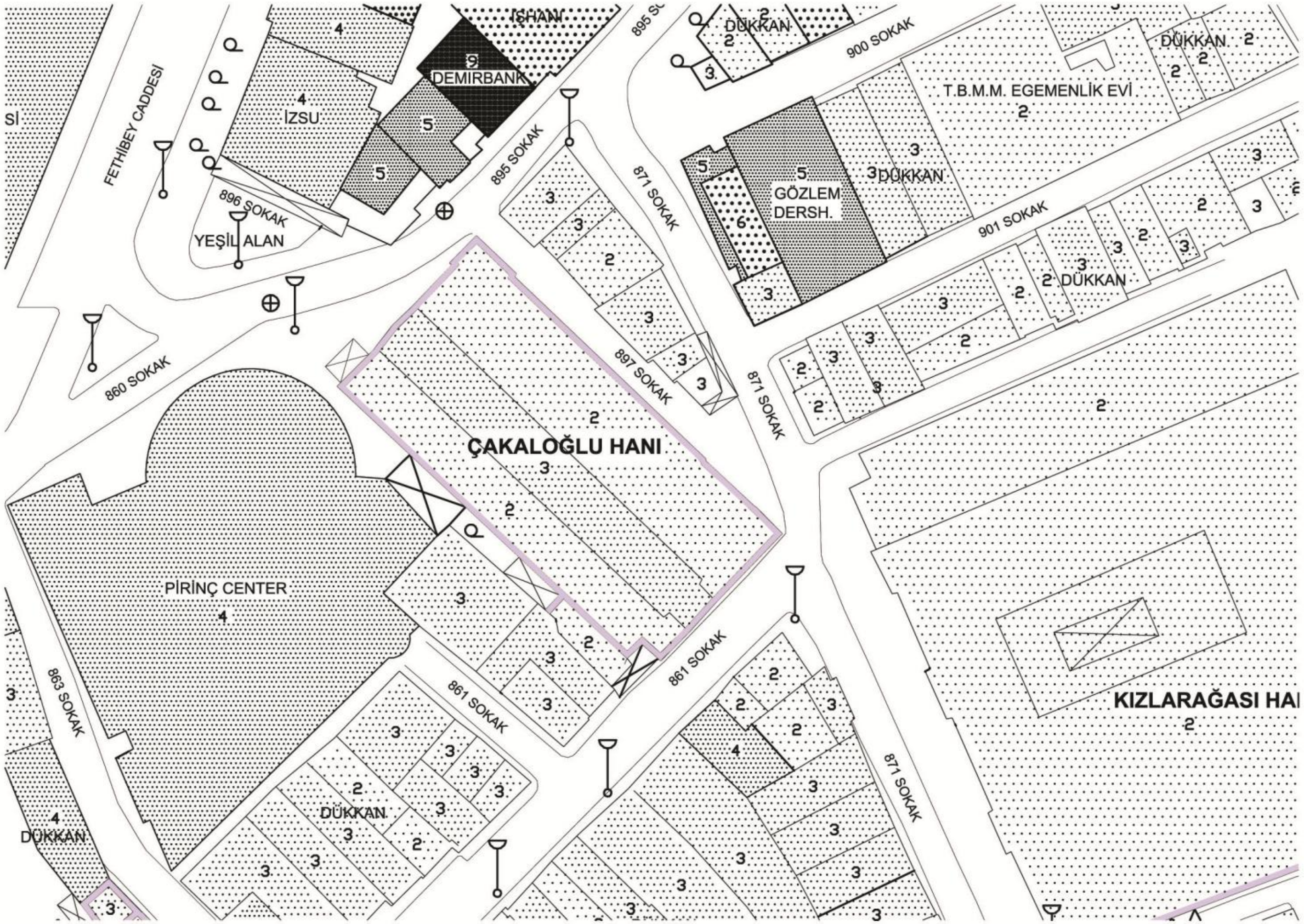
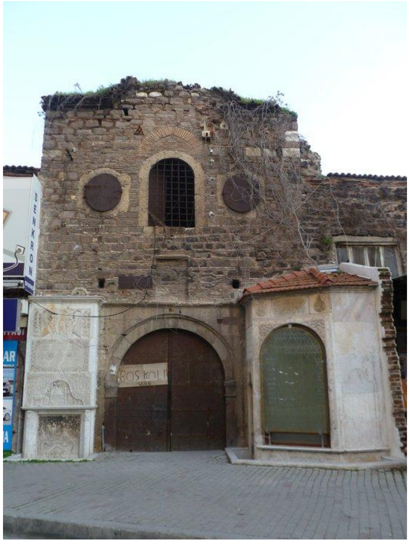
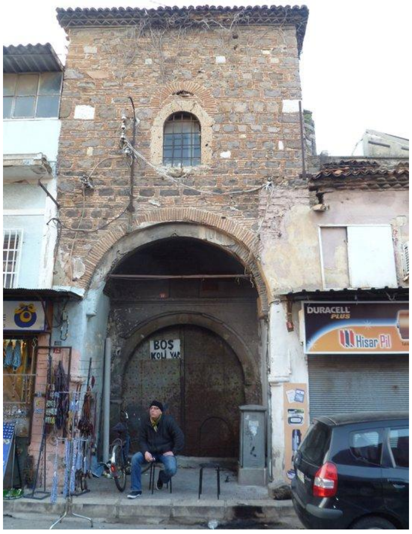


Figure 24. Ground floor plan of Çakaloğlu Khan, measured drawing
(Source: IZTECH, Department of Architectural Restoration – Digital Archive)


a


b

Figure 25. Northwestern facade (front) of the Çakaloğlu Khan on 895 Street (a) southeastern (back) facade of the Khan on 861 Street (b), Kemeraltı, İzmir (Source: Palaoğlu 2011)

Figure 26. Views of the southeastern facade
(Source: Palaoğlu 2011)

Figure 27. Views of the northwestern facade
(Source: Palaoğlu 2011)

Figure 28. Views of the northeastern facade on 897 Street
(Source: Palaoğlu 2011)

2.3. Legislative Context of Çakaloğlu Khan

Çakaloğlu Khan was listed by the Supreme Council of Immovable Antiquities and Monuments (Gayrimenkul Eski Eserler ve Anıtlar Yüksek Kurulu) with Desicion No. A-2954 on 26.06.1981 (Figure 28). Its conservation group was defined as 1st Group by İzmir First Regional Conservation Council of Cultural and Natural Heritage (İzmir 1 Numaralı Kültür ve Tabiat Varlıkları Koruma Bölge Kurulu) for the Preservation of Cultural and Natural Heritage with Decision No. 3680 on 30.04.1992. The same Council, with Decision No. 1502 on 15.06.2006 deemed the expropriation of the Khan by Konak Municipality possible on the condition that the function determined with the Conservation Revision Plan for Kemeraltı Urban Conservation Area and Vicinity is further elaborated. All building lots of the building are private property with the exception of the fountain on the northwesternern facade, which belongs to Konak Municipality (Konak Municipality – File Archive).

2.4. Architectural Investigation of Çakaloğlu Khan

The architectural characteristics like plan and facade characteristics of Çakaloğlu Khan are distinquished from the other 19th century Ottoman khans located in İzmir. Çakaloğlu Khan has architectural and historic values with its middle passage plan type, original architectural elements and mass made up of spaces of various heights.

2.4.1. Plan and Spatial Characteristics

Çakaloğlu Khan has a middle passage plan type (Ersoy 1991). The plan consists of storage spaces situated on each end opening to the middle passage and shops to the northeast opening to the street adjacent to the storage spaces. The rectangular planned building is of 52.5m x 24m dimension and is on a northwest-southeast axis (Figure 29). There is an entrance on the northwest and southeast, while the middle passage provides access between 895 and 861 streets. The middle passage, with dimensions of 46.87m x 5.15m and a height of 9.90m, is covered with a barrel vault. Eighteen spaces on each side of the middle passage are roughly 6.35m x 4.82m in dimension and 6.90m in height. All spaces are covered with barrel vaults with the exception of two spaces that are joined with adjacent shops on the northeast corner. Among the shops on the northeastern and southeastern facades, the ones on the northern, southern and eastern corners have lost their original plan, roof and facade characteristics to a large extent. Aside from these, other shops on the northeast facade are roughly 3.60m x 3.68m in dimension and 5.22m in height and covered with barrel vaults.

The middle passage is lightened by windows 1.02m x 0.75m in dimension situated on each side (17 on the left, 17 on the right) that are level with the spring line of the barrel vault at +6.28m (Figure 30). Spaces on either side of the middle passage have a door and window each opening to the passage. These spaces are lightened with rectangular windows of 0.95m x 0.75m dimensions at an height of +4.55m and clerestory windows of 0.75m x 0.45m dimensions on the barrel vault. The original entrances – that used to open to the middle passage – of two spaces on each side of the northwest entrance, three spaces to the northeast and one space to the southwest of the southeastern entrance are closed and current entrances are from the outside. The spaces Z20, Z19, Z18 and Z16 opening to the middle passage on the northeast and the southwest spaces Z04, Z06 and Z07 have mezzanine floors. Z20 and Z16 have balconies while Z06 has a French balcony. The original timber ceiling and partitions of Z04 differentiate it from other spaces. The original timber staircase, mezzanine floor and French balcony of Z06 are preserved. There is a barrel-vaulted space of 2.27m x 3.09m dimensions and 5.15m height featuring a timber balcony above the southeastern entrance. A round arched window 0.59m above floor level and of 0.65m x 1.04m

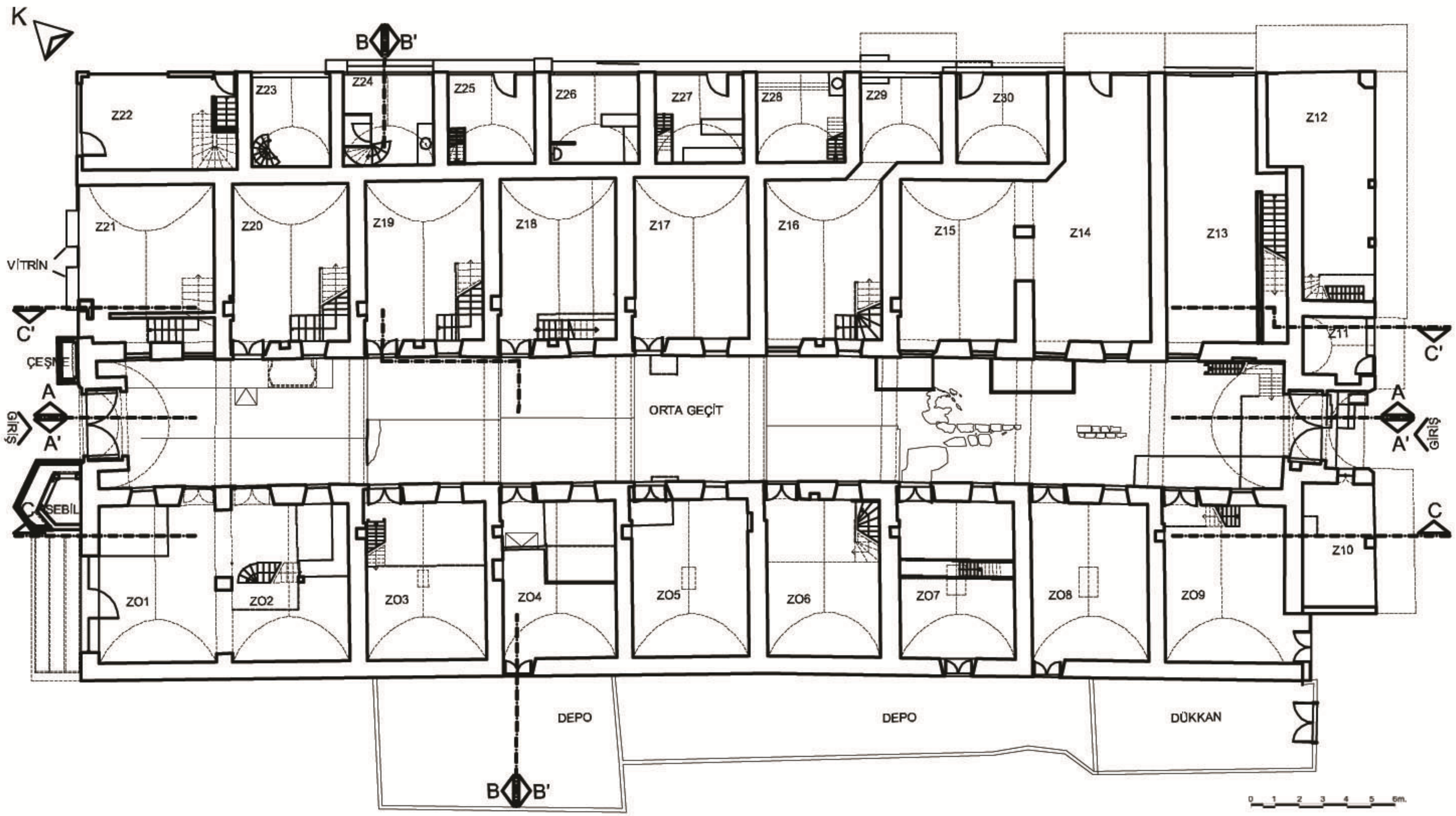


Figure 29. Çakaloğlu Khan, ground floor plan, measured drawing
(Source: IZTECH, Department of Architectural Restoration – Digital Archive)

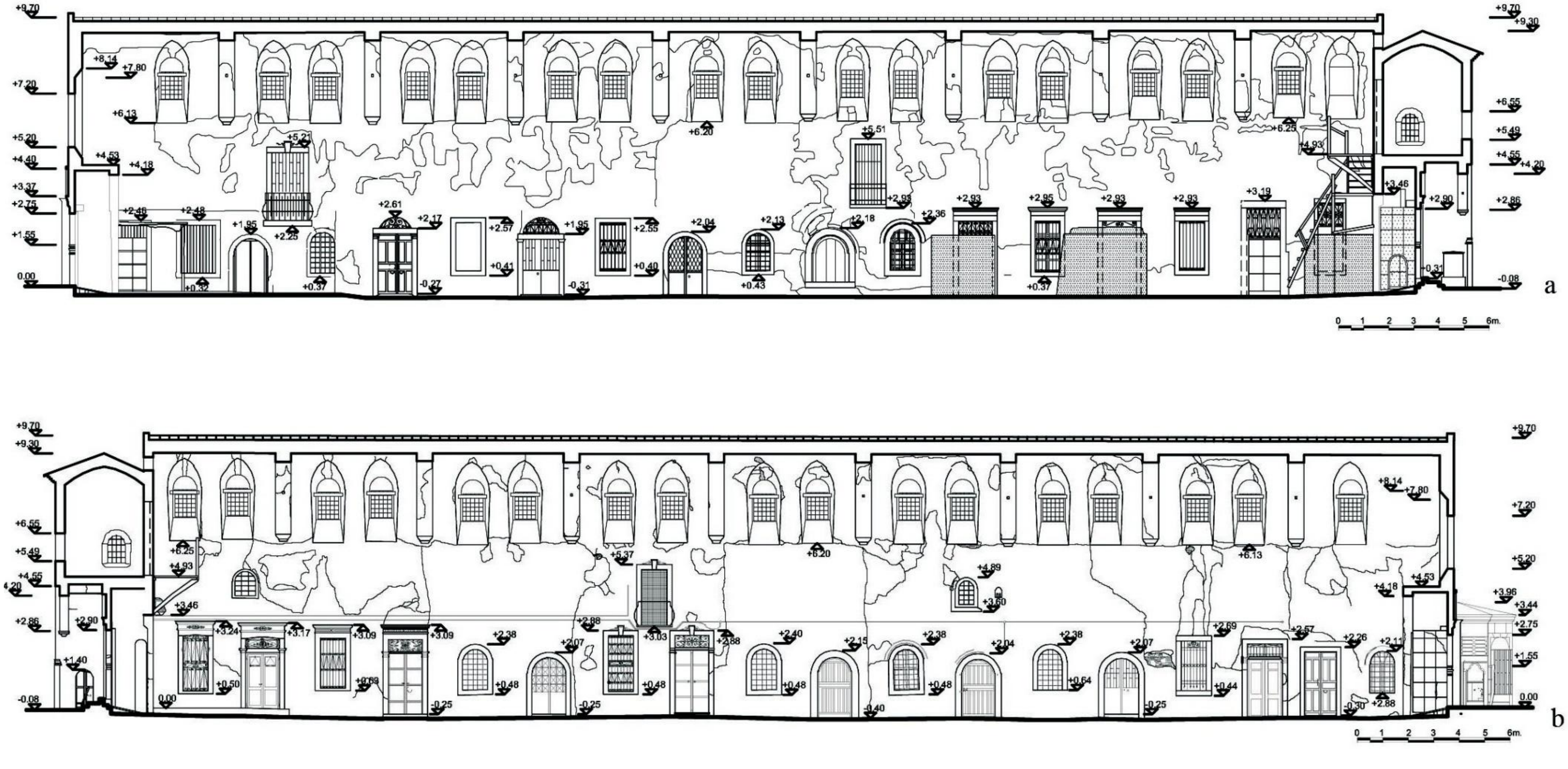


Figure 30. Çakaloğlu Khan, section A-A measured drawing (a) Çakaloğlu Khan, section A´-A´, measured drawing (b)
(Source: IZTECH, Department of Architectural Restoration – Digital Archive)

passage. The timber staircase providing access to this section has collapsed. There is an additional storage space on the southwest facade of the Khan. This space can be accessed from Z04, Z07 and Z08.

