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# A Technical Study and Conservation Proposal for the Glass Mosaic Decoration of Villa Caparra in Guaynabo, Puerto Rico

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**Abstract**
This thesis examines the exuberant cement-embedded glass mosaic ornamentation of Villa Caparra, an early architect's residence in Guaynabo, Puerto Rico in order to document the materials, methods of fabrication and installation; and, to analyze the present condition. The study will rely on archival records, in situ investigation, material analysis and physical testing with the purpose of developing a preliminary conservation plan for remedial and long term preservation.

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# A TECHNICAL STUDY AND CONSERVATION PROPOSAL FOR THE GLASS MOSAIC DECORATION OF VILLA CAPARRA IN GUAYNABO, PUERTO RICO

Yaritza Hernández

A THESIS

in

Historic Preservation

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*'A mis Padres'*

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# CHAPTER 1 INTRODUCTION

## 1.1 Introduction

This thesis examines the exuberant cement-embedded glass mosaic ornamentation of Villa Caparra, an early architect's residence in Guaynabo, Puerto Rico in order to document the materials, methods of fabrication and installation; and, to analyze the present condition. The study will rely on archival records, in situ investigation, material analysis and physical testing with the purpose of developing a preliminary conservation plan for remedial and long term preservation.

## 1.2 Historical Background

In 1927, Villa Caparra was designed and built by Puerto Rican architect Pedro Adolfo de Castro as his home and studio. The house was constructed of reinforced concrete, a fairly new construction method in Puerto Rico at the time, with pre-cast cement decorative elements, glazed clay roof tiles, terracotta and decorative glass mosaics and ceramic tiles. The architect was inspired by Spanish and Moorish design motifs commonly associated with the *Spanish Revival Style*. The house served as his residence and, in addition, as a showroom for exhibiting the mosaics and tiles that he himself designed, promoted and incorporated in all his buildings as an integral part of his architectural design work.[1] (*see figure 1*)

Pedro A. de Castro's home was one of the first examples of a new Puerto-Rican architecture that departed from the popular vernacular style of "L" shaped cottages and bungalows to give way to a new modern, compact Hispanicized house including elements such as central patios and galleries.[2] Villa Caparra is a fine example of his

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[1] Vivoni, Architect of Dreams, p. 55.
*General Note: Most of the Historical Information used in this text was taken from this source.*

[2] Vivoni, Ever New San Juan, p. 40.

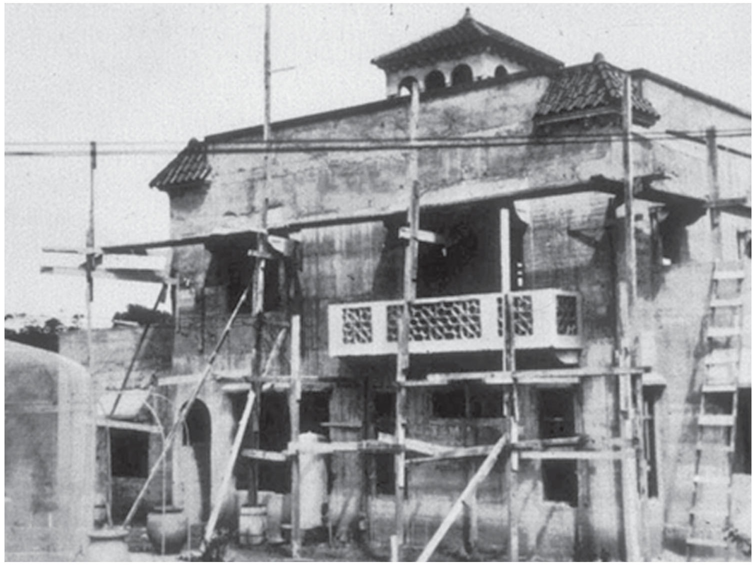

Figure 1: Villa Caparra Residence c.1927 during construction (source: Land Administration of the Commonwealth of Puerto Rico)

early work in domestic design of the Manor type[3]. Although the residence has been abandoned for many years and deterioration and neglect have significantly affected the structure, it is still in reasonably sound condition. It is uncertain if the house will be saved or demolished for further widening of the road due to increased traffic demands. Nevertheless, it is necessary to document one of the first and best examples of this style built on the Island. Furthermore, it is important to study and analyze the exuberant ornamentation associated with de Castro's early 20th century concrete buildings in Puerto Rico. (*see figure 2*)

In 1939, and again in 1945, the estate was reduced in size so as to widen the bordering Highway no. 2, one of the major thoroughfares of Puerto Rico. Because of these actions, the house lost its Moorish inspired garden and multiple fountains among other unique features. As a consequence of the encroaching road, which caused the loss of privacy to the open plan design, the family eventually decided to move out. What

[3] Vivoni, Architect of Dreams, p. 39.

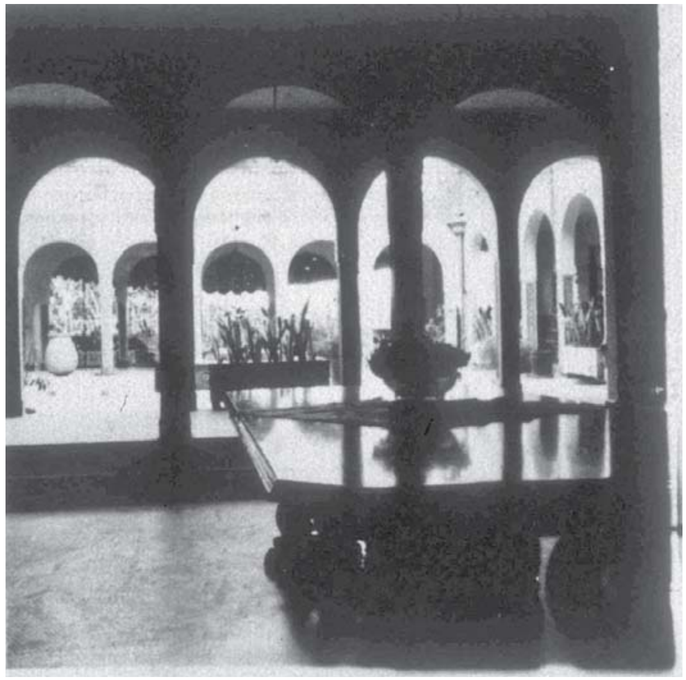

Figure 2: Villa Caparra Residence: view from the dining room to the interior patio, c.1935 (source: Land Administration of the Commonwealth of Puerto Rico)

remained of the original property was sold in 1962 to the Land Administration of the Commonwealth of Puerto Rico and yet another segment of the land was sold for the construction of a high-rise apartment building. After a brief rental period to a social entity, the property was abandoned and remains as such to the present date. The house has been subject to vandalism, graffiti, vegetation overgrowth and neglect. (*see figure 3*)

Villa Caparra is the repository of a unique example of glass mosaic decoration designed and produced by the architect in his own workshop. This type of craftsmanship and attention to detail waned in popularity soon after de Castro's death in 1936. The Spanish Revival style also diminished in popularity in Puerto Rican architecture soon after World War II. For these reasons, understanding the first examples of the use of these modern materials and techniques is critical to the architectural history of Puerto Rico. Their study and record will safeguard at least the knowledge of this exuberant ornamentation that is associated with de Castro's as well as other designers' early 20th

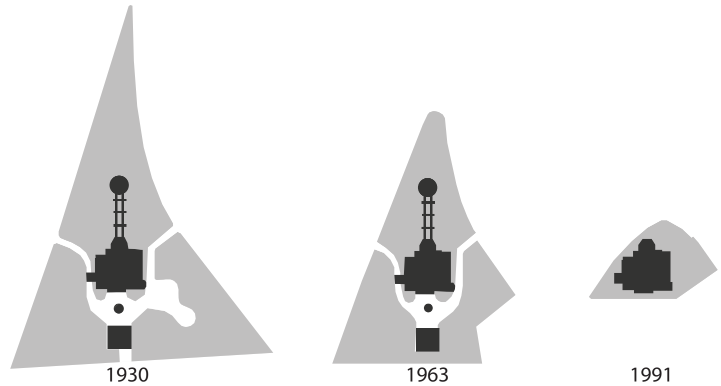


Figure 3: Evolutionary Map of Villa Caparra Residence (source: by author, 2009)

century concrete buildings in Puerto Rico. (*see figure 4*)

### 1.3 Methodology

The study of archival records, physical investigation and material analysis aims to identify a conservation plan appropriate for the care and restoration of the 1920's mosaics of Villa Caparra. The research has traced the revival of decorative glass mosaics to that period, specifically those created by de Castro who popularized their use, and in concrete construction used in Puerto Rico in the early 20th century.

A classification system was developed by type, pattern, location, condition type and level of deterioration. *(see Appendix A)* There are four major plausible factors responsible for the deterioration of the Villa Caparra mosaics: inherent composition, installation, environment, and use/ maintenance. All of them potentially affect the way in which these finishes have weathered.[4]

The goals of the research on the Villa Caparra Mosaics are as follows:

- First, to complete historical research, verify the origins of the glass mosaics, and techniques used for their installation;
- Second, to document the individual types and assembled patterns of glass mosaics used in the house and to identify the different conditions

[4] Getty, Theory and Practice of Mosaic Conservation, p. 34.

Figure 4: Villa Caparra - Main Entrance Door (source: by author, 2009)

and decay mechanisms including the influence of the concrete substrate. This includes a study as to how the environment, such as rain and solar radiation, has contributed to their deterioration.

- Third, to identify potential conservation methods that are most appropriate in a tropical environment.

The site was visited on several occasions in order to record the mosaics and substrate conditions. Representative samples of the glass tesserae were selected for further study. Also a representative fragment of the mosaic and substrate was removed from a deteriorated area of the house and brought back to the conservation laboratory of the University of Pennsylvania for further examination and testing. The tests included composition of the tesserae and concrete substrate, their porosity and the presence of soluble salts. These analyses and tests have assisted in understanding the deterioration process of concrete-glass mosaics and have provided insight into the history of production technology in terms of composition and installation.

During December 2009 and January of 2010 condition assessment of the mosaics was undertaken in situ to determine the current conditions of the glass tesserae. Previous historic research, a set of measured drawings and the results of a general condition survey of Villa Caparra, carried out through the Conservation Praxis courses of the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico, served as the base reference.[5] *(see Appendix B)*

During the first site visit, the mosaics were visually examined, photographed, measured and an initial condition was established. This field work was based on the *Mosaic In Situ Project: Illustrated Glossary* developed by the Getty Conservation Institute and adapted to fit the Villa Caparra glass tesserae conditions.[6] The mosaic patterns were traced in Auto Cad 2010, printed and brought to the site to see how well the initial glossary worked. Changes were made and conditions were discarded as new ones were added. An overall risk assessment was performed to determine the areas that needed urgent attention and where the condition survey was to be performed first.

Analysis of the material composition of the glass tesserae and substrate samples and their condition was performed with different techniques, such as transmitted light microscopy of thin sections. Salts were identified in some samples by micro-chemical spot testing and semi-quantitative, salt strips. Finally, X-ray fluorescence and scanning electron microscopy were also used for further study of some samples. For example,

[5] These Advanced Technology courses, under the direction of Beatriz del Cueto, FAIA, took place between the academic trimesters of Fall 2008 through Fall 2009 under the general title: "Concrete Construction in Puerto Rico between the Wars (1898-1945) and the specific title: "Conservation Praxis III: Conservation and Intervention of Villa Caparra".

[6] The Getty Conservation Institute. "Mosaic In Situ Project: Illustrated Glossary" Los Angeles: The Getty Conservation Institute, 2003.

thin section microscopy was used to measure the binder to aggregates ratio while scanning electro microscopy was used to identify the type of corrosion present in the glass tesserae. X-ray fluorescence was used mainly to determine elemental composition of deteriorated glass tesserae. Salt efflorescences found on the mortar and concrete mixes were analyzed by spot and salt strip tests.

Recommendations for conservation treatments are based on the analysis of the condition survey, material composition and literature review of conservation techniques. The goal of this thesis has been to provide a graphic and photographic record of the current status of the mosaics ornamenting Villa Caparra in the hope that it will aid in future conservation efforts.

### 1.4 Design and Construction of Villa Caparra

The property lot where the Villa was to be erected was acquired in 1925 and construction began around 1927. Pedro de Castro's design for his house marked the start of the Spanish Revival style in Puerto Rico and of a new construction phase in his work that merged the best of Spanish Renaissance aesthetics with the use of new materials.[7] He learned of this style while working as a draughtsman at the Department of the Interior's Division of Public Buildings in Puerto Rico, where he further developed his knowledge as an apprentice to architect Antonin Nechodoma.[8] De Castro used this style advantageously to explore his artistic talents. He successfully established an office/workshop composed of craftsmen, sculptors and artists that carried out his designs. He also maintained complete control by constructing his own designs, ensuring

[7] Vivoni, Architect of Dreams, p. 55.

[8] Antonin Nechodoma, is credited as "the person who introduced modern architecture to the Caribbean…and for adapting Frank Lloyd Wright's Prairie School (designs) to the tropics..." He is also recognized as having established the architectural studio environment in Puerto Rico, which apprentices, like Arch. Pedro De Castro, adopted. Marvel, Thomas S. Antonin Nechodoma – Architect, 1877-1928 – The Prairie School in the Caribbean, University of Florida Press, 1994.

Figure 5: Villa Caparra Residence: view fr om northeast gate (source: Land Administration of the Commonwealth of Puerto Rico)

the quality and endurance of his buildings.[9]

Villa Caparra was designed in what architectural historian Enrique Vivoni has termed, the "*cortijo* or manor typology," a style Pedro de Castro favored from 1927 onward.[10] This type was used mainly on big open lots that were located outside the main urban areas and usually in a grander style reserved for his more affluent clients. The layout generally consisted of a courtyard surrounded by the main living spaces such as living room, dining room, dormitories, kitchen and office all organized around a main axis. De Castro's manor typology plan and elevation were asymmetrical and as part of his unique style the courtyard was accessed through the corners although maintaining the axial organization of the spaces. The courtyard became part of his trademark; it was in this space that he successfully integrated the Spanish Revival Style with the Puerto

[9] Vivoni, Architect of Dreams, p. 26.
[10] Vivoni, Architect of Dreams, p. 39.

Rican climate. The house was richly detailed with architectural elements such as semi-circular arches and arcades, a working chimney and a distinctive tower that also served as a cistern to collect rain water. Spanish clay roof tiles, multicolored glazed ceramic tiles, glass mosaics, semicircular arches, variegated leaded-glass windows and transoms, pre-cast decorative cement elements, iron & tin grill work and Portland cement floor tiles, were all incorporated on and into a reinforced concrete structure, which resulted in a singular architectural design.[11] The house was built of reinforced concrete, a new material at the time that made the house fireproof as well as earthquake and hurricane resistant. (*see figure 5*)

He was able to design and create in his own workshop commissioned pieces such as lamps, furniture, and ornamental objects. He differentiated each area of his residence by changing the pattern or color of the mosaics used. For instance, in Villa Caparra the architect utilized the family coat of arms as a design motif and repeated it in the different mosaic patterns, cement plaster ornaments as well as in the grill work.[12] In the main entrance of his residence he utilized a Moorish inspired alfiz[13] richly embellished with glass mosaics. Other extravagantly ornamented areas were the main porte-cochere, the entrance gates, exterior columns, the gallery arcades, the interior staircase, the multiple fountains and the towers. Since Villa Caparra was his home and showroom, the quantity of mosaic throughout the house is larger than in any other residence or buildings he designed and constructed subsequently. (*see figure 6*)

[11] Vivoni, Architect of Dreams, p. 40.

[12] Vivoni, Architect of Dreams., p. 60.

[13] Islamic influence on architectural ornament that encloses the outward side of an arch in this case the door opening. The space in between the arch and the alfiz is called *enjuta* or *arrabá*, usually richly decorated and in De Castro's case ornamented with a glass mosaic.

Figure 6: Villa Caparra Residence c.1930 (source: Golden Album of Puerto Rico, 1939.)

# CHAPTER 2 CONSTRUCTION TECHNIQUES

## 2.1 Revival of Glass Mosaic during the early 20th century

The revival of glass mosaic ornamentation during the early 20th century was part of an artistic development known today as the Arts and Crafts Movement. This movement experienced its popularity peak in America from 1910 to 1925. It had originally developed in Great Britain and traces its beginnings to the writings of British reformers John Ruskin and William Morris. Due to an increasingly industrialized society in Great Britain characterized by the "evils of mass production," the movement's leaders called for a return to the virtues of hand-craft labor. In the United States and the New World, the movement developed somewhat differently than its European counterpart. The Arts and Crafts movement in the Americas, including the island of Puerto Rico, served to elevate and make accessible industrial consumerism for the middle classes with a touch of craft aesthetic. In the United States it was also influenced by developments in the American Southwest where architects incorporated into their work design elements derived from the Spanish missions and Native American pueblos. In Latin America, the period was influenced by pre-Columbian native cultures as well as the traditional architecture of the mother country, Spain, in the case of Puerto Rico. In short, it was a movement that greatly influenced architecture, interior decoration, craftwork and garden design.

Spanish architecture was enriched with Moorish influences known as the Mudejar or Hispano-Moresque style that is characterized by the use of highly ornamented geometric patterned surfaces executed in inlayed and painted wood, glazed tiles, and carved plaster. During the 1920s, the revival of this decoration style in Spain and Latin America resulted in the addition of materials, such as glass mosaic, to achieve these surface decorations. Ceramic tile and glass mosaic proved to be especially applicable when used in combination with reinforced concrete, appreciated for its plastic and durable qualities and ease of construction. Oswald C. Hering, AIA member and author of *Concrete and Stucco Houses*, wrote:

> *The advent of reinforced concrete brings science to the aid of plastic art, insuring, at an ever lessening cost, greater stability and adaptability, together with endless opportunity for the expression of form, and gives consequent promise of an esthetic awakening of great significance. . .* [14]

Named the "Ferro-concrete style,"[15] this method of monolithic construction allowed the integration of ornament into the surface by embedding tiles or mosaics into the concrete during construction or applied as surface ornament afterwards. If reinforced concrete could not be used, cement stucco on lath and frame, or hollow clay tile, was a second option of construction material. The cement binder was preferable to the traditional lime and sand stuccos of the colonial earlier period and became synonymous with the "Spanish Revival" style as Rexford Newcomb, American academician, architect, and author, wrote in the *Spanish House for America*, ". . .he who would build a Spanish house to-day must erect it in the currently used materials and under the system of labour and construction available at the present time."[16]

Although stone and glass mosaic work has been around since antiquity, it is a medium that has waned in popularity over the centuries because of its labor-intensive process. Moreover, the lack of an easily accessible source of tesserae and the subsequent cost of the material restricted its use, especially in North America. The low accessibility to the primary source of smalti[17] tesserae made the art of mosaic glass expensive and only accessible to the Church and the very wealthy. Several advances in the craft

[14] Onderdonk, The Ferro Concrete Style, p. 8.

[15] Onderdonk, The Ferro Concrete Style, p. 3.

[16] Newcomb, The Spanish House for America, p. 34.

[17] Smalti: refers to the genuine opaque colored vitreous glass from which tesserae are obtained for mosaics. Smalti is ordinary glass with metal oxides added as coloring agents and produces an opaque and fleshy effect. Smalti are unique as a mosaic material and in addition to being weather resistant they offer incomparable reflective power and iridescent brilliance. The color variations are practically unlimited and number over 25,000 and vary according to the type of metal oxides used and the melting temperature. (http://www.dimosaico.com/pages/terms.htm)

paved the way for its resurgence when in 1860, Dr. Antonio Salviati, introduced the 'indirect' system of setting tesserae on a temporary paper base that enabled a complete mosaic to be pre-assembled prior to shipment to its final site.[18] With the advent of industrialization and the popularity of the Arts and Crafts movement, new fast and less expensive ways of fabricating and installing mosaic developed, making the art popular again. Also the manufacture of tesserae evolved, allowing glass to be made in molds of precise size and thickness. In addition, by 1889, three young Germans discovered the methods of smalti manufacture, ending the Venetian monopoly over their production. The new company they founded, Puhl and Wagner Co., began the manufacture of its own glass tesserae in a variety of colors--in 15,000 shades--and also composed mosaics in the indirect system that made prepared designs ready for shipment.[19] Before these advances, the only places where smalti or colored glass tesserae tiles for mosaic could be procured were located in Venice, Italy and their production was zealously guarded. This was a breakthrough in the business, and the pre-assembly of mosaics in the shop allowed them to be easily shipped to any part of the world.

The early 20th century witnessed the modernization of mosaics through the propagation of many advances in the medium and a new breed of mosaic artists was born that not only designed the cartoons but also executed their own works. The growing demand for mosaics made to order encouraged the Puhl & Wagner Company to open a branch in the United States. It was called the Ravenna Mosaic Company and was based in St. Louis, Missouri.

By 1900, mosaic design reached its zenith through the work of the star Catalonian designer and architect Antoni Gaudí. His unique approach towards color and pattern

18 Fisher, Mosaic History and Technique, p.103.
19 Fisher, Mosaic History and Technique, p.103.

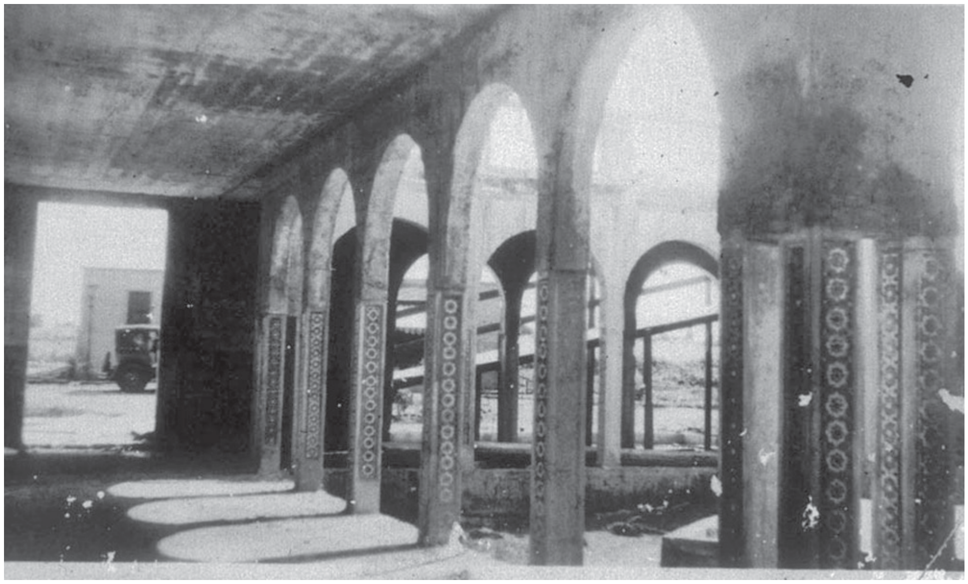

Figure 7: Villa Caparra Residence: view of gallery and patio. c.1927 (source: Land Administration of the Commonwealth of Puerto Rico)

set him apart in the use of mosaic in his building exteriors. Gaudí accentuated his architecture with Hispano-Moresque inspired glazed tiles and often alternated them with small smalto tesserae.[20] He also demonstrated and laid his mosaics in a cement mortar material, a popular construction practice at the time. This design trend was brought to Latin America where the work force was abundant and inexpensive. Some of these craftsmen came from Europe where they had been trained in these trades utilizing the then contemporary installation techniques.

The marriage between cement and mosaic was complete in Gaudí's work and unlike other architects mosaic was not an afterthought in his designs. Like Gaudí and other Catalonian architects, Pedro A. de Castro merged his construction and finish techniques seamlessly. The concrete substrate became the preferred setting for mosaic enrichment, which allowed new decorative possibilities to the concrete medium already in vogue and gave new life to a centuries old art. (*see figure 7)*

[20] Fisher, Mosaic History and Technique, p.118.

### 2.2 Glass mosaic in Villa Caparra

The glass mosaics found in Villa Caparra were designed and fabricated by Pedro de Castro and a crew of skillful craftsmen that worked for him. Mosaics was an integral part of his designs as can be seen not only in his own home, Villa Caparra, but in many of the buildings he designed in Puerto Rico and the Dominican Republic. During his early years as an architect, de Castro designed glass mosaics for architect Antonin Nechodoma and it was in his studio that he got his first direct experience with the mosaic medium.[21] Upon Arch. Nechodoma's death in 1928, he opened his own firm and continued the use of mosaic until his untimely death in 1936 at the early age of 41.[22] It can also be assumed that during his eight year training period at Nechodoma's office, he established good relationships with craftsmen who were eventually recruited for his own office/workshop.[23]

De Castro's love for architectural mosaic was evident in the wall surfaces of his own home, Villa Caparra, which were extensively decorated with a great variety of glass mosaic designs, particularly in the main public spaces. As mentioned in chapter 1, the house was used by the architect as a showroom for prospective clients; it is likely that for this reason alone it is more heavily decorated than any other house he designed and built. The expense of producing these elaborate mosaic designs raised construction costs and thus they were generally installed to accent specific areas, such as the main facade and interior patios or where visitors could see them. (*see figure 8*)

The main spaces and public areas of Villa Caparra, which included among others, the entrances, the galleries surrounding the central courtyard, and the dining room, were ornamented with multi-colored mosaics. *(see Appendix A)* The architectural elements that provided a formal entrance to the property were two reinforced concrete gates,

[21] Vivoni, Architect of Dreams, p. 26.
[22] Vivoni, Architect of Dreams, p. 104.
[23] Vivoni, Architect of Dreams, p. 26.

Figure 8: Castillo Serrallès, Ponce, Pueto Rico: interior patio column. (source: by author, 2010)

each located along one of the two roads that provided access to the site. As can be seen in the only surviving gate, located towards the northeast side of the house, the architect covered the columns, arches, intrados, and dome caps in glass tesserae specially designed for those recessed areas of the gate, and included a lettered inscription. The original greeting inscription as one entered the property reads: "I invite you to enter whether you are friend or foe" while the farewell inscription recited: "You will not depart as an enemy, you will return as a friend."[24] *(see Figure 9)* This remaining gate is one of the most unique features of the house since it is the only place where the architect's words still survive. He continued the decorative experience by highlighting the main entrance door that gave access to the formal sitting area. This ornate, Moorish inspired entrance served to showcase the family shields from Spain and Puerto Rico. (*see figure 10*)

The patio or courtyard that connected all the other important spaces within the house also was Hispanic-Moorish inspired. For this prominent space, the architect covered the

[24] Vivoni, Architect of Dreams, p. 58.

Figure 9: Villa Caparra Residence: view of northeast gate c.1930 (source: Golden Album of Puerto Rico, 1939.)

wainscoting of the gallery and columns with glass mosaics and the fountain with glazed ceramic tiles. The amount of wall surface that is covered with mosaic and the variety of glass colors used is impressive. In the wainscot alone there are: three different types of blue color tesserae; two greens, one dark and of lighter color; a deep purple; a bright red; yellow; beige; white; and, black. This is a total of 11 colors only for the wainscoting and does not include those found in the columns and fountains. More remarkable still is that all four sides of the columns are covered with a different color making the area richly ornate, rivaled only by the dining room.*(see Figure 10)* The latter room and the kitchen were decorated with the same pattern but differentiated by variations in the color scheme and technique. In both spaces 17 different colors are used varying from opaque to slag to transparent. The arrangement of the tesserae is most informal in the kitchen since here he used broken fragments of tesserae to complete the design. In the case of the dining room, the tesserae were cut with precise angles to fit together

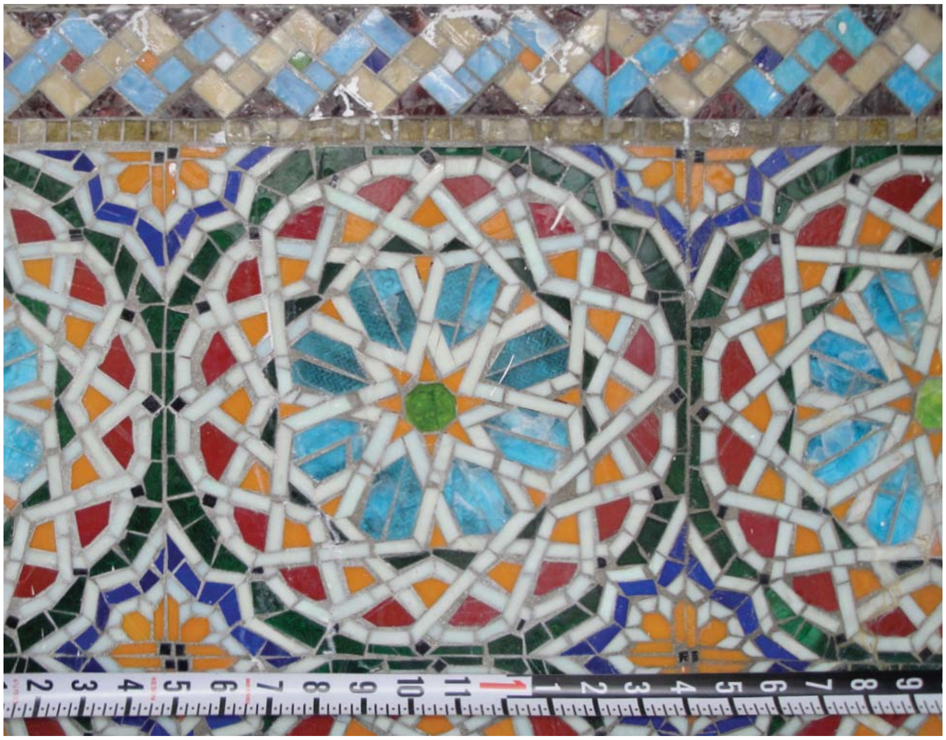

Figure 10: 11x11 Villa Caparra Wainscot Gallery (source: by author, January, 2010.)

in an organized manner giving each space a uniquely different atmosphere. The risers of the stairs, the upper gallery, and tower also have smaller glass mosaic schemes that complete the fantasy of the house.

### 2.3 Preliminary investigations

Based on field investigation and historical research it was determined that the mosaics were probably designed and fabricated as custom work in de Castro's workshop. First, the mosaics exhibit variations in the spacing between the tesserae and the dimensions of their sections. If the mosaics had been commercially made, it is likely they would have had a more systematic and regular spacing between the tesserae. Second, the irregular cuts of the tesserae of the same color and shape were more frequent than for different color. Third, the colors used for a particular design piece could sometimes vary without any apparent reason, probably depending on the availability of that specific color. These irregularities rule out the likelihood that they were ordered from a readymade commercial company. Among de Castro's documents and reference material pertaining to his original studio, at the ACCUPR[25] collection, several commercial catalogs of ceramic tile companies were found which contain designs similar to those in the house. Nevertheless, no catalog was found for glass mosaics and the designs prevalent at the residence appear unique to the spaces. The house has over 20 different colors of tesserae used overall in the mosaic designs. Aside from their color, the glass tesserae can be characterized as opaque, slag or transparent and these were all used together for optimum effect. For example, the mosaic pattern found in the dinning room consists of a typical 11 X 11 inch pre-assembled section of slag, opaque and transparent glass. (*see figure 11*) Slag glass or marbled glass is made from two colors of glass that are combined to resemble marble. The opaque glass refers to a type of glass that transmits light but does not allow light through it, e.g., milky glass, black glass, etc.[26] A transparent glass refers to glass that allows light through it. As can be seen in the transparent glass used for the dinning room mosaic, the glass has no backing and allows the setting mortar to be seen through it. De Castro mixed and used not only these types of glass and tesserae but also gold leaf tesserae.

It was also observed that de Castro used two types of glass: flat glass[27] and rolled plate (figure) glass[28] that varied in thickness from 3/32 to 1/8 inch. Rolled plate glass is cast between two rollers, one of which carries a pattern. Patterns found in the *montantes*[29] or transoms of the house match some of the rolled plate glass tesserae mosaics also

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[25] *Architecture and Construction Files of the University of Puerto Rico (AACUPR).*

[26] Jones, Glass Glossary, p.14

[27] The company is Fowle, Flat Glass, p. 59.

[28] Rolled (or cast) glass is a translucent glass with 50-80% light transmission, depending on its thickness and type of surface. It is used where transparency of the glass sheet is not important or not desired.
The distance between the rollers determines the thickness of the glass. Glass Online, Illustrated Glass Dictionary, available online: (http://www.glassonline.com/infoserv/dictionary/19.html)

[29] *Montante* or Transom window above doorway and window pane that was sometimes movable to let air pass through it while the door or window remained shut. Usually made of wood or glass.

Figure 11: 11x11 Villa Caparra Dining room dado (source: by author, January,2010.)

used in the house. Although it cannot be proven, it is probable that the flat and rolled glass for the mosaics came from the same supplier that provided the glass fixtures above the doorway. In 1917 the flat glass manufacturing technique was improved and mass-produced by The Libbey-Owens Sheet Glass Co. using the Colburn process. With this process the sheet glass made was absolutely flat and had uniform thickness.[30] This process made glass accessible for windows, commercial displays and cars. This could explain why de Castro utilized this glass and not the expensive smalti for his mosaics.

Another type of glass used that differed in composition and manufacturing method was the gold tesserae found as accents in the gate dome caps, the columns of the patio, and in the coat of arms above the main entrance door. The gold tesserae[31] were more regular in size (½ square inch and a thickness of ¼ inch), and made especially for mosaic purposes, unlike the rest of the colored glass used for the mosaics. Distinct from

[30] The company is Fowle, Flat Glass, p. 64.

[31] Gold smalto tessera, smooth surface 20x20mm. Made up of three strata: glass film on top, gold foil (white strip in diagram) and a base of ordinary glass. Fisher, Mosaic History and Technique, p.143.

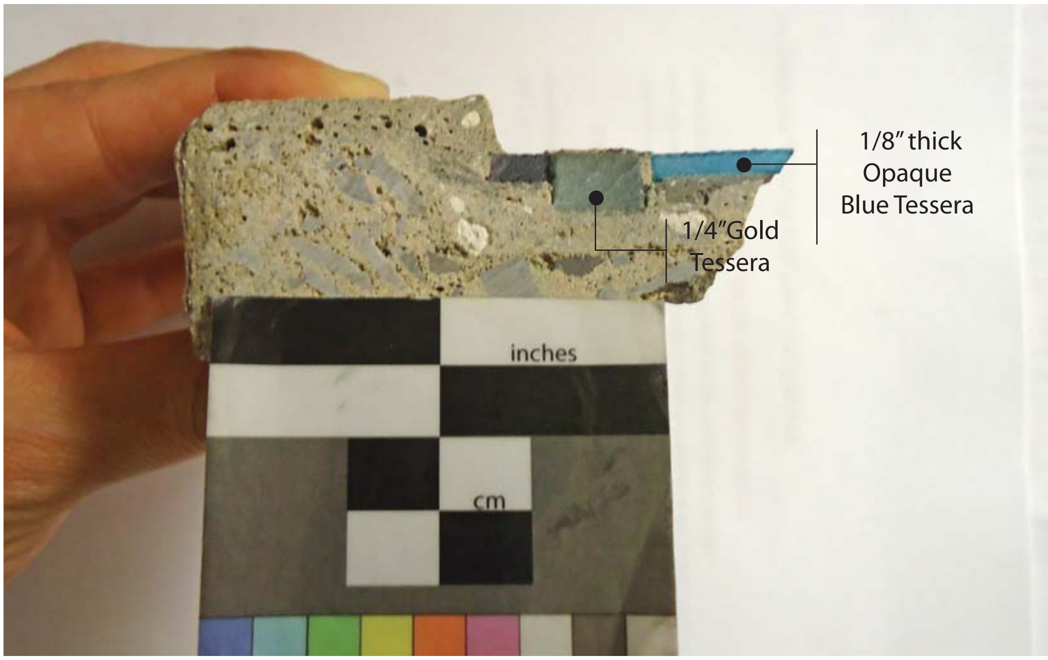

Figure 12: Sample CL_B Villa Caparra Column Porta-Cochere (source: by author, January,2010.)

the regular squared pieces of smalti, the tesserae used by De Castro varied throughout the house in shape, thickness, color and fabrication method. (*see figure 12*)

### 2.4 Fabrication: Assembly and Installation on concrete substrate

After extensive historical research, no photographic or written evidence could be found to explain the mosaic fabrication and installation method. By thorough examination in the field and by the samples obtained, it could be established that the most probable method used in de Castro's workshop was the 'indirect' method. This chapter explains typical 20$^{th}$ century methods of mosaic production that would have been new but were available to Pedro A. de Castro at the time that Villa Caparra was constructed.

The laying technique most common by the early 20$^{th}$ century was the indirect or reverse system, fairly new at the time, but common today. The indirect laying technique is explained best by author Peter Fisher in his book *Mosaic History and Technique*:

> *. . . they (tesserae) are first glued upside down on a paper or canvas backing sheet, which bears the outlines of the design (or a section of it) in lateral inversion. When finished, the section is taken to the site, and its exposed side pressed into the damp plaster. Finally, the backing is peeled off to reveal the completed mosaic.*[32]

The general assembly of the glass mosaic is assumed to have occurred as panels of various sizes in de Castro's workshop. His craftsmen would have first prepared a cartoon with the desired pattern following the architect's design. In the next step the artisans would have to cut the tesserae into the corresponding shape from sheets of glass. For this purpose, the plate glass sheet is first scored so it can be easily broken into the desired pieces. To break a piece, one must hold the glass firmly against the table and press down on it. These steps are repeated until various strips of glass are cut into tesserae.[33] Finally each tessera was assemblied in reverse on a design template and paper was glued to the top surface to hold and transfer the design for installation on site.

Most of the designed patterns were completed using one, or combinations, of four main techniques: Opus[34] Sectile, Opus Palladinum, Opus Tessellatum and Opus Reticulatum. Opus Sectile was used in all mosaic patterns and refers to pieces of tesserae that are cut much larger than regular square shape smalti and could be shaped to define large parts of the design. It was used in two types of decorative geometric patterns (bars, diamonds, triangles and hexagons) and in figurative schemes (leaves, scrolls, etc.) cut out and fitted into the base.[35] Opus Palladinum is a technique where the tesserae are irregularly shaped, and are not laid out in a regular pattern. These tesserae may

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[32] Fisher, Mosaic History and Technique, p.118.

[33] Chavarria, The Art of Mosaics, P. 55.

[34] Opus refers to the technique of positioning the tesserae.
Mosaic Art Source, Mosaic Glossary, available online:
(http://www.mosaicartsource.com/mosaicart/mosaic_art_resource/mosaic_glossary.html#o)

[35] Fisher, Mosaic History and Technique, P. 8.

have been made from left-over glass. Opus Tessellatum is usually used for a background consisting of horizontally or vertically arranged lines but not both. Opus Reticulatum was mostly used in the trim of the gallery area, kitchen and dining room where the mosaic was laid out according to oblique lines. (*see figure 13*)[36]


Figure 13: A)Opus Sectile shown in red, B) Opus Palladinum shown in red, C) Opus Tessellatum shown in red. (source: by author, January,2010.)

Laying the mosaic pre-assembled sections in a vertical position is different than laying them on a horizontal surface. The vertical positioning of mosaics on the wall requires that the lower section be installed so that the top section can rest on the other as in a stacked arrangement. The placement of the mosaic sections onto the concrete substrate is a crucial part in the overall process for, if done incorrectly, it can negatively impact the entire scheme. Improper positioning was observed in Villa Caparra where it could be seen to occur to both smaller and larger degrees.

Before any layering of mosaic could be done, a concrete form was built with recessed spaces to allow for any designs with inset panels. After removing the form, a bedding layer was applied into the recess spaces and the mosaic sections pressed in

[36] Chavarria, The Art of Mosaics, p. 55.

with their reverse layering. The mosaic was left to set in mortar on the wall or column and the glued paper later removed with water to reveal a perfectly even surface. Finally, the mosaic was grouted with another cement base grout, again left to dry, and was then cleaned several times until all the grouting material was removed from the glass surface. In the case of the glass mosaic, no final polish was needed since it could scratch the vitreous surface.

# CHAPTER 3 CURRENT CONDITIONS

## 3.1 Mosaic Survey

The deterioration of the glass mosaics at Villa Caparra is the result of both surface weathering of the tessera and structural failure of the concrete support. These conditions can develop independently or together as a function of location (exterior/interior), exposure (localized conditions), material composition, and installation methods. Due to the large amount of mosaic decoration and lack of time to document their conditions, a risk assessment was performed to categorize all areas according to their severity of condition. This approach allowed areas to be prioritized so that the most critical examples could be studied to a greater degree to define deterioration mechanisms. The risk assessment ranked the current state of the mosaics in three main levels of deterioration. (*see Appendix B)* These ranged from:

1) *Good condition*. Mosaics that exhibit minimal deterioration. The mosaics appear to be in excellent condition in both their support, substrate and tersserae. The integrity of each tessera is intact with no visible deterioration.
2) *Fair condition*. Mosaics show disrepair. Deterioration is visible mainly at the surface but integrity is still good.
3) *Poor condition.* The deterioration of the mosaic is plainly visible and its visual and structural integrity are compromised. The deterioration can be found on the surface as well within the substrate/support. At this level the loss of single and multiple tesserae affects structural and aesthetic integrity of the mosaic.

The Risk Assessment scale from 1 to 3 allowed the identification of areas in critical conditions that require immediate attention and represent areas where damage was more visible. The individual tesserae conditions that were identified are divided in two main categories in the condition glossary. *(see Appendix A)*

### 3.1.1 Glossary of Condition types:

**Structural Conditions:**

Structural conditions affect the concrete support and/or bedding mortar substrate and consequently, cause damage to the mosaic tessera.

*Loss*

This condition is the most severe because it completely disrupts the integrity of the mosaic design. The level of loss can vary; in some cases only a single tessera might be missing, while in other cases and entire group of tesserae may be lost. Loss may be caused by several factors, such as loss of adhesion between the tesserae and the mortar, water infiltration and substrate deterioration, among others.

