



CEE 3000, Section C  
April 24, 2014  
Group 5

# A Systems Analysis of the Restoration Project on the Acropolis

Andrew Caroe | George Doyle | Li He | Samay Lohia | Nick Melton



# Table of Contents

<i>Executive Summary</i> .....	3
<i>General Introduction of the Acropolis</i> .....	4
<i>Components and Functional Characteristics of Acropolis Monuments</i> .....	4
• <i>Purpose of the Restoration Project</i> .....	6
• <i>General Background of the Parthenon</i> .....	6
• <i>Previous Restoration Attempts</i> .....	6
• <i>The Acropolis Restoration Service and its Modern Restoration Attempts</i> ...	7
• <i>Present-day restoration issues and preservation issues on-site</i> .....	9
<i>Quantified Linkages to the Acropolis Restoration Project</i> .....	9
• <i>Economic Linkages to the Acropolis Restoration Project</i> .....	10
• <i>Social Linkages to the Acropolis Restoration Project</i> .....	11
• <i>Political Linkages to the Acropolis Restoration Project</i> .....	14
• <i>Environmental Linkages to the Acropolis Restoration Project</i> .....	15
<i>Environmental Sustainability Analysis</i> .....	15
<i>Sustainability Recommendation and Conclusion</i> .....	17
<i>Limitations of Analysis</i> .....	17
<i>References</i> .....	18

## **Executive Summary**

As one of the most characteristic sites to Ancient Greek civilization, the Acropolis is widely known for its historic importance. What is not widely known is that without the restoration currently taking place, the buildings within the Acropolis could never be restored to their original authentic state again. Acidic rain and pollution, seismic activity, and poor previous restoration attempts leave the Acropolis in danger. The Acropolis is made up of four main structures, including the Parthenon, the Propylaia, the Erechtheion, and the Temple of Athena with its present restoration focuses on the Parthenon.

Previous attempts to restore the Acropolis had only made things worse on the buildings. In order to avoid improper restoration attempts the Committee for the Conservation of the Acropolis Monuments (ESMA) was established in 1976. In 1979 the restorations began and today restorations are still underway under the Acropolis Restoration Service (YSMA) that which began in 2000. The main goal of the YSMA is to depict what the Acropolis would have originally looked like, and to fix the previous restorations mistakes. The restoration project is extremely costly, at about 70 million euros by the time of completion. With declines in visitors coming each year to the Acropolis, it is the expectation that the project will drive more people to want to visit a more historic site.

Educational value and potential drive the project socially. The Greeks believe bringing the Acropolis back to its original state this will lead to an increased interest internationally. The Acropolis is a reminder of the great history of Greek culture. Without the project, many fear it will lose its historical value. While this increases the social value in the future, the annoyance of a 40-year long restoration process leading to a great decline in visitor satisfaction hurts the social value of it during the project.

Political linkages stem back to the fact that the Acropolis Restoration project is being funded primarily by the Greek State. The pressure on the Greek government is high, due to the large cost associated with it, especially because Greece is in a poor economic state.

The restoration project does not harm the environment in any way other than the removal of stone from the quarry originally used to build the Acropolis. However, the environment does affect the system and restoration efforts. Seismic activity in the area has created many issues, causing cracked marble and shifting movements of resting marbles. Sulfur dioxide and carbon monoxide buildups on the calcium marble have also caused questions on how to prevent this buildup in the future.

Due to the nature of wanting to bring the Acropolis back to its original state, the restoration efforts are all done the way it would have been done originally; for example, the use of hammer and chisel. This has led to the great cost and time taken to complete the project. Our recommendations on sustainability include mainly the use of modern day technology in the project. 3D scanning and the use of lasers have been shown to speed up the project and decrease cost, while maintaining the systems sustainability environmentally, economically, socially, and politically.

## I. General Introduction of the Acropolis

The Acropolis, mainly the Parthenon, is the most characteristic monument to the civilization of Ancient Greece. It acts as a staple icon to the pride, success, and achievement of ancient construction as well as western expansion of European culture. The Acropolis is comprised of four major structures that are still relatively known to modern society - the Parthenon, the Propylaia, the Erechtheion, and the Temple of Athena.

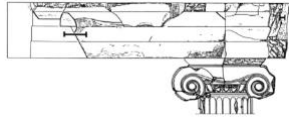
## II. Components and Functional Characteristics of Acropolis Monuments

The Parthenon is a temple of the Doric order. The Parthenon is located within the southern-central area of the Acropolis hilltop. The entrance and rear to the Parthenon is equipped with eight columns while the sides have seventeen, and all 46 columns conform to a ratio of 9:4. This ratio was used to determine the vertical and horizontal proportions of the temple as well as other characteristics of the structure. The dimensions of the base of the Parthenon are, measured from the front step, approximately 69.5 meters long by 30.9 meters wide. The inner chamber of the Parthenon, known as the cella, was 29.8 meters long by 19.2 meters wide. The Doric order columns on the exterior are 10.4 meters high and 1.9 meters in diameter (Meletzis and Papdakis, 2005). The Frieze of the Parthenon is 1 m tall, and wraps around the entirety of the structure. Marble blocks have been removed from all over the Parthenon for various reasons. Some of these blocks have been cleaned using laser technology, and some replaced by new, quarried marble, which has been recreated to meet the specifications of the old pieces (Petropoulou, 2008). The current state of the Parthenon is depicted in Figure 1 to the right.

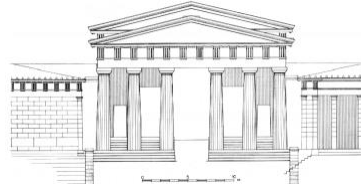


**Figure 1:** The Parthenon

Geographically, the Propylaia is located at the far west corner of the Acropolis Hilltop, which is at the base of the hill. The intention of the lavish Propylaia was to act as a monumental entrance to the Acropolis rock. It is situated around the natural entrance to the plateau that leads visitors right to the steps by a ramp. It consists of a large, main gateway at the center flanked by two “wings” on the northern and southern sides of the gate. The entrance stands at about 7.5 meters high. The Propylaia is also a building of the Doric order, with a few Ionic columns supporting the roof. Figure 2 (below) depicts an example of the Ionic column style. The front of the Propylaia includes the remains of six large Doric columns at the center flanked by six smaller, thinner ones to the periphery as well as a north and south wing (Gouvousis, 1995). An ancient rendition of the structure is depicted below in Figure 3. As of 2009, the roof of this monument has been partly restored and opened up for public viewing (Petropoulou, 2008).



