DOCUMENTATION OF A HISTORICAL HOUSE WITH CLOSE RANGE DIGITAL PHOTOGRAMMETRY

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ABSTRACT

DOCUMENTATION OF A HISTORICAL HOUSE WITH CLOSE RANGE DIGITAL PHOTOGRAMMETRY

This study aims to document the original architectural characteristics, alterations and damages of a historical house by combining the digital photogrammetric techniques with the mapping concepts of architectural conservation so that an architectural conservation project can be guided. The proposed documentation is carried on the entrance façade of a 19th century house located in the urban conservation site of Alaçatı, İzmir, Turkey. The Demiral House has conservation priority among the other listed houses because of its vacant state and damages.

Analytic recording of the façades of the historical houses in Alaçatı can be made fast with the rectification option of close range monoscopic softwares. A calibrated digital camera and a total station are the other tools used in this process. The colored thematic maps prepared are accurate enough for 1/50 scale analysis and they possess the qualitative information on the photographs. After it is checked that the three-dimensional measurements defining the general geometry overlap with the 1/50 scaled rectified image mosaic, the details concerning the deteriorations are decided to be drawn to the scaled elevation drawing from this mosaic.

This study has proposed a contemporary documentation technique so that architect-conservators can easily adapt in their conservation projects. When compared to the frequently applied documentation techniques like hatching on scaled two-dimensional elevation drawings, it takes shorter time to prepare the proposed mapping method on rectified image mosaic. The architect-restorer has also the chance to examine many constructional details on the scaled rectified image mosaic. The end results are more realistic.

Keywords: Architectural conservation, Close range, Rectification, Mapping, Alaçatı.

ÖZET

TARİHİ BİR KONUTUN YAKIN ERİMLİ DİJİTAL FOTOGRAMETRİ İLE BELGELENMESİ

Bu çalışma, dijital fotogrametrik teknikleri mimari koruma disiplinindeki haritalama teknikleri ile birleştirerek, tarihi bir yapının orjinal mimari elemanlarını, değişmişliklerini ve hasarlarını belgelemeyi ve böylece bir mimari koruma projesine rehberlik edebilmeyi amaçlamaktadır. Önerilen belgeleme, İzmir'de Alaçatı kentsel koruma bölgesinde bulunan bir 19. yüzyıl evinin ön cephesi için uygulanmıştır. Demiral Evi, boş durumda olması ve hasarları sebebiyle diğer tescilli evler arasında koruma önceliği taşımaktadır.

Alaçatı'daki tarihi evlerin cephelerinin analitik belgelenmesi yakın erimli monoskopik yazılımların düzeltim opsiyonu ile hızlı bir şekilde yapılabilir. Kalibre edilmiş dijital bir kamera ile bir "total station" (elektronik takeometre cihazı) bu aşamada kullanılan diğer araçlardır. Hazırlanan renkli tematik haritalar, 1/50 ölçekli analiz için yeterli hassasiyettedirler ve fotoğraflar üzerindeki niteliksel bilgiye sahiptirler. Genel geometriyi belirleyen üç boyutlu nokta ölçümlerinin 1/50 ölçekli düzeltilmiş imaj mozaiği ile çakıştığı kontrol edildikten sonra, bozulmalara ait ayrıntıların bu mozaikten çizilebileceğine karar verilmiştir.

Bu çalışma, korumacı-mimarların koruma projelerine adapte edebilecekleri, çağdaş bir belgeleme yöntemi önermektedir. Ölçekli iki boyutlu cephe çizimlerinin üzerine tarama yaparak harita oluşturma gibi sık uygulanan belgeleme tekniklerindekine kıyasla, düzeltilmiş imaj mozaiği üzerine haritalama olarak önerilen yöntemde harcanan süre daha kısadır. Restoratör mimarın, hazırlanan ölçekli düzeltilmiş imaj mozaiği üzerinde birçok yapısal detayı inceleme şansı bulunmaktadır. Sonuç ürünler gerçeği daha iyi temsil ederler.

Anahtar Kelimeler: Mimari koruma, Yakın Erimli, Düzeltim, Haritalama, Alaçatı

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CHAPTER 1

INTRODUCTION

Visual information about the architectural structures can be collected from old photographs, old maps, old drawings and projects, pictures and gravures and documentary drawings. This study considers the visual documentation of architectural heritage and emphasizes scaled two-dimensional visualizations based on close range digital photogrammetric survey.

The improvement of methods of surveying historic structures is counted as an important contribution to recording and monitoring of cultural heritage. The technology to be used in the surveying and recording of these structures depends on the characteristics of the case and the project budget. The specified objectives and the way the records are going to be utilized are also important factors in this decision. In this sense, an initial photographic recording, and a preliminary and a detailed record are pointed out as the main stages in the recording (Feilden and Jokilehto 1993). Adequate documentation allows one to obtain information on the state of the building. This information, when gathered accurately, can be used to undertake several types of interventions such as consolidation, reconstruction, rehabilitation, restoration, etc. With adequate visual documents, the design ideas for the conservation project of the studied structure can become easier to develop.

Architectural heritage recorders should be aware of current standards of documentation and learn how to use relevant techniques. Being able to read and understand the character and values of heritage structures is another important input in the documentation of these structures in a proper way (Feilden and Jokilehto 1993). The common conservation policies expressed in the international charters, recommendations and guidelines provide an invaluable guide for people working in the field of building conservation and build an essential framework for good practice in the protection of the historic environment. The Venice Charter[1], as being one of the principal references in terms of modern conservation principles, underlines the significance and the necessity of a common responsibility to safeguard historic monuments including the historic

1 The Venice Charter (1964): The International Charter for the Conservation and Restoration of Monuments and Sites.

urban and rural areas. It has become the principal reference for the assessment of cultural heritage sites since 1964 (Jokilehto 2002). "Article 16" of the Venice Charter (1964) takes into account the importance and the necessity of precise documentation:

> In all works of preservation, restoration or excavation, there should always be precise documentation in the form of analytical and critical reports, illustrated with drawings and photographs. Every stage of the work of clearing, consolidation, rearrangement and integration, as well as technical and formal features identified during the course of the work, should be included. This record should be placed in the archives of a public institution and made available to research workers. It is recommended that the report should be published.

The Burra Charter[2] considers all types of places with cultural values in the process of conservation. Recording procedure is emphasized in "Article 27.2" of the Charter: "Existing fabric, use, associations and meanings should be adequately recorded before any changes are made to the place". The charter underlines the need to involve people in the decision process. This idea is supported in "Article 32.1" by accentuating the archiving procedure for public availability: "The records associated with the conservation of a place should be placed in a permanent archive and made publicly available, subject to requirements of security and privacy, and where this is culturally appropriate".

The importance of producing reliable heritage records is also emphasized in the set of guidelines originated from a joint meeting by ICCROM[3] and ICOMOS[4], which is gathered in a book, titled as "Management Guidelines for World Cultural Heritage Sites". Under the chapter heading of "Inventory and Documentation", it is stated that "a full inventory and documentation of the buildings with their contents and the landscape of the site should be prepared". The computer is regarded as a necessary tool for inventory, documentation and management by processing basic data supplied in a good field work in many different ways (Feilden and Jokilehto 1993). The attention is drawn to the necessity of preparing a work plan, which defines the resource, the objectives, the extent of documentation and the available technologies that will have to be acquired (Feilden and Jokilehto 1993).

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[2] The Burra Charter (1999): The Australia ICOMOS Charter for the Conservation of Places of Cultural Significance whish is drafted in 1979, revised in 1981, 1988 and 1999.

[3] ICCROM: The International Centre for the Study of the Preservation and the Restoration of Cultural Property

[4] ICOMOS: The International Council on Monuments and Sites. It is an organization dedicated to the conservation of the world's historic monuments and sites. It was found in 1965 (Leterrier 2001).

At the end of the Round Table Meeting of RecorDIM[5] that was held in June 2002 at GCI, a Final Report was prepared which gathered all the agreements of different groups after the working sessions. One of the six areas where they decided that actions were needed was to integrate recording, documentation and information management activities into the conservation process. The participants agreed that heritage recording must be integrated into the conservation process and that there is a strong need for standards and guidelines. The site values, the project objectives and the budget constraints are declared as the three important points to be considered; when defining the scope of recording and documentation.

Some believe that redirecting budgets to documentation activities may reduce the conservation activity budget. On the contrary, recording and documentation can foster better understanding and consequently an acknowledgement of the need for more resources for conservation. In situations where there is very little funding to undertake a conservation activity, recording may become the only justifiable activity, used to salvage information before the assets deteriorate further (RecorDIM 2002).

At the report of "Group 1" of RecorDIM; determination of the methods that will be used in the recording process, selection of these methods, knowing which method is most appropriate, and determination of the level of recording necessary are underlined as important aims in documentation process (RecorDIM 2002).

The metric methods used in the documentation of cultural heritage at present can be categorized as follows: manual/traditional, topographic, photogrammetric and laser scanning (Arias, et al. 2007). It is underlined that the metric method chosen to be used for each particular case depends on the objectives of the study, the required degree of accuracy and the characteristics of the heritage to be documented.

Photogrammetric documentation and related methods are indispensable for the systematic recording of the heritage resources. These invaluable methods form a quantitative inventory of both natural and man-made sites. Close range photogrammetry, which is the type of photogrammetry used in architectural documentation, is defined as a technique for obtaining geometric information such as position, size and shape of any object that was imaged on photos previously (Kasser and Egels 2002).

[5] The International Council on Monuments and Sites (ICOMOS), the Getty Conservation Institute (GCI) and The International Committee for Architectural Photogrammetry (CIPA) together created the RecorDIM (for Heritage Recording, Documentation and Information Management) Initiative partnership.

The photogrammetric methods stand out with the short length of time required at the site to carry out measurements (Arias, et al. 2007). For example, a study has been carried out to compare the work times of photogrammetric and conventional surveys (Yilmaz, et al. 2007). It is proven that measurements collected with photogrammetric techniques in less than 3 days in the field would have taken 10 days in a conventional survey. However, office work during the evaluation stage is actually longer (Yilmaz, et al. 2007). On the other hand, it is also proven that the accuracy of photogrammetric documentation is 10 times more than traditional one.

As a matter of fact, the shortening of field work time can be very important for the documentation of cultural heritage that has difficult working conditions. Feilden (1994) briefly explains the main advantages of photogrammetry in his book. The first advantage underlined is the speed in photographic recording without a need to any scaffolding which also supports the common idea that this process shortens the field work time. When objects to be recorded are irregular, photogrammetry can save time and money in survey. It can also make the measurement of fragile objects possible such as measurement of invisible features by X-ray photogrammetry. Another common opinion is that photogrammetry is practical in surveying buildings that are impossible or dangerous to reach. For instance, a historical building that has been extensively ruined can be reconstructed this way.

Photogrammetry also gives way to compare the changes in the state of an object with the photographs taken in different periods. An important point for the success in this method is taking informative photographs especially for the essential purpose. In measurement, documentation and conservation of historical buildings, it is much more advantageous if architectural photogrammetric drawings are made by people who have knowledge on historical buildings. It is momentous to be able to interpret the historical buildings correctly in every phase of conservation (Feilden 1994).

The significance of close range digital photogrammetry as a universal documentation technique for architectural heritage is emphasized in the reports of the Working Groups in CIPA[6]. In “Working Group 3 (WG3) – Simple Methods for Architectural Photogrammetry”, Almagro (1999) states:

[6] CIPA: The International Committee for Architectural Photogrammetry. It is one of the oldest International Scientific Committees of ICOMOS. It was founded in 1968, in cooperation with ISPRS (International Society for Photogrammetry and Remote Sensing), to facilitate the transfer of technology from the measurement sciences into the heritage documentation and recording

Digital photogrammetry is reducing the cost of the equipment and increasing the possibilities of application of photogrammetry in the field of documentation of monuments and other cultural heritage.

Almagro (1999) defends that the use of photogrammetric softwares based on simple equipment is not more complicated than the use of CAD softwares and they can be more widely used promoting a reduction in costs.

The majority of the data collection and processing studies with medium budgets and which are related with architectural heritage make use of close range digital photogrammetry based on bundle method. For data processing, monoscopic digital stations are mostly preferred, because they provide accurate three-dimensional measurements of historical buildings, and also the architect-restorers with some skill and experience in computer environment may use them in their projects (Hamamcioglu-Turan and Akbaylar 2007).

Consequently, recent researches underline the importance of the development of the simple, cheap and fast photogrammetric methods that are accessible to a great number of people (Dereny 1993, Almagro 1999, Almagro 2001, Arias 2007). International education programs, ARIS[7] (ARIS03 2008) (ARIS05 2008) and CLADIC[8] courses, are initiated to support low-cost, photogrammetric documentation techniques of architectural conservation (Almagro-Vidal and Almagro 2005).

Conventional photogrammetric studies concentrate particularly on the production of elevation drawings, while also supporting the measurement process of them (Swallow et al., 2004: 161). The photogrammetric technique overcomes the general surveying of façades where the issue of access is problematic for taping, as well as, for locating the reflecting prism. At the same time, the field work time and the number of surveyors can be reduced. Photogrammetry is preferred in architectural documentation since it can also allow the rapid capture of detailed and accurate information on façades and their details (Mikhail, et al. 2001). By this way, the elevations can be documented retaining their true size, scale, shape and proportion

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disciplines. Since this name no longer describes the full scope of CIPA activities, 'CIPA Heritage Documentation' was established (CIPA Brochure 2008).

[7] ARIS (Architectural Records, Inventories and Information Systems for Conservation) is a series of courses addressing "Architectural Conservation, Heritage Recording, and Information Management" which were held in October 2003 and April 2005 by ICCROM in Rome. At the first ARIS course ARIS03, 12 students took part in the recording project of the courtyard and square of the church of Santa Cecilia in Trastevere. In ARIS05, an urban survey of the Piazza Mercanti adjacent to Santa Cecilia was done by 16 students. ARIS courses support the improvement of simple tools in Heritage Recording (Nickerson and Chapiro 2005) (ARIS03 2008) (AIRS05 2008).

[8] CLADIC: Centre Liégeois de Documentation et d'Archives sur l'Industrie Charbonnière

(Porter and Woodman 1980). Usually, the topographic measurements are used as a support in the photogrammetric documentation of elevations, as applied in this study.

On the other hand, the contemporary studies concentrating on presentation techniques frequently involve three-dimensional model construction based on the photogrammetric measurements transferred to CAD. Three-dimensional points measured in monoscopic digital stations are generally transferred to CAD environment to construct the three-dimensional models. The purpose of constructing a model of a structure in the computer is explained as it is to convey the functional and the physical transformations and to present its actual state of conservation. It is said that the use of adequate three-dimensional CAD systems and the application of accurately recorded measurements will enable one to simulate the complexity of the structure. Creating models is also needed in managing and representing the built heritage (Santana Quintero, et al. 1997). AutoCAD is extensively used for the modeling work (Hirschberg 1996, Arias 2007, Almagro 2005).

In terms of the contemporary research on presentation of architectural heritage survey results, the three-dimensional models, considering analytical visualization, are at a limited extent (Santana Quintero, et al. 1998, Santana Quintero, et al. 2002, Tucci, et al. 2003). It is evaluated that the three-dimensional model is efficient for perceiving the image of a building at different periods, whereas the conception of conservation concepts still requires graphical tools such as thematic maps.

In some cases, rectified photographs are also presented as essential contemporary products of photogrammetric studies, as much as conventional elevation drawings. An inexpensive and detailed representation of architectural details may be provided by these rectified photographs. If a detailed set of images is provided, then a valuable description of a building façade may be created (Mikhail, et al. 2001). The process of rectification have facilitated the documentation of decorated building details, such as wall mosaics, ground mosaics, wall paintings, attached sculptures, etc.

1.1. Aim of This Study

This study claims that when the scaled underlay necessary for representation of analytic concepts of architectural conservation regarding a historical house façade is prepared through the rectification process handled within the limits of close range digital photogrammetry, the architect-restorer has the chance to examine many

constructional details on the images. So; despite the reduction of the site analysis time, the alienation of the architect-restorer from the material reality of the heritage object is avoided. At the same time, the details on the rectified images provide the opportunity of a realistic representation, yet it is a scaled representation. In this context, the aim of this study is to document the original architectural characteristics, alterations and damages of a historical house with image based techniques, so that an architectural conservation project can be guided. The documentation is carried on a case study: the entrance façade of Yavuz Demiral House, which is a 19th century historical house in the urban conservation site of Alaçatı, İzmir, Turkey.

1.2. Method

The pictorial photographs including general and detail shots (41) and photogrammetric documentation aimed photographs (37) are taken with a Nikon D70S Digital SLR Camera with a resolution of 3,008 x 2,000 pixels, equipped with a Nikon 18-70 mm AF Nikkor lens. Only the 28 mm lens is used for photogrammetric documentation aimed photographs since this lens is calibrated for Pictran (Figure 1).

The coordinates of the control points are accurately measured by a digital total station (Zeiss Rec Elta RL-S). A range pole and a reflector are also used. The measurements by “Zeiss Rec Elta RL-S” total station are done in the special tracking mode with a measuring time of 0,25 sec and an accuracy of 10 mm + 3 ppm (Surveyors Express 2008).

The scaled underlay necessary for illustrating the analytic concepts is prepared with the single image rectification option of the Pictran Release 4 photogrammetric evaluation software. The rectified image mosaic is prepared in Adobe Photoshop CS in 1/50 scale. The maps of analytic themes are also formed in Photoshop.

In order to prove the fact that the rectified image mosaic is a scaled graphic, three-dimensional measurements made in Pictran are transferred to AutoCAD 2004 to prepare a scaled elevation in 1/50 scale. The scaled drawing and the rectified image mosaic are overlapped in AutoCAD and compared.

In order to prove the shortening in the time required for preparing the maps, the Structural Failures and Material Deteriorations map is prepared both in conventional techniques and the contemporary ones. In other words, hatching on a scaled elevation in AutoCAD and painting on rectified image mosaic in Photoshop is made and compared.

The visual qualities and the time of preparation of the conventional and contemporary maps are compared on a table (Table 6).

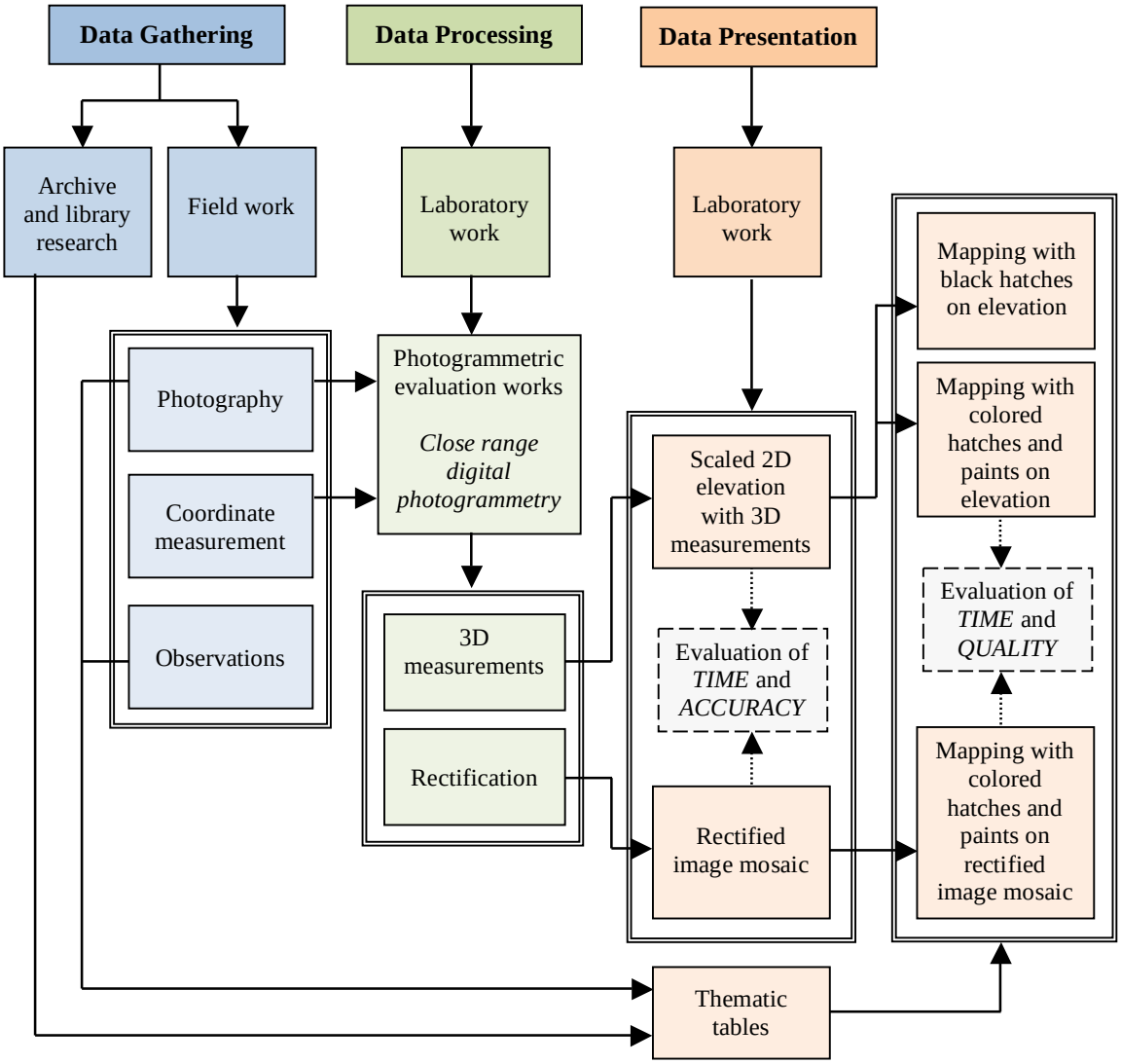


Figure 1. The flow diagram illustrating the method of the study

1.3. Literature Review

As a support to this study, recent studies of photogrammetry related to architectural heritage documentation are examined. In addition to the periodical articles; related books, web sources, proceedings of symposiums and conferences are examined. Subsequently, the studies that can be beneficial in the frame of this study are evaluated briefly below.

There are a number of studies on rectification of the façade photographs of the historical buildings (Siedler, et al. 2001, Maestri, et al. 2001, Erwes, et al. 2003, Cardenal, et al. 2005, Almagro 2001, Nickerson and Chapiro 2005, Arias, et al. 2007). In some of them, mapping of damages on the rectified image mosaics is also made (Siedler, et al. 2001) after all this method which is used in this thesis is not exemplified in many studies.

Siedler et al. (2001) underline the importance of choosing adequate methods for extensive documentation of Basilica of Maxentius. After geodetic measurements with total stations and photogrammetric measurements, the aim is to create rectified image mosaics of the basilica in a scale of 1/25 by rectification and montage of images (Figure 2). Detailed mapping of the damages on façades are produced by hand. In this thesis, thematic mapping is also applied on the rectified image mosaic of the studied façade, whereas a digital image processing software is preferred for the mapping process instead of conventional techniques. Surely, the analytical information gathered during the site survey is considered while producing these maps.

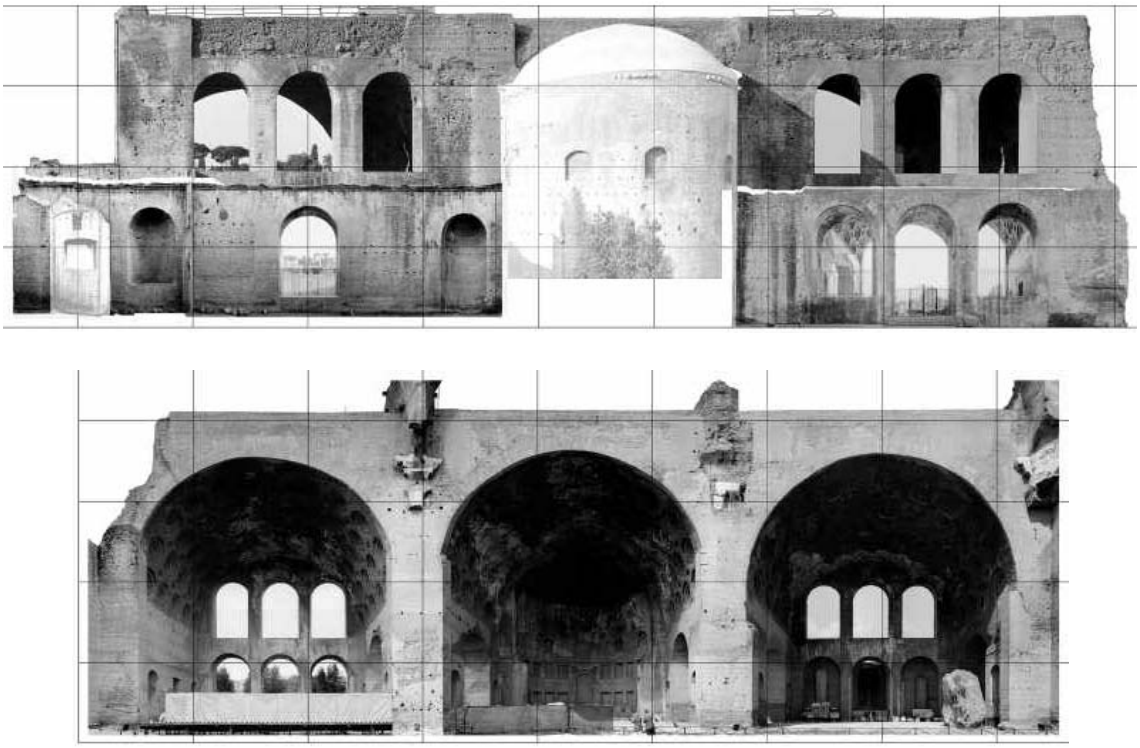


Figure 2. Examples to the image mosaics of the façades
(Source: Siedler, et al. 2001)

Maestri et al. (2001) define the architectural survey as not only a simple representation of the visible parts of a certain building, but also as the gathering of a thorough knowledge about the characteristics of it. In the first phase of the study, traditional survey methods are applied and the morphological characteristics are defined; while in the second phase, rectified images are applied on the three-dimensional model to provide information on the state of the building materials (Figure 3). The material characteristics are presented in three levels; finishing plaster, background plaster and masonry.

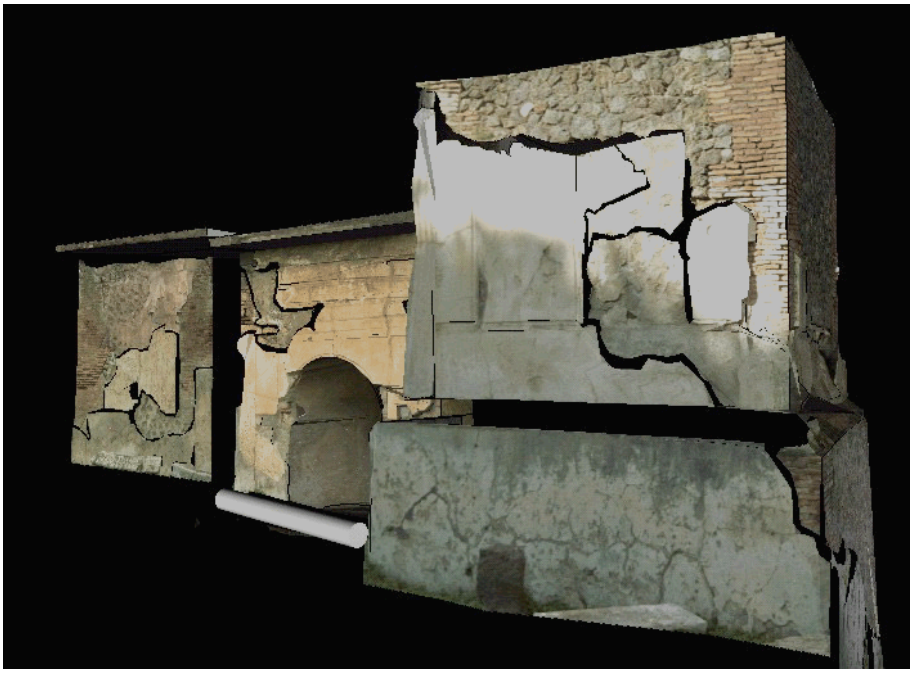


Figure 3. Material representation on the model
(Source: Maestri. et al. 2001)

In the study of Maestri and his team, it is highlighted that the use of new and updated instruments may increase the survey costs, but also may reduce the time required and improve the accuracy and reliability of the process. It is mentioned that the identification of the object's surfaces is easier by working directly on the photos. Hence, PhotoModeler software is used which gives the possibility of obtaining an orthogonal view of the elevation from rectified photographs (Figure 4). In this thesis, the building materials are also preferred to be directly presented on the rectified image mosaic of the studied façade produced from the rectified images. In this way, the materials are able to be analyzed in a more realistic and clear way.

Figure 4. Detachment of the rectified planes for a wall
(Source: Maestri, et al. 2001)

In the study of Erwes et al. (2003), various rectified photos of the main façade of an institute produced by low-cost PhotoModeler software are used to create a rectified image mosaic of the façade (107 x 23 m.) at scale 1/200 (Figure 5). In order to improve the coordinate systems in the generation of such a mosaic, some controls are done such as measuring some horizontal distances by a tape for defining the scale or measuring some other distances for defining the different axes. It is underlined that a simplified ground control using tape and level is sufficient for the rectified image mosaic generation of small plane objects like façades or walls, whereas for large objects, the ground control has to include topographic measurements. In this study, the studied façade has to be divided into three parts because of its scale and length in horizontal direction. Similarly, the studied façade in the thesis is divided into eight parts in order to rectify each part more accurately and produce a better scaled mosaic of the façade.

