The structural specialist meets the demands of pure structure alone. His art has progressed through the interaction of the strength of materials and the physics of forces to produce bridges of lissome beauty, crystalline domes, majestic dams, and brave structures of awesome spans. It is a discipline whose parameters are clear: how, with the least material and minimum effort, the heroic feats of force and span can be accomplished.

Structural Expression in Architecture: An Historical Overview

But that was never the choice of architecture. In recent years, the role of structure has become more confused since architects themselves, intimidated by the bravura of the structural specialists and under pressure from the public gallery to do equally spectacular tricks, have tried to justify their work in structural terms. Techtonics, in fact, have so dominated our priorities and overwhelmed less tangible values, such as the traditional desire to bring a building into harmony with the cosmos by means of geometric proportion and orientation and to implant it with anthropomorphic symbolism, that in the last century we have reevaluated history as man's progress in materials and techtonics. Examples abound. They range from Viollet le Duc's attempt to redefine Gothic architecture in terms of medieval rationalism to the scientific rational approach of some of the most avant garde schools in the early part of the century, which scarcely bothered to teach history at all. We overlooked or conveniently forgot the fact that concrete had been around for several thousand years, that the arch and vault were in use long before the Romans, just as gunpowder and electricity had been known in ancient China, but used only as a source of amusement.

Looking at the historical record, it seems that innovation in itself was not as significant in human progress as the use to which that innovation is put. Thus our historians have mistakenly argued that the Gothic arch was an innovation in technique that brought forth a new exploration of the enclosure of spaces—but it was not. Instead it was a fashion brought back from the Crusades: the returning Normans introduced the already-ancient Saracenic arch into Europe as a decorative motif. It was taste, fashion, and the suitability of the form to the aspirations of the time that decreed its influence. Only incidental to that and much later was its structural potential realized. Structurally, in fact, the Gothic arch was an afterthought in that its structural possibilities were thought about subsequent to its aesthetic ones. As an unbiased look at history will prove, not until this last century was there much concern at all for structural technique in the development of the styles. Before this, it was not an isolated discipline with its own intellectual terms of reference as it is now. Rather it was an unconscious tradition in building method that evolved through decades, even centuries, of collective experience. Techtonics were merely a means to achieve far more important goals in the interest of architecture as a whole.

For the Greeks who were the greatest of artists, structure was wisely of the least importance. Their Doric temples are constructed on a post-and-lintel structural system borrowed from early timber prototypes, a structure which is difficult to build in stone. For the Romans, who were the first real technicians, ingenuity in structure was such a source of embarrassment that they carefully hid masterful brick vaulting under a veneer of Greek trabeation. A Greek portico marks the entry to the Pantheon; its concrete dome spanning 141 feet (43 meters) was the largest clearspan structure for nearly 2,000 years. Much later in the Renaissance and Baroque periods, builders never bothered to surpass by much the structural mastery of the Romans, as they were primarily concerned with the rediscovery and celebration of earthly physicality, an anthropocentric conception of the world which viewed man's body as divine and felt that his proportions and physical attributes should be reflected in architecture. Later builders became caught up in the excitement of shaping new spaces, featuring floodlit interiors topped with illusionistic murals, stately staircases, and highly organized arrangements of rooms. It was only with the subsequent advent of Western industrialism and its consequent division of labor resulting in the specialization of knowledge, experience, and discipline that structure became an end in itself, and a kind of structuralism began to influence our thought.

The Structural Aesthetic

Following the influence of the first engineers at the great 19th-century expositions, it was only in our time that a structural aesthetic began to assert itself in architectural style. At the beginning of the century the Russian constructivists with the sculptures, for instance, of Gabo or Tatlin's Monument to the Third International, the Italian futurists with the drawings of Sant'Elia, and the Dutch purists with the work of Rietvelt, Oud, and

The beams and columns supporting the Smith House are of the same width and section and similar in size and scale to the surrounding trees.

the furniture of Van Doesburg reflected the new preoccupation with the aesthetic of structure. The Bauhaus, which was to move from Weimer and Dessau to America where innovation was a clearly frenetic pursuit, was to institutionalize it for good. The machine aesthetic celebrated by Mies and Corbusier still haunts us to the extent that even today at the very forefront of design the method of doing is more important than what is done. If it had not been for such miscreants as Wright, who wholesomely avoided that whole aesthetic trough, we might have lost the thread of architecture altogether. Today, having nearly reached the sterile end of that mechanistic pursuit, we sense that maybe the threads of architecture in its broadest human sense are about to be picked up again.

