Concrete and heritage

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CONFERENCE

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Ladies and gentlemen,

As written by Cyrille Simonnet, concrete, while being a material, is first and foremost a matter.
Concrete is multiple, which is an asset, or, shall we say, a plural asset, but this also makes it difficult to understand it.
Its modern history, from the beginning of the 19th century, is even more complex and is made up of scientific, industrial, entrepreneurial and architectural components that profoundly affected the technical and moral framework of the world of building.

Various types of structures, concretes, cements, know-how, and all of this evolving over time,
represents great diversity and a great architectural heritage that is particularly difficult to inventory or classify, its influences and origins being so diverse.

Modern cement, that of Louis Vicat, results from will to control the setting of hydraulic limes, so as to improve building processes. This is not a revolution yet
The reinforced concrete provided resistance and compactness to a new material, doubly effective at the mechanical and production levels (Simonnet).

The history of concrete architecture and construction is built through the use of many stages :

- Plasters and light cement concretes. They replace lime and clad ornaments. Their use is decorative.
- Artificial concrete stones, which replace cut stone. Their use is architectonic.
- Reinforced concretes, which result from an optimal combination of cement concretes and metal reinforcing elements, generating a new art of building.
- And fibre-reinforced concretes, open the way for a new architecture.

Mouldings in the 19th century: an ornamented world

No material can revolutionize a building mode, disorganizing established production chains and economies overnight.

Economic models and mentalities put a drag on the evolution of building techniques.

After 3000 years of architecture and a steady progress in the art of carving and assembling stones, we do not tell a mason that it only takes some « fairy dust » mixed up with water to erect a proper house.
And on the other side, how can a customer take the risk of choosing a totally new material for a large investment project?

The first concrete elements that date back to the early 19th century are small objects that pose no risk, be it technical or financial, for the manufacturer or the customer. These are copies of sculptures and garden furniture. Concrete advantageously replaces the ornaments in cut stone but also in terracotta, which is already an ersatz of the latter.

Mouldings start being used for decorative purposes, in two fashions:

Plasters are made in countries where bricks and stucco are part of the building tradition (England, Eastern European countries, Northern Europe, America and later Italy, at the end of the century, among others). Lime is very rapidly replaced by quick-setting cement. Decorative elements are implemented using a template.
It is most often associated with a second process, namely the application of small decorative castings.
This is achieved with the quick-setting Roman cements of the 1800s, named Portland cement by Joseph Aspdin, especially in Neo-Palladian England.

Theophil von Hansen designs the house of the banker Gustav Ritter von Epstein on the Ring of Vienna in 1868, and the house on Reithle street with its caryatids in 1878.
Gottfried Semper builds the Academy of Fine Arts in 1873 in cement moulded.

The architecture of Vienna is made up of 70 to 80% of buildings in cement moulded.
The new Viennese bourgeoisie is able to imitate the high aristocracy by possessing princely palace looking properties at a lower cost.

At first, Italy is not a consumer, as it still produces good limes and masters stuccoes. The shift will take place later but it will be very important.

The Mole Antonelliana by Alexandro Antonelli, in 1863 in Turin or the Vittorio Emanuele II gallery in Milan, in 1867 by architect Giuseppe Mengoni, are the most convincing testimonies of this transition.

The Micca street in Turin, with the Bellia palace built by architect Carlo Ceppi in 1892 is also very good example.
Around 1900, architects choose the technique to create the capricious Liberty-style ornamental elements.

Zsigmund Melczer also uses it around 1900 in Bratislava (Slovakia).
Achille Wolf and Antonin Wiehl use it in Prague (Czech Republic) in 1887.
Wilhelm Dvořák uses it in Brno (Czech Republic) around 1900.
And Jan Zawiejski, in Cracow (Poland).

Decorative moulding meet considerable success, which is why it is also widely criticised by personalities such as John Ruskin in 1849 and, later, Eugène-Emmanuel Viollet-Le-Duc,

and architect Adolf Loos, who publishes in 1910 in Vienna (Austria) an essay titled « Ornament and Crime ». These authors do not consider moulding as one of the components of the art of building but instead as a means to hide a structure, a way of cheating.

France is less affected by the phenomenon of ornamental moulding. Architects will soon be replaced cut stones with concrete masonry units.

