FLIGHTS OF SCIENCE
THE WORK OF SANTIAGO CALATRAVA

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In the architecture of Santiago Calatrava, physical manifestations of phenomena hitherto limited to the realm of ideas are realized. Motivated by the engineer's research into the relationships of forces, his projects are not mere vacuities awaiting the actions of their occupants, but are infused with a structural dynamism wholly their own. Exploiting the strength of his materials, Calatrava expresses the effects of static forces, rather than conceal them behind a bland façade, and he concentrates on mechanisms which operate within a formal system of architectural principles. These precision-based dynamic devices enable him to translate their cybernetics into a mimetic form, sometimes with startling accuracy and literalness.

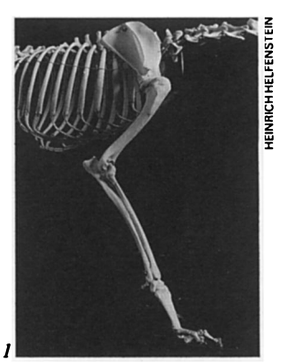
The details affirm their anthropomorphic origins, and the structure discloses its static origins without embarrassment; this, an intrinsic quality of the projects, epitomizes Calatrava's approach. His bridges are characterized by a simple, linear activity and a unilateral direction of movement. He does not reject technical mastery in favour of a freer choice. Instead, he exploits the available mechanical evidence and creates a theatrical effect through variations in the control of static forces. Whilst 'acting more as a co-ordinator than a mathematician', he is also 'a sculptor of forces'.[1] In the Barcelona bridge, for instance, opened in January 1988, the permutations in the handling of the arched bridge type contribute a dynamism which also reflects on the structure as a whole. The plan of the bridge is asymmetrical and fossil-like, with arches placed opposite each other in a subtle overlapping diagonal. The suggestion of a slow frictional movement is confirmed by the inward slant of the arches. Pedestrian staircases on either side extend the interplay of arched forms down to the ground level, giving the bridge a poised and coherent profile. As a self-contained object, it contributes a focal point to the surrounding industrial landscape. The foundation rests on piles grouped underneath the zone of the bearings, of which three types were used: abutments, intermediate bearings and central bearings. A cross-section of the bridge discloses three types of superstructure: the central one, which functions as a motorway, and two lateral, symmetrical ones, which comprise the longitudinal structural elements.

If this project clearly displays Calatrava's interest in the pioneers of concrete engineering such as Maillart, Nervi and Candela, his design for a much smaller bridge in Lerida seems, on the other hand, to draw more on his own kinetic sculptures, which achieve a dynamic tension through the precarious balance of heavy objects supported by taut cables. Although the tensile qualities of the materials are fully exploited, an undeviating high polish appears to negate the textural contrasts of the materials — granite, steel and aluminium. These works examine the effects of gravitational stratagems in order to express the inherent motion of opposing forces.

Because of their small scale, the sculptures can demonstrate these effects in the abstract, but the architectural projects must rely on detail and thematic variations. At times these variations are exaggerated, in order to highlight both detail and the possibilities of the material. Many architects are using steel with concrete or stone in increasingly tensile combinations, but as structures become more sophisticated and the impossible becomes accepted, it is more difficult to show the static possibilities of each material. Calatrava's concern is to express tensile relations in both physiological and visual terms, to exploit each material to the utmost. However, these necessarily heroic representations of the abstract forces of nature hardly impinge on human experience. Although Calatrava does attribute anthropomorphic characteristics to his materials, the references are absorbed within the work itself, without being linked to external circumstances.

