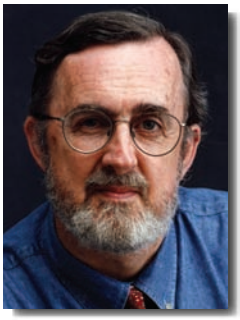
Architectural Precast Concrete Panels Beautify Façade of Kuwait Scientific Center



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The new $75 million Scientific Center in Kuwait City, Kuwait, makes full use of the capabilities of precast concrete. The Center, which includes the Middle East's first aquarium along with science exhibits and an IMAX theater, features a dramatic architectural design that contrasts swooping fabric entry enclosures with a façade composed of architectural precast concrete panels. The precast panels combine two complementary colors which are enhanced by diagonal rib patterns that alternate in bands down the façade, projecting changing shadow and light patterns throughout the day. These striking features are further contrasted by the use of accent panels with a light sandblast finish that evokes the textures and colors of the Arabian desert. Precast concrete panels on the interior, in a whiter shade, create a bright, airy look for the Center. Achieving the proper color and textures took more than one year of work through approximately forty mockups. Precast concrete was also used for the foundation piles, interior panels and sea wall. This article describes the main features of the Center and shows how architectural precast concrete fulfilled its role in beautifying the structure.

Kuwait's rich cultural history blends very well with high-tech, cutting-edge science demonstrations at The Scientific Center (TSC) in Kuwait City, Kuwait. Developed and funded by the Kuwait Foundation for the Advancement of the Sciences (KFAS), the Center provides wonderful environmental education to the public. Visitors can study the natural sea ecology, marine life species, and the habitats of living creatures along the coastal regions and desert of the Arabian Peninsula.

The designers combined the past, present, and future in the design of the structure, yielding a facility that enhances the country's prestige and tra-

Fig. 1. The architectural and structural design of The Scientific Center in Kuwait City, Kuwait, was planned to evoke textures from the desert and the swooping lines of sailboats and nomadic tents. Courtesy: Gustavo Ferrari.

ditional designs while keeping a fresh approach through the use of modern design concepts and construction techniques. Nowhere is this unique blend of high-tech imagery more apparent than in the building's façade and lobby, where architectural precast concrete panels and other precast components replicate a variety of intricate design ideas from Kuwait's cultural past (see Fig. 1).

The Center is located at Ras Al Ard along the city's waterfront on a 1 km (0.6 mile) crescent-shaped peninsula built through land-reclamation techniques that expanded the site to twice its original size. The $75 million, 180,000 sq ft (17000 m^2) project features the first aquarium ever built in the Middle East along with a science museum that includes interactive exhibits and a 250-seat IMAX theater. Also inside the Center is a food court and museum store, while along the shore itself a 20,000 sq ft (1900 m^2) harbor displays seven historic dhows, the traditional Kuwait sailing ship (see Fig. 2).

The KFAS awards up to $20 million in research grants each year. Although the Foundation supports a wide variety of scientific studies and research that benefit the public, its board was con-

Fig. 2. The Center includes a special harbor near its entry where seven historic sailing ships, called dhows, are anchored. Courtesy: Gustavo Ferrari.