If one looks at the catalog of contemporary buildings, it is obvious that those of a predominantly structural bias are not, in the total sense, architecture. By illustration one can observe the buildings of Nervi where the dichotomy is clearest. No one questions the sheer aesthetic beauty of his structures—the bridges, the domes, the hangars—but one would expect that degree of structural taste and refinement from an engineer who is also Italian, because of the long history of Italian aesthetic sensitivity. However, on examination of his buildings, the flaws appear in all those aspects where the functions do not mandate a large span, the aspects that have to do with the human occupation of these structures. The walls, partitions, doors, windows, handrails are unresolved, awkward, and not integral to the total scheme of the building—and a building falls short of architecture if it is not such a totality. The problem stems from the fact that a structural engineer rightfully thinks only of structure—that is his justification after all. If it is a dome, he is only concerned with the system of spanning that dome, how one enters or partitions or furnishes it is quite secondary, and Fuller's domes bear witness to that. Concentrating exclusively on one aspect of the program such as structure is a simplistic attitude which is not valid since there are a multiplicity of concerns to be answered.

Architecture is so much more complex. Not only must it answer questions of purpose, site, suitable spaces, technical systems, and materials in a totally integrated way, but it must be appropriately significant and meaningful in its physical and social context to those who use or observe it. Therefore, the structure is only one aspect of a more subtle and diverse whole—no more or less significant than the human skeletal frame is to the total of a thinking and feeling person. When all factors are balanced in architecture, no one aspect of a building stands out as unique, more important, or separate from the whole. If on seeing a building the response is "what an interesting

Top: At the Museum of Anthropology the concrete piers and channels of the great hall range from low wide spans of 120 feet (36 meters) to tall narrow spans of only 40 feet (12 meters), yet the channels are consistently as deep as the piers are wide.

Bottom: Facing the shore of an artificial lake, the concrete channels and piers of the great hall metaphorically recall the longhouse frames housed within, which were also built on the beaches.

structure,'' something is wrong. Henceforth the structure can be remembered, but the building forgotten.

Structural Ambiguity

Contrary to most contemporary theories of architecture, perhaps, my opinion is that on observation a building should not reveal immediately how it is built. That aspect should only be obvious after study and in the end seem quite sensible, but not necessarily that logical. The open space grids of Mies and Corbu, for instance, are in retrospect both architectural and structural copouts as they do not respond directly to the particular spatial requirements and have little to do with the genius of their architecture. Logic after all is the enemy of art.

But as with so many of my generation, I had to go through the indoctrination of the priority of structure over all other considerations. We were trained to draw structural grids, to put in columns, and then to draw a building around the columns. Such a mechanistic approach to architecture may still persist in some schools of architecture, and I pity the students who must endure it, for it took me long enough to recover from the deception that it was the most appropriate methodology for design. But now I feel fully confident in being independent of the structural crutch and illogical about structure; this shows in my best buildings.

That does not mean that a building should not have a structural veracity, just as any individual must have a structural veracity in order to move about. Since a building is to a degree a structure, it must be resolved and expressed as such. For me, though, this is an aesthetic view: a building needs to have a strong structural presence. But the structure, rather than being the first, should and must be the last aspect to be considered in the evolution of a building.

Structure is the strongest and most powerful element of form, so much so that if it is not the last consideration in the long series of decisions determining form, it distorts or modifies all other important determinates of a building. One finds, in fact, that the structure has dictated all the other aspects of the design. The inhabitants should not behave as the columns dictate—the contrary should surely be the case.

