An Awe-Inspiring Place

Sydney's Punchbowl Mosque showcases the architectural flexibility of concrete

by Deborah R. Huso

In 2018, the Australian Islamic Mission (AIM) celebrated the completion of its stark yet elegant mosque in the Punchbowl suburb of Sydney, Australia. Named after a nearby circular valley that nineteenth-century settlers called "the punch bowl," the suburb is located in Sydney's southwest and is known for its cultural diversity.

The Punchbowl Mosque's design, the brainchild of Greek-Australian architect Angelo Candalepas of Candalepas Associates in Sydney, features what some might call (but Candalepas downplays) a "brutalist" structure with a simplicity of exterior architecture that belies its inspirational interior. Almost the entirety of the structure is rendered in concrete. With no elaborate ornamentation other than gold calligraphy painted on minidomes in the main prayer hall, the combination of formed concrete with wood and stone detailing creates a space that is arresting in its delicate restraint.

Fig. 1: Punchbowl Mosque, Sydney, Australia, with main entry doors facing the street and a single minaret adjacent to the entry (left) *(photo by Brett Boardman, courtesy of Candalepas Associates)*

Concrete as Sculptural Material

Architecturally as well as spiritually, the design speaks to the efforts of AIM and Candalepas to improve interfaith relations in New South Wales. The main entry doors intentionally open to the street (Fig. 1), creating a sense of welcoming and transparency to passersby of all faiths. Adjacent to the entry, a single minaret is subtly incorporated into a wing of the building that frames the mosque's courtyard (Fig. 1).

The architect selected concrete as the primary construction material largely because AIM's construction brief called for a structure that would last 300 years. "Concrete is often mistaken for a material that is only solid and firm," says Angelo Candalepas, "but its ability to be cast in many types of forms gives it a potential that is not often realized." It is that potential that Candalepas sought to manipulate when selecting concrete as the construction material.

The final set of construction drawings were sent to the builder in the fall of 2014. That package included 1:20 scale detail sections showing the mosque's key elements, including details of the concrete ceiling of the mosque's prayer space. In addition to a concrete ring beam with a stepped soffit evoking a corbelled dome structure, the ceiling comprises seven rows of quarter-sphere muqarnas (ornamented vaulting formed as quarter-sphere minidomes) on the northwestern and southwestern sides of the space (Fig. 2). According to Candalepas, the drawings called for a Class 2C finish for all visible concrete in accordance with Australian Standard AS 3610. Project construction began in October 2015 with the mosque's basement car park.

The Muqarnas

The sculptural ceiling of the prayer space features 102 muqarnas spread across two faces of the ceiling like a honeycomb (Fig. 2). Because the

Fig. 2: A view from the floor of the main prayer hall, showing the stepped soffit of the concrete ring beam and rows of quarter-sphere muqarnas. Since this photo was taken, Turkish and Iranian calligraphers have inscribed the smooth and seamless concrete surfaces of the minidomes with the 99 names of Allah in gold calligraphy *(photo by Brett Boardman, courtesy of Candalepas Associates)*

Fig. 3: A mockup was used to verify methods and materials for construction of the muqarnas: (a) formwork with molded and coated fiberglass domes; and (b) finished surface after stripping the molds *(photos by Adrian Curtin, courtesy of Boral Australia)*

concrete was to serve as the painting surface for calligraphers, Candalepas did not want to use any chemical release agents. He also provided no option for patching damaged surfaces.

Thus, casting the muqarnas was the most challenging aspect of the construction. "There was a high level of concern [about] the finish that could be achieved for the exposed concrete surfaces, especially the muqarnas," says Paul Moore, Structural and Section Manager and Principal at Wood & Grieve Engineers, the firm that prepared detailed project designs and documentation and supervised structural work during the mosque's construction. To address this, Wood & Grieve documented reinforcing bars for these elements in three dimensions in Autodesk Revit, producing perspective views as well as the typical plan, sections, and elevations.

