FINAL REPORT

MMS-CONSOL: Concrete Solutions

A standard-setting project for graffiti management, surface cleaning and patch repair of historic concrete, utilizing the Miami Marine Stadium as a test site.

Prepared for:

Friends of Miami Marine Stadium
337 Palermo Avenue
Coral Gables, FL 33134
Attn: Larry Johnson and Jorge Hernandez
jorge@jlharchitect.com

Getty Foundation
1200 Getty Center Drive, Suite 800
Los Angeles, CA 90049-1685
Attn: Antoine Wilmering, Senior Program Officer

Prepared by:
RLA Conservation, Inc.
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The Getty Foundation

Keeping It Modern

TRANSMITTAL LETTER

Friends of Miami Marine Stadium
Attn: Jorge Hernandez
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RLA Conservation, Inc.
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cc:
Getty Foundation
Keeping it Modern Initiative
Attn: Antoine Wilmering, Senior Program Officer
1200 Getty Center Drive, Suite 800
Los Angeles, CA 90049-1685

February 29, 2016

Re: MMS-CONSOL: Concrete Solutions - a standard-setting project for graffiti management, surface cleaning and patch repair of historic concrete utilizing the Miami Marine Stadium as a test site.

Dear Jorge,

It is with great pleasure that the MMS-CONSOL Project Team submits its final report to the Friends of the Miami Marine Stadium (FoMMS), in fulfilment of the Getty Foundation's *Keeping It Modern* grant.

Please review the attached document, and if found to be satisfactory, forward a copy to Ton Wilmering at the Getty Center in Los Angeles. We shall follow up with our financial report shortly so that your application for the final grant payment can be made in due course.

As you are aware, the project team faced increasing and unforeseen challenges in carrying out our planned work at the Stadium. First of all, our test sites were attacked by vandals, and subsequently the City of Miami refused all and any access to the Stadium due to changes of administrative policy which we deemed short-sighted. Nonetheless, we have been able to achieve most of our original goals and can provide the FoMMS and the City with model technical approaches and specifications to aid in the Stadium's restoration in due course.

We had hoped to include with our work a model demonstration of a visually minimalized cathodic protection scheme for the reinforced concrete, i.e., extra over our original planned commitments. But the contractors we invited to join the project were not able to offer an appropriate response in the time allowed. So we would encourage the FoMMS to persuade the City to carry out its own mockup trials well in advance of the main civil engineering contract works, as part of enabling activities, once the main refurbishment of the site gets underway. And if we can assist with the design and specification of such a trial, we should be happy to do so.

Sincerely,

Rosa Lowinger
MMS-CONSOL Project Manager
Rosa Lowinger & Associates

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BUILDING DETAILS:

Building: Commodore Ralph Middleton Munroe Miami Marine Stadium

Location: Rickenbacker Causeway, Virginia Key, Miami, FL (25.74295oN 80.169865oW)

Architect: Hilario Candela (b. 1934, Havana, Cuba), resident of Coral Gables, FL

Engineer: The late Jack Meyer P.E., of Norman Dignum Associates S.E., Coral Gables, FL

Date: Designed 1962, built 1962-3, opened 27 December 1963

Owner: City of Miami, FL has been the building's only owner.

Use: Originally used as a purpose-built stadium for speedboat racing and as a concert venue, the building has been abandoned and shuttered since 1992. Graffiti artists and muralists jump the fence daily and paint tags and murals on the building's walls. At present the basin and site around the building are being prepared to host the 2016 and 2017 editions of the Miami Boat Show.

1.0 INTRODUCTION

1.1 This report presents the methodology and findings of the MMS-CONSOL Concrete Solutions project to set standards for graffiti management, surface cleaning and patch repair of historic concrete, utilizing the Miami Marine Stadium as a test site. The project was funded through grant aid to the Friends of the Miami Marine Stadium (FOMMS) by the Getty Foundation under the latter's *Keeping it Modern* initiative, and was conducted by the authors from October 2014 to November 10, 2015, to examine and test vital aesthetic and technical conservation protocols for the rehabilitation and long-term protection of the iconic structure.

1.2 The Miami Marine Stadium is a bold Modernist building designed by Cuban-American architect, Hilario Candela in 1963. Abandoned, fenced-off, and steadily deteriorating since 1992, the Stadium was threatened for many years by understandable though ill-informed safety concerns following hurricanes and years of neglect. However, the iconic Stadium was eventually saved from demolition by the FoMMS, and others, who commissioned detailed engineering studies that proved the building to be stable and economically viable, subject to various structural and other repairs.

1.3 The Stadium is now locally landmarked as a building of singular significance to the City of Miami. Its local and national popularity has greatly increased because of the Art World's interest in tags and graffiti being illegally applied at the site. The Stadium is currently slated to be renovated as part of a project to convert the site into a venue to host the Miami Boat Show, a huge annual event that draws more visitors to the city than any other. The plans include the cleaning and conservation of the stadium and the retrofitting of its sound and technical systems for future use as a concert and event venue.

1.4 However, the focus of the remedial works is likely to be a Design-Build program of large-scale structural and civil engineering. While the proposed engineering solutions will undoubtedly improve public safety and extend the useful life of the property, no thought has yet been given to sustaining the values and significance of the historic structure's surface appearance upon which the original designer lavished so much care and attention.

1.5 Industry-standard engineering solutions to deteriorated reinforced concrete leave a lot to be desired in terms of historic preservation. The patch repair of concrete surfaces, especially, is almost universally poorly implemented so that colors and textures fail to match the original weathered appearance of the principal character-defining feature of many Modernist mid- twentieth century buildings. The stock response is usually to recommend over-painting to conceal the mismatch.

1.6 While structural engineering remediation is generally well-thought through and effectively implemented in most large engineering projects, aesthetic considerations are never usually paramount. The design development, construction documentation and construction administration phases of construction project implementation rarely focus on concerns for surface color and texture and are therefore usually under-budgeted for time and expense for the type of pilot trial treatment development work that we proposed in our study.

1.7 We therefore proposed to FOMMS and to the Getty Foundation that there was an urgent need to define a conservation-driven plan for the careful cleaning and surface repair of the Stadium's important architectural surfaces. The underlying aim of the project has been to develop methodologies for conservation that can inform the upcoming Request for Proposals (RFP) that will be prepared by the City of Miami in 2016 / 2017 for the building's repair.

1.8 Following careful study and analysis of the building's fabric, the major part of our research and development activities has been to define protocols for hands-on conservation work. These have included: trials of multi-layered graffiti removal; cleaning of dirt, grime, and biological growths; field tests of anti-graffiti barrier systems; tests of means to protect valuable graffiti; and field and workshop mockups of structural and cosmetic patch repairs to concrete. As part of this work, and at the express request of the Getty Foundation, we also organized and conducted a half-day public symposium with experts in street art at the AIA/ Miami Center for Architecture and Design.

2.0 HISTORY OF THE STADIUM:

2.1 In order to appreciate and understand the values and significance of the Stadium's concrete fabric, it is essential to know about and appreciate the genesis of the original building's design, and its designers' intent.

Origins:

2.2 In 1962, the City of Miami Commission hired the Chicago firm of Ralph H. Burke Engineers and Architects to create a master plan for a recreational landscape on Virginia Key intended to turn Miami into the speedboat racing capital of the world. The plan produced by the firm included a grandstand and purpose built racecourse for speedboat racing. The firm's report determined that there was no other facility of this type in the entire world, and that the local water sports culture would make the stadium an economic and public success. The report also found that the selected site on Virginia Key was sufficiently protected from winds to provide optimum conditions for boat racing.

2.3 Burke's proposal called for the dredging of an oval racecourse shaped like Rome's Circus Maximus that measured 6,000 x 1,200 feet - the size of the National Mall in Washington, DC and would be oriented northwest-southeast. The city hired a local firm, Dignum Engineers, to come up with the plan for a grandstand. At the time, it was common for engineers to spearhead municipal construction projects, and Dignum chose Jack Meyer to spearhead the project from an engineering standpoint. They also partnered with the Miami architectural firm of Pancoast, Ferendino, Skeels and Burnham, a firm that was becoming well-known for civic projects of quality and design. Managing partner Andrew Ferendino chose 27-year old Hilario Candela, a recent Cuban arrival, to design the grandstand. Candela and Meyer came up with a boldly avant-garde, exposed concrete building featuring a 326-foot-long roof consisting of eight joint-folded hyperbolic-paraboloid (hypar) shells that were the longest span of cantilevered concrete in its day.

Design Antecedents:

2.4 According to Candela, whom Rosa Lowinger has interviewed at length about the project, the dramatic design was an aesthetic culmination of two related professional interests. The first of these was the use of structure "not as a tool to support a building but as a visible architectonic expression." The second was Candela's self-described "love affair with concrete." [1] Candela's fascination with engineered concrete began in the mid-1950s when he was a student at Georgia Tech. As he described it in several communications with Lowinger, "the great figures of world architecture like Neutra and Frank Lloyd Wright" [2] would come through Atlanta to impart workshops to the students. For Candela, the most stimulating of those encounters were with the practitioners who experimented with thin concrete structures, in particular the Italian structural engineer, Pier Luigi Nervi, Spanish structural engineer Eduardo Toroja, and Spanish-Mexican architect Félix Candela. Hilario would form lifelong friendships with both Toroja and Félix Candela. The influence of Toroja's striking 1935 Zarzuela Hippodrome is echoed in the Marine Stadium's design.

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[1] Rosa Lowinger interview with Hilario Candela October 3, 2011

[2] Ibid

2.5 In summers, Candela would return to Havana to fulfill the apprenticeship requirement of his studies. Working at the firm of fellow Georgia Tech graduate Max Borges, Jr., designer of the 1952 *Arcos de Cristal* indoor nightclub at the Tropicana Cabaret, Candela joined what was the inner circle of Cuba's innovative experimenters with thin shell concrete and expressive roof lines. After graduation, Candela returned to Cuba and joined SACMAG, a firm formed by his boyhood friends Raúl Alvarez and Enrique Gutíerrez in collaboration with engineer Luis Saenz. Considered experts in the design of highly complex roofs for residential properties, the firm changed course less than a year later, when the Cuban revolution halted all private construction. Assigned to take over the design of Havana's National Theater in 1959, Raúl Alvarez brought Candela on board to assist with him. Candela recalled his eagerness to participate in his first public project. However, it was short-lived. By 1960, he also left Cuba, following in the footsteps of his mentor Borges and the majority of Cuba's architectural avant-garde.

2.6 Working with Pancoast, Ferendino Grafton, Skeels & Burnham, Candela was finally able to realize the design of large-scale public projects. The first project was the 1960 campus of Miami Dade College, a compendium of concrete buildings and public spaces that according to Candela, merged the "postwar modern building regionalist trends… exemplified by the work of Mies (Van der Rohe), and the expressive 'concrete' architecture widely popular throughout Latin-America and Brazil." [3] The decision to use the exposed concrete was both an aesthetic and a civic statement that allowed for economic functionality while maximizing the "softness and strength" of the material itself.

2.7 In 1962, while beginning the design for the Marine Stadium, Candela flew to Washington, D.C. to visit his brother. He landed at the newly opened Dulles Airport, designed by Finnish architect Eero Saarinen. For Candela, this was a watershed moment. "I was in love with Dulles from the beginning," he states. "(Saarinen) placed the roof on top like canopy. Every column is gorgeous. The way the form of those columns gets to the ground, and human beings can touch the concrete and feel it and be next to it… This is exactly what I was after." [4]

Original Use:

2.8 Named the *Commodore Ralph Middleton Munroe* Marine Stadium in honor of the first commodore of the Miami Yacht Club, the stadium opened to the public with Miami-style fanfare that included race boats, dancers, and a performance by the Miami Philharmonic on December 27, 1963. Racing began the following day, with the Orange Bowl Powerboat Regatta, a four-day televised event. Though a high-speed accident on opening day claimed the life of one of the racers, the Marine Stadium quickly became the nation's premier boat racing venue, hosting every major race in the sport from 1964-1992. In 1965 a floating stage was constructed to allow for the stadium's use for concerts, religious services, water shows, beauty pageants, poetry readings, music festivals, and political rallies, that included such notable events as annual Easter Sunday services and a flotilla on Sept. 8 each year to honor the Virgin of Charity, Cuba's patron saint; Jimmy Buffet's 1985

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[3] Interview with Hilario Candela by José Vasquez, Miami Dade Community College, November 2005 and published in A Concrete Presence http://www.aconcretepresence.com/#!__page-0/overview.

[4] Lowinger interview with Hilario Candela October 3, 2011

"Concert on the Bay," the artist's most celebrated performance; and the Richard Nixon political rally in which singer Sammy Davis, Jr. announced his switch to the Republican party. In other words, the stadium was a beloved and well-known venue not only for Miami residents and tourists, but for a national audience.

2.9 Despite this, the stadium was never managed properly. As early as 1964, newspaper articles decried the financial debacle that was the stadium, and calls for its shuttering were intermittently proposed to the City Commission. On August 24, 1992, Hurricane Andrew gave the city its excuse to close the building. The overly-engineered concrete and galvanized rebar structure barely took a hit from the Class 5 monster storm. Nonetheless, city officials used the minor damage incurred to declare the building damaged and unsafe to enter.

Abandonment:

2.10 Shuttered at roughly the same time that Miami Beach's Art Deco Historic District was undergoing its transformative preservation and revitalization, the abandoned Marine Stadium soon began to be transformed into a cultural venue of a different sort. Sometime around 1996-7, the City's graffiti counter-culture discovered the venue. Young people began to jump the fence surrounding the building, over time turning it into the city's most popular venue for graffiti, skateboarding, and all manner of unauthorized creative activity. Over the course of the past twenty years, the grandstand's concrete walls, ramps, and ultra-modernist roofline have become a spontaneous open-air venue for taggers, painters, acrobats, fashion designers, videographers, musicians, and photographers worldwide. Inspiring to and revered by generations of artists, the stadium is presently a major inspiration for Miami's newfound fascination with graffiti art. Nonetheless, the building continued (and continues) to deteriorate.

Preservation Efforts:

2.11 In 2008, Friends of the Miami Marine Stadium (FoMMS) was formed under the aegis of Dade Heritage Trust by local activist Don Worth in conjunction with architect Candela and University of Miami architecture professor, Jorge Hernandez. The intent of the grassroots all-volunteer organization was to protect the stadium from demolition by neglect. FoMMS has been the driving force that kept the stadium front and center in the minds of Miamians, securing historic designation for the building and surrounding basin by the City of Miami Historic and Environmental Preservation Board, as well as ongoing national recognition by the World Monuments Fund and the National Trust for Historic Preservation. In 2012, the National Trust named the stadium to its National Treasures program, a portfolio of some of the most significant endangered historic places in America where the organization is dedicated to finding a preservation solution. The Trust has made significant efforts to provide public relations assistance and funding to the stadium through its American Express grants, and presently the stadium has an $80,000 grant from Amex to conduct an engineering study of the pilings that support the building over the water.

2.12 Since mid-2013, raising awareness of the cultural significance of the stadium as a venue for graffiti art has been another tack used to garner support for the building's preservation. In October 2013, Rosa Lowinger curated an exhibit at the Coral Gables Museum that showcased the present condition of the building and its use as a graffiti site. In 2014, South Florida- based street art collector and impresario Craig O'Neil came up with a project that used street art to raise international awareness about the stadium and possibly raise funds for the building's conservation. Titled the *Art History Mural Project*, this effort brought internationally recognized street artists to the stadium to create murals on walls that had already been painted repeatedly. Images of those murals were sold online and because of the artists' wide online audience, the stadium garnered attention in numerous international publications.

Plans for the Future:

2.13 In 2014, the City received a $1 million grant from the State of Florida for restoration of the stadium. However, the proposed budget for the entire restoration project work is in the neighborhood of $30 million. The monies granted by the State will be used to develop construction documents for the purpose of creating an RFP for the full restoration and conservation of the building.

2.14 The results of the MMS-CONSOL project described below are intended to form the basis of the materials conservation specifications in the City's construction documentation project set.

3.0 THE MMS-CONSOL PROJECT TEAM

The MMS-CONSOL project team was comprised of the following companies and staff whose roles and responsibilities are described below. They are responsible for the content and composition of the report, and for the opinions based therein.

3.1 **RLA Conservation, Inc.** (RLA), http://rlaconservation.com), sculpture and architectural conservators of Los Angeles, CA and Miami, FL.

- Rosa Lowinger, M.A. Principal and Chief Conservator
- Kelly Ciociola, M.S. Senior Architectural Conservator
- Humberto Del Rio, Chief Technician
- Pablo Brouwer, Technician
- David Olivera, Technician
- Regina Jestrow, Administrator

RLA provided the following services to the project:

- Client liaison with the Friends of the Miami Marine Stadium (FOMMS); the Getty Foundation; the City of Miami and other key stakeholders.
- Project management and administration including establishment of Owner-Consultant Agreements; RLA/Sub-consultant Agreements; review of billing; onward invoicing; payments and contracts administration.
- Organization of all documentation, review and preparation of final documents, including this report.
- Coordination of testing and scheduling between all professionals.
- Collaboration with John Fidler Preservation Technology on selection of materials and draft specification for techniques for testing for cleaning, stain removal, graffiti removal / mitigation, corrosion mitigation, and concrete patch repairs.
- Undertaking of all cleaning tests, preparation of repair mock ups, and all related hands-on work that was part of the sampling and testing portions of work.
- Coordination of all sub-contractors related to trials, including Ibix Systems, Farrow Systems, and dry ice blasting etc.,
- Procured all materials for hands-on work.
- Facilitated the on-site work of the out-of-town professionals, including coordination of site visits; health and safety provisions etc.
- Provided all general administrative services to the project.
- Co-directed and led consultative workshop / symposium on graffiti as artwork with JF-PT and the University of Miami.
- Coordinated all aspects of the project not specifically assigned elsewhere.

3.2 **John Fidler Preservation Technology Inc.,** of Marina Del Rey, CA. (JF-PT), www.jf-pt.com, international consultancy for technical and other support to architects, engineers, conservators and others, concerned with sustainable management of historic buildings and archaeological sites

- John Fidler, RIBA, IHBC, Intl Assoc AIA, FRICS, FSA, FRSA, FIIC, FAPT

John Fidler Preservation Technology provided the following services to the project:

- Review of pertinent documentation relating to the original concrete design with respect to materials, colors and surface finishes.
- Review, in conjunction with Lynch & Ferraro Engineering Inc., (LFE) current engineering and other documents on the material testing and condition of the Stadium to avoid duplication.
- Support to RLA in collaboration with LFE on choice of inconspicuous test sites for sampling and analysis of surface soiling; painted surfaces; and typical concrete substrates etc.
- Collaboration with LFE on design of in-situ and laboratory-based material examination and testing to complement and extend knowledge already gained from cited engineering reports with special respect to graffiti covered, chloride-rich, spalling concrete surfaces above corroding rebar.
- Design and specification in consultation with RLA of treatment trials for the removal of unwanted graffiti using a variety of chemical and physical removal methods, including poultices for capture of potentially hazardous materials in close proximity to environmentally sensitive tidal marine waterways.
- Design and specification of treatment trials to protect a sample graffiti artwork.
- Support to and collaboration with LFE and RLA to devise and specify engineering standard structural concrete patch repair treatment protocols but based on matching original weathered historic concrete colors and textures.
- Review of materials analysis for colors and textures created by binder/aggregate types and binder/aggregate/water ratios. Review of RLA procurement of matching materials and preliminary mockup cube samples.
- Collaboration with RLA and LFE on concrete treatment trials including rebar treatment, patch build-up, use of corrosion inhibiters, surface color and texture range replication.
- Consultation on future action that can be taken to protect the building including cathodic protection and desalination.
- Liaison with RLA on anti-graffiti barrier trials and monitoring of performance.
- Co-authored this report in conjunction with RLA and synthesis of LFE and RLA sections.

3.3 **Lynch & Ferraro Engineering Inc.**, (LFE, www.lynchandferraro.com) of Oviedo, FL.

- Marjorie Lynch, P.E.
- Christopher C. Ferraro, PhD., P.E.

Lynch & Ferraro, Inc. has provided the following services to the project:

- Working with JF-PT, reviewed available documentation on the construction of Miami Marine Stadium in 1962-3, including original documents, construction phase records, as built drawings, and structural investigation reports addressing the stadium that have been produced since its original construction.
- Made recommendations to City of Miami and Friends of Miami Marine Stadium on safety issues observed on site during assessment and testing phases.
- Selected representative areas for concrete material investigation.
- At representative locations, extracted core samples in accordance with ASTM C42 and C823 for evaluation of concrete strength and qualitative laboratory testing.

- Performed laboratory investigation of materials removed from the stadium.
- Prepared an interim report of findings from the investigation phase.
- Together with JF-PT and RLA, identified currently available materials that are most consistent and compatible with historic materials used at the Stadium.
- Evaluated the use of protection measures to reduce further deterioration and need for future repair.
- Negotiated with cathodic protection specialists with a view to them demonstrating their systems as part of the project work
- Worked with RLA to provide specifications for patch repair materials.
- Worked with RLA to install trail repair patches at selected locations, and recorded the appearance of the trial repairs through photography.
- Worked with the team to draft and review model specifications and produce a final report on the project.

