GIS APPLICATION IN DOCUMENTING AND ANALYZING ARCHITECUTAL HERITAGE.

Dr. Ahmed Mohamed Abd El-rahman Shehata,
Associate Professor, Department of Islamic Architecture, Collage of Engineering and Islamic Architecture, Um Al-Qura University.
Email: elsherouk@hotmail.com

ABSTRACT:

Documentation is one of the most important stages in preserving urban and architectural heritage. Moreover, it is considered as the base for any development decisions (process). Technical tools that can help with documentation has been developed through the last decade. Computer software was one of these tools. It gave the documentation new dimensions.

Geographic Information Systems has emerged as a new tool that can be utilized in this field. It has the ability to link a huge number of different types of data. Such databases can include descriptive and spatial information. Linking building's descriptive data to their geographic ones gives a huge opportunities for detailed and accurate documentation. Moreover, It facilitates monitoring the changes not only in the targeted buildings but also on their surrounding built and natural environment. It also gives a big possibilities for studying and analysis.

The paper also presents a case study for application. A prototype project to document historic central area of Makkah city and its valuable buildings.

The project presents different levels and different dimensions of documentations, It shows, how the changes in the urban form of Makkah city across time can be recorded and presented in three dimensions. It also shows, how architectural changes that tock place on the important and valuable buildings can be recorded and retrieved in their sequence for analysis.

The paper concluded with recommendations for GIS applications in documenting architectural and urban heritage.

Keywords: G.I.S, Heritage, Architecture, Documentation, Analysis.

INTRODUCTIN:

Several technical tools has been developed through the last decade. Such tools has become available for application in many fields. The following are examples for these tools:

> **Geographic Information Systems**: GIS gives the ability to link both spatial and descriptive information. Moreover, It facilitates linking data through hyper-linking it to graphical objects or as an attribute data to it.

> **Virtual Reality**: It is a new developed language. It helps in creating a ٣ Dimensional models. These models can be navigated and walked through.

> **Multimedia**: It is a programs that can be used to create projectors or flashes. These projectors introduce an interactive information in multimedia formats (videos, Pictures, Maps, Drawings, etc.).

This paper put the light on the application of Geographic Information Systems as a new developed tool in documenting and analyzing architectural and urban heritage. It presents a case study to document a whole region including a ٣d contour model. This model has different levels of details.

The level of detailing varies with importance of the area or the building. The paper presents the steps needed to build that model and some applications It.

RESEARCH OBJECTIVE:

The research aims to present the GIS and some other technical tools as a full documenting heritage system. This system is capable of documenting not just separate buildings but a whole historic area.

RESEARCH PLAN:

To achieve the previously stated research objective, An applied analytical Approach was followed. The following steps were taken:
- Defining the needed data to document both the urban character of any historic area and the key buildings within it.
- Designing forms for collecting descriptive data and database structure.
- Collecting the needed Data:
  - Defining criteria for case study selection.
  - Selecting historic case study area.
  - Collecting the needed data for documenting both urban characteristics and historic buildings.
- Creating the GIS Model:
  - Designing and building the Geo-database for the GIS System.
  - Creating the base-maps.
  - Creating the datasets.
  - Creating objects.
  - Linking data and photos to objects.

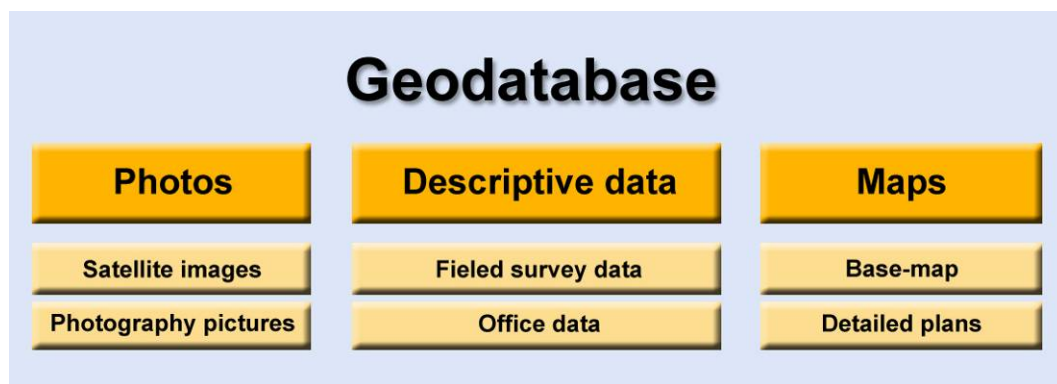Figure (١) illustrates the different data types of the geo-database:

Figure ١: Geo-database Components.