Mezzanine floors and staircases were added to the northeastern shops opening to the 897 Street, with the exception of Z26, Z29, Z30, Z15 and Z14. The original floor heights of the northeastern spaces Z14, Z15 and Z22 and the southwestern spaces Z10 and Z12 were altered and extra floors protruding from the original mass were added.

Both Z01 and adjacent Z02, which are located to the west of the northwestern entrance of the Khan, were joined by demolishing the wall in between them. The shop Z10 at the southern corner of the southeastern entrance was created by joining two original spaces while the shop Z12 at the northeastern corner was created by joining three original spaces. The original plans of the shops Z13, Z14 and Z15 on the northeast were altered to be interconnected. The upper floors of these spaces are accessed by a staircase – a later addition – in shop Z13. The shop Z29 on the northeastern facade and the adjacent Z16 were connected with an added door and the two spaces were used together.

The original floor coverings of spaces on each side of the middle passage and the shops opening to the street have been altered. Traces of earlier stone revetments can be observed in the middle passage.

2.4.2. Facade Characteristics

Today, only the northwestern, northeastern and southeastern facades of the Khan can be perceived. The southwestern facade is blocked by the Pirinç Center. The middle passage is accentuated on the northwestern and southeastern facades by heightened lateral sections (Figure 31). In the northwest, there is a round arched gate in the middle of the two-storey facade organization (Figure 32). The upper level is adorned with a rectangular window with a round arch in the middle, flanked by one round window on each side. There is a *sebil* to the right of the entrance gate and a fountain to the left. The two sides of the facade have lost their original facade organization due to shops. The alternating rough and rubble stone and brick course sections are remnants of the original facade. The southeastern facade has a round arched entrance gate inside a round arched niche in the middle, and a round arched rectangular window above in the middle.

Figure 31. Çakaloğlu Khan, northwestern facade, measured drawing (a) Çakaloğlu Khan, southeastern facade, measured drawing (b) (Source: IZTECH, Department of Architectural Restoration - Digital Archive)

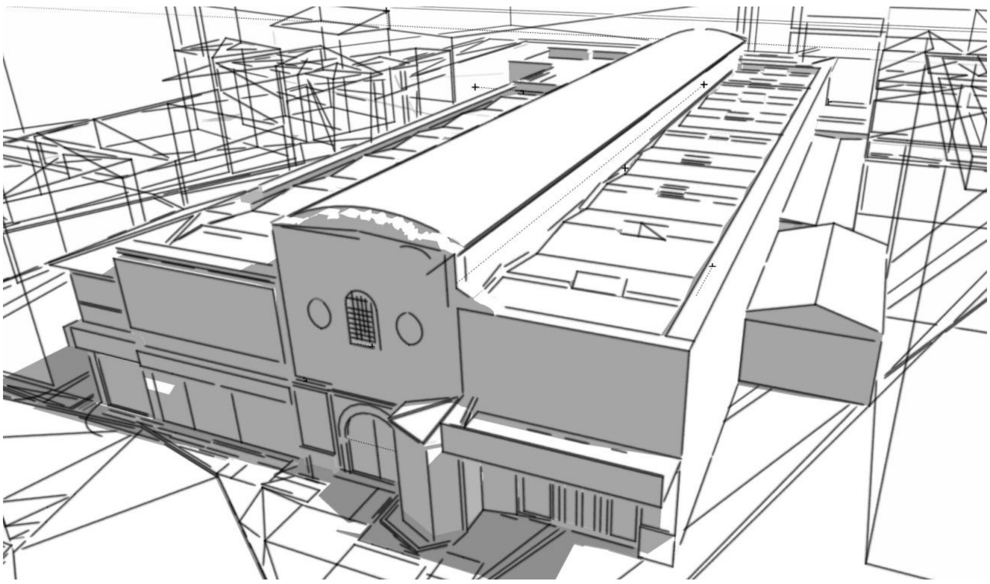


Figure 32 Çakaloğlu Khan, west direction, perspective view

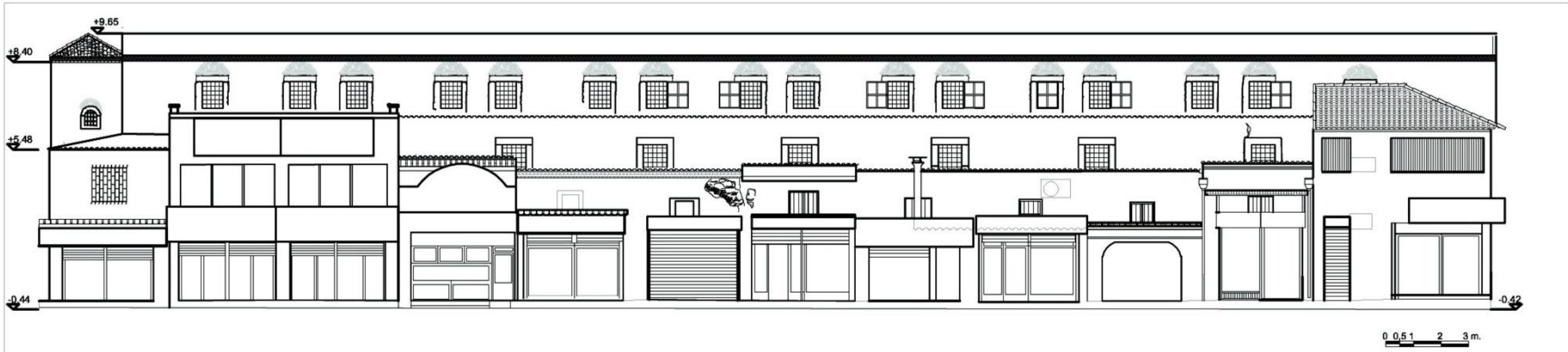


Figure 33. Çakaloğlu Khan, northeastern facade, measured drawing
(Source: IZTECH, Department of Architectural Restoration – Digital Archive)

The alternating rough and rubble stone and brick surfaces are original. The two sides of the facade, as on the northeastern facade, have lost their original order due to inharmonious floor additions to shops. The northeastern facade, overlooking 897 Street, cannot be fully observed due to the narrowness of the street. The shop facades on the ground floor have changed. In the upper section, the facades of the middle passage and storage spaces consist of original window openings and alternating rough and rubble stone and brick course surfaces. The southwestern facade can only be viewed from the terrace of Pirinç Center. This facade, not perceived from the street, is well-preserved with its original wall courses and the window openings of the middle passage and storage spaces.

a b

Figure 34. Northwestern facade (front) of the Çakaloğlu Khan on 895 Street (a) southeastern facade (back) of the Khan on 861 Street (b), Kemeraltı, İzmir (Source:Palaoğlu 2011)

2.4.3. Construction Technique and Use of Materials

The original load-bearing walls of the Khan are constructed of rubble and rough cut stone / brick in alternating bond. In horizontal rows; rubble and rough cut stone / 1-5 rows of brick masonry in alternating bonds and brick masonry in vertical joints varying between 5 and 15cm were used. The exterior surfaces of the building were not plastered while interior surfaces, in the original sections, have single layer lime plaster with chopped straw covered with whitewash. The wall thicknesses range between 68-76cm.

Original stonework can be observed at the entrance section in the northwestern facade and the shop facade to the west as well as in the southwestern facade, the entrance section in the southeastern facade and the wall surface to its south. The vault of the middle passage and eight supporting arches, which run across the vault from side to side as well as the vaults of the spaces, were made of brick (Figure 35). Original plaster layer covering the vaults is altered except for the vault of the middle passage. There are round relieving arches made of brick on top of round arched doors and windows and fine cut stone was used for the casings. Except for space Z16, which is wood, all doors opening to the middle passage are metal. The iron grills used on the windows above original doors are striking as decoration elements. In the middle passage, there are iron grills and shutters on the windows at the springing level of the barrel vault. At present, the timber main gates of the Khan are covered with sheet iron. The facades are finished with saw teeth eave at the top.

Figure 35. Middle passage of the Çakaloğlu Khan, Kemeraltı, İzmir
(Source: Palaoğlu 2011)

Situated to the right of the northwestern entrance, the *sebil*, which is a later addition and dates to 1220 H / 1805 A. D. according to its inscription, is made of marble and decorated with reliefs. The fountain to the left, which again is a later addition, is also made of marble decorated with reliefs.

2.4.4. Alterations

The original plan of Çakaloğlu Khan has mostly been preserved with partial alterations; however the facade characteristics have been lost to a great extent. The architectural features especially, on both sides of the the middle sections where the entrance gates are situated and on the northwestern and southeastern as well as the northeastern facade where shops are located, are completely lost. Alterations in the building can be grouped into additions, divisions, transformations, removals and renewals.

Additions: New floors were added to the shops Z22, Z13 and Z14 on the northeast. Mezzanine floor, second or third floors were added with staircases to the northeastern spaces Z13, Z14, Z15, Z 22, Z23, Z24, Z25, Z27, Z28; to the southeastern spaces Z10, Z11, Z12; northwestern space Z21 and the spaces Z02, Z03, Z07, Z09, Z16, Z18, Z19 and Z20 opening to the middle passage. Storage spaces were later added to the southwestern facade. Sheds added to the front of spaces Z14 and Z15, which have doors opening to the middle passage, block access to the middle passage.

Divisions: Original floor heights of the spaces Z02, Z03, Z07, Z09, Z16, Z18, Z19 and Z20 opening to the middle passage; northeastern spaces Z23, Z24, Z25, Z27, Z28; southeastern space Z11 are divided into two due to the mezzanine floor.

Transformations: The middle passage functions as a storage area today. The wall between Z01 and Z02 on the northwest was removed to obtain one space. On the northeast, the walls between Z13, Z14 and Z15 were removed to make one space. The original door frames of northeastern shops and the original metal frames of shop windows were changed to PVC, aluminum or iron. Original floor coverings in spaces Z03, Z04, Z05, Z06, Z07, Z08, Z17, Z18, Z19, Z23 on both sides of the middle passage were changed to concrete; in Z01, Z02, Z09, Z13, Z14, Z15, Z16, Z20, Z25, Z29 to artificial stone tiles; in Z12, Z21, Z22, Z26, Z27, Z28, Z30 to ceramic tiles; and in Z15 to laminate covering. The door and window of Z21 opening to the middle passage, and the window of Z13 opening to the middle passage were covered and closed with brick.

Removals: The barrel vaults of Z22, Z13, Z14 in the northeast and Z12, Z10 in the southeast were removed. The southeast wall of the southeastern space Z09, the wall between the northwestern spaces Z01 and Z02, the walls between the northeastern spaces Z13, Z14, Z15 and the wall between Z30 and Z16 were removed.

CHAPTER 3

IMAGE-BASED THREE-DIMENSIONAL MODELING PROCESS

Three-dimensional modeling of Çakaloğlu Khan was conducted in three parts. First part which was data acquisition included archive and library research, photographic documentation and two-dimensional CAD drawing. Second part which was digital image processing consisted of single image rectification, the elimination of irrelevant parts and non-desired objects, elimination of unrectified planes, contrast and RGB adjustment and control of transparency. Third part which was three-dimensional evaluation and visualization included three-dimensional solid model, texture mapping, image-based three-dimensional model and render and ilumination settings.

3.1. Data Acquisition

In this study, three-dimensional modeling of Çakaloğlu Khan was conducted in three parts. First, in data acquisition chapter included archive and library research, photographic documentation and two-dimensional drawings.

In archive and library research, The studies related to image-based technique were examined. The advantages and disadvantages of image-based technique were discussed in this part.

In two-dimensional drawings section, the architectural documentation drawings of the Khan were acquired from the digital archive of the Architectural Restoration Department at İzmir Institute of Technology.

In photographic documentation, Çakaloğlu Khan was photographed with a digital compact camera. Dense construction around the Khan and its location within the Kemeraltı commercial center complicated photograph shots. So, the facade of the Khan could not be photographed as a whole. A total of 248 photographs of the facade were photographed from ground and the second floor of the surrounding buildings, 98 photographs of the middle passsage were taken from ground of middle passage with a

Panasonic Lumix FS 30 digital compact camera. A total of 96 photographs were taken from ground at 21 different photograph shot points, 55 photographs were taken from the second floor of surrounding buildings at 2 different photograph shot points, 55 photographs were taken from the third floor of surrounding buildings at 3 different photograph shot points, 42 photographs were taken from roof of Pirinç Center (Figure 36) and 98 photographs were taken from middle passage. Photographs taken with digital compact camera were collected in a digital photograph archive of the Khan. All the photographs were saved in the file of digital photograph archive of the Khan. A total of 34 photographs were used to cover facade surface of three-dimensional solid modeling. A total of 58 photographs were used to cover roof surface of three-dimensional solid modeling.

In two-dimensional drawings section, the architectural documentation drawings of the Khan were acquired from the digital archive of the Architectural Restoration Department at İzmir Institute of Technology.

Figure 36. The points used during photographic documentation

In Zoner Photo Studio 10, it was used a tracklog to add shot location information to the photographs (Figure 37). Also in Figure 37, it was searched for coordinates and assigned them to photograph using on Google maps.