The Ernsting factory in Westphalia, constructed in 1985 in conjunction with Bruno Reichlin and Fabio Reinhardt, brought Calatrava to the attention of architectural critics. Consisting of the design of a new exterior for an existing factory, the project has been described as a 'convincing thematization of industrial architecture, in general and in particular'.[2] The elongated rectangular façade is clad in corrugated metal, the choice of which may have derived from the industrial nature of the building, though the juxtaposition of concrete and aluminium are reminiscent more of Nervi's large exhibition halls than any solemn display of *Sachlichkeit*. Significantly, Calatrava insisted that the technical possibilities of the materials be fully exploited, choosing for this reason to have certain parts of the facing prefabricated. But the most impressive aspect of the building is its three large entrance gates,

1. Skeleton in Calatrava's studio.
2. Foldable structure, 1978–9. Student project.
3. Knife, *1982.*



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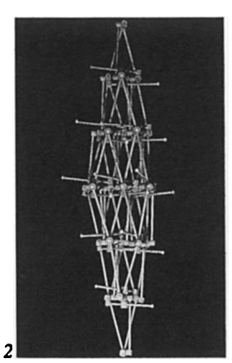
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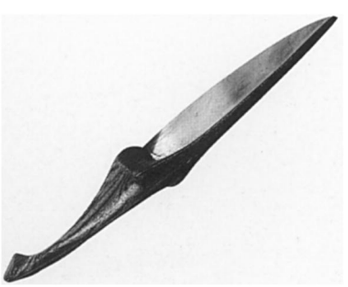
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whose folding mechanism imitates the opening and closing of an eye: movable sheets of aluminium are raised in a fan-like curve to form a gracefully drooping canopy.

These constructions are outstandingly clear, yet they convey an impression of transience, a characteristic shared by the laminated roof constructions that Calatrava has designed for other industrial projects. The basic prototype is the roof of the Jakem factory of 1983, which, in order to make the structure as light as possible, and capable of spanning 1,460 square metres, is designed as a septum. Box girders with a V-section at ninety degrees are linked by the roof lining. The lower part of the girders is straight, while the upper part consists of two parabolic arcs — a form which recurs in later, more theatrical designs, such as a concert hall in Suhr and a nightclub in Basle. The roof structure possesses a dynamics derived from an almost cinematographic sequence of identical but detached structural elements, enhanced by transitory effects of light and shade. The apparent disjunction is deliberate, for it allows Calatrava to achieve an effect of impermanence.

The autonomous quality of Calatrava's work is not so rigorous as to exclude contextual considerations. The Barcelona bridge, for instance, is part of an urban redevelopment scheme, while the Stadelhofen Station in Zurich takes into account its urban setting as well as the need for suburban connections. Calatrava, with Arnold Amsler and Werner Rueger, won a competition for this project in 1982. The 270-metre-long station is composed of three levels — Calatrava describes it as a 'typical design by section', the cross-section remaining almost identical throughout. Above the railway platform, on the middle level, is a portico supported by a row of cross-shaped steel pillars, whose outstretched 'arms' carry a concrete roofing-caisson. The pillars are placed at an angle, as if standing firm to shoulder their weight. On the level above, a promenade covered by a steel trellis has a corrugated concrete wall-surface reminiscent of the Ernsting Factory. A series of large round apertures framed by concrete indentations resemble monstrous, frowning eyes. Four bridges, each one different from the others, connect the staion with existing roads, linking it with the urban surroundings. One of the bridges is vestigial, being a platform covered by a steel and glass canopy, which shares the skeletal qualities of many of Calatrava's constructions, notably a canopy at Sankt Gallen.

