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Engineering Intuition: RFR

RFR was established by Peter Rice in 1981 as a «laboratory interface between architecture and engineering»

Structural engineers as collaborators with architects have received more individual recognition as designers during the past few decades – for instance RFR, as the following projects and designs will show.

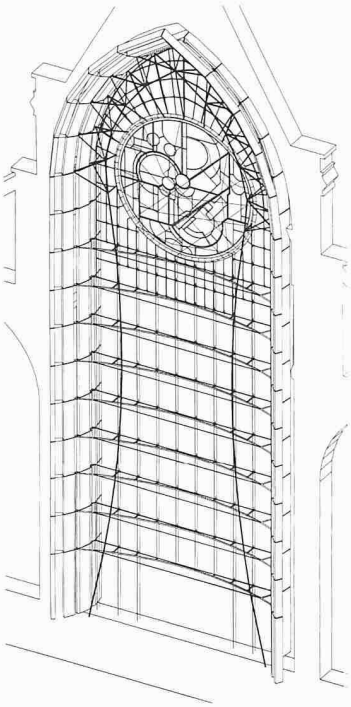
Birdhouse project (on top on the right).
TGV station at Charles-de-Gaulle, Roissy (above and right)

Ove Arup, with his firm Ove Arup and Partners, was instrumental in this transformation of the engineering profession. Forming a symbiotic relationship between engineers and architects, without diluting the importance of making structures work, Arup encouraged engineers to design and innovate using intuition. Peter Rice, who worked for Ove Arup in London for 20 years on projects such as the Sydney Opera House (Jorn Utzon, 1962); the glass Pyramids for the Louvre (I.M. Pei, 1985/1991); and the Centre Pompidou (Piano&Rogers, 1971) directed the unique but connected disciplines of architecture and engineering when he established RFR with Martin Francis, a naval engineer, and Ian Ritchie.

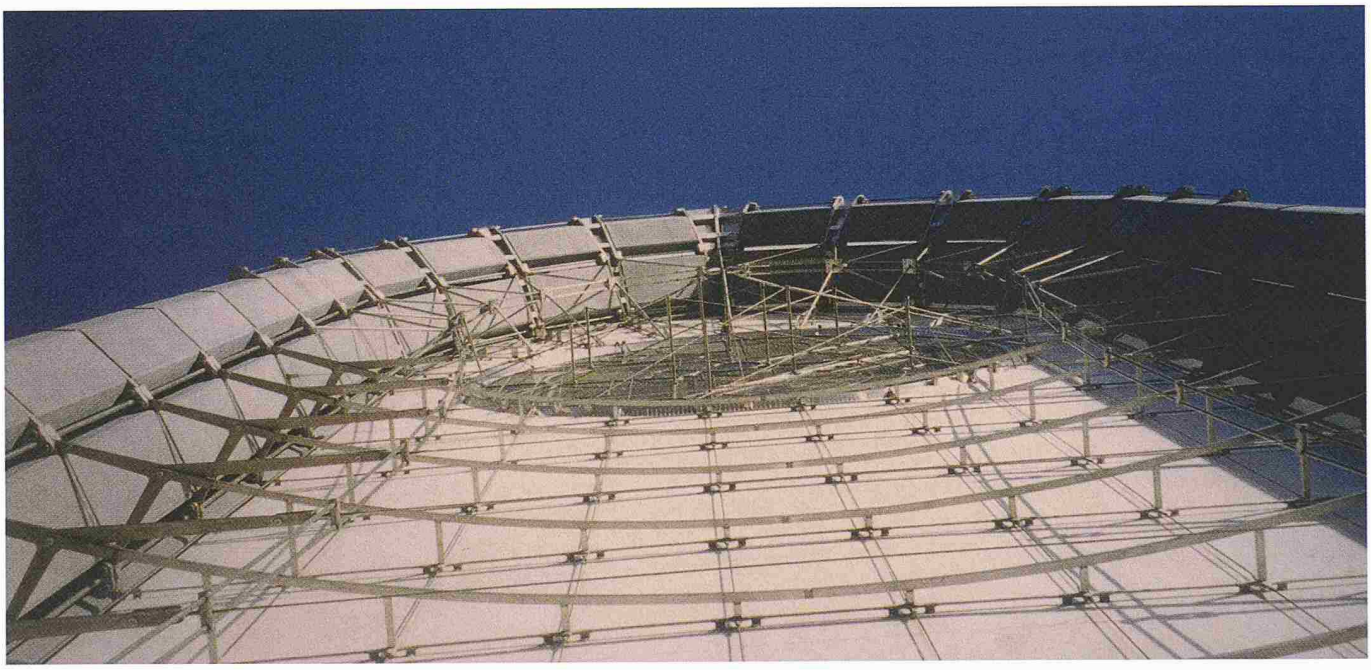
After Rice's untimely death in 1995, the RFR partnership expanded, as did the scope of projects, so that it is now directed by four partners: Henry Bardsley, president, Jean-Francois Blassel, Kieran Rice and Bernard Vaudeville, with continued participation of Martin Francis and Rice's family. An international staff of 35 engineers and engineer-architects now collaborate on projects from the concept and design to the structural systems and construction, uniting their specializations in multidisciplinary teams. At RFR technologies are means to innovate according to the specific needs of each building's design; they try not to do the same thing twice, which can make the selection of projects hard. Rice's vision is sustained in the firms use of materials, technologies and structure.