**Figure 2: Ionic Column**



**Figure 3: Propylaea Entrance Rendition**

The Erechtheion, where construction on it started in 420 BC, is located just north of the Parthenon within the Acropolis hilltop. The purpose of the Erechtheion was to house religious rituals that the old temple conducted. The style of the Erechtheion was ionic. A unique feature of the Temple is the six Caryatids that support the porch of the temple. Caryatids are figures of women sculpted into a column-like structure that replace the functional characteristics of a column. Different areas of the Erechtheion are dedicated to different deities, such as Athena and Poseidon. Restoration attempts on the Erechtheion began in 1977 and concluded in 1988. Much of the restoration involved removing, cleaning and then re-adding replicas of the Caryatid support columns and marble blocks that serve as the foundation. The result of these efforts is depicted in Figures 4 and 5 (below). The British hold one of the original support columns in London’s British Museum, and the Greeks hold the other five in their New Acropolis Museum. Replicas are currently in place at the Acropolis Hill (Kaltsas, 2002). Figure 6 (below) depicts a recreated caryatid support column.

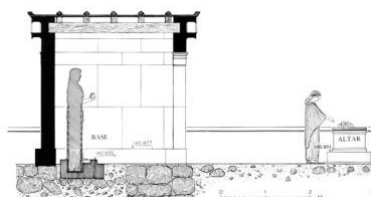


**Figure 4: Erechtheion, South Wall**



**Figure 5: Caryatid Support Column**

The temple of Athena Nike is of ionic style, made of marble, and standing about 7 meters high, 8.2 meters long, and 5.6 meters wide. It is located right next to the Propylaea. The columns of the structure stand at about 4 meters tall. Both the front and the back of the temple are complete with 4 columns each. The temple served as a place to worship gods of war. Dismantlement of its bastion began in 1930 during its initial restoration phase, and the reconstruction of 1998 removed the frieze. The frieze was placed in the New Acropolis Museum and the replacement of the corroded concrete floor and iron beams on the temple was also initiated under the YSMA (George, 2009). A schematic of the Temple as it was used in ancient times is depicted in Figure 6 below.



**Figure 6: Side View of Temple of Athena Nike**

### **III. Purpose of the Restoration Project**

The main focus of the Acropolis Restoration outside of the Erechtheion and the Propylaea structures is the Parthenon. The Greeks, on almost all the other structures with successful outcomes, have initiated extensive restoration and research projects. The current state of the restoration project is mainly focused on the work done on the Parthenon, with final modifications on all other structures within the Acropolis walls and the New Acropolis Museum located at the base of the rock.

### **IV. General Background of the Parthenon**

Work on the Parthenon began at the height of the Athenian Empire in 447 BC and ended in 432 BC under the two main architects Iktinos and Kallikrates. The Parthenon is a Doric peripteral temple that was constructed under the influence of the popular politician, Pericles, to commemorate the Battle of Marathon in the Peloponnesian War. It was also built to replace two earlier temples of Athena on the Acropolis. One of these is represented through an outline of loose marble members and is located south of the Parthenon between the Parthenon and the Erechtheion. The other, which was still being built at the time of the Persian sack in 480, is found within the foundation of Parthenon that stands today (Silverman, 2014). The Parthenon has been through a combination of destructions and constructions throughout the 2,500 years that the temple has been standing. In 227 AD, a barbarian invasion on Athens caused a fire to the cella and roof of the Parthenon. Later in the sixth century AD, the Greek temple was converted to a Christian Church until it was later converted to a Turkish mosque in 1456 after the Ottoman conquest. The Parthenon had a multipurpose through the years, being the home to prayer, and later a fort full of ammunition for the Turks during the Turk and Venetian War. In 1687 during the battles between the Turks and Venetians, the Parthenon exploded from the mass-storage of ammunition in the Parthenon (Lenke, 2014). After the explosion on the Acropolis, the Parthenon and its surrounding monuments were catastrophically destroyed, with hundreds dying as a result. Thousands of pieces of marble from the Acropolis monuments were severely damaged and taken from its original site.

### **V. Previous Restoration Attempts**

Later in 1802, Lord Elgin of Great Britain sent workmen to Athens to retract major marble members from the site and rested them inside the British Museum where they can still be seen today (Jenkins, 2014). Metopes, triglyphs, and fragments of the pediment and frieze are housed in the British Museum in London, England and are known as the Elgin marbles (Lenke, 2014). Between the time of Lord Elgin's removal of the Acropolis' sculptural members and the mid-1970's there have been two major restoration projects led by Greek engineers and architects. Greek engineer, Nikaloas Balanos, led the first project between 1902 and 1933. His studies focused on the Erechtheion from 1902-1909, the Propylaea from 1909-1917, and finally the Parthenon from 1923-1933.

Below, figure 7 depicts Balanos' restoration of the Propylaia's east side before (above) and after (below). After Balanos passed away, only one other restoration went underway until modern times. The other major player in the restoration was Anastasios Orlandos, where his team only focused on restoration of the Propylaia from 1947 until its conclusion in 1957 (Economakis, 1995). Balanos attempted to reconstruct the temple by anchoring and connecting adjacent marble pieces together with iron clamps. Many of these initiatives to reestablish the Parthenon have caused more damage than production, altering the original integrity and structure of the Greek Temple. Although his efforts appeared to be productive, his poorly executed process of assembling connection pieces was destructive to the material. The rusting and consequent expansion of iron elements caused cracks in the marble and enhanced other occurrences of decay, which impacted a large measure of the Parthenon (Lenke, 2014).



