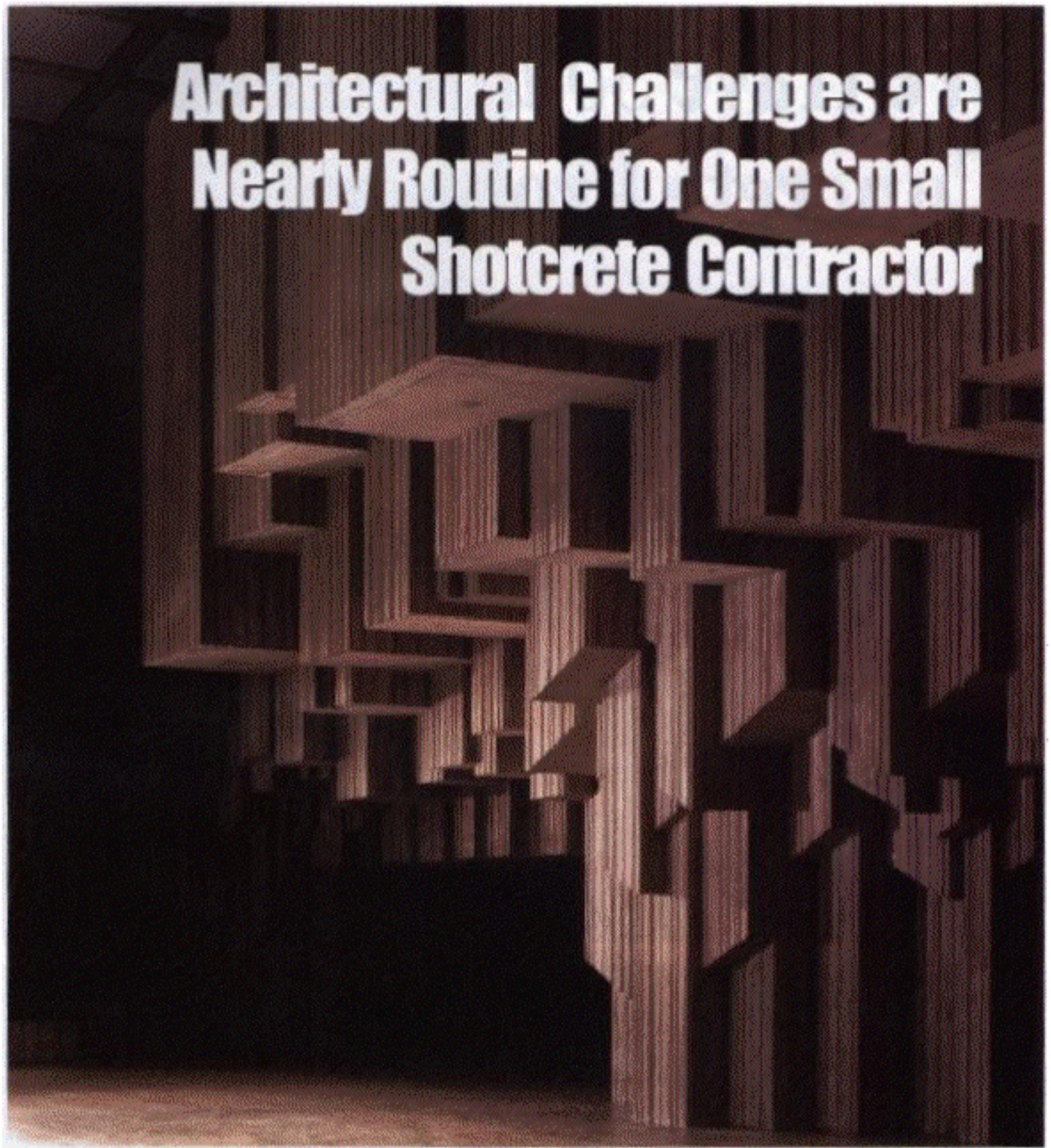


Architectural Challenges are Nearly Routine for One Small Shotcrete Contractor



by Jolly Miller

Washington State Convention Center

Twenty-five years ago I thought everything was going to be built out of shotcrete! However, after building several sandwich panel buildings, and facing the prospect of wood floating acres and acres of vertical walls, our little Seattle company retreated to our growing specialty of building zoo exhibits and aquariums around the United States. We enjoyed the artistic nature of that work, and over the next twenty years built over forty zoo exhibits from Oregon to New York.