The artificial stone of the 19th century: prefabrication

Artificial stone is a concrete cast stone. It does not alter the design of the project or the organization of the construction site.
Not only individual concrete blocks are cheaper than cut stone blocks but they are also perfectly calibrated and therefore easier to lay.
It comes to its limit with undercut ornaments, which are difficult to obtain.

Artificial stone is very present in areas where quick-setting natural cement is abundant, especially if the quality of the cement is homogenous. Artificial stone does not require painting, as the concrete is unstained.

In Burgundy, the cements of Vassy and Pouilly in the 1830s, quickly invade the Parisian market.

In the Alps, the cements of Grenoble are very well known and are exported all over the world: from the colonies of North Africa to Latin America, by sea.

Artificial stone elements are placed at strategic points in the buildings. Very soon, whole buildings made of artificial stone start being implemented.
As the Casamaures in 1850, a copy of a Bosphorus palace.
Churches Saint-Bruno in Voiron by architect Alfred Berruyer in 1857 (who built more than 200 churches in moulded concrete), and Saint-Bruno in Grenoble in 1869.

Artificial stone construction almost completely replaced natural stone construction until about 1920, when reinforced concrete became available.

François Coignet, a chemical industrialist, developed more cost-effective manufacturing processes for concrete agglomerates inspired by raw compacted earth or rammed earth, especially for the construction of his factory in Saint-Denis in 1851, and later the workers' housing structures (recently restored).
He creates the New York and Long Island Coignet Stone Company, which manufactures artificial stone, probably with Rosendale cements, produced in New York since 1825.
He builds the Cleft-ridge Span in 1871-1872, the first artificial stone bridge of the U.S.A, designed by Calvert and Vaux in Brooklyn's Prospect Park, and makes great quantities of artificial stone available for the construction of a significant number of buildings and homes.

The second half of the 19th century sees the appearance of modern artificial cements, known as Portland cements, baked at high temperatures, to meet the needs for regulated-

set cements in civil engineering projects. Nevertheless, this type of cement remains expensive to produce compared to natural cements.
It will be perfect in reinforced concrete. But there are no large markets for cement manufacturers at the time.

Reinforced concretes: a new world

The years 1860-1900 see the emergence of new constructions made of reinforced Portland concrete.

The artificial Portland, produced thanks to the clinker, also invented by Vicat in 1840, ensures the regularity of the product throughout the building process, can be used in large quantities in continuous pouring, properly filling up the formwork.

The principle of reinforced concrete is to combine the qualities of resistance to compression of concrete with the tensile and bend strengths of metal, to obtain an undeformable composite material. It's simple and formidably effective.
You know all of it, nevertheless, reinforced concrete ever competes against metal in the construction of large structure.

The reinforced concrete of 1850 thus follows the same evolution path as the moulded concrete from one generation earlier. It is first used in small, prefabricated objects.

Joseph Lambot or Joseph Monier starts working on gardens. They becomes a manufacturers of garden ornaments and makes bridges, basins and flowerpots.

We shall wait until the 1880s to see the emergence of systems such as Bordenave's, which led to the industrial application of reinforced concrete structural elements for construction purposes.

During the 1890s, four large building companies emerge, managed by Gustav-Adoph Wayss, Paul Cottancin, François Hennebique and Edmond Coignet jr.
They perfect building systems, streamline, obtain many patents and boast about the resistance of concretes, including their resistance to fire.

Edmond Coignet, engineer, builds a highly praised water tower for the Universal Exhibition of Paris in 1900, winning the Gold Medal.
François Hennebique builds the arch bridge of Châtellerault (with a span of 50 metres), one of the first large reinforced concrete structures.
Architect Anatole de Baudot defends Paul Cottancin's patent in the construction of the church of Saint-Jean de Montmartre in Paris, 1894-1904.

In the USA, the evolution of concrete has more to do with the encapsulation of metal than with the actual reinforcement of the latter. The first American reinforced concrete building is the Ingall Building in Cincinnati, Ohio, a 16-storey structure built in 1902.

Around the year 1900:
Cement reviews and construction manuals are published.
Specialized technical departments and calculation rules can be found.
A Syndicate of Reinforced Cement Manufacturers is created.
Factories no longer produce hundreds of tons, but gather to produce hundreds of thousands of tons of cement.
Workers become qualified: woodworkers, boxers, metalworkers, mixers, pounders, and a new tool becomes available: the concrete mixer.