3.4 RJ Lee Group (RJLG, www.rjlg.com), materials testing and analysis subcontractor.

- April Snyder, Concrete Petrographer

RJ Lee Group has provided the following services to the project:

- Conducted ASTM C856 petrographic analysis and C1324 mortar analysis of the core samples.
- Prepared report, together with LFE, of the testing results.

3.4 University of Miami School of Architecture

- Jorge Hernandez, Professor of Architecture

University of Miami and Professor Hernandez have provided the following services to the project:

- Served as an advisor to the project and interfaced with the FOMMS and the Stadium's original designer, Hilario Candela.
- Provided support to project team, through the University School of Architecture, in relation to the graffiti workshop / symposium and students from the preservation program shadowing the project as a learning experience.

3.5 ArtCare Miami, Inc. http://www.artcarenyc.com

- Rustin Levenson, Principal and Chief Conservator
- Veronica Romero, Conservator

ArtCare Miami, Inc., a paintings conservation facility, provided the following services to the project:

- Design and assistance with testing coatings for protection of graffiti murals.
- Determination of efficacy of said coatings in protecting murals in the event that decorative painted surfaces are incorporated into the future design of the building.

4.0 PROJECT RATIONALE, OBJECTIVES AND METHODOLOGY:

4.1 Hilario Candela's Stadium design was based upon a limited pallet of materials, mostly cast-in-place reinforced concrete, but in awe-inspiring shapes created with a variety of formwork that varied the texture of surfaces, depending on the element of construction concerned. So the beauty of the construction is consistently revealed in the subtle hues of the concrete aggregates' natural colors, the formwork textures, and the purposeful absence of paint coatings that remain both technical and aesthetic challenges for extending the durability and water-proofing the building envelope, given the coastal locale on the edge a major ocean-side conurbation, swathed in chlorides, ozone and changing humidity.

4.2 Since the Stadium's abandonment, the site has become a refuge for skate boarders, taggers and graffiti artists to experiment and practice their skills and techniques. Some of the graffiti is of a quality that has attracted art connoisseurs and others interested in the art form, and this in turn has helped to redirect public interest towards the original structure and its preservation.

4.3 Previous engineering studies (summarized in Appendix A attached) have proved the stadium's continuing stability and deemed it viable, subject to various structural and other repairs. But while the proposed engineering solutions will undoubtedly improve public safety, and extend the useful life of the property, no though until now has been given to sustaining the values and significance of the structure's original surface appearance upon which the designer gave so much care and attention.

4.4 So using the Miami Marine Stadium as a test site, we proposed to the Getty Foundation to plan and deliver field, laboratory and workshop investigations and trial mockup treatments to test materials and treatment methods to help complement and refine current engineering plans so that Candela's architectural vision could be restored.

4.5 Our project's main objective was therefore based upon a conservative, scientific and technical response to the architectural challenges of removing graffiti, cleaning concrete, repairing, and maintaining bare-faced concrete surfaces – in the spirit of the place specifically created by Candela – with the intention of retaining viable original materials for as long as possible; conservatively repairing them only where absolutely necessary; and creating unobtrusive details to reinforce or support original component functions without detracting from their use and original appearance. And to do so without detriment to the structural engineering standards applicable to major reinforced concrete repairs as well as more cosmetic responses.

Methodology

4.6 Our investigations were specifically planned to include:

- A thorough documentation review of all previous technical studies undertaken by specialist structural engineers and others for insurance carriers, the City of Miami, and the Friends of the Miami Marine Stadium (Appendix A)
- Identification and analysis of graffiti paint types and delivery systems

- A dialogue with tag and graffiti artists on questions of graffiti documentation; preservation (in various forms); alternative sites for graffiti expression; and ways to honor the artists' roles in focusing attention back onto the Stadium's preservation.

- Trials of various kinds of graffiti removal

- Trials of various means to clean soiled concrete

- Trials of anti-graffiti barrier systems

- Field, laboratory and workshop testing and analysis of the Stadium concrete to determine its original constituents and physical performance for matching purposes

- Trials of structural and superficial concrete spall strategies, including spall removal, spall site preparation, desalination, rebar treatment, use of corrosion inhibiters, and structural cast-in-place and superficial patch trowel repairs to match existing clean concrete in color and texture

- Studies of concrete surface textures, procurement of rough-sawn board and ply formwork, and rubber latex form lining materials to mimic original textures.

5.0 DOCUMENTATION REVIEW

5.1 At the beginning of the project, the team hoped to review all available documentation on the construction of Miami Marine Stadium in 1962. The following documents were sought but sadly _not_ located:

- Shop drawings
- Placing drawings of concrete reinforcement
- Alteration plans, addenda, submittals, and change orders
- As-built drawings, photographs, job field records, test data, and correspondence
- Manufacturer's technical information, descriptions of construction materials, and test data
- Submittals delineating concrete mixture components, proportions, and test results
- Mill test reports on cement and reinforcing steel
- Test data on coarse and fine aggregates
- Ready-mix supplier historical data on specific mixtures used
- Material specifications and drawings, including those prepared by design professionals and material suppliers for use in placing their products in the original construction

5.2 Many of the original engineering records were lost when the original design practice's archives were destroyed by its successor company. The original contractors no longer exist and their records are lost. Many of the City of Miami's construction files and other records are apparently unarchived and poorly catalogued, so they cannot be retrieved.

5.3 We were able to find some architectural drawings (plans and elevations) and engineering design drawings supplied by the FOMMS. Of particular note are Structural Drawings # S1-3 and 5, S8 and 9, and #S14, 16-18 (those not cited could not be found) that revealed that the roof structure was post-tensioned, not something previously discovered. The drawings also reveal designer's intent for shapes and steelwork sizing that will be a boon to the final structural repair specifications when the main project gets underway.

5.4 Team members, Lynch and Fidler, also interviewed Hilario Candela about construction for insights into the designer's intent. Unfortunately, engineer Jack Meyer passed away two years prior to the project's commencement.

5.5 Most of our time then spent of documentation was devoted to reviewing prior technical studies of the structural stability and condition of the Stadium in the five-year period 2008-2013 when its future was under threat. Thanks to reports by structural engineers from Simpson, Gumpertz & Heger Inc., (SGH) of Boston, MA, the future of the stadium was assured by their assessment of the structure's residual life and resiliency that could be reinforced and sustained by remedial work.

5.6 We provide a summary and a review of the technical reports in Appendix A, together with a commentary on the strategies then being promoted for repairs. The recommendations made by SGH and others all point towards traditional civil engineering repair techniques, few if any of which would preserve original surface appearance – views that reinforce the thesis behind our research, that there should be ways to provide better conservation finesse to civil engineering responses.

6.0 FIELD INVESTIGATIONS

6.1 The project team visited the site on 23 September 2014 to start the selection of numerous representative areas of the Stadium to study the characteristics of the existing concrete and the various applied coatings.

6.2 The investigation included: the seating area, the walls at the rear of the stadium, structural beams, columns, and tiebacks, and the hyperbolic paraboloid (hypar) roof. At each area, we investigated the color and surface texture of the concrete; any patina of age or other natural weathering changes of appearance; the presence or absence of bio-films, algae or lichens; the characteristics, degree and extent of overlying graffiti paint, including multiple layered coatings; and the condition of concrete spalls, latent spalls, and exposed reinforcing steel and tie wires. Our purpose was to gather enough data to be able to develop proper appropriate suitable cleaning and repair methods and materials, and to choose more limited areas for sampling, testing and treatment trials.

Surface investigation

6.3 Although extensively covered with graffiti (in many cases up to 200 layers of graffiti), most of the concrete at the Miami Marine Stadium remains exposed in its natural state, and has acquired a surface layer of dirt and other material deposits. As part of the work, we recorded the existing surface appearances of dirty but unpainted concrete, including the various colors and textures with cameras and color reference grids. We had hoped to employ a portable photo-spectrometer to objectively record surface color and gloss. But the budget would not run to the hire of this expensive field equipment and associated software.

6.4 We studied the underlying man-made textures of the concrete surfaces created originally with wooden formwork. The lower, utilitarian areas of the structure are constructed with rough-sawn board-marked formwork while the upper, hypar roof components are made using large smooth plywood sheet formwork upon which can still be seen the lower grain of the ply wood surface.

6.5 Samples were taken from surfaces to determine the causes of discoloration and staining. These samples were used to help determine the original composition of the concrete, and possible causes of discoloration of surfaces include staining from soil, airborne particulates from pollution, biological growth, brown rust stains, grey zinc corrosion stains, potential alkali-aggregate reaction products (we found none), free-lime binder breakdown, and salt efflorescence.

6.6 Many different types of graffiti were found to exist on the building. In many areas, a ground layer of cheap white Home Depot-type latex paint was laid over existing graffiti to produce a “clean” surface for over-painting. Visual inspection, cross section analysis, trial removals, solubility tests, and analytical methods such as polarized light microscopy, Fourier Transform Infrared Spectroscopy, and X-Ray Fluorescence could be used to determine the paint types employed and their binder, filler and pigment constituents. However, we found hundreds of paint cans littering the site from which we recorded their trade names, colors and generic paint and propellant ingredients. We also viewed numerous YouTube videos online that show artists painting the stadium in different locations, and this helped us to understand their technique.

Concrete Investigations: materials, sampling, testing and results

6.7 The Stadium received in-depth and supplementary condition assessment surveys in 2009 and 2013 each carried out by structural engineers from the engineers, SGH (Appendix A). The goals of the current project's concrete investigations, however, were not to perform another structural engineering assessment, but to develop material repair methods and techniques that are sensitive to the historic nature of the facility and its architecture, yet will perform to the required engineering standards.

6.8 An additional site visit took place on 17 and 18 January 2015, led by Dr. Christopher Ferraro (Lynch & Ferraro Engineering) with Jerry Paris (Lynch & Ferraro Engineering) and Ms. Kelly Ciociola (Rosa Lowinger & Associates) in support. Our initial walk-through of the stadium revealed a number of deterioration mechanisms which included various types of surface damage (e.g., scaling, dusting, cracking, staining due to efflorescence, spalling). The quantity of deterioration throughout was not determined, as it is prevalent across the structure and was out of the scope of this project.

Sampling

6.9 Onsite testing and material sampling were performed in an effort to determine the concrete binder type, the aggregate materials and mixture design used for the original construction. Based on the visual observations, it was decided to perform nondestructive testing on the several different concrete surfaces as well as extract core samples for microscopic and physical testing. The methodology used for determining the locations for testing and sampling incorporated the most appropriate consideration and highest level of scrutiny in conjunction with historic preservation standards.

6.10 Based on our site observations, the majority of the concrete from which the stadium structure is composed is from cast-in-place concrete. The nature of building construction which utilizes cast-in-place concrete typically involves the use of ready mixed concrete which is delivered to the construction site. Ready-mixed concrete is delivered to construction sites in relatively small volumes, 12 cubic yards or less, and as a result, there is a potential for variability within the delivered concrete batches from each truck. This phenomenon is inherent to the concrete industry and all cast in place structures.

6.11 Therefore, locations for in-situ testing and sample extraction were selected in an effort to obtain typical samples from several different areas throughout the structure as presented in Figure 1, below. We decided to acquire specimens from several structural elements which were constructed of different concrete batch mixtures and most certainly, the result of different placements from different ready-mix trucks.

In-situ Testing and Sample Extraction

6.12 The nondestructive testing (NDT) program consisted of Standard Test Method for Penetration Resistance of Hardened Concrete (ASTM C803) and the Standard Test Method for Rebound Number of Hardened Concrete (ASTM C805) respectively, used to assess the hardened mixture of the *in-situ* concrete surfaces. Core specimens were also obtained in accordance Standard Test Method for Obtaining and Drilling Cores and Sawed Beams of Hardened Concrete (ASTM C42). A summary of tests performed is provided by Table 1.

Figure 1: Sample extraction and NDT testing locations

Table 1: Field Test and Coring Locations

Location ID	Core Count	Tests Performed
1	1	Core Extraction, Rebound Hammer, Windsor Probe
2	1	Core Extraction, Rebound Hammer, Windsor Probe
3	1	Core Extraction, Rebound Hammer, Windsor Probe
4	1	Core Extraction, Rebound Hammer, Windsor Probe
5	1	Core Extraction, Rebound Hammer, Windsor Probe
6	1	Rebound Hammer, Windsor Probe

6.13 The material sampling did not include survey of conditions for structural adequacy, nor did it include a structural analysis. No structural engineering work or calculations were performed.

Petrographic Examination and Analysis

6.14 Sample extraction was performed primarily in an effort to perform microscopic testing and ascertain the chemical and mineralogical consistency of the concrete within the Stadium's structure. Five cores were drilled and extracted, and portions of them were sent to the RJ Lee Group in Pittsburgh, Pennsylvania for petrographic analysis.

6.15 The samples were analyzed in accordance with Standard Practice for Petrographic Examination of Hardened Concrete (ASTM C 856) using visual examinations, optical microscopy, and a scanning electron microscope. After visual examination, the samples were cut lengthwise and a solution of phenolphthalein, a pH indicator, was applied to determine the depth of carbonation (a low pH caused by absorption of carbon dioxide and/or acid rain from polluted atmospheres reduces the concrete's protective alkalinity around steel reinforcement, exacerbating corrosion). The presence and depth of chlorides were also determined by microscopic examination (Table 2), but chemical testing for the quantification of amount of chlorides was not performed (as this work was done in SGH's testing).

Table 2: Depth of penetration of carbonation and chlorides

Core ID #	Carbonation Depth (in.)	Chloride Depth (in.)
1	3/16	2
2	13/16	1
3	1 – 7/8	0
4	1	1
5	9/32	Trace amount near surface

6.16 The petrographic testing (Table 3) revealed that the concrete was mixed using ordinary Portland cement, and that the coarse aggregate within the concrete is composed of a fossilized limestone consistent with the physical and mineralogical structure of Miami Oolite. The fine aggregate was composed of quartz sand. The mixture components are typical to a standard concrete mixture design, which incorporated approximately 25 percent cement paste content, 3-5 percent air, and a water-to-cement (w/c) ratio of approximately 0.50. The petrographic testing did not reveal the presence of mineral or chemical admixtures within the hardened concrete samples.

Table 3: Petrographic Analysis Summary Results

Petrographic Analysis / Summary Sheet

243 W30th Street 7th Floor New York, NY, 10001
(862) 202-9272

Project Name: Miami Marine Stadium   Tested By: A. Snyder (RJ Lee Group)

Location ID	Max Aggregate Size (in)	Coarse Aggregate Type	Fine Aggregate Type	Paste Content	w/c	Air Content	Comments
1	3/8	Limestone	Quartz	25-27%	0.45-0.50	3-5%	Some carbonation, chlorides observed
2	3/8	Limestone	Quartz	25-27%	0.50	3-5%	Chlorides observed
3	3/8	Limestone	Quartz	25%	0.55-0.60	3%	
4	3/8	Limestone	Quartz	25-27%	0.60	2-3%	
5	3/8	Limestone	Quartz	3%	0.50-0.55	3-5%	Trace chlorides observed

Physical Testing Results: Modulus of Elasticity

6.17 Although the majority of the core samples extracted from the structure were utilized solely for petrographic testing, core sample #5 was split and a portion of the core was used for determining the compressive modulus of elasticity (Figure 2). This test is one of the most commonly used physical properties used for design of concrete structures.

6.18 Typically, the modulus of elasticity of concrete is calculated from compressive strength[5] [6] utilizing data from ASTM C873 Standard Test Method for Compressive Strength of Concrete. However, compressive strength testing of concrete is destructive in nature, requiring many core samples for statistical accuracy. So due to the historic preservation aspects of this project, it was decided to perform testing on the samples obtained that would preserve the integrity of the samples themselves. The modulus of elasticity testing acquired from Sample #5 was approximately 3,880,000 psi. The results are presented in Figure 2.

Figure 2: Modulus of Elasticity testing configuration

6.19 The results from the modulus of elasticity testing are consistent with a concrete similar to the Class II concrete per the Florida Department of Transportation (FDOT) Standard Specification for Road and Bridge Construction[7]. The compressive strength of Sample #5 is approximately 4,500-5,000psi which is appropriate for its use.

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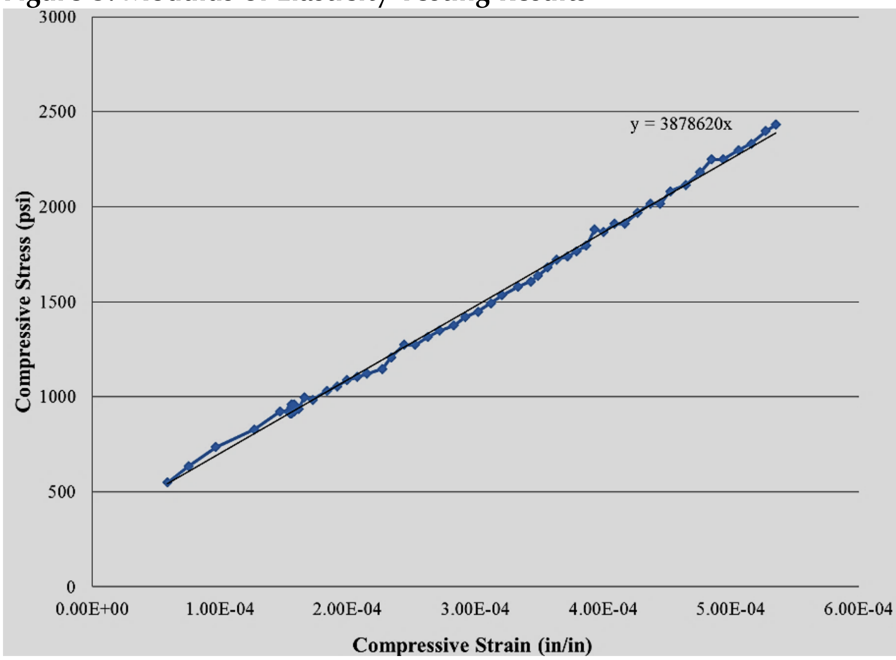
[5] ACI Committee 318: "Building Code Requirements for Structural Concrete (ACI 318- 11) and Commentary", American Concrete Institute, Farmington Hills, MI, 2011

[6] Ferraro C.C., Tibbetts C.M., Perry M.C., Watts B.E., Paris J.M., "Effects of Coarse Aggregate on the Physical Properties of Florida Concrete Mixes" FDOR Report BDV-31-977-08, 2015

[7] FDOT, Florida Department of Transpiration, Standard Specifications for Road and Bridge Construction Section 346, 2015

Figure 3: Modulus of Elasticity Testing Results



Windsor Probe Testing Results

6.20 The *Windsor Probe Standard Test Method for Penetration Resistance of Hardened Concrete* (ASTM C 803) was used to determine the near surface strength of the substrate concrete[8] [9]. Penetration tests are based on the depth of penetration of probes into the concrete surface, which can be used to make a relative strength relationship. There have been a number of studies that have created to approximate compressive strength of *in-situ* concrete using the penetration resistance method. Accordingly, equation 1 below can be used to calculate compressive strength of concrete composed of limestone where “x” is equal to the exposed probe length[10]. Table 4 provides raw data of the probe penetration test and the resultant estimated compressive strength based on equation.

$$f'c \text{ (psi)} = -5333 + 5385 (x) \qquad (1)$$

[8] ACI Committee 228, Mass Concrete (ACI 228.1 R03), American Concrete Institute, Farmington Hills, Michigan, 44 pages, 2005

[9] Malhotra V.M., and Carette, G.G., “Penetration Resistance Methods” Handbook on Nondestructive Testing of Concrete 2nd Ed., Edited by Malhorta V.M., and Carino N.J., New-York, CRC Press, 2-1 – 2- 17, 2004

[10] Malhotra V.M., and Carette, G.G., “Penetration Resistance Methods” Handbook on Nondestructive Testing of Concrete 2nd Ed., Edited by Malhorta V.M., and Carino N.J., New-York, CRC Press, 2-1 – 2- 17, 2004

Table 4: Windsor Probe raw data and calculations

Location ID	Average Reading (in) "x"	Estimated compressive Strength (psi)
1	2.19	6,460
2	2.37	7,420
3	2.13	6,137
4	2.41	7,626
5	2.04	5,670
6	2.29	7,016

6.21 The compressive strength data as calculated by the penetration resistance indicates that the average compressive strength near the surface is approximately 6,500 psi with a standard deviation of approximately 760 psi. Overall, the quality of the concrete is in relatively good condition. Based on the Windsor probe testing, Location 5 recorded relatively low concrete strength which is most likely due to fire damage as the room beneath the substrate concrete exhibited evidence of fire. Although the Windsor probe readings indicate the compressive strength of the concrete strength is in excess of 6,000psi, it should be noted that Windsor probe testing does not always provide conservative values, and thus lower values should be considered with respect for design. The Windsor probe investigation did not include any superstructure or roof testing and was limited to the floors and seating areas.

