Attachment C

December 6, 2011
Project No.: 110876.1

Larry Brugger
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Subject: Chain Reaction Sculpture Investigation and Material Testing
Santa Monica, CA

Dear Larry:

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Twining has performed investigation and material testing on the above subject sculpture located in the city of Santa Monica to determine the as-built conditions and material properties of the structure in accordance with your e-mail correspondence received on October 11, 2011 and our signed cost Proposal Number 11-1136 Revision 1, dated November 7, 2011. A summary of our scope of work, details of the investigation and laboratory testing, along with results and findings are presented in the following sections.

I. Scope of Work

The following is a summary of our scope of work:

- ☐ Provide boom lift machinery and certified operator to access high elevation of the sculpture for the inner structure investigation and fiberglass shell material extraction.
- ☐ Fiberglass coupon sample extraction witness at the project site to document locations and sample identification taken from the sculpture's base and "mushroom" top section. Sample cutting and removal was performed by Rosa Lowinger & Associates.
- ☐ Perform non-destructive survey on concrete foundation inside or near the sculpture base to determine steel reinforcing layout to avoid cutting steel for concrete core sampling purpose for compressive strength test of the concrete.
- ☐ Perform visual inspection and documentation of the sculpture's inner steel structure configuration, member size and connections including anchorage to concrete foundation.
- ☐ Perform lab testing on the extracted fiberglass shell coupons to determine the tensile strength of the material in accordance with ASTM D638, *Standard Test Method for Tensile Properties of Plastics*,
- ☐ Perform lab testing on the extracted fiberglass shell coupons to determine the flexural strength of the material in accordance with ASTM D790, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*.
- ☐ Perform lab compression test on the concrete core samples obtained from the foundation in accordance with ASTM C42, *Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete*.
- ☐ Perform the following lab testing on the copper chains:
  1. Unit weight test.
  2. Screw ultimate pull-out strength from the chain utilizing undamaged screws (found lying inside of the sculpture base) and driven into the chain.
  3. Tension test to establish ultimate pull-out strength between two linked chains.
- ☐ Prepare a cumulative final test report detailing the test results and findings, along with photographs of the testing where applicable.

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II. Field Investigation and Findings

Based on the preliminary information provided and our field investigation, the Chain Reaction sculpture was reportedly built in 1991 and made of fiberglass shell lining in the form of a mushroom-shaped figure measuring approximately 26 feet high. The sculpture's outer shell is entirely covered with approximately 9-inch long by 5-inch wide copper chain links at random orientation. The sculpture base measures approximately 14 feet 8 inches in diameter and sits on top of a circular concrete foundation of approximately 20 feet in diameter.

To minimize damage to the sculpture fiberglass shell, small cut-outs or drilled holes through the shell were made on November 16, 2011 at random locations along the base to determine and/or verify the inner structure composition per the provided sketch on the structural calculations (included in Appendix A) by inserting a boroscope through the holes and cut-outs to view the existing contents and conditions of the sculpture's inner structure. Results indicated the fiberglass shell is supported (or stiffened) by an inner skeleton frame fabricated from 1-inch square stainless steel tubing formed and welded in sections to the shape and curvatures of the shell as shown in Figure 1 below.

Figure 1

Based on the man-sized access hole opening cut at the base shown in Figure 1 above, there exists at the center of the sculpture a main vertical steel tubular member, approximately 13 inches in diameter (wall thickness of $^{7}/_{16}$ inch as tested by our EPOCH 600 ultrasonic flaw detector manufactured by Olympus) running all the way to the top. The bottom of the round tubular member is welded to a 42-inch square base plate of approximately 1½ inches thick and anchored to the concrete foundation with 1-inch diameter anchor bolts (8 bolts total). The round tube member is reinforced all around with ¼-inch thick triangular welded gusset plates (total of 8 gussets). Corrosion was apparent on the gusset plates and more severe on the anchor bolts and nuts as shown in Figures 2A and 2B below.

