SPATIAL INFORMATION SYSTEMS FOR CONSERVATION OF HISTORIC BUILDINGS
CASE STUDY: DOĞANLAR CHURCH İZMİR

SERKAN GÜNAY

MAY 2007

S. GÜNAY METU 2007

SPATIAL INFORMATION SYSTEMS FOR CONSERVATION OF HISTORIC BUILDINGS
CASE STUDY: DOĞANLAR CHURCH İZMİR

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

SERKAN GÜNAY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE, IN RESTORATION
IN

ARCHITECTURE

MAY 2007

Approval of the Graduate School of Natural and Applied Sciences

Prof. Dr. Canan Özgen
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Architecture.

Assoc. Prof. Dr. Güven Arif Sargın
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Architecture.

Assist. Prof. Dr. A.Güliz Bilgin Altınöz
Supervisor

Examining Committee Members

Inst. Dr. Fuat Gökçe	(METU, ARCH)	______________
Assist. Prof. Dr. A. Güliz Bilgin Altınöz	(METU, ARCH)	______________
Assoc. Prof. Dr. Neriman Şahin Güçhan	(METU, ARCH)	______________
Assist. Prof. Dr. Ali Murat Tanyer	(METU, ARCH)	______________
Assist. Prof. Dr. Deniz Özkut	(Anadolu Üni.)	______________

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Serkan, Günay

Signature :

ABSTRACT

HBIS, SPATIAL INFORMATION SYSTEMS FOR HISTORIC BUILDINGS
CASE STUDY: DOĞANLAR CHURCH İZMİR

Günay, Serkan

Msc. Department of Architecture in Restoration

Supervisor: Assist. Prof. Dr. A. Güliz Bilgin Altınöz

May 2007, 126 pages

Conservation of historic buildings requires comprehensive and correct information of buildings to be analyzed in conservation decision making process in a systematic and rational approach. Geographical Information Systems (GIS) are advantageous in such cases which can be defined as computer based systems for handling geographical and spatial data. GIS have the potential to support the conservation decision making process with their storing, analyzing and monitoring capabilities. Therefore, information systems like GIS can be seen as a potential significant instrument for dealing with the conservation projects.

This thesis aims to analyze the transformation process of the data collected in conservation process into practical information in order to adapt this process to a spatial information system.

In this context, use of Geographical Information Systems is tested in the process of historic building conservation on spatial information system designed for Doğanlar Church İzmir chosen as the case study. Hence the advantages and disadvantages of local information systems in conservation decision making process of historic buildings can be criticized.

Keywords:

Conservation, Decision Support, Information Systems, 3D Modeling, Database

ÖZ

TARİHİ YAPILARIN KORUNMASINDA MEKANSAL BİLGİ SİSTEMLERİ KULLANIMI
ÖRNEKLEME ÇALIŞMASI; DOĞANLAR KİLİSESİ, İZMİR

Günay, Serkan

Yüksek Lisans, Mimarlık Bölümü Restorasyon A.B.D.

Tez Yöneticisi: Assist. Prof. Dr. A. Güliz Bilgin Altınöz

Mayıs 2007, 126 sayfa

Tarihi yapıların korunması yapıya ilişkin kapsamlı ve doğru bilgi altyapısının varlığını ve bu bilginin oluşturulacak koruma kararları ve projelerinde sistematik ve rasyonel bir yaklaşımla değerlendirilmesini gerektirir. Coğrafi Bilgi Sistemleri (CBS) mekansal verileri toplama, yapılandırma, analiz etme, değerlendirme, depolama ve bu verilerin paylaşımı konularında birçok avantaj sağlamaktadır. Bu nedenle Coğrafi Bilgi Sistemleri gibi mekansal bilgi sistemleri, koruma projelerinin hazırlanmasında önemli bir potansiyel araç olarak görülebilir.

Bu tez kapsamında koruma projelerinde toplanılan veriler ve bu verilerin kullanılabilir bilgiye dönüşüm süreci incelenip bu sürecin bir mekansal bilgi sistemine aktarımı amaçlanmaktadır.

Bu bağlamda, Coğrafi Bilgi Sistemlerinin tek yapı koruma karar verme sürecinde kullanımı ve örnekleme çalışması için seçilen Doğanlar Köyü Kilisesi için

tasarlanacak mekansal bilgi sistemi üzerinde sınanacaktır. Bu sayede mekansal bilgi sistemlerinin tarihi yapıların koruma karar verme sürecindeki avantajlarının ve dezavantajlarının tartışılması mümkün olacaktır.

Anahtar Kelimeler:

Tarihi Yapı, Tek Yapı Koruma Karar Verme Süreci, Coğrafi Bilgi Sistemi (CBS) , 3 Boyutlu Modelleme, Veritabanı

To My Family

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my supervisor Assist. Prof. Dr. A. Güliz Bilgin Altınöz for her invaluable guidance, understanding, support and encouragement besides her instructive critical viewpoint, her energy and sacrifice throughout the research. I am grateful to Inst. Dr. Fuat Gökçe, Assoc. Prof. Dr. Neriman Şahin Güçhan, Assist. Prof. Dr. Deniz Özkut and Assist. Prof. Dr. Ali Murat Tanyer for their valuable evaluations and recommendations in the critics of the jury and to Inst. Dr. Nimet Özgönül and Assoc. Prof. Dr. Gül Asatekin for their evaluations in the critics of thesis seminar in the beginning of this study.

I would like to present my special thanks to my friends Öget Cöcen, Hikmet Eldek, Güneş Can, Elif Erdem and Kevser Çeltik Şahlan for their friendship and motivations throughout this thesis. I would also like to thank Kemal Gülcen for his deep interest, support and his help including the measured survey of this study.

Finally I would like to express my deepest gratitude to my precious family; my parents Şehriban-Enver Günay and my dear brother Erkan Günay with their helps, endless support and patience in overcoming this study and all my lifetime.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Conservation of historic buildings is a complex and multi-faceted process. This process requires comprehensive understanding and assessment of the properties and condition of the historic building within its present context as well as its historical background. Therefore, it necessitates a systematic and scientific study which consists of survey, analysis, evaluation and decision phases followed by interventions and their continuous monitoring. All through these phases, collecting, structuring and processing data concerning different aspects of the historic building becomes a key issue. Hence, parallel to the complexity of the subject, the data required within the conservation decision making process are complex and in huge amounts.

Especially after 1990s, the developments in Information Technology (IT) have been affecting the conservation field in various ways. The reflections of these developments can also be seen in the conservation process of historic buildings. Hence, different phases of conservation process have been supported by IT.

During the site survey, data are collected with the help of digital cameras, electronic thedolites, laser scanners and various other advanced tools, which are then processed through various softwares for rectified photography and digital photogrammetry in order to produce measured drawings of the historic buildings. Consequently, the metric surveys of the historic buildings become more accurate when compared to the surveys made by using the conventional methods. Besides, they allow easy renewal and modifications over the produced drawings. Last but not least, the time spent during the site survey becomes shorter with the use of digital recording tools. However these advanced tools and techniques still need to be supported by hand sketches and hand measuring, which still keep their importance during the site survey process.

The data obtained throughout the site survey with the help of advanced tools and methods are then graphically documented and presented generally by Computer Aided Design and Drafting (CADD) softwares. These softwares provide high accuracy in graphic documentation and outputs in any scale. Besides, CADD softwares also enable the production of easily correctable and adoptable drawings that can be used for different purposes. R. Dallas, in his article on "Measured Surveys of Historic Buildings: User Requirements and Technical Progress",[1] expresses the importance of CADD in conservation process as follows

> The ability to handle dimensional and spatial information through computers, utilizing computer aided drafting (CAD) programs, has also become significant. Few conservation specialists today are not equipped with CAD workstations or CAD viewer programs – a change that has taken place very rapidly over the past few years. CAD enables us to view drawings, zoom in and out, add and delete information, prepare specification documentation, print out drawings, and indeed transmit information in digital form over the Internet.

In addition to the site survey phase and its graphic presentation, advanced tools and techniques provided by IT have the potential to support all the other phases

[1] DALLAS, R. (2003), '*Measured Surveys of Historic Buildings: User Requirements and Technical Progress'* Journal of Architectural Conservation, 2, 58-81

within the conservation decision-making process of historic buildings. Although there are recent studies and examples on these issues, it can be said that they are mostly utilized as recording and presentation tools more than an integral part of the decision making process.

1.1 Spatial Information Systems (SIS) for Conservation of Historic Building

Conservation decision making process of historic buildings is a process that necessitates the utilization of spatial and attribute data considering different aspects of historic building and coming from different sources. At this point Geographical Information Systems (GIS), as systems developed to deal with complex and multifaceted geographical / spatial data, can be considered as an important supporting tool throughout this process.

In order to understand and assess the support of GIS in conservation of historic buildings, their definition, basic properties, components, functions and examples of their utilization in conservation of cultural heritage should be defined.

1.1.1 General Information about GIS

GIS are a computer based systems for capturing, storing, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the Earth. They are information systems for dealing with graphically or spatially referenced data.

GIS can support the decision making process when dealing with spatial problems. Heywood (2005: 34) explains this support as follows;

> …by allowing data to be organized and viewed efficiently, by integrating them with other data, by analysis and by the creation of new data that can be operated on in turn, GIS creates useful information to help decision making.

GIS deal with data which are related to a location on the earth's surface and are referenced with geographical coordinates. These systems can also used for handling spatial data which do not have geographical references to the earth's surface. In this case, when the concern is data that have a location in space but not necessarily geographically referenced to earth's surface, the term Spatial Information Systems (SIS) are preferred to be used instead of Geographical Information Systems (GIS). Therefore, throughout this thesis SIS will be used to define main system where as GIS will be used to define the software used.

Data in GIS are structured and stored in geodatabases. A geodatabase is composed of features. The features in GIS are representations of real world objects. Each feature is stored in a geodatabase as graphic data in relation to attribute data.

In a GIS, features are graphically represented with geometry, such as points, lines, polygons and multipatches.

In a GIS, there are two basic formats for the graphic representation of features: vector format and raster format. Vector format uses coordinates, where as raster format uses pixels. In both formats features are graphically represented with geometry, such as points, lines, polygons and multipatches. In vector format, a point means a geometric element defined by an x and y coordinate. A line is defined by series of x and y coordinate pairs. The line vector features may be straight or curved according to the representation subject. A polygon is defined by connected pairs of x and y coordinates where the first and last coordinate pairs are the same and all other pairs are different. Polygon is a closed shaped object that represents an area in all forms.

Multipatch geometry represents a real world geographic model using multipatch geometry. This geometry is formed by 3 dimensional planar areas that create a volumetric shape. Multipatch feature may used for representing objects like buildings or landscape elements (Figure-1).

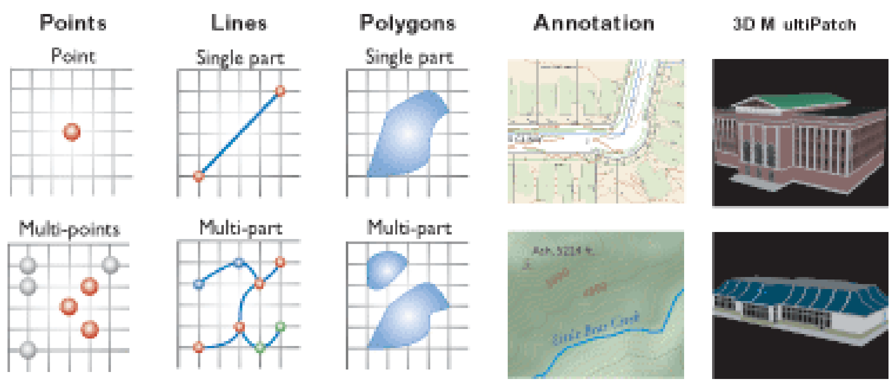


Figure-1 Common feature representations in vector format (ESRI GIS Dictionary, 2006)[2]

Besides the spatial aspects, there is also nonspatial information concerning a feature which is called "attribute". An attribute can be defined as;

> Nonspatial information about a geographic feature in a GIS usually stored in a table and linked to the feature by a unique identifier…

In GIS, the attribute data concerning different aspects of features, are stored and managed in the relational databases. The attribute data of the features are

---

[2] GIS Dictionary (2006), Retrieved May,2, from http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.gateway

arranged as tables in which a row represents a feature and each column represents one feature attribute. In a GIS, attribute tables are often joined or related to spatial data layers, and the attribute values they contain can be used to find, query, and symbolize features. This allows the user to visualize and query different attributes of features.

A feature class in GIS is the representation of geographic features. These features have the same kind of geometry, attributes and references that can be stored in geodatabase in any format.

GIS technology is used in various areas ranging from urban planning to environmental management. Shunj Murai classifies these application areas in his book 'GIS Work Book (Fundamental Course)' [3] (Table-1)

With the help of the continuous developments in IT, the application areas of GIS are extended. Recently, GIS are also utilized as supporting tools through the conservation decision making process and various examples can be found in this field.

[3] MURAI, S. (1998), 'GIS Work Book (Fundamental Course)'.Tokyo, JAS

Table-1 Major areas of GIS applications (Murai, 1998)

Area	GIS Applications
Facilities Management	locating underground pipes & cables planning facility maintenance telecommunication network services energy use tracking & planning
Environment and Natural Resources Management	suitable study for agricultual cropping management of forests, agricultual lands, water resources, wetlands etc. environmental impact analysis disaster management and mitigation waste facility site location
Street Network	car navigation (routing & scheduling) locating houses and streets site selection ambulance services transportation planning
Planning and Engineering	urban planning regional planning route location of highways development of public facilities
Land Information System	cadastre administration taxation zoning of land use land acquisition

1.1.2 Areas and Examples of Use of GIS in Conservation of Cultural Heritage

The developments in spatial information and data management tools, methods and systems have been supporting conservation process. Beginning of 1990s, various examples of GIS based studies for the conservation of cultural heritage can be found.

Utilization of GIS in conservation can be classified in three major topics; conservation of archaeological heritage, urban conservation and conservation of historic buildings. However the examples are mostly on the conservation of archaeological sites and historic towns. In some of these examples concern is only documentation of heritage, where as in some others it also covers the phases like analysis, evaluations and the management of the site.

Though there are respectively few examples, utilization of GIS for conservation of historic buildings is also a developing issue. The use of photogrammetric techniques and information systems provides advantages through the conservation process of historic buildings.

One of the projects that can be considered as the use of geographical information systems in conservation of historic building is about the "*Live Theatre"* project in[4].

This project aims to design a spatial information system for the Baroque Theatre in Krumlow Castle in Czech Republic. First of all the 3D CAD model of the building was prepared with MicroStation software. The spatial data of

---

[4] The project is the proposal and realisation of a spatial information system ofthe baroque theatre of Cesky Krumlov castle in Czech Republic.

this 3D model were collected with photogrammetric techniques. Following this, a spatial information system was introduced as a proposal for the site. This system includes the management of the site, the research and the presentation of the results. The proposal of the conception of a spatial information system was the main result of the project. (Figure-2) The essential feature of the proposed conception is creation of subsystems aimed on three spheres; management, research and presentation of the site. This project mainly concerns the use of GIS in 3D visualization of the case study. Besides the information management for the site of the building is also prepared by using GIS.

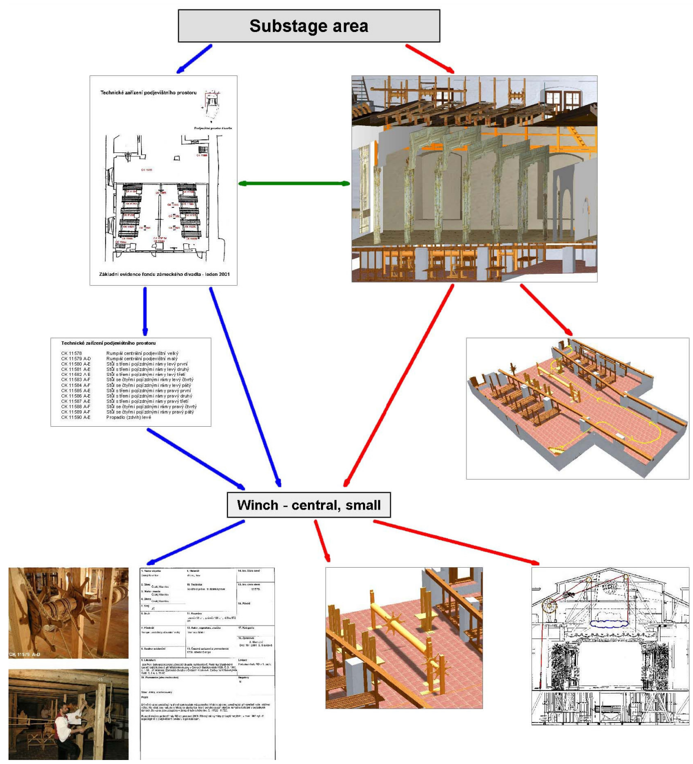


Figure-2 Scheme of data, subsystem – research of site, element of technical equipment

Another example for the utilization of GIS in conservation of historic buildings is the "Scanning of the Pyramids" project[5]. The aim of the project is to apply and test the latest documentation techniques for the conservation of archaeological sites. For this reason, laser scanners combined with a calibrated digital camera for high accuracy was used in order to assess the high resolution and long distance topographic scanning in archaeology. The data that was collected at this project was used in GIS environment and the visualization of the monuments was maintained with the help of laser scanning. At this project we can see an example of 3D visualization of Cheops Pyramids in GIS environment. (Figure-3) This visualization prepared with the help of point coordination that have been measured during the site survey.

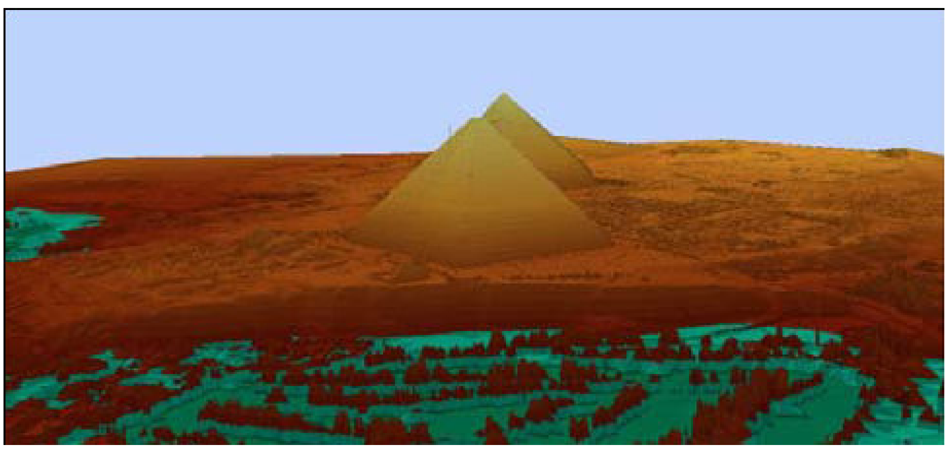


Figure-3 3D visualisations of the triangulated point cloud measured from the top of the Cheops Pyramid using ARC GIS 8.2.

[5] NEUBAUERA W., DONEUSB M., STUDNICKAC N. &, RIEGLC J., (2005), *'Combined High Resolution Laser Scanning and Photogrammetrical Documentation of the Pyramids at Giza'*, CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

Another example for the use of GIS in conservation of historic building is the project about the timber frame buildings in T'ang style in China[6]. In this project a visualization system based on 3D GIS for the case buildings is presented particularly. This building style is essentially important for the Chinese history of architecture. As a result they were chosen as a research task and by using Three-Dimensional Geographic Information System (3DGIS) the graphical presentation of the building were maintained. With the help of this system a digital platform was created for the conservation of these buildings with the help of computer and information technologies. This project is an example of use of GIS for graphical presentation. After the survey phase the data model was designed and the graphic records were prepared. The visualization and presentation of the monuments held with the help of GIS as well as the data storing and monitoring.

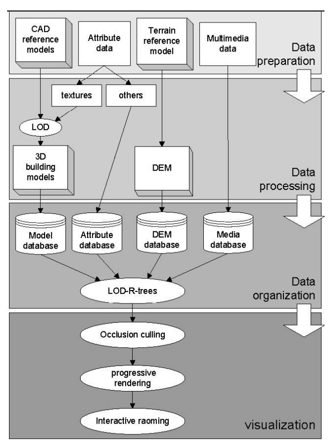


Figure-4 Workflow of T'ang style buildings project

---

[6] DU Z., LI D., ZHU Y. & ZHU Q. (2005), *'3DGIS-Based Digital Reconstruction and Dynamic Visualization of Timber-Frame Building Cluster',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

The project that was prepared for the ancient city of Herculaneum[7] is an example for the use of GIS as a conservation decision making tool for historic buildings. The Herculaneum Conservation Project (HCP) mainly aims to stop the ongoing decay problems of the Roman City. By rescuing the remains from detachment problems the project tries to develop conservation strategy for the conservation of the archaeological site. In order to achieve this goal a building in the site-Insula Orientalis I was chosen as a case study. In this project we can see the use of GIS as a data storing and monitoring tool. The important point of this project is to be able to visualize the building in 3D model. By enhancing the system with additional scripts written for GIS, it became possible to visualize the model that has been prepared in CAD environment. The visualization has been supported by covering the model with rectified photos.

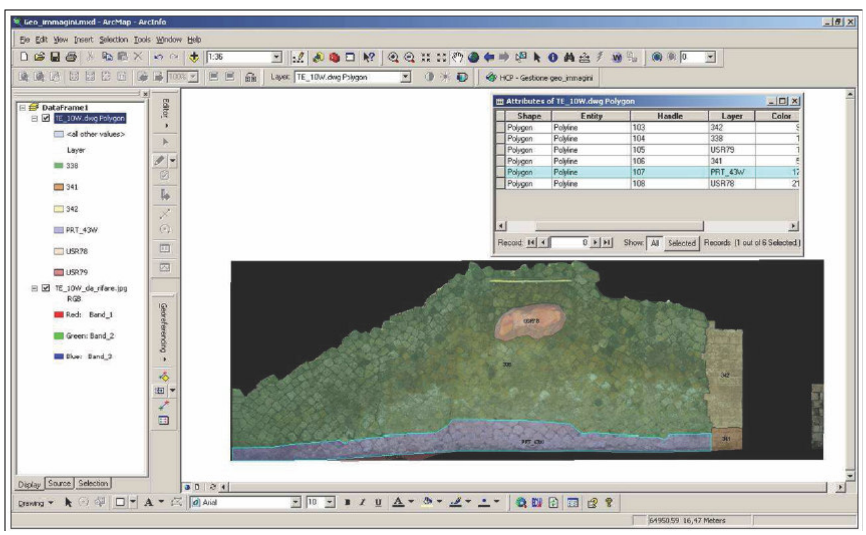


Figure-5 Example of managing the mapping of the stratigraphic units

[7] The Herculaneum Conservation Project (HCP) is a study between the Soprintendenza Archeologica di Pompei, the Packard Humanities Institute and the British School at Rome.

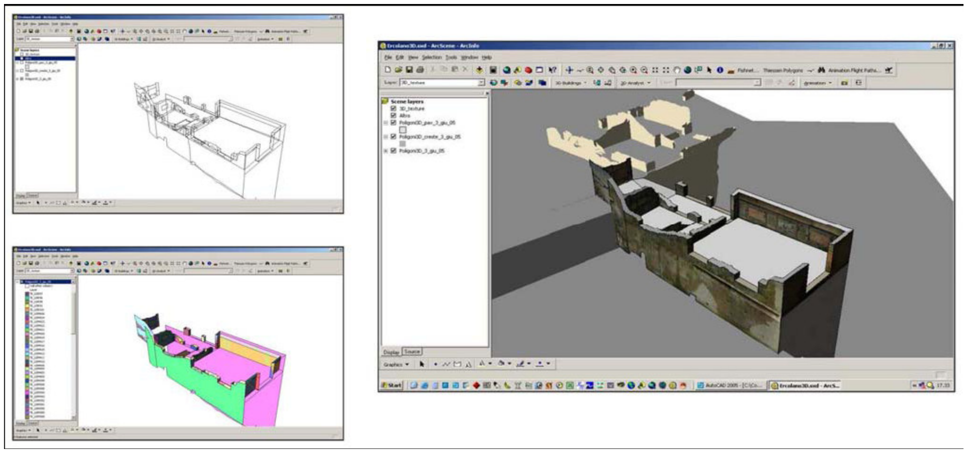


Figure-6 Texturizing the three-dimensional model of *Insula Orientalis I*

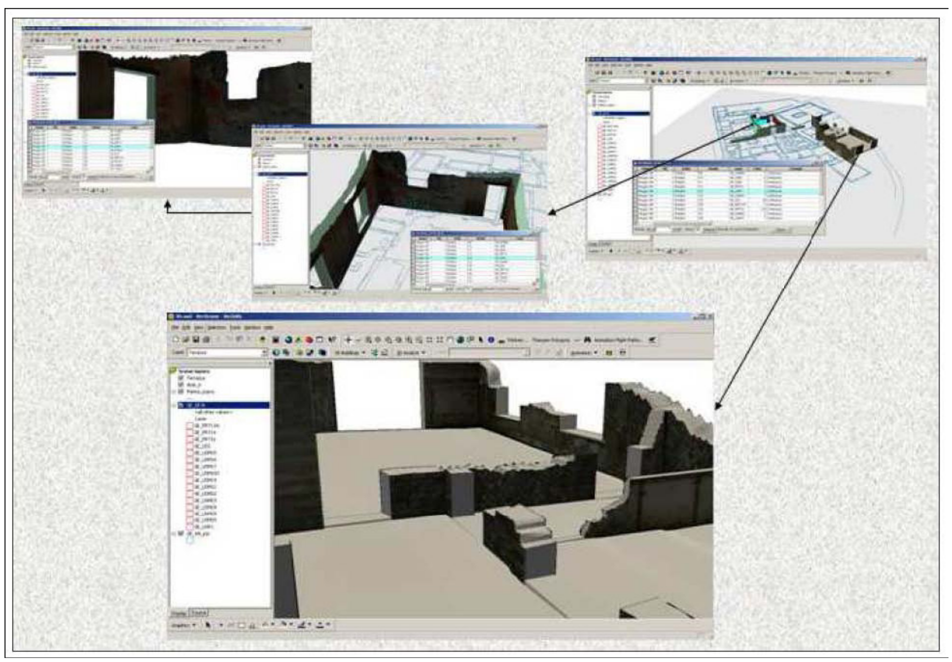


Figure-7 Construction of the digital model and management within the GIS software

The ARKIS[8] project is another example of use of GIS in architectural conservation projects. The project aims to define an information system to be used in architectural heritage conservation. The system is basically designed as an instrument for information analysis to be applied as a tool for the organization, representation and utilization of knowledge of the data.

The system use GIS as a software system but the drawings of the projects were prepared in CAD environment. The layers of the drawings related to a systemized database system in GIS and various operations can be done by using features of GIS. the system allows the user to get information about the buildings in the form of 2D CAD drawings.

The system is an example of use of GIS as a storage, analyzing and sharing tool in the conservation of historic buildings.

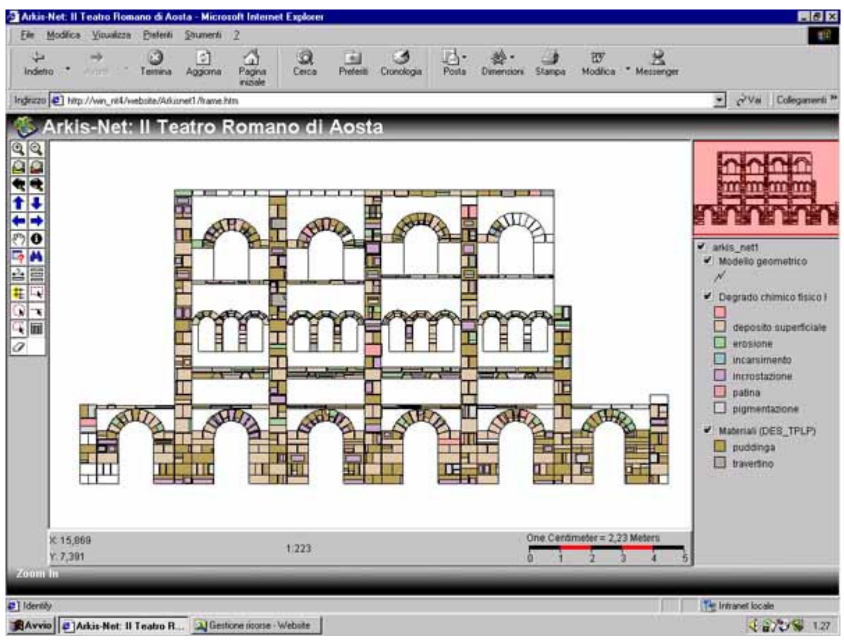


Figure-8 Using raster data (Roman Thatre)

---

[8] Architecture Recovery Information System (ARKIS) is an information system prepared by Paolo Sslonia (Instituto per le Technologie Applicate ai Beni Culturali-AdR di Roma).

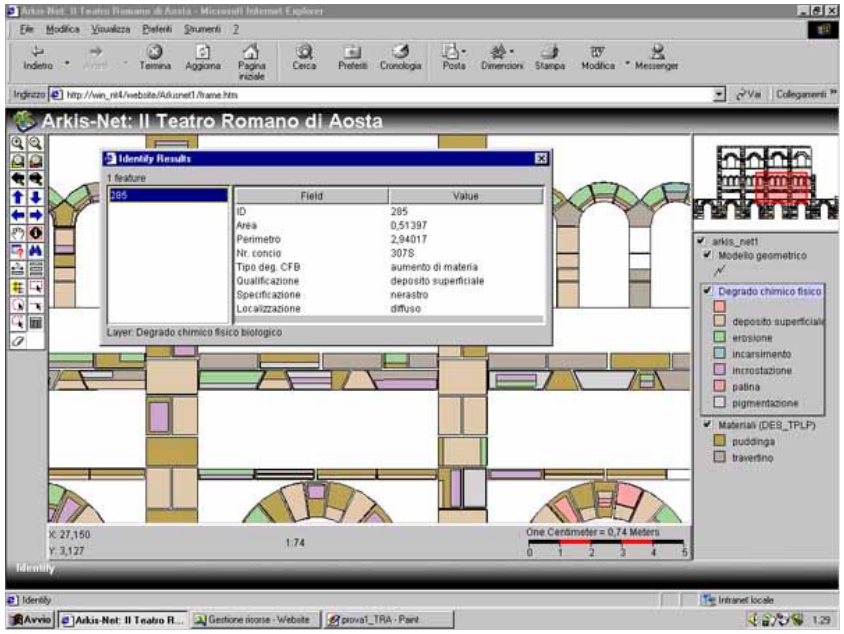


Figure-9 Example of Hot-link usage

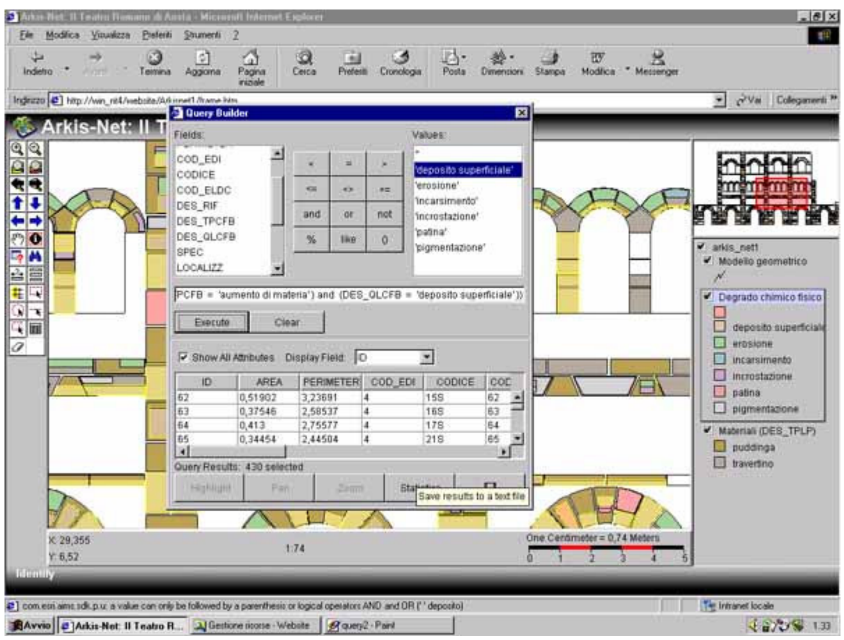


Figure-10 Query operations

When existing examples are studied and evaluated, a number of advantages provided by GIS can be seen. First of all the main area of use of GIS in conservation of historic buildings is for visualization purposes. Most of the projects were prepared in order to have 3D visualization of case studies. For instance the “Giza” project mainly concerns with having the 3D model of the Giza Pyramids in GIS environment. In addition to this there are some examples that uses GIS as a storage tool as well as a visualization tool like; “Tang Style” project.