To ensure the finish could be achieved, Sydney-based builder Infinity Constructions Group made several test placements, including the construction of a mockup of the walls and lower muqarnas at the west corner of the building (Fig. 3). In addition to using the same formwork system and reinforcing layout as required for the actual structure, the mockup was constructed using the concrete mixture and curing techniques that were to be used in the final construction.

Each minidome is a quarter sphere, 1500 mm (59 in.) wide and 750 mm (29.5 in.) high, with a 30 mm (1-1/8 in.) diameter hole created at the center using a tube and a form tie. To allow light yet prevent water from penetrating the ceiling, the tubes were subsequently plugged with clear polymethyl methacrylate caps where they pierce the roof sheathing. The curved surfaces were formed using molded fiberglass domes with a smooth polymer coating. The dome forms were separated by 120 mm (5 in.) to create vertical, semicircular flat planes between the curved surfaces; the flat surfaces between the minidomes were cast against galvanized-steel sheets backed by plywood (shown in Fig. 4).

During construction, each fiberglass dome was penetrated at its center point by a single large form tie that extended to the sloped formwork for the roof of the building. The concrete thickness at this point was 350 mm (13-3/4 in.). "I had imagined we would be able to have large ties since I had desired the entire ceiling to have many small skylights," Candalepas notes. "In ancient Turkish mosques, the night sky was replicated within the domes. I found that the juxtaposition between the eternal values of the form-giving sphere [the dome] above the space was able to be enhanced with the mosque ceiling describing the night sky below it." He also noted that the concave surfaces "showcase the subtle gradation of light at different intensities and concurrently."

The formwork for the mosque ceiling was constructed and scaffolded to progressively step up and out by 810 mm (32 in.) vertically and horizontally with each row of muqarnas. According to Candalepas, "Stripping the lowest levels of formwork after the first concrete pours would, therefore, not be possible until all the remaining concrete pours for the mosque's ceiling and ring beam had been completed." The builder created flat shelves of formwork to set out the stepping profile of the raked ceiling to two sides of the mosque and then cut rectangular slots into these shelves at intervals that matched the set-out of the muqarnas.

"Fiberglass molds placed on the inside face of each formwork slot created the quarter-spherical domes [of the muqarnas]," Candalepas adds, noting that the concrete placements for the main prayer space took up to a full day to pump, given the complex geometry for the interior formwork. Candalepas says the builder cleaned and

polished formwork each day before the next day's concrete placement.

Concrete for Sculptural Finish

During the production of the tender documents, Candalepas collaborated closely on concrete specifications with Sydney-based structural engineering firm Taylor Thomson & Whitting and concrete manufacturer Boral Australia. The team selected a white concrete mixture based on Boral's patented Envisia® system. Envisia mixtures contain a high supplementary cementitious material content and thus have a lower CO_2 footprint than conventional concrete mixtures. Aesthetics and long-term performance were also major considerations. As Candalepas notes, "Low-shrinkage performance, in particular, was a significant consideration given the complexity and volume of the concrete pours proposed for the main prayer space." Envisia concrete consumes much of the mixing water while it is setting, resulting in reduced volume loss from water evaporation. This results in 50% lower shrinkage than conventional concrete mixtures, yet the proprietary mixture can also achieve the same setting times and strength gain as more conventional mixtures.

Fig. 4: Muqarnas were formed using molded fiberglass minidomes spaced 120 mm (5 in.) apart, and the flat surfaces between minidomes were formed using galvanized steel on plywood panels: (a) view of minidome forms installed on scaffolding; (b) view of exterior formwork for the sloping roof; and (c) view of minidomes during stripping operations *(photos by Adrian Curtin, courtesy of Boral Australia)*

The Main Prayer Hall

The walls within the mosque's main prayer hall are typically 200 mm (8 in.) thick and include 300 x 600 mm (12 x 24 in.) pilasters. The walls stop short of the lower level of muqarnas, allowing outside light filtered through translucent glass to illuminate the minidomes from below. To meet thermal and aesthetic requirements, the wall areas between pilasters also have interior insulation as well as granite and hoop pine veneer plywood finishes. The concrete used to construct the walls had an 80 mm (3-1/4 in.) slump and a maximum aggregate size of 20 mm (3/4 in.). The concrete used to construct the muqarnas had a 120 mm (4-3/4 in.) slump.