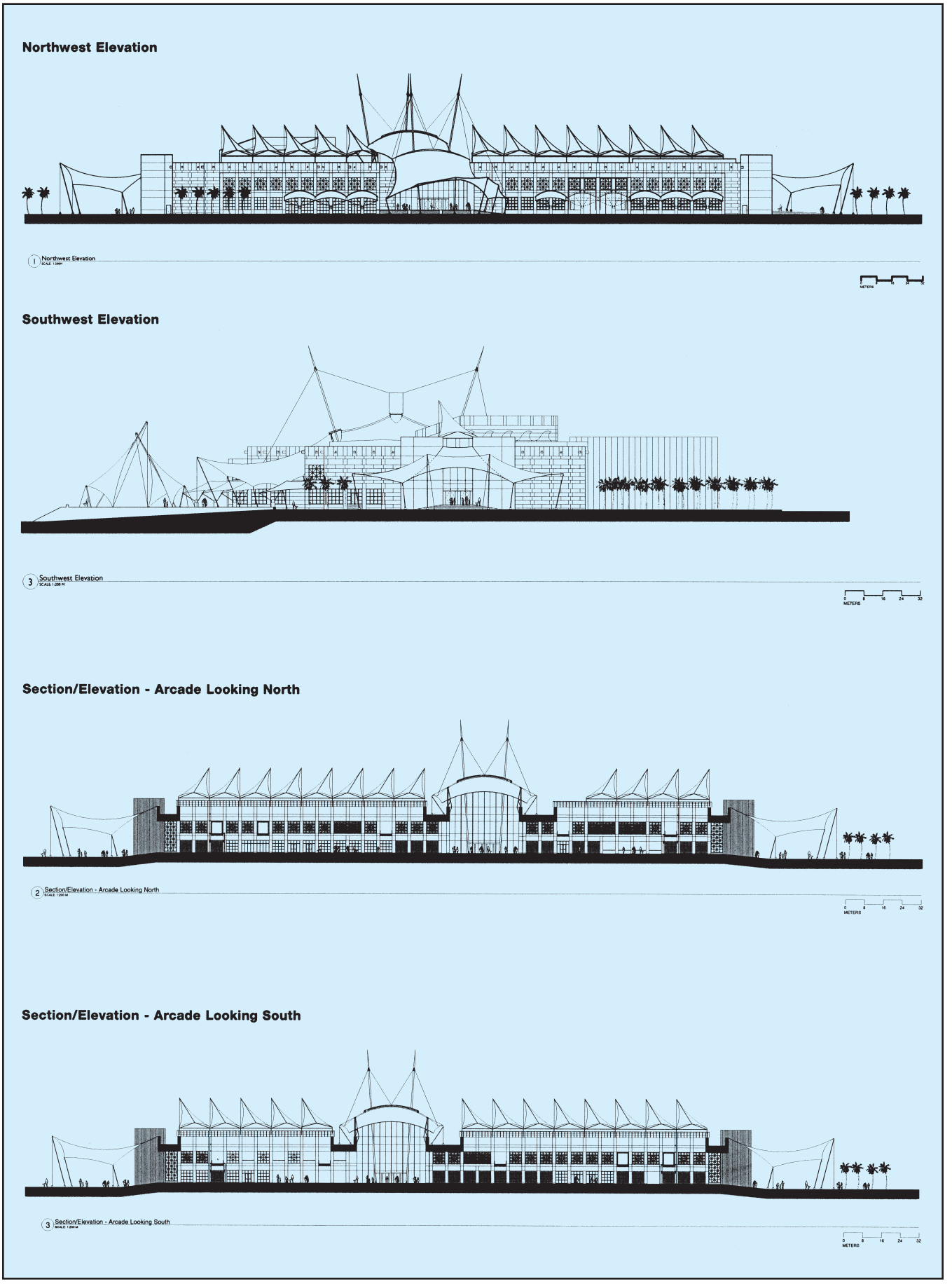

Fig. 3. Various elevations of arcade show varying shapes and textures that were used to evoke different images of the Arabian culture.

Fig. 4. The Center's dramatic entries overhung with fabric structures become a focal point at night. Courtesy: Gustavo Ferrari.

cerned that Kuwait's citizens were not seeing enough apparent benefits from KFAS. For this reason, the Foundation commissioned the design and construction team to create TSC as a gift to the Kuwaiti people to serve as a center for public education on the environment for the entire Gulf region. KFAS appointed Mr. Mijbil Al-Mutawa to lead the planning and development of the project. Its exhibits and programs focus on the natural habitats of the creatures living in the sea, air, and desert lands of the Arabian Peninsula.

To design this complex structure in the harsh environment of the desert, Cambridge Seven Associates (C7A) assembled an international team of designers, engineers, and operational consultants, including its own staff of architectural, urban-design, graphics, exhibit-design, and animal-curatorial experts. Considerable input was provided by Ove Arup and Partners International in London and Gulf Consult in Kuwait City.

The design effort for TSC was completed in about 18 months and included numerous interdisciplinary working sessions in Cambridge, London, and Kuwait City. The team, complemented by specialized consultants, developed an innovative design that drew upon the traditional architecture of the Middle East, a respect for the harsh climate of Kuwait, the unique places and experiences required by the individual attractions, and the opportunities inherent in TSC's waterfront site location.

The building consists of a two-story cast-in-place concrete structure with a partial basement, clad in architectural precast panels. It was designed on a 4 x 8-meter structural module and uses flat plate-slab design for typical floor spans, with the superstructure augmented with shear walls surrounding all stair towers. The structural concrete employs a 4000 psi (28 MPa) concrete mix, with steel reinforcing bars coated with epoxy for corrosion protection from the salty coastal environment.

The superstructure was built using ASTM C 150 Type I cement, while Type II cement was used for the piles and all substructure work. Note that Type II cement was used for these situations because it resists chlorides better than Type V cement, which is commonly used in the Middle East due to sulfates in the soil.

Fig. 5. The precast concrete walls were cast in alternating bands of color and diagonal ribs to emphasize the changing light patterns during the day.

