The Fondation Louis Vuitton
Paris (France)

FIDIC Awards 2015
Candidates: setec, RFR + T/E/S/S, Quadrature Ingénierie
Introduction

The Fondation Louis Vuitton for creation is a private cultural initiative by the LVMH group headed by Bernard Arnault. An iconic architectural achievement of the 21st century, designed by American architect Frank Gehry, the Fondation Louis Vuitton is dedicated to:

- promote and support contemporary artistic creation and open dialogue with artists, intellectuals and the public,
- astound visitors by informing, exhibiting and showcasing the accomplishments of the 20th and 21st centuries in an exceptional space,
- move and surprise the public by exhibiting artists’ work in an innovative building, a model of emblematic architecture.

A creator of dreams, Frank Gehry has designed a unique, iconic and bold building, “a magnificent vessel symbolizing the cultural calling of France”. Respectful of a history rooted in French culture of the 19th century, he dares to use technological achievements of the 21st century, opening the way to pioneering innovation. From initial architectural research to unprecedented engineering cutting-edge building techniques combined with unique artworks, make the Fondation Louis Vuitton a dream come true for all stakeholders in the project.

From artistic statement to construction principle

“To reflect our constantly changing world, we wanted to create a building that would evolve according to the time and the light in order to give the impression of something ephemeral and continually changing”, said Frank Gehry.

From an initial sketch drawn on a blank page in a notebook to the transparent cloud sitting at the edge of the Jardin d’Acclimatation in the Bois de Boulogne, the artistic statement is inspired by the 19th century glass roof architecture of French gardens, the natural, ephemeral shapes and power of icebergs, and the sails of a ship.

From the design to the first models, leading to the building principle designed by innovative Building Information Modeling, 4 years of studies were necessary (see next page).

The Fondation in figures:

- 8 year of studies and 6 of construction
- 100 years: sustainability guaranteed
- 13,500 m²: surface area of the 12 glass sails
- 19,000 unique sheets of Ductal® (ultra-high-performance concrete)
- 3,600 unique glass curved panels
- 7,000 m²: total usable floor space
- 3,850 m²: museum space
- 11 exhibition galleries
- 360 to 1,000 seats in the auditorium
- 15,000 tons of steel and stainless steel
- 24,000 m³ of concrete
- 2,000,000 hours of design / execution studies
Innovation, quality, and professional excellence

The Fondation Louis Vuitton is an undertaking of unprecedented architectural complexity, requiring countless technical and technological innovations with ground-breaking design and construction methods. After a lengthy process comprising 8 years of studies of which 6 were devoted to the actual construction design, the project served to drive forward knowledge of how to build highly complex architectural structures.

Without innovations, it would be impossible to design, study and construct a building like this!

The first steps of the design revealed the building’s geometrical complexity, closely intermingled with the architectural statement. Two-dimensional representations were set aside to the benefit of 3-D models; the project is based entirely on Digital Project, itself derived from Dassault Systèmes’ CATIA software used for high-precision industrial applications and specially developed by Gehry Technologies. Working together on this 3-D model, the engineers developed the gateways needed to directly incorporate the new data into their professional tools.

Because of this structural complexity, the engineers chose to define the contours of an “overall” calculation model to manage the way the components work together. The 12 statically indeterminate glass roofs are extremely sensitive to the stiffness of the supports and sizing the primary structure required calculation of the minutest forces they generate! Because of the great number of interactions, for each stage of the design, a multi-corporate coordination model had to be constructed, culminating in the engineering of a model comprising more than 1.3 million nodes and 7 computation iterations bringing them to converge! VCGP (Vinci Construction Grands Projets), which was in charge of the final model, designed a methodology based on a universal language suitable for any calculation software, for which a patent application was filed with INPI (“Institut National de la Propriété Industrielle”, the French patent office).
The building did not fit in with the strict application of European regulations and, supported by an expert committee, the engineers worked out a method of allowing for wind effects. Wind pressures generated in a physical wind tunnel (with 3000 sensors) were processed and fine-tuned before being injected back into the calculation model, to ensure that dynamic effects were properly allowed for.