Figure 2A

Figure 2B

III. Field Non-Destructive Testing of Welds

A. Visual Inspection

Result of the visual inspection indicated the fillet weld leg size of the round tubular member to the base plate, gusset plates to the round tubular member and to the base plate, was nominal ¼ inch.

B. Magnetic Particle Testing (MT)

The magnetic particle testing of the fillet welds for all gusset plates to the base plate resulted in acceptance per the American Welding Society (AWS) D1.1 requirement. Field non-destructive test report is included in Appendix A.

C. Radiography (RT)

Radiography testing of the fillet welds for all gusset plates to the 13-inch diameter round tubular member resulted in acceptance per AWS D1.1 requirement. Field test report prepared by our subcontractor, Davis Laboratories, is included in Appendix A.

IV. Laboratory Test Results and Findings

A. Copper Chain Unit Weight Test

Three copper chain links were individually weighed on a calibrated scale with results noted in Table 1 below.

Table 1 – Chain Link Weight

Sample No.	Weight	
	Grams	Ounces
1	239.2	8.44
2	243.6	8.57
3	239.4	8.45
Average	*240.7*	*8.48*

B. Screw Pullout

Three undamaged self-tapping crews were obtained from the base of the sculpture that may have resulted from extra screws during construction of the sculpture or loose over time and fell to the bottom. For the purpose of our laboratory testing, the three screws were driven into the hollow copper chain links (obtained from the site) at a minimum of ¾-inch penetration to simulate attachment of the chain links to the sculpture fiberglass shell (Note: By inspection, the screws were driven from the inside of the sculpture through the fiberglass shell and into the copper chain). Tensile tests were conducted using a hand-held calibrated dynamometer as shown in Figure 3 below to determine the screw pull out strength from the copper chain. Results of the testing are summarized in Table 2 below:

Table 2 – Results of Screw Pullout from Copper Chain

Test No.	Maximum Load (lbf)	Failure Mode
1	121	Screw pullout from chain
2	132	Screw pullout from chain
3	109	Screw pullout from chain
Average	*120*	

Figure 3 – Test Set Up

C. Copper Chain Link Tensile

Two linked copper chain section obtained from the jobsite was placed in the tensile testing machine and loaded in tension to determine the ultimate pullout strength from each other (see Figure 4A). The maximum load obtained was 789 pounds; failure was the spot welds at the two halves section shown in Figure 4B below.

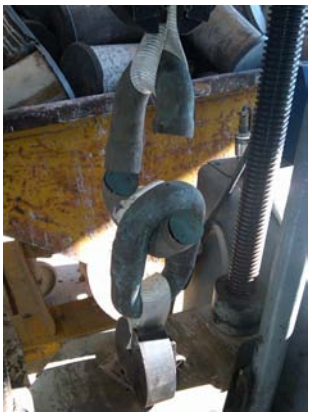

Figure 4A – Test Set Up

Figure 4B – Failure Mode

D. Flexural Test

Two approximately 1-inch wide fiberglass shell coupons identified as Sample #1 cut from the lower stem approximately 4 feet from the base and Sample #2 cut from the mushroom top portion were tested in general accordance with ASTM D790, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*. The following Table 3 summarizes the details of the flexural tests.

Table 3 – Flexural Strength Test Results

Sample ID	Specimen Width (b)	Test Span (L)	Specimen Depth (d)	Max. Load (P)	Flexural Strength (psi)*
1	0.954 in.	6.25 in.	0.070 in.	14 lbs	28,080
2	1.14 in.	6.25 in.	0.089 in.	17 lbs	17,650

*Flexural strength is calculated at breaking load using ASTM D790 Equation (3): $\sigma = 3PL/2bd^2$

ASTM D790 indicates the minimum number of five test specimens; however the number and size of the specimens were limited in order to minimize damage to the existing structure per client's request. The main factors contributing to the large variation in the flexural strength between the two samples noted in the table above may be the non-uniformity and surface irregularity of the material since it appeared that the fiberglass shell was hand-molded during fabrication. Therefore, although ultraviolet exposure will affect the material strength degradation over time, it is inconclusive based on this testing to confirm that the large deviation in the strength between the two samples was caused by more exposure to sunlight from one area versus the other.