Rebound Hammer Testing Results

6.22 The standard test method for rebound number of hardened concrete (ASTM C805) is used to determine the hardness of the concrete surfaces quantitatively. It is often used as a means for determining the uniformity of concrete within concrete structures[11]. The testing regimen for the rebound hammer included the acquisition of ten measurements in a linear configuration at each location. For each of the first locations, it was decided to acquire several sets (of ten) measurements at each location. However, the data was relatively consistent at each location (areas 1-4), and thus it was decided to use a single set of ten measurements at locations 5 and 6 due to the difficulty with regard to access and creating a clean area for testing. Overall, the rebound testing revealed that the concrete is relatively consistent throughout the structure. Table 5 provides a summary of rebound number testing results.

6.23 While there is general agreement between researchers that the rebound hammer provides an estimate of compressive strength for concrete specimens, there is wide disagreement of the accuracy of the strength estimates. Rebound hammer can typically be used to provide relative strength differences within a concrete structure of known compressive strength. Malhotra[12] reports that the rebound number can be used to estimate the in-situ strength of

[11] Malhotra V.M., "Surface Hardness Methods" Handbook on Nondestructive Testing of Concrete 2nd Ed., Edited by Malhorta V.M., and Carino N.J., New-York, CRC Press, 1-1 – 1-15, 2004

[12] Malhotra V.M., "Surface Hardness Methods" Handbook on Nondestructive Testing of Concrete 2nd Ed., Edited by Malhorta V.M.,

concrete, which estimates the compressive strength of tested to be within the range of 4,000-7,000 psi. Thus, the rebound testing results are in general agreement with the Windsor Probe testing results as well as the compressive strength calculated from the Modulus of Elasticity testing.

and Carino N.J., New-York, CRC Press, 1-1 – 1-15, 2004

Table 5: Rebound hammer test data

	Test Number										
Location	1	2	3	4	5	6	7	8	9	10	***Average***
1a	39	46	39	38	39	43	39	40	34	38	40
1b	39	36	38	41	47	39	46	39	36	35	40
1c	36	39	34	40	45	46	39	48	44	38	41
2a	30	40	41	32	42	39	41	38	43	35	38
2b	35	40	35	38	39	35	35	34	40	35	37
2c	44	46	40	44	40	44	43	44	40	44	43
3a	46	46	46	42	48	46	48	38	44	41	45
3b	32	45	51	38	53	52	51	50	50	51	47
3c	53	43	38	48	36	36	36	50	38	38	42
4a	48	48	46	49	45	44	44	40	40	40	44
4b	46	48	52	50	46	50	40	46	45	42	47
5	40	44	38	36	36	35	46	39	39	39	39
6	49	53	46	51	54	38	40	40	53	44	47

Discussion of Concrete Material Testing Results

6.24 The testing program revealed that the concrete for Miami Marine Stadium is composed of ordinary Portland cement, local Oolitic limestone coarse aggregate and quartz sand. No chemical admixtures were used. This was a typical concrete mixture for a structure in the 1950s and 1960s in South Florida, and for conservation purposes, can easily be reproduced today. The aggregate utilized for the concrete is still available in the Miami area.

6.25 The conditions observed at the site and in our testing indicate that the Stadium's concrete reinforcement has been deteriorating due to the concrete's exposure to seawater salt and reduced alkalinity caused by carbon dioxide absorption from the atmosphere. Our team did not perform a structural investigation or analysis, as it was not in the scope of work and had previously been carried out by SGH Inc. However, we concur with SGH's opinion that the condition of Miami Marine Stadium will continue to deteriorate unless a repair and protection program is implemented in the near future.

6.26 Based on our findings, we developed repair mix designs for trials as discussed in Section 8 below that utilized the same raw materials used in the original construction. Therefore, matching colors in the laboratory proved easier than expected.

7.0 SYMPOSIUM: LAYERS OF UNDERSTANDING – graffiti and the Marine Stadium

7.1 At the express request of the Getty Foundation, the Project Team devised, organized and ran a half-day symposium on the question of the highly publicized graffiti at the Marine Stadium.

7.2 Vandalism, street art, and graffiti are ubiquitous in major cities. The works of artists like Banksy, Swoon, Shepherd Fairey, and others like them, are now frequently commissioned on the streets and many have become popular cultural attractions and the subject of museum shows. Similarly, in many historic modern buildings, post-construction interventions are retained for other practical or cultural reasons.

7.3 The Miami Marine Stadium has had three periods of use: 1963-1992, when it was a viable racing grandstand and concert venue; 1992-2014, when it was shuttered and abandoned by all but the street art community, and 2014-present, when it is in the process of study and being notionally protected by security guards hired by the City of Miami. This last step notwithstanding, the building is presently known by the Miami public as two very different sorts of venues that divide on generational terms: people over 40 and certainly 50 recall it as a place they would go on their boats to hear concerts or to see races; and most people under 40 and certainly under 30 think of it as a "penet", a Miami-term which describes an underground and unauthorized cutting-edge graffiti and street art venue.

7.4 Some of the graffiti artists who worked at the Stadium have gone on to have careers in the mainstream art world. Moreover, the Stadium's avant-garde design, coupled with the contemporary edginess and credibility of street art, has breathed new life into the public's view of the site. It is presently seen not only as a potential concert and racing site, but also as a coveted visual arts venue for future cultural events such as the Art Basel fair www.artbasel.com, and commercial use such as the Miami Boat show. Still, the "street" flair of the site is presently part of its cache and there is reason to believe that future uses of the building might therefore require retention of some of the graffiti, and the fostering of future street art on the premises.

7.5 For conservators and stewards aiming to preserve the building, this poses particular ethical and technical problems. For example, though the graffiti is a much-beloved aspect of the building for a portion of the population, it is the project team's strong conclusion that much, if not all, of the graffiti will need to be removed to accommodate desalination and other treatments of the Stadium's concrete. Absorption of chloride salts from the marine atmosphere and proximity to the tidal lagoon have exacerbated corrosion of the concrete rebar, causing the concrete to crack and spall. Moreover, while in some preservation circles the graffiti is seen as visually damaging to the original design intent, the latex and enamel paint coatings may ironically be physically protecting some of the concrete from further chloride ingress. Additionally, there may be areas of deteriorating concrete where the graffito artwork covering is deemed valuable but where the latent and actual spalls of the subsurface concrete need to be repaired and will affect the art.

7.6 The team considered how best to address these overarching questions as part of our work to produce practical conservation plan components for the Stadium. Our initial plan was to assemble an invited panel of professionals in heritage preservation, conservation, contemporary art and street art to participate in a one-day experts meeting, that was to be held at the University of Miami's School of Architecture and open to the public. Instead, we were able to assemble a half-day version of the event at the Miami Center for Architecture and Design on May 11, 2015.

7.7 The ensuing presentations and panel sessions were held during a morning of invited speakers from the Miami area and international experts in murals and street art conservation that happened to be visiting Miami at that time for the annual meeting of the

American Institute for Conservation (AIC). It was a ground-breaking session to discuss a topic in conservation and heritage preservation that had not been tackled prior to our symposium.

7.8 The following description is a report of the Symposium's program which was also videotape recorded by the University of Miami's School of Architecture. Professor Jorge Hernandez is including an edited video of that session along with this report, as part of the FOMMS deliverables to the Getty Foundation.

Symposium Schedule: May 11, 2015, 9 am - 12 noon.

9:00-9:05	*Welcome* by AIA-MCAD Director, Cheryl Jacobs.
9:05-9:10	*Welcome* by City of Miami Mayor, Tomas Regalado.
9:15-9:25	*Introduction to the Getty Grant and the present status of conservation and graffiti removal on the Miami Marine Stadium* - Jorge Hernandez, AIA. Professor of Architecture University of Miami, Co-Founder, Friends of Miami Marine Stadium
9:25 -9:35	*Historical Perspectives- A Brief History of Vandalism*. Rosa Lowinger, President RLA Conservation, Inc. Fellow, American Institute for Conservation, Fellow, American Academy in Rome, editor Vandalism issue of *Change Over Time*, University of Pennsylvania's historic preservation journal.
9:40- 10:00	*Graffiti Management in Heritage Preservation- Historic Perspectives*. John Fidler, Director of John Fidler Preservation Technology Los Angeles, CA.
Coffee Break	FILM: *ABANDONED STADIUM* Parkour Free-running Federation
10:15-11:00	*Perspectives on Street Art versus Historic Buildings and Spaces* - Moderated Panel Discussion featuring:
	Moderator: J. William Shank, Fellow AIC, Fellow AAR, Director of Rescue Public Murals International, former director of conservation San Francisco MoMA: - Shank presented a five-minute introduction to the purpose of the panel. He then posed a series of questions to the panel about the role of graffiti in the stadium, the relative needs of the building versus the mural.
	Panelists: - Brandi Reddick, Miami Dade Public Art Manager. - Megan Cross Schmitt, Historic Preservation Officer- City of Miami. - Luis Berros- Miami-based street artist. - Craig O'Neil South Florida based street art impresario and collector and organizer of ArtHistory Mural Project at Miami Marine Stadium. - Rustin Levenson President, ArtCare Miami, Inc. Murals conservator

	- Jessica Goldman, Director of Goldman Properties, a Miami-based company that has commissioned street art projects as part of real estate development.
11:00-11:20	Dialog between Miami Herald Architecture Critic at Large Alastair Gordon and Miami Marine Stadium architect Hilario Candela.
11:15- noon	Public discussion, and comments, all panelists onstage
Noon-12:10	Conclusion and final remarks- Jorge Hernandez, Architecture Professor, University of Miami and Founder- Friends of Miami Marine Stadium.

7.9 Held in a historic Downtown Miami former bank lobby that now serves as the Miami Center for Architecture and Design, the session was attended by 100+ members of the public. Among those attending were preservation professionals, street artists, developers, and concerned citizens who are either fans of the Marine Stadium or graffiti aficionados.

7.10 The core of the symposium consisted of John Fidler's presentation and the panel discussion. Fidler presented a compelling case for removing the graffiti as a means of accessing the concrete for desalination and other treatments, while also conceding that the present elastomeric coatings of the painted walls are serving to protect the concrete from additional salt ingress. He further suggested that the ephemeral street art could be preserved through photographic documentation and used in light shows, son et lumiére events, and concerts – projected back onto the Stadium's clean and repaired concrete surfaces. He also suggested that screen walls could be erected in the parking lots adjacent to the renovated Stadium and left to the tag teams and graffiti artists to use as their 'blank canvasses' after the property is put back into full use.

7.11 The panel discussion sparked lively conversation that did not entirely run along expected lines. For example, while Jessica Goldman supported the idea of curated walls of street art in a future, renovated Marine Stadium, the street art community was unanimous in its opinion that this was not in keeping with the historic character of the locale as a *penet*, where painting was an unauthorized and uncurated activity. They would take their activities elsewhere without complaint.

7.12 Luis Berros, Craig O'Neil, and the majority of the artists who attended the symposium, also expressed appreciation for the Stadium's original forms and supported the idea of removing all the street art, if it was necessary to do so for its future conservation. The general consensus among artists was that inviting street artists to paint certain walls had no place on the building itself and was in violation of the spirit of its history from 1992- to the present. However, there was consensus that new walls, located within a landscaped area around the building, could be fabricated to allow for the production of new street art. Moreover, there was support for the idea of projecting images of the stadium's street art walls on large screens to be strategically placed in a restored stadium. This could be achieved by gathering the thousands of photos that others have taken of street art murals over time, and honoring the material at the site and on the Stadium's website.

7.13 Other stakeholders, including Ms. Goldman, Ms. Reddick, and architect Hilario Candela saw the value of a half / half position- where there would be some projection and some curation of new murals.

8.0 DESIGN AND SPECIFICATION OF FIELD TRIALS

8.1 After various consultations and technical research, John Fidler drafted the preliminary design and specifications for the graffiti removal, concrete cleaning and application of anti-graffiti barriers in advance of the field trials. Fidler and Lynch & Ferraro also consulted over the design and specification of concrete patch repairs. The project team then collectively reviewed the protocols and specifications, which were then refined and employed to be installed by Rosa Lowinger and Associates, together with specialist sub-contractors.

Graffiti Removal

8.2 The prime objective of the graffiti removal pilot treatment trial was to remove typical multi-layered graffiti (Appendix B, Photo 1 & 2) from off the fair-faced historic concrete without staining of, or damage to, the underlying surface colors and textures on the structure. The usual challenges are that:

- Abrasive cleaning systems can risk roughening the concrete surface and may not remove disfiguring pigments from within the upper substrate's pore structure
- Chemical cleaning systems can risk driving pigments deeper into the concrete substrate where they are difficult to remove

8.3 We therefore planned to test the most ecologically sustainable, conservation benign and cost effective cleaning systems to remove the graffiti in both these classes of cleaning system, using wherever possible soft, round, abrasive aggregates delivered at relatively low pressures and non-etching, low-VOC solvent, chemical cleaners designed for such purposes.

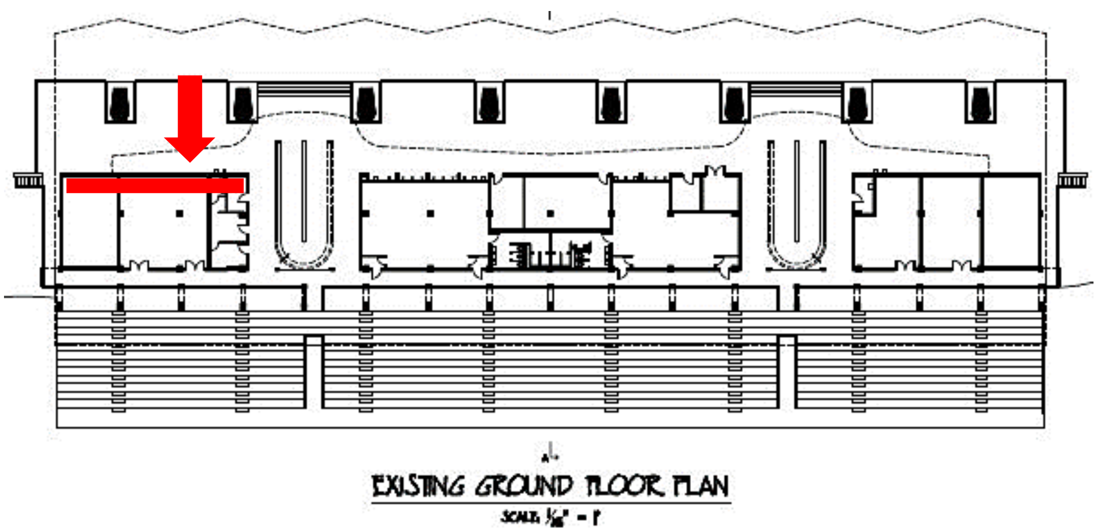
8.4 The typical type of graffiti attack at the Stadium offers various advantages and challenges. Discarded aerosol cans littering the site (Appendix B, Photo 3) reveal that most of the paints used can be readily identified as cheap acrylic or polyurethane enamel car touch-up spray paint, driven by a variety of solvents (e.g., Acetone, Liquefied Petroleum Gas, Toluene, n-Butyl Acetate, Propylene Glycol Mono-butyl, Ether, Ethyl Acetate and 2-Propanol 1-Methoxy- Acetate). They contain mineral fillers and pigments (such as Mica, Titanium Dioxide and Carbon Black). Each tag or painting is frequently over-painted with new attacks, often with opaque white intervening layers of cheap domestic (e.g., Home Depot-type) acrylic latex house paint used to create a 'blank canvass' for the graffiti artists. The multiple layers of freshly applied paint create large surface tensions in the paint system as a whole, as the fresh solvents penetrate previous layers and the paint layers dry and shrink differentially. This helpfully causes some of the layers to blister and curl, lifting them away from the concrete surface:

- This makes the paint coatings physically easier to remove in strips or sheets with wooden or plastic spatulas and 3-M industrial plastic scouring pads.
- But for the chemical paint strippers, the voids and delamination created by the multiple layering of graffiti limit the effective 'soak through' of the active ingredients and may require multiple treatments at each detached coat system.

Test Wall Location

8.5 We intend to set up our cleaning trial area at ground floor level along the graffiti-covered southeast blank wall of the Stadium to the right-hand side of the car park entrance façade (Appendix B, Photo 4). This area is protected from the weather by the overhanging cantilever tie-downs of the hypar roof system, and is on the opposite and less exposed side of the Stadium from the lagoon. As the area remained in use by skate boarders and the graffiti community (site security being poor), we took steps to delineate a safe working area for RLA operatives and planned to temporarily protect our cleaning trials from subsequent attack by vandals.

Figure 4: Location of Graffiti Removal, Cleaning & Graffiti Barrier Trials



Site Protection

8.6 The treatment specification called for the trial site floor area immediately in front of the test wall to be cordoned off with a 3-4 ins. deep waterproof collection point and 'evaporation pond' of solvent-resistant, 4-6 mil, black-colored polyethylene plastic sheeting to capture surface run-off of rinsing water, wet abrasive aggregates, chemicals and paint residues so as not to pollute the site and adjacent lagoon. The sheeting was to be laid over an edging of Coir fiber rolls (or similar) as used to control spillages on construction sites. The plastic sheet joints were to be sealed with duct tape. All collected residues were planned to dry off naturally by evaporation and then for the solids to be carefully removed from site and safely disposed of, according to city, county, and state ordinances (Appendix B, Photo 5).

8.7 All cleaning materials employed were specified to be authorized for use in Florida, and to conform to the latest VOC-reduction and ecological sustainability requirements. We expected _not_ to find any lead-based paint on the test walls. We also specified personal safety equipment to be provided by RLA for its staff appropriate to the hazards defined on the cleaning material manufacturers' Material Safety Data Sheets (MSDS). Similarly, demonstrators from proprietary cleaning system companies were also expected provide their own safety equipment. No authorized public access or visitation was expected or invited for the times when the graffiti removal was to take place, and so no additional public safety mitigation measures were necessary for the trials.

8.8 We specified that the wall chosen surface would be divided into test strips to trial different treatment systems individually and some in tandem as shown in the diagram below (Table 6). Local circumstances, logistics and expediency were permitted to amend the installation protocol at RLA's discretion (Appendix B, Photo 6).

Table 6: Suggested Layout of Graffiti Removal and Concrete Cleaning Trials

Overhanging Balcony Ceiling					
Dimensions of test panels to be no smaller than 16 sq. ft. each with rectangle dimensions determined on site by size of protective sheet overlay to limit new graffiti attacks					
Stage 1: graffiti removal					
Chemical Graffiti Removers			**Abrasive Graffiti Removers**		
ProSoCo *Enviro Klean®* Safstrip 8	Dumond Chemicals Inc., *Smart Strip Pro™*	Dumond Chemicals Inc., Watch Dog® *Wipe Out* graffiti control	Ibix Helix® Tangential micro-air abrasion	Sponge-jet *White* Sponge Media™ SPOCC	Dry Ice blasting
Esters, amines and alcohols pH 8	Formic acid + Benzyl alcohol pH 2	Potassium hydroxide + amines pH 11	Calcium Carbonate Mohr 2.5 2.9-116 psi at nozzle	Spherical Precipitate of Calcium Carbonate Mohr 2.8 30-60 psi at nozzle	Mohr 2 30-60 psi at nozzle
Stage 2: concrete cleaning (on nearby soiled or bio-stained concrete)					
D/2 Biological Solution™ Biocide Un-diluted pH 9.5	ProSoCo Sure Klean® Light-duty Concrete Cleaner Dilution range 1:2-1:6 pH 0.98-1.82				

8.9 The dimensions of each treatment bay, and the test site as a whole, was to be determined by the temporary protection afforded by an overlay during trials of rigid plywood sheeting fastened to the wall surface. We proposed to use a series of 4 ft. wide x 8 ft. tall x 5/8 in.

thick, exterior-grade, plywood sheets, fastened to the wall by 1/2 in. diameter x 3 in. long, zinc-plated, carbon steel concrete sleeve anchors (or similar) at 2-3 ft. max centers, over washers with countersunk hexagonal socket (or similar vandal resistant) screw/bolt heads. Each sheet was mounted over 3/4 in. or larger diameter x 1/2 - 3/4 in. deep steel grommets that keep the sheets standing proud of the wall surface to permit natural ventilation and surface drying. The sheet protection was not be designed for hurricane resistance, as the graffiti removal trials were planned only to take place from January to May 2015. The prime purpose of the sheeting was solely to protect the test site from vandalism when unsupervised (Appendix B, Photo 7).

