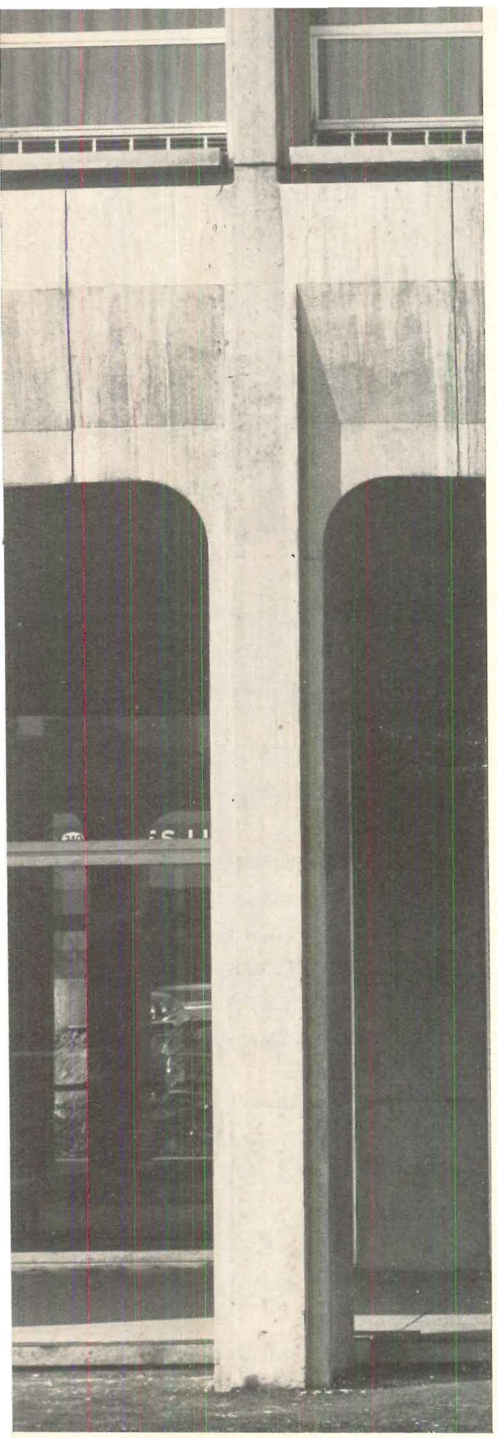

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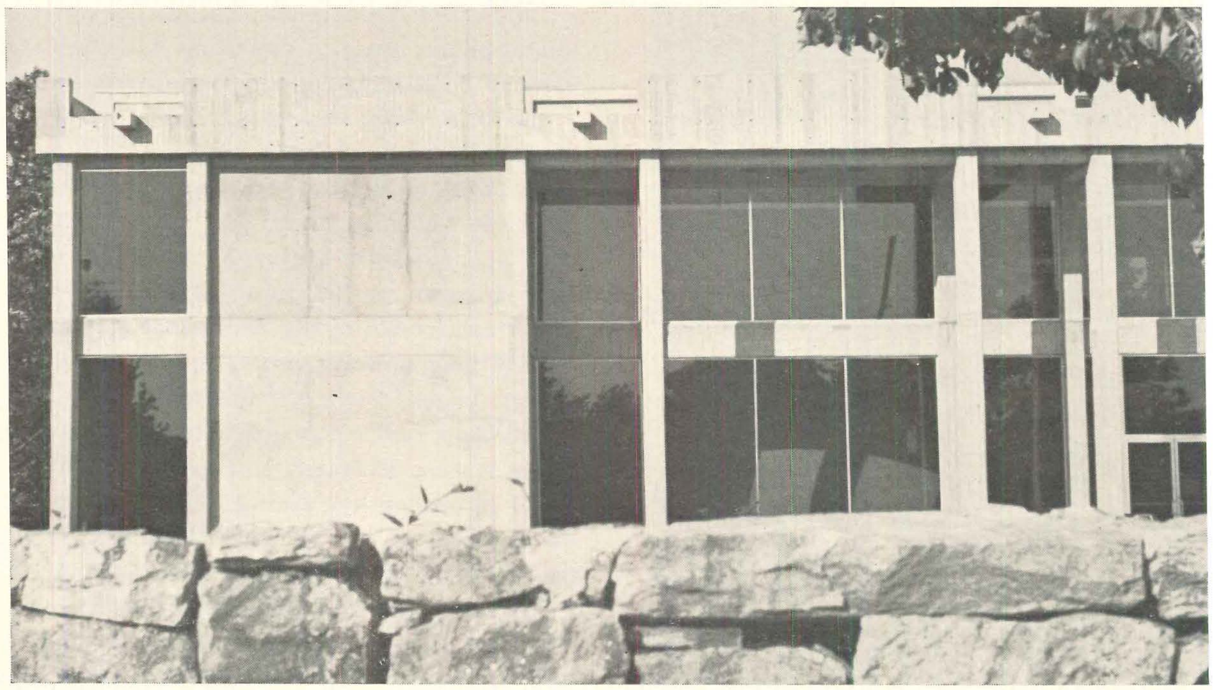

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CONCRETE

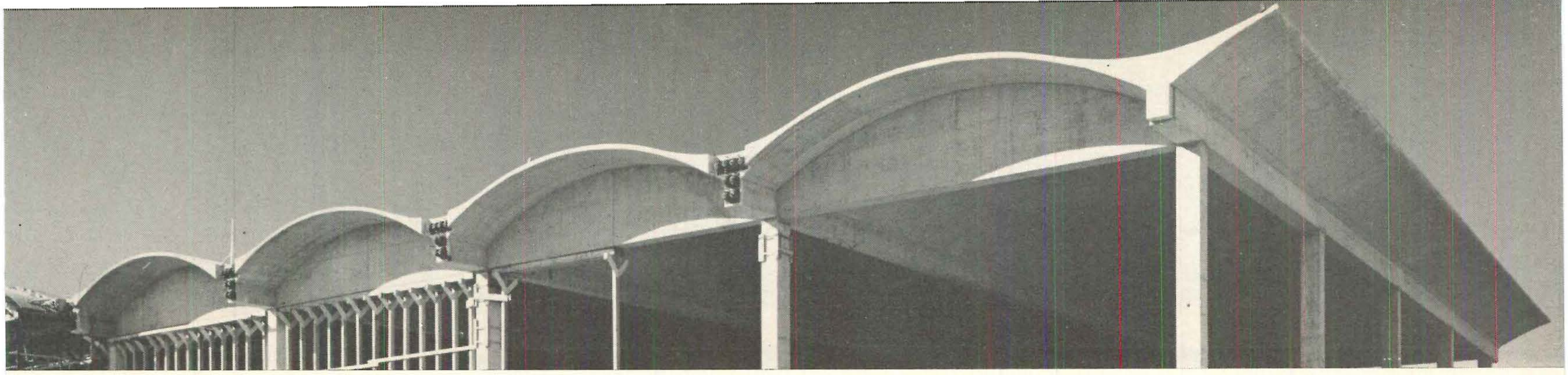
The material that can do almost anything

BY BERNARD P. SPRING AND DONALD CANTY

The slightly fantastic shapes and forms reproduced on these pages have only one thing in common: each is a part of a building constructed of that oldest of miracle materials, concrete. Other than this common denominator, these structures bear little relation to one another: they range in function from a "junk-art" pavilion in India to a polished apartment building in New York City.

These forms do, however, share one further quality: each is part of one of the more significant modern buildings erected anywhere during the past few years. For, suddenly, it seems as if the most striking new buildings the world over were being built of concrete, boldly and expressively exposed.

Perhaps the most significant change in the use of concrete is this increasing exposure. Even the most important, new monumental structures (like the General Assembly Building at Chandigarh, on page 97, or the gateway to Manhattan, page 84) are built of raw, unfinished concrete, and with stunning effect.



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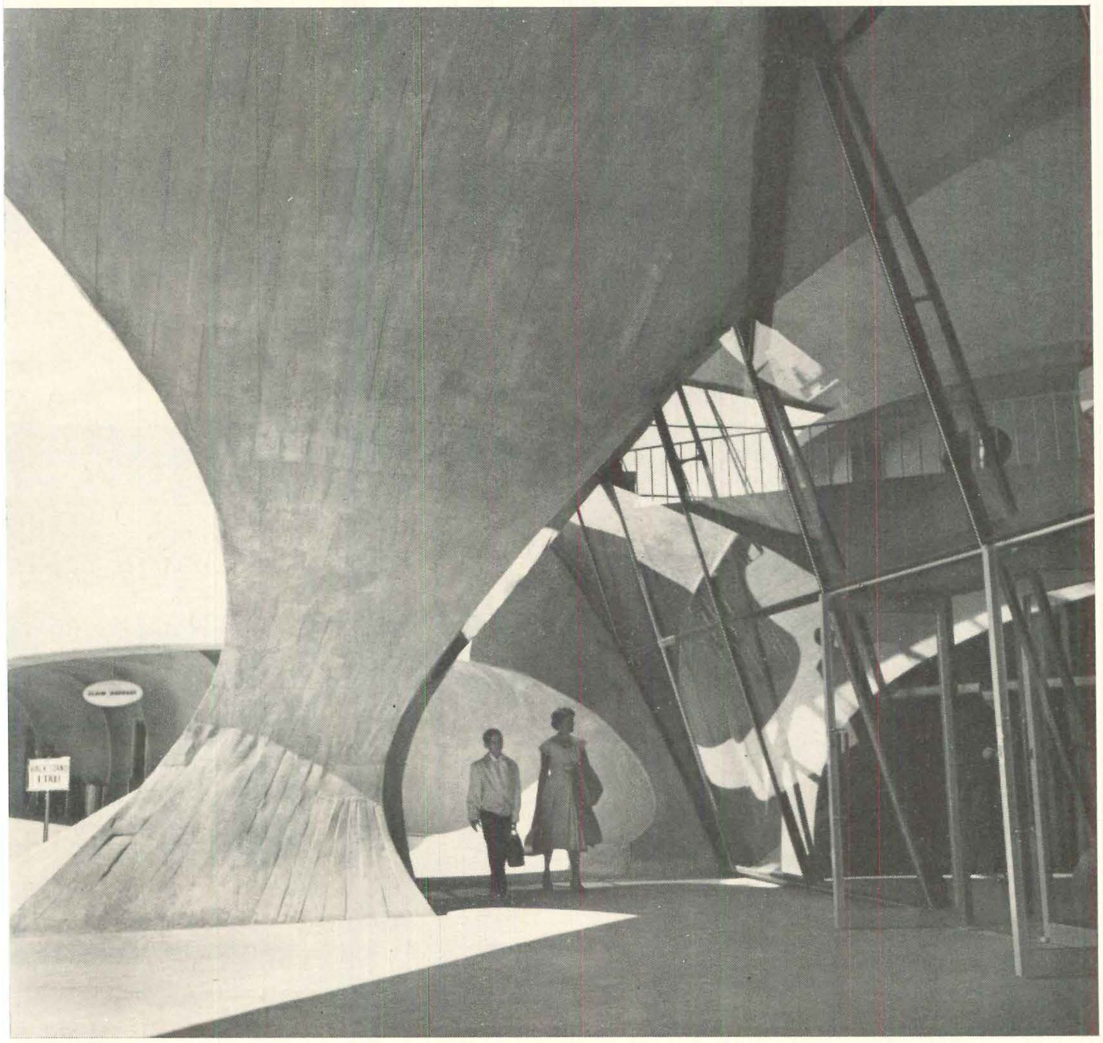

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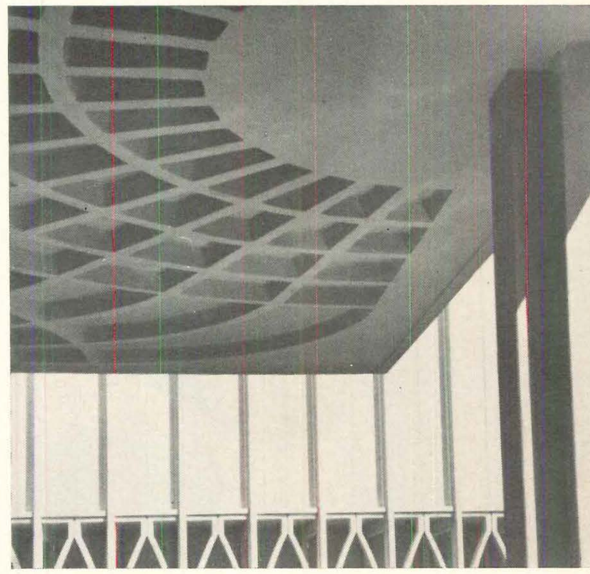

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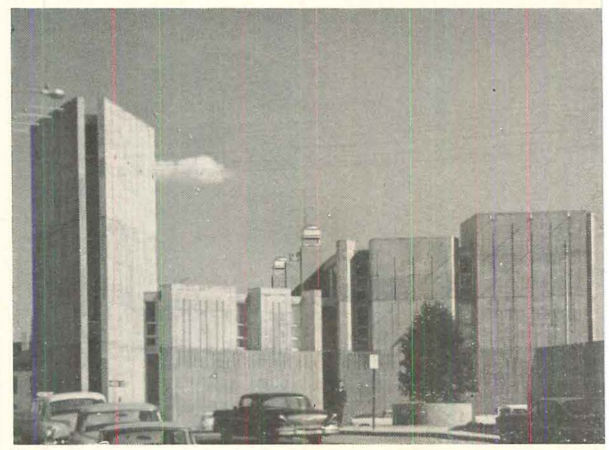

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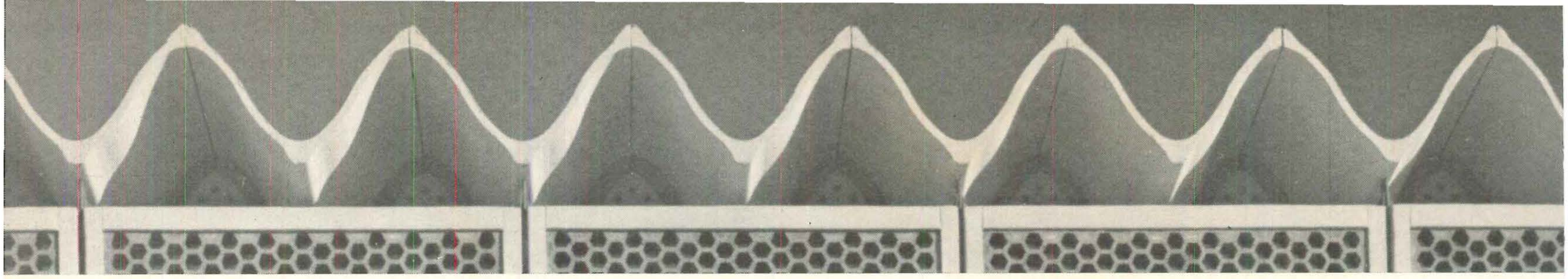
For behind the growing interest in the esthetic potentialities of concrete, there is now a reassuring body of technical knowledge built up over the past 60 years. We now know enough about the strength, the durability, and the appearance of concrete to use it with a high degree of confidence.