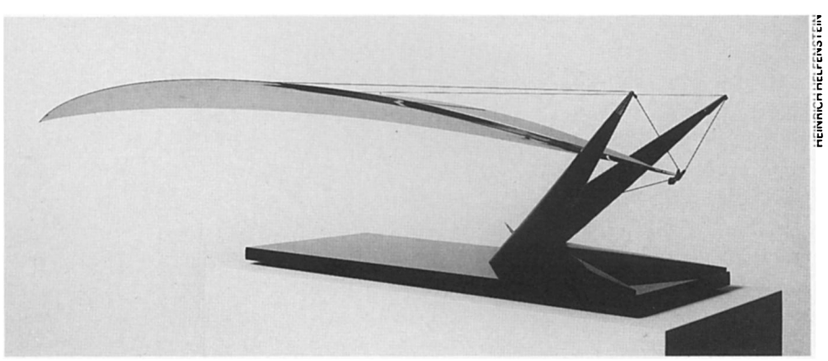
The repertoire of forms is as tightly controlled as the inventory of materials, contributing to a strong sense of finality. Calatrava's evocative visual references are often described as surrealist, but his work contains none of the ambiguity which is characteristic of surrealism. The resolute machine imagery of Picabia's Orphist drawings and of Man Ray's Dadaist objects and photographs provide a closer comparison. Picabia's drawings, for example *Machine tournez vite*, have the same toughness that is striking in Calatrava's work, in which the pursuit of clarity and abstraction leads to configurations which have been stripped of all that is peripheral, leaving only the skeleton. Anatomical preoccupations are not metaphorical in this case, but denote the most impenetrable component of a structure. One is reminded of Thomas Mann's novel *The Magic Mountain*, in which the protagonist is an engineer whose 'treasure' is a 'thin glass plate, which must be held towards the light to see anything on it'. It is an X-ray portrait of a woman, showing not her face, but the 'delicate bony structure of the upper half of her body and the organs of the thoracic cavity, surrounded by the pale, ghostlike envelope of flesh'.[3] This is a telling observation of the engineer's obsession with the cross-section.

As the union of content and surface, the cross-section more than anything else conveys finality. The science of the engineer resembles that of the photographer; even when the photograph is to a large extent manipulated, as it was by the surrealists, it records what *is*, independently of how it is experienced. In the words of Merleau-Ponty, 'scientific thinking, a thinking which looks on from above, and thinks of the object-in-general, must return to the "there is" which underlies it'.[4] For this reason science cannot invent, or imagine. Merleau-Ponty quotes Rodin, who rather sanctimoniously observed that 'it is the artist who is truthful, while the photograph is mendacious; for, in reality, time never stops cold' — and he himself adds: 'the photograph keeps open the instants which the onrush of time closes forthwith; it destroys the overtaking, the overlapping, the "metamorphosis" [Rodin] of time.'[5] To extend this argument, the cross-section too is a lie, for it excludes movement in space, which is how we experience architecture. Like a photograph, it depicts one suspended phase of a sequence. This cinematographic aspect, when translated into sculptural terms, confers an expressive quality upon the work, as it epitomizes the sequence in that one arrested moment.

In Calatrava's projects it is rarely possible to have an overview of the entire structure; the forceful *rhuthmos* of the cross-section, with its 'there is' viewpoint, colours the perception of his works. It seems ironic that such organic forms cannot overcome the stasis of the cross-section. The balancing gesture of, for instance, the supporting limb, or of the shouldered weight, provides an analogue for a construction, and this emphasizes the mechanistic aspect while excluding spatial transgression, which depends on ambiguity of construing. As is also evident in Calatrava's sculptures, these balanced gestures are associated with kinetic energy. The skeletons of movement and gesticulation remind us of the primeval forces which shaped and motivated them. Just as the thought, in the Nietzschean sense, is the shadow of a sensation — 'always darker, emptier and simpler'[6] — the equipoised forms are mere shadows of those kinetic forces; but at the same time they allow an opportunity to grasp that which otherwise remains without substance.