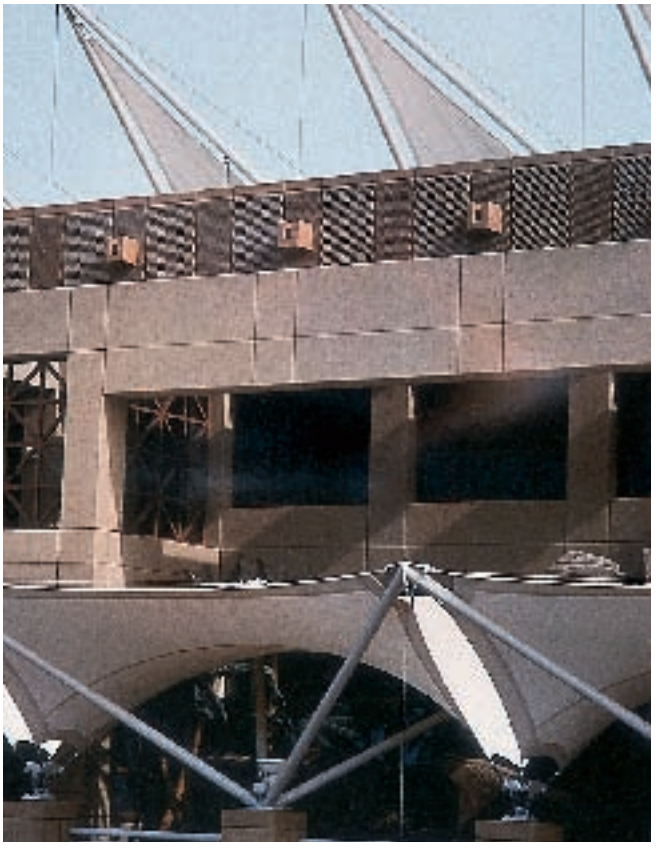

Fig. 6. Architectural precast panels in two colors featuring a herringbone pattern alternating on the façade, contrasted with panels that were lightly sandblasted.

Fig. 7. Precast concrete panels with sand-colored buff and light terra cotta coloring contrast with lightly sandblasted panels to create visual interest.

A striking visual element in the design is the fabric structures that provide sweeping curves above the flat concrete shapes of the building (see Fig. 3). The fabric coverings were designed to provide both a spatial enclosure and adequate shading from the hot sun. Visually, they also serve as a dramatic focal point when lit up at night (see Fig. 4).

The coverings are located at each end of the building and at TSC's central court, spreading out in a fan shape to encourage public gatherings and provide maximum sun protection. Along TSC's 0.75 mile (1.2 km) promenade, which offers spectacular views of the harbor, similar fabric structures were placed using tent-shaped designs that provide shading for benches. These fabric shapes evoke both the traditional Arabian nomadic tents and the sails of the dhows that have plied the waters for many centuries.

The building's design features closed-in faces on the south, east, and west sides to protect visitors and exhibits from the hot sun. To the north, an open façade articulated with trellises presents a more open face to the bay. At each end, tall towers serve as "gatehouses" and define the main entrances of the building. The designers' goal was to reflect the two-story design of traditional settlements and the fortified look of many of these buildings by emphasizing the "walled-in" aspect of the structure.

ARCHITECTURAL PRECAST PANELS

To clad the façade, architectural precast panels were chosen because they allowed the designers to create a stone-like quality that could replicate various Arabian design elements and provide a fortified look. Precast concrete panels had the economic advantage over stone in that they saved construction time and material cost on this large building.

Furthermore, precast concrete is a well-recognized and respected industry in Kuwait, with a large percentage of buildings incorporating the material. Therefore, finding a precast concrete manufacturer that could carry out the design concept with the required quality control would not be difficult.

The façade's panels were cast in two contrasting colors — sand-colored buff and light terra cotta — to blend with the colors of the desert environment. These were used in conjunction with a closely ribbed textural pattern in a diagonal form, with the color bands alternating at 2.5 ft (0.76 m) widths down the side of the walls (see Fig. 5).

The intention of this alternating pattern was to take advantage of the bright and ever-changing Kuwaiti sunlight, which shifts dramatically throughout each day and each season. The light tends to make dark colors appear lighter than in North America and offers a significant color-changing element that could be exploited. But it also can produce a harsh, dizzying effect if the color is too light, a situation that occurs all too often with other buildings around the city.

Fig. 8. The north wall features a two-level "wave" pattern made of architectural precast panels in two contrasting colors. Courtesy: Gustavo Ferrari.

The alternating bands of diagonal patterns are featured predominantly on the south, east, and west sides, adding a visual interest that compensates for the lack of window space. Two sizes of panels create the pattern in each band, with alternating diagonal ribs in each band. The panel sizes were purposely designed to be proportional to the size of the columns and height of the building.

A few small, square windows were interspersed along the façade to ensure that each floor included four or five panels that had the same height. Lightly sandblasted accent panels also were incorporated in several areas (see Figs. 6 and 7).