Projects like; Insula Orientalis and ARKIS are examples of conservation projects in which the focus is the design of spatial information systems for the conservation of historic buildings. These projects represent the utilization of GIS for the storage, analysis and management of data coming from the historic buildings. In these projects GIS enable to make queries between different data topics according to the purposes of the researches. However, in both projects, commercially available GIS softwares are enhanced by additional scripts written specifically according to the objectives of the projects.

As a result, it is possible to say that, examples of the utilization of GIS as an information management tool for conservation of historic buildings are limited, where as, most of the examples using GIS for historic buildings focus its visualization and storage capabilities. Table-2 shows the comparison of different examples of GIS based projects for historic buildings, according to the phases of the study in which contribution of GIS can be seen.

Table-2 Examples of use of GIS in conservation of historic buildings

USE OF INFORMATION SYSTEM	RECORDING	ANALYSIS	EVALUATION	3D MODEL	MONITORING
● *Combined High Resolution Laser Scanning and Photogrammetrical Documentation of the Pyramids at Giza*	●			●	
● *Building 3D Photo-Texture Model Integrated With Gıs for Architectural Heritage Conservation*	●	●		●	
● *Planning A Conservation Project: The Information System of the Insula Orientalis I at Herculaneum*	●	●		●	●
● *3DGIS-Based Digital Reconstruction and Dynamic Visualization of Timber-Frame Building Cluster*	●			●	
● *Full XML Documentation from Photogrammetric Survey to 3D Visualization, The Case Study of Shawbak Castle in Jordan*	●			●	
● *Knowledge for the Recovery of Historical and Architectural Heritage and Information Technology*	●	●	●		●
● *An Approach for Representation of H istorical Objects by means of 2D Web-Based GIS*	●	●			
● *An Integrated Spatial Information System for the Development of the Archaeological Site of Mycenae*	●	●		●	
● *Architecture Base. A Database for 3D-Models of Buildings and Architectural Elements*	●	●		●	

1.2 Definition of the Problem

Conservation decision making process of historic buildings requires systematic study and scientifically planned methodology. A successful conservation process of an historic building should include the evaluation of data concerning different aspects of the historic building as well as the data coming from a multidisciplinary study.

The importance of the use of the information obtained in conservation of historic buildings and the difficulty of the coordination of the interdisciplinary work is explained by D. Whiting in his article "Computer Aided Recording Tools Automate the Creation of a Site Information System"[9] as follows.

> Much of the data gathered on a resource comes from various conservation disciplines spending time on and off site carrying out research, analyzing buildings and their setting and collecting photos, data and measurements which will be used later to create reports and drawings. This work is carried out for a wide variety of purposes including heritage recording, research and analysis, maintenance and monitoring.

The use of comprehensive data from various topics with the coordination of multidisciplinary work requires a medium that combines the analysis and evaluation of this complex data. Spatial Information Systems (SIS) offer the use of huge amounts of complex data. These systems enable spatial data, from different topics and different formats, to be evaluated, analyzed and monitored in the same environment.

---

[9] WHITING D. (2005), Computer Aided Recording Tools Automate the Creation of a Site Information System, Government Services Canada Real Property Services for Parks Canada Calgary, Ontario

The use of information systems for the conservation of historic sites is extensive. With the help of new improvements it

Conservation decision making process of historic buildings necessitates the utilization of an information structure that deals with correct and comprehensive data. It is essential to achieve correct and comprehensive information about the building through the data collected. Hence, starting from the survey phase onwards, collecting, analyzing and evaluating the data about the building is a major problem. Besides, it is also important to monitor the data throughout the conservation process. Conventional methods can be insufficient in dealing with complex and huge amounts of data and in transforming them to useful information. At this point GIS can be utilized as a useful tool for storing, structuring, analyzing, evaluating and monitoring the spatial data concerning various aspects of a historic building and consequently support the conservation decision making process.

1.3 Aim and Scope of the Study

The major aim of this thesis is to asses, with pros and cons, the support of the spatial information systems especially in the analysis and evaluation phases of the conservation decision making process of a historic building from a conservation architect's perspective. Accordingly, the main goals of the study can be described as follows;

- To resolve the conservation decision making process of historic buildings and to state the structure of GIS database.
- To build a spatial information system by using GIS for a historic building and to exemplify the features of the database for analyzing and evaluating the data collected through a case study.

While doing these, the focus will be on data storing, structuring, analyzing, monitoring and visualizing, as fundamental components of conservation decision making process of historic buildings.

1.4 Methodology

As mentioned above, the aim of this thesis is to assess the support of GIS in managing spatial information about 'a historic building' within its conservation process. Hence, as there are very limited number of examples in which GIS is used as a tool for information management in single building scale, there is not an already established methodology and pre-defined processes which can be adopted and followed. Therefore, this thesis study, itself, had been an empirical process of learning from the very beginning till the end.

Accordingly, the first phase of the study had been the literature survey in order to find out similar examples and to learn from them. Even though here only the examples on the use of GIS in single building scale are presented and evaluated, during the literature survey all the examples concerning the conservation of cultural heritage are tried to be reviewed regardless of scale.

In this study as the aim was to assess GIS through the architectural conservation perspective, it had been necessary to review the conservation decision-making process of a historic building so as to define the spatial and attribute data types required within this process. So, another important component of this study had been resolving the data types and procedures within the architectural conservation process. Parallel to this, the definitions, components, data types and data management procedures are also studied so that GIS data model for a historic building can be designed.

These had formed the fundamentals of the following phase, which focused on a specific historic building – Orthodox Church in Doğanlar, İzmir – chosen as the case study for this thesis. The criteria in choosing the case had been the variety in terms of materials used, structural and material problems, construction technique and change. The SIS established for this specific case is named as HBIS (Historic Building Information System).

From the beginning of the case study, some objectives were defined, it was not known if it would be possible to achieve all or not. Among these objectives was trying to provide a 3D SIS which would allow the data entry, structuring, and management and monitoring. Therefore, from the survey phase onwards data is always collected within a 3D coordinate system. Almost all the building except some details was measured with Total Station. Besides, all the inner and outer facades are photographed with high resolution digital cameras[10], which are then rectified by using photomodeler V.5.0 as a part of the documentation process. During the documentation phase data concerning the main topics defined in an architectural conservation process are also collected.

The collected data are later on transformed to CAD by using AutoCAD 2007 and the documentation drawings of the building were produced as CAD files. At this point two parallel studies have been done as producing 2D plan, sections and elevations as well as 3D model of the building.

Although the multipatch geometry in GIS seemed to allow formation of a 3D model, after various trials, the studies showed us that data editing could not yet be possible with a 3D model in GIS without using additional scripts. After that result, this time various other trials are made to design the most efficient system which can support conservation process of a single historic building by using the 2D environment of GIS. Therefore, the data entry was done through the 2D documentation drawings. Following the establishment of the GIS data model with spatial and attribute data, visualization of the structured data and the results of the queries between different topics are made over the sections,

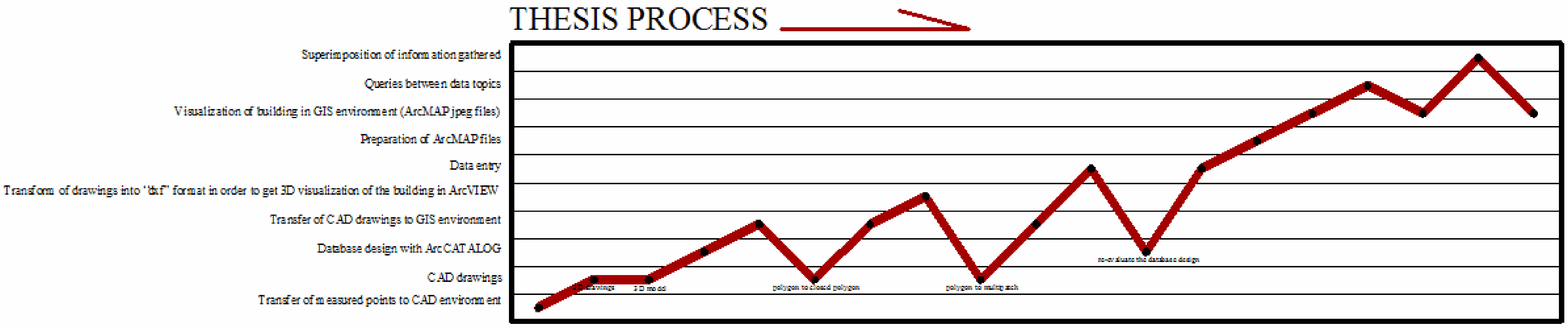
---

[10] Sony DSC-W15 digital camera

elevations and plans. The integration of different 2D drawings and the management of the system are made by the help of a key plan.

Thus, from the beginning of the case study till the production of the final output, there had been a lot of trials, failures, feedbacks and redoings within this process (Table-3).

Table-3 Thesis process



1.5. Structure of the Thesis

The thesis is structured according to the defined aim, objectives and methodology reflecting the empirical aspects of the thesis process. The first chapter is the introduction of the thesis where information systems are described with the brief explanations of data, data structure, database systems and GIS/SIS. The descriptions are exemplified with the areas of use of GIS in the conservation projects changing from urban conservation and archaeological projects to historic building conservation projects. The second half of this chapter explains multidisciplinary conservation process that deals with various data collected and evaluated, followed by the definition of the problem, the purpose of the study and the structure of the thesis.

The second chapter consists of the resolving of the conservation decision making process of historic buildings in conventional method. First of all, the process identified by defining the survey and analysis phase that composed of documenting and recording practices that tells the actual situation of the historic building. The necessary information that is collected through survey phase and the components of this information is being defined at this point. Following this, the evaluation phase is defined that describes the values, potentials and problems of the building. The last part of the first half of this chapter is the defining the decision phase of conservation process that introduces the conservation strategy and the intervention types. This chapter ends with the show of the convenience of the use of GIS in conservation decision making process of historic building.

The fourth chapter concerns with the case study. The general information about the case study and the records of the building in forms of graphic, photographic and written documents is stated. After defining the general information and recording methods the Spatial Information Systems (SIS) for the case study is introduced. Starting from the collection of the data, the structure of the data model and the presentation of the results is defined at this chapter.

The last chapter is the conclusion of the thesis that states the appropriateness of the information systems as a support system for conservation decision making process of historic buildings. After defining the pros and cons of the use of GIS during the conservation process, possible further study topics is being introduced.

CHAPTER 2

FROM DATA TO INFORMATION:

THE CONSERVATION PROCESS OF HISTORIC BUILDINGS

D. Whiting and S. Nickerson expresses the necessity and the importance of information systems in conservation of historic heritage in his article "Computer Aided Recording Tools Automate the Creation of a Site Information System" as follows;[11]

> To be considered as the basis for a site information system, the heritage record must be a comprehensive and living document. It must reflect the full scope of all of the information collected on the resource at many points in time. It must reflect both the as-found condition of the resource as well as its current state. It must be convenient to those carrying out onsite investigations and analysis. It must reflect the interests of a wide variety of disciplines interested in its care.

Historic building conservation is a systematic process where the data collected about the building through the survey phase, and evaluated and used as information through the evaluation and decision making phase. It is a value based

---

[11] WHITING, D. and NICKERSON, S. (2005), 'Computer Aided Recording Tools Automate the Creation of a Site Information System' CIPA 1997 XII International Symposium, 01-03 October 1997, Goeteborg, Sweeden

approach so that for an appropriate conservation process, the values, potentials and problems of cultural heritage need to be established. The possible interventions or conservation criteria are decided as far as these values and problems are identified.

2.1 Resolving the Information in a Conservation Decision Making Process

Documentation, analysis and evaluations of historical, physical, functional and visual aspects of a historic building are indispensable constituents of and principle basis for its conservation decision making process.

The conservation process starts with the recording of the building in order to conceive the present condition of the historic building. To asses the values, potentials and problems of the building there reside the evaluations where the recorded and analyzed data about the building is used. This evaluated results leads to the decisions, in order to develop a conservation strategy for the sustainability or continuity of the cultural identity of the building by defining the interventions. The conservation phases of historic buildings can be classified as follows;

- Survey and analysis; recording, documenting and understanding the actual situation,
- Evaluation; assessing the values, potentials and problems,
- Decisions; developing a conservation strategy and defining the interventions.
- Implementation; maintenance and monitoring.

This thesis will focus on the support of GIS at the survey, analysis and evaluation phases of conservation process of historic buildings.

2.1.1. Survey and Analysis; Recording, Documenting and Understanding the Actual Situation

The heritage recording is defined in Recording Documentation and Information Management (RecorDIM)[12] Initiative as follows; (Letellier, Grek; 2002);

> The capture of information relevant to understanding the physical configuration, evolution and condition of heritage sites and objects, at known points in time, and the basis of decisions made to alter or care for such sites and objects.

The reason behind the recording of the historic buildings is basically to understand the actual situation of historic building. This record can be prepared for different reasons such as; to document a building regarding its unique values, to provide an architectural conservation strategy for the historic building, to establish site management for a group of buildings or to prepare an academic research. In these studies, the recording practice can change in scale, detailing or final result but it is always an interpretation of the recorder that gives information about the historic building.

A. Menuge expresses the importance of survey phase in his book "Understanding Historic Buildings: A Guide to Good Recording Practice"[13] as follows; (Menuge; 2006, p.3)

---

[12] RecorDIM is an international 5-year (2002-07) partnership between international heritage conservation organizations working together to bridge the gaps between the information users (researchers, conservation specialists of all trades, project managers, planners etc.) and the information providers (photographers, heritage recorders, photogrammetrists, surveyors, etc.).

[13] MENUGE, A. (2006), Understanding Historic Buildings: A Guide to Good Recording Practice. London: English Heritage

> Historic-building records must provide information that is accessible and readily intelligible to a range of professional, academic and lay users. In producing and curating them certain guiding principles should be borne in mind:

In the course of the survey phase, it is important to understand the existing condition of the historic building. The drawings and sketches of the building are prepared at this phase in order to document the problems, changes, conditions of the building.

A historic building can not be evaluated without its surroundings. The surrounded edifices affect the building from different aspects. For instance the roads or paths around the building tells the communication to the building, or the architectural construction around the building describes the space quality in site scale, or the existing flora that surrounds the building determines the natural boundaries nearby. All these features define the building as a component of an existing vicinity that describes; a historic building can not be assessed without its surroundings.

The survey phase can be composed of various measurement techniques. Combination of different recording techniques can be used during this phase. The survey technique can be decided due to the aim, components and the detail of the project. The architectural survey need to be prepared in order to achieve a metrically correct and decent study of the historic building. At this point use of different survey techniques can ease the survey phase.

This phase includes the preparation of the documentation drawings as plans, sections, elevations, details, site plans, silhouettes, etc. These topics can vary according to the important features of the monument. These documentation drawings allow understanding the monument with architectural and structural elements in detail therefore the drawings should be prepared in detail.

For further information on the building, laboratory analyses are necessary. These studies can be in different topics. These samples can be plaster samples, structural material samples and architectural material samples. Therefore material samples need to be collected for the documentation of the deterioration condition of the historic buildings. The amount and the type of these deteriorations need to be identified before any interventions. In order to understand and evaluate the problems of the building, these deterioration types should be classified and defined. The definitions of the deteriorations by the time the survey is applied and the previous interventions that caused problems in the building should be identified for further interventions.

As far as the deterioration types are defined and classified, the definition of decay forms on the building, façades or the elements should be presented. These representations are prepared on the documentation drawings and they are used to diagnose and analyze the damages and decay forms on the building. The use of software programs ease the mapping process and allow to have quantitative results and information. The mapping of deterioration types and decay forms ideally carried out using software technologies and rectified images.

Survey of the historic buildings should create information that can be shared and accessed easily. The main survey should include followings; literature and archival research, general definitions, measured drawings that define the architecture of the building, survey of the structural elements and the structure of the building, survey of the architectural elements of the building, survey of the surfaces of the building with its coverings, etc.

After the survey phase information about the building is gathered. This information tells about the facts about the building based on the source and the existing situation of the building at the moment that the survey was applied.

Survey and analysis phase describes the building from different aspects. Information about the building on various types can be gathered during the survey phase. This information can be classified as follows;

- Information about the facts of the building; construction period, construction style, the donor, etc.
- General information about the building; the address, ownership status, legal status etc.
- Information about the function of the building; current and original function.
- Information about the structure of the building; structural system, construction technique, materials used, etc.
- Information about the condition of the building; structural condition, material condition, change status, detachment types, etc.

2.1.2. Evaluation; Assessing the Values, Potentials and Problems

Every historic building gives information about its past. By evaluating the historic building with its components, we can find answers to the questions like; "How the building was built?", "Which materials were used?", "What kind of a construction technique was applied?" These and those similar questions define the values of the building as a cultural heritage and in order to define those values and potentials; analysis and studies are prepared. The metric survey of the building is used as a base map for the preparation of these analyses.

The transformation of data to information starts with the evaluation phase where the values, potentials and problems of the building are defined as reference to the decision phase. At this point the raw data is evaluated in order to assess the future of the building.

The survey phase of the historic building states the importance of the cultural heritage in various approaches such as; historic, scientific, social, cultural and economic etc. The significance of the building is evaluated by assessing these values and potentials during the evaluation phase.

In order to define the possible risk factors of the building such as; material, physical, structural etc., laboratory analysis needs to be evaluated properly.

The evaluations mentioned above should be supported with the comparative studies and restitution drawings so as to organize a conservation strategy and decision making. The comparative study is used to evaluate the missing architectural and structural elements of the historic building. These studies are prepared on different scales in order to understand the building within its built environment, such as; comparative studies on site scale and comparative studies on building scale. Similar building types from the same period are used during the comparative studies. These studies help to assess the building comparing to the similar buildings from nearby district.

Other than the comparative studies restitution drawings are prepared for supporting the conservation decision making process of historic buildings. These drawings are prepared parallel to the historic studies from written and graphic documents and the evaluations prepared from the changes that the building approached. Restitution drawings help us to understand the building as it was first built as well as the phases that the building processed. These drawings are supported with the reliability mappings where the reasons behind the proposed plan organizations, architectural and structural elements described.

The evaluation process should include the following topics; evaluation of material used, evaluation of construction technique, evaluation of structural conditions, typologies about the architectural and structural elements, changes of the building, comparative study in site scale, building scale, restitutions and reliability mappings, etc.

The evaluation phase of this thesis creates evaluations about the building that can be queried through GIS environment. The queries were defined in order to assess the support of GIS to conservation decision making process of historic buildings. The queries were evaluated so as to understand the advantages and disadvantages of GIS through the conservation phases in survey, analysis and evaluation phases.

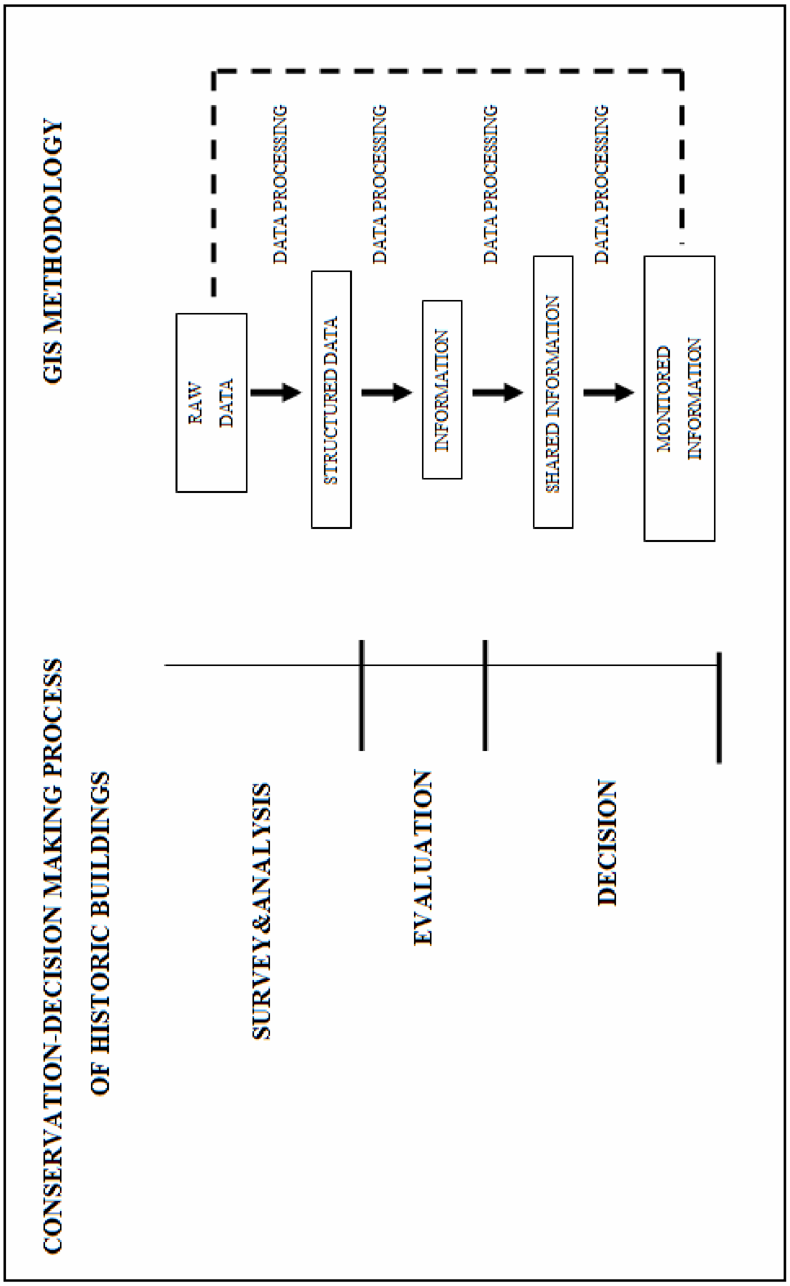
2.1.3. Decisions; Developing a Conservation Strategy and Defining the Interventions

Conservation decision making process of historic buildings is a complex issue deals with several evaluation criteria. Having realized the information defined during the evaluation phase, it is important to state problem definition, conservation strategy and definition of the interventions through the decision phase. Based on the information gathered during the evaluations, the decisions concerning the problems defined, values and potentials developed are stated in decision phase.

Monitoring is also important issue in conservation decision making process. Stating the decisions and intervention criteria for the historic building can only be sustainable if the monitoring is possible. The decision process should include; restoration principles, intervention criteria, function proposal, funding proposal, decisions, etc.

Consequently conservation decision making process of historic building defines the necessary information about the building. In other words; data about the building is collected in order to identify the building from different aspects and this data is analyzed and evaluated so as to define the decisions about the building. From this point of view, conservation process can be defined as a suitable method to be applied in GIS environment. Table-4 shows the convenience of GIS methodology for the conservation decision making process of historic buildings.

Table-4 The relation between conservation process and GIS methodology



CHAPTER 3

HISTORIC BUILDING INFORMATION SYSTEM (HBIS) FOR DOĞANLAR CHURCH

Information Technologies (IT) enable to establish a suitable environment for the management of information. They help the user to handle with complex data from different context.

Within this scope, Historic Building Information System (HBIS) was designed for the conservation of Doğanlar Church, which is a spatial information system built by using GIS, namely ArcGIS V.9.0. The aim is to create an environment where the data collected about Doğanlar Church, can be stored, analyzed, evaluated, visualized and monitored.

The important point here is to manage the spatial data with a scientific and systematic approach. For this reason the data is collected, linked to the system in GIS environment.

This system allows storing any data in any format with any extensions; moreover the user can reach the information about the building with any requested form. The information can be a raw data collected during the site survey or the result of an analysis. The important capability of this system is to operate and query the data due to the purpose of your study.

3.1 Introducing the Case

The case study for this thesis was determined as Doğanlar Church İzmir. The important point while deciding the case study is that the building should have variety in terms of materials used, structural and material problems, construction technique and changes but should be simple in form so that easily documented. From this point of view Doğanlar Church was decided as an appropriate case study for this thesis.

Figure-11 General view of Doğanlar Church

Doğanlar Church is a late 19^{th} century period Orthodox Church located in Pınarbaşı district Bornova which is one of the metropolitan districts of İzmir established 8 km from the city centre. Pınarbaşı is one of the 7 municipal administrative zones of Bornova and Doğanlar is a rural district in the borders of Pınarbaşı covered with industrial territory. Bornova used to be the summer residence of Levantines of İzmir so as there are a lot of residences and churches within the borders of Bornova. Although there is not enough information about the building, Doğanlar Church is thought to be a small rural church used by the Levantines around the area.

Historic information about the Doğanlar district is limited. The area once was called as Hamitli[14] and after the population exchange Turkish people coming from Balkan Peninsula was inhabited to the area and they started to live with the Greek people until the 1930s. Following the Foundation of the Republic the area was left to the Turkish people. As a result of this change the building was reassessed as a school for the local children[15] until the mid 1940s. Following this the building turned into a furniture workshop and a depot for the furniture. Hence there are a lot of interventions and changes due to the previous functions of the building. Today the owner of the church is İzmir Metropolitan Municipality and the municipality is planning the building to be restored as a community center for the women and children in Doğanlar[16].

As a single nave building Doğanlar Church has a rectangular plan situated through the east and west direction with the dimensions of 14.30 m and 7.80 m. The building is a stone masonry building with a timber vault as a superstructure. The western and eastern walls are 0.60 m in depth and the southern and northern walls are 0.70 m in depth. There is an angled apse at the eastern part of the building.

The entrance to the building is from two facing openings with the dimension of 1.50 m at the south and north façades. These doors located at the central axis through the south and north direction. Other than these openings, there is another

[14] Verbal information from the local people
[15] Verbal information from the local people
[16] İzmir Metropolitan Municipality announces at the web page

opening at the northern façade 1.50 m far from the eastern façade. This 1m opening is closed with brick wall. At the northern façade there are four window openings with stone lintels. Two of them are situated at the right of the entrance and the others are situated between the door openings. All window openings are closed with brick walls.

The apse of the church is at the eastern façade. There is a window opening closed with brick wall at the center of this apse. There is an ellipse window with stone lintels opening at the pediment of this façade. This opening is also closed with a brick wall.

The southern façade also have four window openings with stone lintels. Two of them are situated at the right side of the door opening and two of them are situated at the left side. All the window openings are closed with brick walls. Mud brick is used at the window openings on the left side of the door.

The western façade of the building has a pediment with an ellipse window opening at the center, which is closed with a brick wall. There are two other window openings at the western façade which are closed with mud brick wall and framed with stone lintels.

The roof of the building is a pitched roof covered with over and under tile in general. At the south façade there is the use of Marseille tile in a small area.

The outer walls of the building are painted with mud plaster in general but there is a lot of material loss in plaster at every façade of the building. The use of cement plaster also can be found as a previous intervention.

Figure-12 General view of Doğanlar Church

Figure-13 East façade of Doğanlar Church

Figure-14 General view from the entrance

Figure-15 North façade of Doğanlar Church

Figure-16 North-West façade of Doğanlar Church

Figure-17 West façade of Doğanlar Church

The interior façades of the building are painted with white wash in general. Previous interventions can be seen as the application of cement plaster at the detached areas.

There are niches at the church with different dimensions. At the southern wall there is a niche at the left side 0.20 m far from the left corner with a 0.45 m depth. The window openings at this wall are closed with brick walls. The openings at the right side of the door opening are closed with mud brick and the other ones with brick. There is a niche at the center of the western wall with a depth of 0.45 m. this niche is closed with brick wall. The window openings at this wall are situated at each side of this niche. These openings are closed with brick walls with the same width of the walls of the church.

The door opening at the northern wall is situated at the center of the wall with two window openings at each side. All openings are closed with brick wall in 0.10 m in depth. The other door opening at this wall is 0.75 m far from the eastern wall. This opening is also closed with brick wall and was plastered with lime plaster and washed with white wash.

The apse of the church is at the eastern wall. There are two niches at this wall at the each sides of the apse with 0.35 m depth. The niche at the left side of the apse is a circular niche and the other one is a rectangular in shape. There is a window opening at the center of the apse and it is closed with brick wall.

Doğanlar Church is a masonry building constructed with rubble stone and fired brick and there are timber lintels between the stones. Cut stone is used at the corner points of the church. The window and door openings are framed with cut stone lintels. The superstructure of the building is a timber ribbed vault. The inner face of the vault is covered with baghdadi timber and plastered with lime plaster. Iron bar is used as supporting structural element at the roof. There are two iron bars at the levels 4.45m and 5.60 m. The floor covering of the church is concrete.

Figure-18 View from the apse

Figure-19 Inside view of Doğanlar Church

There are ornaments at the ceiling of the building constructed with lime plaster. There are also corniches at the outer façades at the upper ends of the walls.

Figure-20 Detail Picture from the ceiling

Figure-21 Ceiling ornaments

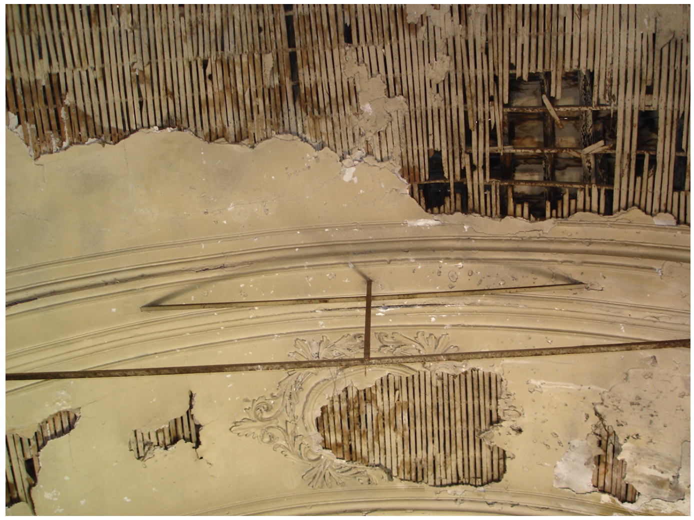


Figure-22 The iron bar

Figure-23 Window opening that closed with brick wall

Similar type churches can be found at the Aegean region as well as the Greek Islands. Çeşme Dalyan Church, Şirince Hagios Demetrios Church, Şirince Mabed Church, Ildırı Church, Gülbahçe Kilise Mosque, Didim Akbük Church, Kula Church, etc. are the similar examples.

Figure-24 Çeşme Dalyan Church

Figure-25 Kula Church

3.2 Constructing the HBIS for Doğanlar Church

The Historic Building Information System (HBIS) prepared for Doğanlar Church can be classified into four main phases. The first one is the survey phase, which covers the metric survey of the building and data collection about various aspects. The second phase is the "data structuring". In this phase, the collected data is transferred to the GIS by designing a database and defining a data model. Later, thematic maps on different topics are provided over the structured data. Then comes analysis and evaluations where queries are made between different data topics. Following these phases, all the raw and processes data are visualized in the GIS environment by using a key plan.