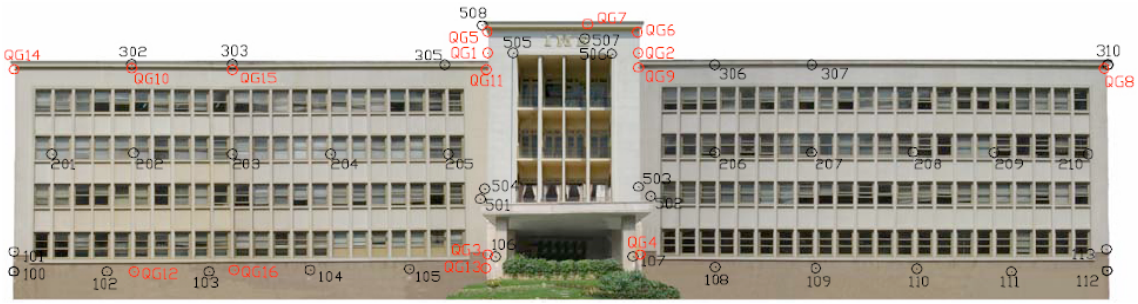


Figure 5. Detachment of the rectified planes for a wall
(Source: Erwes, et al. 2003)

Cardenal et al. (2005) make a photogrammetric record of a church, which was about to collapse, as well as its three-dimensional model. Different photogrammetric techniques are preferred at moderate costs with the extensive use of non metric instrumentation. Mosaics of rectified photographs, orthophotographs and stereoplotting of main walls are some of the main final products (Figure 6). The camera used is calibrated at laboratory conditions, but additional self calibrations are done by using field control points in order to improve the final accuracy. They reach errors between 5-20 mm at camera-object distances up to 15 m. As the distance between the object and the camera increase or high oblique photographs are shot, the image quality of the final product reduce noticeably. These points in shooting the photographs are also taken into consideration in the photographic process of this thesis, whereas the location of the house and its closeness with the opposing buildings can lead to difficulty sometimes in the shooting process.

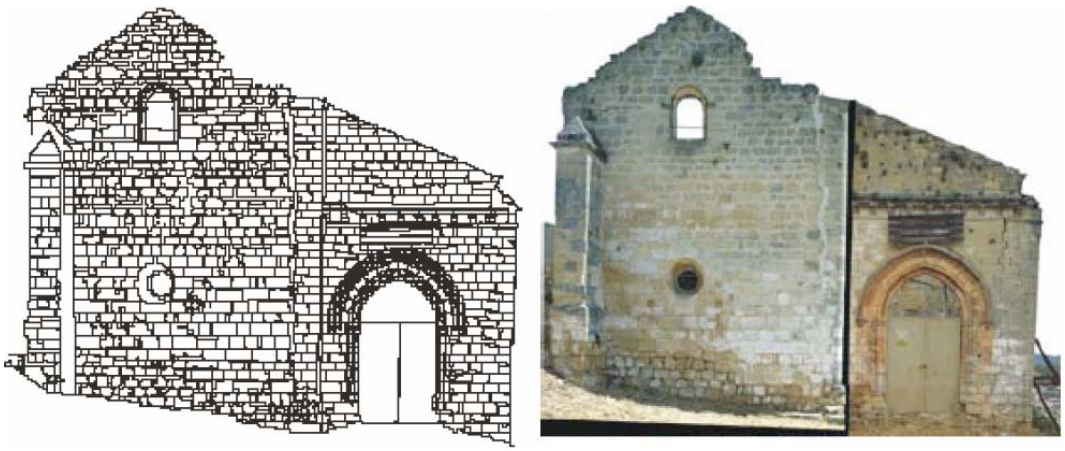


Figure 6. Elevation view of the main façade and mosaic of rectified images (Source: Cardenal, et al. 2005)

Diverse photogrammetric methods and instruments are used according to different conditions found. Digital cameras are found useful in fastening the data acquisition when there are very high stability problems and collapse risks. In the photogrammetric survey, the overall accuracy is better than 3 cm. Image rectification is preferred; since most walls and arches can be projected onto a surface without loss in accuracy. Rectified image mosaics are used to cover a whole wall or arch surface. The

method in the production of the rectified image mosaics is comparable to the method used in this thesis.

Almagro (2001) mentions in his paper the systems they develop for simplifying digital photogrammetry. The devices they use are a self-made software for calculating the topographic measurements, an image rectifier software (ASRix) (Figure 7) and a software for stereoscopic and three-dimensional plotting (VSD); each operating on simple PC's and laptops. Images are obtained by using a digital camera and sometimes photographs obtained with semi-metric cameras were used after scanning. Better results are achieved using digital cameras.

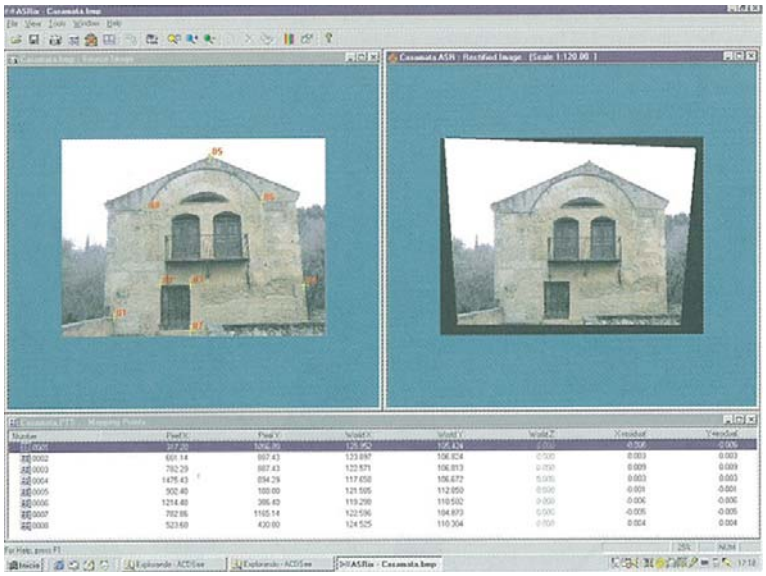


Figure 7. ASRix image rectifier
(Source: Almagro 2001)

Nickerson and Chapiro (2005) also mention that the image rectification programs are required in the documentation of heritage when accuracy is regarded, whereas there are also simple image processors for documenting flat surfaces if one is not looking for accuracy in the first place. They underline the improvement in simple image processors which are trivial and economic compared to the CAD programs. ASRix from the photogrammetric package DIPAD was preferred as an easy to use software for image rectification. The problems being faced in using the rectification program are explained according to the results of the study. They had to enter the coordinates manually, and because of accuracy problems, several images did not match perfectly while forming their collages. It was difficult to transfer the data gathered by

the rectifier to the CAD programs. Besides, correction of any mistake in noting a coordinate or any error in entering a point was very hard and time consuming. Similar difficulties emerged also in this thesis such as; the difficulty of figuring out which coordinates create a problem in the calculations and deciding which ones to use. The coordinates were entered manually to the software as in this project and it was important to be very careful at this step (Figure 8).

A photo collage of the rectified images
(Source: Nickerson and Chapiro 2005)

Another group of studies considered deals with the three-dimensional measurements made with close range photogrammetry and the related presentations such as scaled two-dimensional elevation and plan drawings (Erwes et al., 2003; Arias et al., 2003, 2005, 2007; Almagro, 2001). For this thesis, drawing elevations by making use of photogrammetric rectification is a considerable subject which is at the same time a widespread application at present. For comprehending the building in detail and defining the intervention decisions, conventional elevation drawings are still important at present.

In the previously mentioned study of Erwes et al. (2003), the main façade of the studied institute is surveyed with the method of close range photogrammetry and the scaled two-dimensional elevation drawing of this façade is prepared as well. AutoCAD

is used for plotting the studied façade of the building. Topographic measurements are included for control (Figure 9).

Figure 9. Two-dimensional elevation drawing of the main façade
(Source: Erwes, et al. 2003)

Arias (2003, 2005 and 2007) and his research team exemplify the possibility of producing accurate measured documents of historical buildings with limited budgets in a number of case studies (Figure 10).

Figure 10. Rendering with photo-realistic textures applied from photographic shots
(Source: Arias, et al. 2003)

In their most recent research (2007), the limits of close range photogrammetric survey are broadened with the introduction of plumb lines to the site survey phase. In turn, the amount of control point measurements with theodolite is brought to a minimum level. Besides its outstanding approach in the utilization of low-cost tools such as plumbs and conventional cameras, the shortening of the site work time and the acceptable accuracy reached in the measurements are also worthy of mentioning. Nevertheless, it should be underlined that the traditional farm buildings taken as case study are not particularly high and they are composed of simple prismatic masses (Figure 11) (Figure 12).

Figure 11. Two stones suspended by ropes and acting as plumb lines
(Source: Arias, et al. 2007)

Figure 12. Three-dimensional model of the structure
(Source: Arias, et al. 2007)

In the same study, Arias et al. (2007) prepare the scaled two-dimensional elevation drawings of the studied structure by using the digital photogrammetric monoscopic station, PhotoModeler (Figure 13).

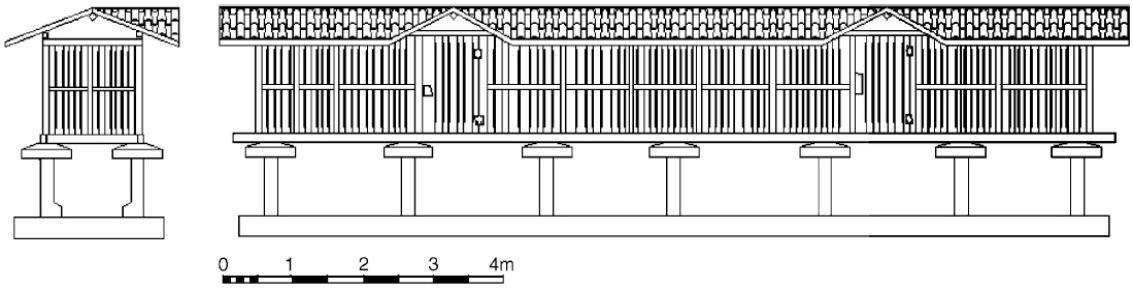


Figure 13. Two-dimensional drawings of the front and side views of the structure (Source: Arias, et al. 2007)

Almagro (2001) also make a contribution to the photogrammetric applications by developing a portable photogrammetric system (Figure 14). The method is to fix the stereoscopes to the screen of a laptop computer and combine it with a digital camera. This system reduces the field survey time considerably. Combining stereoscopes and the camera with the laptop computer in order to use them in a practical way during the field work is a good example, whereas in this thesis, stereoscopic method is not used. Still, being able to transfer the topographical and digital data collected on site right away to the software at the laptop computer would be useful also in this thesis in order to see if any measurements had to be repeated or photographs had be to shot again.

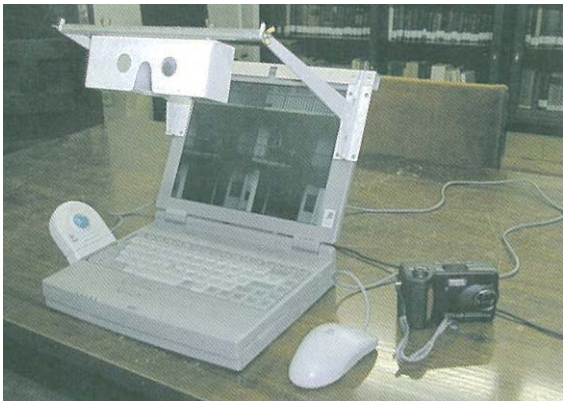


Figure 14. The portable photogrammetric system developed (Source: Almagro 2001)

1.4. Terminology

“Scaled elevation” is a conventional drawing retaining the true size, scale, shape and proportion of an elevation to be surveyed. It is one of the basic scaled drawings for

the documentation of the historical buildings (Porter and Woodman 1980). In this thesis, the scaled two-dimensional elevation drawing is obtained by evaluating the topographic measurements together with photographs in the photogrammetric software and transferring this data to AutoCAD. The scaled elevation drawing is used to check the rectified image mosaic of the façade that is produced. Rectified image mosaics, orthophotos and thematic maps that will be explained are important contemporary products in historical documentation which make use of the photographic data, and which are intended to replace the conventional scaled elevation drawings.

The term “orthophoto” is not preferred, because it is an improved stage of photograph rectification that will be explained. Since it is not possible to maintain the optical axis of the camera truly vertical, tilted photographs are formed as the camera axis is slightly tilted from vertical (Wolf and Dewitt 2000). Rectification of photographs may be explained as making equivalent vertical photographs from tilted photo negatives which are then called rectified photographs. Even after rectification, the images may still contain displacements and scale variations due to topographic data. These can be removed with the process called orthorectification or differential rectification where orthophotos are produced as the resulting products. Orthophotos have better geometric quality than rectified photos (Wolf and Dewitt 2000). A digital orthophoto can be described as a product having the pictorial qualities of a photograph as well as having the planimetric correctness of a map. Softcopy systems are used for the process of differential rectification in order to produce the orthophotos (Wolf and Dewitt 2000). Very accurate measurements obtained from an absolutely oriented stereoscopic model are required for their production (Kavanagh and Bird 2000).

The term “rectified image mosaic” means a single composite picture formed by overlapping two or more rectified photos. They are also called photomaps that may be produced by using single aerial photos (Wolf and Dewitt 2000). In the production of a mosaic, two or more air photos are used to form a continuous picture of the terrain (Kavanagh and Bird 2000). Mosaics were used to be prepared traditionally from hard-copy paper prints. Recently, scanned photographs are used to prepare digital mosaics. In general, mosaics are manually or digitally constructed from a block of overlapping photographs by trimming and joining them (Wolf and Dewitt 2000). In this study, the rectified image mosaic of the studied façade is produced by overlapping 8 rectified digital images. The two-dimensional elevation drawing is used in the scaling of the mosaic prepared. This rectified image mosaic also acts as a realistic background for the

thematic mapping of the façade. In turn, the perception of the analytic information increases.

"Mapping" is defined as the anatomic study of an object related with the analysis of it (Santana Quintero, et al. 2002). The fabric of the object is mapped by using the data including the materials, changes in the fabric and their causes which is mentioned as 'Condition Mapping'. The structural analysis is also an important information to be integrated by mapping. The metric survey is used as base for the mapping process (Santana Quintero, et al. 2002). Fitzner et al. (2002, 2004) apply this method on historical monuments with the aim of registration, documentation and evaluation of stone types and weathering forms. Mapping information is illustrated on the photos or survey of stones by using colors and hatching as symbols (Fitzner and Heinrichs 2002). The thematic maps provide sufficient visual analyses for the guiding of conservation decisions, emphasizing the important characteristics of the studied house as well as underlining its main problems. In this thesis, thematic mapping is preferred as a conceptual presentation method since it is more realistic, fast and sufficiently accurate compared to hatching on conventional drawings.

1.5. The Limits of the Study

Since the photogrammetric documentation process is experienced the first time by the researcher of this study, the time measured for photogrammetric evaluation includes the learning process. It will be reduced after gaining experience.

Secondly, discussing the accuracy of the photogrammetric and tacheometric recording with respect to the conventional recording is beyond the scope of this study. There are previous studies that discuss the accuracy of photogrammetric methods in comparison with others (Almagro 2001, Cardenal, et al. 2005, Nickerson and Chapiro 2005, Arias, et al. 2007). This study accepts the validity of Pictran as a photogrammetric evaluation software. The contribution of the rectification option of this software to the comprehension of the heritage characteristics and conservation problems of a historic house façade by an architect-restorer is searched.

CHAPTER 2

TECHNIQUES USED IN VISUAL DOCUMENTATION OF ARCHITECTURAL HERITAGE

The documentation process has been a valued part of architectural heritage conservation for centuries. This process includes basically recording and representation phases. Various types of recording techniques are used depending on the case including hand recording, photography, rectified photography or video; and at a more advanced stage, tacheometric and photogrammetric techniques are preferred (Feilden and Jokilehto 1993). Sketches of Vitruvius, Villard d'Honnecourt, Leonardo Da Vinci and Le Corbusier are a few examples of important design practitioners who used documentation as a necessary element in their designs. The notebooks of Alberti and Paladio are full of sketches with notes of dimension. Recording architectural heritage gained significance especially after the Second World War in the middle of the 20th century (Warden and Woodcock 2005). On the other hand, the modern understanding of architectural drawing was invented in the Renaissance in the 15th century and architectural representation has been used as a significant depicting tool since this period (Gürer and Yücel 2005). The representation techniques of the Renaissance including orthographic triad, projection methods and perspective are still used as the most commanding tools in architectural drawing.

Today, precise documentation is a prerequisite for appropriate intervention decisions regarding architectural conservation (CIPA 2007). This is further discussed in Nara Document on Authenticity[9] dated 1994: The importance of reliable information sources with regard to heritage conservation is underlined in the Nara Document on Authenticity dated 1994. The difference between tangible and intangible sources is underlined.

In this chapter, the visual documentation of heritage buildings as tangible information sources is focused on. The visual documentation process will be discussed

[9] The Nara Document on Authenticity was drafted by the 45 participants at the Nara Conference on Authenticity in Relation to the World Heritage Convention, held at Nara, Japan, on 1-6 November 1994. The conference was organized in cooperation with UNESCO, ICCROM and ICOMOS (Nara Document on Authenticity 1994).

in three phases: The data gathering, the data processing and the presentation. The data gathering primarily involves measured surveying. Measured surveying is the art of gathering data (distances, position and angles) to locate physical features such as structures and their related elements so that both the horizontal and vertical data can be plotted on a plane (Kavanagh and Bird 2000). The accuracy and the reliability of the survey depend on the field expertise of the surveyor and also on the surveyors understanding of the scientific principles underlining survey measurement (Kavanagh and Bird 2000). In data processing, the previously gathered data in the measured survey of data gathering process is utilized in photogrammetric evaluation works which are mainly three-dimensional measurement and rectification of the studied architectural element. Following this, in data presentation, the basic end results can be listed as the two dimensional scaled orthogonal drawings like plans, sections and elevations. The production of the rectified image mosaic is also an important result of the presentation phase, which is used as a base for thematic mapping in the next stage. The sketches and notes of the observations at the site, as well as the photographs, are valuable records that help in preparing the thematic tables and thematic drawing sets which are the other data presentation techniques in this thesis.

The evolution of documentation techniques has given way to the development of advanced methods in addition to conventional ones. This chapter evaluates conventional and advanced documentation techniques presently used. The related surveying instruments are introduced. The data gathering, processing and presentation phases of both conventional and advanced techniques are discussed separately below.

2.1. Conventional Documentation Techniques

Conventional data gathering, processing and presentation techniques are based on usage of hand in various ways. These techniques are carried out with a wide range of persons with varying skill levels and simple, straightforward equipment (Swallow, et al. 2004).

2.1.1. Conventional Techniques Regarding Data Gathering

The essential approach of conventional data gathering techniques is physical contact with the object being surveyed (Swallow, et al. 2004). Pictorial photography is often used for speed and detail in conventional survey (Warden and Woodcock 2005). Pictorial photography supports the historic building documentation, whereas it is not generally used for measured survey purposes. When carrying out a measured survey of a building, taking photographs and maybe a video can be certainly invaluable in order not to miss any detail (Swallow, et al. 2004).

Sketch plans, sections and elevations of the studied building must be prepared before any measurement. The taping method is used together with sketching in order to obtain a scaled survey of a historical building.

2.1.1.1. Photographing, Sketching and Note Taking

If the aim is an accurate record of the building, the points that should be taken into consideration in taking photographs are as follow (Swallow, et al. 2004):

- Using a large format camera.
- Using a normal to wide angle lens for the camera (A very wide angled lens may lead to distortion).
- Choosing a qualified camera with a lens that is not prone to distortion, when the images will be used for measurement.
- Mounting the camera to a tripod.
- Adjusting the lighting, using flash heads when required.
- Using a minimum 2 megapixel digital camera for snapshot work, and a more advanced camera of at least 4 megapixels for professional work.
- Not relying upon a set of prints as a permanent record. Using permanent archival inks at available places when more accurate prints are required.
- Storing the photographic images also off the computer at least on to CDs.

Sketching is a process in which a proportional but not scaled drawing of a building surface such as a plan, a section, and an elevation is produced so that the dimensions and observations regarding the architectural heritage can be noted down.

Sketching requires time, judgment and interpretation. The process of sketching forces the surveyor to engage the studied structure through questions related to dimension, proportion and scale (Warden and Woodcock 2005). The points that should be taken into consideration in preparing sketches and taking notes are as follow (Swallow, et al. 2004):

- The key reference sketch of the house should be drawn lightly with a pencil on a plain paper clipped to an A3 board preferably. An underlay of graph paper can be used as an aid to draw the sketch in proportion.
    - The key reference sketch should include a north point.
    - For the roof; the roof slopes, positions of chimneys and pipes, and roof windows, lanterns and oculi should be shown.
    - Informative notes should be taken such as the number of storeys, approximate age and materials used.
    - The date of the survey, the name of the job and the sheet number should be noted.
- While preparing the floor plans for each floor level, the following principles should be regarded:
    - The plan should be drawn at about one meter above the floor height.
    - The complete floor plan should be drawn on a single booking sheet, if possible.
    - It is convenient to start recording from the outside of the ground floor. In each wall length, details are recorded such as; projections and setbacks, door and window openings, steps, rails, etc.
    - The internal measurements should be done. Starting with the largest rooms can give an idea of the main walls. Each room should be measured in an order. Load-bearing walls and non-load-bearing partitions should be distinguished.
    - After establishing an overall plan, details should be added such as; reveals to openings, door swings, sanitary, etc. The positions of overhead elements like beams and trusses should be indicated with a broken line.
    - Stairs should be drawn showing the positions of risers and landings, also the parts above plan level with broken lines. Each riser should be numbered. Arrows are used to show changes in level, ramps, etc.
    - Detailed parts should be coded and sketched separately at a larger scale.

    - The direction of the floorboards is noted, considering the fact that normally, joists run at right angles to the original boards.
    - The various wall, floor and ceiling finishes are noted in each room.
    - General and detail photographs should be taken so that any missing information on the overall plan and details can be traced, while working in the office.
- If the interior and exterior of the roof are accessible, a roof plan should be drawn showing features such as roof pitches with the direction of the slope, all hips, valleys and ridges; flat roofs; parapets and gutters; eaves; dormer windows, etc. The various materials used are noted.
- Sections are drawn out through the building at points where the maximum amount of information can be conveyed. The following details are typically shown on a section:
    - The shape and arrangement of the timbers in pitched roofs.
    - The levels of the floors, the floor thicknesses and depths of beams.
    - The staircases.
    - The heights of ceilings, door and window heads and sills.
- An elevation is drawn out for each face of the building. First line drawn is the horizontal eaves line. Then, the vertical wall lines and the rest are drawn. The position of the ground is marked at each side and the ground line is shown. At the end, the details are added. The features that should be shown are as listed below:
    - Window and door openings.
    - Door frames and doors.
    - Window-frames including the details.
    - Decorative features like pilasters, etc.
    - Rainwater elements and sanitary pipework.
    - Roof and roof elements.

The materials and finishes should be noted. General and detail photographs of each façade should be taken.

2.1.1.2. Measuring

Throughout recorded history, people have always had some method of measuring distances. Applying a graduated tape against the marks to be measured has been accepted as the basic technique of direct measurement. Steel tapes are the primary instruments of this technique (Kavanagh and Bird 2000). 5, 10, 20 and 30 meter tapes are the most common while 50 meter tape is seldom used. The standard conditions for the use of steel tapes are defined as 20ºC temperature and fully supporting of the tape throughout the survey under a tension of 50 Newtons. The taping accessories include the plumb bob, hand level, clamp handle, tension handles, chaining pins and tape repair kits (Kavanagh and Bird 2000).

In turn, taping (also known as chaining) is a common method for determining the distance between existing field points. Taping is normally performed with the tape held horizontally. If the distance to be measured is a smooth level land, the tape can be properly aligned and tensioned. The surveyor must make corrections for all significant systematic taping errors and must use techniques and equipment that will satisfactorily reduce random errors. The systematic errors may stem from slope, erroneous tape length, temperature, tension and sag.

Carrying out the measurement in a methodical way is efficient in order nothing to be missed. Usually, plans, sections and then elevations are measured in order, but this order can be changed (Swallow, et al. 2004).

In the surveying of the plans, linear measurements should be taken as running dimensions instead of separate measurements. This procedure can also help the plotting to be faster and more accurate, when working with an assistant in the field. It is usual to hold the zero end of the tape. While taking the measurements for the plans, the following points should be regarded (Swallow, et al. 2004):

- The tape should be held at about chest height.
- Projections and recesses are measured.
- The window and door openings are measured. If a doorway is masked by architraves, it is measured to the edges of the linings.
- Wall thicknesses at window and door openings are measured.
- Sufficient measurements must be taken for each room. In regular plans, the length of each wall and diagonal measurements corner-to-corner should be

taken. For a rectangular wall, the second diagonal acts as a check. Corners that apparently look square might not be exactly 90 degrees always. In irregular plans, sufficient number of diagonals or tie dimensions must be taken.

- Dimensions must be written down clearly with a fine-point pen or in damp conditions a pencil. Dimension lines and measurements may be booked in different colors.
- Angular, curved and meandering walls can be measured by taking offsets from appropriate points of the walls.
- The running dimensions taken are important in tying the survey together accurately.
- The flight width measurements and the positions of the risers at the staircases should be booked.

The sections may be measured by using a tape and rod alone, or in conjunction with a leveling survey using an instrument like a transparent hose filled with water or an optical level. Scaffolding is needed in this process. If these are not used, then more advanced equipment is required. The points that should be considered while measuring for sections are listed below (Swallow, et al. 2004):

- Heights from floors to ceilings, sills and to the heads of openings are usually taken by tape and rod.
- The necessary parts should be leveled and marked.
- Heights that are booked on a plan must be distinguished from linear measurements.
- In general, floor-to-ceiling, head and sill heights are booked on the plan, while floor-to-floor heights and heights related to stairs and roof are booked on the section.
- In each internal space, floor-to-ceiling heights should be measured. For this measurement, there are two basic techniques. In the first one, the rod should be placed vertically against the opening stile of a door and slided upwards until contact is made with the ceiling. The bottom of the rod can be marked. Then, the remaining distance from the mark to the floor is measured separately and added to the first distance. Sill and head heights of window and door openings should be measured as running dimensions. Other required dimensions of details should also be taken. In the second technique, especially when the floor height is big,

the vertical measurements are achieved by attaching a graduated tape to a range pole. The sharp end of the range pole is placed at a point to be measured such as the corner of a beam at the ceiling; the tape is dangled in order to read the value at where it meets with the horizontal string line (datum) that was set up previously. The distance from the corner of the range pole to the zero end of the tape which is attached to the range pole must also be measured in order to add it to the measured value to get the complete distance. The horizontal distances can also be measured with the same method by moving the range pole with the tape attached to it, to the high points in the direction of the datum. Another tape is placed horizontally in the direction of the datum in order to read these distances beginning from the zero end of it.

- The thickness of the floors can be derived by subtracting the floor-to-ceiling height from the floor-to-floor height.
- Roof voids are mostly measured by a pocket tape and a rod. The section sizes of all members of the roof should be booked, as well as the angle of the pitch, the position and size of the chimney flues and other walls constructed in this space.

After measuring the interior of the building as explained above, the exterior of it at ground floor level should be measured (Swallow, et al. 2004). A full survey of the exterior also provides an important check for the interior survey (Swallow, et al. 2004).

In order to establish the upper level dimensions of elevations, the following principles should be considered (Swallow, et al. 2004):

- A plastic hose or a horizontal string line (datum) should be set up and the required vertical dimensions between the datum and the elements like the ground floor level should be measured.
- A tape or a rod can be used for the vertical measurements up or down from the datum. The second technique which was previously explained in the measuring sections can also be used in this process where the surveyor uses a range pole with a tape attached to it. Some measurements can be taken by leaning out from the window openings of the upper floor.
- If a feature can not be measured directly because it is not accessible, building elements of standard sizes like brick courses can be used in order to estimate an accurate distance of these elements. For instance, a definite number of these

bricks can be measured at a convenient place to be used as a standard measurement.

- While measuring elevations of timber-framed buildings, if the frame is distorted or there are irregular timbers, then a grid of nylon lines can be fixed to the face of the building secured by nails. These lines can act as vertical and horizontal datums for measurement procedure, whereas it is important not to damage the building fabric. In critical circumstances, this method may not be acceptable.
- The reliability of all these methods can be improved if scaffolding is available.

2.1.2. Conventional Techniques Regarding Data Processing and Presentation

The processing of data may have various aims. First of all, the architect restorer needs graphics to use along her/his process of restoration design. These may include conceptual information on the dimensions and forms of the building elements, the construction technique and material usage of the historical structure, the authentic architectural elements, the structural failures and material deteriorations, and architectural alterations. These are all generative graphics that help the development of the restoration design (Porter and Woodman 1980).

The set of scaled plans, sections and elevations with the dimensions noted close to the related building elements are known as two dimensional scaled orthogonal drawings. These drawings are the basic end results of a conventional measured survey.

The plan is a conceptual, horizontal cut through a building which in slicing walls at a height accounting for windows and doors. It graphically expresses solid-void and interior-exterior relationships. Although plans are two dimensional visualizations, a strong impression of depth can be implied through the adoption of a simple hierarchy of technical pen or lead line weights (Porter and Woodman 1980).

The section is a vertical cut throughout the building describing one plane representing the best possible vantage point from which to inspect the solid and void concept of a building. Within the documentation of a building, the sections enable the architect restorer to monitor the relationships between the solids and voids, to examine the constructional techniques and the qualities of the third dimension.

The elevation makes one gain view of the exterior faces of a building. In elevations, all planes are parallel to the drawing surface and perpendicular to the observer's line of vision retaining their through size, scale, shape and proportion (Porter and Woodman 1980).

The main points to consider while preparing the scaled orthogonal drawings in relation with a measured survey are as follows (Swallow, et al. 2004):

- First, the survey should be plotted onto tracing paper. Heavy cartridge paper or polyester draughting film should be preferred if possible since they are less affected by changes in temperature and humidity.
- The suitable scale should be decided for plotting. It is recommended that the site plans should be in 1/200 or 1/500. Plans, sections and elevations for buildings could be in 1/50, 1/100 or 1/200 for small houses, medium sized monuments and large warehouses and etc., respectively. Details such as window tracery, paneling, screens, etc. could be in 1/20 or 1/10. Ornaments and moldings could be in 1/5 and 1/1.
- The line thicknesses should be varied so that the depths of various architectural objects are made clear. The thicker pen should be used to denote the building elements that are cut by horizontal or vertical section lines and ground lines. The thinner lines should be used for the outline of elevations and for the lines close to the cutting plane. The thinnest pen may be used for architectural elements such as doors, windows, staircases, fireplaces.
- Conventional symbols should be used for showing the movement of the windows, doors, and other architectural elements, and also the positions of the entrances (Figure 15).
- Every architectural element such as sanitary fittings, drainage elements, ventilation elements, rainwater pipes, machinery and plant should be illustrated.
- A North sign and lines indicating the positions where sections are taken on plan and the direction of view should be provided.
- All of the drawings should be labeled such as First Floor Plan, Section A-A, etc.
- A scale bar in metric system should be provided so that the drawing retains useful dimensional information when it is reduced or enlarged.
- The borders of the drawing should be defined and a title panel identifying the sheet, the surveyors and the project should be designed.

