DIGITISING AEGEAN BRONZE AGE BUILDINGS: BUILDING TYPOLOGIES FROM DIGITAL PLANS.

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ABSTRACT:

How and why did people living in the Aegean region over 3,000 years ago construct their buildings in the manner that they did? By having access to digital building plans our understanding of building techniques used in the region during this era can be improved. The application of digital spatial analyses to determine what could be possible reasons why certain materials and dimensions were used in building construction can be facilitated more readily by making digital plans available. A brief discussion of results from digitising the building plans at the site of Akrotiri on Thera will be presented. This paper then proposes a project to produce a Geographical Information System (GIS) database of architectural remains from the most significantly researched Bronze Age sites in the Aegean. This GIS can then be used to determine what influenced ancient construction techniques based on dimensional and material analyses of these digital architectural plans and records. Furthermore spatial analyses of this larger cohort of buildings can then lead to the formulation of more comprehensive building typologies that may have been used by builders during the Bronze Age era in the Aegean region.

1. INTRODUCTION

1.1 Background

Buildings played a fundamental role in the urbanisation of populations (Branigan, 2001). The development of settled societies is reflected by the construction of buildings and consequent growth of "urban-centers". How the buildings were constructed can be deduced from the architectural remains that are found at many archaeological sites. However why certain construction techniques were used also need to be considered. In many cases construction techniques that developed in certain areas reflect a purely local style. However there are sites that were influenced by neighbouring cultures. This is evident where local building traditions adapted "foreign" architectural elements to varying degrees. A number of analyses can be applied to investigate possible reasons why certain materials and dimensions were used in the construction of buildings. For example the design may have been influenced by social or cultural expectations (which may be apparent in cultures where there is evidence that a strong social hierarchy existed) or by the specific function(s) that the buildings were constructed for. So where there are remains of spindle whorls and loom-weights in certain rooms or buildings weaving activity can be suggested, and hence large and/or many windows are to be expected (Yannouli, 1992). Other factors may be revealed during the course of further research. For instance economic factors may also have played a role in how the buildings were constructed, reflected by the size and quality of the materials used (Kopcke, 1987). Therefore a number of factors that may have influenced the final design of a building will have to be concurrently researched. Such a multi-factor analysis can be better facilitated by digital plans of buildings in a GIS database. As such these analyses can help develop and advance methods for determining the most significant influences or factors that played a role in constructing the buildings in the manner that they were.

1.2 Why create digital building plans?

A GIS containing digital building plans can provide the means for an integrated approach to investigate aspects of social, economic, ritual and climatic factors that may have affected building construction. The determination of Aegean Bronze Age building typologies will be the primary objective for creating such a database. This can be fulfilled by conducting comparative digital spatial analyses of Bronze Age architectural remains in the Aegean. The application of a GIS to digitally record, store and analyse an integrated database of digital images and data about many different site plans has not been undertaken for Aegean Bronze Age sites. These digital maps can enhance architectural research in this area by facilitating an easier method for accessing and analysing the available dimensions of the plans. Having improved access to these plans can contribute to furthering our understanding of building techniques in the region during this era by applying a number of spatial analyses. Digitised site plans can provide an efficient means of analysing and investigating further insights about possible reasons why certain dimensions and materials were used in constructing buildings by taking into consideration their orientation, density and proximity of different types of buildings in relation to each other. The amount of air and sunlight that would be available in a building may have been planned for by the design of the building's window and door dimensions, orientations and the material of the walls that would either retain or reflect heat. This research has the potential to reveal any such pre-determined plans or building typologies.

