OF ELEPHANTS AND BIRDS

On structure

On architecture becoming lighter

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On structure. On architecture becoming lighter

I have noticed how the structures of buildings are being made and will continue to be made ever lighter. At the same time, they have tended to look less like the cave and more like the hut. Clearly, the giant advances of economies, materials, and technology play a role. However, the phenomenon also results from architects' changing mentalities regarding the conception of space.

If in the past one preferred to eliminate pillars in favor of greater luminosity, transparency, or continuous space, today one could say that pillars are dispersed, or more pedagogically, that large bones are replaced with small ones; the *humerus* for the *phalanx*. Small bones substitute for large bones, both decreasing their weight and increasing their quantity, especially when it is a matter of supporting the same load. Now there tend to be more pillars, but thinner ones. The hypostyle, or roof supported by columns, has recently regained currency, though abandoning the clear order of classical geometry; the forest versus the hypostyle, as Kazuyo Sejima repeatedly proposes.

Just as birds, over the course of evolutionary history, developed ever more intricate bones and complex skeletal structures in order to take flight, so too architecture wishes to fly once more, hoping to avoid the fate of Icarus.

FOSTER, PIANO AND ROGERS

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Norman Foster's Hearst Tower[1] in Manhattan proudly rises 182 meters from its privileged spot near Columbus Circle. Its façade of rhombuses, which is pure structure, stands out in comparison to the other buildings.

What interests me most about his building, is that besides departing from a clear idea, of which the structure is the first consideration, this is no mere formal change, but rather the consequence of using a radically different structure that improves upon the conditions of a more conventional one. This structure appears to be rationally dispersed and broken

down into its parts and by dint of being more rational it achieves greater lightness. It is also a patent demonstration of many of the subjects I would like to analyze in this text. Foster's building is a good example of replacing large bones with smaller ones and furthermore distributing them on the façade, thus adopting a less conventional, rhomboidal instead of orthogonal form in the interests of greater structural efficiency.

Of course, the opposite could also be valid. After breaking the structure and walls into smaller parts, one could bring the structure further in, giving more freedom to the façade. A lot of contemporary architecture has moved in this direction. But if that exterior structure is resolved by recourse to dispersion, with beams and geometric forms meeting the needs of a better structural logic, then let the same technique be welcomed in the façade as well. Foster's building is a good example: the *humerus* is replaced by the *phalanx*, while the orthogonal line becomes rhomboidal. The result is that that the structure reveals itself proudly on the surface, not merely within.

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On that note, when people talk about the so-called "disappearance of the façade", they are speaking about something impossible; that is unless cities were to vanish within invisible and transparent clouds. Thanks to steel, however, it is actually possible to disperse the load bearing elements –the structure– and façade into smaller parts. In this way façades of extraordinary lightness can be achieved, a clear example being Mies Van der Rohe's beautifully curved Glass Skyscraper from 1922.[2]

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But if we are to discuss structures that have been broken down and dispersed outwardly on the façade then we cannot fail to mention the Pompidou Center[3] in Paris by Piano and Rogers, built as long ago as 1977. The entire façade is structure.

What is the Pompidou Center, I ask, if not an operation of lightening structure, going for some three-dimensional trusses in bars that are carried with overwhelming logic to the façade? Could it not be considered a first manifestation of this "dispersion" of the bones of structures?

The device, which gains with the passage of time, is not just logical, but beautiful. Jean Prouvé and Philip Johnson, the committee members at the time, were not wrong in their selection of the Piano and Rogers' project.

STRUCTURE

I am more and more convinced of the importance of structure in architecture. It is obviously important since it bears gravitational loads, but above all, it is important since it establishes the order of space.

When I defend the “unity of the architectural fact”, a unity inherent to any artistic creation, I defend neither uniformity nor simplicity. Architecture can be simultaneously complex and unitary. Structures and Construction in a building are as important as the “layout” of the parts in the conception and design. In short, all of these issues must play a role in the developing idea of the Project, from its unitary conception. It could not be otherwise.

At the Madrid School of Architecture where I teach, students learn not only to conceive structures but also to calculate them. And it is my view that it is vital for aspiring architects to understand structures inside out. I will never tire of insisting that architecture cannot be conceived merely in terms of form, and expect that others will intervene later to ensure that it holds up, as if the construction process were some kind of orthopedic exercise! Structure is so much more than a question of transmitting gravitational loads to the ground; it is in essence the establishment of the order of space.

Therefore, when I speak of Elephants and Birds –of many small bones as opposed to a few large bones– I do not intend to make a merely structural reflection, but also one that is basically an issue of design.

