2016 Outstanding International Project

Holcim New Zealand Cement Terminal

By Benjamin Davis

In 2013, Holcim New Zealand, a part of the Lafarge-Holcim Group, set out to design and build two cement storage terminals in New Zealand. With earthquake devastation in mind following severe earthquakes in 2010 (Stuff Reporters 2010) and 2011 (CNN 2011), finding a durable bulk storage structure resilient enough to handle seismic events and a company with a verifiable track record of building such buildings was paramount. Holcim described the entire project as consisting of two 33,000 ton (30,000 tonne) capacity dome silos, two 660 ton/hr (600 tonne/hr) pneumatic ship unloaders, a 720 ton/hr (650 tonne/hr) ship loader at Timaru, and bulk cement tanker loading facilities, all supported by equipment auxiliary buildings, office buildings, roadways, security, and dispatch facilities for a total cost of NZ$105 million (USD$70.8 million) (Williams and Cowie 2016).

The storage domes would be built on two ports and had to be aesthetically pleasing, environmentally friendly, cost-effective, and allow as sustainable an operation as possible. Their thorough evaluation of various types of storage structures selected concrete domes as the best choice. In the end, Domtec International was chosen as the preferred dome vendor in a "Best for Project" approach (Downer Group 2014). Two sites were chosen for Holcim's domes. On the South Island, the dome was to be built in Timaru, a port city approximately 93 miles (150 km) south of Christchurch. The other dome would be located on the North Island in the most populous city in the country, Auckland, with a regional population of over 1.4 million (New Zealand Government, 2013).

This article focuses on the project built in Timaru, on New Zealand's South Island, although both domes are pictured and explained in this article.

WHY A SHOTCRETE DOME?

Although Domtec had built for Holcim in other parts of the world, this was the first shotcrete dome to be built for the storage of cement in Australasia and was quite an innovative design and technique. Holcim cited several reasons for choosing a dome over traditional slip-form or jump-form cylindrical concrete silos, steel silos, or warehouse-type storage silos. Economy and speed of construction were the key factors in choosing a dome, but there were others, such as:

- Control over environmental impact during construction and operation phases due to the weather tightness and dust control properties of the dome. The external air-form and the polyurethane foam lining provide excellent insula-

Fig. 1: Aerial view of Holcim Cement Terminal in Auckland, New Zealand. Dome is 135.2 ft (41.2 m) diameter and 90.2 ft (27.5 m) tall and stores 33,000 tons (30,000 tonnes) of cement powder and used 1400 yd^3 (1100 m^3) of shotcrete to construct

Fig. 2: Aerial view of Holcim Cement Terminal in Timaru, New Zealand. Dome is 118.1 ft (36 m) in diameter and 103.3 ft (31.5 m) tall and stores 33,000 tons (30,000 tonnes) of cement powder and used 1923 yd^3 (1470 m^3) of shotcrete to construct

Fig. 3: Street view of Timaru cement storage dome. Aesthetics were a major consideration when deciding on a storage solution. The dome durability, white fabric color, insulation, price, and Domtec's reputation also figured into the contract award

tion and isolation properties, a benefit during construction and operation of the dome.

- Dome silos can be fitted with a complete reclaim floor, guaranteeing 98% extraction rates.
- The dome shape provides a high volume of storage within a relatively small footprint.
- This port had height and space constraints. The dome could achieve the tonnage required within a footprint and height that would work.
- The dome shape is inherently strong because of the seamless blending of the wall and roof. This provides excellent structural integrity, resistance to earthquakes, and severe weather conditions. This inherent strength also allows the cement to be placed high against the walls and roof.
- The technique of using shotcrete allows efficient and economical construction (eliminating the need for formwork, shoring, and waste). It also enables rapid construction of the domes regardless of weather conditions because after the inflatable form is erected, all works are performed inside the dome.
- Domes are ideal for combining with pneumatic extraction equipment from ships, to dome, to truck loading, and can accommodate high-volume filling and discharge rates.
- The dome supports heavy loads on the apex and asymmetrical loading against the walls, allowing side discharge and avoiding sub-grade reclaim tunnels. Each of the Holcim domes were designed to support 150,000 lb (68,000 kg) without any interior bracing or exterior bents.
- Building authorities had no experience with dome construction, but the lead contractor, together with Domtec International, put together a presentation that answered all questions and alleviated all risk and safety concerns (Williams and Cowie 2016).