8.10 Graffiti removal systems proposed for trial include:

Chemical Systems

a) Enviro Klean® *Safstrip 8* made by ProSoCo of Lawrence, KS www.prosoco.com. This is a new-generation, low-VOC, colorless gel, paint stripper based on a mixture of esters, amines and alcohols that is chemically nearly-neutral at pH 8. It is an effective bond-breaker for alkyd oil-based paints, acrylics, lacquers, spray paint and 'magic marker' ink. It is most effective when applied un-diluted, by a solvent-resistant brush or roller, to dry surfaces in a 1/8 – 1/4 in. thick coat for between 15-60 minutes, at ambient temperatures below 85° F.

b) *Smart Strip Pro*™ professional strength paint remover made by Dumond Chemicals Inc., of Malvern, PA www.dumondchemicals.com. This is another new-generation, low-VOC, water-based, remover of multiple coats of high-performance paints – based upon a combination of <5 percent formic acid, 50 percent Benzyl alcohol solvent, inert fillers and water with a pH of 2. It can effectively remove varnishes, oil-based coatings, water-borne acrylics, urethanes, most epoxies and some elastomeric coatings besides car spray paints. The white paste material is especially formulated so that it can be applied by brush or roller in 1/8-1/4 in. thick layers without covering paper (unless extended dwell times are required), and left in place between 6-20 hours, at working temperatures between 50-90° F.

The original plan was to use the Dumond Laminated Paper with the *Smart Strip Pro*™ to test the efficacy of clean-up and disposal techniques with this method.

c) Watch Dog® *Wipe Out* graffiti control made by Dumond Chemicals Inc., of Malvern, PA www.dumondchemicals.com is a targeted graffiti remover based on an amber-colored alkaline gel of potassium hydroxide and amine solvents with a pH of 11. It works well on spray paint, marker pen ink, crayon, shoe polish, lipstick and most other graffiti marks and stains. The material is best brush or roller applied and left for a maximum dwell time of only 30 minutes at a working range of temperatures between 50-90° F.

We specified that lifted paint and gel were to be rinsed off the concrete surface with cold water only (hot water would dissolve the cement matrix on the surface of the concrete) using a masonry power washing system that delivers a 6-8 gallons water flow rate at 200-600 psi maximum with a 45 degree fan spray tip.

Abrasive Systems

d) The Ibix Helix® masonry cleaning system made by Ibix USA www.ibixusa.com: a tangential delivery, micro-air dry abrasion system using soft calcium carbonate aggregate with a hardness value of Mohr 2.5, deployed at pressure range at the nozzle between 2.9 - 116 psi.

e) The Sponge-jet® *Sponge Blasting*™ system, www.spongejet.com: using the conservation Sponge Media™ SPOCC (Spherical Precipitate of Calcium Carbonate) with a hardness of Mohr 2.8 delivered at the nozzle at between 30-60 psi.

f) Freeze Clean® *Dry Ice blasting* system, or equivalent, using equipment and materials from companies like Continental Carbonic Products Inc., www.continentalcarbionic.com of Miami, FL. The 118 mil. Dry Ice (carbon dioxide) pellets with a hardness of 2 Mohr are delivered at 110º F and deployed at a working pressure range of 30-60 psi at the nozzle. Cleaning takes place through thermal shock, kinetic energy and gaseous expansion. Safety equipment should include: ear noise protectors, dust masks, gloves, etc.

g) Rotec® Vortex wet abrasive system from the Quintek Corporation of Conshohocken, PA., www.quintek.net/products/rotec-vortex-cleaning-system. We investigated the practicalities of testing this tangentially delivered, wet abrasive system which is very popular in Europe. It uses 3.5-4 Mohr hard, Dolomitic limestone (passing 200 mesh sieve) or 5.5 Mohr hard glass powder aggregate at low pressures of 10-55 psi at the nozzle with added water in the range 1-15 gallons per hour – delivering a rotating vortex of air, water and micro-abrasive powder.

8.11 The cleaning bare (unpainted) concrete was also trialed where feasible and as follows:

Biocides

h) D/2 Biological Solution™ made by D/2 Biological Solution of Westport, MA http://d2bio.com (e.g., as used on the Florida state capitol) and distributed by LimeWorks www.limeworks.us. This is a near-neutral pH 9, bio-degradable, biocide based on quaternary ammonium compounds and surfactants. It is used un-diluted on dry surfaces and applied by hand-pump garden sprayers with a dwell time of 10-15 minutes. Lightly misting with water, the treated surface can be agitated with soft nylon brushes to work the material into the upper pores of the substrate. The surfaces are then rinsed with clean, potable water and later power washed (at the water volume, nozzle pressure and fan angle described above) after 2-3 weeks to remove the dead bio-organisms from the surface and substrate.

Chemical Cleaner

i) Sure Klean® Light-duty Concrete Cleaner, manufactured by ProSoCo www.prosoco.com of Lawrence, KS will be used to refresh bare (unpainted) concrete surfaces with a dilution rate with potable water of 1:6 or greater, delivering an acidic pH of 1.82. The material contains Ortho-phosphoric acid and Gluconic acid and will not etch surfaces or corrode steelwork (in fact, it will remove iron stains) if used according to manufacturer's instructions. It should be applied to a pre-wetted concrete surface with a soft-fiber, Tampico-type, masonry washing brush or similar, working from the bottom to the top, and keeping the lower cleaned areas wet to avoid streaking. Dwell times should be limited to under 3-5 minutes or until the stains are gone. Cleaned surfaces should then be heavily rinsed with masonry power washing equipment deploying 6-8 gallons of water per minute, at working range pressures between 400-750 psi through a 45-degree fan tip nozzle.

8.12 Technical and Material Safety Data sheets are attached at Appendix E. We listed adequate performance criteria for paint stripping as follows:

- 95-100 percent of the existing paint shall be removed
- No bug holes, cracks, or other defects shall be observed to have been created by the cleaning process, including physical scraping, pock marks etc.
- The ideal finished surface will have a closed, smooth, surface texture less than Concrete Surface Profile (CSP) #1 (<45-55 mils) per International Concrete Repair Institute (ICRI) Technical Guideline # 03732.

Anti-graffiti Coatings and Barriers

8.13 After a period of drying, following the graffiti removal and concrete cleaning treatments, our specification called out for the testing of anti-graffiti coatings and barriers. We first required the cleaned surfaces to be tested for dryness using a GE *Protimeter* (or similar approved) electrical resistance moisture meter. Thereafter, we required multiple applications of trial treatments of anti-graffiti coatings, including a semi-permanent (non-sacrificial) treatment, and three sacrificial barriers, as described below, for comparative test purposes. See Table 4.

8.14 After the anti-graffiti barriers were intended to be installed and dried, and their effects on the appearance of the historic concrete documented, we originally planned to leave the cleaned and barrier coated test wall unprotected from new vandalism, and assumed that graffiti attacks would recommence. Then when all the test areas had been attacked with graffiti media, we planned to return to trial the second part of the anti-graffiti treatment: the removal of the graffiti above the coatings and barriers according to the manufacturer's protocols described below.

8.15 Permanent and semi-permanent anti-graffiti coatings fall into two distinct classes. Of least interest to us are the permanent surface coatings made of polyurethane, epoxy, fluoro-carbon polymers and similar materials. They form completely water-proof and vapor impermeable surface layers that completely block penetration by graffiti media. However, the materials tend to change the color and sheen of treated surfaces most severely. They also entrap moisture and exacerbate crypto-fluorescence. They were *not* specified to be trialed in this research. The more technically appealing systems are semi-permanent, anti-graffiti coatings that are water-born, penetrating silanes and siloxanes that sit within the substrate pore structure and resist the penetration of graffiti media by keeping them near the surface. Here, they can be better washed away with less risk of deep pigment penetration when graffiti removal chemicals are deployed. They are permeable materials but liquid water repellent. The materials have a clear, flat finish but do risk slightly darkening the substrate's appearance by deepening the color tone. A small, discrete 3 x 3 in. maximum test area was specified to be treated first to trial appearance changes. If the semi-permanent barriers had proved aesthetically unacceptable, we would have abandoned interest in their installation. In this class of materials, we planned to test:

- Dumond Chemical's Watch Dog™ *CPU-147 Graffiti Barrier Coating* in this class of materials in combination with the company's Watch Dog™ *CPU Graffiti Remover*.

- Conservare® HCT (Hydroxylating Conversion Treatment) and HCT Rinse in combination with H-100 water repellent ethyl silicate: a three-part system made by ProSoCo of Lawrence, KS www.prosoco.com.

8.16 We had particular interest in testing the so-called sacrificial anti-graffiti barriers. These materials are absorbed into dry, clean, porous substrates and line the pores. They create clear, matte sheen, vapor permeable films that limit penetration of graffiti media. When attacked, the substrate is washed with hot water and the sacrificial materials either melt / dissolve or swell and push the graffiti media up and out of the surface. Both the barrier and the graffiti are thus rinsed away and the treatment must be repeated to continue graffiti protection.

8.17 The sacrificial barrier systems are entirely reversible. However, the conservation risks (that we planned to evaluate) emanate from multiple re-rinsing with hot water after several graffiti attacks - since the water may start to dissolve the concrete surfaces. The systems included:

- High viscosity, vegetable polysaccharide emulsions in water e.g., Keim PSS-20
- Microcrystalline paraffin or other unspecified wax emulsions e.g., Genesis Coatings' *Graffiti Melt* and ProSoCo's Defacer Eraser® *Sacrificial Coating SC-1*

8.18 Application details summarized in Table 7 below and are as follows:

Semi-permanent Coatings

a) Watch Dog™ CPU-147 Graffiti Barrier Coating is made by Dumond Chemicals of Monroe Township, NJ. www.dumondchemicals.com. The material is a milky-white liquid that dries to a clear, no-sheen. It is a water-based, low-VOC, breathable yet water repellent film barrier that protects from graffiti attacks. Its active ingredients are not referred to in the product literature or in the Material Safety Data Sheets (where only the solvent is mentioned). However, we believe CPU-147 could be a combination silane/siloxane water repellent. It is recommended for concrete porous surfaces. Although CPU-147 dries to a clear, flat finish, it will in some circumstances slightly darken the substrate appearance by deepening color tones. On dense, less porous substrates, a sheen may also be seen.

Two coats are needed for graffiti protection. Application can be done using a garden sprayer but all excess materials must be wiped off the surface within 5 minutes. Drying time can be 20 minutes but will be longer where, as in Miami, there is high humidity.

Graffiti attacks should be removed as soon as possible: applying the Watch Dog™ *CPU Graffiti Remover* (based upon 2-Butoxyethanol and di-basic ester solvents with a surfactant). Treated surfaces should be agitated with nylon brushes, allowing the chemical to dwell between 5-30 minutes, and then rinsed off with a power washer delivering between 500-750 psi through a 45 degree fan tip.

Table 7: Planned Layout of Anti-Graffiti Coatings / Barriers

<table>
<tr><td colspan="6">Overhanging Balcony Ceiling</td></tr>
<tr><td></td><td>Color test zone</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Stage 3: Application of anti-graffiti coating/barrier</td></tr>
<tr><td>Control</td><td>Semi-Permanent Coating</td><td colspan="3">Sacrificial Barriers</td><td>Semi-Permanent Barrier</td></tr>
<tr><td rowspan="3">No Treatment</td><td>(a) Dumond Chemical's Watch Dog™ CPU-147 Graffiti Barrier Coating</td><td>(c) Keim PSS-20</td><td>(d) Genesis Coatings Graffiti Melt</td><td>(e) ProSoCo's Defacer Eraser® Sacrificial Coating SC-1</td><td>(b) ProSoCo Conservare® HCT
pH 4</td></tr>
<tr><td rowspan="2">2-coat Silane-siloxane emulsion in di-ethylene glycol mono-butyl ether solvent

pH 8</td><td rowspan="2">Vegetable Polysaccharide emulsion

pH 6.5</td><td rowspan="2">Paraffin wax in amine solvent

pH 8.8-9.6</td><td rowspan="2">Propylene glycol wax

pH 9.5-10</td><td>ProSoCo Conservare® HCT Finishing Rinse
pH 12.4</td></tr>
<tr><td>ProSoCo Conservare® H 100 Ethyl Silicate</td></tr>
<tr><td colspan="6">Stage 4: Removal of new graffiti attacks</td></tr>
<tr><td></td><td>Dumond Chemical's Watch Dog™ CPU Graffiti Remover 2-Butoxyethanol + di-basic ester solvents with a surfactant</td><td>Unpressurized hot water surface saturation and agitation at 140°F for <5mins, then pressurized hot water rinse under <500 psi</td><td>Hot water 190°F rinse at <500psi or Cold water rinse after application of Eaze Away Remover aromatic petroleum distillates solvent</td><td>High-pressure hot water rinse at <500psi at 180°F</td><td>High-pressure hot water rinse at <500psi at 180°F</td></tr>
</table>

b) Conservare® HCT, HCT Rinse and H-100 is a combined, non-film-forming treatment made by ProSoCo www.prosoco.com of Lawrence, KS. HCT is a hydroxylating conversion treatment based upon heavily-buffered tartaric acid that physio-chemically etches calcite crystals in concrete and renders them attractive to water repellent ethyl silicates such as ProSoCo's Conservare® H-100. In this three-part process, the water-borne HCT concentrate is applied three times by spray to the point of rejection and allowed to dry between each spraying for a minimum of 30 minutes. This is followed by the application of a neutralizing alkaline HCT Rinse and allowed to dry for 24 hours before the application of the H-100 consolidant/water repellent. Like other materials used in this research, the combined system is vapor permeable, clear and will not block pore structures. But it is unique in also strengthening weak concrete surfaces due to the consolidating effect of the H-100.

Graffiti attacks over this system can be removed by medium-to-high pressure power washing (<500 psi) with hot water (approx. 180ºF) rinses through a 45-degree fan tip nozzle. The HCT/H-100 strengthened concrete surfaces should be more resistant to multiple attacks and repeated hot water power washing than with other graffiti barrier systems.

Sacrificial Barriers

c) PSS-20 is manufactured by Keim Mineral Coatings of America Inc., of Charlotte, NC. www.keim.com and is a surface applied treatment comprised of vegetable polysaccharides and water in a high-viscosity emulsion. Applied by airless spray in one or two coats in a transparent film, the manufacturer claims that the coating is undetectable to the naked eye and that surfaces retain their original appearance with no ghosting or marking after cleaning. The film is vapor permeable and totally reversible by means of hot water rinse removal. Designed for concrete and other porous masonry finishes, the coating is however susceptible to high alkalinity. This means that the graffiti protection of fresh concrete patch repair surfaces can only proceed after the concrete surface has been neutralized.

The application technique differs from other sacrificial anti-graffiti barriers, in that the surfaces to be treated should first be thoroughly pre-wetted with water to fill the pores and allow the PSS-20 to form its transparent protective coat at the surface with as little penetration as possible. The PSS-20 is sprayed in two coats at a pressure between 1,500-2,500 psi in first horizontal, then vertical, overlapping bands when temperatures are below <95º F. Each coat will take between 1-4 hours to dry between coats. Drying too quickly will produce an unwanted surface sheen.

When removing graffiti attacks from PSS-20 treated surfaces, the graffiti must be activated for several minutes by soaking using hot water (<140ºF) without pressure and left soaking for 2-4 minutes. During this time, the PSS-20 film will begin to swell, lifting the graffiti off the surface. Once this process is complete, the film residue, graffiti media etc. can then rinsed off the surface entirely using a power washer set for no more than <300 psi with a 45 degree fan nozzle tip. Once the surfaces are washed clean, the PSS-20 can be immediately re-applied while the substrate is still wet.

d) *Graffiti Melt™* is made by Genesis Coatings www.genesiscoatings.com of Vista, CA. It is a sacrificial graffiti barrier based on a paraffin wax (30 percent solids by volume) emulsion dissolved in an amine delivery solvent. It is a zero-VOC product, non-toxic and has low odor. The material is applied by spray and all surplus material at the surface must be cleaned off immediately.

Graffiti attacks can be removed with hot water at 190ºF as paraffin waxes have typical melting points between 115-154ºF. Paraffin wax is not solubilized by water and so technically does not dissolve but melts and floats free to be washed away at <500 psi by power washing with a 45-degree fan nozzle tip.

If however, multiple graffiti attacks and repeated use of hot water power washing starts to erode the concrete surface, then a different graffiti removal strategy can be deployed using Genesis Coating's Graffiti Eaze Away™ graffiti remover (based on aromatic petroleum distillate solvents) but used with cold water.

e) Defacer Eraser® *Sacrificial Coating SC-1* is made by ProSoCo www.prosoco.com of Lawrence, KS and is called a 'removable anti-graffiti shield.' It is a clear, water-based, thin, matte textured sacrificial coating for porous surfaces. It does not darken with age and is claimed not to alter the natural color of building materials. ProSoCo claims the material is vapor permeable, conforms to all US VOC reduction standards, and has good UV stability for a minimum of 5 years. When over-applied it will create a blush on the surface and must be removed right away. It is formulated around water soluble propylene glycol wax (10 percent solids). Applied undiluted by low pressure garden sprayers, the wax should be allowed to penetrate for up to 2 minutes and build-ups then removed with a damp brush or roller. Two coats are recommended for porous substrates with a 30-minute drying period between applications.

Graffiti removal can be achieved with medium-high pressure power washing (<500 psi) using hot water (<180º F). The material can also be removed using ProSoCo's Defacer Eraser® Graffiti Wipe chemical and cold pressure water rinse.

Other Important Issues

8.19 The manufacturers' recommended application techniques and product consumption rates (in gallons/sq. ft.) are important to follow and can be found in the Appendix E to this report where their Technical Data Sheets for all the products here mentioned are located.

8.20 RLA and other treatment installers followed the guidance on personal health and safety hazards contained in the manufacturers' Material Safety Data Sheets (MSDS) also provided in Appendix E

Performance Criteria for Anti-graffiti Barriers

8.21 We planned to use in situ adaptations of ASTM D-6578: 2013, *Standard Practice for Determination of Graffiti Resistance* and ASTM D-7089: 2006, *Standard Practice for Determination of the Effectiveness of Anti-Graffiti Coating for Use on Concrete……Surfaces by Pressure Washing* to assess the effectiveness of the anti-graffiti coatings (non-sacrificial) and barriers (sacrificial). We were, of course, most interested in the technical questions surrounding the concept of re-treatability, and potential harm caused by multiple repeat treatments – especially hot water pressure washing of potentially soluble calcareous surfaces in the concrete. Research findings by English Heritage described in "An investigation of sacrificial graffiti barriers for historic masonry," Vol 2, English Heritage *Research Transactions*, James & James, London 2001 show that calcareous stones and other lime-based building material surfaces (e.g., concrete) can be dissolved by repeated washing with hot water.

Structural Concrete Patch Repair Mixture Design and Performance

8.22 The petrographic testing of the core samples, discussed in detail in Section 6, determined that the original concrete used to construct the Stadium concrete incorporated ordinary Portland cement, Miami oolite for the coarse aggregate, silica sand and water and air. The paste content of the original mixture incorporated approximately 25 percent cement, 3-5 percent air, and had a water-to-cement ratio of approximately 0.50. The physical testing of the in-situ concrete as well and core samples, also discussed in detail in Section 6, determined that compressive strength of the concrete is approximately 5,000-6,000 psi.

8.23 Based on the physical and petrographic data, and information obtained from these samples, four concrete repair mixes were created. These formed the basis for the in-field testing used for the demonstration of repairs in the next section of this report.

8.24 Concrete repair mixtures that are used for structural repair of buildings and bridges today typically contain proprietary cementitious material in addition to Portland cement. Pozzolanic additives, such as fly ash, are used for a number of reasons, for example, to tie up free lime, to create denser material, to aid speed of set, and to save on the amount of Portland cement used (as its own manufacture is more energy-consuming and carbon emitting than other materials).

8.25 Our purpose for using fly ash for the repair mixture was to create a concrete mixture having the correct color match to the original material found in the Stadium. Fly Ash comes in a range of colors from tan to dark gray, depending upon its chemical and mineral constituents. Concrete which incorporates fly ash often lightens in color with age. Two of our four trial mixes also incorporated latex modifiers to replace water content, as the use of latex limits shrinkage, and contributes to tensile and bond strength of concrete[13]. Each of our laboratory mixtures produced 2.0 cubic feet in size and we used a 9-cubic foot rotary mixer to ensure thorough blending of the materials. Mixing, batching, and curing was conducted in general accordance with ASTM C192 standard practice for making and curing concrete test specimens in the laboratory. Three replicate specimens were made for each test (three for each age) and the results are as discussed in the "hardened property testing" paragraph 8.28 below. Detailed descriptions of the exact mixture quantities are presented in Appendix F. The concrete mixture designs used for this project are detailed in Table 6 below and consisted of the following:

- Mix 1 – 100% Portland cement
- Mix 2 – 100% Portland cement and replacement of water with latex modifier
- Mix 3 – 80% Portland cement and 20% class F fly-ash
- Mix 4 – 80% Portland cement, 20% class F fly-ash, and replacement of water with latex modifier

Table 8: Trial Concrete Repair Mixture Designs*

Material	**Mix 1 100% Portland Cement (lbs./ yd^3)**	**Mix 2 100% Portland Cement (lbs. / yd^3)**	**Mix 3 80% Portland - 20% fly ash (lbs. / yd^3)**	**Mix 4 80% Portland - 20% fly ash (lbs. / yd^3)**
Cement	611	611	489	489
Fly ash**	0	0	122	122
Water	318	118	275	83
Latex Modifier	0	200	0	192
Fine Aggregate	1355	1355	1395	1395
Coarse Aggregate	1355	1355	1395	1395

* Note: Mixture designs are based on volumetric mix design and values in Table 6 are based in pounds per cubic yard
** Micron 3 ™

Performance of Concrete Repair Mixtures

Plastic Property Testing

8.26 One of the key aspects with respect to usability of a concrete repair mixture in field use is that it be workable enough to place while maintaining consistency so that it does not segregate. The most commonly used standardized test to measure workability or consistency of concrete is the slump test specified per ASTM C143 and this was performed for each of the concrete mixtures used in this testing series. A normal slump range for concrete and repair materials is typically between 2-4 inches and with a maximum slump

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13 Ohama, Yoshihiko. *Handbook of polymer-modified concrete and mortars: properties and process technology*, Noyes Publications, Park Ridge N.J., 1995.

of 7 inches[14]. Concrete mixtures which do not have adequate slump values may be modified with chemical admixtures (e.g., plasticizers) to increase slump, which typically results in a more usable concrete mixture.