**Figure 7:** Propylaia east side before and after the restoration of Balanos

## **VI. The Acropolis Restoration Service and its Modern Restoration Attempts**

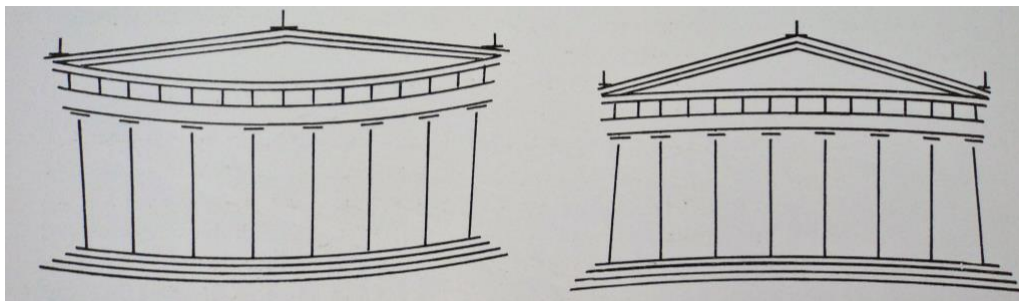
Today, the restoration team continues to replace these oxidized iron connectors with titanium, having the same expansion and contraction properties as the Pentelic marble. Moreover, that is only one aspect of the complex project, demonstrating that the Committee for the Conservation of the Acropolis Monuments, ESMA, recognizes since its establishment in 1976 all harmful procedures and additions to the Parthenon in order to restore it to precision. The Acropolis Restoration Service, YSMA, founded in 2000 under the direct supervision of architect and director, Vasiliki Eleftheriou, is currently doing work on the Acropolis (Archaeology Newsroom, 2013). One of the goals of the YSMA is to restore the Parthenon as best as they can to depict what it would have looked like when Iktinos and Kallikrates built it (Lenke, 2014). Since the beginning of its establishment in 1976, the ESMA spent its first four years recording and initiating extensive study on all the problems of the Acropolis monuments in collaboration with other scholarly foundations in the National Technical University of Athens and the Institute for Geological and Metallurgical Research. Temporary measures of roofing were taken for protection of the monuments, and the first signs of construction started in 1979 beginning with the Erechtheion. The next phase of construction on any other monument did not begin until 1986, beginning with the Parthenon and then in 1990 with the restoration of Orlandos' work on the Propylaia. It wasn't until 2000 that the next phase of construction newly initiated with the temple of Athena Nike under the newly developed YSMA (YSMA, 2011). Today the restoration project has taken almost forty years to complete, and is still underway. The Parthenon has over 14,000 pieces, many of which

are damaged from the past 2,500 years (Lenke, 2014). Before the restoration team could begin, they had to take apart and repair several members of the Parthenon, working piece by piece. The reason this task is so tedious is due to the corrosion and expansion of the rusted iron clamps that Balanos used in the initial restoration process of the early 1900's. To replace any original pieces that are missing or destroyed, the team has turned to the very quarry the ancient Athenians used just 12 miles from the Acropolis. The quarry is known as Pentelicon, and is still considered abundant in material and marble resource. Scholars estimate that in the time of Pericles, workers cut 100,000 tons of marble from the quarry (Glassman, 2007). The modern process of restoring the monuments is as follows: transfer of historic monuments, sculptures, and pieces from its original location to either the conservation workroom or to the Acropolis Museum via crane lift (Lenke, 2014). In the conservation workroom, the workers will evaluate whether the surface of the marble member can be cleaned by hand and returned to the temple, or needs to go to the New Acropolis Museum. The cleaning of the surfaces is a painstaking task, insuring that the integrity of the marble member is not challenged. Most of the highly sculptural metope, triglyph, and frieze pieces are immediately transferred to the museum, where they are showcased (Glassman, 2007).

The workers today use the same techniques and tools that were used in ancient times, including a pantograph (as seen in figure 8 below) that is used to shape a new 3D cast to the missing portion of each piece. Although each block has roughly the same shape as its original, there are slight irregularities, which can be positioned and matched up by their connection pieces and their push direction. The initial irregularities were driven by the original architecture of the temple. Iktinos and Kallikrates designed the structure to have a natural curve to it. Basically, there are no straight lines on the Parthenon, forming an optical illusion to the visitors of the Acropolis. If the temple had completely flat surfaces and straight lines, there would be a bowing-up of the edges, making the temple look unapproachable. The architects designed the temple to have the opposite bend in the straight lines to negate the optical illusion, as seen in figure 9 below (Lenke, 2014).



**Figure 8:** Worker using a pantograph on a marble member



**Figure 9:** A depiction of the illusion to the eye after approaching a tall straight surface (left) to a curved surface (right)



## VII. Present-day restoration issues and preservation issues on-site

One of the most current issues at hand with the Parthenon and its surrounding monuments are the current structural forms of the cella wall blocks that are difficult to replace. The main problems with the age of the Parthenon are the gradual increases in pollution and acidic rain over the past 30 years and the intense seismic area of the Acropolis in which the current restoration project is taking place. The cella walls and the rest of the temple are heavy pieces of marble that consist of rows of rectangular blocks, all with the same height. One cornice block weighs approximately 4 tons with over 30 cornice blocks per short side. With the massive weight to everything on the Parthenon, it makes it difficult to move pieces back and forth by crane. The main issue of the cella walls, and really the whole temple, is that Greece is a very seismic area. Men cannot move 4-ton blocks of marble, but the earth movements can. As a result of too much carbon monoxide from pollution, acidic rain has affected the monuments more in the past 30 years than in the last 24 centuries. The condition of the black soot on the marble seen in figure 10, created by the pollution of carbon monoxide, cannot be scraped off because it will jeopardize the surface of the marble. This is seen in figure 5 to the right. Many of the conservationists in the Acropolis Museum and researchers from Crete have been using a cleaning method with lasers to clear the black soot off of the triglyphs, metopes and the Caryatid columns from the Erechtheion (Lenke, 2014).