New Combinations of Materials

Rice, in his book *An Engineer Imagines* (published in 1995 by Artemis just after he died), discussed the role of the engineer to make «real the presence of materials in use in the building, so that people warm to them, want to touch them.» He said this is «to maintain the feeling that it was the designer, and not industry and its available



West Facade of the Cathedral
Notre Dame de la Treille, Lille



options that decided» what material was used. Rice wrote that «the most powerful way that an engineer can contribute to the work of architects is by exploring the nature of the materials and using that knowledge to produce a special quality in the way the materials are used». He was conscious of how «properties of materials have dominated the way the design choices were made» and the innovative moves needed to go beyond what is considered the normal or standardized use of a material.

Combinations of materials and technologies, steel and glass, fabric and steel, stone and steel, are key in RFR's work today. «What distinguishes engineering today from the past,» says Blassel, «is both the profusion of diverse materials and the erosion of the very concept of material, for indeed, the distinction between materials, structure, and envelope is becoming blurred. New composite materials have microstructures that allow them to form a continuum with the large-scale, or macrostructure. What is more, they integrate complex thermal and acoustic functions, which formerly were the attributes solely of insulation materials. Their coordinated functioning leads to a diminished role for structure, which comes thus to seem no longer an entity in itself, and even less, the construction's skeleton.» The firm's latest projects often investigates the integration of sustainable design in the earliest stages of a project's design with a concern for contextual engineering.

In a small scale experimental project, Birdhouse, RFR explores the economy of materials and structure. The project was inspired by the flight of a bird, as well as the need to protect natural resources, and investigates the issues of economy of means through an economy of materials to create a lightness. Exploring the idea of flexible, unstable, and temporary structures, they used a singular element in an efficient, totally enclosed structure. The suspended shelter is a polyhedral cube-octa-