Knowledge, however, is not enough. It has taken a second indispensable development to overcome our lingering hesitation about the use of exposed concrete: better job management. In the past few years there has been a striking improvement in the contractor's ability to control quality and costs, and, thus, dependability.

The basic contribution to the predictability of concrete was made by the structural theorists; without their mathematical models to reveal stresses and strains before the start of construction, concrete could never have progressed beyond its early use as a substitute for stone masonry. From scientific analysis of the interaction of concrete and steel reinforcing, to similar analysis of thin shell structures and of prestressing, the theorists have greatly advanced concrete technology. And most recently, they have developed ultimate-strength design procedures based on the fact that concrete remains a plastic material, with a bearing capacity far beyond the limits that were once thought safe.

But theory alone can do nothing to improve the inherent strength and durability of concrete. Equally important is a growing understanding of the ingredients and proportions of the mix plus the realization that the best concrete can be ruined if allowed to dry too fast after placement. Perhaps

1. Kips Bay Apartments, N. Y. C., I. M. Pei & Associates, Architects (George Cserna—photo). 2. Lever Pavilion, New Delhi, India, C. M. Correa, Architect, (Studio New Light—photo). 3. Museum, Fairfield County, Conn., John M. Johansen, Architect. 4. High School, Phoenix, Weaver & Drover, Architects (Beinlick—photo). 5. TWA Terminal, Eero Saarinen & Associates, Architects (George Cserna—photo). 6. Science Pavilion, Seattle, Minoru Yamasaki, Architect. 7. Fire station, New Haven, Earl Carlin, Architect (Bruce Cunningham-Werdnigg—photo).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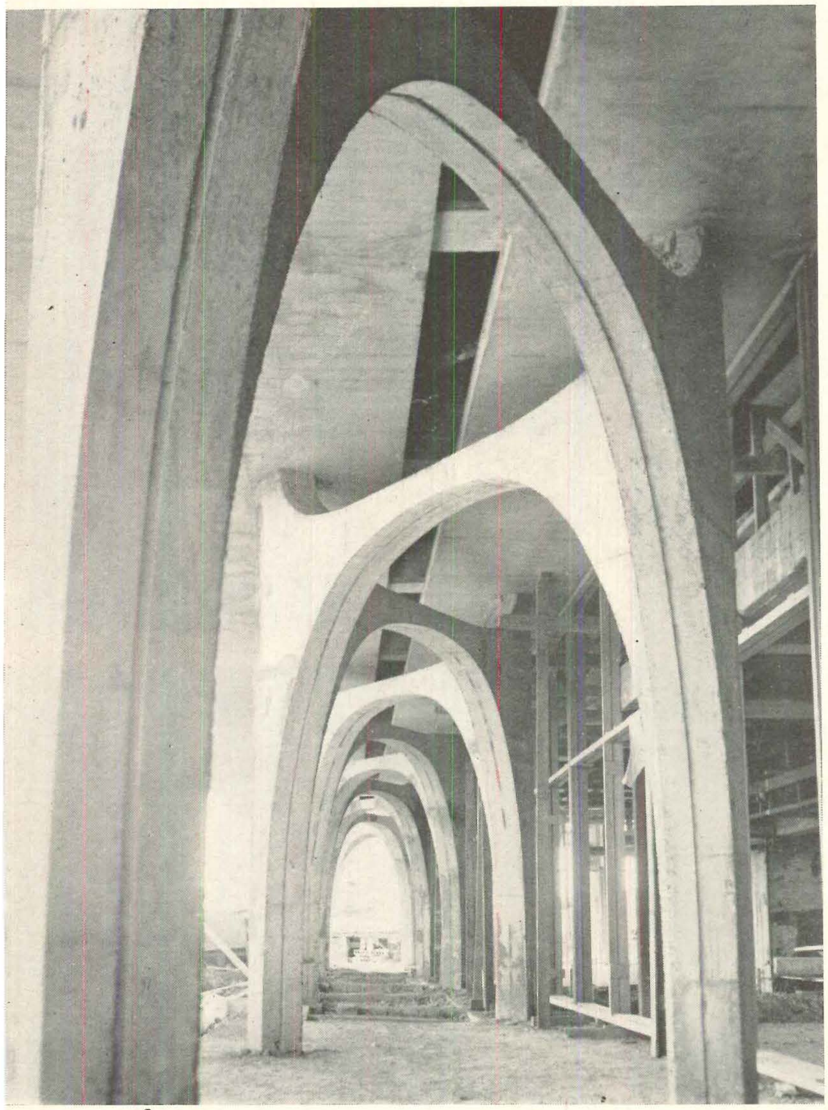
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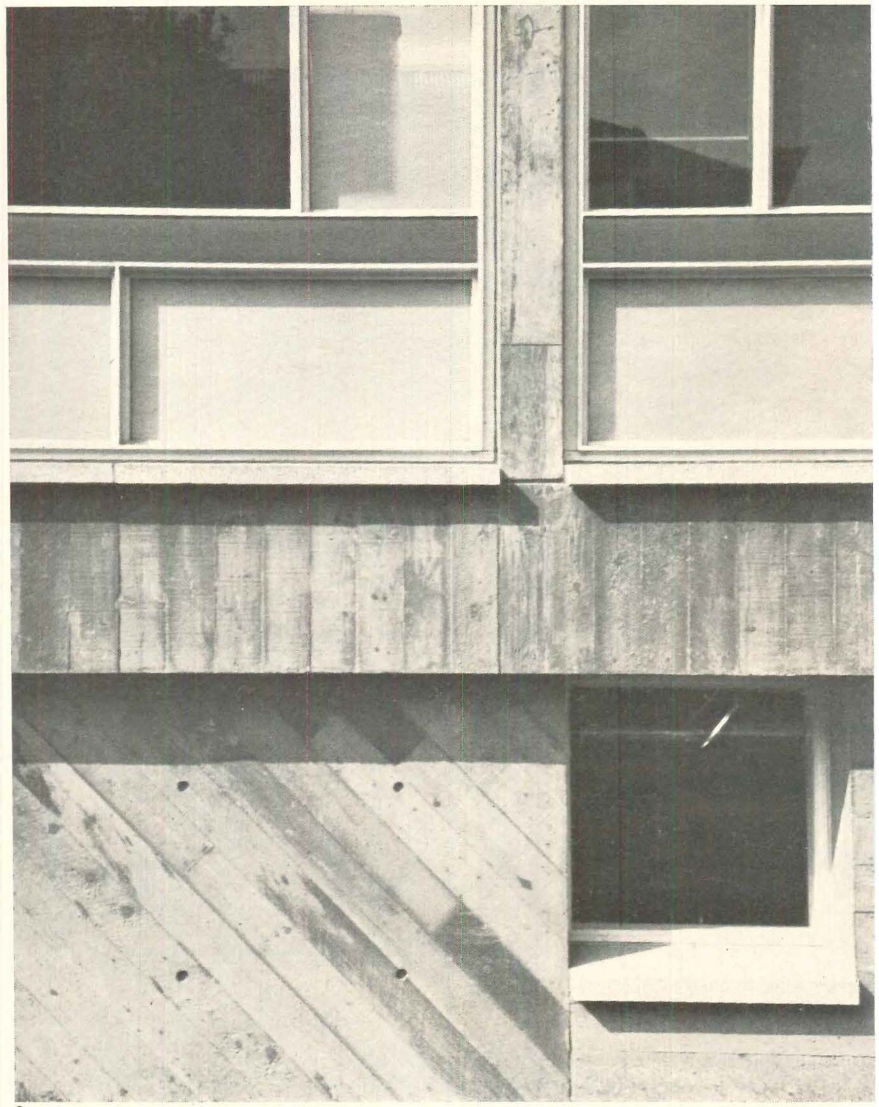
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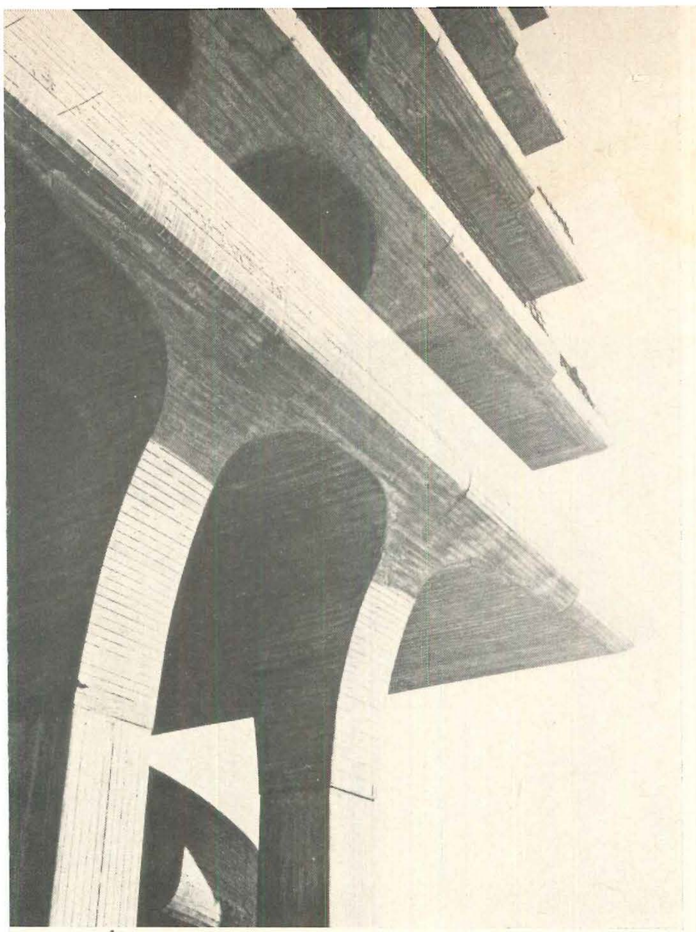
More a process than a building material

the century's most dramatic break-through in concrete technology came in the 1920s, when it was proven that the ratio of water to cement was the main determinant of compressive strength.

Civil-engineering research, meanwhile, has thrown new light on the importance of purity and size grading of aggregates. During the past decade the use of lightweight aggregates increased tremendously. Even in places still blessed by an ample supply of good stone, the one-third savings in weight made possible through the use of manufactured aggregates in long spans and tall buildings easily offsets the 25 per cent additional cost. Highway research also introduced air entraining agents to the mix, and these have been followed by a wide variety of other additives.

During the past 60 years, progress in concrete construction has been hindered by a time lag between theory and practice. Now the gap is being closed to within an irreducible minimum. The learning process goes on daily in the field, in the



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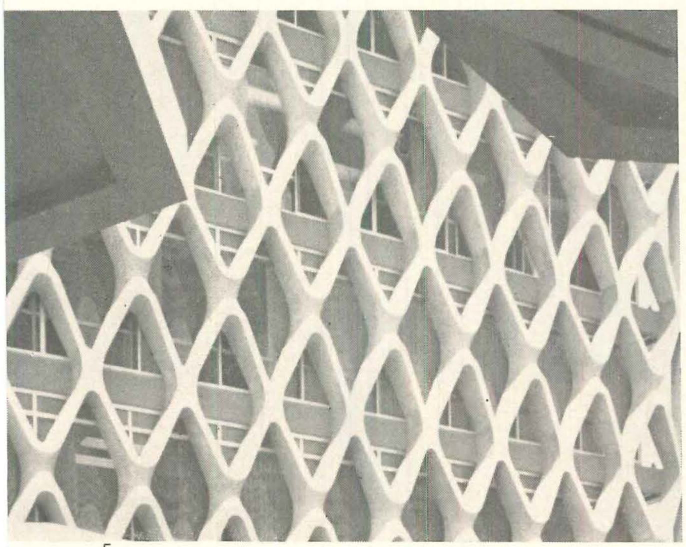

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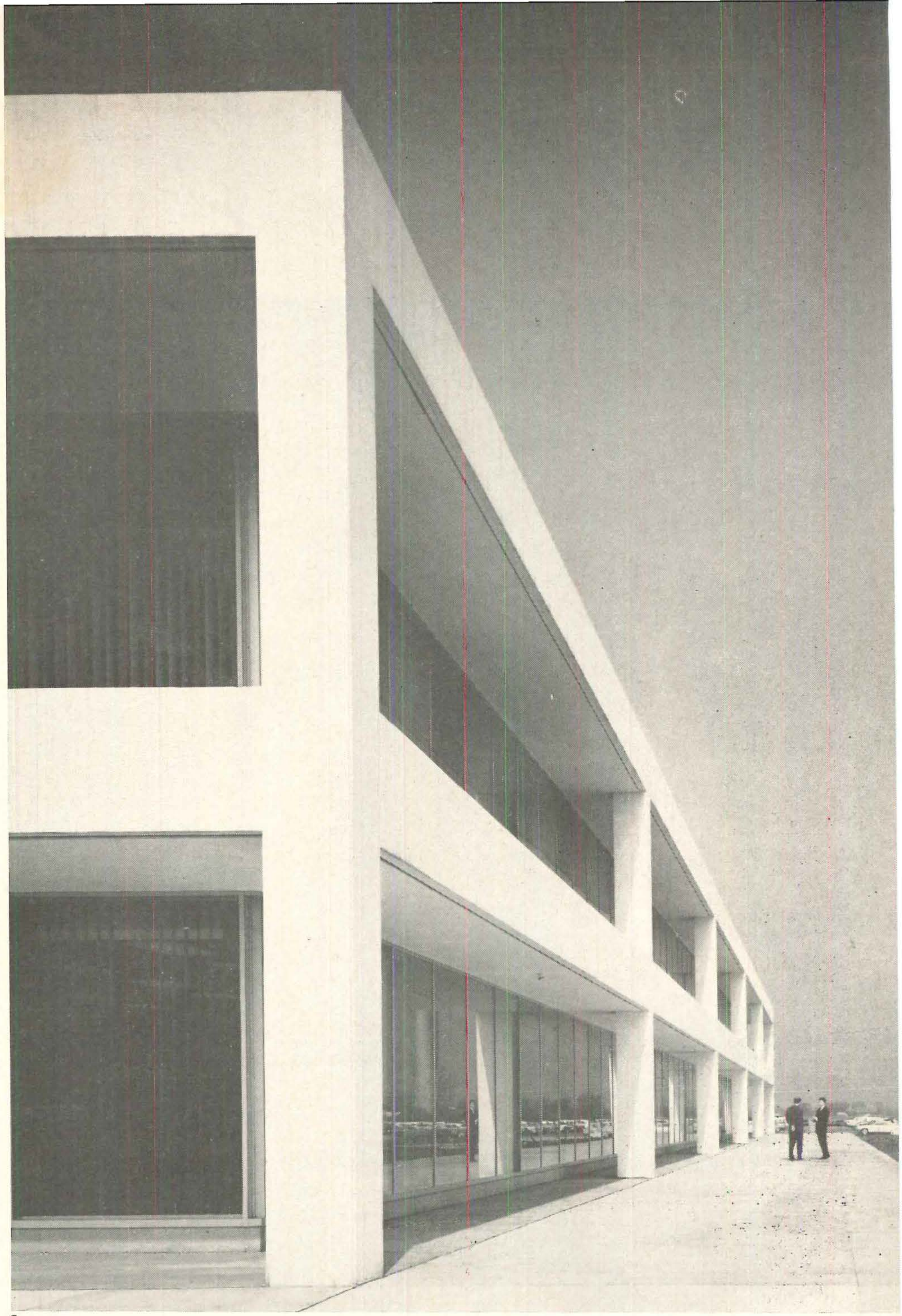

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plant, and at amazingly well-attended conferences (900 are expected at the Prestressed Concrete Institute convention this month, and another 1,000 will take part in the World Conference on Shell Structures in San Francisco in early October).

