

A Stadium for Books

Emulating an open book, the Qatar National Library rises from the earth in Doha

by Deborah R. Huso

Rising from the ground as though it's a page being turned by an invisible hand, the massive 45,000 m² (480,000 ft²) Qatar National Library in Doha, Qatar, is a feat of engineering and architecture. Part of Doha's 1000 ha (2500 acre) master-planned Education City, the library was designed by Rem Koolhaas of the Office of Metropolitan Architecture (OMA) in Rotterdam, the Netherlands.

OMA and London-based engineering firm Arup began collaborating on the building's design in 2006. A challenging project in concrete, steel, and corrugated glass, the library took 12 years to complete. "The concept for the library as a shell was based on an oyster," says Arup Director Chris Carroll. The oyster shell exterior of white concrete enfolds corrugated glazing that filters softened light into the building's interior for reading and study.

According to Sohair Wastaway, former Executive Director of the Qatar National Library, "Her Highness [Sheikha Moza bint Nasser] wanted to build a place that would bring people together." Of Qatar's 2 million inhabitants, only 300,000 are natives. Wastaway points out that the library's design was meant to inspire social change—it reflects a desire for all the

different nationalities in Qatar to converge and interact. "Her Highness didn't want walls between people."

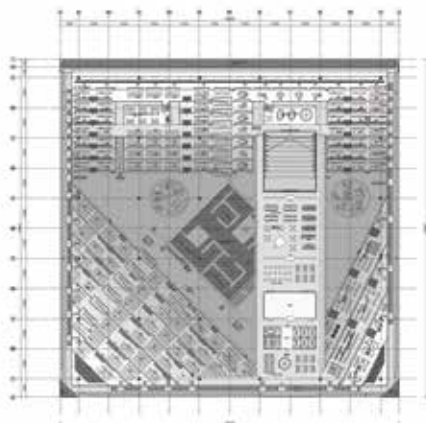
Drivers of Design

Vincent Kersten, Project Architect with OMA, says Koolhaas based the Doha library's composition in part on the Seattle Central Library he designed over 15 years ago. "There [is] a demand for this kind of big public space," Kersten says.

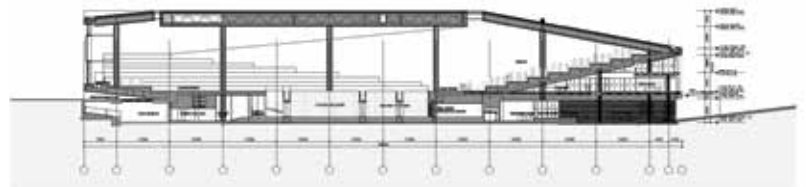
Anyone entering the Qatar National Library immediately sees its collection of 500,000 books at a single glance. Three hundred bookshelves occupy the terraced spaces of the library (138 m [453 ft] in length), while the Heritage Collection—archives containing historical texts and manuscripts on Arab-Islamic civilization—are sunken into an "excavated" foundation clothed in travertine at the library's center. "Rem wanted the whole interior to be like 'a stadium for books,'" adds Carroll. "That's what drove the vastness and openness of the space."

Global contractor Multiplex, working out of its Doha office, began construction in 2012. It took 5 years to complete.

"The soffit of the underside is like a folded paper in four parts," Kersten explains. "On top, you mirror that, and they all come together. Then in between you have the glass façade."



Level 3



SECTION CC

The Level 3 floor plan and Section CC illustrate the tiered main floor and the resulting stadium for books (courtesy of OMA)



The building's west and south façades thrust upward to create a dramatic cantilever over the main entry to the library



Deeply corrugated glazing provides filtered light for reading and study

The structure's roof plate spans up to 38 m (118 ft) between 1200 mm (47 in.) diameter reinforced concrete columns, and the cantilevered span of the library's lifted floor plate is supported by a grillage of custom-designed steel plate girders. Those girders also contain the library's book-sorting equipment and mechanical air systems. Vierendeel trusses stabilize the cantilevered edges.

Carroll says the driving force behind the library's overall design was the objective of creating a column-free and unencumbered interior space. It was very much a process of trial and error. "We just worked through various permutations of the grid," Carroll explains. "The architects started with the form of building as a whole and then worked out in physical methods where they wanted to lift and slope."

After numerous design iterations, it became clear that a field of columns would be far less impactful on the sense of openness inside the library's vast single-room interior than a single massive column at the building's center. "So, we ended up having a regular rhythm of 32 very elegant 47 in. diameter columns that support a steel girder and lattice truss roof," Carroll explains. "When you stand in the interior, you lose the sense of the columns even being there." Around the columns,



A view of the north and west façades

the floor of the library is very much like the stadium Koolhaas envisioned—a grid of concrete beams and precast slabs that establish a stadium "bowl." Carroll says that OMA was insistent on having exposed concrete as the building's exterior shell surrounding the diamond-shaped glazing. "We considered post-tensioned concrete pieces," he says, "but in the end, we needed to use steelwork." The cantilevered floor deck was the main reason for this decision.