- The sizes of structural members, materials and finishes may be noted. Floor levels and changes in level should be dimensioned on both the plans and sections; while ceiling heights should be dimensioned only on the sections. The direction of stair rises on plan should be illustrated.
- The final survey drawing should be produced by tracing off the plots on to polyester film in ink.

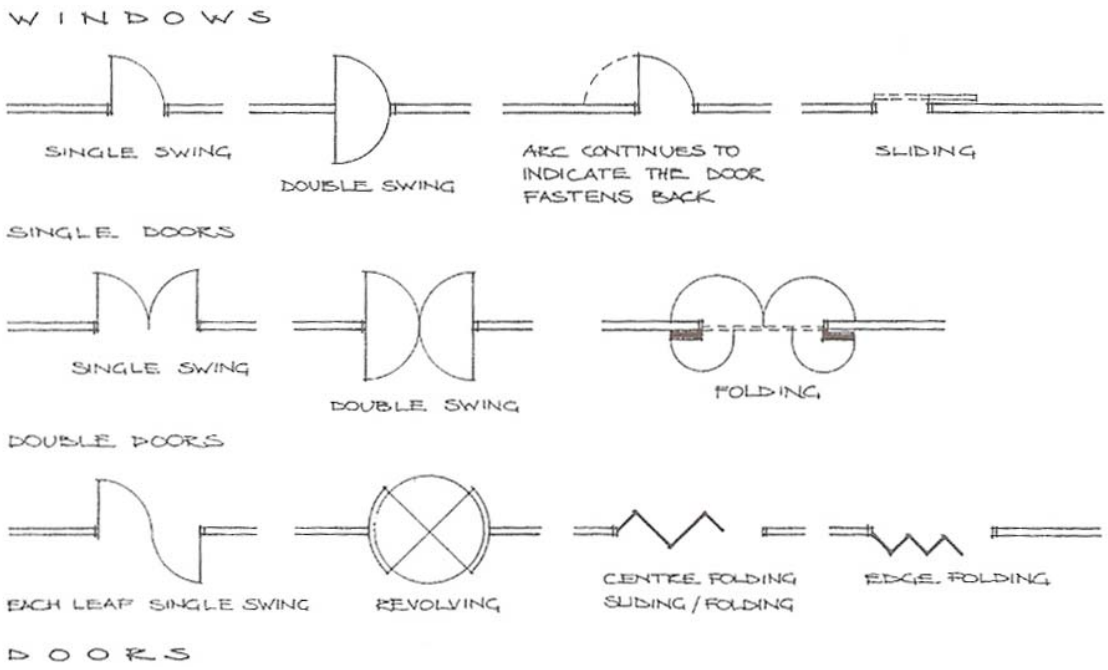


Figure 15. Examples to conventional symbols
(Source: Swallow, et al. 2004)

Once a basic measured survey has been completed, prints from it provide a useful medium on which to record additional information (Swallow, et al. 2004). The sketches with notes regarding the observations at the site and the photographs taken during site survey should be evaluated together with the prints. The following characteristics may be recorded:

- Evidence to help give a better understanding of how the building has been altered over the years could be noted on the drawing in the appropriate positions as a preliminary to preparing thematic drawings. In other words; inserted/removed masses, inserted/blocked openings in walls; differences in material, construction technique, architectural style and decoration, and installation system, etc.

- Disrepair and its extent, in other words, the structural failures and material deterioration, could be noted as a preliminary to preparing thematic drawings, which will be followed by intervention decisions and schedules of work.

In turn, themes specific to each case study are defined and related thematic drawing sets, as exemplified in the above, are prepared. The drawing conventions that should be followed in the preparation of the final thematic presentations are defined clearly in the English specifications such as “ISO 8048: 1984 Construction Drawing – Representation of View, Sections and Cuts”, and the “RCHME (English Heritage at present) Recording Historic Buildings: A Descriptive Specification” (Swallow, et al. 2004) (Figure 16) (Figure 17). In Turkey, however, such drawing standards regarding architectural heritage are not defined. Therefore, the graphic codes are defined specific to each restoration project. (Madran and Özgönül 2007). In this context, the influential effect of Fitzner et al. (1997a, 1997b, 1998, 2002, 2004), who work on classification of weathering forms of heritage building stone and their related hatches, should be pointed out.

Building material	*Colour*
Brick	Vermilion
Cast iron	Payne's grey
Cast or reconstructed stone	Viridian
Concrete	Hooker's green
Earth	Sepia
Faience, tiles	Chrome orange
Glass	Pale blue wash
Planed and moulded timber	Burnt sienna
Plaster	Terra verde
Sawn timber	Raw sienna
Steel	Purple
Stone	Cobalt blue
Wrought iron	Prussian blue

Figure 16. Hatching conventions of the English specifications
(Source: Swallow, et al. 2004)

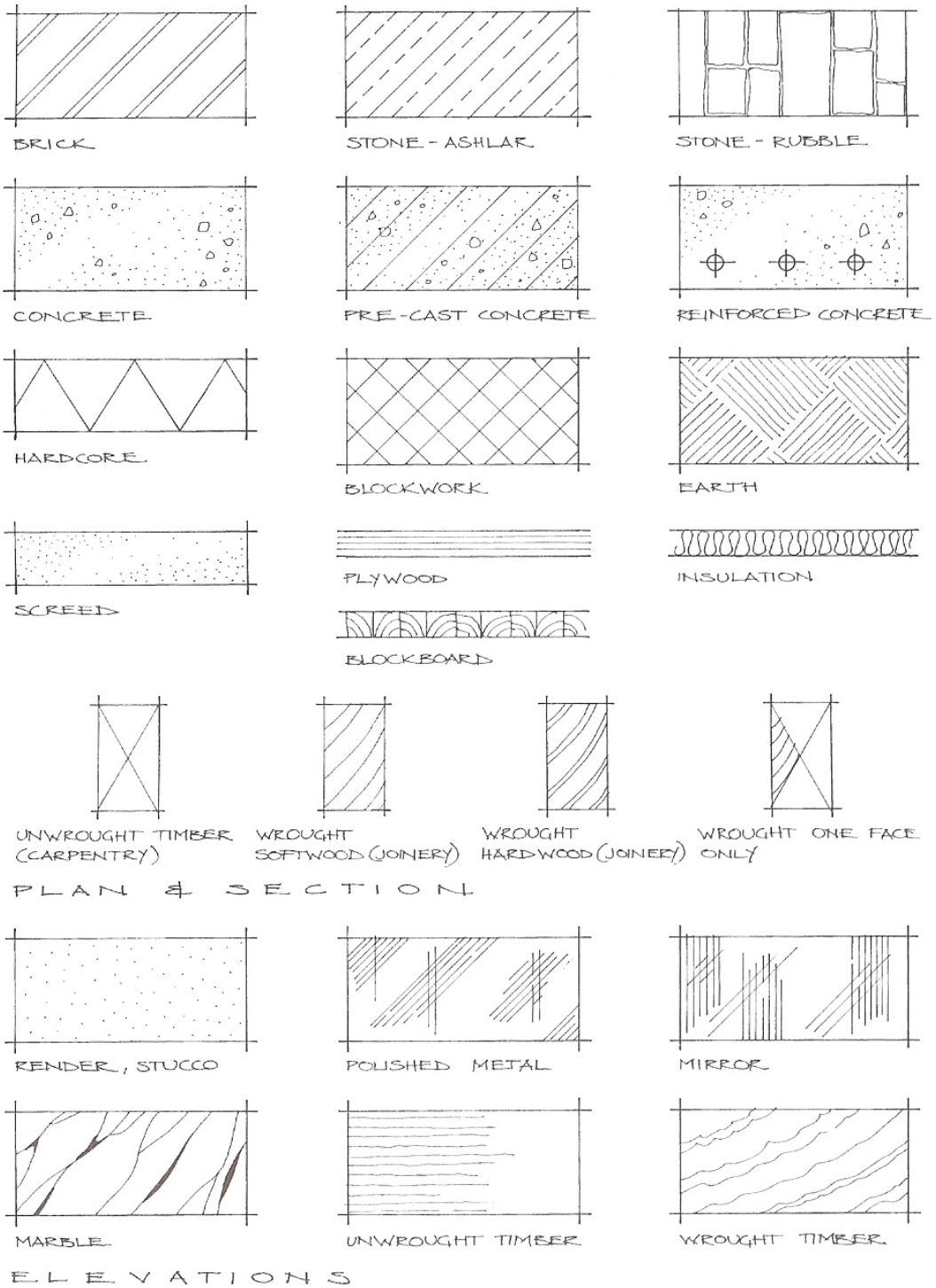


Figure 17. Coloring conventions of the English specifications
(Source: Swallow, et al. 2004)

The construction of these thematic drawings involves the scaled plans, sections and elevations as underlays. The related graphical representations are hatched, painted or laminated on the prints of the mentioned drawings with technical pens, felt-tip pens,

using a water color wash, colored pencils and layers of transparent, adhesive, plastic films with various colors and hatches, respectively. The line thickness for the hatching should be the thinnest in the whole drawing set (Swallow, et al. 2004).

2.2. Advanced Documentation Techniques

With the digital revolution, production of the personal computers and other new technologies related to recording have necessitated new documentation techniques. Analog tools have been replaced by digital tools where information gathered is more compatible with digital production. Software and hardware developed in all disciplines have made the advanced documentation projects possible which were previously not possible to be handled by conventional techniques.

2.2.1. Advanced Techniques Regarding Data Gathering

The advanced surveying techniques are known as non-contact techniques, implying the use of instrumentation of some sort (Swallow, et al. 2004). They can be categorized as tacheometric, photogrammetric, and laser scanning. The method chosen to be used for each particular case depends on the objectives of the study, the required degree of accuracy and the characteristics of the heritage to be documented (Arias, et al. 2007). It is important to recognize that a survey may be achieved using a combination of techniques (Swallow, et al. 2004). For example, measuring window openings or fireplaces will often be quicker and easier by conventional methods. Nevertheless, it is difficult to maintain high standards of accuracy over large areas with conventional methods. Moreover, in the CAD era, the hand drawing from conventional survey does not translate directly into computer form.

All advanced survey, making use of instruments, is based on triangulation and/or radiation approaches. A triangle has three sides and three included angles. If any three properties are known, the others can be calculated. Similarly, if an angle and a distance to point are known, the coordinate of the viewed point can be computed in relation to the standing point (Swallow, et al. 2004).

2.2.1.1. Surveying with Laser Ranging Devices

The hand-held laser ranging device has transformed the ability of the surveyor to measure distances directly and single-handedly. A very well known model today is the Leica DISTO (Figure 18).

Laser leveling devices are also invaluable in hand survey. Instead of using a plastic hose and/or setting up a horizontal string involving knocking nails into the joints and damaging the historic building; the rotating laser is set up. A constant level line is reflected across the building faces to be used as a reference plane by using a leveling device (Figure 19).

Figure 18. Laser measuring device (Leica DISTO A5)

Figure 19. Laser leveling device (QUADRIGA Levelfix 2)

2.2.1.2. Tacheometric Surveying Techniques

Instrument survey can be defined as a survey whose accuracy relies on measurement with a mechanical device and when there is no contact with the object being surveyed. Methods of survey based on the total station theodolite and its derivatives form one group of advanced techniques (Swallow, et al. 2004). The theodolite, used as the major instrument for topographical survey, is still commonly used as a mechanical device providing measuring opportunity without direct contact with the object being surveyed (Swallow, et al. 2004). It measures angles and distances to various unknown points from a known location (Warden and Woodcock 2005).

The problems of the early theodolites which were first introduced for topographic survey in the 18th century have arisen in two areas. The work was very slow and manual computation gave way to many errors. Vernier theodolite was used until the 1940s. After that, optical theodolite became widespread in the 1950s and was used until the 1980s (Swallow, et al. 2004). The use of electronic theodolite in the 1970s was the first great improvement in this area which let the readings to be automatically stored in digital form and increased the speed of the survey (Swallow, et al. 2004). The electronic theodolite provided a great improvement in the process. The operation was speeded up and the amount of errors was reduced. Simply, a wavelength is transmitted to the historical object, bounced back from the object and the time taken and so the distance traveled can be calculated. The electronic tacheometric instrument (total station theodolite) was developed by combining the electronic theodolite with electronic distance measurement (EDM) device. A reflector prism device is used with this type of theodolite to help it locked on to determined positions and record the readings of the measured distances (Swallow, et al. 2004). The development of a laser beam gave rise to reflectorless electronic distance measurement (REDM) (Swallow, et al. 2004). The usage of reflectorless electronic distance measurement in the total station allowed the readings to be carried out without a reflective prism, because the laser beam can return back to the device without spreading and losing its strength. With this instrument, the procedure of surveying elevations became much easier to develop (Swallow, et al. 2004). The surveyor can record hundreds of readings regarding a historic building façade in a few hours. The data captured electronically is transformed to a computer where calculations are carried out.

2.2.1.3. Photogrammetric Surveying Techniques

The first photogrammetric practices began in the second half of the 19th century in Germany. In 1858, Albrecht Meydenbauer, an architect who felt responsible for the recording of cultural heritage objects, started to use photographic images for documentation purposes. The first photogrammetric institution was established in Berlin in 1885 with his leadership where they recorded 2,600 objects on glass plates until 1920. Their first work on architectural photogrammetry was the documentation of the cathedral of Wetzlar which was a high building to measure its façades in terms of safety. They preferred indirect measurements by using photographic images instead of the direct measurements at the façade (Albertz 2001). Meydenbauer combined a photographic camera and a measuring instrument in a system and he developed the first photogrammetric camera with wide-angle lens in 1867 (Albertz 2001). In the same year, the term "photogrammetry" was used for the first time by Meydenbauer in an article.

Photogrammetric methods are generally used for the production of elevation drawings. It is also possible to use them at interiors where there is access to take photographs. Photogrammetry is generally preferred when a more detailed record is required (Swallow, et al. 2004).

In Turkey, the education of photogrammetry began in 1948 in the Department of Geodesy and Photogrammetry Engineering of Yıldız Technical University. Until 1960's, close range photogrammetry, which is the type of photogrammetry suitable to historic building documentation, was not known precisely (Alkış and Alkış 1999). The architectural photogrammetric applications began by the establishment of the Photogrammetry Center in Middle East Technical University (METU), Ankara in 1967. This center was set up by the Restoration Department of the Faculty of Architecture with the intention of compiling an archive of stereoscopic photographs of the ancient monuments in Turkey (Alpay 1975). In sequence, various studies were achieved for documentation of cultural heritage at the Department of Geodesy and Photogrammetry Engineering of İstanbul Technical University in 1970's and also at Yıldız Technical University in 1980's. The Center of Photogrammetric Documentation was set up in 1985. As these surveys started to become familiar in the society in 1980's, public institutions started to work in cooperation with the universities since 1990's with the

purpose of making photographic measurement and documentation studies for cultural heritage documentation (Alkış and Alkış 1999).

It has been accepted that digital photogrammetric techniques applied with the anxiety of architectural documentation shorten the length of field work time, require limited amount of technicians at the site and provide accurate results (Hanke and Grussenmeyer 2002). Photogrammetry is a useful method especially in projects where it is difficult to access directly when using a tape, when there are irregular forms of structures, or when field conditions are dangerous or hard to resist for long periods of time (Warden and Woodcock 2005).

Close range photogrammetry is a technique for obtaining geometric information such as position, size and shape of any object that was imaged on photos previously (Kasser and Egels 2001). It is the process of obtaining accurate measurement by taking photographs with calibrated cameras, then measuring the resulting images in a photogrammetric plotting workstation where line drawings can be derived (Swallow, et al. 2004).

At present, there are two main photogrammetric methods which are the bundle - monoscopic method and the stereoscopic method. They are explained briefly below:
The majority of the contemporary data gathering and processing studies with medium budgets and which are related with architectural heritage make use of close range digital photogrammetry based on bundle method. The main advantages of close range photogrammetry are that the equipments are inexpensive and portable, and measurement information can be accurately recovered. Nevertheless, it requires an extensive amount of user labor at the office (Remondino and El-Hakim 2006).

At present, bundle block adjustment is a wide spread technique in digital architectural photogrammetry which has reliable and accurate results. It combines the application of cameras, convergent photos and measurements in a common computer environment. In the reconstruction of a building, using larger number of photos to cover it as a whole is the main point of this method (Figure 20). The strategy is that each determined point should be intersected by at least two rays of intersection angles (Hanke and Grussenmeyer 2002). In other words, in bundle method, it is important to cover the whole measured area of the building with an adequate number of partially overlapping photographs. The measured area should be viewed at least in two perspectives, using two camera positions that have an acceptable intersection angle in between that is not an acute one. This is approximately a 90° angle (Arias, et al. 2007).

Viewing the area in at least two perspectives helps to increase the accuracy when using an uncalibrated camera. One does not have to look for parallel views since it lets different camera positions to be used. Different cameras can be used for the same work. (Hanke and Grussenmeyer 2002)

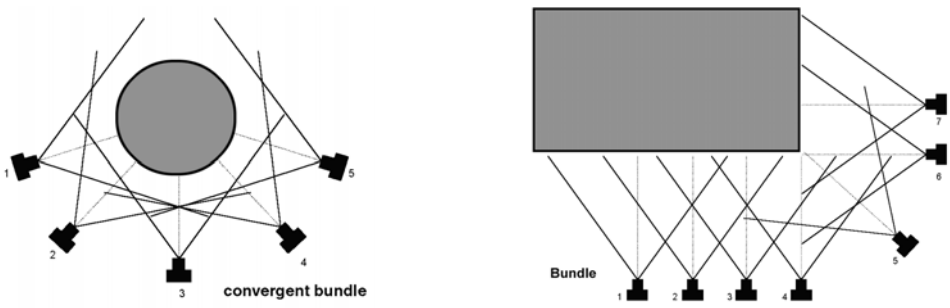


Figure 20. Example of configuration for bundle method
(Source: Hanke and Grussenmeyer 2002)

In stereoscopic viewing (Figure 21), an object is observed in three dimensions by using two images of it from different points in general (Kavanagh and Bird 2000). During the field work of stereoscopic method, the whole studied area should first be photographed as stereopairs that each may cover 60 to 90 m^2 of façade. The photographs are shot usually parallel to the façade, at a position nearly 10 to 15 m. back. Each neighboring photo should be overlapped, providing the stereo images. Each pair of images is evaluated in the stereoscopic software. A higher number of photos are required as the building is higher or larger. Control measurements obtained by theodolite are also needed in general (Swallow, et al. 2004).

Figure 21. Example to stereoscopic viewing
(Source: Kavanagh and Bird 2000)

2.2.1.4. Surveying Techniques Using Laser Scanning

The most current surveying instrument is laser scanner which was directly developed from the principles of the total station (REDM theodolite). It can calculate millions of three-dimensional point coordinates at a great speed by sending out pulses, offering fast field work times (Swallow, et al. 2004). The speediness of data collection, the short field survey time, the accuracy in the measurements and the fast transfer of the gathered data to the computer are some advantages of laser scanning. The handicap of laser scanning can be the huge database of information formed at the end of the survey. The surveyor has to reduce this data to the minimum needed and workable information which is usually done by related applications (Swallow, et al. 2004). Another disadvantage of laser scanning is that the instruments to be used are very expensive in general.

2.2.2. Advanced Techniques Regarding Data Processing

The earlier devices for photogrammetric plotting are known as analogue plotters. Following them, analytical plotters are the most commonly used ones for this purpose (Figure 22). They are normally used for drawing photogrammetric elevations. Two photographs forming a stereopair are inserted into these analytical plotters where they are aligned and viewed in three-dimensional. A measuring mark is being controlled usually with hand wheels of the operator. By moving this dot around the edges of the studied architectural element, the coordinate point values are recorded that will be used for the drawing. At present, this process is achieved automatically by using ‘softcopy’ instruments that require a monitor and computer (Figure 23). Photogrammetric systems using a number of programs are now preferred since they are also less expensive. In the use of these relatively inexpensive programs, the user generally has to mark the matching points in each photograph (Swallow, et al. 2004).

Figure 22. A typical analytical plotter with hand wheels
(Source: Swallow, et al. 2004)

Figure 23. A new type of photogrammetric plotter with a computer and a high resolution monitor (Source: Swallow, et al. 2004)

For data processing, monoscopic digital stations are mostly preferred among the photogrammetric programs mentioned above, because they provide accurate three-dimensional measurements of historical buildings, and also the user does not have to be an expert. They are easy to use by architect-restorers with some skill and experience in computer environment in order to evaluate the gathered data in the laboratory (Hamamcioglu-Turan and Akbaylar 2007). In the contemporary architectural

photogrammetry, monoscopic method, which is also called single image method, is preferred when the surface geometry of the architectural object to be recorded is known in general and the aim is mainly to document the texture of the surface (Hamamcıoğlu-Turan 2004). Examples to major monoscopic digital stations used in this photogrammetric method are RolleiMetric Close-range Digital Workstation[10] (Fellbaum 1992, Pomaska 1998), PhotoModeler[11] (Toz and Duran 2004, Arias, et al. 2007), Pictran[12] (Altan, et al. 1999, Bosch, et al. 2005), MicroStation[13] (Styliadis 2007) and ASRix[14] (Nickerson and Chapiro 2005). A suitable one must be chosen depending on the special case. The photogrammetric surveys based on bundle method and making use of these monoscopic stations are preferred in many case studies (Hanke and Ebrahim 1999, Rottensteiner, et al. 2002, Habib, et al. 2004, Arias, et al. 2005, Arias, et al. 2007). Three-dimensional points measured in monoscopic digital stations are generally transferred to CAD environment later to construct the three-dimensional models.

2.2.3. Advanced Techniques Regarding Data Presentation

At present, plotting is often worked up directly in a CAD program (Swallow, et al. 2004). The data gathered with conventional techniques may be transformed to CAD environment to produce computer aided drawings instead of the hand drafting techniques (Swallow, et al. 2004). The first step is using a computation program where the field survey can be converted into coordinates. Then, this data in vector format is transferred to a CAD program for editing and presentation phases. The use of computer aided drafting (CAD), however, is fundamental to the processes of measured survey

10 RolleiMetric Close-range Digital Workstation (RolleiMetric CDW) is the three-dimensional digital image evaluation software by RolleiMetric that has simplicity in use and user-oriented functions (RolleiMetric 2008). It is a well established close-range software package, especially used for architectural photogrammetry (Wiedemann, et al. 2001).

11 PhotoModeler is a photogrammetry software from Eos Systems that provides image-based modeling for accurate measurement and 3D models. It is widely used by professionals in the fields of accident reconstruction, architecture, archaeology, engineering, forensics, web page design, and 3D graphics (PhotoModeler 2008).

12 Pictran is a software from Technet GmbH which is used in close range photogrammetric applications like rectification, 3D modeling, camera calibration, etc. It has high accuracy and traceable results (Holl 2003) (Technet 2008).

13 MicroStation is a software for vertical applications from Bentley used by architects, engineers, contractors, and GIS professionals to integrate work on buildings, civil engineering projects, and geospatial information (Bentley 2008).

14 ASRix is a simple software package for digital image rectification that is easy to use. It has been one of the tools used and tested in ARIS courses since the beginning (Nickerson and Chapiro 2005) (Nickerson 2008).

through advanced instruments (Swallow, et al. 2004). CAD programs are useful for making changes easily in the drawings like scaling or correcting. At the same time, they reduce the laborious hand work of the surveyor. However, it should be underlined that working with a CAD program may require very good computer skills. In the wide variety of CAD programs, the AutoCAD programs are the most frequently used programs by still having like 70% market share. While deciding which program to choose, the compatibility between programs is an important fact. It is preferred that a program should be able to exchange files with the AutoCAD family (Swallow, et al. 2004).

The CAD drawings could be printed in A3 printers which are available quite inexpensively. If larger drawings such as A1 format are required, the drawing file should be taken to a CAD office where it can be printed off. The information should be classified into layers, which are like a series of transparent film sheets stacked on top of each other. Different groups of information appear in each layer (Swallow, et al. 2004). For example, the same layer should be used for the elements with same line thicknesses.

2.3. Comparison of Surveying Techniques

Consequently, there are several factors that should first be considered in order to decide which surveying technique is suitable for a specific case which is a quite complicated decision. These factors can be mentioned as the main reason for the survey being required, the period of time determined for the surveying procedure of the project, the availability of the surveying tools and the number of surveyors who can take part, the opportunity to employ professional services, the character and level of detail to be recorded, the funding available and so on. At the Final Report of the Round Table Meeting of RecorDIM that was held in June 2002, there is a statement that draws attention to the scope of documentation: “Three of the important elements to be considered when defining the scope of recording and documentation are the site values, the project objectives and the budget constraints.”

In general, surveying instruments are used to improve the speed and accuracy of the survey. According to the aim and kind of the project, the required accuracy is determined first, and the surveying technique that will be chosen is mainly based on this. The availability of specialized equipment is certainly important for a higher accuracy to be achieved. Combining different techniques for achieving a survey is also

possible, since there can be many different conditions to be handled, and every part of a structure may contain different details with different values.

The conventional surveying techniques that include the hand surveying processes like photographing, sketching, direct measurement by taping and the rest may be convenient for the documentation process of a design project. The conventional techniques are suitable for surveying the details of architectural elements such as windows, doors and fireplaces. The limitations of these methods are the difficulties of maintaining high standards of accuracy over large areas, and the impossibility of translating the site work directly into computer environment.

On the other hand, for achieving a more detailed record of a conservation or restoration project, an advanced surveying technique is generally needed. Using an advanced technique may give possibility to the recording of the case study structure electronically and transform this information directly to the CAD environment. The CAD drawings may easily be revised, if it is desired to illustrate the changes over time. Computer softwares are useful and being improved fast for the purpose of adequate documentation.

Photography has a significant role in the historical documentation. It is used to reduce the time spent at the site and is worthy especially in recording of the details. It is usually preferred for documentation as the first stage in the field survey. In spite of its importance as a surveying technique, it may not be used effectively if a case study building is scaffolded, covered with a sheet since it is under repair, covered with dense vegetation like ivy or there are trees very close by. Related to the same circumstances, photogrammetry and laser scanning may not be very suitable to be used as a documentation technique.

Photogrammetry is invaluable for the systematic recording of the heritage resources. Close range digital photogrammetry is generally preferred in historic building documentation, particularly in the production of elevation and detail drawings. It is relatively simple, cheap and accessible. Photogrammetric softwares are less expensive than the other surveying instruments. Rectification of façade photographs by using photogrammetric softwares and producing rectified image mosaics of the façades by scaling them in image evaluation softwares are other works that can be done by using photogrammetry that help the thematic mapping process.

Topographic measurements are usually used to support the photogrammetric survey. The electronic tacheometric instrument (total station theodolite) is a frequently

used recording tool which is especially functional for the production of plan drawings. When a theodolite is used to establish control points in an architectural object, the accuracy of the overall layout certainly increases. The development of the reflectorless electronic distance measurement (REDM), with a laser beam reading the points directly on the surface, made the survey of elevations and also sections easier. This tool is preferred when there is a limited time for the documentation process and the structure to be documented is not very complex.

In order to record details in highly valuable structures like an archaeological wall, some other techniques such as laser scanning can be preferred which is less time consuming at the site. Laser scanning is another contemporary technique that shortens the field work time in a considerable amount, whereas it is less economic than the other techniques.

From various types of conventional and advanced representation techniques for documentation, the ones preferred in the discipline of architectural restoration first are scaled two-dimensional orthogonal drawings (plans, sections, elevations). Three-dimensional model construction based on photogrammetric measurements transferred to CAD is a frequently used contemporary method for presentation. Hatching on scaled two-dimensional elevation drawings is preferred in many architectural restoration and conservation projects, which is helpful in the following intervention and conservation decisions. Thematic mapping on rectified image mosaics, applied in this thesis, may also be used as an effective presentation technique that is more realistic, fast and sufficiently accurate compared to hatching. However, it is not used in many studies.

CHAPTER 3

HISTORIC DOCUMENTATION OF THE CASE STUDY

A historical building must have considerable features and different values to be worth preserving and documentation. These values also play an important role when defining the scope of the documentation. In the selection of the Yavuz Demiral House as the case study of this documentation research; the criteria taken into account in the first place were carrying notable cultural values and contemporary socio-economic values. Requiring urgent repair and being vacant are the other important facts that were considered. In this context, it is important first to understand the historical and morphological characteristics of Alaçatı as the settlement within which the case study building is located. Then, the architectural characteristics of the Yavuz Demiral House, the conservation problems and heritage values are to be presented.

3.1. Evolution of the Historical Settlement in Alaçatı during Ottoman Period

Alaçatı has been one of the places in Anatolian history where various population movements occurred (Gezgin 2007). Nevertheless, it has preserved its urban structure and architectural characteristics well. It includes various examples of the Western Anatolia in the near period (Gezgin 2007).

The Seljuk Turks were in Alaçatı since the 11th century. The Turks dominated the district in the 14th century during the Ottoman Period (Gezgin 2007). Until the 16th century, Çeşme was Anatolia's gate to foreign trade. Genoese merchants were settled particularly in Chios ("Sakız") Island which is across from Çeşme (Alaçatı Municipality 2006). From the beginning of the 16th century when the Ottoman Empire dominated the Aegean Sea, the dense trading activities in the port cities of the Aegean region glamorized İzmir and its surroundings (Gezgin 2007). As the Ottomans conquered Chios Island in 1556; Genoese merchants, who had been living in the island, moved away. İzmir instead of Çeşme became the trading center of the region (Alaçatı Municipality 2006). It was determined that approximately 80% of the population was Turkish in the 16th century. With the aim of economical contribution to the region, the

territories were allocated and the rich Turkish dwellers have obtained groomings. After this, a labor force was needed for land cultivating which also bestirred the migration to the region (Gezgin 2007).