*Intra-layer detachment*

This condition refers to the partial detachment of the tesserae bedding mortar from the concrete support. This condition is visually disruptive to the mosaic pattern but maintains some level of integrity, as the tesserae remain attached. This condition is usually associated with water infiltration and general deterioration of the substrate.

*Incipient Spalling*

This condition specifically refers to an extrinsic characteristic of the concrete support: rebar corrosion. In this case the internal iron reinforcement has corroded due to water infiltration leading to disruptive expansion that pushes the surrounding concrete outward. The upper surface is fractured as a result and with it the detachment, cracking and loss of tesserae is clearly visible.

*Fill*

This condition refers to the use of cement mortar to fill areas where the original tesserae were missing. These lacunae have been filled in an effort to minimize additional deterioration to the rest of the mosaic. It is not a condition that is common since the residence has been abandoned for many years and hardly any maintenance work has been performed.

*Cracking*

Cracking, for this survey, refers to a linear break visible across the surface of the mosaic, which may also penetrate into its lower bedding mortar and concrete support. Cracks can be produced by water infiltration, rebar corrosion and thermal expansion and contraction of the cement base into which the mosaics were laid. It visually disturbs the mosaic pattern and is usually accompanied by loss of tesserae depending on the severity of the condition.

*Displacement*

This condition refers to the movement of a mosaic from its original position. In this case a group of tesserae moves or shifts from its original position while the grout holds the tesserae together. This is very fragile condition for the mosaics since it may lead to imminent loss of the tesserae and mosaic pattern. *(see Appendix C)*

**Surface Conditions:**

As understood for this survey, surface conditions are intrinsic to the material composition of the tesserae or affect the tesserae directly and not its substrate.

*Detachment*

The tesserae have come loose from the bedding mortar and grout but have not fully detached ,, remaining precariously in place. This condition can be identified by tactile and visual inspection of the glass mosaic surface. These conditions usually surround areas of loss that are weakened due to water infiltration, in particular the bedding mortar, upon exposure to the elements. Although not as visually disruptive, these tesserae need to be reincorporated as soon as possible or risk their possible loss.

*Conchoidal Spalling*

Spalling of the tesserae where the glass breaks in a shell-like pattern or concentric circles that can be identified through tactile and visual inspection. This condition is particularly damaging to the surface of the glass that has deteriorated severely allowing water to further infiltrate increasing the damage. The area becomes so fragile it affects the color, integrity and even causing partial loss of tesserae and disrupting the pattern scheme.

*Incipient Spalling*

This condition refers mainly to the gold leaf tesserae, found in many of the patterns around the house. This type of deterioration is of a particular kind as it breaks or delaminates parallel to the tessera surface. The gold tesserae are made up of three layers: the glass base, the gold foil and a thin glass film that covers the gold. The water can penetrate the metal leaf tesserae when the bond between the two layers of glass is not complete.[37] As these layers deteriorate they separate from each other. The thin glass film and gold foil separate from the base glass that mostly remains attached to the bedding mortar. It is visually disruptive and is part of the advanced condition stage where tesserae are lost. The condition is more prevalent on tesserae exposed to the weather. Also structural faults in the building allow water to penetrate behind the mosaic causing their disruption.[38] The deterioration of the gold tesserae in Villa Caparra is a combination of manufacturing defects and weathering mechanisms.

[37] Davidson, Conservation and Restoration of Glass, p. 60.

[38] Davidson, Conservation and Restoration of Glass, p. 60.

*Fracture*

The fractures present in the tesserae are unlike the previous cracking condition, they are an intrinsic part of the glass composition. This condition can be seen in all the mosaic patterns throughout the house in different stages of intensity depending on the glass composition and exposure to the elements. During the survey, it was evident that certain colors exhibit more fractures than others and that once fractured, they tend to deteriorate faster.

*Efflorescence*

This appears as a white-crystalline powder visible on the grout between the tesserae. It was found in few areas around the house and is caused by water infiltration through the concrete walls. Efflorescence is not a widespread condition and does not disturb the integrity of the mosaic. In general, is was found near areas where tesserae had been lost. This condition is not as threatening as others, but as it indicates that water is getting through the back of the bedding mortar, this could eventually weaken the substrate and loosen the tesserae.

*Bio-Growth*

This condition is visually disruptive since it adheres to the mosaic surface and, in some instances, covers the mosaic surface completely. It is more common in areas exposed to the elements, or where there is rising damp and near the water drainage system. It can also be associated with other conditions exacerbating them, such as concoidal spalling and fractured tesserae.

*Paint Spatter*

This condition can be found almost everywhere and probably resulted at the time the house was rented out to the Andalucian Spanish Organization that occupied the residence for a time. Although in some cases it is visually disruptive, it is not harmful to the mosaic and could be easily removed.

*(see Appendix C)*

### 3.1.2 Observations of macro and micro deterioration

Villa Caparra, as ranked in the initial risk assessment survey, can be considered to be in fairly good condition considering that it has been abandoned for several years. Macro conditions of the site were recorded in 2009 by the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico and in conjunction with the risk assessment; a correlation of conditions was outlined.

*Use, Maintenance and Vandalism*

During the period the house was used as a residence it received the care it required. In later years, when the house was sold to the Land Administration of the Commonwealth Puerto Rico and rented out to the Andalusian Spanish Organization, the house was altered to accommodate office space.[39] It is probably during this period that the fills and overpaints that are found over the mosaics were applied. After the Andalusian group left the house it became increasingly difficult to find another tenant. The lack of use of the property in general facilitated its neglect. In recent years the building has been left empty and with no upkeeping except for sporadic lawn mowing. The original windows and doors are mostly all lost and the remaining stained glass windows have fallen victim to vandalism. The lack of maintenance and repair has also accelerated its deteriorated state. The clogged drains have converted the terraces on the second level into pools of rain-water that then infiltrate through ceilings and walls. There are areas in the house where water infiltration has caused serious rebar corrosion allowing the internal structure to fail so that the mosaic substrate and other surface layers are damaged and lost. These conditions are at a crucial point; if something is not

[39] Land Administration of the Commonwealth of Puerto Rico.

Figure 14: Villa Caparra clogged drains and plant growth on roof surfaces. (source: by Beatriz del Cueto,FAIA, 2010.)

done soon, the damage could be beyond repair. *(see figure 14)*

*Materials, Manufacture and Installation*

The construction methods used in the installation of the mosaics were typical of the time period. As with any construction, careful installation is critical, especially when mounting mosaic sheets to a wall. It is during transportation and installation that tesserae are lost. Examples of this are found in Villa Caparra. Unlike regular loss where the tesserae ghost leaves an indentation, if tesserae are lost prior to or during the installation, grout fills the void after placement when the mosaic gets covered by the grouting material. Another typical mishap happens after laying the mosaic, the bottom pane shifts downward from the weight of the second sheet on top of it because the bedding mortar has not set sufficiently to keep it in place. In consequence, the pattern is off at the corners and visible in the juncture with other sections. As can be seen in Villa Caparra, some of the mosaics in the Gallery shifted slightly downward causing them not to match perfectly. The walls of Villa Caparra have another minor source of discrepancy found on the spacing width between tesserae and sections of the mosaic. All of these conditions are indeed present but are not so visually disruptive to undermine the integrity of the original art work.

*Moisture and Permeability*

Moisture affects two of the most important materials in the house, the cement concrete structure and the glass tesserae. The cement substrate, bedding and glass tesserae are an integral part of the building. If the substrate is affected, the mosaic surface layer gets damaged. The presence of moisture combined with the permeability of the concrete has facilitated corrosion of the rebar. The open cracks found in some of the columns of Villa Caparra are the result of the rebar corrosion expansion that leads to the cracking of the concrete.

Another consequence of water infiltration is that the mosaics lose adhesion to the bedding mortar. Both materials, the cement mix and the glass, contain alkalies that are susceptible to deterioration in the presence of water. In the Puerto Rico climate, where the average rainfall per year reaches 52.34 inches[40] this becomes a real problem. The high temperatures also play a role in the deterioration of the glass, as the alkali leaching from the glass is accelerated and the dissolution of the silica network occurs.[41] Water and weather conditions, the additional vandalism and neglect all put the house at a greater risk of deterioration.

*Selecting Areas*

Through the risk and condition assessment, areas at risk level 3 were selected to perform the full condition survey. These areas encompasse four major spaces of the residence that are listed as followed:

[40] World Meteorological Organization, 2010-03-26, available online: (http://worldweather.wmo.int/093/c00850f.htm#climate)

[41] Frank, Glass and Archaeology, p.12.

- The Entrance Gate
- The Main Entrance Door
- Northeast wall of the Galleria
- Northeast wall of Dining Room

The survey of the sample areas of Villa Caparra suggests that there are extrinsic and intrinsic deterioration factors that affect the tesserae. Several sources report that mosaics are impervious to water and resistant to every attack, giving the mosaic almost eternal qualities. The present study has shown that there are some that may be very susceptible to the conditions to which they are exposed that alter their composition and stability.[42] As with any material, there are variations in quality that will determine their resistance to deterioration. *(see Appendix D)*

[42] Vasari, Vasari on Technique, p. 255.

# CHAPTER 4 MATERIAL ANALYSIS

Analysis of the Villa Caparra mosaics, both glass tesserae and their support, was an essential aspect of this study. The lack of information on the origin and manufacture of the glass made it important to identify its composition as this is critical in understanding deterioration modes and providing suitable treatments and recommendations.

One of the critical analytical methods was x-ray fluorescence (*XRF*). This was chosen in order to determine the elemental composition of the glass, especially the coloring agents used, in the selected samples. Another important analytical tool was Scanning Electron Microscopy (*SEM*), which allowed visualization of the glass surface and especially its surface corrosion. Other tests were performed that confirmed and characterized other material components such as optical microscopy (OM) for cross sections, and gravimetric analysis and thin section examination for the bedding mortars and concrete support.

## 4.1 Mosaic Composition by color

Glass has three main ingredients: silica, fluxes and stabilizers. Pure silica ($SiO_2$), generally quartz sand, is the main component of glass. Silica alone, requires a stable and high temperature of 1000º C[43] to be melted but the furnaces available before modern times were not capable of maintaining this temperature for long. It was therefore necessary to lower the melting temperature of the silica by adding what are known as "fluxes." This was accomplished by the inclusion of alkali metal oxides, introduced as carbonates with the sand. The alkali acts as a network modifier in the silica batch. The most common network modifiers are sodium oxide ($Na_2O$) and potassium oxide ($K_2O$). Even with the inclusion of these modifiers, the quality of glass produced is low.

[43] Davidson, Conservation and Restoration of Glass, p. 73.

Stabilizers were added to the batch to reduce its viscosity and eventual crizzling[44]. The most common stabilizers are the alkali earth metals, such as lime or metals, such as lead. Initially color appeared as an impurity common in the silica, such as iron oxide (FeO), which gave glass a green tint. Later, with the addition of other oxides, different colored glasses were produced. By varying the firing conditions in the furnace, i.e., in oxidizing and reducing atmospheres, different colors in the glass could be produced.[45] For instance, iron oxide can produce light green or pale yellow under reducing or oxidizing conditions respectively, and brown colored glass is produced when iron oxides are added in higher concentrations in oxidizing conditions.

There are three basic types of glass: soda-lime glass, potash-lime glass and potash-lead glass.[46] Color is not related to the glass type since green, amber and brown can be produced in any type of glass. Given that color is not directly related to the technology and type of glass, it cannot be used for classification.[47] The amounts of silica, the type of fluxes and stabilizers are more applicable for characterization.

Tessera samples obtained from Villa Caparra were analyzed to better understand the visible deterioration mechanisms observed. The samples removed were already partially detached due to rebar corrosion and deterioration. Other samples taken for the study were partially broken fragments easily removed by hand. *(see figure 15)*

### 4.1.1 GIS Condition Survey Analysis

Three main areas were selected because they exhibited major problems and ranked 3 in the risk assessment carried out on all the tesserae of Villa Caparra. (*see Appendix A*). The three areas are the Entrance Door, the Gallery Wall and the Dining Room.

[44] Crizzling: type of surface cracking that can also develop if the object is placed in a dehydrating environment. Jones, Glass Glossary, p.11

[45] Davison, Conservation and Restoration of Glass, p. 73.

[46] Jones, Glass Glossary, p. 10.

[47] Jones, Glass Glossary, p.13


Figure 15: Sample ME_4 Main Entrance door. (source: by author, January,2010.)

The condition survey documented deterioration in the above areas that are found in different locations ranging from the exterior, semi – interior and interior of the house. This would enable a better comparison of deterioration according to its location and environmental factors. The information was processed using ESRI-GIS software to analyze the data collected and measure quantitatively the conditions present in the tesserae. For analysis, two conditions were selected, conchoidal spalling and fracture, as they are directly affecting the integrity of the tesserae and not its concrete substrate.

*Dining Room*

The wall of the Dining Room of Villa Caparra ranked 3 in the risk assessment and exhibited water infiltration, efflorescence, major cracks and loss of tesserae. The wall is composed of two main components: the I rail and J dado that cover all the dining room walls up to 4 feet high. The dado survey revealed that 6 of the 8 colors that composed the J pattern exhibit conchoidal spalling. Conchoidal spalling is highest in the slag gray tesserae (9.39%) and lowest in the slag green tesserea (0.39%). The condition affected all tesserae to different degrees independent of whether they were opaque, slag or transparent, or by color. The I rail pattern in the dining room has 9 different colors of tesserae and only 3 of these tesserae exhibited conchoidal spalling. Conchoidal spalling was particularly severe in the transparent dark purple tesserae with 66.04% of the total exhibiting conchoidal spalling. The slag beige with 17.22% and the transparent yellow with 1.35% make up the remaining conchoidal spalling visible in the rail portion of the wall. (*see Appendix E*)

The second condition analyzed was the linear fractures visible in the surface of the glass matrix. The fractures on the J dado matrix affect opaque, slag and transparent glass equally. The analysis also revealed that the two transparent glasses used in the dado-- mustard yellow and blue-- are more susceptible to this type of deterioration. The transparent mustard yellow was the glass type most affected with 43.71% of the total area studied followed by 16.60% of transparent blue and 14.90% of slag gray as the most affected of all the tesserae in the J dado. In the I rail the fracture condition is concentratesd in 4 main tessserae: the slag baby blue, transparent dark purple, transparent yellow gold and the slag beige. Thirty percent of the slag baby blue is affected and more than 50% of the yellow gold and dark purple transparent glass is also affected by fracture.

The analysis shows that 88.37% of the tesserae in the Dining room wall have linear fractures and the remaining 11.63% have conchoidal spalling and loss. The analysis shows that the transparent glass, independent of its color, is more susceptible in both conditions but additional study must follow in order to determine which intrinsic component in the transparent glass is the cause of the failure. *(see Table 1) (see figure 16)*

| **DINING ROOM - CONDITIONS** | | |
|---|---|---|
| **CONDITION** | **TOTAL AREA(sq in)** | **%** |
| CONCHOIDAL SPALLING | 57.75 | 6.29 |
| FRACTURE | 811.38 | 88.37 |
| LOSS | 49.04 | 5.34 |
| **TOTAL** | **918.16** | **100.00** |

Table 1: Dining Room Conditions - ESRI GIS

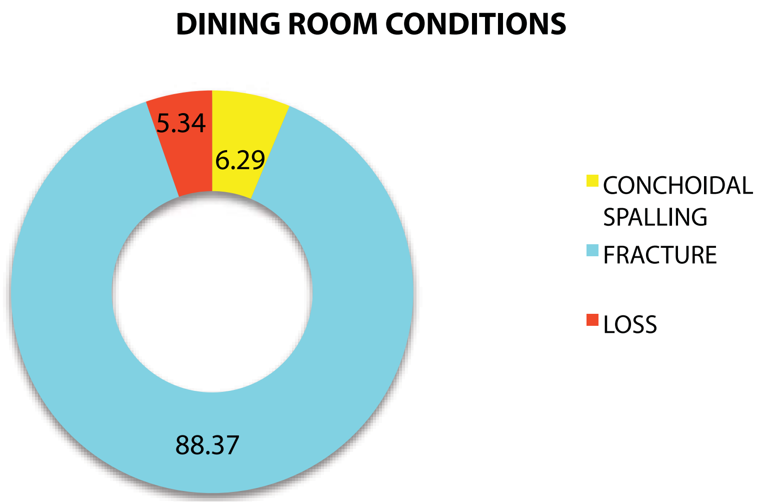


Figure 16: Dining Room Conditions - ESRI GIS

*Gallery*

The gallery, whose walls are decorated with 2-foot high mosaics, surrounds Villa Caparra's interior patio. This area exhibited a level risk of 2 in the general assessment and is located in a semi – interior area of the house. The mosaic patterns of the area are the I rail and the H dado. This area exhibits water infiltration, fracture, and a variety of tesserae that highlighted the importance of its study. This area was analyzed in terms of the two main conditions that affect it fracture and conchoidal spalling. The rail and dado were studied independently because of the difference in color and pattern composition.

The gallery dado has 9 different tesserae colors and 6 of them exhibit conchoidal spalling. The opaque white is the highest with 69.35% followed by 15.62% transparent light blue and 9.71% slag green. The I rail also has 9 different tesserae and is the same color and pattern as the Dining Room rail. The same colors: slag baby blue, slag beige, transparent dark purple and yellow gold appear to be more susceptible to conchoidal spalling. The transparent dark purple in the gallery is the highest with 43.26% of the total conchoidal spalling studied.

The second condition studied was fracture in both the I rail and H dado. In the

H dado 6 different tesserae colors exhibited fracture. The study revealed that 80.17%--more than half --of the transparent light blue tesserae analyzed were susceptible to fracture. This contrasted with the other 19.80% distributed in the other 5 tesserae colors: opaque blue, green, red, yellow, and slag green-white that exhibited linear fracture visible in its surface. The I rail fracture percentages are more evenly distributed across the 4 colors. The transparent dark purple exhibited 30.94% followed by the slag baby blue with 25.20%, the slag beige with 22.82% and transparent yellow gold with 20.48%. *(see Appendix E)*

The gallery analysis revealed that glass in this area of the house exhibited more fracture than conchoidal spalling. Deterioration of the rail of the gallery appears to be concentrated in 4 specific tesserae colors: transparent dark purple, transparent yellow gold, slag beige and baby blue for both fracture and conchoidal spalling. Further study of the composition of the glass could determine the exact or common causes among them. *(see Table 2) (see figure 17)*

| GALLERY CONDITIONS | | |
|---|---|---|
| **CONDITION** | **TOTAL AREA (sq in)** | **%** |
| CONCHOIDAL SPALLING | 208.15 | 21.42 |
| FRACTURE | 763.53 | 78.58 |
| **TOTAL** | **971.67** | **100.00** |

Table 2: Gallery Conditions - ESRI GIS

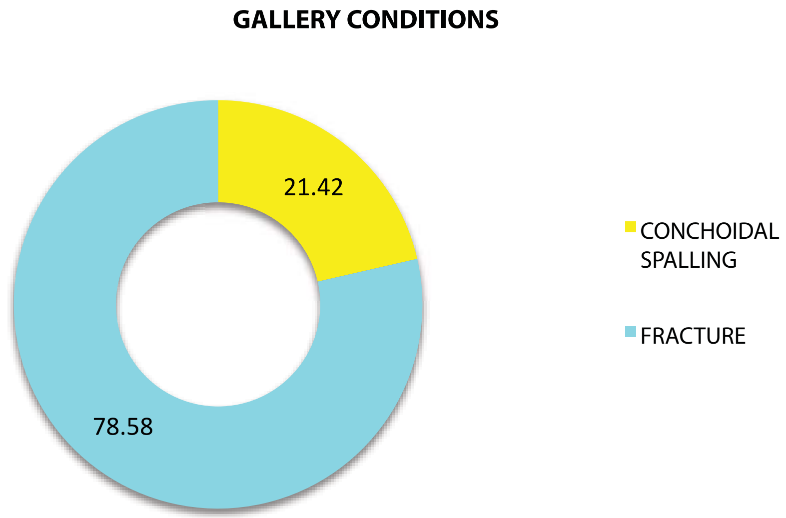


Figure 17: Gallery Conditions - ESRI GIS

*Entrance Door*

The main entrance door has a risk level of 3, the highest, which means it exhibits high levels of deterioration and loss. There are 4 mosaic patterns found in the door composition: D trim, E dado, F shield and G shield. They will be analyzed independently to facilitate their study. All four patterns were analyzed according to the following conditions: conchoidal spalling, fracture and loss. The mosaic exhibits deterioration of the glass surface, minor and substrate cracks, vegetation, loss and the exterior location presents different conditions not present in the other areas surveyed. *(see Appendix E)*

The E dado contains 10 different tesserae colors of which 8 show signs of conchoidal spalling. The tesserae with the highest conchoidal spalling present is the opaque dark purple with 22.72%, followed by slag beige and transparent yellow with 19.06% and 18.25% respectively. Other tesserae colors that exhibited conchoidal spalling were slag baby blue (14.57%), opaque red (11.73%) and slag turquoise (9.78%). In this case the transparent and slag glasses appear to be more susceptible than the opaque glasses; a trend that was also observed in the dining and gallery areas survey.

The F and G shields have 7 different color tesserae and all show signs of conchoidal spalling but not in the same quantities. The transparent gold tesserae are the highest with 49.72% of all the conchoidal deterioration present in the shields. The slag baby blue (13.06%), opaque white (11.44%), opaque red (11.09%), and opaque royal blue (8.71%) also exhibited conchoidal spalling but in less quantity that in the gold tesserae.

The D trim contains 6 different tesserae colors of which 3 show conchoidal spalling to different degrees. Of the total conchoidal spalling quantified, slag tan is the highest with 92.78%. The opaque white and green glasses exhibited minor conchoidal spalling together totaling 6. 70%.

The two main conchoidal spalling tesserea types in the entrance door that need further study and immediate stabilization are the transparent gold tesserae in the shields and the slag tan in the door trim. Additional XRF analysis will be needed to determine their composition in order to identify cause and possible treatments.

The next condition analyzed was the linear fractures in the surfaces of the trim, dado and shields of the entrance door. As done in the previous comparisons, the separation of the areas by pattern allows for an easier picture of the condition.

The E dado displays 10 tesserae types, seven of which have minor fractures visible. The highest quantity of surface fracture is the slag turquoise with 29.20% followed closely by the slag beige and opaque dark purple with 20.96% each. Other tesserae such as the slag baby blue (11.95%) and the transparent yellow (9.26%) appear to have fractured but in less quantity. The F and G shield tesserae present major fractures in its slag baby blue (34.95%) and the transparent gold (31.87%) followed closely by the opaque red (14.21%). The D trim exhibited a high quantity of fracture in the slag tan with 97.59% of all the tesserae with the condition. The slag tan tesserae in the trim have yielded high for both conchoidal and fracture conditions and its composition needs to be studied further.

The final analysis performed in the entrance door was the loss condition and it identifies where the tesserae have completely deteriorated. The E dado exhibited major loss in 3 tesserae colors: the transparent yellow (29.73%), the slag beige (22.43%) and the slag baby blue (17.47%). The other 5 tesserae colors that exhibit loss are: opaque dark purple (14.20%), red (7.12%), green (2.90%) and slag turquoise (2.82%) and pink (2.53%).

The F and G shield losses were concentrated in the transparent gold tesserae with 68.31% of the total loss in the shields. The other tesserae colors found with losses are opaque black (5.59%), red (8.12%), white (14.53%) and slag baby blue (3.48%), these are minimal when compared with the loss of the transparent gold where entire elements of the composition are missing.

The trim of the entrance door presented loss in all the colors that make up the D trim. Once again, the tesserae color that suffered major loss was the slag beige (51.32%) which also displayed a percentage higher in the other previous conditions above. The other colors such as the opaque green (3.26%), light yellow (10.86%), white (31.13%) and royal blue (3.45%) exhibited minor losses when compared to the slag tan. *(see Table 3) (see Figure 18)*

| ENTRANCE DOOR CONDITIONS | | |
|---|---|---|
| **CONDITION** | **TOTAL AREA (sq in)** | **%** |
| CONCHOIDAL SPALLING | 580.28 | 35.07 |
| FRACTURE | 980.93 | 59.28 |
| LOSS | 93.57 | 5.65 |
| **TOTAL** | **1654.78** | **100.00** |

Table 3: Entrance Door Conditions - ESRI GIS

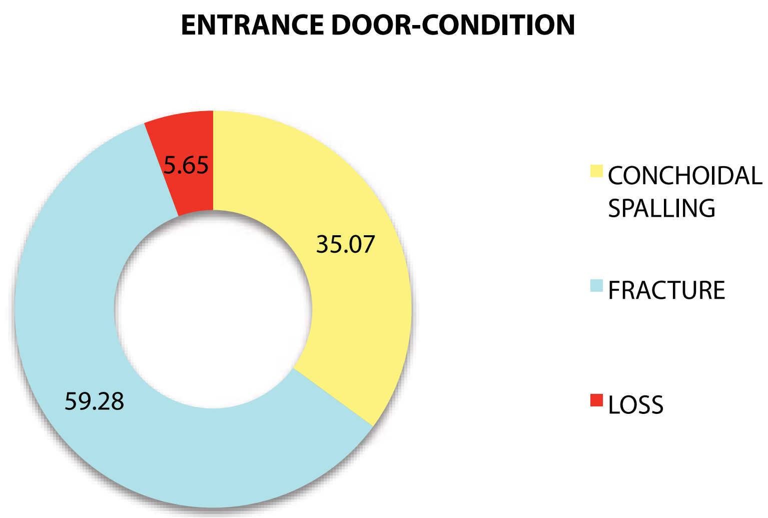


Figure 18: Entrance Door Conditions - ESRI GIS

The analysis performed through the ESRI-GIS software allowed the quantification of the conditions affecting the glass tesserae in the Villa Caparra mosaics. The conditions chosen were those that were most common as determined by the survey and directly affected the tessera. The information presented was separated by pattern, color and characteristics. It was important to this research to identify if color was linked to the deterioration of the glass. Although the information is separated by color, it was done solely to identify the glass and it is not associated to the deterioration. Since many tesserae of different colors deteriorated, a link between color and deterioration could not be proven. The analysis also took into account the characteristics of the glass (opaque, slag and transparent) and whether there was a link between it and the deterioration visible in the glass. Since opaque, slag and transparent glass deteriorated in all areas of the house, a link between these characteristics and deterioration could not be determined conclusively. In addition to these two variables, the location and substrate of the tesserae in the house also played a role in its deterioration. Although a link between the color and characteristics was not proven through this analysis, the tesserae, which exhibited conchoidal spalling, fracture and loss, could if studied, further reveal the causes of their accelerated deterioration and whether location and exposure play a more important role than previously considered. This particular survey can not determine why some glasses deteriorated differently even when beside each other. It can only highlight the tesserae that deteriorate faster and in what quantity. The answer may be found in the chemical composition of the glass and in its interaction with the substrate and the environment.

Materials analysis performed on Villa Caparra glass tesserae are reported and presented in the next section of this chapter.

### 4.1.2 X-Ray Fluorescence (*XRF*)

XRF analysis was performed at the Winterthur Museum by Dr. Jennifer Mass and Dr. Catherine Matsen. Technical specification of the analyses was provided by Winterthur Museum Laboratory (WML). Non-destructive, qualitative ED-XRF (energy-dispersive x-ray fluorescence) spectroscopy determines the sample area's elemental composition. Spectra were interpreted using the Intax version 4.5.18.1 software; an integrated CCD camera allowed a magnified image of the region of analysis to be acquired.[48]

A sample is first irradiated with the appropriate primary x-rays; the sample then emits a secondary X-ray that represents the elements contained in the sample.[49] XRF is a non-destructive technique and it does not harm the glass. It is an ideal test since deteriorated glass is fragile and any chemical test or treatment without prior knowledge of its composition could harm the glass. *(see figure 19)*

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48 Analysis was performed with the ArtTax µXRF spectrometer using the molybdenum tube (600 µA current, 50kvV voltage, 100 seconds live time irradiation, approximately 70-100 micron spot size) with element detection range of potassium (K) to uranium (U). Winterthur Museum, Conservation Laboratory, April 8, 2010.

49 Newton & Davison, Conservation of Glass, pp.194.

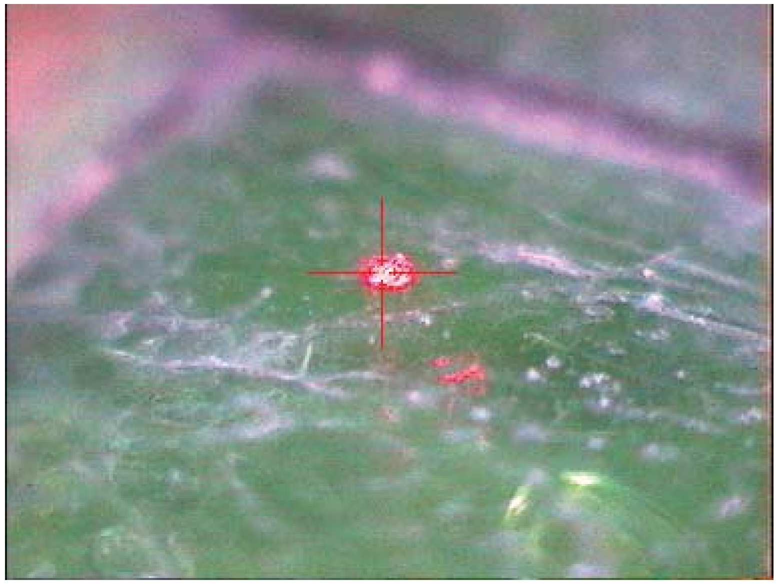

Figure 19: XRF analysis on Sample CL_B Opaque Green (source: Winterthur Museum, April, 2010.

A total of twelve flat glass tessera samples from Villa Caparra in a variety of colors and deterioration were analyzed. Sample CL_B was taken from one of the porte-cochere columns and is still embedded in the bedding mortar. It underwent a full analysis of all of its glass tesserae since it had 9 different colors of glass: gray, amber, green, beige, black, slag pink, red and gold leaf. All of the tesserae measured had a maximum thickness of 1/8" with the exception of the gold tesserae which was ¼" thick. *(see Appendix F)*

XRF showed that the glass used in Villa Caparra varied in composition. Three main types were found: soda-lime glass, potash-lime glass and lead glass. The red, green, amber, grey, and beige were found to be soda-lime glass. Soda-lime glass is one of the most common types used in the manufacture of flat glass. The slag pink in the sample was found to be a leaded soda-lime glass and the glass used in the gold leaf tesserae also was found to be of the lead type. These samples serve to give a range of the glass composition used in the Villa Caparra glass mosaics that could potentially be correlated to their deterioration. *(see Appendix G)*

### 4.1.3 Scanning Electro Microscopy (*SEM*)

The tesserae discussed in this chapter were analyzed by scanning electron microscopy to identify their different phases. The *SEM*[50] provided detailed information about the micro structure of the glass and of the deterioration occurring on its surface or on its base, as well as the elemental composition. SEM scans the surface of the sample with a high-energy beam of electrons that interact with the sample material resulting in a very detailed 3-dimensional image. As the sample image is acquired through electrons instead of transmitted light, the image is rendered in black and white. [51]

Since the sample uses electrons instead of light, special preparations must be made to examine the sample. In the case of non-metallic samples such as glass, they need to be made conductive. For this purpose, the samples are first mounted on a metal specimen holder and sputter coated with a thin gold palladium film.[52] The SEM images were all taken at 500x magnification in order to compare the deterioration of the samples at the same scale. Three samples from different areas of the house that exhibited different types of deterioration were analyzed.

Sample ME_04 was taken from the main entrance door of the house, it had a light beige color and XRF revealed it was of soda-lime composition. *(see figure 20)* It visually exhibited deterioration on the backside rather than on the surface exposed to the environment. The sample was broken in two pieces and mounted so that each surface faced the electron beam, sample ME_04 (B) and ME_04 (T),

*Sample ME_04: ME_04(B) & ME_04(T):*

In sample ME_04*(B)*, the back layer that was embedded in the cement bedding mortar exhibited a highly corroded surface and open fractures. The analysis identified 65.35 % silicon (Si), 10.80% calcium (Ca), 8.41% potassium (K) and 8.81% sulfur (S),

[50] LRSM, Lolita Rotkina , April 18, 2010.
[51] Scanning electron microscope, available on-line: (http://www.mos.org/sln/SEM/)
[52] Purdue University, available on-line: (http://www.purdue.edu/REM/rs/sem.htm)

elements typically found in cement. *(see Appendix G)*

In contrast, sample ME_04*(T)*, the surface layer of the same glass sample, exhibited a less corroded and fractured surface. The analysis revealed that the silicon levels for the surface layer were 83.22% silicon (Si), much higher than in sample ME_04*(B).* Other elements found were iron (Fe) and magnesium (Mg), corresponding to the typical oxides found in the glass structure. In contrast to sample ME_04 *(B)*, sample ME_04 *(T):* had no sulfur. The difference in deterioration and corrosion compounds between the bottom of the glass and its surface layer suggest a pattern that continues in the next samples. (*see figure 20*)

The second sample W_02, divided into samples W_02(B) and W_02(T), was taken from the chair rail of the gallery. It was burgundy color and of soda-lime glass composition. This sample was again mounted with opposing layers facing as sample W_02(B) and sample W_02(T). Surfaces on the top and bottom of the sample were found to have distinct spectra due to different deterioration products found.

*Sample* W_02*(B) &* W_02*(T)*

Sample W_02(B), which is closer to the cement bedding mortar, exhibits corrosion, fractures and also areas with stable glass structure. The spectrum showed the sample to contain 38.46% silicon (Si), 21.45% calcium (Ca) and 27.04% sulfur (S).

Sample W_02(T), as observed in the secondary electron image, appears to have a smooth surface with corrosion areas where the beam of electrons was concentrated. The elemental composition was 58.7 % silicon, nearly twice as much as that found on the bottom of the sample (W_02(B)). Other elements found were 18.62% chlorine (Cl) and 8.62% potassium (K). Chlorine is not an element found in glass and its presence could be attributed to the marine environment and be related to surface deterioration. Further tests should be carried out to determine its influence on the corrosion of the

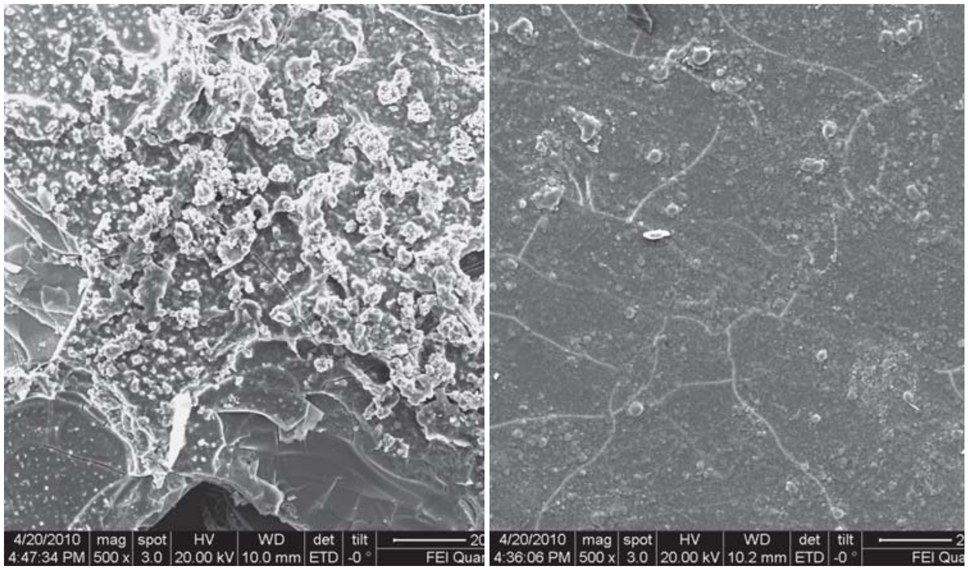

Figure 20: SEM image of Sample ME_04 Main Entrance door, to the left *S4(B)* and to the right *S4(T)* (source: by author, January, 2010.)

glass. *(see Appendix G)*

*Sample W_05*

The third sample W_05(B), was only analyzed on its bottom surface, in contact with the bedding mortar (W_05(B)). It was also taken from the gallery. It is a transparent blue glass that exhibited severe fractures visible to the naked eye. Only its bottom surface, in direct contact with the bedding mortar, was analyzed.

When viewed at 250x magnification, the sample exhibited heavy corrosion and a very fractured glass network. EDS analysis showed that it had 81.54% silicon (Si), 6.30% sodium (Na) and 7.5% calcium (Ca). The sodium and calcium could be part of the cement mix so near the surface of the glass. *(See Appendix G)*

The results are summarized in Table 4

| Sample | Color | Surface | Elemental Composition |
|---|---|---|---|
| ME_04 | Beige | Bottom | Si (65.35%), S(8.81%), Ca(10.80%), Na(5.09%), Al(1.55%), K(8.41%) |
| | | Top | Mg(1.01%), Al(6.04%), Si(83.22%), K(0.73%), Ca (7.19%), Fe(1.81%) |
| W_02 | Dark Purple | Bottom | Na(8.78%), Si(38.46%), S(27.04%), Ca(21.45%), Al(0.19%), Fe(0.42%), K(1.58%), Mg(0.29%), Cl(1.79%) |
| | | Top | Na(7.57%), Si(58.87%), S(0.06%), Ca(4.77%), Al(0.83%), Fe(0.35%), K(8.64%), Mg(0.29%), Cl(18.62%) |
| W_05 | Transparent Blue | Bottom | Na(6.30%), Si(81.54%), K(2.26%), Ca(7.55%), Cu(1.35%), Al(0.99%) |

Table 4 : SEM results, May, 2010.

### 4.1.3 Cross Section

A gold tessera sample was collected for cross section analysis at the University of Pennsylvania's Architectural Conservation Laboratory. The gold leaf tessera was removed from the main entrance exterior surround. In general, gold tesserae on site were observed to perform poorly and even more so in areas that where exposed to the elements.

To embed the samples, plastic molds ½"(w) x ½"(l) x ½"(h), were covered with a thin layer of releasing agent 5ml of Bio-Plast acrylic-polyester resin and 3 drops of catalyst were stirred together to activate the embedding material. The molds were

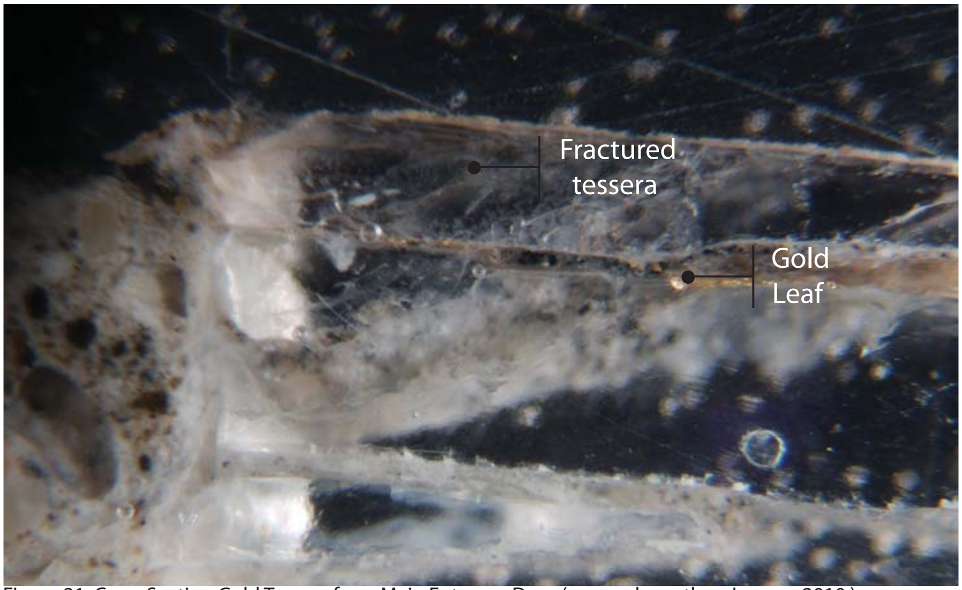


Figure 21: Cross Section Gold Tessera from Main Entrance Door (source: by author, January,2010.)

initially filled with a thin layer and left for 24 hours to set. The sample was placed in the middle of the mold and covered with freshly prepared resin until it covered the sample completely. This was left to cure for at least three days, or until the resin had hardened. The embedded sample was removed carefully from the mold and cut using a Buehler-IsoMet low speed saw. The thin slice obtained by cutting was polished and mounted on a glass slide.

The prepared sample revealed that the tessera had several cracks on the thin layer that covers the gold leaf. The glass used as the base tessera had weakened and broken off from the bedding mortar. It's clear from the cross section that the failure of this particular type of tessarae comes from both the top glass layer and the bottom glass layer by the cement bedding mortar. *(see figure 21)* Additional tests would be required to determine which of the two glass layers deteriorates faster, or if one them triggers the other condition. To be determined is whether a suitable conservation scheme can be developed to save what is left of the original material or if replacement is more appropriate in this particular case.

## 4.2 Concrete Substrate

### 4.2.1 Mortar Analysis by Gravimetric/Acid Digestion Method

The analysis requires visual examination of the sample followed by acid dissolution of the binder. The crushed sample is left to completely dissolve over 24 hours in the acid solution. The aggregate and fines left after the dissolution are separated, weight and characterized.[53]

This process was performed on the bedding and substrate mortars of Villa Caparra to determine the approximate binder-aggregate ratio. The samples tested were taken from areas directly behind the mosaic surface to determine the proportions of the principal components in the mortar. This analysis has some limitations since the acid also dissolves not only the calcareous fraction of the binder but also any calcareous aggregate used in the mix and some hydraulic compounds, if present.[54] Two samples were analyzed: a substrate Cl_C(SB) and a bedding mortar CL_C(BM).