The enormous flexibility of concrete is an open invitation to trickery, and its successful use calls for a craftsmanlike care hard to find in this age of mass production.

An understanding of concrete begins with the realization that it is more a process than a material—an intricate series of decisions and actions rather than a ready-made tool. From mix to finish, all decisions are design decisions and all actions remain the responsibility of the designer.

Generally, his first choice is between two broad alternatives: whether to pursue the possibility of form and continuity inherent in cast-in-place concrete, or the building-block logic and precise control of precasting. Relative costs of the two still vary widely with time and place, but inevitably the basic construction-and-design concept for the building must control the final choice. Once this is made, the designer must seek the shapes and details which flow logically from the chosen method.

If this is a new age of concrete, it is an age of exploration, as the photographs above amply show. Out of this time must come convictions strong enough to give a sense of direction to the intense energies being devoted to a deeper understanding of concrete construction. The following 15 pages show how individual designers are seeking such convictions in the nature of the material itself.

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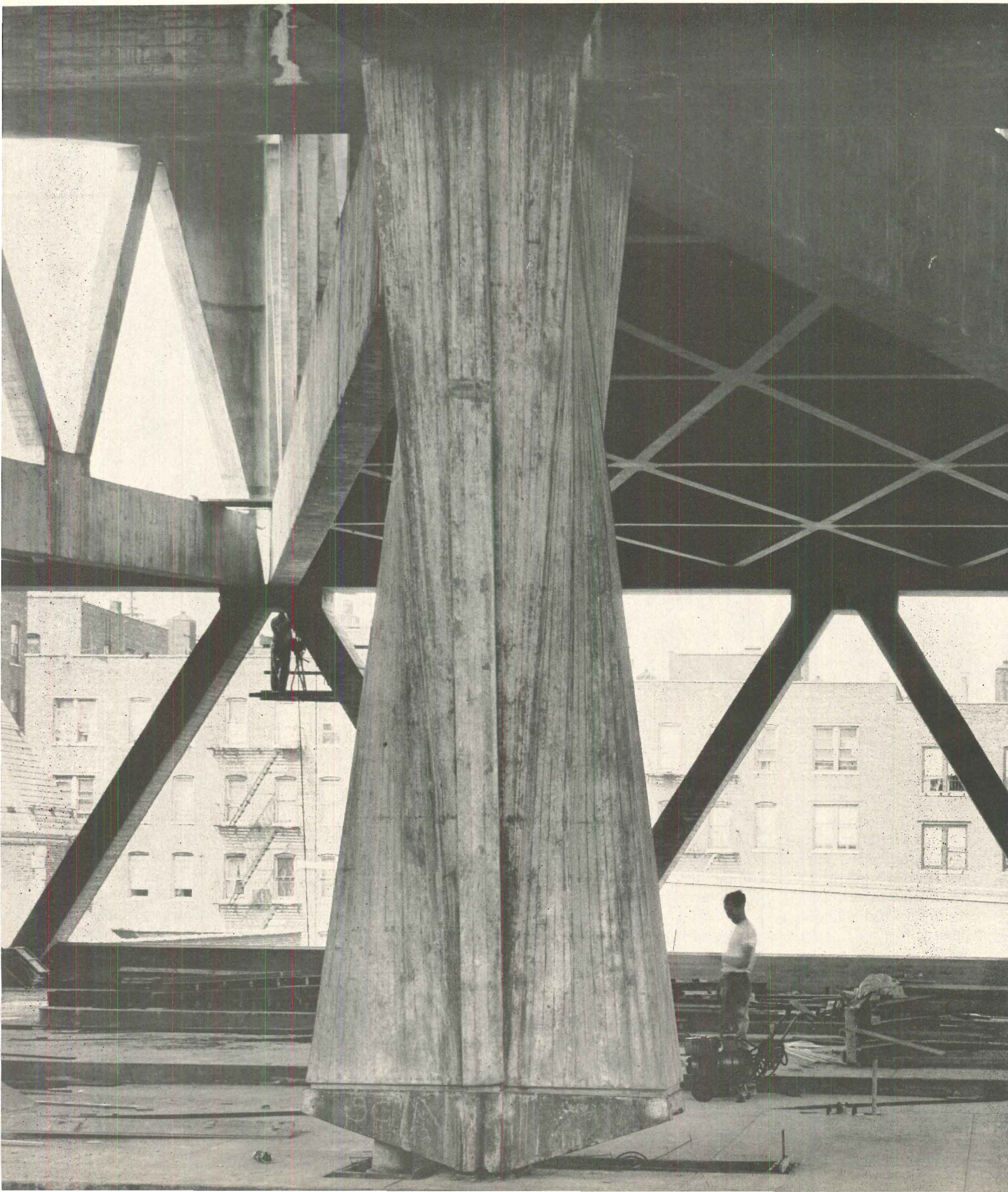
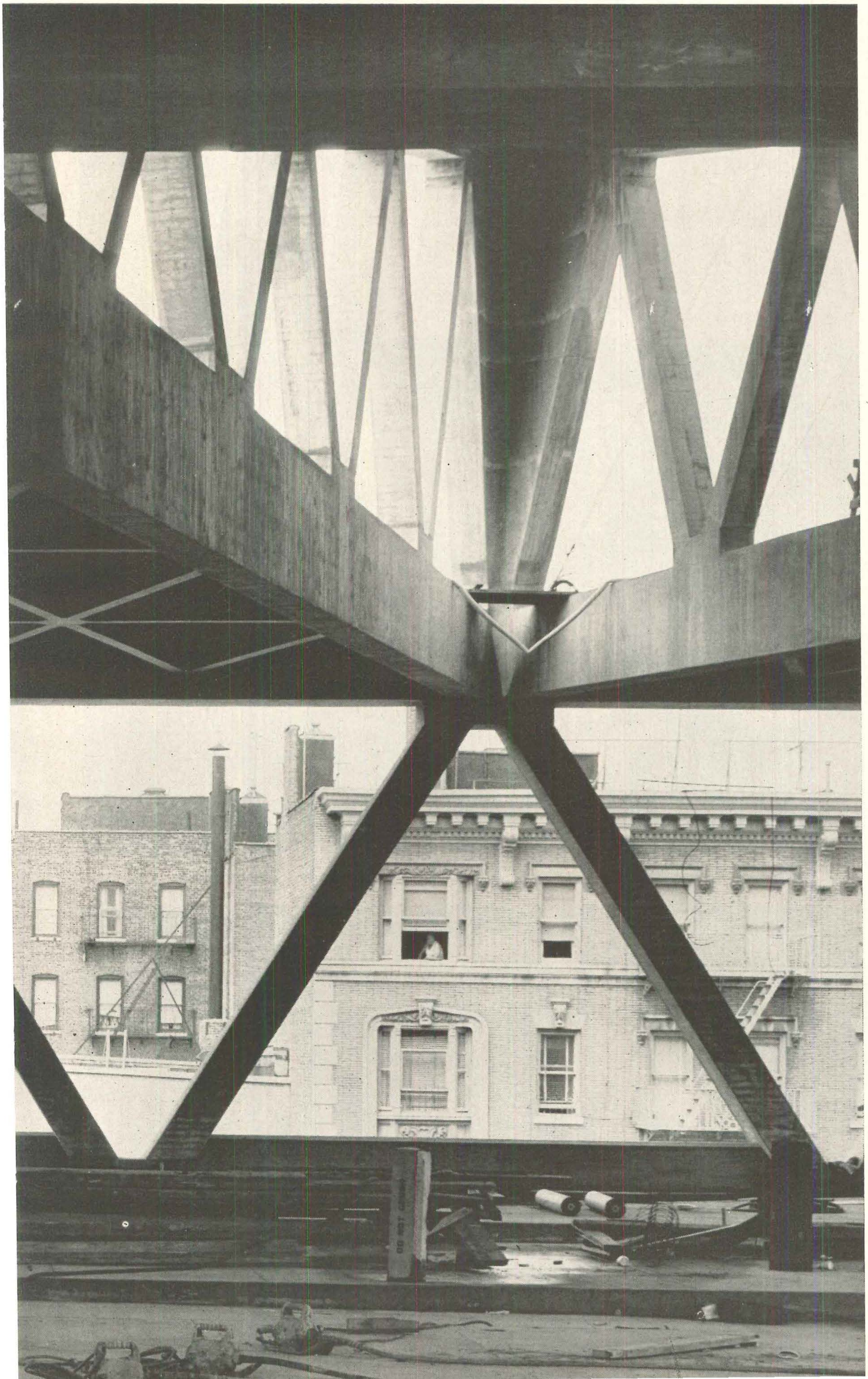
1. College Library, Ellensburg, Wash., Bassetti & Morse, Architects (Hugh Stratford—photo). 2. Commercial Credit Building, Philippine Is., Leandro V. Locsin & Associates, Architects. 3. Holyoke Center, Harvard University, Sert, Jackson & Gourley, Architects. 4. Parking Garage, New Haven, Paul Rudolph, Architect (Perron—photo). 5. American Cement Headquarters, Los Angeles, Daniel, Mann, Johnson & Mendenhall, Architects. 6. United Air Lines Offices, Chicago, Skidmore, Owings & Merrill, Architects (Hedrich-Blessing—photo).

PHOTOS: GEORGE CSERNA



Nervi's new gateway to Manhattan is a cast-in-place trusswork of concrete, full of strong detail and fine surfaces.

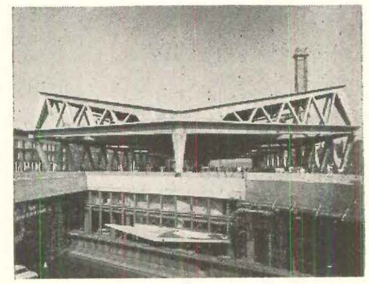


Pier Luigi Nervi's first U.S. building, the Port of New York Authority's mammoth new bus terminal now nearing completion at the end of George Washington Bridge, will come as a surprise to the master's many admirers in this country.

For this is a building very different from his European work: a vigorous, jutting boldness of form has replaced the familiar lacy delicacy; and his favorite device, the closed shell, was obviated by the program requirement for a sweeping stream of natural ventilation through the loading platform. So Nervi turned instead to a trussed structure that seems an extension of the bridge itself.

Perhaps the most unexpected change—and one that shows how concrete technology is shaped by time and place—is that the structure is entirely cast in place. The 12 by 18-foot triangles that comprise the pie-shaped wings of the terminal roof were initially conceived as precast sections. After experimenting with the casting of the triangles and investigating transport and placement, however, the contractors found that it would cost less to cast the entire roof on the job. Nervi accepted their findings.

One Nervi trademark that does appear is in the top deck's six central columns (opposite). They rise 17½ feet in an ever-changing cross section shaped to provide maximum clear floor space for the



buses at the base and maximum bearing area for the four trusses which come together overhead. A single form was used for all six columns; it was made with thin boards lovingly tapered and fitted in a cabinet maker's shop.

Prior to this, the Port Authority had never used exposed concrete on a building. So Chief Engineer John M. Kyle Jr., who deserves

Before putting trust in exposed concrete, the Port of New York Authority tested many mixes and procedures.

the great credit for engaging Nervi for the terminal project, sent his staff out to make exacting inspections of other uses of structural concrete as architectural finish. They came back convinced that concrete would stand exposure to extremities of climate only if the surface were very hard and dense. Most important, there could be no small bubbles of moisture left to create unsightly pits.

The Authority's testing laboratory then launched an intensive research program. A total of 129 different concrete mixes were tried in the search for the ideal proportions and ingredients. The tests soon focused on the bubbles.