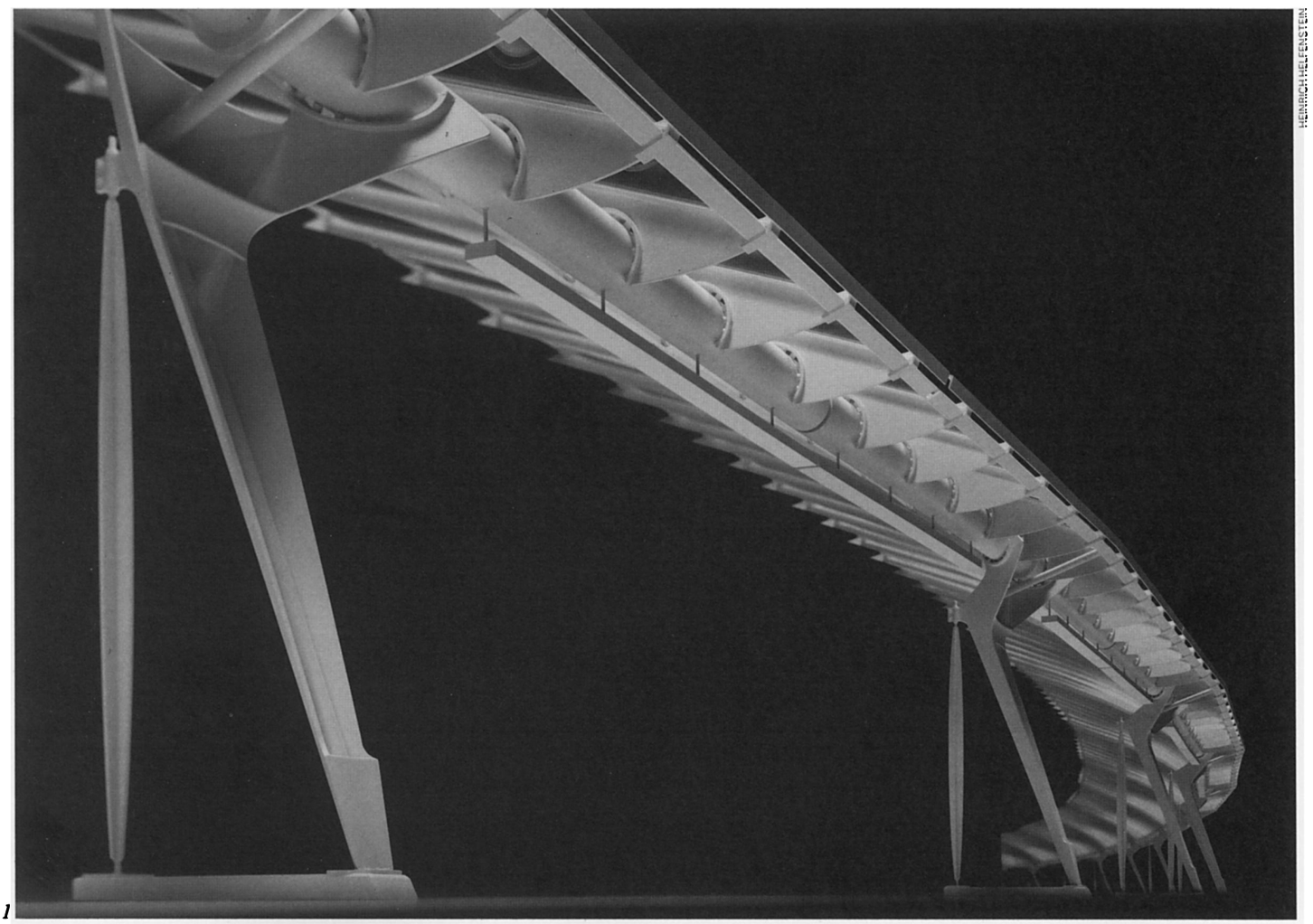
Notes

1. Marcel Meili, *The Model and the Object: Santiago Calatrava — The Daring Flight*, Lotus Documents (Electa, 1987).
2. Werner Oechslin, 'Technology and Representation', *Lotus International* 45.
3. Thomas Mann, *The Magic Mountain* (Penguin, 1980), p. 348.
4. Merleau-Ponty, 'Eye and Mind', in *Aesthetics*, edited by Harold Osborne (Oxford University Press, 1979).
5. Ibid.
6. Nietzsche, *The Gay Science*, translated by Walter Kaufmann (New York, 1974).



Sculpture: Nero assoluto and chrome-plated brass.

Stadelhofen Station, Zurich, 1982–
(with Arnold Amsler and Werner Ruger)
1. View of canopy model.
2. The station under construction.
3. Drawing of canopy support.



