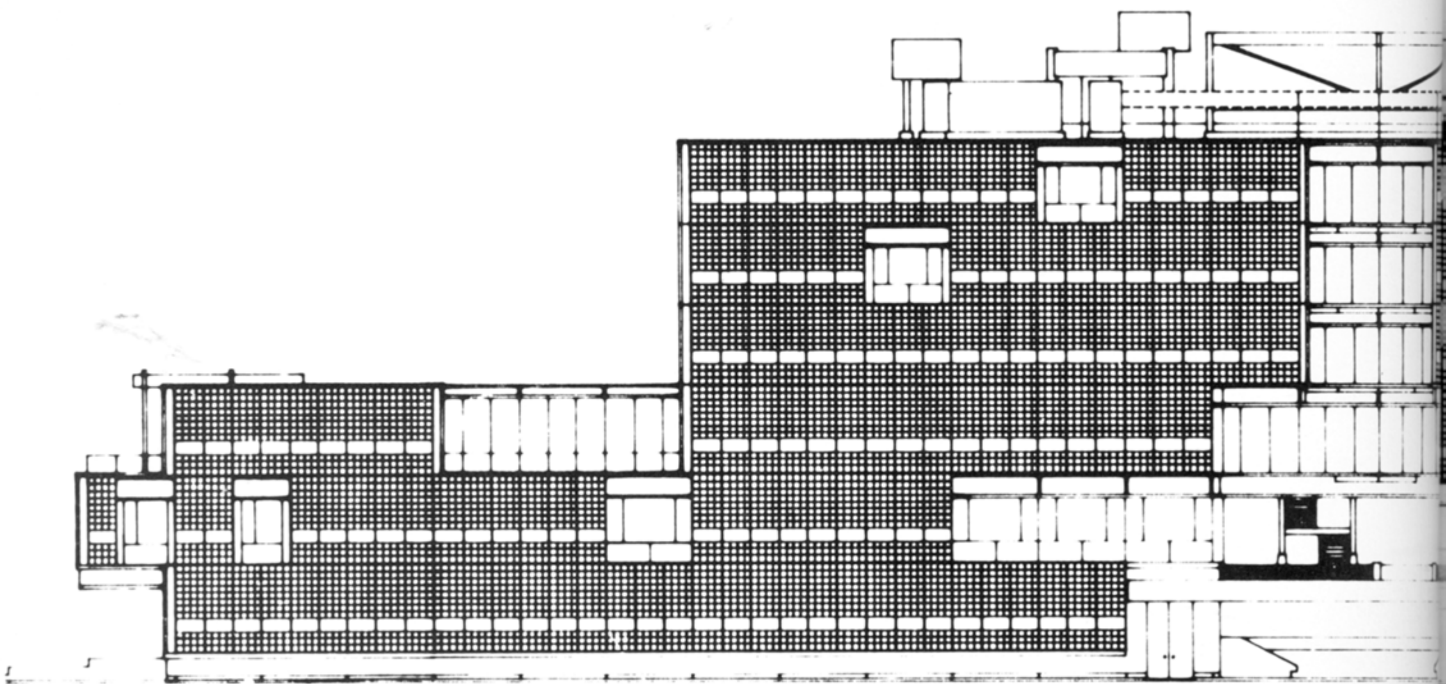
Architecture has concerned itself with the creation of monumental forms in both the Western world and Japan until very recently. In the past few years there has been a turnabout from this way of thinking. We are now witnessing a resurgence of awareness of the human scale, the touchable scale, or the detail.

Amidst the gracious entrances and exits of such historical forces upon architecture, there are certain tenets which to me remain simple and timeless: not a steadfast adherence to a style or the excessive dependence on intellectualized concepts which tend to impose and dictate, but rather an attitude, and a relatively humble one at that, of how spaces ought to be made.

I am very concerned with seeking a rapport between environment and building, between building and program, and between building and the parts from which it is constructed. It is not aphoristic to want to draw sensitively on the rich resources of the ineradicable but endlessly varied reality of the setting, taking from and then giving to it. This is the architect's conversation: a communication between his or her inner landscape and the specific conditions of a part of the world's landscape he or she is to deal with at that particular moment in time. Each project the architect undertakes is a conversation among the unique situation, the ever-increasing range of material and technical resources available, and the architect's ability to draw on the whole of these resources, which, among other things, include much of the world's inherited knowledge, traditions, racial culture, and philosophies.

I mentioned the "inner landscape" of an architect. This refers to the internationalized landscape of each person's sphere over time and space, culture and aspirations, and is basically what the architect has to offer. Thus equipped, I believe poetry in architecture will arise not by forcible application of a theoretical notion, but in the loving treatment of each design problem in its given sphere to create buildings that can exist comfortably within their physical or cultural environment while, at the same time, displaying an integrity and identity of their own.

Since architecture by its very nature is the art of constructing, one might seek a poetry in the way that buildings are put together. With the advent of the assembly line and the mass production ethic, people concerned with the changing nature of architectural problems face a new challenge in the possibilities offered by prefabrication and industrialization of buildings. One wonders whether the same principles which had so successfully produced motor cars and refrigerators can be lifted whole and transposed directly into architecture or whether some sort of editing process is in order. The niche for prefabrication in architecture seems to reside in mass housing projects, where the mere quantity of repetitive units warrants standardization. In other projects where unique conditions dictate individualized design solutions, designing prefabricated components for their own sake may require more than clever maneuvers to gain some very attractive reductions in cost or even assembly efficiency. If one is not careful, it may also be easy to enslave design to a theoretical economy,



for standardization is a process that depends on quantity production and uniform conditions in both physical situations and market demand. Even though the danger of monotony, if not the inhumanity of mindless repetitions of a so-called universal solution, is inherent in the nature of standardization, there are certain things that one can achieve with prefabricated units even in unique situations that the more conventional construction methods cannot offer. Industrialization of construction components has long existed. One finds well-used catalogs of window frames, wall panels, electrical equipment, air conditioners, and so on lining the architect's bookshelves. It is only the degree to which prefabrication dominates a design that has changed over time.

We have long accepted the industrial product in architecture. But it is how one seeks out the special sweetness of those products as suited to the specific conditions of the problem and how one uses those special qualities to serve one's attitude in design that is the important issue for me.