As the utilization of Geographical Information Systems (GIS) in conservation process of historic buildings is comparatively new issue, therefore the process of using GIS in the construction of HBIS for Doğanlar Church has created its own problems and solutions. Usually these problems were solved by reconsidering the application from the beginning.

3.2.1 Survey; Recording & Collecting the Data

Survey phase has consisted of data collection through archival research and through site survey, preparation of the documentation drawings and modeling of the building in 3D CAD environment.

Site survey phase established with the preparation of the sketches of the plans, sections and details of the building. These sketches were used to document the coordinate points of the measured points of the building.

Figure-26 Rectified image of southern façade

Figure-27 Rectified image of western façade

Throughout the site survey the building was documented in order to situate the building into a 3D coordinate system. Total Station[17] was used to measure the coordinates of the building. Some polygon points were defined to set the measurements systematically. The measurements of five polygon points called as P1, P2, P3, P4 and P5, were made from these polygon points. These points were defined in order to capture the entire building. The coordinate points of plans, sections and elevations of the building were measured within a 3D coordinate system. (Figure-29)

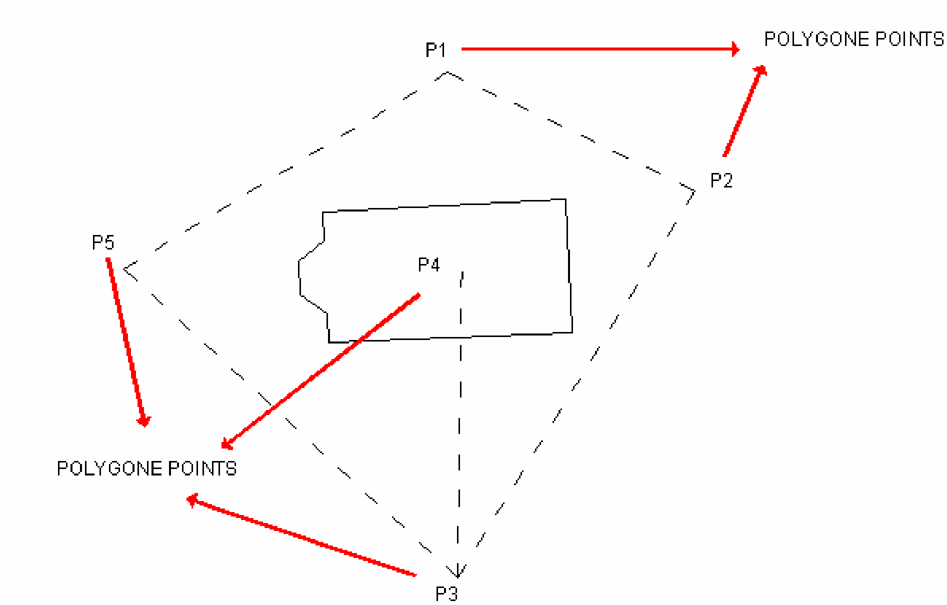


Figure-28 Determination of the polygon points

[17] Sokkia Total Station

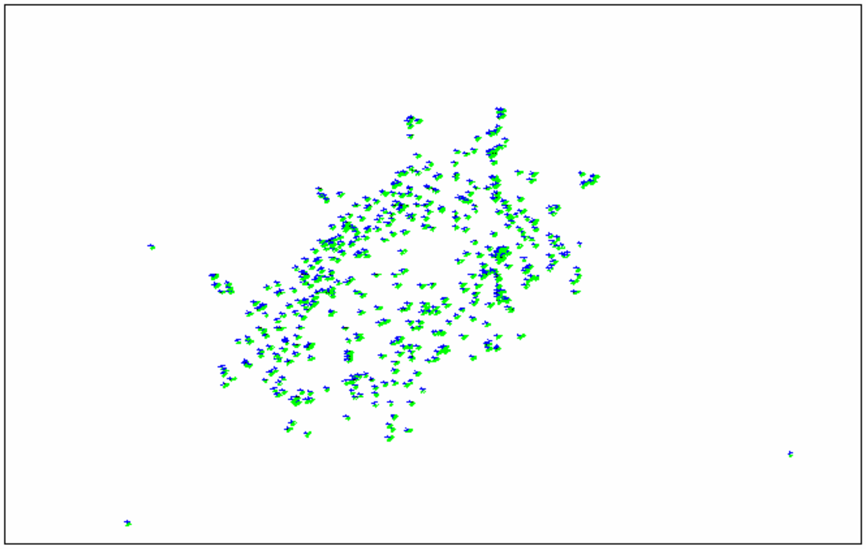


Figure-29 Reference Points

The interior and exterior façade measurements were taken in two ways. In one way the coordinate points that will be used in preparation of drawing were measured and all the window or door openings and the façade elements were captured. All these measured points became the part of the reference point measurements. On the other hand, in order to get rectified images of the façades previously identified points were measured. For the west and east walls four coordinate points were selected on each façade and for the north and south walls, six coordinate points were selected considering the length of the façade. These measured points were noted on to the façade sketches and interior and exterior facades were photographed with a high resolution camera[18].

In addition to these total station measurements, some details were documented as hand measurements and connected with the previously defined coordinate points and became part of the whole measured drawing set.

---

[18] Sony DSC-W15 digital camera

Table-5 Construction Process of HBIS for Doğanlar Church / Site Survey Phase

- Determination of the case study.
- Preparation of the sketches of the building.
- Taking the photos of the building.
- Taking the photos for rectified images.(high resolution)
- Definition of the polygon points.
- Identification of the coordinate points for rectified images.
- Measuring the coordinate points 3D coordinate system.
- Hand measuring of details.
- Visual observation of detachments.
- Visual observation of materials.
- Visual observation of problems of the building.
- Collecting information about the building.(historic information)
- Conversation with local people.

The documentation drawings of Doğanlar Church were prepared with *Auto*CAD 2007. The measured points were transferred to the CADD environment and plans, sections and elevations were drawn in *Auto*CAD. The layers of the drawings were defined according to the material differentiation and decay types that are visually observed. At this point two parallel studies were carried on; definition of the layers of the CAD drawings and definition of the database layers. Despite some changes during the utilization of the method, the layers created during the *Auto*CAD drawings were used for the GIS database.

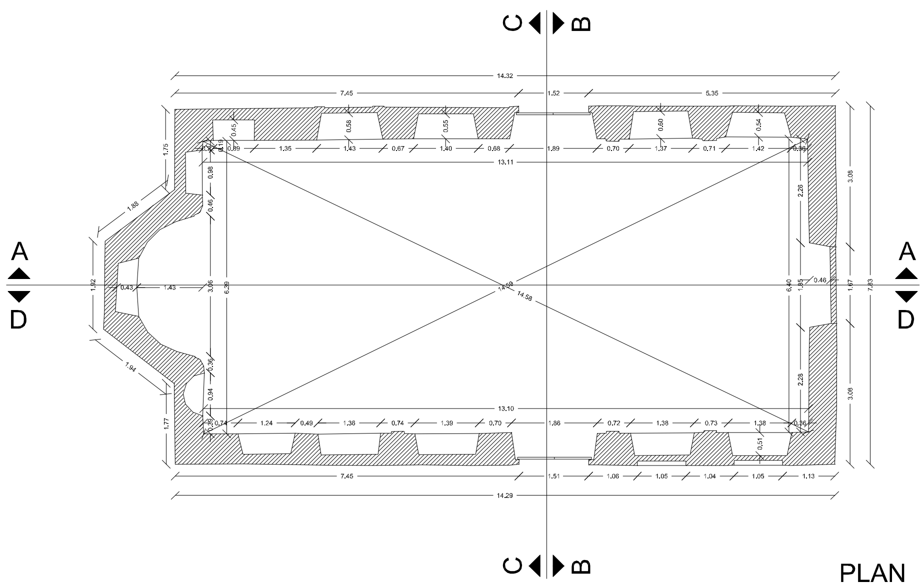


Figure-30 Plan drawing of the building

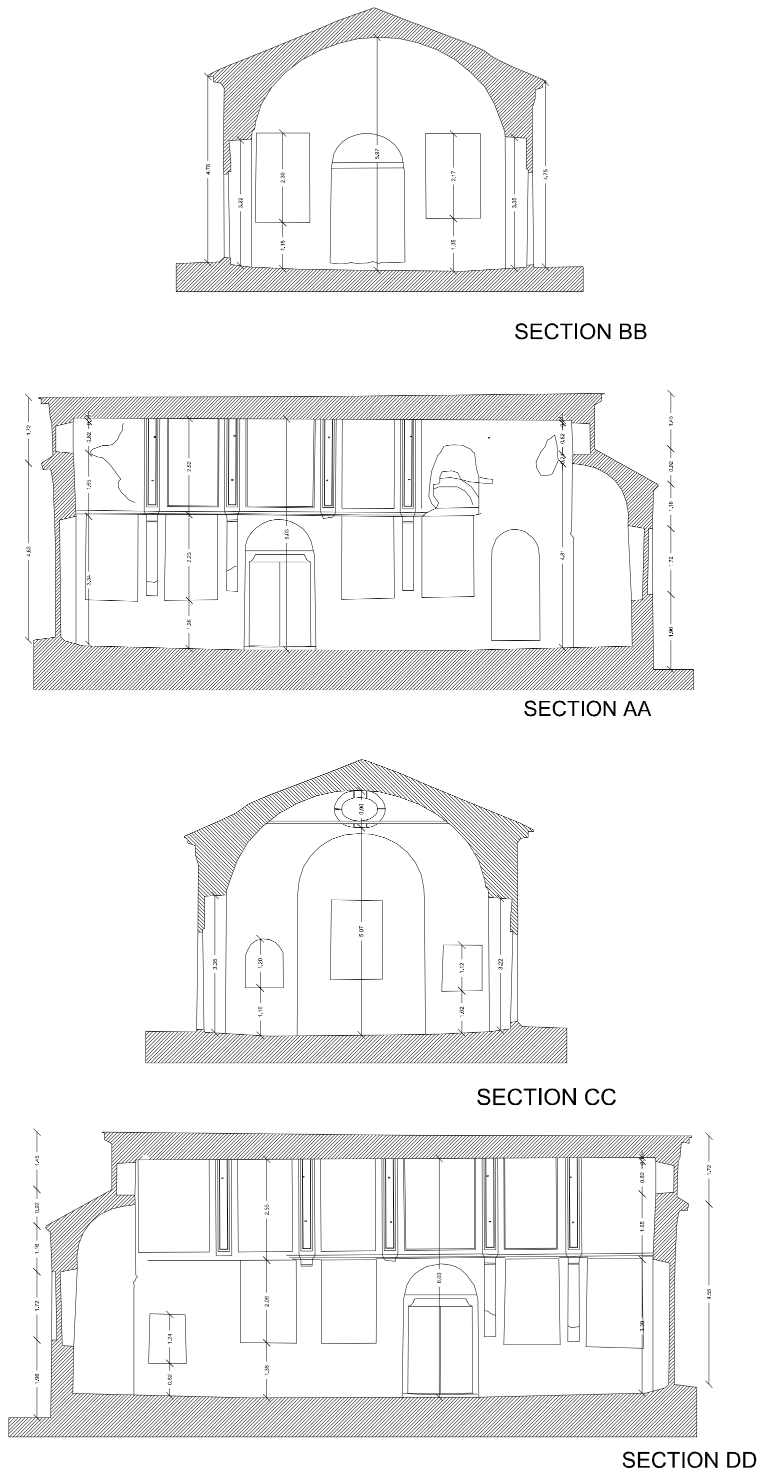


Figure-31 Section Drawings of Doğanlar Church

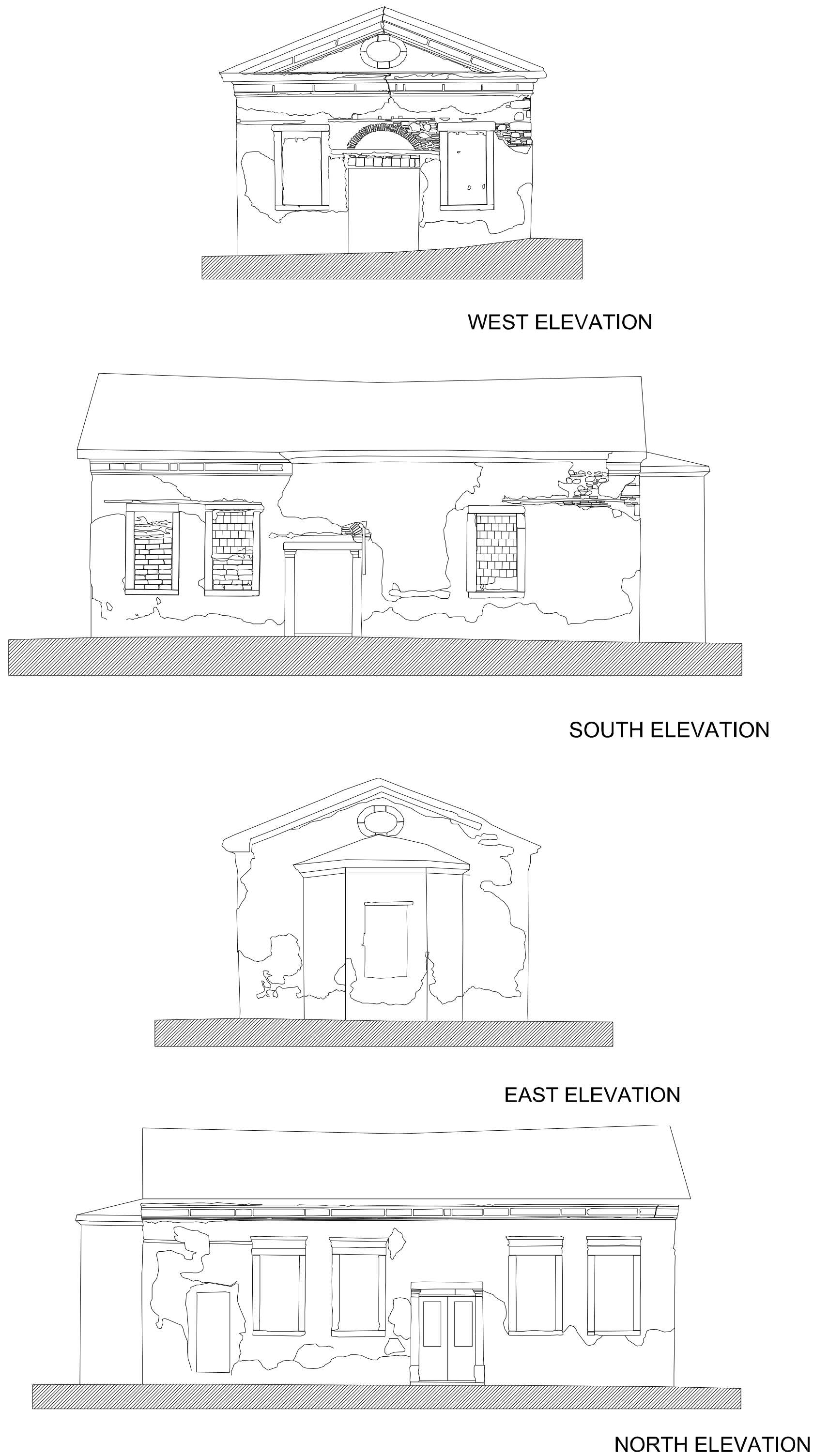


Figure-32 Elevation Drawings of Doğanlar Church

In order to evaluate the use of GIS with different visualization techniques for the conservation decision making process, the building was modeled in 3D *Auto*CAD. Following the preparation of the plan, section and elevation drawings of Doğanlar Church, the 3D model was developed with the points measured with Total Station (Figure-33).

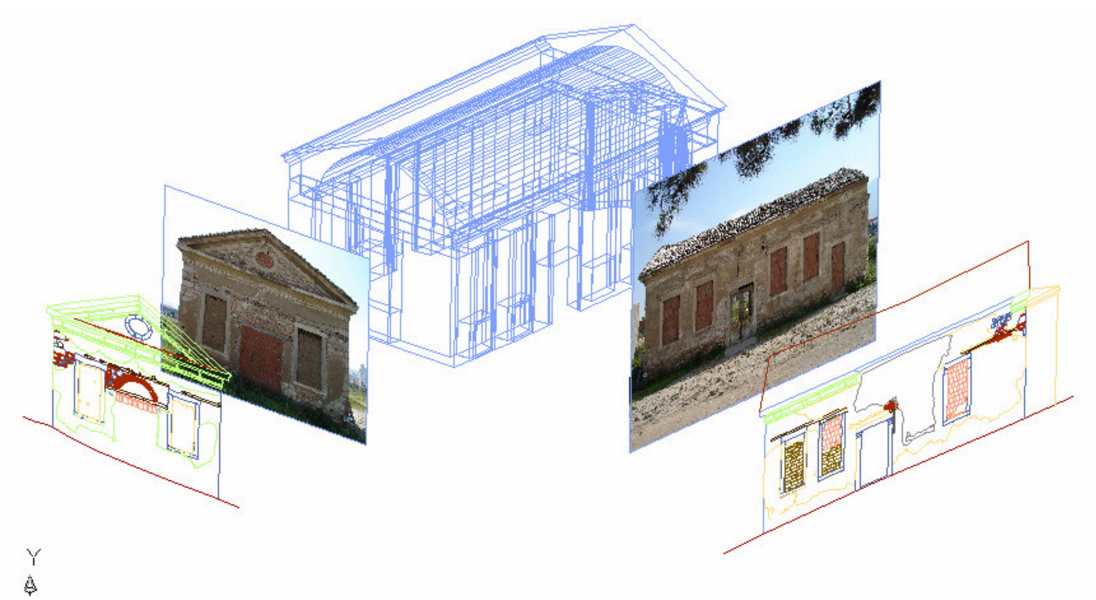


Figure-33 Preparation of 3D model and the use of rectified images

3.2.2 Designing and Defining the GIS Data Model

Design of the database is one of the most important phases of a GIS base conservation methodology. At this phase, the necessary spatial data is decided and the database system is designed before entry of the data.

The content of the data that is used in database system can be very different and comprehensive. The above mentioned phases of the conservation process require information about the contents and components of historic building in order to structure an utilizable conservation process. The meaningful data groups are required in order to use the data for the following phases. Therefore feature classes should be defined with necessary attributes in appropriate formats.

In guidance to the resolving of the conservation process, the historic building can be evaluated with respect to three basic data groups; the building itself with its surrounded site scale, the spaces of the buildings and the components of the building.

It is clear that an historic building can not be evaluated apart from its surrounded site context. Therefore the main attributes were decided for building feature class. First of all the geometry of this feature class was decided as polygon that is appropriate for visualizing the historic building as well as the surrounded buildings. The attribute data defines the data about the building in general. At this phase the data about the building is defined such as; the address, the owner, the registration status, current function, original function, structural system, change degree, construction period, etc. other than the data about the building itself the data about the survey and the method.

The building space was introduced as the next feature class at the database system. At this point the data about the space is defined as well as the data about the survey of the spaces. This feature class represents the attributes in order to have information about the current and original function of the spaces of the building as well as the space quality in guidance to decisions.

The other feature class is defined as the building components in which the data about the components of the building was studied such as the architectural, structural and finishing elements of the building. The data about the components of the historic building was classified according to its type and name and main data was introduced as the construction technique, structural and material condition, the change degree and the reasons and types of detachments.

In order to handle the collected data during the survey phase, the data groups should be classified into logical feature classes and attributes with appropriate geometry. All these feature classes and attributes are decided in order to utilize necessary analyses and queries in GIS environment.

Starting from the survey phase the collected data should be appropriate for GIS environment. The measurements of the 3D coordinate points, the creation of rectified images etc. are needed in order to structure the database system.

As it was mentioned before, historic buildings can not be evaluated apart from its own surroundings, therefore the database structure of the building need to involve the surrounded buildings, roads, natural objects, etc. In order to get brief information about the edifices around the building and about the building itself the database started with the definition of the surrounded site. At this point data model defines the name, the address, registration status, the owner, the donor, the original and existing function of the building as well as the height, structural system, material, etc.

Table -6 Database structure of the "building at the surrounded site scale"

Feature	Geometry	Attributes
Building	**Polygon**	**_ID** (building block + building lot + building number) **_definition** (late 19th century orthodox church) **_method** (survey with total station, hand survey) **_address** (Doğanlar köyü, İzmir) **_owner** (İzmir Metropolitan Municipality) **_ownership** _ public owner **_registration status** _ registered **_name of the building** (Doğanlar Church) **_current function** _ abandoned **_original function** _ religious **_detailed function** _ church **_ number of storey** (1) **_ height** (7,21 m) **_ structural system** _ masonry **_structural and material condition of the building** **_ G** Good (no structural or material problem) **_ F** Fair (deterioration only in finishing)

		_ **M** Medium (deterioration in structural elements) _ **S** Severe (severe deterioration in structural and material elements, partially collapsed or collapsed) **_degree of change** (spatial) _ **TC** totally changed (Original plan scheme, façade arrangement can not be perceived and almost all the architectural element lost / vertical or horizontal division) _ **PC** partially changed (Original plan scheme and façade arrangement is conserved in spite of the changes in architectural elements / spatial division) _ **UC** unchanged **_sources of information** (no historic document, verbal information from local people) **_period of construction** (late 19th century) **_date of construction** (unknown) **_donor** (unknown)

Following the general information about the building and its nearby surrounding, the database should cover information about the spaces of the building. Hence the feature classes defined as building space and the attributes of this feature class described as follows.

Table-7 Database structure of the building representing the “building space”

Feature	Geometry	Attributes
Building Space	**Polygon**	**__ID** (building block + building lot + building number + storey number + space number) **_survey status** _ **TS** totally surveyed (graphic and measured survey applied) **_current function** _ **A** abandoned **_original function** _ **C** church **_type of floor** _ **E** earth **_type of ceiling** _ **T** timber **_degree of change** _ **TC** totally changed (removal or alteration of horizontal elements) _ **PC** partially changed (change in surface coverings) _ **UC** unchanged

Having described the building with its spaces it is the building components need to be utilized as the database feature class. The ‘building components’ feature class is graphically represented by polygon. The attribute data of this feature class are type, material, structural and material condition, decay problem and change degree.

Table-8 Database structure of the building representing the "building components".

Feature	**Geometry**	**Attributes**
Building Components	**Polygon**	**_name** _ **D** door _ **W** wall _ **N** niche _ **P** plaster _ **WI** window _ **F** floor _ **C** ceiling _ **R** roof _ **L** lintel _ **type** (according to construction technique, material used and details) **_material** _ **T** timber _ **S** stone _ **B** brick _ **M** metal **_structural and material condition** _ **G** Good (no structural or material problem) _ **F** Fair (deterioration only in finishing) _ **M** Medium (light deformations) _ **S** Severe (severe deterioration, partially collapsed, collapsed) **_degree of change** _ **TC** totally changed (removal or

		alteration of architectural elements) _ **PC** partially changed (few of the architectural elements changed) _ **UC** unchanged (No change in architectural elements or only small material alterations in elements) **_reasons and types of detachments** _ **B** blind detachment _ **F** flaking _ **M** material loss _ **FI** fissure _ **D** dripping _ **DI** discoloration _ **DI1** efflorescence _ **DI2** micro biological growth _ **DI3** staining _ **DI4** unknown _ **P** plantation _ **G** graphite _ **O** oxidation

3.2.3 Data Entry, Structuring and Querying

Following creation of database design and the data model, the raw data collected during the survey phase is transferred to GIS environment. The data coming from different sources have been entered into the system in the forming relational database.

The spatial objects created through *Auto*CAD were transferred to the GIS environment with relation to the database system that was created with ArcCATALOG.(see Table-5, Table-6 and Table-7) At this point two parallel studies were carried on; the transfer of 2D documentation drawings of Doğanlar Church and the transfer of 3D model of the building.

After creating the geodatabase, which consists of the feature classes with specific geometry and atrributes defined during the database design, by using the ArcCatalog interface of the software, data entry is made in the ArcMap interface (Figures 34, 35, 36, 37).

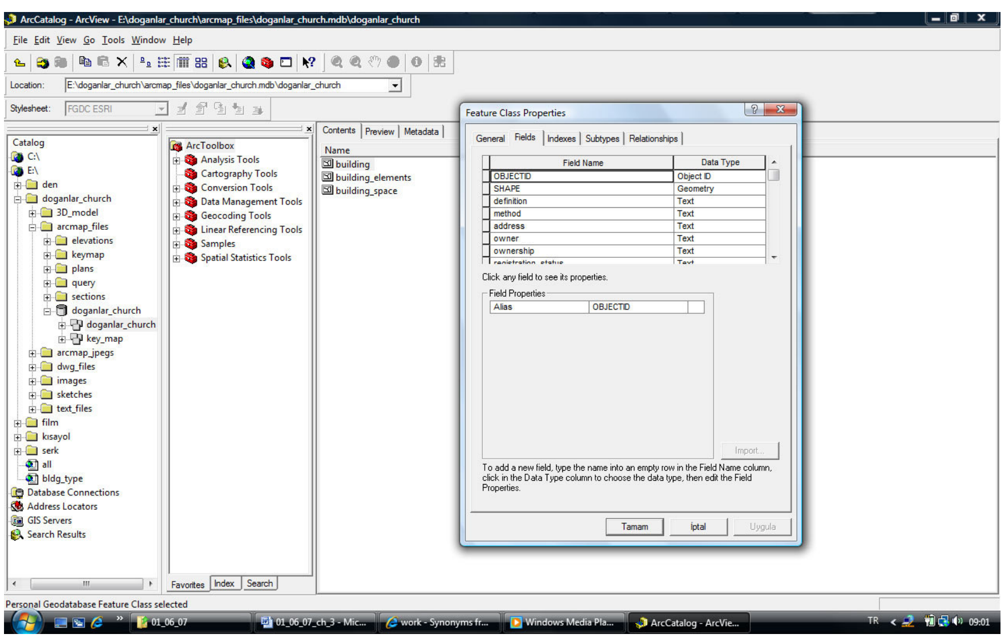


Figure-34 ArcCATALOG filing system for “building” feature class.

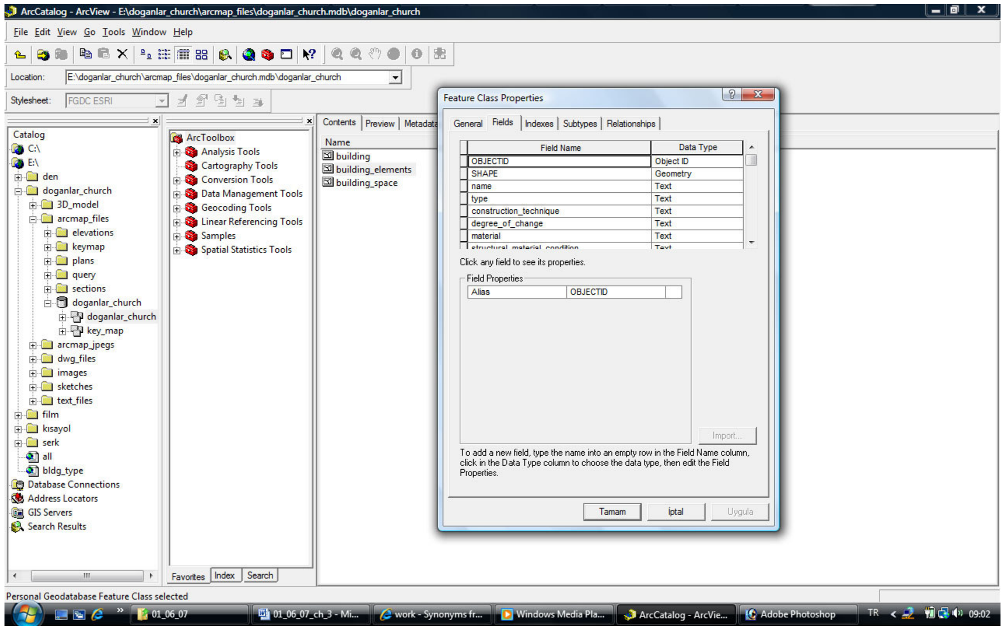


Figure-35 ArcCATALOG filing system “building elements” feature class.

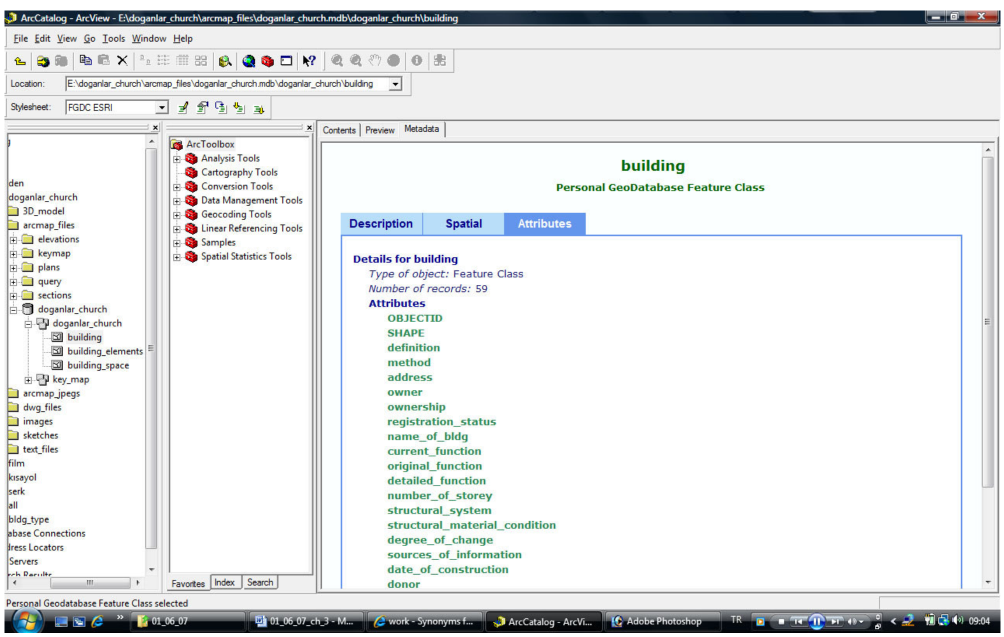


Figure-36 Atttributes for “building” feature class.

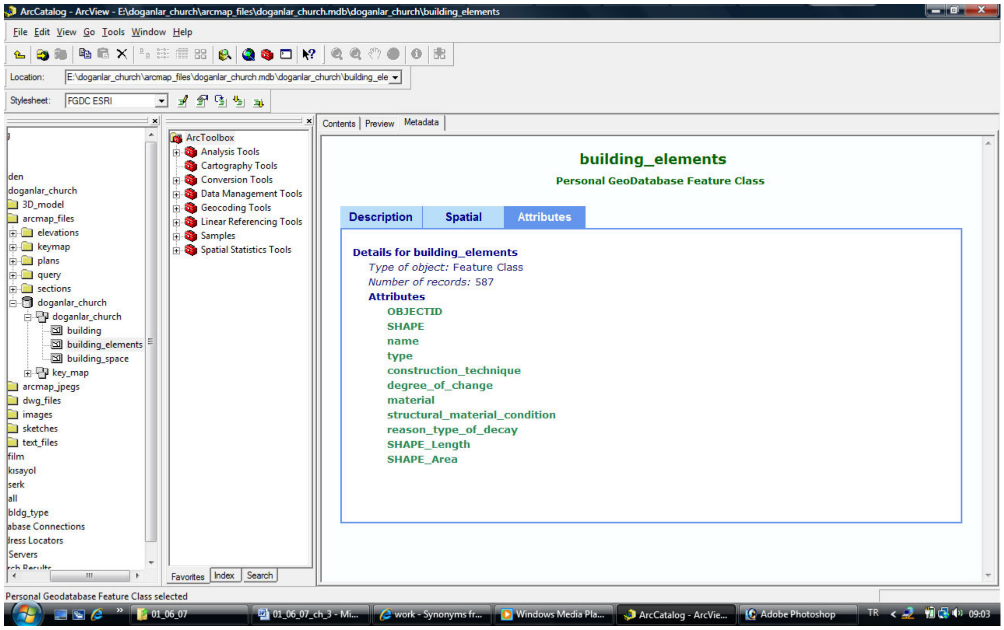


Figure-37 Attributes for “building_elements” feature class.

