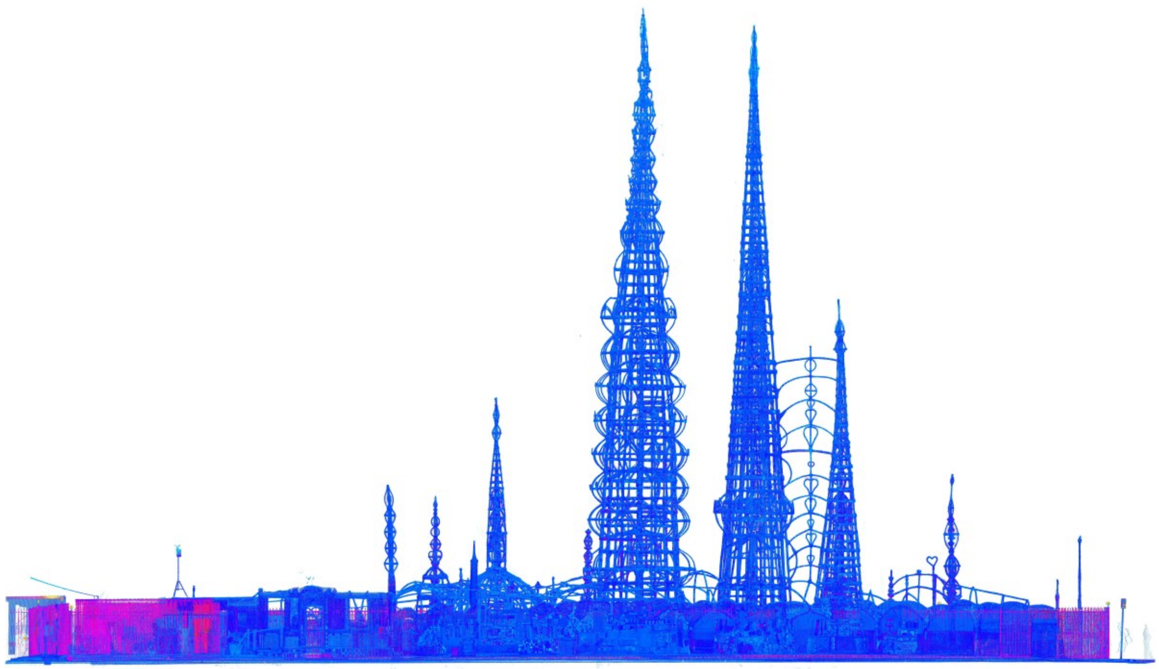
LACMA

LACMA, DCA, and Watts Towers

Progress Report October 2012 through December 2012 (Seventh Progress Report)

Prepared for the DCA, City of Los Angeles, by Frank Preusser and Mark Gilberg



The unacceptably high failure rate for concrete repairs is a major problem in the repair industry. To achieve durable repairs, it is necessary to consider the factors affecting the design and selection of repair systems as part of a composite system.[1]

Summary

During the reporting period we continued the organization and review of existing documentation and information (hardcopy and electronic). Work on the fallen fragments has continued.

[1] J. E. McDonald et. al., Development of Performance Criteria for Dimensionally Compatible Cement-Based Repair Materials, ACI SP 193 (August 1, 2000) p.441

Inspection and photo-documentation of the three tall towers with a spotting scope and photography with a telephoto lens continued. Comparison of the current condition of the monuments with the Rand photographs was continued.

Research in potential crack fillers, repair mortars, and adhesives continued and a variety of materials was purchased for testing and evaluation. Testing protocols have been developed for repair mortars and adhesives and testing has begun. A testing protocol for elastomeric crack fillers is in development. The first of two outdoor exposure racks has been built.

Data-logging crack monitoring equipment (strain gauges, displacement transducers, and thermocouples) was installed in August and operates satisfactory. A clear relationship between crack movement and temperature has been found and the effect of heavy winds on crack width has also been recorded.

A tentative agreement with UCLA's Department of Civil and Environmental Engineering has been reached to start a vibration monitoring program.

The floor of the fragment storage room has been reinforced.

Accomplishments

Staffing

No changes.

Consultants

- Mr. **Mel Green** (Melvyn Green & Associates, Inc.) will address once again the stability of the Towers, starting with a review of the Ehrenkrantz calculations. We also discussed structural safety issues with the office trailer.