DOME DESIGN

The dome storage building went through a strict peer review process that involved structural engineers in five countries on three continents. The dome was engineered using ACI, New Zealand/Australia, and Eurocode standards

Fig. 4: View of dome apex from inside of dome. When completed, each apex was designed to support 150,000 lb (approximately 62 tons [68 tonnes]) without any interior supports

Fig. 5: Finished interior wall of dome. The dome used roughly 1923 yd^3 (1470 m^3) of shotcrete

and codes to ensure all peer review engineers had a good understanding of loads and forces. After looking through the peer reviewed drawings, the owner and founder of Domtec, who has been in the dome business for over 35 years, remarked, "This will be the most stoutly constructed cement storage dome in the world."

Fig. 6: Timaru dome air form ready for inflation. The DomeSkin™ air form is 38,350 ft² (3563 m²)

DOME CONSTRUCTION

Construction of a concrete dome with an air form is relatively unique compared to conventional methods of concrete construction but allows for rapid construction and superior strength and durability. The method for building domes involves inflating a heavy-duty industrial fabric, which serves as a formwork or "air form." Domtec's DomeSkin™ air forms are each custom designed to fit the volumetric capacities of the product to be stored, while also fitting into height and width restrictions of each site. Domes can be built as true hemispheres or a dome on a cylindrical wall and are referred to as "SiloDomes™." Each SiloDome in New Zealand had to be built within a limited available footprint area, which also resulted in decreasing the cost of the reclaim system. Although the cylindrical part of the dome is more expensive to build than a hemisphere, the money saved by decreasing the floor size and reclaim equipment is typically greater than the additional cost to build a cylindrical portion of a dome structure.

The DomeSkin has a dual purpose. It serves as the air form during construction and ultimately, it also performs as the finished exterior roof membrane. The construction takes place on the inside of the DomeSkin, so the dome is built