NEEDED DATA FOR DOCUMENTATION:

Data for Documenting historic Urban areas:

- Maps of the historic area.

- o Arial and satellite photographs
- o Photos and films for urban spaces, street elevations, markets, plazas.
- o Descriptive data for buildings within the area (heights, usage, building types, construction methods),
- o Street elevations.
- o Photos for key buildings.[١]

Data for Documenting Important buildings:

- o Building drawings (elevations, plans, sections, ٣d details).
- o Building details (doors, windows, ornaments and patterns).
- o Movies, Pictures for the building and its elements.
- o ٣d VRML for buildings and their details.
- o Descriptive data (construction details, usage of building spaces, etc.).

Data formats and file extensions are given the table ١.

Table ١: Documentation Data Types.

	Data Format	File's extension
Graphical data	Photos,	Jpg, Gif, Tiff
	Movies,	Avi, Mpg
	VRML Model	Vml
Descriptive Data	Text,	Pdf, Doc, txt
	Excel charts	Exl.

CASE STUDY SELECTION:

Selected area for study have to be historic one, It should have historic or traditional buildings. Such area should represents the character of the traditional Islamic city.[٢] The central area of Makkah city was selected as a good example for such area.

Central Area of Makkah City:

Makkah is a city surrounded by a series of Mountains and hills. This is the old historic city of Makkah Figure (٢). In the eighties, a network of tunnels and bridges constructed. This new road network extension allow the city to grow behind Its surrounding mountains. Now, Makkah city is more than four times bigger than the old city. Figure (٣). Central area of Makkah city has many traditional buildings, its urban pattern represents the traditional Islamic urban pattern. Figure (٤) illustrates the different patterns recognized within Makkah city. Al-Modaa Market within the central area was selected as a case study for documentation. Figure (٥) shows layout of Al-Modaa Market and its surrounding buildings. [٣]
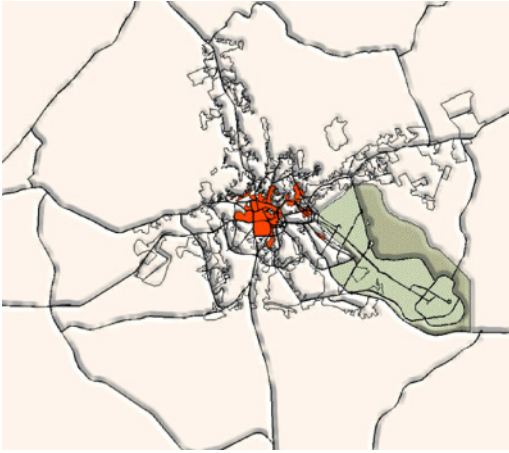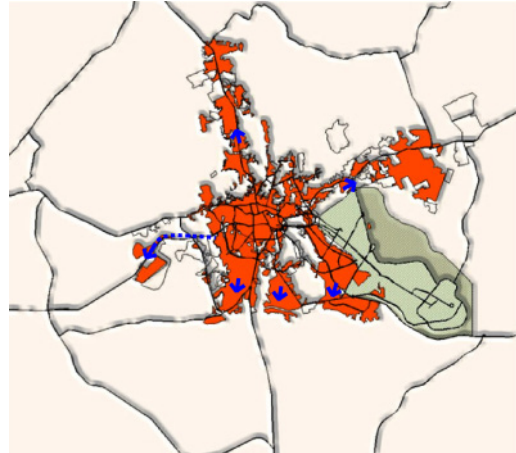
Figure ٢ Map of old city of Makkah. [٣]

