Philadelphia connections in Renzo Piano's formative years: Robert Le Ricolais and Louis I. Kahn

Author(s): Lorenzo Ciccarelli

Source: *Construction History* , Vol. 31, No. 2 (2016), pp. 201-222
Published by: The Construction History Society
Stable URL: https://www.jstor.org/stable/10.2307/26476242

Philadelphia connections in Renzo Piano's formative years: Robert Le Ricolais and Louis I. Kahn

Lorenzo Ciccarelli
Department of Enterprise Engineering, University of Rome Tor Vergata

Abstract

At the beginning of 1969, when he was thirty-two years old, Renzo Piano went to Philadelphia to meet the French engineer and academic Robert Le Ricolais. During his stay on campus at the University of Pennsylvania, Piano also met Louis I. Kahn. The American architect was known in Italy as "the friend of the past", so Piano probably considered him to be at the extreme opposite pole to his own first interests: prefabrication, lightweight structures and plastic materials. However, after working for him and visiting his buildings, Piano discovered Kahn as an 'unexpected maestro', sharing his care for natural light, the clarity of the composition and attention to the fine detailing of the building. Therefore, it was not by chance that Kahn immediately hired the young Italian architect to design the skylight in the roof structure of the Olivetti-Harrisburg factory in Harrisburg (1967-70). The paper explore the collaboration between Kahn and Piano during the design and the construction of the factory, and the legacy of the American master valuable also in following buildings of Renzo Piano, like the Menil Collection in Houston (1982-87) or the extension to the Kimbell Art Museum in Fort Worth (2007-13).

Keywords

Renzo Piano, Louis Kahn, Robert Le Ricolais, Zygmunt Makowski, Olivetti, Harrisburg

Introduction: the client, the architect, the building

Between 1966 and 1970, Louis I. Kahn (1901-74) designed the Olivetti-Underwood factory in Harrisburg, outside Philadelphia.[1] Renzo Zorzi (1921-2010), then current head of the Olivetti cultural department, explained that:0

> When, in the United States, the Olivetti Company decided to leave the old factory of Hartford, inherited with the acquisition of the Underwood company… and to build a new factory for the computer era that was already ushering, two problems arose: which location and which architect. [2]

Following logistical evaluations, Harrisburg, the capital of Pennsylvania was chosen because the city was well connected to the harbours of the east coast and to the most important road networks of the country. "If Harrisburg had to be, Louis Kahn, the architect of Philadelphia, was the predestined name" said Zorzi.[3]

The first contacts between the parties dated back to October 1966.[4] Even though Kahn was engaged in the major projects of his life at the four corners of the world during this time – from the Kimbell Art Museum in Fort Worth (1966-72) to the National Capital of East Pakistan in Dacca (1962-83) – the opportunity to collaborate with a company of Olivetti's prestige immediately elicited the enthusiasm and commitment of the American architect.

After several meetings and discussions, in particular with Gianluigi Gabetti (b. 1924), the Olivetti chief executive for North America, Kahn received the letter of appointment in summer 1967. The general contractor was Barclay White & Company of Philadelphia. The building started on site in April 1968. The factory opened in early 1970.

Gabetti requested a working space characterized by maximum flexibility, able to adapt itself to the sudden changes in production imposed by electronics and automation. Taking this into account, Kahn, together with August Komentant (1906-92), went to the decisive meeting in the Olivetti headquarters in New York City, at One Park Avenue, with two proposals. Both shared the same design principle of having the surface and the form of the factory resulting from the multiplication and juxtaposition of a module. It would be both spatial and structural.[5]

In the first project proposal, Kahn and Komendant devised a regular grid of columns supporting a series of concrete pyramidal elements, prefabricated on the ground, set in place by a crane and connected to the columns by post-tensioned cables. The pyramidal elements were open at the top to filter natural light. The second project proposal, the one ultimately implemented, conceived of the factory as the result of 72 repetitions, in 9 rows and 8 columns, of a spatial and structural module composed of a prefabricated column in reinforced concrete that supports a cast-in-situ irregular octagonal slab, obtained by removing the vertices of a 18 x 18 metres square. The slab is concave, to carry the rainwater into drainage ducts inside the columns. The juxtaposition of the octagonal modules leaves open an area of 6.4 metres per side, where the air-conditioning plant and skylights were located. (Figs 1 & 2)

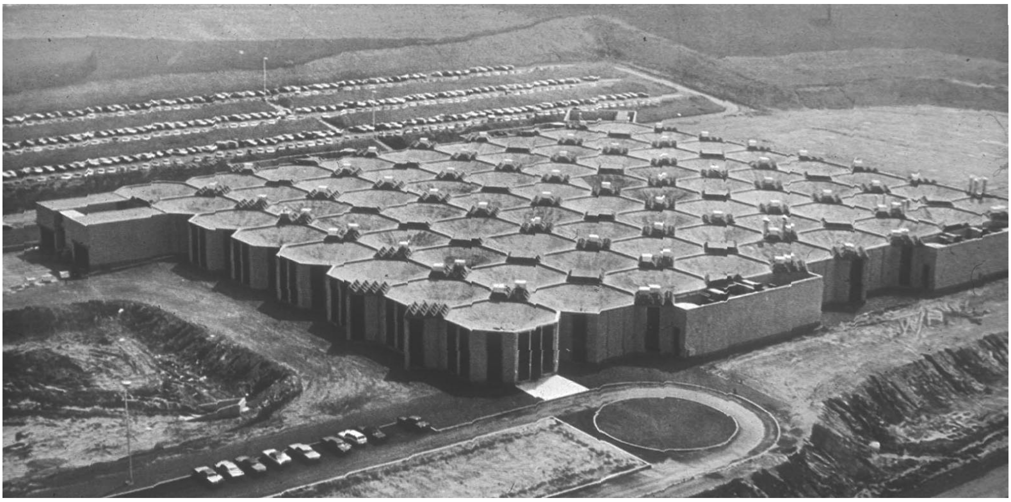

Figure 1. Olivetti-Underwood factory, Harrisburg (PA), 1970. Architect, L.I. Kahn; Engineer, A. Komentant. (Associazione Archivio Storico Olivetti)

The perimeter walls, released from any structural function, follow the perimeter of the roofline. Composed of prefabricated panels in lightweight concrete, the walls are pierced by generous openings from floor to ceiling. Thus, the working space, free and flexible, is punctuated only by the regular grid of columns 18 x 18 metres, with the ducts simply suspended from the roof structure: "a sharp configuration… that could grow with additions following the needs, respecting its grid and continuing to be itself".[6]

The construction of the Harrisburg factory ran smoothly under Komendant's supervision and, above all, with the collaboration of the engineer Antonio Migliasso. Trained in the Olivetti industrial engineering division, Migliasso had, in the early 1960s, founded SERTEC, a design and engineering consulting

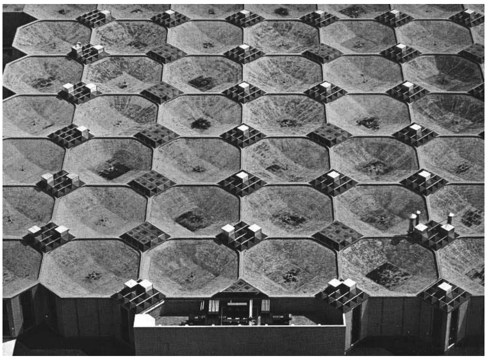

Figure 2. Olivetti-Underwood factory. Detail of the roof showing the skylights designed by Renzo Piano. (Fondazione Renzo Piano)

company in Ivrea, a town near Turin in Italy. Since the 1950s, Migliasso had collaborated on the design of all the Olivetti factories all over the world, and his contribution in Harrisburg was also remarkable.[7]

During the design and construction phases the biggest problem turned out to be the square surfaces between the octagon modules, where the skylights had to be placed. Leafing through the sketches and the drawings of the project in the Kahn Collection in the Architectural Archives of the University of Pennsylvania, it is possible to follow the many solutions developed by Kahn, from December 1966 to the first months of 1969: cylindrical elements or sectioned cones that, leaning on the cover slab, overwhelmingly pierce the spaces below; or extravagant pulling fans, shaped like a fungus, that are narrow at the top to open skylights.