Currently no comprehensive digital repository of Bronze Age Aegean building plans exists. The application of a GIS to digitally record, store and analyse an integrated database of digital images and data of site plans can be used to more comprehensively investigate the different typologies and aspects influencing the construction of buildings. The proposed

GIS database of architectural remains from the most significantly researched Bronze Age sites in the Aegean can be used to determine what influenced ancient construction techniques based on dimensional and material analyses of these digital architectural plans and records. Are thicker walls found in certain locations if so why? Were any "ritual objects" found in certain rooms, if so how were these rooms built? By answering these questions and others may also lead onto advance developments in the approaches and methodology of interpreting the design of buildings. Major outcomes will be to determine what/if any patterns or new building typologies may be revealed. For instance do distinctive building types exist, if so which sites shared common characteristics and why? This GIS database of digital building plans can be analysed in conjunction with already known building typologies to clarify and determine any new building patterns and/or typologies in the region. Furthermore the availability of a GIS database that can be easily accessed for detailed analyses of various aspects of architectural remains found at archaeological sites may also lead to new approaches for future enhanced Virtual Reality models of ancient buildings.

Many archaeological excavation plans still remain in an analogue format. This paper proposes that GIS be applied to digitise previous and future archaeological site plans in the Aegean in order to facilitate easier access for their analysis and final publication. Digital photos of architectural remains and significant artifacts found in the buildings can also be included in this database. This GIS database will enable comparative analyses to be made across many sites. However to enable comparative analyses to be made across many different sites standard digitising techniques will need to be applied. The process used to digitise analogue plans at the site of Akrotiri and their subsequent analysis will be briefly presented with examples of some of the benefits for digitising site plans. Some of these benefits include the easier categorisation of buildings as separate entities, and in the case of Akrotiri subdivided by floor levels, showing their type and location relative to other buildings at the site. Excavation plans that were digitised at Akrotiri can also provide a basis from which other sites can now be digitised in a standard format. A standard template can be developed from the methodology used at Akrotiri to enable comparative digital spatial analyses to be performed about how the architectural heritage of a specific era and area developed over time.

2. DIGITIAL SITE PLANS AT AKROTIRI

Digital plans and analyses of dimensions of the buildings at the site of Akrotiri on Thera now exist from research that was conducted at the site (Constantinidis, 2005). This research developed an approach to digitise and record architectural remains that can now be applied to other sites at a much faster pace because a methodology has already been formulated. Essentially during the initial phase site plans are located and then scanned from excavation reports and then details of all the walls, and architectural features are digitised in a GIS database (in this case MapInfo was used). Figures 1a.-b., below, illustrate the dimensions of all the wall sections, including door and window lengths that are included in these digital site plans and their associated spatial database.

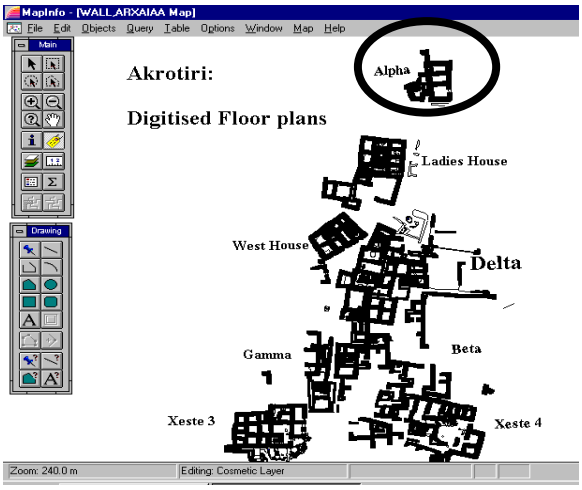

Figure 1a. Digitised building plans at Akrotiri on Thera.

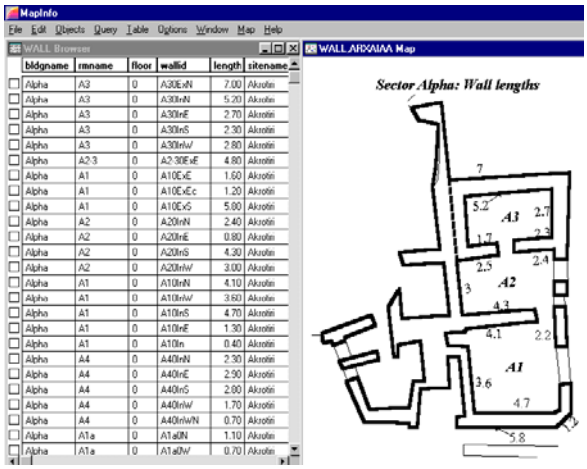

Figure 1b. Detail of dimensions of Sector Alpha at Akrotiri.