- Prof. **Bruno Pernet** from the California State University Long Beach continued his study of the seashells on the Towers.[2]

- On October 5 we met with Prof. **Ertugrul Taciroglu** (UCLA Department of Civil & Environmental Engineering) at UCLA to discuss the possibility of physical testing of mortar samples at UCLA.

- On October 12 Profs. **Ertugrul Taciroglu** and **Robert L. Nigbor** (UCLA Department of Civil & Environmental Engineering) visited us at the Towers to discuss a potential collaboration in the long term vibration monitoring of the Towers

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[2] LACMA is only providing access to the site and to the existing photographic records.

Office

Nothing to report.

Chemical Safety

No incidents to report.

General Safety

In discussions with Mr. Mel Green it was determined that the floor in the sample storage room of the Office Trailer needs to be re-enforced. Mel prepared a proposal and the work was carried out in early October.

During this reporting period we had one minor injury involving a power tool and one near miss when a staff member broke through the house platform. Subsequently power tool safety training was conducted by Frank Preusser

Site Maintenance and Improvements

The site is surveyed daily for any fallen ornaments and other problems. The daily survey also includes visual examination for new cracks or significant changes in existing cracks.

Archival Research

Jennifer Kishi continued the archival research at UCLA and Spaces.

Treatment Database

The latest version of the treatment database underwent additional testing and a variety of problems were identified.

Re-Photography of the Artwork

The re-photography of the higher elevations of the tall towers with a telephoto lens continues.

X-Radiographs

Ms. Mariana Ruiz is currently matching the existing X-radiographs to the specific locations where they were taken. The following X-radiographs have been shot between October 1990 and December 1991, with follow-up shots for the West Tower taken on September 7th 1994 under the direction of Bud Goldstone. Figures 1-4 illustrate x-radiography comparisons with present day photographs of each structural member/joint. Along with insight on alterations and deformation of concrete members, continuity of steel members or lack there off, gives us insight into the application of future corrosion preventive compounds/methods in the major structures. A detailed comparison report for the more than 60 X-radiographs is in preparation.

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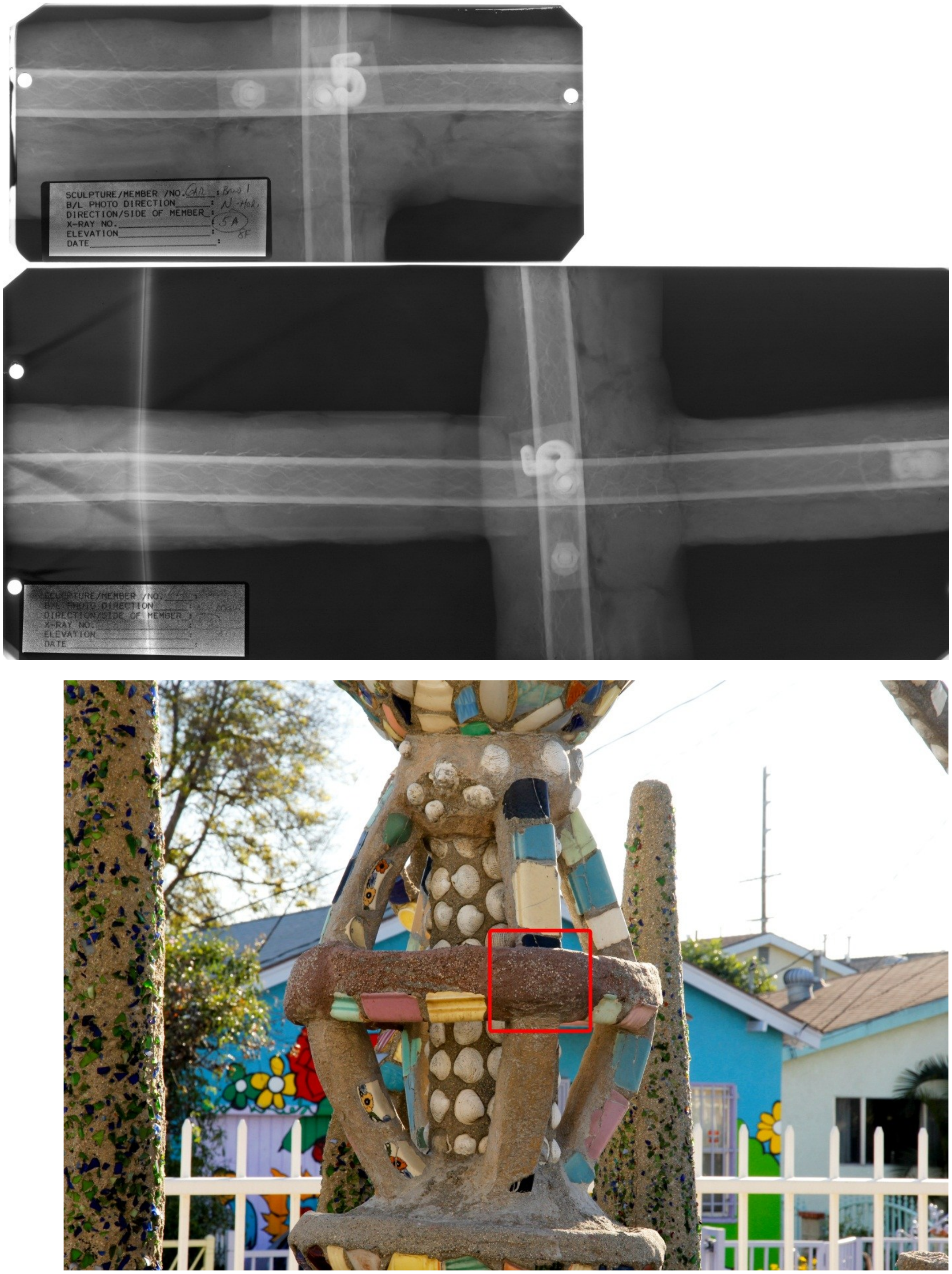