All these solutions proved not to be feasible, even slowing down work on the construction site; in particular the casting of the cover slabs. The problem became so severe that, in the project site report of 1st May 1969, it is written: "the monitors design… has been scrapped. The architect is working on a new design. It has been decided that the roofing will have to start without the monitors".[8] Komendant later recalled:

> The design of skylights was an agony for Kahn – mainly because glare shadows had to be avoided, which, if intensive, would interfere and hamper the work with tiny items. Glare reduction could be made possible by the use of plastic, but Kahn did not like plastic. Finally he had to accept it, and the design was completed in collaboration with an Italian architect. [9]

The "Italian architect" was Renzo Piano.

Experiments with plastics by the young Renzo Piano

Milan: Giulio Natta and the Politecnico

After two years at the University of Florence, Renzo Piano (b. 1937) graduated from the Politecnico di Milano in 1964. In the following seven years, until the competition for the Centre Beaubourg in Paris in 1971, Piano did not construct any significant buildings. He spent this long formative period traveling and experimenting with new plastic materials in a series of lightweight prefabricated structures, built in Genoa, using the equipment and the labour force of his family's construction company, founded in the 1930s by his father Carlo (1892-1973) and, from the early 1960s, run by his older brother Ermanno (1928-91).

Piano's interest in plastics began when he was a student at the Politecnico di Milano. The most famous professor of the University was undoubtedly Giulio Natta (1903-79), the "father of the plastics", who won the Nobel Prize for chemistry in 1963. Natta graduated in Chemical Engineering at the Politecnico in 1924, and from 1938 he was appointed Full Professor of Industrial Chemistry, founding the eponymous institute. On campus at the Politecnico in 1952 he opened the famous *Laboratorio prove materie plastiche*: an experimental workshop, which Piano certainly knew and in which, during that decade, Natta discovered many new plastic materials, such as polypropylene in 1957.[10]

In those years Milan was the industrial heart of Italy and the most advanced centre for testing the use of plastics in industrial design and in prefabricated construction. At the IX Triennale in 1951 several architects including Gio Ponti (1891-79), Angelo Mangiarotti (1921-2012) and Marco Zanuso (1916-2001) introduced the first plastic furniture. In 1954 Gio Ponti, the influential editor of the review *Domus*, wrote: "everything is moving towards plastics … Modern architecture needs plastics to meet the new demands of the construction: economy, speed, lightness, precision, colour, transparency".[11] In the second half of the 1950s, with the introduction of reinforced plastics, in particular reinforced polyesters, it became possible to experiment with applications in buildings too. Also in this field Gio Ponti was a pioneer in Italy, with the prefabricated plastic house at the X Triennale of 1954, and the design of the first sandwich panels, shown at the 1956 Turin Technical Fair. The designer Alberto Rosselli (1921-76), in collaboration with the reviews *Stile Industria* and *Materie plastiche*, organized the *Prima Mostra internazionale per l'estetica delle materie plastiche* in Milan in 1957. Already in Milan there was Kartell, founded in 1949 by Giulio Castelli (1920-2006), the first industrial design company that pursued the realisation of objects and furniture in plastics. It was Kartell that produced the Marco Zanuso K4999 chair in 1964, and the Joe Colombo (1930-71) *Universale* chair in 1967. As for building prefabrication, at the 1967 Milan Fair, Cesare Pea introduced the first Italian prefabricated house in reinforced polyester.[12]

Zygmunt Makowski and the Structural Plastic Research Unit

Following his interest in plastics and prefabrication, Piano decided to move to London in 1965, to meet Zygmunt Makowski (1922-2005), the Polish structural engineer who co-founded the *Structural Plastic Research Unit* in the Department of Civil Engineering at the University of Surrey-. A pioneer in the field of plastics in building construction, he was one of the organizers of the *International Conference by The Plastics Institute*, held in London, 14th-16th June 1965.[13] A rare volume of the proceedings of this conference is still preserved in the library of the Renzo Piano Building Workshop in Genoa.

In two presentations at the Conference, Makowski showed results he had developed in his workshop, starting from the idea that 'new materials create new architectural and structural forms'. To achieve the most effective structural forms it is necessary to start by understanding the properties of the material. In particular, as already mentioned, plastics had the disadvantage of an extremely low modulus of elasticity, so "to offset this disadvantage it is very essential to use structural forms which give added stiffness by virtue of [its] shape: folded plates, singly and doubly curved shells and stressed-skin space structures offer the greatest possibilities".[14] Structures that work by shape: thin sheets of reinforced polyester, the strongest plastic material, that, through folding, acquire the necessary rigidity.

Makowski explored two paths: a barrel vault obtained by assembling rhomboid elements with a central fold, and a shelter made with pyramidal pieces joined by tubular steel, plates and bolts. Piano looked to this second solution when he began to build his first structures made using pyramidal elements in reinforced polyester.[15]

The structures were obtained by assembling a large number of identical units or modules, the prototype for which had been developed through drawings and the testing of models, which were mass-produced by Piano's family construction company. Piano chose reinforced polyester which, in combination with glass fibres acting as a "continuous armature", was the only polymer product that could make modules with a tensile strength and bending stiffness comparable to those of other building materials. To study in detail its shape and behaviour under load, the pyramidal piece was initially manufactured by hand moulding. Although this process was "slow and expensive", it was of "great interest from the operational and experimental point of views".[16] Indeed, given the low cost of the wooden moulds on which the polymer resin was sprayed, building up successive layers to achieve the final thickness, the technology of hand moulding offered "the possibility of checking all geometric, structural and functional aspects of the prototype at very low cost".[17] Once all the details of the prototype had been established by numerous load-tests on many variants and options, the 'module' could be mass-produced, faster and cheaper, by hot moulding. The pyramidal shape was the result of the specific production process, and was the easiest to create in such a way that a balanced distribution of the forces within the module was achieved. Each module has, at the top, a steel plate embedded in the plastic material, through which, by the use of bolts and steel rods, it is possible to connect the many identical modules and assemble the basic shelter. Neoprene joints between each module ensure the waterproofing of the structure, and the natural translucency of the reinforced polyester guarantees illumination of the space beneath. (Figs 3, 4 & 5)

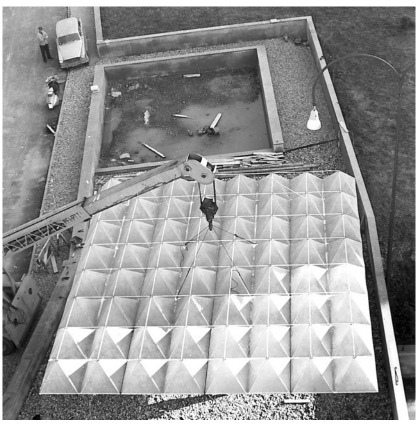


Figure 3, 4. Reinforced polyester space frame, Genoa, 1965. Renzo Piano. (Fondazione Renzo Piano)

A master of lightness: Robert Le Ricolais

Makowski invited Piano to present his reinforced polyester space frame at the *First International Conference on Space Structures* at the University of Surrey, September 21-23, 1966. Makowski also invited Robert Le Ricolais (1894-1977) to this conference.[18]

Robert Le Ricolais was born in France, in La Roche sur Yon, in 1894.[19] He undertook graduate studies in mathematics and physics, but these were interrupted by World War I and he never completed them. From 1918 to 1931 he lived in Paris, getting to know the painters of Montparnasse and the *Académie de la Grande Chaumière*. He painted 'constructivist' paintings, made using an airbrush, and began to compose verses, activities that he would continue throughout his life, occasionally publishing them. Between 1918 and 1943 he worked as a hydraulic engineer. Meanwhile, driven by curiosity and attracted to the complexity of the structures, he studied biology, chemistry and mineralogy through the texts of D'Arcy Thompson (1860-1948) and Ernst Haeckel (1834-1919). Following the crisis of 1929, he left Paris in 1931 and moved to Nantes. In 1935 Le Ricolais published the essay that brought him to

Figure 5. Reinforced polyester space frame, Genoa, 1965. Renzo Piano. A young Renzo Piano at the age of 27 under one of his structures. (Fondazione Renzo Piano)

international attention: *Les Tôles composées et leur applications aux constructions métalliques légères (Composite laminates and their application to lightweight metal construction)*; this was awarded the Medal of the French Society of Civil Engineering.[20] In this paper, starting with a study of the form of the shell of the Mediterranean scallop, the engineer introduced corrugated shell structures, characterized by minimum thickness and maximum shape resistance. In 1940 he published two articles in the prestigious "Annales des Ponts et Chaussées", the second of which was entitled *Essais sur des systèmes reticulés à trois dimensions (Essays on reticulated structures in three dimensions)*, and dealt with the configurations and methods of calculation of tetrahedral spatial structures, inspired by the forms of protozoa radiolarian.[21] For this research, and the many patents resulting from them, the Ricolais received in 1962 the *Grand Prix* of the *Cercle d'Etudes architecturales de France*.