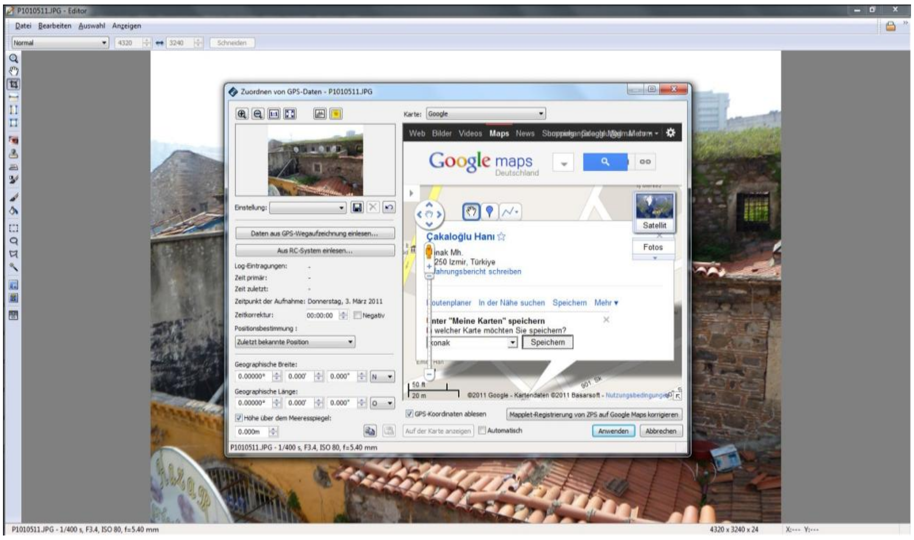


Figure 37. The GPS Data of Çakaloğlu Khan

3.2. Digital Image Processing

In second phase, digital image processing involves single image rectification, elimination of irrelevant parts and non-desired objects, elimination of unrectified planes, contrast and RGB adjustment, control of transparency. These parts, in these processings, the photographs were edited by using the softwares Zoner Photo Studio 10, Adobe Photoshop Elements 7.0 and Inkscape.

3.2.1. Single Image Rectification

The photo can be rectified by using minimum four points on the same facade surface. It can be used many commercial program. In this study, Zoner Photo Studio 10 software was used the process of single image rectification, correction of the images having optical lens distortions and resampling to produce texture maps.

First, the photographs selected in the file of the digital photograph archive of the Khan were edited in Zoner Photo Studio 10. Second, perspective views and optical distortion in the photographs depending on photograph shot angle and shot distance were rectified using the Zoner Photo Studio 10 software. Then, the photographs were cropped, edited and saved in jpeg format in Zoner Photo Studio 10.

- At the beginning of the digital image processing, the facade photographs were opened with the "File - Open" selections in Zoner Photo Studio 10. Using the "Perspective correction" tool, the rectangle seen on screen is attached to the four corners of the facade photograph (Figure 38, 39).
- The rectification of the photograph occurred automatically with a right-click. This process remedied the perspective view and optical distortion. Using the "Crop" tool, the desired section in the photograph is selected and cropped.
- The facade photograph was saved in the related file using "File -Save As" selections.

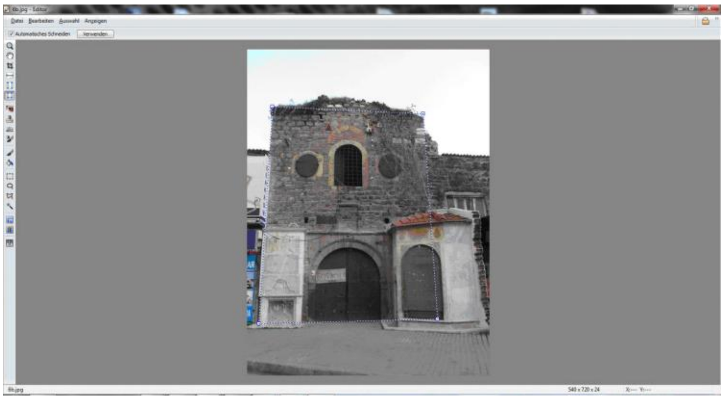


Figure 38. Northwestern facade photograph as seen in Zoner Photo Studio 10

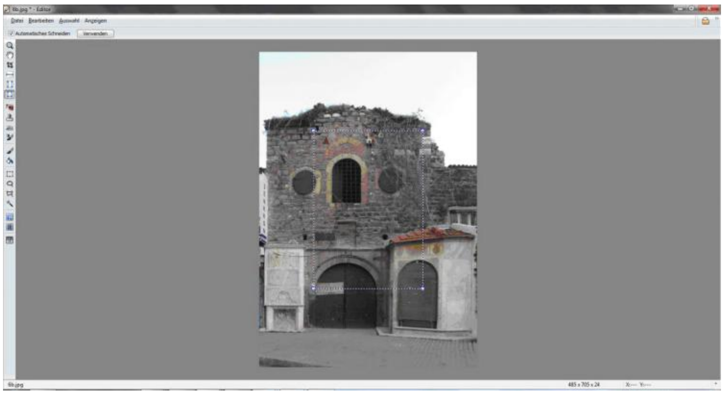


Figure 39. Digital image processing, rectification of perspective view in the photograph

Figure 40. Digital image processing, rectification of perspective view

The northeastern facade of the Çakaloğlu Khan on 897 Street could not be perceived as a whole because of the dense buildings around the Khan. The facade is blocked by obstructing elements such as signs of the shops. Therefore, shop facades were photographed in two parts: the first part was photographed from the ground and has perspective view due to the narrowness of the 897 Street (Figure 40). The second was photographed from the second floor of the neighbouring building (Figure 42). First, the photographs taken from the northeastern facade on 897 Street were opened in Zoner Photo Studio 10. Perspective views in the photographs were corrected by selecting the "Perspective correction" tool and the photographs were cropped and edited using the "Crop" tool. The edited photographs were saved using the "File-Save As" selections (Figure 41, 43). In the second phase, the photographs were opened in Adobe Photoshop Elements 7.0 and they were edited by deleting obstructing elements such as people, trees and cars. The edited photographs in Adobe Photoshop Elements 7.0 were saved in jpeg format by using the "Save As" command (Figure 44).

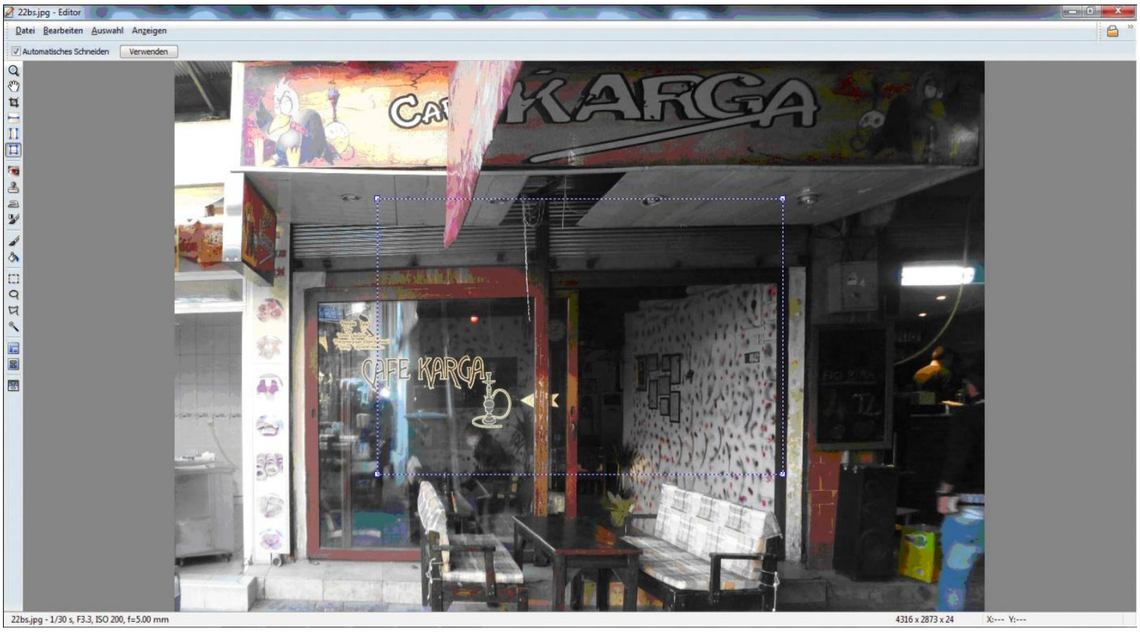


Figure 41. Single image rectification in Zoner Photo Studio 10 software

Figure 42. The original photograph taken from the shop on 897 Street

Figure 43. Pespective rectification, Zoner Photo Studio 10 software

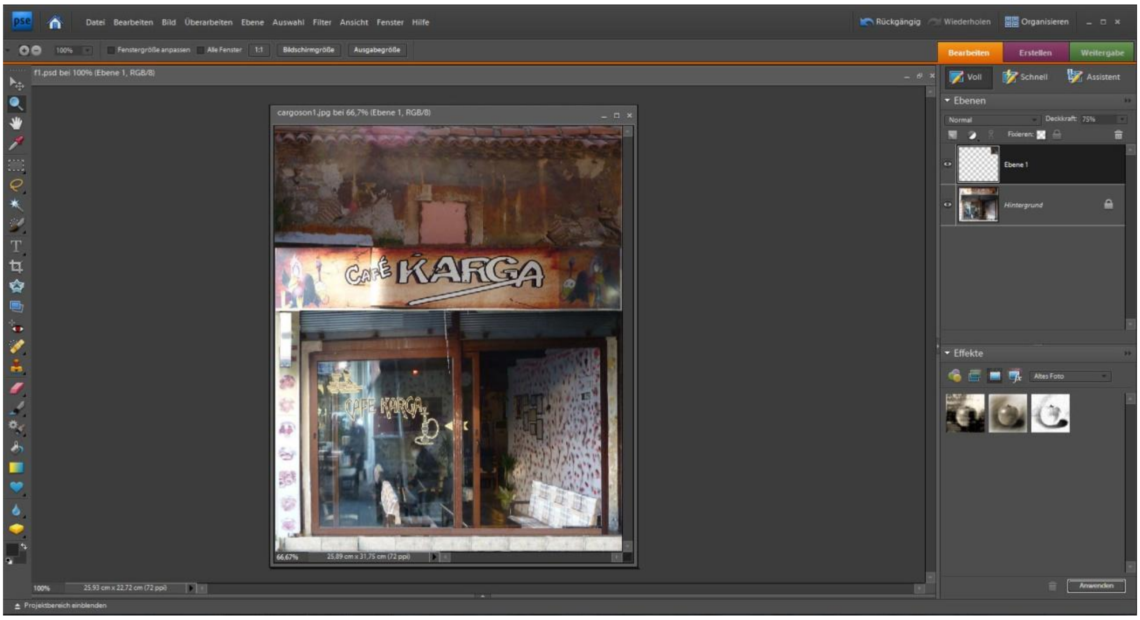


Figure 44. The combination of two photographs taken from a shop on 897 Street

3.2.2. Elimination of Irrelevant Parts and Non-desired Objects

The second part of digital image processing was eliminating irrelevant parts and non-desired objects. Non-desired objects on photographs were obstructing elements which blocked facade surface such as car, people and trees. Irrelevant parts on photograps were objects such as signs and water pipe located on building. Common software related to digital image processing is available. However, Adobe Photoshop Elements 7.0 software was preferred for its ability for taking photographs in JPEG format, the tools in software, experience related to using software, easy to use solutions, editing photographs and sensational result.

In this section, the edited photographs in Zoner Photo Studio 10 were opened in Adobe Photoshop Elements 7.0. The irrelevant parts and non-desired objects in the photographs were erased and the photographs were edited.

- First, the edited photograph was opened in Adobe Photoshop Elements 7.0. using the "Open"command (Figure 45, 46).
- Non-desired elements such as people, panels and trees in the photographs were deleted by selecting them with the "Rectangle" command the deleted photograph face was pasted original material face using with "Rectangle" command and "Copy-Paste" command (Figure 47) and the current facade photograph was reached.
- Last, the edited photographs were saved in jpeg format.

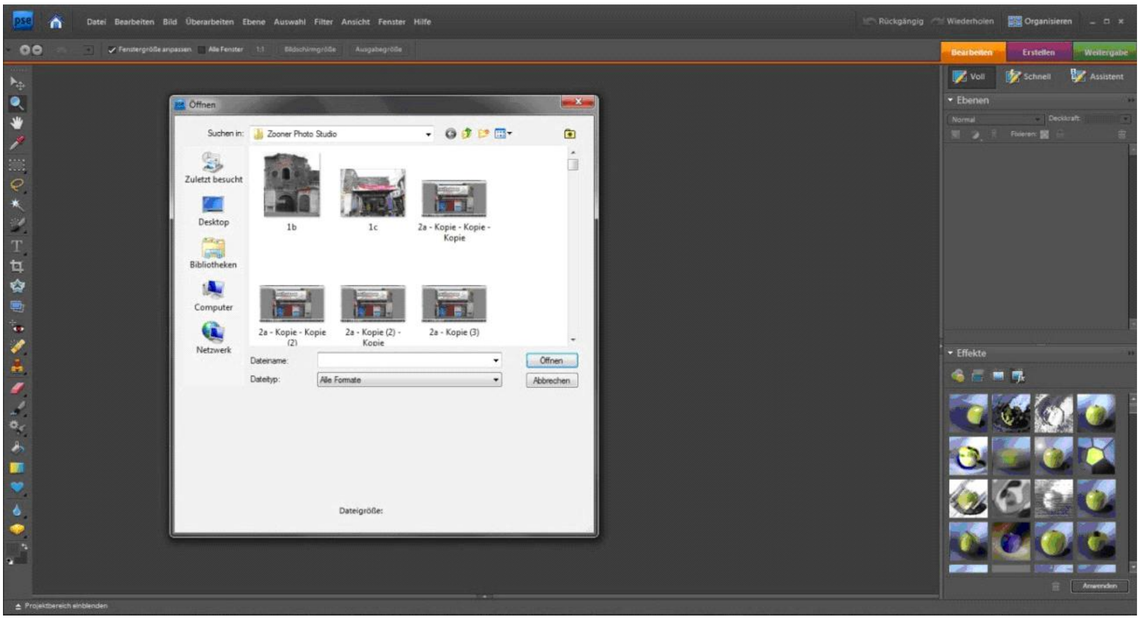


Figure 45. The photograph selected from the digital image archive was opened with "File - Open" selections

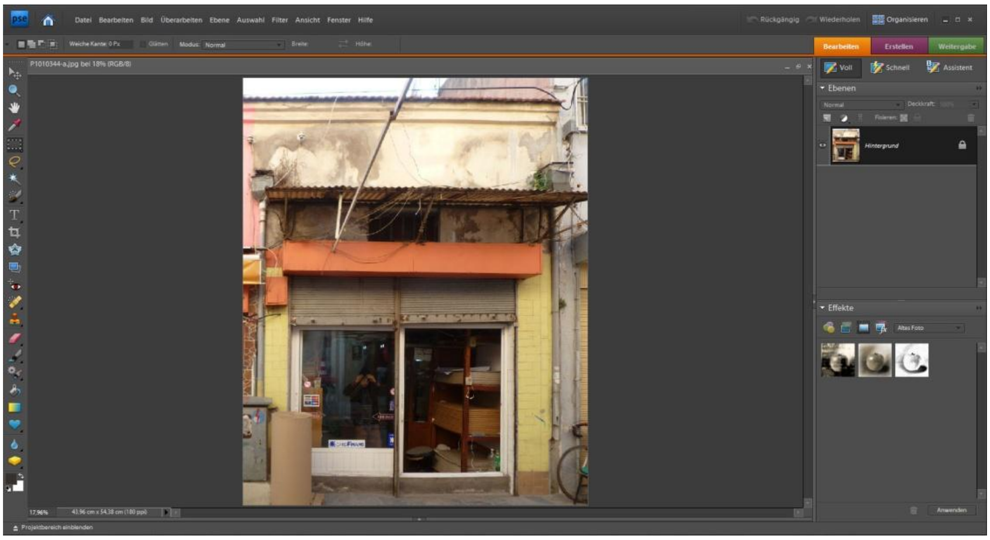


Figure 46. Selecting a photograph of a shop on 897 Street from the digital image archive