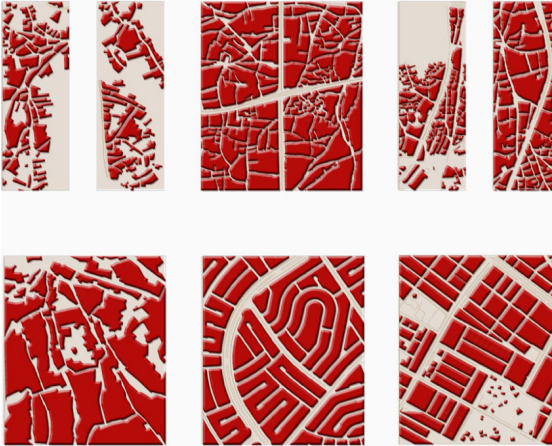**Figure ٣ Urban pattern of Makkah in ٢٠٠٦.** [٣]

Figure ٤: Different Urban Pattern recognized within Makkah city.[٣]
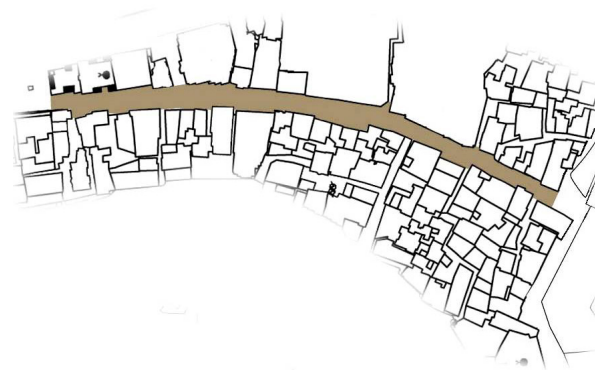

Figure ٥: Al-Modaa market as traditional Islamic markets.

Important Buildings Within Central Area:

The central area of Makkah city Has many Important buildings. The Kabba and its surrounding holy mosque are the most important buildings within this area. Many other traditional housing buildings found within the area. Al-Haram building was selected as a case study for documentation. Figures (٦،٧) shows photos of key buildings within the Makkah central area.

Figure ٦: Arial photos for important buildings

Figure ٧: Holley mosque and Its plazas.

٤

COLLECTING THE DATA FOR DOCUMENTATION:

Data needed for documenting the urban characteristics were defined. It was collected and transformed into digital format. They were composed of:

- Digital CAD Maps supplied by the Makkah Municipality dated ١٤١٩. Figure (٨).
- Satellite Images for central area of Makkah city. They are ١ meter resolution dated march ٢٠٠٥. Figure (٩).
- Photos for spaces, street elevations, main landscape features, focal points and key buildings within the area. Figures (١٠, ١٢).
- Physical survey for buildings of the study area. Figure (١١).
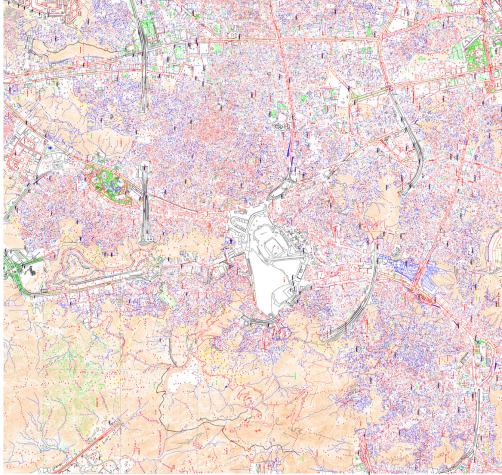
Figure ٨ Digital Maps for the Study Area.

Figure ٩ Satellite image for the Study Area.

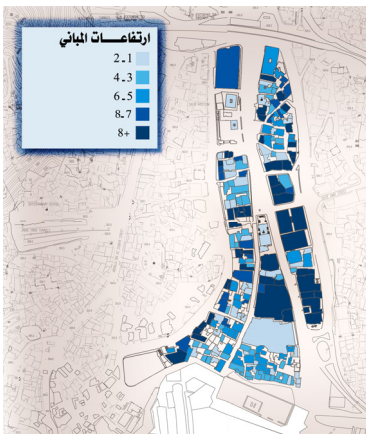**Figure ١٠. Photos for Al-Modaa Market**
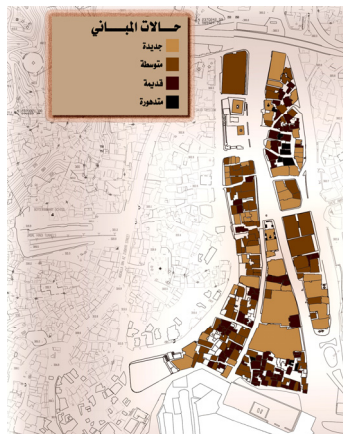
Figure ١١ Physical Survey for Study Area (Building Heights, Construction Type and Usage).
[٤]