**Figure 10:** Soot buildup on marble surfaces from carbon monoxide

## VIII. Political, Social, and Economic Linkages to the Acropolis Restoration Project

With the current restoration efforts made by the Greeks in modern times, there have been global efforts to bring awareness to the issue of political, social, and economic liberties and constraints, set on the Greeks, to achieve the current tasks they are limited to in this extensive project. There are causes and effects to the demands of this extensive and expensive restoration project that are arguably benefiting the Greek culture and heritage, yet destroying the social and economic status of the Greek people. Data has been extracted from multiple sources to validate the arguments fighting both for and against the prolonged extension of the costly restoration project.

### VIII(a). Economic Linkages to the Acropolis Restoration Project

According to the Greece Government official announcement in 2006, the overall Acropolis restoration, which includes work on the Parthenon and Athena Nike Temples, is expected to finish in 2020 at a cost of about 70 million euros. Why does the restoration project cost so much? Is it a valuable present and future investment from the perspective of economics? Beneficially, visitor amounts and admission tickets are the main sources of restoration income. Listed below are tables that indicate the visitor numbers that have visited the New Acropolis Museum in recent years.

<b>Year</b>	<b>Visitor Numbers</b>	<b>Decline in Visitors From Previous Year</b>
June 2009 – May 2010	1,950,539	–
June 2010 – May 2011	1,309,859	640,680
June 2011 – May 2012	1,143,886	165,973
June 2012 – May 2013	1,036,059	107,827

**Table 1.** *Acropolis Museum.* Official visitor numbers spanning June 2009-May 2013.

<b>Year</b>	<b>Visitor Numbers</b>	<b>Decline of Visitors From Previous Year</b>	<b>World Ranking (Based on Visitor Numbers)</b>
2010	1,355,720	–	25
2011	1,244,702	111,018	38
2012	1,020,920	223,782	59

**Table 2.** *Art Newspaper.* Visitor numbers for the New Acropolis Museum, 2010-2012.

In summary, the amount of tourists that have visited the New Acropolis Museum since 2009 has decreased every year. According to the official website of the Acropolis Project, the admission ticket is presently 12 euros, which indicates that the annual operating costs of managing the museum is really hard to maintain. Maintenance comes close to 7 million euros of annual operating costs. In addition, the placement of visitations to the Acropolis Museum has dropped 13 places in 2011, and an additional 21 places in 2012, finishing last year in 59th place – a fall of 34 places in just two years. All data indicates the Acropolis does not make any realistic benefits in the perspective of lucrative economics.

### VIII(b). Social Linkages to the Acropolis Restoration Project

In recent years the restoration of the Acropolis, in particular the Parthenon, has become an important factor affecting the comprehension of the monuments on the part of the visitors. While some people argue against the restoration, the vast majority as indicated by recorded data seems to show arguments in favor of the restoration. This resulting standpoint, whether in favor or against the restoration initiatives, effects society most.

Year	Number of foreign students	Percentage of total students
2010-11	29917	12
2011-12	31565	24
2012-13	29990	23

**Table 3.** Attendance of foreign students at the New Acropolis Museum

*(Data retrieved from: Acropolis Museum. “Acropolis Museum, A highlights report June 2010 – May 2011, Year two”; Acropolis Museum. “Acropolis Museum, A highlights report June 2011 – May 2012, Year three”; Acropolis Museum. “Acropolis Museum, A highlights report June 2011 – May 2012, Year four”)*

One of the major objective outcomes of the restoration of the Parthenon is its educational value and potential. Education is seen as the bedrock of modern society. The restoration on the Parthenon is ultimately educating people. This has been seen primarily due to the constant attendance of foreign students that visit the Acropolis structures as shown in Table 3. These numbers represent a high number of cultures learning about Greek culture and history leading to globalization. Globalization has been identified as a parameter for development. The percentage of foreign students of the total students visiting has increased but this number is deceiving because this percentage increase is attributed to a decrease in the total number of domestic students visiting the monuments. Like any establishment, there is always an explosion of visitors at the beginning. The New Acropolis Museum opened in 2009. This explains the drop in number of domestic visitors over time. Currently it is difficult to say at what specific point will constant visitation numbers be observed but as seen in Table 1, the rate of the decline of visitors is reducing. While the number of domestic students visiting the Acropolis is reducing, they still form the 77 percent majority of students visiting from 2012-13. These results can only help the Greek society. It would help enhance the national identity of the people of Greece, and also help push the nation out of its current economic crisis.

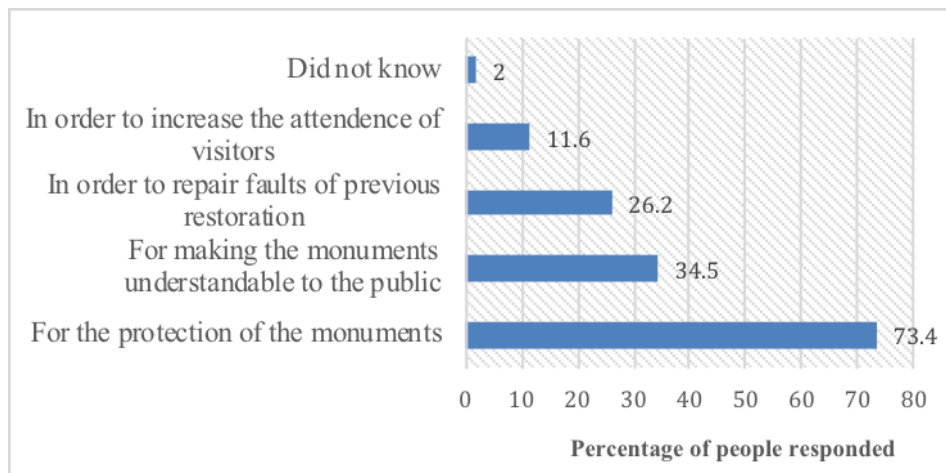
A service that the Acropolis Museum offers is the Virtual Tour of the Acropolis that includes a visit to the Parthenon.