Wide scale recourse to Fire safety engineering and fire testing, headed by Efectis (an accredited French laboratory) served to validate the fire resistance of the various elements. Structural stability with respect to fire comes from “conventional” construction systems, diverted towards a geometrically complex solution and the structural redundancy of certain components, ensuring that the building remains unaffected by the possible failure of one or several structural components, especially of the glass roofs.

Beyond the management of transversal subjects, envelope design embodies innovation, in particular through:

- The use of 800 m³ of glued laminated high-density larch for the 3D secondary structures in the 12 glass roofs. Following discussions with the European expert committee, the wood-on-metal bonds were subjected to a research program and laboratory loading tests. A calculation tool was developed specifically to individually size and optimize the 480 bonds, each of which is a one-off solution!
- The construction of 3,600 glass panes forming the 13,500 m² of glass roofing. Each of the 3,600 panes is different with geometry determined by cylindrical surface optimization. It meant establishing an innovative manufacturing process from the design stage, by working in conjunction with the makers and using a process to validate positioning on the structure by an ATEx (a Technical Experimentation Assessment) conducted by accredited French laboratory CSTB.
- Production of the 19,000 outer cladding panels (called Iceberg), made of UHPC (Ultra-High Performance Concrete, DUCTAL®) through a process developed specifically for the project, starting from the design stage in conjunction with Lafarge, and for which the mechanical strength of the fastenings was validated by appropriate testing to obtain ATEx approval.
- Construction of the enormous cladding support panels, up to 12.5 m high and 2.5 m wide, prefabricated entirely in the workshop and incorporating a steel structure much like a ship’s hull, as well as insulation and waterproofing.
- Construction of the inner iceberg shells with rendered plaster, forming a fire barrier and extending to heights of 12 m with complex curved shapes.

High quality and professional excellence, on a par with the complexity of the structure!

- The building is guaranteed to last for at least 100 years, thanks to the outstanding quality of its structures and component materials, whether industrialized or hand-made. From industrial production to installation on site, demanding quality control procedures were devised for all the components.
- On-site, watch-making like precision was the benchmark for the assembly of tens of thousands of parts, all differing in their geometry, and made possible solely by the extreme rigour of the workers and surveyors involved in the process. Geometrical inspection by on-site topography and the comparison with theoretical objects, all using 3-D drafting techniques, represented a major step forward in the technique.
- The building satisfies all European safety standards, and fulfils the expected energy efficiency objectives after one year of tests in real using conditions.
- Several engineering prizes awarded in France and the United States rewarded the completion of the project:
  - Gehry Technologies won the BIM Excellence Prize, (Building Information Model) awarded by the American Institute of Architects.
  - Bonna Sabla won the FIB Trophy (Fédération des Industries du Béton) for the vacuum moulding of the Ductal®.
  - In September 2013, Harvard University chose to include the Fondation in its architecture curriculum.
Sustainability and respect for the environment

Regarding all the sustainability aspects of a construction project, the Fondation Louis Vuitton proudly justifies high performance for the following items:

Environmental: an example for future cultural buildings.

- Selected by CERTIVEA to be the pilot project for the experimental development of the new French HQE (High Environmental Quality) label for cultural buildings, the FLV building is the first building of its category to receive HQE certification, reaching the “Excellent” level.
- Early in the design stage, highly detailed calculations were made of the building’s carbon footprint. The purpose was to help to select the appropriate materials and construction methods, for the civil engineering portion of the work and for the shell and core. Then towards the end of the design stage those calculations included all materials used in the project, from civil engineering through to the finishing work: a very new concept.
- A highly ambitious water management project aimed at saving drinking water and ensuring zero discharge of rainwater into the sewage system while also exploiting the site’s geothermal energy:
  - Recovery and storage of rainwater from the glass roofing to feed the three pool systems, all bathrooms in the building and the softened water used to clean the roofing.
  - Storage of storm water in a tank of sufficient capacity to catch historic one-hundred year precipitation, and infiltration.
  - Re-infiltration in the garden of excess rainwater, drain water from the pools and water from the back-washing of the geothermal wells after settlement, etc.
  - Pumping and re-injection of water from the groundwater table and chalk for the functioning of the heating and cooling systems, associated with the air conditioning systems. Functions and automations for water management and energy efficiency are integrated.
  - Energy efficiency: a 50% gain over the performances stipulated in the regulations: an energy efficiency concept associating heat pumps on boreholes into the aquifer, with reversible radiant floors providing “free” cooling using water from the aquifer (galleries, forum, lobby).