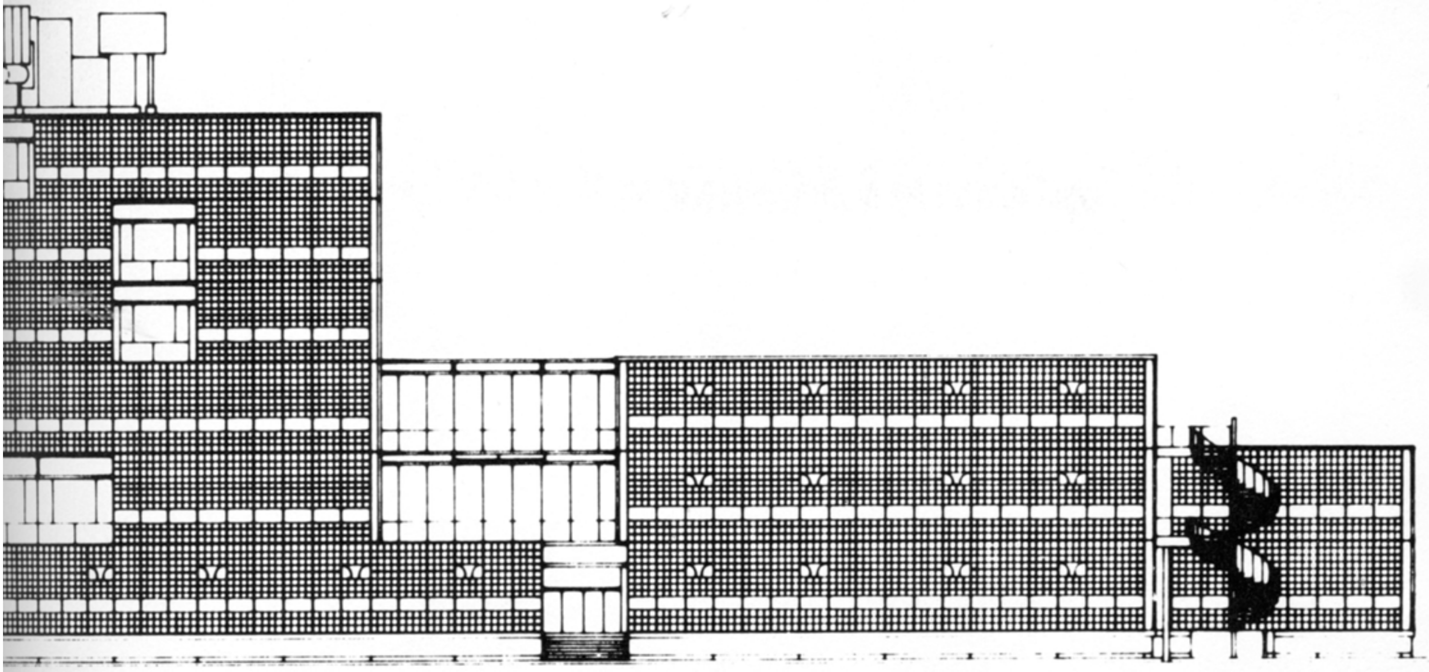
Somewhere in each of the three projects I am going to touch on, the unique conditions called for the proficiency of a quick assembly system, and in each case I drew on the technical resources of prefabrication to produce a rather interesting marriage between the program and the design solution. As I find delight in the mellow humanness of the handmade scale and I also derive pleasure out of exploiting the potential of industrialized elements at an appropriate scale, we generated a prefabricated unit of intermediate scale for each of these three recently completed buildings. The typical prefabricated building element is usually small, giving the building the characterless appearance of being many, many identical or nearly identical pieces bolted together. One-of-a-kind design solutions, however, tend to be economically impractical in all but the most extravagant commissions. The intermediate scale is a way of trying to have the best of both worlds.

The thought process in such cases is not necessarily linear. From the germinal idea of using prefabricated units to facilitate assembly, there was constant interplay between the designs of the prefab element and the building as a whole. It is hard to distinguish or to delineate between cause and effect in the series of interdependent design decisions. The total effect of each project is partially a function of the prefab units, which in turn are partially a function of the nature of each project. The elements possess special potential, which was explored and integrated into the aesthetics of the project conditions. ''Prefabrication'' elicits an image of coarse-grained expansiveness, but here three different sets of conditions tailored some very individualized elements that serve the designs, while possessing the qualities of safety and efficiency of assembly which inspired the architects in the first place.

Central Building at Tsukuba University

The ''out-and-out curtain wall,'' as the facade of the Central Building at Tsukuba University has

The Central Building gateway leads to the Tsukuba University campus. Since this was one of the first buildings at the university, the building is also a kind of gateway. Behind the large window are the student lounges and meeting areas.



been described, is a composition of three prefabricated panel types: one with an operable, horizontal, transparent window near its base; one with two; and a third with a circular vent in a glass block plane. Together they clad the exterior of the building while allowing natural light to filter into the inside spaces of the art and physical education departments they house. Glass blocks are used throughout on the southern and northern facades. On the inside, they extend from the ceiling to eye level, where a window of transparent glass is placed horizontally, framing a view of the outside. Then the translucent blocks continue to the floor level and below. A clear amber tone, which varies slightly at different times of day, was made especially for these blocks. The warm amber filtered light was one effect we aimed at, vaguely reminiscent of paper shoji screens. The translucency of the wall vocabulary is echoed in the larger scale by the spatial treatment of the outside and the inside of the building. A central well sheltered by a hovering steel roof defines and protects a series of meeting spaces and intersections of traffic, an inside outside, which in a way is also translucent.

Here we attempted an architectural expression based on light and walls, experimenting with this through the use of prefabrication. I was interested in a new, more efficient way of handling a delicate material, the glass block, to which, incidently, one can easily become addicted. We were especially concerned with the insulation, luminosity, and strength of the panels. Since this was an experiment and because Japan has a history of earthquakes, I made sure to repeatedly test the panels against torsion in anticipation of stresses which might be caused by the earthquakes.

The translucent blocks were set into steel frames that measure about 4 by 10 feet (1.2 by 3 meters). The frames were fully fabricated, with the glass blocks and windows in place, and then the sections were raised up for installation. Steel framing and floor decking, poured concrete, lightweight steel studs, and cast aluminum panel partitions completed the structural language. In all, there were few materials and the method of construction was made simple and fast through basic patterns and frames which can be combined and recombined to form spaces appropriate to the specifics of the program.

Assembly on site was relatively uncomplicated. Whole panels were hoisted up and slip joined into the main structure. It took only a few installations for the workers to tune into the assembly techniques, and then the job proceeded quite elegantly, taking practically no time at all.