8.27 The mixtures developed for this testing program did not incorporate water reducing chemical admixtures, as it was intended to re-create the original mixture used to construct the Stadium. A latex modifier was; however, added to mixtures #2 and #4 to evaluate its effectiveness on the repair concrete. Table 9 below provides a summary of slump and temperature values for each mixture. The incorporation of fly ash to mixes #3 and #4 resulted in an increase to the slump values, which is consistent with the reported literature[15]. By contrast, the addition of the latex modifier reduced the workability of mixtures #2 and #4 respectively.

Table 9: Temperature and slump values for each mixture

	Mix 1	Mix 2	Mix 3	Mix 4
Temp (°F)	82	81	82	81
Slump (inches)	4	2	8.5	7.5

Hardened Property Testing

8.28 Compressive strength of concrete is the primary physical property and as stated in Section 6 often used as an indicator of modulus of elasticity and other physical properties. To evaluate each of the repair mixtures quantitatively and comparatively, the compressive strength testing in accordance with ASTM C39 was performed at ages of 7 and 28 days. Additionally, bond testing was performed using the slant shear bond test as presented in Figure 5 below[16]. The standard test method for the bond strength of epoxy resin systems used with concrete by slant shear as per ASTM C882 was used for our testing but with the following exceptions

Par 7.1 – Concrete was used for the substrate material instead of mortar

Par 7.1 – Type III cement was replaced with Type I cement.

Par 7.1.2 – 4 x 8 in. specimens were used in place of 3 x 6 in. specimens

Par 10.2 – Conditioning of the sample followed the procedure specified in ASTM C192 section 7.3.2 – 7.5

Figure 5: Slant shear bond strength specimen[17]

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14 FDOT, Florida Department of Transpiration, Standard Specifications for Road and Bridge Construction Section 346, 2015

15 Wilson, M. L., and Kosmatka, S.H.. "Design and control of concrete mixtures." Portland Cement Association: Skokie, IL.2011.

16 Ferraro, C.C., Boyd, A.J., Ishee, C.A., *Qualification of Repair Materials by Mechanical and Durability Properties*, Concrete Under Severe Conditions Volume 1. Editor(s): Castro-Borges, P., Moreno, E.I., Sakai, K., Gjorv, O., Banthia, N., CRC Press, London July 2010

17 Ibid

8.29 The average of three replicate specimens for each age and testing type is provided by Table 8 below. This provides a summary of the average compressive and bond strength for each repair mixture accordingly. Revisiting Section 6, the physical testing performed in the field, and on the core specimens extracted from the field, indicate that the compressive strength of the concrete used to construct the stadium is approximately 6,000 psi. Based on the results from the compressive strength testing, the concrete mixture we made which is most comparable to the *in-situ* concrete used to build the Stadium is concrete mixture #1. It obtained the highest compressive strength, as well as the highest bond strength.

Table 10: Compressive and bond strength values for each mixture

Test Type /Age	Mix 1	Mix 2	Mix 3	Mix 4
Compressive Strength 7 day (psi)	4,583	3,502	3,971	1,853
Compressive Strength 28 day (psi)	5,442	4,572	4,570	2,869
Slant Shear Bond Strength 7 day (psi)	2,647	1,492	1,283	956

9.0 FIELD TRIALS

9.1 Taking into account the background information, field observations, and laboratory analyses that informed our understanding of existing materials, performance and conditions, we used manufacturers' data, and field and laboratory testing to aid the design of compatible treatment systems. We then planned to deploy treatment trials at sites located by the project team and agreed with the City of Miami.

9.2 The bulk of our mockup treatment sites were centered on the specified graffiti removal wall on the southwest side of the Stadium (Appendix B, Photo 2), and also around the chosen site for reinforced concrete structural repair patching, at the deteriorated grade beam on the southeast side of the building (Appendix B, Photo 8). We otherwise chose mockup areas that were typically deteriorated and/or vandalized, safely accessible, relatively secure, and which could provide us with sufficient discrete physical areas for testing so that results could be observed in the same line of view.

9.3 Through the FOMMS, permissions were sought and obtained from the City of Miami for authority to proceed with the initial trials. Our submissions included a full justification for the mockup testing, together with a detailed specification, and the submission of Technical and Material Safety Data Sheets.

9.4 Field testing was conducted at various stages throughout 2015. The main areas of testing were concrete cleaning, graffiti removal, protective barrier coating testing, corroding rebar steel cleaning, and cast-in-place and trowel applied concrete repairs. These methods form the largest single portion of the work that will be required to stabilize and conserve the stadium. Field application protocols and results are provided in detail below.

Graffiti Removal: logistics

9.5 Six wall and floor surfaces were chosen for treatment applications, based on John Fidler's specification and our agreed testing location (Appendix B, Photos 2, 9, 10, 11). The primary wall chosen for testing was at ground floor level along the graffiti-covered southeast wall of the Stadium to the right-hand side of the car park entrance façade (Appendix B, Photo 2). This area is protected from the weather by the overhanging cantilever tie-downs of the hypar roof system, and is on the opposite and less exposed side of the Stadium from the lagoon.

9.6 This wall is one of the prime areas for street artists and graffiti. There are more layers of paint on this wall than on typical surrounding surfaces, as it is a large flat area, ideal for large overall murals. As a result, the paint is very thick and at times very spongy and slick. It is estimated that the depth of the paint on this wall is approximately 1/4 in. thick. The substrate construction below the paint coatings appeared upon investigation to be a cement stucco parged facing layer for a concrete block wall. Because of the variations in concrete surfaces, tests were also done on the floor, columns, and near-by ramp in order to get an idea of how the cleaning methods would affect these differently worn and textured surfaces. The ramp, floor, and ceiling are all made of poured-in-place concrete with a visual surface texture remaining from the plywood forms used in construction.

Test Areas

9.7 Test areas presented on the primary mockup wall were made each to 16 sq. ft. Other areas tested on the ramp, floor and ceiling, varied considerably based on the conditions presented. In some cases, because of the amount of material provided by cleaning media and equipment vendors (who provided some expert demonstrations), or the location to be tested, these additional areas were smaller than the 16 sq. ft., though generally tended to be approximately 4 sq. ft. or larger. (Appendix B, Photos 6, 11, 12, 13).

Site protection:

9.8 All cleaning test sites were covered overnight with plywood sheets. Wooden 2 x 4 in. boards were secured into the walls with concrete anchors above and below the test areas. The protective plywood was then secured into the boards with torx head (or star head) vandal-resistant screws. The 2 in. space between the board and the wall allowed for airflow and drying of the tested surfaces. (Appendix B, Photos 7, 14, 15)

9.9 Additional site protection included the containment of abrasive and chemical waste products, including removed paint. The floor area immediately in front of the test wall was cordoned off with a 3-4 inch deep waterproof collection point and 'evaporation pond' of solvent-resistant, 4-6mil, black-colored polyethylene plastic sheeting to capture surface run-off of rinsing water, wet abrasive aggregates, chemicals and paint residues so as not to pollute the site and adjacent lagoon. The sheeting was laid over wooden 2 x 4 ins. boards. The plastic sheet joints were sealed with duct tape. All collected residues were allowed to dry off naturally by evaporation and then the solids were carefully removed from site and safely disposed of, according to city, county, and state ordinances – as per the specification. (Appendix B, Photos 5, 6, 8)

Paint Stratigraphy and Adhesion

9.10 The paint stratigraphy for these walls is not uniform, as the paint was not uniformly applied overall. The nature of the paint layers changes not only on the various walls of the building, but also within the same wall.

9.11 Some recurring conditions can be noted, however. In general, it appears that the bottom-most paint layer for this wall is yellow colored and is present uniformly over the entire surface. (Appendix B, Photo 16) The paint is a water-based coating and well-adhered as it appears to have penetrated the porous cement stucco surface. It was most easily removed with paint stripper and pressure washing. There are other, overall painted layers that appear over the entire surface of the wall, particularly, a glossy gray color that is present approximately 8-10 layers from the bottom surface. (Appendix B, Photo 17) This is not surprising, as it is common for street artists to paint the entire surface of the wall before beginning a mural. The top-most layers are not well-adhered. Some pressure either manually applied or with abrasive systems, causes large chunks to pop off while leaving some pieces stubbornly in place.

Chemical Removal Methods

9.12 Three different ecologically safe paint strippers were decided upon for the testing procedures. It was important during the chemical testing that all products and waste be contained because of the location of the building, particularly the proximity to the lagoon waterway. Protection procedures were outline earlier in this report. Chemical cleaning tests were completed on the same wall as the abrasive tests in order to compare surface finishes once clean. No alternative surfaces were tested with chemical cleaners as it was clear that the test wall had the most severe conditions visible and other surfaces would realistically respond in a similar manner.

9.13 Pressure washing was most effective at removing paint and chemical stripper residue from the surface. In addition, this was particularly important for removing the bottom most layer of paint, which was well-adhered to the porous cement stucco. After pressure washing, the concrete surfaces were visible, including any tooling marks from installation. The chemical testing also provided an overall idea of the original surface texture for comparison to the subsequent abrasive tests. In all the tests, because of the multiple thick layers of paint coating, the pressure washer was used with 25° and 40° fan tips at a constant pressure of approximately 2,600 psi at a stand-off distance of approximately 2 ft.

9.14 Per Fidler's specifications, we applied the following chemicals and noted their performance:

(a) **Prosoco EnviroKlean SafStrip 8** (Appendix B, Photos 18 – 19)

- For each application, the product was applied by brush 1/8-1/4 in. thick to dry surfaces.
- The material was allowed to dwell for approximately 30-60 minutes in each application. Longer dwell times were not effective.
- Stripper was removed with paint scrapers and then residue was cleaned with a pressure washer.

Observations

- The stripper had minimal effect on the very thick multiple paint layers, appearing to remove only a couple layers of paint with each application.
- Tests were stopped after 15 applications and there was very little movement of paint layers. The concrete surface was not exposed with this product.

(b) **Dumond Chemical Inc., Smart Strip Pro™** (Appendix B, Photos 20 – 23)

- A thick coat of stripper was brush applied overall to the surface and covered with thick black plastic.
- The product was allowed to dwell for approximately 24 hours, while covered.
- After dwelling the product was removed with paint scrapers and rinsed clean with a pressure washer.

Observations

- After two applications of Smart Strip Pro (allowed to dwell for 24 hours each), we were able to remove coatings down to the bottom-most layer, though not completely. Removal was assisted with paint scrapers.
- After pressure washing (after 4th application of stripper), large sections of the wall were visible but lower portions were still covered by well-adhered paint. The pressure washer only helped to remove the bottom-most layer of paint.

(c) **Dumond Chemical Inc., Watch Dog Wipe Out** (Appendix B, Photos 24 – 27)

- The product was thickly brush applied over the test area.
- Dwell time was approximately 30 minutes for each application.
- Stripper was removed with paint scrapers and residue was rinsed from the surface with a pressure washer.

Observations

- Ten applications of paint stripper were required on the test wall in order for the entire 16 sq. ft. section of concrete to be cleaned.
- This paint stripper had a shorter dwell time than the Smart Strip Pro but removed fewer paint layers with each application.
- This product was used later during testing to remove a few layers of paint around patching test areas and was effective at removing the limited number of layers in a short amount of time.

Abrasive Systems

Operator Skills

9.15 It was very clear while undertaking graffiti removal tests with the various abrasive systems that a competent and qualified operator is key to the success of any treatment. Abrasive systems are only as good as the people who can operate them. The Farrow system, for example, was tested with three different operators on three different days. Two out of three people were able to get better results with the same system and media. This affected the trials to an extent because in some places surfaces were marred due to operator error in determinations of the appropriate pressure, dwell time and/or choice of abrasive media. It is clear that whatever system is used, much of the quality of the results lie in the skill of the operators and their ability to use the equipment in such ways that are not too aggressive. (Appendix B, Photos 24 – 27)

Media Choice

9.16 In two mockup testing cases, the choice of media also changed the effectiveness of the cleaning system. Because the equipment vendors (and our conservator team) came into the situation with one set of ideas for how best to remove the graffiti, in some cases the appropriate media was not on hand. Adjusting different media, pressures, and techniques led, in some cases, to finding a better solution. The same machine with even slightly different media showed dramatically different results. This was seen particularly in the results of a slightly larger particulate size used with the final operator of the Farrow system.

Abrasive Methods Employed

9.17 We invited various abrasive equipment manufacturers or licensees to demonstrate their tools and choices of abrasive as part of the mockup evaluation. Each company was contacted prior to testing and asked to provide a qualified operator, equipment, and media to present a 16 sq. ft. test to be done on the Miami Marine Stadium. They were told that the surfaces were concrete and heavily coated with various forms of graffiti. Vendors were also told that alternatives would be considered based on site conditions.

9.18 Prior to each abrasive test, the situation was assessed by a conservator with each vendor and the best choices were determined to fulfill our performance specification and criteria, based upon field conditions. Each test helped to inform later tests as we learned more information on the nature of the coating materials and surfaces. Because of this learning process, some vendors asked to return with alternate machines or media and this was allowed in order to obtain the best results. We provide here notes on the various systems deployed:

(d) **Ibix System**

Trials took place on two separate occasions: February 16, 2015 and February 27, 2015. Machines were operated by Ibix Surface Technologies USA employees, under the direction of Robert Langhans, President and CEO of IBIX North America.

Floor Testing – Day 1 (Appendix B, Photos 28 – 33)

- All media was delivered by dry blasting without water on the first day, as water provisions were not available at that time.
- The vendor used hard Australian Garnet blast media (Mohr scale 6.5 to 7), and not the expected softer calcite material (Mohr scale 3).
- Pressures used were 24-30 psi, with the 200 mesh size, rounded garnet-superfine, "Australian Red Garnet" and 60 psi with a wider spray pattern for larger coverage and stand-off distance of 12 inches.
- Approximately 1/2 lb. of media was used for 4 x 4 ft. section of floor.
- The Ibix system was not able to remove the thick drops of paint on the surface of the floor without marring the concrete around the drop. As a result, chemical stripper (Wipe Out) was applied, allowed to dwell and removed with a paint scraper. This was later abraded with the Ibix machine to remove remaining residue.

Wall Test – Day 1 (Appendix B, Photos 34 – 37)

- The vendor used 43 psi (3 bar), with 120 mesh sized Garnet and the rotational nozzle to remove heavy coats of paint.

- The Ibix representatives were concerned about being able to cut through the large amounts of paint on the chosen wall for the test panels. As a result, paint stripper (Wipe Out) was applied to the lower portion of the wall test area, removed after 1-hour dwell time, and wiped down with acetone and cotton cloth. This was done in an attempt to lessen the number of paint layers on the wall for the Ibix machine.

- Five attempts were made to remove the coatings in different passes, using a variety of pressures and blast media sizes. For example:

  - 74 psi (5 bar), 120 mesh Garnet (1st attempt);
  - 116 psi (6 bar), 200 mesh Garnet (2nd attempt) which caused damage
  - 70 psi (4 bar), 200 mesh Garnet (3rd attempt-lower portion)
  - 70 psi (4 bar), 60 mesh Garnet (sharp edged) (4th attempt) and
  - 116 psi (6 bar), 60 mesh Garnet (5th attempt) which caused damage

- The tests on the thick painted wall areas (even in the areas of reduced paint layers due to paint stripper application) were not successful with the Ibix machine using Garnet media. Various pressures and sizes of the Garnet material were used, all with negative results. In some cases, damage was done to the lower surfaces as the garnet was not the right material for the thickest and most well-adhered layers. No other media was brought with the representatives on this day and Ibix asked to return with other materials at a later date.

- A full section 4'x4' section was not completed due the fact that the process was not working well.

Column – Day 1 (Appendix B, Photos 38 – 40)

- The column had a different surface texture than the cement stucco on the wall and was also dissimilar to other poured-in-place concrete areas, such as the ramp and floor. Its surface had many irregularities and air bubbles.

- Here, the vendor deployed 60 and 70 psi (3 and 4 bar), 200 fine mesh Garnet

- The Ibix tests on the column were successful in removing the paint layers and maintaining the surface of the concrete layer. The method was quick and easy to maneuver.

Wall test – Day 2 (Appendix B, Photos 41 – 44)

- Access to water was available during the second day with Ibix and therefore all tests were performed in wet abrasive slurry mode with this function, in order to decrease the mess of airborne media.

- The vendor applied 100 psi (7 bar), 30-40 mesh Garnet with a stand-off distance of 12-18 ins. The equipment nozzle was changed from rotational to a straight shot.

- He also tried 90 psi, with a 200 fine mesh Garnet at a stand-off distance of 6-8 ins. The smaller I9 machine was used.
- At 90 psi, with a 120 mesh Garnet, the vendor switched to larger helix nozzle but this caused too much damage to the concrete.
- At 70 psi (4 bar), the 120 mesh Garnet was also too aggressive.
- The vendor then tried 70 psi (4 bar), with a 200 mesh Garnet and straight nozzle, and 116 psi (6 bar), with 200 mesh Garnet with another non-rotational nozzle.
- Various other permutations were attempted with the 200 mesh Garnet blast media, including 3 psi (2 bar), 47psi (3 bar), and 65 psi (4.5 bar), utilizing rotational and non-rotational nozzles for finishing work, close to the concrete. The lower pressures were able to remove the paint from the cement stucco without damage when only a couple paint layers were remaining.
- The vendor also tried crushed glass as a blast media. At 47 psi (3 bar), with 40 - 70 mesh material and a non-rotational nozzle deployed at a stand-off distance of 6-8 ins, the glass was able to penetrate the paint without marring the surface.
- At wall test #9, the vendor then tried 40-70 mesh Crushed Glass at 35 psi (2 bar), on a small area before the media ran out. Here the paint was removed without visible damage.
- Crushed glass at 35 psi (2 bar) with water was the most effective at removing the paint from the stucco. This method produced the best surface finish without much visible marring.

(e) **Sponge Jet System**

Testing took place on February 17, 2015. The system was operated by a Sponge Jet operator from High Tech Enviro Systems: our point of contact was Alain Belanger.

Wall Tests (Appendix B, Photos 45 – 52)

The following pressures and media listed outline the variety of materials and methods used onsite by the vendor.

- The 70 psi, Silver 80 Sponge Media was able to get down to concrete substrate level but some abrasion of the surface was noted. The operator stated that a heavier grit would help to take down early layers. However, supplies of the heavier material were limited during testing. It was suggested that the best method would be to get to the lower levels with courser grit and then use finer grit.
- 70 psi - Silver 220 Sponge Media
- White SPOCC Sponge Media (Calcium Carbonate-Softest) with a stand-off distance of 8-12 ins.

- Several tests were done at the substrate surface level to see what would work the best without marring the surface. While the SPOCC sponge media worked the best of the Sponge jet options, when compared to the smooth surface shown with the paint strippers, the surface was definitely marked.
- A full 4 x 4ft. section of wall was not completed, as the vendor did not bring enough media for a 16 sq. ft. test.

Floor Test (Appendix B, Photos 53 – 55)

- At 70 psi, with the 220 Sponge Media, and a stand-off distance of 2 ft. declined at an angled approach to the floor, the media did not appear to mar the surface.

Column Test (Appendix B, Photos 56 – 59)

- Trials were undertaken with a pressure of 70 psi, and 220 gauge Sponge Media and SPOCC deployed down to bare substrate. The observed concrete surface of the Column had air pockets and a remedial cement skim coat applied to even out the surface. The Column also showed signs of patching above, in areas not covered with graffiti. Minor surface marks left by SPOCC cleaning were visible.

(f) **Dry Ice Blasting**

Testing took place on February 18, 2015. The equipment was operated by Kevin McNeil, a representative from Cold Jet, and supplied by Dry Ice Blasting Miami. Though this method was originally intended to be used for fine finish work on the surface for its ease of clean up and gentle nature, the Cold Jet representative and vendor both recommended that another system be used for the finish work. Dry Ice Blasting Miami estimates a rate of $1,580 per day for Dry Ice calculated at $0.55 per pound, and 3 pounds of ice per minute needed.