From the beginning of the 18th century, a Greek migration was eventuated towards Western Anatolia. The Greeks rebelled for independence at the end of the 18th century and revolted from Western Anatolia, but their population increased again as Greece gained independence. They brought their own traditions and way of life, such as viniculture and wine production (Atilla and Öztüre 2006). Until the 20th century, Greek population was much higher than the Turkish population (Gezgin 2007).

It is known that Hacı Memiş Ağa, who had been a janissary in the Ottoman Empire, went to work in Egypt as an agriculturalist for a short period of time (Gezgin 2007). At the end of the 18th century, he came to Çeşme and settled in Alaçatı. The south of Alaçatı was totally boggy until 1850's (Atilla and Öztüre 2006). Hacı Memiş Ağa took the lead in drying of the bogs at the southern part with a project of opening canals reaching the natural port at the south. He then built the Turkish district at this southern area (Gezgin 2007). This is the first inhabited area built to the south around Hacı Memiş Mosque (1813), today known as Hacı Memiş Quarter (Figure 24). This mosque is almost the only evidence of the Turkish Period (Hersek 1986). One of the hearsays is that the Greeks were brought from Chios Island in the beginning of the 19th century in order to provide labor force for the farms of Hacı Memiş Ağa (Gezgin 2007).

Hacı Memiş Ağa became the owner of a great part of Alaçatı and Çeşme. He caused many Greeks from the islands, and helots from Egypt to be brought to Alaçatı and Çeşme where they worked in the farms. He had a fundamental contribution in the development of Alaçatı (Gezgin 2007).

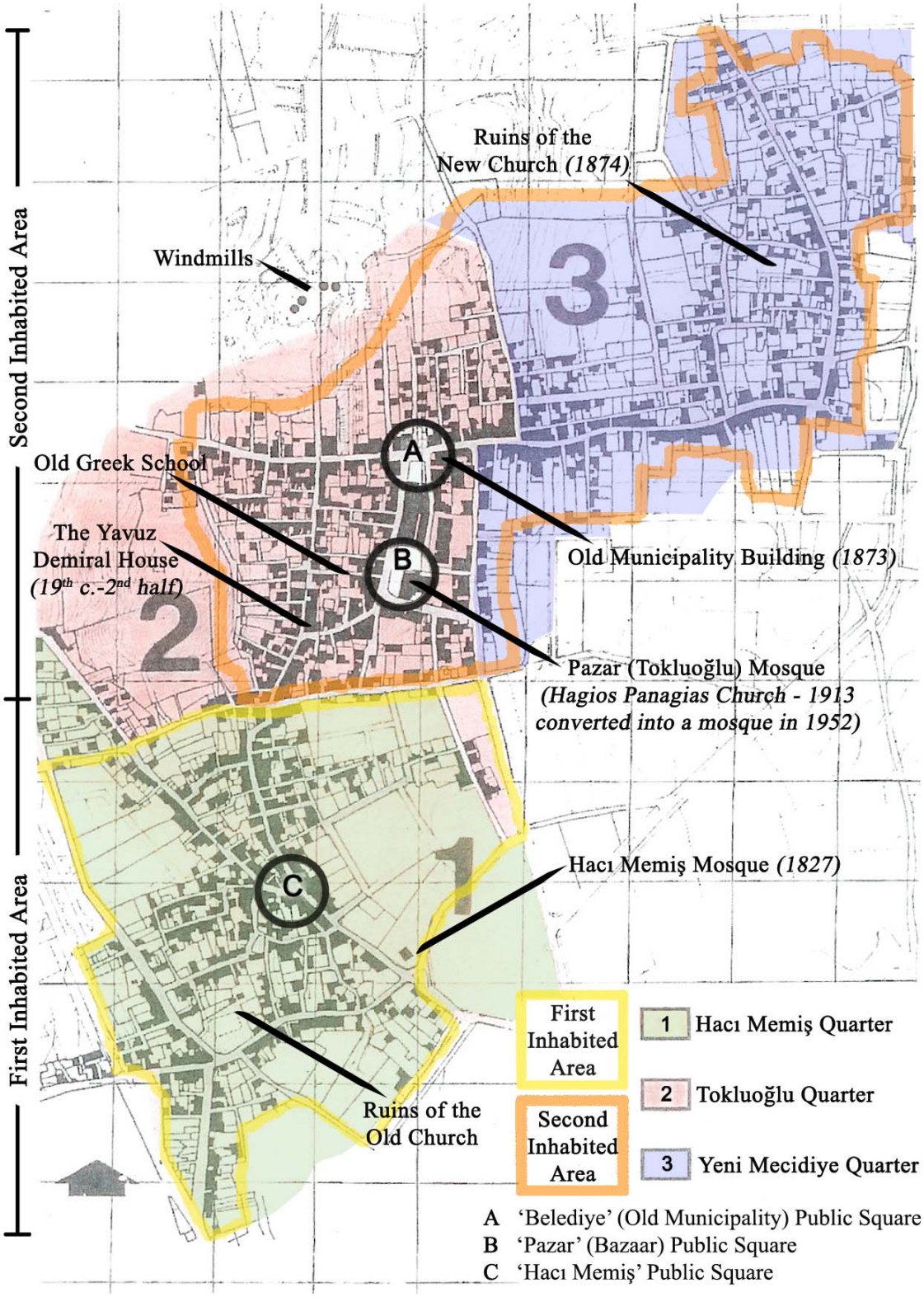


Figure 24. The quarters, the main public squares and the distribution of the monumental buildings in the historical development of the built-up areas in Alaçatı, including the Yavuz Demiral House in the second inhabited area (Source: Boundary of the quarter attained from Alaçatı Municipality Archives 2006)

In the 18th century, there was a dense population of Greeks, so that many churches were built. Only one of these churches still exists which was named Hagios Panagias Church (Meryem Ana Church). It was started in 1874 by the Greeks and completed in 1913. After Republic, a minaret was added and the church was converted into a mosque (1952). At present, its latest function is named as Pazar (Tokluoğlu) Mosque (Gezgin 2007). It is also significant by still carrying various characteristics of a church such as the arched narthex, worship space with three naves and the big apse (Ürer 2005). It takes place in the second inhabited area where the neighborhoods were located around the administrative (Old Municipality Building, built in 1873) and commercial center, today known as Tokluoğlu Quarter, in the second half of the 19th century (Özgönül 1996). Following the first residential settlement of Alaçatı around Hacı Memiş Mosque, the new monumental buildings were built towards the northern direction as the town developed (Figure 24).

Municipality of Alaçatı was established in 1876 (Atilla and Öztüre 2006). According to the yearbooks of Aydın province; in 1881, Alaçatı's population was 4,122; 78 of them being Turks and 4,055 of them being Greeks (Özgönül 1996). In 1895, total population of Alaçatı was 11,947; 11,606 being Greek (Gezgin 2007). It is seen that the Greek population had gradually increased during the 18th and 19th centuries, and dominated the others in the 19th century (Ürer 2005). Hilmi Uran who was the head of Çeşme in 1914-15 also explains in his book his observations about the increase in Greek population. He states that there were not enough people to work in the farms of Çeşme, whereas the population was too much in the islands. Some Greeks in the islands received permission from the land owners in Çeşme to build vineyards in parts of lands given to them. In this way, more Greeks spread and settled in the district (Uran 1959).

After the Balkan Wars (1912-13), the Greeks living in Çeşme Peninsula decided to migrate to their main land. Çeşme and its villages were almost empty because of this Greek movement (Özgönül 1996). At that time, the Turkish immigrants in Balkans started to move to Anatolia (Uran 1959). In the same year of Hilmi Uran's appointment to Alaçatı as the head of the district, which was 1914, the first Turkish inhabitants came to Çeşme by ship particularly from Yugoslavia and Macedonia (Alaçatı Municipality 2006). Most of the Turkish immigrants who were sent to Çeşme Peninsula from Rumelia's high places with austere climates were villagers. These new inhabitants could not adapt to this new geography. Since they were foreign to viniculture, they did not know wine production (Uran 1959). Depending on their own needs, they made some

inadequate interventions to the houses left from the Greeks such as making some windows of the exterior façades smaller or filling them in (Gezgin 2007). Until the migration of the Turks, they had a very low population in Alaçatı, and Hacı Memiş Mosque was the only mosque there at that time which still exists as one of the oldest mosques in the peninsula (Gezgin 2007).

The Turkish army entered İzmir in 1922 (Gezgin 2007). Since September 1922, a great part of the Greek population inside Turkish boundaries had to leave the country. The first big organized Greek migration was at the time of İzmir's conquest, on September 9th 1922 (Gezgin 2007). The Turks occupied Alaçatı on September 15th 1922. The Turkish immigrants who migrated in big numbers after the conquest were also accommodated in the houses that were emptied by the Greeks (Gezgin 2007). They came from Thessaloniki, Macedonia and islands like Crete, and caused the development of tobacco production in Alaçatı. Tobacco production, melon production and cattle breeding were the professions that carried Alaçatı into the 1980's (Alaçatı Municipality 2006).

In the case study of Özgönül's Ph.D. thesis, according to the inscription panels on their walls, 20 historical houses were documented as they have been constructed between 1854 and 1911 (Özgönül 1996). Accordingly, it can be deduced that the present built historical heritage dates to the second half of the 19th century.

The monumental buildings in Alaçatı are Hacı Memiş Mosque (Figure 25) and Pazar (Tokluoğlu) Mosque (Figure 26) as mentioned above (Özgönül 1996). The ruins of the windmills (Figure 27) dated back to the beginning of the 18th century are also monumental structures that are on Değirmentepe (Karaturgut 2001). These windmills that were 14 in the past used to supply the flour of Alaçatı and its surroundings (Gezgin 2007). There are also ruins of two Greek churches observed in the town (Özgönül 1996). On the other hand, the newest parts surrounding the new Municipality Building were constructed in 1950's (Özgönül 1996).

Figure 25. Hacı Memiş Mosque
(October 18, 2006)

Figure 26. Pazar (Tokluoğlu) Mosque
(August 22, 2006)

Figure 27. The ruins of the windmills on Değirmentepe
(Source: Alaçatı Municipality 2008)

3.2. Settlement Characteristics of Alaçatı

At present, Alaçatı is a typical Aegean town located on the western coast of Anatolia, in Çeşme Peninsula. It is a sub-district of Çeşme County. The town is 7 km. to Çeşme town center and on the highway connecting Çeşme to İzmir (Özgönül 1996). It is surrounded by Alaçatı Port to the south, Ilıca Gulf to the north, Çeşme to the northwest and Urla to the far east. Çeşme covers an area of 250 km^2 where the altitude of Alaçatı is 16 m (Çeşme Municipality 2006).

The southern part of the town has an organic pattern compared to the pattern of the northern part where the commercial center takes place in a more geometric order. This change of pattern can be engaged to the fact that the southern part is older than the northern neighborhoods of Alaçatı (Özgönül 1996).

3.3. Architectural Characteristics of the Historical Houses in Alaçatı

The historical buildings in Alaçatı present similarities, when evaluated according to the location of the building on the lot, and relationship between open space and building. (Özgönül 1996) This is one of the main reasons why the historical heritage of Alaçatı possesses a common language.

Most of the built historical heritage in Alaçatı has two stories and rectangular forms. Since these contiguous buildings lack front gardens and courtyards, they define a continuous order of street façades. Nevertheless, there are rear or side gardens and courtyards. The ones which are relatively large are mostly situated on Kemalpaşa Main Street and Mektep Street (Özgönül 1996).

Houses in Alaçatı were designed considering dwelling, producing and trading functions. Trading section is at the ground floor with a direct entrance from the street. It generally contains a shop (“mağaza”) for retail, opening to the street. There is a second entrance on the ground floor reaching an entrance hall (“taşlık”) with a staircase that leads up to the first floor where there is the living section (Madran and Özgönül 2005). The entrance hall is usually wide enough to take a carriage in and usually has a cistern underneath. Some buildings have storage spaces and stables at the ground floor (Özgönül 1996). In a recent study (Kaplan, et al. 2006), wine production spaces have been documented at the ground floor of an Alaçatı house.

In general, the entrance hall ("taşlık") of the houses and also service spaces like storage, stable and toilet open to the courtyard. The open air stairs, providing access to the upper floor terraces, juxtapose the building mass at its courtyard façade (Özgönül 1996). The courtyard is often located at the back or side of the house. Toilets are usually located in the courtyards, in the gardens or on the terraces of the houses. In gardens or courtyards, there is often a source of water like a well or a cistern (Şahin 2006) (Figure 28).

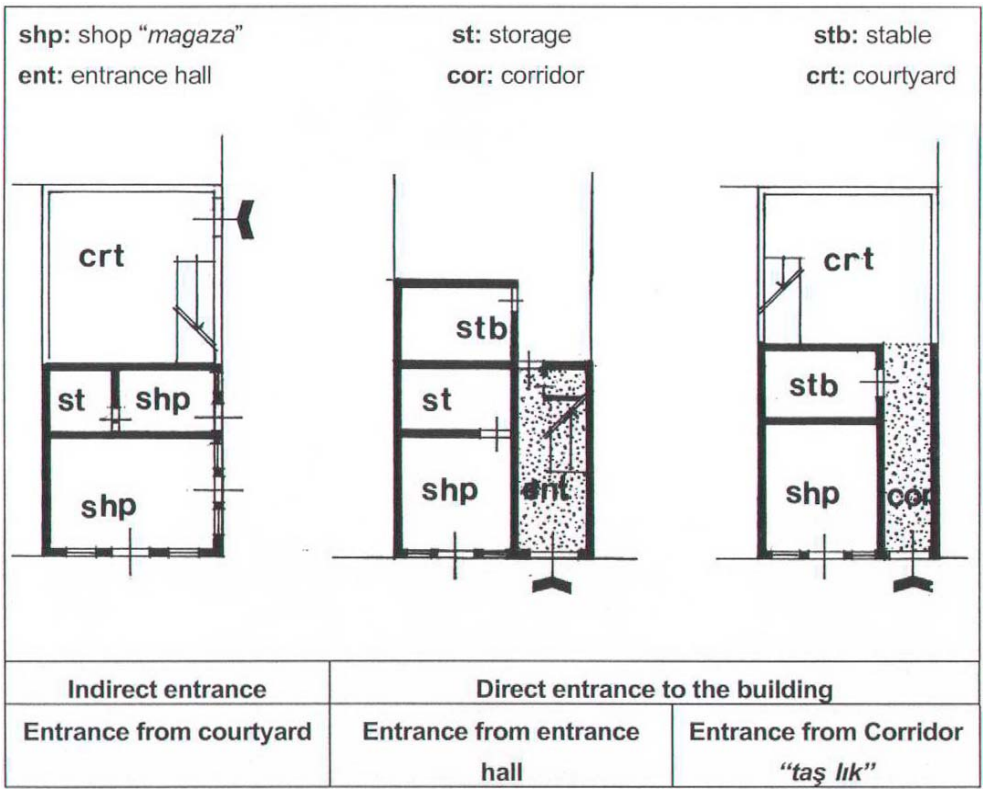


Figure 28. The spatial relations in ground floors surveyed in 1993
(Source: Özgönül 1996)

At the upper floors, living and kitchen spaces are generally arranged around a small sized hall ("sofa") that serves as the common circulation area. The terrace which is used for daily living also takes place at the upper floor, generally situated above the spaces like stable in the courtyard. "Sofa" or one of the rooms at the upper floor may have a balcony or a projection providing relation with the street (Madran and Özgönül 2005) (Figure 29).

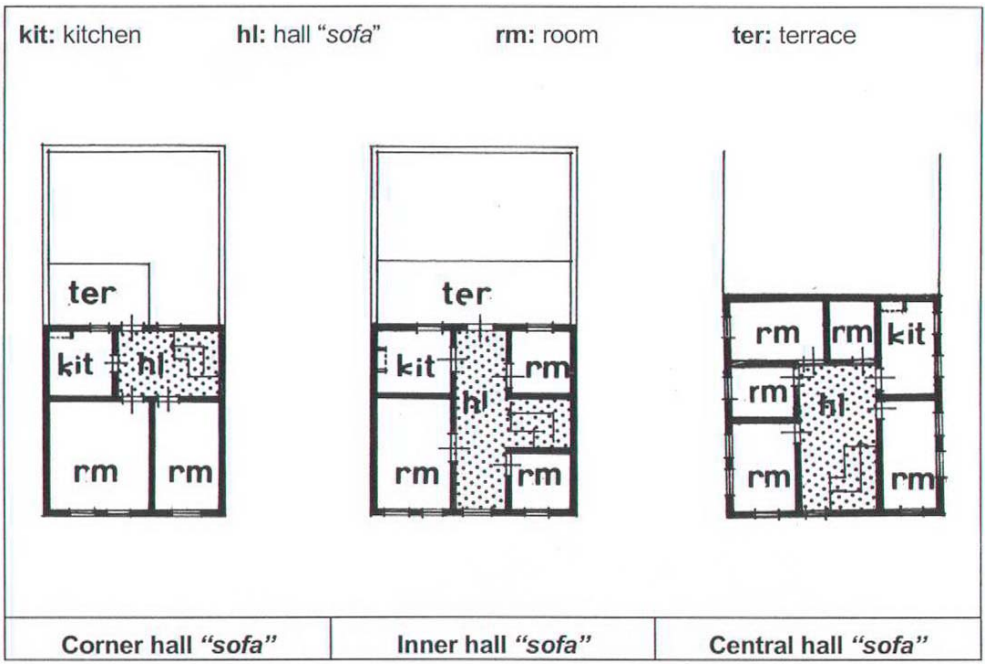


Figure 29. The spatial relations in first floors surveyed in 1993
(Source: Özgönül 1996)

The façade elements such as windows, doors and their frames, shutters, cornices, iron bars, projections, balconies and eaves are the main architectural elements that define the façade order of the historical houses in Alaçatı (Figure 30).

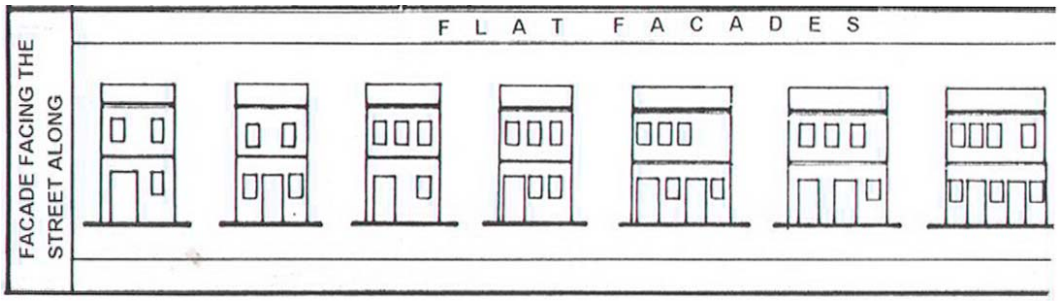


Figure 30. Façade typology for the houses in Alaçatı with flat order
(Source: Özgönül 1996)

Exterior doors have important roles in the character of the façades, being single or two winged according to the different functions of spaces. They are generally rectangular in form, some in the ground floors are arched and some have an arched opening on top (Figure 31). The forms of windows also differ according to the space they belong. The windows of the rooms are usually rectangular, while the ones at the

ground floors are usually arched like the doors at the ground floors (Figure 32). Projections and balconies are carried by timber or iron beams which are also façade elements. The façade types can be divided into two groups; the ones with projections and the ones without projections. There are three projection types which are the ones on the whole façade, semi-open projections and balconies. Roofs are covered with Turkish tiles (Özgönül 1996).

Figure 31. Typological study for the doors of historical houses in Alaçatı
(Source: Özgönül 1996)

On the other hand, the inner architectural elements are floor coverings, ceiling coverings, stairs, cupboards, niches, fireplaces, doors and windows (Özgönül 1996).

The interior doors are made of timber and have simple forms. The stairs inside the houses combine the ground floors to the first floors, usually reaching the corridors or halls in the first floors. The stairs placed in the courtyards outside the houses reach the terraces that are also used as living spaces.

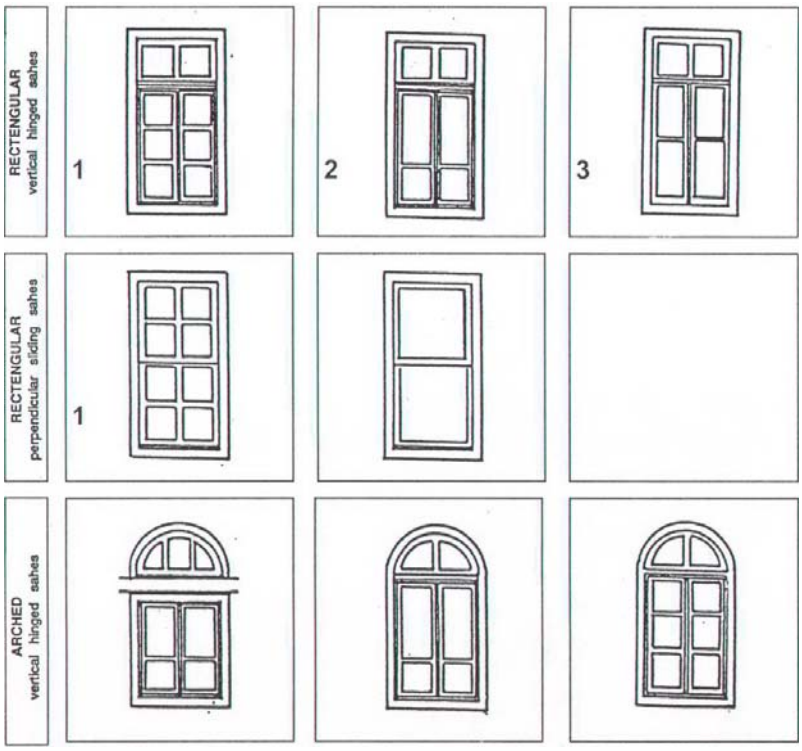


Figure 32. Typological study for the windows of historical houses in Alaçatı
(Source: Özgönül 1996)

The general structural characteristics of the historical houses in Alaçatı can be described as follows: The walls have a height of approximately 3.50 m. and a width of 0.50 - 1.00 m. Mud or lime mortar is used. Rubble stone masonry at every floor; and rubble stone masonry at the ground floors and timber skeleton technique on the first floors are the two major techniques observed in wall constructions. The partition walls are made of timber skeleton system. If there is a second floor, lime plaster with a thickness of approximately 2.5 cm and enriched with clay and hay is applied on the timber skeleton walls. In general, flooring system used in these houses is timber flooring with timber beams and covering, whereas pressed earth is the material used for covering in stables and storage. Stone pavement is also observed at the entrance halls of the ground floors (Özgönül 1996). The stairs inside are made of wood, while the ones placed in the courtyards outside the houses are made of stone (Şahin 2006).

3.4. The Yavuz Demiral House as a Historical Building in Alaçatı

The Yavuz Demiral House, which is documented in this study, is located at the secondary inhabited area around the Pazar Public Square. On the basis of visual analysis; it owns the characteristics of a historical house built in the late 19th century with its construction composed of rubble and cut stone masonry on the ground floor, and timber skeleton system on the first floor, and with its original architectural elements such as a wooden projection, rhythmic wooden openings and fireplaces. Its position in the second inhabited area is another reason for dating the house to the second half of the 19th century.

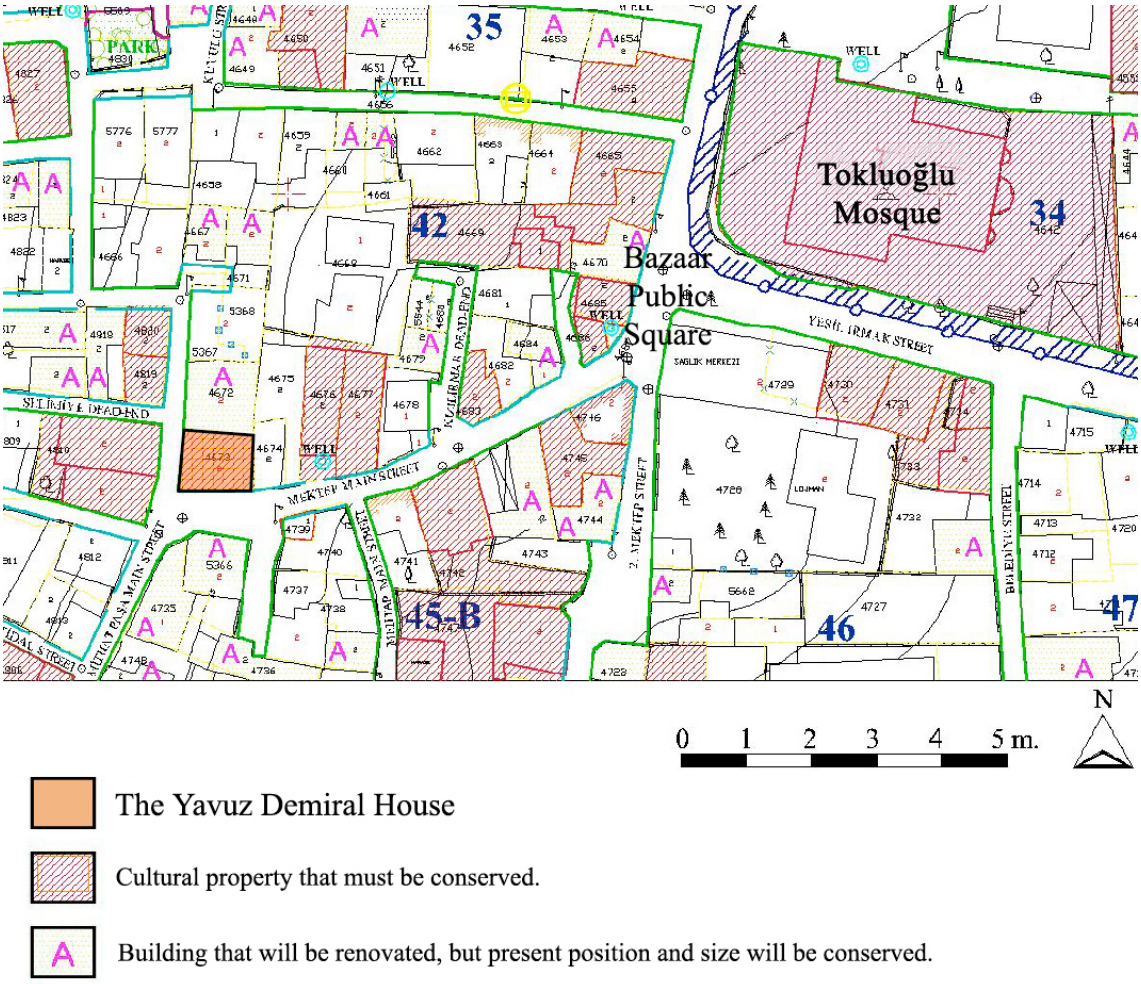


Figure 33. The studied house as illustrated in the Alaçatı Urban Conservation Plan (Source: Alaçatı Municipality Archieves 2006)

The studied Yavuz Demiral House is situated in Tokluoğlu Quarter, and it is close to Pazar (Market) Public Square in front of Pazar (Tokluoğlu) Mosque (Figure 24). It faces both Mektep Main Street and Mithat Paşa Main Street as being a corner building (Figure 33) (Figure 34). It is a second degree listed building (Mektep Main Street, Sheet 77, Plot 4673) with the decision of İzmir Number 1 Conservation Council of Natural and Cultural Properties dated 01.07.1988 and numbered 422 (Şahin 2006).

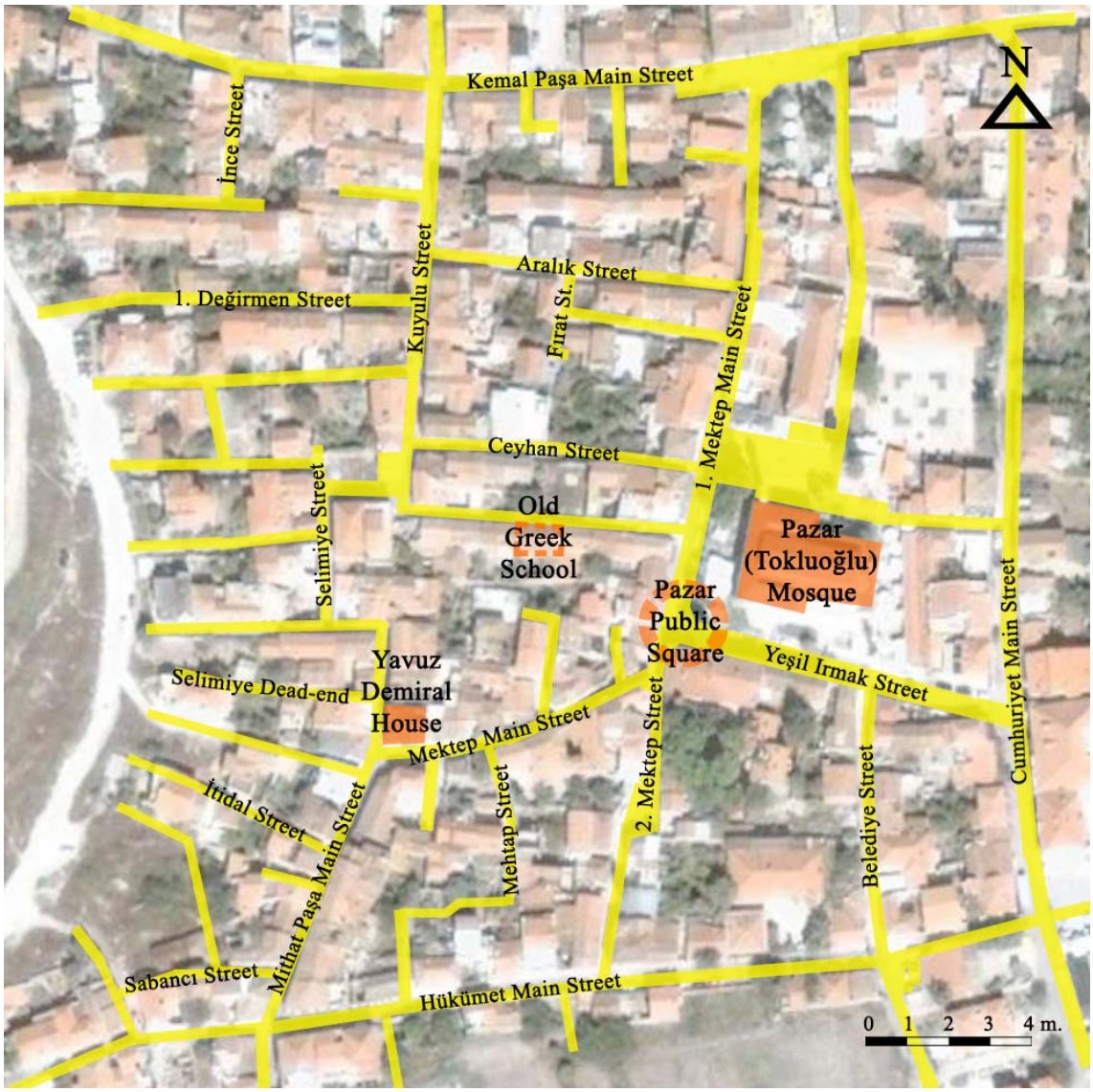


Figure 34. An aerial photograph of the house and its near surroundings
(Source: Google Earth 2008)

The house is abandoned in the existing state. It is a singular mass; however there are fairly new buildings on both sides of it. As it is emphasized in the Report about the Urban Analysis of Alaçatı (Conservation Development Plan Notes of Alaçatı) (Şahin

2006), any kind of application and repair on the listed cultural values will be made in the direction of the principle laws that are in force. According to this, interventions can be made to the listed Yavuz Demiral House and it can be refunctioned in the direction of the present conservation laws.