The north side of the structure, facing the bay, features a more open design with angled walls framing a canopied curtain wall entrance. The long, curved face of the wall, behind which sits the IMAX theater, features a three-dimensional "wave" pattern created with the lighter terra cotta color recessed 2 in. (51 mm) from the face's darker buff color (see Fig. 8).

The undulating wave was originally planned to feature a sloped shape that would create a shadow effect at the base of each wave in both colors. But the complex curvature was deemed unnecessary and impractical for the precaster to produce. The design solution instead was to offer an overlay with the inset, creating contrasting but flat surfaces (see Fig. 9).

Producing the intricate ribs, shapes, and colors was the most challenging aspect of the precast concrete design and construction. To ensure that the appropriate sizes, shapes, textures, and tints could be achieved, a lengthy pre-qualification and sample-development phase was undertaken before

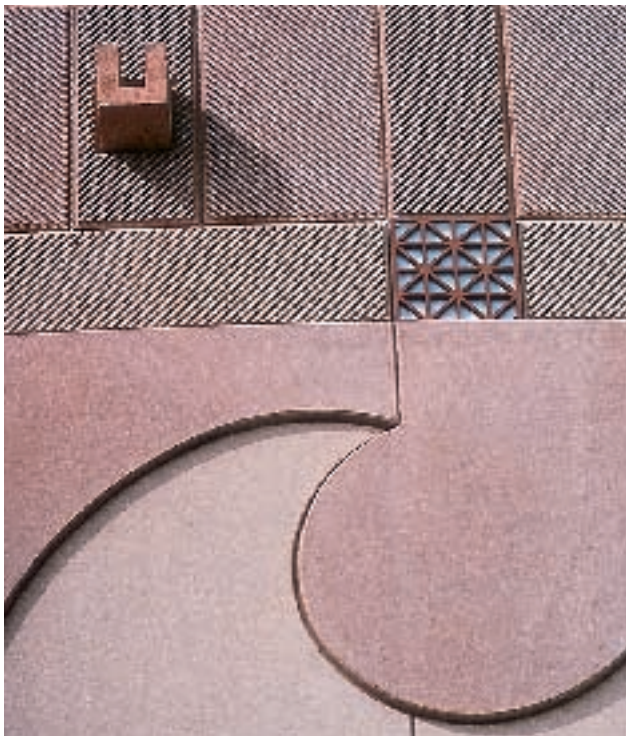

Fig. 9. This detail of the north wall shows the precast concrete panels inset with a wave pattern and the GFRC window screens. Courtesy: Gustavo Ferrari.

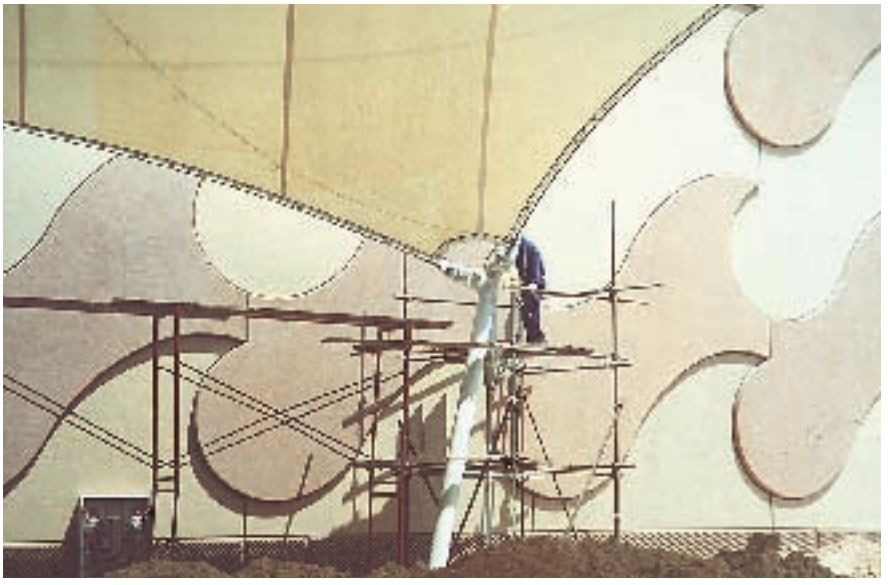

Fig. 10. The north wall features panels cast with a wave pattern, which impacted the shape of the panels.

production and erection of the cladding elements took place.

This preparatory work was a lengthy process that took more than one year to complete, but it was a necessary exercise to assure the owner that the design concept for the panels' color and texture would be fully realized. In the end, this proved to be very successful, with the project reflecting accurate color, precise dimensions, and an overall high quality installation.

The challenges surrounding these details stemmed in part from the precaster's normal approach of approximating designs. Seldom had the company been called upon to execute such precision in its matching techniques; prior to this job, the plant personnel were more experienced working with the popular white and light buff colors rather than the darker, subtler tones being specified on this project.