As a new construction system emerges, the search for an adequate aesthetic language and for a specific visual identity come up as well.
Reinforced concrete is totally undefined in terms of form. It overturns the certainties acquired (Simonnet).
Concrete would hardly be showcased. It remains a replacement material for a long time.
Cyrille Simonnet speaks of a « deficit in iconicity » which concrete combats by exploiting an image of modernity allowed by the equally modern and chemical medium that is photography. And photography renders the texture of the material visible.

Reinforced concrete is thus precisely the material of the Modern Movement in architecture. It allows the expression of it's geometrical language.
Le Corbusier publishes very appropriately « The New Spirit in Architecture » in 1925, whose character is derived from a « healthy and powerful technique capable of supporting an aesthetic ».
The Villa Savoye built in 1931 showcases reinforced concrete as a tool that makes it possible to express the horizontal line.

Auguste Perret, architect and entrepreneur, promotes reinforced concrete defending a new rational use, free from any type of stone imitation, in structures and as well as in finished surfaces.
The tower of Grenoble, in 1925, defines a « concrete order »: a sober, radical and efficient architecture composed of straight lines and a surface appearance that simply result from the logic of assembly of wooden formwork structures.

Between the two World Wars, architecture will shed its historicist clothes and reinforced concrete will create its own expression.
For Auguste Perret: « form is not submitted to matter, but rather it is matter that brings about the form ».

Reinforced concrete becomes a subject of debate. Two families of builders are born:
Calculators and Expressionists.

-Calculators, who think in structural terms: Eugène Freyssinet, Robert Maillart, Pier-Luigi Nervi, Bernard Zerhfuss, Eero Saarinen, who will create architectures featuring thin concrete structures in the 1960s.
The hangars of Orvieto by Nervi of 1935 are a seminal project as are the thin structures of the CNIT of Camelot, Zehrfuss and Esquillan, or the concrete shells of Terminal 5 at JFK airport in New York by Eero Saarinen, or later architecture of Calatrava or Toyo Ito.

-Expressionists, who think in terms of form and matter: Auguste Perret, Le Corbusier, Marcel Breuer, who will create the Brutalist architectures in the 1960s as well.
In the post-war period, after 1945, concrete became the reference material for reconstruction in Europe, as it was both efficient and inexpensive. Concrete would also become a noble, intricate and varied matter.

The buildings of Marcel Breuer express a sculptural use of concrete, an example of which is the Begrisch Hall Conference Unit (University Heights campus, New York, 1967), whose shattered arrangement of formworks create interesting surface effects, or later architecture of Louis Kahn or Carlo Scarpa.

Last, how can we not conclude by mentioning the UNESCO Headquarters in Paris, built between 1946 and 1958 by Zehrfuss, Breuer and Nervi.
UNESCO headquarters represents all the architectural qualities that can be achieved with concrete, both as a raw material and a pleated shell structure.
And I don't speak about the Meditation Space by Tadao Ando, sort of a new Brutalism.

CONCLUSION and PERSPECTIVES

With concrete, everything seems possible. But, this is not the case. Concrete is often a locally sourced material and know-how. Concrete is the opposite of abstract, of virtual.

As such, over the last 20 years a great number of concrete structure restoration projects have taken place, as concretes are nowadays considered heritage materials. Technology and study of building cultures allows the rediscovery of know-how make it possible to preserve the original aspect of materials. A new era, that of the restoration of concrete structures, including the Perret tower of Grenoble which has been programmed as a distinguished project, is sure to bring together science and the crafts.
That's why, an international colloquium on the restoration of concretes, fort the Becentennial too, is organized in November 2017, in Grenoble, historic city of cement, and the fifth the most innovative city to the world, according to Forbes magazine.

The last 20 years have also saw the emergence of Ultra High Performance Concretes.
They followed the same path as the first concretes, with a relative early success as they totally altered the rules of design and implementation and they were promoted through the production of small, prefabricated design pieces.
Today, UHPCs are mastered but not democratized. One should not expect them to simply enable the post-beam constructions with a slimmer structure.
High performance structures are lighter and more resistant. UHPCs are particularly fine and liquid and are ideal for the moulding of pieces in a workshop setting. The implementation logic for UHPCs becomes one of prefabrication of elements following their dry assembly at the construction site.
The modern hero for this type of architecture is undoubtedly architect Rudy Ricciotti.

Openings for the improvement of this building process are not to be expected from the concrete itself but instead from the evolution of formwork design. A development made possible through the use of digital tools, and an equally efficient manufacturing, also digital, to obtain forms with complex assemblies or double curvatures more easily.