Throughout his research, Le Ricolais adopted the same conceptual process. He started from the observation of one of the "wonders created by nature" - the shells, radiolarians, and some crystals - from which he extracted the basic geometric configuration linked to a precise mechanical action. From this combination, with the help of graphic methods and mathematical formulations, Le Ricolais derived similar geometric structures and pursued their application to structures, submitting them to load tests in order to refine and demonstrate their integrity.

In 1951 Le Ricolais moved to the United States to continue his research with increased funding. From 1951 to 1953 he taught at the University of Michigan, Harvard University and the University of North Carolina. Probably because of a shared interest in space structures, Anne Tyng (1920-2011), at the time partner and collaborator of Louis Kahn, had become aware of Le Ricolais' studies by 1952 and, in the following year, the French engineer was introduced to Kahn by John Fitzgibbon, an assistant of Buckminster Fuller (1895-1983) who was a Fellow at the University of North Carolina.[22] In December of the same year Kahn began corresponding with Le Ricolais, sending him drawings that he was developing with Anne Tyng for the City Tower in Philadelphia. In 1954 Kahn was able to appoint Le Ricolais to the University of Pennsylvania where, from 1954 to 1976, he held the course *Experiments in Structures* and led a research workshop on experimental structures. Here, for the first time, Le Ricolais had the opportunity to develop his research with continuity. In 1974 he inherited the prestigious Paul Cret Chair of Architecture from his friend Louis Kahn. In 1973, in recognition of his research, he was made a member of the American Institute of Architects. Le Ricolais returned to Paris in 1976, where he died the following year.

Zygmunt Makowski was one of the first admirers of the work of Le Ricolais. The two met in the 1950s and Makowski was the author of the first article - in number 850 of the *Architectural Association Journal* in 1961 – that introduced the British public to the wide spectrum of research and achievements of the French engineer. After noting that "the article which follows has been prepared by an engineer, but, it is hoped, it will prove of interest to architects", Makowski underlined the pioneering role of the Ricolais, declaring that "the distinguished French engineer seems to be one of the first to have realised fully, many years ago, the potential possibilities of double-layer grids".[23]

In light of this we should not be surprised that, among the 160 engineers, architects, mathematicians and scientists of various specialization that Makowski invited to the First *International Conference on Space Structures* at the University of Surrey, Robert Le Ricolais was the only one who presented two papers. These two papers prompted the profound interest of Piano, impressed by the wideness and variety of the knowledge of the French engineer, by his ability to combine sophisticated mathematical formulae, geometric graphical methods, and load tests on models.

Piano was so impressed that, in early 1969, he decided to go to Philadelphia to present the structures he had designed and built to Le Ricolais, and to visit his experimental workshop at the University of Pennsylvania.[24]

As mentioned above, since 1954, the French engineer had taught the course *Experiments in Structures* at Faculty of Design. He also contributed to the master class directed by Louis Kahn, giving lectures in structural engineering, together with August Komendant (1906-92), and participating in design reviews. Above all, Le Ricolais led the research workshop on experimental structures, located in the basement of the Fisher Library, in front of the Faculty of Design, at the centre of the University of Pennsylvania campus. These same rooms now house the Architectural Archives in which Le Ricolais' archive is preserved. Le Ricolais spent most of his time in this workshop where he not only pursued his research, but also taught his students, rather than in classrooms. These rooms were at once a laboratory, an art studio and the workshop of a craftsman, as shown in rare vintage photographs: a hardworking place where Piano must have felt immediately at ease. (Fig. 6) Francesco Dal Co noted that, working in Le Ricolais' workshop, Renzo Piano "had the opportunity to have confirmation that the working method he was developing in his own workshop in Genoa, can succeed" and that, through experimentation on models, he had confirmation that "in architecture every aesthetic result is the direct consequence of experimental research".[25]

The working method of Le Ricolais was, in fact, centred on constructing models to verify the statical intuitions derived mostly from a great many observations from nature. Le Ricolais developed the construction of these models and the associated load tests with the students who attended his course. The course was based on this experimental work and the fundamental principles of structural engineering. As recalled in the 1960s by Carles Enrique Vallhonrat, one of the closest collaborators of Kahn and Le Ricolais: "He insisted that his students touch the models with their hands".[26] In a recent conversation, Peter McLeary, former close associate of Le Ricolais, recalled that: "Piano arrived in Philadelphia with two bags full of models of his structures, which he then discussed with Le Ricolais".[27]

Piano and Le Ricolais spoke the same language, the empirical language driven by physical contact with

Figure 6. The research workshop on experimental structures led by Le Ricolais at the University of Pennsylvania, Philadelphia, early 1970s. (Architectural Archives of the University of Pennsylvania)

materials, by the pleasure of handling the models, and they were both convinced that "the contact with things is full of meaning".[28]

A master of light: Louis Kahn

During the journey undertaken to meet Le Ricolais, Piano had another, completely unexpected meeting – with Louis Kahn – and Piano decided to extend his stay in Philadelphia until the end of May 1969.

Kahn first became known in Italy in the early 1960s through a series of long articles written by Francesco Tentori (1931-2009) in *Casabella-Continuità*, and through the translation of the monograph on Kahn by Vincent Scully just one year after its publication in the United States in 1962.[29] From these essays Kahn emerged as an architect for whom it was necessary to "rewrite the history of contemporary architecture", who was dazzled by the Parthenon and the ruins of ancient Rome, who was marked by the '"love of the past". This monograph contributed to the cultural project pursued in *Casabella-Continuità* by its editor, Ernesto N. Rogers, aimed at reassessing the Modern Movement and overcoming the rigidity of its premises, by integrating a concern for the *preesistenze ambientali* and historical context into architectural design.

The meeting between Kahn and Piano took place during a design review. Le Ricolais lived very close to the campus of the University of Pennsylvania and for this reason, as Komendant recalled, the final revisions of the students' master class projects took place at the home of the French engineer. These meetings usually started at 2 p.m. and "very often lasted beyond 1 a.m.".[30] It was during one of these discussions that Piano, invited as a collaborator of Le Ricolais, met Louis Kahn.[31]

Piano probably considered the American architect to be his extreme opposite. However, after getting to know him personally and visiting his buildings, Piano discovered unexpected similarities with Kahn.

At the time Piano, like most European architects, was unaware of what Kahn had produced in his 'first life' when, during the 1930s in Philadelphia, he had designed "prefabricated building units with a definite advance in the lowering of construction costs for medium price housing".[32]

The Italian architect immediately noted how some of his own key themes were of profound interest to Kahn also: the construction process and the building site, clarity of design, the attention to natural light.

As suggested by Thomas Leslie: "the technologies of building construction and function were of profound interest to Kahn, an aspect that has been recognized but never fully explored".[33] Already in his seminal article *Monumentality* (1944), Kahn had discussed how to "convey a quality of monumentality to our buildings", and focused on the great buildings of the past, testifying "a striving for structural perfection which has contributed in great part to their impressiveness, clarity of form, and logical scale".[34] The structural perfection, the clarity of form and the logical scale were concepts that Kahn even experienced in the Gothic cathedral where he saw "the members of the structural skeleton with the same love of perfection and search for clarity of purpose".[35]

The clarity of a structure, its accuracy, reflected in a logical architectural composition, in a building that could be easily readable, visually separable into its fundamental components, were all concepts crucial to Kahn and his closest collaborators; Kahn must have found Piano in perfect agreement. August Komendant, for example, revealed that the first time he met Kahn in 1956 "he was very pleased with my work, especially with the proposals and the clarity of the structural system".[36]

According to Kahn, the eloquence of the building could be measured by the clarity of its construction:

"how it was done, how it works should filter through the entire process of building".[37] In this process of clarification it is clear that the nodes connecting the various components are raised to prominent role, to which Kahn gave the maximum design attention. Vincent Scully already noted how Kahn was "an architect devoted to the analysis of the structural components, of the individuality that assume from time to time the column, the architrave and the static structure of the junction point".[38] In his keynote address to the last meeting of CIAM in Otterlo in 1959, Kahn spoke these heartfelt words:

> I feel that the beginning of ornament comes with the joint. The way things are made, the way they are put together, the way one thing comes to the other, is the place where ornament begins. It is the glory of the joint, which is the beginning of ornament. The more a man knows the joint, the more he wants to show it. The more he wants to show the joint, the more he wants to show the distance.[39]

Piano probably did not expect to find in Kahn's work so many concepts that he himself was pursuing, perhaps with a more instinctive than deliberate awareness. But, finally, he had to convince himself during his stay in Philadelphia, by making several visits to the Richards Medical Research Laboratories which Kahn had built on the University of Pennsylvania campus between 1957 and 1965. This was the building that revealed Kahn as a world-renowned architect, and to which the Museum of Modern Art in New York dedicated a solo exhibition in 1961.