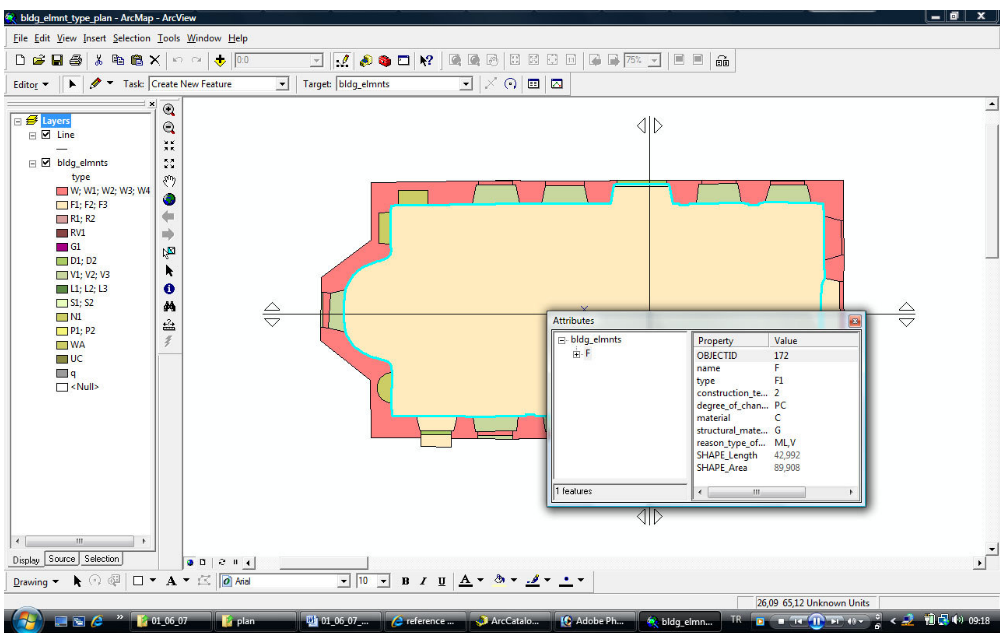


Figure-38 Data entry

During the data entry first the graphic data created in AutoCAD is transferred to ArcMap as different feature class and attribute data for each feature is entered (Figure 38).

However, the data entry process had not been so unproblematic. Especially during the transfer of both 2D and 3D graphic data created in AutoCAD, the study had to be reconsidered several times. The important point here is the format of the spatial objects at the drawings throughout the transfer of the drawings to GIS environment. At first the drawings were prepared in AutoCAD as polylines that represents the façade or plan objects. During the transfer of these drawings, it was realized that the spatial objects at the drawings (i.e. the plaster covering at the exterior façades, the stone lintels, the brick walls, etc.) should have been prepared as polygons in order to introduce the objects in GIS environment as visible and usable data. Hence the drawings revised and were changed to the polygons and transferred to GIS environment. But again the drawings could not be visualized as usable data objects in GIS. At this phase it is understood that the spatial objects should have been closed polygons in order to be visualized in GIS. Considering this problem the drawing process was repeated and the spatial objects that were created in AutoCAD were changed into closed polygone objects. By this exercise it was understood that, in order to use the spatial objects that were drawn in AutoCAD, it was necessary to draw closed polygone objects.

The other study was maintained with the transfer of the 3D model of the building that was prepared in 3D AutoCAD. The model was prepared as vertical and horizontal elements of the main building and completed with the architectural and finishing elements similar to the database system. (see Appendix-A) At this study the important point was to evaluate the whole building as a complete model in order to visualize the building on different data topics with all components. The visualization of this model at GIS environment could not be possible. Only the model was transferred to the ArcVIEW in which no kind of data query is possible. (Figure 39-40)

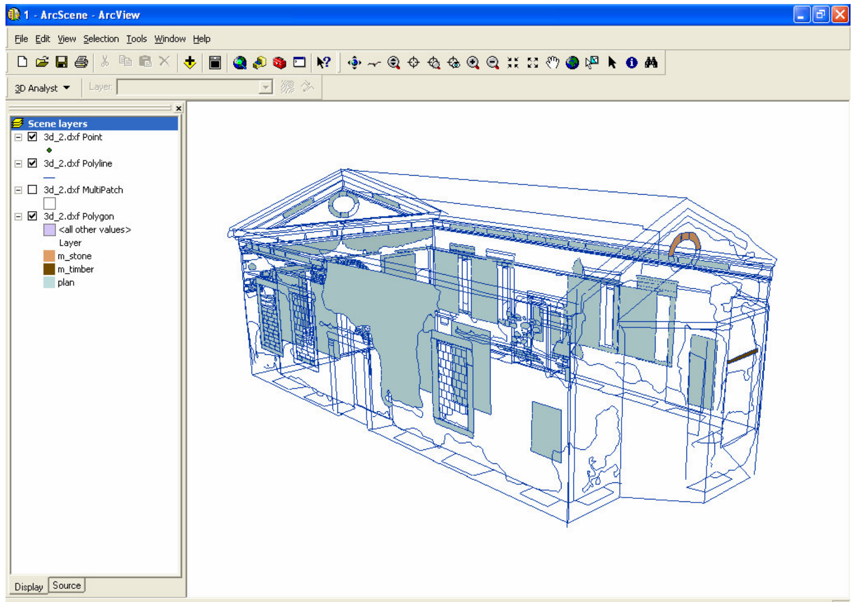


Figure-39 Visualization of 3D model in ArcVIEW

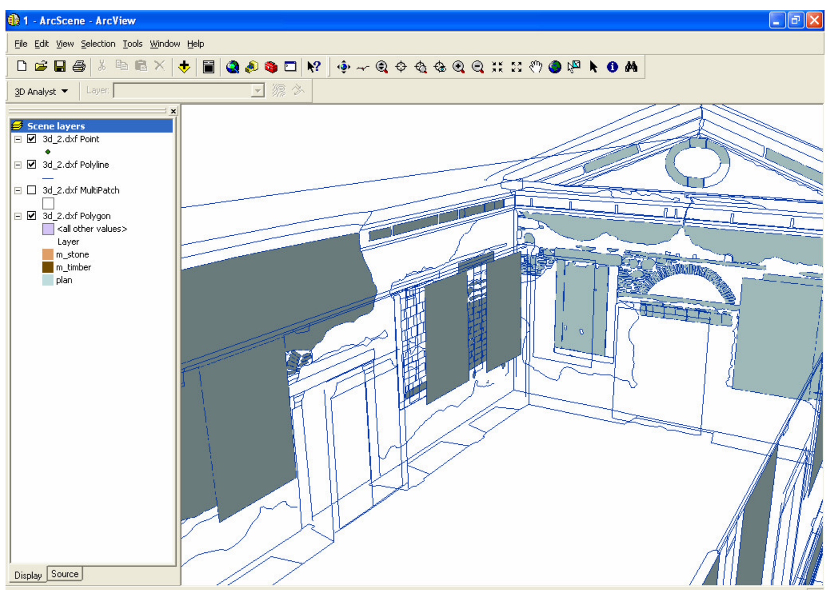


Figure-40 Visualization of 3D model in ArcVIEW

The queries in GIS could be prepared with closed spatial objects as previously mentioned, but it could not be possible to transfer and query the multipatch data to GIS. The model was evaluated as documentation drawing with the layer system that was prepared according to the material diversity of the building. (see Appendix-A)

Following the entry of graphic and attribute data about each feature class, thematic maps are provided over different data topics.

Starting from the larger scale, first of all a map showing the building within its surrounding site is prepared. In this map, the roads, the buildings and natural environment around the building were documented. The basic information about the building is given within its surrounding context, for instance; the address of the building, the ownership and the owner of the building, the registration status, the original and the current function of the building, date of construction, sources of information, height of the building, etc. these parameters documented with the building's surrounded site.

Following the site plan, various thematic maps are also prepared for the building itself over the measured drawings of plan, sections and elevations. In these maps, material, construction technique, degree and types of changes, structural condition and material condition are given. The detail drawings and pictures for the areas that were investigated in detail are linked by hyperlinks.

Last but not least are the thematic maps about finishing elements of the building. At this point the elements were studied according to their name, construction type, material diversity, change degree, structural and material condition and reasons and types of decays. The detail drawings, photographs and the documents related to the surveyed area was added with hyperlinks to the places that are studied in detail.

Table-9 Construction Process of HBIS for Doğanlar Church / Office Work

- Transfer of measured points to CAD environment.
- Preparation of CAD drawings.(2D ***AutoCAD*** drawings)
- Preparation of 3D model.
- Database design with ***ArcCATALOG***.
- Transfer of CAD drawings to GIS environment.
- Re-evaluate the CAD drawings.(line to polygon)
- Re-transfer of CAD drawings to GIS environment.
- Re-evaluate the CAD drawings.(polygon to closed polygon)
- Re-transfer of CAD drawings to GIS environment.
- Transform of drawings into "***dxf***" format in order to get 3D visualization of the building in ***ArcVIEW***.
- Re-evaluate the 3D CAD drawing.(polygon to 3D multipatch)
- Data entry.
- Re-evaluate the database design.
- Re-construction of database design.
- Re-entry of data.
- Preparation of ***ArcMAP*** files.
- Production of thematic maps
- Queries between different data topics.
- Visualizing thematic maps and results of the queries
- Creating hyperlinks over a key map.
- Designing the users' manual for data entry and visualization

Besides the thematic maps queries are also produced over different data topics in order to see the relation between them and consequently evaluate the building in a better way.

Having superimposed layers allows making different kinds of queries. These queries enable the information to be evaluated from a better perspective and provide new kind of information. For instance, the primary interventions can be decided by making queries between logically related data topics. These queries were tested by some certain data topics. The system allows displaying the requested queries by superimposing the selected data topics. At this point the selected data are "the change status of the building components" and "the structural and material condition". (see Appendix-G) Demanding the mostly changed areas with severe material and structural problems gives information about the primary intervention areas. For instance, if the problematic area is a later addition without any authentic features, the intervention type can be decided as to be removed. With the help of this kind of queries, new and improved information can be stated to be used throughout the conservation decision making process of historic buildings.

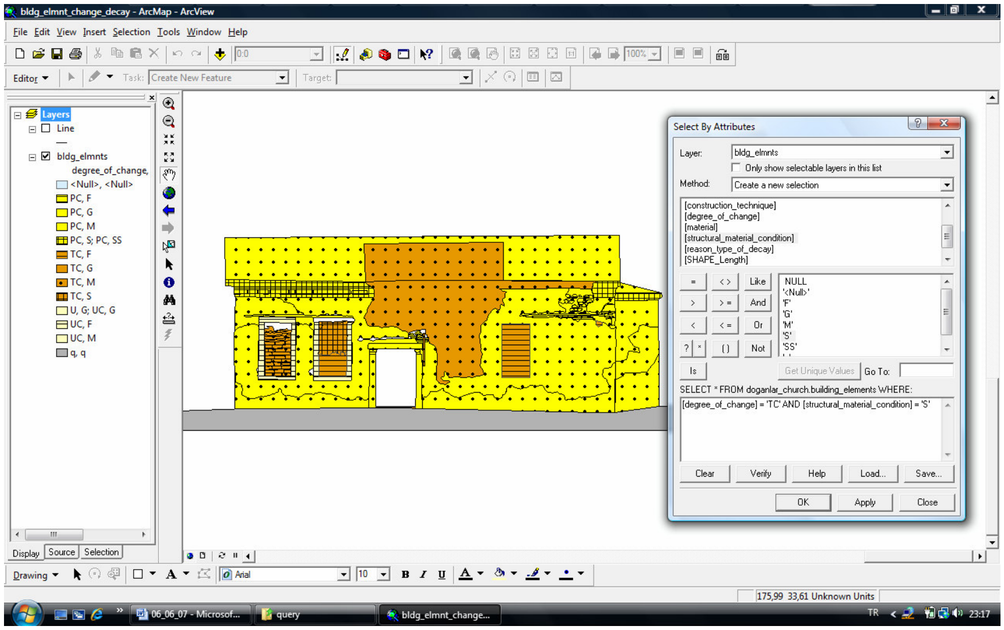


Figure-41 Queries about the material condition and change status

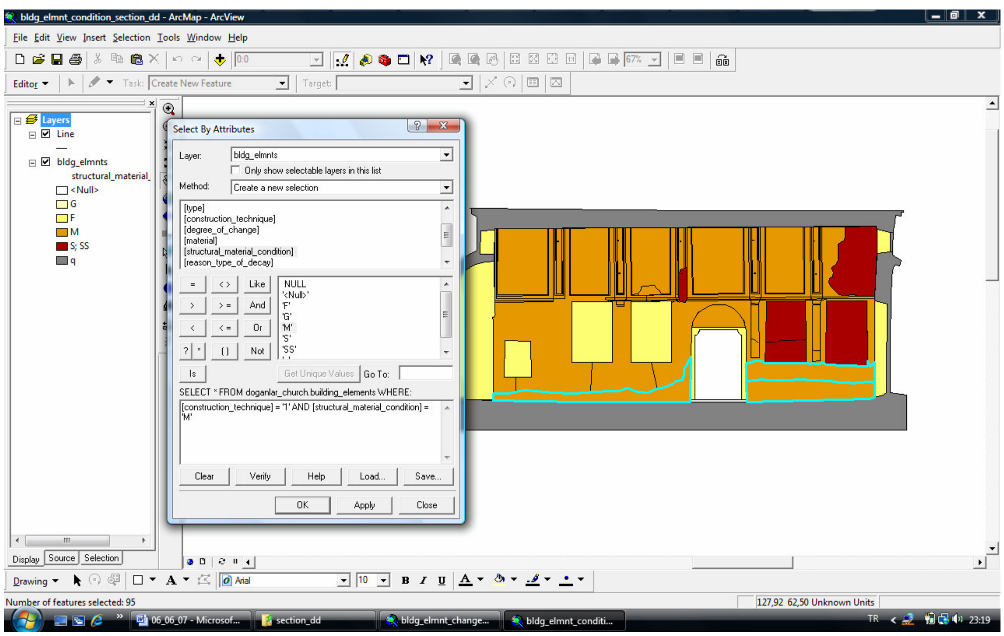


Figure-42 Queries about the construction technique and structural and material condition

2D drawings are integrated with each other in GIS environment through a key map. Each drawing has been established so as to define a relation with this key model. For instance, the elevation drawings have been related to the key model with the hyperlinks placed on to the walls.

The key map that associates the entire study is the plan drawing of the building. The relevance was established by using hyperlinks for the section and elevation drawings as well as the detail drawings. Related drawings were studied on three main topics which are; building with its surrounded context, building space and building elements. These three main groups were studied on the subjects that were decided during the database system design.

At this phase, visualization of the data is provided by the 2D drawings. 3D textured model could not be transferred to ArcMAP and visualization and querying could not be possible. The 3D model could only be visualized in ArcVIEW, but the editing could not be possible through this program.

The reason of the lack of visualization and editing of 3D model in ArcGIS is because the system becomes active for the utilization of data in x and y coordinates system. The system requires data with reference points connected to Earth's surface. With the technological developments or with an additional program the visualization and editing capabilities of multipatch data can be improved for future studies.

3.2.4 Data Visualization

The components of HBIS of Doğanlar Church were stored through a file system. Each file related to the building stored according to its data type. First the main file was created with the name "Doğanlar Church". This file consists of six files that store all the documents due to the file type. First one is the "arcmap files" where the ArcMAP documents were stored. Another file is about the images of the building. This folder contains the image files with reference to their locations. The sketch files that have been prepared throughout the site survey also stored through this filing system and these files were located as sketches under the main file "Doğanlar Church". Another file folder was created for the text files related to the building, such as the descriptions.

This filing system also provides the organization of hyperlink files. The 2D visualization files were connected through a key map. This key map combines all the information and document about the building such as the sketches that have been made through the site survey as well as the ArcMAP jpeg files. With the help of this filing system all the information and documents about the building can be managed.

The utilization of this filing system could be possible through GIS. With the help of this storing system the updated information about the building can also be added, this way monitoring of the building is provided.

Finally a user's manual is designed which defines the procedures for data entry and inquiry for different users with different purposes.(see Appendix-H) For instance; if the user want to view the ArcMAP files of Doğanlar Church, the procedure defines the user what to do. First of all the ArcMAP file is opened, and following this the requested feature class is chosen (such as; plan, sections, elevations, etc.) and the "Layer Properties" folder is opened by right-clicking the previously decided feature class. (Figure-43) At this point the "Display" property is chosen and the "Support Hyperlinks Using Field" is checked and activated by clicking "OK" button. Following this the requested attribute (at this point the "arcmap_files" attribute) is chosen. (Figure-44) Now the system is activated for the selected display. For displaying the ArcMAP files of the selected feature class, the hyperlink icon is chosen and the requested display is utilized simply by clicking the requested representation displayed as lines, points or areas. (Figures 45, 46)

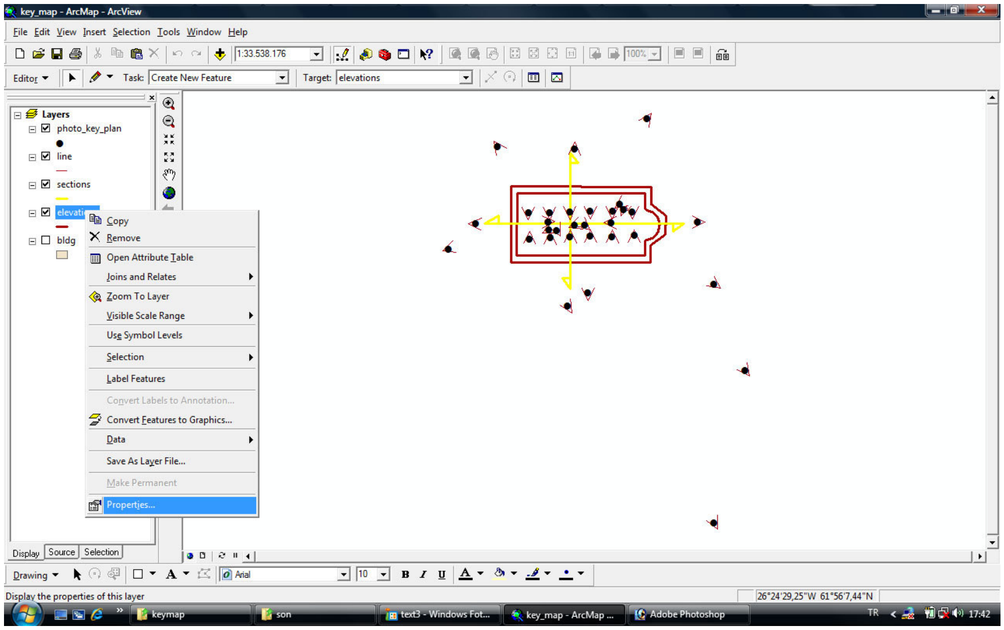


Figure-43 Opening the “Layer Properties” folder is opened by right-clicking the requested feature class.

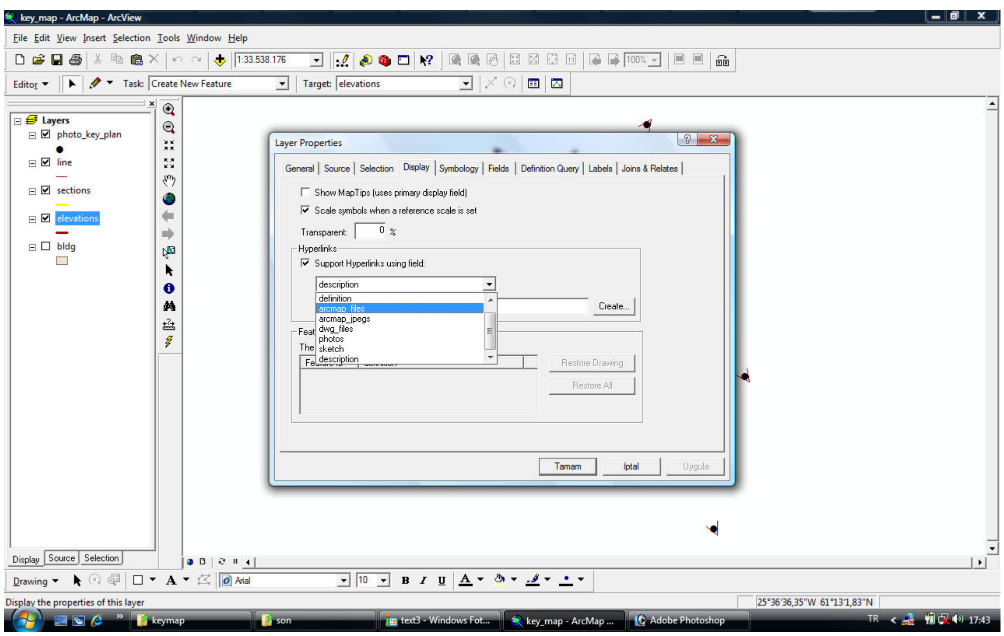


Figure-44 Selecting the requested attribute.

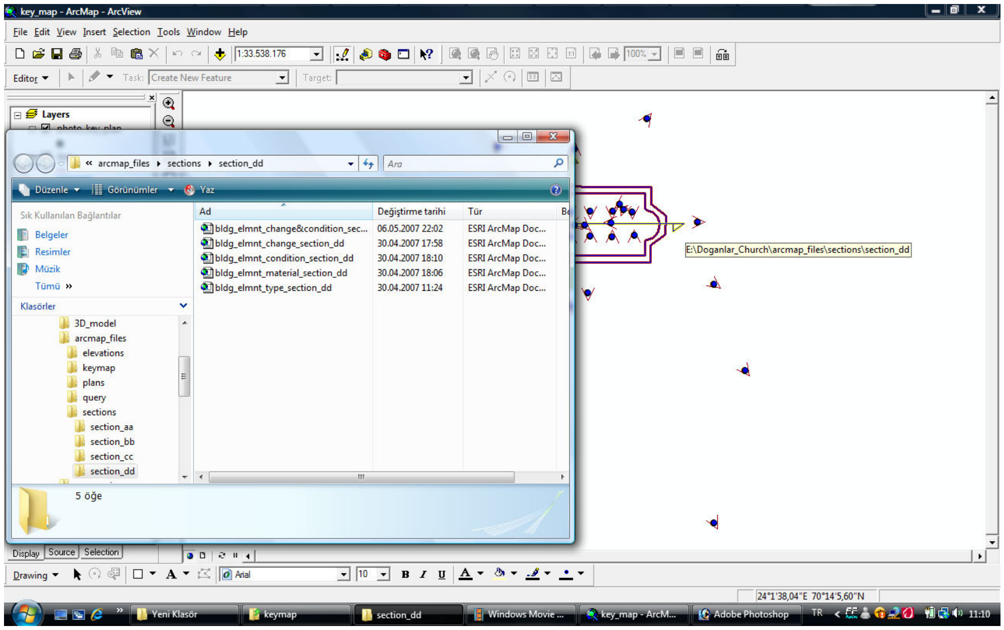


Figure-45 Utilization of hyperlink.

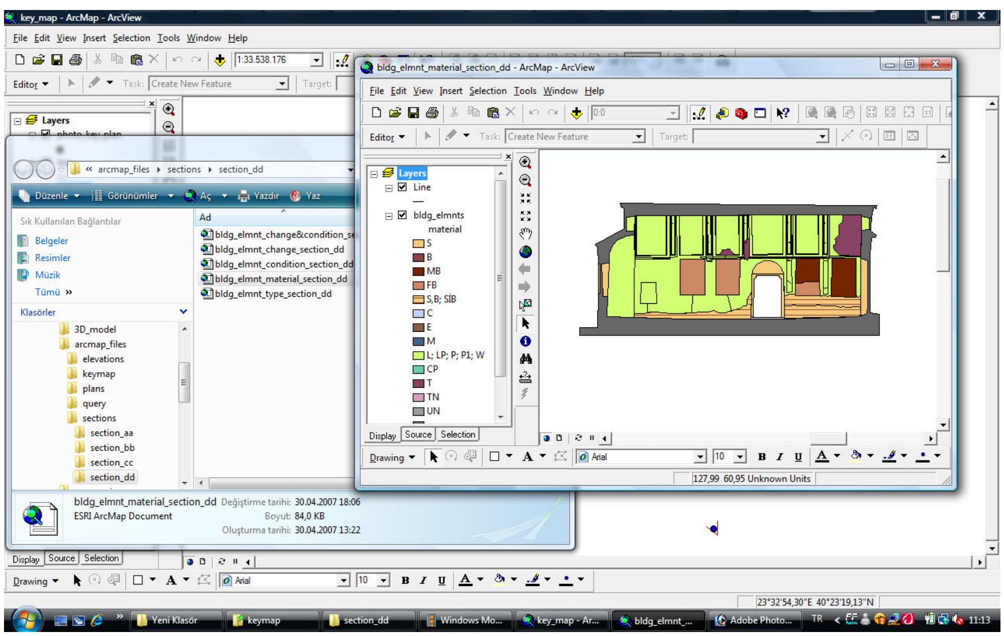


Figure-46 Opening the selected ArcMAP file.

The utilization of HBIS at this project enabled the author to deal with the comprehensive data through a pre designed data structure. So, the collecting, analyzing and evaluating the data about the historic building was utilized in GIS environment. The transformation of collected data to utilizable information was handled with HBIS by making different queries and different data analysis.

CHAPTER 4

CONCLUSION

Throughout the conservation decision making process of historic buildings, rich and complex data is evaluated. These data groups, coming from different sources, necessitate the management of data in order to provide utilizable information. Conservation process includes the collection, evaluation, analysis, visualization and continuous monitoring of data collected from the historic building. With the purpose of getting an organized data structure this process should be systematic and efficient.

At this point categorization and questioning of information is very important. Furthermore, the sharing and display of this information with different professions is also important so that the information can be used efficiently.

One of the major conclusions of this thesis is that the conservation process of historic building requires the management of collected and evaluated data in order to improve the quality of information gathered. The data is the major component of conservation decision making process and information systems are efficient tools for storing, organizing, analyzing, evaluating and monitoring this data.

Although the use of information technologies in conservation of historic buildings is an improving issue, the application of information technologies as a supporting for conservation decision making process of historic building is not evolved yet. Even the methodology of the use of these systems for this purpose is not defined properly. This thesis shows the importance of such systems in conservation process of historic buildings.

4.1. Appropriateness of the Proposed HBIS as a Supporting Element for Conservation Decision Making Process

Historic Building Information System (HBIS) prepared for Doğanlar Church enables making an assessment of the advantages, disadvantages and problems of the utilization of GIS as a supporting element in conservation decision making process.

First of all GIS is a useful data management tool that enables the classification of data in different formats. Starting from the data entry to the system data is classified and categorized due to the data features. These obtained information can also be visualized in different formats in the system such as; thematic maps, table graphics or charts. This provides the variety in presentation techniques compared to the conventional techniques. The production of these kinds of display opportunities creates more efficient analysis and evaluations. With the help of various queries of different data topics enables more efficient analysis and evaluation phases. For instance, the material distribution, decay problem-intervention relation, decay types-material relation etc. can be queried with the help of the system and can be evaluated as valuable information for the conservation decision making process.

Secondly the opportunity of renewal and updating the data is a great advantage of GIS. These changes and additions can provide the continuous conservation of the building and creates a sustainable conservation decision making process. The monitoring can be provided by updating the data in the system and automatically all the changes and updates can be visualized thorough the system, however in the conventional technique this kind of corrections or updates can be provided only by utilization of the updated information for each map individually.

Additionally GIS is a useful storage tool for spatial data. Any data with any extension can be stored in the system and can be related with each other. These various data can be related with each other with the help of hyperlink feature of GIS and all these hyperlinks can be related with the help of a key map. GIS creates an integrated environment in which the spatially referenced data is connected with attribute data. The system provides the use of database system that enables making queries between different data topics. The visualization of these queries can be seen in thematic maps that can be the utilization of multiple data queries. This related environment is a consequence of different data types produced by different software programs. For instance, the transfer and adaptation of the CAD drawings or digital images is possible within GIS environment.

GIS creates information that can be shared easily through internet or shareware connections. This connected environment provides the use of the data in different systems and projects. For instance the information gathered from Doğanlar Church can be adapted to a large scale urban project. The scale of the data that is entered to the system is 1/1 scale, hence evaluations can be visualized and be a part of a project in any scale.

The utilization of GIS in Doğanlar Church also created some problems, such as; editing insufficiency (lack of 3D editing), complex and long preparation phase and limited possibility of renewal of data transferred from other software.

The documentation drawings of Doğanlar Church were prepared in CAD environment and the drawings transferred to the system. The lack of preparation of drawings in architectural detail in the GIS environment provided the correction and renewals held in CAD environment and transferred to the system. And the lack of 3D editing in GIS environment resulted as the inappropriateness of the system for 3D models. The capabilities of the system should be improved according to the use of 3D editing.

The process of the utilization of GIS in historic building conservation is a new issue. Therefore the process itself is challenge to understand the capabilities of the system properly. This creates a long time during the preparation and decision making process.

The spatial data that was used through the conservation process of Doğanlar Church was prepared in different software. The measured drawings were prepared with AutoCAD and the data entry was made with GIS. Hence the correction and renewal of the drawings had to be done in CAD environment. For instance the use of polygons could only be possible as if they were closed polygons and this correction was held in CAD environment. All the process was renewed and all the drawings were transferred to the system one more time and this provided a long process.

4.2. Further Study Topics

Within this thesis, it could not be possible achieve all the objectives which were defined at the very beginning of this study. This was partially due to the constraints of the technology and partially due to the impossibility of a multidisciplinary teamwork. Therefore this thesis brought out new questions and research topics which require further studies, joint efforts and collaboration of GIS specialists and conservation architects, such as:

- Establishing a 3D GIS environment which allows both data entry and visualization over a single environment
- Establishing data modeling procedures for providing basis for interventions

Table-10 Comparison of different visualization techniques

	METHOD	SOFTWARES	TIME SPENT	CONVERSION TO SIS AND IMPLEMENTATION IN GIS	ABILITY TO BE MONITORED	QUALITY OF PRESENTATION	EVALUATION OF PROBLEMS	DEGREE OF DIFFICULTY	EVALUATIONS
2D SIS IN GIS	The 2D CAD drawings were prepared by AUTOCAD 2007 program.Rectified images and coordinate points were used.	AUTOCAD 2007 MSR GIS	The 2D CAD drawings were prepared in one week.	2D drawings can be prepared easily.	Update of the information and monitoring is possible.	Similar to conventional method.	Unable to see whole building at the same sheet.	2D drawings can be prepared easily.	Storage and monitoring is an advantage compared to the conventional method. The queries can be made between all the data topics that were decided. Queries about the intervention types are successful.
3D KEY MODEL IN GIS	Key model was prepared in AUTOCAD 2007. The 2D drawings is linked to this model in GIS.	AUTOCAD 2007 MSR GIS	The 2D CAD drawings were prepared in one week. 3D key model was prepared in one day.	2D drawings and the key model can be adopted to GIS and similar programs.	Update of the information and monitoring is possible.	Similar to conventional method.	Unable to see whole building at the same sheet.	2D drawings and 3D key model can be prepared easily.	Key model is a combining element that is an advantage for storing the data. This key model helps to realize the building as a whole. Presenting in 2D drawings make it difficult to understand the building as a whole.
3D SIS IN GIS	The 2D CAD drawings were prepared by AUTOCAD 2007 program. 3D render was prepared in 3D AUTOCAD.	AUTOCAD 2007 MSR	The 2D CAD drawings were prepared in one week. 3D rendered model was prepared in two week.	3D model can not be adopted to GIS.	3D model can not be applied to GIS monitoring is not possible.	Observation of the building as a whole is an advantage.	Unable to adopt to GIS.	The preparation of 3D rendered model is difficult.	Pesentation on 3D model is an advantage to observe the building as a whole in the topics like, material, problems, solutions, etc. But the adaptation problem of the model to GIS is a disadvantage. This method can be improved with the help of technological developments.
3D SIS IN MICROSTATION GEOGRAPHICS	The 2D CAD drawings and 3D render was prepared in AUTOCAD 2007. The drawings uploaded to Microstation Geographics.	AUTOCAD 2007 MSR MICRO STATION GEOGRAPHICS	The 2D CAD drawings were prepared in one week. 3D rendered model was prepared in two week and drawings uploaded to Microstation Geographics	3D model can be adopted to MICRO STATION GEOGRAPHICS and queries can be made.	3D model can be applied to MICRO STATION GEOGRAPHICS and monitoring is possible.	Observation of the building as a whole is an advantage.	Program used is not used so common like GIS.	The program is more complicated.	The use of MICROSTATION GEOGRAPHICS is queried for only some topics because of the limited time, this method should be investigated in more detailed way.