Year	Number of virtual visitors	Percentage increase
2010-11	397656	-
2011-12	450468	13.28082564
2012-13	465943	3.43531616

**Table 4.** Number of Virtual visitors of the Acropolis  
*“Acropolis Museum, A highlights report June 2010 – May 2011, Year two”*; *Acropolis Museum. “Acropolis Museum, A highlights report June 2011 – May 2012, Year three”*; *Acropolis Museum. “Acropolis Museum, A highlights report June 2011 – May 2012, Year four”*)

A high number and increase in the number of virtual visitors of the website directly corresponds to increased international interest in the Acropolis and the Parthenon. This would again be an indicator of globalization. Furthermore, it helps establish technology’s role in society as an educator.

There has been an increased understanding for the need to protect and maintain monuments due to the restoration. An understanding of the reasons for the restoration of Parthenon can be an indicator of this.

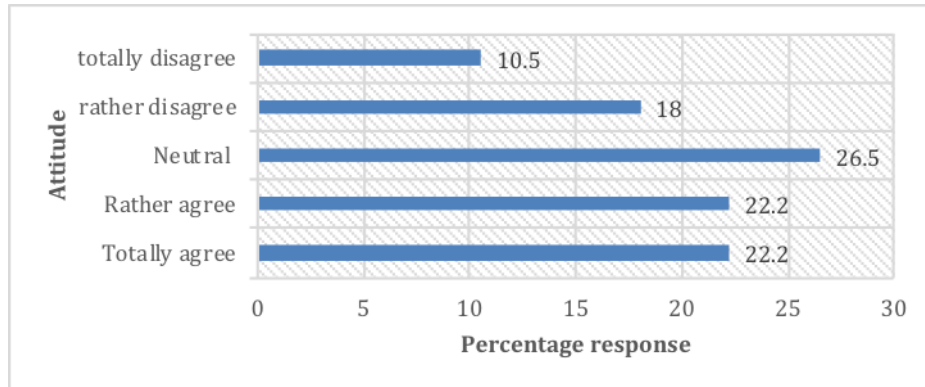


**Table 5.** Analysis of the responses to the question ‘According to your opinion, what are the reasons for the restoration of the Acropolis monuments?’  
*(Conservation & Management of Archaeological Sites. May2008, Vol. 10 Issue 2, 144)*

In a survey conducted in 2006 by Metron Analysis, a questionnaire was handed to visitors of the Parthenon. From analysis of one of the answers of the data in Figure 1, an overwhelming majority of the people identified with the ‘protection of the monuments,’ hence understanding the YSMA’s goal. While economic goals are important to any organization, only 11.6 percent of the people thought that the goal of the restoration was to increase the visitation attendance for monetary reasons. This is consistent with the YSMA’s primary goal of increasing cultural value rather than economic value.

In terms of viewing experience, the restoration can be identified as a barrier. The restoration can be argued as a serious reduction in the quality of the visiting experience

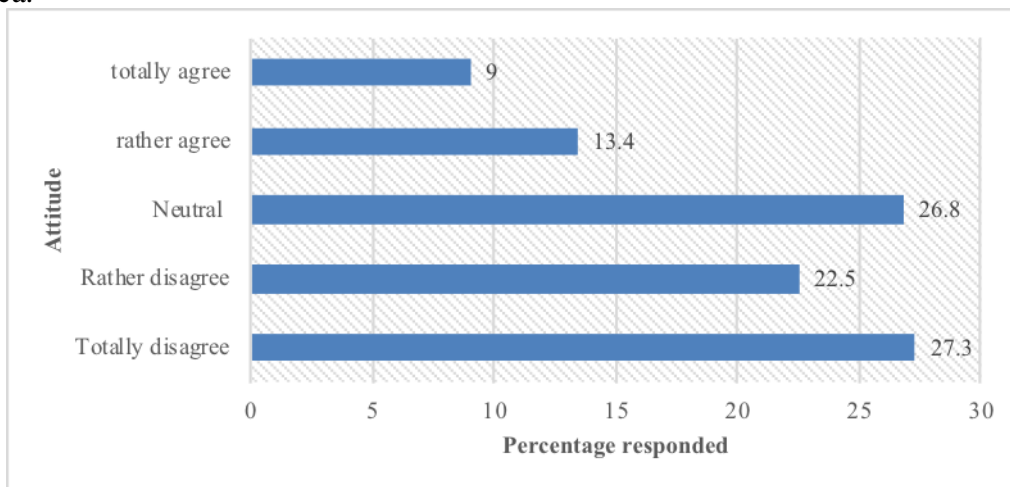
because of the visual effect of the scaffolding and the noises produced by the cranes and machinery.



**Table 6.** Analysis of the response to the statement ‘The restoration brings out the appearance of the monuments.’  
(*Conservation & Management of Archaeological Sites. May2008, Vol. 10 Issue 2, 147*)

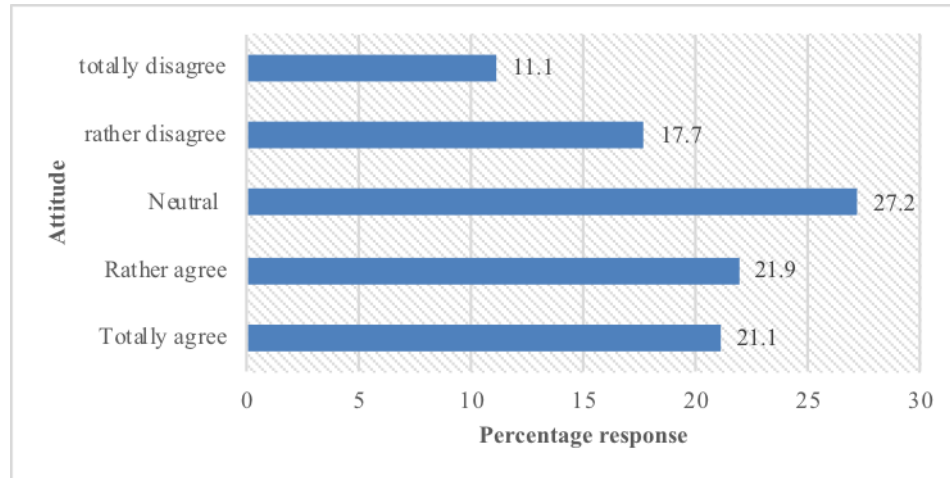
A large part consisting of 28.5 percent of the people generally disagreed that the restoration rings out the appearance of the monuments and hence distorts the appearance of the monument. Such a large observation cannot be ignored, as incomplete or distorted visits can lead to negative attitudes towards the restoration process and the Greek culture and society as a whole. This could lead to a developmental barrier.