Figure ١٢: Photos for Key Buildings Within the Study Area.

Data needed to Document Historic Buildings:

Key buildings within the old historical area of Makkah city was defined. As mentioned before Al-Haram Mosque was selected as an example for the process documenting these buildings. The following data were collected:

- Building drawings (elevations, plans, sections, ٣D details). Figure (١٣) shows samples of the digital drawings of plans and elevations.
- Building details (doors, windows, ornaments and patterns). Figures (١٤).
- Photos for Internal and exterior of building Elements. Figures (١٥ to ١٧)
- ٣d VRML of buildings and their details.
- Descriptive data (architectural design concepts and goals, building elements, usage of building different elements, construction details, Ornaments, areas utilization, security and camera zones, lectures' locations and prayer zones).
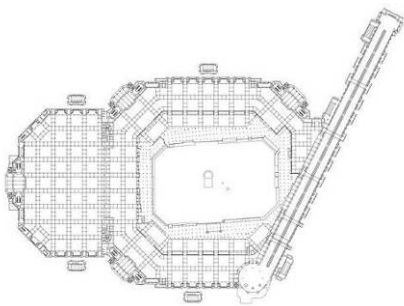

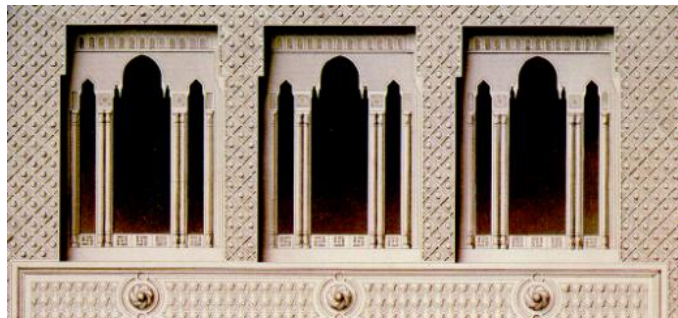**Figure ١٣: Sample Plan for Drawings for Al-Haram.**
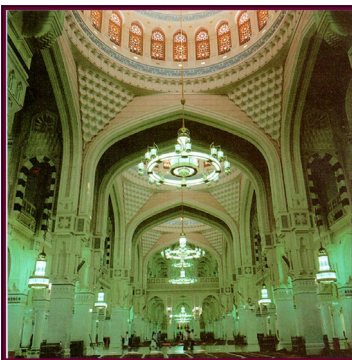**Figure ١٤: Sample of Window Detail.** [٥]

Figure ١٥: Internal View of the
Figure ١٦: Internal View of Al-Massa

٦

Second Saudi Extension.

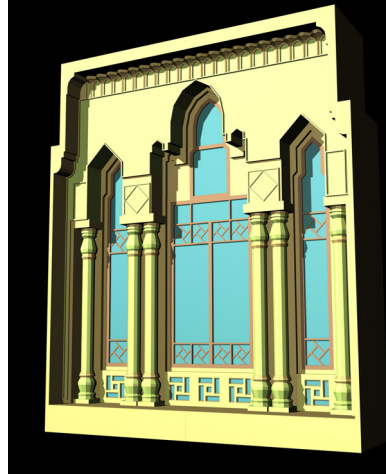**Figure ١٧: Picture of Al-Haram Real and ٣D Model for the Minaret.** [٥]

Figure ١٨: ٣D Simulated Model for Building Details (Window and Lighting). [٥]

BUILDING THE GIS MODEL:

After collecting the needed data and transforming it into digital formats, the following steps were taken:

- Creating the Geo-database: The following steps were taken to create the geo-database:
  - Designing the database structure.
  - building the geo-database
- Creating the Base Map: using the DWG files,
  - A ٣D Cad for the contour lines were created using a special subroutine developed by the author for this purpose. Figure(١٩)
  - A ٢D cad polygons and ٣D blocks for buildings were created.
- Creating the ٣D Model: using the Arc-info and Arc-seen The GIS Model were created through the following steps:
  - ٣D cad contours, the Satellite images, The ٢D polygons and the road network were imported to the Arc-info. Figure (٢٠).
  - A Tin was created using the ٣D contours. Figure (٢١).
  - The satellite images were applied to the tin. Figure (٢٢).
  - Road network has been applied to the tin. Figure (٢٣).
  - Building blocks were raised to their contour base level and extruded to their heights. Figure (٢٤, ٢٥).
  - Haram building plans was imported. Figure (٢٦).
- Linking data to their objects.
  - Every urban object was linked to its corresponding database.
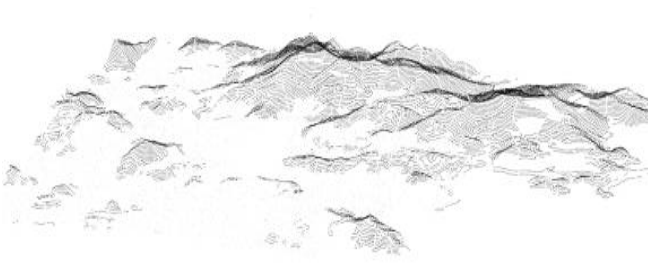 - Each element of the Haram building was linked to its corresponding database. [١،٦]

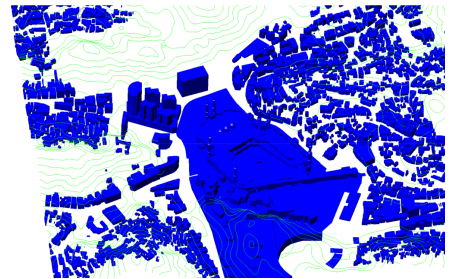**Figure ١٩: ٣D Cad Contour Levels of Central Area of Makkah.**

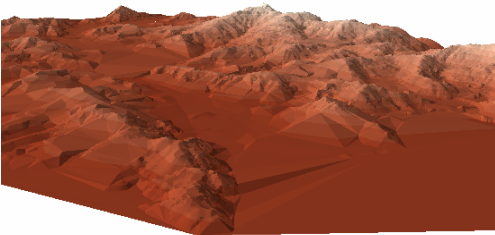**Figure ٢٠: ٣d Model for Buildings of Historic Area of Makkah City.**

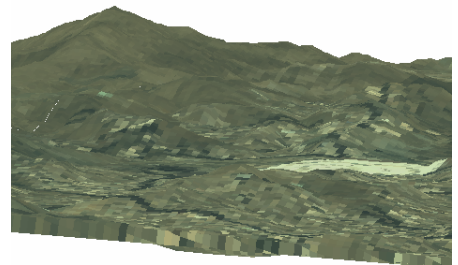**Figure ٢١: Tin Created Using Arc-info From the ٣D Contours.**

Figure ٢٢: Applying the Satellite Images on the Tin Using Arc-seen.

Figure ٢٣: Road Network Applied to the Tin. [٧]
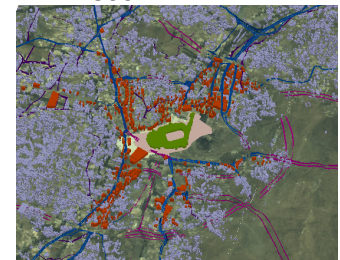

Figure ٢٤: Extruded Building Blocks.