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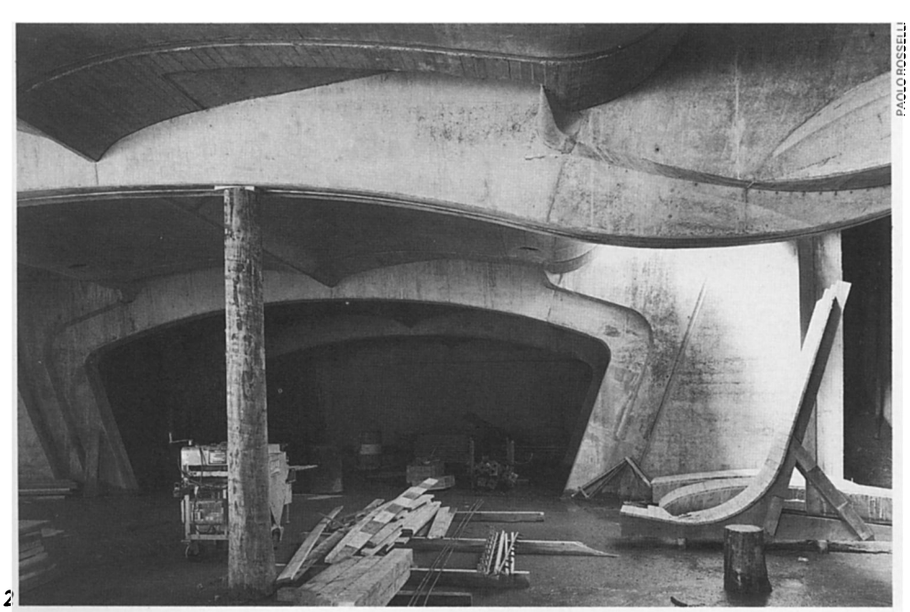

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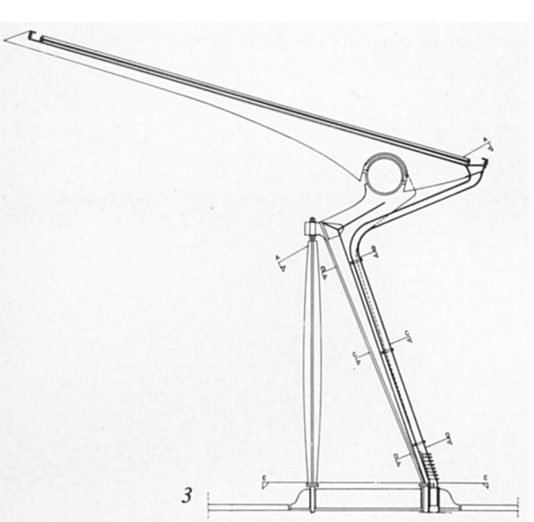

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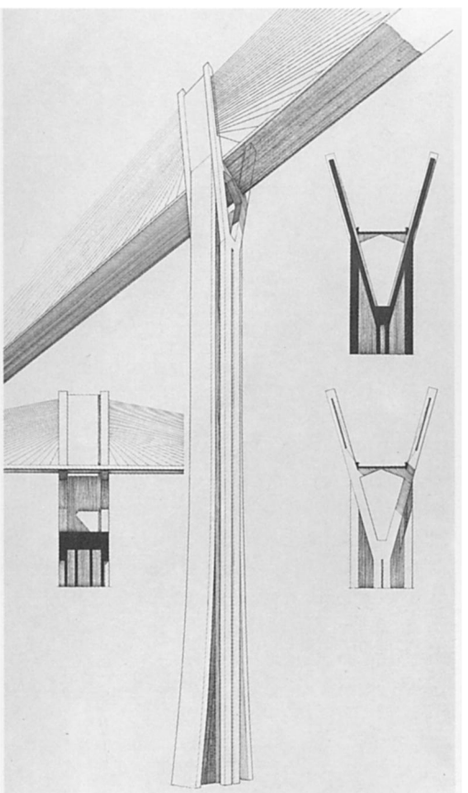
Roof structure, Wohlen High School.

1. Bridge for an Alpine valley: Study drawing.
2. Bridge in Barcelona (with the Department of Urban Projects: J. A. Acebillo, P. Barragon, B. Desola, O. Tarrasoo).
3. Bridge in Lerida (with the Department of Urban Projects).



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