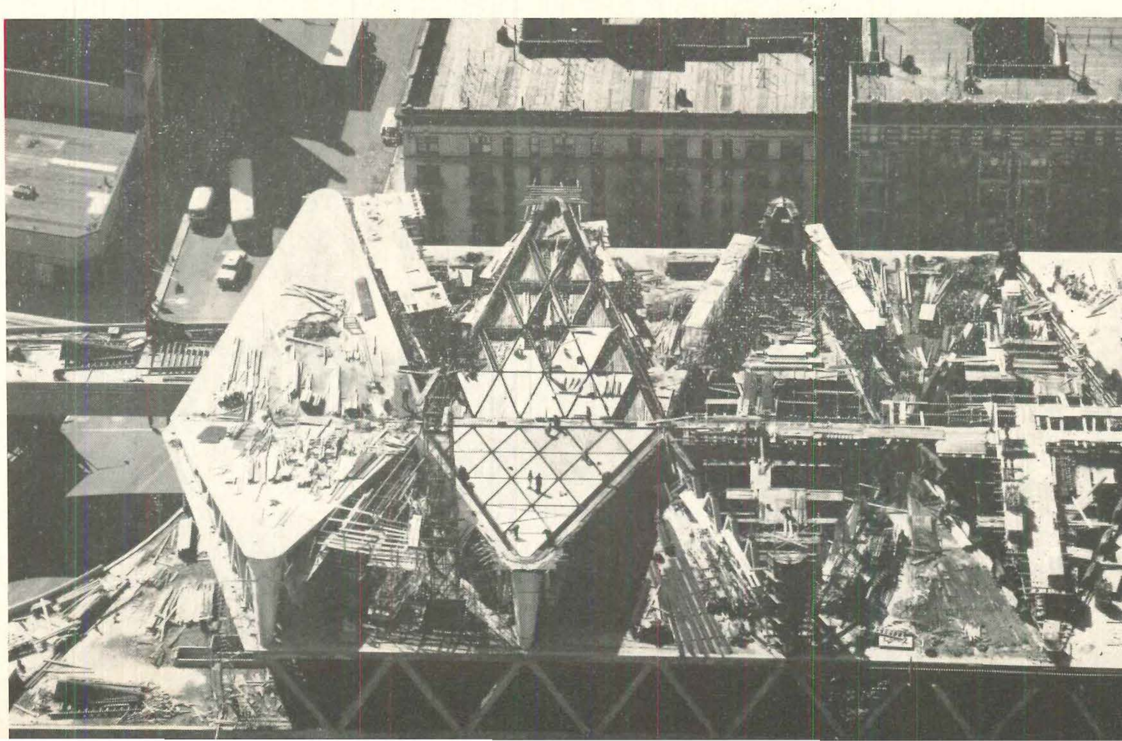
Globules of moisture that gather against the formwork or behind thin layers of cement leave surface pits when they evaporate. The Authority's materials engineer, M. E. Pitman, found that these bubbles are not caused by poor compaction of the material in the form, as was often suspected. Instead, in the two hours after the concrete is placed, the tiny beads of water force themselves to the surface through even the best-congregated mass.

Pitman tried a variety of remedies (including addition of "Mr. Clean" to the mix). The final recipe for the concrete specified included air entraining agents; a rounded, well-graded pea gravel for large aggregate; a 40 per cent proportion of sand in the aggregate; a slump near four inches; a mix of seven bags of cement per yard, with only 5¾ gallons of water per bag; and filling forms completely before vibration.

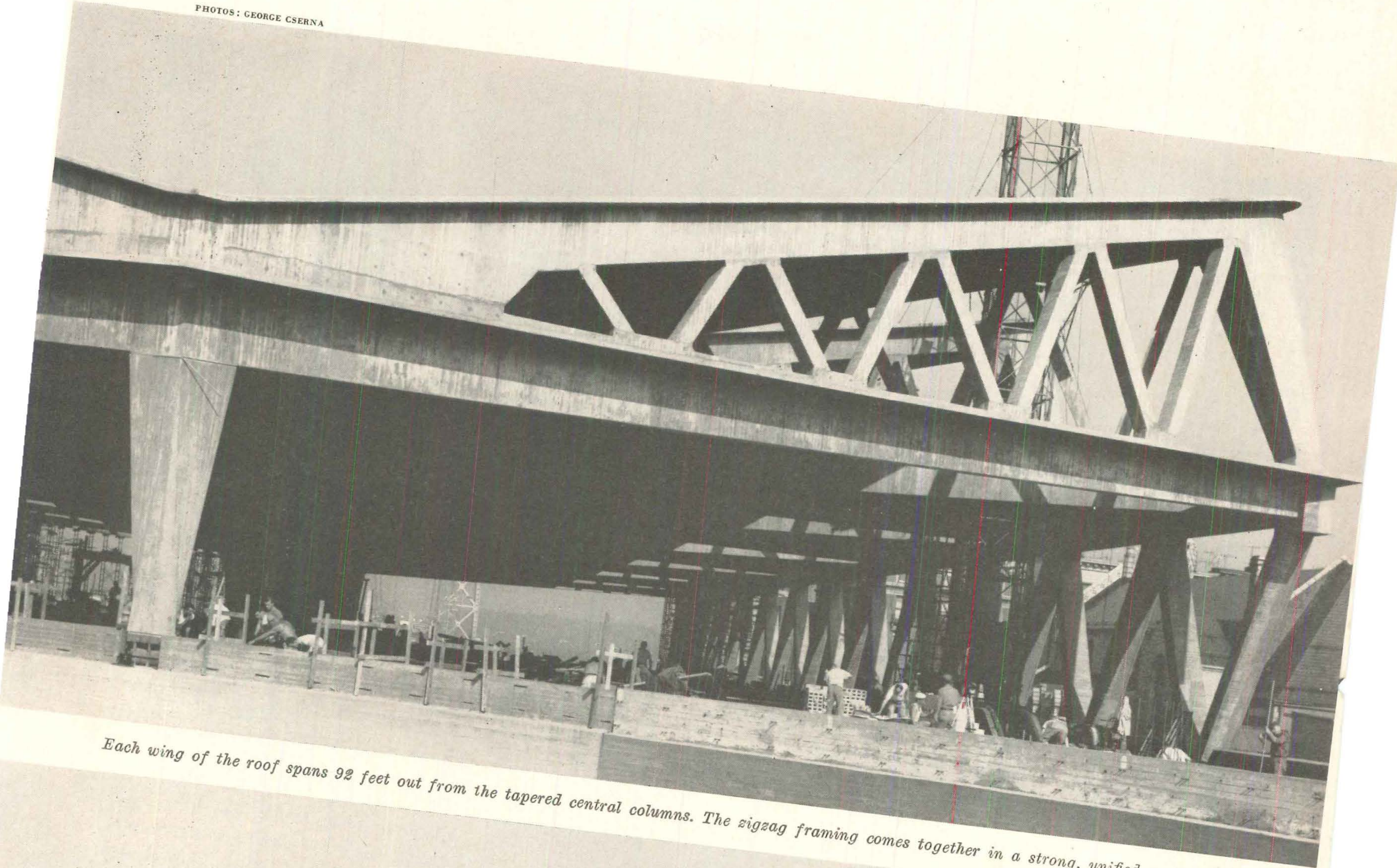
Casting was completed last month (see opposite page), and the resulting surfaces are spectacular in quality. Partly this was due to the research, and partly to the fact that Kyle had specially trained inspectors on the job, at the mixing plant, and even at the cement plant. By happy accident most of the workmen were of Italian origin; they were inspired by two visits Nervi made to the site. The 72-year-old master climbed the scaffolds with amazing agility. "*Bene, benissime,*" he said, smiling broadly at their work. "It couldn't be better."

PHOTOS: COURTESY THE PORT OF NEW YORK AUTHORITY

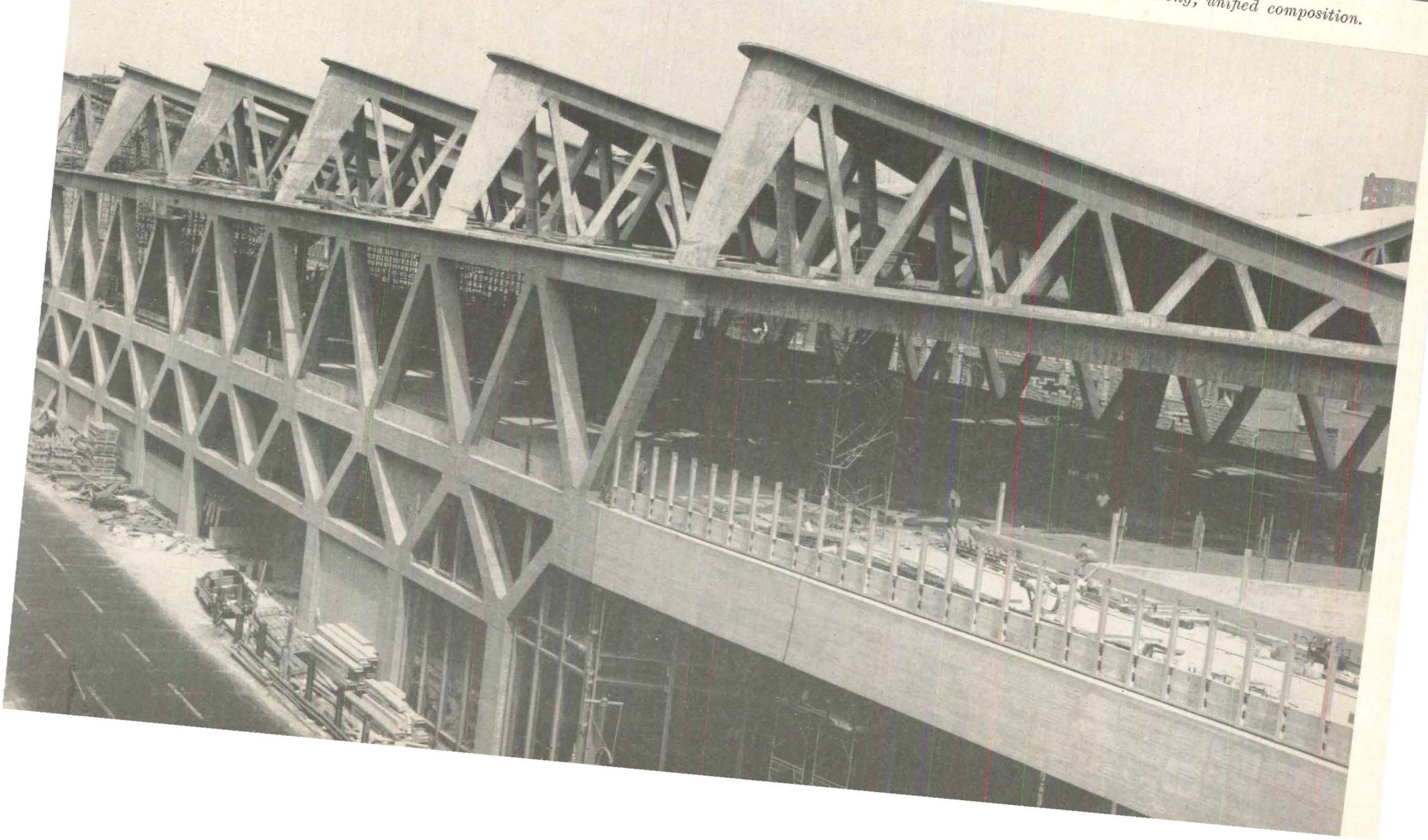
The terminal grows organically from the bridge. Early photo below shows casting of roof sections.