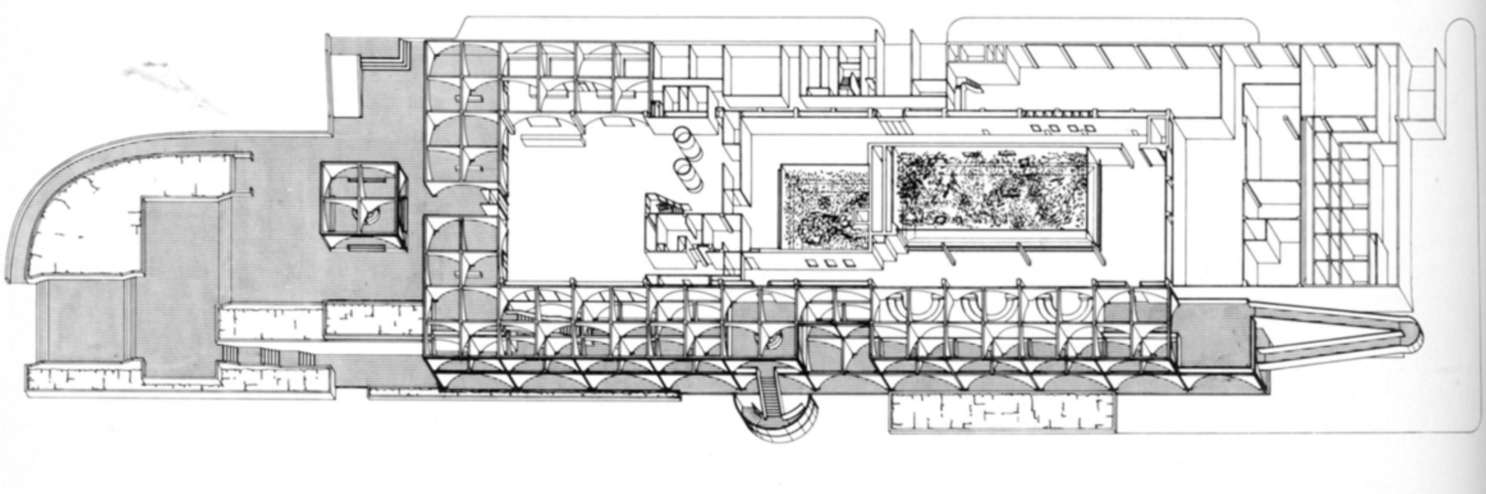
Opposite page: The southern facade of the Central Building at Tsukuba University shows the combination of the three basic panel types. The cost of this wall is comparable with that of a normal curtain wall.

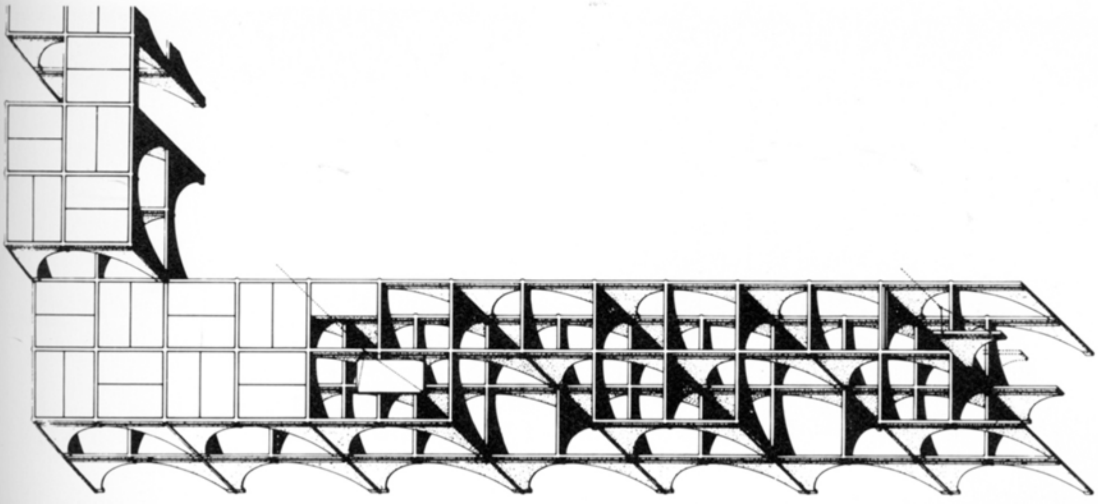
Left: Joining the panels to the structure was a very delicate problem as the joint had to be strong enough to keep water out and flexible enough to expand and contract with changes in temperature so as not to transmit forces from the structure to the panels.