BIBLIOGRAPHY

AGOSTO E., OSELLO, A. PERETTI L. & RINAUDO F.(2005), *'S. Marco's Church in Vercelli: The Shape Model for the Reutilize Lidar Project in a Simple Architectural Space Survey',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

AL BAYARI O. (2005), 'New Survey Technologies for Production of GIS Model of the Ancient Roman Jerash City in Jordan', CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

AKCAY O. & YILMAZTURK F(2005), *'An Approach for Representation of Historical Objects by Means of 2D Web-Based GIS',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

ALMAGRO, A., CARBONARA, G., CASIELLO, S., CUNDARI, D., DE FIORE G., DOCCI M., FONDELLI M., KIROVA T., MANDELLI E., TOTA P., DORIA R., ROBOTTI C., SAINT-AUBIN J. P. & STARACE F. (2000), 'Architectural Survey Chart', Il Rilievo Aarchitettonico per la Conservazione Congress, Rome, 16-18 November 2000

ALTINOZ A. G. B. (2002), Assessment of Historical Stratification in Multi-layered Towns as a Support for Conservation Decision-Making Process; a Geographic Information Systems (GIS) Based Approach Case Study: Bergama, Unpublished PHD Thesis, Department of Architecture – Restoration Program, METU

ARDISSONE P. & RINAUDO F. (2005), *'A GIS for the Management of Historical and Archaeological Data',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

BACIGALUPO C., CESSARI L., FANGI G. & GIGLIARELLI E. (1999), *'Information and Cataloguing Systems for the Conservation and Re-use of Vernacular Architecture',* 2nd International Congress on Science and Technology for the Safeguard of Cultural Heritage in Mediterranean Basin, Paris, 5-9 July

BALLETTI C., GUERRA F. & ADAMI A. (2005), *'3D Multiresolution Representations in Archaeological Sites',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

BARATIN L., CUPPINI G. & SAINT-AUBIN J. P. (1999), *'Systeme 3D d'Informations Localisees pour l'Etude et la Conservation des Bıens Architecturaux dans la Cite Historique: Reflexions sur la Structuration des Donnees',* 2nd International Congress on Science and Technology for the Safeguard of Cultural Heritage in Mediterranean Basin, Paris, 5-9 July

BARNOBI L., COLAIACOVO L. & ANDREOZZI L. (2005), *'Three-Dimensional Digital Models for Architecture's Documentation: Badia di S. Agata in Catania',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

BAUMANN S. M. (1999), *'Integrating GIS and Cultural Resources Databases for Archaeological Site Monitoring',* Cultural Resource Management, 9, 33-35

BELFORTE S., LOGGIA A. & RIVA D. (1999), *'Historical Building Guidelines Information Basis for Architectural Property Restoration',* 2nd International Congress on Science and Technology for the Safeguard of Cultural Heritage in Mediterranean Basin, Paris, 5-9 July

BILGIN, A. G. (1996), Urban Archaeology: as the Bases for the Studies on the Future of the Town Case Study: Bergama, Unpublished Msc Thesis, Department of Architecture – Restoration Program, METU

BURROUGH P. & MCDONNEL R. (1999), Principles of Geographical Information Systems, Oxford

CELENK E., OZALP T., ARIKAN F., & AYDIN E. (2005), *'Establishing a Digital Platform for Culture of Turkey',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

CLARKE K.C. (1997), Getting Started With Geographic Information Systems, Prentice Hall, New Jersey

CUNDARI C. & MESCHINI A. (1999), *'Le Sirpa-Systeme Informatise pour le Releve et le Projet Architectonique',* 2nd International Congress on Science and Technology for the Safeguard of Cultural Heritage in Mediterranean Basin, Paris, 5-9 July

CUNDARI C., BARLOZZINI P. & PISCITELLI M. (1999), *'La Communication Multimediale en Architecture: le CD-ROM',* 2nd International Congress on Science and Technology for the Safeguard of Cultural Heritage in Mediterranean Basin, Paris, 5-9 July

DALLAS, R. (2003), '*Measured Surveys of Historic Buildings: User Requirements and Technical Progress'* Journal of Architectural Conservation, 2, 58-81

DAVIS B.E. (2001), GIS: a Visual Approach, Delmar Thomson Learning, Albany New York

DEMERS M. N. (2005), Fundamentals of Geographic Information Systems, John Wiley & Sons, New York

DRAP P., DURAND A., SEINTURIER J., VANNINI G. & NUCCIOTTI M. (2005), *'Full XML Documentation From Photogrammetric Survey to 3D Visulization; the Case Study of Shawbak Castle in Jordan,* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

DU Z., LI D., ZHU Y. & ZHU Q. (2005), *'3DGIS-Based Digital Reconstruction and Dynamic Visualization of Timber-Frame Building Cluster',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

EL-HAKIM S. F., BERALDIN J. A., GONZO L., WHITING E., JEMTRUD M. & VALZANO V. (2005), *'A Hierarchical 3D Reconstruction Approach for Documenting Complex Heritage Sites',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

ERDEM R., DURDURAN S., CAY T., DULGERLER O. N. & YILDIRIM H. H. (2004), '*An Experimental Study of GIS-Aided Conservation Development Plan; the Case of Sille-Konya',* ISPRS Congress, Istanbul, Turkey, 12-23 July

FRANCESCO C., DI BORTOLOTTO S. & LOCATELLI E. (2005), *'Creation of a Information System Relating to the Archives of Architectural Sites'*, CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

FOTHERINGHAM S. & ROGERSON P. (1994), Spatial Analysis and GIS, Taylor & Francis, London

HODAC J. (2004), *'Spatial Information System of Historical Site-Proposal and realization of Functional Prototype',* ISPRS Congress, Istanbul, Turkey, 12-23 July

HARMON J. & ANDERSON S., (1993), The Design and Implementation of Geographic Information Systems, New York, USA

HEYWOOD D. I. (2006), An Introduction to Geographical Information Systems', Harlow, England; New York: Person Prentice Hall

HODAC J. (2004), *'Spatial Information System of Historical Site-Proposal and Realisation of Functional Prototype',* ISPRS, Istanbul, Turkey, 12-23 July

HOFFER J. A., PRESCOTT M. B. & MCFODDEN F. R. (2005), Modern Database Management, Pearson Education, New Jersey

HUXHOLD W.E. (1995), Managing Geographic Information System Projects, Oxford University Press, New York

IONANNIDIS C., POTSIOU C. & SOLIE S. (2004), *'An Integrated Spatial Information System for the Development of the Archaeological Site of Mycenae',* ISPRS, Istanbul, Turkey, 12-23 July

KARSLI F., AYHAN E. & TUNC E. (2004), *'Building 3D Photo-texture Model Integrated With GIS for Architectural Heritage Conservation',* ISPRS, Istanbul, Turkey, 12-23 July

LELO K. & TRAVAGLINI C. M. (2005), *'The GIS-Based Historical Atlas of Rome',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

LONGLEY P. A. (2003), Advanced Spatial Analysis: the CASA Book of GIS, ESRI Press, Redlands-California

LETELLIER R. and GRAY, C. (2002), 'Bridging the Gap Between Information Users and Information Providers' Report of Roundtable 1, Los Angeles, 4-5 March

MITCHELL A. (1999), The ESRI Guide to GIS Analysis, ESRI Press, Redlands California

MENUGE, A. (2006), Understanding Historic Buildings: A Guide to Good Recording Practice. London: English Heritage

MOSCATI P. (1999), *'The Caere Project: Methodological and Technical Considerations',* 2nd International Congress on Science and Technology for the Safeguard of Cultural Heritage in Mediterranean Basin, Paris, 5-9 July

MURAI S. (1998), GIS Work Book (Fundamental Course).Tokyo, JAS

NAYCI, N., BİLGİN ALTINÖZ, A. G., GÜÇHAN, N. Ş. (2003). *'An Appraisal of the Utilization of GIS in an Urban Conservation Project in Antakya'*, in M. O. Altan (ed.) *Proceedings of the XIXth International Symposium, CIPA 2003: New Perspectives to Save the Cultural Heritage*, Antalya (Turkey), 30 September-04 October 2003,

NEUBAUERA W., DONEUSB M., STUDNICKAC N. &, RIEGLC J., (2005), *'Combined High Resolution Laser Scanning and Photogrammetrical Documentation of the Pyramids at Giza'*, CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

PINI R., SIANO S., FABIANI F., SALIMBENI R., GIAMELLO M. & SABATINI G. (1999), *'Laser Cleaning of Stones: Basic Research, Development of an Optimized Laser System, and Applications to Italian Monuments',* 2nd International Congress on Science and Technology for the Safeguard of Cultural Heritage in Mediterranean Basin, Paris, 5-9 July

REIS S., NISANCI R., YILDIRIM V., INAN H. I. & YOMRALIOGLU T. (2004) , *'An Immovable Historical Asset Information System Design and Application: A Case Study of Trabzon',* ISPRS Congress, Istanbul, Turkey, 12-23 July

SALONIA P. (1999), *'Knowledge for the Recovery of Historical and Architectural Heritage and Information Technology: Theorotical and Methodological Aspects and Practical Applications',* 2nd International Congress on Science and Technology for the Safeguard of Cultural Heritage in Mediterranean Basin, Paris, 5-9 July

SCOTT, C., BOOTH B., DALTON, K., MITCHELL A. and CLARK, K., (2004), ArcGIS 9: Getting Started With ArcGIS. New York: ESRI

SCHMID, W. (1999), GRADOC (Graphic Documentation Systems in Mural Painting Conservation) Research Seminar Notes, Rome, 16-20 November

SPANO A. & BONFANTI C. (2005), *'Large Scale Spatial Database Supporting Archaeological Research',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

STILLWELL J. & CLARKE G. (2004), Applied GIS and Spatial Analysis, Wiley, Chichester, England

SURUL, A., ÖZEN H. & TUTKUN M. (2004), *'Icomosdigital Database of the Cultural Heritage of Trabzon',* ISPRS Congress, Istanbul, Turkey, 12-23 July

TSIOUKAS V., TSIRLIGANIS N., PAVLIDIS G., ARNAOUTOGLOU F., CHAMZAS C., MPAKOUROU E. & MEXIA A., (2005), *'Photogrammetric Modeling of Byzantine Churches',* CIPA 2005 XX International Symposium, Torino, Italy, 26 September – 01 October

WALDHAUSL, P. And OGLEBY, C. (1994), *'3x3 Rules for Simple Photogrammetric Documentation of Architecture'*. Close Range Techniques and Machine Vision Symposium, Melbourne, 1-4 March 1994

WADSWORTH R. (1999), Geographical Information Systems: an Introduction, Longman, Harlow-Essex

WEINMANN R., FLETCHER I., FREIWALD N. & VOGEL B. (2000), *'Moving the Image: Visual Culture and the New Millennium',* 16th CHArt Conference, London, 1-2 September

WHITING D. (2005), Computer Aided Recording Tools Automate the Creation of a Site Information System, Government Services Canada Real Property Services for Parks Canada Calgary, Ontario

ZLATANOVA S. (2002), *'Advances in 3DGIS'*, Disegno e Design Digitale (DDD) Rivista Trimestrale di Ddisegno Digitale e Design Edita da Poli Design, 20 December

11th International Congress on Architectural Archives (International Council on Archives/ Architectural Archives Section). Retrieved May 2, 2007, From Web site: http://www.vitruvio.ch/

Architectural Archives of the University of Pennsylvania . Retrieved May 2, 2007, From Web site: http://www.upenn.edu/gsfa/archives/archives/index.html

English Heritage. Retrieved May 2, 2007, From Web site: http://www.english-heritage.org.uk/

Getty Art & Architecture Thesaurus. Retrieved May 2, 2007, From Web site: http://www.getty.edu/research/tools/vocabulary/aat/index.html

Getty Guide to the Description of A.D. Retrieved May 2, 2007 From Web site: http://www.getty.edu/research/institute/standards/fda/index.html

SICOM-About Spatial Information System. Retrieved May 2, 2007 From Web site: http://www.environment.sa.gov.au/mapland/sicom/info/index.html

APPENDIX-A

THEMATIC ANALYSIS AND QUERIES

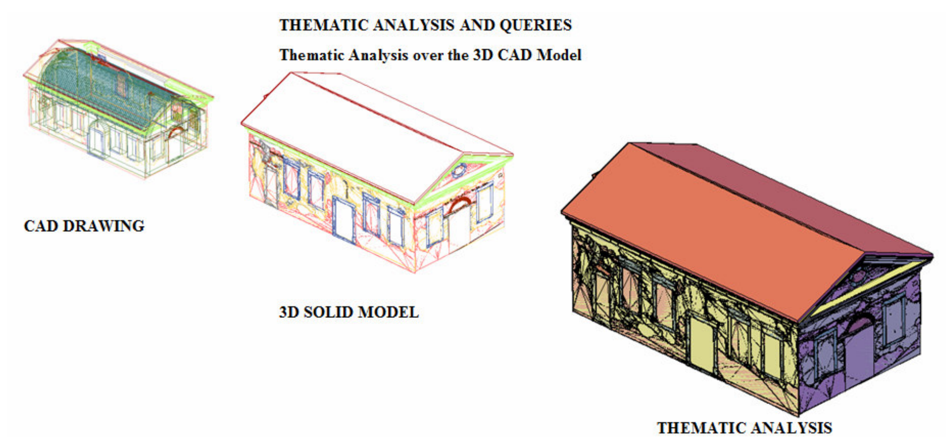


Figure-A.1 Thematic analysis and queries in CAD environment

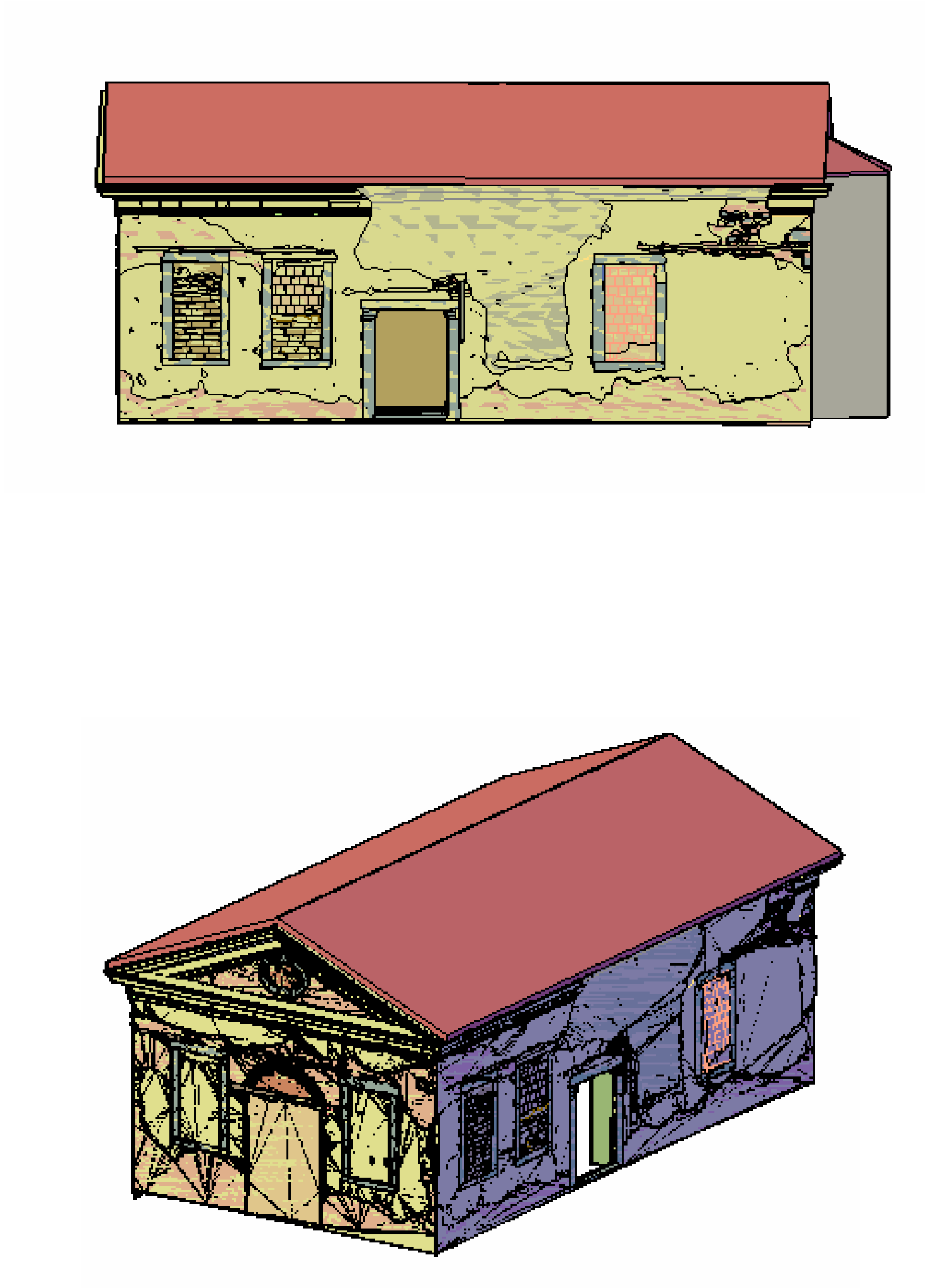


Figure-A.2 Visualization of 3D model in AutoCAD

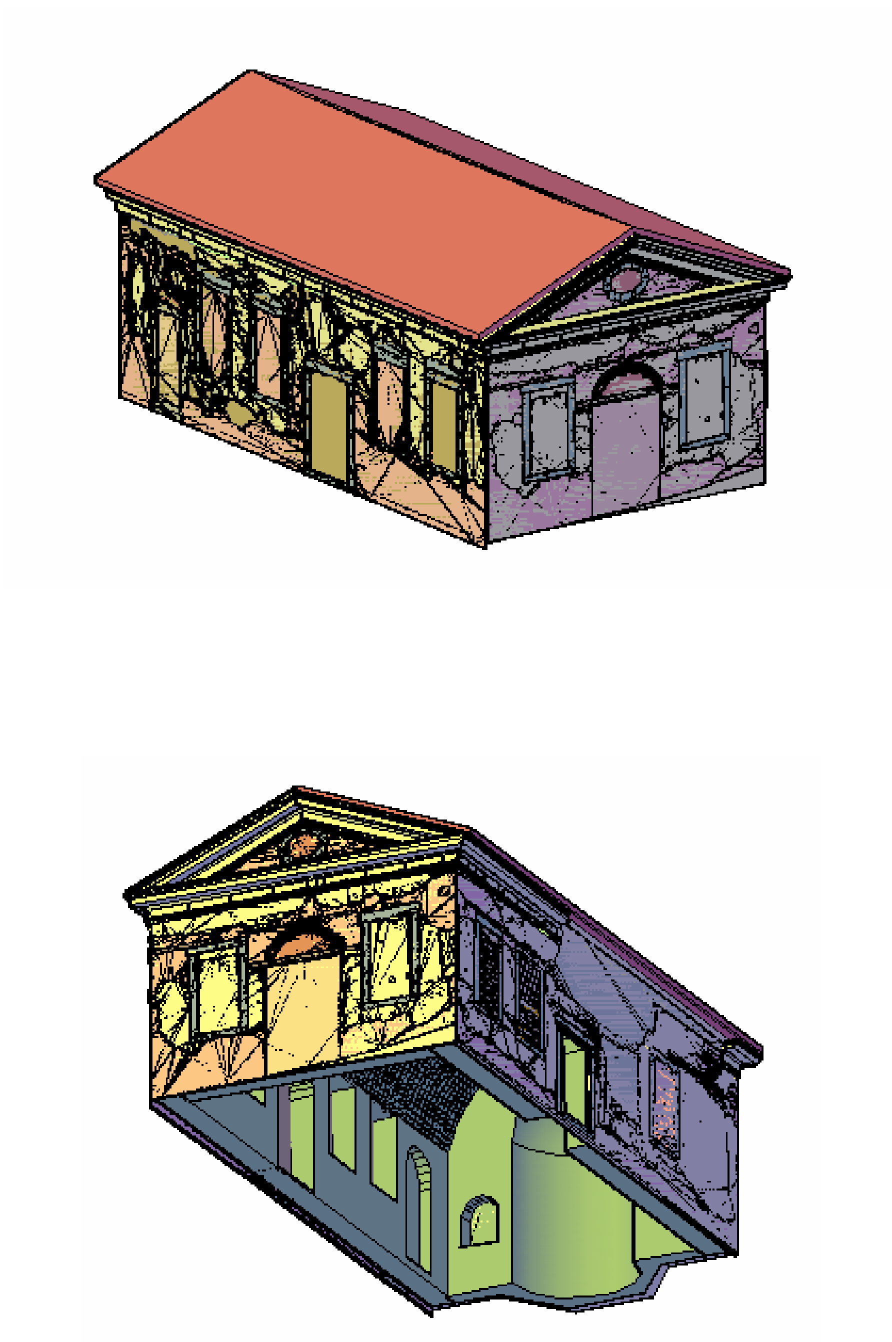


Figure-A.3 Visualization of 3D model in AutoCAD

APPENDIX-B

THEMATIC VISUALIZATION IN GIS; SITE SCALE

This paper shows Doğanlar Church with its surrounded site. The building is situated in Doğanlar village, Bornova. The village is an old village but there is no historic building nearby the church. There are no boundaries between the church and the surroundings like walls.

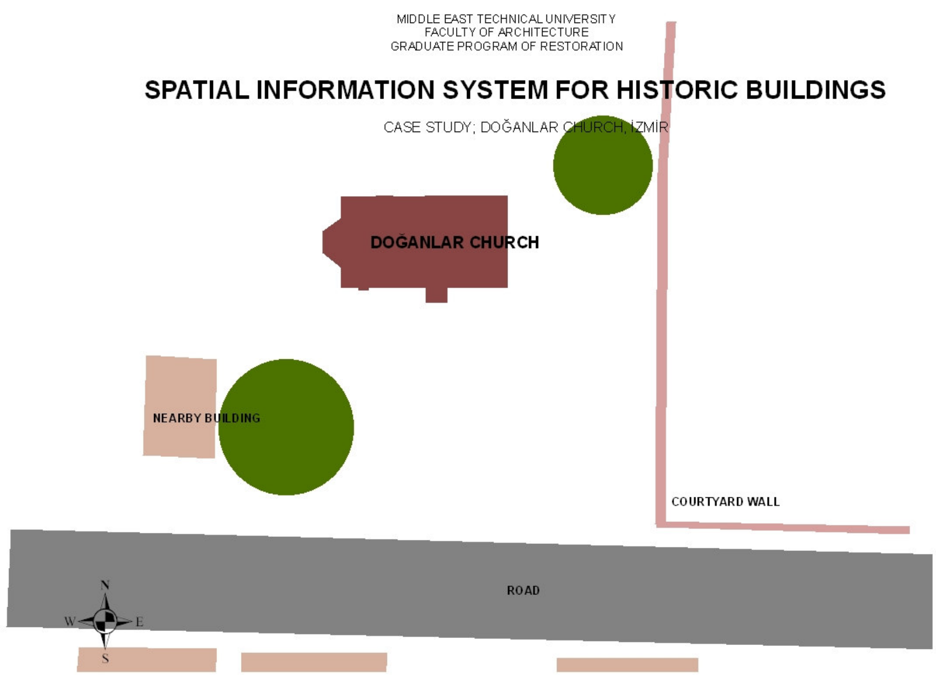


Figure-B.1 Site plan of Doğanlar Church

APPENDIX-C

THEMATIC VISUALIZATION IN GIS; BUILDING ELEMENTS AND TYPE

This query was prepared in order to classify the elements of the building. First of all the components of the building were divided into three groups; building elements, architectural elements and finishing elements of the building. Each group was specified with the appropriate subgroup.

Building elements were visualized as walls, floor, roof, superstructure and tie beam. Architectural elements were visualized as; door opening, window opening, lintel and niche. Finishing elements were visualized as; plaster, wall and uncovered.

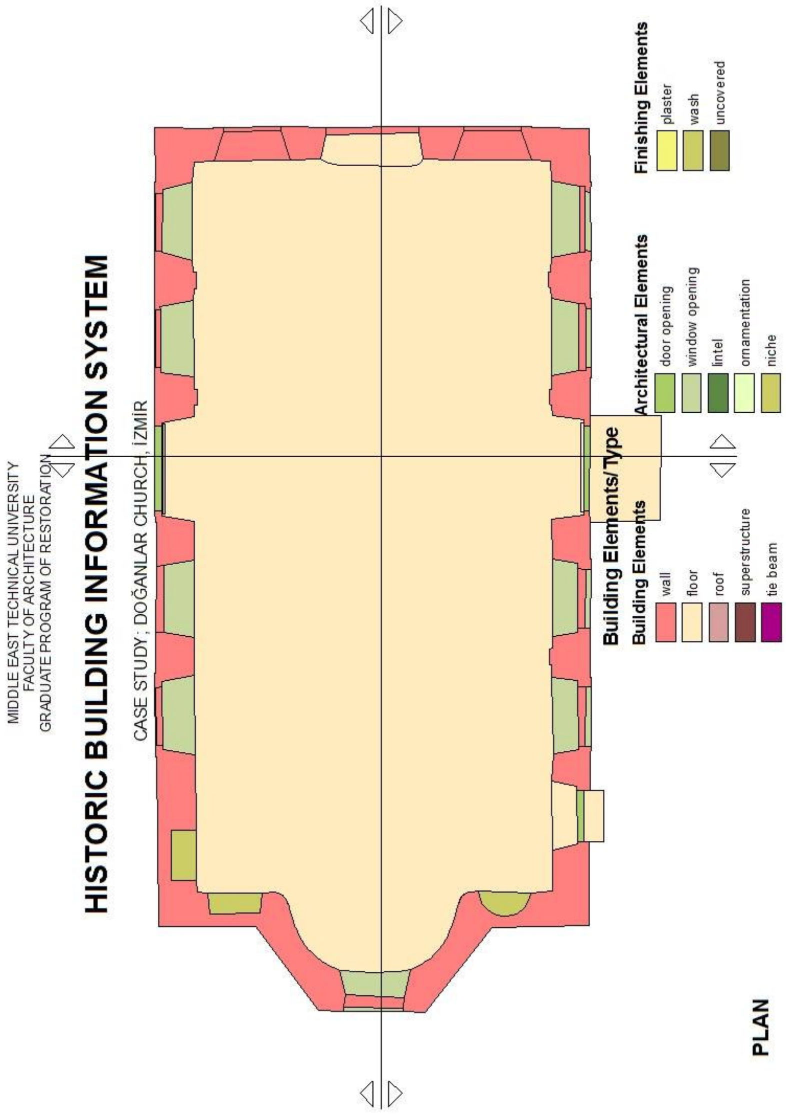
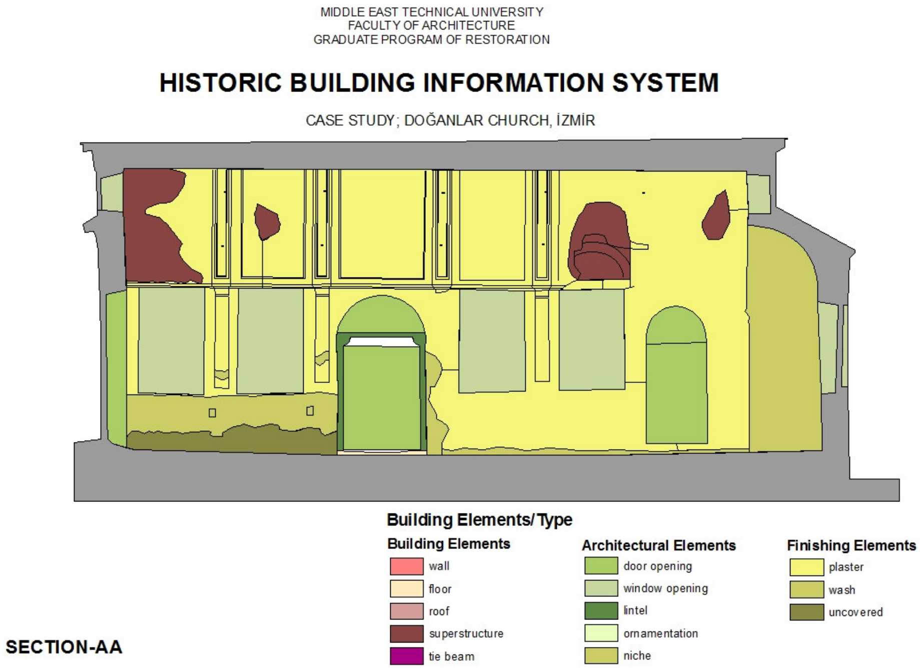


Figure-C.1 Plan/Building elements & type



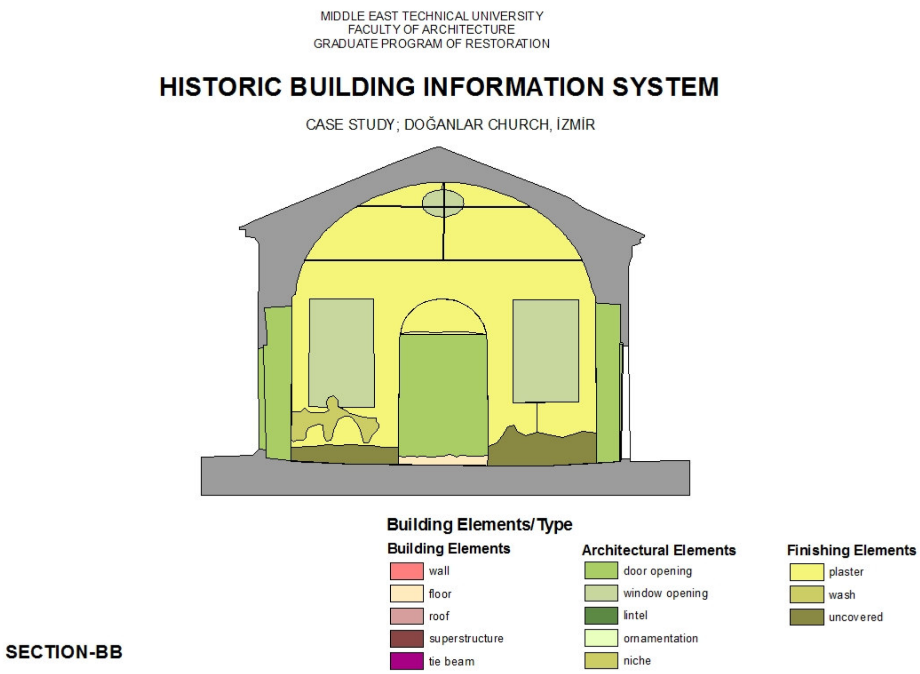
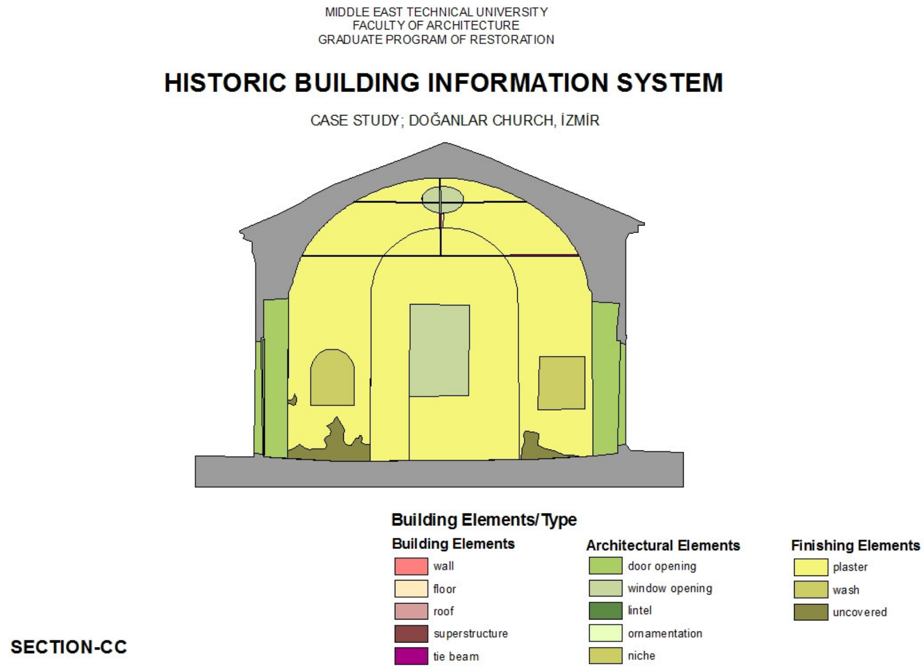


