2019 Outstanding International Project

The Pretoria Canopy

Transforming an "Ordinary" Edifice into an Architectural Landmark

By Eamonn Ryan and Dustin Strever

A 26 m (85 ft) long, highly unusual concrete portico over the entrance of a government building (The Pretoria Canopy), located in Silverton, Pretoria, South Africa, transforms a fairly ordinary looking building into an architectural milestone (Fig. 1).

Due to the organic nature of the structure, the architect proposed to use shotcrete early in the design process. Consultations with Shotcrete Africa SCP were held about 9 months prior to the start of construction.

The flowing, curved shape of the structure would probably have been nearly impossible with use of form-and-pour techniques. The one-sided formwork was a custom fabrication with over 300 individually laser-cut pieces creating a complex, undulating surface. To have to double the amount of formwork, precisely align the two sides, and brace for the incredible pressures that form-and-pour would have generated would most likely have necessitated a re-design of the structure to more easily accommodate the limitations and costs of standard formwork. Using shotcrete mitigated a lot of these problems and reduced the cost. Shotcrete thus enabled the architect to realize their one-off design in the shape and form as originally visualized (Fig. 2).

Sustainability advantages are typically recognized in varying degrees on all shotcrete projects when compared to form-and-pour concrete construction. Although this was a difficult and challenging shape to construct formwork for, the use of the shotcrete process achieved at least a 40% reduction in formwork, labor, and crane costs. This substantial reduction highlights shotcrete's natural sustainability benefits. The formwork took approximately 3 months

Fig. 1: View walking into the canopy

Fig. 2: View from inside the canopy

to erect from date of award to final use. Any extension in this time and the ensuing cost would probably have rendered the project unfeasible without a major redesign.

THE PROJECT

The R3-million Pretoria Canopy project entailed R1.6-million of formwork, just 70 m^3 (90 yd^3) of shotcrete, and a substantial 18 tonnes (20 tons) of reinforcing steel. The project was a tremendous learning curve for all and already interest has been generated in duplicating these skills and methods on other interesting projects.

Architect Pieter Breytenbach, Deter Architects & Designers, was given free imaginative reign on the concrete portico cover over the entrance. It was a fairly old building, so it was a challenge to design a structure which would complement the existing building while contributing something to its aesthetics. To achieve that, he employed one of the oldest and most robust structures ever designed—the arch.

Making it especially challenging was that the surrounding ground ramped up towards the entrance, so the design had to accommodate the gradient slope up to the building plinth. The only guidance from the client was that they wanted something "impressive."

The structure rises up towards the building entrance and narrows down to a diminishing point, indicating the way to the door almost like a target. That was the biggest challenge from a design point of view. Once the design was selected, the architect had to look at what could be taken away. One usually has heavy buttresses on an arch, but these were able to be done away with due to the capabilities of the concrete and the expertise of the engineers involved.

The idea was to open up the western side of the structure to provide sufficient natural light. It was fortunate that protection from the elements was afforded by the existing building. Polycarbonate (used as a roofing material because it doesn't transfer a lot of heat) was clad over ribs tucking into the structure on the sides which turned three-dimensionally.

As a result, when one approaches the building, the portico opens up in a well-lit manner, then closing in while tilting up slightly as the entrance is neared. Two large pillars and the gutters act as the keystone to the structure. There are long spans of unsupported, cantilevered concrete between the pillars, and that's a homage to the material worked with and what it is capable of.

SCOPE OF WORK

It is believed this is one of the only structures where every element of reinforcing bar has its own bar-mark—every single piece is individual, because everything is either diminishing or increasing in size and the whole structure is moving in three directions. It's definitely not like a normal column. The reinforcing steel design was done by the engineer, SCIP.

The concrete mixture design included admixtures such as Penetron, silica fume, and high-range water-reducing agents to achieve a slump of just 80 mm (3.2 in.). The columns are 800 mm (32 in.) deep and 2.4 m (8 ft) wide.

Peri was responsible for the design of the formwork and shoring. All formwork elements for the soffits were prefabricated by Peri off site to be delivered for assembly on site. The structure is asymmetric in section and formwork design had to be done in three-dimension (3-D), taking existing structures into account. From a formwork point of view, this project was highly unusual, and many contractors made the decision to not get involved.