Another negative idea associated with the restoration is that the restoration distorts the originality and aesthetics of the monuments. What makes matters more concerning is that a majority of the original sculptures are inside the museum being restored, and replicas of it are erected in its original placement. This leads to arising questions on whether or not the visiting people are viewing the actual monument or its replica.



**Table 7.** Analysis of the response to the statement ‘The replacement of the ancient sculptures with replicas spoils the original character of the monument.’  
(*Conservation & Management of Archaeological Sites. May2008, Vol. 10 Issue 2, 147*)

As noted from the data in Figure 3, about 22.4 percent of the visitors generally agree that the restoration is taking away from the original character of the monument. This is compounded by the fact that a large size of visitors also feel that the new marble being introduced into the Parthenon is distorting the aesthetics of the monument. This is primarily because the stark difference between the shades of the old marble and new marble. This has been shown in figure 4.



**Table 8.** Analysis of the response to the statement ‘The color contrast between the ancient and new supplements has unpleasant aesthetic results.’

*(Conservation & Management of Archaeological Sites. May 2008, Vol. 10 Issue 2, 147)*

### **VIII(c). Political Linkages to the Acropolis Restoration Project**

Although the Acropolis Museum does not make any benefit, the restoration project may have a chance to bring new economic outcomes to the table. Greece is a developed country highly dependent in its tourism. Currently Greece is facing a financial crisis, which has had a serious impact the Greek tourism industry. If the Greeks can successfully pass the world’s financial crisis and bring a new form of tourism to its society, the Acropolis Museum will be full of potential benefit in the future. In 2013, the total tourist numbers within Greece rose because of political upheavals affecting countries, such as Egypt and Turkey that redirected many tourists to Greece. Once the Acropolis can increase its amount of annual tourist numbers, it may bring more benefits into related industries. These benefits could increase the national fiscal revenue, increase hotel and food industry, and promote the marinas business. However, there are two primary topics to explain in the reasoning behind the costly projected 70 million euro restoration project on the Acropolis (Parthenon Temple, 2009).

First is the use of modern technological applications on site. Second is the use of 2,350 tons of expensive marble (Sevaan Franks, 2009). A special service of the Ministry of Culture, established in 1999, is responsible for the execution of the works by the YSMA. The works have always been scholarly and supervised by a joint committee of experts, the ESMA, whose members are specialists of authority in various fields. The ESMA includes archaeologists, architects, civil engineers, chemical engineers and

conservators. Presently, there are over 11 new technological applications that have been developed just for restoration work. In addition, a highly trained staff of marble workers has been established. A majority of these marble workers come from the Aegean islands and in particular Tinos, an island with a long tradition of marble working. The Acropolis conservation project constitutes a national program and is financed primarily with funds from the Greek State. From 1983, there has been a considerable financial contribution by the European Community. The restoration project, incorporated in the programmed “culture” of the 3rd Community Support Framework, accumulated a total of approximately 27,500,000 euros between 2000 and 2006 (YSMA, 2011). Due to this costly price on the people of Greece and its government, there has been a lot of pressure on the government to find some form of political stability.

In recent years of Europe’s debt crisis, Greece has been hammered by a vicious financial crisis since late 2009 that later developed into an economic depression. The economy has shrunk to approximately a quarter of its initial size while unemployment has soared to over 25 percent (European Economy Guide, 2014). If the price to restore the Acropolis is projected to be 70 million euros, in which the government is partially aiding, there will be a large percentage of the general public that will oppose the behavior of the government. This has been seen in the violent 2010 strikes against the new governmental plan to cut public spending and raise taxes. In the case of more public involved protesting, there may very well be a more serious political crisis within Greece and its government.

Athens used to have glorious history in various areas during its peak in ancient times, including Greece’s ancient military, political, cultural, religious, and artistic successes and legacies. As time progressed, the former prosperity of Athens gradually regressed and in some cases disappeared. The Greek government can regain political momentum by attracting the global community through the restoration of the Acropolis and the usage of the New Acropolis Museum to praise and rebuild Athens by reviving its brilliant ancient civilization.

## **IX. Environmental Sustainability Analysis**

The environmental linkages of the Acropolis Restoration Service are practically unvoiced. There is no negative environmental impact that the system has on its surroundings. The Acropolis and its restoration projects do not harm any portion of the environment. In return, it does not gain anything from the environment as well. Instead, the modern environment it is surrounded by negatively affects the system. Structural effects on the Acropolis that include movement in marble blocks and the rotation of column drums are mainly caused by the physical actions of the seismic area, and the earthquakes it produces, of the hill. Other structural effects on the Acropolis include negative impacts of human interventions, such as the massive collections of carbon monoxide on marble surfaces from industry and exhaust, and the interior erosion of the marble from the iron clamps due to Balanos’ initial restoration project.

Acropolis Hill is a block of Late Cretaceous grey limestone. The structures of the Acropolis are built of marble stones in the form of blocks or drums without mortar, connected together in precision by dry masonry. The Acropolis is centered on a hotspot of seismic activity, which in return has caused severe marble cracking in specific portions of the Parthenon. The locations of these seismic actions are the southwest corner of the Parthenon, the West side of the Parthenon, and the south wall of the Propylaea. According to the Director Emerita of the YSMA, Maria Iannidou, a total of 10 accelerographs have been installed from the Geodynamic Institute of the National Observatory in Athens between 2008 and 2013. The purposes of these accelerographs, seen in figure 11, are to record and monitor the seismic activity of the Parthenon on the Acropolis and the shifting movement of the resting marbles seen in figure (Ioannidou, 2013).