The first few mockups and sample color pieces did not produce an acceptable color or texture, so samples from two previous C7A jobs were gathered from the United States and brought to Kuwait City as examples.

The architects had first used a variation on the alternating, textured pattern for the Tennessee Aquarium in Chattanooga, where the designers had experimented with light, shade, and shadows to great effect. The Tennessee project also clearly demonstrated how the apparent color of the

Fig. 11. Slightly whiter precast concrete panels were used on the interior of the two-story exhibition areas to provide better lighting.

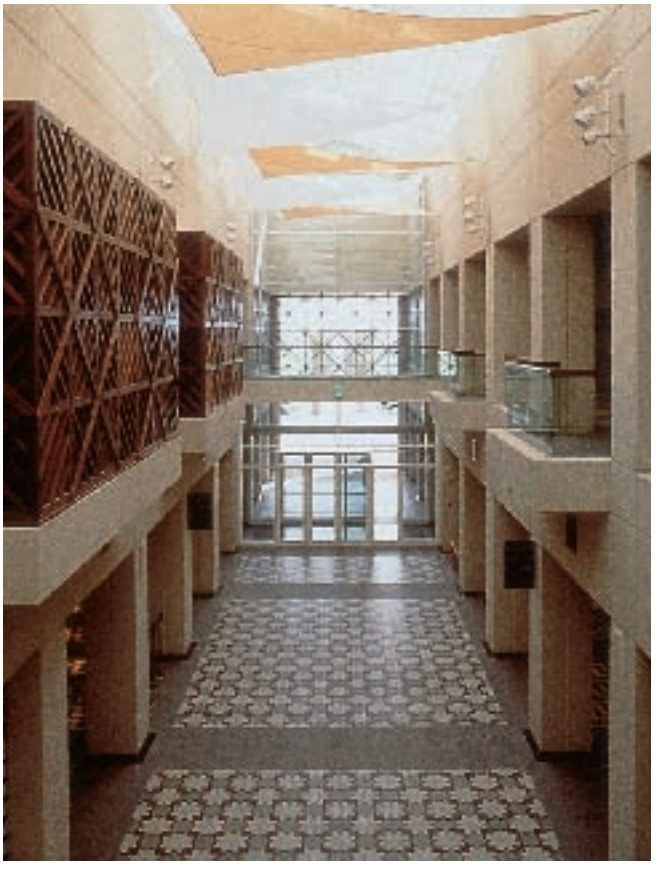

Fig. 12. Corridors feature faux second-story balconies that project into the space, replicating the feel of an Arabian street "souk" or bazaar. Courtesy: Gustavo Ferrari.

panels could be influenced by the color mix, the size and spacing of ribs, and the degree of sandblasting.

Samples of the specific rib patterns desired were selected from the firm's design for the Hilton Hotel at Logan International Airport in Boston, which also had used similar colors. These samples were delivered to the precaster for matching. In all, about 40 samples of textures and colors in various sizes were produced before the final approved textures and colors were achieved.

The mix design was specially selected for the aggressive environment encountered in the coastal regions of the Middle East, which was very familiar to the precaster. The cementitious material for the Ocean Tank cast-in-place concrete consisted of a 50:50 mixture of portland cement and ground granulated blast-furnace slag (GGBFS) cement. However, because GGBFS has a color of its own, it could not be used in the precast concrete components because it would have affected the carefully chosen final colors. Instead, Gulf Consult recommended using microsilica as an additive to increase the density of the concrete and reduce the possibility of corrosion of the reinforcement in the marine environment.

Casting the panels in the style desired also created a challenge to convey across cultures. The goal was to produce panels with rusticated edges to generate a sense of having a "broken off" edge with exposed aggregate that replicated a stone look. But the precaster had never produced such mold fabrications before. The company experimented with wood and polyurethane molds to find the best options.

Ultimately, polyurethane forms were used for the ribbed pattern and flat panels, with the edges nicked with a hammer and heavily sandblasted to roughen them. The degree of sandblasting on the flat panels varied from light to medium, depending on how much it changed the final color.

This process had to be monitored carefully for each individual panel by a full-time member of the architect's supervision team to ensure no significant variations were produced. Fiberglass forms were used to produce the wave patterns, with each wave design

Fig. 13. Stone and tile were used on the floor and at the base of the walls, joining architectural precast panels that continued to the roof. Courtesy: Gustavo Ferrari.

fabricated as a large individual puzzle piece and then independently erected by stacking the panels, one on top of the other, starting at the bottom (see Fig. 10).

Another concern, which ultimately could not be resolved, was the precaster's traditional method of providing a chamfer on the panels' edges. The designers wanted to produce a square edge with only a slightly rounded lip, but the precaster traditionally furnished a $^1/_2$ in. (13 mm) chamfer. The main concern with this approach was that when this is added to the $^1/_2$ in. (13 mm) precast concrete joint and placed beside another panel, the overall joint width appears to be $1^1/_2$ in. (38 mm) wide, which was wider than desired.