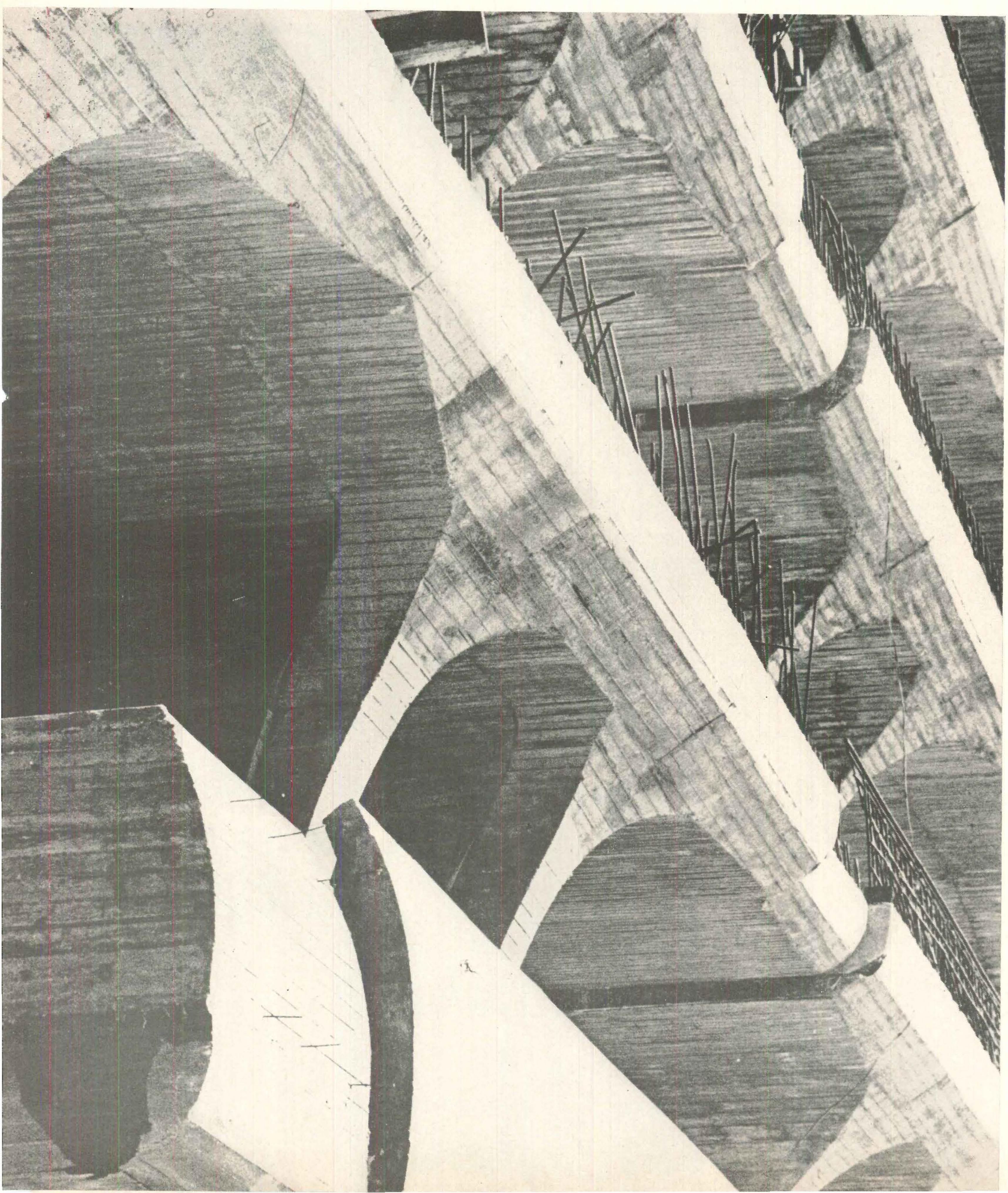


PHOTOS: GEORGE CSERNA



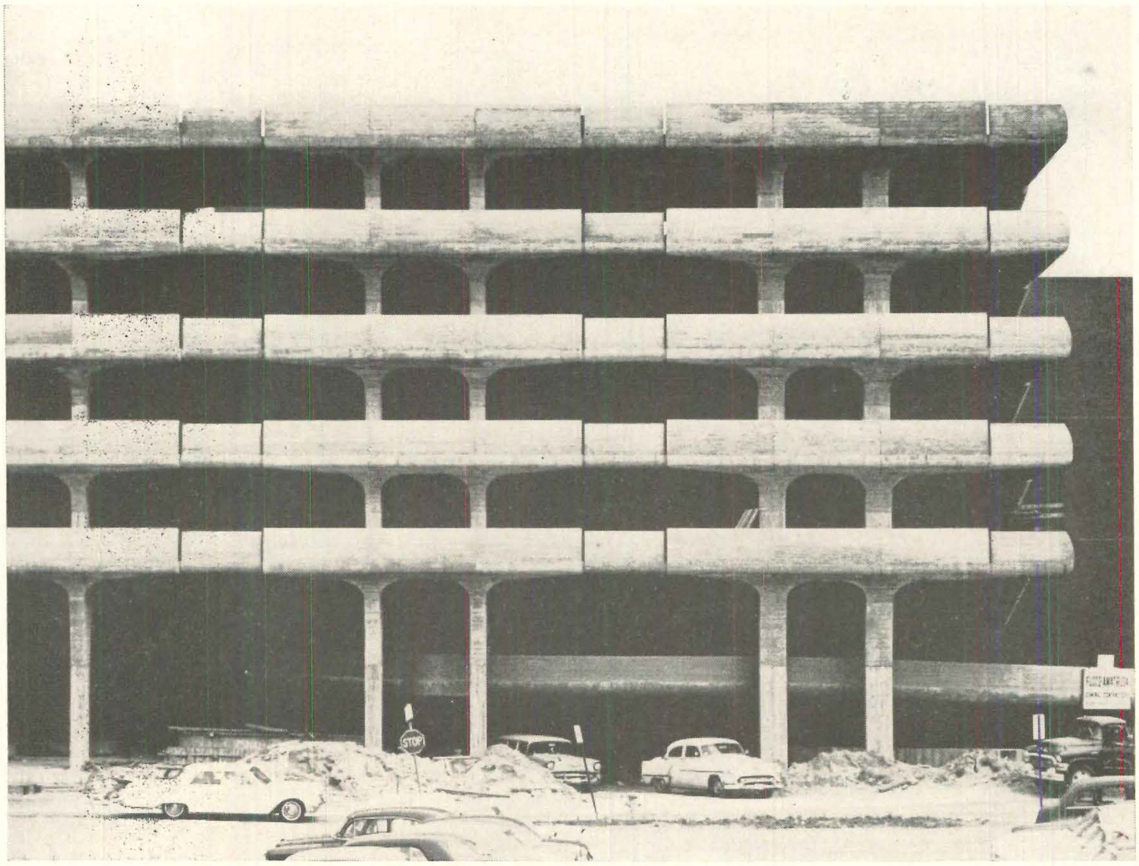
Each wing of the roof spans 92 feet out from the tapered central columns. The zigzag framing comes together in a strong, unified composition.





Rudolph employs special formwork to produce rugged textures that add depth and scale to concrete surfaces.

ROBERT PERRON



Boards striped the curves of the New Haven garage. Below, slotted forms lean against the Yale walls.

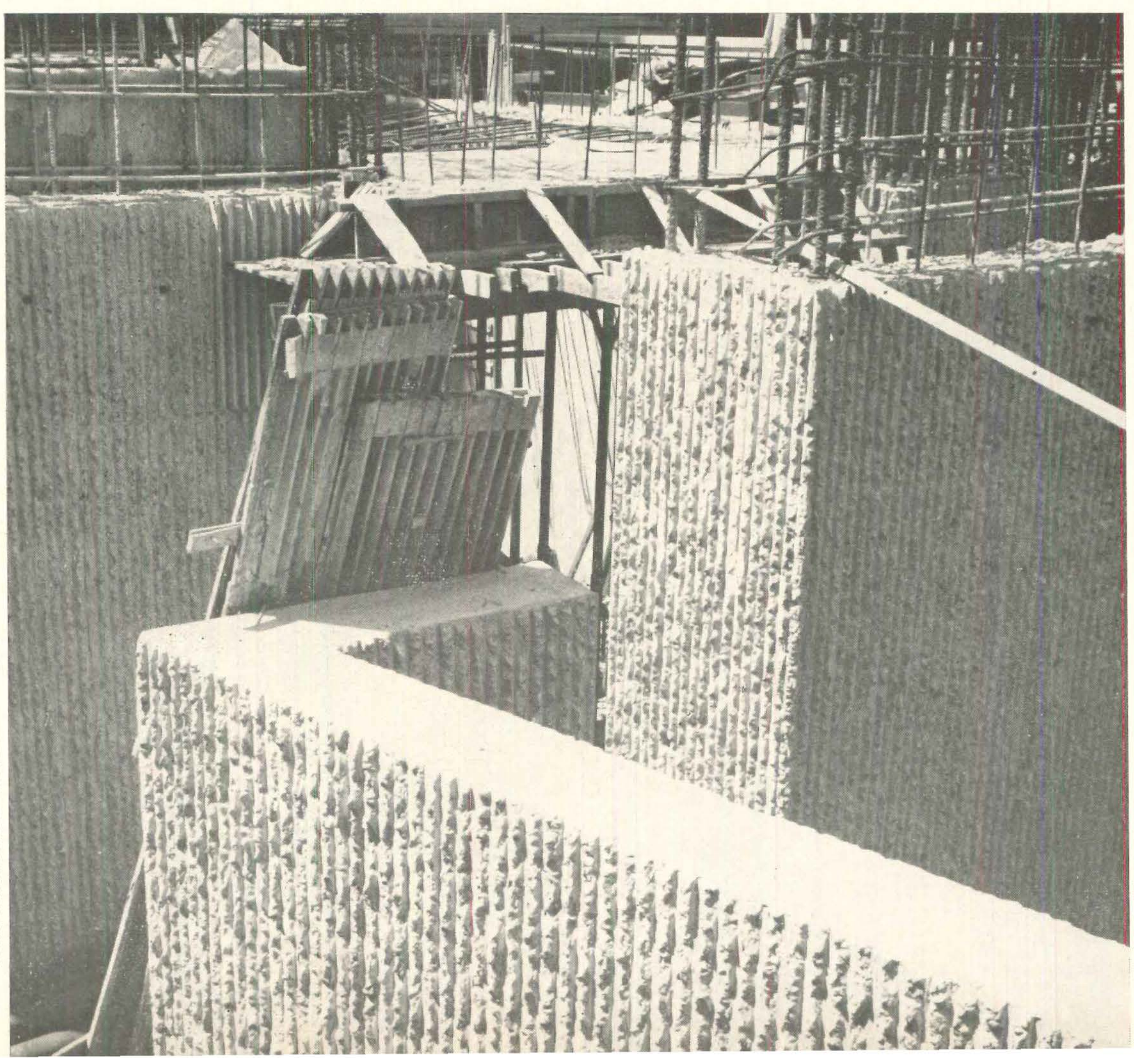


PHOTO OPP.: ROBERT PERRON; RIGHT: DER SCUTT

No phase of the process of concrete has more impact on the building's final appearance than formwork. Design of the forms, the precision with which they can be built, and the technique of placement all must be closely investigated by the architect who wants to design in the spirit of the material.

He must be familiar with the new forming materials—plastic, steel, coated plywoods—and the distinct design expression that flows naturally from use of each. Will he have just a few forms built and reuse them? Can placement and vibration be done carefully enough to prevent surface defects, or should irregularities be accepted as unavoidable and hidden in a rough texture? Should the formwork be so carefully crafted that it creates the final surface, or should it be built in a less costly way and the savings spent on a surface treatment?

In a pair of recent projects, Architect Paul Rudolph has used his forms as a primary design tool. He regards concrete as an essentially continuous and rough material, and believes that both characteristics should be expressed. He does so with considerable frankness in the city of New Haven parking garage (opposite and top, left), a building that is soft in shape and hard in surface. Here plain board forms emphasize the structure's two-dimensional curves, impart a bristling texture, and in Rudolph's view, establish the desired scale for this kind of construction.

But the pockmarked, striated walls of Rudolph's Arts and Architecture building at Yale (left), just beginning to rise, make the garage look almost smooth by comparison. Under a patented process, the forms are standard plywood panels bearing parallel wood strips of a truncated triangular cross section. Within 20 hours after the low-slump concrete is placed (the timing is critical), the protruding fins left by the vertical strips are knocked off with claw hammers, exposing the large aggregate. The irregular surface is then wire brushed, and the form re-used down the line.

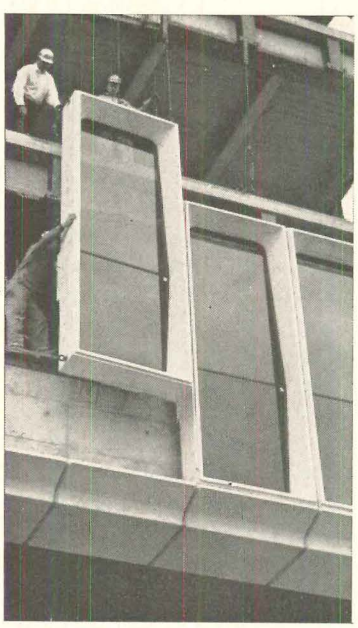
Several architects have used precast concrete for a variety of curtain walls that offer bold texture and solidity.

In mid-town Manhattan, the last of 9,000 precast concrete panels are being hoisted to top floors of the Pan American Building (right). In Houston, 2,300 precast frames are being placed across the broad face of the Jefferson Building (below). All across America, precast curtain walls are bringing new spots of brightness to the skyline.

In part, their sudden popularity is due to the same esthetic reasons that have turned architects to other uses of concrete—a desire for visual solidity and texture. But there are other, deeper reasons as well.

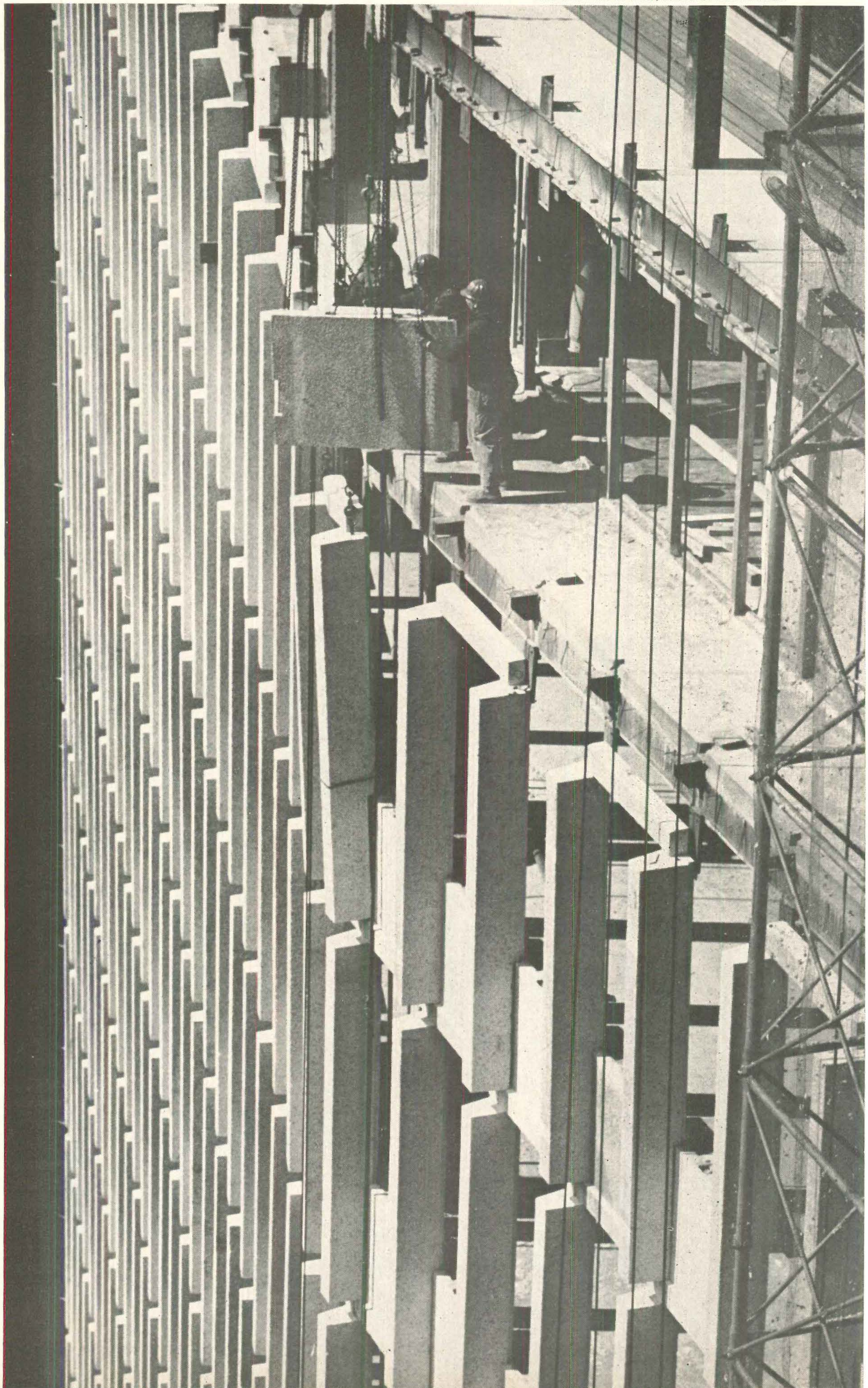
Cost of precast concrete curtain wall has been brought down to the point where it is competitive. Precast panels easily meet code requirements for fire resistance, can be prefinished inside as well as out. The surface absorbs some moisture, relieving pressure on the joints. Shipping the panels is no longer a major problem. Big new cranes allow erection directly from the truck without rehandling.

The handling process, in fact, often puts more stress on precast wall panels than they will ever feel after erection. They are far stronger than their ultimate use demands, prompting some designers of curtain walls to switch to using precast pieces as load-bearing elements. In short, we may be coming full circle—from bearing wall to curtain wall and back.



ARCHITECTS: WELTON BECKET & ASSOC.; PHOTO: LOU WIT

ARCHITECT: EMERY ROTH; PHOTO: J. ALEX LANGLEY



Others are pursuing the great potential in precast units for integrating structure, enclosure, and services.

The adjoining photos show samples of the wide range of structural shapes that are today coming from the precasting plants. These shapes demonstrate that designers are beginning to bring precast members out from behind the skin and make them the building form.

Precasting is the industrialization of the concrete process, a partial realization of the ancient dream of the philosophers of building to move work from the job site to the factory. But it remains a far cry from the economy and efficiency of large-scale U.S. mass production.