The house composed of a single prismatic mass (11x10.5x8.5 m) crowned with a hipped roof has two stories. It is located on an inclined site beveling towards the west (7%). The front (southern) façade is slightly elevated from the Mektep Main Street 50-80 cm (Figure 35).

Figure 35. An exterior view of the Yavuz Demiral House from southwestern direction (September 12, 2006)

When building/lot/street relationship of Alaçatı houses is considered, the types can be listed as; houses without courtyards, houses with front courtyards and houses with back or side courtyards surrounding two perpendicular façades (Özgönül 1996). According to this mentioned relationship, the studied building is in the houses without courtyards group. The lot of the house is surrounded by two streets (corner lot) and the building has two façades oriented to the street. Indeed, the house stands out with its

corner location. There are adjoining houses constructed next to both sides of the house. The southern façade of the house with the façades of the adjoining houses was documented roughly in the Alaçatı Analytical Research Report of Ercüment Şahin prepared in 2006 (Figure 36). The fact that these houses are not listed in the Conservation Plan of Alaçatı make one think that the Yavuz Demiral House could have had a garden or a courtyard, like the similar historical houses in Alaçatı's general house typology. Nevertheless, the lot organization typology of this house, a corner lot and no courtyards scheme, is observed in a few other Alaçatı houses.

Figure 36. The Mektep Street and the Yavuz Demiral House
(Source: Şahin 2006)

On the front (southern) façade facing the main street, there is an entrance door at the right part which opens to an entrance hall ("taşlık"). Here, there are wooden stairs leading up to the first floor. At the left part of the southern façade in the ground floor, there is a large space that could have been used as a shop ("mağaza") in the past. The fireplace at the back wall inside is the datum element of the large shop (Figure 37). This space has three openings on the front (southern) façade and three more openings on the side (eastern) façade. At each façade, it has one door flanked by a window on each side. The entrance hall which is thought to be serving to the family living upstairs has also an access to the shop section with a smaller door compared to the street entrances (Figure 38). When Özgönül's study of plan typology for the ground floors (Figure 28) is considered, it can be thought that this house is a type that is directly entered from the street (Özgönül 1996).

Figure 37. The northern wall of the shop section and the fireplace (September 12, 2006)

Figure 38. The eastern wall of the shop section, and a small sized door as an access between this section and the entrance hall (September 12, 2006)

In the first floor, only the posts of the partition walls are present, but since these posts are lined up in an alternating order, it is emerged that the space is divided into one hall ("sofa") that has a projection to the main street and three small rooms surrounding the hall. These rooms should have included kitchen and toilet spaces in them. In these kinds of plans in Alaçatı, the kitchens are generally placed around the halls with the other living spaces, while the toilets are usually located in the courtyards, in the gardens or at the terraces of the houses (See Section 3.3). If there has been a wall separating the fireplace section from the rest, this space could have most probably been used as a kitchen. If the spaces in the first floor did not include a toilet, the toilet could have probably been somewhere outside the house in the past, for instance in the garden of the house if it had one. The front façade in the first floor has two window openings other than the projection. The side façade has three window openings. There is a fireplace in the hall at the opposite side of the projection, in the middle of the back wall. On the upper east side of the same wall, there are two small window openings that are probably for lightening the space where a staircase is placed leading up to the roof. This wooden staircase reaches a small sized terrace like opened space at the northeast of the roof. Even though it is a terrace like space, contrary to the general position of toilets in Alaçatı houses which are terraces, the position of this terrace as being at the roof section is inappropriate for a toilet to be located.

If Özgönül's study of plan typology for the first floors (Figure 29) is investigated, it can be mentioned that this house belongs to the group with having a hall surrounded by rooms on three sides, where the fourth side is oriented towards the street with a projection (Özgönül 1996) (Figure 39) (Figure 40) (Figure 41).

The façade elements of the house are listed low according to the floors and spaces they belong. At the ground floor, there are arched, two winged, side-hinged wooden doors with cut stone casings; arched wooden windows with cut stone casings and side-hinged wooden shutters; and a two winged iron door with one wing being larger; whereas the part of the façade at the first floor includes wooden sash windows with wooden frames, a projection carried by timber beams and supported by iron bars. The main entrance door has an arched top window with an iron grid, surrounded by arched stone casings. The frames, wings and sashes of wooden doors and windows are rather decayed; some are out of repair. Wooden eaves are the other façade elements that attract attention at the upper part. The pitched roof is covered with *A'la Turca* tiles like

the other examples in the settlement. They all attract attention by having common characteristics with the traditional Alaçatı dwelling types.

Figure 39. The staircase at the first floor (September 19, 2006)

Figure 40. The staircase (September 19, 2006)

Figure 41. The northern wall at the first floor and the posts (September 12, 2006)

The entrance doors of the shop section ("mağaza") are arched, two winged, wooden doors. The main entrance door leading to the entrance hall and the staircase is an iron door having two rectangular wings; one larger in dimension while the other one is narrower. It also has a head window decorated with ironwork. The interior opening between the entrance hall and the shop section is a simply carved one without having any cash or wings, but having a threshold.

As mentioned above, the arched wooden windows at the ground floor have arched wooden frames and shutters. Alternatively, the wooden windows in the first floor are rectangular in shape, having more plain forms. The statement in Özgönül's typological survey study which expresses the existence of rectangular window types in the living units on the upper floors verifies the presence of rectangular windows at this house in the first floor. The existence of arched window types at the ground floor also is confirmed in Özgönül's study (Özgönül 1996). The sashes do not exist in two of the windows at the south wall, while the other three at the west wall are sash windows which are perpendicularly sliding. There are no top windows in the window types of this house.

It is observed from the damaged parts of the walls that in the ground floor walls of the house, rubble stone masonry was used at the inner parts of the walls; whereas, cut stone masonry was used outside, giving face to the exterior side. Timber skeleton system was used on the first floor. The walls are approximately 3.85 meters high and 0.55 meters wide at ground floor, and 3.70 meters high at first floor. In timber skeleton system, brick was used as infill material in between timber posts, timber beams and timber diagonals. There are timber posts for the partition walls in the first floor. Approximately 2.5 cm. thick plaster has been applied on the ground floor walls. According to visual analysis, straw pieces were observed in the plaster.

There are timber lintels on the windows and doors; and timber beams at the level of the roof in the first floor. Flooring system is timber flooring with timber beams and covering. Foundation of the building is rubble stone as it is observed from the collapsed parts of the ground floor. The depth of the foundation is approximately 1.60 meters when measured from the ground floor. The width of the foundation wall extends about 0.75 meters towards the interior of the house from the interior border of the wall surface.

The major conservation problem of this 19th century historical Alaçatı house is its highly damaged structural system due to its abandonment for about fifty years as

previously mentioned. The building materials are also highly damaged. The house requires both urgent repair and an appropriate use. The detailed documentation of this historical structure is a prerequisite for its conservation.

On the other hand, the Yavuz Demiral House has the following values:

Traditional value: It is a value related to the ingrained traditions, ways of life and beliefs of the community that built the architectural object or structure (Madran and Özgönül 2005). The Yavuz Demiral House contributes in defining the urban identity of Alaçatı with its scale, mass and façade characteristics. The traditional elements of the house which represent the lifestyle of a certain period in Alaçatı increase this value.

Technical value: This title includes the technical and structural design characteristics of the cultural value, and also the standards reached at that period of time along with the quality of the workmanship (Madran and Özgönül 2005). The case study building is a representative of a construction tradition peculiar to the district with its masonry and timber skeleton system. This construction system resembles the system used in Alaçatı in the late 19th century. Also, it is a sample of a house with a combined function by including both residential and trading functions.

Economic value: Every piece of land on earth has an economic value. This value increases if it supplies certain requirements of life with the arrangements of people living there (Madran and Özgönül 2005). It should also be mentioned that the mismanagement of the potential economic sources, such as tourism, commerce, use and amenities, may lead to the undesirable development or even destruction of the heritage resource (Feilden and Jokilehto 1993). By being in a tourism area, the Demiral House has a commercial value and has a contribution to the building stock. Its architectural and design characteristics related to its construction period are also facts increasing its economic value.

Social value: It is related to traditional social activities and compatible present-day or prospective use of the heritage source that can involve social interaction in society and play a role in the establishment of social and cultural identity (Feilden and Jokilehto 1993). Preserving a traditional building that represents the cultural values of an important period of a settlement also strengthens the bonds between the inhabitants and the settlement. The studied house has the potential of involving contemporary social interaction and playing a role in establishing social and cultural identity. It is empty but has the potential of being refunctioned. The zone is still a preferential residential area, so it can be documented and preserved as a dwelling. Besides, the ground floor can

again be used as a shop for tourism purposes. Another function to be suggested can aim the education and socialization of the local public or the people who came to Alaçatı and internalized it at a later period of time. Preserving this house by giving a function may play an important role in the rehabilitation of its surroundings.

It is known that the presence or absence of different values can lead to the preservation of cultural heritage resources or to their neglect in some cases (Feilden and Jokilehto 1993). It can be stated that the presence of the above listed values has lead to the documentation of the case study house. Its protection and restoration will hopefully follow this documentation.

CHAPTER 4

PHOTOGRAMMETRIC DOCUMENTATION OF THE CASE STUDY

The photogrammetric documentation phase in this study is divided into two stages; the field work (survey) and laboratory work (data processing and presentation). In the first phase, defined as field work, the photographic shots of the chosen construction are taken and enough information for its subsequent orientation and scale is collected. The colored printouts of these photographs are used in the second phase of the field work to note down the measured control points and the observations about the building in a more detailed way. In the second phase which is the laboratory work, all the information collected in the field work is processed to obtain the scaled elevation drawing, the rectified image mosaic and thematic maps. It includes photogrammetric evaluation and representation works.

4.1. Field Work

Photography has a significant role and a long history in historical documentation. Digital photography is used to reduce the time spent at the site and it is worthy in recording of the details (Warden and Woodcock 2005). Therefore, an initial photographic recording is carried out to plan the detailed field work. These photographs are color printed in A4 format to note down control point locations. With regard to these initial photographs, sketches of all building surfaces are drawn to provide further ease in site surveys and get acquainted with the studied structure.

The detailed field work can be divided into two as topographic and photographic works. These two groups of work should be carried out in accordance with each other, in order not to give way to the repetition of work.

4.1.1. Photographic Works

In the photogrammetric documentation, it is aimed to obtain accurate drawings by obtaining numerous photographs of the house. The photographic shots are made by a digital camera equipped with a 28 mm lens (Nikon D70S Digital SLR[15]) (Figure 42).

Figure 42. Digital camera (Nikon D70S Digital SLR)

The scale of a vertical photograph may be defined simply as the ratio of camera focal length to the object distance (Wolf and Dewitt 2000). The shorter the object distance (the closer the object to the camera), the greater the photograph scale, and vice versa (Wolf and Dewitt 2000).

$$\text{Scale} = \frac{\text{Focal length (Photo distance)}}{\text{Object distance}}$$

In turn, the focal length in this study is 28 mm. The distance from the camera to the façade is taken as 7 meters at maximum, because 1/50 scale is aimed:

$$\text{Negative scale of } 1/50 = \frac{\text{Focal length, 28 mm}}{\text{Distance, 7000}} = 4/1000 = 1/250$$

[15] Nikon D70S Digital SLR Camera features a 6.1-Megapixel CCD that yields 3,008 x 2,000 pixel images suitable for making large prints. It includes AF-S DX Zoom-Nikkor 18-70 mm f3.5-4.5G ED-IF lens, covering the focal length range of 18 to 70 millimeters.

The enlargement factor of the output scale should not exceed four or five times the negative scale (Swallow, et al. 2004).

Output scale = (4/1000) x 5 = 20/1000 = 2/100 = 1/50

The rectification aimed photographs and measurement aimed photographs are considered separately in the shooting process. For the specification of the camera in image acquisition, drawing a sketch of how the cameras are placed is useful when photographs are taken (Figure 43). This sketch also shows that the camera positions are planned according to the bundle method of close range photogrammetry. While deciding on the positions of the cameras, the rectification and measurement processes are considered separately as explained below.

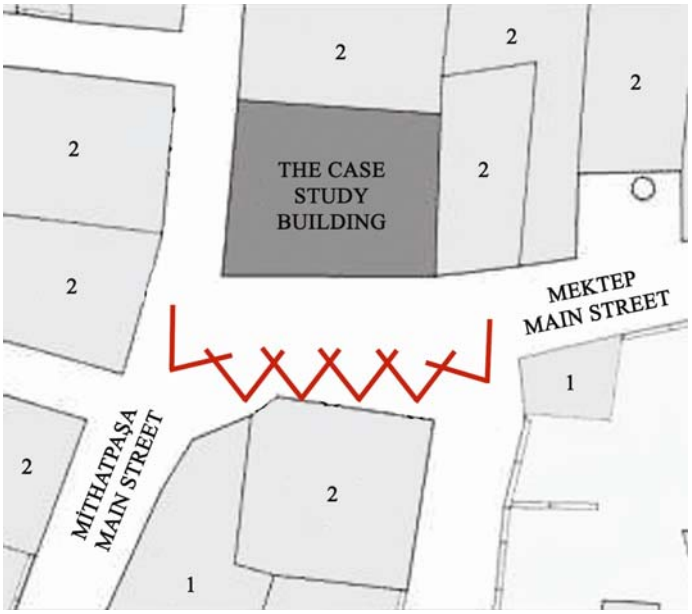


Figure 43. A sketch showing the positions of the camera when the measurement aimed photographs were taken

The rectification aimed photographs are taken considering the following points:

- Each building plane at different depth should be photographed separately. It is recommended to work with a series of individual photos covering every plane (Swallow, et al. 2004).
- The photographs of the building façade surface should be taken the most perpendicular to the plane (Hanke and Grussenmeyer 2002).
- The photographs must be slightly overlapped (Hanke and Grussenmeyer, 2002).

- Tilts should be avoided as much as possible (Swallow, et al. 2004). The photographs may be taken by using a portable scaffold tower or by a similar tool (Swallow, et al. 2004). In this work, a ladder is used for the upper zone to provide the parallel shooting to the façade.

The measurement aimed photographs are taken considering the principles of bundle method (Hanke, et al. 2002). Accordingly, the following aspects should be taken into account:

- The right lighting conditions should be used (Arias, et al. 2007).
- Shadows, reflections, and backlights or burned photographs should be averted (Arias, et al. 2007).
- The depth of the field should be calculated correctly (Arias, et al. 2007).
- The speed of the camera should be adjusted (Arias, et al. 2007).
- The camera should be held possibly stable, trying not to shake it (Arias, et al. 2007).
- The position of the camera is determined for each photograph, taking into account the requirements of the bundle adjustment method:
    - Every building element being documented must be included in at least 2 photographs, preferably in 3 photographs (Hanke and Grussenmeyer 2002). In monoscopic digital photogrammetric stations, like Pictran, one can achieve more reliable calculations with two or more overlapping photographs of each element taken from different angles (Hanke and Grussenmeyer 2002).
    - 2 photographs should be taken with an angle of 90° in between them, whereas the third one has to be the most perpendicular to the façade of the building which provides complete validation and allows one to obtain photorealistic textures of the object (Arias, et al. 2007).
- The mass of the building in the photograph should be adjusted in a way that the sky does not take up too much space and the element to be photographed covers most of the picture (Arias, et al. 2007).
- A large number of general and detail photographs must be taken to provide ease in evaluations (Arias, et al. 2007).

4.1.2. Topographic Works

A Zeiss Rec Elta RL-S total station[16] is used to determine the coordinates of the control points (Figure 44). A range pole and a reflector are the other tools used in control point measurement (Figure 45). These measurements are done in August 2006 and September 2006 (Figure 46).

Figure 44. Total station (Zeiss Rec Elta RL-S)

Figure 45. Range pole and reflector

[16] Zeiss Rec Elta RL-S total station includes a measurement sensor, and also an operating and displaying unit. It has the following technical features: "For large-area surveys, a coordinate system is needed as a frame. The measured data is oriented in a coordinate system for processing in the office when the measurement program modes are used. However, in many applications it is necessary or desirable to create or use coordinates directly in the field. The modes required for this purpose are grouped in the Coordinates Program of this tool. The Coordinates program offers four modes for determining, displaying and recording coordinates created in different ways, e.g. stationing on a known point, which is required for side shots and for setting out. In mode area you can additionally determine the contents of area by coordinates" (Surveyors Express 2008).

Figure 46. Measurement of the control points with total station

In the beginning of the topographic works, 2 station points are determined to place the total station by considering the fact that they will see the façade to be documented from appropriate angles (Figure 47). The control points (87) are noted down on the photographs of the front façade of the house.

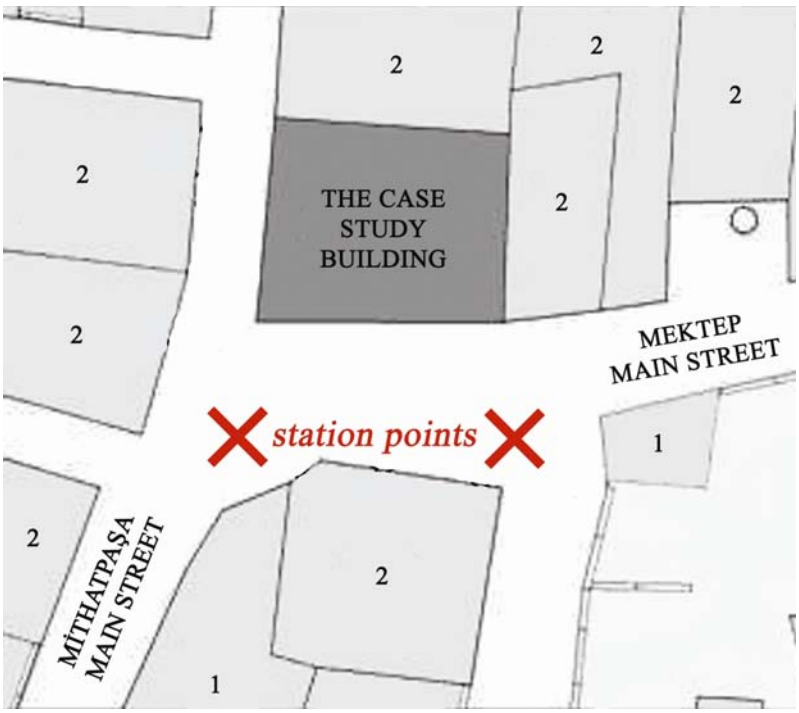


Figure 47. A sketch showing the positions of the station points

The issues considered in the selection of the control points are listed in the below:

- The measured coordinate points should be homogeneously distributed and cover the whole façade being studied (Habib, et al. 2004).
- It is important that at least 5 control points are provided at each photograph.
- Each control point must be visible in two or more images. If the same points appear in larger number of images, the accuracy of the three-dimensional coordinates will be improved (Habib, et al. 2004).

4.2. Laboratory Work

The laboratory work generally serves the purpose of processing previously gathered data in the field work. It can be divided into two phases as photogrammetric evaluation and presentation works, where the outcome of the photogrammetric evaluation phase is used at the presentation phase.

4.2.1. Photogrammetric Evaluation Works

There is a variety of software packages used for the digital photogrammetric applications such as RolleiMetric CDW, PhotoModeler, ASRix and Pictran. For the process of close range digital photogrammetry in this study, Pictran Release 4.0 was chosen as the software, which is from Technet GmbH, Germany. Pictran is widespread in Turkey, especially in the universities that have photogrammetry education. It is partially translated into Turkish, has relatively reasonable prices and the accuracy of it was proved with numerous studies.

Pictran, founded in 1989, is module based: Module Pictran D was used for interior orientation and point measurement. Module Pictran B was used for calculating the exterior orientation (bundle block adjustment) (Bosch, et al. 2005). Three-dimensional coordinates of the points are measured with the help of this software, and accurate measurement data produced is transferred to CAD environment (AutoCAD).

In the first step, the digital camera used for taking the photographs of the building is introduced to the Pictran software. In order to facilitate the work, the photographs of the exterior façade of the southern wall are saved in a folder. As the next

step, the exterior orientation of the photographs is done. Since a digital camera is used during the shots, interior orientation is not required (Technet GmbH 2000). After the necessary points are measured, graphical objects are formed by using the ones which are desired to be observed in connection with each other. These objects are transferred into a CAD program with the purpose of creating the complete drawings and presentations in the following phase.

4.2.1.1. Loading the Calibration Folders

In order to achieve accurate results in photogrammetry, the Interior Orientation Parameters (IOPs) of the camera has to be known. These are the principle distance (c), the principle point of autocollimation (x0, y0) and the radial and decentring distortion of the lens. Camera calibration is the method to determine these IOPs. It is a different research area in photogrammetry which is also studied in Working Group I of CIPA (Data Acquisition and Recording Techniques) (CIPA 2007). From this CIPA group, Bosch et al. (2005) state in their paper that there are different calibration methods such as test field calibration, on-the-job calibration and self calibration method. In the test field calibration method, the unknown IOPs are determined by using an adequate number of well marked control points on an object which are precisely measured (Bosch, et al. 2005). This stage of the thesis was supported by the Computer Company that the Photogrammetric software was bought from (Erdoğan 2005). They calibrated the 28 mm lenses of Nikon D70S digital camera that was used in the shooting process. These electronic folders of the camera are loaded to the Pictran-D program by clicking on ‘Import’ in the ‘Camera Data’ window, under the ‘Options’ tool of the top tool bar (Figure 48). By this way, the folders (in ‘cam’ format) arranged for 28 mm objective (Figure 49), are imported from the related cd prepared by the related company.

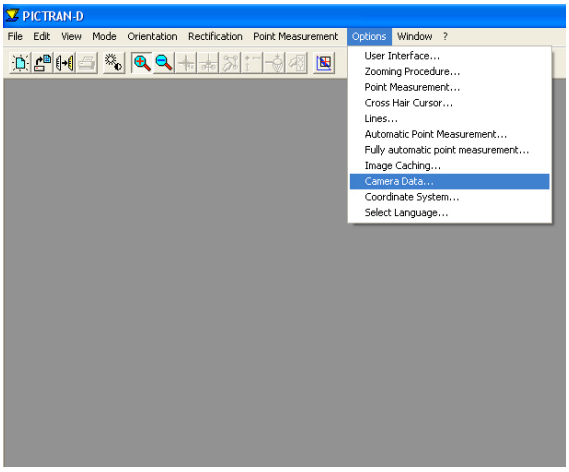


Figure 48. Choosing 'Camera Data' from the toolbar

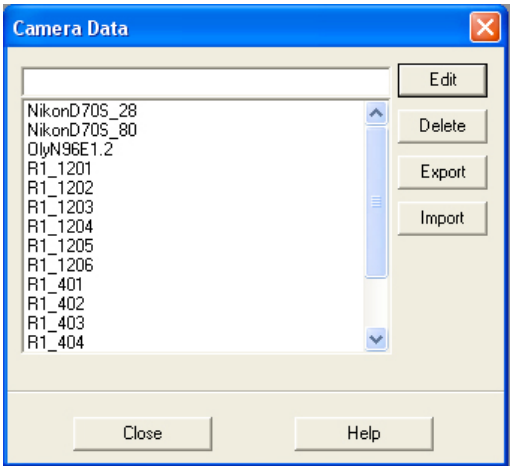


Figure 49. Importing the camera folders that were previously calibrated

4.2.1.2. Loading the Photographs

The photographs taken in 'jpeg' format are imported into Pictran software, by 'Import' under the 'File' tool at the top tool bar (Figure 50). They can be used in the program after they are converted into 'btf' format this way. For each photograph imported, the name of the digital camera used and the right lens type are chosen from the previously loaded list of the calibration folders. The direction of each photograph is also checked and the ones which are turned in the wrong direction should be corrected. By clicking on the 'Start Import' command, all the required photographs are loaded. At the left top corner of the program screen under the top tool bar, the list of the photographs imported can be viewed by clicking on the symbols.

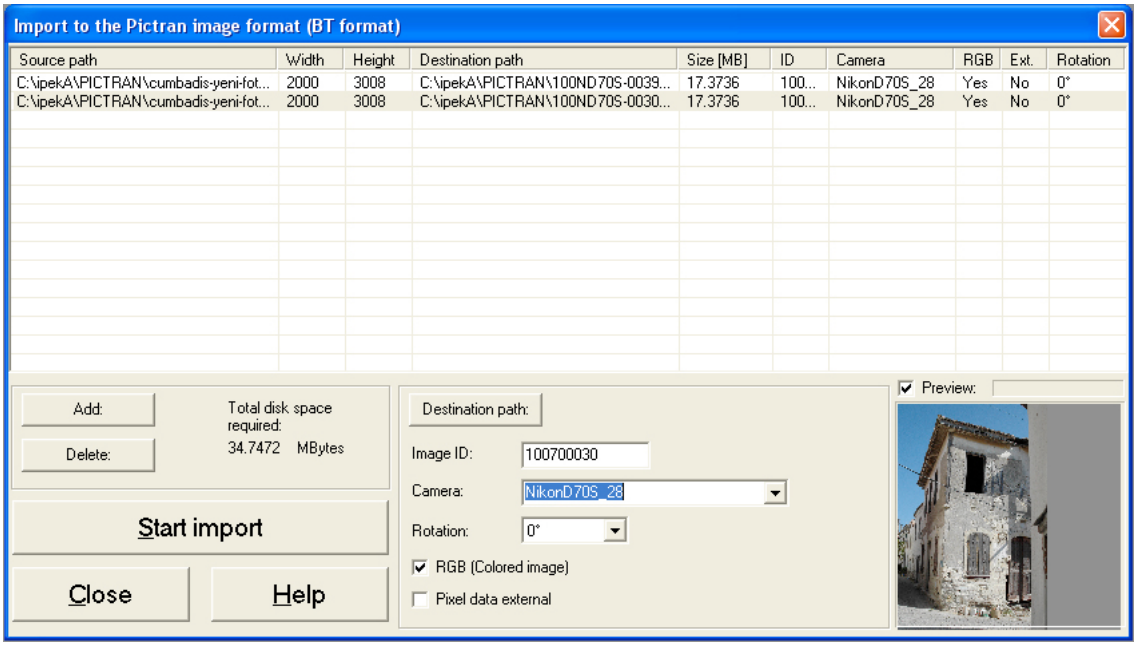


Figure 50. Importing the photographs into Pictran

4.2.1.3. Exterior Orientation[17]

Exterior orientation is the process of orienting the photographs that are to be used that lets them to be interconnected with each other in the next phase where three-dimensional measurement is taken on the images (Technet GmbH, 2000: 32). 'Exterior Orientation' is chosen under the 'Orientation' tool at the top tool bar. At the 'Exterior Orientation' window opened, identity information ('ID') is clicked on under the 'Object Points' column. The number of one of the control points is entered. In the lines below this, the entered control point's x, y and z coordinate values are entered. 'Insert' command is clicked on. After these steps are repeated for all of the control points, the coordinate values are saved by clicking on 'Save Object Point File' (Figure 51).

[17] For digital cameras, the relationship between pixel and image coordinates is almost constant. This is determined during the calibration procedure. Interior orientation that covers this purpose is not required since the photographs were taken by a digital camera, so only exterior orientation is carried out (Karabork et al., 2004: 811)

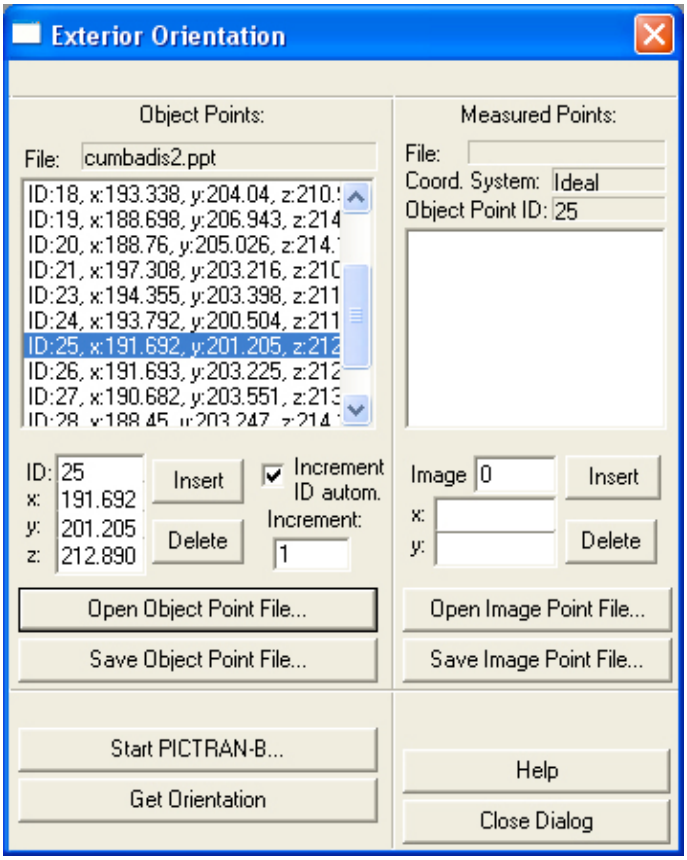


Figure 51. ‘Exterior Orientation’ window.