Because the chamfer provides the precaster with a safety margin against chipping or breaking the precast pieces when stripping them from the mold, the $^1/_2$ in. joint with $^1/_2$ in. (13 mm) panel chamfers was approved.

Once the colors, patterns, and casting forms were approved, the actual production of the components went smoothly, quickly, and on schedule. The finished project shows the great craftsmanship that was available in the region and that could be achieved when effective communication and respect for cultural differences were reached.

The benefits of glass fiber reinforced concrete (GFRC) also were exploited on the project, with small, square screened windows adorning the north façade. These windows replicate the look of the traditional

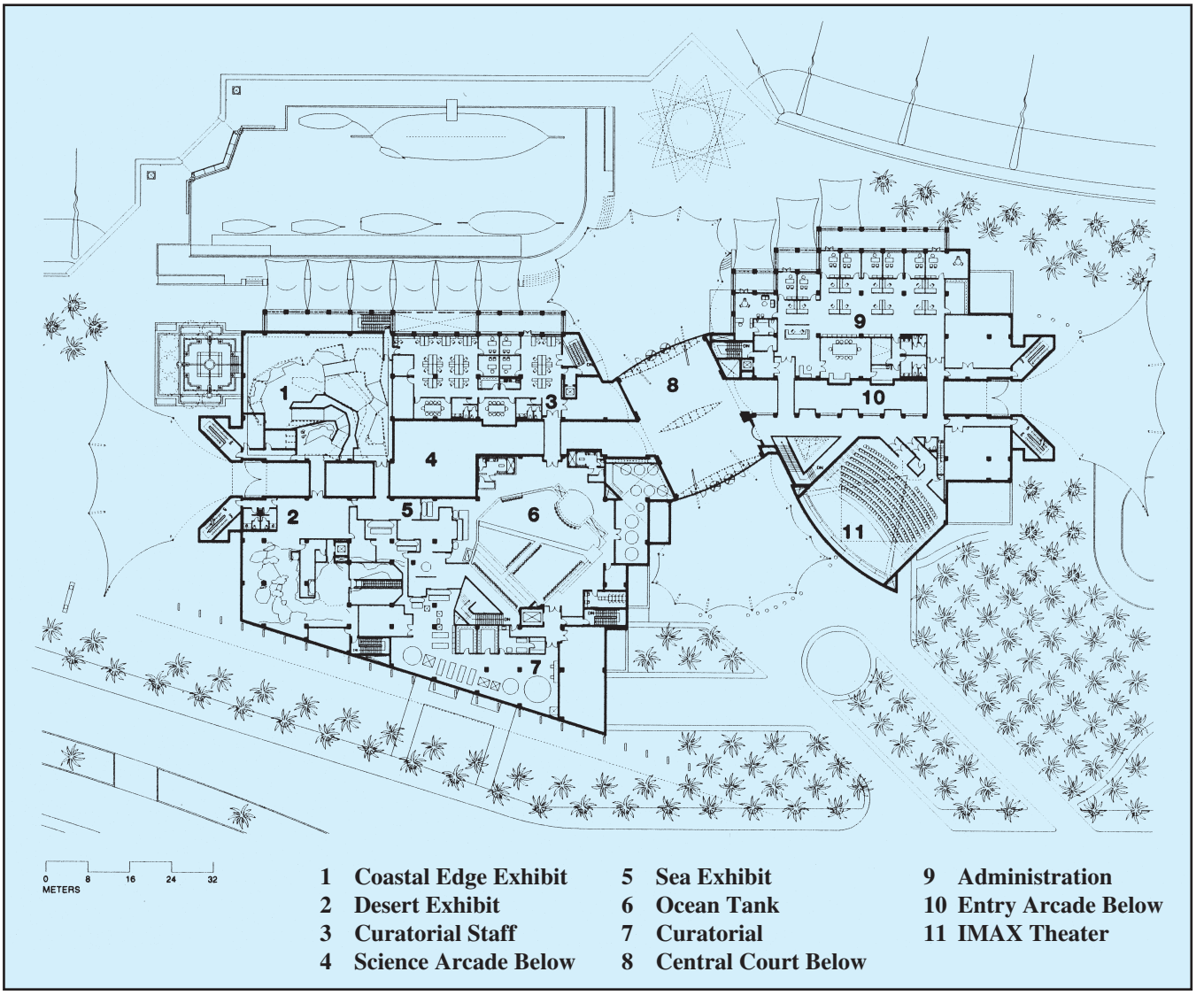

Fig. 14. This site plan shows how the museum is laid out and its relationship to the harbor.

screened window, called "mishrabiyah," which is commonly used on Arabian houses. Originally, the frames of the windows were planned to be built from a mahogany-like wood to reflect the actual techniques used in residential construction.

