LARGE SCALE MONUMENT DATABASE DESIGN

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ABSTRACT:

For the thorough geometric documentation of the Katholikon of the Daphni Monastery in Athens, the compilation of a thematic database of large scale was also specified. A database with content of such detail was compiled for the first time. The contents of the database and the various records of qualitative information were formed with the help of specialized experts and in cooperation of the interested users.

The information management was carried out with the help of AutoCAD Map 2000i® software in combination with Microsoft Access, based on several criteria. Modern technology and the evolution of GIS allow today the fast and systematic recording of such information, but also their recover at will. On the other hand the possibility for direct connection of these pieces of information to the geometric position of the various objects in 3D space is possible.

The database design is very important, because it will allow for the various interrelations of the data to be determined and exploited to the full. The database of such a large scale was set up referencing every brick and every stone on the monument's surface. The various tables were of course interrelated in such a way as to bring out the logic which should be valid when monuments like that are being studied. The database was materialized in a way that the information and properties of all parts of the monument may be interrelated, but also absolutely related to the monument's space. While designing the database a close cooperation was necessary with the end users. In this paper all considerations and decisions taken for the compilation of such a database are presented and discussed.

1. INTRODUCTION

For restoration purposes or significant interventions on large monuments, such as buildings, fortification walls, castles etc, that have been damaged due to natural (ie. earthquakes) disasters or human activities through time, it is absolutely necessary that a detailed and complete geometric documentation should be precedent. The completeness, the efficient use of the products and the visualization methods used for the documentation influence not only the compilation procedure of the restoration studies but in many cases their results also (Ioannidis et al, 1999).

During the recent years under the term 'geometric documentation' we do not mean simply the survey (with combination of photogrammetric, field surveying and other methods) and the production of 2D digital drawings or 3D modeling, but also the development of a GIS, which will combine the geometric information with quality characteristics that are stored in an internal or even external database. Thus, a multi-level and multi-purpose documentation useful for a range of tasks varying from the simple geometric recording up to the development of a decision making systems is achieved. Such examples of IS can be found in many relevant applications (Ioannidis et al, 1992; Cooper et al, 1994; Smars, 2001). Especially for interventions on significant monuments, that constitute treasures of the global cultural heritage, the development of an IS is more than necessary.

Such a monument, which is internationally protected by UNESCO, is the Dafni Monastery. It is one of the two remaining today excellent specimens of the culmination of Byzantine architecture (Figure 1). It was built in the 11th century and is situated in the southeastern part of Attica near Athens. The whole monastery extends on an area of 0.7 hectares and in the center of that area lies the majestic central church, the Katholikon. In essence it is a cross-domed octagon type of church extending approximately 25×15 m² and 20 m in height. The Monastery is considered to be the Parthenon of the Byzantine era, with extraordinary mosaics at the interior of the church.

The strong earthquake of 7th September 1999 caused severe damage to the Katholikon and the rest of the buildings of the monastery. The Ministry of Culture immediately decided to take strong measures in order to protect the monument. Before any static or structural interventions a detailed geometric documentation of the monument was decided. The Laboratory of Photogrammetry of NTUA undertook this task. The restitution of the Katholikon includes:
- vector and raster (ortho-photomosaics) products for 5 horizontal and 20 vertical (longitudinal and transverse) sections and for all the external facades at a scale of 1:25 and
- orthoimages of all the mosaics at a scale of 1:5.

One of the project's requirements was to create a database suitable to record and manage all pertinent information concerning the constructional elements recorded in the drawings.
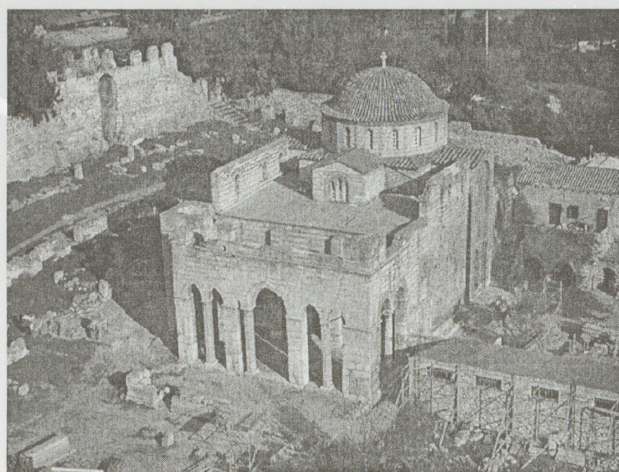
Figure 1. Southwestern view of the Dafni Monastery