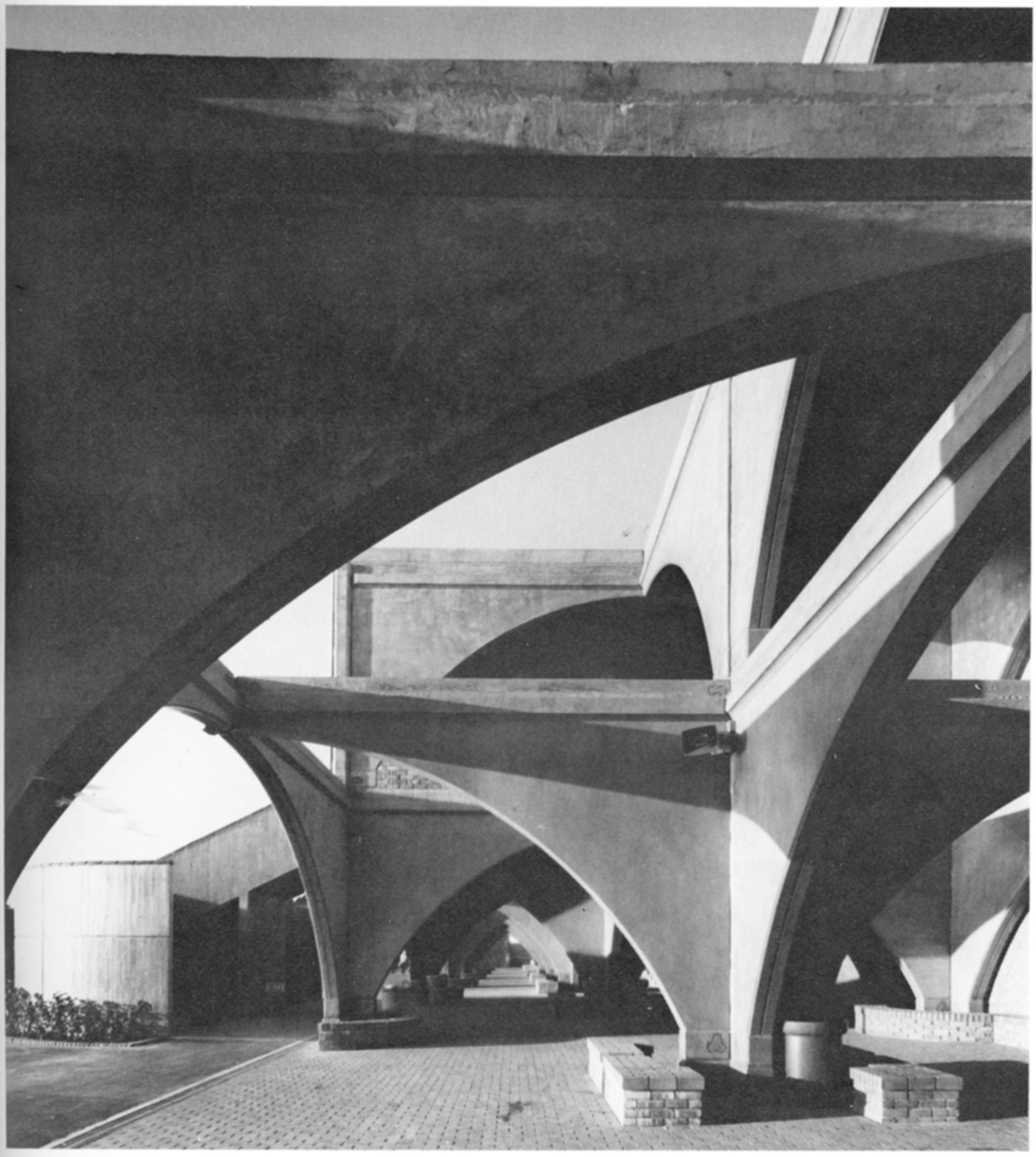
The predetermined dimensions of the panels were large enough to be recognizable as units and at the same time small enough to be easily joined to the building. They also allowed us to articulate the gateway to the future university and mountain range beyond, perforations in an aesthetic generated from their own logic. But because the old hand-laying method was not employed, the resulting facade has a contemporary quality to it.

The Okinawa National Aquarium

The Okinawa National Aquarium was the principal building for the Fish Cluster in the International Ocean Exposition of 1975. Built in the subtropical climate of Okinawa, the building's arcade—a significant part of the program—provides shade from the brutal sun for the people waiting to see the aquarium inside. The necessity for relatively quick construction suggested that a prefabricated element be developed. In this case, precast concrete components in the shape of a quadrant of a circle are detailed to form the structure of the arcade around the aquarium periphery as well as provide a major expressive element in





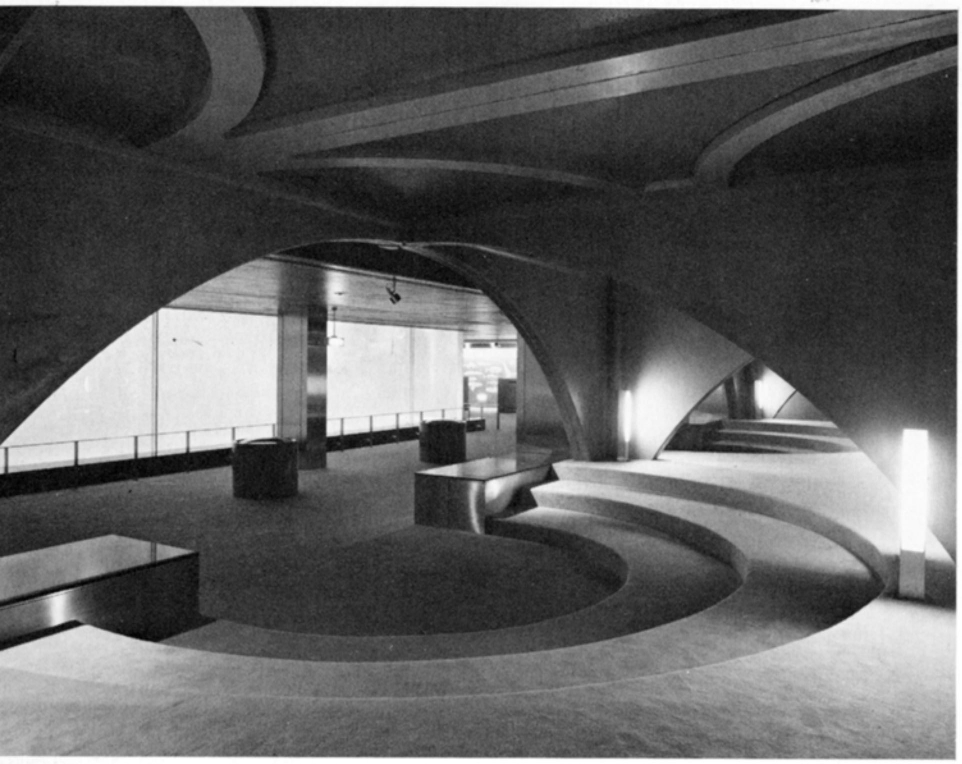


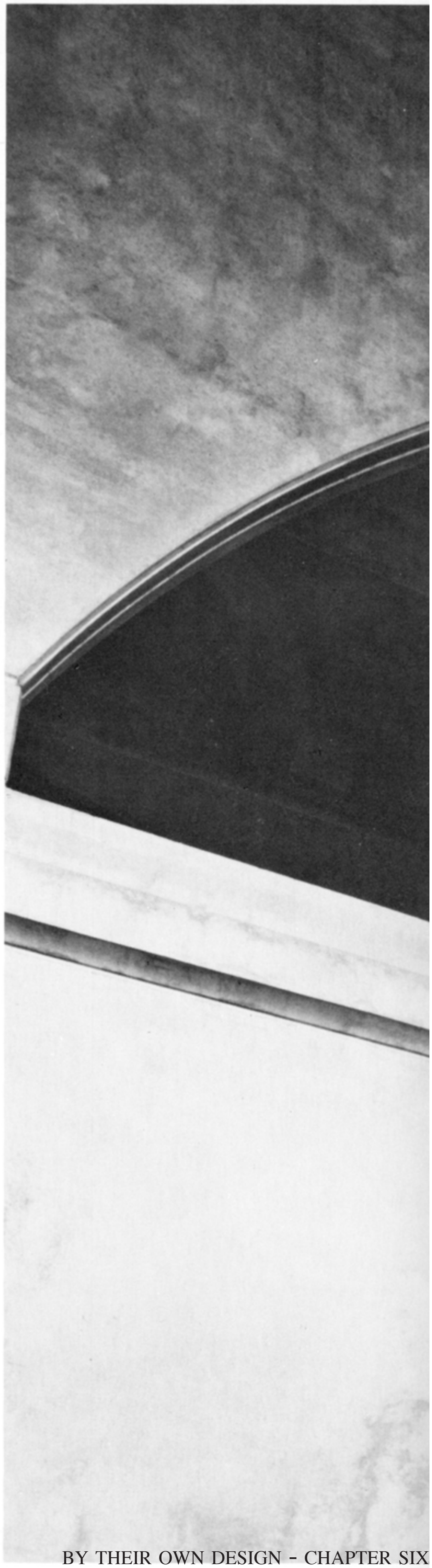
Opposite page, top: Overview of the Okinawa National Aquarium. On the right are two steel arches from which are suspended a tensile structure made out of a fisherman's net. This gives shade to the people watching the dolphins perform while picking up the semicircular forms of the arcades.