The building exhibits a structure in precast, pre-stressed concrete elements assembled on site.[40] Not by chance, it was the first example of collaboration between Kahn and Komendant, the US expert in pre-stressed concrete, who in 1952 had published *Prestressed Concrete Structures*, the first American book on the subject.[41]

Piano, like many architects of his generation, was deeply involved in the issue of prefabrication and by buildings whose structure proclaimed the assembly of prefabricated parts on site. The Richards Medical Research Laboratories was the first building where Piano saw prefabrication that was applied, not to industrial warehouses, but to an architectural work of the most exquisite refinement and formal expression, in which structure and building are inseparable terms: the one implies the other.

Piano and Kahn also shared a great concern for natural light and the careful design of the roof structures of buildings that would ensure the careful balance of that natural light. In these years Piano began to experiment with cover panels that capture only a certain amount of natural light, particularly from the north, as in the cover panel in reinforced polyester, patented in 1969, which was the origin of the complex articulated leaves at the Menil Collection, the 'flying carpet' of the Fondation Beyeler and the skylights that cover the extension to the High Museum in Atlanta.[42] Indeed, natural light was a point of obsession for Kahn, indicated continuously in his writings:

> I would say all spaces need natural light… all spaces worthy of being called a space need natural light. Artificial light is only a single little moment in light… and natural light is the full of the moon and it just makes a difference… I can't define a space really as a space unless I have natural light.[43]

Kahn was always looking for the "endlessly changing qualities of natural light in which a room is different every second of the day".[44] Thus a central role was assigned to the covering structure that filtered its quality: "the means of making a space already implies that light is coming in… and the very choice that you make of the element of structure should be also the choice of the character of light that you may want".[45]

It was thus not a coincidence that the collaboration between Kahn and Piano, on the Olivetti-Underwood factory in Harrisburg, was on the design of roof structures capable of ensuring natural light.

Piano's contribution in the Olivetti-Underwood factory

The folders of sketches and drawings for the Olivetti-Underwood factory, now at the Kahn Collection at the Architectural Archives of the University of Pennsylvania, also contain a series of sketches and drawings by Renzo Piano, dated April 1969.[46] (Figs 7, 8 & 9) The drawings have the office stamp of Louis I. Kahn Architects with the words "in collaboration with Renzo Piano Architect" at the end. These are unique in the whole production of the Kahn office.

Kahn probably discussed with Le Ricolais the problems he was having in designing the skylights of the factory, and the French engineer suggested showing them to the young Italian who, in those weeks, was in Philadelphia and had shown Le Ricolais some space structures in plastics. By coincidence, Piano, in collaboration with Marco Zanuso, had already designed skylights in reinforced polyester for the Olivetti factories in Scarmagno (1967) and Crema (1968).[47] On those occasions Antonio Migliasso had been impressed by the young architect's work and his opinion must have finally convinced Louis Kahn to entrust Piano with the "damned" skylights.

Piano quickly designed a structure similar to those he had already built in 1965: a square skylight, 6.40 metres on each side, made up of 16 pyramidal elements in reinforced polyester, 1.60 by 1.60 metres, assembled using steel rods and bolts. The pyramidal elements were connected in such a way that the skylight presented a slight incline towards the four edges, to ensure rainwater would drain away. The fitting and the attachment to the reinforced-concrete slabs were studied carefully. A double aluminium flashing and a continuous neoprene joint protect this delicate node.

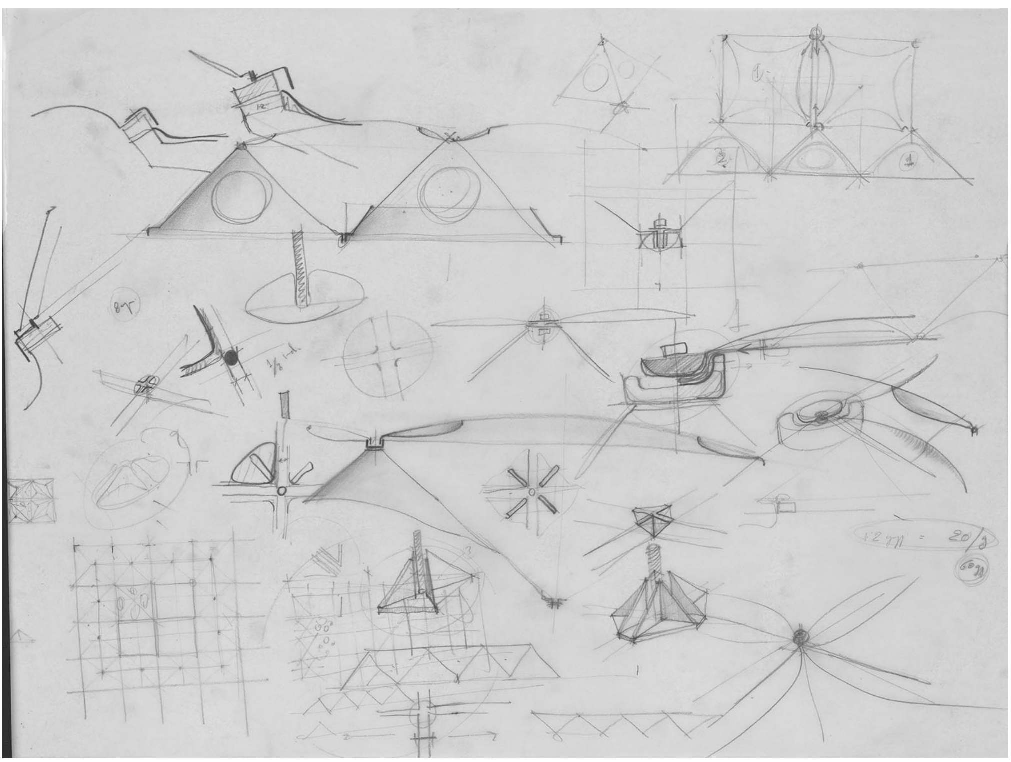

Figure 7.