2. DATA BASE CONSIDERATIONS

After the main bulk of the geometric documentation works had finished, it was decided to proceed to the data base creation. The contents of the database would be mainly qualitative information for all structural elements of the monument. This meant that for every stone, for every brick, for every ornamental or other single element of the internal and the external surfaces of the church relevant information should be available. Structuring such a database with that level of high detail was one of the main research issues of the whole project. It was for the first time that such a data base was specified, at least to such an extended detail. Contemporary technology and the advancement of GIS allow today the fast, systematic recording of such information, but also their recovery according to the users' desire. On the other hand the possibility for direct connection of these pieces of information to the geometric position of the various objects in 3D space is possible.

For the implementation of the data base the combination of two commercially available pieces of software was chosen:
- AutoCAD Map 2000i®, which provides the possibility of bridging the geometric and topological base map (i.e. the vector or raster drawing) to a data base software
- MS Access 2000®, which carries the desired quantitative information

based on the following criteria:
1. AutoCAD Map 2000i® software is actually a GIS and co-operates, among others, with MS Access 2000®.
2. In this software there is the possibility of recording, analysing, processing and presenting various qualitative phenomena in the form of thematic maps, but also the execution of logical queries by the user.
3. There is also the possibility for the base map to be either a traditional vector drawing or a raster product (such as an orthophotography) and, in addition, it is possible to access more than one drawings at the same time.
4. MS Access 2000® is a widely accepted software with a lot of possibilities of managing descriptive information and is connected easily to AutoCAD Map 2000i®.

The data base design was carried out in co-operation and according to pertinent discussions with the supervisors of the Direction of Restoration of Byzantine Monuments of the Ministry of Culture. The various qualitative pieces of information were connected to the vector drawings and the ortho-photomosaics (Delinikolas et al, 2000). The end products require the installation of the two parts of the software and offer to the users the possibility to edit, update and complement the various elements.

3. DATA BASE DESIGN

This part specifically concerned the implementation of the conceptual and logical database design. The high level of detail and the intrinsic complexity of the subject render the task of database design extremely hard. The design considerations and especially the determination of the various qualitative information fields for every conceptual entity specified were studied in detail in co-operation with the interested users, belonging to several different scientific fields like preservers, architects, civil engineers etc. It should be noted at this point that the design of the database highly depends on the spatial analysis taking place inside the GIS context. In other words the database itself, disconnected from the spatial entities will not be functional.

Database design is a three-step procedure including the design of the conceptual schema, the logical schema and the implementation of the logical schema in the physical level. Conceptual design concerns to the explicit description of the database regardless of the way it is materialized in the hardware level. The most known and widely used conceptual model is the Entity Relational model well known as E-R. The E-R model for the facades of the Katholikon, representing the different basic conceptual entities and the relations among them, is shown in Figure 2.

Four (4) basic conceptual entities were specified, named: Structural_Zones, Stuctural_Sections, Structural_Set and Structural_Elements. Structural_Elements was the main entity representing every separate structural element of each facade of the monument. The necessary attribute properties determined for the specific entity concerned to:
- geological properties
- deterioration-degradation type
- processing type
- dimensions.

In addition, to each stone or brick of the outer walls, a property concerning the surrounding connecting material was assigned. Joint_type was the term used to specify this kind of property as it is shown in the E-R diagram. There are 8 different types of joints on the walls and the roof of the church.