Figure 1: Garden Spire (Pinnacles along the south wall), north view- horizontal (1A) and vertical (1B), Band 1- Jahn Mortar repair at 8 ft

Figure 2: West Tower, Column 12, 1st band

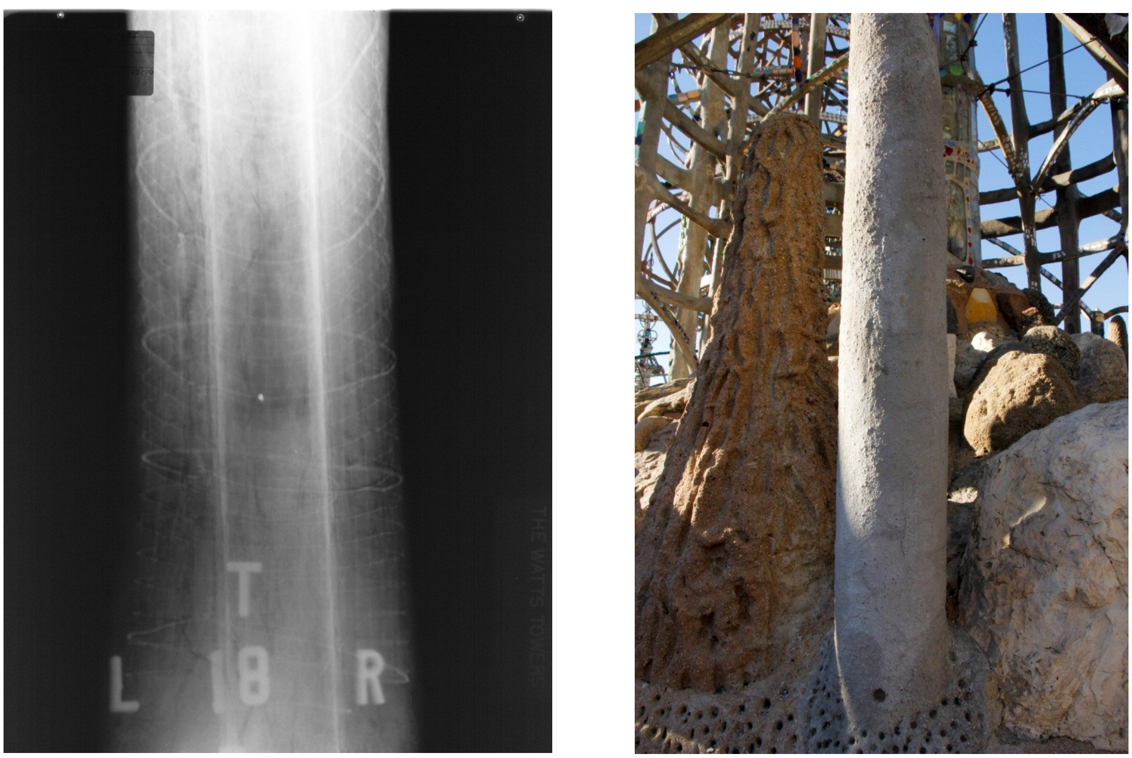

Figure 3: Center Tower, Middle Column 03, elevation: 4’6”