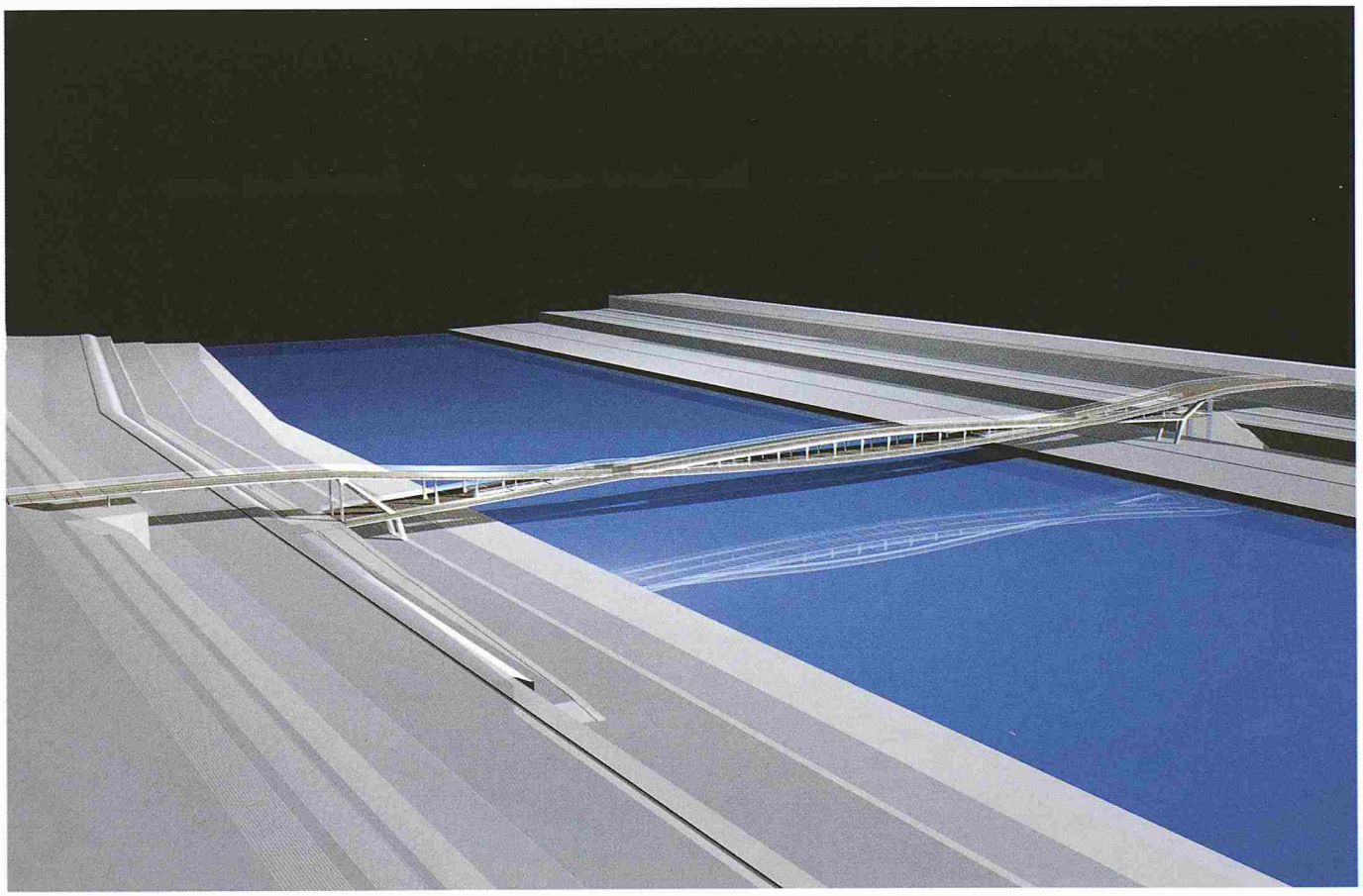
hedron of repetitive elements, in an interesting organization of facets and simple geometric numerical analysis. Using materials such as reeds, twigs, vines, and bamboo, which are easily renewable, Birdhouse was economical, generating its own requirements for technique and craftsmanship as well as its own aesthetic expression.

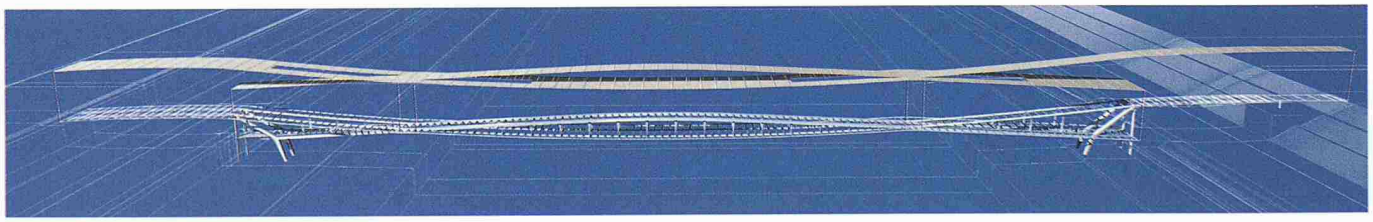
For a TGV station at Charles-de-Gaulle, Roissy (designed by the architect of Aeroports de Paris, Paul Andreu and his counterpart at SNCF, Jean-Marie Duthileul, with RFR), glass and steel are combined to create a novel architectural effect for the roof of the 22,000-square-meter station. The underground train tracks and station are covered with a skylight roof that appears to float. At the periphery the roof opens to outside activity. The design concept was to keep the glass smooth and lightweight, so RFR created a hierarchical composition in superimposed layers, where the dimensions are dictated by calculations. Each of the layers is differentiated from the previous one, not only by the progressive reduction of the slope, but also by the distinct geometry that creates the form while constantly maintaining the architectural integrity of the project.

Two pieces of cast iron articulate the cluster of the tubular pylons, and a crescent beam is supported off the double central support. It is held in part by the pre-tension of the vertical ties at each of its extremities so the upper membrane is never in compression. Steel rods support the roof and crescent beams follow the curve of the roof. The separation between the glass sheet and the crescent beams permit the elimination of expansion joints, and a cleaning robot can operate on the underside of the roof. The roof glass is fritted with a white mineral ceramic coating to soften the sunlight and reflect the night sky.