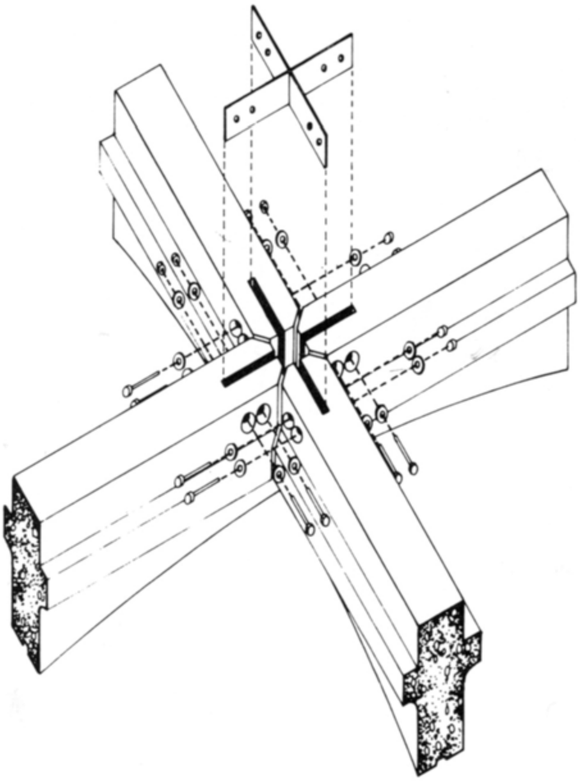
Opposite page, bottom: This axonometric shows the interweaving of the precast concrete arcades with the long-span steel hybrid structure of the central part of the building.

Top: The precast system works both vertically and horizontally; each unit with its 12 parts took a day to erect. It is possible to continue this system for several more stories either by thickening the concrete of the bottom arcs or by varying the reinforcing inside.

Bottom: Some of the precast units are placed outside the building enclosure to form an arcade, which provides shade for people queuing up in the tropical heat.







Above: At the Okinawa National Aquarium the world's largest fish tank is enclosed by eight layers of plastic, which comprise each 9-in. (22.9-cm) thick panel and are cantilevered from below. Instead of conventional steel mullions, the joints between the panels are neoprene so that people can see the totality.

Right: The precast concrete joint at the apex of the arches. Since the structural system is a three-hinged arch, minimum moment is transmitted between the members. This system of bolting is simple enough for unskilled laborers to handle on the site.

Far right: Each roof panel has a quarter circle secondary beam in it; four of them make a complete circle, which is consistent in expression with the circular forms of the arcade. This kind of expression can only be done effectively through the use of prefabrication.

Below: Model showing the profile of the entire Osaka Prefectural Sports Center. The variation in the undulations of the roof distinguishes the different functions within.

Opposite page: The reflected ceiling plan shows the relationship among the structure, the ducts, and the 88 ceiling panels.

Key:
1. *Small gymnasium*
2. *Entrance*
3. *Concrete circulation spine*
4. *Swimming pool / skating rink*
5. *Large gymnasium*

and outside the main spaces of the building.

The steel frames of the precast concrete components were designed and made in the mainland of Japan. They were then shipped to a temporary factory in Okinawa where concrete was precast to make those units. Besides shortening construction time, prefabrication eliminated the need for skilled labor, which was scarce in the Okinawa region at that time.

The structural system involves two kinds of elements. The first, 16′ by 10′ by 10″ (4.8 m by 3 m by 25.4 cm) concrete arcs, combines the functions of post and beam. Two such elements form a three-hinged arch; twelve of them make up a complete unit. This three-hinged arch transmits minimal moments at the joints, making them simpler to assemble. It is possible to repeat the system vertically and horizontally. On top of the arches rests the second kind of element, the ribbed floor or roof slabs. The rib takes the form of a quarter circle. Four of these 8 by 16 foot (2.4 by 4.8 meter) slabs form a complete circle. Both kinds of elements may be combined in diverse ways. With a minimum number of different elements, a great number of arrangements are possible.