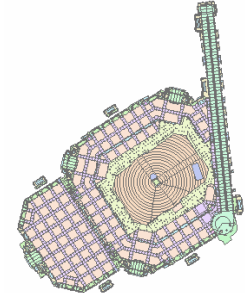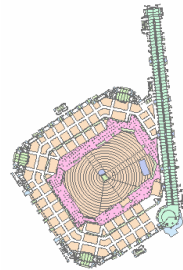**Figure ٢٥: Descriptive Data are Representation on the ٣D GIS Model.**
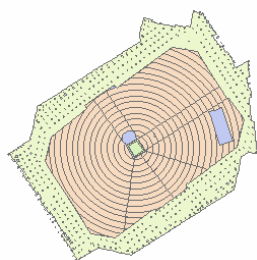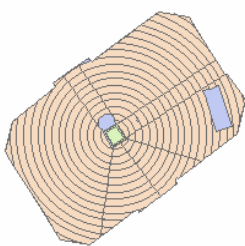

Figure ٢٦ GIS Plan for Different Haram Extensions.

GIS MODEL APPLICATION:

The resulted documentation system can be utilized in many different ways. The following are some examples of its applications:

- Developing Time-Based GIS Display for both Historic urban and important buildings data. This can allow monitoring changes on certain historic area or building over certain period of time.
- Navigation through ٣ dimensional data representation.
- Using the documentation system as a decision support system. Such system can be utilized in many ways. The following section demonstrates how this could be conducted? [٩, ١٠]

Analyzing Women Praying areas using the GIS documentation system: [٩،١٠]

Using the documentation system as a decision support system. It was used to Study and re-arranging the women Praying and Tawaf areas. Through the following process:
- A new bridge to serve as special mataf for women was proposed.
- Three different alternatives for this bridge were suggested.
- ٣D models for the three suggestions were added to the existing ٣D model of Al-Haram building.
- In addition to many simulated pictures, animations were produced to study the visual impact of the proposals on the existing spaces. Figure ٢٧ illustrates some of these captured views.

Aspects affecting Women praying areas were investigated:
- Distribution: Women praying areas were defined on every floor. Their relations to other prying areas were analyzed.
- Accessibility: Women praying areas relationship to exits and staircases were investigated.
- Capacity: Capacity of women praying areas were calculated.

Figure ٢٨ shows a captured screen for the GIS documentation model of Al-Haram. Relations of the women praying areas in the ground floor were investigated.

Based on the previous analysis, a decision were taken to:
- Rejecting the idea of creating new bridge inside the mataf, because it will have a negative impact on the visual perception of the building elements.
- Re-arranging the women praying areas and planning to increase it during the seasons.
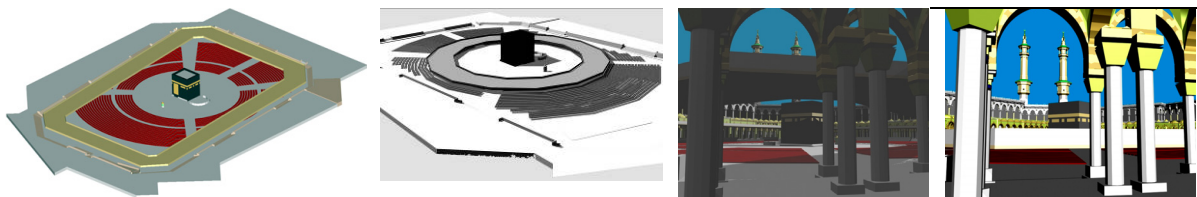