What can also be included in this database are the dimensions of the rooms in square and cubic meters (m^2, m^3) where available, the number, orientation and dimensions of windows and doors of each room. Because architectural details are relatively well preserved at Akrotiri these can be used to extrapolate building designs at other sites where the remains are fragmentary. The proposed GIS database of Aegean sites will contain similar dimensions for all buildings at other sites. These can then be used to investigate the relationship of the dimensions, material, size and position of buildings across many Aegean Bronze Age sites. Any extreme variations in any of these dimensions will be considered as to why they appear. Were thicker walls, windows or doors placed at certain positions? Based on the intensive research of the relatively well preserved buildings at Akrotiri a comparative analysis with other sites may reveal patterns as to why buildings were constructed in the way they were. The extent to which either social requirements or other factors may have dominated construction can be better explored by comparing sites throughout the Aegean. The size of the rooms, the length of doors and windows will be included for multi-factor analyses of all of these features across many different Bronze Age Aegean sites. Figure 2., below, provides the internal dimensions of rooms in the West House at Akrotiri. If similar building types from other sites were already digitised then comparative analyses could have been carried out much more easily to discover possible reasons why these dimensions were used in similar building types. Conversely building typologies can be

determined by categorising buildings by the number and size of rooms they have.

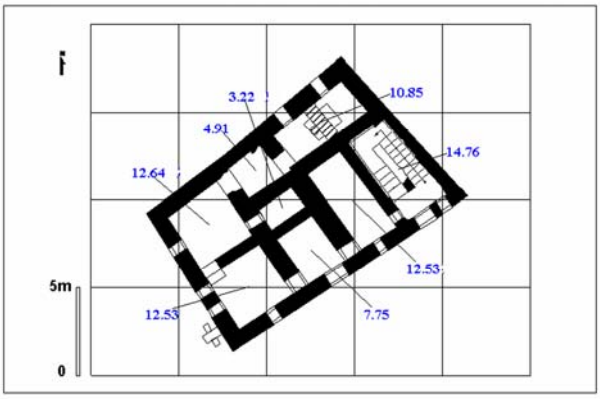

Figure 2. The dimensions (in m^2) of rooms in the West House at Akrotiri (ground floor plan).

A GIS database can be utilised for this research to facilitate a comparison of site plans and building layouts. Based on the available and relatively more complete dimensions at Akrotiri further insights may be gained at other sites by proportionally applying these better and more complete dimensions to fragmentary architectural remains at other sites. New approaches to determining the original dimensions of architectural features where remains are scant may be further developed by this comparative analysis of the buildings throughout the Aegean. Photos of existing architectural remains and significant artifacts at sites should also be incorporated into the GIS database of the buildings found at Aegean sites. This GIS database will enable comparative analyses to be made across many sites by introducing standard digitising techniques that have already been applied at Akrotiri. A comparative analysis of building materials that were used in relation to the design of the various building types can also be made. This can then reveal a relationship between the material used and the dimensions of the building or rooms of particular building types throughout the region.

3. ANALYSING DIGITAL SITE PLANS

In many cases the use of a GIS to include details about spatial data associated with the finds has extended the application of database technology at a site (Berg 2001). GIS technology offers the possibility of storing data with spatial attributes. Subsequently "map-based" searching facilities have been created in order to analyse the spatial characteristics that most archaeological data, and especially architecture consists of. Spatial or GIS databases have the ability to store and retrieve spatial and attribute data about every line or point on a map. A GIS can thus allow archaeologists to see the location and have information about their data on interactive maps. A GIS can allow plans of excavations to be stored in a digital format that allow access to data about everything found at the site on a daily basis. But most importantly is the ability for GIS databases to facilitate a variety of spatial analyses. In this case a GIS provided digital plans for the site of Akrotiri on Thera. The digitised site plans were used to investigate the dimensions of buildings such as the dimensions of each wall. The GIS database was also used to store images of the buildings at the site, but most importantly it was used to derive, for example the size of each room in all of the buildings, as is shown for the West House in Figure 2. above. If architectural data from other sites were available then comparative analyses could be performed. In this case buildings at other sites that have similar sized rooms can be found relatively quickly, and may then be used to develop a building typology for a particular era and area.