Inventory of Detached Ornaments

Ms. Kimberly Blanks has completed the inventory of the fragments with the exception of the very heavy pieces that have been removed during previous restoration campaigns[3]. This leaves only the fallen fragments that have been collected and are currently held by the Watts Towers Art Center. These will be documented and entered in the database as soon as the WTAC hands them over.

Evaluation of Changes since Rand Photo Campaign

Mariana continued the comparison of the Rand photographs with the current state of preservation of the monument.

Evaluation of Cracks

Monitoring of selected cracks with plaster bridges and telltales continued. We also continued monitoring cracks to determine if they are propagating lengthwise.

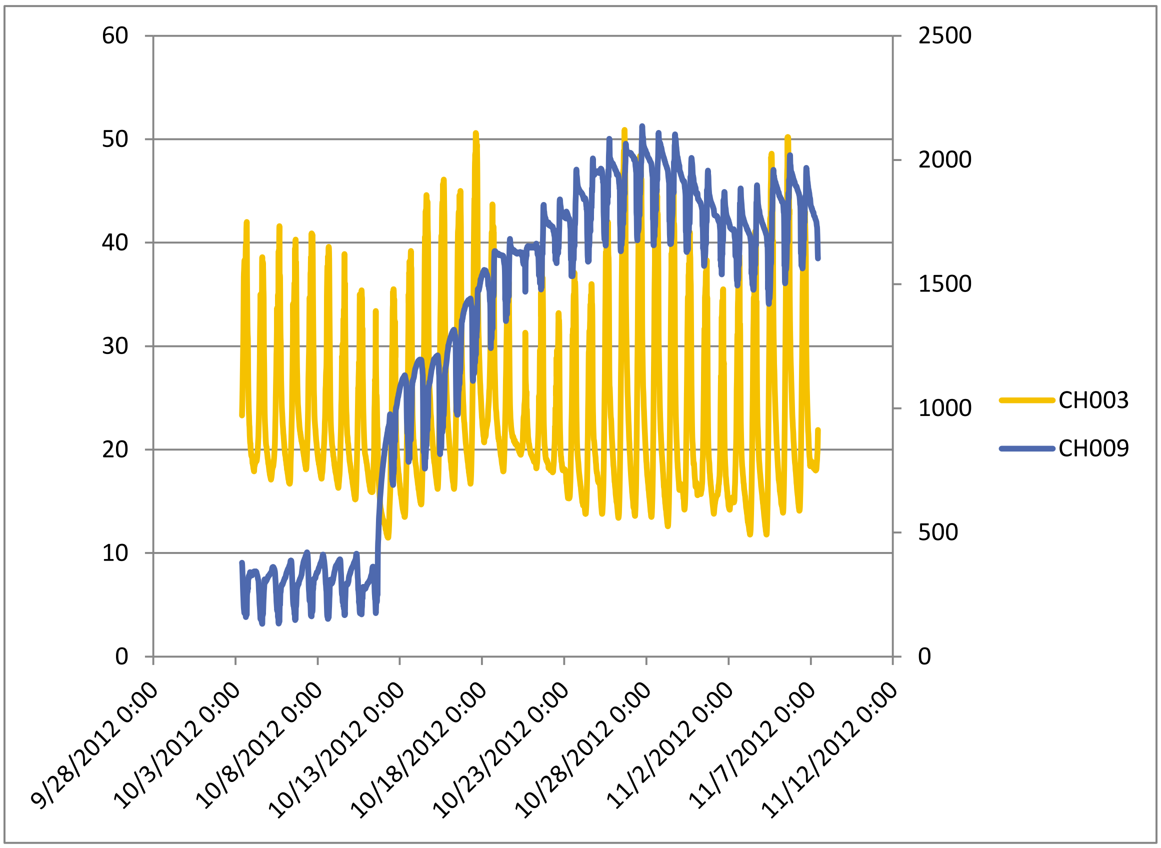

Figure 4: Crack movement during wind event (yellow: temperature, blue: crack width)

[3]This will be completed once we have secured help in moving the big pieces for photography.