The rest conceptual entities were specified and used in order to describe univocally the location of each structural element of the outer walls of one specific facade. The Structural_Zones entity represents the horizontal division of each facade in different adjacent horizontal zones. The Structural_Sections entity represents the vertical division of each facade in different adjacent vertical zones. Finally the Structural_Set entity refers to every distinct part of the outer walls consisting of several structural elements like windows, other architectural entities This particular conceptual organization helps to
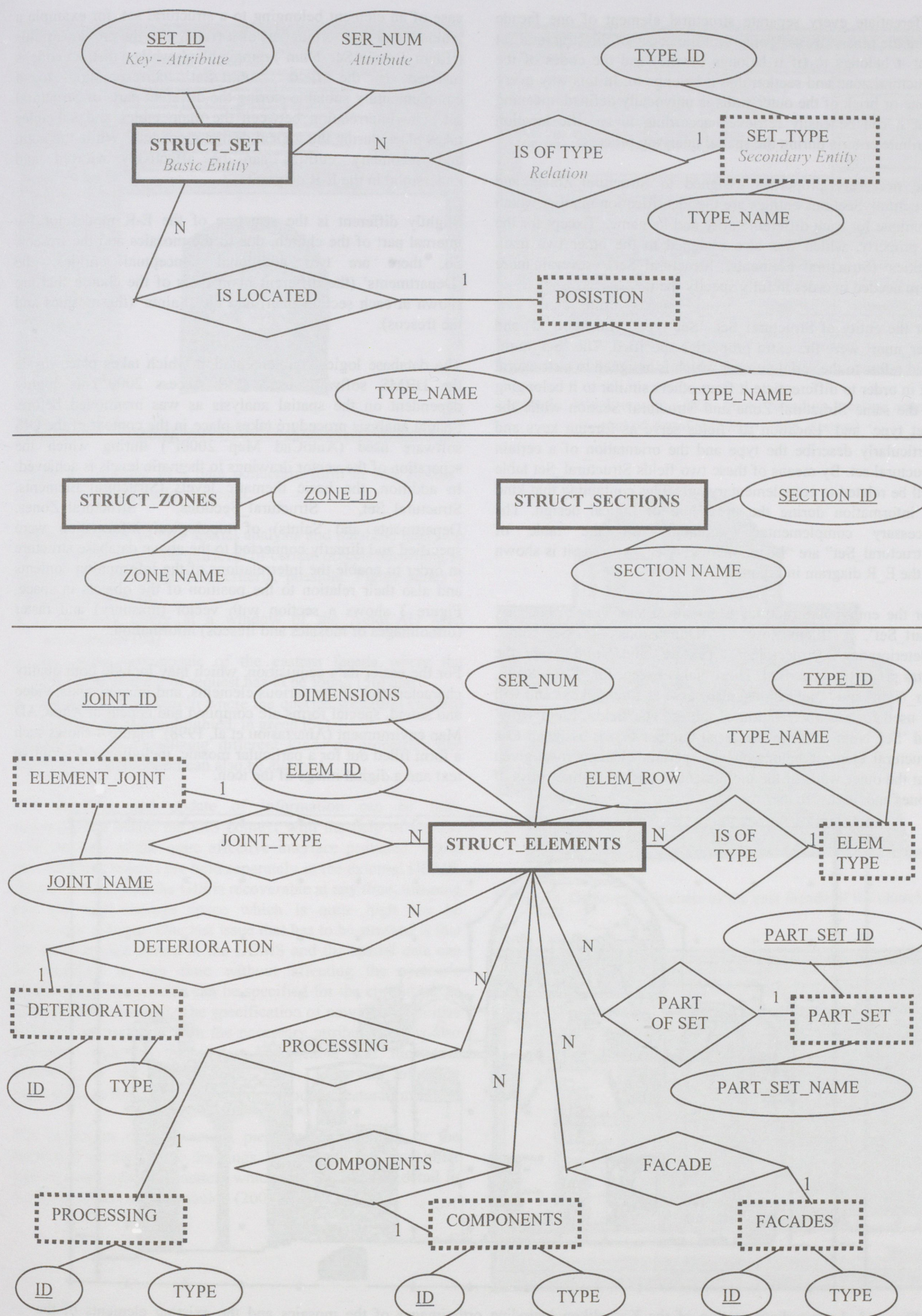
Figure 2. Entity-Relational model for the outer walls of the Katholikon

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differentiate every separate structural element of one facade from the others, by assigning to it the codes of the structural set that it belongs to (if it belongs to one) and the codes of the structural zone and section that it belongs to. In this way every stone or brick of the outer walls is univocally defined, meaning that it can be easily retrieved according to specific location attribute criteria during the spatial querying process.