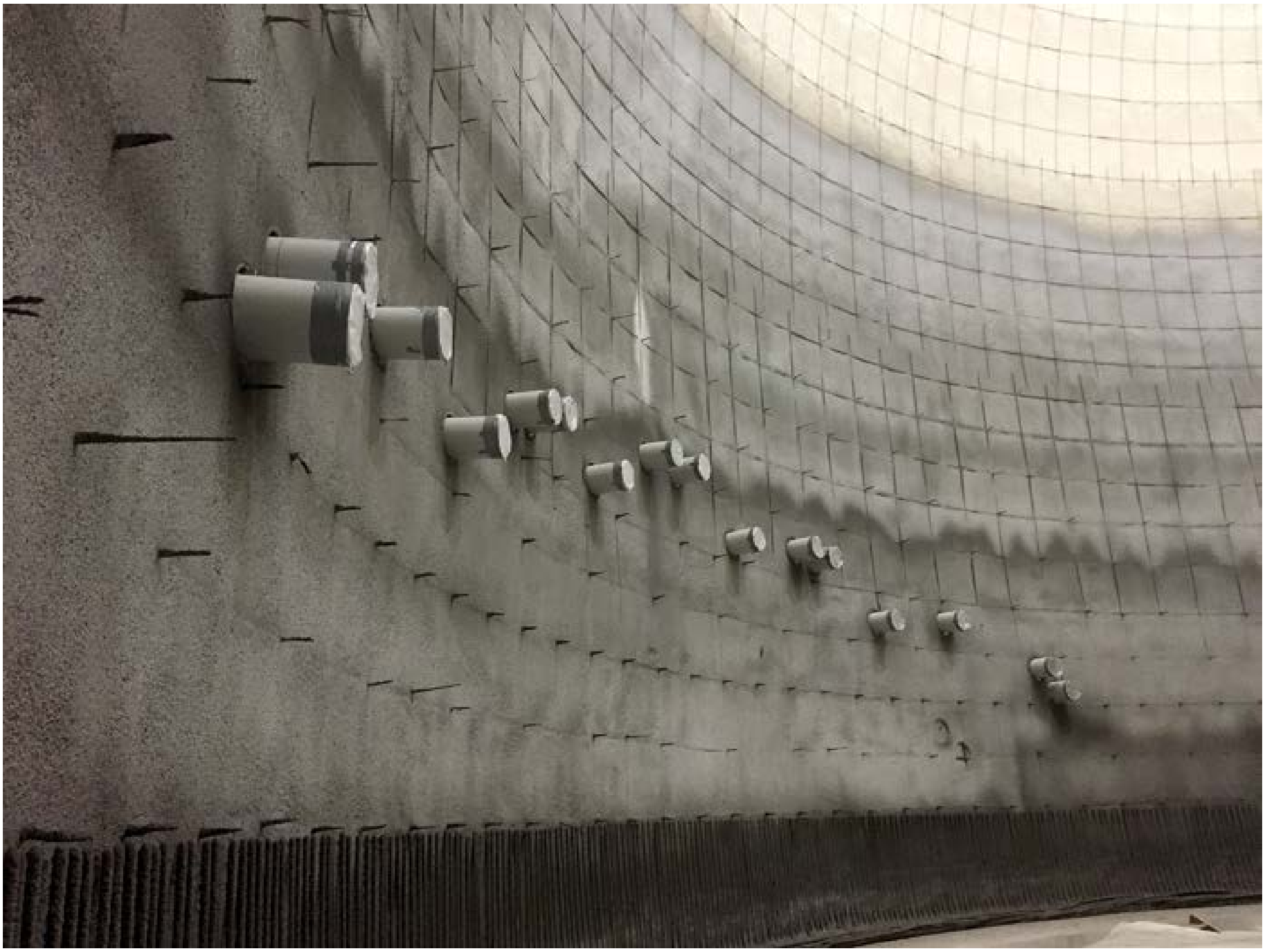

Fig. 7: First pass of shotcrete over first mat of structural bar. Both domes were completed on budget and ahead of schedule

from the outside in: roof, insulation, and finally the structural concrete structure. All reinforcing bars and heavy equipment to be used in the project such as cranes and forklifts must be placed under the air form before it is inflated because once inflated, the form must remain under pressure for the duration of construction. The construction equipment only leaves the interior once the dome is complete. This meant a 38 ton (35 metric ton) mobile crane, a telehandler, and all the reinforcing bar had to be strategically positioned within the pile cap and under the air form prior to it being inflated.

In February 2015, construction began on the Timaru dome, a 120 ft (36 m) diameter, 103 ft (31.5 m) tall dome. First, the custom-fabricated DomeSkin air form was carefully attached and bolted down to the foundation and then inflated. The dome was built following Domtec's quality control methodology and safety procedures. 1923 yd^3 (1470 m^3) of shotcrete were placed in the dome along with 562 tons (510 tonnes) of reinforcing bar. After the Timaru dome was completed, Domtec's specialty equipment was shipped to Auckland to build the 33,000 ton (30,000 tonne) cement storage dome there. The Auckland dome was 135 ft (41.2 m) diameter and 90.2 ft (27.5 m) tall and required approximately 529 tons (480 tonnes) of reinforcing bar and roughly 1400 yd^3 (1100 m^3) of shotcrete (Downer 2014). The dome structure stayed on schedule and was completed in 14 weeks from inflation of the air form to the final layer of shotcrete.

Fig. 8: Typical dome structural reinforcing bar mat; over 550 tons (500 tonnes) of reinforcing bar was used in the Timaru dome

Downer also worked closely with Domtec to create specific methodology and safety controls, and set up a workshop with WorkSafe NZ, the government's health and safety regulator. The presentation was accepted the first time without any comments or changes.

Overall, the two 33,000 ton (30,000 tonne) cement storage domes were built on-time and Domtec proved to be a suitable supplier to Holcim's chosen General Contractor, Downer Group. This project marks the first two concrete domes in New Zealand and has overall been well received.

To learn more about Holcim New Zealand, please visit **www.holcim.co.nz**. To learn more about Downer Group, please visit **www.downergroup.com**. To learn more about Domtec International, visit **www.domtec.com**.

References

Downer Group, 2014, "HOLCIM CMSP – Cement Storage Dome – Auckland," Report on Dome Contractor Findings, Auckland, New Zealand.

