Beverly Pepper's *Denver Monoliths* and Concrete Artificial Rock Construction

DENVER ART MUSEUM

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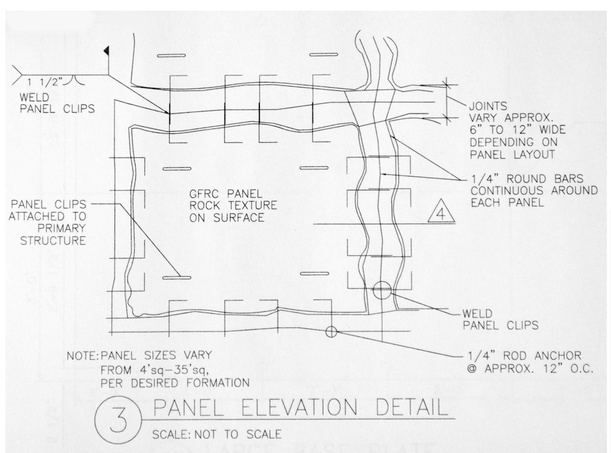
Introduction

This poster presents a case study of a monumental outdoor artwork in the collection of the Denver Art Museum, the *Denver Monoliths* (2005-2006) by Beverly Pepper. The two sculptures making up the artwork, one 42' tall and one 31.5' tall, were commissioned by the museum and made using "artificial rock" concrete construction methods like those used for naturalistic concrete environments in zoos, botanic gardens, and amusement parks. Beginning in 2007, a number of condition issues became apparent with the sculptures, including cracks, efflorescence, and uneven discoloration. Following investigation of the condition issues with specialized contractors and a structural engineering firm, a treatment was carried out on the sculptures in 2012 to clean and recolor their surfaces. Treatment of the cracks was decided against at that time. The construction methods, condition issues, and treatment decisions are detailed below. The intent of this presentation is to provide useful information for those with artificial rock structures in their care, as well as those involved with the design and commissioning of outdoor sculptures.

Beverly Pepper, *Denver Monoliths*, 2005-2006. During installation, 2006. Note dark coloration and subtle streaking on taller sculpture. (Denver Art Museum Collection: Funds from Jana and Fred Bartlit, 2006.64, © Beverly Pepper)

Materials and Construction Methods

The *Denver Monoliths* are hollow structures, consisting of glass fiber reinforced concrete (GFRC) panels mounted on an armature of structural steel plates and tubes. GFRC is a composite material consisting of alkali-resistant glass fiber and aggregate in a cement matrix and features flexibility, impact resistance, high toughness and crack resistance, and ability to create thin forms thus reducing weight.[1,2] The GFRC panels are each approximately 4-6' high x 4-6'wide and are ½" to 1" thick. The panels are cast forms made from molds taken from actual rock faces. There are 6-12" joints between the GFRC panels that have been filled in with pneumatically applied concrete, known as *shotcrete* or *gunite*.[3] In order to contain the shotcrete, the gaps between the panels were backed with plastic lathe prior to application. Once applied, the shotcrete seams were shaped and tooled by hand to match the texture and follow the contours of the cast GFRC panels. According to the fabricator, all of the original coloring of the sculpture was integral pigmentation mixed into the GFRC and the shotcrete. However, evidence of spray-applied paint or stain was noted in some locations on the sculptures themselves.



Excerpt from as-built construction drawings, showing layout of GFRC panels and attachment points to steel armature. Shotcrete was used to fill in the 6-12" joints between the panels. © Cost of Wisconsin

Condition Issues

By about a year after installation, condition issues with the sculptures were appearing. Hairline cracks were noted, as well as efflorescence. (Some efflorescence-like streaks were noted at installation, though conversations with the sculpture's fabricator, Cost of Wisconsin, indicated that some streaking was intentional.)[4] Overall lightening of the coloration and more extreme lightening of several of the GFRC panels is visible in photographs of the sculptures taken in 2007. In 2011-2012, a close assessment of the sculptures was undertaken. Cracks, hairline and wider, were present around each GFRC panel and some cracks crossed shotcrete seams. The entire surface appeared faded, and several panels stood out stark white. The illusion of a continuous rock face was completely disrupted.

Beverly Pepper was contacted and shown images of the sculptures' current condition. She referred the museum to her associate at Marlborough Galleries,[5] and preferred contractors were recommended to resolve the change in appearance.

Beverly Pepper, *Denver Monoliths*, 2005-2006. Before treatment, 2012. Note uneven light discoloration and efflorescence. (Denver Art Museum Collection: Funds from Jana and Fred Bartlit, 2006.64, © Beverly Pepper)

Details of the *Denver Monoliths*. Left: Example of vertical crack along left edge of GFRC panel, before treatment, 2012. Right: Cracks and efflorescence on side of larger sculpture, before treatment, 2012.