Revealing Structure

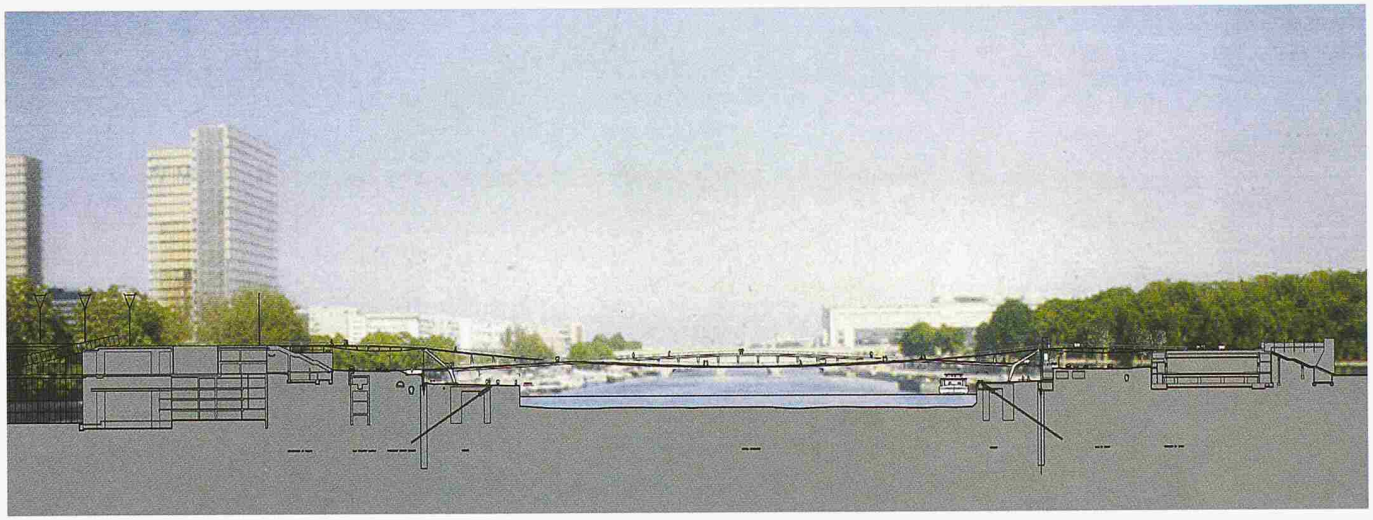
RFR became known in the 1980s for innovative structural systems, where the structure is revealed in a subtle way so that

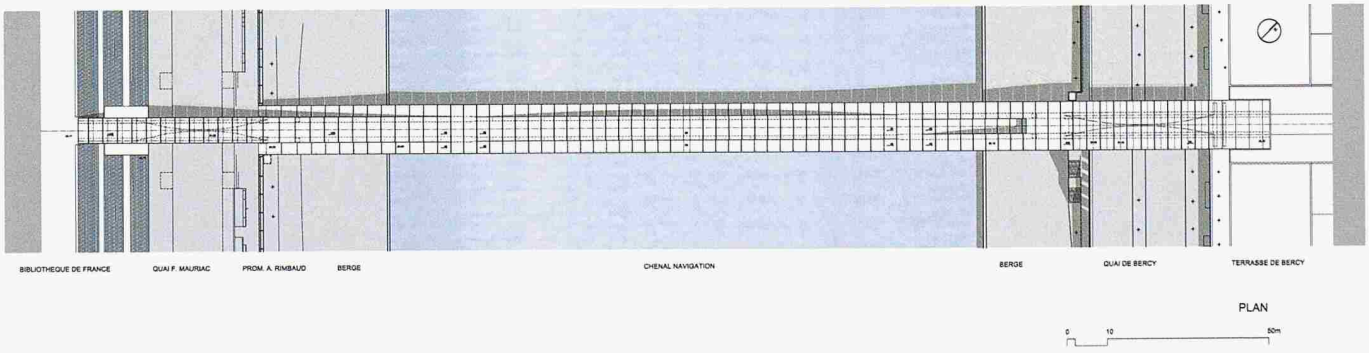




one can follow the cables, masts, supports, and tension rods to their points of contact and connection to comprehend a system. This is explicit in the structural-glass developed for the Science Museum at La Villette with architect Adrien Fainsilber and Arups, where glass sheets are held in place with steel components and rods. The system incorporated technology from the aviation industry, and its specialized fabricated steel components can be varied for different situations and projects. This fabrication process is described in detail in Rice's book «Structural Glass», written in 1992 with Hugh Dutton, a colleague at Arup's. Other innovative systems are tent structures in the tradition of Frei Otto for the Nuage at La Grande Arche in La Defense, Paris, designed in 1986 with architect J. O. Sprekelsen and Andreu.