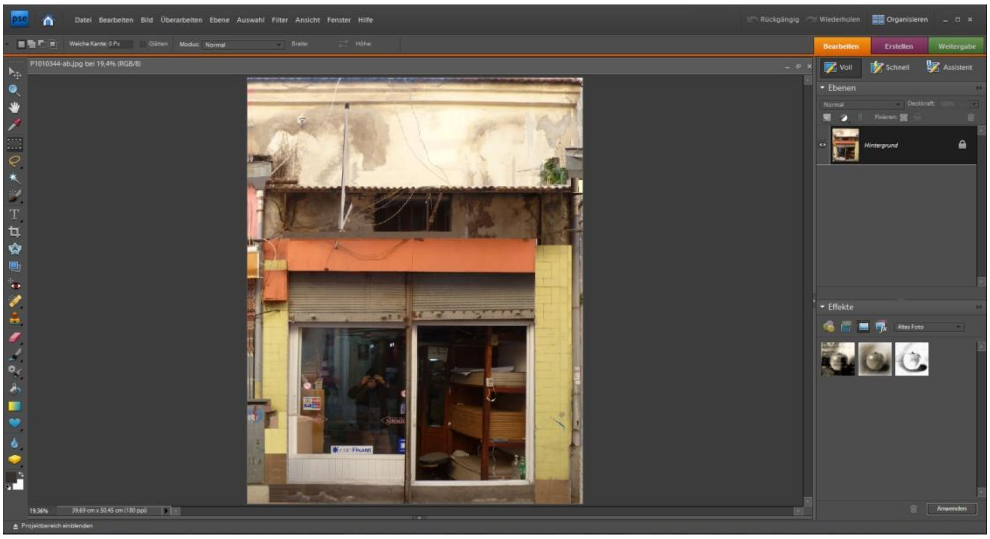


Figure 47. The eliminating of non-desired objects which are bicycle and carpet in photograph

3.2.3. Elimination of Unrectified Planes

This section includes the third phase of the digital image processing, after the photographs were automatically rectified and corrected with Zoner Photo Studio 10, the parts that could not be rectified and still contained unrectified planes.

- The rectified photograph selected was opened in Adobe Photoshop Elements 7.0. (Figure 48 and 49).
- Unrectified planes on photograph such as signs and eaves could not be corrected automatically by using Zoner Photo Studio 10 were rectified by using Adobe Photoshop Elements 7.0. These planes were cut using "Rectangle" tool and later, its position was changed with using "Copy-Paste" selections (Figure 50).

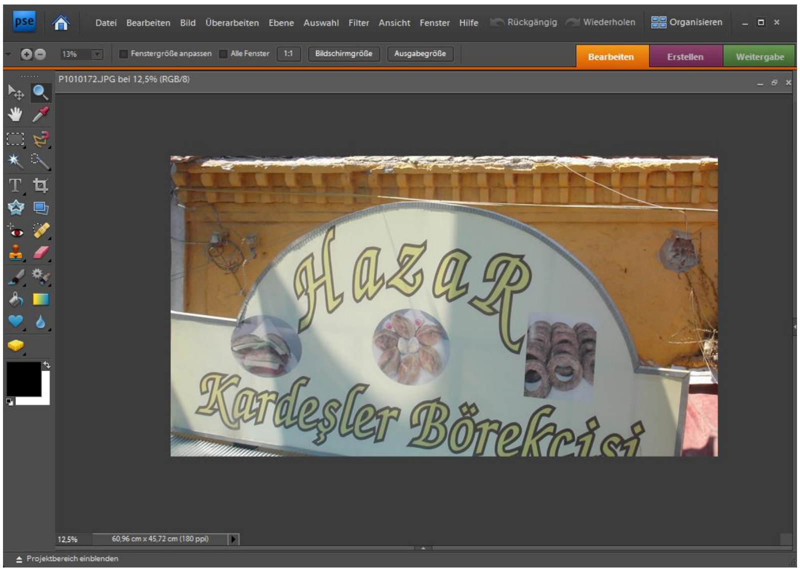


Figure 48. Unrectified planes in photograph taken from the shop on 897 Street

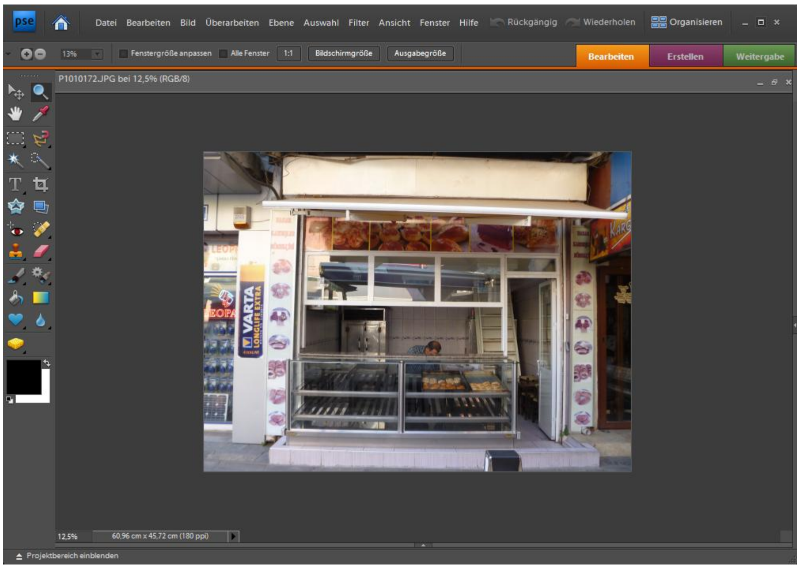


Figure 49. The rectified photograph of a shop on 897 Street

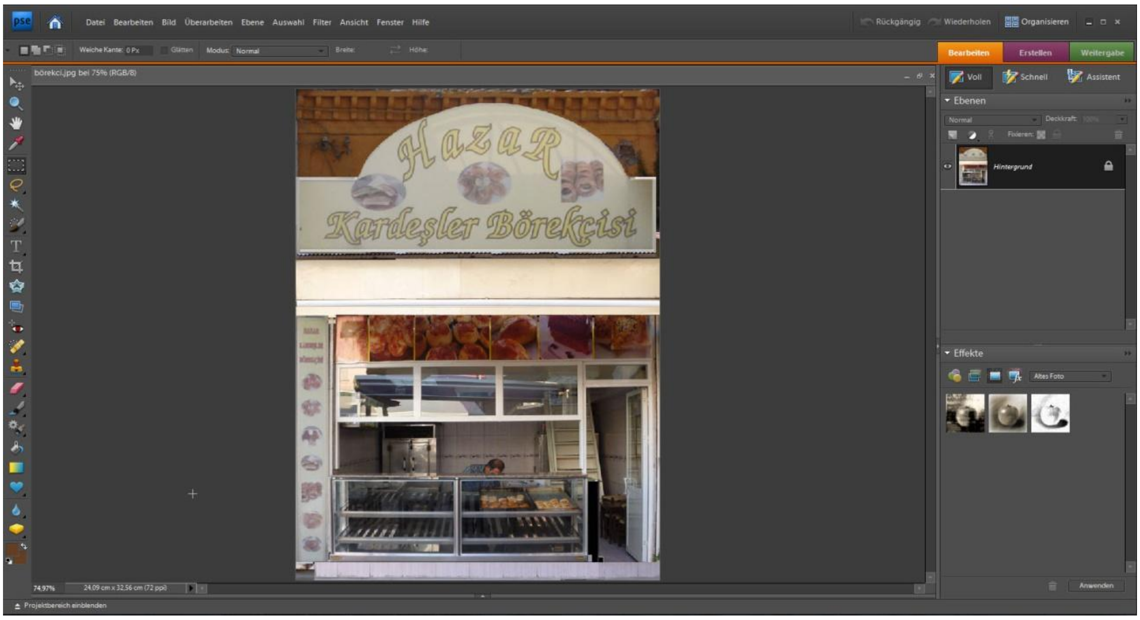


Figure 50. The rectification of perspective objects in the photograph

3.2.4. Contrast and RGB (Red, Green, Blue) Adjustment

This section includes the fourth phase of the digital image processing; tone adjustment was made on all photographs of the Khan. Adobe Photoshop Elements 7.0 software was preferred for tone adjustment on photographs. In image-based modeling, it is important to adjust the tones in the edited photographs to a similar level so as to create a whole some model. Therefore, the tones in all photographs were adjusted.

- In order to achieve the same contrast levels on all photographs, tone adjustment was performed with the "Tone correction"command (Figure 51).
- The RGB (Red, Green, Blue) tone adjustment was made with the "Color Picker" command.
- In the last phase, the photograph was saved with the "Save As" command in the Adobe Photoshop Elements 7.0 software.

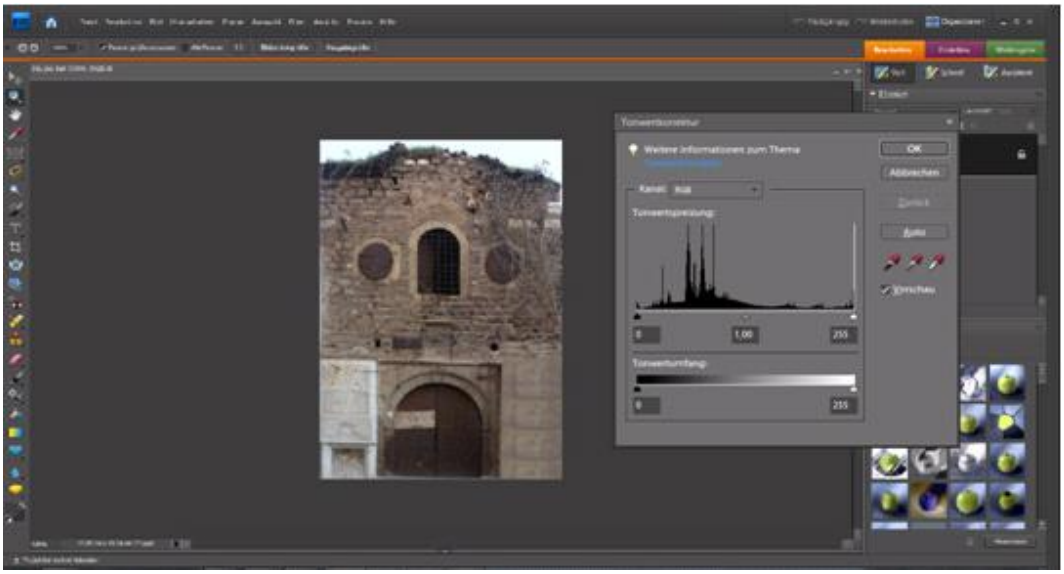


Figure 51. Contrast tone adjustment in the Adobe Photoshop Elements 7.0 software

3.2.5. Control of Transparency

This part included the fifth phase of the digital image processing. Inkscape software was used to derive non-photorealistic texture from photographs. This software was preferred for easy availability, vector-based drawing program, saving photograph with svg format and the easy-use of tools. The svg format can be directly by all viewed the major web browsers including Firefox, Opera, Safari, Chrome and Internet Explorer on the web in html 5. In this part, the reflection effect on glass face of the shop windows of the exterior shops were contraled with painting to black color in Inkscape software to create visual model.and saved in svg format.

- First, neutral surfaces were created in the photographs opened in Inkscape in order to eliminate the effect of objects behind the shop windows and windows that complicated perception. The shop windows and glass sections on the facades were painted in black using the "Rectangle" command (Figure 52).
- Second, Selecting Page with "File – Export" selections and chosing the location to save the file with Browse, the photographs were saved in png format (Figure 53) and they were made ready for the image-based model.

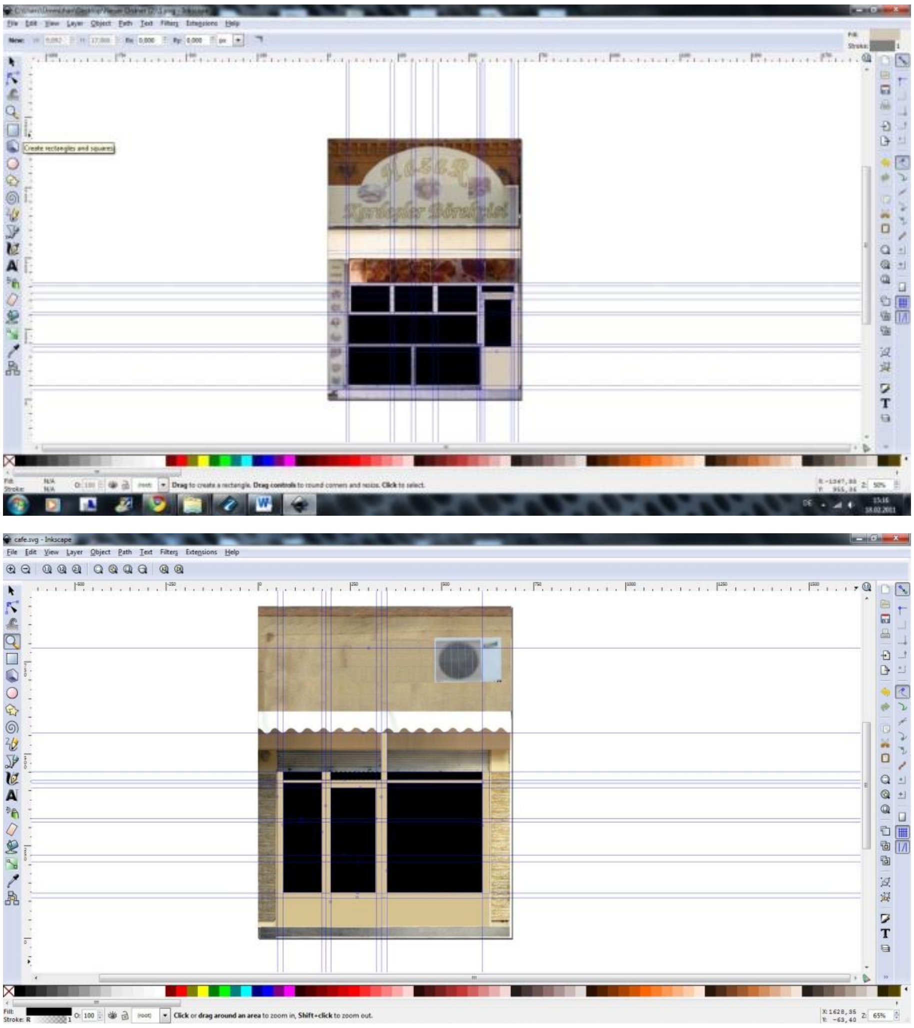


Figure 52. Creating neutral surfaces on shop windows on the southeastern facade at 897 Street

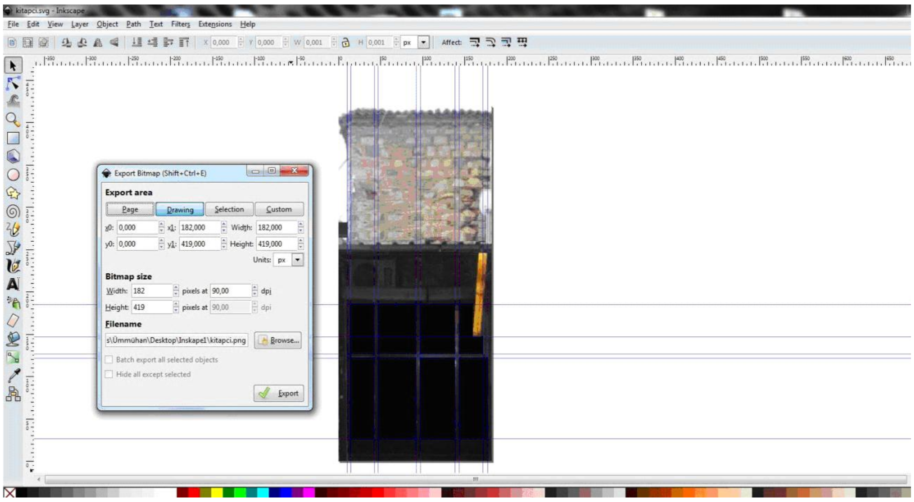


Figure 53. Importing of the edited photograph in Inkscape

3.3. Three-Dimensional Evaluation and Visualization

Third phase which is in three-dimensional visualization and evaluation part included three-dimensional solid model, texture mapping, image-based three-dimensional model and render and illumination settings. In first phase, three-dimensional solid model based on measurement from taking two-dimensional CAD drawing was created in Google SketchUp 7 software was chosen for its online accessibility, its fast modeling process and its ability to transfer dwg format. In the second phase, image-based three-dimensional modeling was prepared. Three-dimensional solid model opened and the edited photographs with using "Edit - Face - Texture - Position" selections attached to the four corner of solid model face. Thus 1/200 scale image-based three-dimensional modeling was prepared in Google SketchUp 7. And last phase is the presentation of three-dimensional model. Render and Ilumination settings were adjusted.