Wall Test (Appendix B, Photos 60 – 65)

The following pressures and media listed outline the variety of methods used onsite by the vendor.

- At a minimum, 50 psi but typically requiring 80 psi for an effective surface cleaning, the operative moved from right to left and was able to blast off layers of paint from the surface with a stand-off distance of some 6-8 ins.

- With Dry Ice ablation, a barrier would need to be built to keep the scattering paint pieces from going into the lagoon. The paint chipped off the building in big pieces (approx. 8 x 6 ins. and smaller), and approximately 1/16 inch in thickness.

- Dry Ice works well on the areas of heavy paint, to quickly and easily take it down to fewer paint layers.

(g) **Farrow System**

Although not specified, RLA trialed the Farrow System, www.farrowsystem.com, originally developed for the marine industry, which has proven effective in cleaning many materials quickly, easily, and without damaging them. It cleans wood, plastics, composites, steel, aluminum, brass, ceramic tile, concrete, asphalt, decorative pavers, stone, brick, and more. The Farrow System®, is a low-pressure system that works by adding heat to the cleaning process. This adds energy, creates free flow, adds control, and increases cleaning speeds. The system uses Farrow System® media, which is made from 100% recycled glass, optimizing its properties of environmental safety, cleaning without damage, and incredible efficiency. Testing took place on three separate occasions in 2015: on February 18, February 26, and March 19. A different operator was used during each test. The first was Kevin McNeil the representative of Cold Jet; the second was an operator from Dry Ice Blasting Miami; and the third was Dustin Kisler from Hail Storm Ice Blasting.

The first Farrow vendor was not able to get this system to work on heavy layers of paint. The third operator was able to get the process to work on the thicker layers of paint with a courser media; however, he did not have the finer glass to appropriately clean the lower layers of paint. Farrow appears to work best for areas with fewer paint layers (e.g., at the Stadium on the columns, side walls, and floors).

Floor test – Day 1 (Appendix B, Photos 66 – 67)

The following pressures and media listed outline the variety of methods used onsite by the vendor.

- 65 psi, *"Black Beauty"* glass media at a stand-off distance of 12-18 ins.

Column test – Day 1 (Appendix B, Photos 68 – 69)

- Same parameters as above. After cleaning with Farrow on the Column the original surface texture was still visible.

Wall test – Day 2 (Appendix B, Photos 70 – 71)

- 40 psi, *"Black Beauty"* glass media with a stand-off distance of 6-8 ins. This method was effective at removing the bulk of the paint layers. The stand-off distance was increased to 12 ins for the bottom-most yellow layer.
- Where the wall was cracked, the damage was exacerbated by the abrasive.
- *"Black Beauty"* media costs $13.00 per bag. Two bags of media were used at a rate of three bags per hour.
- Cleaning took place at a pressure of 55 psi, and a stand-off distance of 1.5 – 2 ft., moving the nozzle in a circular motion.

Ramp test – Day 2 (Appendix B, Photos 72 – 73)

- At 50 psi, the *"Black Beauty"* glass media was used to test paint removal on the ramp at a stand-off distance of 6-8 ins.
- The pressure was lowered to 40 psi to maintain surface texture.
- Lines of the original plywood board formwork were visible in reverse. Air pockets and some surface abrasion were also visible, however.

Ceiling test – Day 2 (Appendix B, Photos 74 – 75)

- At 40 psi, and a stand-off distance of 8-12 ins., the *"Black Beauty"* glass media was effective at cleaning the surface and left the texture of the boards in place.

Wall test – Day 3 (Appendix B, Photos 76 – 77)

- At the higher pressure of 50 psi, the *"Black Beauty"* glass medium was used to remove thick paint coatings on the wall surface. The vendor was able to remove from top layer of paint effectively, but it was not possible to keep the surface details as smooth. There were also doubts about the consistency of the abrasive mesh size.

Concrete Cleaning: Dirt and Biological Growth removal

9.19 The nature of the site is such that the only areas not affected by graffiti are found on the higher surfaces. Because of this, areas on the upper portions of the structural columns were chosen to test for dirt and fungal removal. Though not consisting of entirely representative sites, the dirt and bio-growths on the stadium's walls are relatively easy to clean, as will be seen below.

9.20 Surfaces generally displayed overall dirt and grime from years standing in an outdoor marine environment with little or no protection. Dark areas of run off from water are visible on the exterior portions of the columns.

9.21 Two methods of concrete cleaning were chosen for this purpose: chemical and abrasive methods. These were tested independently, but it is understood that they can be used together as needed, and varied depending upon the requirements of the City of Miami's Department of Environmental Resources Management (DERM).

Chemical methods

9.22 An area high up on the right-hand column of the car park entrance façade was chosen as the test site for chemical cleaning of unpainted but stained concrete. This was in the same area as the previous tests but located opposite to the wall testing site. Due to ladder access limitations, one sample area of D/2 was located on the East side of the column, while two sample areas located on the West side of the column were devoted to Sure Lean Light Duty and Heavy Duty Restoration Cleaners. All the areas exhibited similar general soiling conditions. For each of the chemical cleaning tests, surrounding areas were kept saturated with water so as not to affect neighboring surfaces.

h) **D/2 Biological Solution™** (Appendix B - Photos 78 – 79)

- The product was applied to the surface and allowed to dwell on the surface for approximately 10 – 15 minutes.
- While lightly misting with water, the area was agitated with a nylon bristle brush to work the material into the upper pores of the substrate and then rinsed with filtered tap water.
- Biological growth was completely removed in the area tested.

i) **Prosoco Sure Klean® Light Duty Restoration Cleaner** (Appendix B, Photos 80 – 81)

- The product was diluted with clean, filtered tap water at a rate of 1:6 and was applied by brush and allowed to dwell for 5-15 minutes.
- The area was agitated with a nylon bristle brush and then thoroughly rinsed with filtered tap water.

j) **Prosoco Sure Klean® Heavy Duty Restoration Cleaner** (Appendix B, Photos 80 – 81)

Although not specified, RLA trialed the Sure Klean® Heavy Duty Restoration Cleaner, manufactured by ProSoCo www.prosoco.com, of Lawrence, KS in case of the need for heavily soiled concrete. The product is a concentrated acidic cleaning compound for the removal of heavy atmospheric staining from unpolished masonry.

- The product was diluted with clean, filtered tap water at a rate of 1:6 and applied by brush, then allowed to dwell for 3-5 minutes.
- The area was agitated with a nylon bristle brush and then thoroughly rinsed with filtered tap water.

Abrasive methods

9.23 Because we lacked physical access during the trials to the Stadium's upper areas of non-painted but soiled roof and wall surfaces, we tested the cleaning of dirt and fungal growth from concrete using abrasive systems by reference to floor and ceiling mockups, which displayed uneven coverage of paint with dirty concrete surfaces. Here, the Ibix, Sponge Jet, and Farrow systems all successfully completed floor tests and were all able to not only remove the thin paint layers but also clean away the dirt and grime left on the surface without much damage. (Appendix B, Photos 82 – 85)

Anti-graffiti Barrier Coatings

9.24 We installed two of the three types of anti-graffiti barrier available on top of the areas we cleaned free of graffiti, in the knowledge that the areas would be re-tagged and painted, so that we could test re-cleaning of the newly treated sites. We deployed the semi-permanent anti-graffiti barriers and sacrificial anti-graffiti barriers as specified according to the manufacturers' instructions. (Appendix B, Photos 86 – 89)

9.25 During our second application of Defacer Eraser on the wall, it was noted that there was beading of the product, and not as much was absorbed. Three coats were applied to wall test #6 and two coats were applied to wall test #8. (Appendix B, Photos 90 – 91)

9.26 The ProSoCo H-100 water repellent ethyl silicate consolidant was applied in two or three cycles of three successive applications of product, over the HCT and HCT Rinse. We tested it on a clean area of concrete under the Stadium ramp. (Appendix B, Photos 92 – 95)

Removal of Graffiti and Sacrificial Anti-Graffiti Barriers from Re-tagged Areas

9.27 Almost all of the systems specified and installed, as above, require the deployment of hot water at raised temperatures, in sufficient volume, and at adequate pressure to loosen the anti-graffiti barrier, remove it and the graffiti paint at the same time. However, although our mockup test sites did receive the expected new graffiti attacks that warranted our tests of the removal protocols, we were sadly prevented from trialing removals for the following logistical reasons.

9.28 At the time that our testing was to be performed, in the summer of 2015, the City of Miami was in the process of major temporary construction around the Marine Stadium for the purpose of preparing the site for the upcoming 2016 Boat Show. Water sources that we had planned to use became disconnected, thus making it impossible to test removals according to the manufacturers' instructions. We did experiment by bringing hot water to the site in thermal containers and applying the hot water to the surfaces with longer dwell times. We also agitated the hot water on the paint surface with a nylon bristled brush. But neither technique was successful in removing the new graffiti attacks because we lacked sufficiently high temperature water in appropriate volumes to deploy at medium to high pressures.

9.29 We recommend that this testing of the anti-graffiti barrier systems is tried again at an appropriate time during the initial stages of the renovation of the Marine Stadium, as its results will greatly inform future graffiti management strategies for the site.

Challenges of Protecting the Miami Marine Stadium Site from Graffiti

9.30 The Marine Stadium site's environmental context, as an active gathering place and street art venue for the last 20 years, makes the need for a useful graffiti coating system a managerial priority. Surfaces are regularly tagged even while there is a security guard onsite during the day and a fence surrounding the area at night. New graffiti appears relatively quickly especially after areas have been cleaned. Changing these conditions would require extensive surveillance as well as a change in the culture of how a portion of the Miami population views the stadium. Twenty-four hour security will be necessary to maintain this structure from future attacks, while restoration occurs.

9.31 Even our protect mockups and tests suffered from vandalism and graffiti damage. (Appendix B, Photos 96 – 97) The cleaning tests were tagged over the weekend after our first tests were complete, and before the graffiti coatings could be applied. This necessitated the application of graffiti protective coatings quickly after the second cleaning of the surfaces i.e., on some surfaces before they were adequately dry, and this may have impacted the effectiveness of the barrier coatings.

Potential Graffiti Art Protection Methods

9.32 There is general agreement within the City of Miami, and at the Friends of the Miami Marine Stadium that the rehabilitation of the Stadium does require all tags and graffiti to be removed back to bare concrete in order to restore the original concept and delivery of Hilario Candela's masterpiece. However, it is fair to state that the Miami art community is somewhat divided upon the issue: on the one hand, pointing to the expressive street culture's success in bringing a new generation of the public to appreciate artwork; and on the other (as witnessed at the above-mentioned symposium), the graffiti artists themselves wanting to move on once officialdom returns to manage the site. Furthermore, it is recognized by all parties that some graffiti art can be extremely fine and have artistic and commercial value warranting special measures to ensure its survival.

9.33 The CON-Sol project team had already devised a strategy to honor the graffiti art through documentation and light projection at special events. We also propose blank stuccoed walls be provided in the adjacent landscaped areas next to the Stadium that the artists might continue to use once the Stadium is back in use. However, planning for all eventualities as part of our work, we also planned trials of methods to carefully remove examples of the finest graffiti art (determined by others) from the site for installation elsewhere i.e., not at the Stadium. We also planned to test methods to protect some of the artworks in-situ by installing reversible clear coatings / varnishes on top of the graffiti to safeguard their welfare from overpainting or cleaning damage.

9.34 However, we believe it would be entirely feasible from a technical perspective to cut away and remove some of the latest artwork at the Stadium for reinstallation elsewhere, because it sits towards the top of many layers of paint that provide a degree of substrate stiffness for the *stacco* process, commonly used in the rescue of frescoes. Where however, the many paint layers and resultant surface tensions in film-forming materials has tended to cause the paint systems to crack and curl away from the concrete, such removals may be more problematic, as it might be difficult to soften the many layers adequately to make them lie flat in one plain.

9.35 We did manage to commission Ms. Rusty Levenson of ArtCare www.artcaremia.com to experiment with in-situ preservation of graffiti by applying a reversible protective aqueous coating system. (Appendix B, Photos 98 – 101) Unfortunately, the proprietary product she insisted on using, 41-41e, was provided by Richard C. Wolbers, Associate Professor at the Winterthur Conservation program, University of Delaware, and is of his own making, whereby he refuses to provide background technical and safety information that would be required for any public works project. On this basis, we abandoned the Artcare trial and provide no other information on this subject here.

CONCRETE PATCH REPAIRS

Standards of practice

9.36 The American Concrete Institute has determined that 50 percent of all concrete repairs are not performing well due to design, construction and material selection errors, and that a code of practice for minimum standards is necessary to raise repair and protection performance. We therefore determined our generic patch repair trials strategy based upon ACI 562-12 *Code Requirements for the Evaluation, Repair and Rehabilitation of Concrete Buildings*[18], Section 2.2 Definitions thus:

- **Structural concrete -** plain or reinforced concrete in a member that is part of a structural system required to transfer gravity and/or lateral loads along a load path to the ground.

- **Structural repair** - to replace, correct, or strengthen deteriorated, damaged, or understrength load-resisting members and nonstructural members which, if failed, would result in an unsafe condition.

9.37 We also took heed of guidance from ACI 364.1R-07, *Guide for the Evaluation of Concrete Structures before Rehabilitation*, and ACI 562-12 Part III, (Repair) *Implementation*, besides referencing various pertinent publications of the International Concrete Repair Institute[19].

9.38 Taking into account the various evaluation and repair codes and guidance, we decided to design and install two classes or categories of patching repair necessary for the differing concrete components and finishes throughout the building. These were:

- Minor surface repairs to structural or non-structural concrete (e.g., where concrete tie wires without sufficient concrete cover had corroded and caused superficial, minor spalling) (Appendix B, Photos 102 – 107)

- Major repairs to load-bearing structural concrete. (Appendix B - Photos)

In practical terms, this involved minor, cosmetic mortar patch repairs to small, unconnected areas of surface loss, i.e., less than 1/2 inch deep where there is no impact on the structural stability of the building. Such areas would be patched purely for aesthetic reasons, to recreate a cohesive wall, floor or column without visible marring. Major repairs impact the structure and contribute to the engineered stability of the building or a part of the building. The latter treatments generally cover any and all areas with cracks, spalls and latent spalls more than 1 inch deep that warrants exposed rebar treatments and/ or replacement or supplemental steelwork introduction, besides cast-in-place renewal of the concrete cover over the spalled area. They tend to be more substantially sized patches in areas where damage is often contiguous.

Supporting Treatments

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[18] This document is due for revision in 2017

[19] ICRI www.icri.org Technical Guidelines #310, Surface Preparation; #320, Repair Materials and Methods; #330, Strengthening Systems and #510, Electro-chemical Techniques

9.39 We did not address in any detail supporting remedial treatments such as the introduction of impressed current cathodic protection systems, carbon-fiber wrap supports, epoxy-injection systems, etc., because, although such measures will play a vital role in extending the life of the Stadium and of its repairs, they fell outside the scope of our grant-aided work.

9.40 We dismissed common concrete protection measures such as sealers and coatings as being too aesthetically obtrusive for the historic Stadium. We also found them technically flawed for this situation, because the concrete has a high salt content that could crypto-fluoresce for example, and cause more damage under film-forming paints. Previous reports by others cited in this document have mused over the possibility of deploying electro-chemical chloride extraction and concrete re-alkalization as remedial measures. But we deem them to be impractical and mostly palliatives that would have to be repeated with increasing frequency – not worth the investment, given the local environmental conditions around the Stadium.

9.41 We do think that cathodic protection via sacrificial passive anodes and/or an impressed current system does have great potential to aid concrete patch repairs at the Stadium. We met with providers of these repair methods, and discussed the possibility of them installing complementary trials of their products alongside our mockup sites. However, the costs of such exercises proved to be beyond the project's budget.

DESIGN AND DEVELOPMENT OF TRIAL CONCRETE MIXTURES

9.42 Key goals were to develop effective and durable repair methods that aesthetically matched the surfaces of the Miami Marine Stadium. Candidate materials and techniques for the trial patch repairs were identified and evaluated. The final selection of materials and techniques was based on the exposure conditions for both installation and service, installation constraints, structural performance requirements, service-life requirements, architectural requirements, and compatibility with existing materials, especially from a conservation point of view. We also limited our technical responses to some of the most typical deterioration problems where we found them to be both accessible and discrete for our trial purposes.

9.43 In addition to the conservation aspects of the future repair program, the durability of the repairs themselves are of utmost importance. According to ACI 562-13 – The *Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings*, "The durability of materials incorporated into a repair depends on their ability to withstand the environment where they are installed. The durability of repairs is dependent on the compatibility between repair materials, the structure, and the surrounding environment. To achieve compatibility, the repair and the structure need to interact on several levels, including chemical, electro-chemical, and physical behavior, without detriment."

9.44 To achieve this, we selected repair materials that are compatible with the existing structure, durable within the environment of Miami Marine Stadium, and consistent with the anticipated maintenance of the rehabilitated in-use structure. We considered the condition of the existing reinforcing steel and its concrete cover, which was often not always adequate to provide corrosion protection. We are of the opinion that the ultimate conservation of the building will require installing alternate means of providing sufficient cover, such as corrosion inhibitors and/or the cathodic protection systems mentioned above.

9.45 Our proposed trial mixtures were designed to limit cracking, due to drying, shrinkage or other means, and to provide sufficient bond to the substrate. Cracks reduce the protection provided by the repair material and allow ingress of water and deleterious materials such as salts, and insufficient bond can lead to failure of the repair. In repair areas with existing reinforcing steel, we removed damaged concrete and corrosion products from reinforcement prior to the application of the repair materials. Sufficient concrete was removed to allow for the new repair materials to completely encapsulate the reinforcement.

9.46 In concrete repair, the on-going corrosion of embedded metals adjacent to the repair area may be accelerated by the "ring anode effect" due to differing electrical potential between continuous reinforcement in the repair area and the surrounding area, depending upon the relative humidity and chloride content. We investigated the likelihood that the anodic ring effect could be induced by our repair methods, and installed corrosion inhibitor on the cleaned rebar as an appropriate corrosion mitigation strategy.

9.47 Our project design envisaged that the minor / cosmetic patch repairs would ultimately be delivered for the Stadium's major rehabilitation scheme via custom-matched proprietary concrete repair mortars (i.e., with mortar slumps of 3-5 inches according to ASTM C143[20]) from nationally-known suppliers. By contrast, the major structural repairs would likely be engineer-designed and made locally as poured cast-in-place concrete to match existing (i.e., with concrete slumps of 8-12 inches). On the basis of this hypothesis, the mixes and installation procedures tested are described below.

Trial Logistics

9.48 Subsequent to the creation and physical testing of the concrete repair mixtures in the laboratory, field trials were conducted at the Stadium on a structural ground beam to the right (south) of the cleaning test wall at ground level ((Appendix B, Photo 8). Practice tests and sample coupons of the trial materials were also produced at the RLA studio.

9.49 The large onsite mockup was not initially successful in providing an exact color match for the original concrete. This was because of an installation finishing error concerning the cast-in-place concrete formwork: for RLA and LFE mistakenly assumed that a chemical release agent would be needed to help remove the relatively smooth plywood form from the curing concrete. But this was not the case. In error, with hindsight, conveniently cheap and available WD-40 penetrating (water displacing) mineral oil http://wd40.com was used as the release agent (as it commonly is in civil engineering projects), sprayed onto the inside of the formwork before the concrete was placed. The brown-black oil unfortunately dark-stained the concrete and ruined the initial color-matching exercise.

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[20] ASTM C143 *Standard Test Method for Slump of Hydraulic-Cement Concrete*

9.50 Alternative proprietary non-staining mold and formwork release agents based on concrete set retardants employing mild citric acid (e.g., Edison Coatings System 22 product), and alternative light oil and soap barriers, are all available in the concrete industry. But, as we describe further below, our subsequent use of pliable rubber latex formwork liner material, entirely negated the need for any concrete retardation or formwork separation.

9.51 This initial staining set-back did inform later mockup testing, and eventually led us to achieve the required and appropriate results. Most of our subsequent testing was performed away from the Stadium, off-site, due to increasingly difficult access and security conditions. We made onsite latex negative molds of cleaned concrete surfaces and used the rubber material then off-site as formwork liner to create replica concrete coupons. Once cured, the coupons were returned to site and assessments made of the replica colors and textured finishes.

Minor / Cosmetic Patch Repairs

9.52 Two samples of concrete, taken from the Stadium, were sent to each of two national suppliers / manufacturers of custom-matched, concrete patching materials: namely, Cathedral Stone Products Inc., www.cathedralstone.com (the American supplier of Jahn repair products www.jahn-international.com/en/products) and Edison Coatings Inc., www.edisoncoatings.com with a request for them to create custom restoration mortar mixes, which would match the existing concrete surfaces and could be applied in small, non-structural areas. We sent two samples to each vendor to provide them with a sense of the color range in the concrete.

9.53 Mockup test areas were chosen close to the structural concrete tests to the right of the cleaning test wall, at the right-hand side of the car park entrance façade. The areas were first locally cleaned of surrounding graffiti with Watch Dog *Wipe Out* paint stripper, chosen from our previous trials as being effective on few paint layers and a short dwell time.