The strain gauges and displacement transducers continue to provide useful data (one strain gauge detached due to adhesive failure and was removed). The data are downloaded on a monthly schedule and data reduction is carried out by Dr. Charlotte Eng[4] and Ms. Mariana Ruiz. The most interesting data were obtained during a heavy Santa Ana wind event (figure 4).

Previous vibration monitoring (see 4th Quarterly Report) has shown a direct correlation between wind speed and movement of the Towers. The resultant g-forces were of a magnitude comparable to a medium seismic event.

During the Santa Ana events in the second half of October the displacement transducers recorded irreversible widening of the monitored cracks (blue curve in figure 4). The magnitude of this movement was far greater than the daily thermal movement of the cracks. The thermal movement of the cracks is mostly reversible and leads only to a gradual widening of the cracks[5]. Based on these preliminary results it appears that wind and seismic events are the primary causes for the observed severe cracking and that thermal and corrosion cracking may be of secondary importance. This would also explain why it was observed that many more decorative elements and mortar fragments are detaching during severe weather events. This has serious implications concerning the design of future crack repairs and the performance criteria for the repair materials. The repair materials will have to be able to accommodate movements that are much larger than those caused by thermal stresses.

Weather Station

The Weather Station continues to reliably record the environmental conditions. The data are downloaded and processed at regular intervals by Ms. Kimberly Blanks.

Thermal Imaging and Monitoring

Currently the thermal imaging program is on hold due to other, more pressing issues. We did however carry out some spot temperature measurements in October, using the Fluke IR thermometer. Peak surface temperatures of 50°C (122 °F) were recorded.

Triggered by the results of some laboratory experiments we decided to also determine how deep into the cement the temperature fluctuations progress and if the supporting steel is also affected. We selected an area which was cut open in the past[6] and never had been restored (figure 5).

The exposed steel was mechanically cleaned from loose corrosion products (rust), and then treated with tannic acid. Four thermocouples were installed, one directly on the steel, two at different depth on the cement plaster, and one on the surface (figure 6). The

[4] LACMA Conservation Center, Research Laboratory
[5] The degree to which widening occurs will have to be determined through long term monitoring.
[6] It is currently unknown when this work was done.

opening was then filled with an amended cement mortar and the thermocouples connected to a data-logger (figure 7).

A similar installation is planned in a location with full sun exposure.

Figure 5: Selected area for thermocouples

Figure 6: Thermocouples installed

Figure 7: Completed installation

Weather Events

During the reporting period we had a number of Santa Ana wind events (see discussion under crack monitoring).

Identification and Evaluation of Conservation Materials

Almost all of the repair mortars, elastomeric crack fillers, and adhesives we identified as promising have been obtained. Testing procedures have been designed. The Getty Conservation Institute agreed to let us use some of their aging facilities and discussions are underway with the UCLA Department of Civil & Environmental Engineering about some physical testing of mortar and adhesive samples.

Repair Mortars

After a review of the literature and consultation with manufacturers and suppliers we obtained 20 polymer modified mortars (PMM) for evaluation. 56 mock-ups were prepared (figure 8) and the mortars were evaluated for workability and shrinkage crack formation. The test plates consist of cast cement plates with a cavity, which then was filled with repair mortar. The plates are exposed outdoors on the house platform and in regular intervals inspected for shrinkage cracks and/or separation between repair mortar and cement plate.