3.3.1. Three-Dimensional Solid Modeling

In this part, solid modeling of the exterior and architectural elements of the Khan was carried out in Google SketchUp 7. The CAD drawings in AutoCAD 2011 were transferred to Google SketchUp 7. Later, it was started to draw wall and vault surfaces. As a result, solid modeling study of the Khan with using measurement in CAD drawings was carried out.

3.3.1.1. Transform from AutoCAD Software into Google SketchUp Software.

The CAD drawings were imported to the SketchUp software (Figure 54). The transformation of dwg format of CAD drawings to skp format in Google SketchUp 7 facilitates the modeling process. The dwg formatted files can be opened on SketchUp in order to access the dimensions of the building.

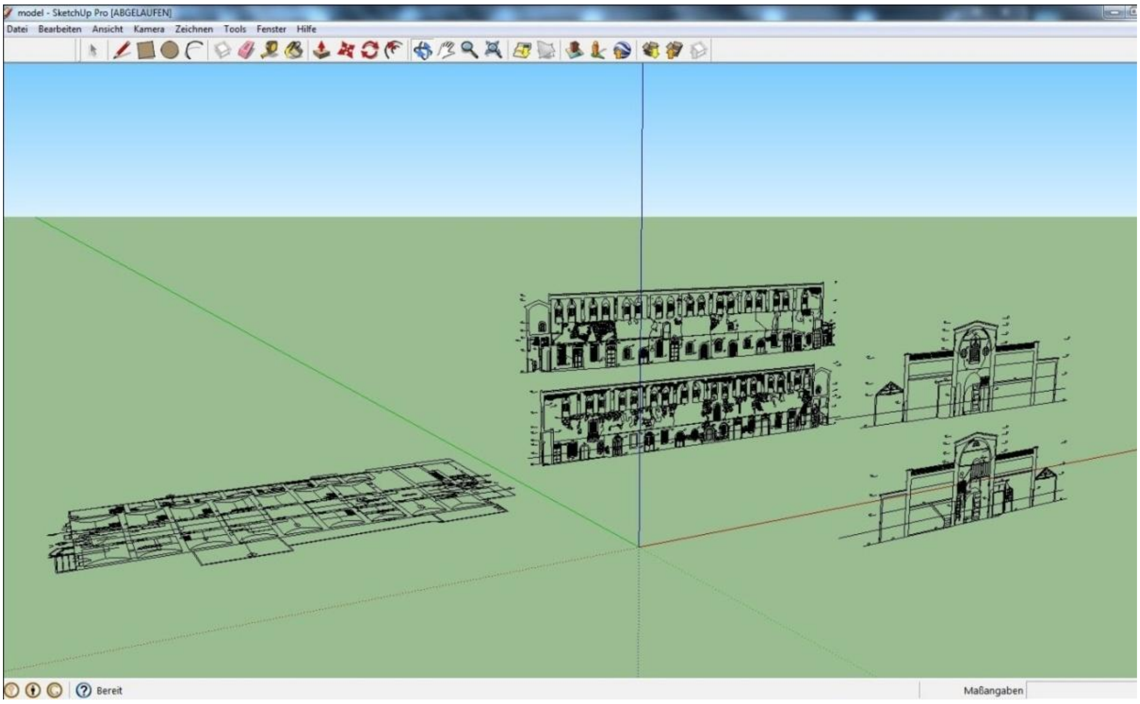


Figure 54. Transferring the dwg-format CAD drawing from the related file by using "File – Import" command in Google SketchUp 7 software

3.3.1.2. Drawings Floor and Walls in Google SketchUp

With two-dimensional plan and section in hand, the next step is to extrude it into three-dimensional model. This basically one step process "Push / Pull" tool is involved in SketchUp. In the following step, the simple floor plan and sections is taken, three-dimensional walls and vaults are drawn earlier and turned into.

- Google SketchUp 7 software is started and dwg-format two-dimensional CAD drawing files are transfered with the "File - Import" selections (Figure 55).
- The surfaces are formed using the dimensions in the plan and section drawings with the "Line" tool  (Figure 56).
- The surfaces are extruded with the "Push / Pull" tool  (Figure 57).
- The rendered surface model is saved in skp-format with the "File - Save As" selections (Figure 58).

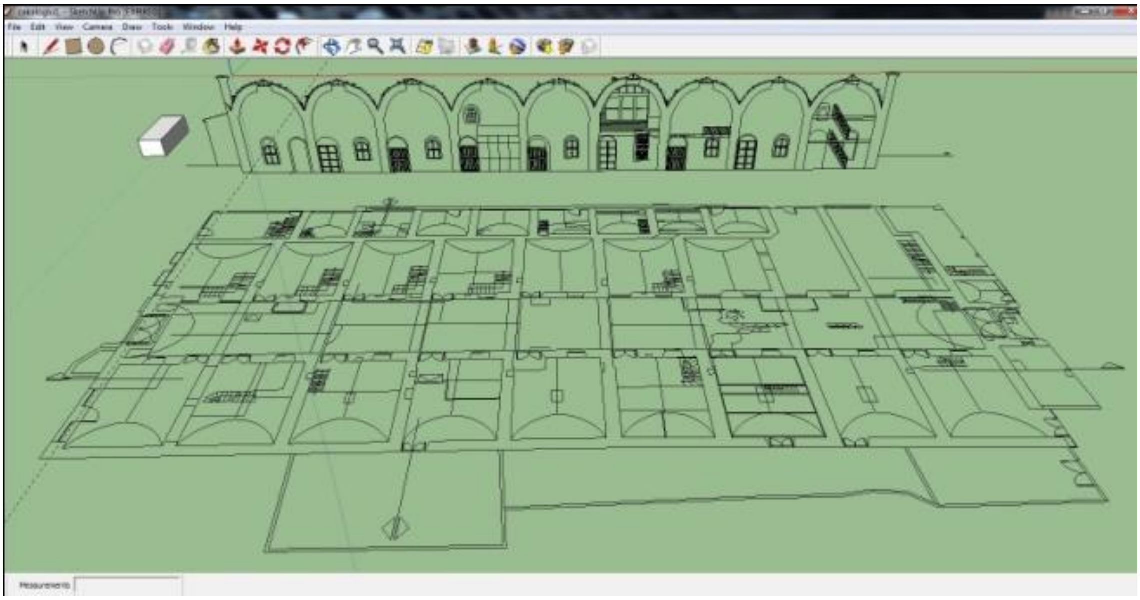


Figure 55. Ground floor plan and A-A section measured drawings

Within this framework;

- At first, Google SketchUp 7 software is opened and then the dwg-format ground floor plan and A-A, A´-A´, B-B, C-C architectural documentation drawings of the Khan are transfered from the CAD software with the "File – Import" selections (Figure 55).
- The modeling process is started in SketchUp based on the dimensions in the CAD drawings.
- In SketchUp, initially, the solid modeling of the storage spaces opening to the middle passage and then the middle passage itself is generated with the "Line" tool  using the dimensions in the architectural documentation drawings. The wall and vault surfaces of the storage spaces are formed by entering the dimensions in section C-C using the "Line" tool . The formed surfaces are extruded with the "Push / Pull" tool . Then the wall, vault and roof surfaces of the storage spaces are formed by entering the dimensions in section B-B using the "Line" tool . The formed surfaces are again elevated with the "Push / Pull" tool  (Figure 56 and 57).

- In the second phase of the modeling, the 11 shops on the 897 Street were generated using northeastern facade CAD drawings. The geometrical modeling of the shops was carried out by entering the dimensions on the facade and section drawings along the x-y-z axes with the "Line" tool (Figure 58).
- In the third phase of the modeling, the dimensions of the two shops on the northwestern facade on the 895 Street were entered along the x-y-z axes with the "Line" tool and the three-dimensional scaled solid model was generated (Figure 59).
- In fourth phase of the modeling, the dimensions of the three shops located on the southeastern facade on 861 Street were entered along the x-y-z axis with the "Line" tool and the three-dimensional scaled solid model was generated.

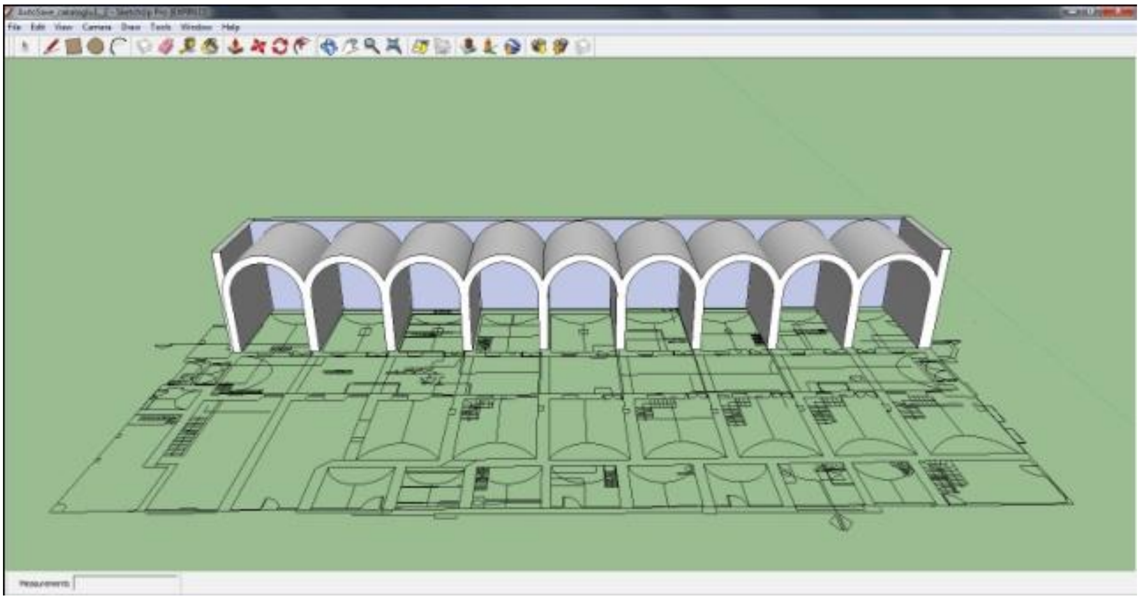


Figure 56. Extruding section surfaces

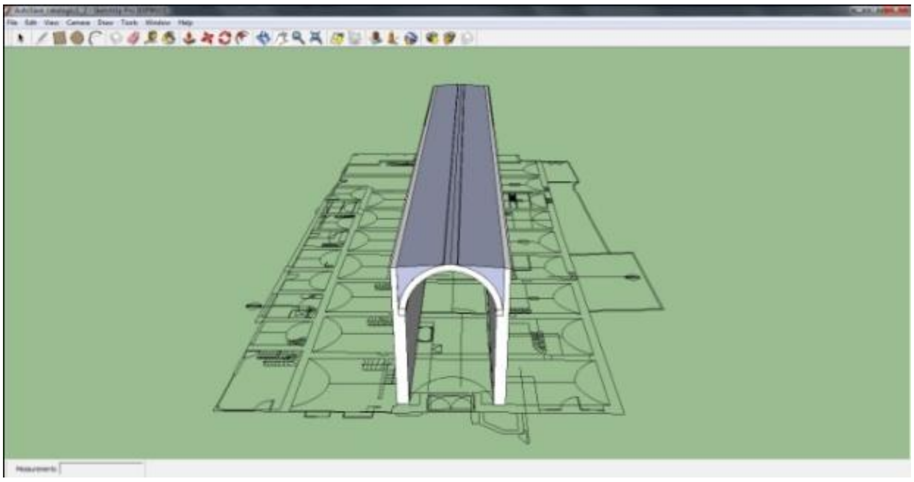


Figure 57. The solid model of the middle passage (view from the top)