The necessary properties assigned to Structural_Zones and Structural_Sections entities are the identification number which is unique for each different entity and its name. Except for the id property, which was also assigned to the other two main entities (Structural_Elements, Structural_Set), several more were needed in order to fully specify them.

For the entity of Structural_Set, 'Set_type', 'Location_id' and 'Ser_num' were the extra properties specified. The 'Ser_num' field refers to the serial number which is assigned to a structural set in order to differentiate it from others similar to it belonging to the same Structural Zone and Structural Section while the 'Set_type' and 'Location_id' fields serve as foreign keys and particularly describe the type and the orientation of a certain structural set. By means of these two fields Structural_Set table will be related to complementary subtables containing that kind of information during the procedure of logical design. The necessary complementary subtables for the table of "Structural_Set" are "Location" and "Set_Type" as it is shown in the E_R diagram in Figure 2.

For the entity of Structural_Elements 'Elem_Type', 'Facade', 'Part_Set', 'Elem_Row', 'Dimensions', 'Ser_Num', 'Deterioration', 'Processing', 'Texture' and 'Joint' were the extra properties specified. These fields except for 'Elem_Row', Ser_Num' and 'Dimensions' also serve as foreign keys and will be used for the interrelation of tables. The fields 'Elem_Row' and 'Ser_Num' refer to the serial number that is assigned to a structural element belonging at a certain element row, given that the outer walls of the monument consist of distinct rows of stones and bricks. In the

case of an element belonging to a structural set, for example a window and at a certain part of it (relief arc) the previous fields ('Elem_Row', 'Ser_Num') remain blank while a distinct code is inserted in the field 'Part_Set' corresponding to a complementary subtable storing the different parts of Structural set. The interrelation between the main tables and subtables takes place during the logical design procedure. While the main and secondary entities can be affectively viewed and understood in the E-R diagram.

Slightly different is the structure of the E-R model for the internal part of the church, due to the mosaics and the frescos. So, there are two additional conceptual entities: the 'Departments' (the different main parts of the church that are shown at each section plan) and the 'Saints' (the mosaics and the frescos).

The database logical implementation which takes place inside the DBMS software used (MS Access 2000®) is highly dependent on the spatial analysis as was mentioned before. Spatial analysis procedure takes place in the context of the GIS software used (AutoCad Map 2000i®) during which the separation of the vector drawings to thematic levels is achieved. In addition, the basic thematic levels (Structural_Elements, Structural_Set, Structural_Sections, Structural_Zones, Departments and Saints) of topological information were specified and directly connected to the above database structure in order to enable the interrelations of the information contents and also their relation to the position of the objects in space. Figure 3 shows a section with vector (masonry) and raster (orthoimages of mosaics and frescos) information.