The first sample, CL_C(SB), is the concrete support that exhibits gravel as well as sand. These were separated from the binder before processing. The three main components were found in the following weight percentages: 64.0% acid soluble binder fraction that includes calcareous material in the aggregate (see next section for this point), 18.65% aggregate, and 17.35% fines

The second sample, CL_C(BM), was taken from the bedding mortar and appeared more compact than the substrate sample. The three main components were found in the following weight percentages: 60.25% acid soluble fraction of the binder including calcareous material in the aggregate (see next section for this point), 20.55% aggregate and 19.20 % fines.

The particle size distribution for the aggregate of both samples showed them

[53] Teutonico, A Laboratory Manual for Architectural Conservators, p. 1-2.
[54] Charola, Mortar Analysis: A Comparison of European Procedures, p.1

to be well graded but poorly sorted. Both of them had aggregate 150-300 µm. The aggregate, although having a wide range of particle sizes, is not evenly distributed. *(see Appendix I)*

### 4.2.2 Optical Polarized Light Microscopy

Optical Polarized Light Microscopy of thin sections is used to characterize and interpret many materials used in construction.[55] The sample for thin section was mounted in a blue-dye epoxy to better observe pores and cracks. The sample, after completely set, is cut and mounted on a slide and polished. The thin section is examined under transmitted polarized light.

The sample for thin section was chosen from the column of the porte-cochere. This sample contains four of the main layers involved in the mosaic laying. (Starting from the bottom, the first layer is the concrete substrate; then the bedding mortar; followed by the glass tesserae; and, the decorative cement border constitutes the fourth layer. The selected area was mounted in an oversized slide 2″x 3″. Observed through a polarized light microscope at 10x magnification, the support shows calcareous aggregates and reveals a high porosity, represented by large pores. At the same magnification, the bedding mortar also showed similar calcareous aggregates but had smaller pores and less quantity of voids. By the size of pores it can be assumed that the permeability of the support is higher than that of the bedding mortar. The sample also shows that the glass tessera in section has a network of tiny cracks that go through from the surface to bottom. The thin section analysis has proven valuable in viewing the differences between the mortars used. *(see figure 22)*

[55] Reedy, Thin Section Petrography, p.1

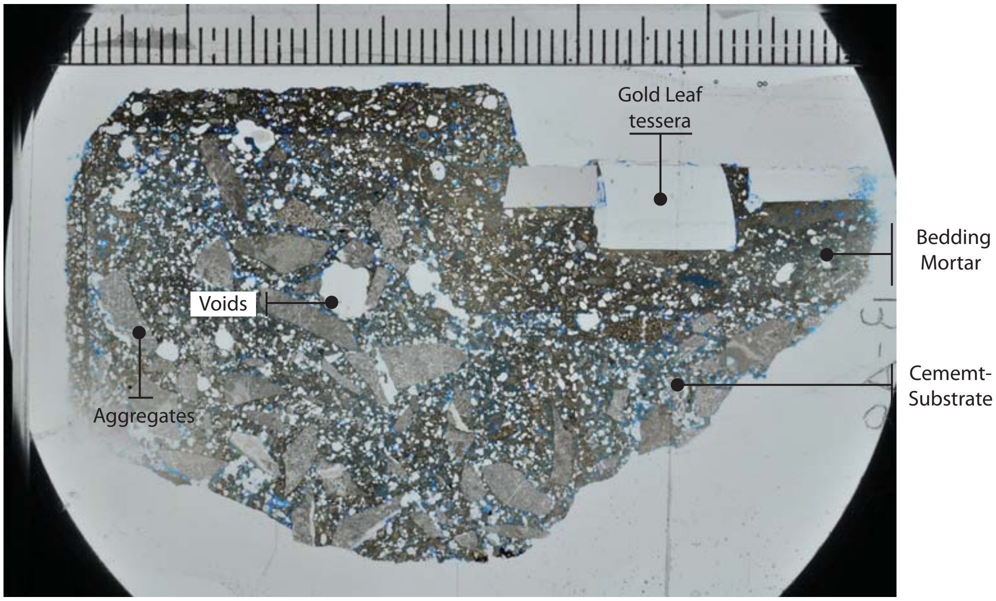


Figure 22: Sample CL_B petrography slide [2”x 3”] . (source: Jamie Hayden May, 2010)

### 4.3 Diagnosis

During the course of the investigation of the possible causes for the deterioration of glass it became clear that the composition of the glass was not the only cause for its deterioration. Other possible causes for glass deterioration can be considered, such as fracturing and water infiltration. The samples reveal a distinct difference in the deterioration pattern of the external surface of the glass from its bottom surface embedded into the mortar. It was necessary to get a closer view of these surfaces to understand the different deterioration patterns on these two faces.

When compared to the several centuries old deterioration of the *Last Judgment Mosaics* in the St. Vitus Cathedral, Prague,[56] those glass tesserae, although opaque by corrosion, did not exhibit the amount of spalling, fractures and glass disintegration present in the Villa Caparra glass mosaics, which have only been exposed for 80 years.

By knowing the composition of the glass through XRF analysis and comparing those results to the SEM micrographs, it can be determined that the Villa Caparra glass

[56] Getty, Conservation of Last Judgment Mosaic, 2004.

is deteriorating due to contact with the cement support (concrete) and bedding mortars. There are several factors that contribute to the acceleration of this type of deterioration and they are the climate, water infiltration into the substrate and the intrinsic composition of the materials involved.

Before the 20$^{th}$ century, mosaics were generally laid in lime based substrates. Lime substrates are permeable and less rigid than the cement substrates used today. The Villa Caparra mosaics are laid in a rigid concrete structure with brittle cement mortars that can suffer from iron reinforcement corrosion in the warm and damp climate of Puerto Rico. This can present a serious problem for the brittle nature of the tesserae.

When observed by optical microscopy, it was noticeable that more deterioration occurred on the back (bottom) surface than on the top surface of all the tesserae examined. The exposed surface of the tessera although cracked, was smoother; the interior bottom surface was coarse and did not exhibit a clean break. Initially it had been considered that the fracture was initiated at the surface allowing water to pass through the glass. But similar deterioration was also observed in interior areas such as the gallery and dining room, therefore another deterioration mechanism was affecting the tesserae. The answer was found by correlating the observed deterioration of the tesserae with the deterioration patterns already observed on the concrete structure itself.

In this comprehensive analysis conditions such as water infiltration were outlined. Correlating locations of these areas with the mosaic deterioration it was possible to see a pattern emerge: where there was water infiltration, the mosaics were deteriorated. It can safely be said that there are two different processes occurring simultaneously on opposite sides of the glass. Once the glass is completely deteriorated on the backside of the tessera, it becomes evident on the exposed surface. The extensive deterioration shown on the back (bottom) surfaces of the tessarae appears to confirm this hypothesis.

Water deteriorates glass over time. As water wets a glass surface, the high mobility and small size of the hydrogen ions present will enter the glass structure and leach out the alkali ions, such as sodium. The location of the house adjacent to highly congested highway increases the acidity of the normal rain through the air pollution generated by traffic. The removal of the alkali ions, that are the main stay of the silica glass structure, results in its shrinkage and the generation of cracks. Furthermore, if glass is not washed regularly, the extracted alkali ions concentrate on the surface of the glass and increase the alkalinity of subsequent wetting cycles. These in turn, help in solubilizing the silica network of the glass.[57]

The deterioration on the opposite surface is explained by the high alkaline pH of the bedding mortar that accelerates the attack by solubilizing the silica structure directly, as explained above. This is probably the more important deterioration mechanism. The combination of both deteriorating mechanisms is detrimental to the glass and unless something is done, the individual mosaic tesserae as well as the overall designs will be lost.

This last deterioration mechanism is enhanced by the decay of the building structure and adds to the already extreme environment. The concrete structure has two problems: deferred maintenance and rebar corrosion. The neglect of the building has caused the drain spouts to fail and invasive vegetation has compounded this problem. As, water cannot flow down the drain spouts, it accumulates on terraces allowing water to percolate through cracks, ceiling and walls of Villa Caparra. Once the water is in the walls, it will try to evaporate through the surface and will keep the bedding mortar in contact with the glass mosaic damp allowing the deterioration to occur.

Both deterioration mechanisms, on the exposed surface and the back of the

[57] Getty, Conservation of Last Judgment Mosaic, p. 168.

mosaics are enhanced by the location of Villa Caparra in Puerto Rico year round by high humidity and temperature.

# CHAPTER 5 RECOMMENDATIONS AND CONCLUSIONS

The mosaics found in Villa Caparra are only one component of a structure that incorporates traditional construction material such as glazed tiles, Spanish roof tiles and mosaics with emerging early 1920's construction materials like precast cement elements and reinforced concrete. It was therefore impossible to predict at the time of Villa Caparra construction how these materials were going to interact and behave with one another. Primarily, Pedro de Castro selected these materials for their aesthetic, plasticity and durability. De Castro viewed his home as a work of art and as the embodiment of his family's heritage. In addition the intrinsic plasticity and malleability of the cement allowed for its seamlessly union with the traditional materials and highlighted the architect's creativity. By choosing reinforced concrete, a material that at that time promised to stand the test of time, De Castro wanted to reestablish the family's heritage in Caparra.

In the early days it was assumed that concrete strength and durability reduced the need for maintenance that the traditional materials required. The passage of time definitely not been kind to reinforced concrete buildings that lack the proper design, maintenance, raw materials and construction knowledge that are essential to prolong the intended life of the structure.

## 5.1 Structure Stabilization

Villa Caparra was constructed with reinforced concrete, a building technology relatively new in Puerto Rico in the 1920's. A recent condition survey of the structure found significant clues to the causes of its deterioration. These were mainly clogged drains in the roof terraces as well as exposed rebars of the ceilings installed to close

Figure 23: Rebar damage to porta-cochere column (source: by author, January,2010.)

to the surface. This study discovered that the reinforcement bars in some areas of the residence had benn exposed after removing the original formwork.[58] This was due to their installation too close to the bottom of the wooden forms and the concrete mix. Pedro De Castro's solution at the time was to cover the areas with a thin layer of cement to cover the rebar and correct the problem which created a weak bond. In addition, the building's vacancy and its lack of maintenance has allowed plants to grow through the drains causing multiple cracks to the substrate and complete failure to the drainage system of the house. The water infiltration, cracks and high temperatures of the tropical climate have combined to reduce the high alkalinity protecting the rebar and allowed the corrosion(rust) to begin.

The first step to stabilize the structure is to completly arrest the entrance of any

[58] Advanced Technology courses, under the direction of Beatriz del Cueto, FAIA, took place between the academic trimesters of Fall 2008 through Fall 2009 under the general title: "Concrete Construction in Puerto Rico between the Wars (1898-1945) and the specific title: "Conservation Praxis III: Conservation and Intervention of Villa Caparra".

water and remove all intrusive vegetation. It is then important to clean and repair all the drain spouts of the building. Areas of major rebar corrosion should be address by patching, replacement of concrete and crack repairs. These steps should be performed initially to stop the damage to the interior support or walls of the structure which as a consequence to minimize further damage to the mosaics.

### 5.2 Reinforcement Bar Corrosion and Repair

Villa Caparra's rebar corrosion is visible in the patio columns, arches and ceilings. These problems stem from years of neglect and clogged drains that have concentrated water in the roof terraces. Stagnant water started to seep through the porous concrete material and traveled to the rebar. The repairs to the rebar can be divided in two: direct and indirect. *(see Figure 23)*

To understand the deterioration process that has taking place in the building it is necessary to understand how the corrosion process works:

> *When the concrete surrounding embedded steel reinforcement becomes carbonated, the likelihood is that a series of corrosion cells will be formed along the bar in the affected areas. Their close proximity will normally result in uniform corrosion of the whole of the steel surface to produce the ferric oxide (rust). The rust product will have an increased volume of up to ten times that of the steel, which they replace. The expansive forces that are generated result in the cracking and spalling of the concrete cover.*[59]

As can be ascertained by the previous description, in Villa Caparra the rebar corrosion is not only visually disruptive but also structurally weakening. Several repair methods have been developed troughout time to address this problem. The first repair option and probably the least expensive is to remove (cut out) the contaminated concrete surrounding the corroding reinforcement and cover the area with an alkaline

[59] Fadayomi, The Deterioration of Reinforced Concrete, p.109.

repair mortar.[60] This method has several problems:

- The area surrounding the cut its more susceptible to cracks and spalling.
- The repair can lead to the accelerated deterioration of the surrounding areas.
- The repair may be visually intrusive as it is difficult to match the color and texture of the original mix.
- The new mix will weather at a different rate than the original.

More indirect approaches that may be used are electrochemical techniques such as Cathodic Protection, Electrochemical Chloride Migration or 'Desalination' and Re-alkalisation. These alternatives are visually less noticeable and better for restoration purposes. This is achieved by placing in contact with the metal to be protected another more easily corroded metal to act as the anode of the electrochemical cell.

*Cathodic Protection:*

This method involves the installation of anodes, a power supply and control system that are permanent in the structure. This process creates additional hydroxyl ions, rebuilds the passive alkaline layer and repels chloride ions. It controls corrosion rate even when chlorides are present and if alkalinity has been lost. The problem with this method is that it needs continuous monitoring and periodic maintenance. In addition, the use of the external anode can affect the appearance of the building.[61]

*'Desalination':*

Desalination is a method used to rebuild the passive layer of protection between the rebar and the concrete. The process uses a temporary anode that over a period

[60] Fadayomi, The Deterioration of Reinforced Concrete, p.115.

[61] Pullar-Strecker, Corrosion-Damaged Concrete, p. 116.

of four to six weeks applies 50 volts to the rebar that repells the negatively charged chloride ions.[62] This method is preferred to the cathodic method because it affects less the appearance of the structure although its permanence in the building must be monitored.[63]

*Re-alkalization:*

Is a non-destructive method that acts similar to the desalination process and re-alkalizes the concrete from the surface inwards. A steel or titanium mesh electrode is attached to the structure and electric contacts connect it to the reinforcement bars. An electric field is applied and the alkali ions migrate from the electrolyte into the concrete, reestablishing the original pH, Its permanence in the building is unknown.[64]

## 5.3 Cleaning

Initially, artwork produced with glass tesserae was considered a better alternative to mural paintings, a technique that tended to fade and erode faster. The '*eternal*' qualities of glass mosaics appeared to be the perfect solution by withstanding weathering for a longer period of time. However, over time these surfaces became dull as the colors of the tesserae were affected. Additional deterioration mechanisms were further increased in the 19th and 20th century as a direct result of the increase in air pollution. Acidic contaminants with water enter the mosaics and interact with the glass, altering its composition. The removal of this patina of dirt and corrosion is necessary to return. The visibility of the colors and is crucial to allow consolidation coatings to properly adhere to the glass surface.[65]

[62] Broomfield, John. The Repair of Reinforced Concrete. Building Conservation Directory, 1996. Available online: (http://www.buildingconservation.com/articles/concrete/concrete.htm)

[63] Pullar-Strecker, Corrosion-Damaged Concrete, p. 117.

[64] Velivasakis, Emmanuel E., Sten K. Herinksen and David Whitmore Chloride Extraction and Realkalization of Reinforced Concrete Stop Steel CorrosionJ. Perf. Constr. Fac. Volume 12, Issue 2, pp. 77-84 (May 1998)

[65] Corrosion: The product of water reacting with the glass surface, the siloxane link structure of the glass acquires hydroxyl groups, and the glass surface gradually changes into silica acid gel. The aqueous solutions of alkaline hydroxides of the leached metal elements react further with carbon dioxide and sulfur trioxide in the environment, while relevant salts are formed, namely, potassium

For these reasons, prior to any cleaning, a thorough study of the composition of the glass as well as the identification of the patina produced by the interaction of pollution, environment and water needs to be performed. Different glass compositions will deteriorate at different rates making it difficult to find a methodology that can be applied to all cases. Nevertheless, lessons can be learned from the different approaches and techniques used in the preservation of mosaics at other sites.

There are several materials and techniques required to clean glass and remove the corrosion layer formed during its decomposition. The most common are water, detergents, chelating (sequestering) agents, acids, organic solvents, and biocides.[66] Most recently, mechanical alternatives for cleaning glass have become available such as laser cleaning and micro air-abrasion.[67] The processes listed in the following paragraphs describe processes that were used by glass conservators but not necessary for glass mosaics. As mentioned, glass composition and deterioration must be established in order to successfully clean the glass.

*Water*

Water is the most common among all the cleaning agents and can be used for initial cleaning. Only distilled water should be used instead of regular tap-water that contains calcium and magnesium hydrogen carbonates, chlorides and sulphates[68] that can potentially harm the glass.

*Detergents*

Detergents are commonly used with water as a solvent to remove soiling and contaminants. Commercially available detergent formulas can contain alkali, surface-active chemicals, chelating agents, suspension and thickening agents that can damage

carbonate, potassium sulfate, calcium carbonate, and calcium sulfate. Getty, Conservation of the Last Judgment Mosaic, p. 168.

[66] Newton & Davison, Conservation of Glass, p.165.

[67] Getty, Conservation of the Last Judgment Mosaic, p. 171-176.

[68] Newton & Davison, Conservation of Glass, p.165.

the glass surface.[69] If detergents are to be used, only the non-ionic type should be considered, as they would not leave any ions as residues. New alternatives such as non-aqueous detergents have been developed that can be used to 'dry-clean' the glass. As with the other detergents' ingredients the product should be appropriate for cleaning glass and its instructions should be followed to minimized adverse effects. Detergent types that can be used for glass cleaning vary graeatly such as a high-foaming mixture of surfactants and non-foaming compositions that would need rinsing. Ammonia solutions and Ethanol or Methanol washer fluids may be used for glass cleaning and they don't need rinsing. They must be tested first in a small area and observed for any adverse effect.

*Chelating (sequestering) agents*

Chelating agents are commonly used to remove glass corrosion products and patinas. The chelating agent has to be mild enough to remove the metal ions of the corrosion and not react with the glass. Other uses of these sequestering agents are to weaken the corrosion so it can be gently removed by mechanical means. For example, citric acid as an active ingredient can be found in commercially available products, such as bathroom and kitchen cleaning solutions. A solution with a 6% concentration of citric acid will remove hard water stains and corrosion products from glass without scrubbing.

*Acids*

Mineral acids commonly used on glass are hydrochloric, nitric, sulphuric and hydrofluoric acids. During flat glass manufacturing the glass is given a bath in hydrochloric acid before cutting.[70] Other acids such as hydrofluoric acid are used in etching glass. Extreme care should be used when handling these acids, as they are harmful to the skin.[71] Furthermore, acids can attack calcium silicates, the components in

[69] Newton & Davison, Conservation of Glass, p.166.
[70] Fowle, Flat Glass, p. 64.
[71] Davison, Conservation and Restoration of Glass, p.203.

the bedding mortar of the mosaic, weakening the binding medium and loosening the tesserae.[72] Their use as a cleaning agent is not recommended since they dissolve the glass surface.

*Organic Solvents*

Organic solvents are used for the removal of greasy dirt as well as diluting and removing any polymers that may be present from previous restoration interventions. It is recommended to utilize them with extreme precautions, as they are highly flammable and toxic. It is recommended to utilize milder organic solvents[73], when available, as they are less toxic and retain sufficient solvent properties to do the job.[74]

*Laser*

Laser cleaning has been successful in other material conservation but its application to glass cleaning still needs further study. In theory, the laser would be able to remove the surface corrosion layer on glass. The laser works by sending out photons that are absorbed by the corrosion layer that heats up sufficiently to evaporate. The problem with this technique is to find the appropriate wave-and pulse length, as well as radiation density so as not to affect the matrix of the sound glass damaging it.[75]

*Micro Air-Abrasion*

Air-abrasive technology has been around since the 19$^{th}$ century and further increased in the 20$^{th}$ century developing a wide range of equipment and applications. From industrial work to medical use as well as fine delicate objects restoration, its applications are practically unlimited. The abrasion machines can use a wide range of

[72] Getty, Conservation of the Last Judgment Mosaic, p. 170.

[73] Solvents are substances that are capable of dissolving or dispersing one or more other substances. Organic solvents are carbon-based solvents (i.e., they contain carbon in their molecular structure). Many different classes of chemicals can be used as organic solvents, including aliphatic hydrocarbons, aromatic hydrocarbons, amines, esters, ethers, ketones, and nitrated or chlorinated hydrocarbons.
NIOSH, National Institute for Occupational Safety and Health, 2010-07-26, available online: (http://www.cdc.gov/niosh/topics/organsolv/)

[74] Davison, Conservation and Restoration of Glass, p. 203.

[75] Getty, Conservation of the Last Judgment Mosaic, p. 171.

products such as aluminum oxide, soft marble dust, ground olive kernel and glass beads among many others. These different types of materials, their shape and composition play a crucial part in the versatility of this product. This technique allows matching the object's properties and characteristics to the appropriate abrasion product. Since the method does not leave any chemical residues or alteration products, it can be a safe method to use on weathered glass tesserae. [76] Micro Air – Abrasion has been used successfully in glass cleaning since the 1970's and most recently in The Last Judgemnet Mosaic in St. Vitus Cathedral, Prague.[77]

*Biocides*

The appropriate treatment should be used to effectively eradicate the growth of microorganisms, algae and lichen. The 2-Hydroxybiphenyl is recommended in a water solution and has been used successfully in glass conservation. Weak concentration of this solution can make the organisms resistant to the biocide.[78] Algicides and fungicides of the quarternary ammonium salt type have been successful, less toxic and recommended for in situ applications because it can form strong bonds with glass. In *Conservation of Glass* the authors recommend Santobrite, Tego 51B and Thalnox Q that have been used successfully with minor re-growth. [79] If these biocides are not available, suitable replacements should be found following the recommended examples. Additional tests should be carried out to see how the biocide reacts on site. In any case it is preferable that the treatment be as non-toxic as possible, doesn't harm the glass and that it be monitored to continue applications as needed.

## 5.4 Consolidation

[76] Getty, Conservation of the Last Judgment Mosaic, p. 171-172.

[77] Getty, Conservation of the Last Judgment Mosaic, p. 172.

[78] Newton & Davison, Conservation of Glass, p.169.

[79] Newton & Davison, Conservation of Glass, pp.169-110.

Appropriate consolidation techniques need to be studied in situ for Villa Caparra. Consolidation techniques and procedures for glass mosaics can be carried out after cleaning. By cleaning the surface of the glass reduces any possible failure and ensure proper adherence of the consolidant. As explained in the *Conservation of the Last Judgment Mosaics*:

> *Without prior cleaning, the protective function of the coating could be weakened. The corrosion products could reduce the coating's (consolidant) adhesion to the glass surface either because of their physical and chemical properties or because of water and soot and other particles of grime.*[80]

The consolidation process should stabilize the glass and return strength to the silica network. The use of non-alkali material is recommended. Ethanol has been used successfully in glass conservation to reduce the loss of the silica network. When the ethanol is applied on the surface it is absorbed by hydrated silica which will form insoluble ethyl silicate that protects and retards the leaching.[81] Any consolidation will be unfruitful if the water infiltration problem on the walls is not addressed first. This treatment has been successful in the conservation of glass objects and serves as a protective layer. Its usefulness in exterior glass mosaics as found in Villa Caparra needs further study.

### 5.5 Compensation

Compensation[82] in some areas of loss in Villa Caparra is recommended. Compensation is suggested strongly in areas where the gold tesserae has deteriorated

[80] Getty, Conservation of the Last Judgment Mosaic, pp. 167.

[81] Davison, Conservation and Restoration of Glass, p.194.

[82] Compensation: something that constitutes an equivalent or recompense. Merriam-Webster Dictionary, 2010-07-26, available online: (http://www.merriam-webster.com/dictionary/compensation)

and fallen off. The compensation of these areas with new tesserae will help return integrity of the art-work and more importantly protect the adjacent tesserae. Covering areas of loss with mortar material instead of tesserae should be done only for temporary stabilization and not as a permanent repair. As with any intervention it must be documented and clearly distinguised from the original tesserae.

It is recommended that repairs to mosaics be done with lime mortars, due to the more flexible and softer qualities of the material. This advice does not apply to 20$^{th}$ century mosaics that were originally embedded in cement bedding mortars; although an appropriate mix softer and less alkaline can be applied in areas were repairs are performed.

### 5.6 Crack Monitoring

As identified in both of the condition surveys performed on Villa Caparra in 2009[83] and 2010, there are several cracks in columns, walls and facades. These cracks are a result of corrosion, contraction and expansion of the concrete due to thermal changes (climate) and root growth of intrusive vegetation. If these cracks remain open, water infiltration will continue to accelerate the steel corrosion. The re-bar corrosion has already altered some of the mosaics located in columns. The repairs of cracks in Villa Caparra can extend the lifetime of the building and lessen the deterioration of the mosaics.

Crack monitoring should be installed in areas were the gaps are noticeable to record movement. The crack monitor consists of two plates, one is marked with a millimeter grid and the other with cross hairs centered over the grid. They are checked periodically and any movement is recorded on a Crack Progress Chart. The crack

[83] Advanced Technology courses, under the direction of Beatriz del Cueto, FAIA, took place between the academic trimesters of Fall 2008 through Fall 2009 under the general title: "Concrete Construction in Puerto Rico between the Wars (1898-1945) and the specific title: "Conservation Praxis III: Conservation and Intervention of Villa Caparra".

monitor is installed across the crack; the crosshairs shift vertically or horizontally on the grid when movement occurs. It is recommended that the monitors be installed with the use of an epoxy putty to minimize surface damage that can be caused by drilling the anchor holes for the screws.[84] Isolating films of B72 can be used before attaching the epoxy gauges.

### 5.7 Removal & Re-laying

The history of conservation of mosaics has evolved over time. Earlier conservation practices in mosaics consisted of removing them from their original location for safeguard and protection. Removing mosaics requires a strategic plan to avoid damaging them further. The rem oval of entire panels of mosaics can be done trough several methods but they need to be consolidated, the bedding mortar removed and the mosaic panel re-laid in a temporary surface. While in storage the mosaic should be maintained dry and laid horizontally until it can be re-laid on the wall again. Inadequate storage has been known to damage the glass further.

This conservation practice has provided a safe environment for mosaics today living in museums away from their original sites; leaving the sites barren of adequate interpretation. For this reason, the International Committee for the Conservation of Mosaics (ICCM) rejects the idea of removing mosaics from their sites if an appropriate plan is not established first.

It was not until the 1950's that Cesare Brandi recommended that the mosaics in Villa del Casale In Piazza Armerina, Sicily be conserved in situ that a new era in the conservation practices of mosaics was launched.[85]

In the case of Villa Caparra, removal is not necessary except in areas where the

[84] Avongard crack monitor, 2010-07-26, available online: (http://www.crackmonitor.com/prod01.htm)

[85] Getty, Lessons Learned: Reflecting on the theory and practice of Mosaic Conservation, p. 10.

rebar corrosion has already pushed out the glass and bedding mortar. In this case,h the mosaics should be carefully removed and stored in a dry place until the columns are repaired. Areas where the tesserae are completely lost, relaying of new tesserae should be considered to protect the structure underneath and the surrounding tesserae. The area should be clean; the bedding mortar removed as well as any tesserae that are left. A new mortar and grouting mix should be prepared that matches color and compatibility.

### 5.8 Recommendations

Additional testing that will confirm the corrosion and deterioration of the historic mosaics of Villa Caparra should be performed to ensure adequate and compatible treatments. A conservation plan should be established that includes an initial repair to the structure prior any treatment to the mosaic surface. It is recommended that additional tests be carried out in situ to determine the best cleaning and consolidating methods.

The Conservation Treatment for Villa Caparra should follow the following steps:

- Repair leaking roofs and walls to stabilize the building's substrate
- Address rebar corrosion issues
- Stabilization loose tesserae
- Clean glass surfaces
- Repair gilded areas by re-laying and stabilizing
- Apply consolidating and protective coatings.
- Document all repairs, consolidation and stabilization carried out on site.

These are only standard recommendations and could change as more information is gathered and analyzed on this important landmark building in Puerto Rico. Whenever possible the conservation of the mosaics should take place in situ, since mosaics are best viewed in their original context. The adhesion of the tesserae is not a problem in Villa Caparra and removal for conservation treatment is not recommended.

Due to the great loss this landmark building would suffer. Only when the survival of the mosaic becomes an issue on site due to lack of maintenance and protection should the mosaics be removed from the site.[86] The municipality of Guaynabo has recently acquired Villa Caparra. The city has announced in June 2010 that the house will become a Historical Museum about the figure of Juan Ponce de León as first governor of Puerto Rico in 1509. And an original neighbor of the first Spanish settlement of Puerto Rico: Caparra. This settlement was located across the road from Villa Caparra.[87] The house will need extensive conservation work in order to be used as a *house museum.* This new use could potentially ensure the mosaic survival for many generations to come.

*(see Figure 24)*

Figure 24: View of Villa Caparra (source: Polythecnic University of Puerto Rico, 2009.)

[86] Getty, Lessons Learned: Reflecting on the theory and practice of Mosaic Conservation, p. 23.

[87] Vivoni, Architect of Dreams, p. 57.

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# APPENDIX A

# VILLA CAPARRA GLASS MOSAICS - TYPOLOGIES

*The glass mosaic decoration of Villa Caparra, Puerto Rico: a technical study and conservation*

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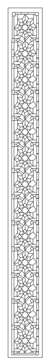
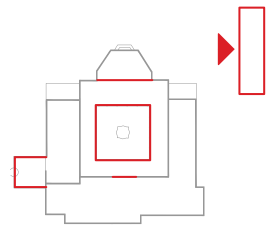
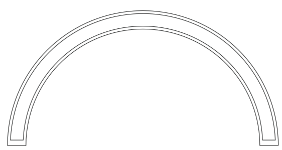
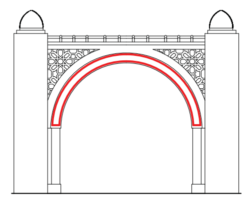
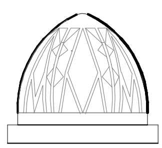
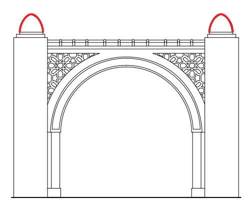
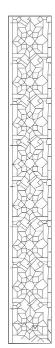
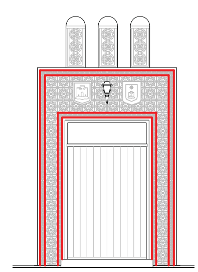
| A |  | COLUMN |  |     |
| B |  | ARCH INTRADOS |  |  |
| C |  | DOME CAPS |  |  |
| D |  | DOOR TRIM |  |  |

# VILLA CAPARRA GLASS MOSAICS - TYPOLOGIES

*The glass mosaic decoration of Villa Caparra, Puerto Rico: a technical study and conservation*

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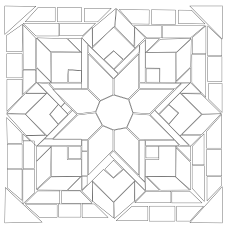
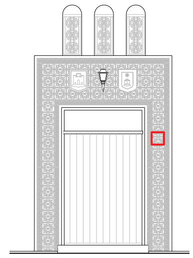
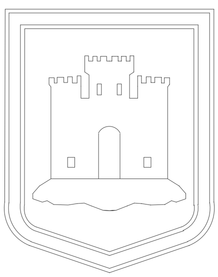
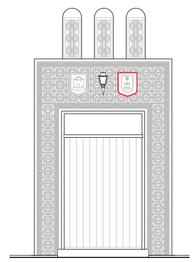
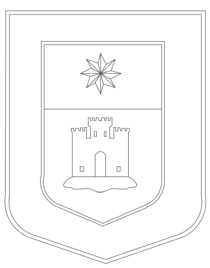
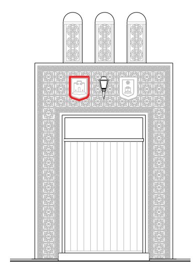
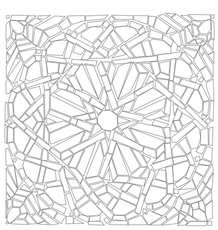
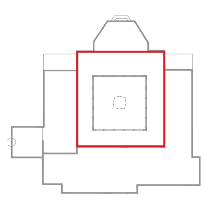
| E |  | DADO |  |  |
| F |  | COAT OF ARMS |  |  |
| G |  | COAT OF ARMS |  |  |
| H |  | DADO |  |  |

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*The glass mosaic decoration of Villa Caparra, Puerto Rico: a technical study and conservation*

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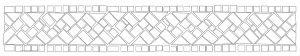
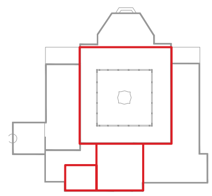
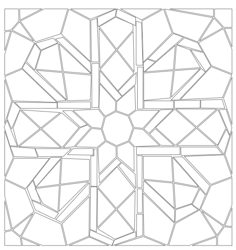
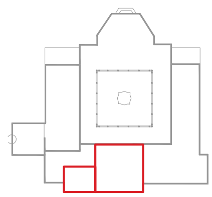
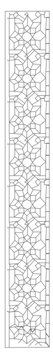
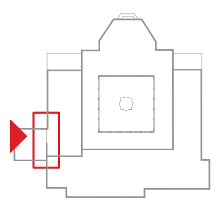
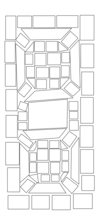
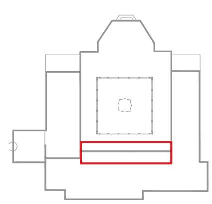
| I |  | RAIL |  |  |
| J |  | DADO |  |  |
| K |  | DOOR TRIM |  |  |
| N |  | INSERT |  |  |

# VILLA CAPARRA GLASS MOSAICS - TYPOLOGIES

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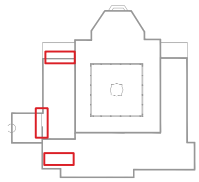
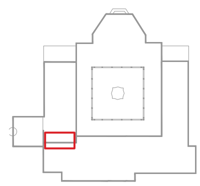
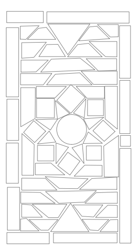
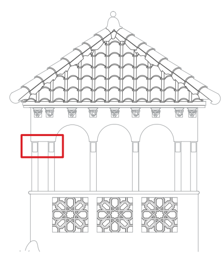
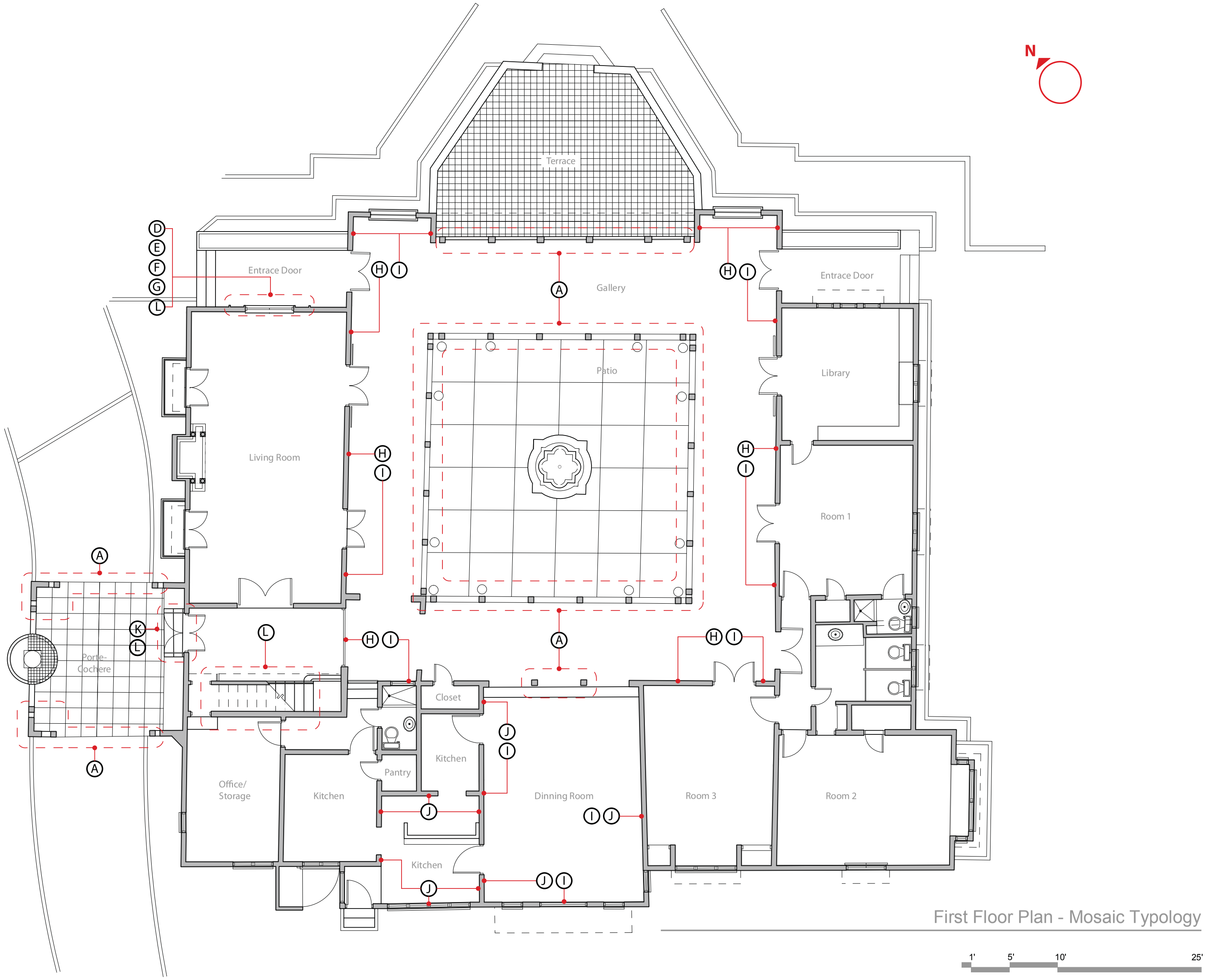
| L | | RAIL |  |  |
| M | | DADO |  |  |
| O |  | DADO |  |  |




First Floor Plan - Mosaic Typology

GENERAL NOTE:
Existing conditions were recorded on architectural drawings prepared and supplied by the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico.

# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

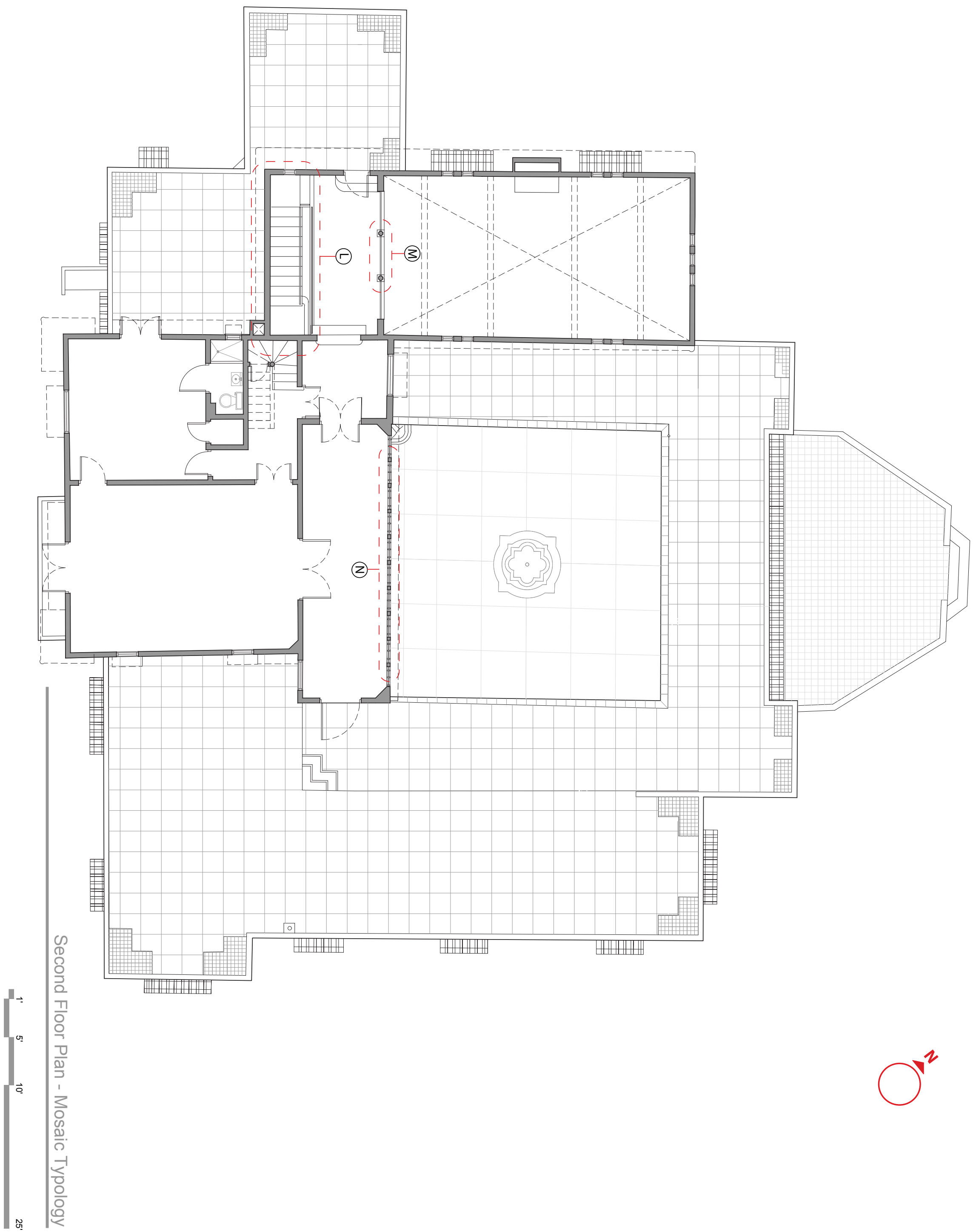
Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12 .15 . 2009

SHEET NO.:
A -1




# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal   Guaynabo, Puerto Rico

Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

GENERAL NOTE:
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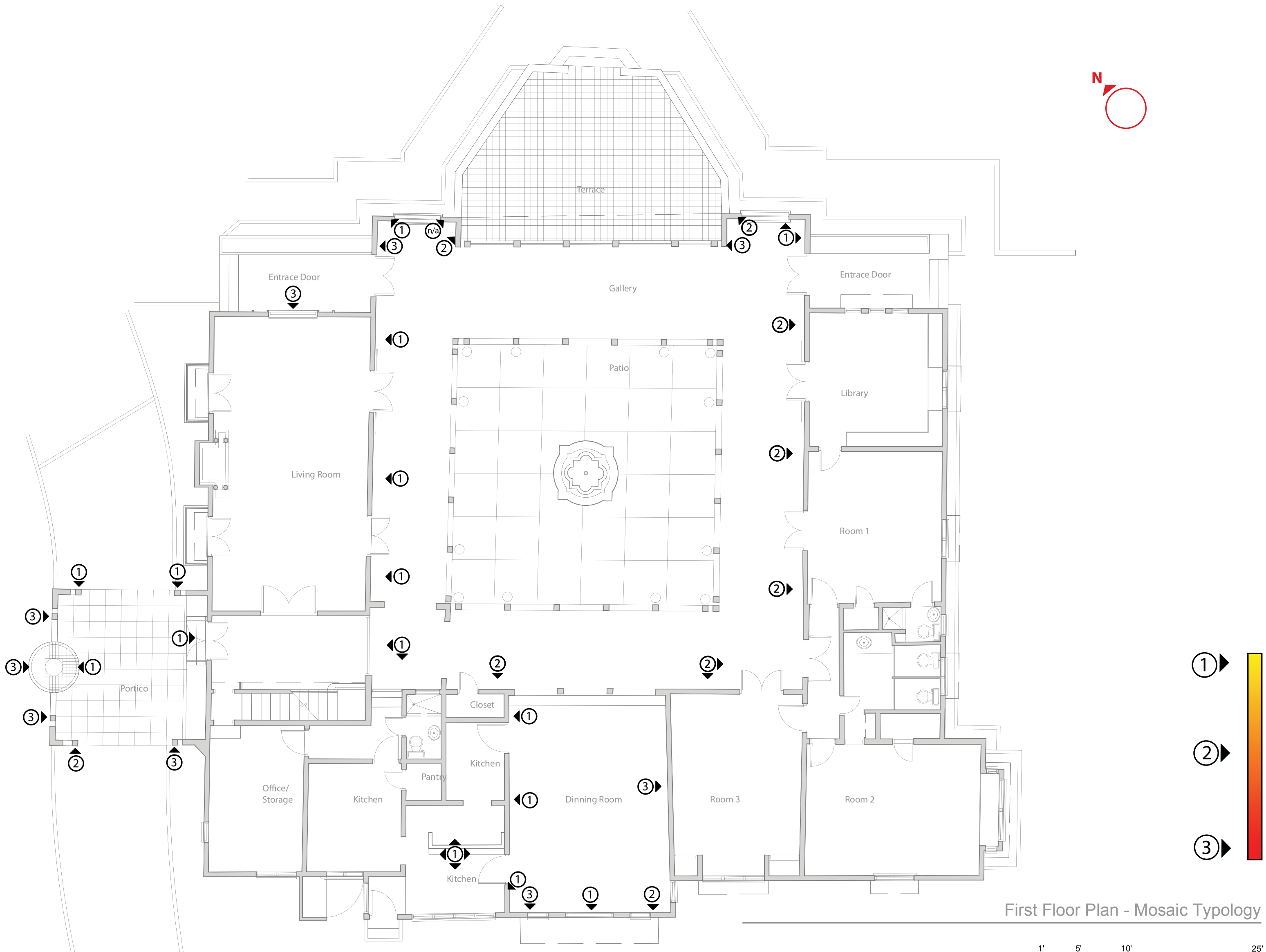
DRAWING BY:
POLYTECHNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12.15.2009

SHEET NO.:
A - 2

# APPENDIX B




First Floor Plan - Mosaic Typology

1' 5' 10' 25'
Scale: 3/32" = 1'-0"

GENERAL NOTE:
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# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

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CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12.15.2009

SHEET NO.:
B - 1

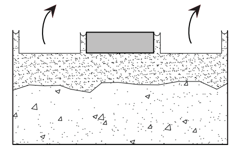
## APPENDIX C

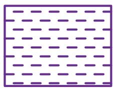
# VILLA CAPARRA GLASS MOSAICS - CONDITION GLOSSARY

*The glass mosaic decoration of Villa Caparra, Puerto Rico: a technical study and conservation*

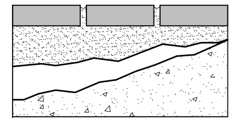
***STRUCTURAL CONDITIONS:***

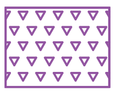
**LOSS**
Area of the mosaic where the tesserae is missing.



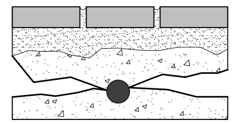


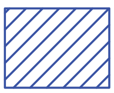
**INTRA-LAYER DETACHMENT**
Detachement of the tesserae bedding mortar from the concrete support.



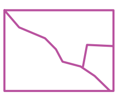


**INCIPIENT SPALLING**
Fracturing within the upper surface of the concrete substrate due to rebar corrosion.

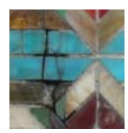


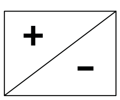


**FILL / REPAIR**
Area where the original tesserae is missing and the resulting lacuna has been filled, in recent years.



**CRACKING**
Linear breaks visible across the surface of the mosaic, which may also penetrate into its lower bedding mortar and concrete substrate.





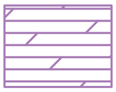
**DISPLACEMENT**
Movement of mosaic from original position.

Definitions of terms used are based on Mosaic In Situ Project: Illustrated Glossary developed by the Getty Conservation Institute. [Getty, Illustrated Glossary, 2003]

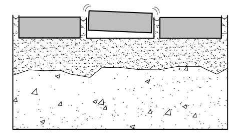
# VILLA CAPARRA GLASS MOSAICS - CONDITION GLOSSARY

*The glass mosaic decoration of Villa Caparra, Puerto Rico: a technical study and conservation*

***SURFACE CONDITIONS:***

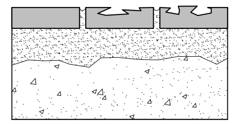


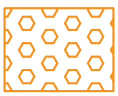
**DETACHED TESSERAE**
Tesserae which have lost adhesion to the bedding mortar but remain in place.



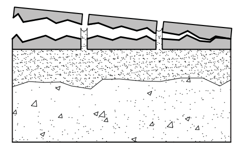


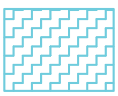
**CONCOIDAL SPALLING**
Tesserae displaying an irregular and generally concoidal surface due to partial loss.



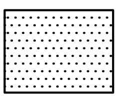


**INCIPIENT SPALLING**
Tesserae displaying remove internal loss in layers parallel or perpendicular to the mosaic surface.

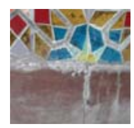


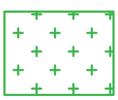


**FRACTURED TESSERAE**
Tesserae diplaying linear network of cracks through their matrix.

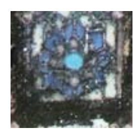


**EFFLORESCENCE**
Generally white and crystalline substance, loosely adhering to the mosaic surface, powderlike or whisker-like in appearance.

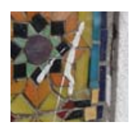




**BIO-GROWTH**
Microflora varying in color and shape, and adhering to the mosaic surface, such as algae, lichens, mosses, etc.

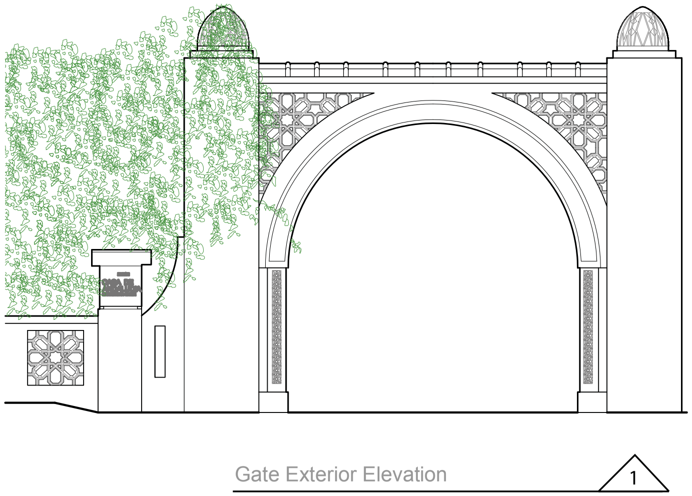


**PAINT SPATTER**
Thin layers of paint that partially cover the mosaic.



Definitions of terms used are based on Mosaic In Situ Project: Illustrated Glossary developed by the Getty Conservation Institute. [Getty, Illustrated Glossary, 2003]

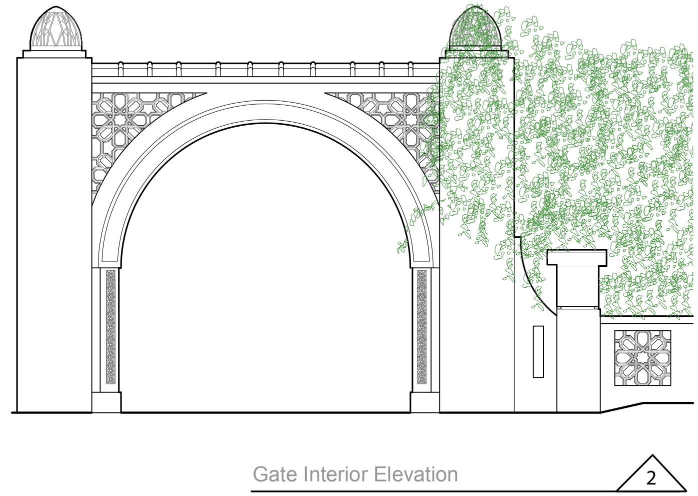
## APPENDIX D





Gate Exterior Elevation

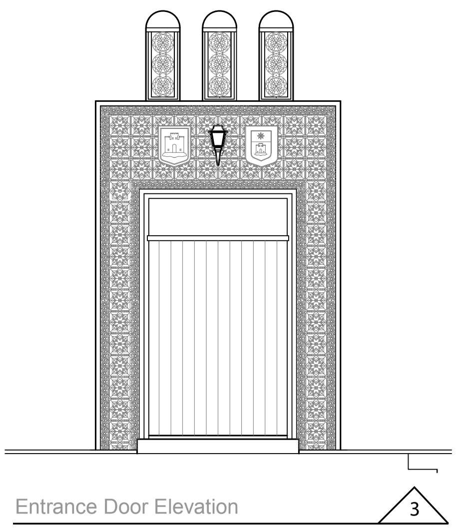
Scale: 1/4" = 1'-0"





Gate Interior Elevation

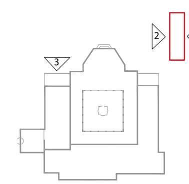
Scale: 1/4" = 1'-0"





Entrance Door Elevation

Scale: 1/4" = 1'-0"





Gate and Entrance Door Elevations



Scale: 1/4" = 1'-0"

GENERAL NOTE:
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# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

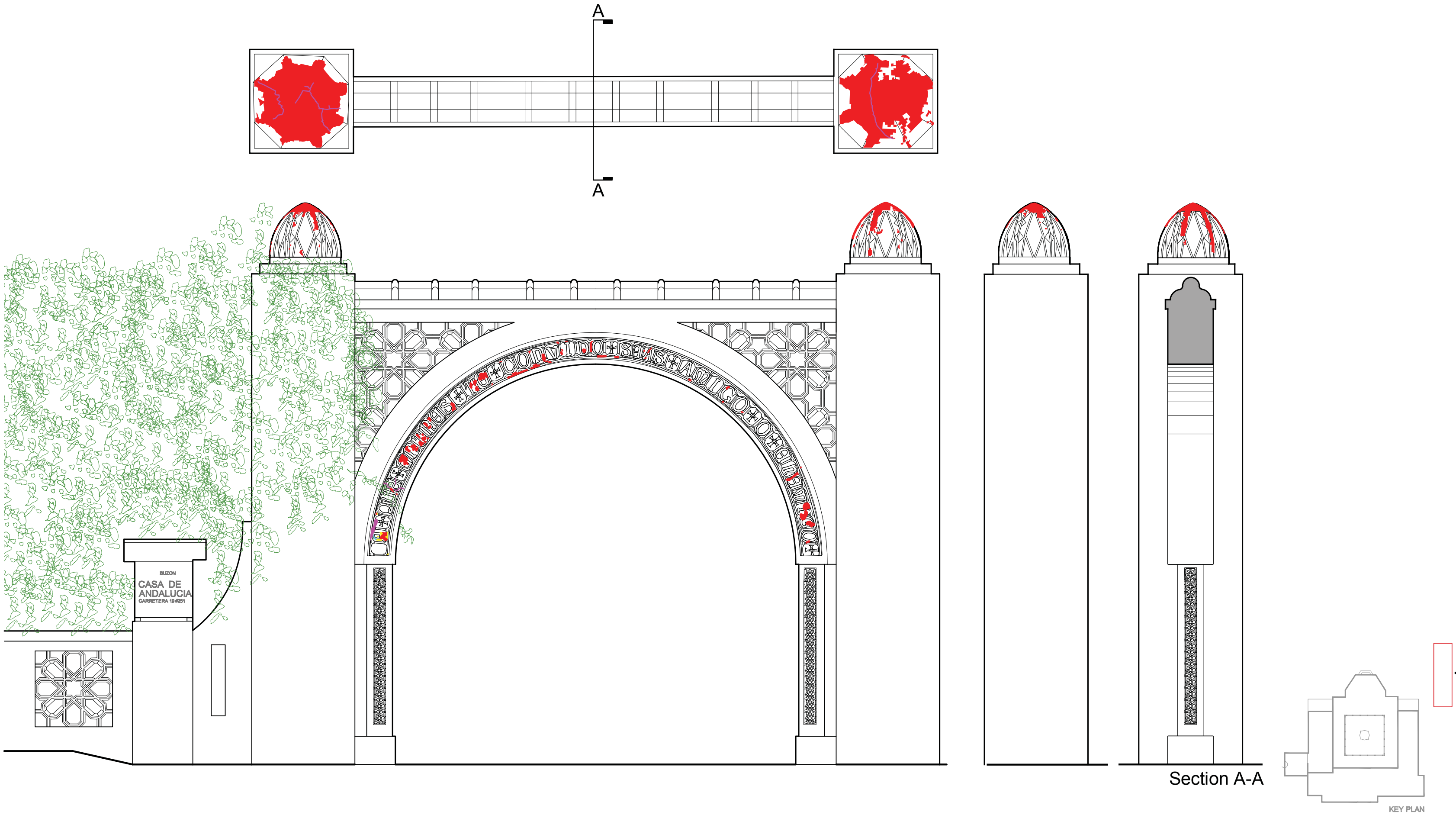
Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12.15.2009

SHEET NO.:
D-1




Entrance Gate - Exterior Elevation 1

0 6" 1' 3' 6'
Scale: 3/8" = 1'-0"

General Conditions:

- Loss
- Detached Tesserae
- Fill/Repair
- Conchoidal Spalling
- Intra-Layer Detachment
- Incipient Spalling
- Incipient Spalling
- Fractured Tesserae
- Cracking
- Efflorescence
- Displacement
- Bio-Growth
- Paint Spatter

GENERAL NOTE:
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Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

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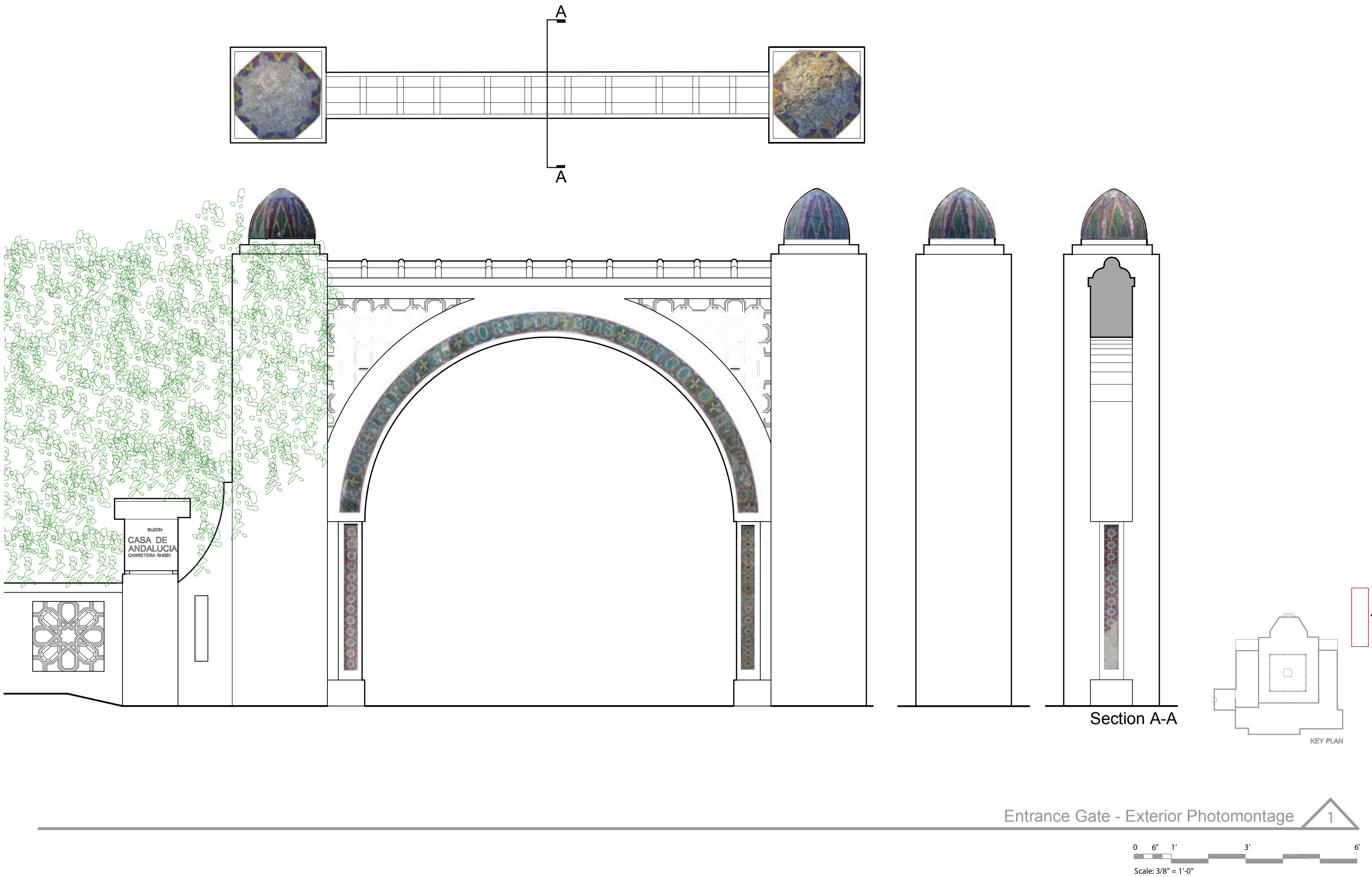
DATE:
12.15.2009

SHEET NO.:
D -2




Entrance Gate - Exterior Photomontage

GENERAL NOTE:
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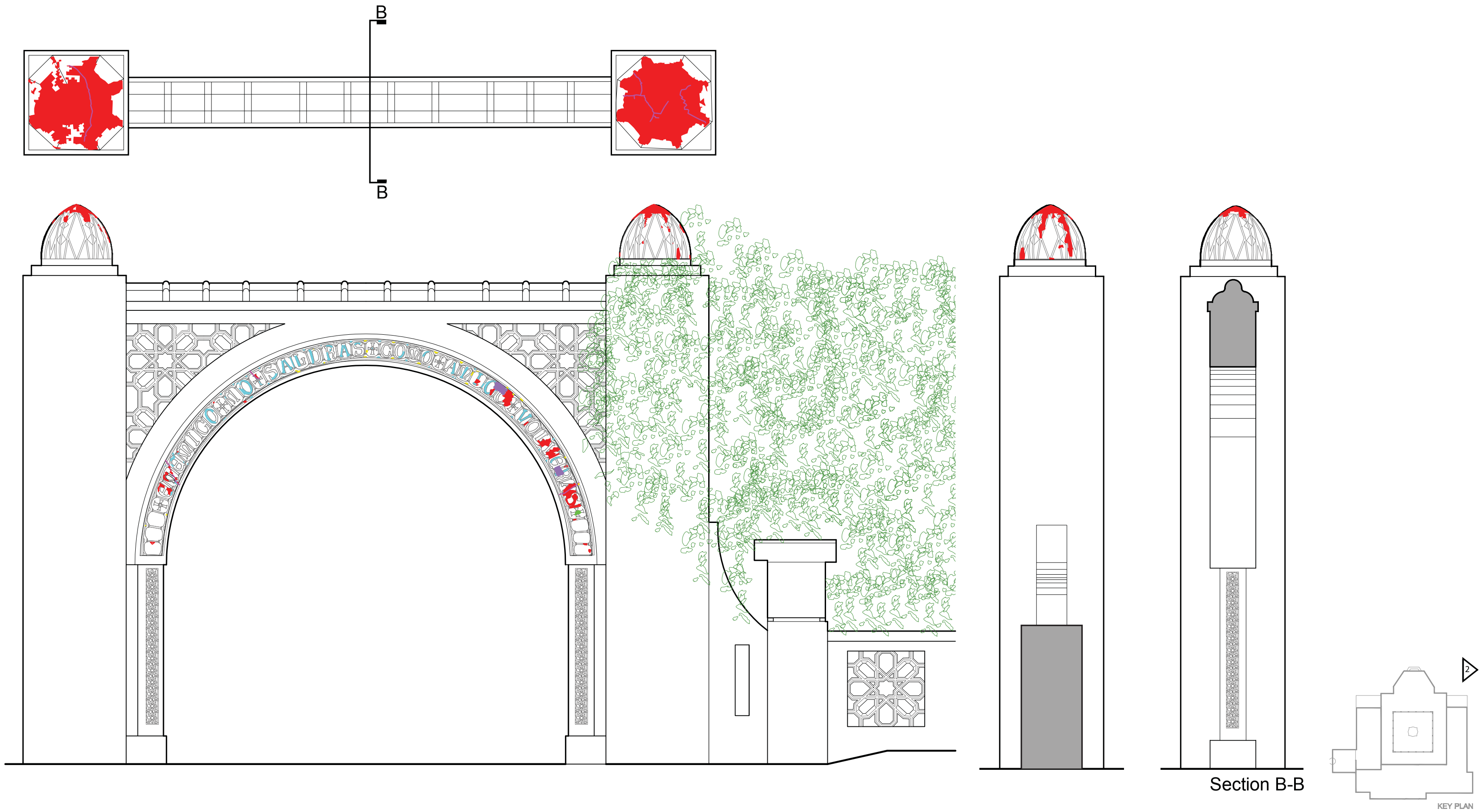
CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12 .15 . 2009

SHEET NO.:
D -3




## Entrance Gate - Interior Elevation 2

0 6" 1' 3' 6'
Scale: 3/8" = 1'-0"

### General Conditions:

- Loss
- Detached Tesserae
- Fill/Repair
- Conchoidal Spalling
- Intra-Layer Detachment
- Incipient Spalling
- Incipient Spalling
- Fractured Tesserae
- Cracking
- Efflorescence
- Displacement
- Bio-Growth
- Paint Spatter

GENERAL NOTE:
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# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

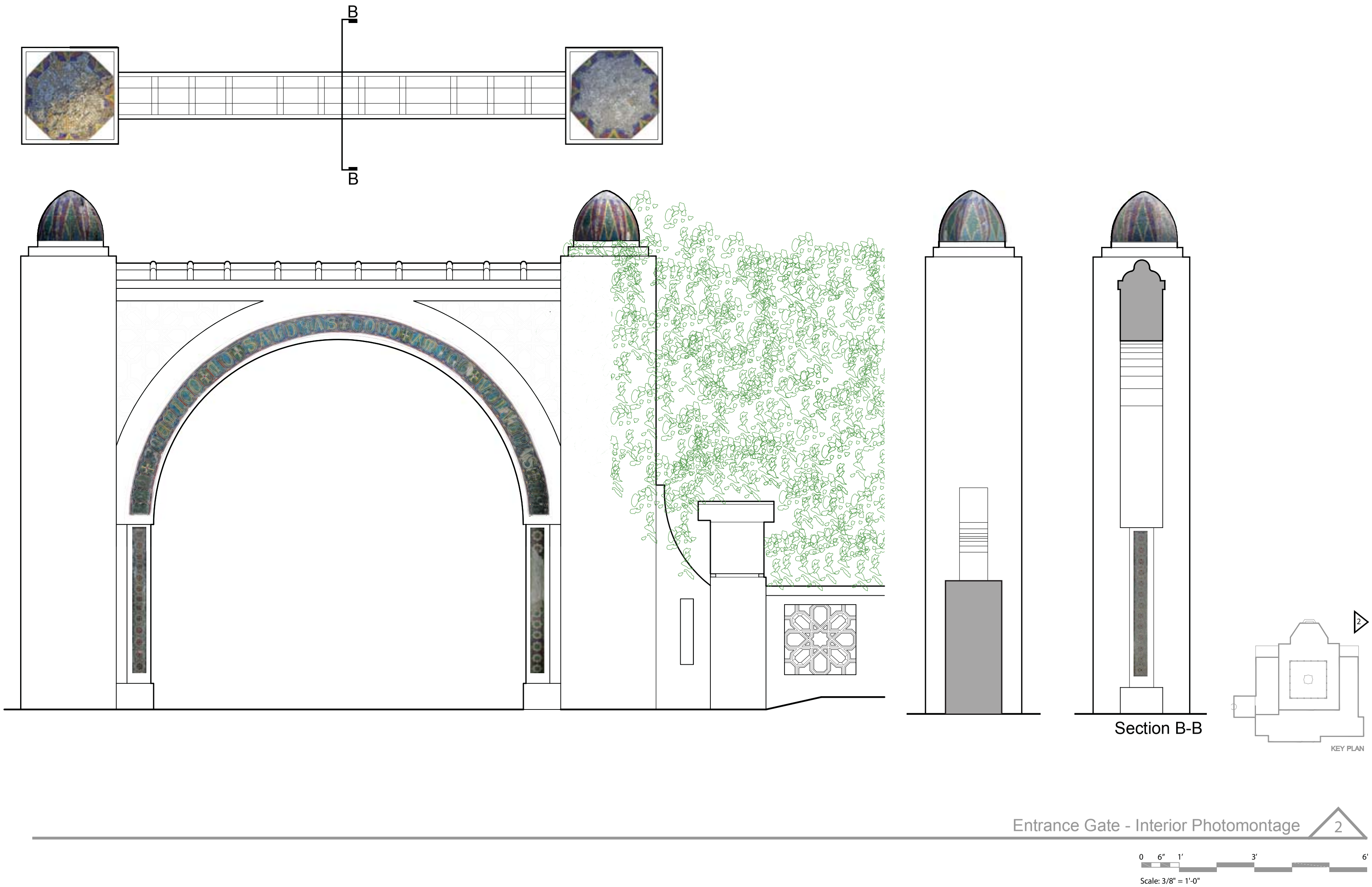
Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12.15.2009

SHEET NO.:
D - 4



Entrance Gate - Interior Photomontage 2

GENERAL NOTE:
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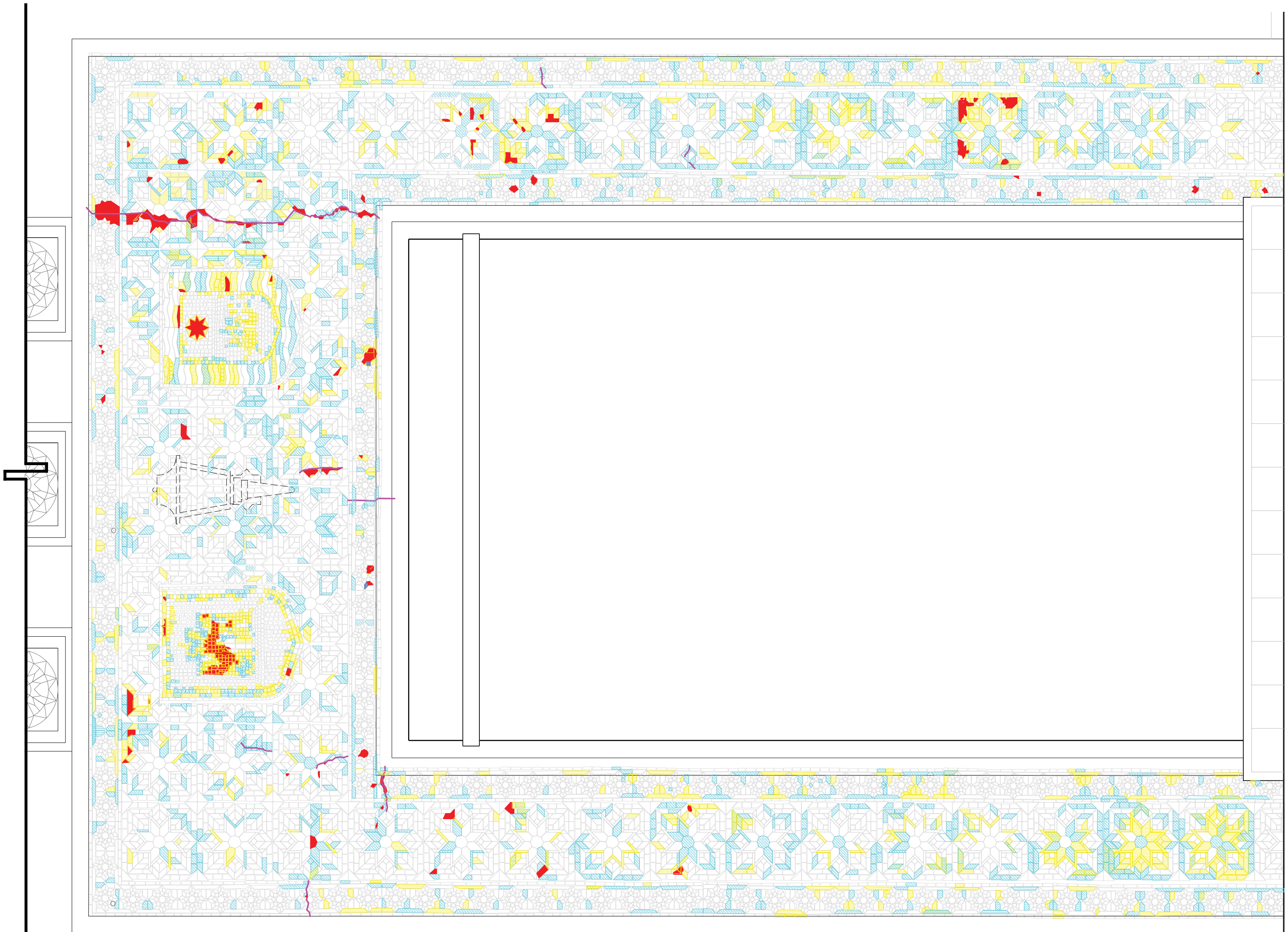
YARITZA HERNANDEZ

DATE:
12.15.2009

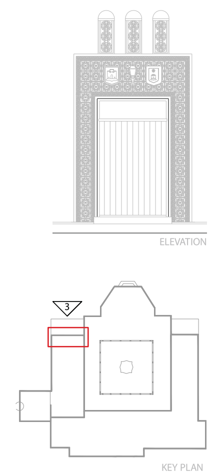
SHEET NO.:

D - 5



General Conditions:

Loss | Detached Tesserae | Fill/Repair | Conchoidal Spalling | Intra-Layer Detachment | Incipient Spalling | Incipient Spalling | Fractured Tesserae | Cracking | Efflorescence | Displacement | Bio-Growth | Paint Spatter




Main Entrance Door

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

GENERAL NOTE:
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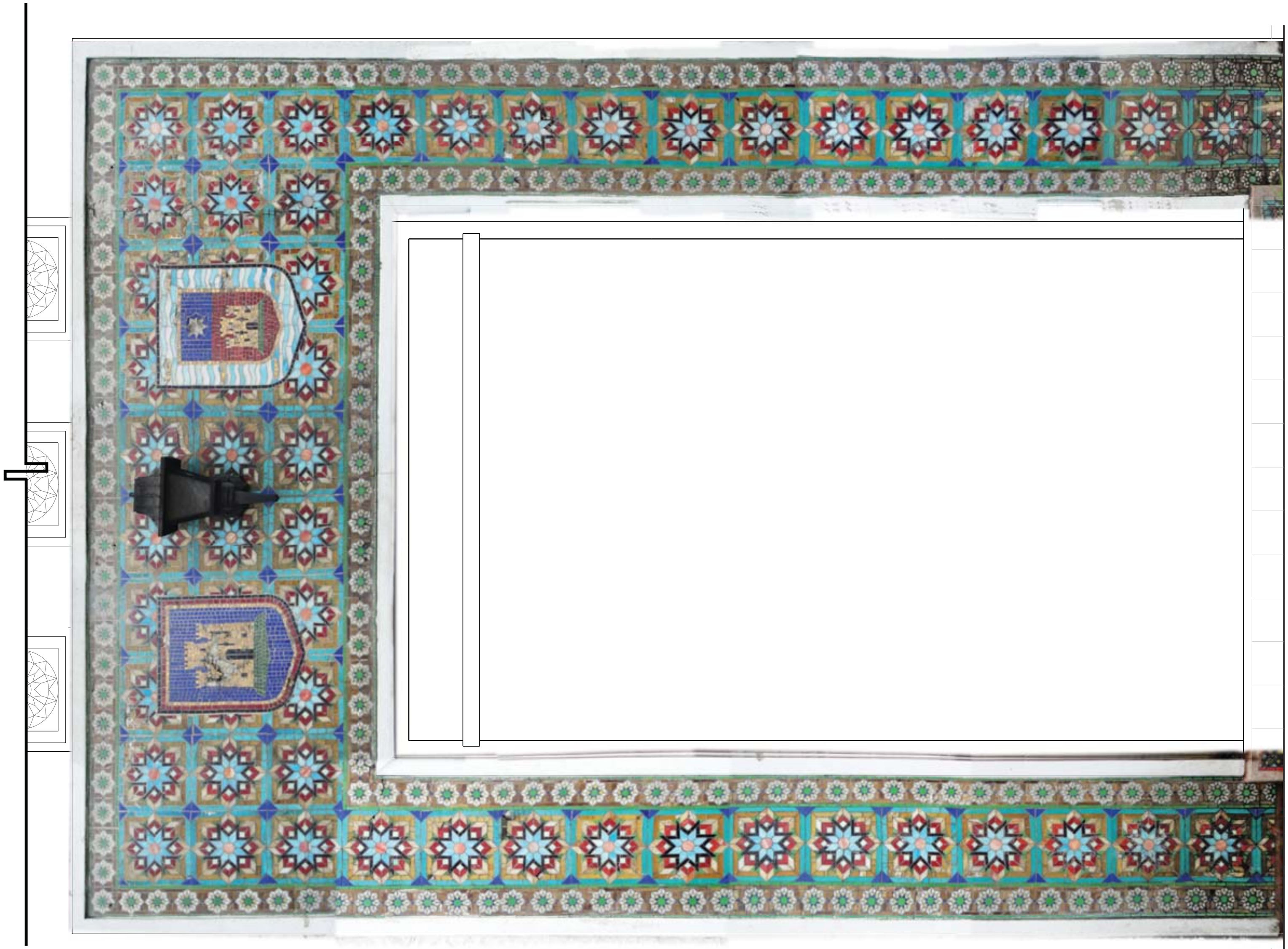
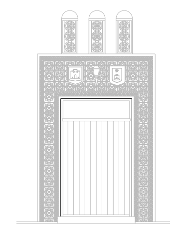
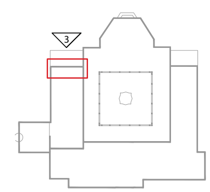
SHEET NO.:
D - 6






Main Entrance Door
Photomontage

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

GENERAL NOTE:
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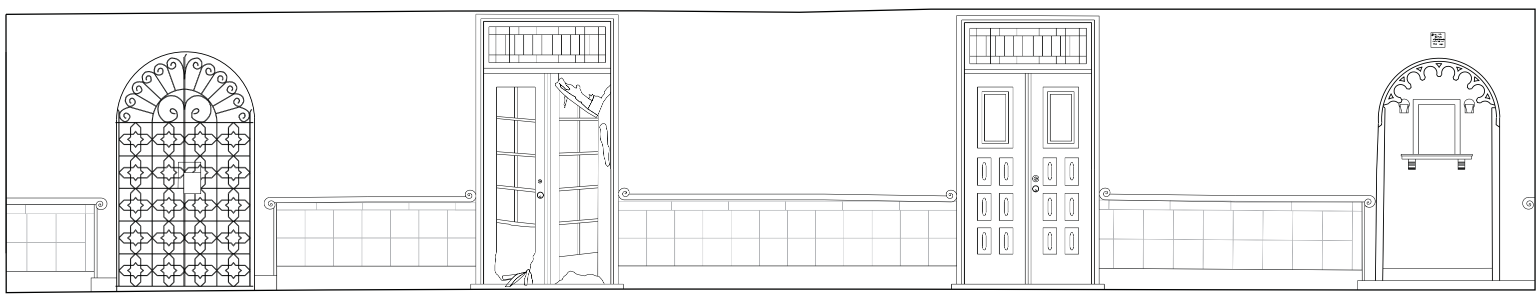
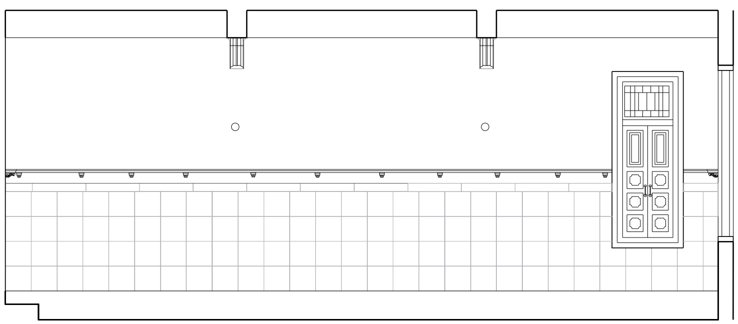
SHEET NO.:
D - 7



Gallery Northeast Elevation Wall

4

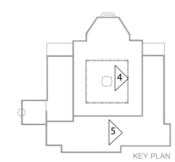
Scale: 1/4" = 1'-0"



Northeast Dinning Room Wall

5

Scale: 1/4" = 1'-0"




Gallery and Dining Room Elevations

1' 5' 10' 25'

Scale: 1/4" = 1'-0"

GENERAL NOTE:
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THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

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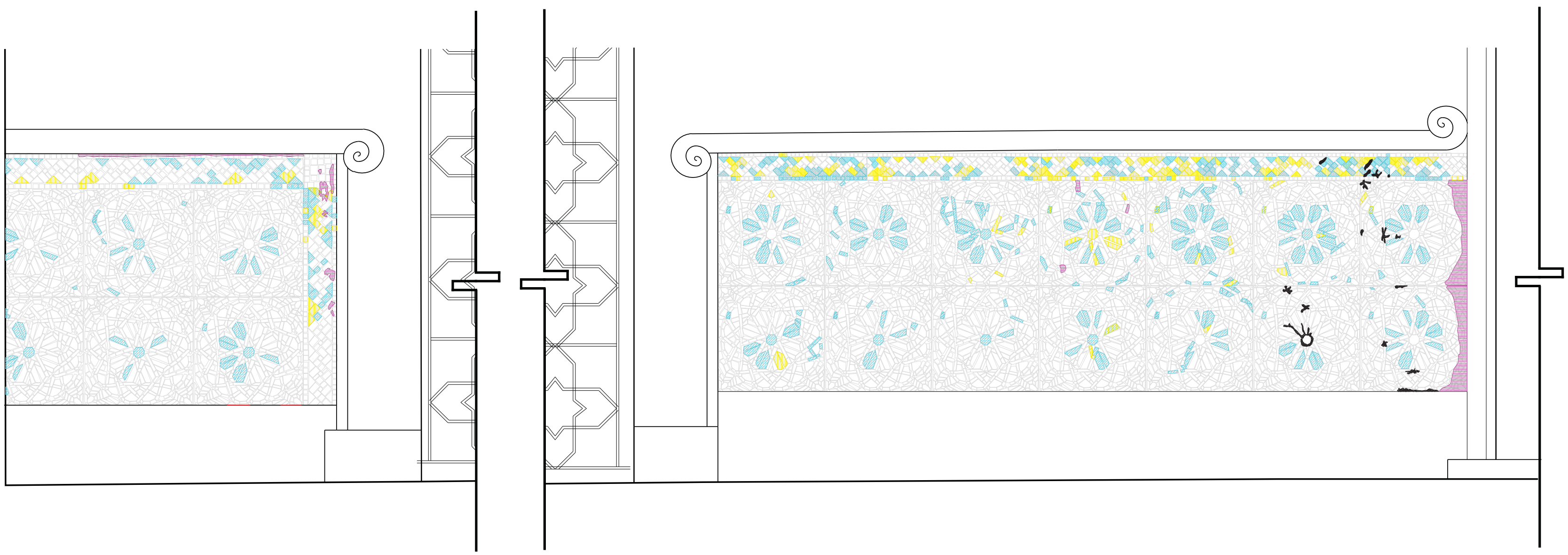
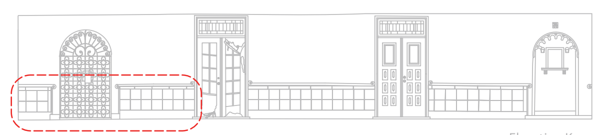
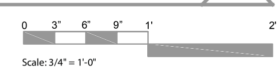
SHEET NO.:
D - 8






## Northeast Gallery Elevation - Wainscot Conditions

4




### General Conditions:

- Loss
- Detached Tesserae
- Fill/Repair
- Concoidal Spalling
- Intra-Layer Detachment
- Incipient Spalling
- Incipient Spalling
- Fractured Tesserae
- Cracking
- Efflorescence
- Displacement
- Bio-Growth
- Paint Spatter

GENERAL NOTE:
Existing conditions were recorded on architectural drawings prepared and supplied by the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico.