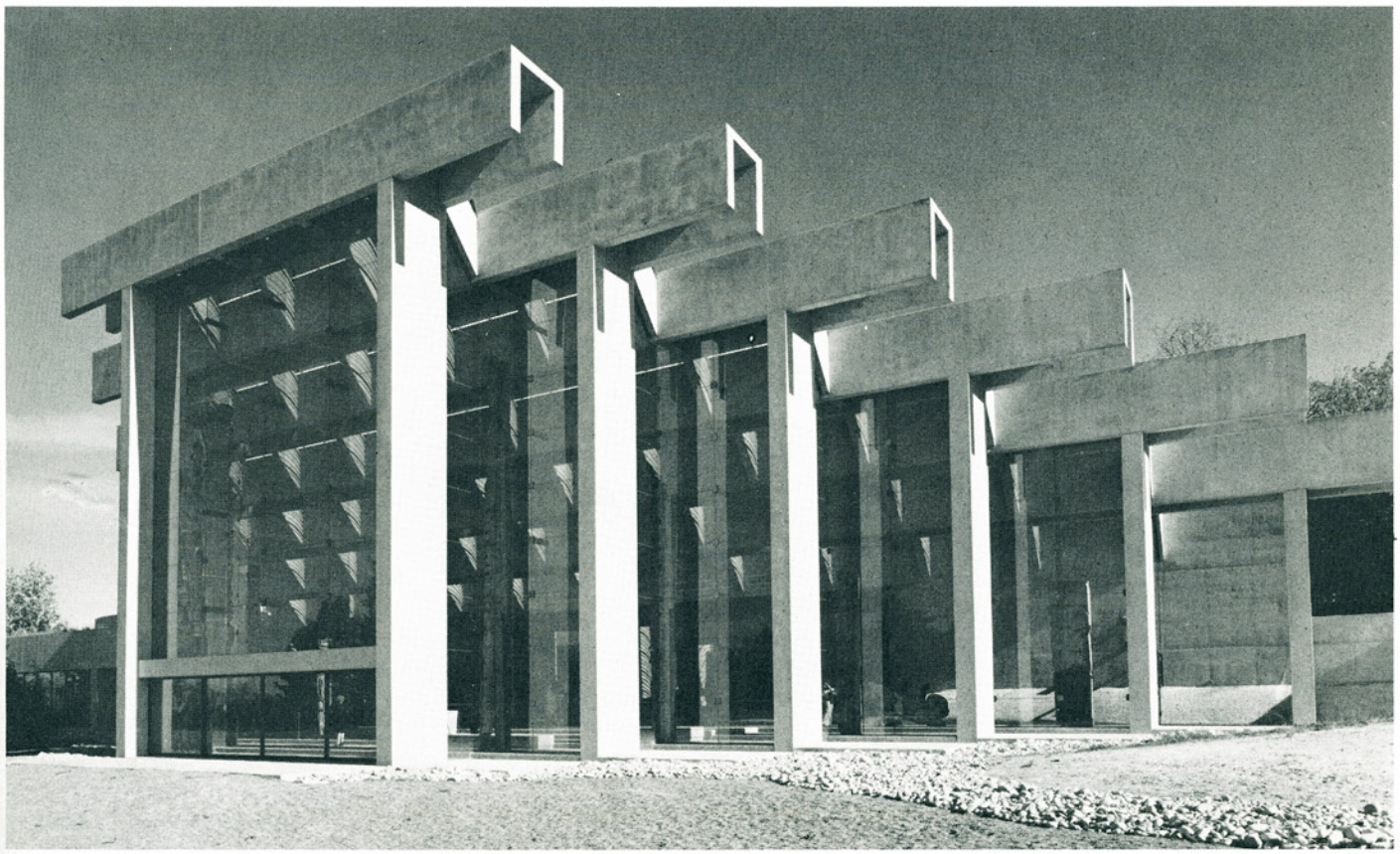
Museum of Anthropology

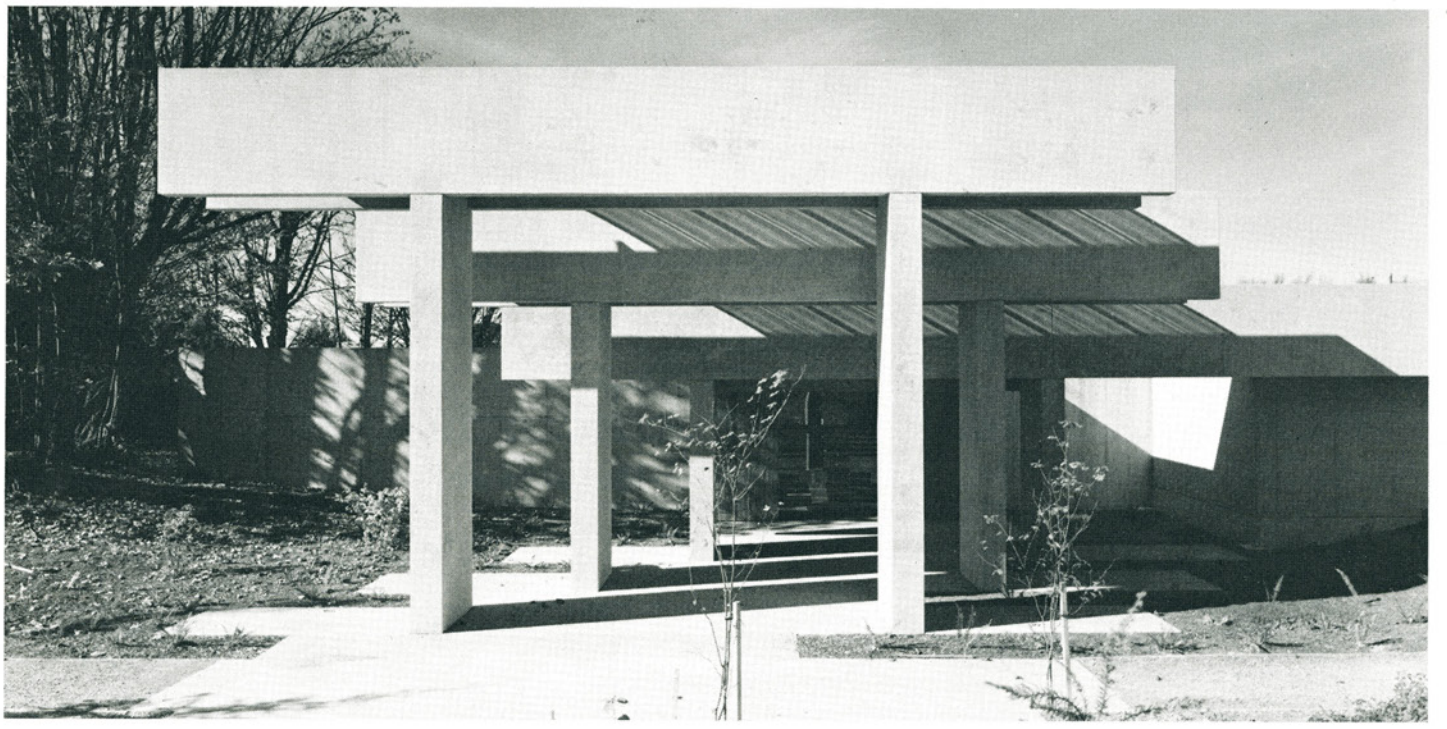
An example of my approach to structure is the recently completed Museum of Anthropology at the University of British Columbia in Vancouver. There perhaps could not be a better case of structural ambiguity: the structure is not the most efficient or optimal to support the space and it doesn't work as it appears to. But it works superbly for what it is and has a strong and unforgettable structural impact. As with all my buildings the structure was not even considered until the main premises of the design—the shape of the spaces and the form of the building—had been determined. Thus, the structure did not preclude but followed the design intent.