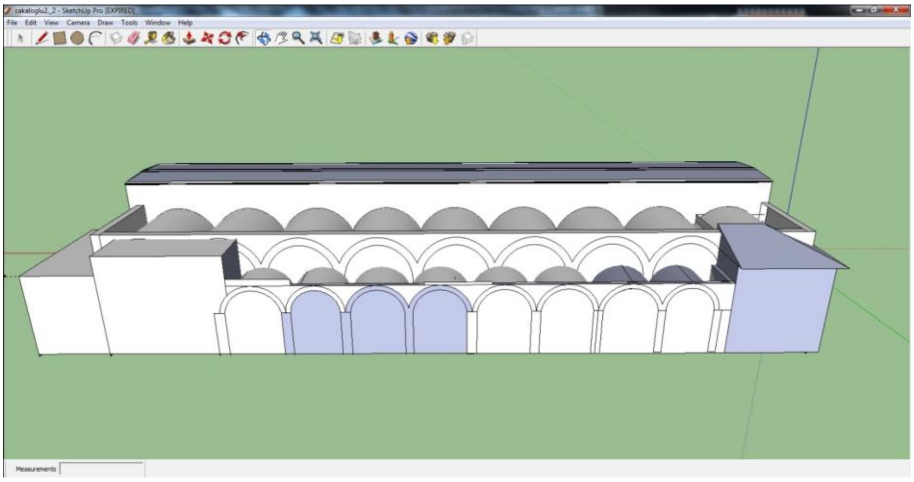


Figure 58. The perspective view from the solid model of the northeastern facade

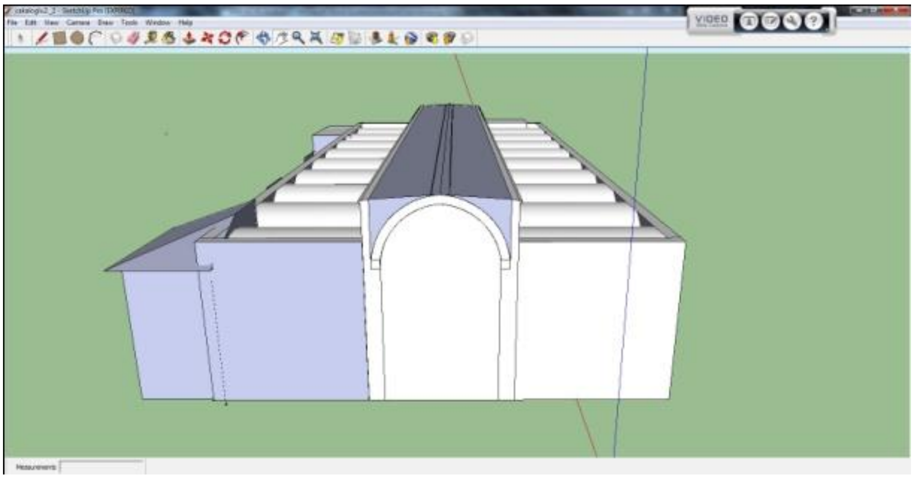


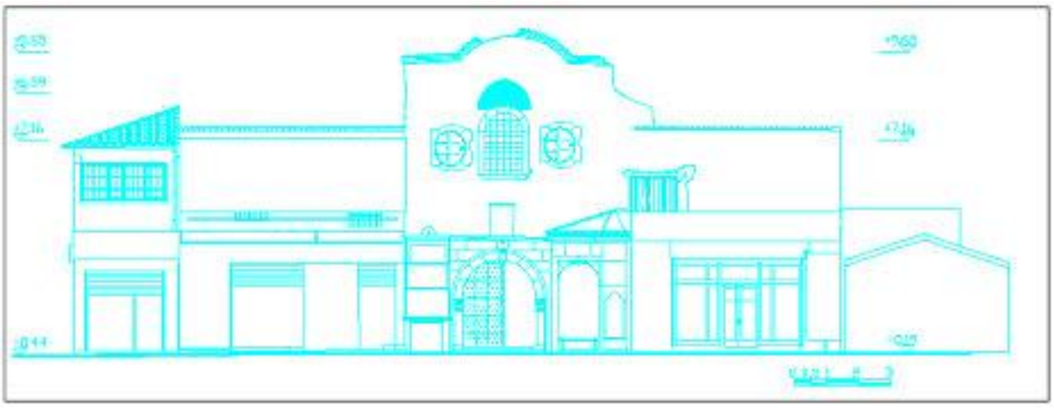
Figure 59. The perspective view from the solid model of the northwestern facade

3.3.2. Texture Mapping

Texture should be added on each side of solid model to get realistic impression of building. Texture was assigned by selection of the best quality images of the Khan. With texture mapping properties in Google SketchUp 7 image-based three-dimensional model was produced. "Texture" tool was used to attach photograph for filing the whole facade. If the proportions of the image perfectly match the face, SketchUp automatically tiles the image for filling the whole facade (Chopra 2007).

Texture mapping of the whole facade of Çakaloğlu Khan was assigned on the model. The texture of northwestern facade was overlapped with two-dimensional measured drawing of northwestern facade (Figure 60).

a



b

Figure 60. Çakaloğlu Khan, northwestern facade, image from model overlapped with measured drawing (a) Çakaloğlu Khan, northwestern facade, measured drawing (b) (Source: IZTECH, Department of Architectural Restoration - Digital Archive)

The texture of southeastern facade was overlapped with two-dimensional measured drawing of southeastern facade (Figure 61). The same process was made on the northeastern facade (Figure 62).

a

b

Figure 61. Çakaloğlu Khan, southeastern facade, image from model overlapped with measured drawing (a) Çakaloğlu Khan, southeastern facade, measured drawing (b) (Source: IZTECH, Department of Architectural Restoration - Digital Archive)

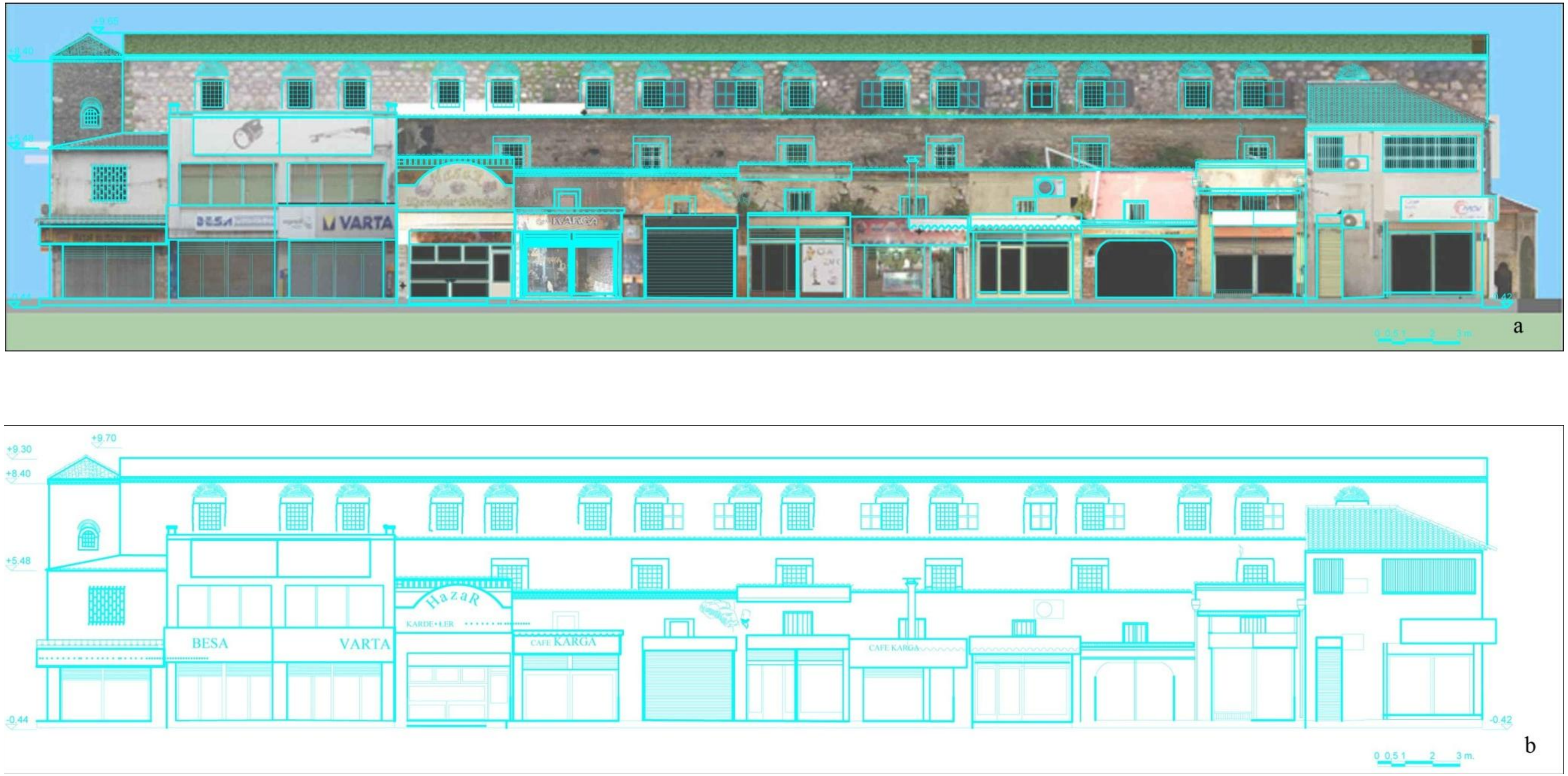


Figure 62. Çakaloğlu Khan, northeastern facade, image from model overlapped with measured drawing (a) Çakaloğlu Khan, northeastern facade, measured drawing (b) (Source: IZTECH, Department of Architectural Restoration – Digital Archive)

3.3.3. Image-Based Three-Dimensional Modeling

- The image-based model of the Khan was generated with Google SketchUp 7. First, the solid model was created based on the two-dimensional CAD drawings. Second, an image-based model was created from the solid model using the "Texture" tool in the software. The solid model was opened and the "Texture" tool was selected. The image-based mass model and original architectural elements model were created by attaching the related facade photographs selected from the digital image archive to the solid model.
- To begin with, the solid model file was opened with "File – Open" in Google SketchUp 7 (Figure 63).

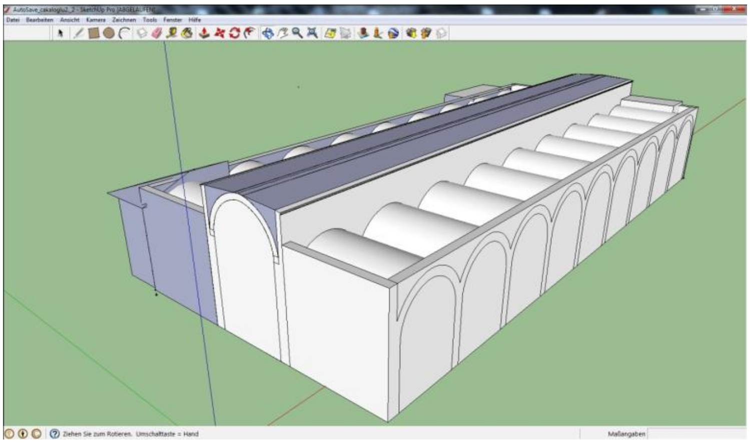


Figure 63. Opening the related file with "File – Open" selections in Google SketchUp 7

- In the second phase, the related photograph was selected using the "Paint Bucket" command  and "Create Material" command  in "Browse for Material Image File". The photographs were attached to the related facade using the "Paint Bucket" command  (Figure 64, 65). The four corners of the facade surface on the photographs were overlapped with the related part of the model surface by selecting "Texture – Position" selections with the right-click of the mouse (Figure 66). All photographs were attached to the model surface in this way and the photographs were then attached to the model surface. After this process, the necessary photograph editing operations were carried out with the "Line" command.

- Later on, contours and lines were drawn on the photographs with the "Line" tool to create different surfaces. The foreground and background sections of the surfaces were extruded with the "Push / Pull" tool based on the dimensions in the architectural documentations drawings (Figure 67).
- Some parts on model were painted with the "Paint" tool due to the lack of texture (Figure 68).
- As the Khan could not be fully perceived due to the dense buildings around it, creating a three-dimensional model was considered essential for the presentation of the Khan as well as conservation work. It is important in terms of making it possible to follow the condition of the building by updating the building's digital photographs.