The sheet, on which the values of the control points measured by the electronic theodolite were written down on the studied façade photograph during the field work, is made ready. At the Pictran, the mouse is activated for the marking process of exterior orientation by clicking on the command with a thin plus sign on (‘Cross Hair’). The mouse cursor gets the shape of a thin plus sign. The color of this plus sign can be changed in order to make it clearer on the photographs. For this act, ‘Cross Hair Curser Settings’ window is opened from the ‘Options’ tool at the top toolbar (Figure 52). The photographs including the studied control point are opened one by one. The control point is marked on at least two photographs by clicking with the left command of the mouse. For marking more accurately, the command with a plus sign on (‘Zoom +’) is clicked on so that the desired part of the photograph can be zoomed in. When the point is marked on the zoomed photograph, the point is taken inside a circle and the number of the point is written next to the circle. The same control point is marked on the second photograph in the same way. In order to reach the entire photograph again, the command with a minus sign on (‘Zoom –‘) is clicked on over and over again (Figure 53).

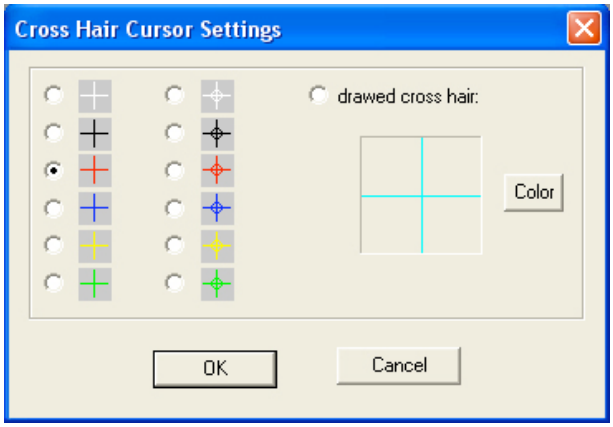


Figure 52. Choosing an appropriate color of the plus sign used for marking

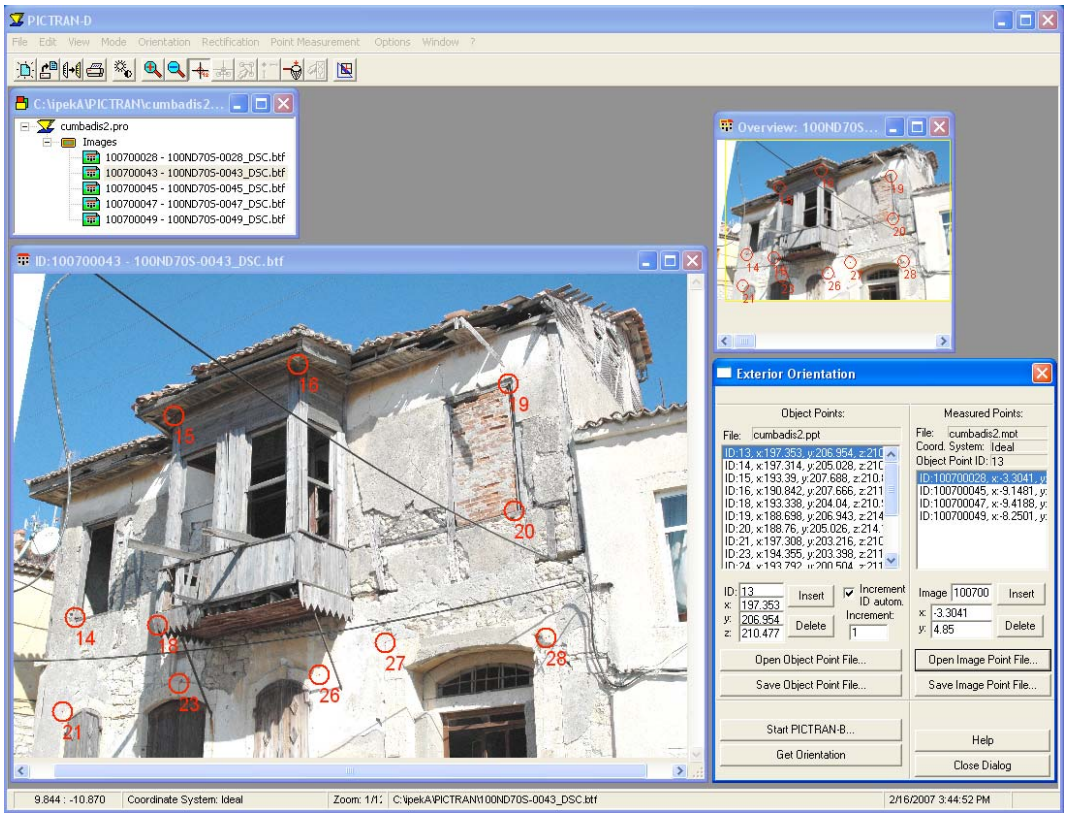


Figure 53. Marking the control points with the ‘Cross Hair’ command

When the number of marked photographs is kept high and a number of photographs taken from different angles are used, it is seen that the accuracy of the end result increases. The photographs which are not marked at all or the ones with only one marking on are left out of the system, and they can not be used at the following measuring phase.

After the studied control point is marked on enough number of photographs, the next control point is clicked on under the object point column at the window. The marking process is repeated. ‘Save Object Point File’ and ‘Save Image Point File’ are clicked on to save the coordinate values marked on the photographs.

The stage that comes after the control points are marked on the photographs is the bundle adjustment stage. ‘Start PICTRAN-B’ is clicked on, at the ‘Exterior Orientation’ window. This way, Pictran-B is activated which is the calculation unit of Pictran software. Pictran-B software is opened and the window where the basic legend including the project parameters is going to be formed appears on the screen (‘Basic project settings’ window) (Figure 54). The appropriate values for architectural documentation are defined as follows: ‘Medium recording distance’ value is 1.2, ‘maximum object dimensions’ value is 0.4, ‘factor of elimination’ value is 200, and ‘standard deviation of image coordinates’ are 0.01 for x, 0.01 for y (Technet GmbH 2000). ‘OK’ is clicked on after entering the values. The file name of the project which is studied appears right under the top tool bar, next to the symbol of green triangle. Under the folder name, next to the symbol of red lightning, ‘Calculate project’ is clicked on (Figure 55).

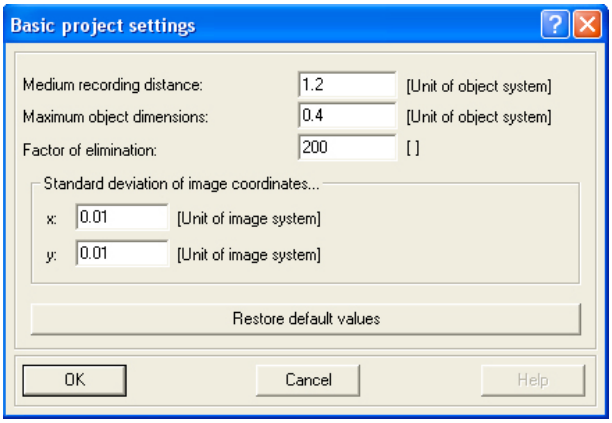


Figure 54. Adjusting the ‘Basic Project Settings’ before the calculation process

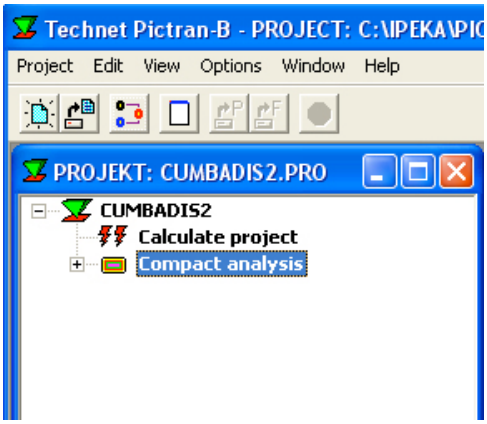


Figure 55. ‘Calculate project’ clicked on for the calculation to begin

The calculations of the project’s data can be observed at the report (‘Meldungen’) window. At the end of this window, the result is seen. Pictran-B software makes the calculations in four stages: ‘Bunkon, Bunnae, Bunob, Bunbil’. The ‘Sigma 0’

value should be between 0.7 and 1.3 (Figure 56). It should not be reached to the 'Termination limit'. Pictran-B is closed by clicking on the 'X' sign at the top.

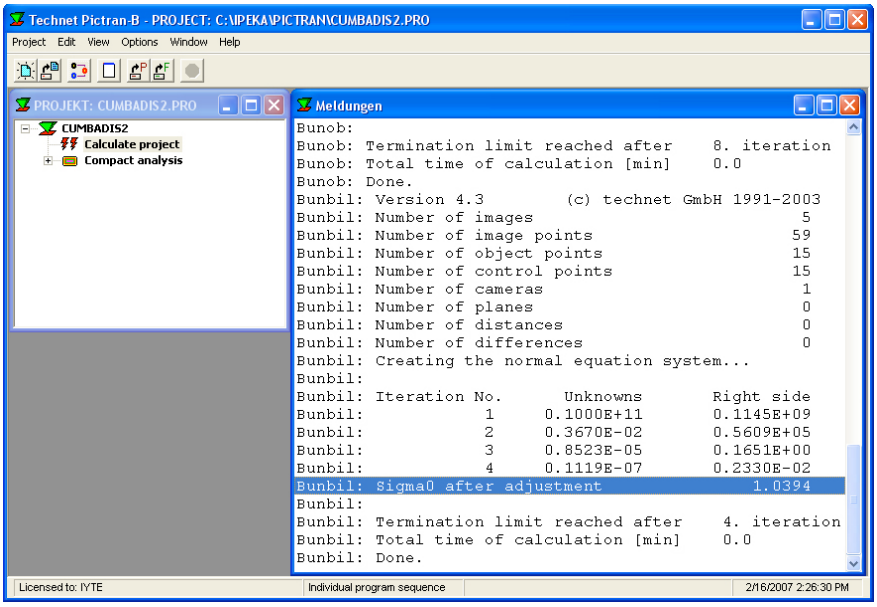


Figure 56. A project folder after the calculation is finished

Being able to acquire these required conditions, some phases should be passed in precision. 'Last listing' under the 'View' tool at the top tool bar is clicked on (Figure 57), and the problems related to data entry are determined. Then, 'Last error-File' (Figure 58) under 'View' is clicked on, so that the classified errors can be viewed.

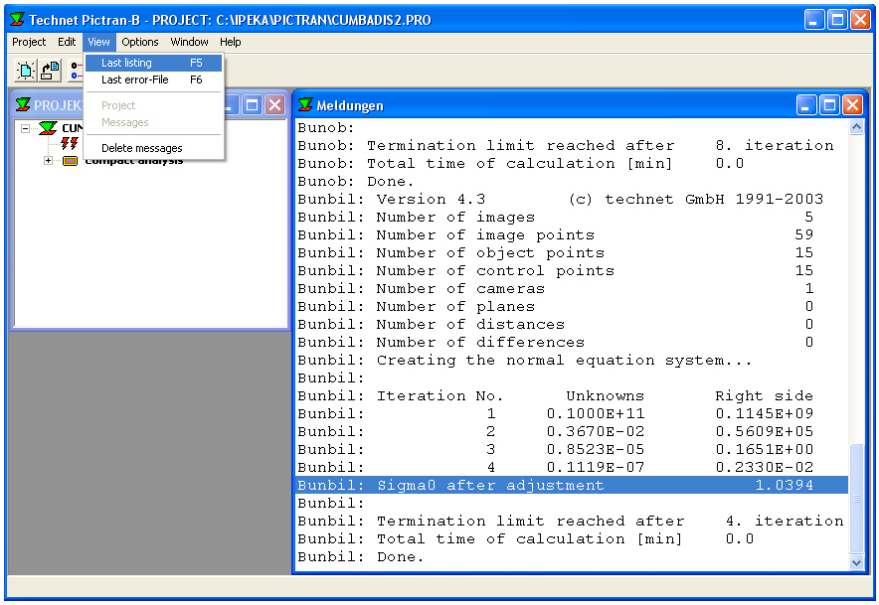


Figure 57. Opening the 'Last listing' folder to view the Last Protocol File

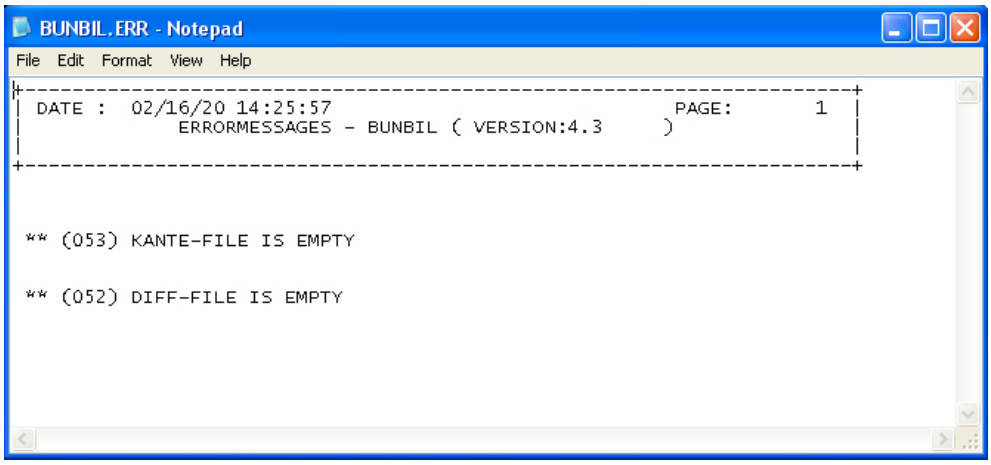


Figure 58. An example to the 'Last error-file' result

After calculation, the error or warning given in Pictran-B and the way of handling any error can be checked in the folders under 'Help' at the top tool bar. If there is a warning in the explanation of an error that the iteration number should be increased and the calculation should be repeated, then one can increase the maximum number of iterations in the parameters window about the 'Compact analysis'. This window for these adjustments can be opened from the project window on the screen, under 'Compact analysis' where the mentioned folder is chosen from the 'Bunkon, Bunnae, Bunob or Bunbil' stages (Figure 59). In the parameters window opened, the required adjustments can be made (Figure 60).

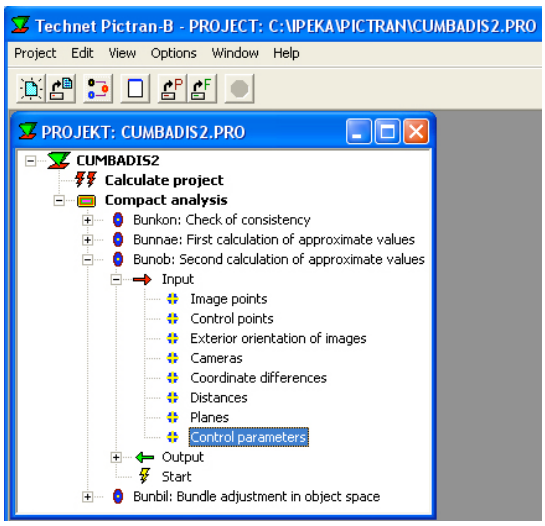


Figure 59. The 'Control parameters' folder, for the southern façade project

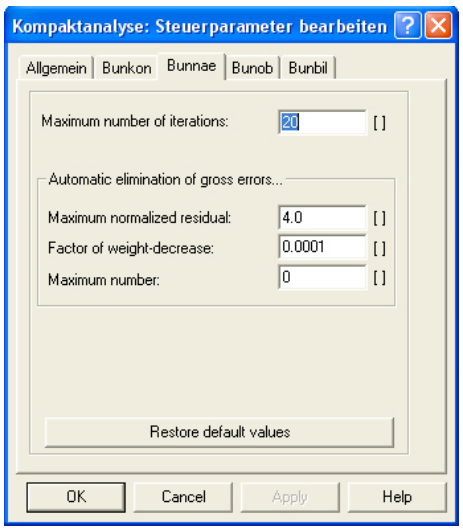


Figure 60. The window for making adjustments after analysis

Another way of learning the source of errors is looking at the last error file where there is the list of the points with problems in a prioritizing order. The points that have the highest 'Normalized Residual' value are remarked on the mentioned photograph, and the calculation is repeated. If the problem caused by a remarked point can not be solved at all, it would be appropriate to erase this point completely, on condition that the number of the remaining points is enough. There can also be a problem at the data entering process in Bunkon or Bunnae. The coordinate values of the control points could have been measured or entered wrong. The digital camera used could have been incorrectly introduced, too.

If an obstacle occurs at the Bunob Phase, 'Maximum Normalized Residual' value is examined at the end of 'Last protocol', in 'Output' file of the previous phase 'Bunnae'. The control point with a problem ('POINT NU.') and the photograph ('SYSTEM NU.') that it is marked on are noted down (Figure 61). The point is remarked and the calculation is repeated. This point can also be erased from the determined photograph if there is not a problem about the number of points and the calculation is made again. The same steps are repeated until the 'Maximum Normalized Residual' value gets smaller. At the end of this stage, the sigma value becomes a value between 0.7 and 1.3. The 'Get Orientation' command at the window opened is then clicked on, to end the process.

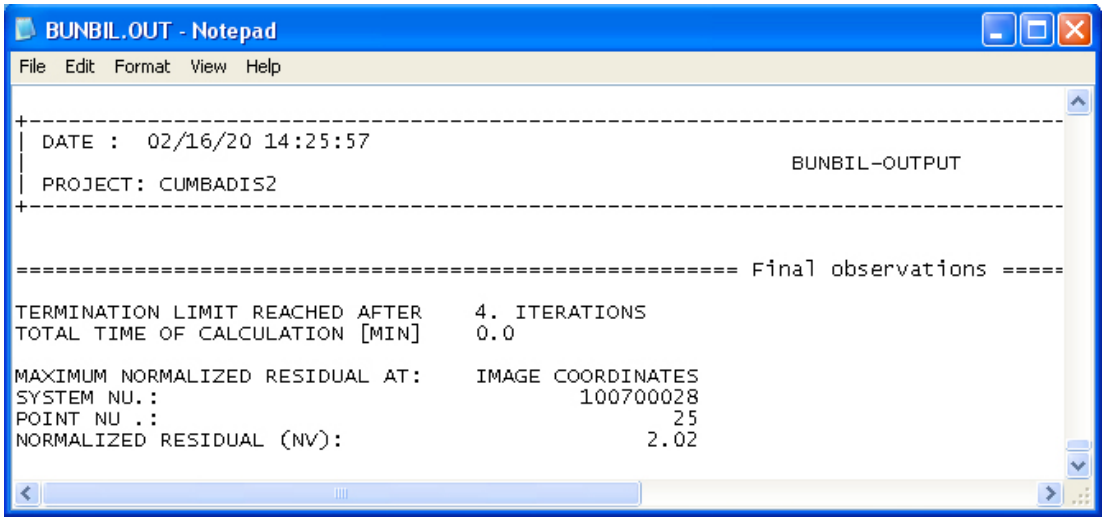


Figure 61. An example to the 'Last listing' – A warning about the point with the maximum normalized residual

4.2.1.4. Three-Dimensional Measurement

In general, the three-dimensional measurement phase is considered as the most tedious and time consuming part of the digital documentation (Rizzi, et al. 2007). In Pictran, three-dimensional measurement is supported by epipolar lines and the accuracy information is always available (Holl 2003).

'3D Restitution' under 'Point Measurement' at the top tool bar is clicked on (Figure 62). The point that will be measured should be visualized on at least two, and if possible on three photographs. The photographs that show a part of the studied façade from different angles/perspectives are opened one by one (Figure 63).

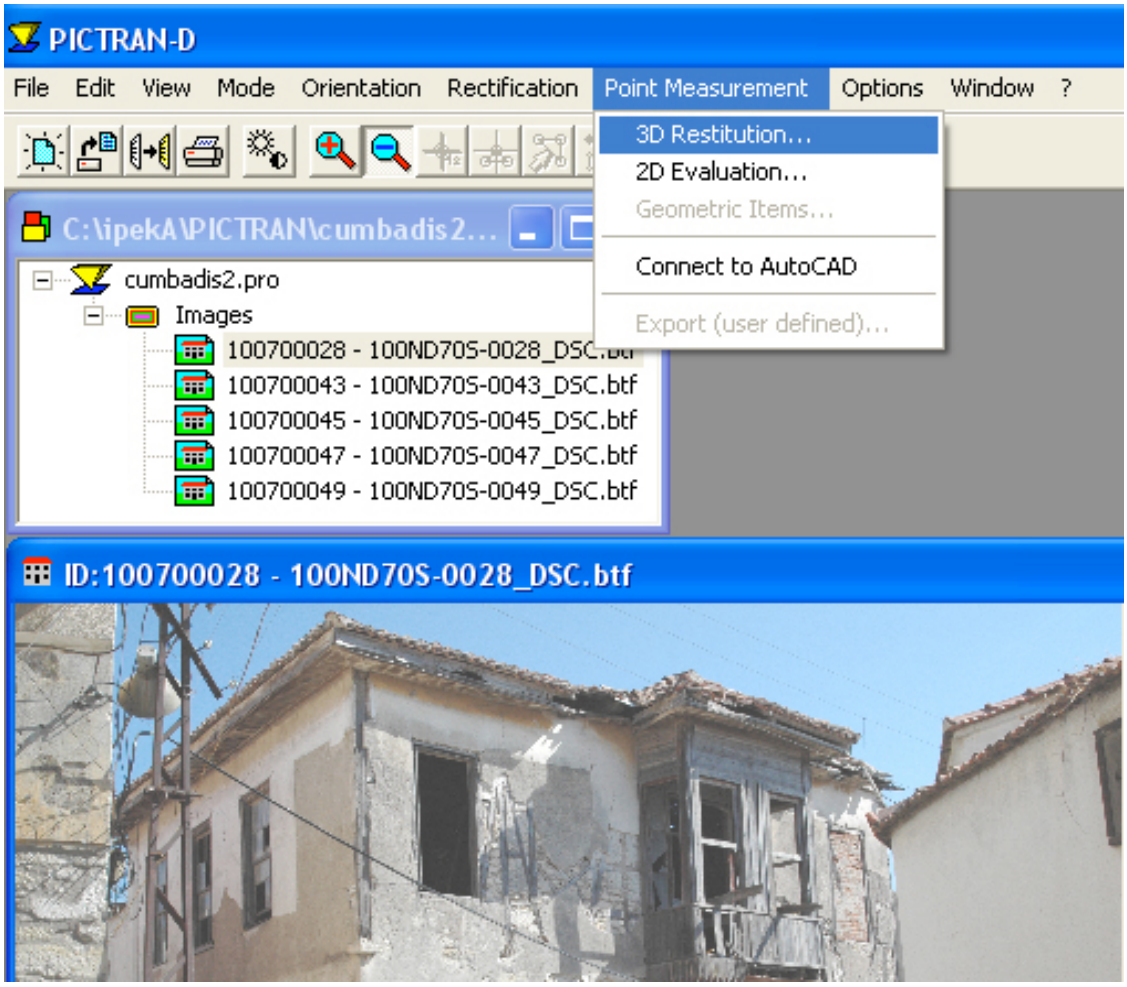


Figure 62. Choosing '3D Restitution' at the top tool bar

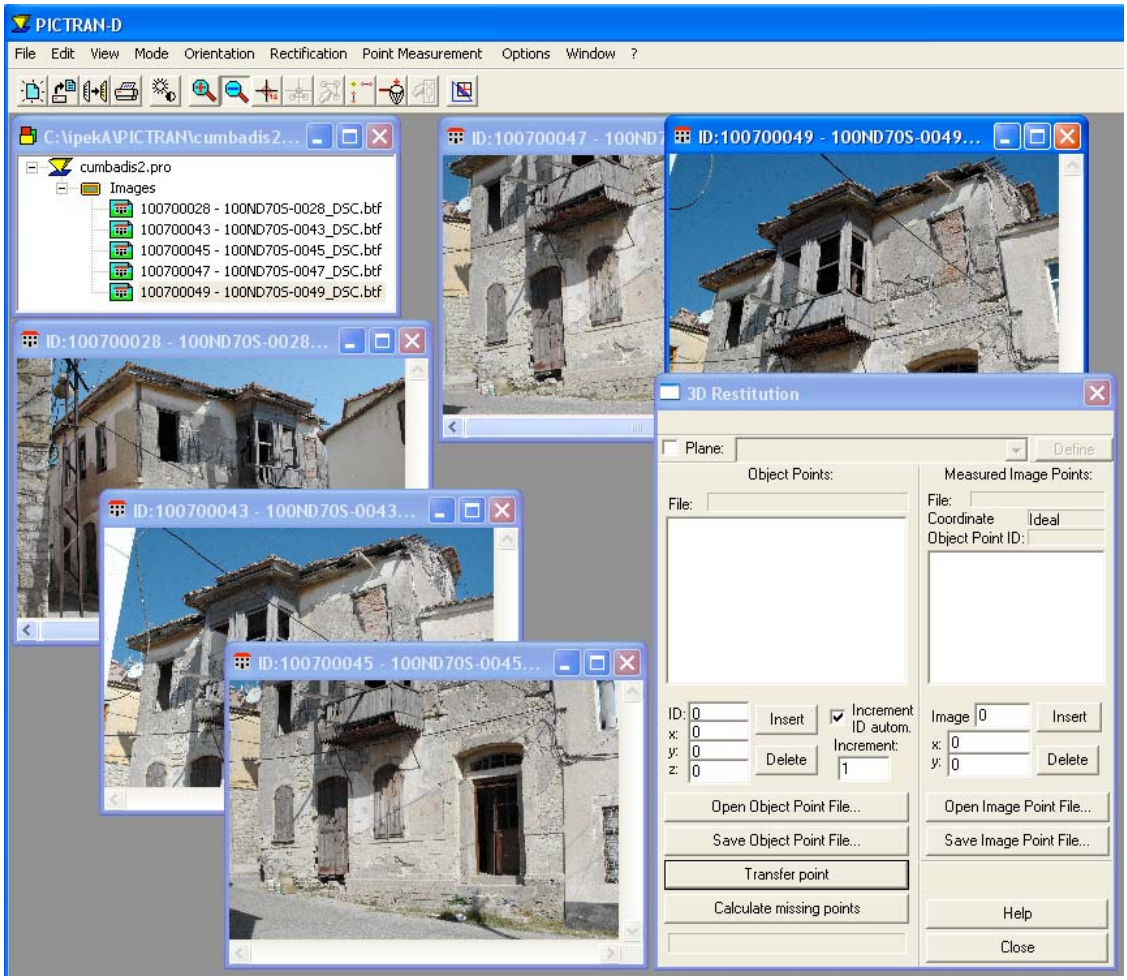


Figure 63. Opening the suitable photographs related with the studied façade

When the three-dimensional evaluation window is opened, the ‘Cross Hair’ command at the second line of the top tool bar can be chosen by clicking on it (or ‘Cross Hair’ under the ‘Mode’ tool at the top tool bar) (Figure 64). Then, the point that will be measured on the photograph is clicked on. For each photograph that is marked, a help line appears which is also called epipolar line (Figure 65). The same point is clicked on every other photograph by making use of these epipolar lines. If an epipolar line passes from the point exactly, it can be declared that the exterior orientation has been done precisely.

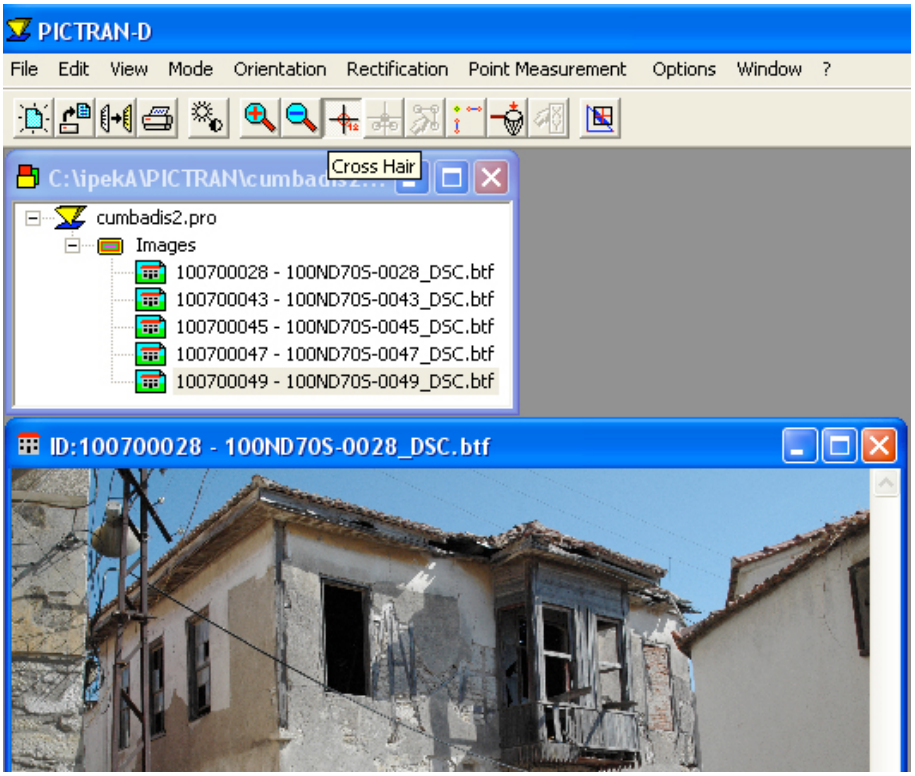


Figure 64. Choosing ‘Cross Hair’ command for marking the points to be measured

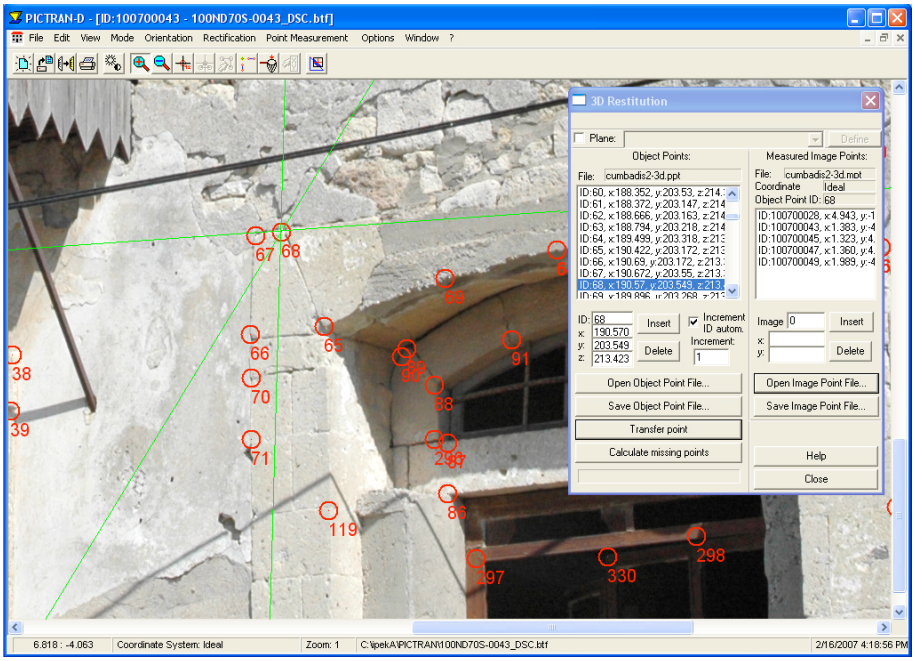


Figure 65. Epipolar lines which help the marking process

In order to view the studied area in detail, the plus sign is pressed. Conversely, the minus sign is pressed for a far off view. At the ‘Object Points’ column, a number is given to the measured point, and its x, y and z coordinates are calculated. On each

photograph, the related point is measured on and the pixel coordinates of the point can be viewed at the 'Measured Points' column (Figure 66). The measured object points and measured photograph points are saved, in the formats of 'ppt' and 'mpt', after they are completed. These steps are repeated for each chosen point.