Every once in a while, however, the urge to see just how far shotcrete could go would be stimulated by some designer wanting to do something unconventional. Off we would go into chaos, the “learning curve,” and an occasional success. For example, along the water of Puget Sound are many homes, built high on cliffs overlooking the water. But these cliffs erode and over time become a real concern to

the owner. We discovered that our mud and sand bank techniques, developed in doing naturalistic habitats in zoos, worked very well in stopping erosion while retaining the natural appearance of the landscape.

In the early days, we would dig a footing at the base of the wall, use a grid of #3 or 4 steel on 9 inches (230 mm) centers, and shoot a six inch (150 mm) thickness of shotcrete using integral color matching that of the soil in the area. While the shotcrete was still wet we would collect a few five-gallon (19 L) buckets of dry soil from the bank and seed it into the wet colored shotcrete. We were careful to leave and protect trees, salal, and other small shrubs growing out of the bank. When the plastic was removed, the plants appeared to be growing out of the shotcrete bank. In the Gig Harbor area in Washington, we also saved puffin nests that were dug into the high sand



cliffs. After we left, the puffins soon learned that 4,000 psi (28 MPa) shotcrete was somewhat difficult to dig into to build a nest!

Environmental concerns eventually eliminated the use of heavy equipment on the beach, so the excavation and poured footings have been replaced with grouted soil anchors, with an occasional augered concrete pier at the base to support the shotcrete erosion mat. One erosion control mat currently under construction in Seattle reaches 80 feet (24 m) high and runs 500 feet (150 m) long.

In the late 80s, designer Angela Danadjieva was concerned that the Italian marble specified to be installed inside the Washington State Convention Center would be too expensive and probably not arrive in time to meet the construction schedule. As a substitute, she proposed duplicating the board-form look being used throughout the center with shapes made of concrete. Contractors convinced her that it could not be formed and poured in the overhead locations, but we suggested that perhaps we could do it with shotcrete. The architects and engineers were skeptical, so we shot a sample section. After stripping the boards a week later, they inspected the results and immediately approved our

method. We then faced the challenge of building it the suspended sections inside the convention center. The general contractor installed support columns and beams, then welded re-bar to those before shoring up and installing the forms with the board form pattern on the inside.

The forms were soaked with water for a full week before shotcreting. A plaster machine was used to precoat the forms, followed by a six-inch (150 mm) thick finish coat shotcreted using a swing tube pump. The forms were left in place to dry for almost a month before stripping. As they dried, they shrank and the stripping left some wood splinters embedded in the concrete, which made it impossible to tell whether this material was shotcreted or cast-in-place.

In 1996, we were asked by the Director of the Wildlife Conservation Society to go to the Bronx Zoo in New York and do the exhibitry work for their new seven-acre gorilla exhibit called Congo. The work took almost three years to build and included over 70 artificial trees, some as high as 80 feet (24 m), with many streams, waterfalls, mud banks, and rock formations carved out of shotcrete. Some of the trees were all shotcrete, some were fiberglass and epoxy, and many





were shotcrete structures with a texture coat of epoxy. The streams and waterfalls were waterproofed with a proprietary integral waterproofing admixture, after which a colored texture top coat was applied.

Gorilla enclosures must be at least 14 feet (4.5 m) high. Footings were constructed with vertical bars stubbed out, after which #3 and #4 rebar was shaped in place, using scale models built by the design staff at the Wildlife Conservation Society. The shapes simulated large mud bank and rock cliffs, with an occasional stream or waterfall. Many of these were shot structurally with dry mix, then textured with integral color wet mix. Final painting was completed by experienced exhibit artists, often the same people who carved the shotcrete, using



acrylic latex paints and occasionally muriatic acid containing stain.