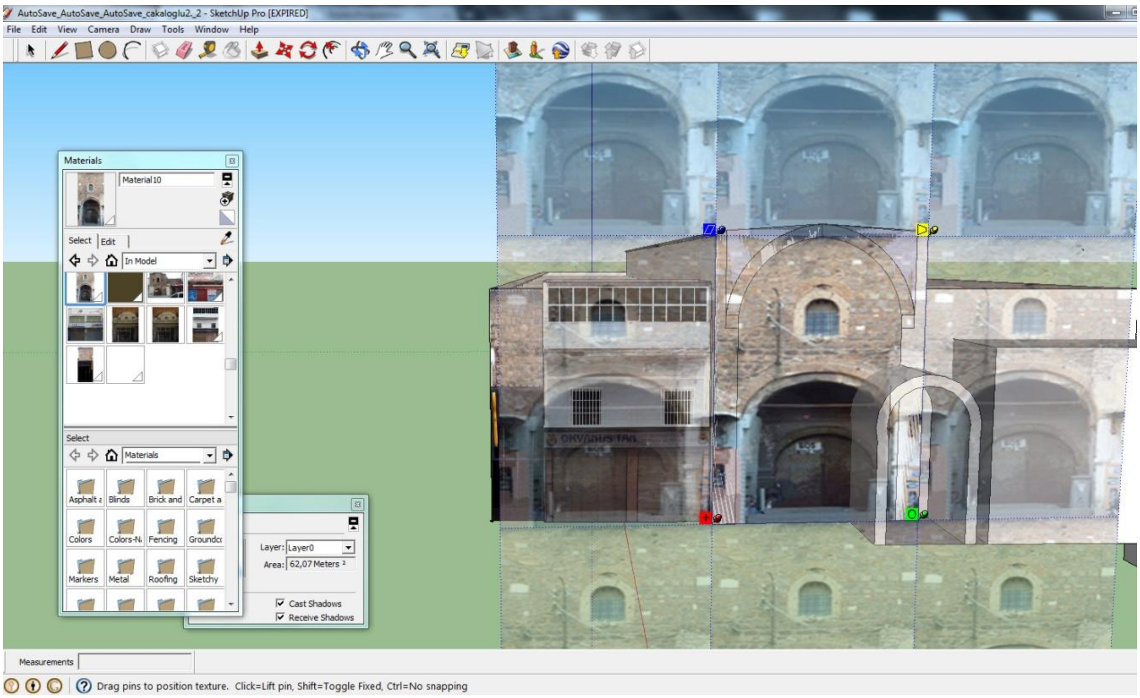


Figure 64. Attaching the photograph to the related surface

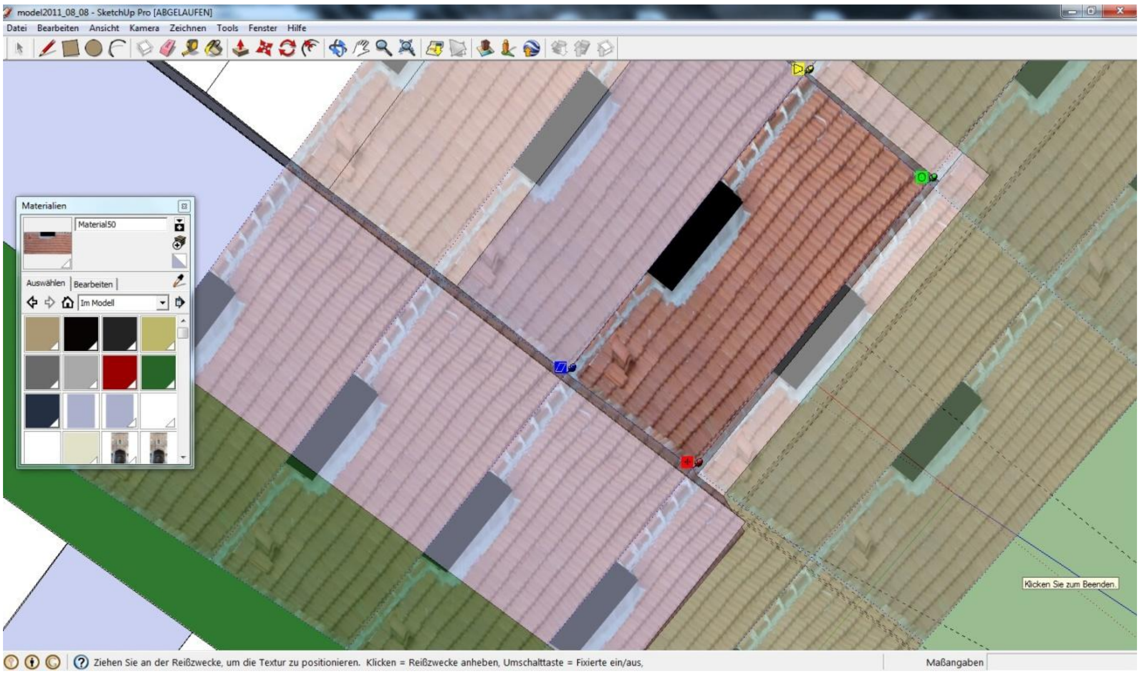


Figure 65. Attaching the roof photograph on the related surface

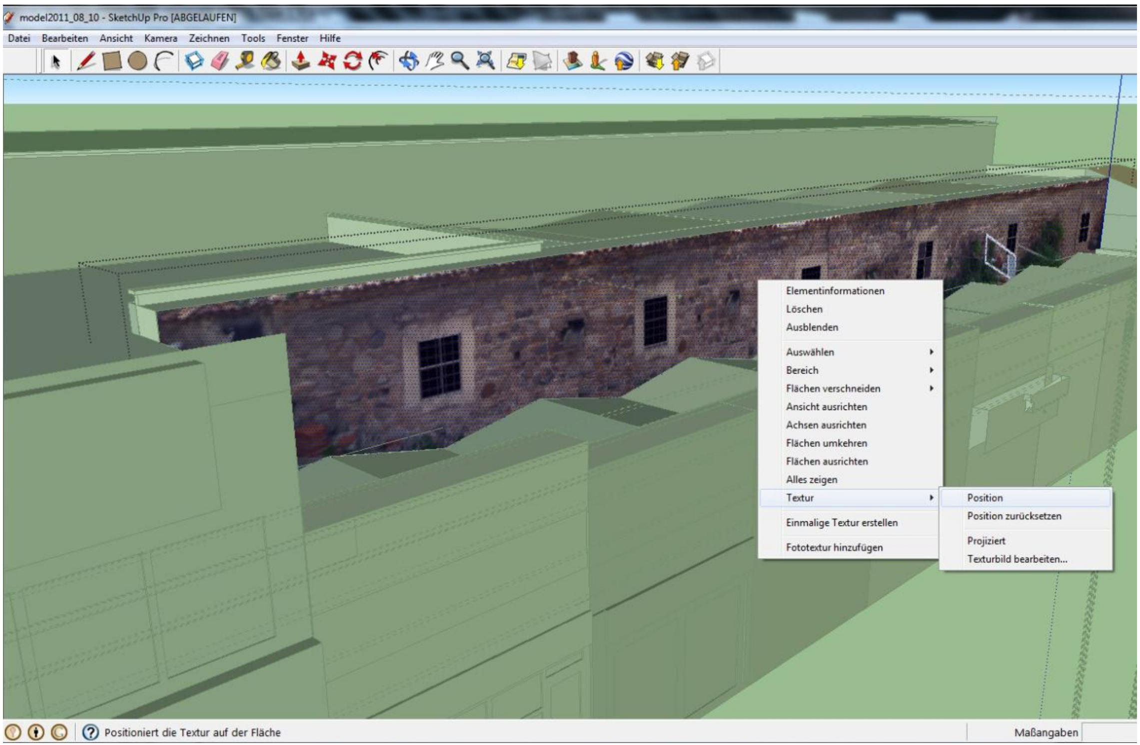


Figure 66. Choosing the exact position to attach the photograph using the "Texture – Position" selections

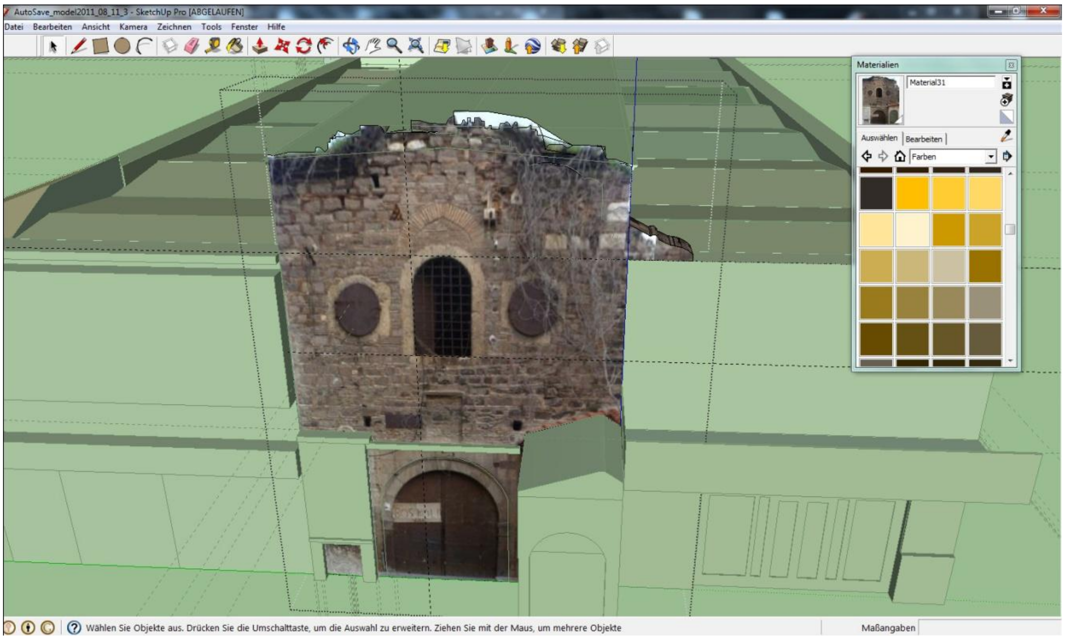


Figure 67. Attaching the entrance photograph of the northeastern facade on 895 Street on the model surface

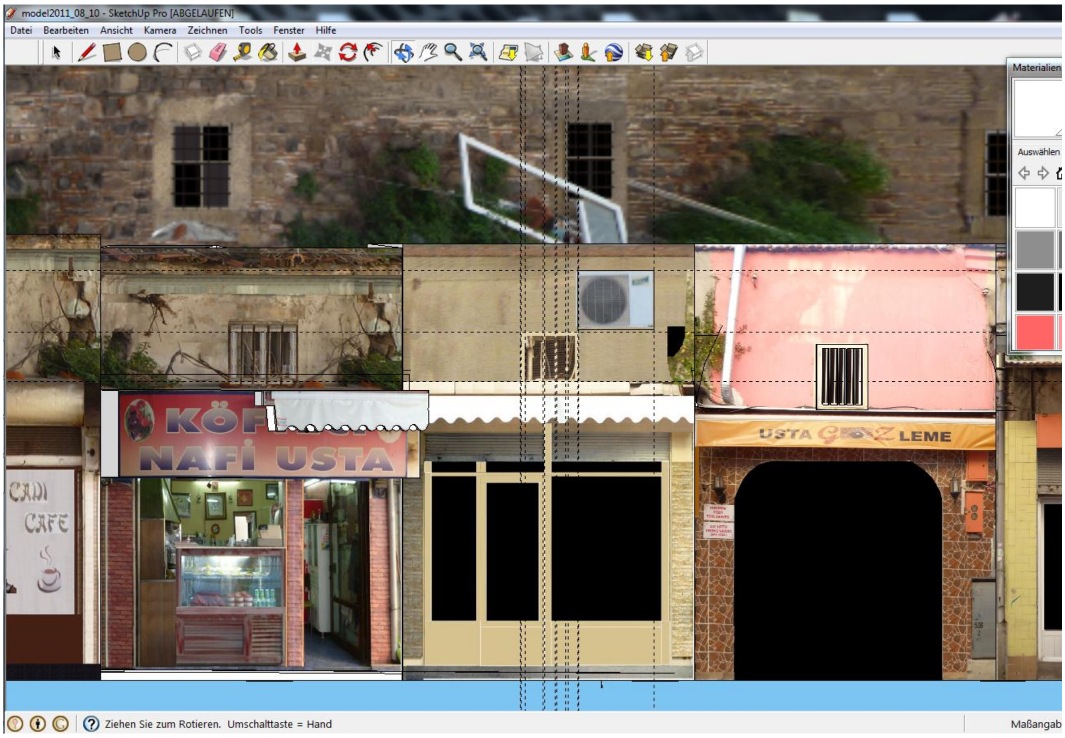


Figure 68. The shop model on the northwestern facade on 897 Street

The original architectural elements of the Khan were created with helping Google SketchUp 7. The original based, material, shape of the doors and windows was created

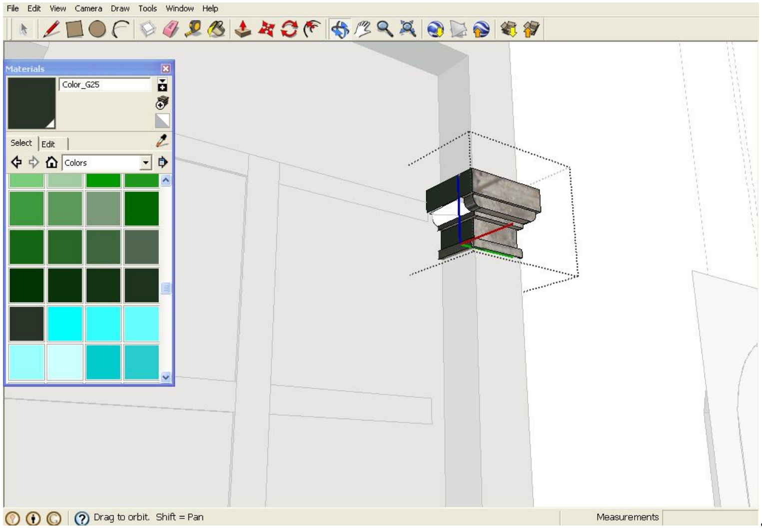


Figure 69. The modeling of the architectural elements of the Khan

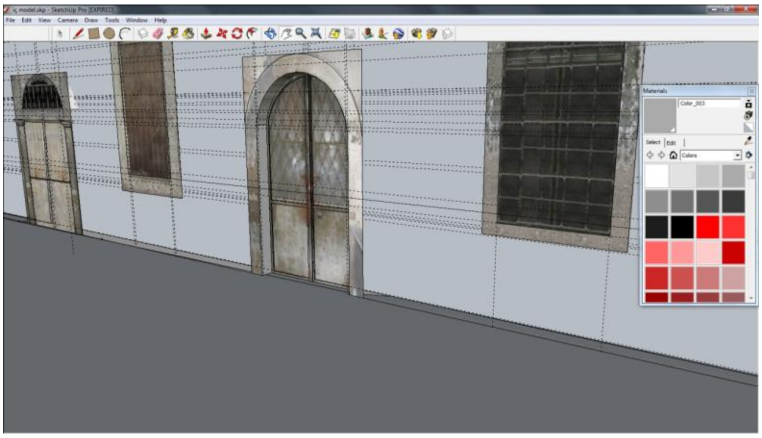


Figure 70. The modeling of the architectural elements of the Khan

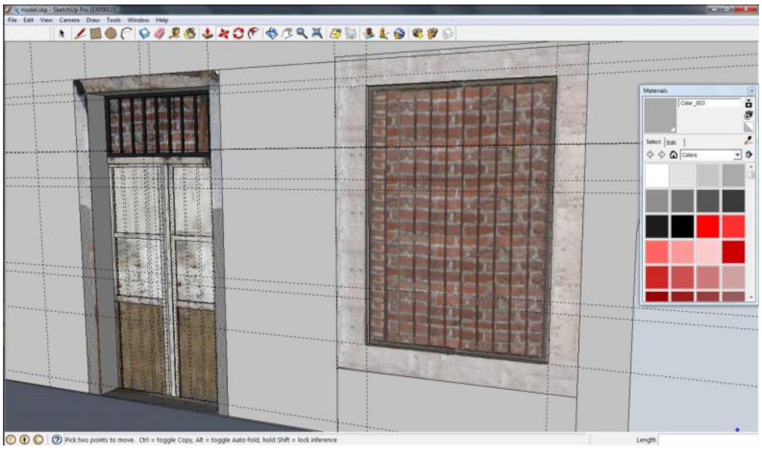


Figure 71. The modeling of the architectural elements of the Khan

Figure 72. Image-based three-dimensional model of the door of Z13 in middle passage

Figure 73. Image-based three-dimensional model of the window of Z15 in middle passage


Figure 74. Image-based three-dimensional model of the door of Z17 in middle passage


Figure 75. Image-based three-dimensional model of the window of Z17 in middle passage

Figure 76. Image-based three-dimensional model of the door of Z18 in middle passage

Figure 77. Image-based three-dimensional model of the window of Z18 in middle passage

Figure 78. Image-based three-dimensional model of the door of Z21 in middle passage

3.3.4. Rendering and Illumination Settings

A geometrically accurate image-based three-dimensional modeling was created in Google SketchUp 7 software. The same software was used for render and illumination settings. This adjustment is important for the presentation of modeling. Camera position and shadow effect were adjusted. The perspective view taken from different camera position was saved with "File-Export-two-dimensional Graphic" selections in jpeg format.

Figure 79. Northwestern view of Çakaloğlu Khan

Figure 80. North view of Çakaloğlu Khan

Figure 81. Northeastern view of Çakaloğlu Khan

Figure 82. Eastern view of Çakaloğlu Khan

Figure 83. South view of Çakaloğlu Khan

Figure 84. Southeastern view of Çakaloğlu Khan

CHAPTER 4

RESULT AND DISCUSSION

This study showed a scaled image-based three-dimensional modeling could be created by using low cost technology in three-dimensional documentation and visualization of cultural heritage.

In this modeling process, first; digital photograph archive of the Khan was created by using low cost digital compact camera during photographic documentation work on survey area. Second; the selected 92 photographs from digital photograph archive consisted of a collection of photograph recording was edited with related softwares depending on the principles of single image rectification. Later; scaled solid model of Khan was made by using two-dimensional CAD drawings of Khan**.** The edited images were attached to the related surface of solid model to create texture. The importance of this model different from a solid model in the documentation of historical building is the perception through photographs, the illustration of alterations through photograph and periodical updating of photographs. This study supplied a visual whole of Çakaloğlu Khan that is not available due to the surrounding dense construction.

The used software during the study was preferred because of easy accessibility, free and pre-experience softwares. The longest time was spent during digital image processing. Therefore, each photograph was edited using Zoner Photo Studio 10, Adobe Photoshop Elements 7.0, Inkscape softwares. The modeling process was completed quicker with the help of the properties of Google SketchUp 7 software.

As a result, a scaled, geometrically accurate model of Çakaloğlu Khan was created. With this three-dimensional model, the visual three-dimensional data was generated related to the size, shape and texture properties of Khan.

4.1. Remarks for Photographic Documentation

- Digital camera and lens type are important. SLR cameras or digital compact camera should be preferred.
- Each photo should be taken parallel to the building facade. It is better to take photographs of building facade as much as perpendicular as possible to the facade (Turan 2003).
- Facade objects at different depths such as shops, entrance and middle passage should be taken in different images.
- A sufficient number of photographs should be taken to cover facade surfaces. In this study, 92 photographs were used to cover three-dimensional model.
- The maximum shooting distance should be considered. It was determined 28 meters according to focal length of camera.
- Attention was paid to photographic documentation in cloudy weather and refrain from shaking the camera.
- Shadows, reflections and backlights or burned photographs should be averted (Arias, et al. 2007).
- It is important to refrain from having unnecessary elements such as people, trees and cars in the photographs.