Ultimately, the GFRC proved it could achieve what the designers needed while offering an economical and low maintenance alternative. The screens are approximately 4 in. (102 mm) thick and 3 in. (76 mm) wide, with the total window width measuring about 10 ft (3.2 m).

The typical panels in the alternating bands measured 2.5 ft high and 13 ft wide (0.76 x 4.0 m). The only exception to this sizing occurred at the stair towers, where 4 ft (1.2 m) wide vertical panels were used to span the full floor-to-floor height of 18 ft (5.5 m). Precast concrete beams were used in only one section, to span clear across the theater to create ideal sight lines throughout the room.

Connections were fairly conventional for these panels, using galvanized-steel anchor clips on the backside. They include a slotted angle piece bolted to the back for load handling and a connection at the top for vertical positioning. The erection proceeded routinely and quickly.

INTERIOR PRECAST PANELS

Architectural precast panels also were used on the interior of the Center. These feature a whiter cement mix than on the exterior and a lightly sandblasted, flat texture to provide a well-lit environment (see Fig. 11). The goal was to invoke the look of a traditional Arabian "souk" or market but to make it bright enough to keep the exhibit halls and walkways from appearing dingy.

Aiding this imagery was the installation of balcony-like projections on second-floor conference rooms, which extend into the two-story corridors (see Fig. 12). These protrusions were filled with concrete masonry units and faced with fabric acoustical panels and wood screens, simulating "mishrabiyah" balconies along a typical Kuwaiti street.

Stone and tile were used for flooring, with an additional 6 in. (152 mm) layer of stone along the base of the walls (see Fig. 13). Precast concrete panels were used above this layer, giv-

ing a simple and straight-forward interior look that did not come across as too rugged. The Center's interior is organized as a progression of arcades, pathways, and courtyards that run parallel to the city's harbor and are open at both ends at the expansive, fabric-covered entries.

The aquarium exhibits the area's three natural ecosystems and demonstrates life in the desert and in the sea throughout history. Walk-through habitats, interactive exhibits, and audio-visual presentations are provided in each area (see Fig. 14).

A key part of the design came in integrating the various components together and ensuring that the foundation and structure could support the loads. This was particularly significant because of the massive aquarium exhibits, which are a first for this region. Precast concrete piles were driven, and grouped to accommodate the different load conditions throughout the building. Typical pile caps were 3.3 ft (1.0 m) deep and were formed using concrete masonry units.

The foundations for both the steel masts and tie-downs required for the fabric structures used massive concrete mats or grade beams (see Fig. 15). A critical coordination issue revolved around setting the final grade elevations for the mast and cable anchor-plate foundation pads on top of the foundation structures. These anchors had to overturn load reactions of the sails along the seashore, which required extraordinarily massive concrete foundations.

The masts themselves were fabricated of painted structural steel, cables were made from stainless steel, and the fabric is a Teflon-coated fiberglass. The most critical construction issues throughout the project centered on design and scheduling coordination and the technical integration of these elements into the building's concrete frame.

PRECAST CONCRETE PAVERS AND SEA WALL

Precast concrete components were used in two other significant exterior locations, which served both aesthetic and functional uses. The first and most prominent application was the series of precast concrete paving units used for the walkways around the facility. The pavers feature a curved wave pattern using red and gray tones.

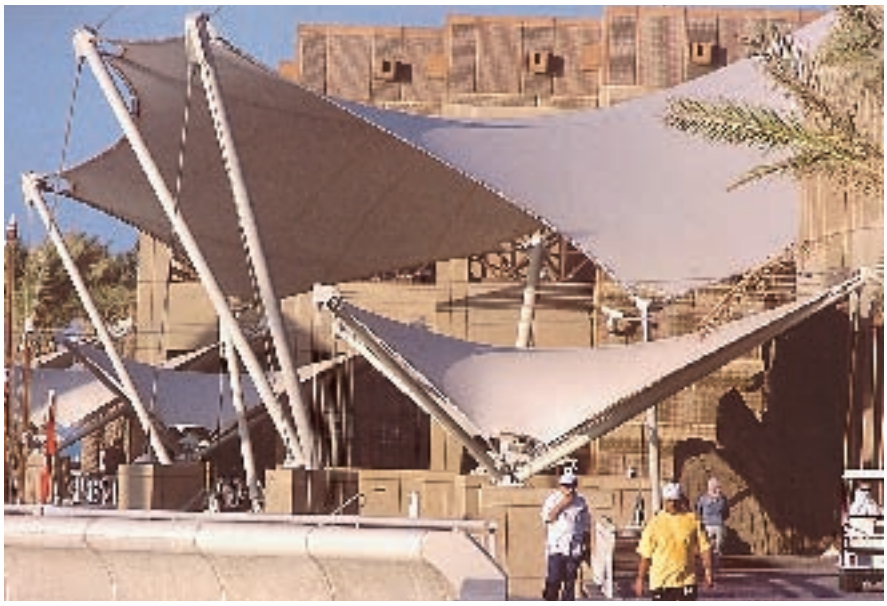

Fig. 15. The masts supporting the fabric coverings were massive to support the wind load required but add visual contrast with the precast concrete walls. Courtesy: Gustavo Ferrari.