For the easier data acquisition, which may include both quality characteristics of the various elements, and images, texts, video and sound, special forms are compiled and appear at AutoCAD Map environment (Anastasiou et al, 1998). Figure 4 shows such a form filled out for a particular mosaic, including a descriptive text and a digital image of the icon.
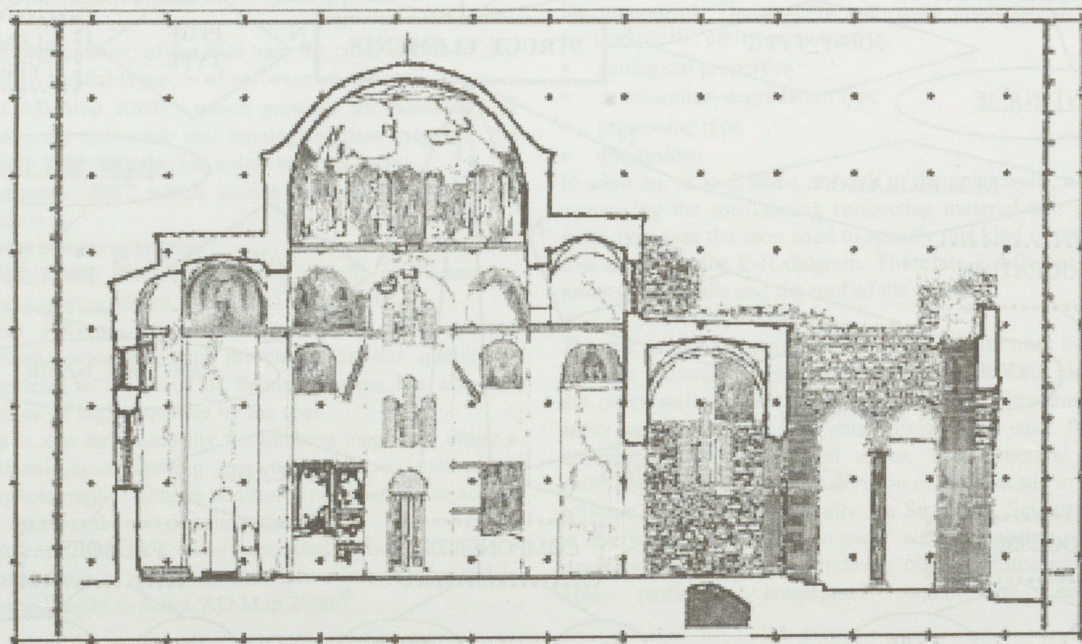

Figure 3. Longitudinal section of the Katholikon including orthoimages of the mosaics and the existing elements of the masonry
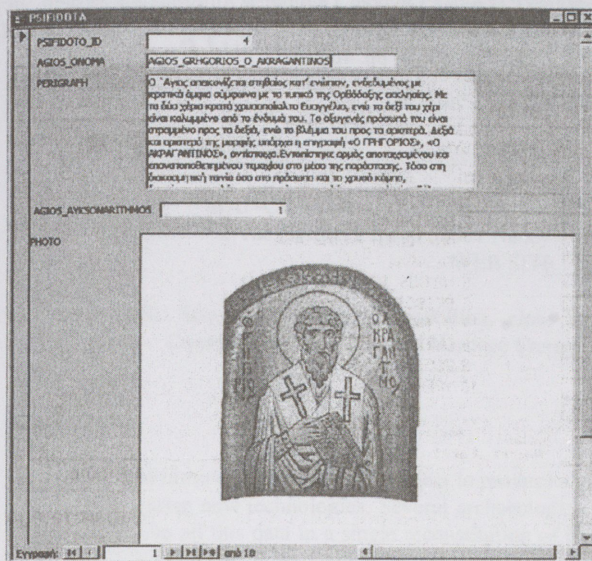
Figure 4. Example of a data collection form in MS Access®
filled out for a mosaic

The combination of GIS spatial analysis and database querying (SQL syntax) makes the retrieval of certain objects according to various location or attribute criteria, possible. Figure series 5 show an example of:

- a topology query at a window of the AutoCAD Map environment (5a)
- the ortho-photomosaic of the eastern façade where the structural element of request has to be found (5b) and
- the result of the search where the queried structural element is retrieved and highlighted, in green (5c).

Thematic maps visualizing different kinds of properties like humidity or degradation can also be attained.

The insertion and update of information can be fully accomplished inside the GIS context with the help of context with the help of the quite affective interface provided. While the database contents are held separately in the external DBMS, the connection with the GIS is recoverable at any time, meaning that the total storage space which is quite high can be affectively reduced. One last issue that has to be stressed is that the attribute data stored in the DBMS and the spatial data can be modified at any time without affecting the system's functionality. New fields can be specified for the current tables and new tables as well. The specification of new spatial entities and their interrelation with the necessary attribute data is also possible, rendering the system changeable and functional according to the user' needs. These tasks are of great importance in the case of a monument under a restoration study.