The Passerelle Pietonne at Bercy in Paris succeeds in this way as a 270-meter-long pedestrian bridge designed in 1998 with architect Feichtinger. The bridge leads from the Bibliothèque Nationale de France to the park at Bercy across the Seine, urbanistically uniting two recently developed areas. The bridge's unique structural focus is that it crosses the river without an intermediary pylon. In one free-span of 190 meters, it consists of two synergetic elements, a shooting arc and a suspended catenary that equilibrate each other making the bridge both robust and light. The curvatures are connected to three parallel aprons: one lifts at the center with the arc, and the other lateral ones follow the camber of the lateral catenary ties. The various paths along the deck of the bridge correspond to the lines of axial forces of the truss, formed by the arch and the catenary. It gives pedestrians the freedom to go to the street level or down to the water. The central part, where the arc and catenary form a lens, makes a unique public place suspended in the middle of the river. From above there is a panoramic view of Paris, and below, a 65-by-12-meter platform serves as a rest area with kiosks and temporary installations. The bridge's materials and structure follow in the tradi-





PLAN

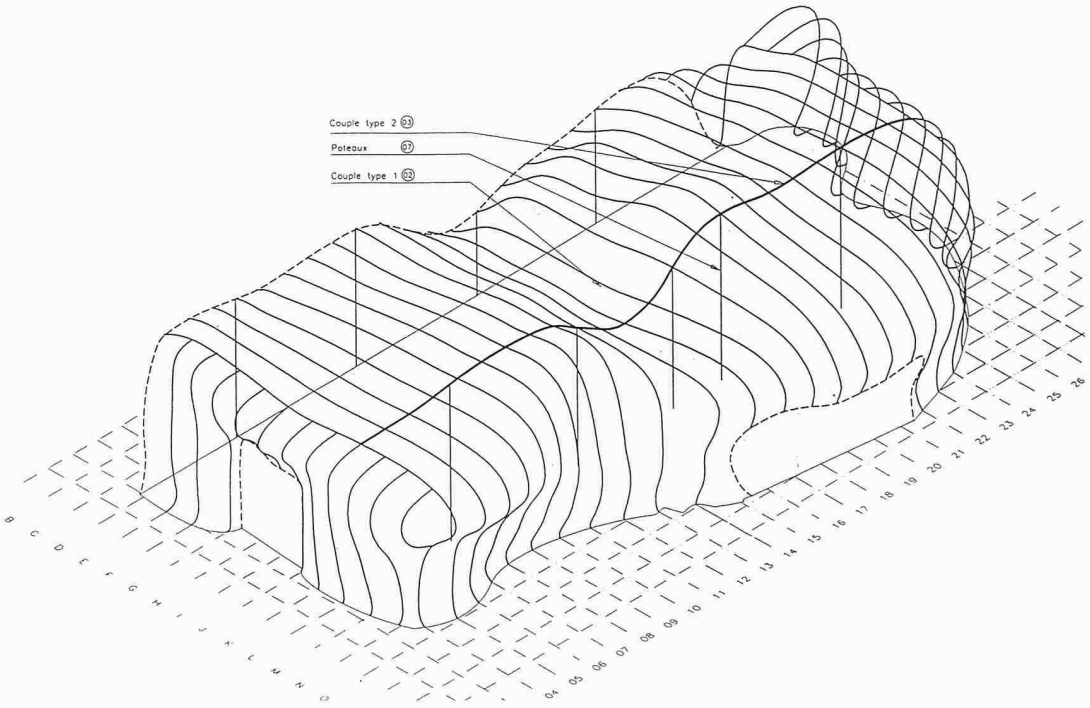
Passerelle at Bercy, Paris

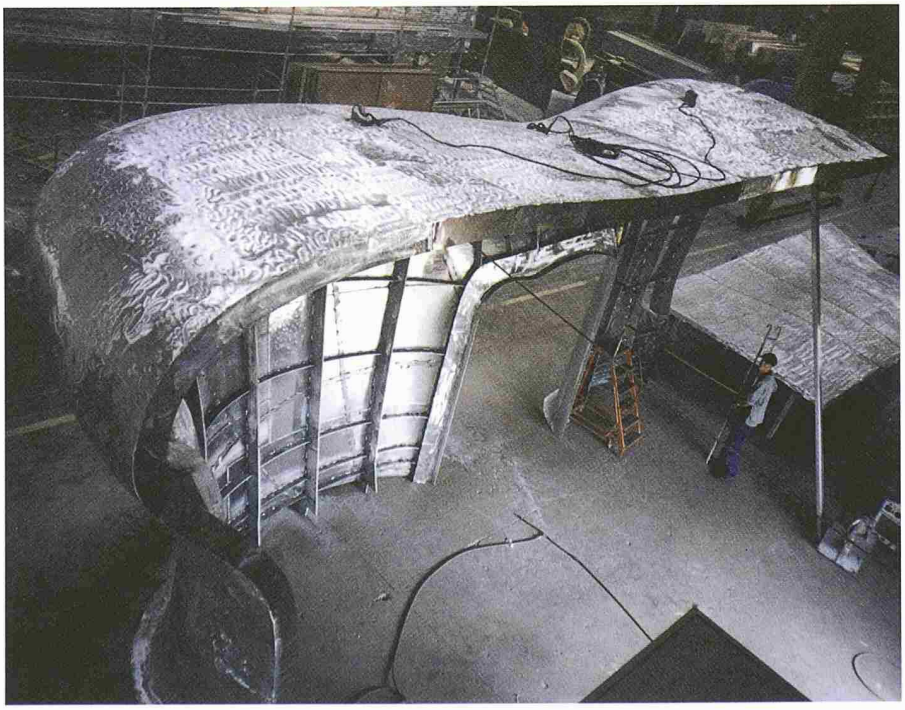
tion of many earlier Parisian bridges. It also follows Rice's belief that after satisfying all of the rules and regulations, projects «if intelligently interpreted, have a lot of scope for invention and innovation.»

