1. Mimar Sinan

1.1. Who is Mimar Sinan?

Mimar Sinan is known as the greatest architect of the classical period of Ottoman architecture, who lived from 1489 to 1588. He joined the elite corps of the Ottoman army, the Janissaries as a young man. In the Janissaries, Sinan showed his early talent as an engineer. In 1538, he was given a position of chief architect of the palace. For nearly 50 years, he was the manager of all construction work of the Ottoman Empire, who was working with a large team of assistants consisting of architects and master builders. During the reigns of sultans Selim I, Suleyman, Selim II, and Murad III., 50 years of his tenure, Sinan is said to have built or supervised 476 buildings, according to the official list of his works, the Tazkirat-Abniya 1 (Archnet.org). The building types he constructed were mosques, colleges, bath-houses, palaces, mausoleums, caravanserai, public kitchens, bridges, store houses or granaries, Koranic schools, aqueducts and hospitals. The development and maturing stages of Sinan’s career can be illustrated by three major works. The first two of these are in Istanbul: the Sehzade Mosque, which is known as the work of his apprenticeship period, and the Suleymaniye Mosque, which is the work of his qualification stage. And, The Selimiye Mosque in Edirne is the product of his master stage. In this work, he reached his artistic peak with the design, architecture, tile decorations and land stone workmanship.

1.2. Sustainability of Sinan’s Reputation

Even though Sinan worked within a highly bounded political, religious, and artistic setting, his works are continuously acknowledged by their inventiveness. His works were always beyond of that era. “Furthermore, one can trace a lineage of rational, sequential experiments throughout his oeuvre. In particular, his late works were a culmination of his previous experimentation, which achieved a maturity of formal, structural, symbolic and religious expression that both reflected and transcended their cultural setting.” (Barrie T., 2003) However, though the quality, inventiveness and breadth of his work were commensurate with his Renaissance contemporaries, it is not still well known in the West as his Renaissance peers. For this reason, it is crucial for us to ensure the sustainability of his reputation by studying his life, works and experiments deeply.

2. Mimar Sinan’s Birth Place, Ağırnas

The selected site for this study is the village of Ağırnas, within the boundaries of Kayseri metropolitan area in Central Anatolia, Turkey. Ağırnas has also an important symbolic feature which is being the birthplace of the Greatest Ottoman Architect Mimar Sinan. Kayseri is an important settling area which
is carrying the social structure and architectural characteristics of different civilizations. And, Agırnas has the traces of these civilizations, too. Although they remain far from having been explored in full, the town appears to extend for quite a length below the ground as well. And, the underground cities in Agırnas are estimated as the extensions of the Cappadocia region, which had important functions before and in the first years of Christianity. The rock cliff churches in the region are also thought to date from this period. Also, the stone buildings made from the volcanic rocks found in the region are remarkable. In addition, the town includes several fountains built by Sinan himself. In 2000, initial steps were taken by the government to preserve Agırnas’ architectural heritage as well as its symbolic and historical value. (Okyay A.G., 2007, p.1) When we look through the characteristics of historic buildings in this area, they have some structural properties in common with The Great Architect Mimar Sinan’s buildings. He informs us about his observations in his own words in Tazkiratal-Abniya¹: «I saw the monuments, the great ancient remains. From every ruin I learned, from every building I absorbed something». From this point of view, to find out Sinan’s early inspirations also would be one of our valuable reasons to study in Agırnas (Sinanasaygi.org).

3. Environmental Opportunities and Conditions in Agırnas

3.1. Climate and Orientation

The Longitude and Latitude of Agırnas are respectively 33º 30’ East and 38º 45’ 30” North. The site has a continental climate consisting of cold, snowy winters and warm, dry summers with cool nights due to Kayseri’s high elevation. Rainfall occurs mostly during the spring and autumn, yet precipitation is generally low throughout the year. Over the course of a year typical wind speeds vary from calm to moderate breeze, rarely exceeding fresh breeze². In Agırnas, since the buildings sited on a south facing inclined land, this site already benefits to energy-efficiency and sustainability. The buildings do not block each other’s view, daylight, and wind and they are surrounded with green areas. Also, the historic stone buildings are exceptionally durable and benefit from significant thermal mass. These historic buildings were traditionally
designed with many sustainable features that responded to climate and site. When effectively restored and reused, these features can bring about substantial energy savings.