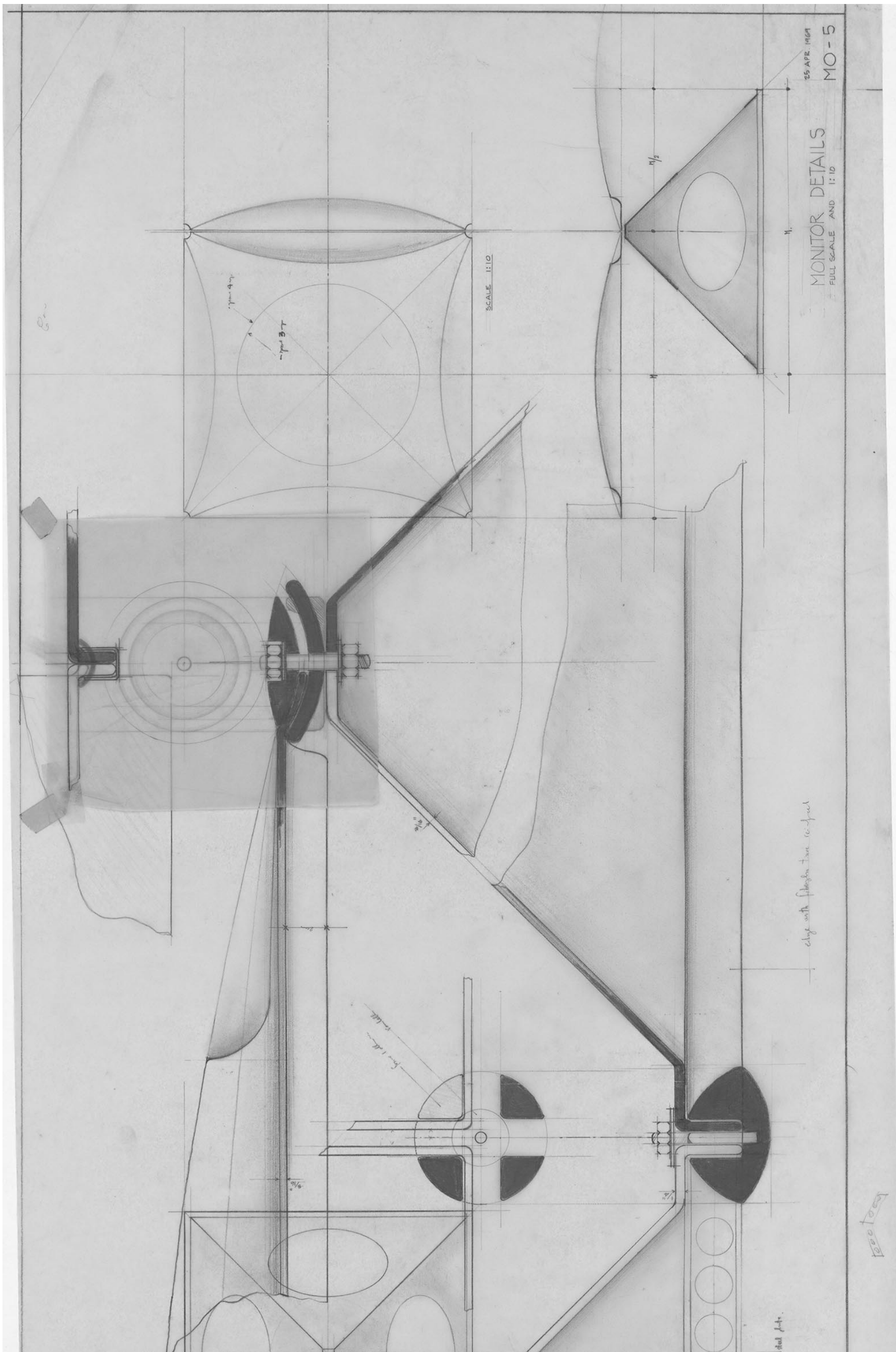

Figure 7, 8. Sketches of the skylights of the Olivetti-Underwood factory, 1969. Renzo Piano. (Architectural Archives of the University of Pennsylvania)

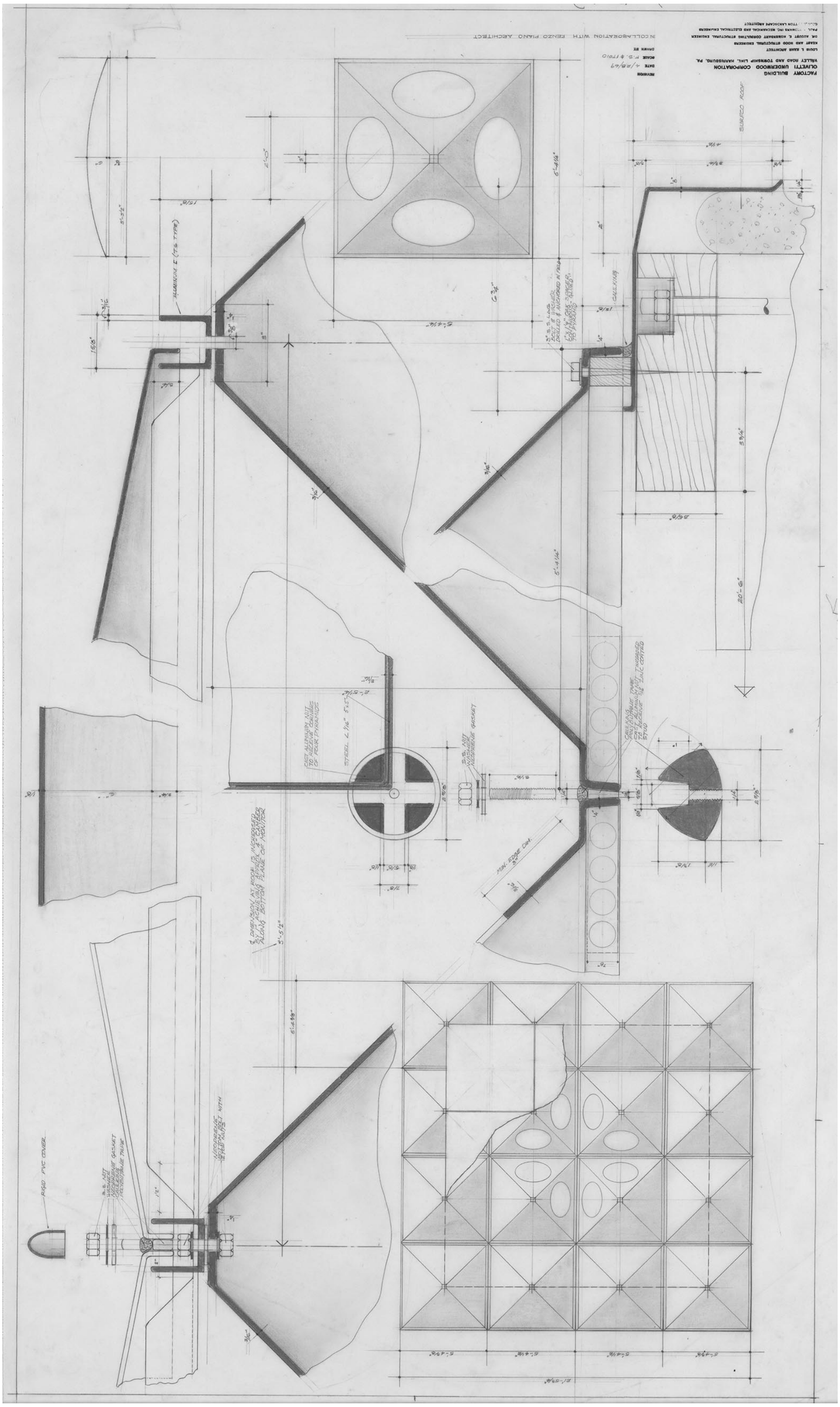

Figure 9. Plan, sections and details of the skylights of the Olivetti-Underwood factory, 1969. Renzo Piano. (Architectural Archives of the University of Pennsylvania)

Unlike the space structures using pyramidal elements that Piano had already built, the skylights at the Olivetti-Underwood factory not only had to bear their self-weight and the live loads but, in the case of 52 of the 80 skylights, also the weight of the 57 cabins housing extraction fans of the air treatment system.

Each of these square cabins were supported by four adjacent pyramids, fixed to the same steel rods that fasten the pyramids to each other. The faces of the pyramids carrying the extraction fans channel the air rising from the work spaces below into the inlet of the fans. A sharp, simple solution.

This additional weight on the pyramids led Piano to design a bespoke aluminium fixing for each skylight that clamps the nine internal nodes of the four adjacent pyramids.

The design phase was quickly completed in April because Piano presented something that he had already designed and built. In the minutes of the site meeting of 15th May 15, 1969 it is noted: "the new design drawings Monitor 05, Monitor 06, Monitor 07 & Monitor 08 received 5/13/69".[48]

On May 29 Piano supervised the assembly and load testing of the first of the skylights which was recorded in photographs now kept at the Fondazione Renzo Piano. (Figs 10 & 11)

> The pyramids were inspected on the assembly jig and Mr. Piano expressed concern with the fit of the aluminum castings. It was suggested that a different type of connection be used and much discussion followed. Mr. Piano suggested that he be given some men to do experimental work over the weekend. Barclay White and Company said that the testing would have to go ahead today because there was no time left for further experimental work. It was felt that only through an actual load test would be able to determine what corrective measures would have to be taken. It was decided to proceed with the test. The interior support of the jig were removed and the monitor was supported only on the edges and was ready to for test… At this time Mr. Piano and Mr. Gianopulos agreed that the monitor test proved the design was satisfactory… It was then decided to pick up the monitor with a crane to see if we could handle it with the helicopter without losing camber. This was done and the monitor was replaced on the test jig and measured with the result that there was no less of camber.[49]

Figure 10. Renzo Piano assisted the load test of the skylight, Philadelphia, 1969. (Fondazione Renzo Piano)

Figure 11. Renzo Piano (left) with Nick Gianopulos (center) during the load test of the skylight, Philadelphia, 1969. (Fondazione Renzo Piano)

The load test provided results that were useful in refining the design of the bespoke aluminium fixing, and showed that the skylight could be assembled on the ground and placed without damage on site, using a helicopter. After verifying the success of the load test and the effectiveness of the skylights, Piano felt his collaboration with Kahn was complete and he came back to Europe. In the meantime, at the building site, the casting of the self-supporting octagonal slabs was completed and McClarin Plastics started production of the pyramidal elements in light-blue reinforced polyester, as chosen by Kahn. The first pyramids were delivered to the building site on 6th June and assembled the following day. On 2nd July 46 skylights were set in place. On 29th August "the monitor erection is complete". (Figs 12 & 13) In the following months the external walls were assembled and the pipelines fixed. On 24th December 1969, Kahn informed the Olivetti-Underwood Corporation and Barclay White & Company by letter that the building was complete.[50]

An endless legacy

The predilection for natural light and for the careful design of covering structures were the cornerstones of the brief but significant collaboration between Renzo Piano and Louis Kahn, and the legacy that the American master passed on to the young Italian architect.