These pieces were laid in alternating color bands, 6.5 ft (2.0 m) wide, to create a scalloped wave pattern that begins at the parking area and surrounds the building, drawing patrons toward the Center. This large decorative field helped differentiate TSC's site from the surrounding area and set a festive tone (see Fig. 16).

The wave design consisted of 4 x 8 in. (102 x 203 mm) brick laid on a 17 ft (5.2 m) radius. Fitting these rectangular shapes into the changing landscape proved difficult, as the arcs had to be cut off at different segments to adjust to the walkway geometry. This created small, brittle slivers that had to be fit into the puzzle without breaking.

To resolve this design and labor problem, the paving contractor suggested using an 8 x 8 in. (203 x 203

Fig. 16. Precast concrete pavers in red and gray tones were installed on all walkways in a scallop pattern to add visual interest and set off the complex's landscaping.

Fig. 17. The retaining wall along the harbor consists of a continuous precast concrete beam that includes a bench for visitors.

mm) double-sized brick with a centerline score. This made it easier to cut off the unnecessary portions and keep the joint line where it was needed to align with the next paver.

Curbs and edging pieces between the paved areas and the landscaping, as well as the protective rings around each of the 800 palm trees on the grounds, also were created from precast concrete components.

The final precast concrete element used on the site was a long, continuous bench that was installed at the shore line (see Fig. 17). The bench measures approximately 20 in. (508 mm) wide and stands 20 in. (508 mm) off the floor, sitting on a stem about 6 ft (1.8 m) long. This bench actually serves as a sea wall at the shore line and was built essentially as a retaining wall to support the back-filled soil that was added to provide sufficient site area for the Center.

The land-side of the harbor was constructed with steel sheet piling capped with the precast concrete beam, while the seaside was formed by placing precast concrete mass block concrete units on top of a rock-armor foundation. The precast concrete "wave crash wall" was cast on top of the seaside to reduce spray impact on pedestrians. This is a typical design in this region for protecting harbor-side structures from erosion.

The deep water and strong current required a sizeable structure, and several options were considered. One proposed solution, using a large three-dimensional structure similar in appearance to children's jacks, was discarded because they could not be nested closely enough together to prevent debris from becoming entangled. Large local stones 18 to 48 in. (457 to 1220 mm) in diameter ultimately were used instead for shoreline rip-rap.

Fig. 18. The Scientific Center presents a magnificent structure to the harbor skyline at night. Courtesy: Gustavo Ferrari.

Construction of The Scientific Center was completed in several phases, including site preparation and building. The precast concrete erection was accomplished in approximately 14 months, with the Center ready for occupancy in April 2000. This was about three months later than the original plan, due to delays caused by the longer-than-anticipated time to acclimate the fish and animals to their new homes and to finalize exhibits.

CONCLUSION

The end result of the design-construction team's close communication and steadfast effort is a magnificent jewel along the harbor of Kuwait that draws attention to itself and invites citizens in to a wide array of learning experiences (see Fig. 18). The Center's exhibits combine with the region's first aquarium to convey the theme of living in harmony with the sea, desert, and sky.

The sense of wonder begins as visitors walk to the Center along the colorful, scalloped walkways, and continues as they pass through the fabric-covered entries into the bright marble, stone, and precast concrete interior. The sharp contrast between the colorful precast concrete façade and the flowing lines of the fabric coverings provides an attractive visual display while evoking the textures, colors, and shapes from Kuwait's rich historical past.

The Scientific Center has quickly become a popular landmark in Kuwait City. Today, scores of Kuwaitis and visitors from around the world are enjoying the facility while admiring the architecture as a backdrop. Indeed, the new Center has fulfilled its promise to the owner, the design-construction team and the people of Kuwait.

CREDITS

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Engineer of Record: Gulf Consult, Kuwait Construction Supervision, Kuwait City, Kuwait

General Contractor: M.A. Al-Kharafi & Sons, Kuwait City, Kuwait

Operations Contractor: IDEA Inc., Cambridge, Massachusetts

Architectural Precast Concrete Panel Manufacturer: The Index Company, Kuwait City, Kuwait

Precast Concrete Paver Manufacturer: Aziz Block, Kuwait City, Kuwait