Construction started with the installation of a designed network of props and scaffolding to support the ribs of the canopy. Each individual rib was laser-cut and no two were the same. The forming ply was then placed and fastened to the support structure. At all times, strict health and safety was maintained. An initial layer of shotcrete was then placed to avoid using "spacers" that would have negatively impacted the smooth finish required by the architect. This, however, did not go 100% to plan.

The design and installation of the reinforcing bars was also a challenge. A hands-on approach was the only way to get the job done (Fig. 3). This project was a question of complete commitment from all involved and required clear vision in terms of what had to be achieved. The progress meetings required detailed technical discussions and the various trades worked much closer together than normal. The reinforcing steel bending schedule was complex and required many clarification meetings to ensure it was designed and installed correctly.

Fig. 3: Complex reinforcing steel for the canopy

Fig. 4: Shooting the canopy

Shooting this intricate web of steel was easy enough (Fig. 4); however, work had to stop occasionally to "catch up" with rebound removal. At all times, an airlance was used to prevent encasement of rebound in the finished sections. We did struggle with "finishing" the placed shotcrete in time before it hardened, but any unfinished work was cut down to 30 to 50 mm (1.2 to 2 in.) below the final surface whilst still wet. This allowed slower placement and careful attention to finishing the following day. A saturated surface-dry (SSD) condition was achieved before applying the final finish coat and hessian burlap and a mist system was used overnight to ensure good curing.

Fig. 5: A view of the curved column with canopy sitting on the form

The mixture design was critical to achieve an ideal slump that enabled the company to shoot the 800 mm thick columns through two layers of heavy reinforcing bars with a minimum of rebound and excellent encapsulation of the bars (Fig. 5). The addition of Penetron to the mixture reduced the concrete permeability and helped ensure a long-lasting, durable concrete structure.

On completion, the structure was allowed 14 days to achieve 80% of design strength and then the formwork was removed in stages. It was a tense moment when the final formwork was lowered. The structure sagged less than 10 mm (0.4 in.) at the furthest point and a collective sigh of relief was no doubt shared by all involved. The top of the structure was then inspected for any movement cracks and as a precaution some micro cracking (found to be less than 1 mm thick and 15 mm deep) was repaired using dry-mix shotcrete. A week after completion the repaired section exhibited no further visible cracking.

CONCLUSIONS

Shotcretes uses and benefits continue to allow far sighted architects, engineers, and contractors to push the boundaries of what is sometimes thought of as impossible to achieve. This project exemplifies shotcrete's creative ability to transform the architect's vision into a solid and durable concrete structure (Fig. 6).

Fig. 6: A side view of the finished structure before painting

***Eamonn Ryan** is a Journalist and Editor with more than 20 years of experience contributing to almost all South Africa's financial newspapers and magazines, as well as several overseas publications. He previously served as the Business Editor of* Finweek *and as Editor of various technical magazines, including* Civil Engineering Contractors *(a 50-year-old magazine) and* Quarry SA*. He currently serves as Editor of* Plumbing Africa *and* SA Affordable Housing*.*

***Dustin Strever** is the Founder and Managing Director of Shotcrete Africa SCP—Africa's largest specialist shotcrete contractor. Based in Johannesburg, South Africa, Shotcrete Africa SCP offers a variety of shotcrete application services, ranging from small concrete repair using the dry-mix process to bulk structural using the wet-mix shotcrete application. Together with his wife Lynne, Business Manager, they employ over 75 staff. Strever has been involved in the shotcrete industry for over 15 years and was first exposed to dry-mix shotcrete when a client asked him to spray a 7 km (4 mile) precast concrete wall to add robustness. Since then, Strever has made it his mission to improve the perception and quality of shotcrete in South Africa, educating himself and staff with the assistance of the American Shotcrete Association and other leaders in the field. Shotcrete Africa SCP has been a corporate member of ASA since its inception.*

2019 OUTSTANDING INTERNATIONAL PROJECT

Project Name
Pretoria Entrance Canopy

Location
Pretoria, Gauteng, South Africa

Shotcrete Contractor
Shotcrete Africa SCP*

Architect/Engineer
Pieter Breytenbach - DETER Architects

Materials Supplier
Metier Mixed Concrete

Equipment Manufacturer
REED Shotcrete Equipment*

General Contractor
Bhekinani Civils & Projects

Engineers
SCIP

Formwork Design and Shuttering
Peri

Steel Supplier
Piovesan

***Corporate Member of the American Shotcrete Association**