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DANCED WITH CONCRETE – THE ART OF EDUARDO TORROJA

TANIEC Z BETONEM – SZTUKA EDUARDO TORROJA

A b s t r a c t

When new materials and technologies are introduced, it is often the engineers who are interested in exploring and demonstrating the technical and formal potential of this material. Eduardo Torroja (1899–1961) was a Spanish engineer who pioneered, in his work, the use of reinforced concrete, connecting structural logic to formal expression. A prominent example of his art is the hippodrome Zarzuela in Madrid (1941) in which he applied simple yet refined principles to create a work of great logic and beauty. It seems that sometimes engineers are the better architects.

Keywords: Concrete, engineers, formal expression, Eduardo Torroja, hippodrome Zarzuela Madrid, structure, logic, beauty

S t r e s z c z e n i e

Kiedy prezentowane są nowe materiały i technologie, często to inżynierowie są zainteresowani badaniem i demonstrowaniem ich technicznego i formalnego potencjału. Eduardo Torroja (1899–1961) był hiszpańskim inżynierem budowlanym, który w swoich pracach zapoczątkował zastosowanie żelazobetonu, łącząc konstrukcyjną logikę z formalną ekspresją. Sztandarowym przykładem jego sztuki jest hipodrom Zarzuela w Madrycie (1941). Konstruktor posłużył się prostymi, ale wyrafinowanymi zasadami, aby stworzyć dzieło charakteryzujące się niezwykłą logiką i pięknem. Można odnieść wrażenie, że inżynierowie bywają lepszymi architektami.

Słowa kluczowe: beton, inżynierowie, formalna ekspresja, Eduardo Torroja, hipodrom Zarzuela w Madrycie, struktura, logika, piękno

Very often in the history of architecture, we have seen that engineers and technicians have been the creators of magnificent buildings that have a right to be defined as true works of art, i.e., as architecture. This has often happened in times when new materials and building technologies had just appeared, through scientific progress and inventions. More often than not, engineers and technicians with a sense for art adapted and transformed the use of those new materials and technologies into new art forms, while architects were often stuck in

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traditional patterns and ways of thinking. Architects have usually accepted new materials and technologies just as a means to produce more easily the same forms that they had produced previously, while engineers were often the first to see the potential of a new kind of artistic expression when a new material appeared.

The invention and introduction of concrete reinforced with steel – various kinds of unreinforced concrete have been known in architecture for thousands of years – can be seen as a typical example of this phenomenon: Technologically developed in the late 19th century, it was first used to great expressive effect by pioneers like Eugene Freyssinet, Francois Hennebique, Robert Maillart and others, mostly in civil, military, commercial and industrial constructions like bridges, hangars, market halls, factories etc. At the same time, many architects were still busy with exercises in various traditional styles. By architects, reinforced concrete was mostly accepted in only two ways: Either as a bearing structure that was well hidden under architectural decorations of some style, or, in order to imitate forms and elements that had up to then been made from other materials, like stone or wood. For a long time, concrete was considered by architects as a means to make it easier to build in old styles, and not, as by some artistically minded engineers, as a means for a new formal expression. The formula for most architects was just: Concrete as a new material for old forms, or, a material that has no logical form of itself.

Some engineers, however, right from the beginning, recognized in reinforced concrete a new material for new forms. They declined to use the new material as if it was stone or wood from which beams, columns and slabs are made. They understood that through the new material and its specific technical and physical capacities, new shapes and dimensions could be created that had never been seen before.

In France, Germany and Switzerland, building in reinforced concrete was established very early, around the turn of the twentieth century, and extraordinary examples can be found in buildings in those countries. In Spain, the establishment of reinforced concrete as a material for a new architecture happened some decades later, but when it happened, it did in a way that brought about an entire school of pioneers and masters of the new material. It should suffice to mention the names of Eugenio Ribera, and most of all, Felix Candela, who have all left to the world's cultural and technical heritage buildings of reinforced concrete that count among the most audacious and beautiful.

Eduardo Torroja Miret (1899–1961), as a disciple of Eugenio Ribera and a teacher of Felix Candela, is certainly a central figure within this "dynasty" of Spanish "concrete artists" that, by the way, continues to this day. With Felix Candela being the most prominent exponent of the Spanish concrete engineers of the last century, Eduardo Torroja is often somewhat overlooked, even though Frank Lloyd Wright once called him "the most important living engineer". With this article, I would like to recall his mastery and importance, and at the same time emphasize the specific potential of beauty contained in the material of reinforced concrete.

Eduardo Torroja was an engineer, running his own practice, and a university teacher, and certainly did not call himself an architect. In fact, in many of his projects, he and his office collaborated with various architects. The identity and strength of all of his buildings, however, was always consisting in the constructive system and the formal expression, and in the spatial quality derived from it. In Torroja's days, before the arrival of the computer, calculating complex structures was infinitely difficult and lengthy. Risks of errors in calculated structures could never be totally excluded. This is why simulation in models, often full-size, was of primary importance in Torroja's practice.