Structure is revealed at the new terminal for the Aeroport Charles-de-Gaulle, Roissy, where RFR worked with Andreu to build a 8,500-square-meter terminal to accommodate 14 aircraft in a podlike or peninsular glass building. The 200-meter-long transparent peninsula on a solid base is similar to an upturned boat hull because of its continuous structure - without expansion joints - and is fixed to the existing concrete structure with a single point at the ridge. The movement is controlled by articulated arm connections, which creates a sense of floating appropriate to an airfield.

The 50-meter-long continuous transverse ribs have slender tubular-steel arcs stabilized by a fan-shape array of tension rods at each side, becoming trusses that meet the apex at the longitudinal ridge beam. A perforated folded stainless-steel plate above the glass forms a screen to limit solar gain. RFR developed a global nonlinear computer model of the whole peninsula and did detailed analyses to refine the element sizes to their optimum. The complex geometry was one of the most elaborate calculation models they developed.

A new structural concept for the construction of the west facade of the 1860 Cathedral Notre Dame de la Treille, Lille, was Rice's last project and was completed in 1997, after he died. RFR did a structural study and concept for the 11-by-29-meter west facade and rose window, which like so many cathedrals had never been completed. Artist Ladislas Kijno designed a rose window and the doors of the nave, and together with architect Pierre-Louis