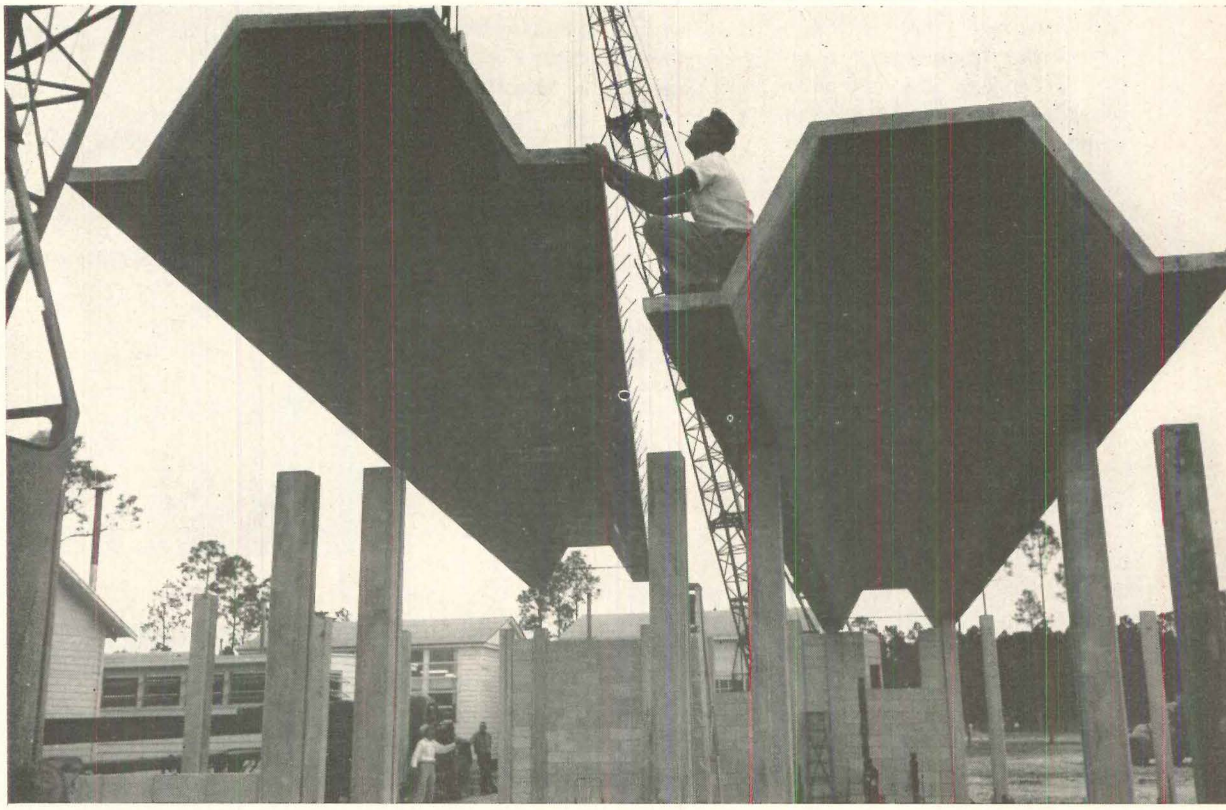
Typically, the precaster's plant is a small one and his trade is in tailor-made shapes. The upshot is that the total cost of research, development, and design—and above all the premium price of crafting special forms—must be charged to a single project. Obviously the unit cost could be sharply cut if the producer were able to sell standard items out of stock, but he is loath to make them without evidence that they will find acceptance among designers. For his part, the designer is unwilling to give up his flexibility.

The result is a stalemate that must be broken if precast concrete is to keep up its headlong progress. There are two possible answers: to put an all-out push behind standardization, or to accept custom shapes as a fact of life and develop machines to make them cheaper. It's time that both designer and producer got together on which to follow.

But an even more pressing challenge lies in further development of the opportunities in the fantastic precision of precasting. The kind of refined members that precasting can turn out are eminently worthy of expression; in precast concrete, the distinction between skin and bones no longer makes much sense. Moreover, the process is precise enough to permit the further step of integrating mechanical services.

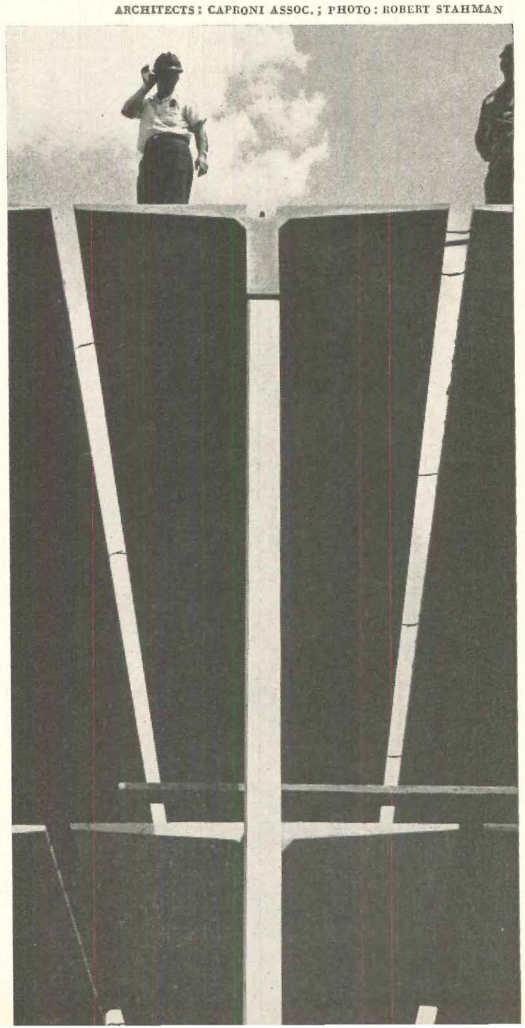
On the following pages is a report of how some designers and producers are pursuing these directions to move precast concrete toward maturity.

ARCHITECT: ROBERT BROWNE; PHOTO: JACK HOLMES

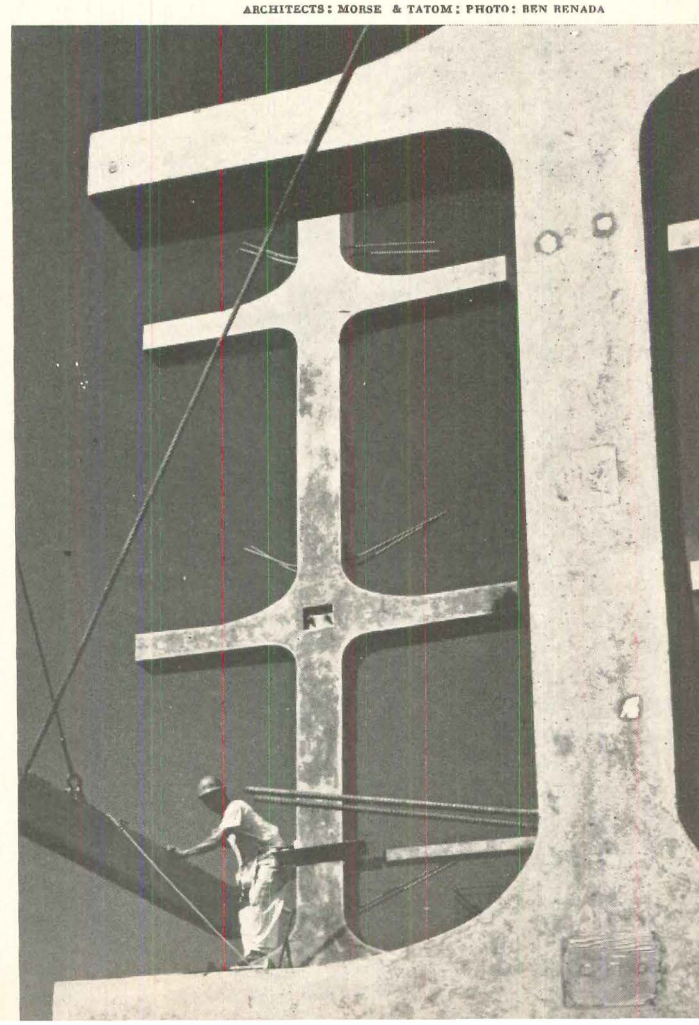


Today the shape of a precast concrete structural member is limited only by the designer's imagination. Above, blunt-nosed folded plates for a Florida school. Below left, clean and classic T beams for a Connecticut office building. Below right, exotic column trees for an apartment house in Hawaii.

ARCHITECTS: CAPRONI ASSOC.; PHOTO: ROBERT STAHMAN



ARCHITECTS: MORSE & TATOM; PHOTO: BEN RENADA



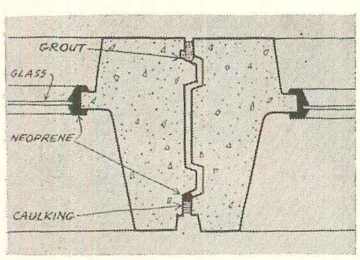
SOM's Banque Lambert in Brussels uses cross-shaped units of Schokbeton to form a grille of columns and beams.

With the Belgian bank building shown at right, the Schokbeton process has completed a round trip to the U.S. and back to its home territory. It has picked up a steadily increasing number of admirers along the way.

Schokbeton arrived in the U.S. in 1959, just 27 years after it was discovered by a man pushing a wheelbarrow over a bumpy road in Holland. In principle it is uncomplicated: A very stiff mix (zero to half-inch slump) is compacted into the forms by giving it a sharp jolt at the rate of 250 times a minute. Yet the material thus produced has such unusual properties that its full potential can only be realized through a thorough reexamination of many of the old limitations on concrete design.

In most of its first uses in this country, Schokbeton was chosen for what might be termed its fringe benefits. One is that it produces exceptionally dense watertight surfaces with ease and unerring certainty. Also, it is capable of reaching very high 28-day compressive strengths. Specifications generally call for a 6,000-pound compressive strength for a 6-inch test cylinder, but Schokbeton could probably double that if asked to.

But the qualities of Schokbeton



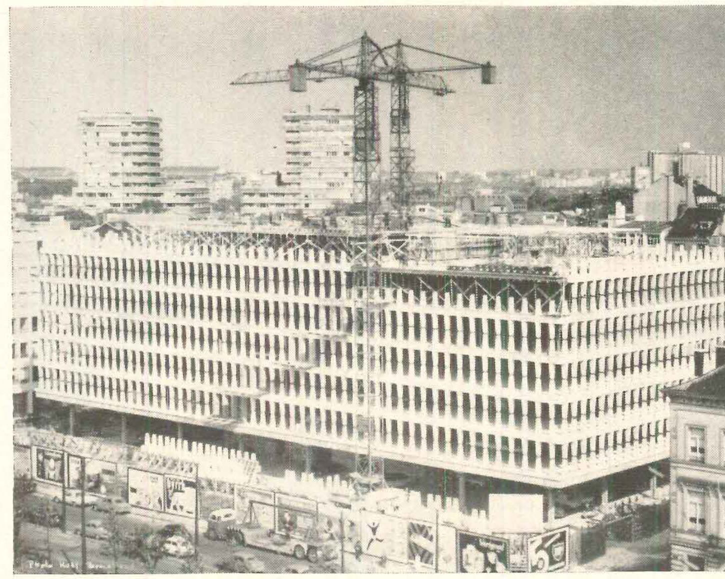
that could mean the most to the designer are only beginning to be plumbed in actual practice. The most challenging of them derives from the fact that Schokbeton sections can be cast in dimensions up to 12 by 40 feet. Their sheer size is a logistical challenge, but allows economies of production that can balance the extra shipping and handling costs. The minimum content of cement allows a tolerance range from plus zero inches to minus 3/32 of an inch. And within these wall-size building blocks, the architect has close control of line and detail.

Reinforced sections of Schokbeton can be shaved down to as little as two inches in thickness (the Dutch have gone so far as to use these thin sections for glazing bars). Projections not requiring reinforcement can be even more delicately detailed, just so long as a one-in-five slope is held on surfaces from which the formwork must be stripped.

Beyond the opportunities for crisp articulation of form, the refinement of shape possible with Schokbeton opens up new ways of looking at the critical design problem of detailing joints. Use of window frames between the concrete wall and its glazing can be totally eliminated by casting in a projecting lug around the openings; it is then fitted directly with a gasket to support the glass (see drawing). Simple tongue and groove joints lined with a strip of gasketing offer a much more secure barrier to weather than the more complex details required when panels are simply butted.

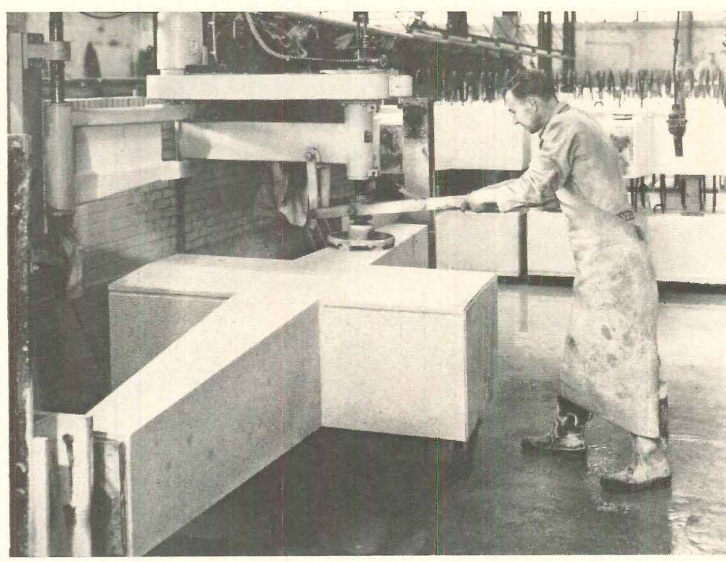
Schokbeton was brought to the U.S. by George J. Santry, an international trade expert who had been impressed by its use in rehabilitating war-torn Dutch cities and subsequently spent several years there working with the parent company. After a brief period of market testing (during which Santry excited the interest of such architects as Yamasaki and Belluschi) and a search for qualified franchisers, the first two U.S. Schokbeton plants went into operation, one near New York and, last year, a second near Chicago. From the start they have been busily producing parts for major buildings. This fall others will open in Pittsburgh, Miami, and Montreal.

One of the most impressive uses of Schokbeton by an American firm, however, is taking place back in Brussels. The structural grid of Banque Lambert, designed in the New York office of Skidmore, Owings & Merrill, is composed of cross-shaped Schokbeton units joined by a jewel-like stainless-steel connector at a point halfway between the floors and ceilings. The crosses were lovingly honed to a granite-like finish at Schokbeton's Rotterdam plant.