Jahn Restoration Mortar – Jahn M90 (Appendix B, Photos 102 – 105)

9.54 Areas for the Jahn repair were cut back according to the Jahn installation guidelines, allowing for a 90-degree ledge into which the material can key. Patches were finished to match the surrounding surface texture.

9.55 Jahn Restoration Mortars are manufactured by Cathedral Stone Products of Hanover, MD (www.cathedralstone.com). They consist of a range of single-component, cementitious, mineral based repair mortars designed for the restoration of concrete, stone and terra cotta. Latex, acrylic bonding agents, or additives are claimed not to be part of the mix and the manufacturer states that they are not required for the mortar's application[21]. The mortar is stated to provide a healthily high pH factor and strong resistance to carbonation, creating an environment "that does not allow corrosion to begin". Cathedral Stone claims that the material can be applied in a single layer build-up for faster application and reduced installation costs, regardless of the depth of the spalled area.

9.56 Three sample mixes were made by Cathedral Stone with different Jahn Restoration Mortars for the Marine Stadium mockup: i.e., M90 35238 – CR-22 (HG), M90 35238 – CR-21 (HG), and M90 35238 – CR-11 (HG). Coupons of each of the patching samples were made at RLA's studio and brought to site for comparative purposes when placed next to the existing structure.

9.57 Jahn mortar M90 35238 – CR-21 (HG) (Appendix B, Photo 103) was determined to be the best color match of the three options for the area used for mockup comparisons. It is possible that the alternative mixes could match other areas of the building more satisfactorily, since there is some minor color variation in the concrete throughout the structure, due to weathering exposure, soiling slightly different concrete batch mixes, and

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21 This claim is made as a direct counter to the acrylic latex- and plasticizer- amended, cement-based mortars marketed by Edison Coatings, Cathedral Stone's largest competitor in the preservation market. However, in conversations with John Fidler, Cathedral Stone has admitted that, for shallow patch repairs with feathered edges, it can and does add acrylic latex to some formulations to resist undue shrinkage.

surface textures. The above-mentioned mix was installed in the prepared area around the outer wall of the Stadium at ground level to the right of the previously mentioned testing wall.

Edison Coatings – Custom System 45 (Appendix B, Photos 106 – 109)

9.58 The Custom System 45 products are manufactured by Edison Coatings of Plainville, CT (www.edisoncoatings.com) and consist of a two-component, latex-modified, cementitious compound used, as the manufacturer claims, "to produce highly durable and compatible aesthetic repairs to masonry and concrete." A range of additives complement the system and can be applied for set enhancement or retardation; super-plasticizing and other required characteristics.

9.59 Two concrete sample specimen pieces were sent to Edison Coatings from which one custom test kit sample was made: Custom 45 #7983 – CN (Appendix B, Photo 109). This sample was determined to be a good match and was installed in a superficial area prepared along the same beam as the structural repair test. This is located on the structural ground beam to the right of the cleaning test wall at floor level.

FIELD PREPARATION AND INSTALLATION METHODS

Application methodologies and challenges

9.60 As stated above, the area chosen for onsite patching tests was a structural ground beam located to the right (south) of the cleaning test wall at ground floor level. The beam showed evidence of considerable rebar corrosion and spalling along its top and east sides (Appendix B, Photo 110). The concrete and rebar were prepared in the following manner:

Concrete Preparation

9.61 The area was inspected for loose and spalling concrete. Any areas that were spalling and could be removed with gentle pressure were removed and collected. These were brought back to the RLA studio to continue concrete testing and compare to patching tests.

9.62 The area around the concrete was cleaned of surrounding graffiti. This had to be done because the concrete patching tests were being installed in an area not previously cleaned of graffiti by prior testing. The area presented only a few layers of graffiti and in an effort to reduce time in an exposed place, liable to vandalism, RLA used Watchdog *Wipe Out* as the chemical paint stripper offers a shorter dwell time than the Smart Strip Pro. (Appendix B, Photo 112).

9.63 The cavities in the spalled area were then cut deeply behind the corroding rebar so that access to the back of the steelwork was facilitated (Appendix B, Photo 111). Sides of the spalled area were then addressed with chisels to be slightly undercut, to better receive and hold the poured concrete patching material. All surfaces in the spall cavities were roughened to provide a key for the repair patch, and all dust and debris removed.

9.64 After the rebar steelwork had been cleaned and prepared, as described in the following bullet points, the concrete spall cavities were spray drenched with water until saturated-surface-dry (SSD) conditions had been achieved: this to limit excessive absorption of moisture from the cast-in-place repair mix, and to foster wet curing of the concrete.

Steel Rebar Cleaning and Protection

9.65 RLA then removed corrosion products mechanically from the exposed rebar utilizing the Ibix and Farrow abrasive cleaning systems, and followed up upon stubborn patches with a wire wheel attached to a power drill. All three cleaning systems were effective in removing the extensive corrosion, but the Ibix and Farrow systems were much quicker and produced a cleaner surface for the metal. As was expected, it was clear during these tests that the steelwork needed to be coated immediately following cleaning, as the proximity to the humid lagoon shoreline and nearby ocean's saline sea mist caused the steel to tarnish within minutes of cleaning with the abrasive systems. (Appendix B, Photos 112-119)

9.66 Note that the cleaning of reinforcing steel prior to structural repairs must be done with caution, to avoid removing too much of the rebar cross section and thereby reducing its ability to carry structural loads. Guidance is provided in ACI Tech Note 364.10T – *Repair of Structure with Reinforcement Section Loss*. A loss of reinforcement section of less than 10 percent is generally accepted, provided that the engineer is satisfied that the original design is adequate and no changes of use or functional demand issues have occurred (e.g., changes in applied loads or environmental exposure). However, for larger section loss, the original structural design must be checked by a licensed structural engineer to determine if the remaining reinforcement is adequate, and if not new rebar introduced as substitute material.

9.67 To treat the freshly-cleaned corroding metalwork, RLA deployed Skyco's Ospho corrosion converter[22] to the surface and allowed the coating to stand overnight. For additional protection, the metal was then coated with Sika Armatec 110, an epoxy resin modified, quick-setting, cementitious mortar paste[23]. This was applied by brush and allowed to sit for 2 hours prior to patching, according to the manufacturer's instructions. (Appendix B, Photos 121, 123)

Formwork Preparation

9.68 RLA used bare plywood boards for the formwork surfaces to create a surface texture like the surrounding poured in place concrete (Appendix B, Photos 124-125). At the time, it was thought that a form release agent was needed to safely remove the forms from the concrete quickly as it was curing. Because of concerns about how a form release agent might affect the color of the concrete mix (a concern validated after the WD40 trial), a separate area of the forms was made with a smooth, black, polyethylene plastic sheet in contact with the concrete, instead of the plywood boards. This acted as a control and did no replicate either the rough board-marked or ply sheet form work surfaces of the historic concrete.

9.69 Frames of 2 x 4 ins. softwood were constructed around the beam to support the plywood formwork, tightly fitting to the existing flat outer surfaces of the concrete.

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22 Previously referred at paragraph 8.11(i) above: a balanced formula of phosphoric acid (H_3PO_4), dichromate salts, wetting agents and paint extenders[22]. This converts iron oxide (rust) into inert ferric phosphate.

23 See https://usa.sika.com/.../pds-cpd-SikaArma110EpoCem-us.pdf: a 3-part, water-resistant, epoxy-modified, quick-setting, cementitious mortar paste

9.70 When casting poured-in-place concrete with the appropriate fluidity i.e., an 8-12 ins. slump to ASTM C143[24], it is important to design and construct controllable vent holes in the tops and sides of the formwork to release air trapped by the gravity feed pressure of incoming concrete – otherwise, air pockets in the casting will not permit an exact replica of the existing surfaces to be achieved.

9.71 Another challenge is the limited ability to vibrate the mixture once within the formwork to ensure that it settles efficiently and encapsulates all the steelwork and any changes of plane or section in the repair casting and surfaces.

Preparation of Off-site Patching Coupons

9.72 When onsite mockup testing became too problematic due to access and security concerns, RLA created patching material coupons off-site that could be taken to the Stadium when cured and there compared to original historic concrete surfaces. Key to replication of the historic rough-sawn board and smoother ply formwork finishes was the employment of a natural liquid rubber latex as a formwork liner.

9.73 The product specified by JF-PT was a high-quality, vulcanize-able, natural rubber latex with a solids content of between 68-70 percent (to minimize shrinkage), made by Aero-Marine Products Inc., of 8659 Production Avenue, San Diego, CA 92121 Tel: (877) 342-8860. The website (including training videos) is at www.aeromarineproducts.com. The company sells 1/2, 1 and 5 gallon containers ($45, $88 and $298 respectively) where a half-gallon of latex should cover 7 sq. ft. at 1/16 ins. thickness. The natural liquid rubber latex molding material was cast as a negative formwork face against cleaned, weathered surfaces of the historic concrete.

9.74 An alternative Silicone molding material is not recommended, as it would require a separating layer because of the risks of a silica reaction that might chemically adhere the molding material to any exposed aggregates in the concrete surfaces.

9.75 Latex 'air dries' like paint but much thicker. To speed up drying, heat guns can be used to blow warm air over the surface. The curing time recommended is approximately 3 days at 72oF. A test for the vulcanization of the surface after drying is to poke the latex surface with a pencil end, if the indentation does not spring back within one hour then more time and heat need to be applied. Apply each new coat of latex within 36 hours of the last application. When complete, lightly dust the outside face of the latex mold with talcum powder to stop it from sticking to itself.

9.76 Safety issues: RLA cast the natural latex rubber in a well ventilated place. The liquid latex is preserved with ammonia and it off-gasses a distinct ammonia odor. The material can sensitize skin and direct contact was avoided by RLA staff wearing safety goggles, gloves and barrier cream where splashes were expected. Technical and Material Safety Data Sheets are attached in the Appendices.

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[24] ASTM C143: Standard Test Method for Slump of Hydraulic-Cement Concrete

9.77 To scale up the project team's formwork liner approach for matching historic concrete surface textures in the major restoration contract to come will require further trials for refinement of methodology, and to obtain best value for money. For example, important technical and economic issues relate to the thickness of the formwork liner thus created. What is the optimum thickness for best casting and repeat usage in the formwork? The thinner the latex mold, the more pliable it should be to remove from the subtly profiled surfaces of the historic concrete. But thin casting molds do not last as long as thicker molds. Thicker molds are less pliable but last longer.

9.78 In the off-site mockup coupon trials at RLA's studio, RLA staff made two, shallow, rectangular formwork boxes measuring 3 ft. x 3 ft. x 4 ins., out of 2 x 4 ins. softwood, in which to cast concrete coupons. The previously described natural rubber latex was used to create negative molds of typical plywood board surfaces. The rubber liquid was brushed directly onto the bare plywood surface, allowed to dry and then reapplied in four unadulterated coats until sufficient thickness is achieved. Then, ten backing coats were added, reinforced with open-weave "cheese cloth" and black rubber powder fillers to create a resilient mold. (Appendix B, Photo 126)

9.79 Two mockup test coupons were made by casting concrete into the formwork boxes. The top surfaces were then lined: one with the latex mold, and the other with a fresh plywood board surface. The plywood board was pre-wet to allow the wood to swell so that, as it later dried, it would shrink and help release itself from the concrete casting. Once the concrete had cured, the forms were removed and revealed that the latex molded surface did provide a very good match for the former ply sheet's surface texture. (Appendix B, Photo 127)

9.80 On the basis of the successful poured-in-place casting using the latex molded formwork liner for the structural repair concrete, we carried out additional mockup tests at RLA's studio to see if the subtle plywood board texture could also be replicated using the less fluid cosmetic repair mortars. Our preliminary trials showed that it could also be effective at reproducing the required textures. However, air bubbles were visible on the sample cubes – suggesting too much mortar mix aeration, insufficient packing of the mortar into cavities, and limited venting of the formwork.

9.81 In all cases, the patches were regularly misted with water after installation to ensure that they did not dry out too quickly, shrink or cure differentially. We determined that the latex rubber formwork liner might also be used as a stamp on horizontal surfaces that had nearly set, though judging the appropriate time to stamp the wet concrete might be difficult to determine with any certainty on a major building site. Nonetheless, the project team feels confident that it is entirely feasible to replicate the original surface textures of the historic concrete by the application of rubber latex molding as formwork lining. (Appendix B, Photo 128-131)

Concrete Repair Mortar Mix Compatibility and Color Match

9.82 Finally, we should refer again to the concrete mortar mixes fabricated to the designs of Lynch & Ferraro Engineering, and based on the core samples taken from the Stadium site in January 2015. (Appendix B, Photo 132 - 133) Besides replicating the surface texture of the historic concrete, as described immediately above, the largest challenge for the project team has been to match the historic concrete colors, while providing a concrete mixture physio-chemically compatible with the original design mix that can deliver structural repair patches of appropriate and adequate engineering strength.

9.83 To recap: as described in paragraph 8.22 above, the paste content of the original structural concrete mixture incorporated approximately 25 percent cement, 3-5 percent air, and had a water-to-cement ratio of approximately 0.50. Our physical testing of the in-situ concrete, as well as of core samples, determined that the compressive strength of the historic concrete is in the range from 5,000 to 6,000 psi.

9.84 Lynch & Ferraro Engineering made four trial mixes in the laboratory with the aim of replicating these parameters for the structural concrete repair mortar. The 28-day compressive strengths delivered by these trial mixes were as displayed in Table 11.

Table 11: Compressive Strength of 28-day Cured Structural Concrete Repair Mortars

Test Type / Age	Mix 1	Mix 2	Mix 3	Mix 4
Compressive Strength 28 day (psi)	5,442	4,572	4,570	2,869

9.85 From the laboratory test results, it was therefore clear that L&FE's Mix #1 was the best match to the historic concrete in terms of engineering characteristics. But for our color trials, we deployed all four mixes to check upon comparative appearance characteristics in the field.

9.86 RLA evaluated color matching of the concrete repair mixes in a variety of natural lighting conditions, on various geometric planes, both in shade and bright light, at different times of the day, compared to original historic concrete, both in the field at in-situ repair sites, and at RLA's studio where coupons were compared to extracted spall samples. It was determine that Mixes #1 and #2 provided the best match of color, and because Mix #1 was most compatible in engineering terms, it should be the recommended recipe emanating from the CON-Sol project: Table 12.

Table 12: Constituents of Structural Concrete Repair Mix #1

Material	Mix 1 100% Portland Cement (lbs. / yd)
Ordinary Portland Cement	611
Water	318
Fine Aggregate	1355
Coarse Aggregate	1355

9.87 The most important aspect of the concrete mix from a color matching perspective is the coarse and fine aggregate system and its grain size distribution. In this case, as our petrographic studies revealed, the original historic concrete was made from a Florida Coral Stone, known locally and as specified by various State departments engaged in construction as "Miami Oolite 89 stone."[25] The Coral stone aggregate can be found at four supplier locations in the Miami area:

- Vulcan Materials, (Sales Contact: Victor Valerio Tel: 305-219-0798), at 12201 N.W. 25th Street, Miami, FL 33182, Tel: 305-592-4100, Fax: 305-592-8576, www.vulcanmaterials.com/construction-materials
- Titan America, www.titanamerica.com/products_services/aggregates
- Tarmac Florida Inc., at 290 NW 171st Street, North Miami Beach, FL 33169, Tel: 305-654-8929
- Lejune Ready-mix Concrete at 2201 NW 38th Court, Miami, Florida 33142, Tel: 305-871-3871 and 305-558-0315

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[25] An Oolitic limestone with grain size distribution, according to ASTM C33, *Standard Specification for Concrete Aggregates*, as passing sieve #89: i.e., possessing the following gradation: 1/2-inch sieve—100% passing; 3/8-inch—90 to 100%; No. 4 sieve—20 to 55%; No. 8 sieve—5 to 30%; No. 16 sieve—0 to 5%; No. 50 sieve—0 to 5%

10.0 CONCLUSIONS

From the Project Team's documentation review, research, on-site observations, in-situ and laboratory examinations, analysis and testing; and from our various field trials of in-situ and coupon-based mockups of both structural and cosmetic patch repair systems for historic concrete, we draw the following principal conclusions:

General Context

10.1 The Miami Marine Stadium is an iconic structure of local, regional and national importance, and it remains a rare survival of a unique building type. It's excitingly engineered and elegant reinforced concrete geometry is counterpoised by exquisite surface detailing in a hierarchy of plain, board-marked and ply-marked forms. Sadly, natural weathering in a hot and humid, saline-rich environment, when combined with long periods of neglect and abandonment, have led to various dilapidations and deterioration that now need to be resolved by repair and rehabilitation in accordance with the Secretary of the Interior's *Standards for the Treatment of Historic Properties*.

10.2 We noted and acknowledge that partial illegal occupation of the site during its abandonment by tag and graffiti artists has inadvertently brought the public's attention to the values, significance and sad condition of the Stadium through looking at it as an architectural backdrop to their temporary artwork. We established a dialogue with the graffiti artists through holding a symposium and gained mutual respect and at least partial resolution to issues of mutual concern.

10.3 Previous engineering studies have described the state of, and explained the reasons for, rebar corrosion and therefore structural and cosmetic concrete deterioration at the Stadium. But the extent of the damage has not yet been precisely mapped and quantified. Structural concrete members both in and near the lagoon in the wet / dry tidal zone, or which have previously been sprayed with salt water in practice fire-fighting exercises, appear to be most contaminated with chloride salts and most damaged. Other areas exhibit brown and grey colored stains, cracking and spalls that suggest moisture ingress to reinforcement where rebar are too close to the surface. All these issues can be resolved with an investment in suitable repairs.

10.4 Because previous studies did not have access to original design drawings, and were not afforded the opportunity to speak with the design architect, a major item of structural importance appears to have been overlooked in earlier repair strategies. We discovered that the hypar roof construction at the Stadium is based upon post-tensioned concrete technology, and therefore will require specialized techniques to repair areas currently weakened by concrete section losses due to corrosion.

10.5 The CON-Sol project objectives were to investigate the reinforced concrete and to design and carry out field mockup trials to successfully remove graffiti, clean the concrete, trial anti-graffiti barriers, and expedite structural and cosmetic patch repairs of engineering quality that would also match the historic, weathered surfaces in both colors and textures.

Site Limitations

10.6 Various external factors affected our ability to deliver the project objectives in the way that we originally intended, in terms of scope and time:

- Our various field campaigns were materially affected by the changing attitudes of responsible departments in Miami City Council. At first, we could gain little interest or engagement from those safeguarding the property. Later, through the good auspices of City Landmarks, we were provided with facilitated access and collaboration on finding missing design drawings. But towards the middle of the project, and in critical periods, the City hindered access and provided no security for our site trials. For example, because of limitations in access to the site after May 2015, we were unable to test the removal of new graffiti with hot pressurized water from off the anti-graffiti barriers.
- Our field trials were vandalized to such an extent that we could no longer use some sites for ongoing evaluations. For example, at the graffiti removal wall, we documented cleaning trials during and after treatment, and then protected the treatment surfaces with an elaborate system of plywood covers, attached to the wall with stainless steel bolts. This protection was designed to stand proud of the wall to let the surfaces breathe and dry out; to protect the cleaned surfaces from continued graffiti attacks; and as importantly, to provide the graffiti artists with a new superimposed blank surface (the cover) to continue their activities. Despite these precautions, however, our protective sheathes were not only tagged, they were ripped off the wall and four of our cleaning tests were tagged deliberately. In the most dramatic example, one cleaning test was tagged with the words “don’t destroy history”, implying that the removal of graffiti murals was a destruction of historical murals. This topic was extensively discussed during the graffiti symposium on May 11, 2015.

Preservation of Graffiti or Total Removal?

10.7 During the course of the work and during the aforementioned symposium, we considered the idea of preserving aspects of the street art as part of the long-term conservation planning for the Stadium. Though the project team did not identify *which* areas of graffiti to preserve, strategies for such were evaluated as part of this testing program and as part of the graffiti symposium including:

- Cleaning and preservation in situ of painted surfaces, including removal of fungal growths;
- Selective removal of tags on top of murals or other painted surfaces
- Re-adhesion of painted surfaces to the concrete substrate and to paint under-layers.

10.8 We did however conclude that, because of the amount of salinity and especially harmful chlorides permeated within the concrete matrix, we are presently of the opinion that the graffiti is likely trapping the salts in the surface and it should all be removed to make appropriate repairs. Moreover, the participants in the graffiti symposium and general public opinion at the event did not support the idea of curated walls that included new or old murals that would be purposely preserved on site. Therefore, we are of the opinion now that the consensus for preservation of graffiti or murals would best be achieved through photographic recording and documentation of the artwork before its destruction through graffiti removal and concrete cleaning, and then the recorded artwork could be film projected back onto cleaned, bare concrete walls at special night time events.