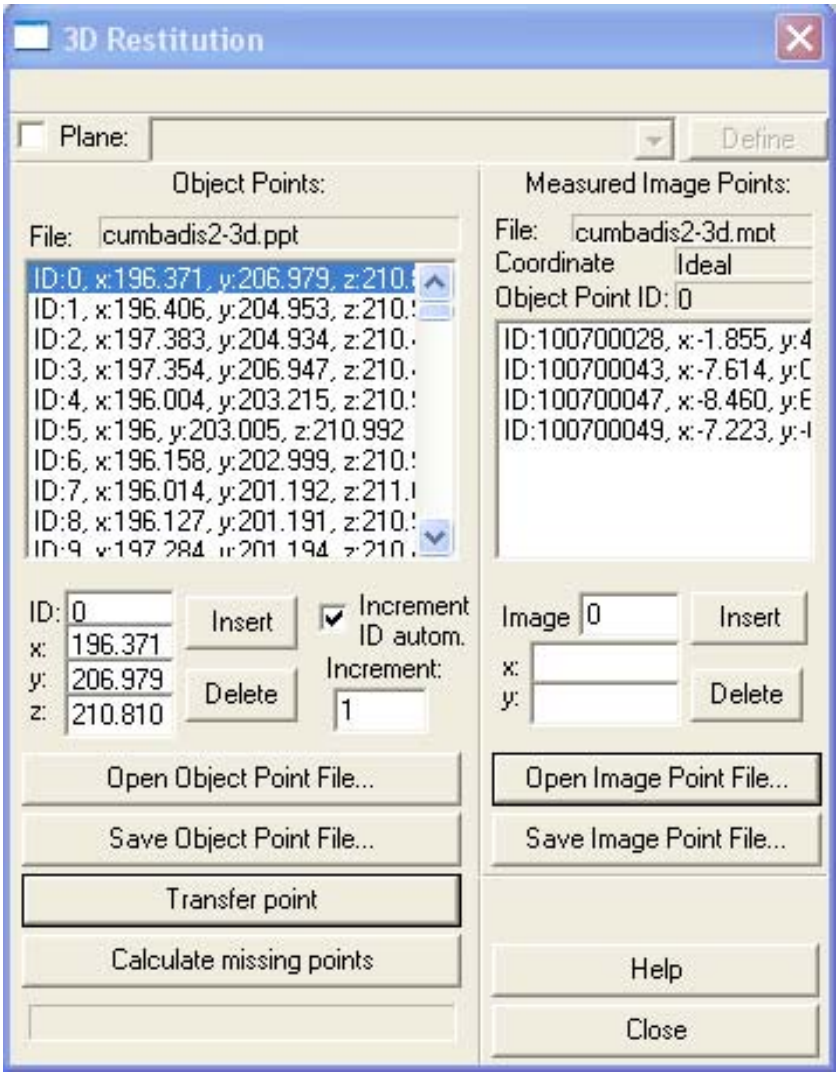


Figure 66. The values of the measured points in the '3D Restitution' process

In the scope of architectural conservation projects, the attention is paid on analyzing the geometry of architectural elements in the project in a sufficiently detailed way, so that the adequate documentation of the formal disorders is obtained (Figure 67) (Figure 68).

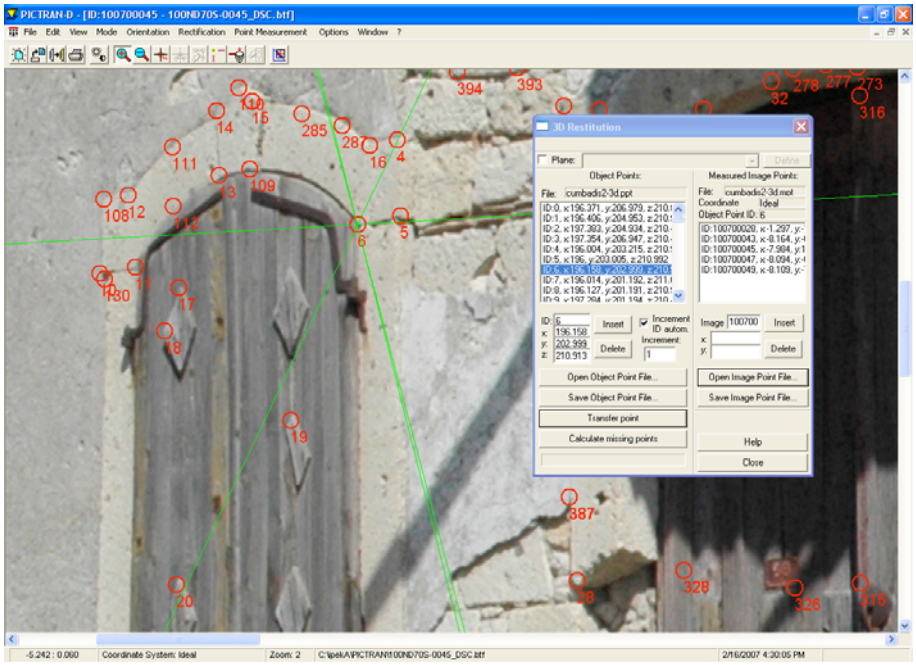


Figure 67. The measurement of a window at the southern façade

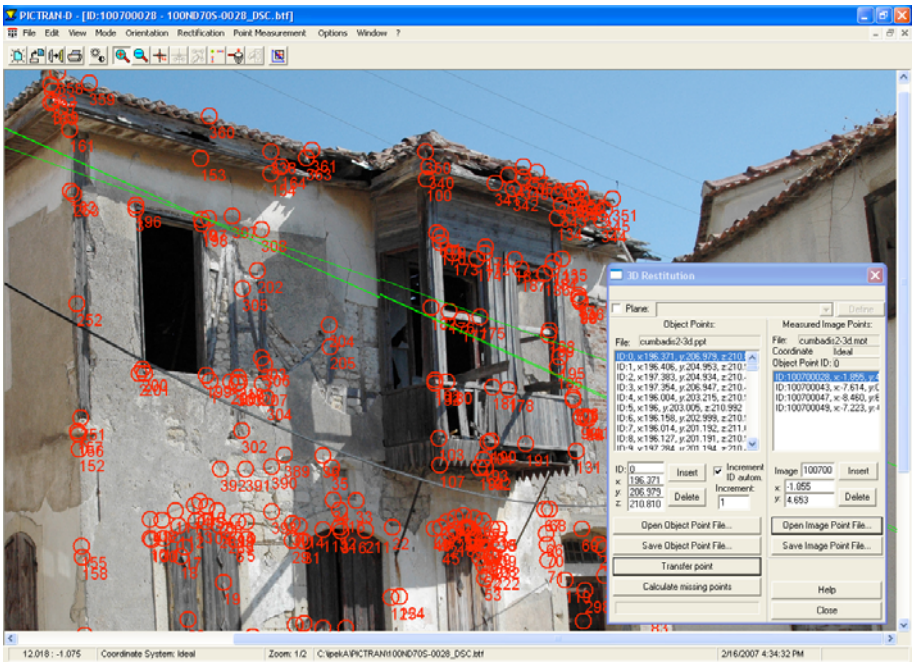


Figure 68. Three-dimensional points marked and measured on the southern façade of the house

4.2.1.5. Forming the Graphical Objects

Graphical objects are formed by overlaying them on the measured surface as vectors, and they may also be used for visual checking of the three-dimensional

measurement (Holl 2003). After completing the point measurements for each element on the southern façade, a graphical object is formed by grouping the related points together in the explained way. ‘Geometric Items’ under the ‘Point Measurement’ tool at the top tool bar is used for these acts. In this case, ‘Polyline’ and following that ‘Insert’ command is clicked on at the window opened, so that one can start marking (Figure 69) (Figure 70).

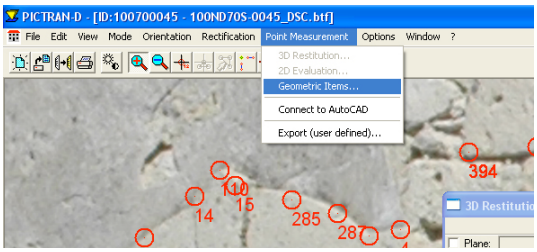


Figure 69. Clicking on ‘Geometric Items’ under ‘Point Measurement’

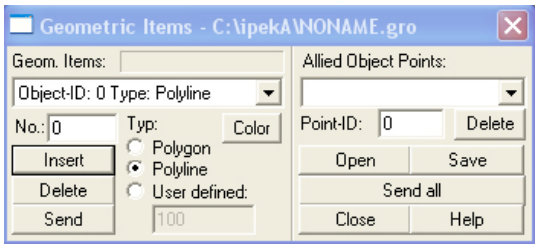


Figure 70. The ‘Geometric Items’ window

At the tool bar on the screen, the command that is defined by a blue triangle surrounded by red circles at the corners which is pointed by a white arrow is clicked on (Figure 71). By this way, the points which are desired to be drawn conjointly are clicked on and a colored polyline forms between them (Figure 72). ‘Save’ is clicked on, after the marking is completed. It is preferred to name these graphical object folders by mentioning the first letters of the façade and numbers following them, such as ‘swe12’.

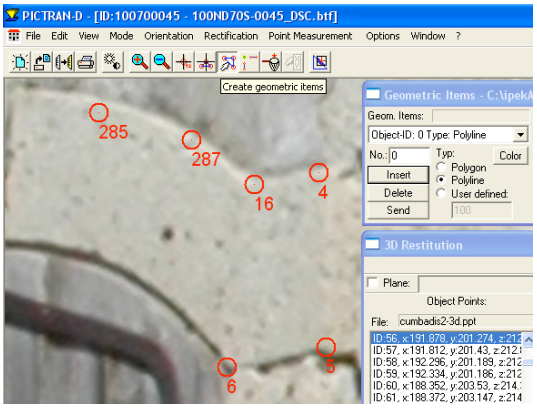


Figure 71. Activating the mouse for graphical object formation

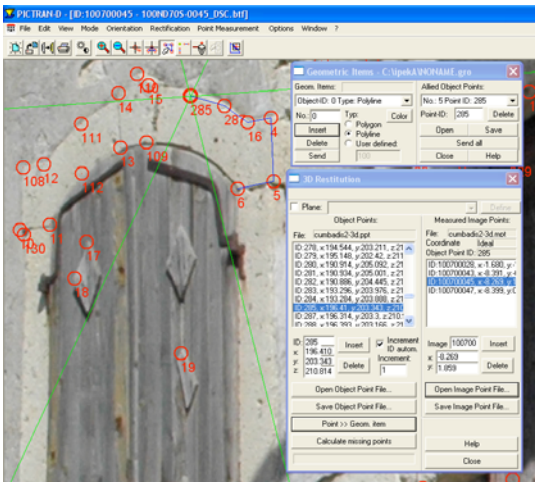


Figure 72. Formation of the graphical objects with polylines

After the point measurement, ‘Export’ under ‘Point Measurement’ at the top tool bar is clicked on, so that the graphical object saved is transferred into the drawing media (Figure 73). At the communication window, the reason why both ‘Points’ and ‘Geometric items’ are selected is that both measured points and the graphical object are going to be exported and transferred into the drawing media (Figure 74). It is optional to export only a definite part of the points or all of them.

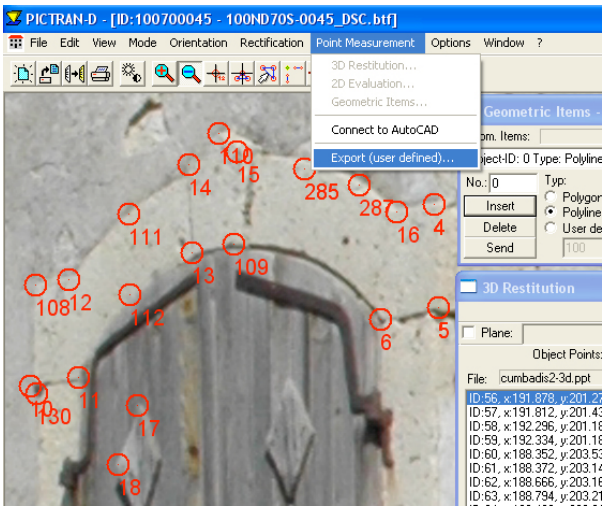


Figure 73. Choosing the ‘Export’ command from the top tool bar

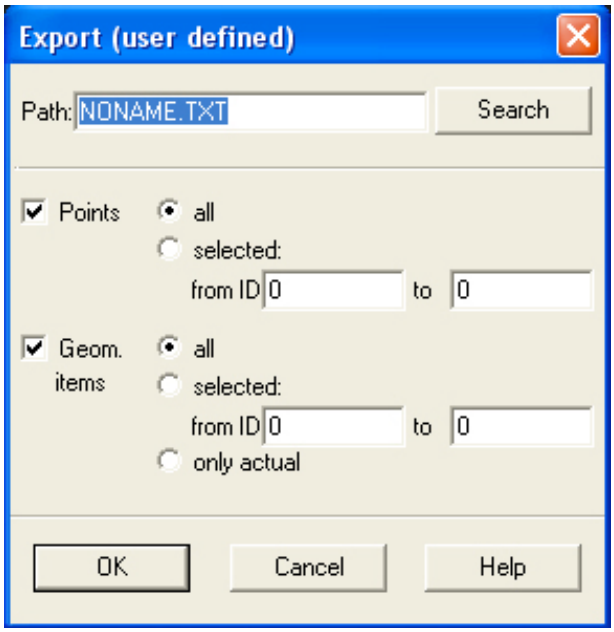


Figure 74. The ‘Export’ window

‘Search’ is clicked on. The studied folder is named different from the names of the folders exported previously (Figure 75). It is preferred to name this folder (‘dxf’) with the same name given to the graphical object (‘gro’). The ‘dxf’ folder which is transferred from Pictran software is checked at AutoCAD software (Figure 76). It is returned to Pictran and the process of graphical object (geometric item) formation is ended by ‘Close’ command.

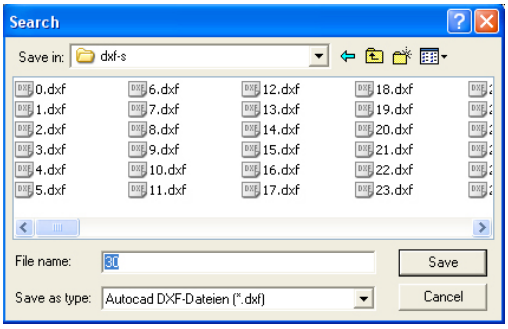


Figure 75. Naming the file which is exported

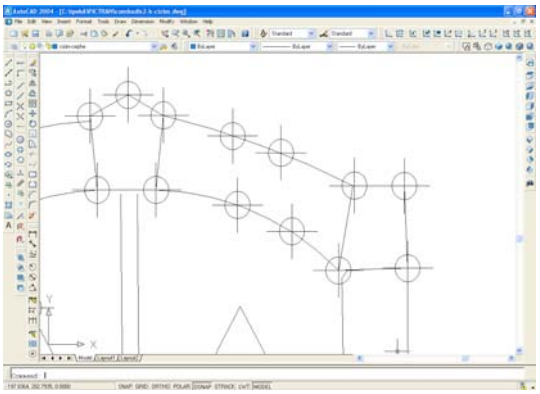


Figure 76. The CAD drawing in the exported ‘dxf’ folder

4.2.1.6. Rectification

In Pictran Release 4.0, the project folder, about the façade that the photographs are going to be rectified, is opened. The photographs which were taken by positioning the camera as parallel to the façade surface as possible are noted down. It is important that a variety of photographs are chosen that covers the entire façade. The project folder is closed and a new folder for the rectification project is created; its name giving reference to the related façade. For example; ‘rectified_swe.ppt’ can be chosen as a folder name for the exterior façade of the south wall. The photographs chosen previously are loaded into the project, by clicking on ‘Add File to Project’ under ‘File’ at the top tool bar. At the window opened, the required ‘btf’ folder is chosen and ‘Open’ is clicked on.

The photographs are opened one by one after the loading is completed. ‘Exterior Orientation’ under ‘Orientation’ at the top tool bar is clicked on. At the window opened, the control point folder (‘ppt’), related to the studied façade, is opened by clicking on the ‘Open Object Point File’ command. The folder which includes the measurements of

the control points is also opened by clicking on the ‘Open Image Point File’ command. The measurement folder is saved with a different name, like ‘swe_rectified.mpt’. By this way, the measurement folder, created in the beginning of the project, is protected, in case the points which give error are needed to be canceled.

The rectification is started by clicking on the ‘Start PICTRAN-B’ command. At the calculation results which are opened after the rectification, the ‘Sigma 0’ value is checked. The success increases at the perspective check, as this value gets closer to zero. The window of the calculation result list is closed. At the information window about the picture format, the dimensions are arranged, and a name like ‘rectified_image1’ is given to the final photograph. The window of the rectified photograph appears on the screen. At the top tool bar, ‘File – Export’ is clicked on. In the window opened, the place where the folder is saved and the folder type (ex; jpeg) is determined. This process is repeated for each photograph (Figure 77).

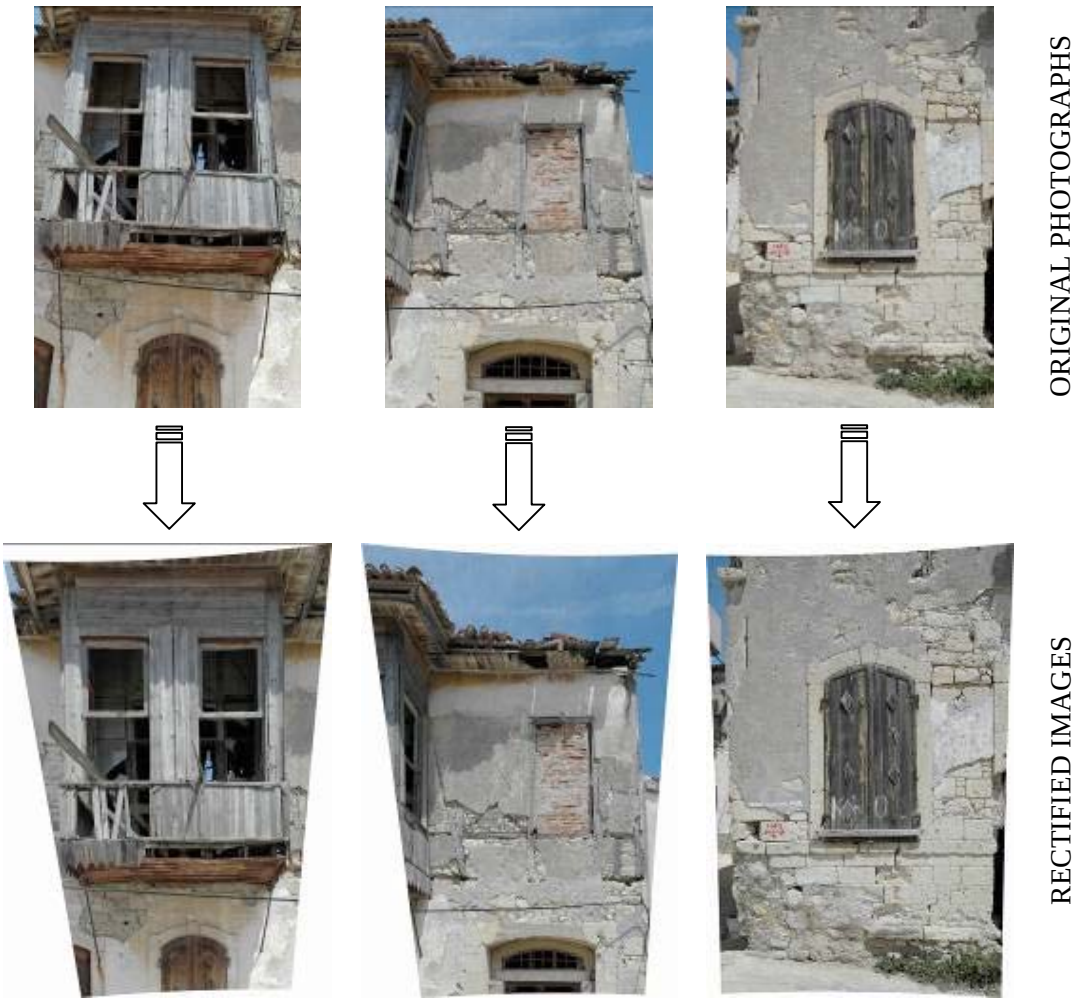


Figure 77. Examples to single image rectification

4.2.2. Representation Works

The representation methods used in this study are the rectified image mosaic, thematic mapping on this mosaic and the scaled two-dimensional elevation drawing. The tools used at the representation phase are CAD software (AutoCAD 2004) and an image processing software (Adobe Photoshop CS). The conventional elevation drawing is in 1/50 scale. The perception of the house is supported by the rectified image mosaic and thematic maps produced.

Similar house types with human scale, prismatic mass organization and plain façade treatments can be systematically recorded with this combined method. All these presentation documents are aimed to support the value judgments, treatment approaches, intervention decisions and the following application phase. They become important aids in presenting the information of the house in a more effective way and the required treatments for the building can be guided easier in the future works.

4.2.2.1. Forming the Rectified Image Mosaic

The exported rectified images are opened at the Photoshop program. With the 'Rectangular Marquee' tool, the required part of each rectified image is chosen. The excesses are cropped with the 'Image Crop' tool. The new photograph is saved with a name like 'swe'. All the rectified images in 'eps' formats are placed by using the 'File-Place' tool in the new Photoshop folder that is created. Each placed photograph takes place in a different layer. The place of a photograph can be changed by choosing its layer first.

While attaching the photographs, the right dimensioning and color adjustment are important for them to gain the expression of a whole façade. When the photographs are arranged in an order adjoining each other side by side, and the height of the same elements are different; the related images are opened one by one, and dimensioning and placement are repeated.

Colors can be adjusted by using the 'Image – Adjustments' tool. Photographs that are taken at closer lighting conditions are easier to work with. Spaces, like window niche, that take place at a plane behind plane of the front façade, are determined by using the 'Rectangular Marquee' tool or the 'Lasso' tool and the level of light is

increased with ‘Image – Adjustments – Brightness / Contrast’ tool. The layers, of which the attachment of the photographs is completed, are collected under one layer. The rectified image mosaic created is saved. The rectified image mosaic is created for the exterior entrance façade (Figure 78).

Figure 78. Formation of the rectified image mosaic

For the scaling of the rectified image mosaic, three-dimensional measurements of approximately 4 points for each photograph are transferred from Pictran to AutoCAD, and then to Photoshop. The roof, which is an inclined surface, is not rectified since it is not shot parallel to its plane. Similarly, the eaves are not rectified because they’re extensively ruined so they’re no more positioned parallel to the façade plane. So, these parts all appear white in color (Figure 79).

Figure 79. The rectified image mosaic of the southern façade

Therefore, they are filled with realistic colors so that the façade can be perceived as a whole. The sky and the ground are also represented with in-fills so that the gap effect is avoided. Nevertheless, the textures of the filled in parts and the rectified ones can be differentiated when closely inspected (Figure 80).

Figure 80. The rectified image mosaic after adding the textures of the filled in parts

4.2.2.2. Forming the Thematic Maps

Image rectification and processing (1/50 scale) are preferred for thematic mapping since this presentation method is more realistic, fast and sufficiently accurate compared to hatching on conventional drawings. The legends of the thematic maps are determined as “Spaces and Architectural Elements” (Table 1), “Construction Technique and Material Usage” (Table 2), “Alterations” (Table 3) and “Structural Failures and Material Deteriorations” (Table 4). The analytic concepts, their colored graphic codes, and detail photographs for each theme are gathered on four separate tables. Then, the rectified image mosaic is processed for each theme separately in the image evaluation software (Photoshop) and the thematic maps are produced on it considering the analytical information gathered. Brief descriptions are also systematically presented on each map.

Table 1. Spaces and Architectural Elements

	SPACES	1
	Shop (1)	
	Entrance hall (2)	2
	Living section (3)	
	ELEMENTS	
	Hipped roof (4)	3
	Wooden eaves (4)	
	Doors	4
	Two-leaf, wooden, arched doors with stone casings (5)	5
	Two-leaf, iron, rectangular door having a stone arched head window decorated with ironwork	
	Windows	
	Two-leaf, wooden, arched windows with stone casings and wooden shutters (6)	6
	Wooden, rectangular sash windows with wooden frames	
	Small sized, square top window (7)	7
	Wooden bay window	
	Concrete stairs	

Table 2. Construction Technique and Material Usage

WALLS

First floor walls:

Timber skeleton system with tuff stone as infill material and mortar (1)

Plaster layer on the exterior façades of the walls

Original plaster layer (2)

Repair plaster layer (2)

Bay window with timber skeleton system – carried by timber beams, supported by iron brackets (3)

Ground floor walls:

Rubble and cut stone masonry with mortar (4)

Cut stone masonry with mortar (5)

Plaster layer on the exterior façades of the walls

Original plaster layer (2)

Repair plaster layer (2)

Stone casings at the windows, stone arches on top of the window openings (6)

Stone casings at the doors, stone arches on top of the door openings (6)

Stone belt course (7)

ROOF

Hipped roof covered with Turkish tiles (8)

1

2

3

4

5

6

7

8

Table 3. Alterations

	VACANT SPACES Shop Entrance hall Living section	1
	TOTALLY MISSING ELEMENTS	2
	Door	
	PARTIALLY MISSING ELEMENTS	
	Eaves (1)	3
	Wall	
	Casing	
	Window: Frame / Sash / Glazing (2)	4
	Wooden elements on window shutters and bay window (3)	
	Stone belt course (4)	5
	Threshold	
	ADDITIONAL ELEMENTS	
	Iron door	6
	Concrete column (5)	
	Concrete casing (5)	
	Concrete basement wall (5)	
	Concrete stairs (5)	
	Concrete threshold (5)	
	Infill in window opening (6)	

Table 4. Structural Failures and Material Deteriorations

	STRUCTURAL FAILURES	
	Partial loss of the wall (1)	1
	Loss of structural integrity of timber skeleton system (bay window) (2)	2
	MATERIAL DETERIORATIONS	
	Stone:	3
	Loss of stone (3)	
	Loss of layer on stone (4)	
	Change in stone color and deposit formation	4
	Mortar:	
	Loss of mortar in joints (5)	
	Timber:	5
	Loss of timber (6)	
	Change in timber color and deposit formation (3)	
	Plaster:	6
	Loss of plaster (5)	
	Crack in plaster (7)	7
	Change in plaster color and deposit formation (7)	
	Metal:	8
	Rusting in metal (8)	
	Plant formation (9)	9

For each of the determined analytical theme, the rectified images are saved with different suitable names in Photoshop software. For instance, ‘swe_cons’ folder name can be used for the construction characteristics of the exterior south wall. By using color layers, different characteristics are indicated on the photographs with different colors. Their transparencies are adjusted for a clear perception of the present state of the façade. The coincidence of different color layers is not preferred, since the perception grows difficult as the colors coincide. The colorings in the thematic maps are supported by brief descriptions of the different characteristics.