Figure-C.2 Sections/Building elements & type



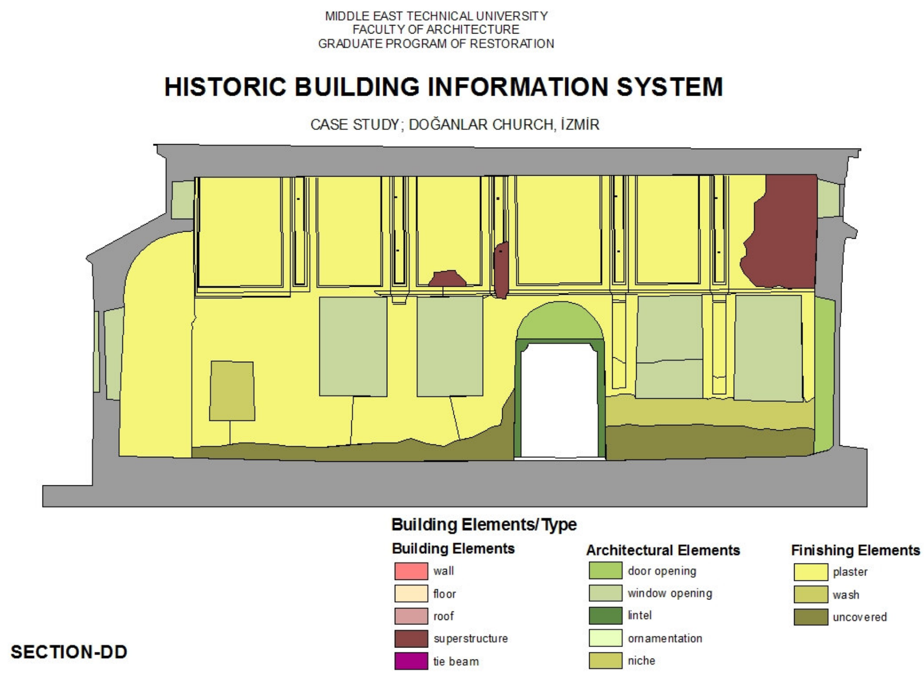
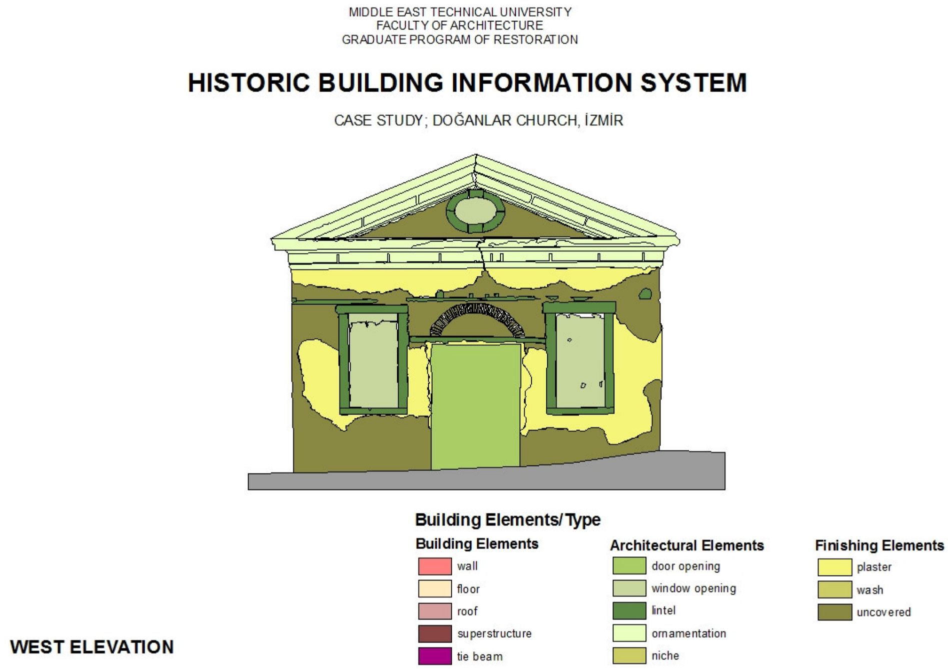


Figure-C.3 Sections/Building elements & type



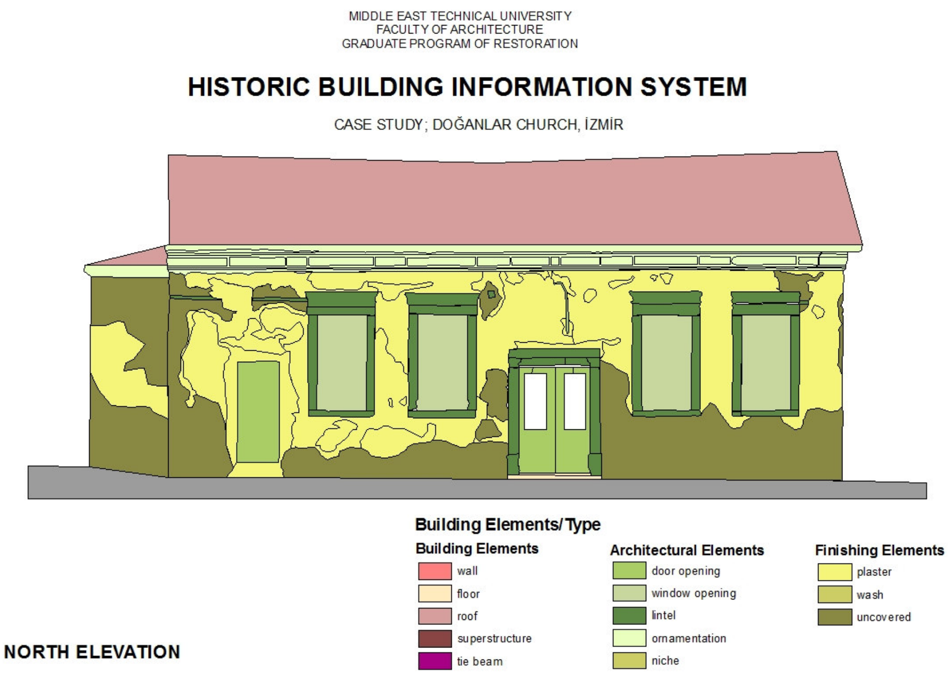
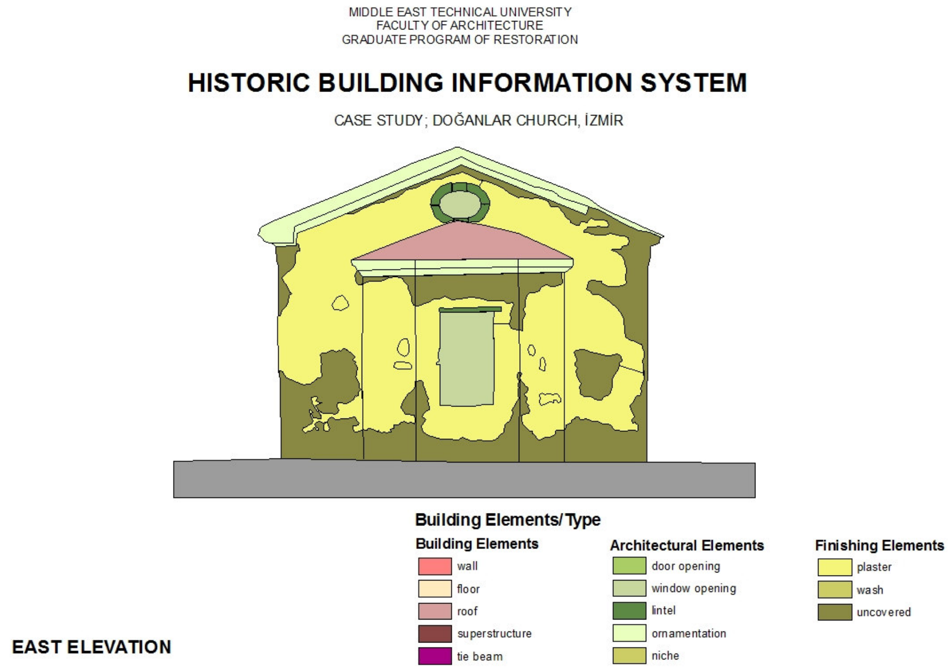


Figure-C.4 Elevations/Building elements & type



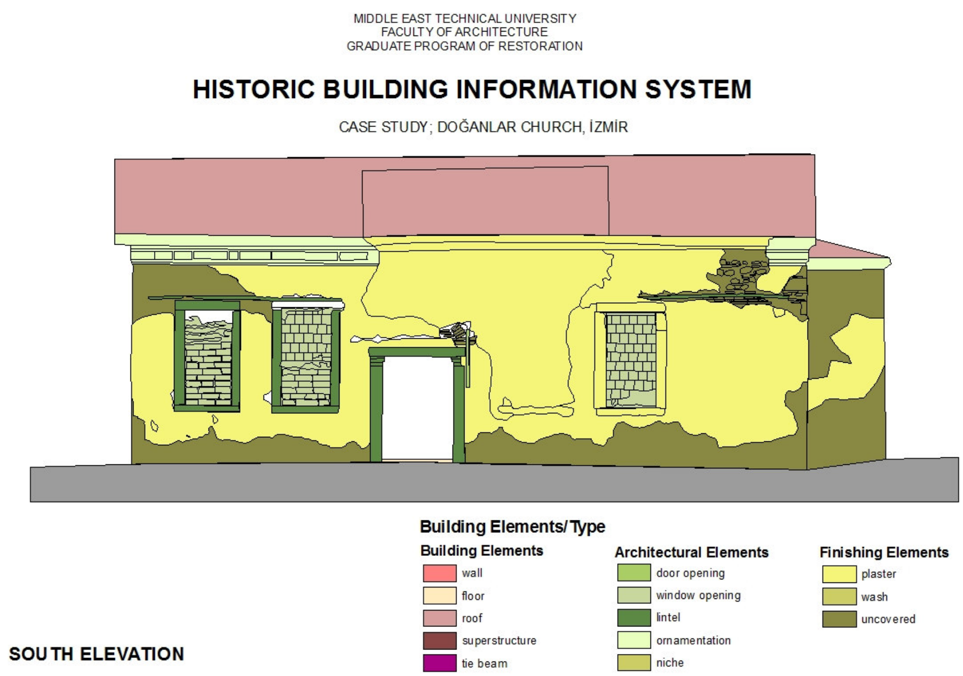


Figure-C.5 Elevations/Building elements & type

APPENDIX-D

THEMATIC VISUALIZATION IN GIS; BUILDING ELEMENTS / MATERIAL

The material used in the building was in three main groups. The components of the building were classified as; building elements, architectural elements and finishing elements.

Building element materials are; concrete, earth, metal, over and under tile and new tile. Unidentified objects were shown in unidentified layer. Architectural element materials are; stone, brick, mudbrick, fabricated brick and the mixed use of those listed. Materials as finishing elements are lime and cement plaster.

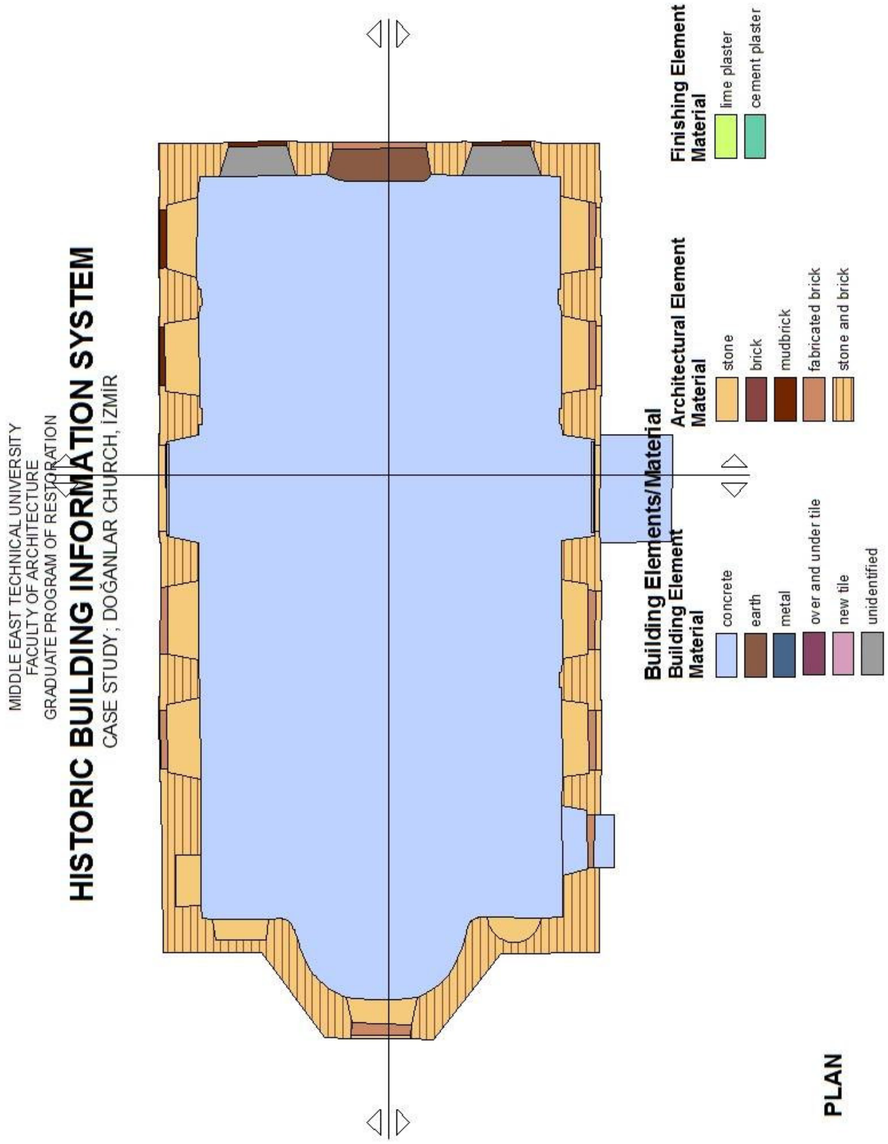
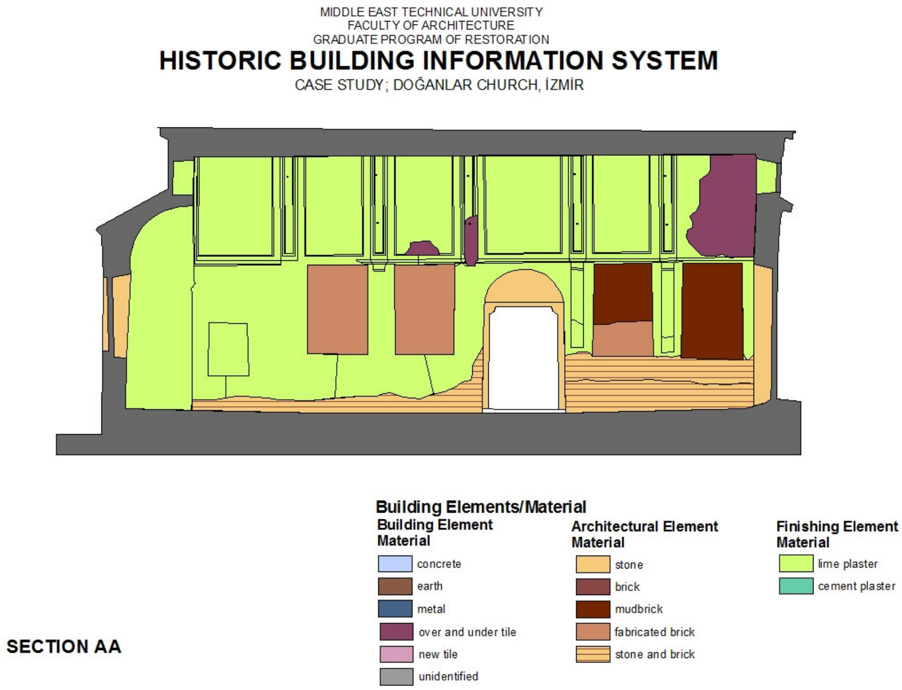


Figure-D.1 Plan/Building elements & material



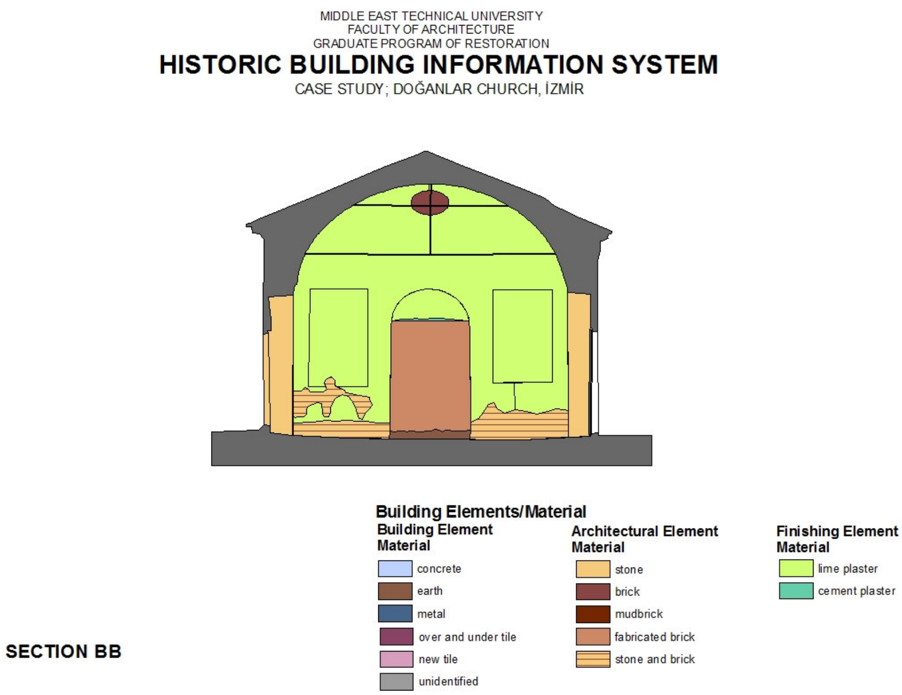
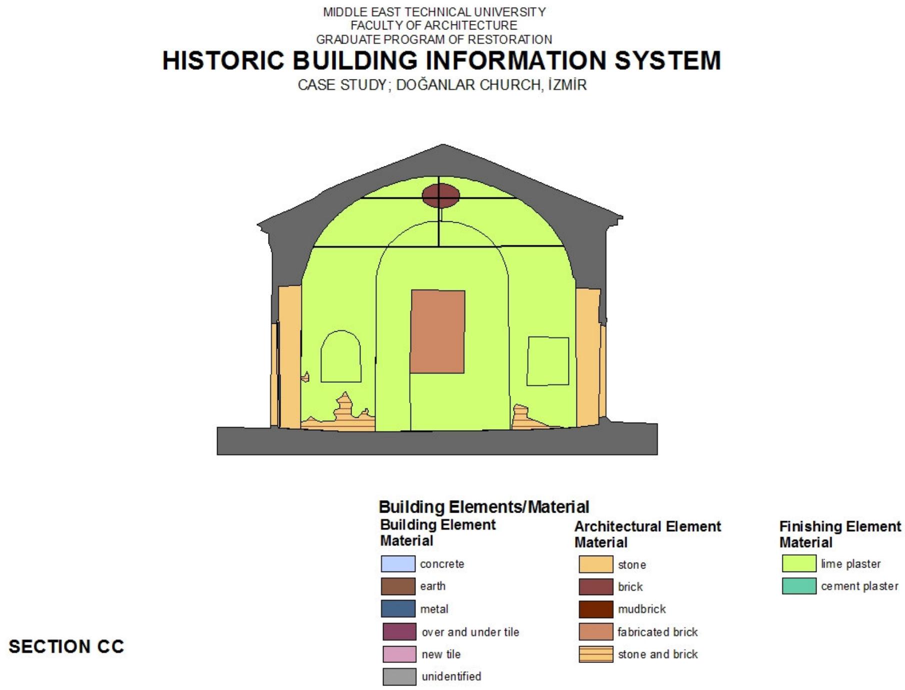


Figure-D.2 Sections/Building elements & material



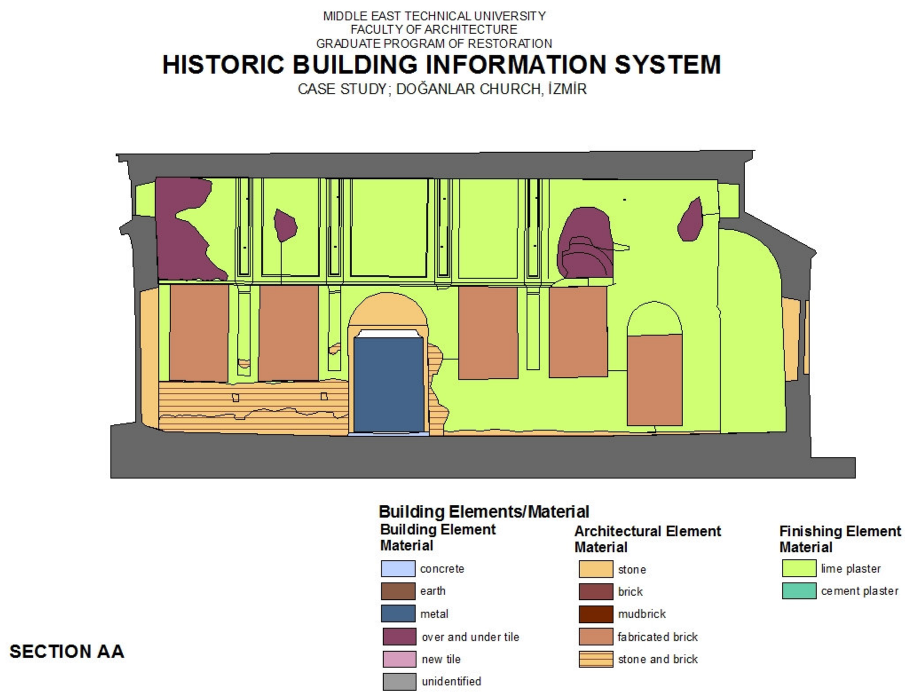
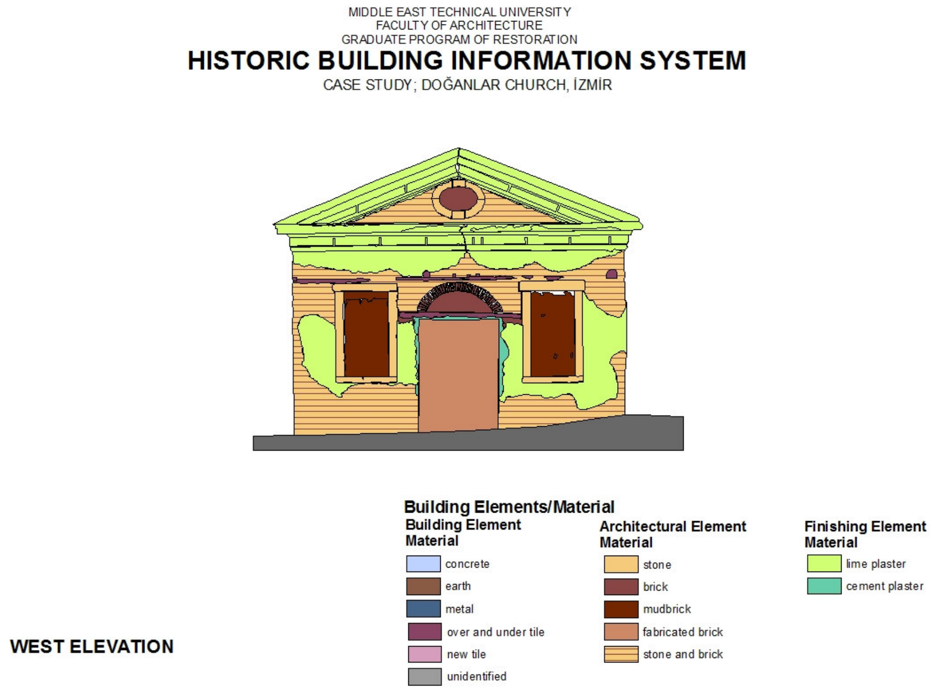


Figure-D.3 Sections/Building elements & material



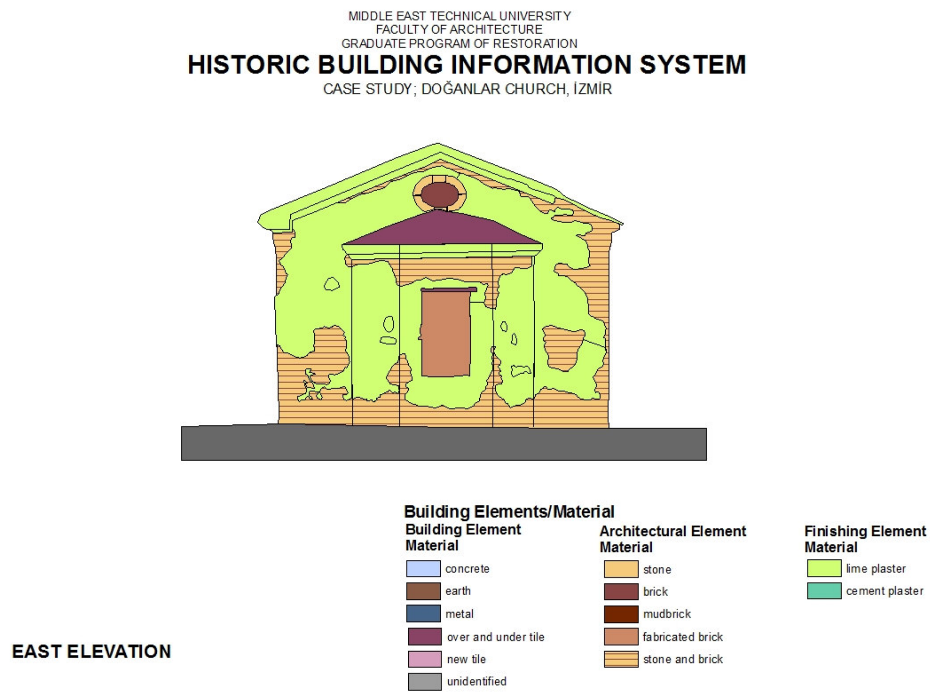
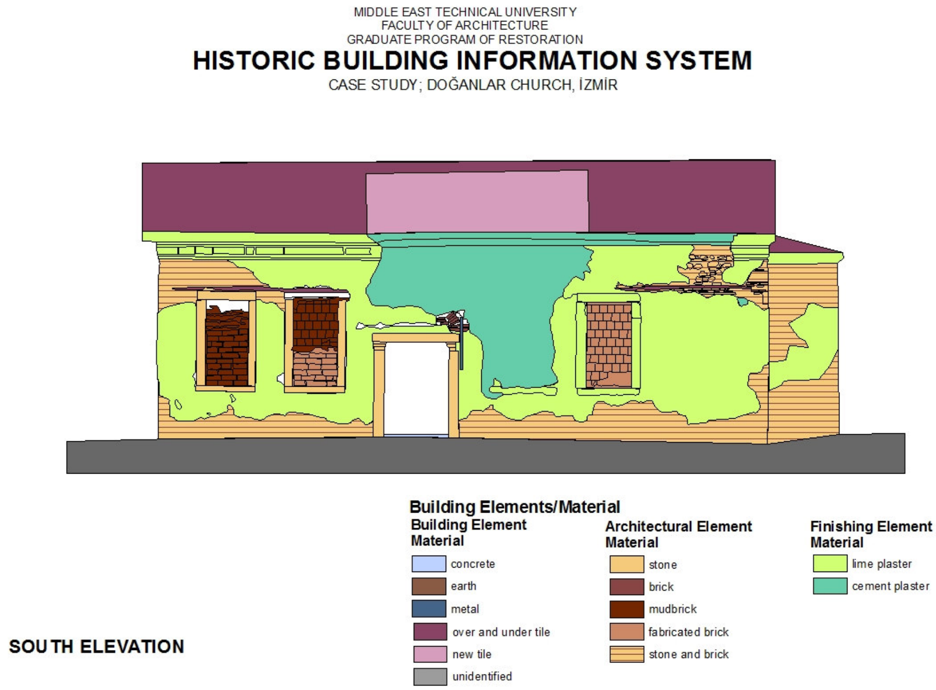


Figure-D.4 Elevations/Building elements & material



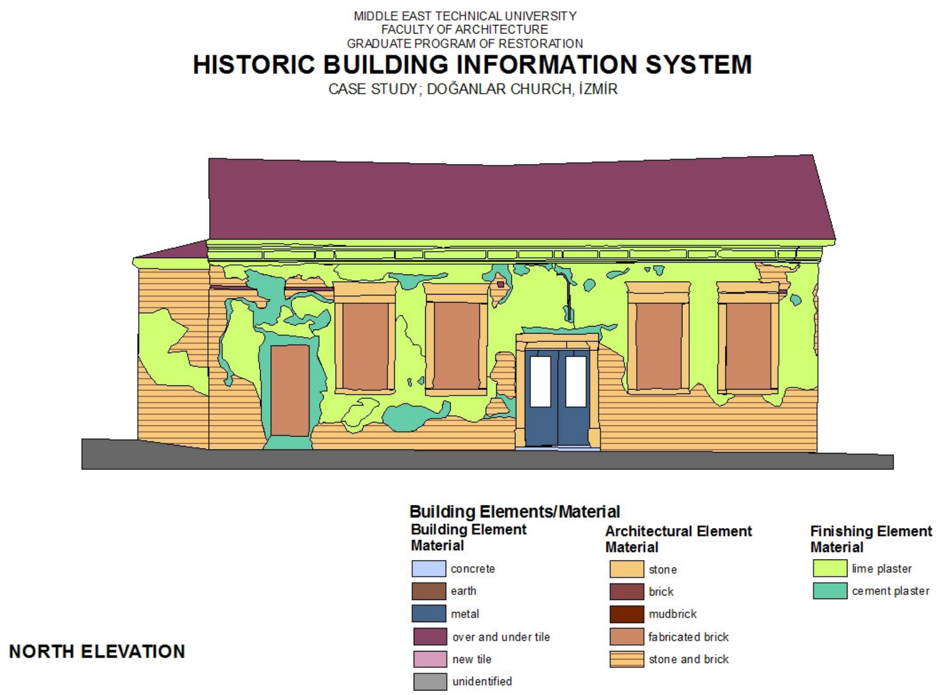


Figure-D.5 Elevations/Building elements & material

APPENDIX-E

THEMATIC VISUALIZATION IN GIS ; BUILDING ELEMENTS / CHANGE DEGREE

Change degree of the building was visualized as the feature characteristics of the elements. The elements are classified as; unchanged, partially changed and totally changed.