Economic: overall cost control to master the economic impact.

- Technical solutions systematically developed and assessed for the 100 year sustainability assigned to the structure required extensive study of the operation and maintenance. The construction costs therefore systematically considered the impacts on maintenance, service life and technical problems relating to repair or replacement so as not to interfere with the use of the building. Some materials were specifically selected for their durability, for instance stainless steel was used everywhere where access might be a problem for corrosion-proofing maintenance and equipment such as a personal fall arrest protection system was integrated early on in the project to enable an ergonomic solution for safe access at least possible cost.
- Optimizing the costs to build the structure called for a contractual framework appropriate to the services performed by the Contractors along with detailed on-going analysis of the costs of the work, to consolidate the costs of a structure that was impossible to estimate ahead of time due to the unique nature of the project.

Social: art for All!

- The Fondation Louis Vuitton for Creation is a cultural project that contributes to the worldwide renown of the City of Paris and France. The building will be donated to the City of Paris and its citizens in October 2061.
- This architectural work encourages dialogue and opens all branches of the arts to a global audience of all ages in total synergy with the nearby Jardin d’Acclimatation dedicated to children. It also fits perfectly into a vibrant system of knowledge and expertise transmission through dedicated music masterclasses and workshops for children.
- The building is exemplary in terms of access, particularly for those with any kind of disability. To achieve this ambition, the owners and project managers worked together and sought the help of experts so as not only to meet regulatory requirements, but also look ahead to the future and ensure that the Foundation would always be accessible to all.
- This jobsite advanced the knowledge of many architects, engineers, contractors and industrial companies, driving them progress beyond anything done previously. Many trades and much of the traditional expertise were given the opportunity to forge ahead, and familiarize themselves with the new techniques demanded to solve the technical difficulties posed by the structures.
- A proud achievement indeed for the people of Paris and for the 120,000 employees of the LVMH Group, of which the Fondation Louis Vuitton resides at the core of the internal and external communication.
Transparency and integrity

- This project, as inclusive as possible, with a cultural vocation, the dream of the Fondation Louis Vuitton, was made possible thanks to exemplary orchestration on the part of the project managers, uniting the most intelligent construction know-how and expertise in total transparency on each and every aspect of the project, from the initial outlines through to inauguration.

- All partners involved – engineers and architects – were located at a single address, initially on one floor of the Louis Vuitton offices then later on the jobsite, under the supervision of the Company’s management. Even more than geographical unity, this achievement is due to the quality of human relations that prevailed.

- Working in a climate of trust encouraged by the Client, each discussed his progress and the difficulties encountered in a fully transparent manner, enabling a solution to be found for the common good of the project. From the architectural aspect to the technical challenge, to the manufacturing and installation methodology, the engineers, the Contractors and the architect considered all subjects jointly. Although transparency was absolute, the roles of each part were clearly established and the integrity of the project respected. Each part had the resources to perform its work and the controls each exercised over the others were very extensive.

Conclusion

The Fondation Louis Vuitton, once considered impossible to build, is a dream come true. This exceptional architectural concept called for engineering of a high level, both in its diverse technical disciplines and in its management functions. For this was an exceptional project of structural, shell and core technologies entrusted to setec bâtiment, RFR, T/E/S/S, and Quadrature Ingénierie. The engineering for this project, more than any others, cannot be attributed to a few engineers. It is the collective work of a group of men and women of all nationalities engaged in the adventure, to successfully complete this visionary cultural project, which will have advanced human knowledge of the art of construction.

The project management for the Fondation Louis Vuitton was innovative also in the contractual strategies, adapting the general contractor agreement to the high risk that comes with innovative processes, and placing the project management in a cooperative approach with the general contractor. Thus, the most complex design aspects were studied jointly, even at times bringing the owner in for some portions of the execution studies, or conversely encouraging research and development work with European industrial companies and experts from the early design stages. This was a totally collaborative, innovative, transparent, and integrated approach.