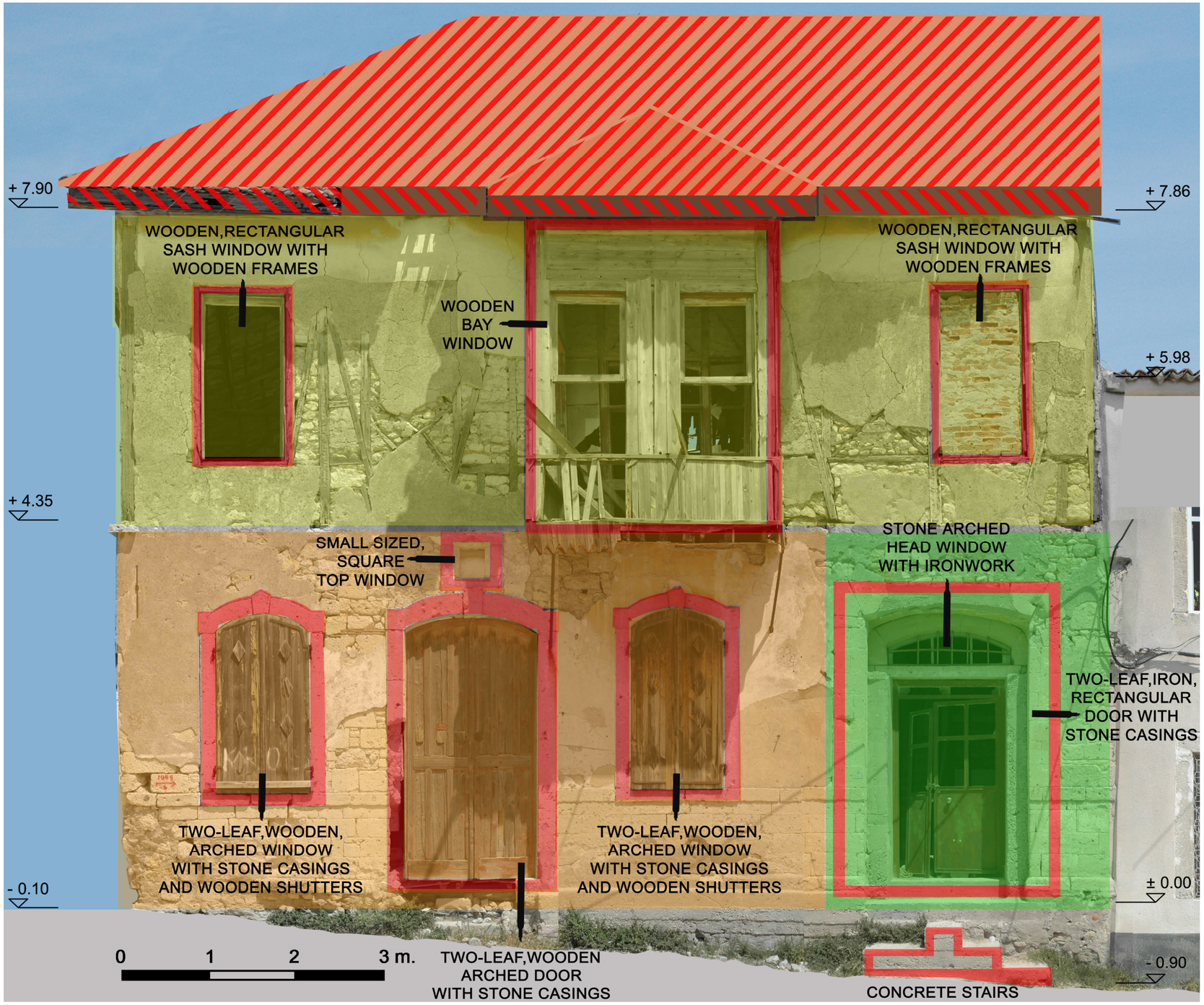
In the Analysis of Spaces and Architectural Elements (Figure 81), the shop area with an entrance is indicated with blue color. The entrance hall for the living section is indicated with green which includes a recessed entrance. At the first floor, the living section is indicated with yellow. The living spaces surround a hall which ends with a wooden bay window. The façade elements are bordered with red color, whereas the Hipped roof is indicated with red hatching. As a result, the façade has preserved the design characteristics of the 19th century in Alaçatı such as rhythmic order of the openings; door and window casings and wooden shutters emphasizing the commercial space; the main entrance to the living area and bay window providing street vista.

Different colors and hatchings are used to explain the Analysis of Construction Technique and Material Usage (Figure 82). The major construction technique at bottom zone of the ground floor is cut stone masonry with mortar, indicated with yellow. At the upper zone of the ground floor, rubble and cut stone masonry with mortar are observed which is indicated with light orange. The construction technique at the first floor is timber skeleton with tuff stone infill, indicated with green. The bay window has timber skeleton system indicated with green diagonal hatching. The original plaster indicated with yellow dots is only left at the upper zones of the first floor and at a zone under the bay window. The repair plaster applied is indicated with orange dots. At the ground floor, the stone casings of the windows and doors are shown in orange. Stone belt courses surrounding the bottom zone of the ground floor are seen as orange diagonal hatching. And the roof in red is a hipped one covered with Turkish tiles.

The most important alteration of the house is that it has been vacant for nearly 50 years, and the architectural elements have been ruined as a result of lack of maintenance (Figure 83). In the Analysis of Alterations, the original door of the dwelling entrance which is totally missing is indicated with orange. The partially missing elements are indicated with yellow. These include eaves, wall piece at the

bottom corner, door casings at the ground floor, sash and glazing of windows at the first floor, wooden elements at the window shutters and bay window, stone belt course and threshold. The blues on the graphic represent the additional elements which are the iron door, concrete columns, concrete casing, concrete threshold and concrete stairs. The concrete basement wall at the bottom zone and infills in window openings are the other additions. These alterations including the inconsiderate material usage indicate that the house was repaired at an early period.

In the last thematic map illustrating the Analysis of Structural Failures and Material Deteriorations (Figure 84), the two major structural failures are determined as partial loss of a wall piece at the bottom corner indicated with red and loss of structural integrity of timber skeleton system at the bay window indicated with red diagonal hatching. The two main types of material deteriorations are loss of material and change in material's color and deposit formation. Orange indicates the loss of the load-bearing elements which are stone and timber while yellow indicates the loss of plaster. Changes in colors of stone, timber and plaster are all indicated with yellow dots. Loss of mortar in joints is indicated with an orange infill. And, plaster cracks are shown by yellow infill. Apart from these, rusting in metal in blue is observed at the iron elements of the house. Plant formation in front of the building is indicated with green. The results of this last analysis also proved that most of the structural failures of this house stem from its abandonment and lack of maintenance. The structural failures are mainly intensified at the bay window due to rain penetration while material deteriorations are widespread all around the building façade. Also, there must be a drainage problem especially at the west bottom corner of the wall since it is ruined. Although the slopes of the two streets surrounding the house seem to support the running of surface water away from the building, it is suggested that the drainage system underneath the street coverings should be checked.



ANALYSIS OF SPACES AND ARCHITECTURAL ELEMENTS

SPACES

Shop

Entrance hall

Living section

ELEMENTS

Hipped roof

Wooden eaves

Doors

Two-leaf, wooden, arched doors with stone casings

Two-leaf, iron, rectangular door having a stone arched head window decorated with ironwork

Windows

Two-leaf, wooden, arched windows with stone casings and wooden shutters

Wooden, rectangular sash windows with wooden frames

Small sized, square top window

Wooden bay window

Concrete stairs

Figure 81. Analysis of Spaces and Architectural Elements

ANALYSIS OF CONSTRUCTION TECHNIQUE AND MATERIAL USAGE

WALLS

First floor walls:

Timber skeleton system with tuff stone as infill material and mortar

Plaster layer on the exterior façades of the walls

Original plaster layer

Repair plaster layer

Bay window with timber skeleton system – carried by timber beams, supported by iron brackets

Ground floor walls:

Rubble and cut stone masonry with mortar

Cut stone masonry with mortar

Plaster layer on the exterior façades of the walls

Original plaster layer

Repair plaster layer

Stone casings at the windows, stone arches on top of the window openings

Stone casings at the doors, stone arches on top of the door openings

Stone belt course

ROOF

Hipped roof covered with Turkish tiles

Figure 82. Analysis of Construction Technique and Material Usage

ANALYSIS OF ALTERATIONS

VACANT SPACES

Shop
Entrance hall
Living section

TOTALLY MISSING ELEMENTS

Door

PARTIALLY MISSING ELEMENTS

Eaves

Wall

Casing

Window: Frame / Sash / Glazing

Wooden elements on window shutters and bay window

Stone belt course

Threshold

ADDITIONAL ELEMENTS

Iron door

Concrete column

Concrete casing

Concrete basement wall

Concrete stairs

Concrete threshold

Infill in window opening

Figure 83. Analysis of Alterations

ANALYSIS OF STRUCTURAL FAILURES AND MATERIAL DETERIORATIONS

STRUCTURAL FAILURES

Partial loss of the wall

Loss of structural integrity of timber skeleton system (bay window)

MATERIAL DETERIORATIONS

Stone:

Loss of stone

Loss of layer on stone

Change in stone color and deposit formation

Mortar:

Loss of mortar in joints

Timber:

Loss of timber

Change in timber color and deposit formation

Plaster:

Loss of plaster

Crack in plaster

Change in plaster color and deposit formation

Metal:

Rusting in metal

Plant formation

Figure 84. Analysis of Structural Failures and Material Deterioration

4.2.2.3. Preparing the Scaled Two-Dimensional Elevation Drawing

The process to create the geometry of façades, walls, openings etc. and their integration in the same model with textures is mainly done in AutoCAD, as it is explained below:

The three-dimensional measurements which are exported from Pictran are opened in AutoCAD 2004. The rectified image of the studied façade is inserted by 'Insert - Raster Image'. The rectified image is scaled according to the measured drawings of the architectural elements. After the measured drawing and the image coincide, the façade can be drawn at a different layer. At first, the main geometries of the façade elements are drawn. Then, the details such as stone texture, plaster deteriorations, cracks, are drawn at different layers (Figure 85).

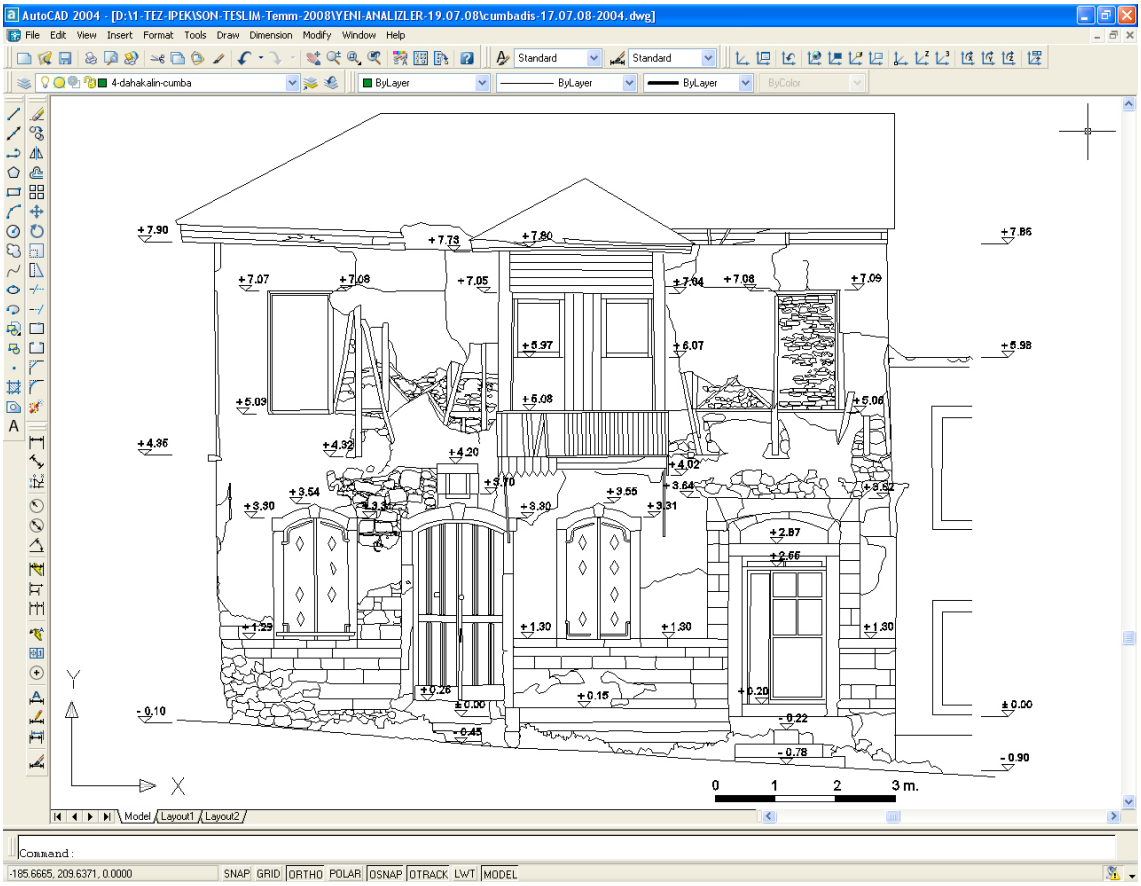


Figure 85. Scaled two-dimensinonal elevation drawing of the southern façade in AutoCAD 2004

4.2.3. Evaluation of the Photogrammetric Documentation

It is important to produce a survey to a sufficient degree of accuracy for the purpose for which it is required (Swallow, et al. 2004). An architectural heritage survey is generally plotted at a scale of 1/50 according to the present regulations in Turkey (Madran and Özgönül 2005). The thickness of a fine line may be 0.2 mm at least (Swallow, et al. 2004). Therefore, if a building survey is to be plotted at a scale of 1/50, a dimension of 0.2 mm on paper will represent 0.2x50=10 mm on the building being measured. Thus, a detail smaller than 10 mm cannot be plotted. Some appropriate standards of measurement relative to the scale of the drawing to be produced are given below:

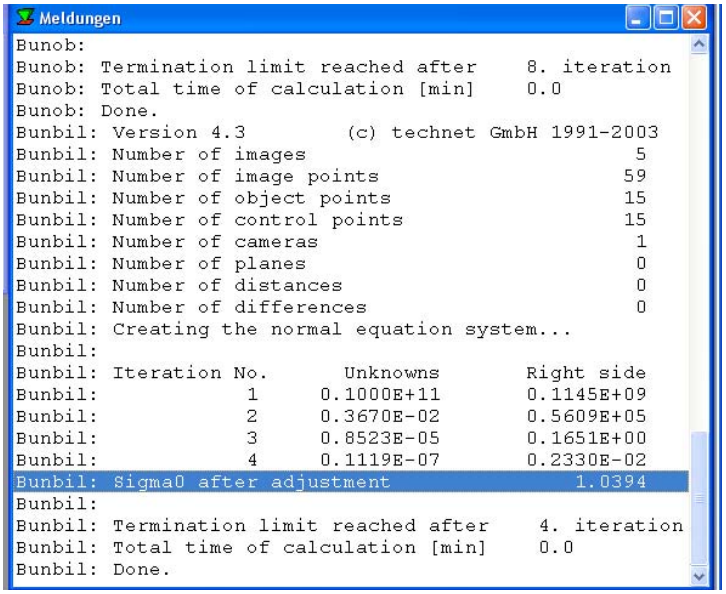
Table 5. Appropriate measurement standards relative to the scale of the drawing (Source: Swallow et al. 2004)

Scale of survey drawing	*Measure detail to the nearest mm*
1 : 500	100
1 : 200	40
1 : 100	20
1 : 50	10
1 : 20	5

Photogrammetry is mostly appropriate when drawing at scales of 1/20 and 1/50 (Swallow, et al. 2004). The scale of the survey drawings of the Demiral House is defined as 1/50 since the survey is carried out to support a succeeding conservation treatment.

Figure 86. The scaled two-dimensional elevation drawing at 1/50 scale

In Pictran, the accuracy of the calculations is evaluated with regard to a value named SIGMA. It is the standard deviation of weight unit after the adjustment (Technet GmbH 2000). SIGMA indicates the standard deviations of the observations. In order to reach to its acceptance range, the value should be increased or decreased and a new calculation should be performed in each case. If 0.7<SIGMA<1.3 is guaranteed, it is assumed that the three-dimensional measurements can start to be carried out. In this study, the SIGMA value is 1.0394 which is a value in the correct range (Figure 87).



```
Meldungen
Bunob:
Bunob: Termination limit reached after    8. iteration
Bunob: Total time of calculation [min]    0.0
Bunob: Done.
Bunbil: Version 4.3        (c) technet GmbH 1991-2003
Bunbil: Number of images                           5
Bunbil: Number of image points                    59
Bunbil: Number of object points                   15
Bunbil: Number of control points                  15
Bunbil: Number of cameras                          1
Bunbil: Number of planes                           0
Bunbil: Number of distances                        0
Bunbil: Number of differences                      0
Bunbil: Creating the normal equation system...
Bunbil:
Bunbil: Iteration No.      Unknowns       Right side
Bunbil:            1     0.1000E+11       0.1145E+09
Bunbil:            2     0.3670E-02       0.5609E+05
Bunbil:            3     0.8523E-05       0.1651E+00
Bunbil:            4     0.1119E-07       0.2330E-02
Bunbil: Sigma0 after adjustment                1.0394
Bunbil:
Bunbil: Termination limit reached after    4. iteration
Bunbil: Total time of calculation [min]    0.0
Bunbil: Done.
```

Figure 87. The SIGMA value calculated after adjustment in Pictran

In addition to the concept of accuracy, the concept of error should be considered in a building survey. It may be in the field work or laboratory work. Due to carelessness, the measurements may be read incorrectly or the instruments may not be set up right. In order to reduce the possibility of error and inaccuracy to a minimum, the surveyor should make sure that the topographic values are correctly read and transformed to the software used, which is Pictran here. The instrument to be calibrated correctly is an important fact to eliminate a systematic error. The photogrammetric surveying techniques described in this study reduce the possibility of error to a minimum. When errors occurred in the first stage, the exterior orientation has been repeated by using less number of but qualified photographs. The photogrammetic process has been carried out with this new group of photographs. Also, after checking the maximum normalized residual in Pictran, the repositioning of the control points has been made for preventing errors stemming from the carelessness of the surveyor.

In this study, the measurements that are imported digitally to Pictran are directly transferred to AutoCAD. This is a fact that reduces the possibility of error, whereas in the production of conventional drawings, the measurements are taken and noted down by hand, and also they are entered one by one to AutoCAD again by hand. For this reason, in conventional drawings, the chance of making mistake in transferring the measurements is higher compared to the digital techniques.

On the other hand, the limitations of rectified photography such as displacement of building elements with respect to one another and partial correction of tilts (Swallow, et al. 2004) have been controlled to a great extent in this documentation. The careful choice of the camera with a calibrated lens and usage of a special photogrammetry program, Pictran, instead of a standard program such as Adobe Photoshop, Photoshop Elements, etc. have contributed to this success.

The accuracy of the rectified image mosaic has been assessed comparing the coordinates provided by the three-dimensional measurement obtained by the photogrammetric software with the coordinates obtained by means of rectified image mosaicing with regard to points homogeneously distributed on the façade (Figure 88). For accuracy control, the rectified image mosaic prepared with the eight images in 1/50 scale is overlapped with the scaled elevation in 1/50 scale. The overlapping of the points close to zero suggests that the relative location of the points according to both systems is very similar. So; eight images with 300 dpi, taken from maximum 7 m distance with 28 mm objective, have been sufficient for mapping 11x8.5 m façade area. After it is checked that the three-dimensional measurements defining the general geometry are overlapped with the 1/50 scaled rectified image mosaic, the details concerning the deteriorations are decided to be drawn on the scaled elevation drawing from this mosaic (Figure 89).

32 number of control points (4 per image) have been sufficient for rectification. 87 number of control points measured by the total station have been sufficient for three-dimensional measurement process. At the end of this measurement process, 304 points were obtained in Pictran, and they were transferred to CAD.

The rectification in the photogrammetric software and image evaluation in the related software have provided opportunity to observe the images of the façade in detail. In turn, the photorealistic information in these images with high resolution (300 dpi) has given the architect-restorer the chance to visually analyze the original architectural elements, the construction technique and material usage; and their problems.

Figure 88. The three-dimensional measurements overlapped with the 1/50 scaled rectified image mosaic

Consequently, the maps prepared on the basis of the rectified image mosaic represent the heritage characteristics and their problems in a more realistic manner compared to the conventional ones, because the real texture can be observed underneath the transparent paint layers illustrating various analytic ideas. The distribution of the present construction techniques and material usage, the missing and added elements can be distinguished with their colors and textures on the photographs. The area of spread of various material problems can be viewed. These realistic documents which are not only in scale, but also in “texture and color” will guide the intervention decisions correctly.

In order to prove the shortening in the time required for preparing the maps, the Structural Failures and Material Deteriorations map is prepared both in conventional techniques and the contemporary ones. In other words, hatching on a scaled elevation in AutoCAD and painting on rectified image mosaic in Photoshop is made and compared (Figure 90) (Figure 91).

Figure 89. The scaled rectified image mosaic used to draw the details of the scaled two-dimensional drawing

Figure 90. Mapping with black hatches on scaled two-dimensional elevation drawing

Figure 91. Mapping with colored hatches and paints on scaled two-dimensional elevation drawing

The visual qualities and the time of preparation of the conventional and contemporary maps are compared on a table below:

Table 6. The table of comparison for different documentation methods

		Proposed Works ***(for mapping on rectified image mosaic)***		Photogrammetric 3D Measurements ***(for scaled 2D elevation drawing)***		Conventional Works ***(for mapping on conventional 2D elevation drawing)***	
	Works in order	No. of people	Time in min.	No. of people	Time in min.	No. of people	Time in min.
1	**Photographic survey**	1	30	1	90	1	10
2	**Tacheometric survey**	2	90	2	240	__	__
3	**Loading the camera's calibration folders** **Loading the photographs** **Exterior orientation**	1	5 60 150	1	5 60 150	__	__
3	**Rectification of a single image x 8 images**	1	5x8 = 40	__	__	__	__
4	**Stiching, scaling, color management of 8 images**	1	60	__	__	__	__
5	**3D measurements**	__	__	1	240	__	__
6	**2D measurements (Sketching+Measuring)**	__	__	__	__	4	420
7	**Scaled elevation with 3D measurements**	__	__	1	540	__	__
8	**Scaled elevation with 2D measurements**	__	__	__	__	1	720
9	**Mapping in Photoshop (for a single map)**	1	300	__	__	__	__
10	**Mapping in AutoCAD - Black**	__	__	1	210	1	210
11	**Mapping in AutoCAD and Photoshop - Colored**	__	__	1	300	1	300

TOTAL TIMES	**735 min.** (Mapping with colored hatches and paints on rectified image mosaic)	**1535 min.** (Mapping with black hatches on 2D elevation drawing) **1625 min.** (Mapping with colored hatches and paints on 2D elevation drawing)	**1360 min.** (Mapping with black hatches on 2D elevation drawing) **1450 min.** (Mapping with colored hatches and paints on 2D elevation drawing)

It is seen that the time required for the site work of a rectified image mosaic (Photographic survey + Tacheometric survey = 30 + 90 = 120 min) is much shorter compared to the site work time of the underlay (scaled conventional elevation) used in conventional works (2D measurements + Scaled elevation = 420 + 720 = 1140 min). However, the laboratory time required for a map on rectified image mosaic is 615 min (Preparatory steps + Rectification + Mosaicing + Mapping = 215 + 40 + 60 + 300 = 615 min). The time spent for the conventional map on scaled elevation is 1360 min (10 + 420 + 720 + 210 = 1360 min) for a presentation with black hatches and 1450 min (10 + 420 + 720 + 300 = 1450 min) for a colored one. As seen above, approximate laboratory time spent in the preparation of the proposed colored mapping on the rectified image mosaic is almost half of the time spent in the preparation of mapping with black hatches or mapping with colored hatches and paints on the elevation drawing.

On the other hand, the number of people required in the proposed contemporary method is 2 for the tacheometric survey, whereas the number of people required for the conventional measurements is 4. So, photogrammetric works require less number of people at the site compared to the conventional ones. Photographic survey and the laboratory works require 1 person for all mentioned methods.

In this context, the rectified image mosaic produced for the Yavuz Demiral House is a realistic and rapid form of documentation for marking up heritage characteristics and problems. These may be followed by marking up intervention decisions.

CHAPTER 5

CONCLUSION

This thesis has put forward that an adequate combination of contemporary and conventional documentation techniques of built heritage can be made so that architect-conservators can better conceive the qualities of historic buildings. The opportunities of close range digital photogrammetry, which is the type of photogrammetry suitable for historic building documentation; the advantages of image evaluation softwares and the concepts of mapping are all molded together. Illustration of thematic concepts of architectural conservation on scaled two-dimensional drawings with regard to a defined set of graphic codes is a frequently applied visual analysis technique, which is known as mapping. This study is an attempt to develop the potential of conventional mapping so that conservation treatments can be better guided. The developments in modern photogrammetry have provided the advantage of controlling the perspective photographs belonging to planer surfaces through a process called rectification. The rectified images of historic façades composed of planes parallel to one another can be processed in image evaluation softwares so that they are scaled and brought together to form mosaics representing the whole façade. These rectified image mosaics may be used for mapping the thematic concepts instead of the scaled elevations.

In order to test the hypothesis of the study, a historical building façade was chosen as the case study. This is the entrance façade of the Yavuz Demiral House in Alaçatı, İzmir, Turkey. The building owns the authentic characteristics of a historical house that was built in the 19th century with its rubble and cut stone masonry walls on the ground floor, timber skeleton walls on the first floor, and at the same time with its original architectural elements such as a wooden bay window, wooden openings and fireplaces. The major problem of this house is its highly damaged structural system due to abandonment. It requires both comprehensive structural interventions and installation of an appropriate use since it has been empty for fifty years. For these reasons, it has conservation priority among the other listed houses within the settlement.

The tools used at the site are a Nikon D70S Digital SLR Camera with a resolution of 3,008 x 2,000 pixels and equipped with a Nikon 18-70 mm AF Nikkor lens which is calibrated for 28 mm, a Zeiss Rec Elta RL-S total station, and a ladder. The

tools used at the CAD laboratory were Pictran Release 4.0 photogrammetric evaluation software, Adobe Photoshop CS image processing software and AutoCAD 2004 software. The aimed scale is 1/50. The themes to be illustrated are Spaces and Architectural Elements, Construction Technique and Material Usage, Alterations, and Structural Failures and Material Deteriorations.

The following points are found valid to be considered during the site survey:

- The photographs should be shot only with the calibrated lens of the camera.
- The photographs should be shot parallel to the façade plane.
- A ladder on the openings of the building across the studied façade should be used for shooting the photographs of the first floor level.
- The façade elements at different depths such as the projections and recessed entrances should be included in different images.
- The photographs should slightly overlap with one another.
- At least five control points should be measured for each photograph.
- The control points should be distributed homogeneously.

The following points are important for the success of the laboratory work:

- The digital camera and the lens type should be chosen while importing each photograph to Pictran.
- The three-dimensional coordinates obtained from the electronic theodolite should be correctly entered to Pictran for an accurate exterior orientation.
- Each control point should be carefully marked on at least 2 photographs including the point. The accuracy increases if these photographs are shot from different angles.
- In the bundle adjustment stage, the calculation should be repeated until the ‘Sigma 0’ value is in between 0.7 and 1.3.
- In the three-dimensional point measurement, each point to be measured should be marked on at least 2, and if possible 3 oriented photographs with the help of epipolar lines in Pictran.
- In the rectification, the photographs chosen should cover the entire façade to be documented and they should be the ones shot as parallel to the façade surface as possible. The adequate number of photographs which cover the whole measured area should be partially overlapping. The rectification should be made separately

for the architectural elements that project from the façade like the projection itself, which are photographed from a shorter distance.

- In the production of the rectified image mosaic, the right dimensioning and color adjustment should be considered for the expression of a whole façade.
- For the scaling of the mosaic, three-dimensional measurements of approximately 4 points for each photograph are transferred from Pictran.
- The unrectified parts should be differentiated with in-fills in realistic colors for the perception of the façade as a whole.
- The thematic maps should include all the information about the surveyed façade clearly in order to create an adequate source for the following conservation decisions.

As a result of the proposed documentation process, a rectified image mosaic composed of eight images and four thematic maps are produced. A scaled elevation is formed on the basis of the site survey with bundle method and three-dimensional measurements in Pictran. It is plotted in a line width accuracy at 1/50 scale. The overlapping of the three-dimensional measurements by the photogrammetric software and the rectified image mosaic based on rectification has presented that the rectified image mosaic is accurate enough for a 1/50 scale presentation. In turn, the number of eight rectified images with 300 dpi, taken from maximum 7 m distance with 28 mm objective, has been sufficient for the mapping of the selected façade area (11x8.5 m.). Since the rectified image mosaic is accepted as a reliable document for thematic mapping, the details of the elevation such as material deteriorations are also drawn on the scaled two-dimensional elevation drawing after it is overlapped with the rectified image mosaic.

The time required for data gathering (30 + 90 = 120 min) and processing (215 + 40 + 60 = 315 min) of a rectified image mosaic (Total = 120 + 315 = 435 min) is less compared to that spent for a scaled elevation drawing based on photogrammetric survey (90 + 240 + 215 + 240 + 540 = 1325 min) and on conventional survey (10 + 420 + 720 = 1150 min). Moreover, the details included in photographs such as texture, color and material are useful for comprehending the thematic concepts.

On the other hand, the thematic maps have illuminated the following conservation concepts related with the studied façade:

In the thematic map for Analysis of Spaces and Architectural Elements, spaces are indicated with different colors and hatching according to their different functions.

The façade elements are bordered with a color, while the roof material is indicated with hatching. At the final product of this map, it can be observed that the façade has preserved the design characteristics of the 19th century in Alaçatı such as rhythmic order of the openings; door and window casings and wooden shutters emphasizing the commercial space; the main entrance to the living area and bay window providing street vista.

In the Analysis of Construction Technique and Material Usage, different colors and hatchings are used in order to distinguish the different construction techniques and materials used at every zone of the façade. The colors and hatchings facilitate the process of observation and evaluation of the building structure by presenting at which parts the original techniques and materials were preserved, whereas at which parts repair materials are observed instead of the original ones.

According to the Analysis of Alterations, the most important alteration of the house is defined as it has been vacant for nearly 50 years, so the architectural elements have been ruined as a result of lack of maintenance. Three different colors are used representing the totally missing elements, the partially missing elements and the additional elements. Different types of elements in each group are differentiated with different hatchings of the same color. These alterations including the inconsiderate material usage indicate that the house was repaired at an early period.

In the Analysis of Structural Failures and Material Deteriorations, the two major structural failures are determined as partial loss of a wall piece at the bottom corner indicated and loss of structural integrity of timber skeleton system at the bay window, which are indicated with darkest color in the table that is red. The two main types of material deteriorations are loss of material and change in material's color and deposit formation, indicated with different colors and hatching according to their level of importance. Loss of load-bearing elements is indicated with one color, while loss of layer in these elements is indicated with hatching of the same color. Changes in colors are indicated a lighter color. Loss of mortar in joints, rusting in metal and plant formation are also indicated with colors. The results of this last analysis also proved that most of the structural failures of this house stem from its abandonment and lack of maintenance. The structural failures are mainly intensified at the bay window while material deteriorations are widespread all around the building façade. Also, there must be a drainage problem especially at the ruined corner of the wall.

The thematic maps provide sufficient visual analyses for the guiding of conservation decisions, emphasizing the important characteristics of the studied Alaçatı house, as well as underlining the main problems.

The documentation method developed for the case study can be easily adapted to other listed houses at the discussed urban site, after appropriate calibration. Gathering, processing and presenting visual data regarding architectural conservation with contemporary techniques will give way to new discussions in the field of architectural conservation.

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