

Shotcrete and Waterproofing Works Multifaceted Conference Centre at Brigade Tech Gardens

By Rajendra Pai and Manthan Pai

Brigade Tech Gardens Whitefield is a Grade A project featuring a total development of 3.3 million ft² (310,000 m²) spread across 26 acres (10 hectares). The commercial project is in the middle of Bengaluru's IT corridor in Whitefields, Bengaluru, India. The master plan of the project integrates planning, landscape, and architecture in perfect harmony to create the idyllic 21st-century environment. Salient features include modern commercial development featuring a contemporary design with a responsive approach to business needs, as well as a world-class conference center situated near the entrance offering state-of-the-art facilities for events and meetings.

A CONCRETE APPLICATION WITH A COMPLEX SHAPE

Shotcrete domes need special consideration because the shape can be complex to build. Here are some of the important considerations for using shotcrete placement to build domes:

Shape and geometry: Domes are double-curved structures with some complexity in both the design and the construction. It is critical to plan for positive thickness control during shotcrete placement. Domes are structurally dependent on having an accurate geometrical shape for strength, thus maintaining uniform thickness on a properly shaped form is a key structural consideration.

Shotcrete placement facilitates construction with the ability to accurately place the required thickness of concrete material on complicated curved forms. The dome shape would be difficult to build efficiently or economically with conventional form-and-pour concrete construction methods, as form-and-pour concrete sections generally need a double-sided form to retain the liquid concrete during casting. The curved, irregular shape of a dome would be difficult and expensive to manufacture. Shotcrete can use a one-sided form and can be lighter since it doesn't need to carry the liquid forces of wet concrete.

Using shotcrete speeds up the construction process since each layer does not have to cure before applying another, thus saving time during construction. Form-and-pour concrete has a series of operations — including placing, vibrating, protection, and curing — that need to be

performed sequentially and are time consuming.

Shotcrete's high velocity placement compacts the concrete against the receiving surface. This fully consolidates the concrete and typically produces higher bond strengths against old or finished surfaces, as is often found in repairs. In comparison, if form-and-pour concrete is not fully vibrated to provide full consolidation, you may get a weaker bond to an existing substrate and more potential for voids.

CONCRETE MATERIAL SELECTION FOR SHOTCRETING

Selecting a concrete mixture that is appropriate for overhead and vertical surfaces needs to provide both workability for pumping and the required structural strength. Additions to the concrete may include fiber and admixtures. Fiber is often provided as supplemental reinforcement to help control cracking. Accelerators can be helpful when placing overhead or in colder weather. Air-entraining admixtures materials may be needed in geographical regions that experience many freezing and thawing cycles.

Dome construction benefits greatly with shotcrete placement as it substantially cuts costs (by minimizing complex, expensive formwork and scaffolding) while providing equal or better strength when compared to traditional concrete methods. Custom formwork that doesn't use flat panels or plywood can be much more expensive to build and often generates a lot of waste material. Shotcrete can be used to provide the exact thickness needed within the dome structure: Thicker at edges and openings, thinner in most of the uniform shell areas.

High-velocity shotcrete placement creates a denser concrete material than many cast-in-place sections, providing improved durability, crack resistance, and environmental resistance. Form-and-pour concrete may need extra treatments or coatings to reach a similar level of durability, particularly in aggressive climate or exposure regions.

These factors all make shotcrete an attractive option for dome construction, offering efficiency, strength, and cost savings compared to form-and-pour concrete.

APPLICATION PROCESS

The embedded steel reinforcement included 8 mm and 12mm (#3 and #4) laid out on an orthogonal pattern. The reinforcement had a tensile yield strength of 550 N/mm² (80,000 psi) and was placed at the center of the concrete thickness. Reinforcement was secured with chairs off the form.

The wet-mix shotcrete was applied in layers so the concrete didn't sag or slough. Shotcrete placement started at the base and then worked up to the top.