The Dome

The designer initially envisioned the dome to be constructed in stone. However, after a series of prototypes were considered, a structural steel dome supported by a concrete ring beam was selected. The ceiling of the dome is finished with sheets of marine plywood with hoop pine veneer (Fig. 5). The stepped concentric circles of the ceiling and ring beam, along with the diffuse light provided by the dome's

Fig. 5: The dome is a structural steel structure that includes a clerestory base: (a) a view during construction, showing the steel structure above the concrete ring beam; and (b) a view after completion, showing the visual drama created by the diffuse lighting of the stepped ring beam and veneer ceiling *(photos by Adrian Curtin, courtesy of Boral Australia)*

oculus and clerestory, create an ethereal aesthetic in the main prayer hall.

The builder cast a 100 x 100 mm (4 x 4 in.) rebate into the top of the mosque walls and muqarnas to recess the construction joint for the flat concrete ceiling and profiled ring beam. Then the construction team fashioned a construction deck above the flat ceiling and placed the form for the ring beam, constructing it in two concrete placements (Fig. 6). Candalepas says the construction deck remained in place as the formwork for the muqarnas was stripped below it in December 2016. After that, the builder began working on the steel structure of the dome, clerestory glazing, and oculus. By the end of January 2017, the formwork of the muqarnas as well as the scaffolding had been stripped away to reveal the main prayer space's finished interior.

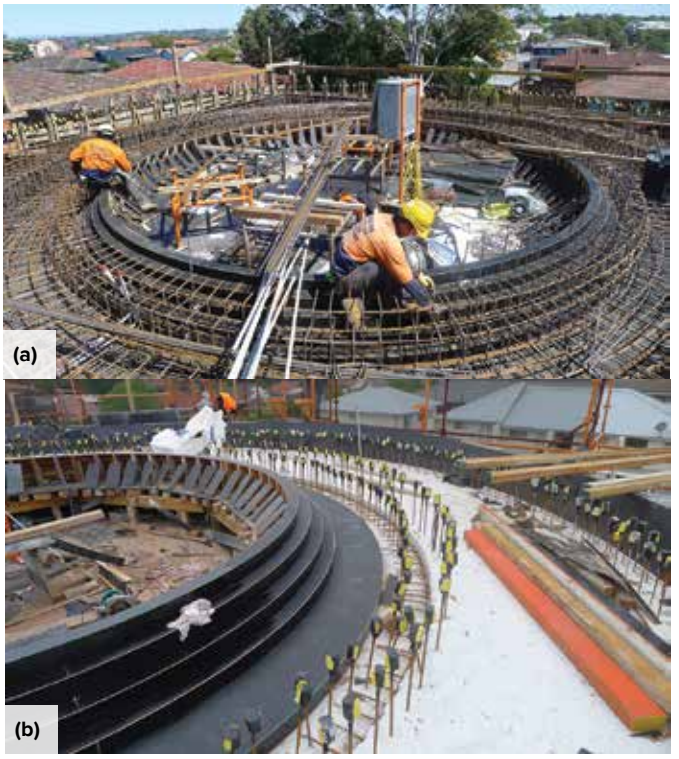

Fig. 6: Ring beam construction: (a) before the first concrete placement; and (b) before the second placement *(photos by Adrian Curtin, courtesy of Boral Australia)*

Appreciation

Punchbowl Mosque won the 2018 Sulman Medal for Public Architecture before it was completed in December 2018. The mosque opened for worship in the summer of 2019.

Note: Additional information on the Australian standard discussed in this article can be found at **www.standards.org.au**.

Selected for reader interest by the editors.

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