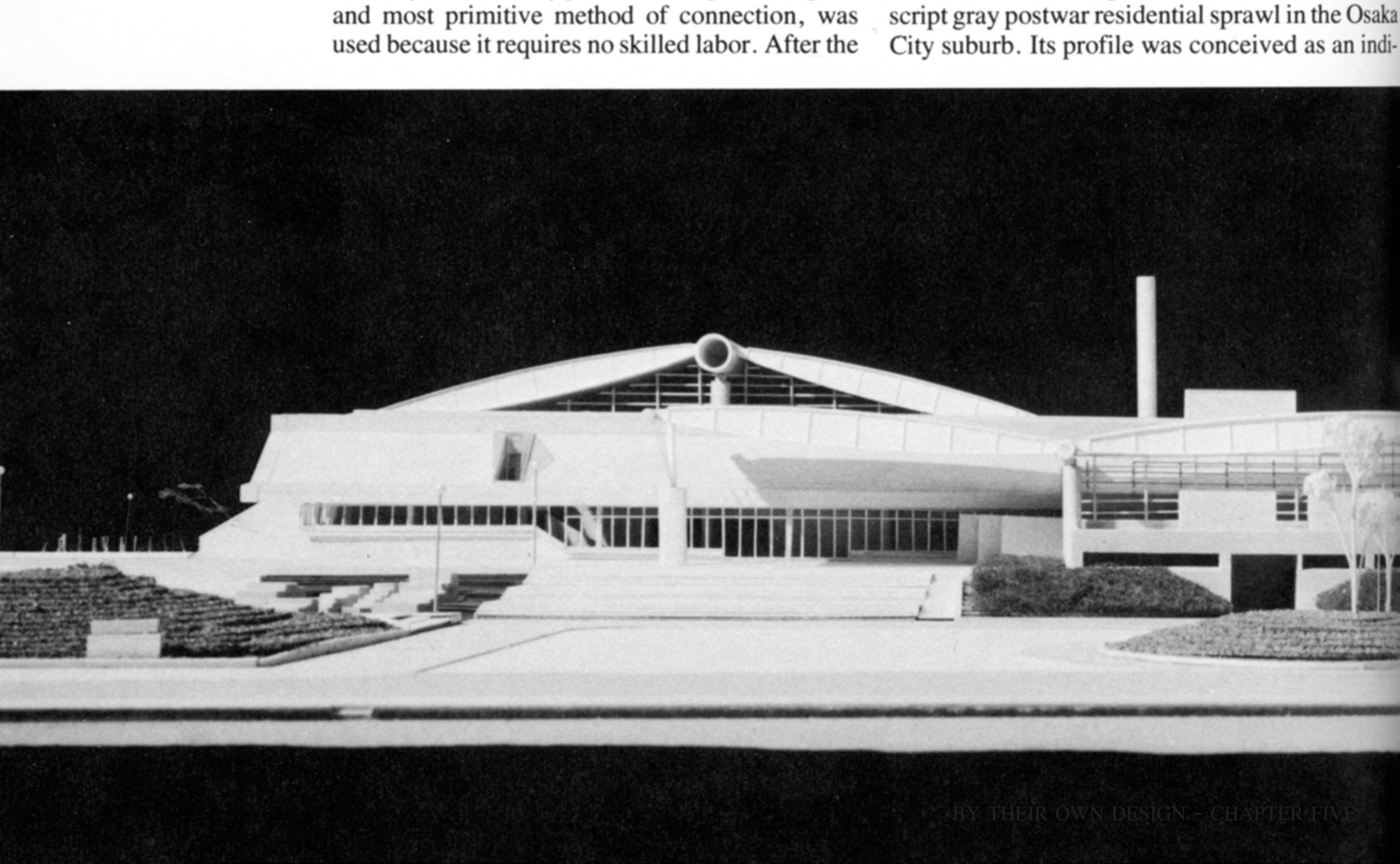
A total of nearly 300 post and beam units and 150 floor/roof slabs were used. They were combined by means of dry joints. Bolting, the simplest and most primitive method of connection, was used because it requires no skilled labor. After the pieces were fabricated in the temporary factory they were ready for erection. Just before the time of assembly, the pieces were transported by trucks to the construction site where they were hoisted into place and connected.

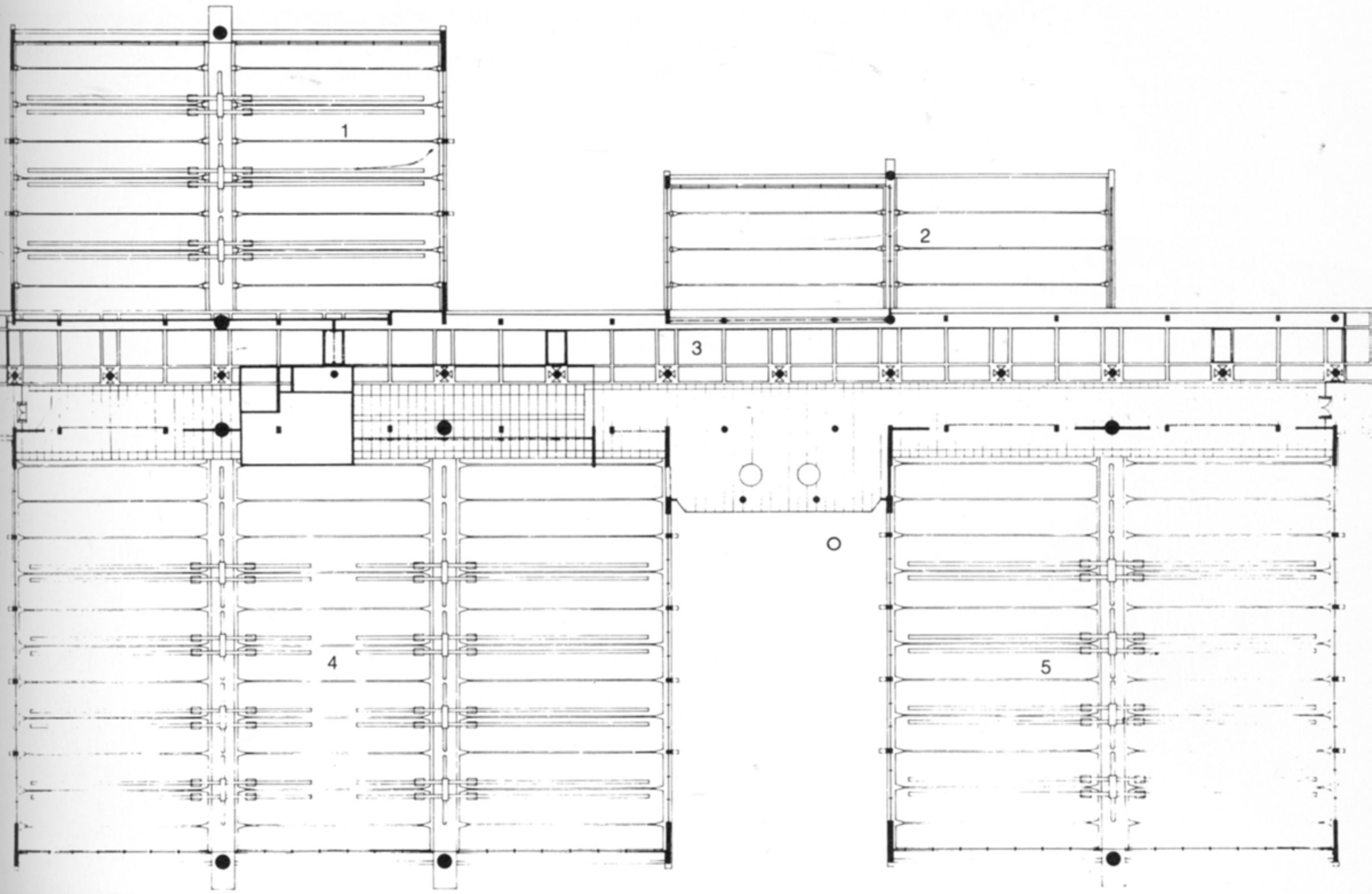
By producing changing patterns of light and shade, the arcades punctuate and vary the scale of what, without them, would be a bulky mass. These raw concrete elements, coated with a clear acrylic spray, are juxtaposed against deep brick infill facade walls, forming cool strong shadows, while simultaneously framing views of the blue ocean and sky for those who care to nestle into their recesses. Most important, they provide shade, which is very much needed in the scorching Okinawa summers.