Current scholarly research concerning the Aegean Bronze Age (ca. 2200-1200 BC) covers a broad area of topics that can be incorporated into these analyses. These areas range from investigations about climatic conditions in the region (Moody, 2000 and 2005) to the cultural and social contexts and meaning of the artefacts and architectural remains (Werner, 1993 and Manning, 1997). There are ongoing developments in this area of research as new data continue to be excavated. Given this growing plethora of data, theories continue to develop to reflect the latest evidence. Various aspects about the buildings have to be integrated with, for instance the latest available environmental data in order to advance research about architectural remains at a site by taking into consideration all possible influencing factors. So multi-dimensional or multi-factor analyses based on recent research results can extend and make available new data by determining whether or not and to what degree the construction material, orientation and size of the buildings were influenced by either social, climatic, economic or other reasons. This may be determined by comparing buildings at sites in the northern Aegean with comparable sites in the relatively warmer south, such as those on Crete, and see if any significant differences or similarities in architectural patterns or elements are apparent (Driessen, 1995).

To date minimal systematic research has been carried out to determine the extent or degree of influence that was due to either socially construed functions of the buildings, techniques designed for the purposes of combating harsh climatic conditions or other factors. Architects and engineers have discovered evidence that in many Bronze Age or "Minoan" Buildings on Crete and on other islands such as at the site of Akrotiri on Thera, anti-seismic techniques integrated vertical and horizontal timber posts into the walls to prevent the buildings from collapsing in this relatively seismically active region (Tsakanika-Theohari, 2006). Hence it is also of significant importance to better understand and determine if other techniques to improve living conditions in the buildings were also incorporated into the design. The proposed GIS will provide a more holistic approach to understanding past construction techniques. Currently the principles for investigating ancient buildings are based on determining their construction technology, typology, form, and function (Palyvou, 2005).

However building techniques that may have been used for a variety of purposes, including climatic control; have not been explored in any great depth. This is because the number and combination of analyses are prohibitive if carried out manually to determine the role of various influencing factors on design and construction. However with the GIS database that this paper proposes a combination of multi-dimensional analyses can be facilitated more efficiently. Further insights and additional perspectives on past building technologies may be gained by using digital plans. Research should be based on an integrated investigation of these plans and it should focus on the buildings at Akrotiri because most of the buildings there have been relatively well preserved, where two of the buildings found so far provide evidence that they were originally three

storey buildings (Doumas, 1983). Figure 3. below is a photo of one of the better preserved houses that were uncovered at Akrotiri. The buildings at Akrotiri provide an excellent context for many aspects of the construction techniques that were used and offer a unique insight so that comparisons with other Aegean sites can then be made.

Figure 3. The "West House" at Akrotiri preserved up to 2 storeys high.

Architectural research for this region and era has previously considered aspects of possible ritual functions that rooms or whole buildings may have had. Interpretive approaches have also been developed to determine construction patterns that may have been based on pre-defined modules of space (Hitchcock, 1998 and Preziosi, 1983 and 2003). The proposed GIS could make a positive contribution to current efforts in the area by providing digital plans and new approaches to re-interpreting architectural remains from a multi-dimensional perspective. By analysing all the wall dimensions at Akrotiri it was demonstrated that discrete units of measurement were most likely used to construct the buildings there. Furthermore internal pathways within each of the buildings can also be plotted, as depicted in Figure 4. below, and considered in the overall analysis of the spatial organisation within each of the buildings and then compared with similar buildings at other sites.