**Figure 11:** An accelerograph attached to a shifted column

Another issue that has developed over the past several decades is the accumulation of sulfur dioxide and carbon monoxide settled on and in the calcium marble. There has also been an accumulation of erosion seen in figure 12 within the marble due to the iron clamp anchors that initially supported the seismic movement under Balanos' team. The present restoration teams have taken actions to intervene and restore the marble to its initial state. Actions on the accumulation of sulfur dioxide and carbon monoxide on marble members include laser treatment and scraping of the soot from the marble. A step process of filling in missing marble pieces with new marble pieces and replacing the old, eroded iron clamps with titanium clamps is a modern practice.



**Figure 12:** Oxidized marble members and iron clamps

Now, the accelerographs and titanium clamps replaced the older forms of restoration (Ioannidou, 2013). The marble masons only use environmentally friendly tools that include basic hammer and chisel techniques to avoid any environmental issues. It also keeps the idea of classical construction alive (Lenke, 2014). The only issues with these solutions are time and money. In both cases, it takes too many resources to achieve the intended job. The issue of money and time cycles back to the issue of previous data extractions on whether or not more money should or should not be implemented and spent on the restoration.



## **X. Sustainability Recommendations and Conclusion**

In conclusion the gradual increase of sulfur dioxide and carbon monoxide in the air, the frequent recurrence of seismic activity within the area, and the potential of a revival in Greek culture and economic upheaval within Greece has become the initiative of this modern restoration process of the Acropolis. However, the actions taken by the YSMA over the past couple decades have been time consuming and expensive even though the actions have been meticulously thought out (Lenke, 2014). Based on the analysis of the scientific and technical choices of the YSMA during the restoration process, our team believes there are still initiatives that can be made to speed up the process of sustainability of the Parthenon and its surrounding monuments without being much more costly on the Greek government. Associate professors within the College of Architecture at Georgia Tech have recommended to the YSMA to begin implementing 3D scanning instead of the traditional pantograph process currently used to construct new marble pieces in replacement of old or eroded pieces (Lenke, 2014). This new technology would be very beneficial to the restoration team in many ways. It would decrease the amount of time needed to complete the restoration process, and it can recycle the workforce into different departments to achieve more with the same amount of time. If this idea is implemented and pursued, these new forms of technology can speed up the process of completion. In return, this can lead to the revival of Greek culture, which will develop economic upheaval within Greece due to international recognition of the UNESCO World Heritage Site.

Many positive and negative points were made previously in the paper about the sustainability of the restoration project economically, environmentally, socially, and politically. However, we deem this restoration effort a sustainable effort due to the main point that restoring an ancient and highly historical area is extremely sustainable. Allowing this project site to succumb to its natural surroundings would be devastating to the ancient Greek culture and our world's history.

## **XI. Limitations of Analysis**

Since the restoration project on Acropolis Hill is still underway, our group does not have concrete evidence and data to back up main linkages in the economic, social, and political realm. The YSMA has mainly focused its objectives on reinforcing the idea of environmental sustainability and cultural revival through the restoration process. A majority of the results extracted from our collected data are projected numbers based off up-to-date spending's on the YSMA and ESMA to complete the project by 2020. Also with the inability of any group member knowing the Greek language, a barrier was immediately set up. Some diagrams used in our project were labeled in Greek and unable to be read. However, some of the visuals used have enough detail in the drawings that enable it to be comprehensible to a universal degree. Other ideas brought up by outside sources on the restoration, including laser-scraping technologies, have not yet been implemented in the modern restoration process but are currently under review by the ESMA. Rather, sustainable recommendations have been requested by legitimate sources and have yet to be initiated.

## XII. References

Acropolis Museum. "Acropolis Museum, A highlights report June 2010 – May 2011, Year two" Online. June 2010. Web. 7 April. 2014.

<[http://www.theacropolismuseum.gr/sites/default/files/acropolis\\_web\\_eng.pdf](http://www.theacropolismuseum.gr/sites/default/files/acropolis_web_eng.pdf)>.

Acropolis Museum. "Acropolis Museum, A highlights report June 2011 – May 2012, Year three" Online. June 2012. Web. 7 April. 2014.

< [http://www.theacropolismuseum.gr/sites/default/files/annual\\_report\\_3\\_site\\_en.pdf](http://www.theacropolismuseum.gr/sites/default/files/annual_report_3_site_en.pdf)>.

Acropolis Museum. "Acropolis Museum, A highlights report June 2011 – May 2012, Year four" Online. June 2013. Web. 7 April. 2014.

<[http://www.theacropolismuseum.gr/sites/default/files/acropolis\\_en.pdf](http://www.theacropolismuseum.gr/sites/default/files/acropolis_en.pdf)>.

"Acropolis Museum Is Back On Track And Wants The Parthenon Marbles To Come Home." *Archaeology* 57.4 (2004): 10-11. Academic Search Complete. Web. 25 Feb. 2014.

"ACROPOLIS RESTORATION SERVICE." *ACROPOLIS RESTORATION SERVICE*. YSMA, 2011. Web. 13 Feb. 2014. <<http://www.ysma.gr/en/>>.

Brouskari, Maria. "The Acropolis In Ruins." *Sciences* 24.3 (1984): 36. Academic Search Complete. Web. 25 Feb. 2014.

Economakis, Richard. *Acropolis Restoration: The CCAM Interventions*. London: Academy Editions, 1994. Print.

Evans, James Allan. "The Parthenon Marbles-Past And Future." *Contemporary Review* 279.1629 (2001): 212. Academic Search Complete. Web. 25 Feb. 2014.

Fani Mallouchou-Tufano, "The Restoration of the Athenian Acropolis", Lecture delivered on Jan 18, 2006, <[https://www.lsa.umich.edu/UMICH/modgreek/Home/Window%20to%20Greek%20Culture/Lectures%20at%20U-M/LaUM\\_Mallouchou\\_restorationacropolis.pdf](https://www.lsa.umich.edu/UMICH/modgreek/Home/Window%20to%20Greek%20Culture/Lectures%20at%20U-M/LaUM_Mallouchou_restorationacropolis.pdf)>, Web April 04, 2014.