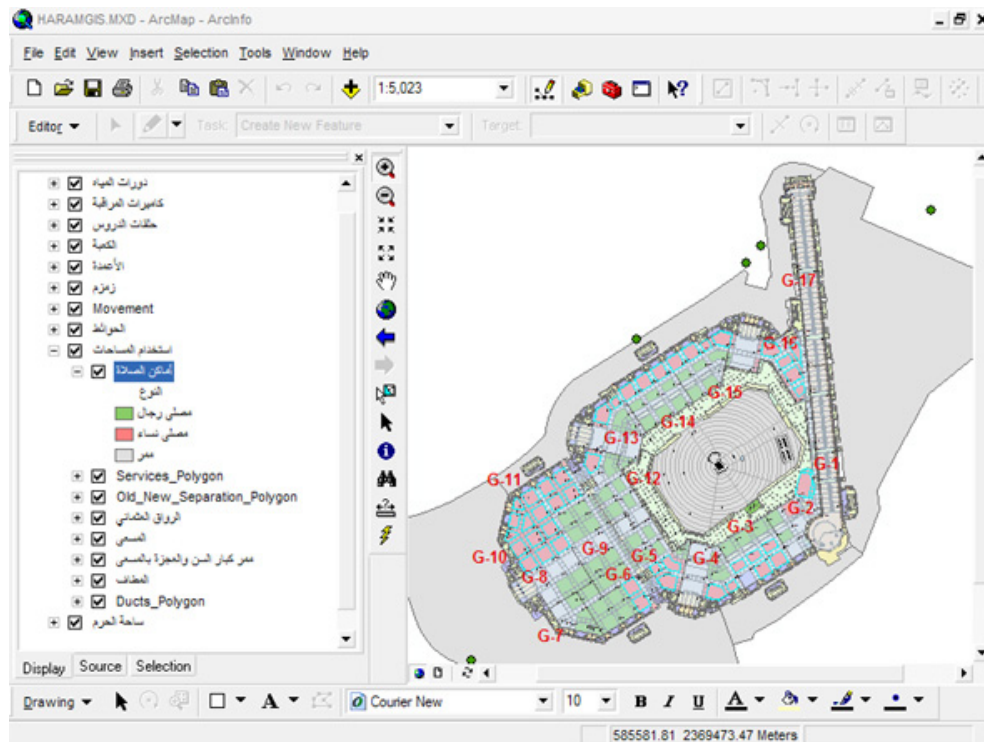**Figure ٢٧: Different Views for Suggested Bridges. [٩]**

Figure ٢٨: A Captured Screen for the GIS Model of Al-Haram. [٨]

CONCLUSION:

- Documentation should take advantage of new computer technologies.
- GIS technology offers a comprehensive system for documentation.
- GIS can be utilized to document urban characteristics of historic areas within Islamic and Arab cities.
- GIS can serve in documenting historic buildings and linking both descriptive and spatial data of every element of the building.
- GIS documentation system can serve as a decision support system.
- ٣D GIS provides a tool to represent urban areas and their landscape.
- There is a need to build a more accurate and comprehensive ٣D GIS for the historic old area of Makkah city.

REFERENCES:

١. ArcGIS Spatial Analyst: Advanced GIS Spatial Analysis using Raster and Vector Data, An ESRI white paper, (٢٠٠١), Esri ٣٨٠ New York St. Redlands, CA ٩٢٣٧٣-٨١٠٠, USA.
٢. Madiha A. A. Farag (٢٠٠٦), "Studying the Past to Understand Today's Environment - Prehistoric Sites on the Island of St. Kitts Studied Using GIS". ArcNews, Spring Issue.
٣. "Regional Plan of Makkah", Final Report, volume I, (٢٠٠٤). Makkah municipality.
٤. Shehata, "Built Environmental Conservation Project", (٢٠٠٥). A Supervised Field Survey Conducted by Postgraduate Students as Part of Maters Program. Department of Islamic Architecture, Um Al-Qura university.
٥. Shehata, Ahmed, (٢٠٠٣). "Interactive ٣d model for Al-Hram", Unpublished Research, Hajj Research Institute, Umm Al-Qura University, Makkah, Saudi Arabia.

٦. Joseph W. Berry III, (٢٠٠٣) "Historic Sanborn Maps in the Digital Age: City of New Orleans" Journal of GIS in Archaeology, Volume I, pp. ٧٥-٧٨

٧. Nabeel, Koshak and Shehata Ahmed, (٢٠٠٥). "Internet based GIS for Road network and traffic plan during Haj ١٤٢٥". Research Project, Hajj Research Institute, Umm Al-Qura University, Makkah, Saudi Arabia.

٨. Fouda Abullah, Shehata Ahmed, (٢٠٠٥) "GIS Project for Al-Haram Mosque". Unpublished Research, Hajj Research Institute, Umm Al-Qura University, Makkah, Saudi Arabia.

٩. Shehata, Ahmed, (٢٠٠٦). "Alternatives for the new bridge for Women Tawaf". Unpublished Research, Hajj Research Institute, Umm Al-Qura University, Makkah, Saudi Arabia.

١٠. Fouda Abdullah, (٢٠٠٦). "Analyzing Women Praying Area". Unpublished Research, Hajj Research Institute, Umm Al-Qura University, Makkah, Saudi Arabia.