Kahn died a few years later, in 1974, while Piano was engaged full time in the difficult building site of the Centre Pompidou in Paris. Piano did however have the opportunity to reflect on the teachings of

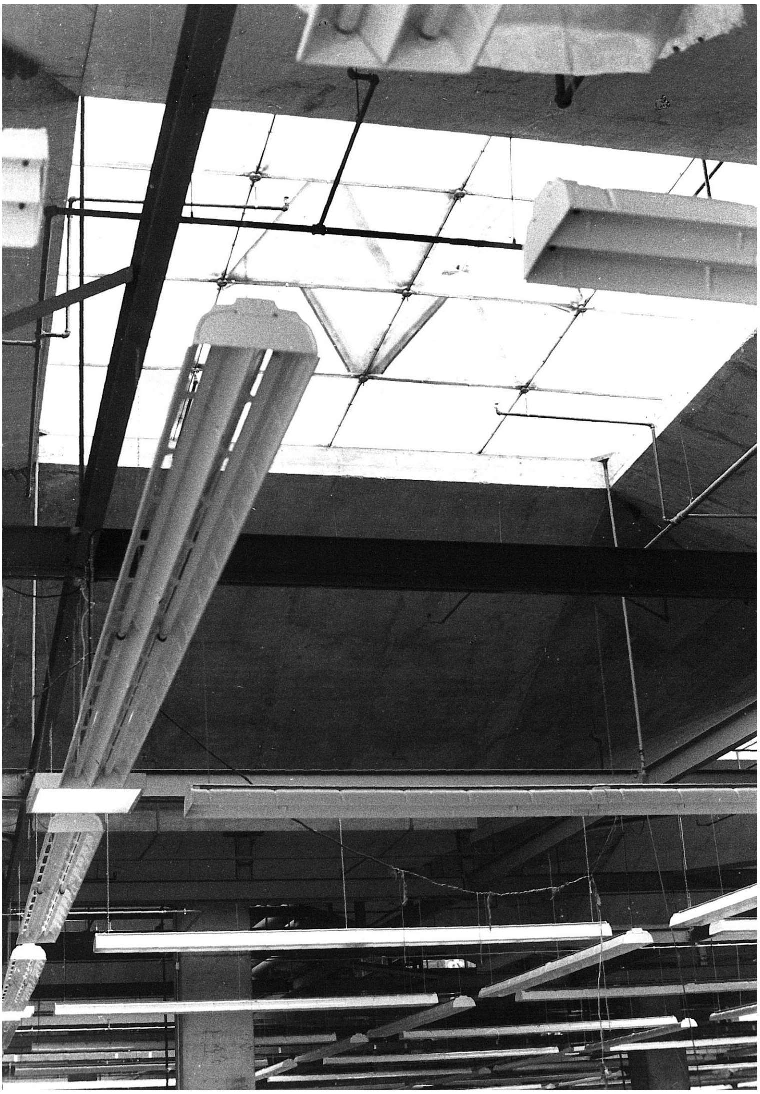

Figure 12. One of the skylights seen from the inside of the factory, Harrisburg (PA), 1970. (Fondazione Renzo Piano)

Kahn and, indirectly, to collaborate with him in two projects: the Menil Collection in Houston (1982-87) and the extension to the Kimbell Art Museum in Fort Worth (2007-13).

The Menil commission for Kahn came about following his meeting with Dominique de Menil (1908-97) for the first time in 1967 in Houston. She had arrived from France in 1941 with her husband John, and they had brought with them the art collection that was slowly enriched over the course of a lifetime, including archaeological material, Byzantine works of art, objects of tribal cultures and twentieth century paintings, notably of the surrealist masters.[51]

In November 1972, John and Dominique De Menil decided to entrust to Kahn the design of the museum that would house their collection, to be located in the peripheral Montrose district, where it had to harmonize with the surrounding, mostly single-family residential buildings of the Twenties.

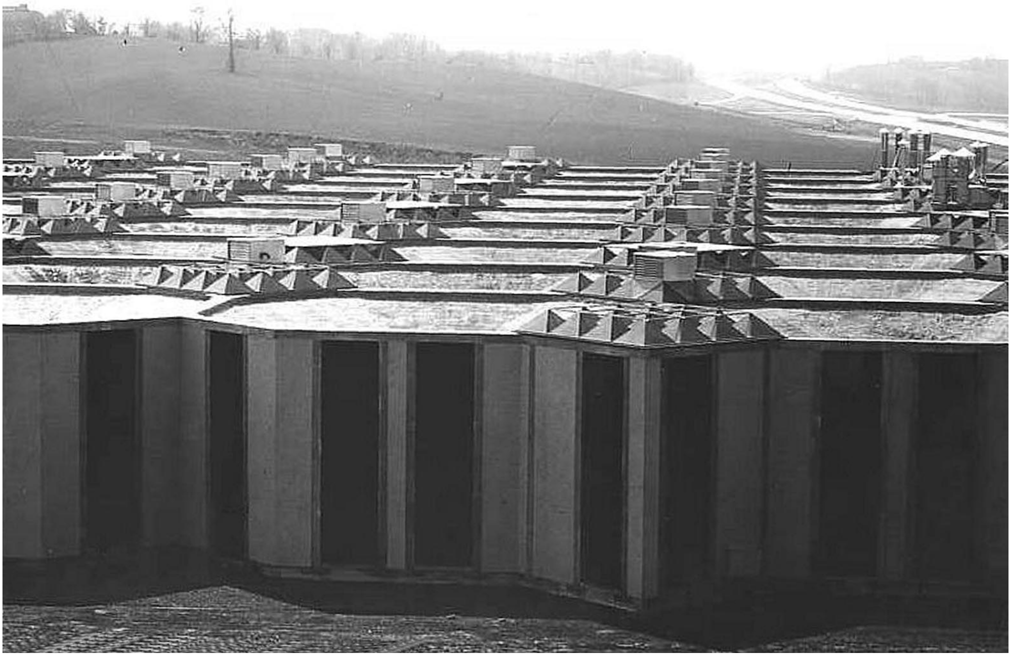

Figure 13. The completed Olivetti-Underwood factory, Harrisburg (PA), 1970. (Associazione Archivio Storico Olivetti)

The museum would need to be designed for a specific size, a horizontal rather than vertical development and the choice of humble materials. The galleries, according to the precise request of Madame De Menil, would have to be illuminated solely by natural light, which would reflect, within the museum, the external conditions: the weather, the passage of clouds, the changing colours of the hours of the day.

In the Kahn Collection of the Architectural Archives of the University of Pennsylvania are 53 of Kahn's drawings relating to the project for the Menil Collection. The architect had begun to think of a series of pavilions in the park, punctuated by a series of semi-circular vaults, perhaps on the model of the Kimbell Museum, inaugurated in 1972 not very far away in Texas. In a floor plan of 10 March 1973 Kahn began sketching small sections of vaults with skylights.

Unfortunately the death of John de Menil in 1973, and that of Kahn, a year later, interrupted the project's progress.