The variations produced by those very simple forms would have been difficult to create without appearing contrived if conventional methods of pouring concrete were employed.

Osaka Prefectural Sports Center

Built in a long, narrow industrial belt of reclaimed land beside a shoreline fronting a public canal, the Osaka Prefectural Sports Center faces a nondescript gray postwar residential sprawl in the Osaka City suburb. Its profile was conceived as an indi-

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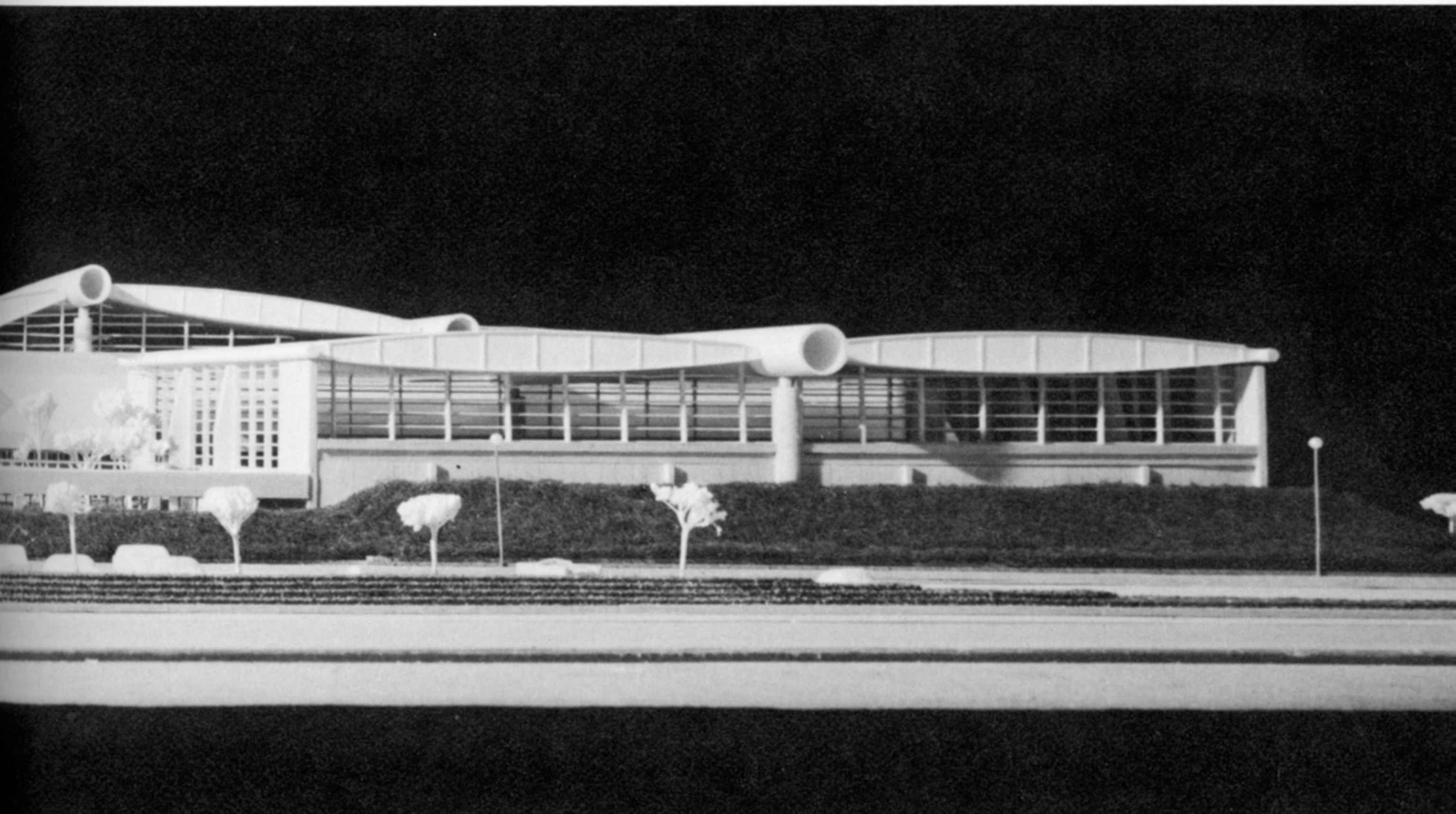
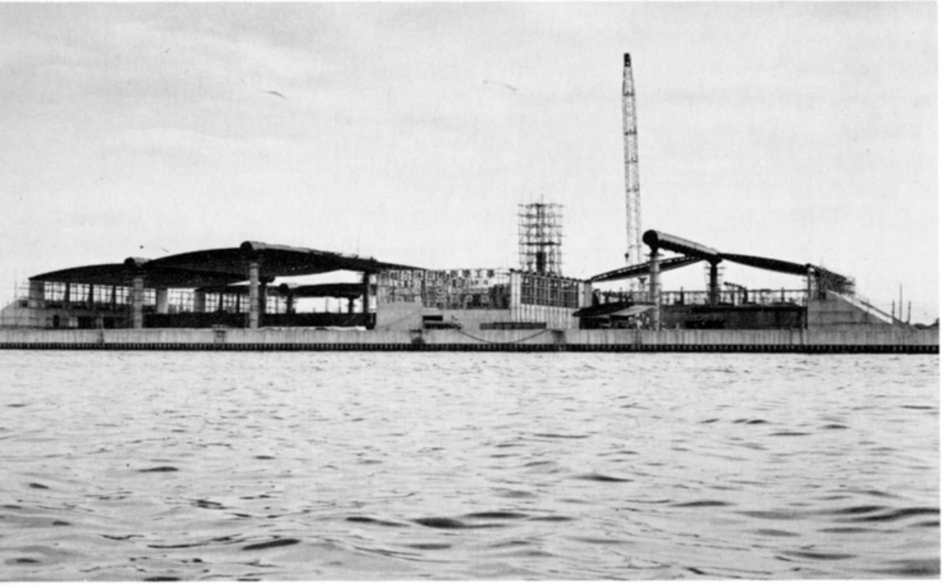
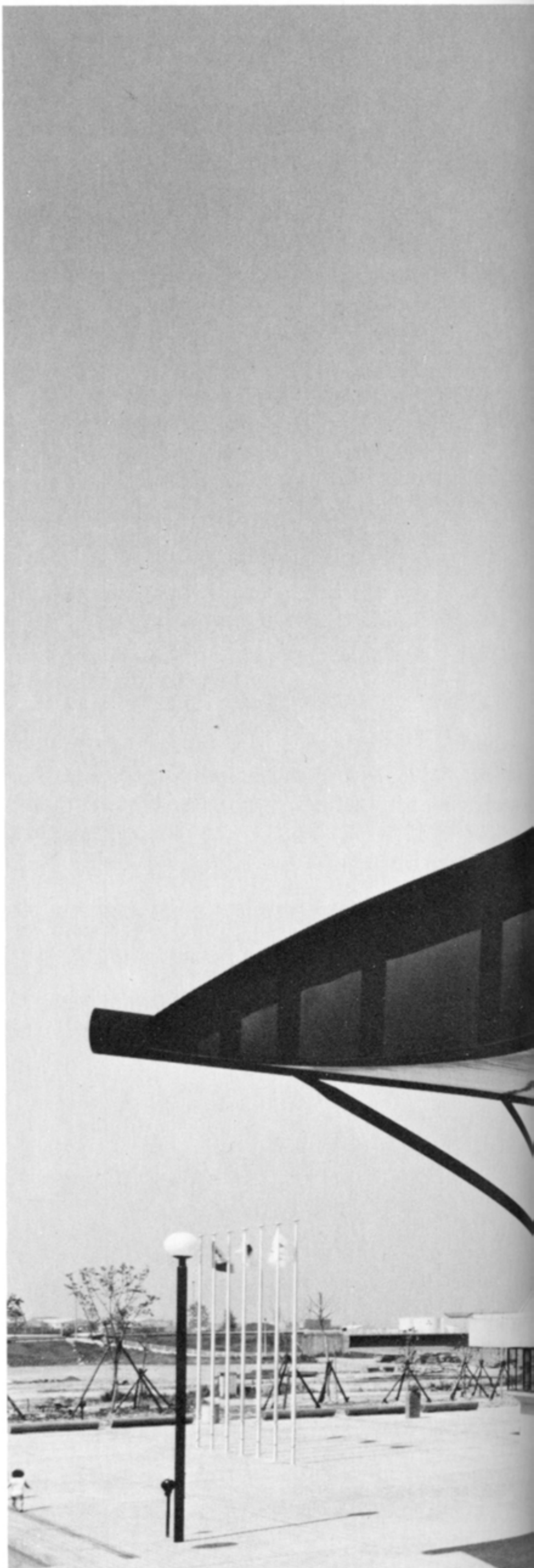