The Challenges of White Concrete

Both Kersten and Carroll say the composition of the white concrete was one of the largest challenges of the project. Carroll notes the team had to use the Qatar national specifications; "the state's building control authority insisted on it," he says. But the team also enhanced those specifications. "We did a lot of trial mockups to get the concrete right," Carroll adds.

OMA wanted white portland cement, but, as Carroll points out, "It takes a lot of effort to control consistency." The formwork must be incredibly clean. The team used steel forms for the columns to ensure the quality of the finish. The 32 columns were all cast on site, and the color had to match that of the precast.

Kersten said achieving the right coloration was an ongoing challenge. "The problem in Doha was the limited [number of] concrete factories," he states. Initially, the concrete came out grayish, so the producer had to clean up the whole production line and start with white concrete.

Kersten says that many column mockups were needed. "We had to clean the formwork every time. And a lot of the pours occurred at night because of intense heat during the day."

Controlling for heat in the Qatari desert was an ongoing challenge. At midday in the summer months, temperatures can climb to over 50°C (120°F). To help keep the maximum temperatures within the specified limits for placements, the builder had to set up shades prior to some placements.

The environment was challenging. The team decided to construct the library floor using precast concrete elements primarily to limit on-site work and protect the welfare of the



An interior view, looking toward the northeast



The entry to the Heritage Collection is accessed below the soffit at the southeast corner of the building



Views of the complex structure required to create the stadium for books desired by designer Rem Koolhaas



workers. “You want to make as many components as you can in more worker-friendly environments,” Carroll says. “Having precast pieces and prewelded steel was critical.”

The basement was cast in place. “Above the basement are three tiers with a triangular envelope in the middle and then two folded tiers,” Kersten explains. “The two folded tiers, where there is no [foundation] underneath, are all steel. The cast-in-place north tier of the library stabilizes the building. There is no exposed soffit.”

While most of the library’s floor structure is concrete, the one exception is where the building cantilevers. “Where we have the cantilevers—the two wings of floor structure where they lift up—those are made out of steel,” says Carroll. Here the parallel girders go on either side of the columns, placing them inside a box.

While OMA considered using precast concrete on the underside of the building, the design team decided to use cast-in-place concrete to avoid the look of panelization. “We wanted a monolith ongoing soffit,” Kersten says, “but the inclination was problematic.” Where the incline was steepest

or when the soffit was horizontal, concrete placement was easiest. In the first case, the workers could situate formwork on both sides. In the second case, the concrete stayed in place on the soffit form. The most problematic inclination was in between. “We had to create mesh wire stops, pour a little bit, then stop, pour a little bit, then stop,” Kersten says. “In the end, it was not as smooth as we expected.” Remedial work didn’t help much, he notes, “so we had to accept the imperfections. The achievement was that there were no joints or panelizations.”

Creating a Floating Roof

Another major challenge of the project was supporting the roof. “The roof is steel, and it’s only supported by these huge columns. It’s basically steelwork sitting on top of bearings,” Carroll says. “The roof expands and contracts as it heats and cools, and the [reinforced concrete] columns provide the stability of the roof via cantilevering from the ground.” Carroll compares the design concept to that of a bridge where the bridge deck is a steel girder sitting on concrete piers. The

column connections to the building and foundations had to be stiff enough to stabilize the building. “That became a complicated process because the columns are different heights, and hence different stiffnesses,” Carroll points out. “Where the columns are the tallest, you don’t have book tiers.”

Each of the columns had exposed steel at the top that connected with horizontal roof trusses, according to Kersten. “The concrete column stops just above the top ceiling inside the building and continues above that with just steel,” he explains. Essentially, the roof floats on the columns and is connected only at the perimeter. “Not all of [the columns] are connected rigidly to the roof because we wanted to allow the roof to expand thermally as it heats up and cools down.” Without that room for expansion, the forces generated in the columns would have been large. Thus, Arup had to devise a bearing arrangement to secure stability from the columns while allowing the roof to expand and contract. “The whole building looks completely concrete from the outside,” Kersten says, “though structurally, it’s mostly steel.” The roof structure is steel clad with precast elements, some of them as large as 1.2 x 8 m (4 x 26 ft).

Officially opened in April 2018, the Qatar National Library won first place in the Decorative Concrete category of the

American Concrete Institute’s 2019 Excellence in Concrete Construction Awards competition.

Acknowledgments

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Selected for reader interest by the editors.



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