4.2. Remarks for Rectification and Image Processing

- Photographs were taken considering the principles of single image rectification.
- Four control points are enough to rectify a scaled image (Turan 2003).
- Rectification should be made separately for image series.
- An important point is the organization of rectified image. The production of rectified image, the right dimension and the scale of rectified image should be considered.
- The color adjustment should be considered for the expression of the whole facade.
- Unrectified planes should be edited for the perception of facade as a whole.
- The irrelevant parts such as signs and water pipe and non-desired objects such as car, people on photographs were deleted. In addition, deleted parts on photograph should be painted with realistic color.

4.3. Remarks for Three-Dimensional Modeling in Google SketchUp 7

- Google SketchUp 7 software was chosen for its online accessibility, its fast modeling process and its ability to transfer dwg format CAD drawings.
- It is also possible to transfer the three-dimensional modeling study to Google Earth, where the three-dimensional model of the Khan can be accessed and the location of the Khan can be viewed.
- Utilizing Google SketchUp 7 to construct image-based models is advantageous as it allows a more realistic surface texture with the texture mapping feature and makes it possible to update alterations in the model.
- In Google SketchUp 7, in modeling process, non-textured surfaces were painted similar tone to the original texture.

CHAPTER 5

CONCLUSION

Scaled image-based three-dimensional model of Çakaloğlu Khan, located in the historic Kemeraltı commercial district based on two-dimensional drawings was created by using a low cost digital compact camera. In this study, the advantages of the proposed methodology are given in the following.

The advantages of the methodology:

- Easy to obtain by using low cost digital compact camera.
- Easy-to access free softwares from the internet.
- Short survey time in photographic documentation (3 hours for this survey).
- Easy to update the model periodically by taking new photos of the alterations on building.

The primary difficulty in this modeling process of Çakaloğlu Khan is the dense construction around of the Khan during photographic documentation. Due to lack of aerial photographs of roof surfaces, the roof texture could not easily be seen on the model.

As a result, the image-based three-dimensional model of the exterior of the Khan and its original building elements can be regarded as a supplementary data and tool to facilitate conservation decisions. Due to the dense urban texture only through viewing this model can be observed as a whole entity. The image-based modeling technique makes it possible to update the condition of the building through determining alterations in the building by updating the photographic documentation.

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APPENDIX A

ARCHIVE DOCUMENTS

KÜLTÜR VE TURİZM BAKANLIGI
İZMİR 1 NUMARALI KÜLTÜR VE TABİAT VARLIKLARINI KORUMA BÖLGE KURULU

KARAR

720.00

TOPLANTI TARİHİ VE NO : **15.06.2006-54**

KARAR TARİHİ VE NO : **15.06.2006-1502**

Toplantı Yeri
İZMİR

İzmir İli, Konak İlçesi, 895 Sokak ile 861 Sokak arasında bulunan, tapunun 221 ada, 1-3-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-42-43-44-45-46-47-48-49-50-51-52-53-54-55-56-57-58-65 parsel numaralarında kayıtlı Çakaloğlu Hanının kamulaştırılması istemine ilişkin 26.5.2006 tarih ve 782-5042 sayılı Konak Belediye Başkanlığı yazısı ve uzman raporu okundu, işlem dosyası incelendi, yapılan görüşmeler sonunda;

İzmir İli, Konak İlçesi, tapunun 221 ada, 1-3-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-42-43-44-45-46-47-48-49-50-51-52-53-54-55-56-57-58-65 parsel numaralarında kayıtlı, İzmir 1 Numaralı Kültür ve Tabiat Varlıklarını Koruma Kurulu'nun 30.1.2002 tarih ve 9728 sayılı kararı ile belirlenen ve Koruma Amaçlı İmar Planı revizyonu aynı Kurul tarafından uygun bulunarak yürürlüğe giren Kemeraltı Kentsel Sit Alanında kalan Gayrimenkul Eski Eserler ve Anıtlar Yüksek Kurulu'nun 20.6.1981 tarih ve A-2954 sayılı kararı ile korunması gerekli taşınmaz kültür varlığı olarak tescillenen, İzmir 1 Numaralı Kültür ve Tabiat Varlıklarını Koruma Kurulu'nun 30.4.1992 tarih ve 3680 sayılı kararı ile koruma grubu, 1.grup olarak belirlenen Çakaloğlu Hanı'nın kamulaştırılması isteminin, 2863 sayılı yasanın kamulaştırmaya ilişkin 5226 ve 3386 sayılı yasalarla değişik 15.maddesi doğrultusunda, Koruma Amaçlı Revizyon İmar Planı ile öngörülen kullanım kararı kapsamında belirlenecek işlevin projelendirme aşamasında detaylandırılması şartıyla uygun olduğuna (OLUMLU); karar verildi.

BAŞKAN
Tankut ÜNAL

BAŞKAN YARDIMCISI
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ÜYE
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ÜYE
Yrd.Doç. Dr. Rahmi ERDEM

ÜYE
İhsan TUTUM

ÜYE
Hasan TOPAL
Büyükşehir Belediye Başkanlığı

ÜYE
Muhittin SELVİTOPU
Konak Belediye Başkanlığı

ÜYE
Vakıflar Bölge Müdürlüğü
BULUNMADI

Figure A1. Desicion of İzmir First Regional Conservation Council of Cultural and Natural Heritage

APPENDIX B

THE EXTERIOR MODELING OF THE KHAN IN 1/200 SCALE

Figure B1. The roof plan of Çakaloğlu Khan Scale: 1/200

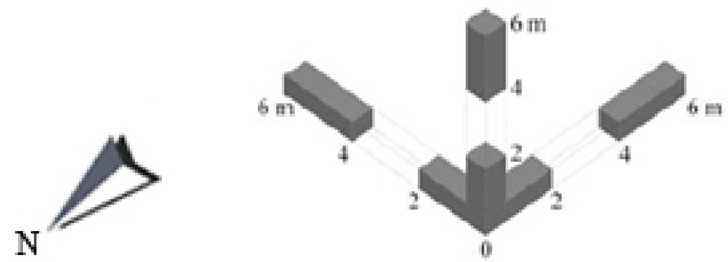


Figure B2. Northwestern facade of Çakaloğlu Khan Scale: 1/200

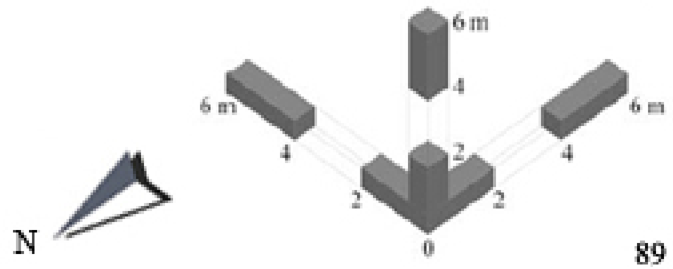
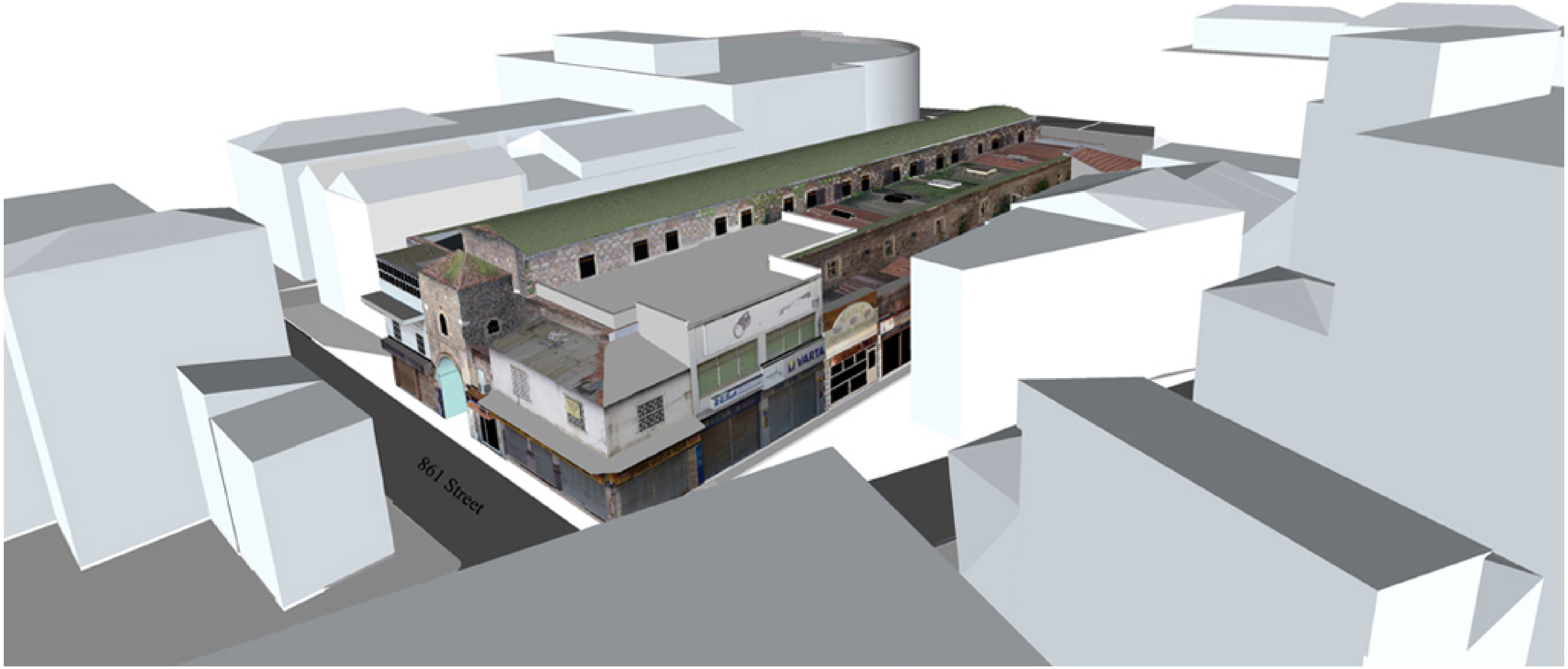


Figure B3. Western facade of Çakaloğlu Khan Scale: 1/200



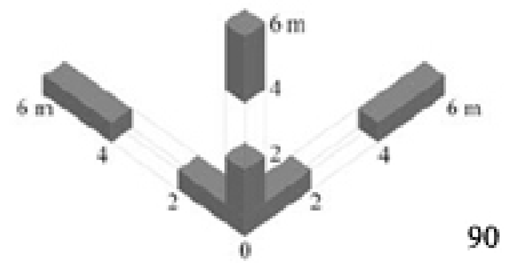


Figure B4. Eastern facade of Çakaloğlu Khan Scale: 1/200

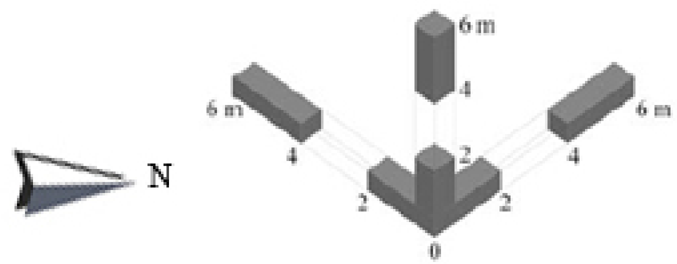


Figure B5. Northeastern facade of Çakaloğlu Khan Scale: 1/200

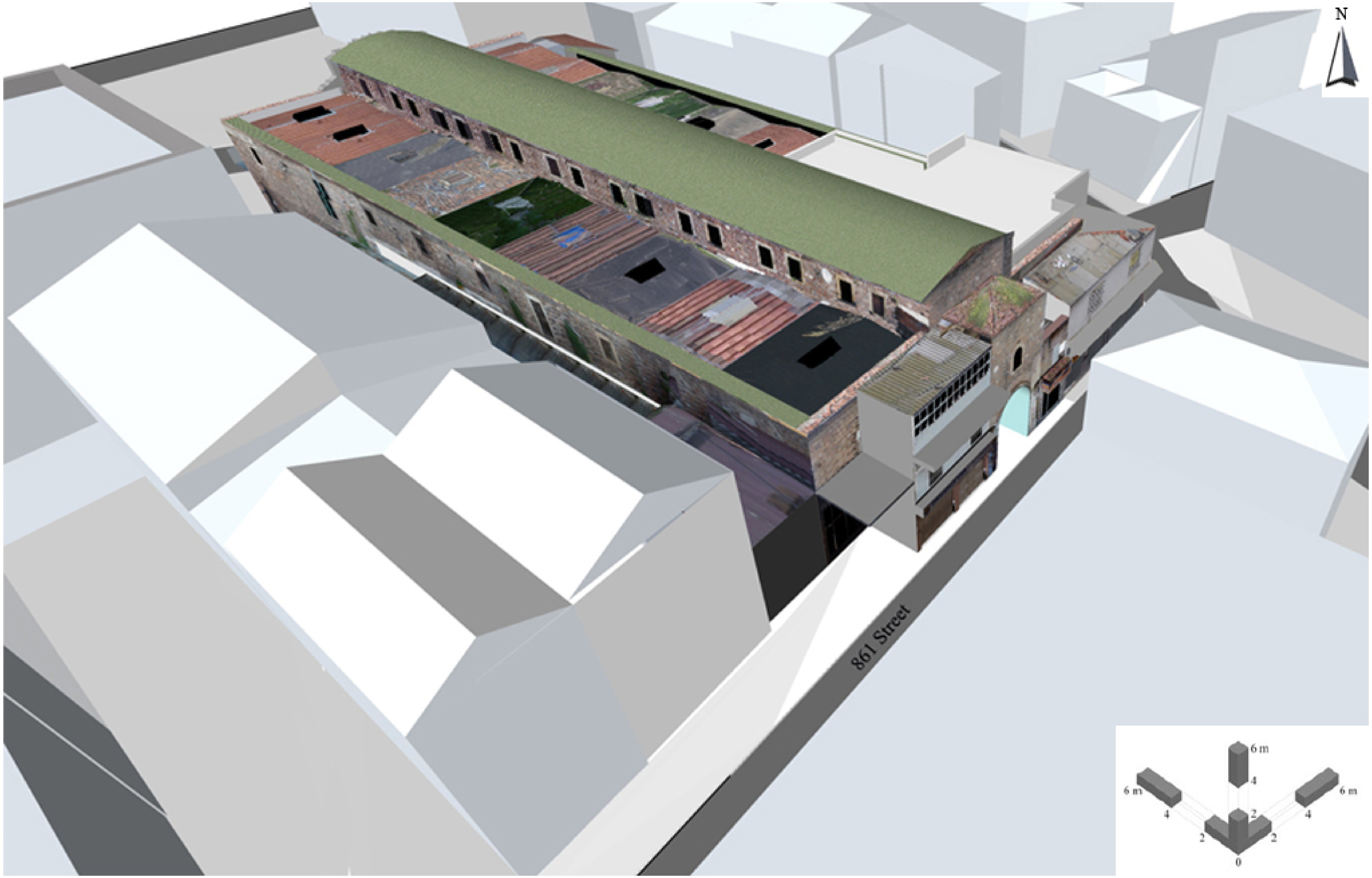


Figure B6. South facade of Çakaloğlu Khan Scale: 1/200