Top: While the structure of the Osaka Prefectural Sports Center is being erected, panels are being assembled on the ground nearby.

Above: It took only 16 days to install all 88 roof panels.

Right: At the entry a weathering steel plate was used instead of a net on the underside of the panels. The angle of these panels was inverted to heighten the sense of entry.



Roof of the swimming pool/ skating rink of the Osaka Prefectural Sports Center shows the integration of the structural, mechanical, and spatial systems.

vidualized transition between them. The plan is organized along a circulation spine, with the major spaces staggered on both sides. These include a main gymnasium for basketball, volleyball, and other indoor sports; an indoor swimming pool that can be used as a skating rink in winter; a subgymnasium; communal facilities; lobbies; administration offices; and a restaurant. We wanted it to be a district nucleus with an intimate, approachable image. Hence, besides the large-span spaces, we tried to create an identity for the entry and, as far as possible, for the other spaces as well.

I developed prefabricated pieces for the roofs as a unifying but intermediate scale element. These roofing units consisted of spindle-section and rectangular-section trusses bound together to form large, unified panels. There were 88 sections in all. Each measured 10 by 70 feet (3 by 22 meters) in cross section and was covered by thin weathering steel plates as exterior protection against the polluted environment. The underside of the spindle-shaped unit was covered with a metal net and penetrated by secondary ducts feeding into the major ducts and the 140-foot (42-meter) long, 9-foot (2.7-meter) deep exhaust duct which acted as a major girder for these units.

The spindle-shaped pieces formed the intermediate-scale prefabricated components and the unifying vocabulary of the whole. While the major skeleton of the sports center was being built, these roof units were assembled simultaneously on the ground. Each truss was combined with its subducts, lighting fixtures, and ceiling. They were lined up on the ground, joined, and prepared to be hoisted up when the primary skeleton was complete. A row of spindle-section units joined laterally was attached perpendicularly to the pipe girders to form part of the roof.

The angle at which each row meets the girder determines the pitch of that part of the roof, and was used as one of the means to differentiate and span the various large spaces within the program. Two such panels cover the main gymnasium, another three span the pool, two cover the smaller gymnasium, and two roof the entrance hall.

The main beams, placed strategically at the pinnacles formed by the junctures of the large panels, bear the load of the roof and transmit vertical compression, which is then absorbed by the pins and by deflection of the cylindrical posts. Formed of thick curved sheets, the main roof beams are hollow, like bamboo stalks. They are ribbed at fixed intervals and fitted with axial flow exhaust fans.

The use of intermediate-scale prefab units allowed efficient construction in a congested industrial zone. All units were factory produced, combined on the ground, and hoisted up to be installed, a process which took only 16 days.

The prefabricated pieces also allowed the large spaces to be gently scaled and, in a way, particularized on both the inside and the outside. The entry is given special articulation by a reverse curvature of those same panels of prefab units, opening up and out to project a welcoming approach. Over the administration areas the curve is neutralized, as opposed to the generous slopes over the swimming and the court spaces.

In all three projects we were looking for a way to create a unit element larger than a person, yet smaller than a room, which had a character of its own and which could be combined and permuted to respond to specific functional requirements. In addition we were interested in exploring the horizons of prefabrication, of industrialized building, in a way that might point out possibilities for the future. These buildings were efficient to erect, not costly, satisfied the programs, and did so in a poetic way.