3.2. Architectural Characteristics
Most of the buildings (which are above the ground level) date from the late 19th century. The houses are mostly built on the abandoned caves previously used by Christians. They were built from a finely grained volcanic tuff stone that was light in weight and easily worked. Also, the houses may consist of a cave on its own. We see the buildings as simple cubical patterns with 1 to 2 stories and basements. The upper stories often overhung the narrow streets or the adjacent buildings. So, the roofs of some buildings were used as parts of the street, gardens or extensions of other buildings. Behind the entrance there was often a small internal courtyard, sometimes a house would have its own well inside this courtyard. Courtyards traditionally provided shaded outdoor spaces and well-ventilated indoor spaces. And, all the buildings are connected to each other below the ground as well. The underground tunnels which provided the connections were closed with stone walls by users inside the buildings [Okyay A.G., 2007, p.103-120].

3.3. Environmental Opportunities of Architectural Components
In this site, the cubical houses are built out of stone and local adhesive mortar with stone foundations and roofs of wood and a kind of mud. The houses have thick walls with few windows to conserve heat in the winter and remain cool in the summer. The openings of the buildings were usually small rectangular windows and had two distinct sections. On the outside they were protected by an iron grill that was flush with the windows. Above some of the doors there were much smaller windows called “upper light”. Its function was probably for ventilation, as well as serving to throw a diffuse light onto the ceiling. Rooms had an elaborate system of storage cupboards, shelves, niches and sitting areas that were an integral part of the stone walls. Ceilings were clad in timber and floors were generally paved with cut stone slabs. These slabs rested either on stone vaults, or on timber beams covered with a layer of stone. The roofs are built with roughly shaped wooden beams laid perpendicular to the walls of the house and covered with a layer of slate stones or thatch which is then covered with local adhesive mortar and plaster. This last layer’s local name is pisirik mud, which contains clay, lime and soil. The mud on the roof is kept flat and water proof with a section of cylindrical stone which is rolled over the roof. After the rain and snow, the last layer should be cleaned and renewed if needed. On the roofs, simple stone gargoyles are used to drain the waters from the roofs and convey it away from the side of the buildings, thereby preventing rainwater from running down masonry walls and eroding the mortar between [Okyay A.G., 2007, p.103-120].

4. Sustainable Design
4.1. What is Sustainable Design?
Sustainable design is a philosophy of designing buildings to comply with the
principles of social, economic and ecological sustainability. This is also known as green design, sustainable architecture or ecological architecture. Sustainable design is a broad concept which aims to decrease the adverse effect of human activities on our world, particularly climate change and global warming. «Constructing new developments consumes resources such as land, materials, water and energy, and can cause pollution. The form and design of new developments also largely determines the future demand for energy and water. Sustainable design approaches minimize resource requirements and the risks of pollution. In particular, the use of renewable and low carbon technologies can dramatically cut adverse environmental impacts globally and locally» [Tameside Metropolitan Borough, 2005, p.23].

4.2. Why is Sustainable Design needed in this century?
For the future climate change in the world we might expect continuing warming, drier hotter summers, more intense rainfall in winters, flooding, subsidence, wind damages and drought. For this reason, we will have to adapt the design of our buildings to climate change and develop new strategies to manage and conserve our natural systems. And, we are going to have to substantially lessen our production of greenhouse gases and particularly carbon dioxide to beware the worst impacts of climate change. To achieve this we need to reduce our overall energy requirements, use energy more efficiently, cut our use of fossil fuels and increase our use of renewable resources. Also, water is a key element in our natural environment and we should avoid pollution of groundwater, watercourses and rivers, and use water efficiently. [Tameside Metropolitan Borough, 2005, pp.23-31].

4.3. Why should Sustainable Design be adapted in Ağırnas?
Mimar Sinan was a great architect whose works have been consistently distinguished by their inventiveness, and they were always beyond of their era. After so many years after Sinan’s death, he is still known as a pioneer in architecture and his works serve as models to us. For this reason, while we are offering restoration treatments in Sinan’s birthplace, we consider the opportu-
nities of sustainable design in a futuristic approach to set a valuable example to today’s architecture. Also, the historic buildings in Agirnas were traditionally designed with many sustainable features that responded to climate and site. When effectively restored and reused, these features can bring about substantial energy savings.

4.4. What is the current status of Sustainable Design in Turkey?
Sustainable design implementation requires strong support from the public and government and the building industry. Even though, there is a trend in Turkey that is moving towards sustainability, the true application of sustainable design is difficult. Because, the public awareness of this concept is very low. And, there are very few people in the industry, who comprehend the understanding of the language and the correct meaning of environmental design.