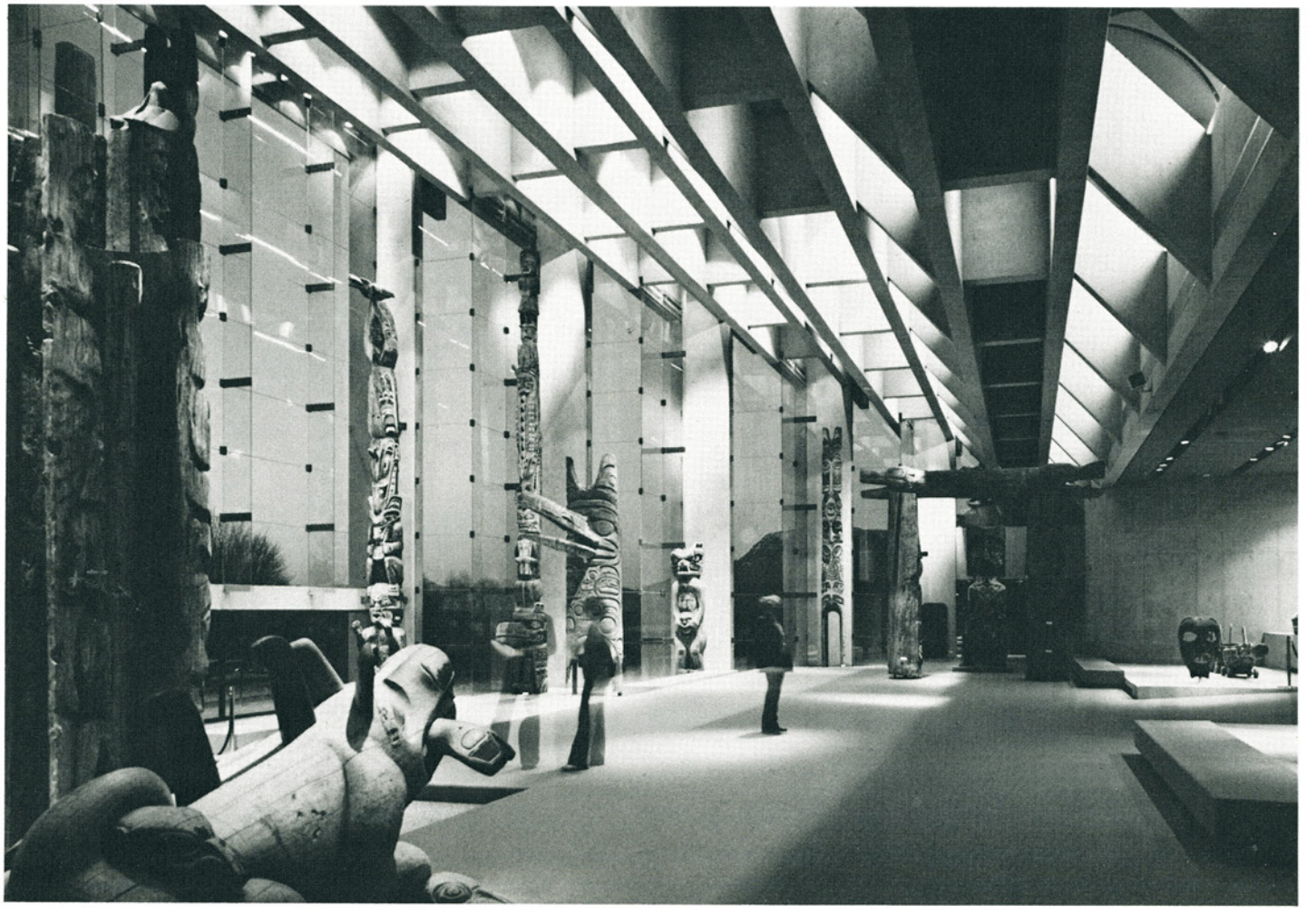
The design stemmed from several issues: the need to house a superb collection of Northwest Coast native art, including an imposing group of Haida and Kwakiutl massive carvings, some up to 45 feet (14 meters) in height; the need to be a teaching museum for a collection of other aboriginal cultures; the potential of an inspiring cliffside site overlooking the inlets of the British Columbia seacoast; the existence on the site of some World War II gun emplacements which would have to be incorporated in the museum; and the severe limitations of budget.

The design evolved out of the determination to use the site, gun emplacements and all, to the maximum advantage and began more as a landscape concept than an architectural one. The sea view offered the opportunity to recreate outside the museum the true Northwest Coast village seaside setting. A body of water placed at the cliff edge and visually merging with the sea below could, with poles and long houses set on its banks, give the illusion of the typical native village on a coastal inlet.

With this idea established, a model of the site was built: then the poles and house frames as well as the poles to be housed inside the museum were mocked up and placed on the site model. The order of viewing the poles in the museum could be established from the model, and in turn, the kind and sequence of spaces enclosing them could be determined, proceeding from the entrance lobby down the slope to the great exhibition hall containing the massive carvings. The existing gun emplacements on the site produced a tight constriction in the series of spaces, their curved forms easing the transition from the introductory rooms to the great hall. The other elements of the building—the exhibition, storage, work, and administrative spaces, not of significance here—fell into place around the spine of spaces thus created. Only after this had been laid out, the spaces articulated, and the size and height of the building determined was there any consideration of how to ''structure'' these spaces—in particular the long spans of the great hall. The peculiar shape of the great hall bursting outwards to the lake and distant







view was determined by the height of the poles and the desire for them to be viewed in a natural light against a natural setting with as unprepossessing a background as possible.