MIES

When Mies van der Rohe constructs his cruciform and brilliant, mirror-like pillars, first in Tugendhat House,[4] and later in the Barcelona Pavilion[5] of 1928 he does nothing more than attempt to prove that he actually can make the pillars vanish, so that the superior plane – the ceiling– floats. Of course, Mies always makes his structures with bones–complete pillars, precise and perfectly laminated profiles, and welded seams that wish to disappear. He, who spent his life making “Architecture” with a capital A, with capital bones and athletic profiles, did not cease to pursue at other times something of what we are talking about here.

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In contemporary Architecture, the idea of changing large bones for smaller ones is gathering momentum. Architecture had always transmitted the loads directly, with continuous structures that, like stone and brick, worked basically by force of compression. Only wood, despite its problems of durability and conservation, could work in a different way.

HISTORY

The end of the Gothic period produces a certain phenomenon of such dispersion. Antonio Mas Guindal, professor of Structures at the Madrid School of Architecture, recently published a book with the suggestive title *When Structures Were Not Calculated*. The cover is illustrated, as if a précis of its more than interesting contents, with the drawings of several well-known Gothic battlements, roofline stone adornments, which in so far as they resemble lace seem impossible. My interpretation, albeit biased, is that the Goths lightened structure from above not only for motives of weight, but in order to procure more light. But in any case, if it were a matter of bones, the humerals become phalanges. A few humerals being replaced with many phalanges.

When at the start of the previous century structures composed of steel began to appear, they were generally used in industrial constructions or bridges, so as to balance considerations of structural aesthetics with greater usage load. Later on, structures composed of latticework came around for reasons of financial, logistical, and technical viability. All of the beautiful industrial architecture and bridges of that time are a testimony to this decomposition of structure.

TECHNOLOGY

Of course technology has a lot to do with all of this. To make the first compound structures, the joints were entrusted to rivets and bolts, screws and nuts. Later on, welding could be trusted. Mies, naturally, fully trusted welding.

And what used to be done solely for economic reasons in those first steel bridges and industrial buildings is now done for other reasons. One can now speak of the search for a greater lightness, or even a better penetration of light.

CENTRAL FORMAL THEME

However, in architecture, generally speaking, this substitution of the large bones for smaller ones has never been conceived of in the same way as it is now: replacing the powerful, one-piece rolled steel beams with compound exposed profiles, making a show of it, and perhaps even turning it into the central formal theme.

In the 1960s, when Alejandro de la Sota builds the Maravillas Gymnasium[6] in Madrid, he not only utilizes the compound structure in service of the large hall's light, following the form of the catenary, but he also makes it "occupy that structure". He dares to situate the class-rooms among the beams, which he leaves exposed on top of it all. Something of a premonition of this dispersion of the structure already permeates the whole idea of that building.

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But it would be figures from the international scene, like Fuller, who would directly propose, for financial reasons, the generalized use of these structures of bars and small bones.[7]

It is a movement from elephants to birds.

OF ELEPHANTS AND BIRDS

If you have ever eaten a well-cooked bird, you have certainly noted how difficult it is to eat an animal with so many tiny bones, no matter how delicious it may be. And even if none of us have eaten an elephant, you may assume that the meat would come to the table without the bone.

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As I can only assume that we will be collectively ignorant about animal bones, it might be helpful to browse through Google to look at elephant,[8] bird,[9] and human skeletons.[10] They are marvelous sculptures by a very wise artist in which the bones drastically reduce in quantity, size, and intricacy as they reach the extremities, the hands and feet, for example. The skeletons of elephants too, made up of huge bones, stand in great contrast to the skeletons of birds, which are comprised of smaller, thin light bones.

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Of course, there are evolutionary reasons for all of this: birds have to fly and elephants do not. Only when they alight on a branch do birds have

to bear gravitational force directly. When they fly, on the other hand, the forces at work are more complex; when they walk, they do so hopping, as if dancing.

A common feature in contemporary architecture, with the construction of large-scale spaces of light –or "elephants"– whether horizontal or vertical, is the rational dispersion of their structures for purposes of economy and stability. In the spirit of "birds".

Bridges with large spans and heavy loads are resolved with compound structures either with huge girders or powerful steel cables capable of resisting massive tensions.

For similar reasons, tall towers which, in view of their exposure to wind, could be considered as great cantilevered beams jutting out from the globe, have no alternative: their structure must be compound.