E. Tensile Test

Two approximately 1-inch wide fiberglass shell coupons identified as Sample #1 cut from the lower stem approximately 4 feet from the base and Sample #2 cut from the mushroom top portion were tested in general accordance with ASTM D638, *Standard Test Method for Tensile Properties of Plastics*. The following Table 4 summarizes the details of the tensile tests.

Table 4 – Tensile Strength Result Summary*

Sample ID	Specimen Width, in.	Section Thickness, in.	Section Area $in.^2$	Ultimate Load, lbs	Tensile Strength, psi
1	0.75	0.100	0.075	539	7,190
2	0.57	0.060	0.034	209	6,110

*Test specimens were cut to Type I configuration as noted in ASTM D638.

ASTM D638 indicates the minimum number of five and 10 test specimens for isotropic and anisotropic materials, respectively; however the number and size of the specimens were limited in order to minimize damage to the existing structure per client's request. The main factor contributing to the variation in the tensile strength between the two samples noted in the table above is likely due to the non-uniformity and surface irregularity of the material since it appeared that the fiberglass shell was hand-molded during fabrication. Therefore, although ultraviolet exposure will affect the material strength degradation over time, it is inconclusive based on this testing to confirm that the deviation in the strength between the two samples was caused by more exposure to sunlight from one area versus the other.

F. Foundation Concrete Compression Test

A nominal 4-inch diameter core bit was used to originally obtain one concrete sample for compressive strength testing at one specified location of the sculpture concrete foundation. At approximately 5½ inches deep of coring, the sample broke off at a straight planar layer which indicated a topping layer and thus assigned an identification of CR-F-1 for testing traceability purpose. Coring at the same location continued further down to determine the thickness of the foundation but was limited to additional 4½ inches of depth which the sample was assigned an identification of CR-F-2.

Results of the compressive strength test for Samples CR-F-1 and CR-F-2 were 5,530 psi and 7,060 psi, respectively. Detail test results of the compression testing are included in Appendix A.

V. Conclusion

Based on the results and findings as noted above, and our understanding of the scope of work, we make no statement of compliance or noncompliance to the project specification or standards.

Any findings presented in this report were prepared based on our understanding of the scope of work, general accepted and applied engineering principles and practices. The findings are applicable to the area investigated and therefore may or may not represent the structure at its entirety. No other warranty, either expressed or implied, is made.

This report was prepared for the above named client to be used at its entirety for investigative and/or design purpose. The use of this report other than noted and portions there of shall be at the user's own discretion based on their own interpretation of the results contained within.

In closure, Twining is pleased to be of service to you for this project and we look forward to working with you again in the near future. Please contact us at 562-513-1502 or via email atan@twininginc.com should you have any questions.

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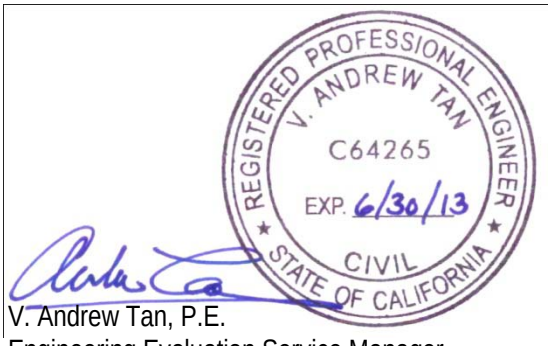
Respectfully submitted,
TWINING INC.



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Engineering Evaluation Service Manager

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APPENDIX A

NDT and Laboratory Test Reports