5. Misapplications of Transformation in Agirnas
5.1. Converting Flat Roofs to Sloped Roofs
The flat roofs are one of the remarkable characteristics of the buildings in this historic site. Flat roofs are more economical and efficient than sloped roofs because all the space above and below the roof can be utilized. And, flat roofs are easier to inspect than sloped roofs and can survive longer with proper maintenance. Both flat and pitched roofs require regular maintenance. However, although sloped roofs may be more difficult to clean and inspect flat roofs often require more maintenance throughout the life of the roof. And, flat roofs’ repair costs are more expensive than sloped roofs’ are, and because they are less bias to moisture damage, a sloped roof may be more affordable in the long-term. For those reasons, the users in Agirnas are inclined to convert the flat roofs to sloped or pitched roofs. However, this application damages the integrity and originality of this historic site.

5.2. Concrete Additions to The Constructions
Turkey has one third of the world’s total natural stone reserve and Kayseri is one of the important volcanic sites that has a significant amount of tuff stone reserve. Tuff stone is a type of rock consisting of consolidated volcanic ash which is ejected from vents during a volcanic eruption. It is an ideal construction material in the form of cut stones, and has excellent insulating properties. Since, tuff stone has a porous structure, its density, thermal conductivity value and P-wave velocity is lower than other rocks. And, this characteristic is so optimal for evening out the swings in temperature between the hot summers and cold winters.
This relatively light stone can be cut with simple tools. Besides, its ecological merits as a building material are perfect. After tuff stones are applied on building, they have been sticked together firmly each day due to their consolidation characteristic [Yasar E., Tolgay A., Teymen A., 2009, p.271].
Tuff stones were used densely in historic buildings constructed in Agirnas. But, in recent years, users have made of concrete and brick additions to the buildings. By doing this, besides damaging the historical characteristics of
this older town, they are also decreasing the environmental efficiency of the buildings.

6. Integration of Modern Systems in a Historic Site and the Considerations

6.1. Installing Green Roofs on Historic Buildings

As it is discussed in the previous chapter, the users in Agırnas prefer to convert the flat roofs to pitched roofs because of their practical use. However, this application damages the integrity and originality of this historic site. To prevent this destruction we offer the installation of green roofs on top of the historic buildings in Agırnas. With this application, we aim to reduce the maintenance loads and costs to the users. Also, this application benefits to improve storm water management, reduce urban heat island effect, improve air quality, insulate the building, improves efficiency of mechanical equipment, reduce green gas emissions and extend roof life. There are three main green roof categories: extensive, intensive, and semi-intensive. And, an extensive green roof is the most suitable one for our site since it has a shallow growing medium, with a modest roof load, limited plant diversity, and minimal watering requirements. The visual impact of a green roof on a historic building has primary importance. A green roof and its plantings on a historic building should not alter the building’s character by being visible from the public right of way. In Agırnas, the buildings mostly have substantial parapets to help shield the green roof from view. And, there is an important physical issue we should take into account that is the increased roof load. Adding plants, growing medium, waterproofing and support layers, and water load, can drastically increase the amount of weight being supported by a roof. If the historic building was not constructed to support such loads, it may be necessary to supplement the structural system. Another physical factor to be aware of is that a green roof will change water/moisture patterns on the roof. Green roofs are meant to retain water over a longer period of time to slow storm water runoff and to nourish the plants. And, the roof covering should be watertight to prevent leaks into the building. Green roofs still require maintenance as the existing traditional roofs in the area. Weeds and other plant seeds are likely to be deposited on the roof by birds, insects, and the wind. Thus, the roof should be weeded periodically to
remove invasive species and to prolong the life of the plants and growing medium. While extensive green roofs do not need irrigation systems, a temporary irrigation system or watering plan should be in place to nurture the plants until they are established or when there is a drought. Although any green roof is not completely maintenance free, with regular attention it may last a long time.

6.2. Combining Green Roofs and Solar Panels
Flat roofs also work well for solar panels installation. Panels should have a more horizontal orientation and existing parapets may also hide these panels. Green roofs can also be supplemented with solar panels. “Combining a green roof and solar panels may benefit both installations. Lower roof temperatures that result from a green roof help to boost the efficiency of solar panels, which operate less efficiently at extreme temperatures. And, mounted solar panels can protect vegetation by sheltering it from gusting winds and shading it to keep plants from dehydrating in intensive heat or periods of drought.” (National Park Service, U.S. Department of the Interior, Technical Preservation Services). Solar panel installations should not become prominent new elements that detract from the character-defining features of a historic building or landscape. The main disadvantage of installing green roofs and solar panels in this historic site is the higher initial cost. But, there is a protection plan which was formed by the government towards the preservation of Agırnas’ architectural heritage. After preparing a well-organized profit and loss analysis, a government grant can be requested for the applications in this historic site.