"Figure 1: The Parthenon  
Pr. Athanassios Economou, GIT"

"Figure 2: Ionic Style Column  
Pr. Athanassios Economou, GIT"

"Figure 3: Propylaea Entrance Rendition  
Pr. Athanassios Economou, GIT"

“Figure 4: Erechtheion, South Wall  
Evi Petropoulou, 2008”

“Figure 5: Caryatid Support Column  
<http://knowhowledge.com/website/staticpages/Edutainment/Goldratio/Goldratioancient/3965a.jpg>”

“Figure 6: Side View of Temple of Athena Nike  
Pr. Athanassios Economou, GIT”

“Figure 7: Propylaea east side before and after the restoration of Balanos  
Maria Ioannidou”

“Figure 8: Worker using a pantograph on a marble member  
Emily Lenke”

“Figure 9: A depiction of the illusion to the eye after approaching a tall straight surface  
(left) to a curved surface (right)  
Emily Lenke”

“Figure 10: Soot buildup on marble surfaces from carbon monoxide  
Emily Lenke”

“Figure 11: An accelerograph attached to a shifted column  
Emily Lenke”

“Figure 12: Oxidized marble members and iron clamps  
Emily Lenke”

George, R. Nike Temple. *Nike Temple*. March 25, 2014. <<http://www.goddess-athena.org/Museum/Temples/Nike.html>>.

Glassman, Garry. "Restoring the Ruin." *PBS*. PBS, Oct. 2007. Web. 13 Feb. 2014.  
<<http://www.pbs.org/wgbh/nova/parthenon/rest-nf.html>>.

Gouvousis, N. *Acropolis of Athens, The*. Athens: 1995. March 25, 2014.

"Hellenic Society for Law and Archaeology: Central Archaeological Council  
(CAC)." *Hellenic Society for Law and Archaeology: Central Archaeological Council  
(CAC)*. Central Archaeological Council (CAC), 30 Aug. 2006. Web. 13 Feb. 2014.  
<<http://www.law-archaeology.gr/Index.asp?C=76>>.

Ioannidou, Maria. "Seismic Actions on the Acropolis Monuments." *YSMA*, 2 Dec. 2013.  
Web. 10 Mar. 2014.  
<<http://ecpfe.oasp.gr/sites/default/files/files/Maria%20Ioannidou.pdf>>.

James Beresford, "Is The Acropolis Museum Losing the Numbers Game?", GreeceReport, Nov 6, 2013, <<http://greece.greekreporter.com/2013/11/06/is-acropolis-museum-losing-the-numbers-game/>> Web April 04, 2014.

Jenkins, Ian. "The 1930s Cleaning of the Parthenon Sculptures in the British Museum." *British Museum*. The British Museum, n.d. Web. 13 Feb. 2014. <[http://www.britishmuseum.org/about\\_us/news\\_and\\_press/statements/parthenon\\_sculptures/1930s\\_cleaning/surface\\_condition.aspx](http://www.britishmuseum.org/about_us/news_and_press/statements/parthenon_sculptures/1930s_cleaning/surface_condition.aspx)>.

Kaltsas, Nikolaos. *Sculpture in the National Archaeological Museum, Athens*. Trans. Dr. David Hardy. Athens, Greece: Kapon Editions, 2002. March 25, 2014.

Kathimerini, "Acropolis project inches ahead" Parthenontemple, May 25, 2009, <<http://www.parthenontemple.com/index.php?s=disbelief>>, Web April 04, 2014.

Lambrinou, Lena. "Preserving A Monument: The Example Of The Parthenon." *Conservation & Management Of Archaeological Sites* 12.1 (2010): 60-74. Academic Search Complete. Web. 25 Feb. 2014.

Lamprinou, Vasiliki, et al. "Phenotypic And Molecular Biological Characterization Of Cyanobacteria From Marble Surfaces Of Treated And Untreated Sites Of Propylaea (Acropolis, Athens)." *Geomicrobiology Journal* 30.4 (2013): 371-378. Academic Search Complete. Web. 25 Feb. 2014.

Lubell, Sam, and Deborah Snoonian. "Parthenon's Rebuilding May Be Aided By Laser-Scanning Technology." *Architectural Record* 190.6 (2002): 175. Academic Search Complete. Web. 25 Feb. 2014.

Lenke, Emily. Personal Interview. 7 Feb. 2014.

Meletzis, Spyros and Papadakis, Helen. *National Museum of Archaeology Athens*. Athens: Art Editions Meletzis & H. Papadakis, 1985. March 25, 2014.

Petropoulou, Evi. "Restoration And The Public: Results Of A Visitors' Survey On The Restoration Of The Acropolis Monuments." *Conservation & Management Of Archaeological Sites* 10.2 (2008): 132-156. Academic Search Complete. Web. 25 Feb. 2014

Phil Jones, Paulo Pinho, Jo Patterson, Chris Tweed, "Low Carbon Urban Built Environment: European Carbon Atlas", The Welsh School of Architecture (2009), 75-85.

Plantzos, Dimitris. "Behold The Raking Geison: The New Acropolis Museum And Its Context-Free Archaeologies." *Antiquity* 85.328 (2011): 613-625. Academic Search Complete. Web. 25 Feb. 2014.

James, N. "The Acropolis And Its New Museum." *Antiquity* 83.322 (2009): 1144-1151. Academic Search Complete. Web. 25 Feb. 2014.

Silverman, David. "The Parthenon." *Parthenon*. Hum110 Tech, n.d. Web. 13 Feb. 2014. <<http://academic.reed.edu/humanities/110tech/parthenon.html>>.

"The 6th International Meeting for the Restoration of the Acropolis Monuments Has Been Completed" *Online*. Archaeology Newsroom, 8 Oct. 2013. Web. 13 Feb. 2014. <<http://www.archaiologia.gr/en/blog/2013/10/08/the-6th-international-meeting-for-the-restoration-of-the-acropolis-monuments-has-been-completed/>>.

Toumbakari, E.-E. "Analysis And Interpretation Of The Structural Failures Of The Orthostate In The Northern Wall Of The Athens Parthenon." *Strain* 45.5 (2009): 456-467. Academic Search Complete. Web. 25 Feb. 2014.