Condition Evaluation and Treatment Decisions

The sculptures were reviewed with their fabricator Cost of Wisconsin, as well as a second contractor specialized in artificial rock, Cemrock. The discoloration of the surfaces was found to be a relatively straightforward issue to address. Discussions focused on the significance and possible treatment of the cracks. After investigation of possible treatment approaches for the cracks indicated that treatment would be invasive and possibly problematic, the decision was made to contract a local structural engineering firm, Martin/Martin Consulting Engineers, to evaluate the structures.

The engineers carried out a visual review of the sculptures, reviewed as-built construction drawings, and interviewed the fabricator of the sculptures. They found that the cracks were caused by one or a combination of three factors: differential shrinkage of the GFRC and shotcrete during curing, differential thermal expansion and contraction of the two materials, and/or wind pressure deflecting the sculptures. Wind movement at the top of the larger sculpture was calculated to be 1 ½". The cracks were not found to be undermining the structural integrity of the sculptures or posing a hazard to passersby, as the panels and shotcrete were securely tied into the steel structure, and cracks were not affecting the panels. Although the cracks were admitting water, closed cell foam filling the interior voids of the sculptures and epoxy coating on the structural steel were protecting the integrity of the steel armature.

If treatment of the cracks were to be undertaken, the engineers recommended use of a flexible sealant that would move with the structure. Cracks would need to be widened to at least ¼" to accommodate the sealant. Repairs were likely to be or to become visible and would need periodic maintenance.[6]

Weighing of this information led to the decision to refrain from treatment of the cracks at that time and to limit treatment to cleaning, recoloring, and sealing of the surfaces.

Beverly Pepper, *Denver Monoliths*, 2005-2006. After treatment, May 2013. Note streaks of white efflorescence. (Denver Art Museum Collection: Funds from Jana and Fred Bartlit, 2006.64, © Beverly Pepper)

Treatment, Results, and Conclusions

Treatment of the sculptures was carried out by Cemrock in August 2012 and consisted of power washing, spray application of an exterior grade, flat finish acrylic paint matching the original coloration, and application of an alkoxysilane penetrating sealant. The intended purpose of the sealant was to repel water from the fine cracks and help to reduce efflorescence.

Eight months later, precipitation has led to water entering and exiting the cracks and depositing streaks of efflorescence in various locations. The efflorescence is not totally inconsistent with the appearance of natural rock faces and some efflorescence-like streaking was visible at the time of installation. However, the current streaks stand out against the recolored surface. Further exploration with the artist on this issue is under consideration. Moving forward, the impact of the efflorescence versus the limitations of treating the cracks will need to be weighed.

Even setting aside treatment of the cracks, the *Denver Monoliths* require ongoing and intensive maintenance. In all likelihood, the recoloring and sealing process will need to be repeated every 5 years. An annual wash and inspection with a boom lift is also recommended. Work plans will need to include rental of a boom lift and site preparation. In addition to the discussion above, ongoing maintenance requirements are factors to consider for those planning for care of existing large-scale sculptures and artificial rock structures as well as for those considering acquiring works of similar size or features.

Beverly Pepper, *Denver Monoliths*, 2005-2006. During treatment, August 2012. Note use of boom lift, fencing, tarps and plywood. (Denver Art Museum Collection: Funds from Jana and Fred Bartlit, 2006.64, © Beverly Pepper)

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Footnotes:

1. Nippon Electric Glass Co., Ltd., *ARG Fiber, High Zirconia Alkali-resistant Glass Fiber*, March 2007, http://www.negamerica.com/p14_brochures/ARG_brochure.pdf (accessed May 19, 2013).
2. Richard Pieper, "Preservation Brief 42, The Maintenance, Repair, and Replacement of Historic Cast Stone," *National Park Service Technical Preservation Services,* September 2001, http://www.nps.gov/tps/how-to-preserve/briefs/42-cast-stone.htm#gfrc (accessed May 19, 2013).
3. Anne T. Sullivan, "Shotcrete," *20th Century Building Materials – History and Conservation*, ed. Thomas C. Jester (Washington, DC: McGraw-Hill Companies, 1995).
4. John Stanwyck, Cost of Wisconsin, Meeting, Denver, CO, July 25, 2011.
5. Beverly Pepper, personal communication, January 11, 2012.
6. David J. Wittman, Martin/Martin Consulting Engineers, unpublished report, July 6, 2012.