6.3. Water Recycling Installations
Water recycling systems may be used to save water through the use of water-efficient appliances, and recycled ‘grey’ water systems. Or, rainwater may be captured for use in toilets, gardens and surrounding landscapes. Again, the visibility of the system components must be limited to preserve the historical characters of the buildings.

6.4. New Addition of Solar Rooms
In a solar room, when sunlight enters the enclosed space through the glazing, it gets absorbed and stored as heat energy. The heat is then constrained to stay in the enclosed space via the same glazing’s insulation properties. When the solar room is warmer than the inside, the heat from the sunroom warms up the house on cold winter days. Besides, when the solar room is warmer than the outdoor temperature, the solar room reduces heat loss from the building where the room is attached. And, during the hot season, we can completely close off the space from the rest of the house. While designing these rooms, all wall and the ceiling should be chosen as transparent materials not to obstruct and damage the integrity of historic building’s appearance. Also, the use of operable glazing would help to get open spaces in summers and consolidate to preserve the visual appearance of the historic building.

6.5. Reuse of Historic Windows
Historic windows are important character defining features of historic buil-
Buildings. Instead of their removal, which may dramatically change a structure’s integrity, their energy efficiency can be upgraded. Historic windows’ performance can be significantly fortified by using storm windows, caulk, and weather-stripping. The primary cause of infiltration can be addressed with jamb insulation, weather stripping, and trim repair. To provide an extra layer between the occupant and materials, a storm window can be mounted to the existing window’s interior or exterior with little change to the character of the original unit (WBDG Historic Preservation Subcommittee, May 2012, Sustainable Historic Preservation).

Conclusion and Suggestions
In this study, we established our aims and scope of sustainable design in a historic site, and assessed the environmental opportunities in this area in an explanatory way. While we are offering restoration treatments, we consider the sustainability of local features in this site. Around this concept, we propose new methodologies for intervention, preventive conservation and maintenance with the integration of sustainable design techniques. To take a step forward and offer an architectural project for this site, we must do a more detailed study to find the answers of a set of questions. These questions can be: What are the plan layouts in the buildings? Which buildings are abandoned and ruined, and what should be the new strategy to reuse them? What should be the new functions of the buildings? What are the quantitative properties of the materials? And, we should have the same detailed analysis for the underground caves. Also, by using simulation tools we should derive the facts about the climate, solar exposure and wind in the area, then we will define our design strategies based on these facts. And step-by-step simulation programs will help us to evaluate our design decision effect on the overall performance of the buildings, and develop our design for the best performance.

As a result, we have to carry out the detailed site analysis and use of simulation tools to optimize energy performance through rigorous measurement and verification. Otherwise, we cannot ensure the quality and accuracy of preserving this historic district by using, reclaiming, and enhancing historic sustainable features through compatible sustainability techniques.

Notes
1 Tazkiratal-Abniya is the official list of Mimar Sinan’s works. The two manuscripts Tezkiretü’l-Ebniye and Tezkiretü’l-Bünyan written on Sinan, by Sai Çelebi, who was a friend of Sinan.
2 Data analysis are carried out based on the material from Orman ve Su Isleri Bakanligi, Meteoroloji Genel Mudurlugu: Kayseri’s Climate Data, Kayseri 17196 (1975-2012).

References
Archnet: Archnet is an international online community of scholars, students, and professionals addressing the built environment in Muslim societies. Sinan-Archnet URL: http://archnet.org/library/parties/one-party.jsp?party_id=630.
Energy Laboratory, September 2004, A New Technology Demonstration Publication,
Abstract

Conservation increases the use of existing materials and infrastructure to the highest amount, minimizes waste, and preserves the historic character of older towns and cities. Also, conservation keeps our nation’s history and culture alive and we reach the opportunity of learning much from the methods and practices of those who came before us. With our threatened environment, sustainable living became an integral part of our lives in this century. The public benefits of both preservation and sustainability are very obvious and these goals should work together for the best practices [WBDG, 2012].

The selected site for this study is the village of Agirnas in Central Anatolia, Kayseri, Turkey. Agirnas is the birthplace of the Greatest Ottoman Architect Mimar Sinan and a site rich in historic buildings. In this study, the aim is to rehabilitate this historic district by using, reclaiming, and enhancing historic sustainable features and by adding compatible sustainability improvements with using treatments that do not interfere with or damage the property. In this explanatory paper, with the involvement of sustainability and historic preservation specialists, integrated design principles in a historic site are discussed in a collaborative way.