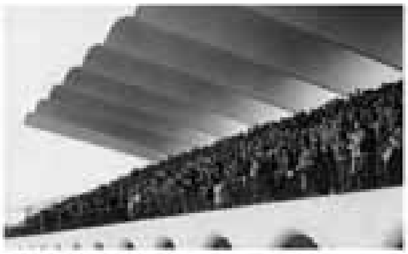
Among his most prominent work from three and a half decades we find many bridges and roof structures for buildings as diverse as market halls, stadiums, hangars, water reservoirs and churches. Each of those buildings features a structural system made of reinforced concrete that unites a simple logic to minimalistic elegance and a strong sculptural expression.

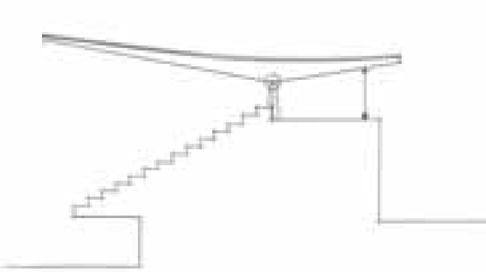
As an example that illustrates Torroja's way of thinking and creating, we want to take a closer look at what is arguably his best known realization: The grandstands of the Zarzuela hippodrome in Madrid, finished in 1941 and splendidly restored in recent years (Ill.1). This work was realized in collaboration with the architects Carlos Arniches and Martín Dominguez. It is very clear which one is the important part of the design: It is the engineering part, the concrete roof structure over the grandstand seats, in correlation with the concrete structure of the grandstand building itself that contains the access ways and the necessary service functions.

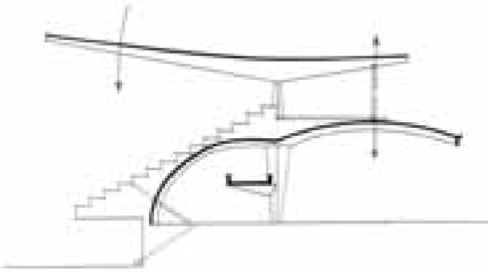
There was clearly an intention to make the roof over the grandstand look as light as possible, like a textile sunshade that is "floating" over the spectators' seats. For this purpose, it had to look as thin as possible, and rest on as few pillars as possible that additionally had to be placed as much as possible out of the visual field. On the other hand, the longitudinal spaces and passages under the seating area were intended to be as open towards the surrounding landscape as possible.

After considering various different and more simple solutions, a system was chosen that consists in a series of parallel shell-like elements, made in situ from reinforced concrete, that lend their exact shape from a sector of a hyperboloid (Ill. 2). Along the line in which two adjacent halves of two of those shells meet, one concrete pillar is placed that carries the entire weight of this sector (Ill. 3). This pillar, however, is placed so far back from the front end of the roof that a tie-rod at the rear edge of the roof is necessary to balance the structure and to make a free overhang of 12.80 metres possible (Ill. 4). To save as much weight as possible and to make the roof look almost weightless, these shells are, in their thinnest part, no thicker than 5 cm!

As if that was not enough, the tie-rod is also used to hold up the big vault that covers the space underneath the grandstand (Ill. 5). In this manner, the entire structure is a system of counter-balancing elements that hold each other in place against gravity. Gravity is actually cheated by balancing separate elements against each other in order to neutralize their weight. It is impossible to say whether the weight of the enormous overhang of the grandstand roof is used to carry the equal weight of the huge vault underneath the grandstand, or if the weight of the vault is used to carry the overhang of the grandstand roof!







Ill. 1. Eduardo Torroja: Zarzuela Hippodrome in Madrid, 1935–1941 (photographed in 1962), source: Archivio General de la Administración (AGA) Alcalá de Henares, Madrid
Ill. 2. Shaping of the roof shells, source: author
Ill. 3. Addition of the roof shells, source: author
Ill. 4. Balancing of the roof structure, source: author
Ill. 5. Balancing of the entire structure, source: author
Ill. 6. Full size test model of the roof structure, source: Informes de laconstrucción, vol. 14, n° 137, enero-febrero 1962

The shells of the roof and the structures that hold it were developed and tested in a full-size model (Ill. 6), as calculations were found to be too complex and inconclusive. The cast of this model, once it was found as good, was later used in the real construction. To underline the structural quality of the building, it is worth mentioning that, during the Second World War, the roof structures have survived no less than 36 hits by airplane bombs without any serious damage.

Apart from the logical finesse and audacious minimal dimensioning of the structure, or maybe because of it, the three similar buildings radiate an impression of solar serenity that is unique captures to this day the attention of even the most inexpert observer. There is a quality and expression of space that would normally be expected from an excellent architect's work. And yet it is obvious that those qualities were achieved exclusively through an engineer's logical structural thinking.

When calculated structure is being used to achieve formal and spatial quality, then the work of engineers creates architecture. Engineers really sometimes seem to be the better architects!

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