In the early 1980s Dominique de Menil, on the advice of Pontus Hultén (1924-2006), the famous collector and director of the Centre Pompidou, decided to entrust the project to Renzo Piano, a choice that reaffirmed the centrality of natural light in the characterization of the museum's galleries.[52]

The design was largely undertaken by the Italian architect working on particular models, 1:10 and 1:5, called "solar machines": sections of a room of the museum, with different hypothesis of coverage, illuminated by particular sources of light designed to reproduce the intensity and the degree of natural light. Detectors within the model measured the gradient and the quality of the filtered light. (Fig. 14)

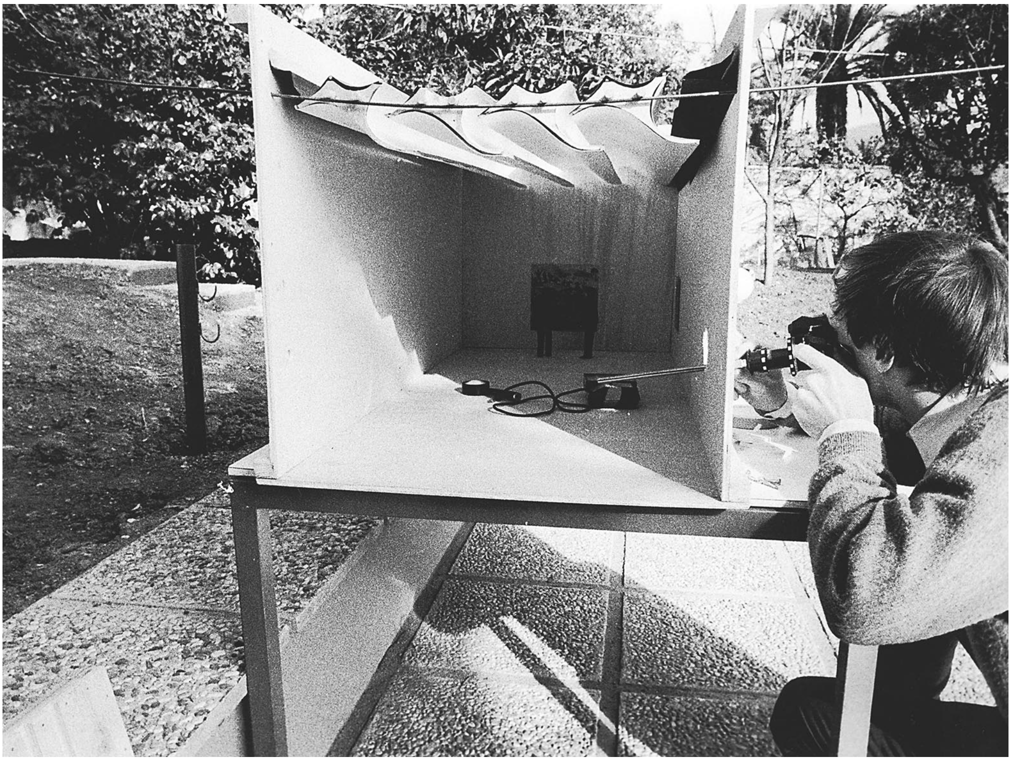

Figure 14. Architect Shunji Ishida using the "solar machine" for studying the shape and size of the ferrocement "leaves" for the Menil Collection, Genoa, 1983. (Fondazione Renzo Piano)

These tests - with the substantial contribution of the Irish engineer Peter Rice - led to the design of the famous ferrocement "leaves" that, according to Reyner Banham, filter a light "of a sheer beauty ... Its quality may well set standards that will make other architects lie awake at night".[53]

Despite the fact that neither the forms nor the material are the same, Piano revealed that the constant reference was the natural light achieved by Kahn in the Kimbell Art Museum. Arriving from Italy for the building site inspections Piano invariably recalled, "We went to see the Kimbell Art Museum by Louis Kahn".[54]

So, inevitably, the circle was closed when to Renzo Piano, in 2007, more than forty years after their first and decisive meeting, was given the task of designing the expansion of Kahn's masterpiece.[55]

Kahn was commissioned to design the Kimbell Art Museum in 1966 and, in the months that Piano spent in the office of Philadelphia, working side by side with the American master, the Italian architect certainly had not missed the opportunity to observe the plants and sections of the cycloid vaults: a powerful mechanism for filtering the natural light.

In the "Piano Pavilion" the Italian architect pointedly pays homage to the lessons of the American master. Piano designed his building on a triangular lot in front of the original museum, set approximately 50 metres to the west, respecting the dimensional forms, the height of about 6.50 metres and the bay divisions set by Kahn. The same spatial clarity, the same structural power and the same seduction of natural light join the two buildings.

The laminated wood beams that mark the spaces and supports the roof of the "Piano Pavilion" are 31 metres long, as are the cycloid shells in the Kahn building.

The eleven double beams support an elegant steel and glass coverage made, in the upper portion, with skylights and with canvas apt to filter the light inside the galleries at the bottom. The first level is modelled with curved glass screens with a satin texture, attached to a secondary steel structure. Above these panels are supported, on steel IPE beams, the sheds that capture only the portion of light comes from the north, as the pyramidal elements above the Olivetti-Underwood factory in Harrisburg in 1969.

Acknowledgments

I would like to thank William Whitaker, director of the Architectural Archives of the University of Pennsylvania, Lucia Alberton of the Associazione Archivio Storico Olivetti and Professor Claudia Conforti of the University of Rome Tor Vergata with whom I discussed the themes of this essay. Particular thanks go to Chiara Bennati and Nicoletta Durante, archivists of the Fondazione Renzo Piano.

The Author

Lorenzo Ciccarelli (1987) obtained his Master's Degree in Building Engineering-Architecture at the Università Politecnica delle Marche in 2011. In January 2016 he was awarded his Ph.D. *cum laude* in Architecture and Construction at the Università di Roma Tor Vergata, with a thesis entitled *Renzo Piano before Renzo Piano. The formative years 1958-71*. He works on Italian architecture of the Twentieth Century and its relationship with Europe and the USA. From 2016 he is postdoctoral researcher at the Università di Roma Tor Vergata.

Contact details: Lorenzo Ciccarelli, via Montelatiero 9, 60035 Jesi (AN), Italy.
E-mail: lorenzociccarelli@hotmail.com

Notes and References

1. The building is considered to be one of Kahn's minor works and, therefore, is often overlooked in the monographs or studies concerning the American architect. See A. Komendant, *My 18 years with Architect Louis I. Kahn*, Englewood: Aloray, 1975. pp. 91-104; R. Zorzi, 'Ricordi di un committente. La costruzione della fabbrica dell'Olivetti, Harrisburg 1967-70', *Casabella*, vol.651-652, 1997-98, pp. 114-125; F. Dal Co, *Renzo Piano*, Milano: Electa, 2014. pp. 385-89.
2. Zorzi, Ricordi, (See note 1) p. 114.
3. ibid. p. 114.
4. 'Reminder of telephone change in date of meeting' (Architectural Archives of the University of Pennsylvania, Louis I. Kahn Collection, 030.II.A.7.14)
5. Komendant, *My 18 years* (See note 1) pp. 96-97.
6. Zorzi, Ricordi, (See note 1) p.114. See also: A. Pica, 'Una nuova opera di Louis Kahn. Il nuovo stabilimento Olivetti a Harrisburg, Pennsylvania', *Domus*, vol.493, 1970, pp. 2-11; J.M. Dexon, 'More than just a volume', *The Architectural Forum*, vol.4, 1971, pp. 20-25.
7. Antonio Migliasso is constantly cited in the documentation; constantly present right from the beginning of 1966, thorough all the advances of the construction site from 1968 to 1970. (AAUP, Louis I. Kahn Collection, 030.II.A.7.42)
8. 'Minutes of Meeting n°51 held Thursday, May 1, 1969 at 1:15 P.M. at the Job Site, Harrisburg, Pa' (AAUP, Louis I. Kahn Collection, 030.II.A.7.42)
9. Komendant, *My 18 years* (See note 1) pp. 97-98.