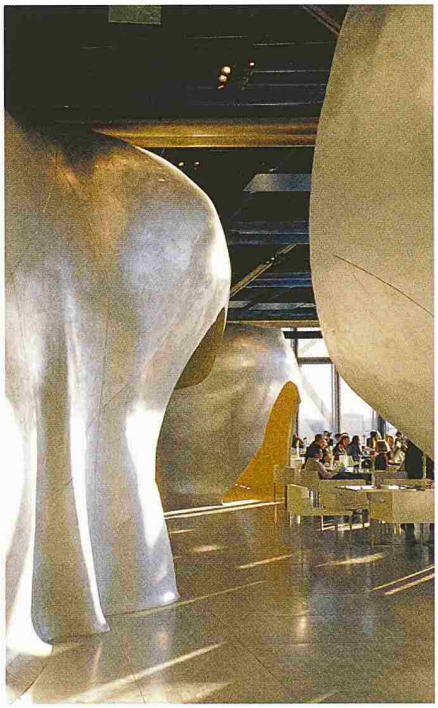


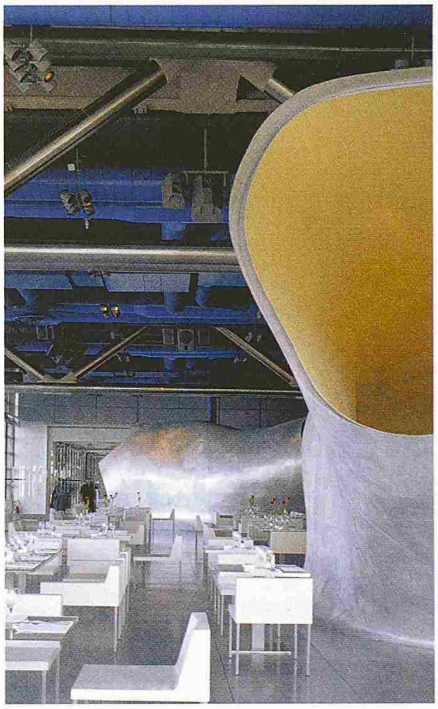
Carlier created a contemporary response to gothic ideals that evoked the spirituality of the church. RFR developed a blue limestone gothic arch from which they suspended a thin marble facade as a veil-like wall that both respected the existing church and was a contemporary technical achievement. Natural light penetrates the marble allowing the solid material to be transformed by light. An exterior steel framework of tension cables and rods supports the stone facade so that the stone is always in compression. A cross-shaped piece holds the marble panels together at the nodes.

In the office's most recent project, a restaurant at the Centre Pompidou in Paris, designed by architects Dominique Jakob and Brendane McFarlane, they combined new computer modeling methods with the sculptural and aluminum-welding techniques from naval architecture. Undulating metal rooms, or bubbles, were made with an irregular geometry. The metal pieces were cut by a computer from the fabricator to optimize the number of cuts and to position the structural elements. Architectural joints were independent of the fabrication and are decorative or informative, relating the project formally to its context. The aluminum hull is structural, with a nonstructural skin above that is more sculptural. The inside face of the shell is clad with brightly colored welded plastic tiles forming a continous film. The bubbles are on flexible supports, so they can be situated any-where within the long span, high deflection floors of Beaubourg.

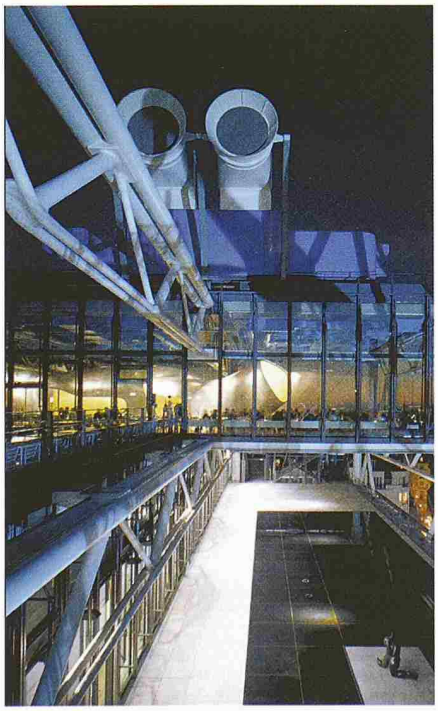
Working Methods

Today RFR makes physical as well as computer models to experiment with structures and materials with an intuitive and inventive approach. Competitions comprise many projects in collaborations





Restaurant at the Centre Pompidou, Paris



with architects from an early stage, on both architectural and engineering elements. Project teams, headed by a project director, have rigorous reviews, but the flow of information is informal so that each person's professional expertise can be tapped when needed. In addition, new computer programs have changed the way the office works but does not dominate. «The engineer is located between calculation on the one hand and experience on the other», said Blassel, «between audacity and rigor, but also between the risk of technological folly and the yoke of total control».

In working with architects with different aesthetic preferences, RFR's consistent approach is to create innovative technical resolutions for each situation not to create a style. One aesthetic does not dominate but their concern for the resulting effect from structures and materials consciously creates an ambiance. In fabric structures Rice was concerned with scale and the way fabric was cut and pieced together as a determinent of appearance that would reveal the nature of the surface to give it a physical context with depth and body in space. Rice used glass to achieve a lightness and transparency that created a sense of nonmateriality and communicated the structure through the transparent skin. This created a lightness and perception of fragility so that it served both a structural and an aesthetic goal.

In its multidisciplinary approach, RFR continues to build on the philosophy of the architect-engineer between intuition and mathematical formula and between aesthetics concerns and structural rationality, which pushes them to unexplored potentials of materials and structure. However, it is always tactile and visible, not concealed - because there is nothing to hide.