STRUCTURE IS THE KEY

When I teach my students about the importance of structure, of the skeleton, I give them an example they will never forget. I tell them that if Halle Berry, the American actress, is gorgeous, which she is, it is above all because she has a perfect skeleton, which she has: a perfect structure. From the first moment of her life, her structure –her skeleton– has established a perfect arrangement of space and order which allowed her stunning completeness. They all smile, but not one of them will forget the importance of structure in architecture.

An elephant cannot have small, delicate bones. It cannot have the skeleton of a bird. Nor can a bird have the powerful bones of an elephant. One must consider, throughout the construction of a building, about how many elements, like a door or a window, a material or a color, a texture or a detail, can be exchanged. But what one cannot do, and must not do, is change the structure inappropriately. One cannot put the little bones of a bird on something that was born an elephant and vice-versa.

If we had to mention some contemporary architects who use more small bones than large bones in many of their works, we might bring up Foster or Piano. Foster continues to follow Fuller's already quoted advice to the tee when he asked him, *"How much does your building weigh, Mr.*

Foster?".[11] We might imagine Renzo Piano, moreover, without a Fuller to scold him, following the recommendation by W.Strunk and E.B.White in their book *The Elements of Style: "omit needless words"*. All writers in English are familiar with that injunction, and architects should know and practice it as well.

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But it is perhaps Kazuyo Sejima, SANAA, who in a most provocative, almost demagogical manner poses this question in some of his latest buildings like Park Café, the Yokohama and Naoshima terminals, and the Rolex Center of the EPFL of Lausanne.[12] J.Jaraiz, in his illuminating doctoral thesis, compares and contrasts this Forest Space by Sejima with the hypostyle space so often employed in the history of architecture.

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ADDENDA

In some of my latest projects, when there were clear reasons for it, I have tried to apply this system of lightening the structure, replacing the big bones with little ones, a few humerals with many phalanges.

In my first design solution for the Center for Nature Interpretation in the Salt Flats of Janubio in Lanzarote,[13] since the building "flew" over the powerful existing slope, I resolved the protruding part of the structure with a few large triangular trusses. These trusses had sufficient height, 6 meters, to house the requested functions inside, diagonals included. The resulting space, in which the diagonal bars gave a special quality to the space as one moved among them, was large and well tensed by the structure and the light. Naturally, the structure was the protagonist of the space.[14]

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In the end, zoning regulations obliged us to change the site to another, completely flat lot, and the design had to change. In the new project, all resting upon a now completely flat plane, it made no sense to repeat the structural solution that the large protrusion had called for in the other situation.[15]

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In the Porta Milano space I designed with the Portuguese architect Paulo Durao for Malpensa Airport, we conceived of a stereo structure: a straight parallelepiped rectangle, that is a six-faced polyhedron, all of it comprised of white-painted small bones. An internal and external

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double skin, in laminated translucent glass, provided both thermal insulation and protection against the elements. A few deliberate perforations in the translucent butryal that binds the glass would allow a play of lights that could be defined as a solid light perforating the space of translucent light: rays of sunlight crossing the large interior space as if it were a cloud. All of this was clearly dependent on a three-dimensional structure of white-painted small bars situated between the two translucent skins, such that the light could be adequately diffused within.[16]

A similar solution of double translucent skin encasing a light structure of small white pillars is what we planned for the entrance piece to the MIA, the Museum of Italian Art, for the Olnick Spanu family in New York. In order to give this space a special lighting and quality, I make use of a 10x10x10 meter, semi-underground cubic room of which the emerging upper half is a translucent half-cube. The structural support for this upper translucent half cube is a dispersed, light structure of small bones, comprised of delicate white pillars. Like a delicate gown, a double skin of laminated glass covers it. The exterior skin, with carpentry, solved the matters of water and thermal control. The inner skin was more delicate in its construction. Both skins had many small transparent perforations in butryal, so that as the sun passes through them in its daily habitual movement, solid rays of light, thanks to the scale of the construction and perforations, become visible. We thus achieved a space of diffuse light pierced by solid light –a cloud pierced by the sun.[17]

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CONCLUSION

Make structures lighter? In pursuit of a lost ethereality?

Architecture is about making things with meaningful intent. If this search for structural lightness has a deeper meaning, it is most welcome! In our museum in New York, there were clear reasons for making the translucent glass box that covers the entrance with a very light structure, the lightest we could construct. We were not only seeking greater lightness, but simultaneously greater light. Moreover, as the structure arose out of the graceful hands of geometry and translucent glass, we wanted it to dissolve into the mist.

The structures of the future will be lighter: clear in their conception; simple in their construction; perfect, durable, and easy to maintain in their final execution. Once again, structure will be, as it has always been throughout history, the architecture's central consideration: structure that establishes the order of space.