10. I. Pasquon, 'Giulio Natta e l'industria chimica', in E. Decleva (Ed.), *Il Politecnico di Milano nella storia italiana (1914-1963)*, Milano: Cariplo-Laterza, 1988. pp. 461-486.
11. G. Ponti, 'Materie plastiche ed architettura moderna', *Materie plastiche*, vol.1, 1954.
12. C. Pea, 'Casette prestampate', *Domus*, vol.334, 1957. For an overview on architecture and industrial design in Milan during the 1950s and the 1960s see: F. Irace, 'Milano', in F. Dal Co (Ed.), *Storia dell'architettura italiana. Il secondo Novecento*, Milano: Electa, 1997. pp. 58-81; V. Gregotti, *Il disegno del prodotto industriale in Italia 1860- 1980*, Milano: Electa, 1986. pp. 231-355; P. Fossati, *Il design in Italia 1945-1972*, Torino: Einaudi, 1972.
13. *Plastic in Building Structures: Proceedings of a conference held in London, 14-16 June 1965*, Oxford: Pergamon Press, 1966. On Makowski see: H. Nooshin, *Z.S. Makowski at Sixty Five*, Guildford: The University of Surrey Publication, 1987; G. Parke, S.A. Behnejad, 'Z.S. Makowski: A Pioneer', in J.B. Obrebski, R. Tarczewski, (Ed.), *Proceedings of the International Association of Shell and Spatial Structures*, Wroclaw: Wroclaw University of Technology, 2013; S.A. Behnejad, G. Parke, 'Half a Century with the Space Structures Research Centre of the University of Surrey', in M. Brasil, R. Pauletti, (Ed.), *Shell, Membranes and Spatial Structures: Footprints*, Brasilia, 2014.
14. B.S. Benjamin & Z.S. Makowski, 'The analysis of folded-plate structures in plastics', in *Plastic in Building Structures: Proceedings of a conference held in London, 14-16 June 1965*, Oxford: Pergamon Press, 1966, pp. 149-163.
15. For these structures see: Z. Makowski, 'Structural Plastics in Europe', *Arts&Architecture*, vol.7, 1966, pp.20-30; M. Scheichenbauer, 'Progettare con le materie plastiche. Le strutture adatte al poliestere rinforzato', *Casabella*, vol.316, 1967; R. Piano, 'Ricerca sulle strutture in lamiera e in poliestere rinforzato', *Domus*, vol.448, 1967, pp. 8-22. Furthermore, for an overview on the evolution of plastics in Italy, see: A. Rinaldi, *Evoluzione delle materie plastiche nel design per l'edilizia*, Milano: Franco Angeli, 2014.
16. M. Zanuso, R. Piano. R. Lucci, *Elementi di tecnologia dei materiali come introduzione allo studio del design*, Milano: Tamburini, 1967. In this book Piano analysed all the different ways by which plastics could be moulded.
17. ibid.
18. R.M. Davies (Ed.), Space Structures. A study of methods and developments in three-dimensional construction resulting from The International Conference on Space Structures University of Surrey, September 1966, Oxford and Edinburgh Blackwell: Oxford, 1967. For the paper of Piano: R. Piano, 'Experiments and projects with industrialised structures in plastic materials', pp.753-764. The two paper of Le Ricolais: R. Le Ricolais, 'Octahedronal cells for tensioned steel structures', pp. 1032-1038; R. Le Ricolais, 'A simple method of computation for planar networks', pp. 1026-1031.
19. On Robert Le Ricolais see: *Robert Le Ricolais. Visions and Paradox*, Madrid: Fundacion Cultural COAM, 1997; T. Vreeland, 'Robert Le Ricolais', *The Architectural Design*, vol.10, 1960, pp.412-416; 'Robert Le Ricolais: 30 ans de recherches sur les structures', *L'Architecture d'Aujourd'Hui*, vol.108, 1963, pp. 85-101; 'Le Ricolais', *Zodiac*, vol.22, 1973, pp. 1-69.
20. R. Le Ricolais, 'Les Toles Composées et leur applications aux constructions metalliques légères', *Mémoires de la Société des Ingénieurs Civils de France*, 1935.
21. R. Le Ricolais, 'Essais sur des Systèmes Reticulés à trois dimensions', *Annales des Ponts et Chaussées*, July-August 1940, September-October 1941.
22. Letter from John Fitzgibbon to Louis Kahn, March 3, 1953; reported in S.W. Goldhagen, *Louis Kahn's situated modernism*, New Haven & London: Yale University Press, 2001. p. 233. On Anne Tyng see: A. Tyng, 'Form finds Symmetry in Geometry', *Zodiac*, vol.19, 1969; S.J. Weiss, *Anne Tyng. Inhabiting geometry*, Philadelphia: Institute of Contemporary Art, University of Pennsylvania, Graham Foundation, 2012. On the relationship between Kahn and Le Ricolais see: T. Leslie, 'Unavoidable nuisances. Engineering and engineers in the work of Louis Kahn', in *Louis*

Kahn. The power of architecture, Weil am Rhein: Vitra Design Museum, 2012. pp. 203-218.
23. Z. S. Makowski, ‘Double-layer grid structures’, *Architectural Association Journal*, vol.850, 1961, pp. 218-238.
24. The approximate period of Piano’s journey to Philadelphia is derived from the dates on the drawing Piano made in the office of Louis Kahn: April 1969. (AAUP, Louis I. Kahn Collection, 030.I.C.735)
25. Dal Co, *Renzo* (See note 1) p. 389.
26. C. Vallhonrat, ‘The in-visibility of tectonics’, *Perspecta*, vol.31, 2000, p. 31.
27. McCleary, interview with the author, June 9, 2015.
28. Le Ricolais, ‘Essais’ (See note 21) p. 34.
29. F. Tentori, ‘Ordine e forma nell’opera di Louis Kahn’, *Casabella-Continuità*, vol.241, 1960, pp.3-17; F. Tentori, ‘Il passato come un amico’, *Casabella-Continuità*, vol.275, 1963, pp. 26-41; V. Scully, *Louis I. Kahn*, Milano: Il Saggiatore, 1963.
30. Komendant, *My 18 years* (See note 1) pp. 186-187.
31. Piano, interview with the author, February 26, 2015.
32. L. Kahn, ‘Outline report on Jersey Homesteads’, 1936, p. 2; reported in Goldhagen, *Louis Kahn’s situated modernism* (See note 24) p. 14.
33. T. Leslie, *Louis I. Kahn. Building art, building science*, New York: George Braziller, 2005. p. 3.
34. L. Kahn, ‘Monumentality’, in P. Zucker (Ed.), *New architecture and city planning. A symposium*, New York: Philosophical Library, 1944. pp. 77-88. Reported in A. Latour (Ed.), *Louis I. Kahn. Writings, Lectures, Interviews*, New York: Rizzoli, 1991. pp. 18-27.
35. Latour, *Louis I. Kahn* (See note 34) pp. 18-19.
36. Komendant, *My 18 years*, (See note 1) p. 3.
37. L. Kahn, ‘How to develop new method of construction’, *Architectural Forum*, 1954, p. 157.
38. Scully, *Louis I. Kahn* (See note 29) p. 49.
39. New frontiers in architecture, CIAM in Otterlo 1959, in Latour, *Louis I. Kahn* (See note 34) p. 98.
40. Komendant, *My 18 years* (See note 1) p. 10.
41. A. Komendant, *Prestressed Concrete Structures*, New York: McGraw Hill, 1952.
42. L. Ciccarelli, ‘Architecture as construction in the beginnings of Renzo Piano. Five patents for construction systems and “pieces” of buildings (1965-69)’ pp.447-454 in B. Bowen, D. Friedman, T. Leslie, J. Ochsendorf, (Ed.), *Proceedings of the Fifth International Congress on Construction History*, *Chicago 2015*, Chicago: Palmer House, 2015.
43. ‘Louis I. Kahn. ‘A discussion recorded in Louis I. Kahn’s Philadelphia office in February 1961’, *Perspecta*, vol.7, 1961, pp. 9-18.
44. L. Kahn, ‘Architecture: Silence and Light’, in A. Toynbee, *On the Future of Art*, New York: Viking Press, 1970, pp. 20-35.
45. Kahn, ‘A discussion recorded’ (See note 43) p. 14.
46. They are 6 sheets with sketches and studies without any office stamp, and 3 sheets with the stamp of the Kahn office and the words “in collaboration with Renzo Piano Architect”. (AAUP, Louis I. Kahn Collection, 030.I.C.735)
47. R. Piano, ‘Le materie plastiche nella produzione edilizia per componenti’, *Materie plastiche*, vol.5, 1971.
48. ‘Minutes of Meeting No.53 held Thursday, May 15, 1969 at 1:15 P.M. at the Job Site, Harrisburg, Pa’ (AAUP, Louis I. Kahn Collection, 030.II.A.7.42)
49. AAUP, Louis I. Kahn Collection, 030.II.A.7.42
50. Letter from Louis I. Kahn to the Olivetti-Underwood Corporation and Barclay White & Company, December 24 1969. (AAUP, Louis I. Kahn Collection, 030.II.A.8.14)
51. About the project of Louis Kahn for the Menil Collection see P. Cummings Loud, *The art museums of Louis I. Kahn*, Durham: Duke University Press, 1989, pp. 263-279.

52. About the project of Renzo Piano for the Menil Collection see R. Banham, 'In the Neighborhood of Art', *Art in America*, vol.6, 1987, pp.124-129; 'La costruzione del Museo De Menil', *Lotus*, vol.78, 1993, pp.54-65; Lia Piano (Ed.) *Menil Collection*, Genova: Fondazione Renzo Piano, 2007.
53. Banham, 'In the Neighborhood' (See note 52), p. 128.
54. Piano, *Menil Collection* (See note 66), p. 151.
55. About the Renzo Piano Building Workshop project of the for the expansion of the Kimbell Art Museum see F. Dal Co, F. Bucci, 'Kimbell Art Museum 1972-2013', *Casabella*, vol.833, 2013, pp. 76-103.