2012 Outstanding Architecture Project

VanDusen Botanical Gardens

By Gary Hawkins

Torrent Shotcrete Structures was approached by the project team with a particular problem that was unforeseen at the design stage. The original design called for a rammed-earth wall for all the structural/architectural walls in this project.

One of the issues that surfaced with rammed earth in this application was the inability to provide enough strength for the structure's required bearing loads and seismic specifications. "The New Mexico building code defines qualified rammed earth as soil consolidated to full compaction that attains 300 psi (2 MPa) compressive strength and has a modulus of rupture equal to at least 50 psi (0.34 MPa).[1] This is a much lower strength than the 1450 to 5800 psi (10 to 40 MPa) compression strength range reachable by concrete."[2]

Another concern that arose was the thermal performance of a rammed-earth wall that is exposed both on the exterior of the building and the inside of the building. Frost-resistant walls made of steel studs with insulation were not part of the desired finished look. "The thermal resistance of rammed earth alone is not great enough to retain heat in a cold climate building. Obtaining a meager *R*-20 would require an 11.5 ft (3.5 m) wall thickness. Cold climate design dictates that rammed earth should be coupled with thermal insulation to attain higher thermal resistance."[2]

The solution to the thermal issue was to use an internal rigid insulation to increase the *R*-value. However, with the combination of these two key issues (structural and thermal resistance), it became apparent to the design team that alternates had to be explored.

Structural architecturally finished concrete was the only answer. However, due to the unique design of the building with varying geometry from the curved walls that oscillated up and down, and the free-formed configuration of the living roof, as well as new requirements to have sandblasted concrete walls, a conventional cast-in-place formed concrete wall would have been very difficult and costly. Even with exposed concrete walls, the thermal resistance issue required insulation to be sandwiched in the wall itself. This may have been easy for a flat, straight wall on a tilt-up building, but would have been extremely challenging in a cast-in-place wall with this unusual geometry.

The management team from Ledcor Construction, in conjunction with Whitewater Concrete, approached our management team for some alternative solutions using structural shotcrete

Fig. 1: VanDusen Botanical Gardens (Photo Credit: Nic Lehoux; Courtesy: Perkins+Will Canada)

methods. Through consultation with our operations and design team, a solution was born and the project proceeded.

Unusual Project Challenges

- An oscillating up-and-down structure with convex and concave curves throughout the project, similar to a roller coaster, made conventional forming of this project a very daunting task with time-related milestones difficult to overcome and to remain in budget.
- A uniform concrete finish on the exterior and interior of the wall. Both sides were to be sandblasted and remain with an exposed concrete finish.
- Internal insulation sandwiched in the wall itself.
- Designing the means, in collaboration with the engineer, by which to tie the two separate structural and architectural walls together with the integral insulation inside the wall, to support the intricate roof design that had additional loads from the green living roof on it.

To cast-in-place this structure with the integral insulation in the middle of the wall would have been difficult enough to achieve on straight walls, but to add in the extensive creative design of the oscillating curved structure and to achieve perfect elevations for the roof attachment made this project uniquely suited for the shotcrete process.

Solutions

Torrent created custom shoot panels made for the shotcrete industry. These panels were ideal for one-sided forming of the complex wall shapes on this project.

The ability to use our custom shoot panels and adjust them on the radius area was a huge time saver on this project. The one-sided forms worked well because only the exterior troweled face needed to be finished. Additionally, the ability to produce a perfectly curved radius, and a finished product with no need for any patching or repair work was unheard of on such a complex project. As the shoot panels were removed, spray-on insulation was applied to the exposed formed surface and became the inside (middle) of the wall. Once the insulation was applied and the steel reinforcing bars were installed, we then shot the inner wall. Thus, we created two superior exposed finish faces with multiple hand cut-in reveals and a smooth steel-troweled finish.

Once completed, the exposed wall surfaces were sandblasted and the resulting finish is amazing. Unlike cast-in-place concrete, with shotcrete, the higher density and compressive strength of the shot wall when sandblasted does not open up as much as normal cast-in-place concrete, leaving a much more uniform finish than possible with cast-in-place concrete.

Sustainability Benefits

- Reduction of lumber to build forms for walls. No one area of curved walls had the same radius, so every inch of the project required custom-built radius forms if cast-in-place concrete was to be used. With the use of shotcrete, standard shoot panels were able to be used—there were no radius panels whatsoever on this project.
- Reduction in trucking due to less need for lumber.
- Producing the structural walls for the project reduced time. Less carbon footprint realized on the site.
- Eliminating the need for patching and parging materials as per usual with cast-in-place concrete.

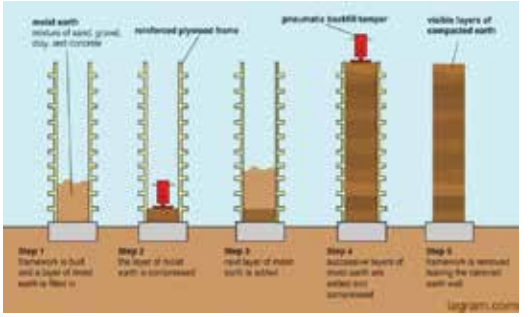

Fig. 2: Diagram of the construction process for a rammed-earth wall

Fig. 3: Completed feature wall prior to sandblasting. Exterior area view, post-shoot

Fig. 4: Torrent custom shotcrete panels

About the Gardens

VanDusen Botanical Gardens is self-sufficient, carbon-neutral, and has LEED Platinum certification. It has won numerous other awards for its design and implementation. Winning ASA's 2012 Outstanding Shotcrete Project of the Year Award for Architecture adds credibility to the shotcrete industry as an established and recognized process for building our cities and infrastructure. "Shotcrete is Concrete."

Fig. 5: Preparing one of the feature walls for shooting. Exterior area view prior to shoot

Fig. 6: Applying the steel trowel finish on the walls and detailing in the vertical architectural reveals

Fig. 7: Curved and oscillating up and down, structural and architectural sandblasted concrete structure for VanDusen Botanical Gardens

References

1. Government of New Mexico, 2006.*
2. Fix, S. and Richman, R., "Viability of Rammed Earth Building Construction in Cold Climates," Report, May 11, 2009.

**Contact the author at Torrent Shotcrete Structures Ltd. for more information.*

***Gary Hawkins**, Business Development Manager for Torrent Shotcrete Structures Ltd., has been in the construction formwork industry for over 25 years and takes care of the estimating and client management. Torrent's management team is comprised of individuals with extensive experience in the formwork industry who contribute to elevating the level of expertise in the structural shotcrete industry.*

Recognition for the success of this project particularly goes out to Torrent's Operations Manager, Carl King, whose attention to detail and understanding of building in general made this project successful, and T. Ross King, Founder of the company and pioneer of the shotcrete industry in Canada.

2012 Outstanding Architecture Project

Project Name
VanDusen Botanical Gardens

Project Location
Vancouver, BC, Canada

Shotcrete Contractor
Torrent Shotcrete Structures Ltd.*

General Contractor
Ledcor Construction Ltd.

Architect/Engineer
Perkins+Will Canada

Material Supplier/Manufacturer
Ocean Heidelberg Cement Group

Project Owner
Vancouver Board of Parks and Recreation

*Corporate Member of the American Shotcrete Association