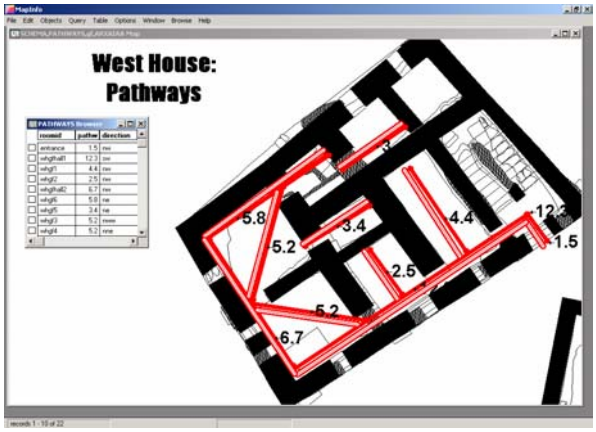

Figure 4. Proposed internal pathways in the West House at Akrotiri and their corresponding dimensions.

Other questions that can be considered for these building analyses are whether the construction techniques that were used resulted from plans to counter the effects of extreme climatic conditions or whether they are more a reflection of the cultural and ritual aspects of the society that affected the final design of the buildings. For instance were any "ritual objects" found in certain rooms; if so how were these rooms built? Are thicker walls (providing better insulation) found at certain sites; if so why? Were windows or doors orientated to capture any cool evening breezes during summer? Figure 5., below illustrates the location and direction of external doorways that could be compared with other sites in the proposed database to see if any climatic controls were incorporated in the building plans.

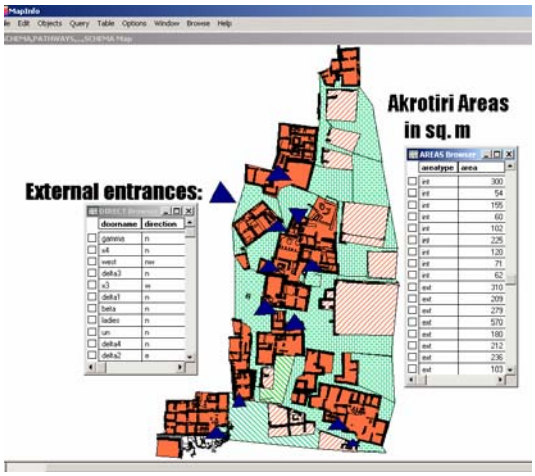

Figure 5. The location and orientation of external doorways.

Answering these questions and others will lead to advance developments in the approaches and methodology of interpreting the design of Aegean Bronze Age buildings. A GIS database that can be easily accessed for detailed analyses about various aspects of architectural remains at archaeological sites can lead to new approaches for modeling how ancient buildings may have appeared, in cases where the remains are very fragmentary. The GIS database will provide the ability to seek out distinctive building types and investigate possible reasons why some sites may have shared common characteristics. Subsequently this will assist in discovering architectural aspects and elements that may have been incorporated into the design to combat changes in the climate, hence reflecting people's ability to adapt buildings to suit any new environmental or other requirements. A multi-dimensional analysis of the buildings can be based on the digital plans and data in the GIS database. The dimensions, orientation and material of each of the buildings can be analysed for any patterns and variations indicating possible adaptation to suit the local climate or culture. Comparative analyses of material that was used and the design of the various building types will also be made. This can reveal a relationship between the material used and the dimensions of the building or rooms of a particular building type. This may eventuate in answering whether ultimately culture or climate affected building construction. Did the building dimensions and material suit the environment, if not were any cultural or ritual expectations fulfilled by the design? Finally this database could also allow the determination if building techniques spread throughout the Aegean. Was there an exchange of building designs or an adaptation of ideas? How were modifications made to building design? Perhaps certain climatic conditions at the site may have influenced certain adaptations? It is planned that the process of standardising architectural data analysis and presentation will be developed further by implementing the proposed architectural GIS database for Bronze Age sites in the Aegean.

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