10.9 We did suggest to the street artists at the symposium that, as part of the Stadium's rehabilitation, new concrete walls could be erected in the landscaped areas adjacent to the stadium as part of the hard landscaping and that they, rather than the Stadium itself, could be used by the graffiti artists when the facilities were not otherwise in use. The artists stated; however, that the thrill of occupying sites illegally for their artwork would disappear and that they would rather take their interests to other abandoned sites in the City.

Evaluation of Graffiti Removal Materials and Techniques

10.10 The mockup test wall that we chose at the Stadium for the graffiti removal trials provided a worse-case-scenario for materials and techniques because it was had a relatively delicate cement stucco substrate over concrete blockwork (instead of the more robust, cast-in-place, fair-faced concrete), and was more heavily covered in multiple paint coatings than other less accessible surfaces around the building. So the graffiti removal challenges here were manifold and included:

- Thicker cross-sections of paint requiring more aggressive systems on the outer coats and changes to more sensitive cleaning methods approaching the historic surface below
- Delaminating interstitial paint layers that prevented efficient passage of chemical strippers to underlying strata

10.11 From our secondary cleaning tests, it is clear that the poured-in-place concrete surfaces, which do constitute the largest portion of the building, have fewer graffiti paint layers on them and are easier, quicker and therefore cheaper to treat with less harmful results.

10.12 All of the abrasive cleaning systems marred the surface of the stuccoed concrete wall to some extent. However, on the poured-in-place concrete, most systems (with the exception of Sponge Jet) were able to clean the surfaces without visible marring, staining or gun-shading. Once the cleaning systems operators become more familiar with the types of walls and their conditions, it may be possible to lessen the adverse effects on the stuccoed wall. But more skilled operators with experience of historic surface cleaning would be necessary to ensure more effective and benign results.

10.13 Of the abrasive systems, the crushed glass media with water seemed to have the best results on all of the surfaces tested, with the media used in both the Farrow and Ibix systems. However, both these systems require highly skilled operatives to control the application.

10.14 All of the chemical strippers were able to remove the paint and leave the wall surfaces intact and clean. Of the chemical strippers, the Dumond *Smart Strip Pro* (5 applications) was the most efficient at removing the paint, with half the number of applications needed with *Wipe Out* (10 applications) to get to the concrete surface. The dwell time is longer for Smart Strip Pro; however, the best results are achieved when left covered overnight.

10.15 The chemical systems are all slower than the abrasive systems but they do capture paint residues without risk of dust clouds. That stated, the chemical residues from rinsing also have to be captured and safely removed to prevent contamination of the adjacent lagoon. The systems that work the best all generate waste material, which will need to be collected and disposed of in an appropriate fashion. This is not unusual or difficult in most situations; however, in the case of the Stadium's ground beams that extend over the water, this work becomes more precarious, not only for the application of the system, but also for the protection of the area and the collection of waste.

Evaluation of Concrete Cleaning Materials and Techniques

10.16 The D2 biological solution was successful at removing biological growth and could be used, as needed, for long term control of algae, mold, mosses and lichens. The material is successfully used on historic surfaces by the US National Park Service, the General Services Administration, by the National Cemeteries Administration, and by the American Battle Monuments Commission.

10.17 Both concrete cleaning tests were successful at removing surface grime without damage to the weathered board- and ply- marked formed surfaces. As specified, the ProSoCo's *SureKlean Light Duty Restoration Cleaner*, diluted 1:6 with potable water, and applied for between 5 and 15 minutes, appeared to be sufficient for this task.

Evaluation of Anti-Graffiti Barriers

10.18 Anti-Graffiti barriers applied to clean concrete will be essential for the preservation of untagged, historic concrete surfaces at the Stadium once restored. As stated in our introduction to their specification earlier in this report, we favor the semi-permanent and sacrificial rather than permanent systems because they are theoretically reversible in terms of conservation ethics, and because they tend to be more permeable than the permanent coating systems – thus enabling the underlying concrete to 'breathe.'

10.19 The semi-permanent barrier systems deployed were Dumond Chemical's *Watch-Dog* CPU-147 *Graffiti Barrier* (probably a silane-siloxane moisture repellant), and a three-part system based upon ProSoCo products: HCT, HCT-Rinse and *Conservare H100* hydrophobic consolidant (a combination of a heavily buffered tartaric acid hydroxylating treatment; an alkaline neutralizing wash; and a water resistant ethyl silicate). The sacrificial barrier systems were: Keim's *PSS-20* (vegetable polysaccharide coating), Genesis Coatings' *Graffiti Melt* (a microcrystalline wax), and ProSoCo's *Defacer Eraser* (a propylene glycol wax).

10.20 RLA reported no difficulties installing the coatings onto the cleaned concrete surfaces. However, when it came time for us to remove the various coatings to eradicate fresh outbreaks of graffiti, and then to reinstall the anti-graffiti coatings on re-cleaned walls, RLA was not able to carry out the work – since access and the supply of site water was then being restricted by the City of Miami, and our work sites were being vandalized.

10.21 Thus, none of our removal tests were expedited or conclusive without the use of a hot water pressure washer. Once site conditions have improved and water is accessible on site again, it may be possible to test the removal processes then to complete the evaluation. However, technical research by Fidler and his colleagues at English Heritage suggests that only long term studies of multiple treatment, cleaning and reinstallation of coating cycles in between graffiti attacks would simulate real life situations. Multiple cycles of hot water pressure washing of concrete surfaces can cause erosion due to the dissolution of carbonate material. So we see the anti-graffiti treatments as a short term palliative for the historic Stadium's welfare, pending more active graffiti deterrent and control when the site is fully secure and managed once again.

Evaluation of Concrete Patch Repairs

10.22 Petrographic and other examinations and analyses of core samples taken from the Stadium confirmed most of the findings from previous reports but more importantly articulated in great detail what the precise constituents and proportions were of the original historic concrete. Luckily for any future repair project, the concrete recipe was found to be pretty standard for the period of construction: comprising ordinary Portland cement and local coral stone aggregate. Existing strength characteristics were obtained from onsite non-destructive and off-site laboratory testing to ASTM norms. The concrete paste consisted of approximately 25 percent cement, 3-5 percent air, and had a water-to-cement ratio of approximately 0.50. Physical testing determined that compressive strength of the concrete is approximately 5,000-6,000 psi.

10.23 L&FE designed four concrete repair test mixes with permutations on the original design: one as a complete replica, and the others containing a pozzolanic additive and / or latex additive to support modern-day sustainability goals. However, only Mixture #1 (the replica mix) achieved the required matching compressive strength range at 28-days. In the fieldwork, Mix #1 also matched the original material in color.

10.24 In laboratory preparations, Mix #1 had an ASTM Slump Test value of only 4 ins., which is relatively low for a material needing to be cast-in-place as part of structural repair work. Improvements in the field were small (no vibrating equipment) and some of the air pockets and bubbles observed by RLA when striking formwork from in-situ repairs and mobile test coupons may have been associated with the modest water content. However, L&FE were attempting to balance Slump against a 0.50 cement/water ratio that delivers the concrete strength. Improvements in a final mix slump when used for major repairs could be achieved by use of a superplasticizer.

10.25 The custom-made proprietary repair mortars devised for the project from the standard range of colors available from both Cathedral Stone (Jahn mortar) and Edison Coatings (Custom 45 range) provided satisfactory results for the smaller scale superficial cosmetic concrete repairs.

10.26 We complied with ASCE technical guidance and norms when preparing spall cavities for patching, preparing the friable concrete and corroded rebar in accordance with the requisite standards. However, RLA did not find time to desalinate the concrete in and around the repair site by means of poulticing, as originally intended, due to the urgency to make good work sites each day for fear of vandalism. Localized desalination is a slow and time consuming business, made more difficult in the Stadium's case by the prevailing hot, humid and locally saline conditions that negate straightforward absorption through diffusion and advection. This area of work requires further investigation.

Cathodic Protection

10.27 We did investigate the possibility of adding passive or active cathodic protection of the corroding steelwork to our project as a means of preventative conservation. However, restrictions prevented us from commissioning even a small scale demonstration of the systems, and we were unsuccessful in persuading the country's largest commercial corrosion engineering company[26] to offer a modest capability demonstration. Given the limitations of active poulticing in this marine environment, and taking into consideration the levels and depths of chloride already extant in the concrete structure, we feel that impressed current cathodic protection would be an invaluable tool to safeguard the life of the Stadium and help warrant a long life for all the necessary repairs. The challenge, as ever, with this system is an aesthetic one: to conceal the necessary wiring in what is a totally unclad Stadium design.

Evaluation of Patch Repair Colors and Textures

10.28 Since our petrographic and other laboratory examinations determined that the original concrete's aggregate system is of local coarse and fine Floridian coral stone, a medium-cemented oolitic limestone quarried in the Miami region, our concerns about matching the color of the historic concrete have been allayed. We know the cement/aggregate and cement/water ratios, so replicating the original colors in the large scale cast-in-place structural repairs was not too difficult. L&FE also sourced wholesale suppliers of the aggregate for future use.

10.29 Unfortunately, we did make some formwork casting errors at the start of the fieldwork mockup installation that inadvertently stained the concrete so that it failed its color match test. We mistakenly deployed WD-40 oil as a formwork release agent when non-staining systems involving Vaseline[27], light oils or mild acid set retarders, and even rubber formwork liners were all viable alternatives. Nonetheless, once corrections were made, and RLA was able to cast concrete coupons in a more accessible and safe environment at its Studio, the small color range generated did match that found at the Stadium with a high degree of certainty.

10.30 Both the Jahn and Edison Coatings cosmetic repair mortar mixes also matched the historic concrete, though the aggregate systems used were not such a faithful match for the Florida coral stone – having been manufactured in Maryland and Connecticut respectively. However, both manufacturers will import and use exact matching aggregate systems if clients (with significant orders) want custom-made materials.

10.31 Finally, our in-situ repair trials and mobile coupon mockups all proved that it would be possible to replicate the weathered textures of the plain, board- and ply- marked concrete in future repair programs by a variety of means:

- By careful choice of rough-sawn softwood boards, and plywood sheets similar textures can be produced in new repair formwork to those found on the historic concrete.

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26 Vector Corrosion Technologies Inc., 3822 Turman Loop STE 102, Wesley Chapel, Florida 33544 Tel: 813-830-7566 www.vector-corrosion.com

27 Vaseline® is a clear petroleum jelly, patented in 1872 and now manufactured by Unilever.

- And if exact copies of the original surfaces are required for historic preservation requirements, then natural rubber latex molding materials can be used to make negative casts of historic concrete surfaces, and then be used as formwork liner material in newly poured-in-place repairs.

11.0 RECOMMENDATIONS

Taking fully into account our documentation review, site observations, technical and scientific research, materials examination, analysis and testing, symposium findings, and fieldwork trials of materials and techniques, the CON-Sol Project Team makes the following recommendations with respect to the City of Miami's intended rehabilitation of the Marine Stadium.

Standards and Guidance for the Future Rehabilitation Project

11.1 The following national standards and international guidance should be adopted for the future rehabilitation of the Marine Stadium:

- National Park Service, 1997 (as amended), "Secretary of the Interior's Standards for the Treatment of Historic Properties: Rehabilitation," US Department of the Interior, Washington DC.

- Custance-Baker A, Crevello G, Macdonald S and Normandin K, 2015, "Conserving Concrete Heritage: an annotated bibliography," Getty Conservation Institute, Los Angeles.
  www.getty.edu/conservation/publications_resources/pdf_publications/concrete_biblio.html

- Macdonald S and Ostergren G (Eds), 2013, "Conserving Twentieth-Century Built Heritage: a bibliography," Getty Conservation Institute, Los Angeles.
  www.getty.edu/conservation/publications_resources/pdf_publications/twentieth_century_built_heritage.html

- Australia ICOMOS, 2013, "Burra Charter for Places of Cultural Significance," International Council on Monuments and Sites, http://australia.icomos.org/publications/charters Burwood, VIC, Australia.

- Odgers D, 2012, "Concrete," in Martin W and Wood C (Eds), The English Heritage *Practical Building Conservation* series, English Heritage with Ashgate Publishing, Farham, UK.

- Macdonald S (Ed), 2003, "Concrete Building Pathology," Blackwell Publishing, Oxford

- Macdonald S (Ed), 2001, "Preserving Post-War Heritage: the care and conservation of Mid-Twentieth Century Architecture," English Heritage with Donhead Publishing, Shaftesbury, UK.

- Macdonald S (Ed), 1996, "Modern Matters: principles and practice in conserving recent architecture," English Heritage with Donhead Publishing, Shaftesbury, UK.

City Archives Research

11.2 Friends of the Miami Marine Stadium have copies of original architectural and engineering design drawings for the Stadium (Appendix C). But structural drawings vital to the upcoming rehabilitation project are missing from the set and need to be found by the City authorities. The missing drawings are from the Structural Set: S4, S6, S7, S10, S11, S12, S13 and S15, plus any other drawings with a higher number than S18, and any marked SX-a in the set where "a" denotes a revision. The archives of the City's property and building code department for 1963-64 would be the appropriate place to look. Locating and retrieving any "as built" drawings, construction observation notes, and/or annotated notes of invoices and receipts for materials acquisition would be an added bonus to the project's understanding.

Further Structural Engineering and other Investigations

11.3 Outside the scope of the CON-Sol Project, but of vital importance to the future rehabilitation project, will be early foresight and enhanced understanding of the current performance and condition of:

- The reinforced concrete piles in and adjacent to the lagoon, especially at the 'wind-and-water' line in the tidal zone.
- The configuration, cable types, and state of the post-tensioned hypar roof construction
- Concrete reinforcement generally across the Stadium: nondestructive evaluations will be necessary to validate "as built" conditions against design drawings; to check of concrete cover thicknesses, and to size and check orientations of rebar steelwork.

In these areas, additional exploratory openings will be necessary, together with a general mapping of decay, cracking, spalls etc., across the Stadium.

11.4 Outstanding work remaining from the CON-Sol project, that we could not complete, should also be expedited at the beginning of the rehabilitation project to inform future graffiti management strategies. In particular, trials need to be conducted to compare the removal and later reinstallation of the installed anti-graffiti barrier coatings. Of special concern, besides cost effective and efficient removal of the graffiti attacks, is the potential for pressurized hot water rinsing to dissolve and erode the surface texture of the historic concrete in the long term, after multiple attacks and system applications.

Overarching Strategy toward Painted Surfaces

11.5 For the long-term benefit of the Stadium's material welfare, we recommend that all concrete surfaces be stripped and cleaned of paint, street art graffiti and tags.

- Artwork extant prior to removal can be documented and recorded photographically and published as a record online or used periodically as back projection onto the cleaned concrete of the Stadium at public and other events. Tens of thousands of images of prior graffiti and murals would be available in artists' archives and online for creating a significant light display on cleaned portions of the building, as a means of honoring the years 1997-2015, when the building served primarily as a graffiti site. Both the street art community and the original architect are on board with this as a creative solution to the street art question.
- The underlying concrete surfaces need to be washed of salts and dried out before treatment.

- After concrete repairs are cured and dried, we recommend that the top side of the hypar roof including gutters, spillways and scuppers are coated with suitable primers and long-life reflective waterproof materials in order to protect the roof system from high risk deterioration. The roof top offers commercial opportunities for development funding, advertising and sponsorship in this regard.

- As a homage to the street artists and taggers who drew public attention back to the Stadium, the City might also consider painting the concrete entrance ramp, alleyways and stair cases in a graffiti type color pattern – though this does, we admit pose technical challenges with respect to ADA safety, slippage, and maintenance concerns.

Graffiti Removal

11.6 For chemical stripping of thinly coated painted surfaces, we recommend the low-VOC, bio-degradable, overnight long-dwell-time, Dumond *Smart Strip*™ Pro using Dumond Laminated Paper coverings to extend the active ingredients' actions and capture waste materials.

11.7 For areas covered in large numbers of thick paint coatings, we recommend the Dry Ice ablation system, provided that its operatives are highly skilled and can stop the cleaning before the bare concrete is reached. The crushed glass wet abrasive media also performed well when used in either the Farrow or Ibix systems.

11.8 Whether a chemical or abrasive cleaning method is adopted (and some painted areas may need attention with both techniques), wind-blown and/or water-borne waste and debris from the cleaning sites will have to be efficiently captured at the paint stripping sites and disposed of in an environmentally safe manner.

Concrete Cleaning

11.9 Before repair patching materials can be matched in color and texture to historic surfaces, and before anti-graffiti barriers can be installed to protect vulnerable surfaces, we recommend that all stripped and bare concrete surfaces are cleaned, as follows by applications of:

- D/2 Biocidal Wash in accordance with manufacturer's instructions
- ProSoCo's SureKlean® *Light Duty Restoration Cleaner*, diluted 1:6 with potable water and applied for between five and 15 minutes, sufficient for the task, in accordance with the manufacturer's instructions.

Anti-graffiti Barrier Coatings and Other Management Systems

11.10 We cannot state with any certainty what our site specific treatment of choice would be for anti-graffiti barrier coating at the Stadium because we could not complete our trials due to lack of access and water supplies at the property. Nonetheless, we favor the sacrificial systems based on conservation ethics and recommend early trials of hot water removal and re-application of the wax (Genesis Coating's *Graffiti Melt* and ProSoCo's *Defacer Eraser*) and polysaccharide (Keim PSS-20) surface coatings.

11.11 For long term, graffiti-free Stadium sustainability; however, anti-graffiti coatings should form just one part of a graffiti management system that incorporates high levels of active site security (e.g., fences, night time illumination, CCTV surveillance etc.), active damage response (repair of vandalism within 12 hours), and passive deterrents (e.g., thorny hedgerow planting near vulnerable walls, use of climbing vines to cover wall surfaces etc.).

Structural and Cosmetic Concrete Repairs

11.12 We recommend the CON-Sol Project Team's concrete mixture #1 for structural repairs because it is made from the same materials as the historic Stadium. Having the same proportions and properties, it is compatible in physical engineering terms and also produces a good match for colors and texture. The material obtains 5,442 psi compressive strength in 28-days in our tests with a 3-5 percent air content and a water/cement ratio of 0.50. The mix recipe is provided here by weight, not by volume, as it would be made in bulk at a cement works. It is based on 611 lbs. / yd^3 of ordinary Portland cement, and equal 1355 lbs. / yd^3 weights of fine and coarse Florida coral (Oolitic lime) stone aggregate, passing sieve #89 (to ASTM C33). We suggest local sources of supply for the aggregate at paragraph 9.87.

11.13 Of the custom mortar mixes provided for cosmetic patch repairs to concrete by Cathedral Stone and Edison Coatings, we recommend Jahn M90 35238-CR-21 (HG) and Custom 45 #7983-CN respectively. They both provided a close color match to Stadium surfaces.

11.14 We recommend that the rehabilitation project specifications and works implementation for concrete repairs are based upon ASCE and ICRI technical guidance and norms for surface preparation, rebar cleaning and coating, and concrete repair mortar installations. We favor the employment of a corrosion converter such as Skyro's Ospho after bright metal cleaning of rebar before application of SIKA's Armatec® 110 *EpoCem* epoxy modified cement paste. However, we do understand that the City of Miami will enforce the minimum requirements for concrete in a marine environment from the Florida Building Code[28], and/or utilize its own Public Works standards or those of the Florida Department of Transportation. We attach at Appendix F a Model Specification for concrete repairs from which key clauses can be extracted where necessary to bolster the project's Construction Documentation.

Replicating Historic Concrete Surface Textures

11.15 We recommend that historic concrete surfaces be accurately replicated on the surface of all concrete patch repairs at the Stadium: be they structural or cosmetic in nature. The replication of surface finishes includes indentations and marks for the size (i.e., width and length), pattern and junction of boards in board-marked concrete; the panel sizes and coursing patterns and junctions of plywood-marked concrete; besides the raised grain and surface profile of the concrete.

11.16 To match the existing surfaces, we recommend use of a natural rubber latex molding material, available from Aero-Marine Products Inc.[29] that can be used to create reusable formwork liners and embossing stamps.

Preventative Conservation Treatment: Cathodic Protection

11.17 Finally, to safeguard the welfare of the Stadium for the medium- to long- term, considering the aggressive environment in which it sits, and to help warrant structural concrete repairs over the short- to medium- term, we recommend that the City installs a combination of

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[28] Florida Building Code Existing Buildings (2014) http://codes.iccsafe.org/app/book/toc/2014/Florida/Existing%20Building%20Code/index.html

[29] Aero-Marine Products Inc., of 8659 Production Avenue, San Diego, CA 92121 Tel: (877) 342-8860. The website (including training videos) is at www.aeromarineproducts.com

passive (sacrificial anode) and active (impressed current) cathodic protection systems at the site as part of the rehabilitation works.

11.18 The systems rely on sacrificial anodes, either buried in the fabric adjacent to each concrete repair, or installed nearby in discrete locations but linked by electric cables to the reinforced concrete steelwork in its entirety. If not carefully sited and installed, such systems can be visually damaging and materially and detrimentally affect the special appearance and character of historic buildings. We therefore recommend that planning, design and field trials of appropriate and suitable systems take place early in the project's design development stage, so that concerns can be addressed at an early juncture and aesthetic issues mitigated without recourse to surface parging or similar techniques.