Over the years some of the finest craftsmen and women in the industry have joined our company. They all have slightly different techniques for carving, shaping and brushing to create the organic feeling that becomes a rock, a tree, or a stream. Rarely do we find artists who are willing to work with such a difficult medium in very hot or very cold weather, on scaffolding or inside a tiny exhibit bumping into each other for a month! However, we are constantly training new people that express a desire to do just that. It is certainly a growing industry, and for those of us who love to be outside creating neat things and are will-

ing to shovel rebound, repair concrete pumps, and have everything you wear take on the color of whatever exhibit you are working on at the time, there will always be a job.

Architectural shotcrete has definitely taken root throughout the world and not for the reason that I thought twenty-five years ago, "that we are running out of wood and will have to use concrete."

I think all natural resources, including all of the materials that compose the concrete mixes that we all use, are going to have to be used carefully and we are all going to have to learn to conserve and reduce waste. The reason that people are building out of concrete is because they like it!

The past several years we have shotcreted two very nice homes in the Seattle area. The designers and the owners liked the "feeling" of shotcrete. One customer wanted her home to feel and look like an old French castle and wanted big cracks periodically to make it look 200 years old. We did rock work around an indoor swimming pool, all of the sidewalks, driveway, sea-wall along the lake, an outside spa, fireplace, and mud bank planters to conceal the house. Some of the shapes are conventional, with square corners and real doors and windows. But the medium of shotcrete makes it easy to do graceful curves, overhangs, caves, tunnels, fireplaces, barbecue pits, wine cellars, stairs going anywhere, or waterfalls and streams meandering in or out of a home.

Thanks to people like Rusty Morgan, Neil McAskill, George Yoggy, and Michael Rosenzanz, just to name a few, this industry is gaining credibility with engineers and architects. These people have developed programs to train inspectors how to inspect shotcrete,

teachers to teach the advantages of using this medium, and suppliers to do reliable mix designs. Their focus is on the necessity of consistency and high quality that we shotcreters need to achieve the dreams of our customers.

College teachers are now even teaching prospective engineers that this is a medium which can hold up buildings and roofs, it can be 10,000 psi (70 MPa) if need be, can be beautiful, can be waterproof, and does not necessarily have to be square, plumb, or level to work. Shotcreters are being trained how to use the latest techniques, equipment, and especially the myriad possibilities of mix designs so that the QUALITY of the product is at the highest level.

The demands that these initiatives have achieved is phenomenal! Equipment designers went into overdrive to develop more sophisticated and better equipment to deliver both wet and dry mixes farther, higher, faster, and more reliably. And the most important point of all is that high quality shotcrete work is so good, whether it is 5,000 feet (1500 m) underground in a mine or on a tree that a gorilla climbs in front of a million people a year, that it has become the *only* way to do some things, and an *accepted* way to construct almost anything from concrete!

The challenge to the shotcrete industry in this century is to always keep quality at the top of the list. Because shotcrete is so fast and easy to use, it can easily be abused. Almost anyone can rent equipment and spray shotcrete, paint, or manure anywhere. The reputation of shotcrete was tarnished in the early years because people did not understand how good it could get. Many considered it barely adequate to line a ditch or fill a hole. But, in the last fifteen years, the miners working deep underground have been pioneering the use of fiber and steel reinforcing, silica fume, and fly ash. They have been creating tunnels of high-strength shotcrete that may crack under stress but don't fail – they love shotcrete because it saves lives. We who shotcrete at the surface have been building pools, waterfalls, zoo exhibits, shear walls in seismic upgrade projects, retaining walls, straw-bale houses, and lining miles of ditches and water storage ponds for the future.

This industry is growing and we think that it is on the brink of tremendous success because we are able to provide and guarantee QUALITY. This is the century where we get to shine. The groundwork has been laid; the

product is high quality, reliable, appealing, and very cost effective. This is the time for Architectural Shotcrete! ■■■

Jolly Miller, Inc. has won the American Zoo and Aquarium (AZA) Best New Exhibit award three times in the past ten years, as well as awards from the American Concrete Institute. In addition to contracting, they also work as design consultants in numerous design-build projects. Jolly Miller founded the company in 1970 and is as happy as his name implies when supervising or shooting a complex shotcrete project.

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