The shotcreter adjusted the distance to the receiving surface as required to maintain a perpendicular angle of placement. This was usually about 1 m (3.3 ft). The shotcreter had to pay close attention to not apply thicknesses on the curved areas that were too thick or too thin. The shotcreter also needed to make sure that the compaction of shotcrete was proper, especially at intersections and edges where layers were meeting.

CURING

We start curing immediately after the shotcrete is placed, usually within a few hours of placement. An initial moist cure with a fogging nozzle on a pressure washer can help reduce early-age plastic shrinkage cracking. Wet curing using cool water is the preferred method for curing concrete. Misting the surface regularly or using concrete curing blankets are good methods for keeping water available at the surface of the concrete for curing. The shotcrete must be cured for a minimum of 7 days, and an even longer curing time will increase the strength and durability of the shotcrete. Curing is particularly critical with domes since all sections of a dome shape are carrying loads.

QUALITY CONTROL

Since the designed dome shape and thickness is critical to the structural performance, the shotcrete placement should be continuously measured to ensure that it is uniform and meeting the design requirements. Verification of the concrete hardened properties was accomplished by testing cores taken from the dome to confirm compressive strength and density. Additionally, all exposed surfaces can be inspected visually or by hammer sounding for voids, cracks, or inconsistencies in the regions of complex curvature.

SURFACE DÉCOR AND TEXTURE CONSIDERATIONS FOR DOME DESIGN

Depending on the architectural theme of the dome, an aesthetic, uniform-color plaster may be applied to the surface. If a natural concrete color finish is desired, the freshly shot concrete can be textured in a variety of ways — most common is a smooth floated finish, though a steel trowel or gun finish can be provided if desired. When the dome is tying into other elements, make sure that shotcrete transitions are tight and smooth.

SAFETY PRECAUTIONS

It is important that workers have been trained and equipped with appropriate PPE. This is particularly relevant for work at height or when working on a curved surface that may not be easy to stand or walk on. Scaffolds and manlifts are helpful in sections of the dome that are more vertical. It is important to monitor the formwork during shotcrete placement, as stability issues — especially in larger domes — can cause problems. One should monitor the formwork stability both during and after shotcrete placement.



Brigade Tech Gardens Whitefield



Aerial view of Brigade Tech Gardens Whitefield

Shotcrete placement produces dust. It is necessary to ensure proper ventilation for the work space and you may need to employ dust control techniques to increase the safety of crewmembers working in close proximity to the shotcrete placement on the dome.

IN SUMMARY

Using shotcrete placement for construction of this complex, double-curved concrete structure was, without question, the most efficient and cost-effective approach. Needing only one-sided forms cut formwork costs by more than half. Shotcrete placement also allowed us to closely control the thickness of the concrete to meet the structural design requirements while provided a strong, durable concrete section. Shotcrete placement allows architects to dream of concrete structures with curves — and a quality shotcrete contractor and experienced crew can turn those dreams into reality.



Raj Pai is the Founder and Director of Kasturi Projects Pvt Ltd. After completing his Master's in Physics from the University of Mumbai, he went on to pursue various courses and diplomas in management, underground construction, and civil engineering. He has 37 years of industry experience in injection, repairs and protection of concrete, underground construction, and overground construction. He has also won awards for the repair and rehabilitation of heritage structures and stormwater drains in Mumbai City from the International Concrete Repair Institute.



Manthan Pai is a geotechnical engineer at ANS Geo, Austin and holds a Master's Degree in Civil Engineering with a focus on Geotechnical Engineering from Arizona State University. He has a strong background in both civil and geotechnical engineering, with experience in underground construction, tunneling, geotechnical, and mining engineering. Manthan has a proven ability to design and execute complex projects while ensuring compliance with industry standards and regulations.

2024 HONORABLE MENTION PROJECT

Project
Shotcrete & Waterproofing - Brigade Tech Gardens

Project Location
Bengaluru, India

Shotcrete Contractor
Kasturi Projects Private Ltd*

Architect/Engineer
Brigade Properties Pvt Ltd

Equipment Manufacturer
Epiroc India

Materials Supplier
Prism Johnson Ltd

Owner
Brigade Properties Pvt Ltd

*ASA Sustaining Corporate or Corporate Member