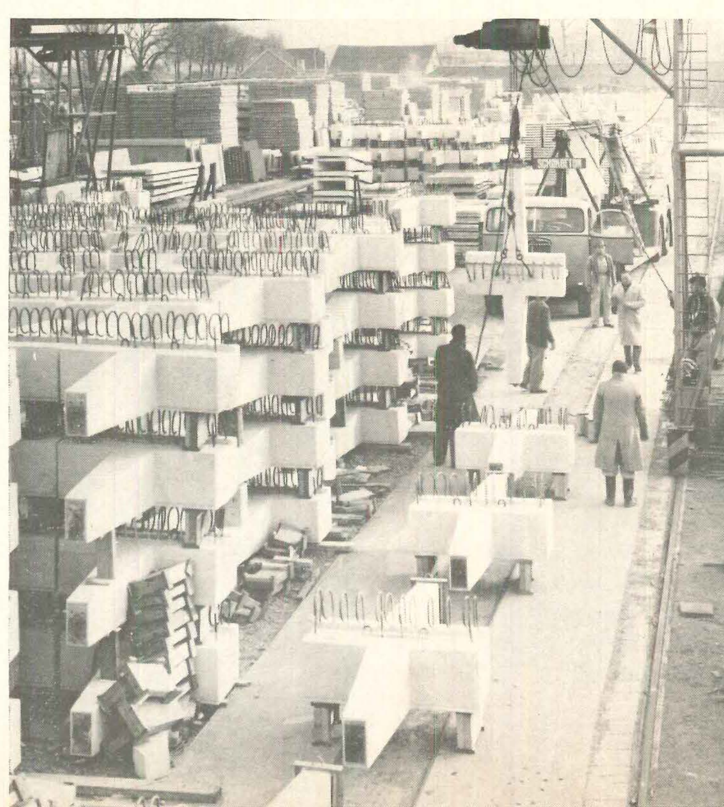


CH. HULEY

The crosses of Banque Lambert: erection, manufacture, and storage.



DU PARANT



DU PARANT

Chicago manufacturer shows how producers can advance the technology of prestressed structural concrete.

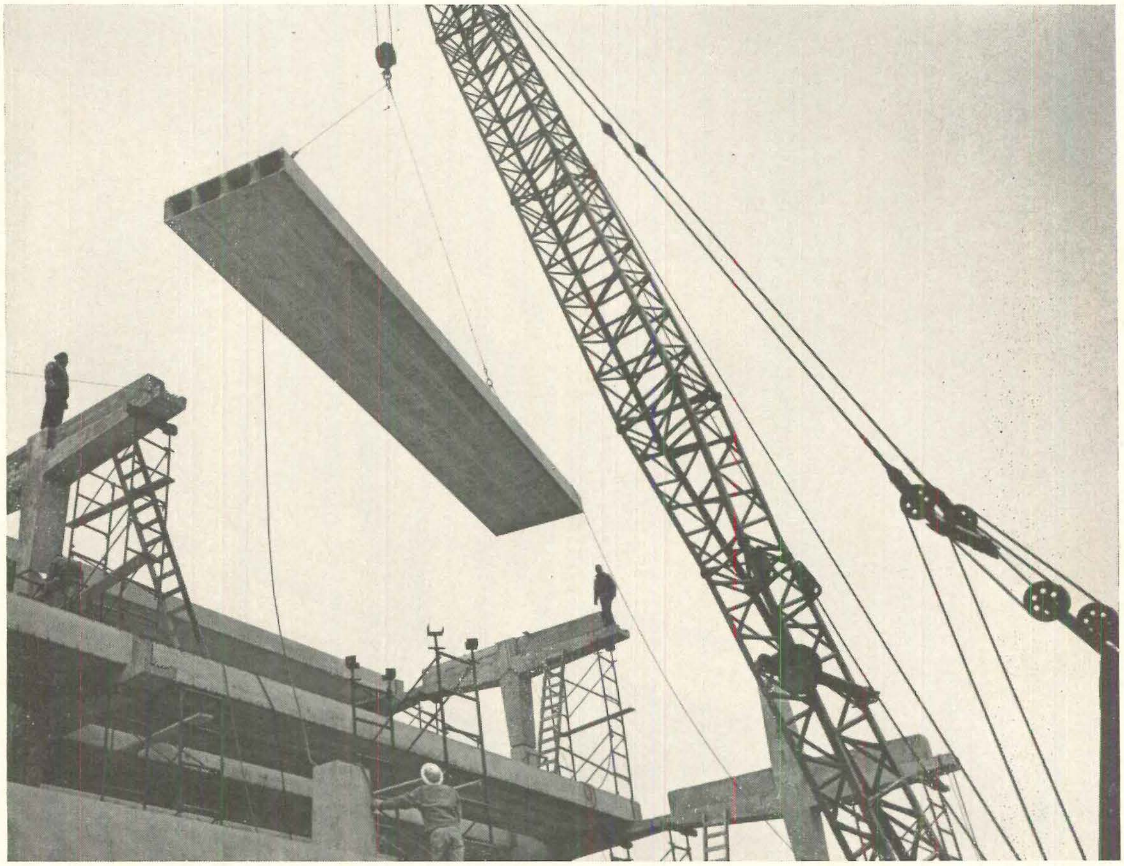
It takes extensive research to develop the tools to make the most of the break-through in concrete technology, and it takes real money for research. In many areas, producers of concrete ingredients and components simply cannot afford the cash, so advances occur at a snail's pace.

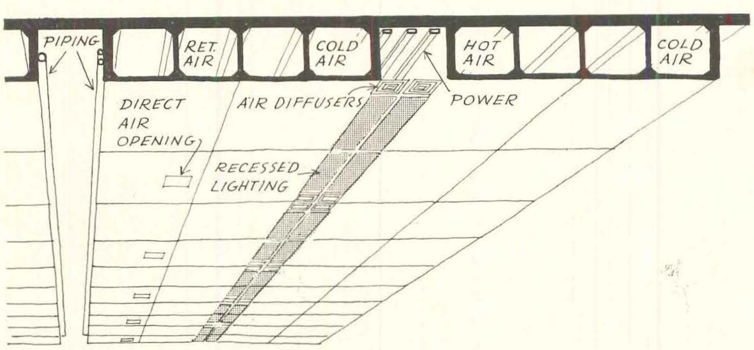
Elsewhere, however, well-capitalized companies are acting as prime movers of rapid progress. One such is Material Service Corp., since 1960 a part of General Dynamics. Bulwarked by gross annual sales well over $100 million, Material Service has spent the last decade bringing a highly advanced technology to the six-state area around Chicago.

In the mid-1950s, the company began an intensive geological search for a shale deposit which would yield a superior lightweight aggregate. It found the stone, then built a plant in Ottawa, Ill. The plant is automatic to the point of functioning like a single, giant machine. The resulting aggregate would delight the most meticulous designer—smooth, round, and watertight.

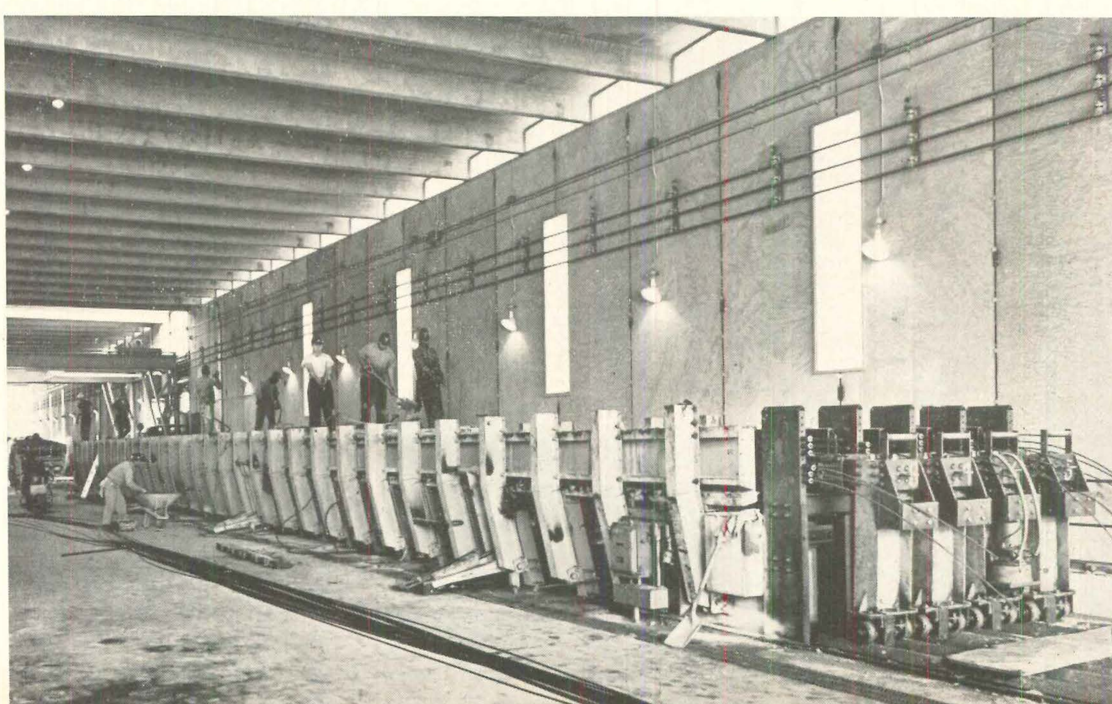
But the company's most spectacular contribution is its deceptively simple-looking precast, prestressed cored slab. The 8-foot-wide slabs eventually will be made in depths ranging from 8 inches to a 24-inch unit spanning up to 100 feet. They are detailed like a series of connected I beams, using concrete near its ultimate efficiency. The 1-inch thickness of the top and bottom flange areas is made possible by use of a casting bed that allows 0.183-inch-thick wires to be stretched transversely as well as lengthwise.

Some 100,000 square feet of the cored slabs are being used in the extension of Evergreen Plaza shopping center in suburban Chicago. SOM's Chicago office, the architects for Evergreen Plaza, made full-scale load tests to see how the 20-inch-thick slab would stand up under the 100-pound-per-square-foot design loading over 49½-foot spans. It took the first 100 pounds easily—then went on to support an additional 300 before collapsing when deflection reached an astounding 23 inches.

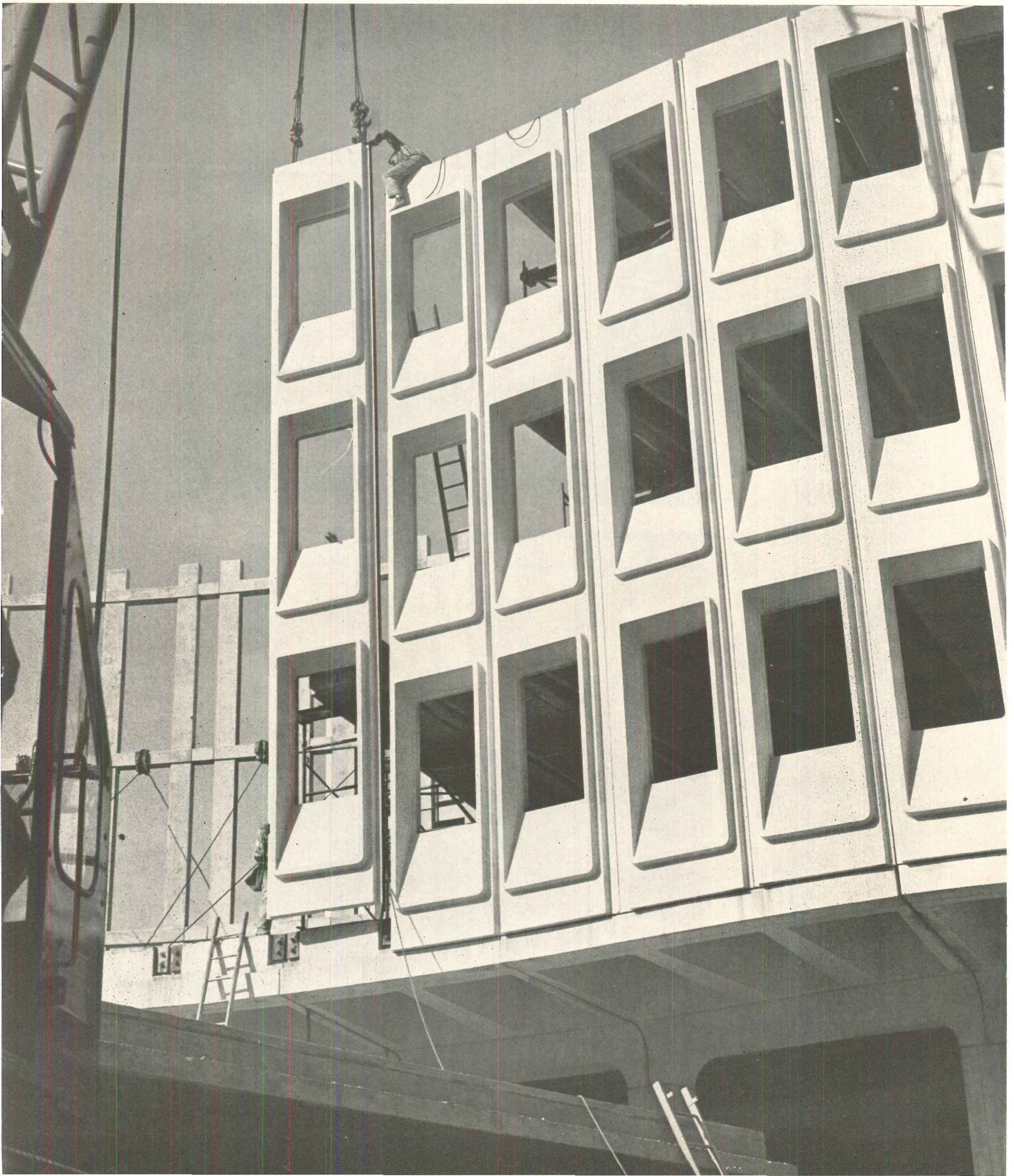




Above, a crane lifts one of Evergreen Plaza's cored slabs into place. Twenty inches deep, they span 49½ feet. Left, Material Service's next development: a completely integrated building system based on its prestressed members. Air handling, piping, wiring, and recessed lights all are accommodated within the structure. Below, giant casting machine can produce beams up to 100 feet long.