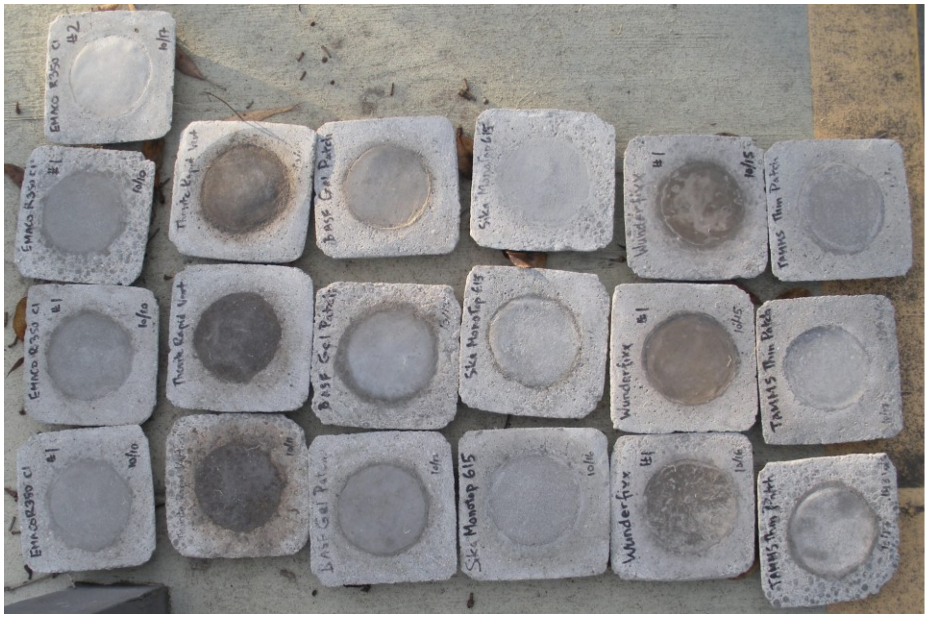

Figure 8: PMM workability and shrinkage test specimens

Figure 9: Exposure rack

Based on the results of these tests we reduced the number of mortars to be considered to seven. These seven mortars will undergo laboratory testing (temperature cycling in an oven at the Getty Conservation Institute; potential physical testing at UCLA), outdoor exposure on a recently completed exposure rack (South facing at a 35 degree angle; figure 9), and limited *in-situ* testing at areas of previously failed restorations on the monument.

A further complication arose when we discovered that some of the failures and losses of past repairs are caused by lack of adhesion of the mortar on epoxy based repairs (figure 10).

Figure 10a: failed cement mortar cover

Figure 10b: exposed epoxy mortar after removal of failed cement mortar cover

Further inspection of the monument and the files indicated that this type of repair may have been used quite extensively. As a consequence the testing program had to be expanded to determine if the selected repair mortars have sufficient adhesion to old epoxy mortar repairs. Blanka also obtained two adhesion promoters that may help solve this problem[7]

[7] The other alternative would be complete removal of the old repair.

Blanka and Christina also began developing a method of surface finishing with the goal of creating a textured surface that matches the surrounding cement plaster.

Adhesives for Decorative Ornaments

All adhesives that have been used in the past to re-attach ornaments, or secure loose ornaments have failed. Sylvia identified a dozen adhesives that may have better performance. She prepared Portland cement test plates and adhered glass plates (microscope slides) to them (figure 11). These test plates are currently undergoing thermal cycling in the environmental oven at LACMA's Conservation Center. A second set is being exposed to UV-B radiation in a ultra-violet exposure chamber, and a third set is undergoing outdoor exposure.

Figure 11: Adhesives test plate

Elastomeric Crack Fillers

Seven elastomeric crack fillers have been identified and purchased. A testing protocol is currently being developed.

Water Repellents

Since it is anticipated that the application of a water repellent will be the final step in any future treatment we identified and obtained four high end products. At this point we will test their compatibility with the repair mortars, adhesives, and crack fillers. Limited *in-*

situ tests may also be carried out. We also obtained some Karsten Tubes to be able to measure their effectiveness[8].

Four cement test plates will be impregnated with the selected water repellents and undergo outdoor exposure and performance monitoring.

Next Steps

- Installation of accelerometers (vibration monitors) and associated monitoring equipment in collaboration with the UCLA Department of Civil and Environmental Engineering.
- Expansion of the crack monitoring program with additional displacement transducers and thermocouples.
- Implementation of the repair mortar testing program.
- Development and implementation of a detailed testing program for elastomeric crack fillers.
- Identify equipment and potential consultants for corrosion monitoring.
- Begin evaluating migrating corrosion inhibitors.

Fundraising

No updates this quarter.

Other

Respectfully submitted by Frank Preusser, Senior Conservation Scientist, Conservation, with support from Mark Gilberg, Suzanne D. Booth and David G. Booth Conservation Center Director

Submitted January 2013

[8] We are grateful to Dr. Beril Bicer-Simsir (Getty Conservation Institute) for donating the tubes for our first round of testing.