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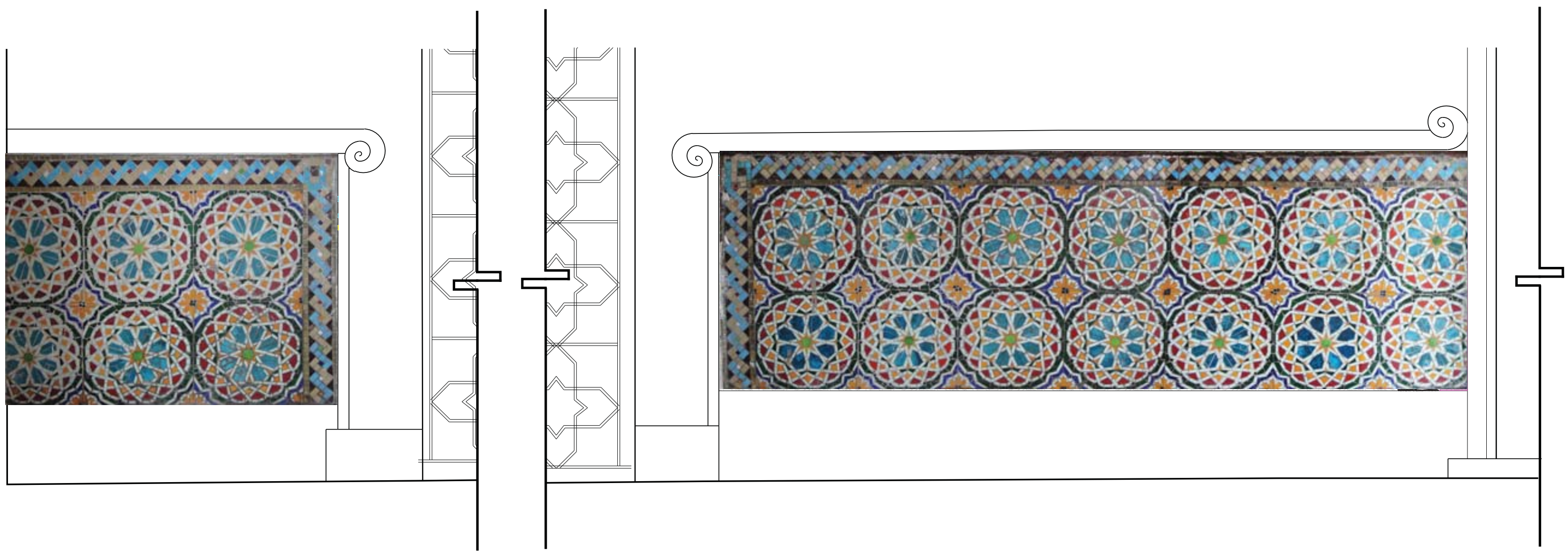
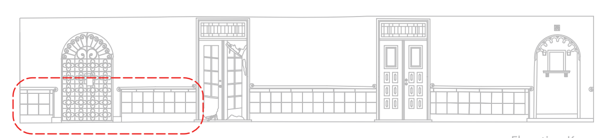
SHEET NO.:
D - 9






Northeast Gallery Elevation - Wainscot Photomonge 4

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

GENERAL NOTE:
Existing conditions were recorded on architectural drawings prepared and supplied by the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico.

# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

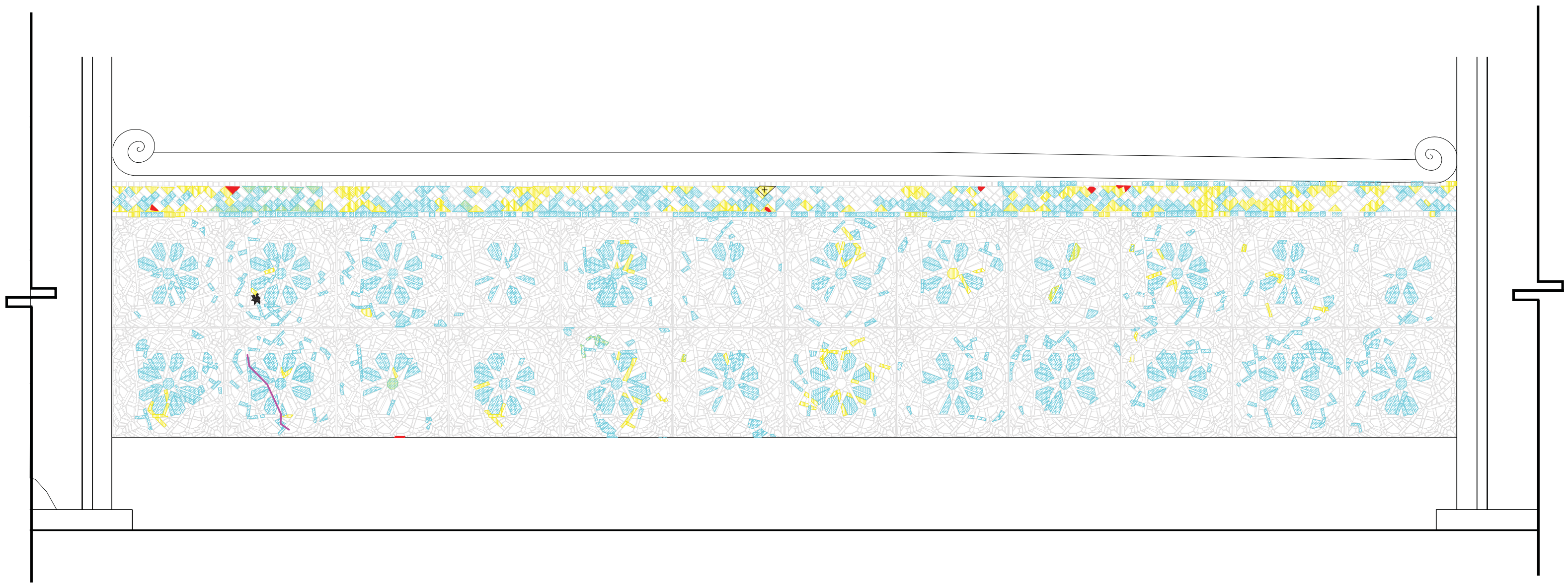
Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

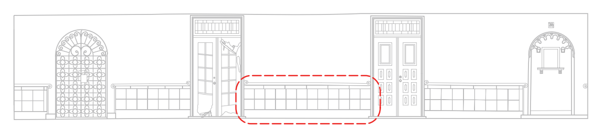
DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12 .15 . 2009

SHEET NO.:
D - 10






## Northeast Gallery Elevation - Wainscot Conditions

4

General Conditions:

- Loss
- Detached Tesserae
- Fill/Repair
- Conchoidal Spalling
- Intra-Layer Detachment
- Incipient Spalling
- Incipient Spalling
- Fractured Tesserae
- Cracking
- Efflorescence
- Displacement
- Bio-Growth
- Paint Spatter

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

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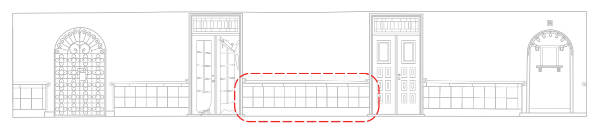
D -11




Northeast Gallery Elevation - Wainscot Photomontages 4

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

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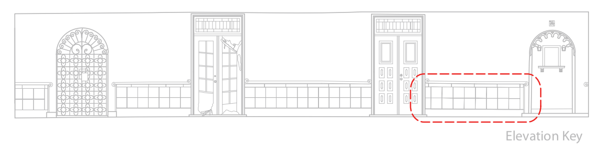
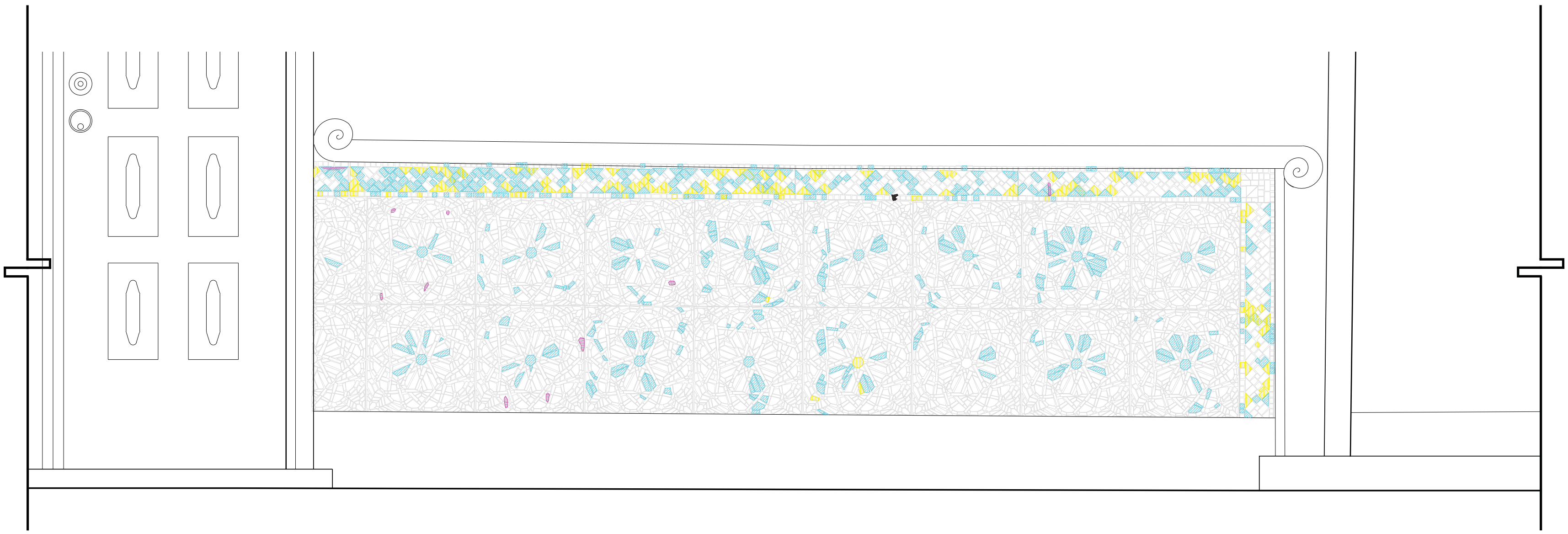
12 .15 . 2009

SHEET NO.:
D -12



## Northeast Gallery Elevation - Wainscot Conditions

4

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

### General Conditions:

- Loss
- Detached Tesserae
- Fill/Repair
- Conchoidal Spalling
- Intra-Layer Detachment
- Incipient Spalling
- Incipient Spalling
- Fractured Tesserae
- Cracking
- Efflorescence
- Displacement
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- Paint Spatter

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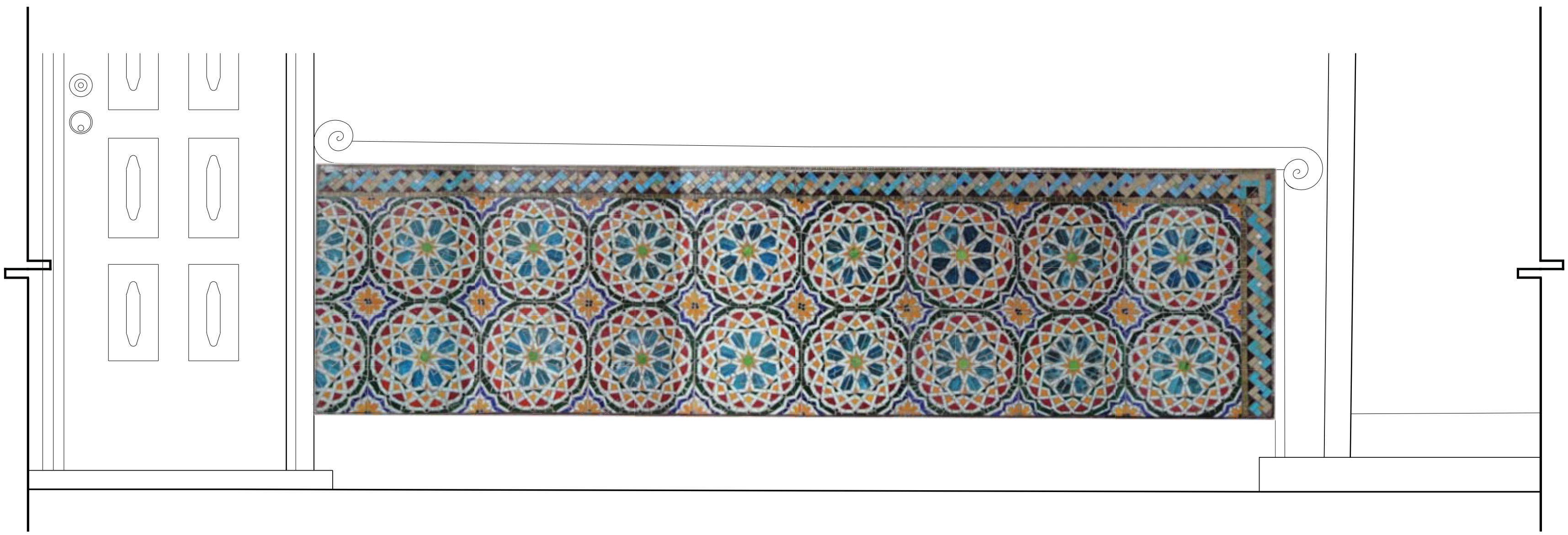
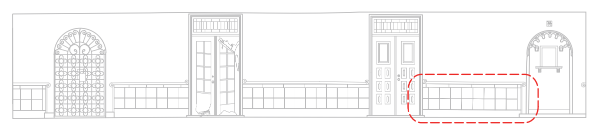
12.15.2009

SHEET NO.:
D-13





Elevation Key

Northeast Gallery Elevation - Wainscot Photomontages

4

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

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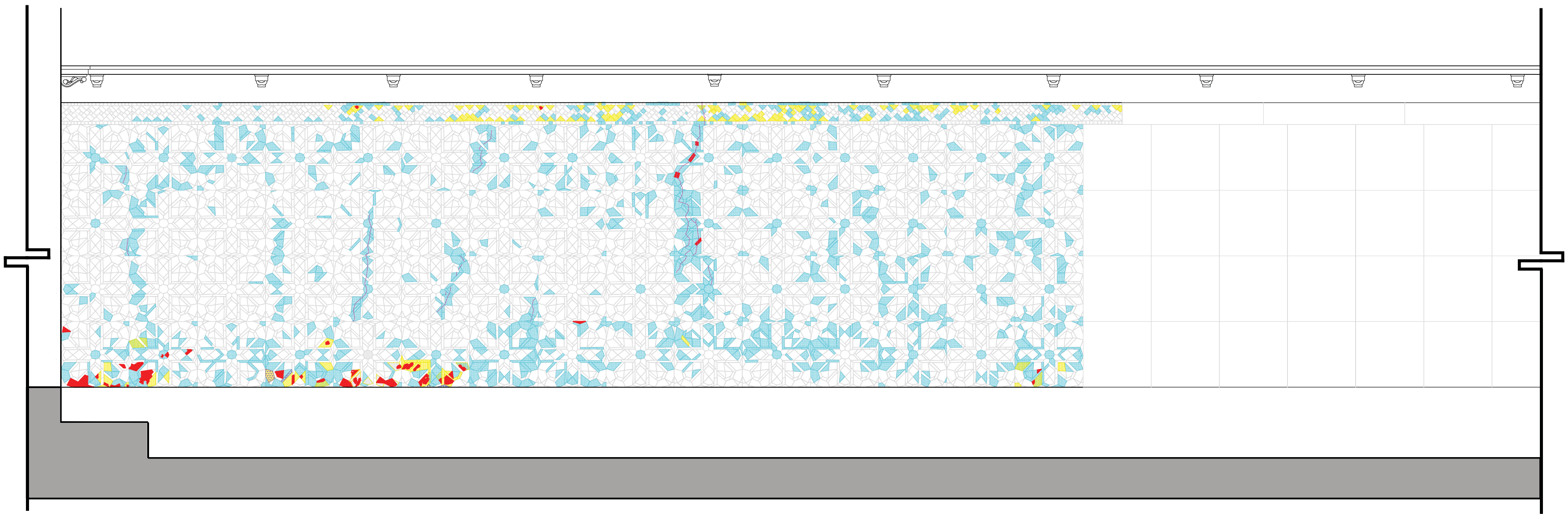
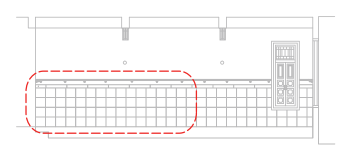
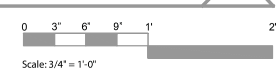
SHEET NO.:
D -14






Northeast Gallery Elevation - Wainscot Condtions 5

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- Fractured Tesserae
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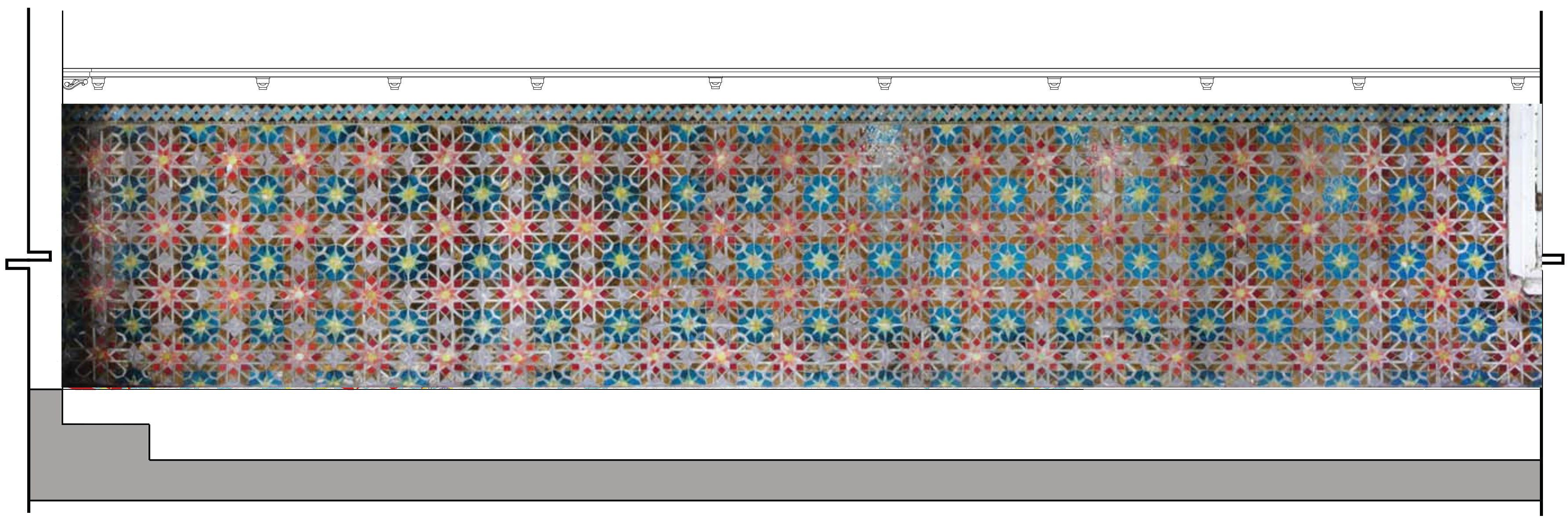
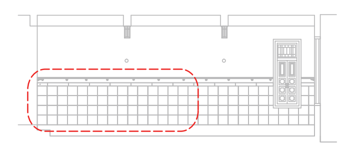
DATE: 12.15.2009

SHEET NO.: D-15






Northeast Dinning Room Wall- Photomontage 5

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

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YARITZA HERNANDEZ

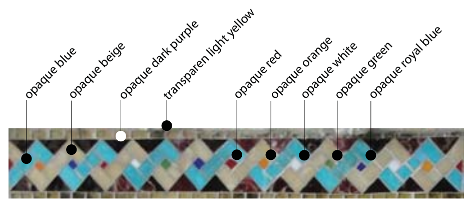
DATE:
12 .15 . 2009

SHEET NO.:
D -16

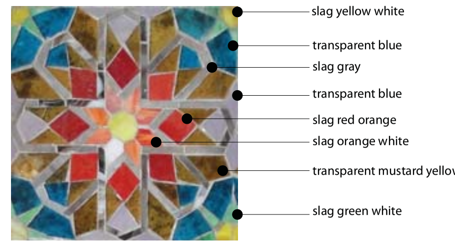
# APPENDIX E

| DINING ROOM_DADO_CONCOIDAL SPALLING | | | | |
|---|---|---|---|---|
| **CHARACTERISTIC** | **COLOR** | **CONDITION** | **AREA** | **%** |
| OPAQUE | LAVANDER | CONCOIDAL SPALLING | 1.9184 | 3.32 |
| OPAQUE | RED-ORANGE | CONCOIDAL SPALLING | 3.5464 | 6.14 |
| SLAG | GRAY | CONCOIDAL SPALLING | 5.4217 | 9.39 |
| SLAG | GREEN-WHITE | CONCOIDAL SPALLING | 0.2230 | 0.39 |
| SLAG | YELLOW | CONCOIDAL SPALLING | 0.8298 | 1.44 |
| TRANSPARENT | BLUE | CONCOIDAL SPALLING | 4.7968 | 8.31 |
| **TOTAL** | | | **16.7361** | 28.9821 |

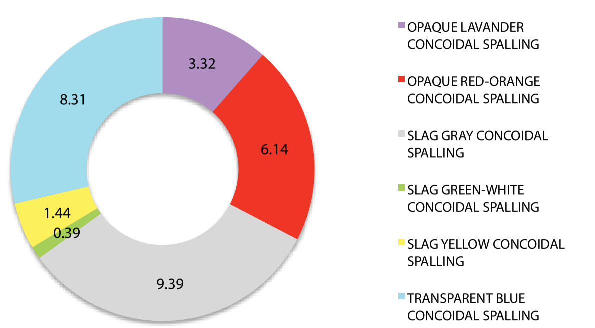
| DINING ROOM_RAIL_CONCOIDAL SPALLING | | | | |
|---|---|---|---|---|
| **CHARACTERISTIC** | **COLOR** | **CONDITION** | **AREA** | **%** |
| SLAG | BABY BLUE | CONCOIDAL SPALLING | 6.3110 | 15.39 |
| SLAG | BEIGE | CONCOIDAL SPALLING | 7.0626 | 17.22 |
| TRANSPARENT | DARK PURPLE | CONCOIDAL SPALLING | 27.0846 | 66.04 |
| TRANSPARENT | YELLOW GOLD | CONCOIDAL SPALLING | 0.5522 | 1.35 |
| **TOTAL** | | | **41.0104** | 100.00 |

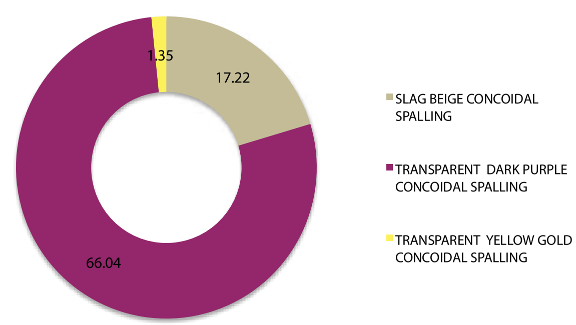


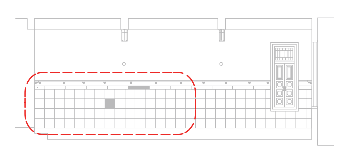

**DINING ROOM RAIL**




**DINING ROOM DADO**



Elevation Key

Dining Room Rail & Dado - Wall B

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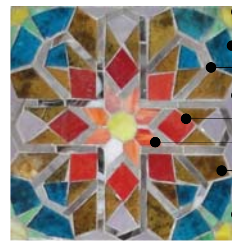
DATE: 12.15.2009

SHEET NO.: E-1

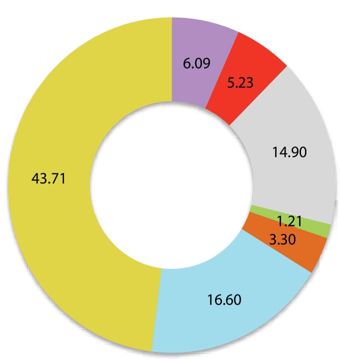
| DINING ROOM RAIL - FRACTURE | | | | |
|---|---|---|---|---|
| CHARACTERISTIC | COLOR | CONDITION | AREA | % |
| OPAQUE | LAVANDER | FRACTURE | 49.37 | 6.09 |
| OPAQUE | RED ORANGE | FRACTURE | 42.44 | 5.23 |
| SLAG | GRAY | FRACTURE | 120.93 | 14.90 |
| SLAG | GREEN WHITE | FRACTURE | 9.84 | 1.21 |
| SLAG | ORANGE | FRACTURE | 26.81 | 3.30 |
| TRANSPARENT | BLUE | FRACTURE | 134.66 | 16.60 |
| TRANSPARENT | MUSTARD YELLOW | FRACTURE | 354.66 | 43.71 |
| TOTAL AREA | | | **738.73** | 91.05 |

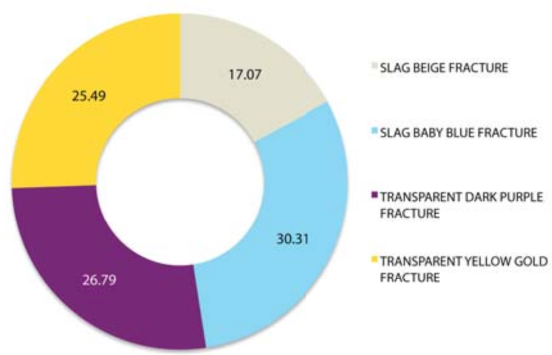
| DINING ROOM RAIL - FRACTURE | | | | |
|---|---|---|---|---|
| CHARACTERISTIC | COLOR | CONDITION | AREA | % |
| OPAQUE | ORANGE | FRACTURE | 0.12 | 0.01 |
| OPAQUE | WHITE | FRACTURE | 0.13 | 0.02 |
| SLAG | BABY BLUE | FRACTURE | 22.02 | 2.71 |
| SLAG | BEIGE | FRACTURE | 12.40 | 1.53 |
| TRANSPARENT | DARK PURPLE | FRACTURE | 19.46 | 2.40 |
| TRANSPARENT | YELLOW GOLD | FRACTURE | 18.52 | 2.28 |
| TOTAL AREA | | | **72.65** | 8.95 |

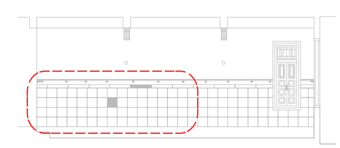

**DINING ROOM RAIL**




**DINING ROOM DADO**



Elevation Key

Dining Room Rail & Dado - Wall B

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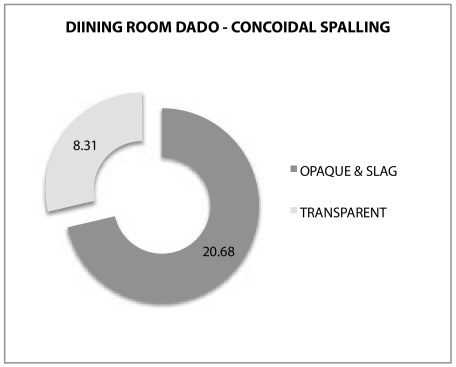
DATE: 12.15.2009

SHEET NO.: E-2

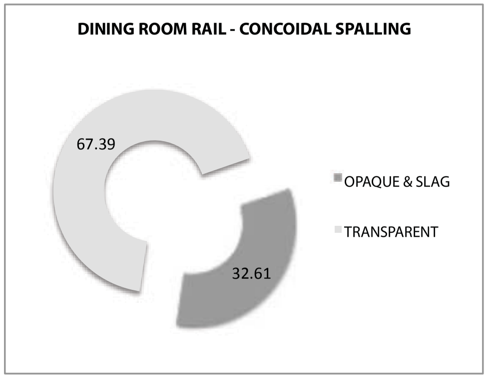
## DINING ROOM DADO - CONCOIDAL SPALLING

| CHARACTERISTICS | AREA % |
|---|---|
| OPAQUE & SLAG | 20.68 |
| TRANSPARENT | 8.31 |
| TOTAL AREA | 28.98 |



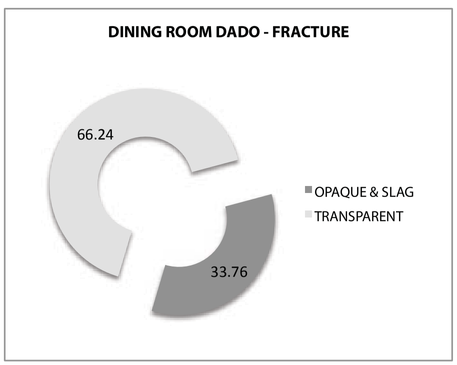

## DINING ROOM RAIL - CONCOIDAL SPALLING

| CHARACTERISTICS | AREA % |
|---|---|
| OPAQUE & SLAG | 32.61 |
| TRANSPARENT | 67.39 |
| TOTAL AREA | 100.00 |



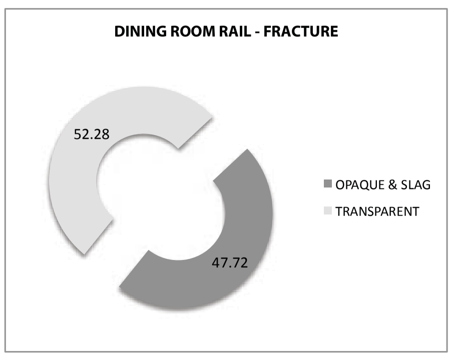

## DINING ROOM DADO - FRACTURE

| CHARACTERISTICS | AREA % |
|---|---|
| OPAQUE & SLAG | 33.76 |
| TRANSPARENT | 66.24 |
| TOTAL AREA | 100.00 |



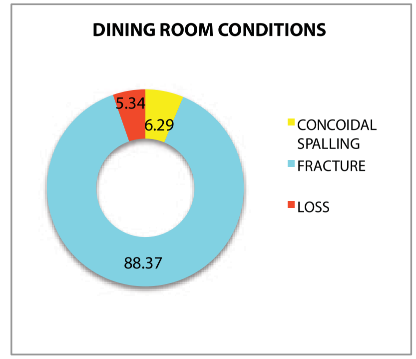

## DINING ROOM RAIL - FRACTURE

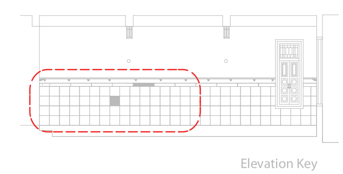
| CHARACTERISTICS | AREA % |
|---|---|
| OPAQUE & SLAG | 47.72 |
| TRANSPARENT | 52.28 |
| TOTAL AREA | 100.00 |




## DINING ROOM - CONDITIONS

| CONDITION | TOTAL AREA | % |
|---|---|---|
| CONCOIDAL SPALLING | 57.75 | 6.29 |
| FRACTURE | 811.38 | 88.37 |
| LOSS | 49.04 | 5.34 |
| TOTAL | 918.16 | 100.00 |




Dining Room Rail & Dado - Wall B

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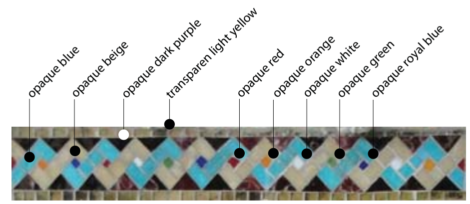
DATE:
12.15.2009

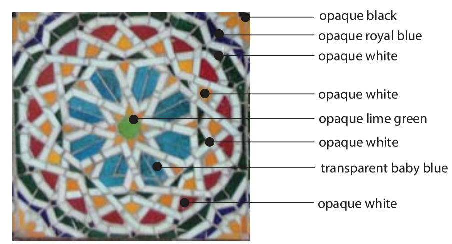
SHEET NO.:
E-3

| GALLERY DADO - CONCOIDAL SPALLING | | | | |
|---|---|---|---|---|
| CHARACTERISTICS | COLOR | CONDITION | AREA | % |
| OPAQUE | BLUE | CONCOIDAL SPALLING | 0.47 | 1.28 |
| OPAQUE | RED | CONCOIDAL SPALLING | 1.11 | 3.02 |
| OPAQUE | WHITE | CONCOIDAL SPALLING | 25.49 | 69.35 |
| OPAQUE | YELLOW | CONCOIDAL SPALLING | 0.37 | 1.01 |
| SLAG | GREEN WHITE | CONCOIDAL SPALLING | 3.57 | 9.71 |
| TRANSPARENT | LIGHT BLUE | CONCOIDAL SPALLING | 5.74 | 15.62 |
| **TOTAL AREA** | | | **36.76** | **99.99** |

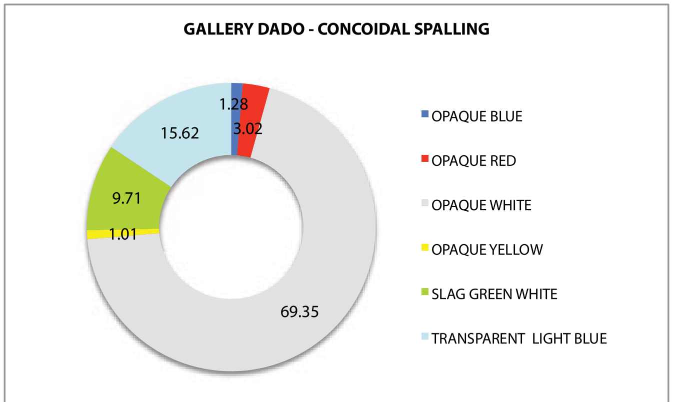
| GALLERY RAIL - CONCOIDAL SPALLING | | | | |
|---|---|---|---|---|
| CHARACTERISTICS | COLOR | CONCOIDAL | AREA | % |
| OPAQUE | LIME GREEN | CONCOIDAL SPALLING | 0.17 | 0.10 |
| SLAG | BABY BLUE | CONCOIDAL SPALLING | 43.17 | 25.19 |
| SLAG | BEIGE | CONCOIDAL SPALLING | 36.67 | 21.39 |
| TRANSPARENT | DARK PURPLE | CONCOIDAL SPALLING | 74.15 | 43.26 |
| TRANSPARENT | YELLOW GOLD | CONCOIDAL SPALLING | 17.23 | 10.06 |
| TOTAL AREA | | | 171.39 | 100.00 |

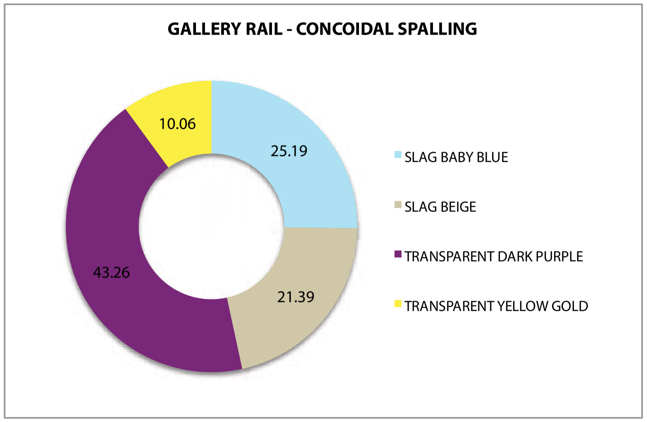


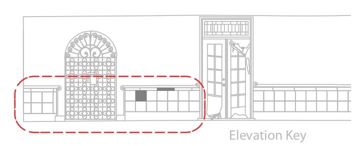

GALLERY RAIL




GALLERY DADO




Gallery Dado & Rail

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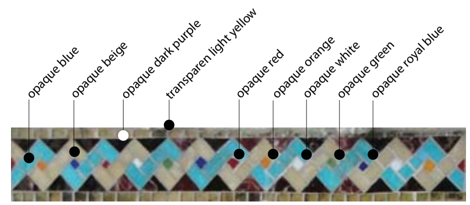
DATE: 12.15.2009

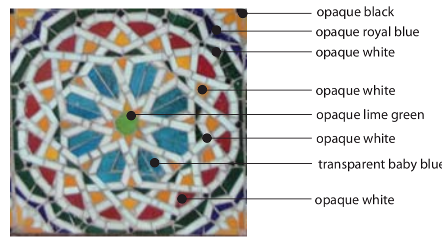
SHEET NO.: E-4

| GALLERY DADO - FRACTURE | | | | |
|---|---|---|---|---|
| CHARACTERISTIC | COLOR | CONDITION | AREA | % |
| OPAQUE | BLACK | FRACTURE | 0.08 | 0.02 |
| OPAQUE | BLUE | FRACTURE | 3.14 | 0.68 |
| OPAQUE | GREEN | FRACTURE | 20.74 | 4.49 |
| OPAQUE | RED | FRACTURE | 19.48 | 4.22 |
| OPAQUE | YELLOW | FRACTURE | 9.23 | 2.00 |
| SLAG | GREEN WHITE | FRACTURE | 38.81 | 8.41 |
| TRANSLUCENT | LIGHT BLUE | FRACTURE | 369.88 | 80.17 |
| **TOTAL AREA** | | | **461.35** | 19.83 |

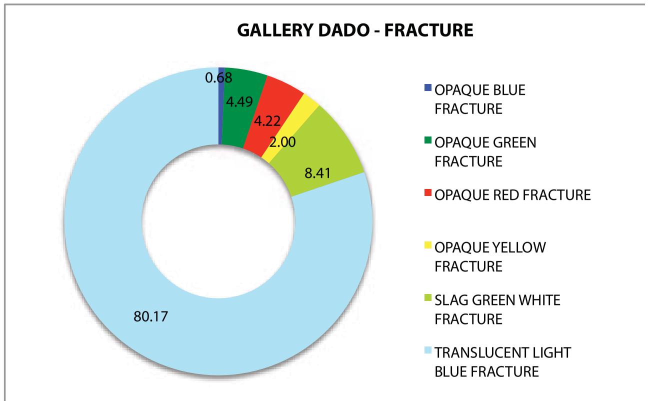
| GALLERY RAIL - FRACUTE | | | | |
|---|---|---|---|---|
| CHARACTERISTIC | COLOR | CONDITION | AREA | % |
| OPAQUE | BLUE | FRACTURE | 0.16 | 0.05 |
| OPAQUE | LIME GREEN | FRACTURE | 0.61 | 0.20 |
| OPAQUE | WHITE | FRACTURE | 0.92 | 0.30 |
| SLAG | BABY BLUE | FRACTURE | 76.15 | 25.20 |
| SLAG | BEIGE | FRACTURE | 68.97 | 22.82 |
| TRANSPARENT | DARK PPURPLE | FRACTURE | 93.49 | 30.94 |
| TRANSPARENT | YELLOW GOLD | FRACTURE | 61.89 | 20.48 |
| **TOTAL AREA** | | | **302.17** | **100.00** |

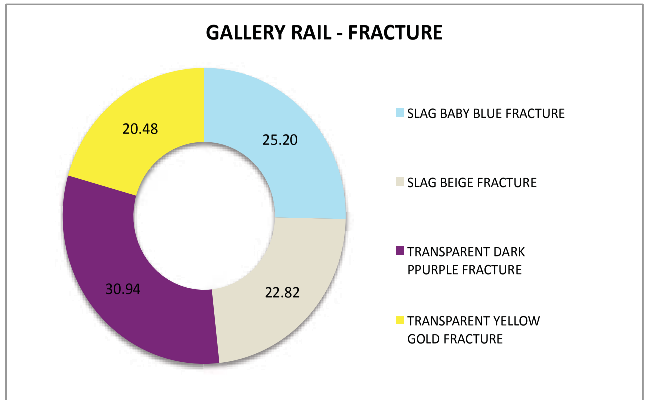


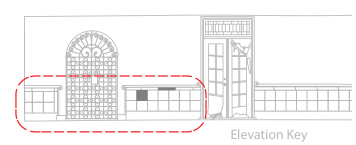
GALLERY RAIL



GALLERY DADO



Gallery Dado & Rail

GENERAL NOTE:
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# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

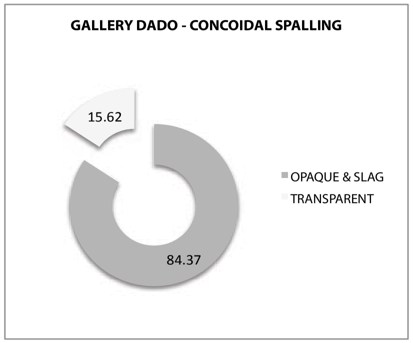
CONDITION RECORDED BY:
YARITZA HERNANDEZ

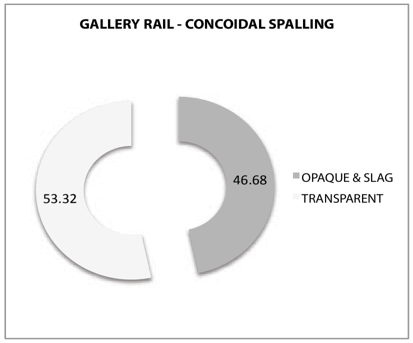
DATE:
12.15.2009

SHEET NO.:
E-5

| GALLERY DADO - CONCOIDAL SPALLING | |
|---|---|
| **CHARACTERISTICS** | **AREA %** |
| OPAQUE & SLAG | 84.37 |
| TRANSPARENT | 15.62 |
| **TOTAL AREA** | **99.99** |