I have long preferred in spite of structural inefficiency, the visual ambiguity of columns and beams being the same size. Logically the beams should be narrow and deep for bending moments and the columns in compression proportionately smaller. But this makes for a great deal of visual tension. The appeal of uniform size is best shown in my early Smith House where the lack of the expected visual tension between column and beam (because both were cut out of the same timber) gave the structure a great visual repose. So in the great hall of the museum, a simple column and precast channel system, both of the same width and section, was chosen, though the columns were single piers instead of channels. But the discipline imposed upon the structural solution was that whatever the span of the channel, which varied from 40 to 120 feet (12 to 36 meters), or the height of the pier, which varied from 15 to 45 feet (4.5 to 14 meters)—whatever the variation in stresses—I did not want to show it. Rather, I wanted the structure to appear as a uniform backdrop for the display. There is, therefore, enormous redundancy in the structure proposed; the structure in fact does not even work the way it seems to. Instead of spanning the space as they appear to do, most of the channels hang in the space. The real structural members are the almost invisible sloping beams which seem to be spaces between the channels. It was the ingenuity of my very skillful and patient engineer, Bogaslav Babicki, who made sense out of my whim.

I have been questioned by students as to why I did not resort to a lighter column system—an open steel space frame for the walls, for instance—more in keeping with the expressed desire to open the great hall to the natural surroundings. But such schemes would have introduced a pattern disturbing, in my view, to the visual quiet necessary for the contemplation of the massive carvings. I wanted the wide blank surfaces of the concrete piers to show off by their very blandness the exquisite and subtle relief of the weathered gray carvings of the Haida and the more dramatic carvings of the Kwakiutl. There is a monumental gravity to those carvings that would not be complimented by too thin, nervous, or highly patterned a structure. They required a weightier rhythm—a quietness of line and surface that would seem beyond time and fashion and outside of history as they themselves seem to be.

The frames formed by channel and pier bear an uncanny resemblance to the aboriginal house frame, abstracted and repeated as a sequence of portals, which contributes to the ritualistic feeling of the great hall. It is not just the space, but the massive carvings, the space, the structure, and the setting which combine to achieve this effect. The structure is forceful, but not more than the space, nor the space more than the objects shown therein.

Structure as Afterthink

How can one isolate structure and its logic from such subjective considerations as these that are fundamental to design? Such intangible concerns are almost beyond the scope of analysis and stem from the unconscious levels of the mind—surely a far richer resource than conscious thought. Structure must take its directions from there as well. That is the difference between pure structure and architecture. When structure is influenced by other factors of a building and a space, it cannot retain its purity. By definition it must be subject to other, nonstructural determinates to function as architecture and act as a totality.

Through familiarization with the building's intent, the design evolves out of the complexity of the myriad considerations that the building must resolve. It is perhaps not structure as afterthought, for the process is too cohesive for any part of it to occur after the fact, but it is structure that emerges only as the final tailoring of the forms which have emerged in the process. Structure makes the formal idea buildable as the form itself must in the end be structural.

Thus may we try to bury finally and irrevocably the notion of structure as a predeterminant of form. So also must we abolish the idea of a logic to the design process or of an order of priority to the considerations that enter a design. To consciously decide that the site, the climate, the use, or techniques should have priority is to eliminate the possibility of some unannounced or unpremeditated aspect offering the motivation for design. In the process of conceptualizing a design, all aspects of a project have to be viewed equally without bias or prejudgment. The deeper and broader the scan of the subject and the wider the intake of factors impinging even remotely on it, the more pertinent the solution will be. Structure alone cannot be the subject of that scanning process unless the project is predominantly structural, for structure has to do with the final stage of realization, the actual construction. It is only then, when the idea is fully rounded and flushed out, that structure should come into play and bring its discipline to give shape and substance to the amorphic form. In that sense it is afterthink.

Top: The concrete channels and piers of the Museum of Anthropology entry hall reflect not only the Indian longhouse frames, but relate to the framing of the great hall.

Bottom: While the concrete channels appear to be supporting the roof of the great hall, the nearly invisible cross members are actually doing the work.