New Zealand Government, 2013, "2013 Census Usually Resident Population Counts," Statistics New Zealand, http://www.stats.govt.nz/browse_for_stats/population/census_counts/2013CensusUsuallyResidentPopulationCounts_HOTP2013Census/Commentary.aspx#aucklandfastest. (last accessed April 20, 2016)

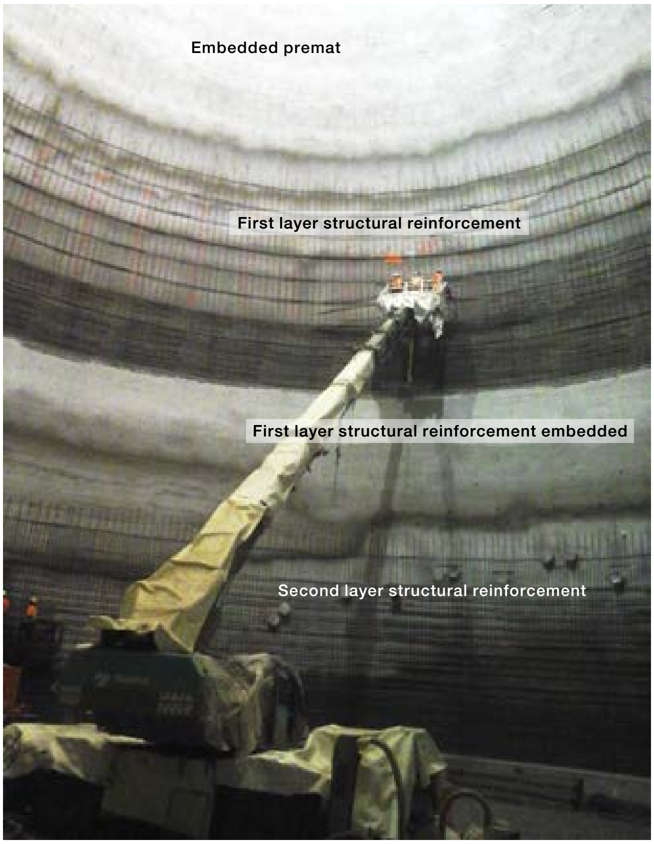

Fig. 9: View showing multiple phases of dome building process. Domtec shotcrete technicians average over 25 years of experience each

CNN Wire Staff, 2011, "Dual Quakes Rock Christchurch, New Zealand," CNN.com, http://edition.cnn.com/2011/WORLD/asiapcf/06/12/new.zealand.quake. (last accessed April 20, 2016)

Stuff Reporters, 2010, "7.1 Earthquake: Aftershock Damage," stuff.co.nz, http://www.stuff.co.nz/national/4098378/7-1-earthquake-Govt-gives-5-million. (last accessed April 21, 2016)

Williams, D., and Cowie, K., 2016, "Holcim (New Zealand) Ltd. - Cement Terminals Project," The New Zealand Concrete Industry Conference 2015, Rotorua: The New Zealand Concrete Industry.

THE OUTSTANDING INTERNATIONAL PROJECT

Project Name
Holcim Cement Market Supply Project (CMSP)

Project Location
Timaru, Canterbury, New Zealand

Shotcrete Contractor
Domtec International*

General Contractor
Downer Group

Architect/Engineer
Chris Zweifel, ZZ Consulting

Material Supplier/Manufacturer
Lafarge Holcim*

Project Owner
Holcim New Zealand, Ltd.

*Corporate Member of the American Shotcrete Association

***Benjamin Davis** is the Vice President of Business Development at Domtec International, an industrial construction company specializing in insulated, reinforced concrete storage domes, typically storing dry bulk commodities such as grains and fertilizers, cement powder, wood pellets, and mining ores in quantities from approximately 5000 to 100,000+ tonnes. He has worked with leading global firms such as Lafarge, Holcim, Cemex, Italcementi, Votorantim, CalPortland, and Kinder Morgan. Davis has presented at Intercem, World of Coal Ash, American Shotcrete Association, and BioEnergy Conferences and his publications can be found in periodicals like* World Cement, International Dry Cargo, *and* International Mining. *He is a member of the Institute of Electrical and Electronics Engineers (IEEE) and American Concrete Institute (ACI). Davis is a Leadership in Energy and Environmental Design Accredited Professional (LEED AP BD+C) a credential awarded by the US Green Building Council (USGBC) to professionals with expertise in the design and construction phases of green buildings who pass rigorous testing and maintain on-going continuing education. He is also a Certified Green Professional, a credential from the National Association of Home Builders (NAHB). Davis received his master's degree in construction management from Brigham Young University and his bachelor's degree in public relations and business management from Utah State University. He was also an adjunct professor at BYU-Idaho.*