The unchanged elements are the elements that did not have any change in material, structural and in detail. If the elements material and structure did not change and only detail is missing or changed than it is called as partially changed. If the element is changed with its element, structure and detail it is called totally changed.

- totally changed (removal or alteration of architectural elements)
- partially changed (few of the architectural elements changed)
- unchanged (No change in architectural elements or only small material alterations in elements)

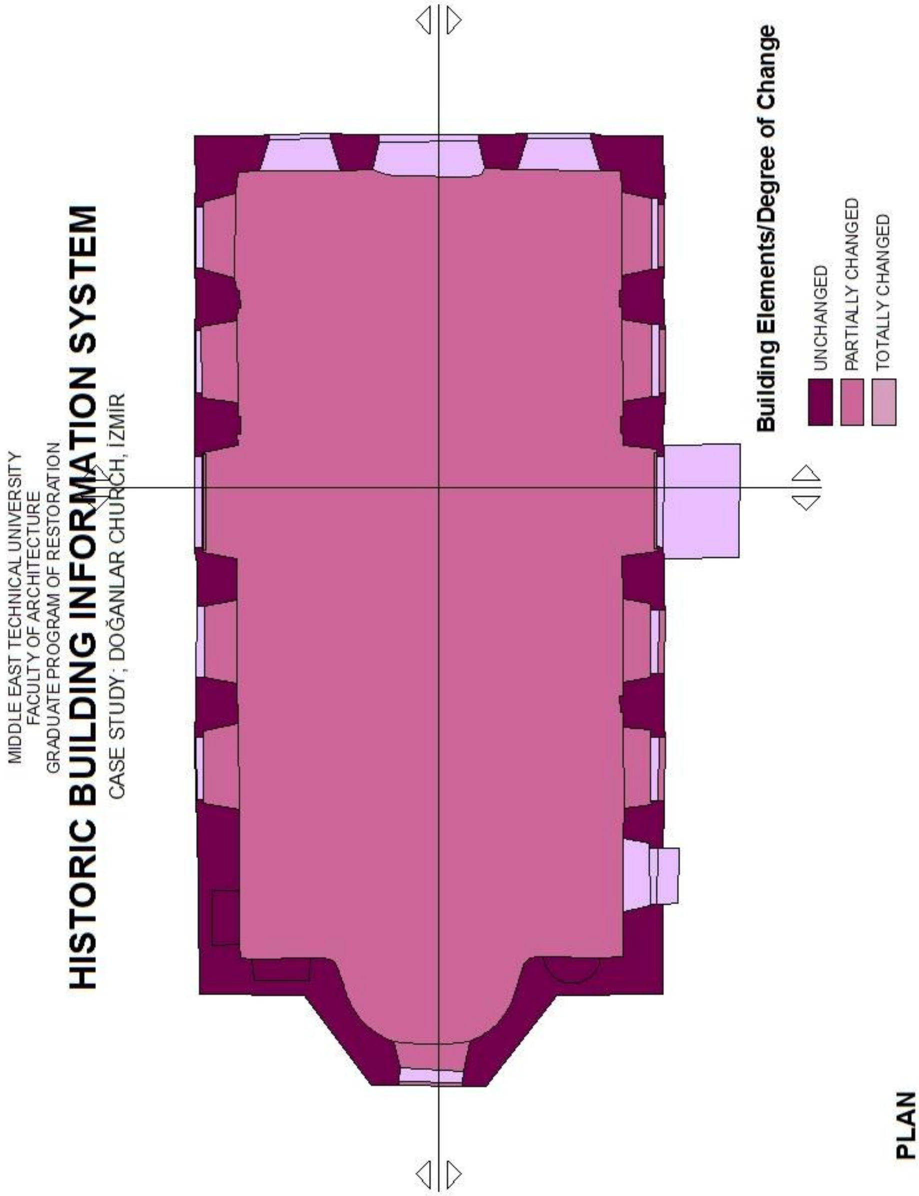
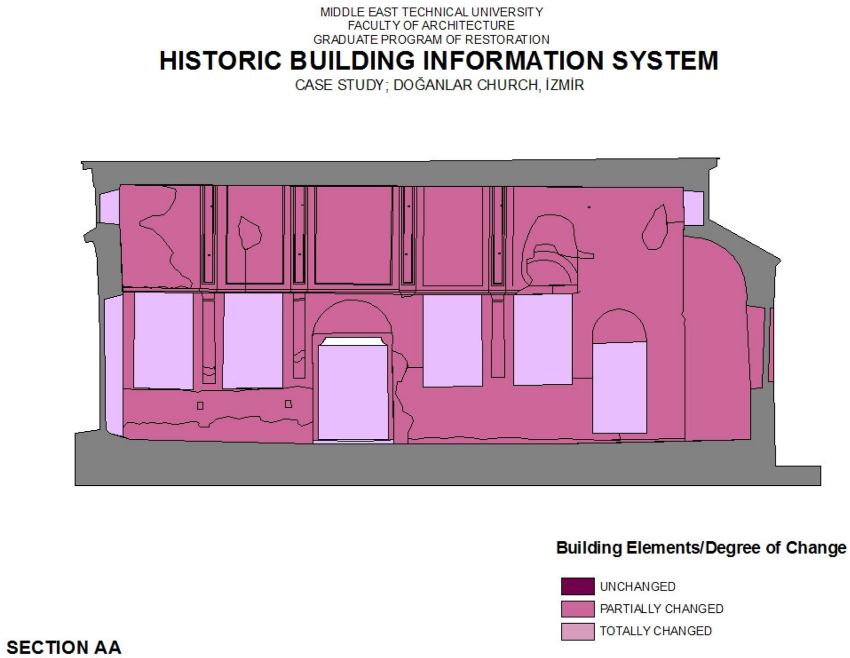


Figure-E.1 Plan/Building elements & change degree



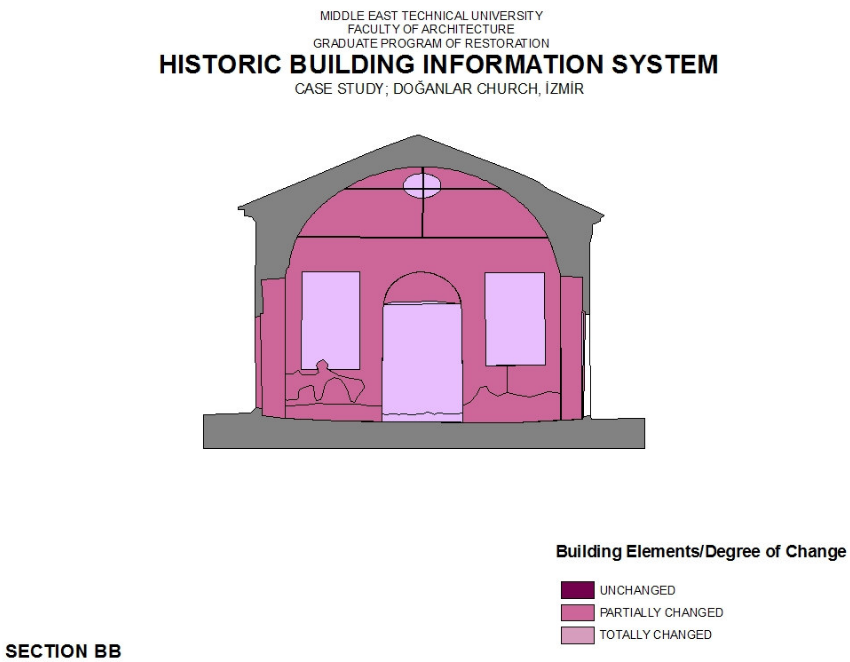
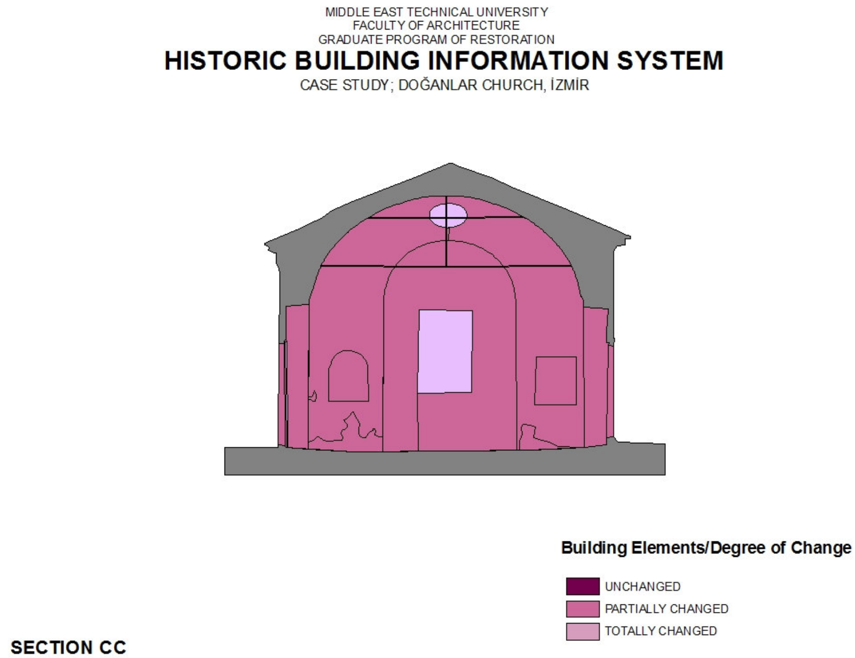


Figure-E.2 Sections/Building elements & change degree



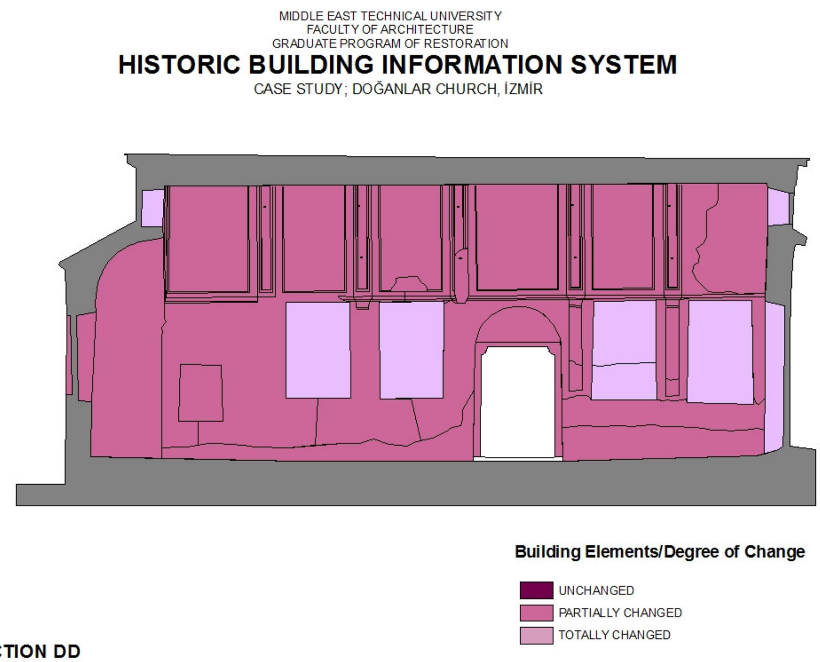
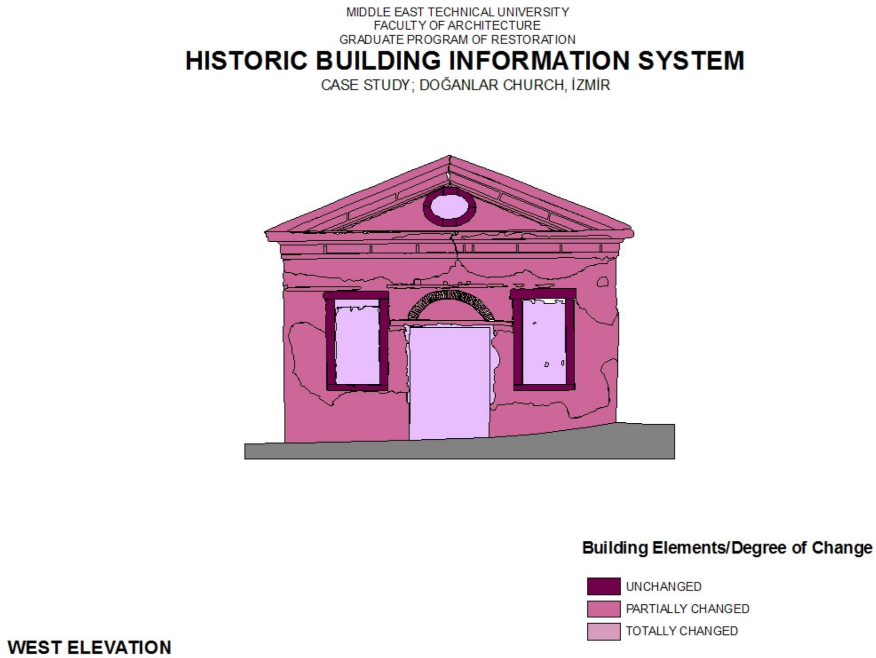


Figure-E.3 Sections/Building elements & change degree



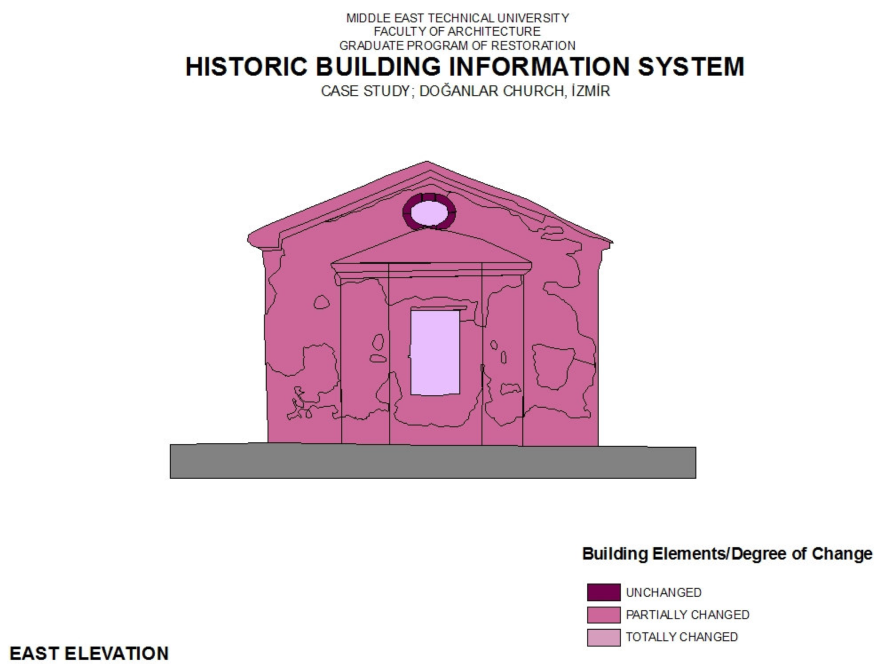
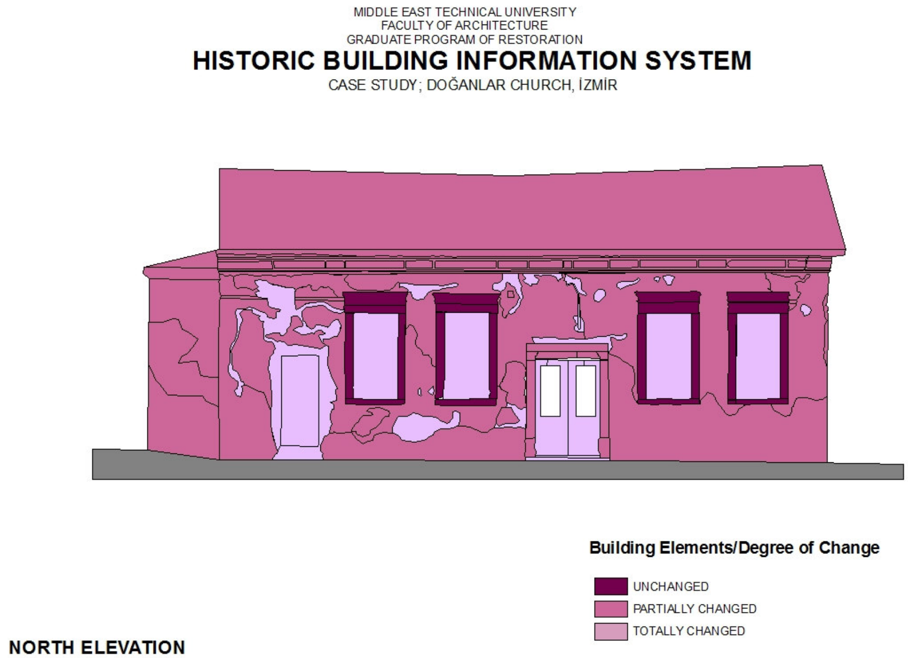


Figure-E.4 Elevations/Building elements & change degree



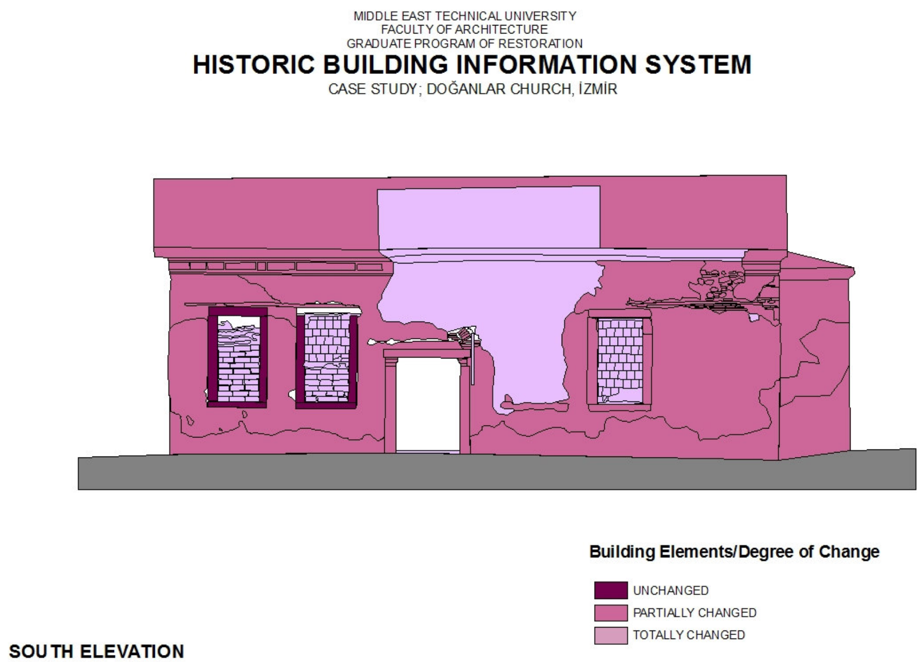


Figure-E.5 Elevations/Building elements & change degree

APPENDIX-F.

THEMATIC VISUALIZATION IN GIS; BUILDING ELEMENTS / STRUCTURAL & MATERIAL CONDITION

Structural and material condition of the building was investigated visually and in comparison between the similar components. First the structural and material condition of the components of the building was classified as; good, fair, medium and severe. If the material has no structural or material problem it was visualized as good. If component has partial deteriorations only in finishing, I was visualized as fair. If the deterioration of the component is in structural elements and there is a material loss than it was visualized as medium. And finally if the component of the building has severe deterioration in structural and material elements or the element was partially collapsed or collapsed, it was visualized as severe.

- Good (no structural or material problem)
- Fair (deterioration only in finishing)
- Medium (deterioration in structural elements)
- Severe (severe deterioration in structural and material elements, partially collapsed or collapsed)

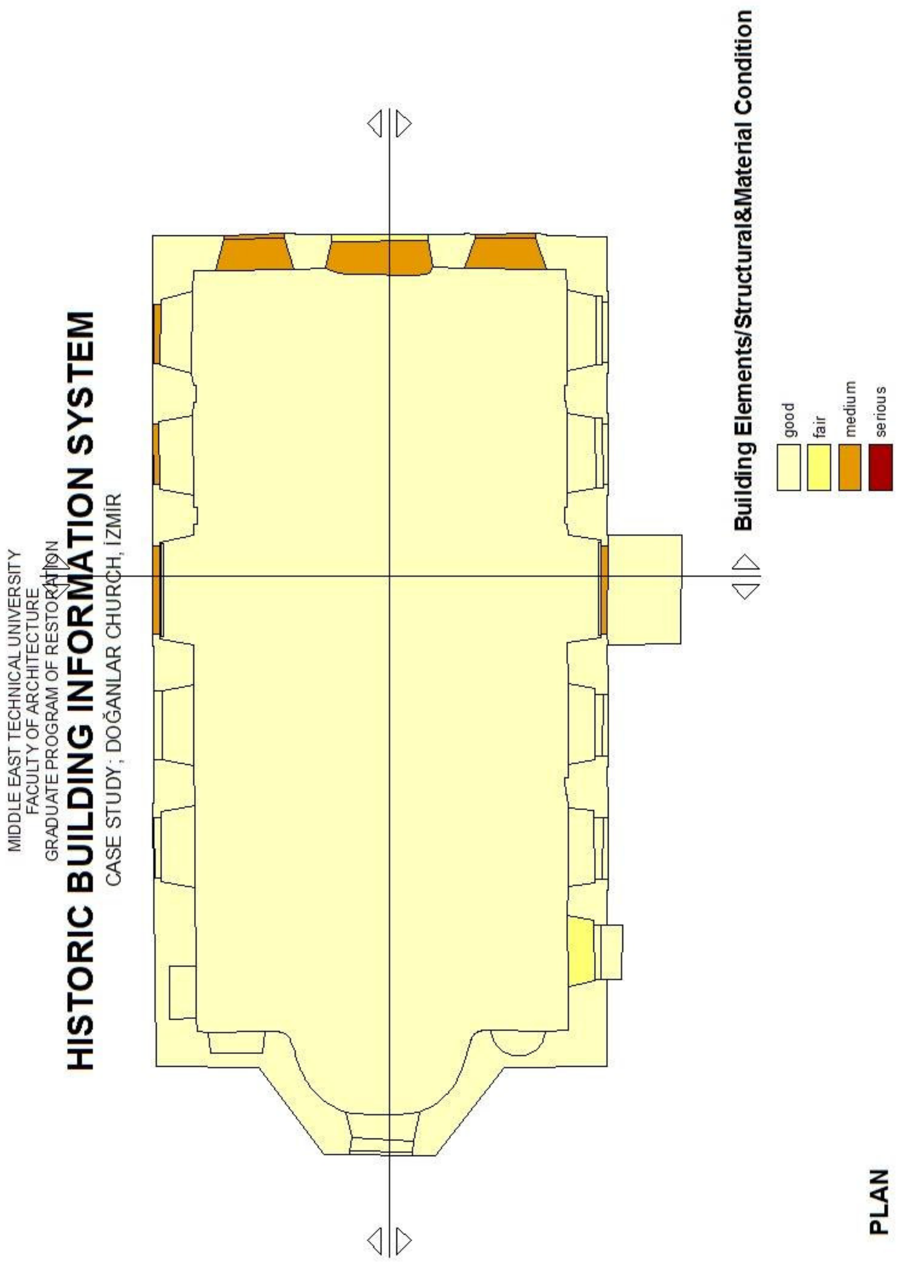
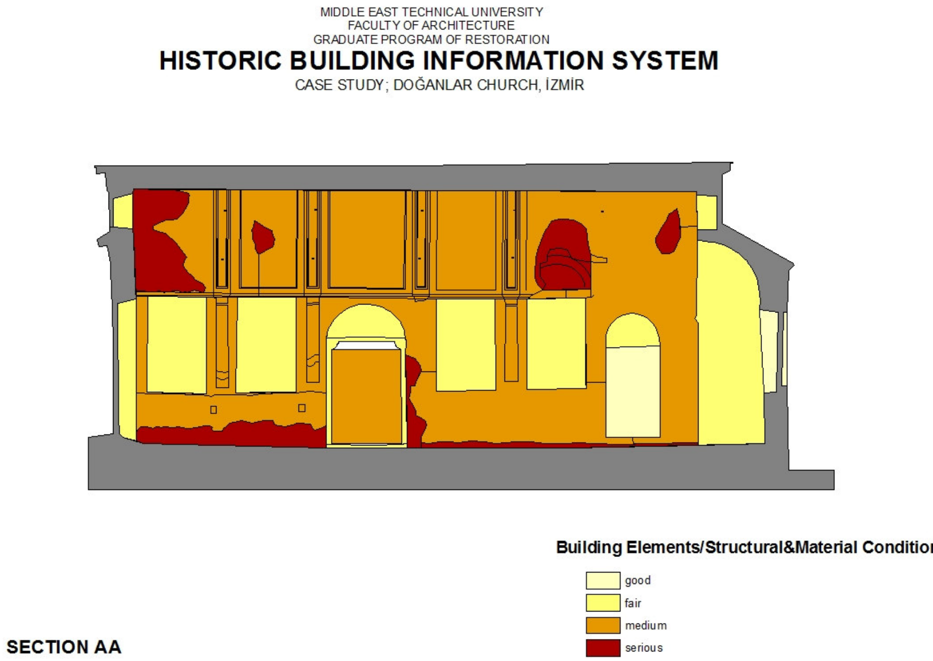


Figure-F.1 Plan/Building elements & structural and material condition



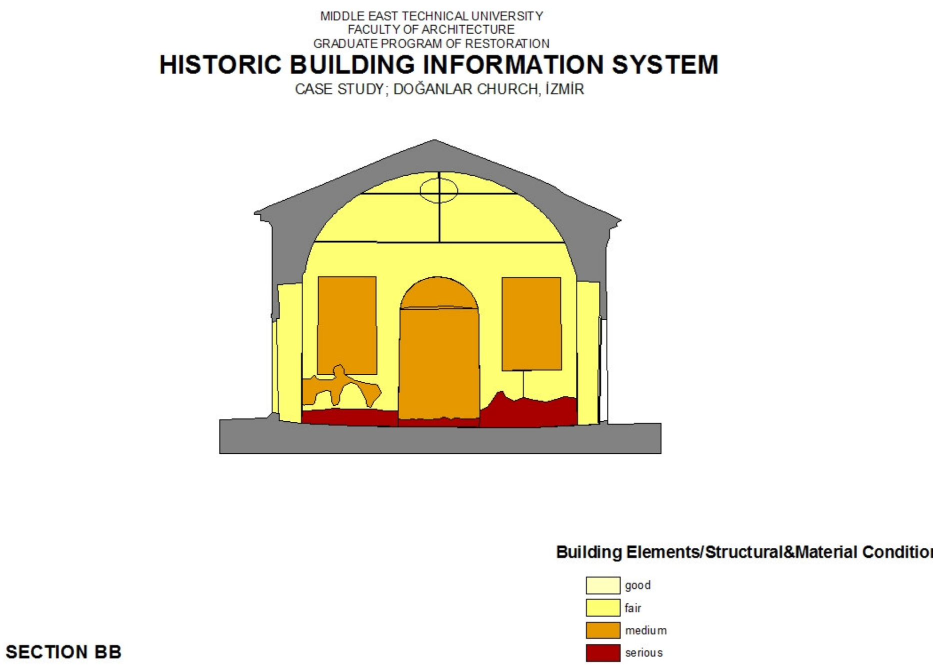
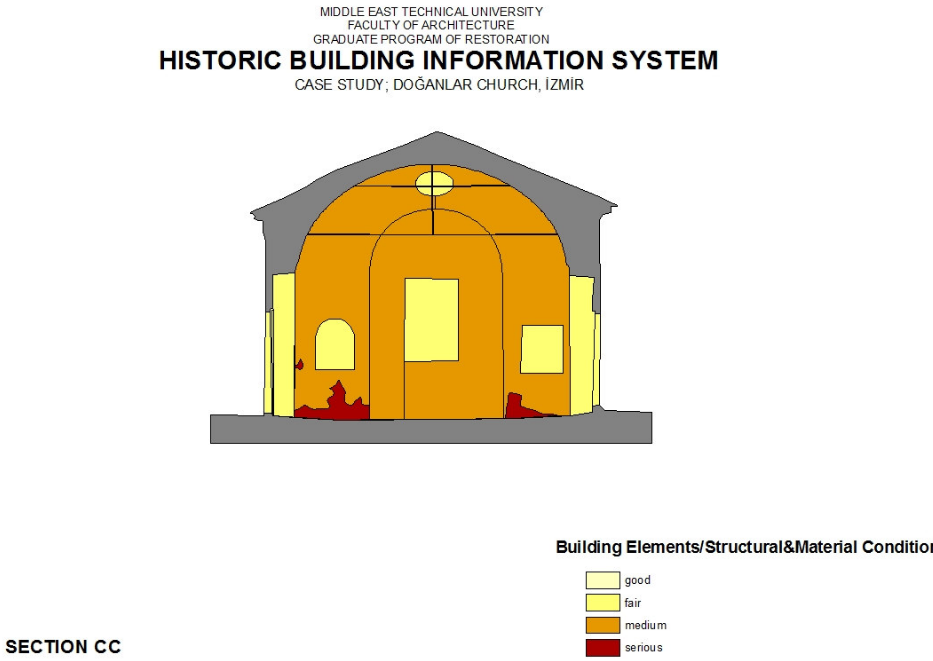


Figure-F.2 Sections/Building elements & structural and material condition



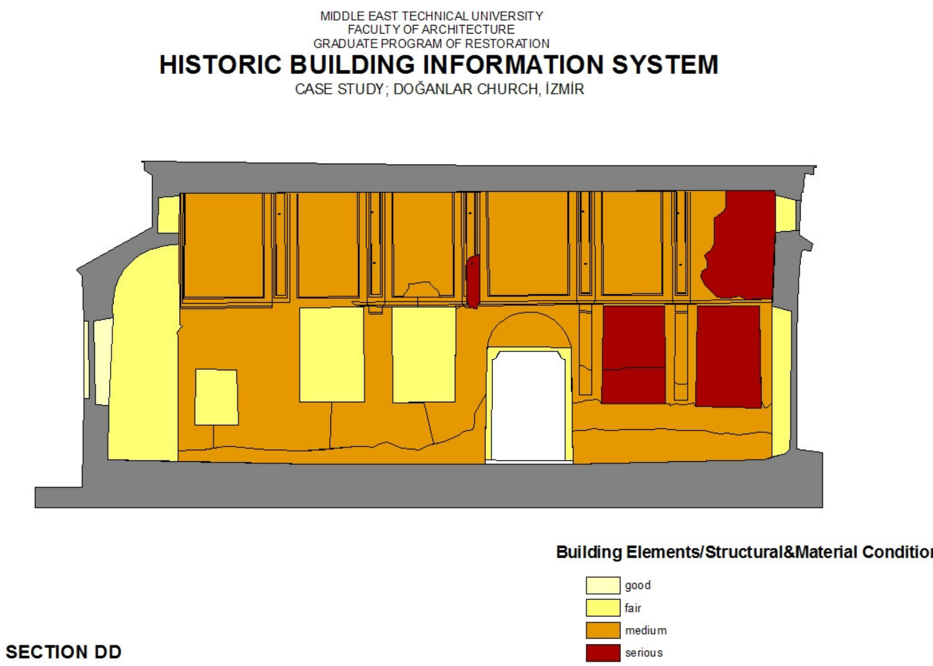
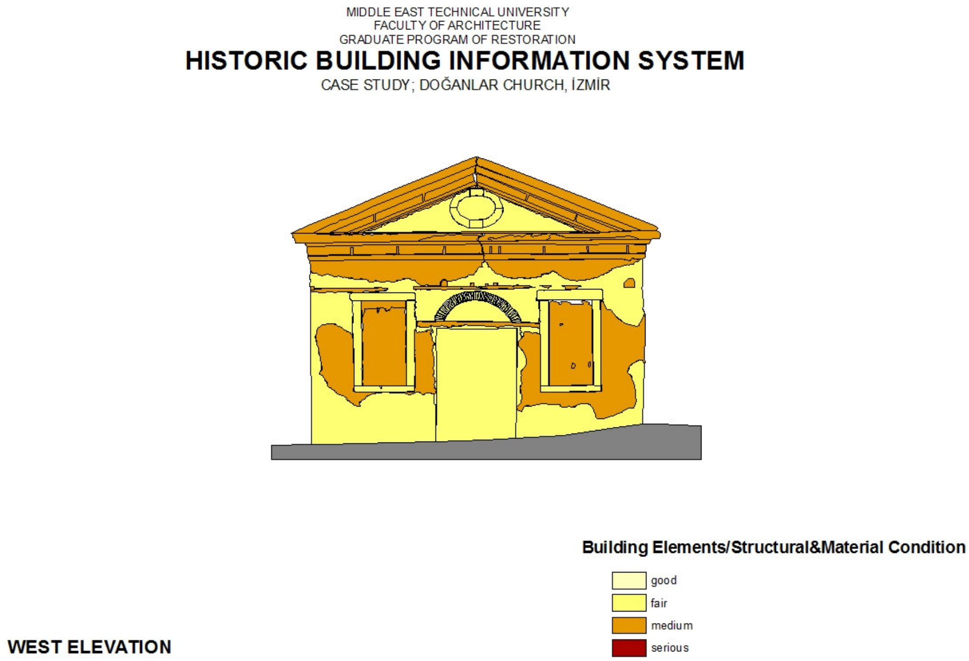