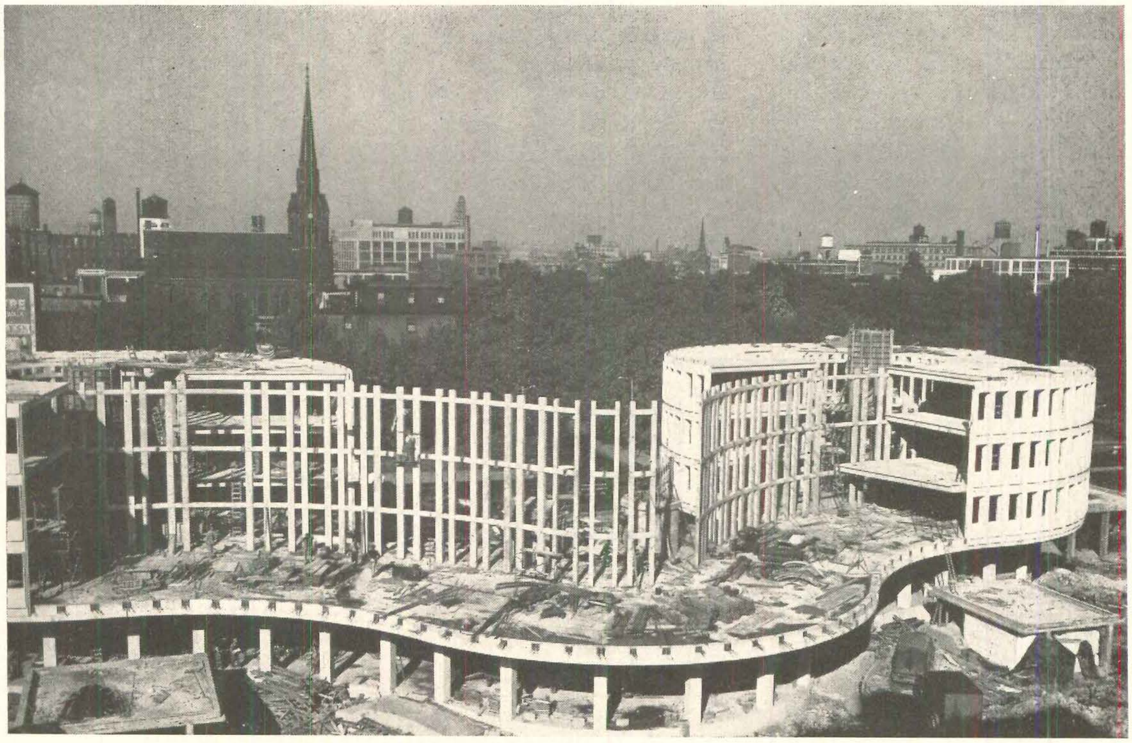


LAWRENCE S. WILLIAMS, INC.



Philadelphia architects develop a precast concrete system of 2,000 load-bearing units that do three separate jobs.

LAWRENCE S. WILLIAMS, INC.



Assembly of the superstructure went from both ends to middle. Cantilever below bears the crucial steel strands.

GEORGE ADAMS JONES

In Philadelphia's new Police Administration Building, Architects Geddes, Brecher, Qualls, & Cunningham have drawn a curvilinear form from a process normally associated with a prismatic approach to design. Moreover, they made each of the 2,000 pieces of precast concrete work hard for them as major structural elements and matrices for the mechanical systems.

The lone portion of the superstructure cast in place was the latticework of columns at the building's core (see photo at left). This went up first, creating a permanent scaffolding used as the corridor wall. It serves as inner support for the deep-ribbed, wedge-shaped floor panels, each of which spans 32 feet.

It is the outer wall, however, that most clearly shows just how much freedom and structural interdependence can be extracted from precast units. The three-story window sections (opposite page) actually carry the lion's share of the loads from the two upper floors and roof; they are taken on vertical ribs which are

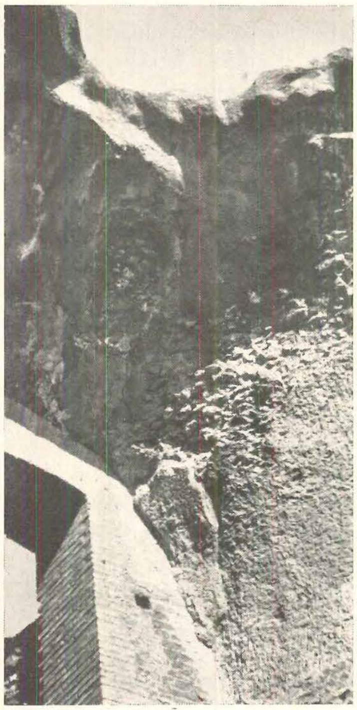
formed to leave space for the air-conditioning system's pipes and ducts. The integral window spandrel acts as a web.

The tall panels rest on the ends of precast sections cantilevered 12 feet from a line of columns at ground level (left). Strands of high-tensile post-tensioning steel knitting the overhang into the body of the first-floor slab actually hold the building together.

All panels exposed to the weather were given the Schokbeton treatment (see page 92). Those exposed to exterior view are of a distinguished mix of white cement, white sand from Maryland, and white quartz from Georgia. It cost six times as much as the gray concrete used for the coffered floor slabs.

But, in the end, the one question asked by all is: how will concrete look after 30 years? Here are 10 empirical answers.

HENRY MILLON



Roman ruins, like those above, give mute evidence after 18 centuries that concrete can be made to stand the test of time and weather. Unhappily, some later experiments in the U.S., after the turn of the century, proved less convincing: there were so many conspicuous failures of surface that most architects and engineers were certain it was folly to bare concrete to the elements.

But these experiments also produced some surfaces which somehow stayed sound as time passed. A few hardy scientists and engineers were intrigued, and over a period of 30 years assembled bits and pieces of information about the durability of exposed concrete. There was little evidence of how the occasionally brilliant results were achieved. So the investigators had to concentrate on what not to do, painstakingly examining specimens of deteriorating concrete to isolate the exact source of every type of failure.

Their findings add up to a reliable body of highly empirical rules for making concrete that can be depended upon to last through the useful life of the building. They can be summarized as follows:

1. Cement content of the mix has to be kept within fairly narrow limits. Too little will leave particles of aggregate unbonded to the mass; too much will produce a concrete which shrinks and swells with changes in the weather.

2. Pure, well-graded aggregates must be used. The cement paste holds up best if it is reduced to a thin film surrounding a dense, completely interlocked mass of stone and sand—the kind of mass that can only result from just the right percentage of each size of aggregate. Unsuspected impurities in the aggregate can result in small, delayed-action explosions; it is vital to know the pedigree of the quarry.

3. Probably the single, most powerful influence on durability, as it is on strength, is the water-cement ratio. It is also the most troublesome. To make the mix workable, far more water must be used than is required for the hydration process which hardens the cement. The excess water evaporates, eventually leaving pores. If the water content is increased too greatly, the pore structure grows large enough to leave the surface vulnerable to attack.

4. Job-site conflicts over the water-cement ratio have raged for years. Today they can at last be simply resolved by introduction of air entraining agents. A few ounces in a truckload of concrete is enough to create some 500 billion tiny bubbles per cubic yard, amounting to 3 to 6 per cent of the total volume. Unlike the pores caused by excess water, these bubbles act as safety valves to relieve the hydraulic pressures developed in the microstructure of the concrete when moisture penetrates, freezes, and thaws.

5. Mechanical vibrators have done much to insure proper compaction of the mass in the forms, but timing has to be just right. Vibration after the concrete has begun to set can be ruinous.

6. Careful curing is indispensable. The clear summer days that seem so ideal for casting concrete in the field have their drawbacks. Water evaporates rapidly from the surface of newly cast sections left unprotected, and the top layer is parched for even the small amount of moisture needed to complete the set. The surface will look fine at first, but after a few springs and winters it will suddenly disintegrate. In cold weather, of course, the same thing can happen if the freshly cast concrete sits unprotected and the water is allowed to freeze.

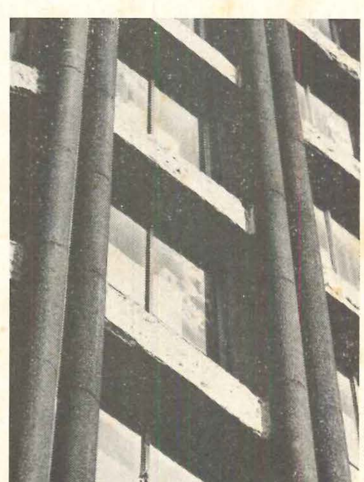
7. Spears of rusty reinforcing poking through an old concrete surface are a depressingly familiar sight. Here there are no magic remedies; only conscientious attention by both the designer and the men who place the bars and cast the concrete will prevent this from happening.

8. Prestressing, in addition to its structural contributions, can serve to keep cracks closed on exposed precast sections.

9. Much of the pressure for exacting control of workmanship can be eased by use of one of the many protective surface coatings now available. But careful investigation of the coating's performance is essential.

10. Finally, the designer must keep constantly in mind that concrete structures are always in motion. He must create smooth transitions of shape and relieving joints if the building is not to be broken up by its own internal stresses, meeting the dismal fate of the one below.

Laboratory tests have shown that concrete continues to harden almost indefinitely, gaining strength and durability. (Some test cylinders are found to be 50 per cent stronger after ten years than in their 28-day tests.) If concrete is protected from deterioration in its infancy, it will be able to take care of itself later in life.



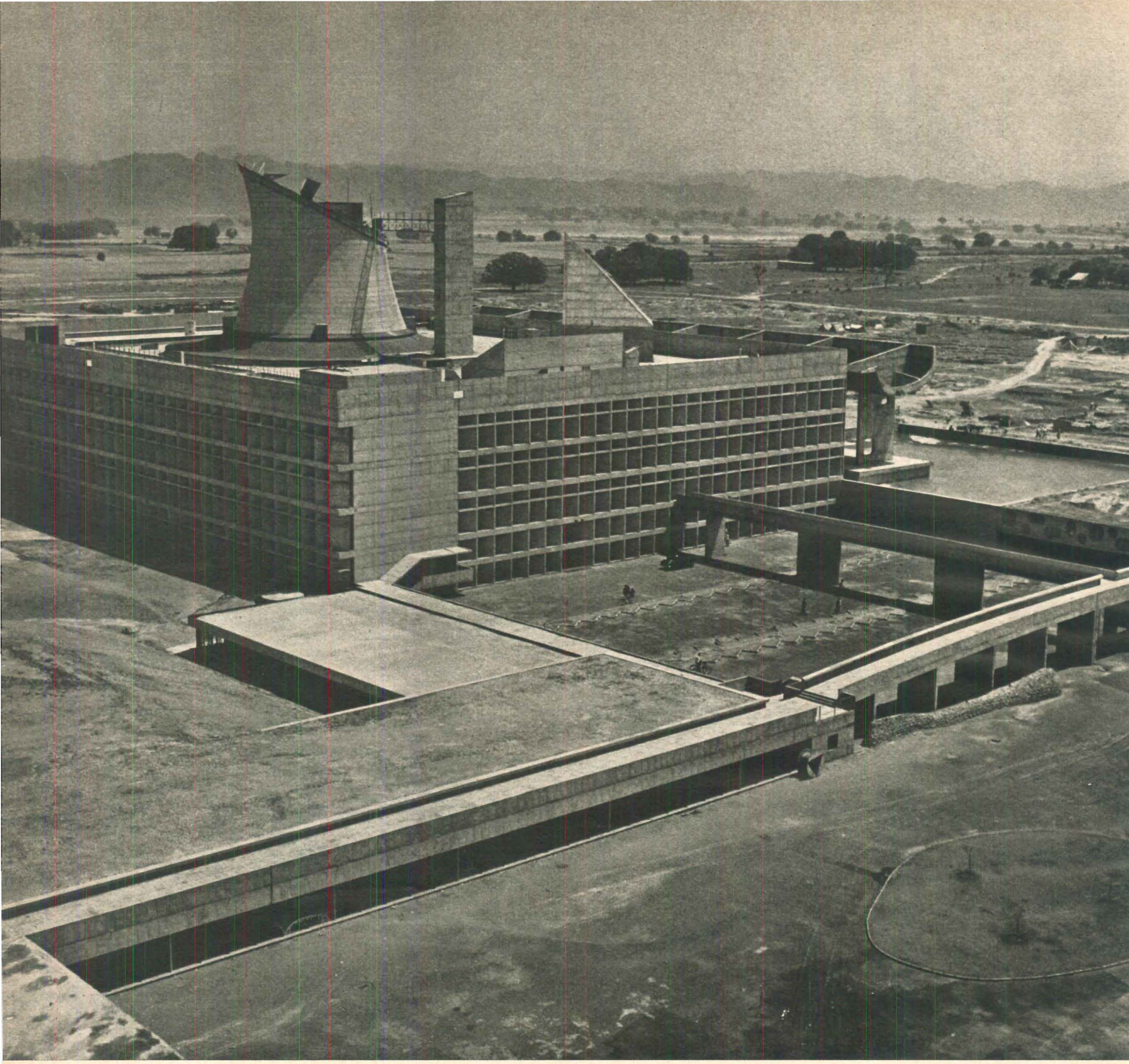
A. D. DIJKSMA

LE CORBUSIER'S NEW MASTERPIECE IN CONCRETE

The great concrete parasol shown above shades the 300-foot-long, 50-foot-high entrance portico to the new Assembly Building at Chandigarh, capital of the Punjab. The Assembly is Le Corbusier's third major structure completed at the core of the new Indian city (the first two were the Palace of Justice and the Secretariat—FORUM, April '61). The Assembly is also quite possibly his best.

It is not really a single building at all: it is, instead, a framework into which the architect has placed forms and spaces so complex that no plans can do them justice.

To the south, facing the Palace of Justice a quarter of a mile away, is the huge ceremonial portico. Behind this portico is a kind of walled city: the walls are honeycombed with offices and galleries on three or four levels, and these galleries overlook a great interior court, about 200 feet square, which Le Corbusier calls "the forum." Within this forum, he has placed the two most important elements of the building: the Assembly Chamber—a hyperbolic form that penetrates the roof—and the smaller Council Chamber, which is topped by a pyramidal concrete-and-glass skylight.



View from roof of the Secretariat Building shows honeycombed walls of Assembly containing offices protected by sunshades. Hyperbolic Assembly Chamber and pyramidal Council Chamber are seen penetrating the roof, which doubles as a delegates' terrace. Automobile entrance is located under the elevated pedestrian walk at right. Below: site plan of center of Chandigarh: (1) Assembly, (2) Secretariat, (3) Governor's Palace, and (4) the Palace of Justice.