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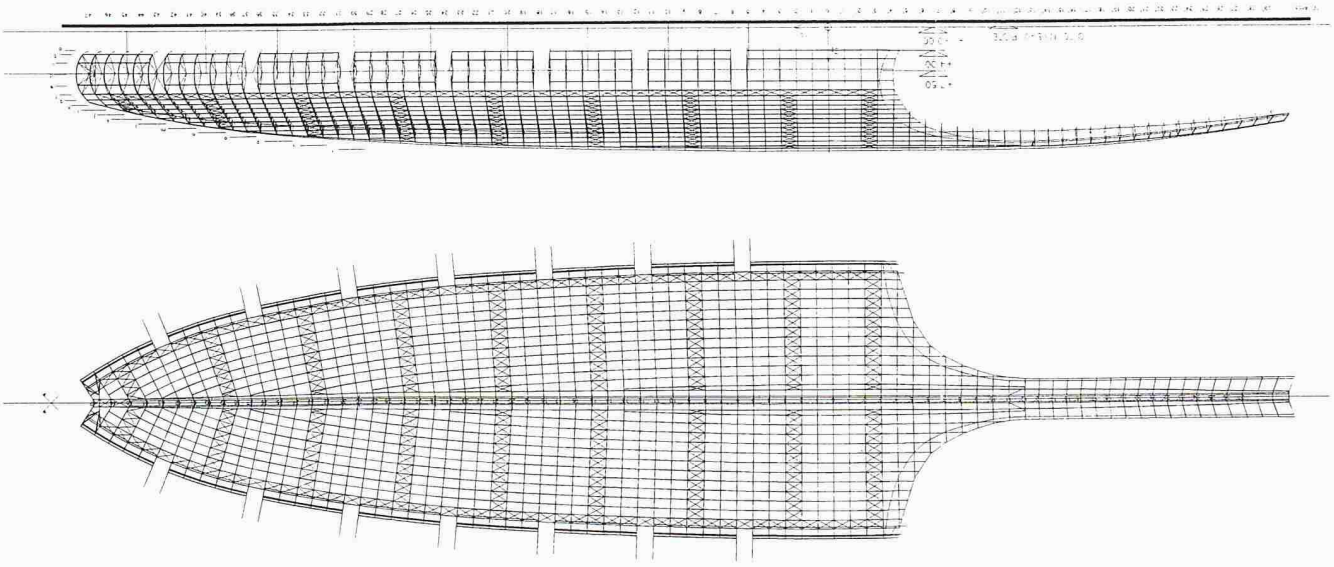

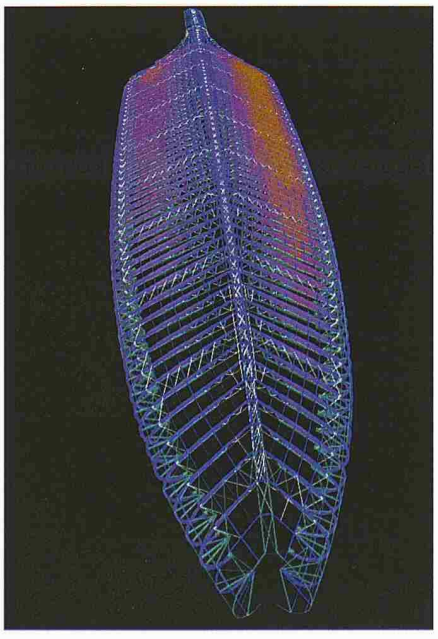

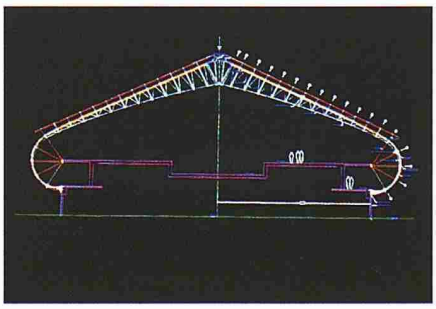

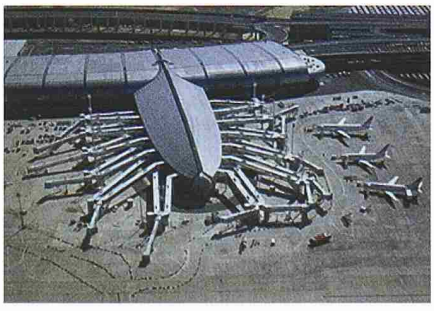

New terminal for the Aeroport Charles-de-Gaulle, Roissy