The collection of the various pieces of information or the correction of the vector drawings, in order to construct their topology, are practical matters which are described in detail in Karkanis (2001) and Iliopoulou (2001).
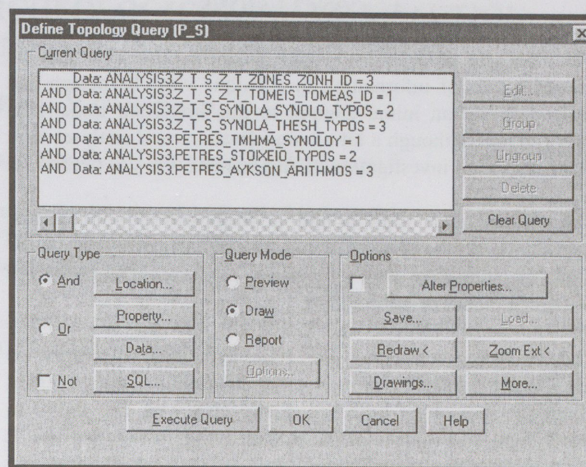

Figure 5a. Window with a SQL query based on location criteria
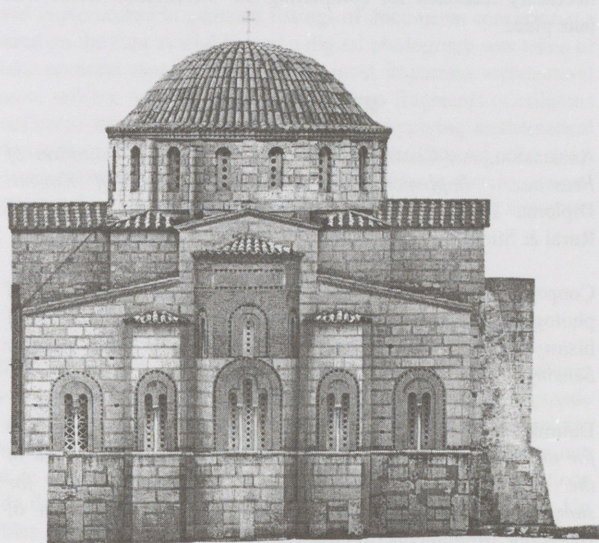(output of AutoCAD Map – MS Access)

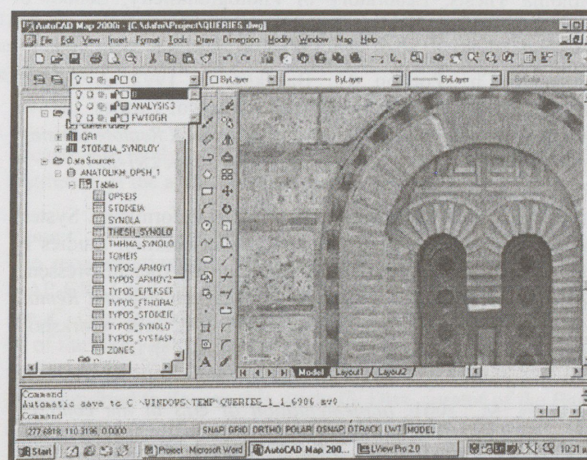Figure 5b. Ortho-photomosaic of the east façade of the church

Figure 5c. The result of the query: the queried element of the
masonry highlighted in green

4. CONCLUSIONS

The data base developed has confronted the monument and the related pieces of information in a unique way. Its design and realization are an initial attempt to this important issue. It is believed that, although a lot of considerations and analyses took place, thorough investigation of all parameters is still needed.

The rational data base design is unquestionably of utmost importance. At the same time special care has been given to the kind, the hierarchy and, of course, the interrelations of the contained pieces of information.

The realization of such a data base with these specifications leads to the possibility of recovering information and properties about the monument with speed and also with the ability to relate them to the space of the monument and to themselves. It is up to the users to make good use of these possibilities, but also to re-specify the data base design according to their needs. For the finalization of the data base structure, it should be put to thorough practical tests for some time. In this way, the necessary feedback for completing the information fields will take place.

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