Figure-F.3 Sections/Building elements & structural and material condition



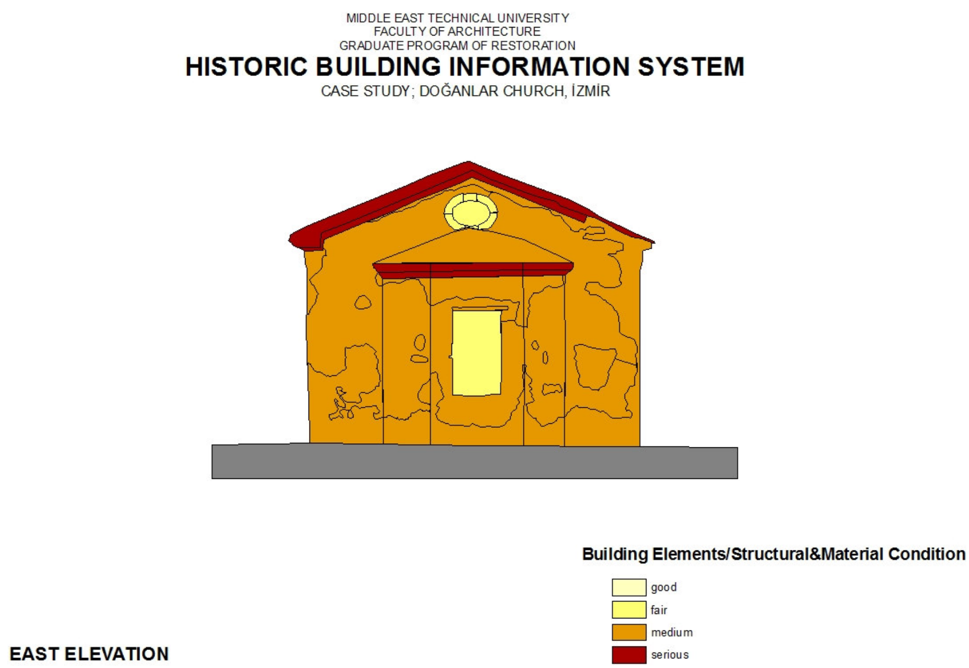
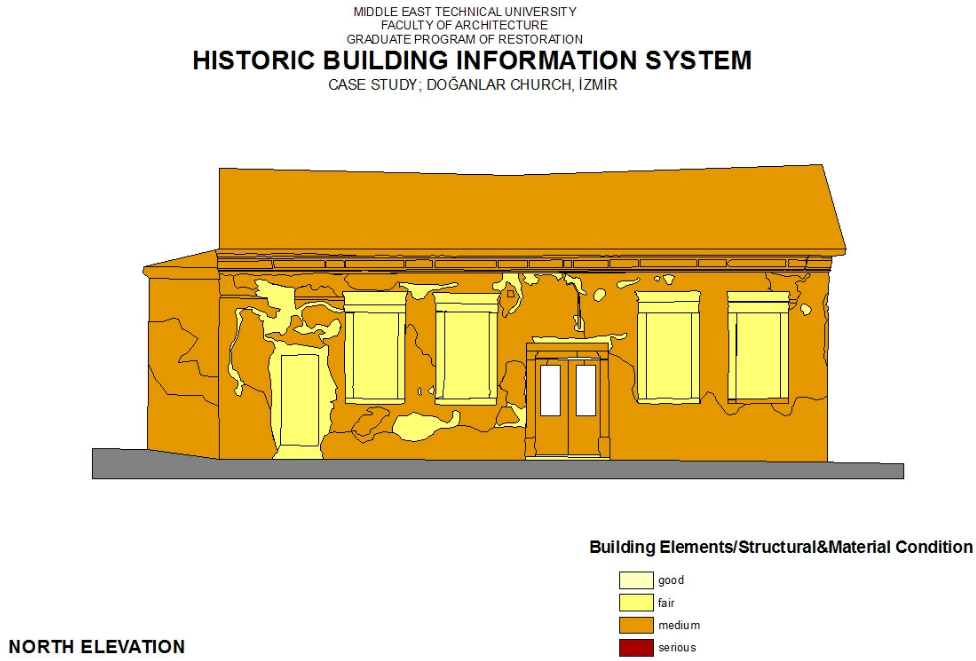


Figure-F.4 Elevations/Building elements & structural and material condition



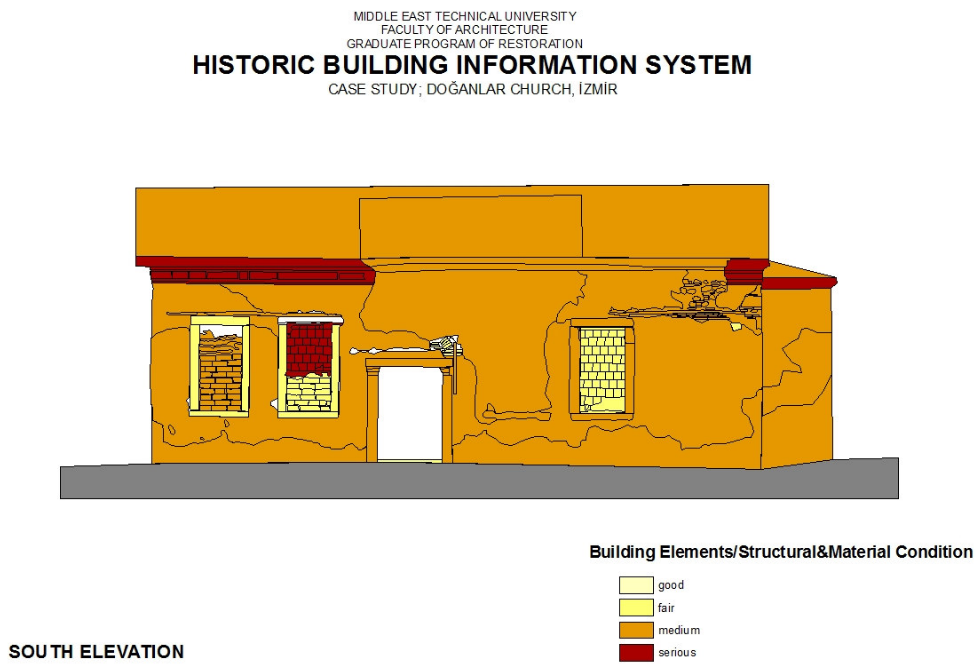


Figure-F.5 Elevations/Building elements & structural and material condition

APPENDIX-G

THEMATIC VISUALIZATION IN GIS; QUERY OPERATIONS

Having superimposed layers allows making different kinds of queries. These queries enable the information to be evaluated from a better perspective and provide new kind of information. For instance, the primary interventions can be decided by making queries between logically related data topics. These queries were tested by some certain data topics. The system allows displaying the requested queries by superimposing the selected data topics. At this point the selected data are “the change status of the building components” and “the structural and material condition”. Demanding the mostly changed areas with severe material and structural problems gives information about the primary intervention areas. For instance, if the problematic area is a later addition without any authentic features, the intervention type can be decided as to be removed. With the help of this kind of queries, new and improved information can be stated to be used throughout the conservation decision making process of historic buildings.

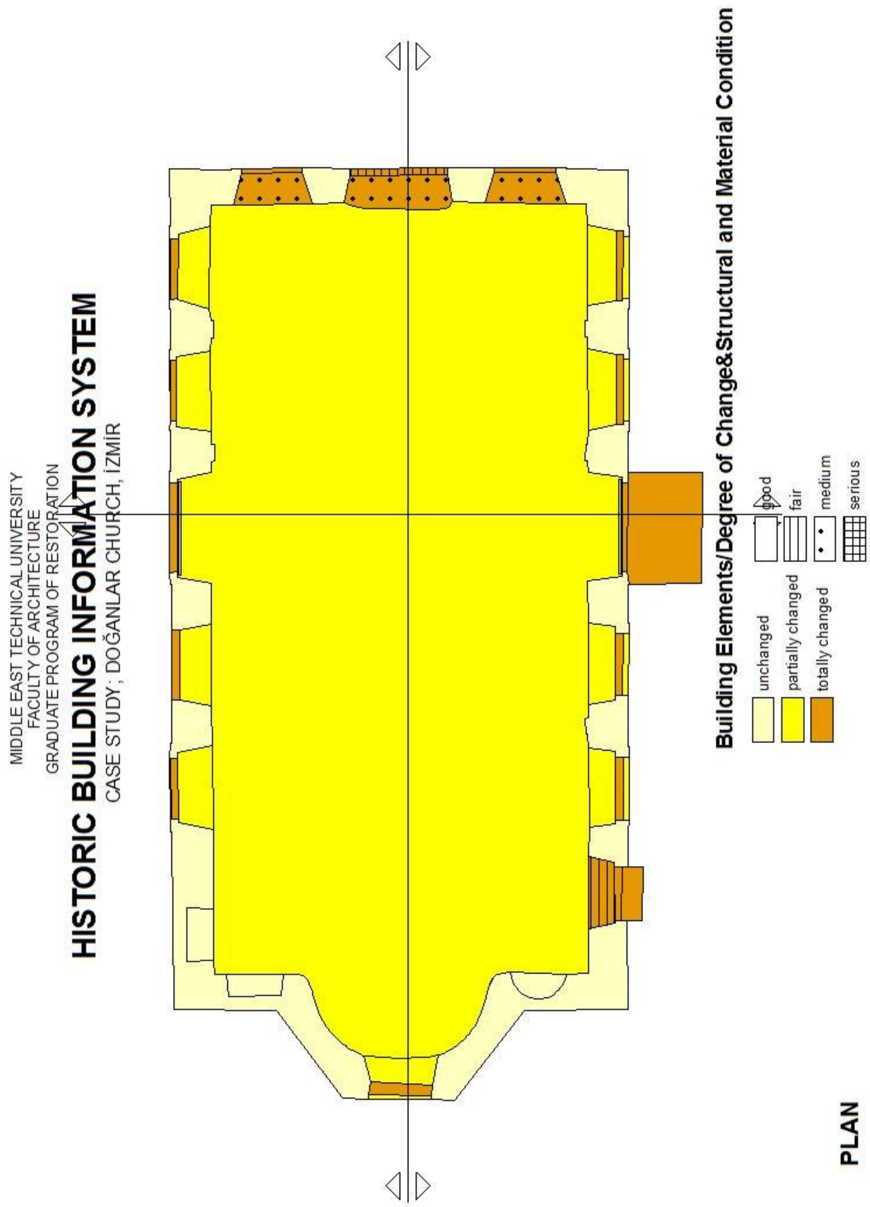
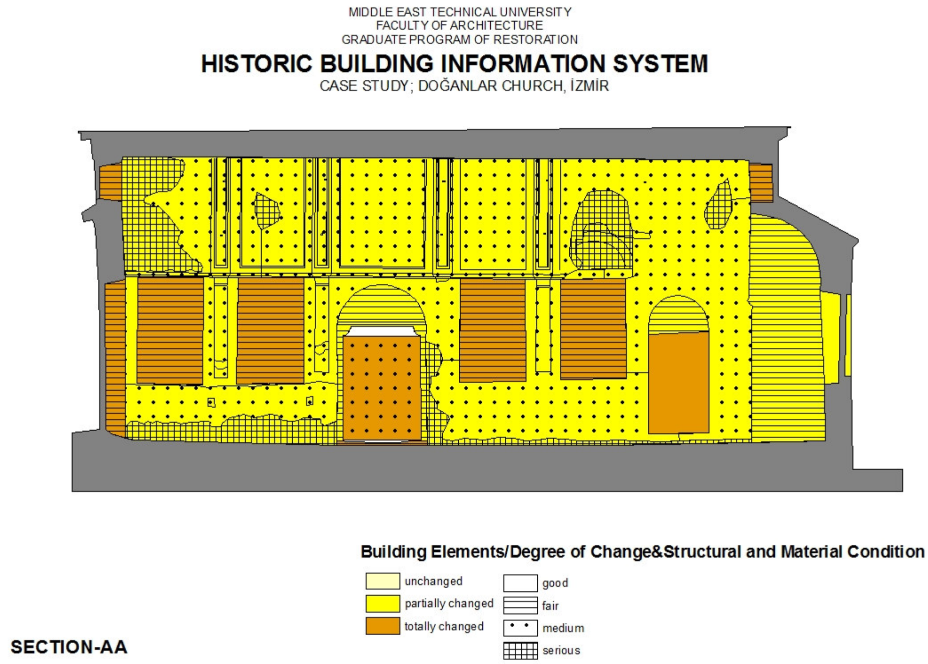


Figure-G.1 Plan/Query operation



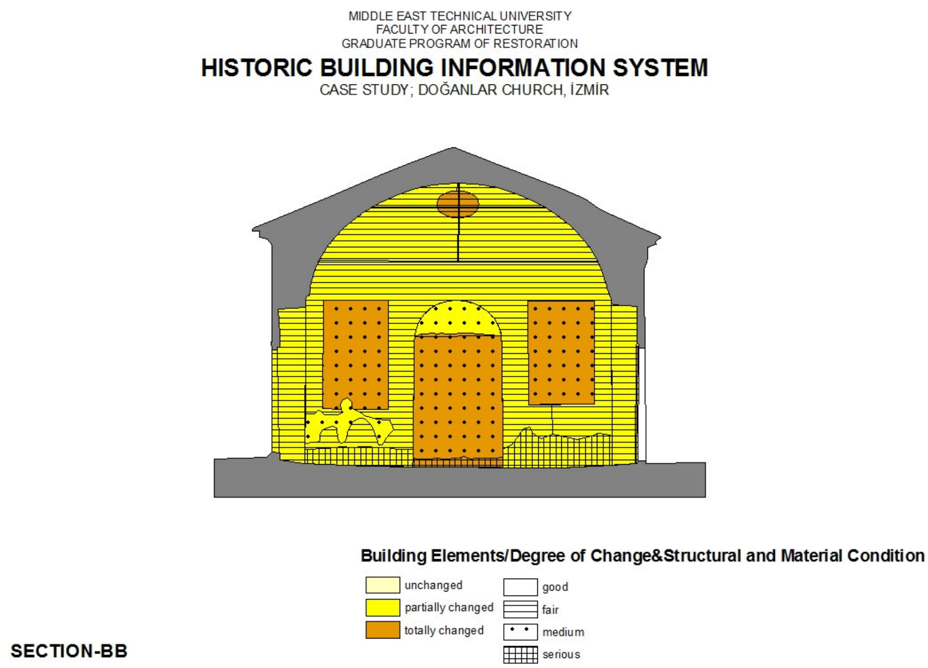
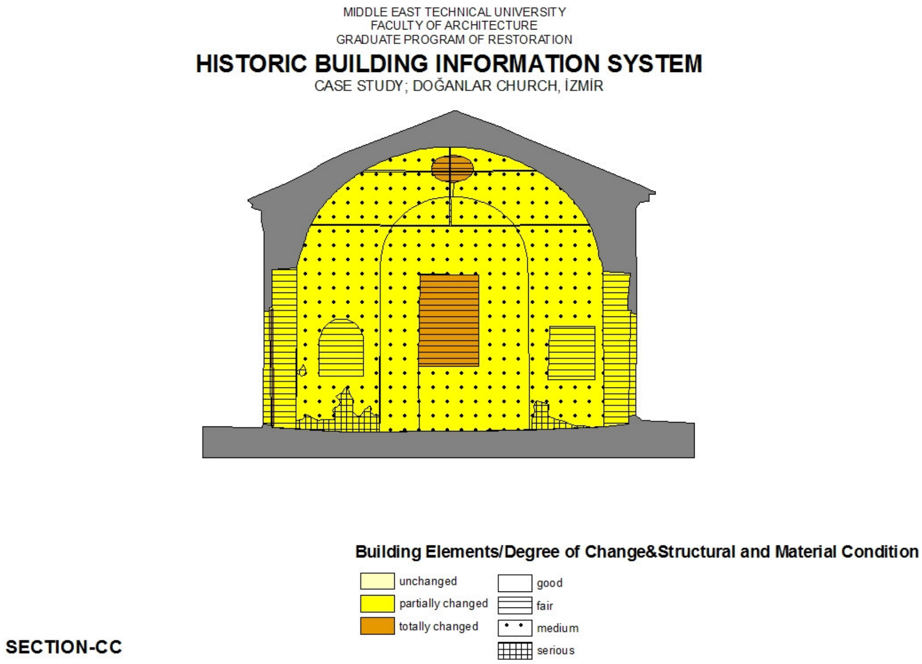


Figure-G.2 Sections/Query operation



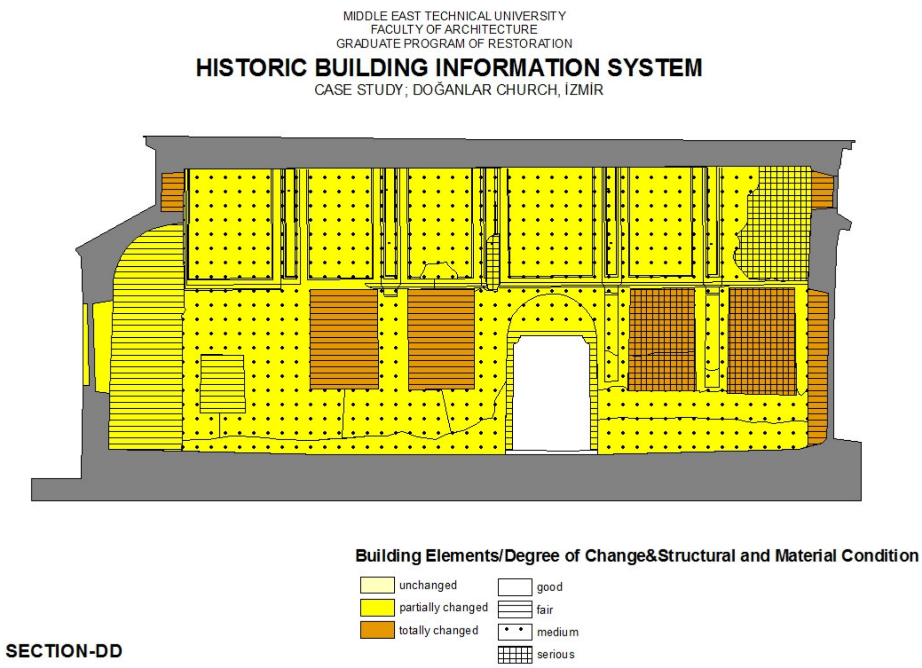
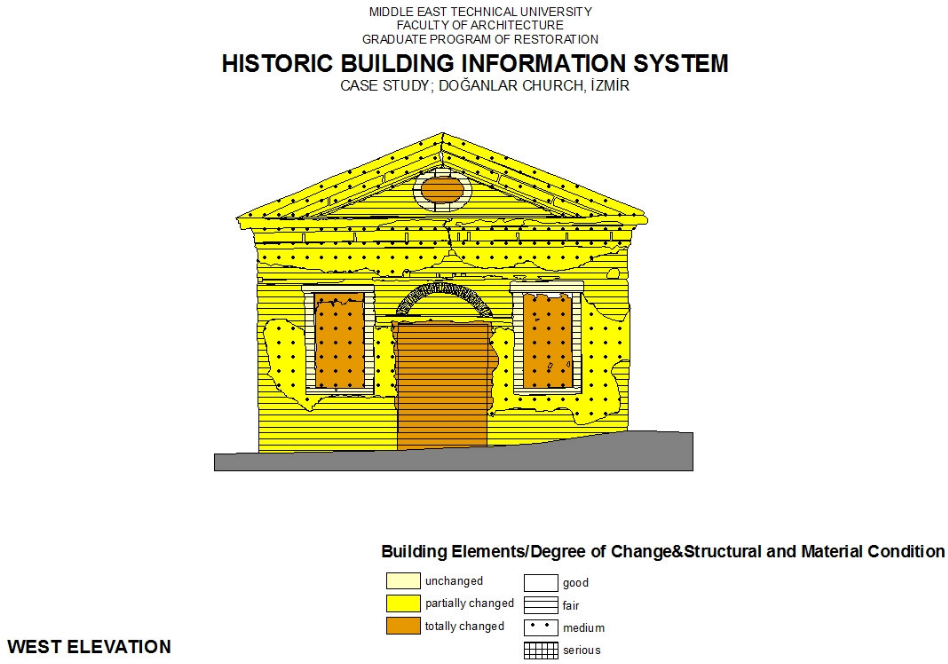


Figure-G.3 Sections/Query operation



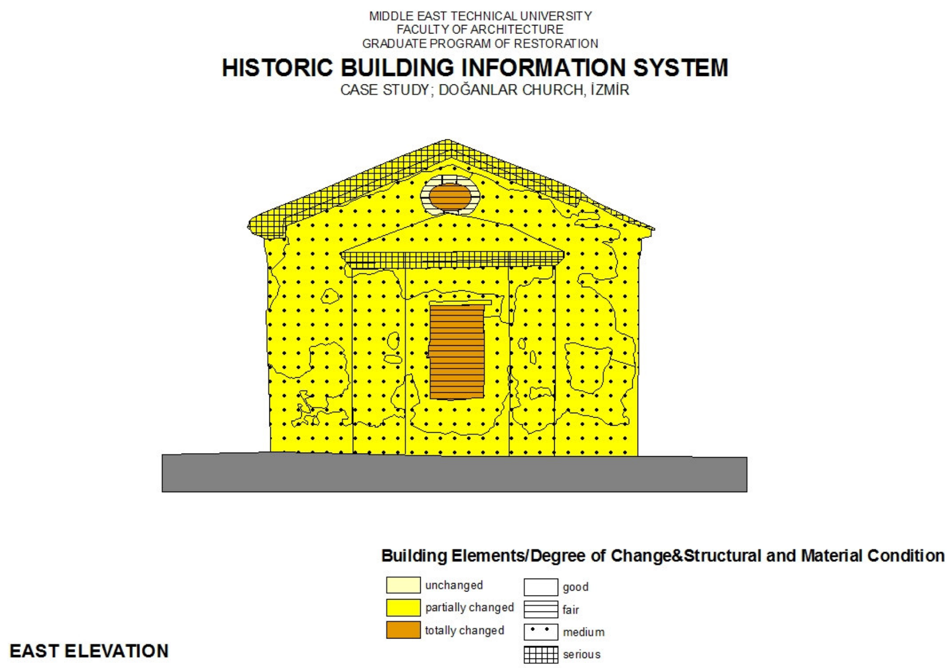
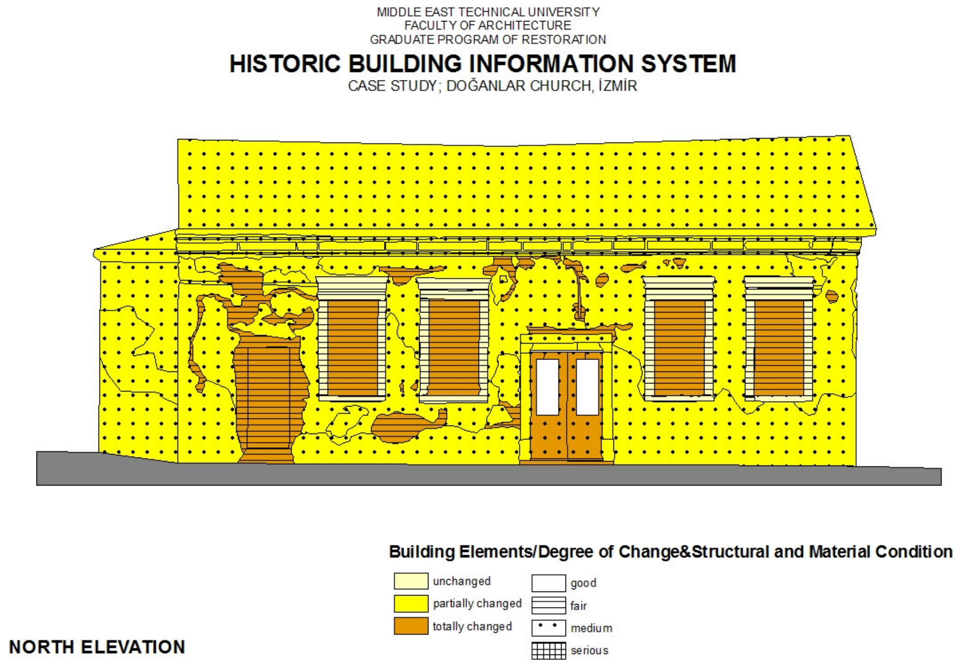


Figure-G.4 Elevations/Query operation



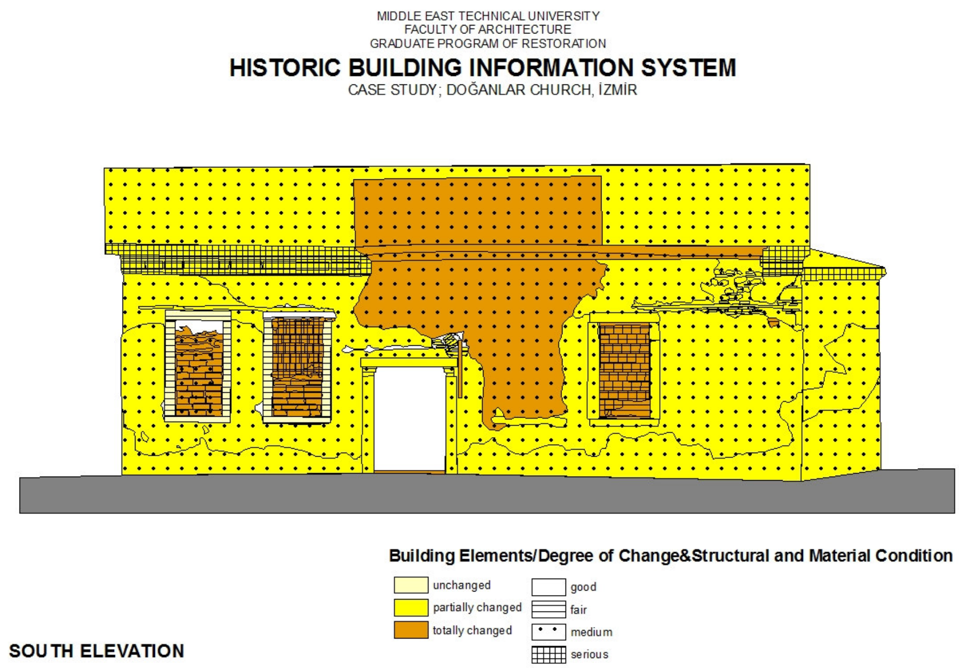


Figure-G.5 Elevations/Query operation

APPENDIX-H

MANUAL FOR USERS

- Open; (E:\Doganlar_Church\arcmap_files\key_map\key_map.mxd)

Data Entry:

- Data entry about plan;
    - Right-click to ‘plan’ at layers,
    - Open ‘Layer Properties’,
    - Click ‘Display’,
    - Check ‘Support Hyperlinks Using Field’,
    - Select feature class ‘arcmap_files’
    - Click ‘OK’.
    - Click hyperlink icon.
    - Click the plan display. (displayed as polygon)
    - Choose the requested ***ArcMAP*** files. (i.e. bldg_elmnt_material_plan, bldg_elmnt_change_plan, etc.)
    - Click (Editor/Start Editing)
    - Enter the data.
    - Click ‘Save Edits’
- Data entry about sections;
    - Right-click to ‘section’ at layers,

    - Open ‘Layer Properties’,
    - Click ‘Display’,
    - Check ‘Support Hyperlinks Using Field’,
    - Select feature class ‘arcmap_files’
    - Click ‘OK’.
    - Click hyperlink icon.
    - Click the section display. (displayed as lines)
    - Choose the requested ***ArcMAP*** files. (i.e. bldg_elmnt_change_section_aa, bldg_elmnt_material_section_bb, etc.)
    - Click (Editor/Start Editing)
    - Enter the data.
    - Click ‘Save Edits’
    -

- Data entry about elevations;
    - Right-click to ‘elevation’ at layers,
    - Open ‘Layer Properties’,
    - Click ‘Display’,
    - Check ‘Support Hyperlinks Using Field’,
    - Select feature class ‘arcmap_files’
    - Click ‘OK’.
    - Click hyperlink icon.
    - Click the section display. (displayed as lines)
    - Choose the requested ***ArcMAP*** files.
    - Click (Editor/Start Editing)

        - Enter the data.
        - Click ‘Save Edits’

Inquiries:

- Inquiry about plan;
    - Right-click to ‘plan’ at layers,
    - Open ‘Layer Properties’,
    - Click ‘Display’,
    - Check ‘Support Hyperlinks Using Field’,
    - Select feature class (i.e. photos, text_files, sketch, description, etc.) according to the inquiry,
    - Click ‘OK’.
    - Click hyperlink icon.
    - Click the plan display. (displayed as polygon)
- Inquiry about sections;
    - Right-click to ‘sections’ at layers,
    - Open ‘Layer Properties’,
    - Click ‘Display’,
    - Check ‘Support Hyperlinks Using Field’,
    - Select feature class (i.e. photos, text_files, sketch, description, etc.) according to the inquiry,
    - Click ‘OK’.
    - Click hyperlink icon.
    - Click the requested section display. (displayed as lines)
- Inquiry about elevations;
    - Right-click to ‘elevations’ at layers,

    - Open ‘Layer Properties’,
    - Click ‘Display’,
    - Check ‘Support Hyperlinks Using Field’,
    - Select feature class (i.e. photos, text_files, sketch, description, etc.) according to the inquiry,
    - Click ‘OK’.
    - Click hyperlink icon.
    - Click the requested elevation display. (displayed as lines)
- Inquiry about images;
    - Right-click to ‘photo_key_plan’ at layers,
    - Open ‘Layer Properties’,
    - Click ‘Display’,
    - Check ‘Support Hyperlinks Using Field’,
    - Select feature class (i.e. photos, text_files, sketch, description, etc.) according to the inquiry,
    - Click ‘OK’.
    - Click hyperlink icon.
    - Click the requested photo display. (displayed as points)