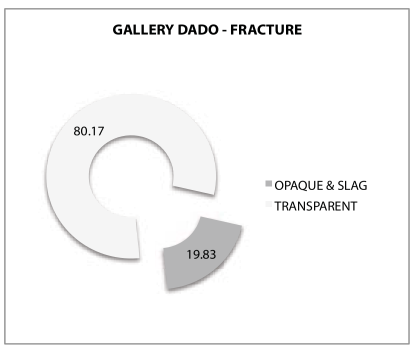
| GALLERY RAIL - CONCOIDAL SPALLING | |
|---|---|
| **CHARACTERISTICS** | **AREA %** |
| OPAQUE & SLAG | 46.68 |
| TRANSPARENT | 53.32 |
| **TOTAL AREA** | **100.00** |

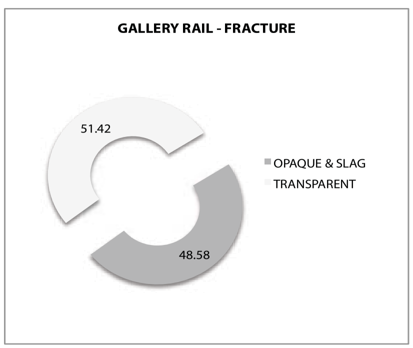


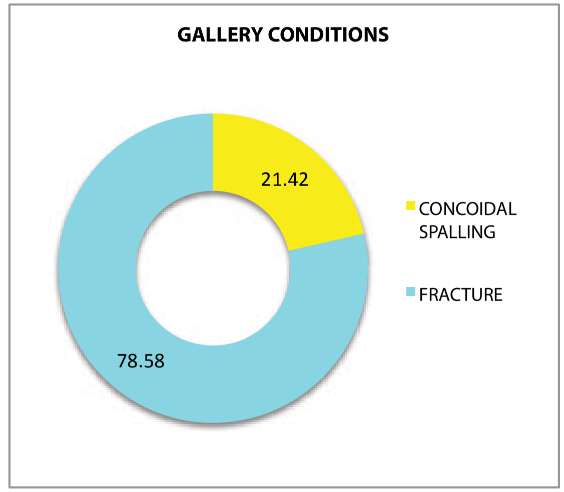

| GALLERY DADO - FRACTURE | |
|---|---|
| **CHARACTERISTICS** | **AREA %** |
| OPAQUE & SLAG | 19.83 |
| TRANSPARENT | 80.17 |
| **TOTAL AREA** | **100.00** |

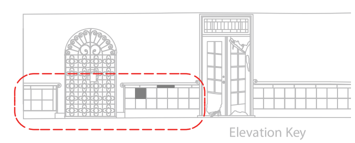
| GALLERY RAIL -FRACTURE | |
|---|---|
| **CHARACTERISTICS** | **AREA %** |
| OPAQUE & SLAG | 48.58 |
| TRANSPARENT | 51.42 |
| **TOTAL AREA** | **100.00** |




| GALLERY CONDITIONS | | |
|---|---|---|
| CONDITION | TOTAL AREA | % |
| CONCOIDAL SPALLING | 208.15 | 21.42 |
| FRACTURE | 763.53 | 78.58 |
| **TOTAL** | **971.67** | **100.00** |




Gallery Dado & Rail

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THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY: POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY: YARITZA HERNANDEZ

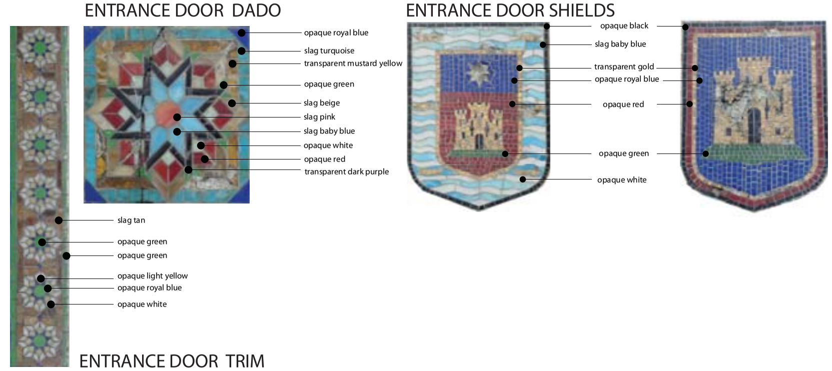
DATE: 12.15.2009

SHEET NO.: E-6

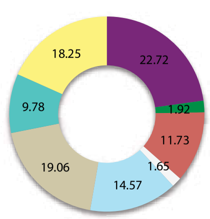
| ENTRANCE DOOR DADO - CONCOIDAL SPALLING | | | | |
|---|---|---|---|---|
| **CHARACTERISTICS** | **COLOR** | **CONDITION** | **AREA** | **%** |
| OPAQUE | DARK PURPLE | CONCOIDAL SPALLING | 69.67 | 22.72 |
| OPAQUE | GREEN | CONCOIDAL SPALLING | 5.90 | 1.92 |
| OPAQUE | RED | CONCOIDAL SPALLING | 35.96 | 11.73 |
| OPAQUE | ROYAL BLUE | CONCOIDAL SPALLING | 1.01 | 0.33 |
| OPAQUE | WHITE | CONCOIDAL SPALLING | 5.05 | 1.65 |
| SLAG | BABY BLUE | CONCOIDAL SPALLING | 44.67 | 14.57 |
| SLAG | BEIGE | CONCOIDAL SPALLING | 58.46 | 19.06 |
| SLAG | TURQUOISE | CONCOIDAL SPALLING | 29.99 | 9.78 |
| TRANSPARENT | YELLOW | CONCOIDAL SPALLING | 55.98 | 18.25 |
| **TOTAL AREA** | | | **306.69** | 100.00 |

| ENTRANCE DOOR SHIELD - CONCOIDAL SPALLING | | | | |
|---|---|---|---|---|
| **CHARACTERISTICS** | **COLOR** | **CONDITION** | **AREA** | **%** |
| OPAQUE | BLACK | CONCOIDAL SPALLING | 4.54 | 4.57 |
| OPAQUE | GREEN | CONCOIDAL SPALLING | 0.81 | 0.81 |
| OPAQUE | RED | CONCOIDAL SPALLING | 11.01 | 11.09 |
| OPAQUE | ROYAL BLUE | CONCOIDAL SPALLING | 8.66 | 8.71 |
| OPAQUE | WHITE | CONCOIDAL SPALLING | 11.36 | 11.44 |
| SLAG | BABY BLUE | CONCOIDAL SPALLING | 13.57 | 13.66 |
| TRANSPARENT | GOLD | CONCOIDAL SPALLING | 49.40 | 49.72 |
| **TOTAL AREA** | | | **99.35** | **100.00** |

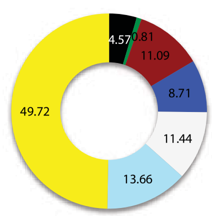
| ENTRANCE DOOR TRIM - CONCOIDAL SPALLING | | | | |
|---|---|---|---|---|
| **CHARACTERISTICS** | **COLOR** | **CONDITION** | **AREA** | **%** |
| OPAQUE | GREEN | CONCOIDAL SPALLING | 6.33 | 3.61 |
| OPAQUE | LIGHT YELLOW | CONCOIDAL SPALLING | 0.66 | 0.38 |
| OPAQUE | ROYAL BLUE | CONCOIDAL SPALLING | 0.24 | 0.14 |
| OPAQUE | WHITE | CONCOIDAL SPALLING | 5.42 | 3.09 |
| SLAG | TAN | CONCOIDAL SPALLING | 162.60 | 92.78 |
| **TOTAL AREA** | | | **175.26** | 100.00 |



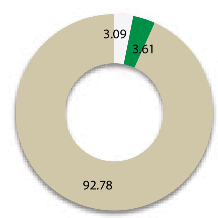

**ENTRANCE DOOR DADO - CONCOIDAL SPALLING**

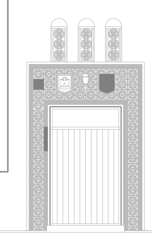



**ENTRANCE DOOR SHIELDS - CONCOIDAL SPALLLING**




**ENTRANCE DOOR TRIM - CONCOIDAL SPALLING**



Elevation Key

Entrance Door

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# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY:
POLYTECHNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

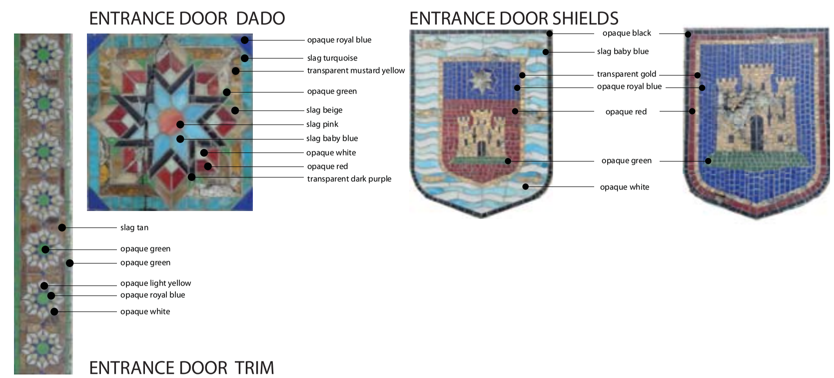
DATE:
12.15.2009

SHEET NO.:
E-7

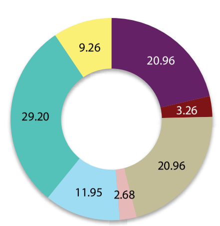
| ENTRANCE DOOR DADO - FRACTURE | | | | |
|---|---|---|---|---|
| CHARACTERISTICS | COLOR | CONDITION | AREA | % |
| SLAG | BEIGE | FRACTURE | 164.64 | 20.96 |
| OPAQUE | DARK PURPLE | FRACTURE | 164.64 | 20.96 |
| OPAQUE | GREEN | FRACTURE | 4.11 | 0.52 |
| OPAQUE | RED | FRACTURE | 25.59 | 3.26 |
| OPAQUE | ROYAL BLUE | FRACTURE | 4.60 | 0.59 |
| OPAQUE | WHITE | FRACTURE | 4.94 | 0.63 |
| SLAG | PINK WHITE | FRACTURE | 21.07 | 2.68 |
| SLAG | BABY BLUE | FRACTURE | 93.88 | 11.95 |
| SLAG | TURQUOISE | FRACTURE | 229.39 | 29.20 |
| TRANSPARENT | YELLOW | FRACTURE | 72.72 | 9.26 |
| **TOTAL AREA** | | | **785.60** | **100.00** |

| ENTRANCE DOOR SHIELD - FRACTURE | | | | |
|---|---|---|---|---|
| CHARACTERISTICS | COLOR | CONDITION | AREA | % |
| OPAQUE | BLACK | FRACTURE | 1.40 | 2.73 |
| OPAQUE | GREEN | FRACTURE | 0.56 | 1.10 |
| OPAQUE | RED | FRACTURE | 7.30 | 14.21 |
| OPAQUE | ROYAL BLUE | FRACTURE | 3.25 | 6.32 |
| OPAQUE | WHITE | FRACTURE | 4.53 | 8.82 |
| SLAG | BABY BLUE | FRACTURE | 17.95 | 34.95 |
| TRANSPARENT | GOLD | FRACTURE | 16.37 | 31.87 |
| **TOTAL AREA** | | | **51.37** | **99.99** |

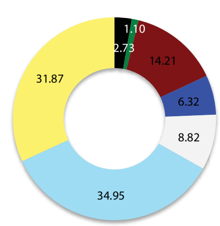
| ENTRANCE DOOR TRIM - FRACTURE | | | | |
|---|---|---|---|---|
| CHARACTERISTICS | COLOR | CONDITION | AREA | % |
| OPAQUE | ROYAL BLUE | FRACTURE | 0.05 | 0.02 |
| OPAQUE | WHITE | FRACTURE | 4.57 | 1.72 |
| OPAQUE | LIGHT YELLOW | FRACTURE | 1.79 | 0.67 |
| SLAG | TAN | FRACTURE | 259.43 | 97.59 |
| **TOTAL AREA** | | | **265.84** | **100.00** |



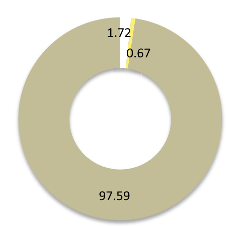

**ENTRANCE DOOR DADO - FRACTURE**

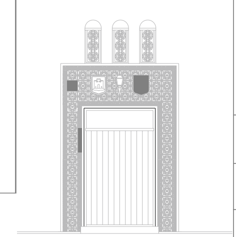



**ENTRANCE DOOR SHIELD - FRACTURE**




**ENTRANCE DOOR TRIM - FRACTURE**



Elevation Key

Entrance Door

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A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY: POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY: YARITZA HERNANDEZ

DATE: 12 .15 . 2009

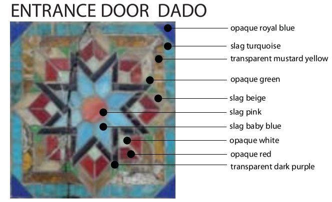
SHEET NO.: E-8

| ENTRANCE DOOR DADO - LOSS | | | | |
|---|---|---|---|---|
| CHARACTERISTICS | COLOR | CONDITION | AREA | % |
| OPAQUE | DARK PURPLE | LOSS | 9.09 | 14.20 |
| OPAQUE | GREEN | LOSS | 1.85 | 2.90 |
| OPAQUE | RED | LOSS | 4.56 | 7.12 |
| OPAQUE | WHITE | LOSS | 0.52 | 0.81 |
| SLAG | BABY BLUE | LOSS | 11.18 | 17.47 |
| SLAG | BEIGE | LOSS | 14.36 | 22.43 |
| SLAG | PINK | LOSS | 1.62 | 2.53 |
| SLAG | TURQUOISE | LOSS | 1.80 | 2.82 |
| TRANSPARENT | YELLOW | LOSS | 19.04 | 29.73 |
| **TOTAL AREA** | | | **64.03** | **100.00** |

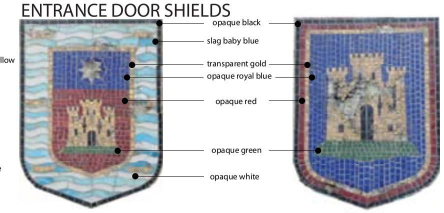
| ENTRANCE DOOR SHIELD - LOSS | | | | |
|---|---|---|---|---|
| CHARACTERISTICS | COLOR | CONDITION | AREA | % |
| OPAQUE | BLACK | LOSS | 0.91 | 5.59 |
| OPAQUE | RED | LOSS | 1.32 | 8.12 |
| OPAQUE | WHITE | LOSS | 2.36 | 14.53 |
| SLAG | BABY BLUE | LOSS | 0.57 | 3.48 |
| TRANSPARENT | GOLD | LOSS | 11.10 | 68.31 |
| **TOTAL AREA** | | | **16.25** | **100.03** |

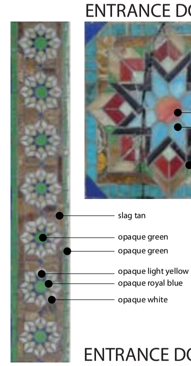
| ENTRANCE DOOR TRIM - LOSS | | | | |
|---|---|---|---|---|
| CHARACTERISTICS | COLOR | CONDITION | AREA | % |
| OPAQUE | GREEN | LOSS | 0.43 | 3.26 |
| OPAQUE | LIGHT YELLOW | LOSS | 1.44 | 10.86 |
| OPAQUE | ROYAL BLUE | LOSS | 0.46 | 3.45 |
| OPAQUE | WHITE | LOSS | 4.13 | 31.13 |
| SLAG | TAN | LOSS | 6.81 | 51.32 |
| **TOTAL AREA** | | | **13.28** | **100.02** |

ENTRANCE DOOR DADO

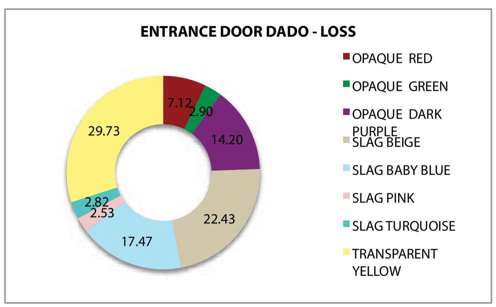


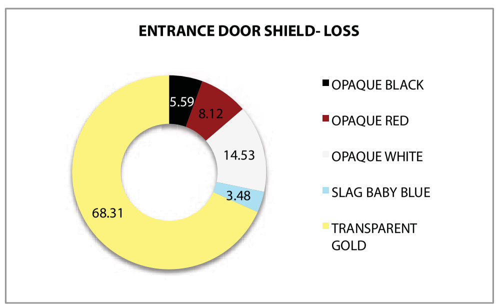

ENTRANCE DOOR SHIELDS

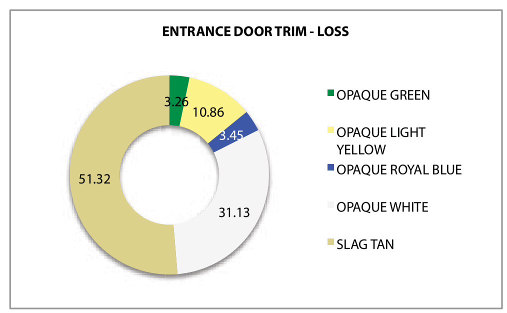


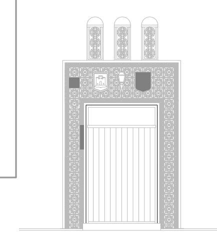




ENTRANCE DOOR TRIM



Elevation Key

Entrance Door

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Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

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CONDITION RECORDED BY:
YARITZA HERNANDEZ

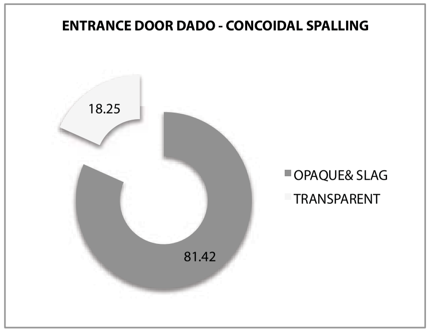
DATE:
12.15.2009

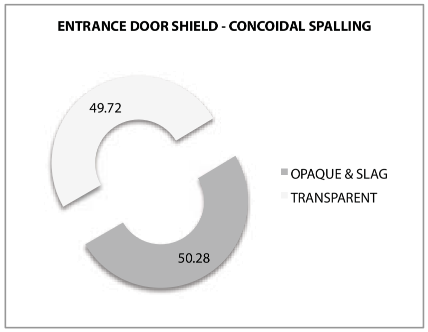
SHEET NO.:
E-9

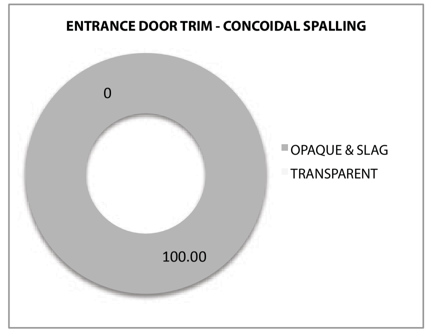
| ENTRANCE DOOR DADO - CONCOIDAL SPALLING | |
|---|---|
| **CHARACTERISTIC** | **AREA %** |
| OPAQUE& SLAG | 81.42 |
| TRANSPARENT | 18.25 |
| **TOTAL AREA** | 99.67 |

| ENTRANCE DOOR SHIELD - CONCOIDAL SPALLING | |
|---|---|
| **CHARACTERISTIC** | **AREA %** |
| OPAQUE & SLAG | 50.28 |
| TRANSPARENT | 49.72 |
| TOTAL AREA | 100.00 |

| ENTRANCE DOOR TRIM - CONCOIDAL SPALLING | |
|---|---|
| **CHARACTERISTIC** | **AREA %** |
| OPAQUE & SLAG | 100.00 |
| TRANSPARENT | 0 |
| TOTAL AREA | 100.00 |



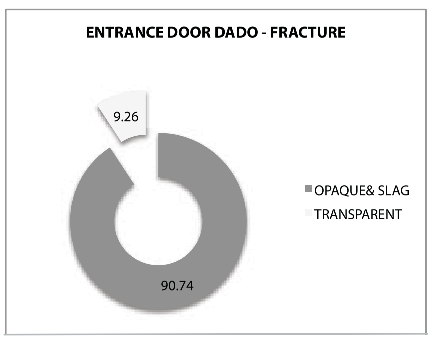



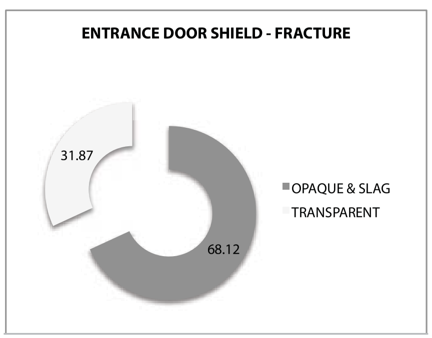



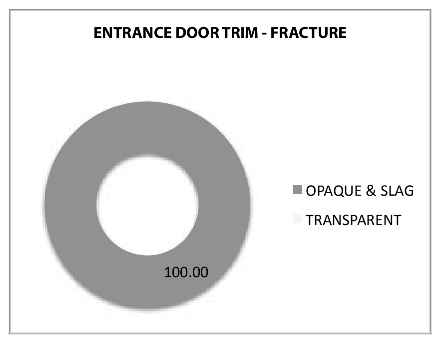

| ENTRANCE DOOR DADO - FRACTURE | |
|---|---|
| **CHARACTERISTIC** | **AREA %** |
| OPAQUE& SLAG | 90.74 |
| TRANSPARENT | 9.26 |
| **TOTAL AREA** | **100.00** |

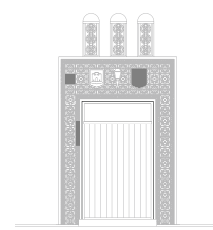
| ENTRANCE DOOR SHIELD - FRACTURE | |
|---|---|
| **CHARACTERISTIC** | **AREA %** |
| OPAQUE & SLAG | 68.12 |
| TRANSPARENT | 31.87 |
| **TOTAL AREA** | **99.99** |

| ENTRANCE DOOR TRIM - FRACTURE | |
|---|---|
| **CHARACTERISTIC** | **AREA %** |
| OPAQUE & SLAG | 100.00 |
| TRANSPARENT | 0 |
| **TOTAL AREA** | **100.00** |



Elevation Key

Entrance Door

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CONDITION RECORDED BY:
YARITZA HERNANDEZ

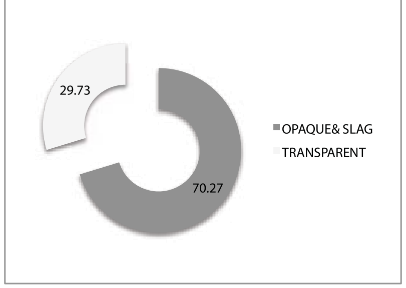
DATE:
12.15.2009

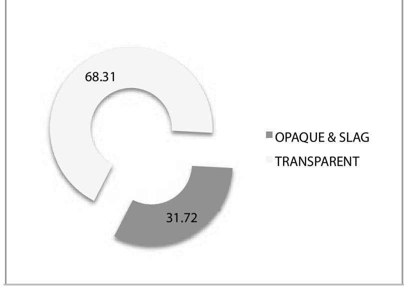
SHEET NO:
E-10

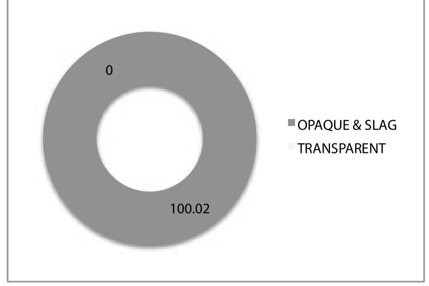
| ENTRANCE DOOR DADO - LOSS | |
|---|---|
| **CHARACTERISTIC** | **AREA %** |
| OPAQUE& SLAG | 70.27 |
| TRANSPARENT | 29.73 |
| **TOTAL AREA** | **100.00** |

| ENTRANCE DOOR SHIELD - LOSS | |
|---|---|
| **CHARACTERISTIC** | **AREA %** |
| OPAQUE & SLAG | 31.72 |
| TRANSPARENT | 68.31 |
| TOTAL AREA | **68.31** |

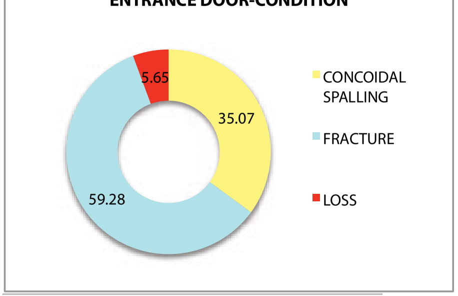
| ENTRANCE DOOR TRIM - LOSS | |
|---|---|
| **CHARACTERISTIC** | **AREA %** |
| OPAQUE & SLAG | 100.02 |
| TRANSPARENT | 0 |
| **TOTAL AREA** | **100.02** |

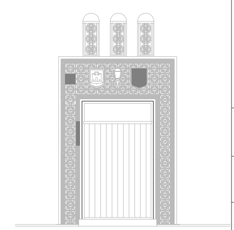



| ENTRANCE DOOR CONDITIONS | | |
|---|---|---|
| **CONDITION** | **TOTAL AREA** | **%** |
| CONCOIDAL SPALLING | 580.28 | 35.07 |
| FRACTURE | 980.93 | 59.28 |
| LOSS | 93.57 | 5.65 |
| **TOTAL** | **1654.78** | **100.00** |



Elevation Key

Entrance Door

GENERAL NOTE:
Existing conditions were recorded on architectural drawings prepared and supplied by the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico.

THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

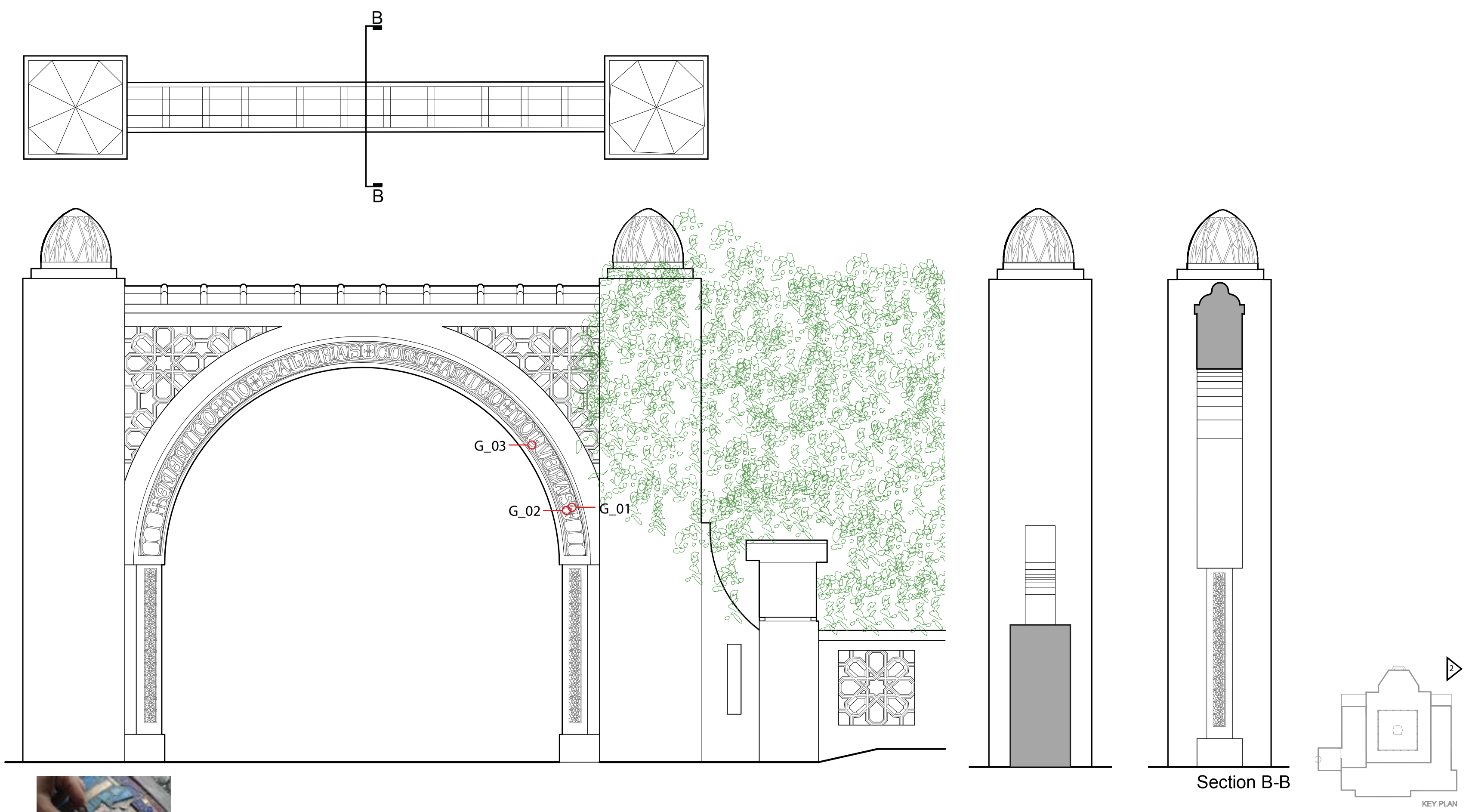
CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12 .15 . 2009

SHEET NO.:
E-11

# APPENDIX F

| VILLA CAPARRA MOSAIC SAMPLE TABLE | | | | | | |
|---|---|---|---|---|---|---|
| **LOCATION** | **SAMPLE #** | **GLASS COLOR** | **XRF** | **SEM** | **PETROGRAPHY** | **SALT STRIPS** |
| **Gate** | G_01 | GREEN | | | | |
| | G_02 | BLUE | | | | |
| | G_03 | BLUE | | | | |
| **Main Entrance** | ME_01 | BEIGE | | | | |
| | ME_02 | DARK PURPLE | | | | |
| | ME_03 | BABY BLUE | | | | |
| | ME_04 | BEIGE | ● | ● | | |
| | ME_05 | RED-ORANGE | | | | |
| | ME_06 | AMBER(TRANSPARENT) | | | | |
| | ME_07 | TURQUOISE | | | | |
| | ME_08 | RED-ORANGE | | | | |
| | ME_09 | TURQUOISE | | | | |
| **Gallery** | W_01 | LIME GREEN | | | | |
| | W_02 | DARK PURPLE | ● | ● | | |
| | W_03 | BLUE | | | | |
| | W_04 | GREEN | | | | |
| | W_05 | BLUE (TRANSPARENT) | ● | ● | | |
| | W_06 | BURGUNDY | | | | |
| | W_07 | BLUE | | | | |
| | W_08 | BEIGE | | | | |
| **Dining Room** | DR_01 | YELLOW | | | | |
| | DR_02 | AMBER(TRANSPARENT) | | | | |
| | DR_03(s) | WHITE | | | | ● |
| | DR_04(s) | WHITE | | | | ● |
| **Columns** | CL_B | MULTICOLOR | ● | | ● | |
| | CL_C | MULTICOLOR | | | ● | |





Sample G_03

GENERAL NOTE:
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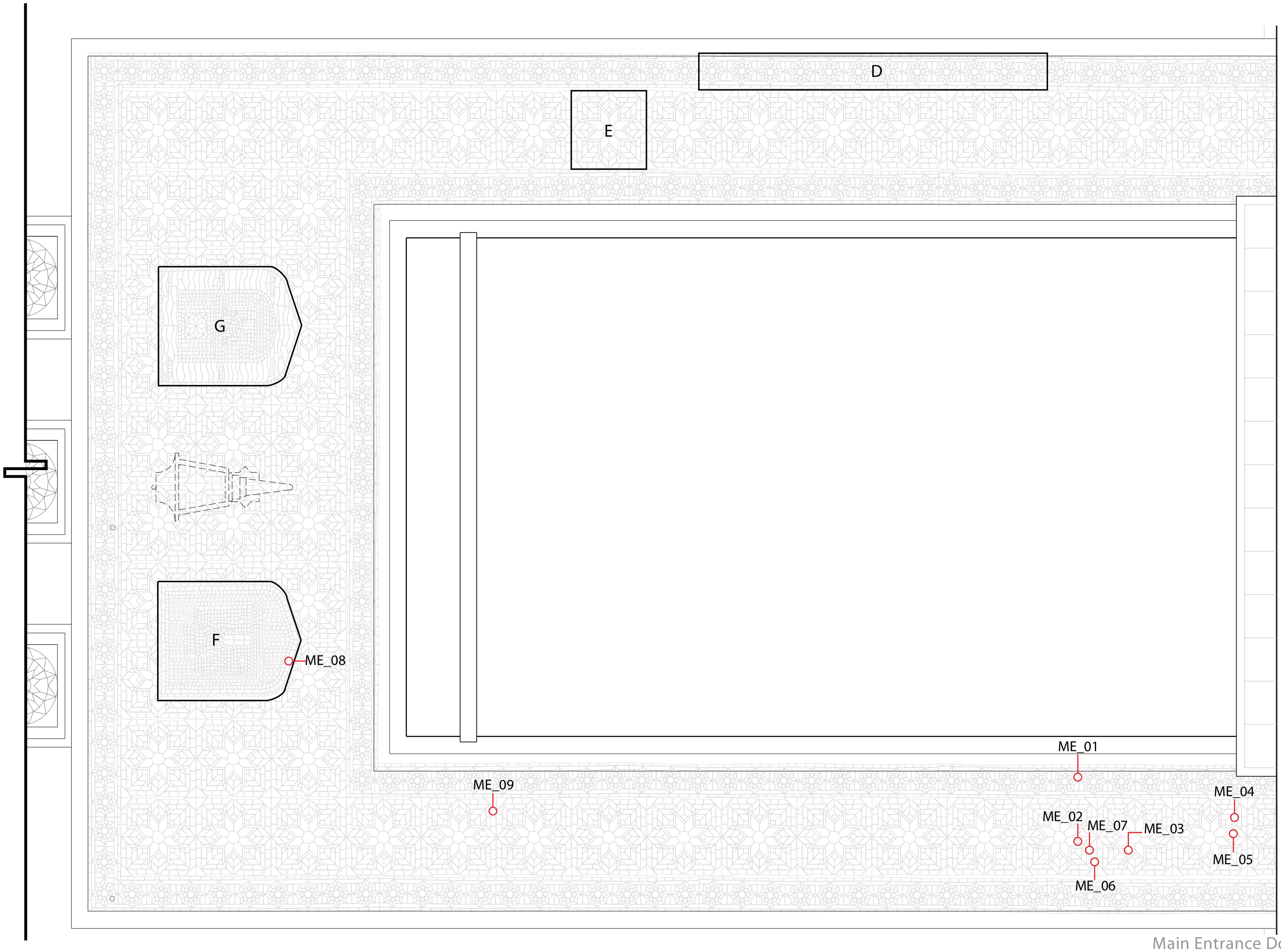
Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY: POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY: YARITZA HERNANDEZ

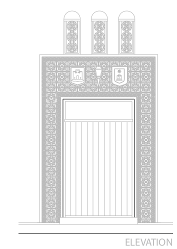
DATE: 12.15.2009

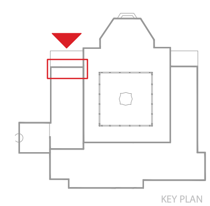
SHEET NO.: F - 1

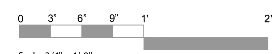



Main Entrance Door - Samples

3


GENERAL NOTE:
Existing conditions were recorded on architectural drawings prepared and supplied by the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico.

# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

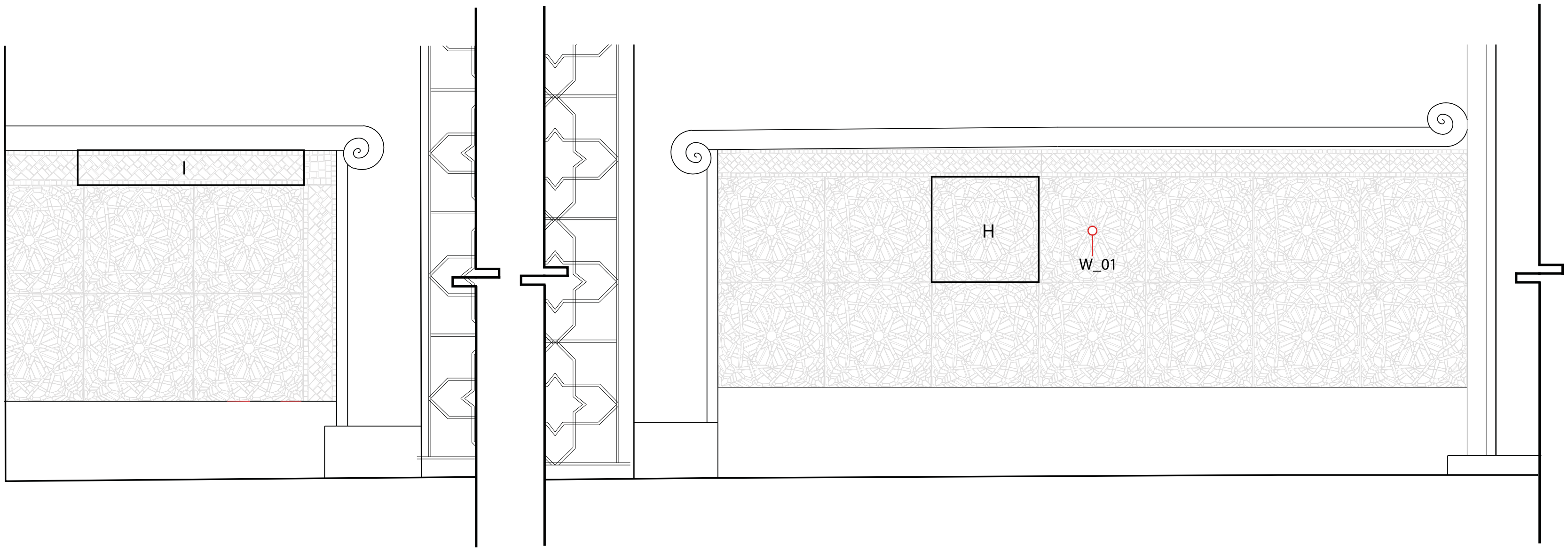
Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

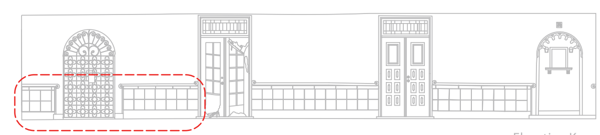
DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12.15.2009

SHEET NO.:
F-2



Elevation Key

Dado H

Rail I

Northeast Gallery Elevation - Wainscot Samples 4

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

GENERAL NOTE:
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# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

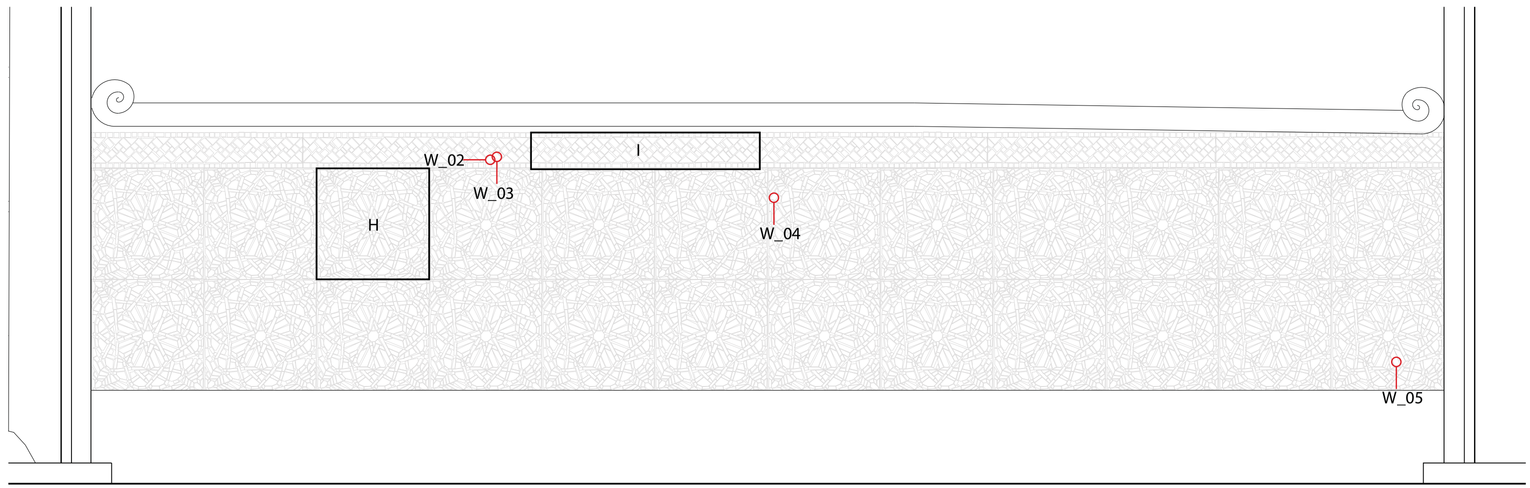
Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

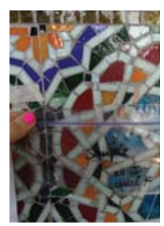
DATE:
12.15.2009

SHEET NO.:
F - 3




Dado H

Rail I



Sample R_4

Northeast Gallery Elevation - Wainscot Samples 4

0 3" 6" 9" 1' 2'

Scale: 3/4" = 1'-0"

GENERAL NOTE:
Existing conditions were recorded on architectural drawings prepared and supplied by the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico.

# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

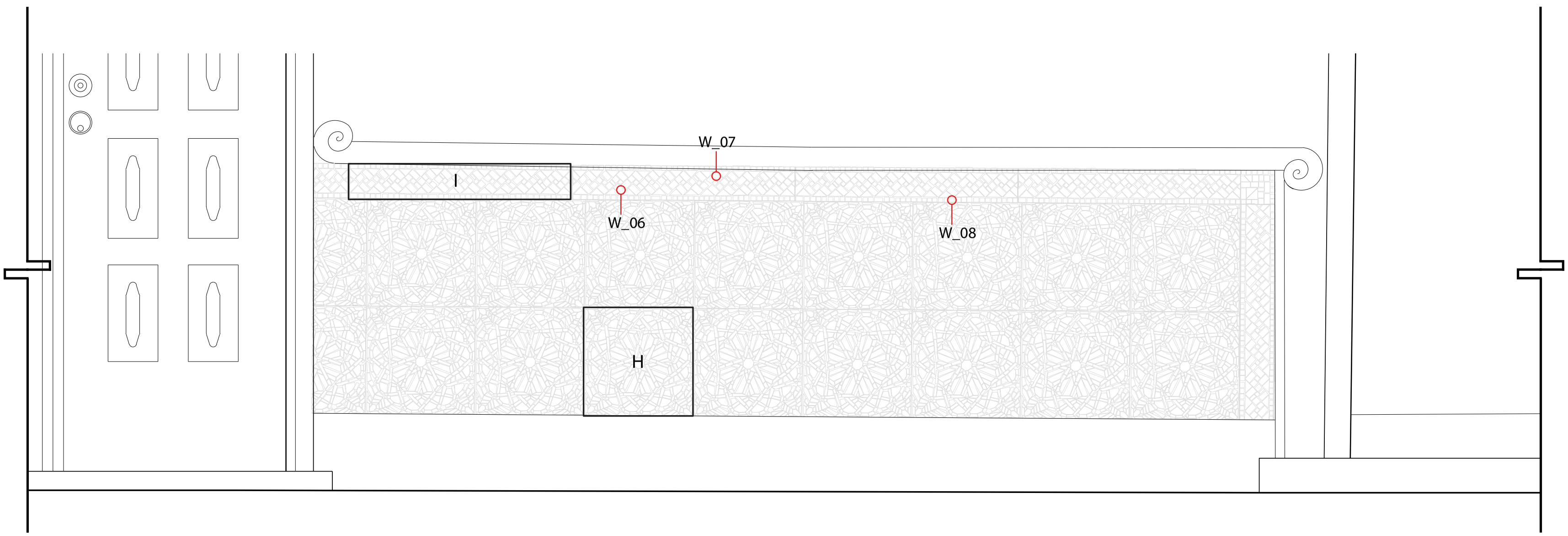
Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

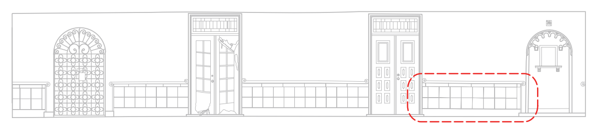
DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12 .15 . 2009

SHEET NO.:
F - 4



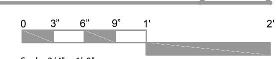
Elevation Key

Dado H

Rail I

Northeast Gallery Elevation - Wainscot Samples

4




Scale: 3/4" = 1'-0"

GENERAL NOTE:
Existing conditions were recorded on architectural drawings prepared and supplied by the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico.

# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

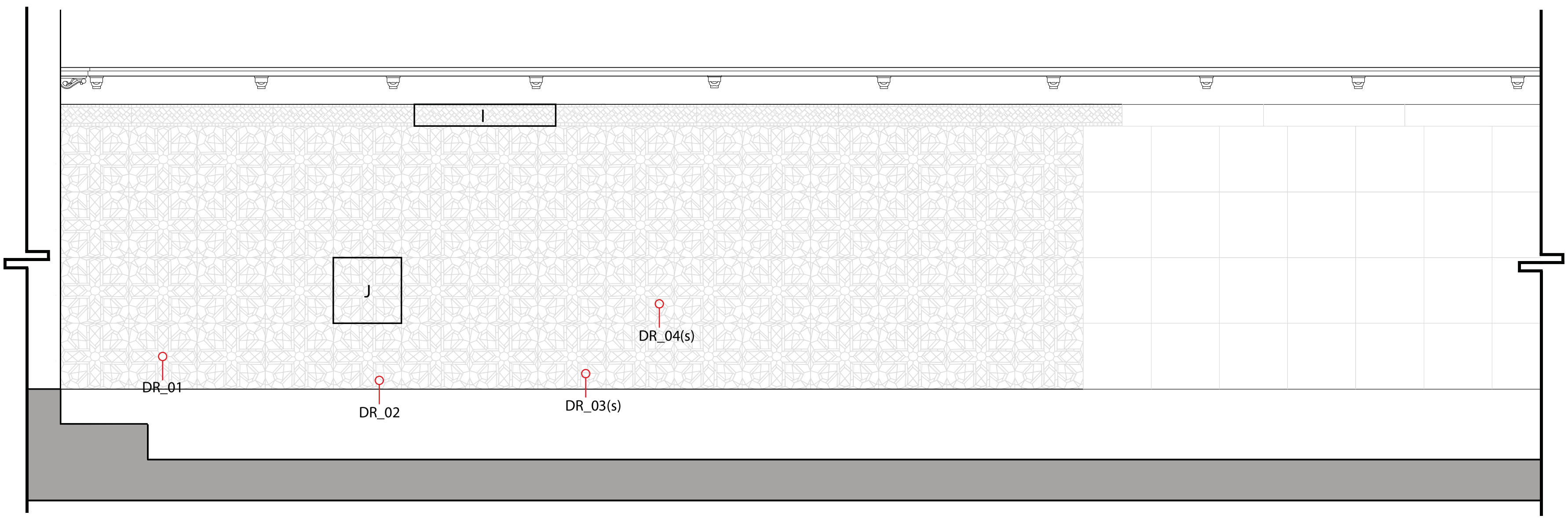
Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

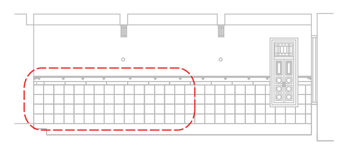
DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12 .15 . 2009

SHEET NO.:
F - 5



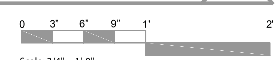


Dado J


Rail I

(s): Efflorescence sample

Northeast Dinning Room Wall- Samples 5




Scale: 3/4" = 1'-0"

GENERAL NOTE:
Existing conditions were recorded on architectural drawings prepared and supplied by the Architectural Conservation Laboratory of the Polytechnic University of Puerto Rico.

# THE GLASS MOSAIC DECORATION OF VILLA CAPARRA

A Technical Study and Conservation Proposal Guaynabo, Puerto Rico

Arquitectural Conservation Labor atory, Penn Design, University of Pennsylvania

DRAWING BY:
POLYTHECNIC UNIVERSITY OF PUERTO RICO

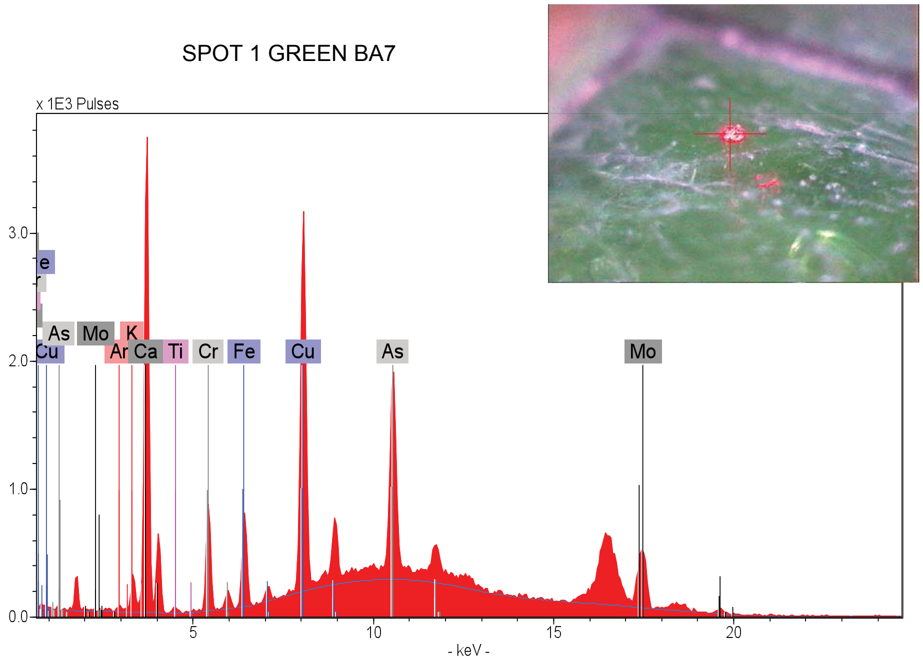
CONDITION RECORDED BY:
YARITZA HERNANDEZ

DATE:
12 .15 . 2009

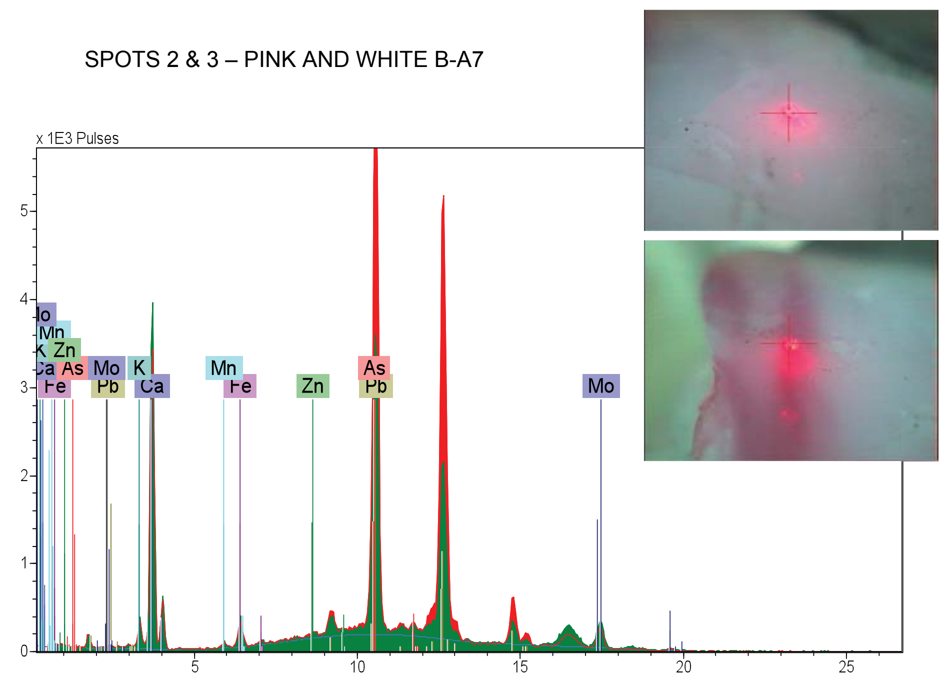
SHEET NO.:
F-6

**APPENDIX G**

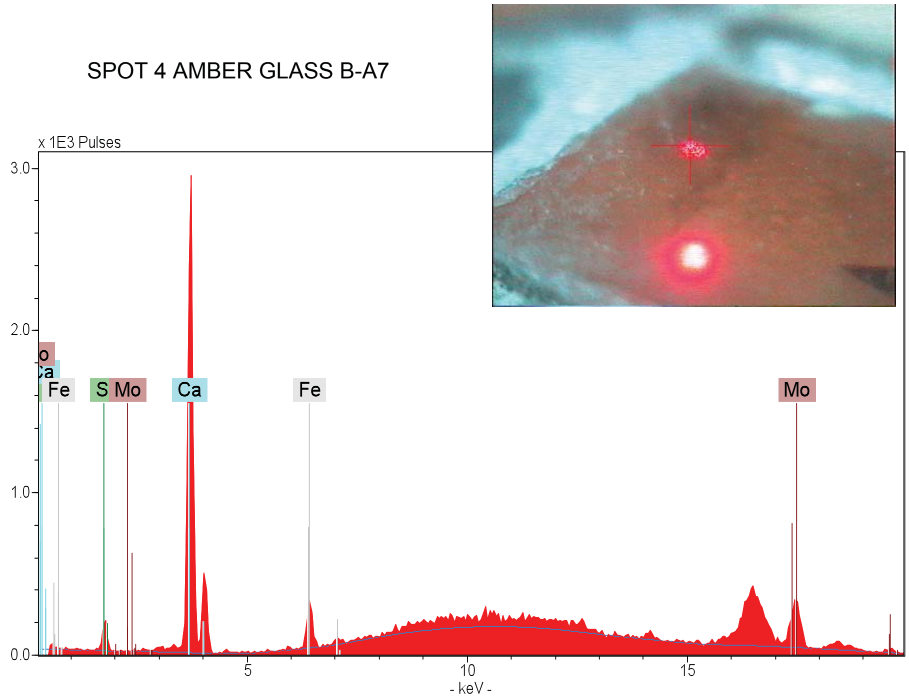
SPOT 1 GREEN BA7



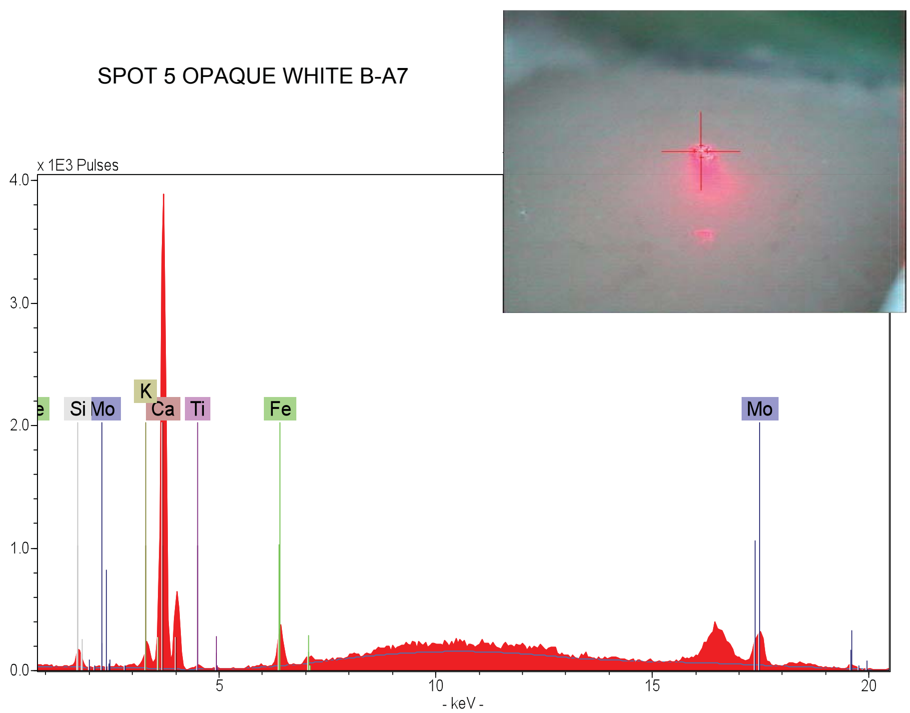

SPOTS 2 & 3 – PINK AND WHITE B-A7



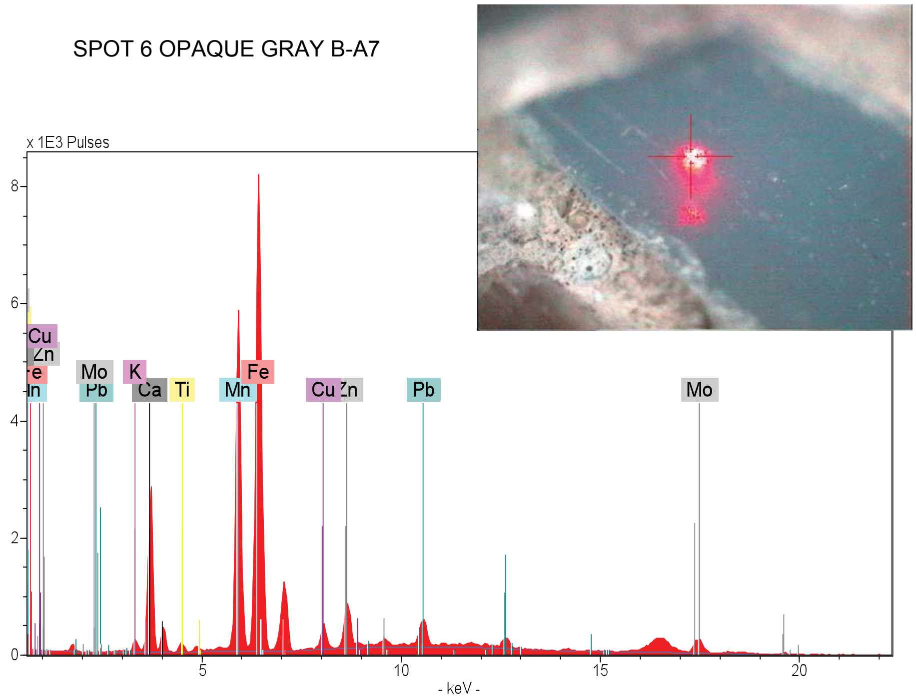
SPOT 4 AMBER GLASS B-A7



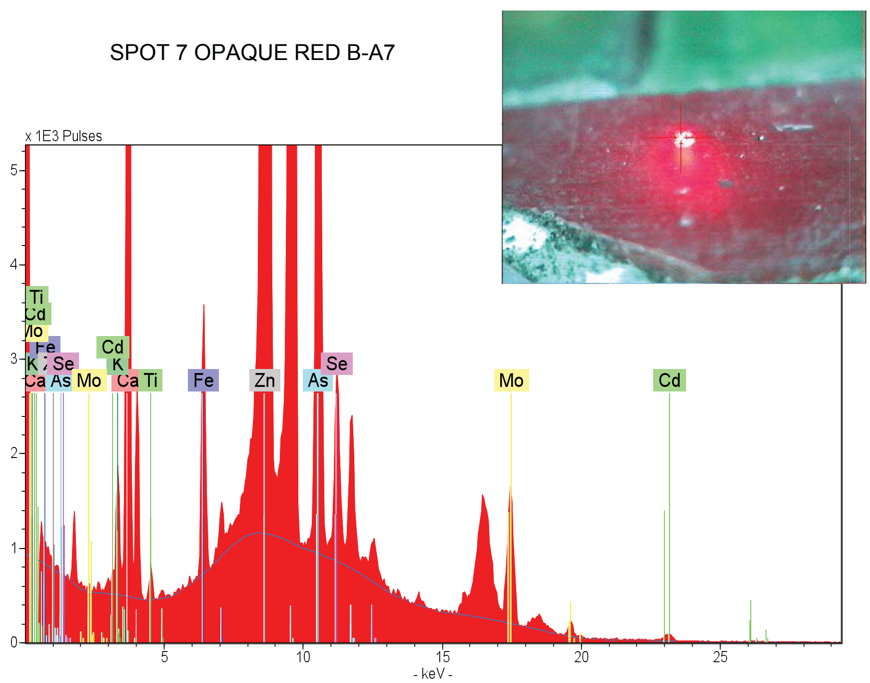

SPOT 5 OPAQUE WHITE B-A7



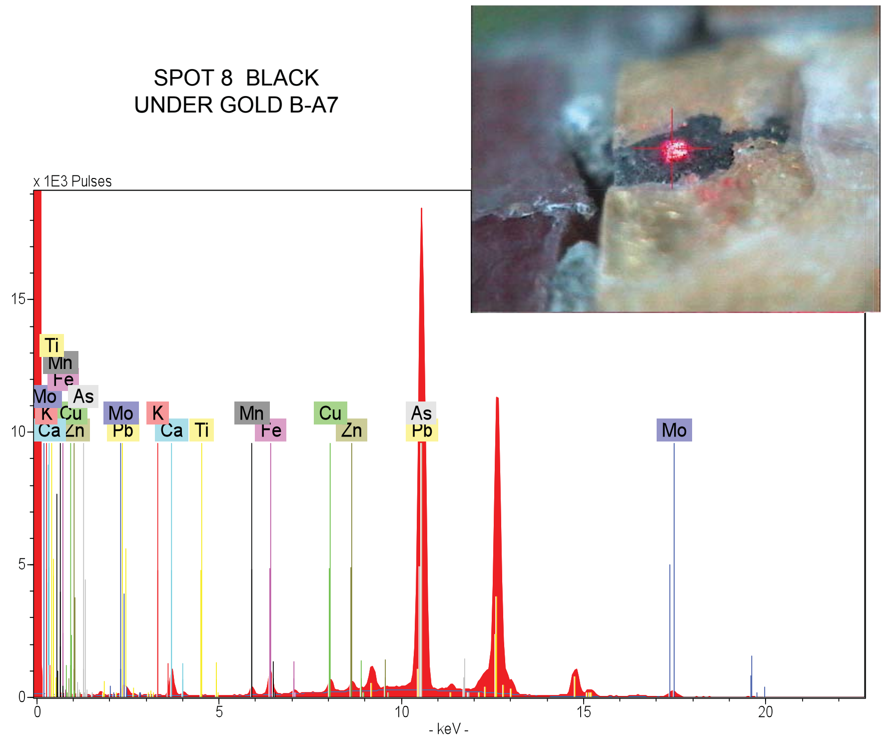
SPOT 6 OPAQUE GRAY B-A7



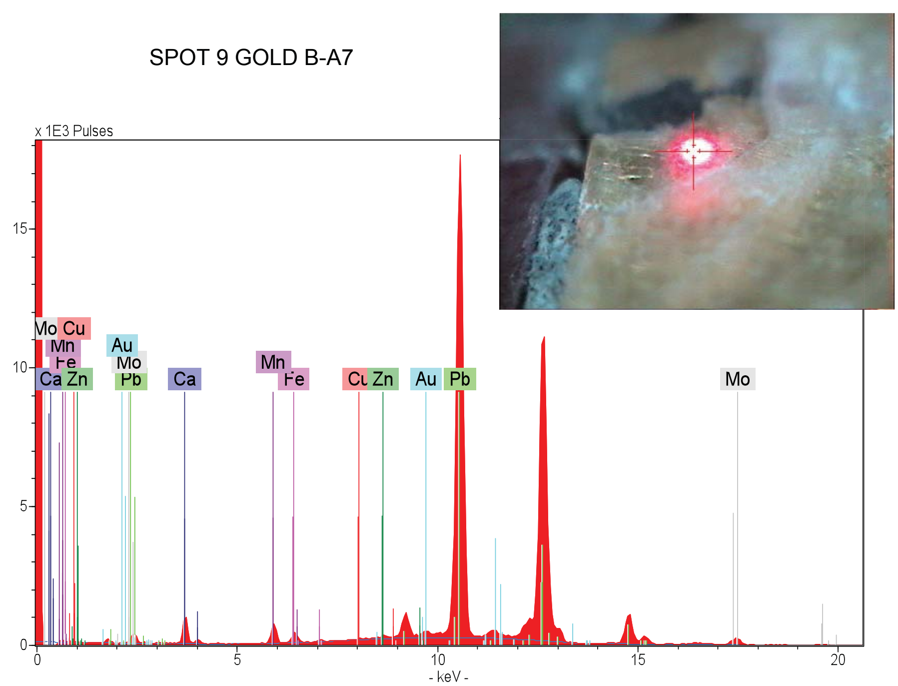

SPOT 7 OPAQUE RED B-A7



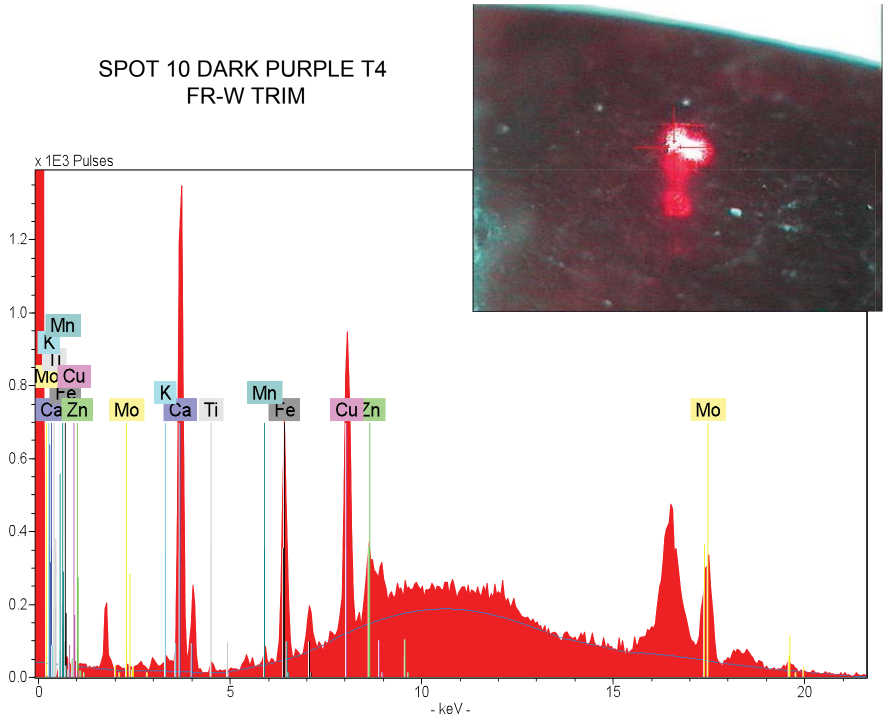
SPOT 8 BLACK
UNDER GOLD B-A7



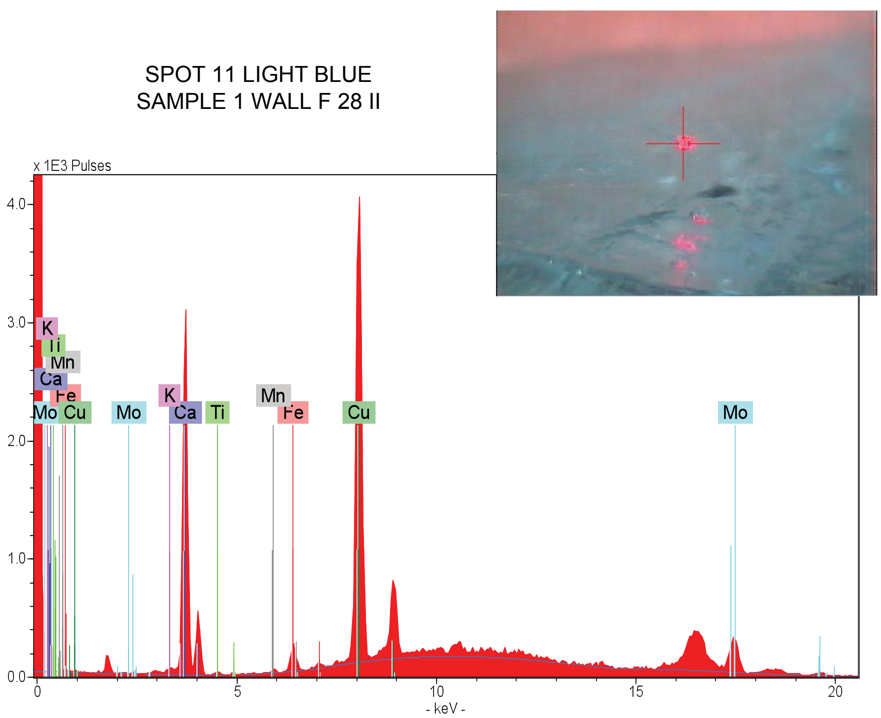

SPOT 9 GOLD B-A7



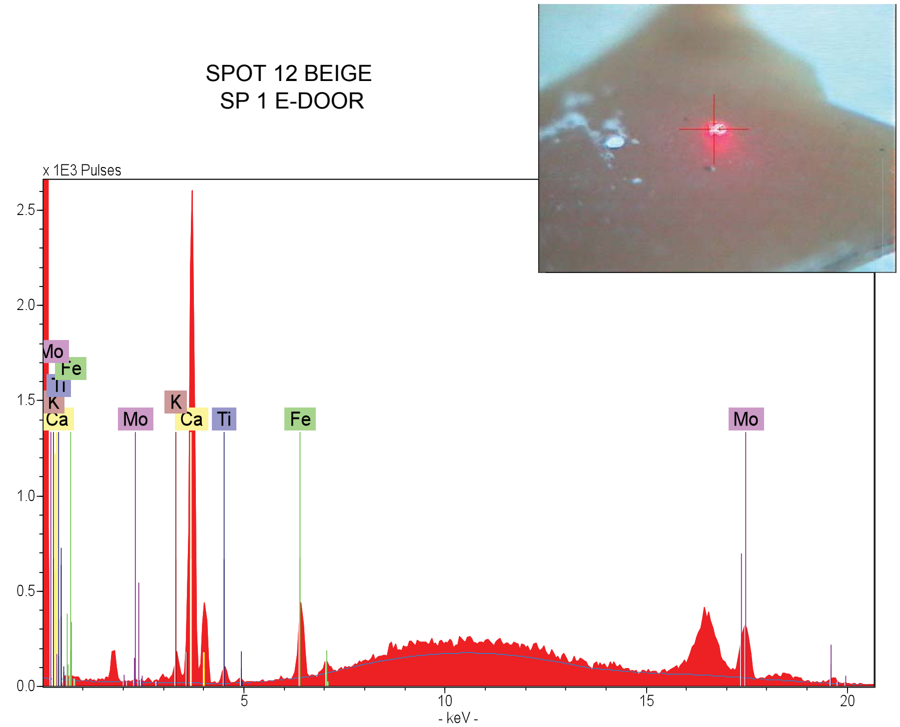
SPOT 10 DARK PURPLE T4
FR-W TRIM



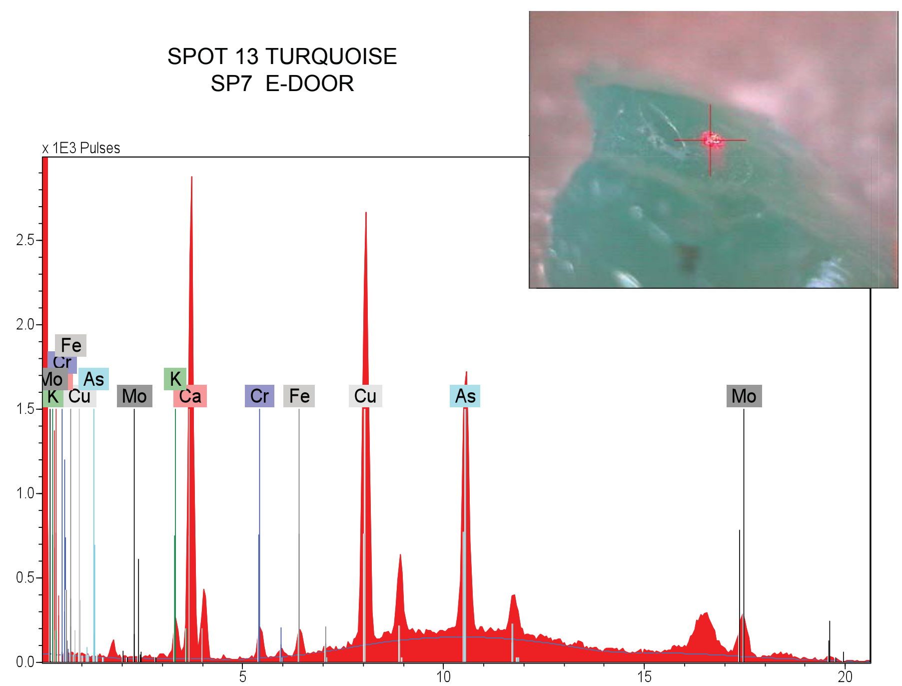

SPOT 11 LIGHT BLUE
SAMPLE 1 WALL F 28 II



SPOT 12 BEIGE
SP 1 E-DOOR




SPOT 13 TURQUOISE
SP7 E-DOOR

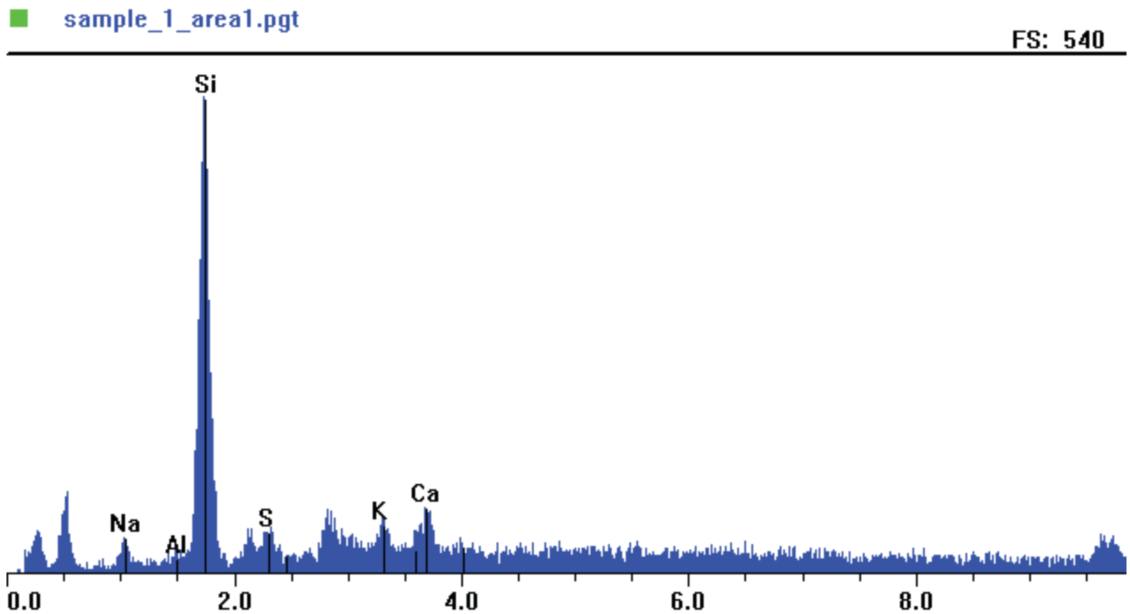


## APPENDIX H

Spectrum Report
Tuesday, April 20, 2010

File: Y:\Architectural Conservation\Yara\Glass_1\sample_1_area1.pgt
Collected: April 20, 2010 16:42:51

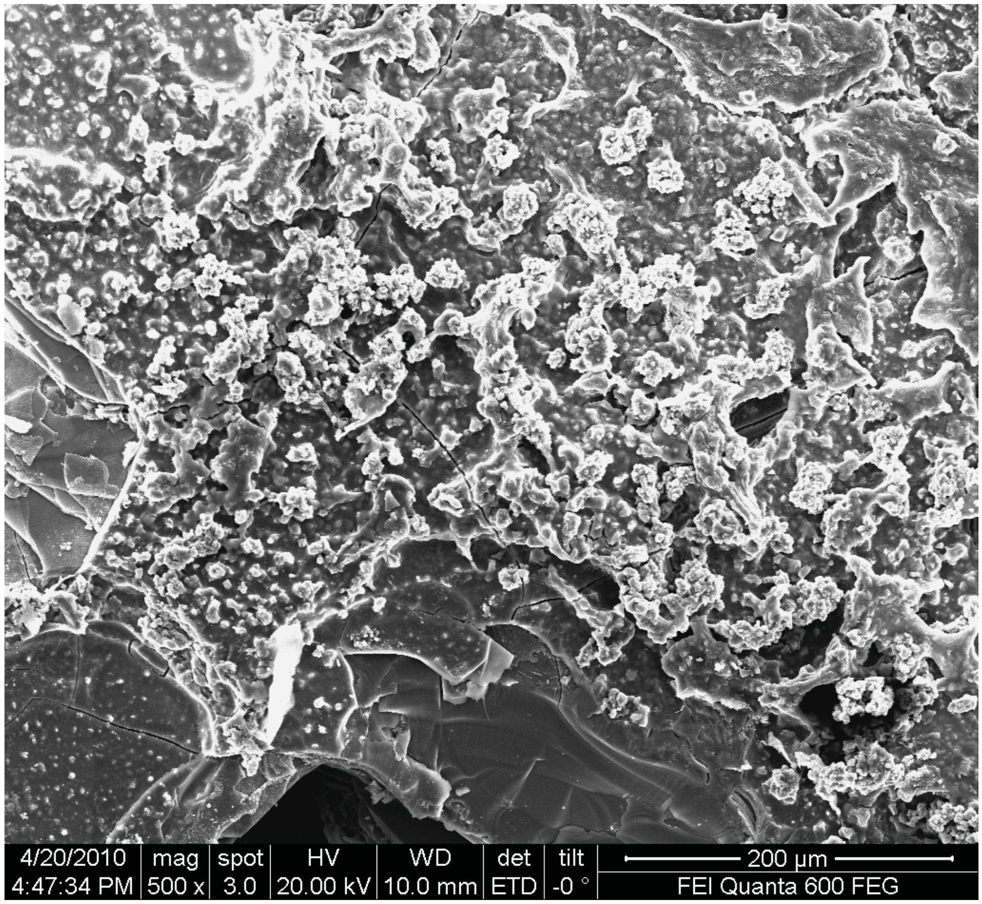
| | | | | | |
|---|---|---|---|---|---|
| Live Time: | 90.00 | Count Rate: | 348 | Dead Time: | 15.16 % |
| Beam Voltage: | 20.00 | Beam Current: | 2.00 | Takeoff Angle: | 49.25 |




| Element | keV | KRatio | Wt% | At% | At Prop | ChiSquared |
|---|---|---|---|---|---|---|
| Si | 1.740 | 0.5918 | 65.35 | 69.15 | 0.0 | 3.31 |
| S | 2.307 | 0.0574 | 8.81 | 8.16 | 0.0 | 2.74 |
| Ca | 3.691 | 0.0880 | 10.80 | 8.01 | 0.0 | 0.99 |
| Na | 1.041 | 0.0334 | 5.09 | 6.58 | 0.0 | 0.60 |
| Al | 1.487 | 0.0134 | 1.55 | 1.71 | 0.0 | 3.31 |
| K | 3.313 | 0.0669 | 8.41 | 6.39 | 0.0 | 0.99 |
| **Total** | | **0.8509** | **100.00** | **100.00** | **0.0** | **4.16** |

| Element | Gross (cps) | BKG (cps) | Overlap (cps) | Net (cps) | P:B Ratio |
|---|---|---|---|---|---|
| Si | 52.1 | 1.8 | 0.0 | 50.3 | 28.7 |
| S | 6.1 | 2.4 | 0.0 | 3.7 | 1.5 |
| Ca | 9.3 | 3.9 | 0.2 | 5.2 | 1.3 |
| Na | 3.5 | 1.1 | 0.0 | 2.5 | 2.3 |
| Al | 2.7 | 1.6 | 0.0 | 1.1 | 0.7 |
| K | 7.6 | 3.6 | 0.0 | 4.0 | 1.1 |

| Element | Z Corr | A Corr | F Corr |
|---|---|---|---|
| Si | 0.988 | 1.124 | 0.995 |
| S | 1.006 | 1.534 | 0.994 |
| Ca | 1.037 | 1.183 | 1.000 |
| Na | 0.990 | 1.565 | 0.984 |
| Al | 1.010 | 1.213 | 0.943 |
| K | 1.058 | 1.205 | 0.986 |

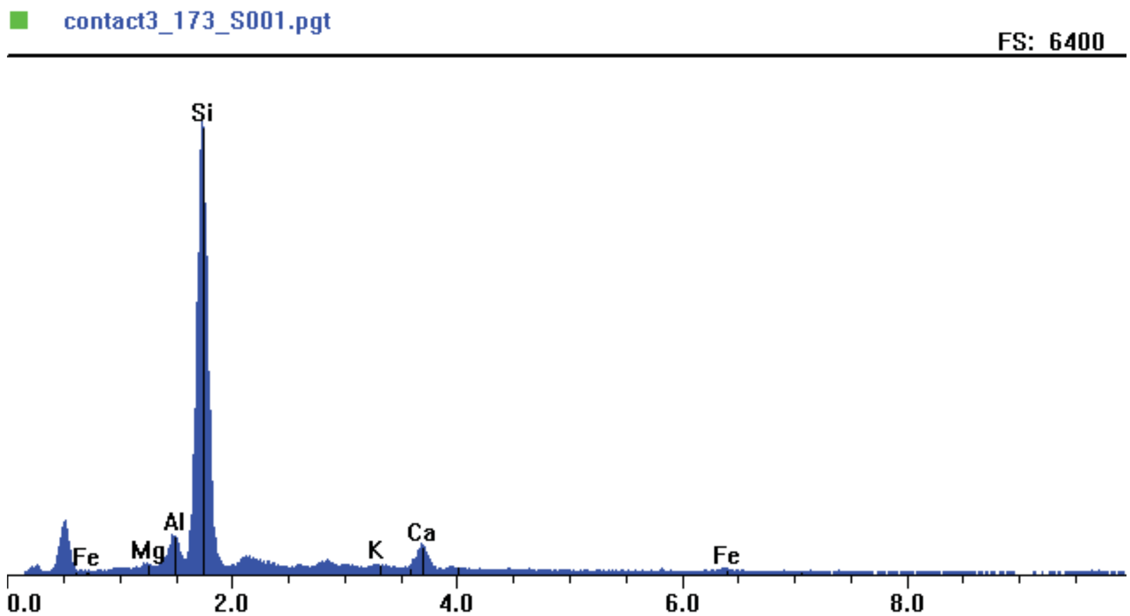


4/20/2010
4:47:34 PM
mag
500 x
spot
3.0
HV
20.00 kV
WD
10.0 mm
det
ETD
tilt
-0 °
200 µm
FEI Quanta 600 FEG

Spectrum Report
Tuesday, April 20, 2010

File: Sample2_area1
Collected: April 20, 2010 16:28:08

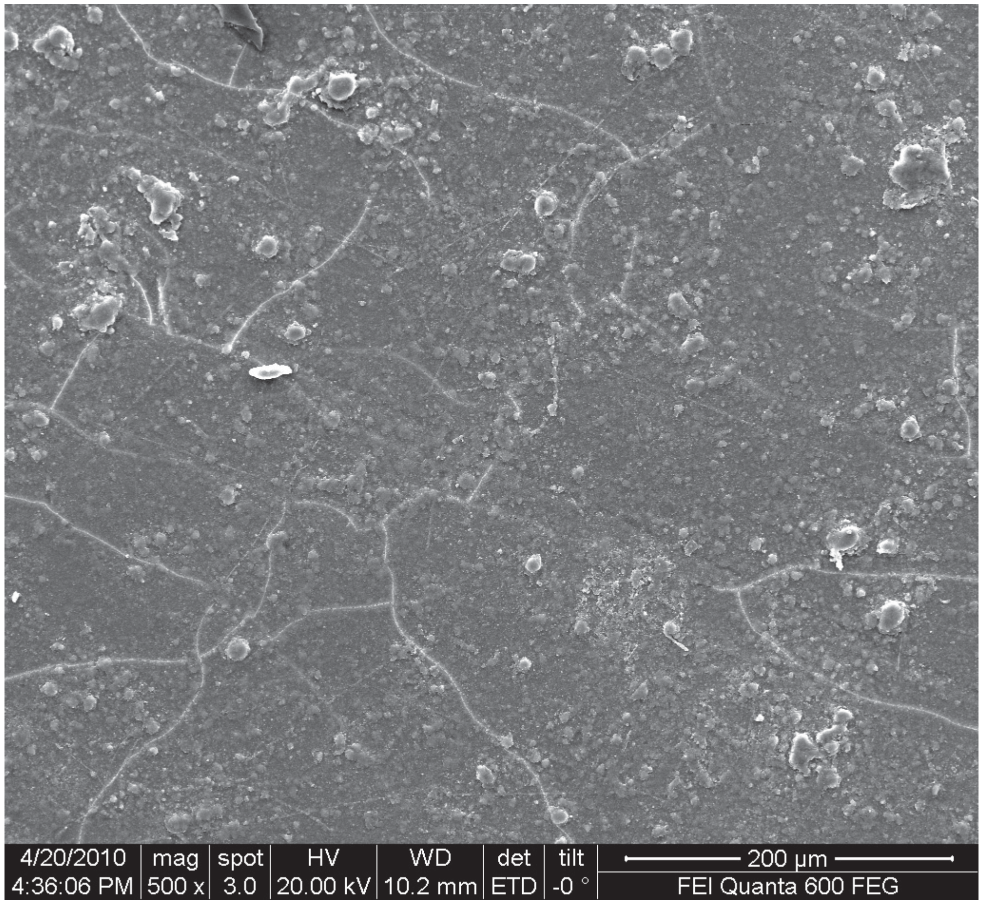
Live Time: 90.00 Count Rate: 1670 Dead Time: 24.26 %
Beam Voltage: 20.00 Beam Current: 2.00 Takeoff Angle: 49.25




| Element | keV | KRatio | Wt% | At% | At Prop | ChiSquared |
|---|---|---|---|---|---|---|
| Mg | 1.254 | 0.0088 | 1.01 | 1.20 | 0.0 | 28.45 |
| Al | 1.487 | 0.0569 | 6.04 | 6.47 | 0.0 | 28.45 |
| Si | 1.740 | 0.7472 | 83.22 | 85.66 | 0.0 | 28.45 |
| K | 3.313 | 0.0056 | 0.73 | 0.54 | 0.0 | 2.77 |
| Ca | 3.691 | 0.0594 | 7.19 | 5.18 | 0.0 | 2.77 |
| Fe | 6.403 | 0.0152 | 1.81 | 0.94 | 0.0 | 0.94 |
| **Total** | | **0.8932** | **100.00** | **100.00** | **0.0** | **37.70** |

| Element | Gross (cps) | BKG (cps) | Overlap (cps) | Net (cps) | P:B Ratio |
|---|---|---|---|---|---|
| Mg | 16.9 | 10.1 | 0.0 | 6.8 | 0.7 |
| Al | 59.2 | 12.8 | 0.0 | 46.4 | 3.6 |
| Si | 637.7 | 14.6 | 0.0 | 623.1 | 42.7 |
| K | 19.9 | 16.7 | 0.0 | 3.2 | 0.2 |
| Ca | 48.4 | 14.5 | 0.2 | 33.6 | 2.3 |
| Fe | 12.5 | 7.5 | 0.0 | 5.0 | 0.7 |

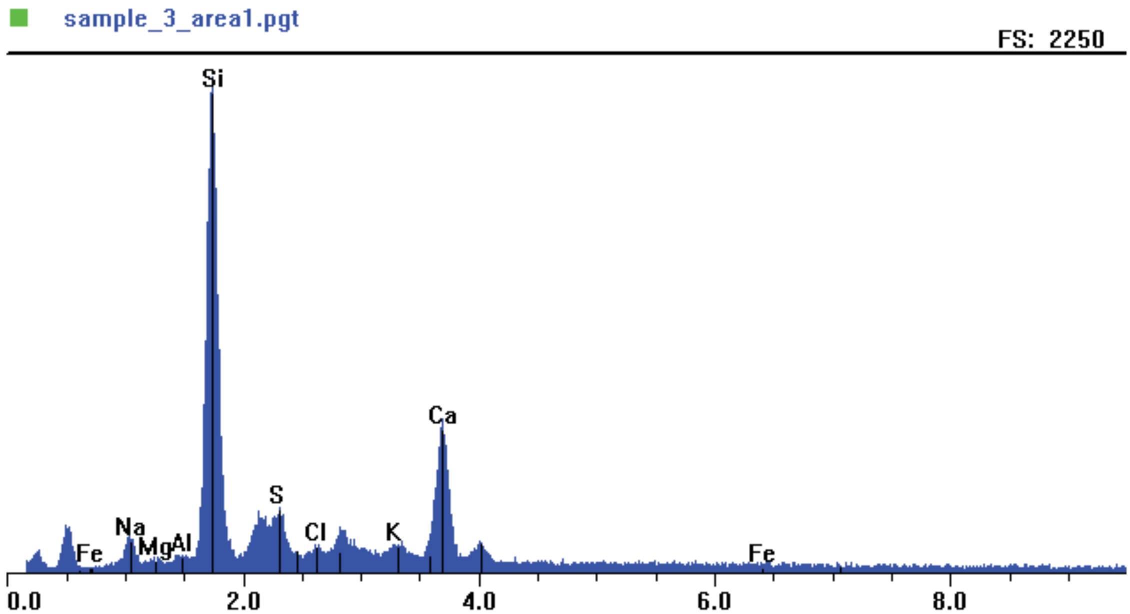
| Element | Z Corr | A Corr | F Corr |
|---|---|---|---|
| Mg | 0.979 | 1.229 | 0.954 |
| Al | 1.015 | 1.127 | 0.928 |
| Si | 0.993 | 1.123 | 0.999 |
| K | 1.064 | 1.224 | 0.989 |
| Ca | 1.043 | 1.160 | 0.999 |
| Fe | 1.160 | 1.026 | 1.000 |


4/20/2010
4:36:06 PM
mag
500 x
spot
3.0
HV
20.00 kV
WD
10.2 mm
det
ETD
tilt
-0 °
200 μm
FEI Quanta 600 FEG

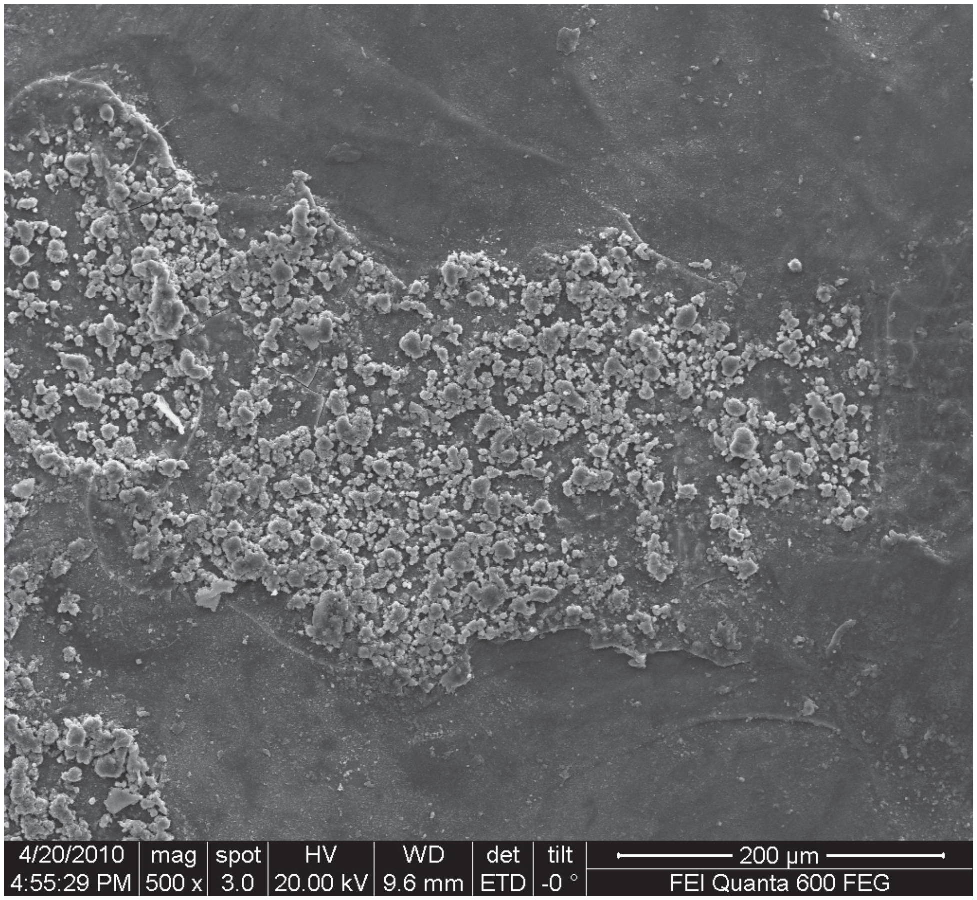
Spectrum Report
Tuesday, April 20, 2010

File: Y:\Architectural Conservation\Yara\Glass_3\sample_3_area1.pgt
Collected: April 20, 2010 16:56:02

| | | | | | |
|---|---|---|---|---|---|
| Live Time: | 90.00 | Count Rate: | 1064 | Dead Time: | 20.55 % |
| Beam Voltage: | 20.00 | Beam Current: | 2.00 | Takeoff Angle: | 49.25 |




| Element | keV | KRatio | Wt% | At% | At Prop | ChiSquared |
|---|---|---|---|---|---|---|
| Na | 1.041 | 0.0526 | 8.78 | 11.76 | 0.0 | 17.05 |
| Si | 1.740 | 0.3417 | 38.46 | 42.18 | 0.0 | 17.05 |
| S | 2.307 | 0.2000 | 27.04 | 25.97 | 0.0 | 19.66 |
| Ca | 3.691 | 0.1796 | 21.45 | 16.48 | 0.0 | 5.24 |
| Al | 1.487 | 0.0015 | 0.19 | 0.22 | 0.0 | 17.05 |
| Fe | 6.403 | 0.0035 | 0.42 | 0.23 | 0.0 | 1.13 |
| K | 3.313 | 0.0127 | 1.58 | 1.24 | 0.0 | 5.24 |
| Mg | 1.254 | 0.0020 | 0.29 | 0.36 | 0.0 | 17.05 |
| Cl | 2.622 | 0.0120 | 1.79 | 1.55 | 0.0 | 19.66 |
| **Total** | | **0.8056** | **100.00** | **100.00** | **0.0** | **11.71** |



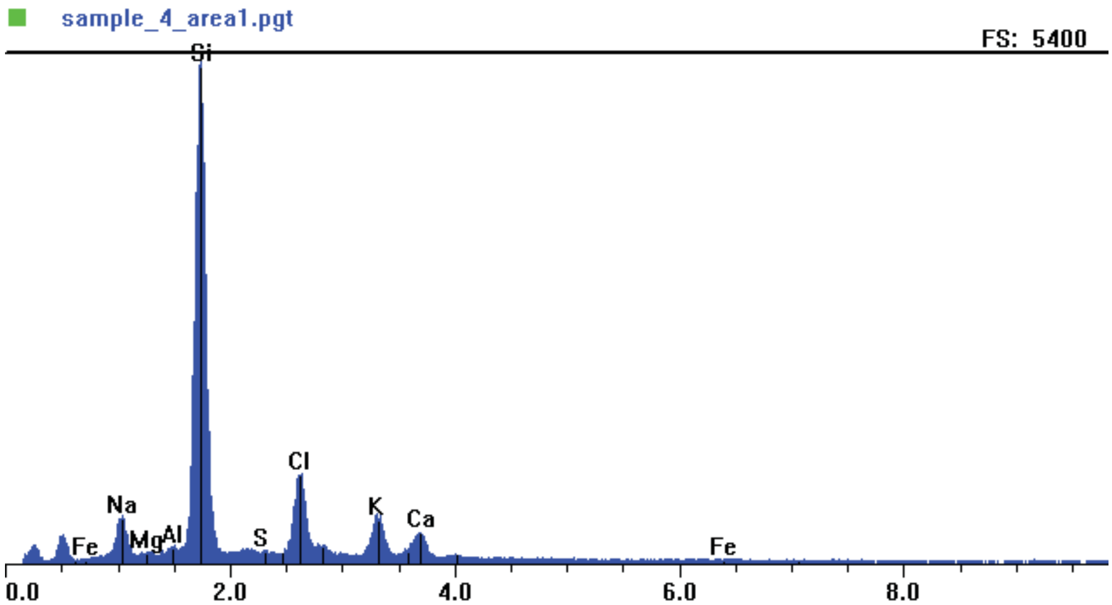

| Element | Gross (cps) | BKG (cps) | Overlap (cps) | Net (cps) | P:B Ratio |
|---|---|---|---|---|---|
| Na | 17.1 | 5.3 | 0.0 | 11.8 | 2.2 |
| Si | 242.7 | 10.7 | 0.0 | 231.9 | 21.6 |
| S | 38.0 | 14.0 | 0.0 | 24.1 | 1.7 |
| Ca | 83.1 | 12.5 | 0.3 | 70.4 | 5.6 |
| Al | 9.9 | 9.0 | 0.0 | 0.9 | 0.1 |
| Fe | 7.8 | 6.7 | 0.0 | 1.1 | 0.2 |
| K | 18.9 | 14.7 | 0.0 | 4.3 | 0.3 |
| Mg | 7.6 | 6.8 | 0.0 | 0.9 | 0.1 |
| Cl | 17.0 | 14.6 | 0.1 | 2.3 | 0.2 |

| Element | Z Corr | A Corr | F Corr |
|---|---|---|---|
| Na | 0.985 | 1.713 | 0.990 |
| Si | 0.982 | 1.161 | 0.987 |
| S | 1.001 | 1.362 | 0.991 |
| Ca | 1.032 | 1.158 | 1.000 |
| Al | 1.004 | 1.294 | 0.962 |
| Fe | 1.147 | 1.043 | 1.000 |
| K | 1.052 | 1.214 | 0.969 |
| Mg | 0.969 | 1.509 | 0.979 |
| Cl | 1.051 | 1.437 | 0.988 |

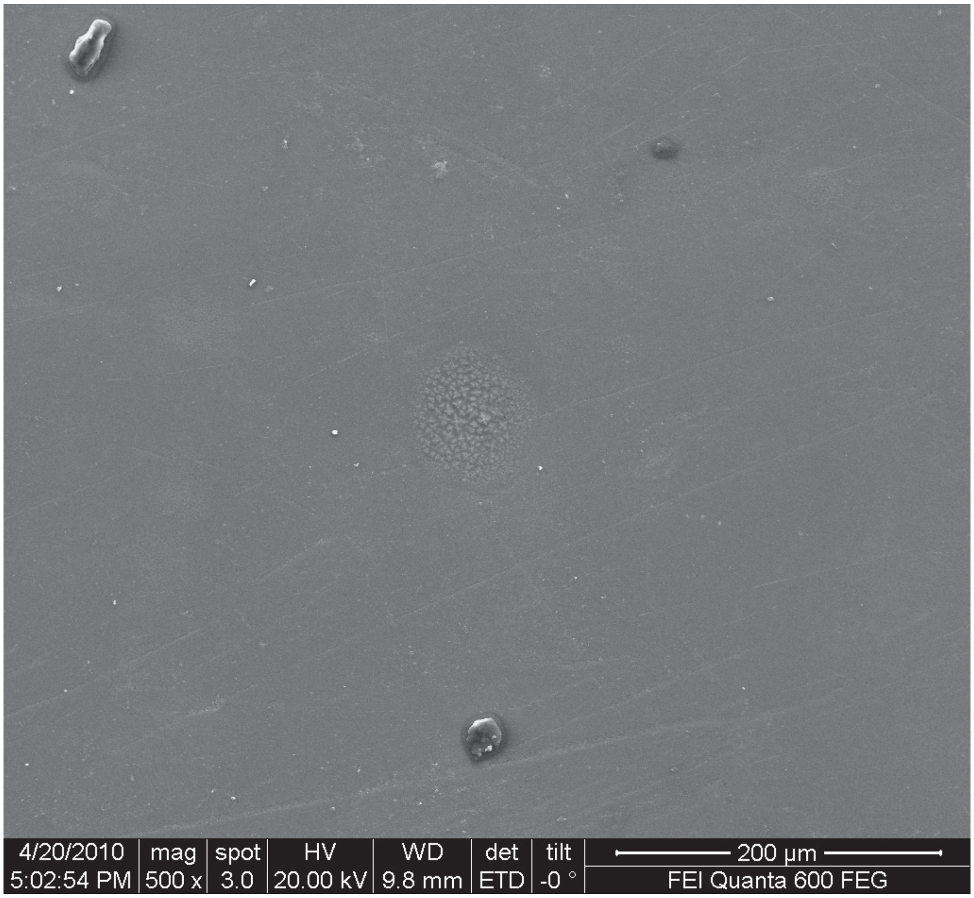
Spectrum Report
Tuesday, April 20, 2010

File: Y:\Architectural Conservation\Yara\Glass_4\sample_4_area1.pgt
Collected: April 20, 2010 17:03:27

| | | | | | |
|---|---|---|---|---|---|
| Live Time: | 90.00 | Count Rate: | 1758 | Dead Time: | 24.86 % |
| Beam Voltage: | 20.00 | Beam Current: | 2.00 | Takeoff Angle: | 49.25 |




| Element | keV | KRatio | Wt% | At% | At Prop | ChiSquared |
|---|---|---|---|---|---|---|
| Na | 1.041 | 0.0510 | 7.57 | 9.85 | 0.0 | 24.93 |
| Si | 1.740 | 0.5385 | 58.87 | 62.73 | 0.0 | 24.93 |
| S | 2.307 | 0.0004 | 0.06 | 0.05 | 0.0 | 7.88 |
| Ca | 3.691 | 0.0384 | 4.77 | 3.56 | 0.0 | 5.21 |
| Al | 1.487 | 0.0072 | 0.83 | 0.92 | 0.0 | 24.93 |
| Fe | 6.403 | 0.0029 | 0.35 | 0.19 | 0.0 | 1.09 |
| K | 3.313 | 0.0668 | 8.64 | 6.62 | 0.0 | 5.21 |
| Mg | 1.254 | 0.0023 | 0.29 | 0.36 | 0.0 | 24.93 |
| Cl | 2.622 | 0.1312 | 18.62 | 15.72 | 0.0 | 7.88 |
| **Total** | | **0.8386** | **100.00** | **100.00** | **0.0** | **16.61** |



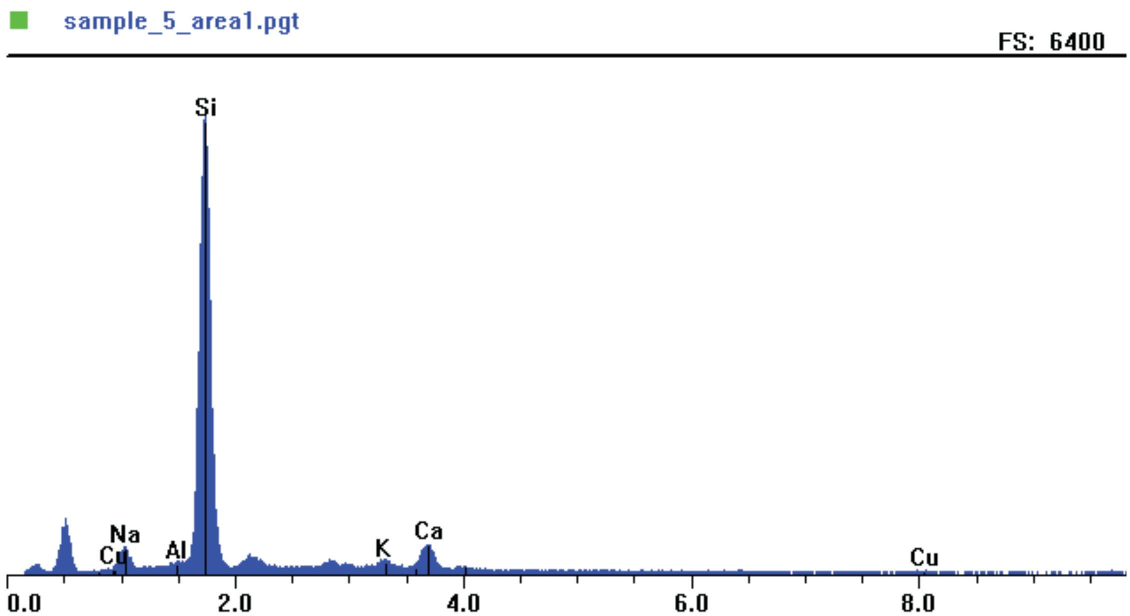

| Element | Gross (cps) | BKG (cps) | Overlap (cps) | Net (cps) | P:B Ratio |
|---|---|---|---|---|---|
| Na | 58.5 | 11.5 | 0.0 | 47.0 | 4.1 |
| Si | 606.6 | 17.2 | 0.0 | 589.4 | 34.2 |
| S | 20.2 | 19.9 | 0.0 | 0.3 | 0.0 |
| Ca | 46.9 | 14.9 | 2.9 | 29.1 | 2.0 |
| Al | 24.3 | 16.5 | 0.0 | 7.8 | 0.5 |
| Fe | 8.4 | 7.1 | 0.0 | 1.2 | 0.2 |
| K | 68.5 | 17.3 | 0.0 | 51.2 | 3.0 |
| Mg | 15.7 | 13.3 | 0.0 | 2.4 | 0.2 |
| Cl | 120.9 | 20.6 | 0.0 | 100.3 | 4.9 |

| Element | Z Corr | A Corr | F Corr |
|---|---|---|---|
| Na | 0.985 | 1.533 | 0.984 |
| Si | 0.982 | 1.120 | 0.994 |
| S | 1.000 | 1.523 | 0.986 |
| Ca | 1.031 | 1.205 | 1.000 |
| Al | 1.004 | 1.218 | 0.943 |
| Fe | 1.147 | 1.032 | 1.000 |
| K | 1.052 | 1.237 | 0.994 |
| Mg | 0.968 | 1.390 | 0.967 |
| Cl | 1.050 | 1.361 | 0.993 |

Spectrum Report
Tuesday, April 20, 2010

File: Y:\Architectural Conservation\Yara\Glass_5\sample_5_area1.pgt
Collected: April 20, 2010 17:10:46

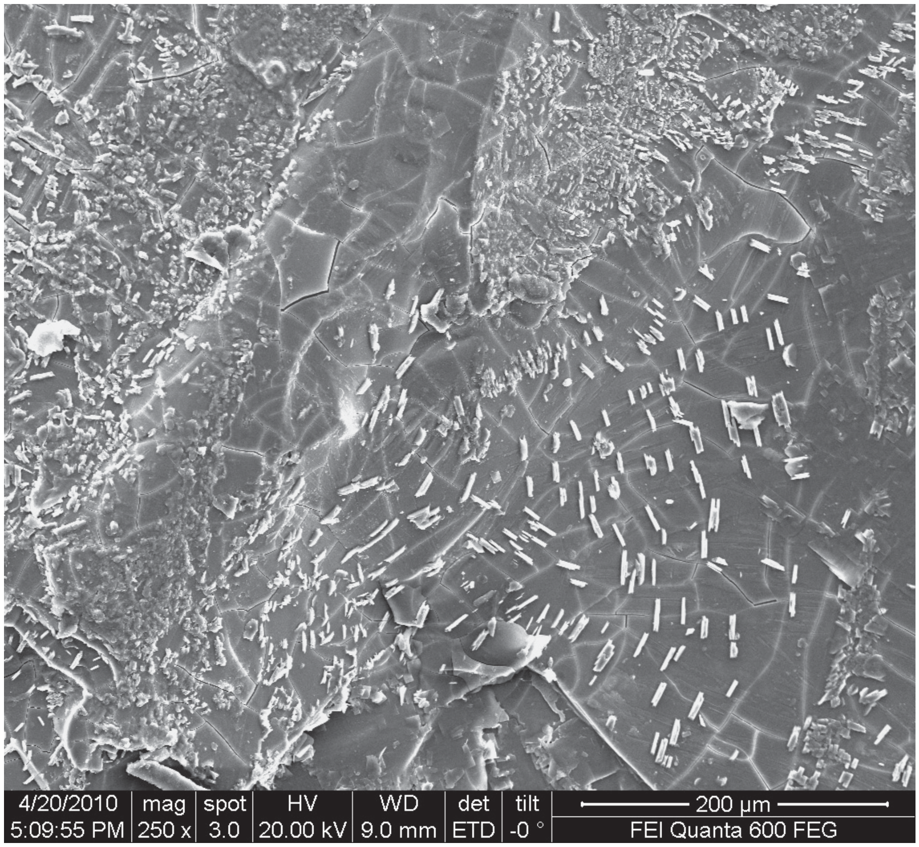
| | | | | | |
|---|---|---|---|---|---|
| Live Time: | 90.00 | Count Rate: | 1642 | Dead Time: | 24.01 % |
| Beam Voltage: | 20.00 | Beam Current: | 2.00 | Takeoff Angle: | 49.25 |




| Element | keV | KRatio | Wt% | At% | At Prop | ChiSquared |
|---|---|---|---|---|---|---|
| Na | 1.041 | 0.0437 | 6.30 | 7.87 | 0.0 | 0.86 |
| Si | 1.740 | 0.7425 | 81.54 | 83.39 | 0.0 | 30.97 |
| K | 3.313 | 0.0177 | 2.26 | 1.66 | 0.0 | 2.40 |
| Ca | 3.691 | 0.0624 | 7.55 | 5.41 | 0.0 | 2.40 |
| Cu | 8.046 | 0.0111 | 1.35 | 0.61 | 0.0 | 0.80 |
| Al | 1.487 | 0.0088 | 0.99 | 1.06 | 0.0 | 30.97 |
| **Total** | | **0.8862** | **100.00** | **100.00** | **0.0** | **38.98** |

| Element | Gross (cps) | BKG (cps) | Overlap (cps) | Net (cps) | P:B Ratio |
|---|---|---|---|---|---|
| Na | 38.0 | 9.4 | 0.0 | 28.5 | 3.0 |
| Si | 653.7 | 14.6 | 0.0 | 639.0 | 43.7 |
| K | 26.4 | 16.2 | 0.0 | 10.2 | 0.6 |
| Ca | 51.4 | 14.4 | 0.6 | 36.4 | 2.5 |
| Cu | 8.3 | 5.8 | 0.0 | 2.5 | 0.4 |
| Al | 21.4 | 13.9 | 0.0 | 7.4 | 0.5 |

| Element | Z Corr | A Corr | F Corr |
|---|---|---|---|
| Na | 0.996 | 1.477 | 0.980 |
| Si | 0.993 | 1.108 | 0.999 |
| K | 1.063 | 1.216 | 0.989 |
| Ca | 1.043 | 1.161 | 1.000 |
| Cu | 1.207 | 1.008 | 1.000 |
| Al | 1.015 | 1.198 | 0.928 |


4/20/2010
5:09:55 PM
mag
250 x
spot
3.0
HV
20.00 kV
WD
9.0 mm
det
ETD
tilt
-0 °
200 µm
FEI Quanta 600 FEG

# APPENDIX I

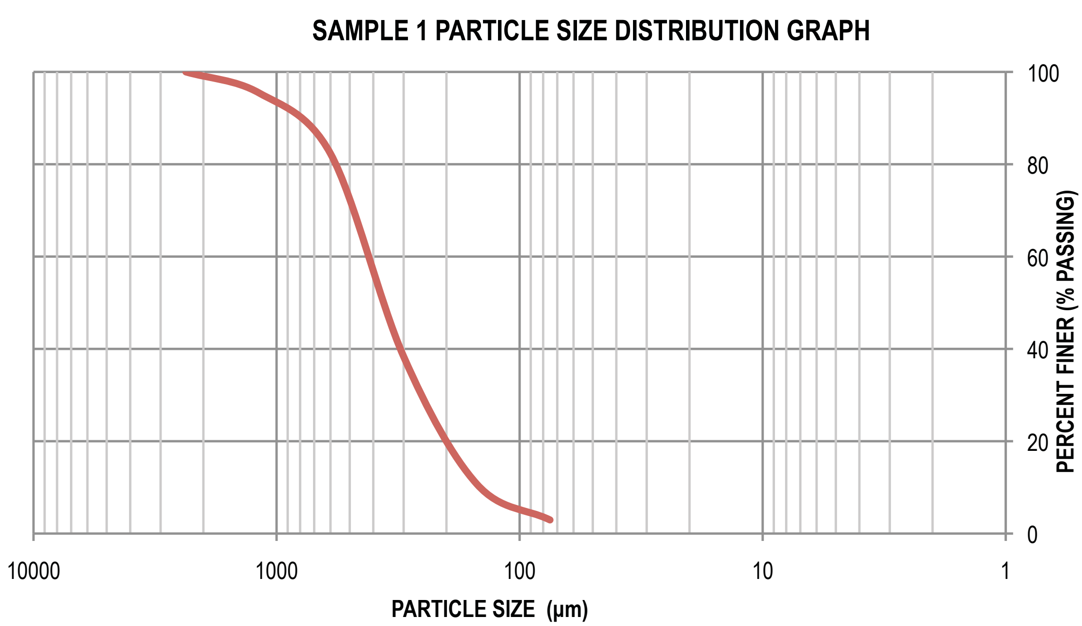
**ARCHITECTURAL CONSERVATION LABORATORY**
**UNIVERSITY OF PENNSYLVANIA**

**MORTAR ANALYSIS**

| | | | |
|---|---|---|---|
| Project/Site: **VILLA CAPARRA, PUERTO RICO** | | | |
| Location: **COLUMN OF PORTA-COCHERE** | | Date Sampled: | |
| Analysis Performed By: **YH** | | Date Analyzed: **APRIL 18, 2010** | |
| **DESCRIPTION OF SAMPLE** | | | |
| Type/Location: **SUBSTRATE** | | **SAMPLE No. C** | |
| Surface Appearance: | | | |
| Cross Section: | | | |
| Color: | | Texture: | |
| Hardness: **HIGH** | | Gross Wgt.: **20.00 g** | |
| **COMPONENTS** | | | |
| Fines: | Color: **7.5YR 5/8 STRONG BROWN** | Wgt.: **3.47 g** | Wgt. %: **17.35%** |
| | Organic Matter: | | |
| | Composition: | | |
| Acid Soluble Fraction: | Wgt: **12.80 g** | | Wgt. %: |
| | Desc. Of reaction: **HIGHLY REACTIVE TO HCL** | | Filtrate Color: **64.00%** |
| | Composition: | | |
| Aggregate: | Color: | Wgt.: **3.73 g** | Wgt. %: **18.65%** |
| | Grain Shape: **SUB-ANGULAR & SUB-ROUNDED** | | |
| | Mineralogy: | | |
| | Sieve analysis: | Screen | % Retained |
| | | 8 | **0%** |
| | | 16 | **4.55%** |
| | | 30 | **17.69%** |
| | | 50 | **61.66%** |
| | | 100 | **89.27%** |
| | | 200 | **97.05%** |
| | | pan | **100%** |
| **ASSESSMENT** | | | |
| Mortar Type: | | | |
| Fines:<br>Acid Soluble:<br>Aggregate:<br>**MATCHES :** | | | |

**SAMPLE:SB** **20.00g (Ms)**

| SIEVE NUMBER | SCREEN SIZE | Mc (g) | M2 (g) | Mr (g) | %Mr | %Mrt | %Mpt |
|---|---|---|---|---|---|---|---|
| 8 | 2360 | 0 | 0 | 0 | 0 | 0 | 100 |
| 16 | 1180 | 0.57 | 0.74 | 0.17 | 4.557640751 | 4.557640751 | 95.44235925 |
| 30 | 600 | 0.57 | 1.06 | 0.49 | 13.13672922 | 17.69436997 | 82.30563003 |
| 50 | 300 | 0.58 | 2.22 | 1.64 | 43.96782842 | 61.66219839 | 38.33780161 |
| 100 | 150 | 0.59 | 1.62 | 1.03 | 27.61394102 | 89.27613941 | 10.72386059 |
| 200 | 75 | 0.59 | 0.88 | 0.29 | 7.774798928 | 97.05093834 | 2.949061662 |
| pan | 0 | 0.59 | 0.7 | 0.11 | 2.949061662 | 100 | 0 |



**ARCHITECTURAL CONSERVATION LABORATORY**
**UNIVERSITY OF PENNSYLVANIA**

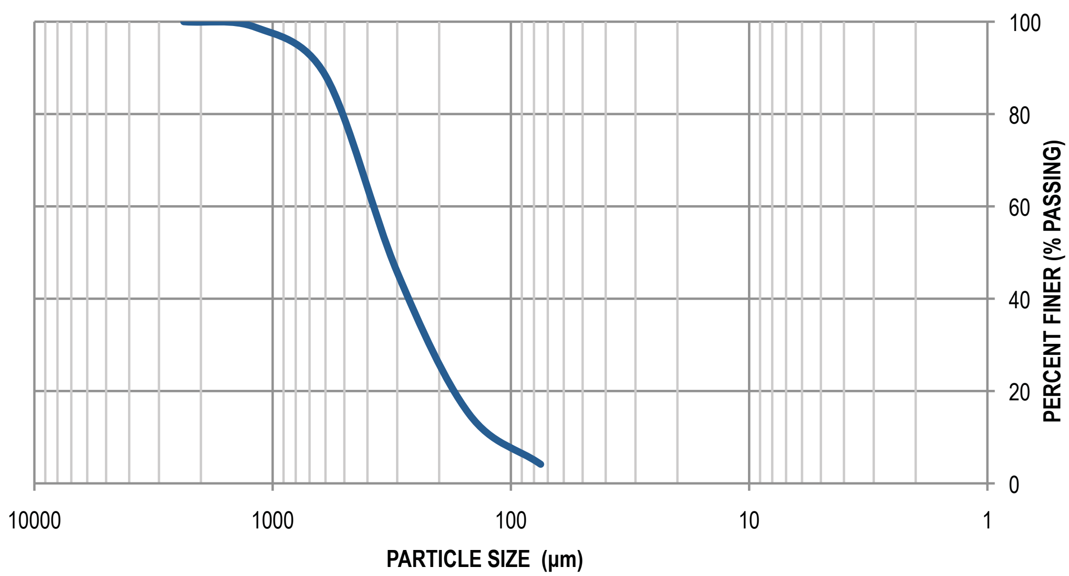
**MORTAR ANALYSIS**

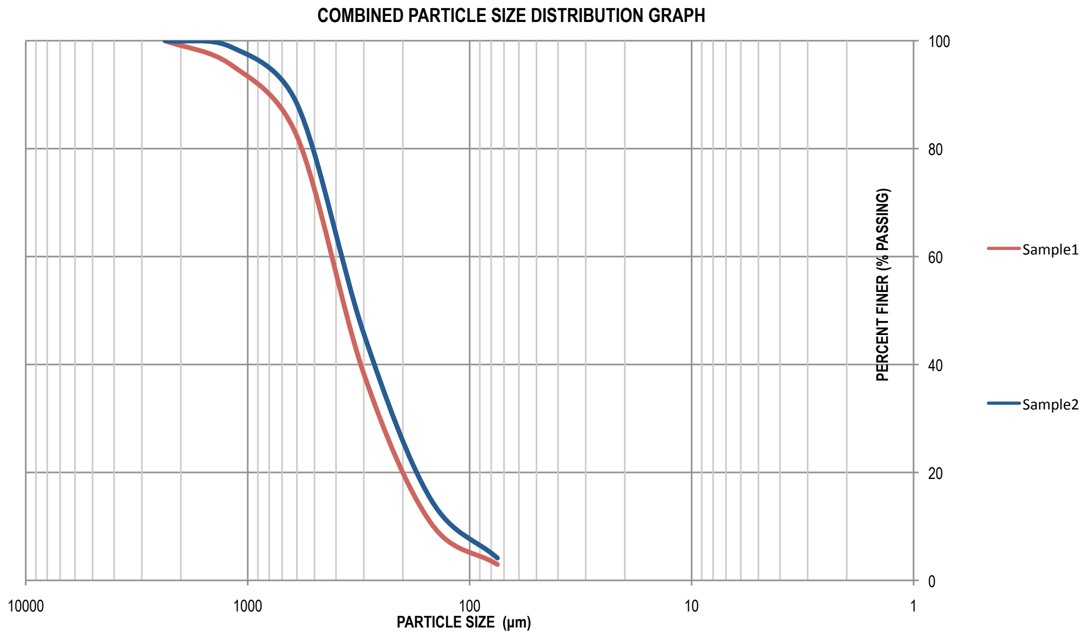
| | | | |
|---|---|---|---|
| Project/Site: **VILLA CAPARRA, PUERTO RICO** | | | |
| Location: **COLUMN OF PORTA-COCHERE** | | Date Sampled: | |
| Analysis Performed By: **YH** | | Date Analyzed: **APRIL 18, 2010** | |
| **DESCRIPTION OF SAMPLE** | | | |
| Type/Location: **BEDDING MORTAR** | | **SAMPLE No. C** | |
| Surface Appearance: | | | |
| Cross Section: | | | |
| Color: | | Texture: | |
| Hardness: **HIGH** | | Gross Wgt.: **20.00 g** | |
| **COMPONENTS** | | | |
| Fines: | Color: **2.5YR 8/4 PALE YELLOW** | Wgt.: **3.84 g** | Wgt. %: **19.20%** |
| | Organic Matter: | | |
| | Composition: | | |
| Acid Soluble Fraction: | Wgt: **12.05 g** | | Wgt. %: **60.25%** |
| | Desc. Of reaction: **REACTIVE TO HCL** | | Filtrate Color: |
| | Composition: | | |
| Aggregate: | Color: | Wgt.: **4.11 g** | Wgt. %: **20.55%** |
| | Grain Shape: **SUB-ROUNDED** | | |
| | Mineralogy: | | |
| | Sieve analysis: | Screen | % Retained |
| | | 8 | **0%** |
| | | 16 | 1.21% |
| | | 30 | **11.67%** |
| | | 50 | **54.25%** |
| | | 100 | **84.91%** |
| | | 200 | **95.86%** |
| | | pan | **99.75%** |
| **ASSESSMENT** | | | |
| Mortar Type: | | | |
| Fines:<br>Acid Soluble:<br>Aggregate:<br>**MATCHES :** | | | |

**SAMPLE BM** **20.00g (Ms)**

| SIEVE NUMBER | SCREEN SIZE | Mc (g) | M2 (g) | Mr (g) | %Mr | %Mrt | %Mpt |
|---|---|---|---|---|---|---|---|
| 8 | 2360 | 0 | 0 | 0 | 0 | 0 | 100 |
| 16 | 1180 | 0.55 | 0.6 | 0.05 | 1.216545012 | 1.216545012 | 98.78345499 |
| 30 | 600 | 0.58 | 1.01 | 0.43 | 10.4622871 | 11.67883212 | 88.32116788 |
| 50 | 300 | 0.57 | 2.32 | 1.75 | 42.57907543 | 54.25790754 | 45.74209246 |
| 100 | 150 | 0.57 | 1.83 | 1.26 | 30.65693431 | 84.91484185 | 15.08515815 |
| 200 | 75 | 0.56 | 1.01 | 0.45 | 10.94890511 | 95.86374696 | 4.136253041 |
| pan | 0 | 0.57 | 0.73 | 0.16 | 3.892944039 | 99.756691 | 0.243309002 |

**SAMPLE 2 PARTICLE SIZE DISTRIBUTION GRAPH**




COMBINED PARTICLE SIZE DISTRIBUTION GRAPH
100
80
60
40
20
0
PERCENT FINER (% PASSING)
10000
1000
100
10
1
PARTICLE SIZE (µm)
Sample1
Sample2

**Symbols**



**A**



**B**



**C**

**O**



**P**



**R**



**S**

**T**



**U**



**V**



**W**



**X**