FROM HI-TECH TO ENVIRO-TECH: THE EVOLUTION OF ARCHITECTURAL TECHNOLOGY IN THE SEARCH FOR ENVIRONMENTALLY RESPONSIVE DESIGN

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INTRODUCTION

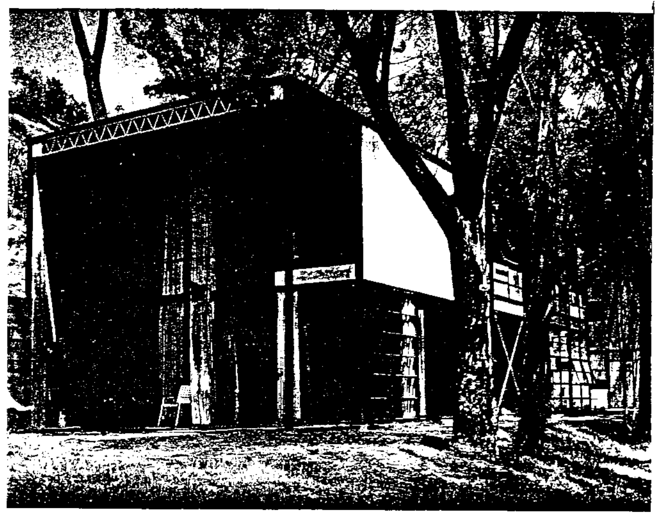
"Hi-tech," post modern, deconstructivism are but names, more relevant perhaps for the theorist's search for the "isms" in architecture than the *reality* for the designer. As Renzo Piano says:

All the talk...it's not the point. You have to put your faith in reality as Brunelleschi did a long time ago. You have new technologies, new materials, new processes and new aesthetics and these elements that have been changing so dramatically in the last fifty years make it necessary to invent a new architecture.[1]

This thing called "hi-tech" or high technology is actually a misnomer. There is, in reality, very little architecture that comes close to "advanced technology" (a better description) like that of other performance based design industries, namely aerospace, automobile and marine. A concern for a re-defining the working relationship with industry and the common use of industrialized products and components was the starting point of this movement and was founded upon a new means of responding to the needs of the industrial sector with lower cost, greater efficiency and an understanding of the organizational needs of industry. In the past 25 years this movement has developed an increasing level of sophistication in the ability to respond progressively to evolving patterns in commerce and industrial manufacturing and with it, the changing nature of the workplace. Most recently it appears to have turned it's attention to the question of the relationship of architecture to our environmental future, the focal point of this paper. The influences upon this lineage of architects (I refer to Foster, Piano, Rogers, Hopkins and Grimshaw, *et al*) can be traced ultimately to the pioneering engineers of Victorian England and the lateral thinking innovators of pre and post-war United States and Europe, whose interest in the role and capability of industrial manufacturing was accelerated by the intensity of wartime production. I refer more specifically to the influence of architects and engineers, such as Paxton and Brunel and later to the innovative design strategies of Schindler,[2] Buckminster Fuller,[3] Charles and Ray Eames[4] and Jean Prouve[5]—all of whom it is interesting to note have developed their own approaches to the environment, climate and the natural world.

COLLABORATIVE ENGINEERING

This interpretation of the role of architectural technology to the *architectural problem* is coupled with a close collaboration with industry and the engineering disciplines. As a process



of working it depends upon a multi-disciplinary design ethic that enables innovative performance oriented design solutions to develop, admittedly with some element of determinism. The influence of the engineer Peter Rice until his untimely death in 1992) upon the work of both Rogers and Piano, for example, is to be seen in the strategy and detail in every project.[6] Over the years this form of relationship has strengthened the hand of Ove Arup and Partners, Anthony Hunt and environmental engineers like, Max Fordham[7] and more recently Battle Mc.Carthy,[8] in most aspects of architectural engineering and collaborative design, thereby generating a new direction to environmental engineering, structure and architectural form. An extensive collaborative network of inter relationships of architect and engineers (a chartable taxonomy) can now be seen to be central to the ability to respond creatively to new environmental agendas and enabling new design technologies to play a role in a "sustainable architecture."

The principle of integrating form and ideas of habitation with structural and environmental technology can be seen as a property that Charles Jencks[9,10] has called *"multi-valence"* in design and is, perhaps, closer to a true definition for "high-technology," at least within the architectural realm. The Gothic cathedral used the technology of the day to create space, light and structure in an integrated form of architectural delight as well as spiritual humility. Frank Lloyd Wright in the language of the prairie houses such as the Robie House, used the chimney stack as a structural, environmental, spiritual and formal anchor which not only heats but also ventilates as it works in consort with the roof. Traditional forms of building, wherever they existed in the world, learned to express cultural and climatic context through the material, construction, production and the means by which the people inhabited forms. These buildings embody "high-technology" but not a definition that we recognize today: cool when it is warm and warm when it is cool, resource efficient adaptive and expressing intention. They knew how to live with the world.

The Modernist idiom appears to have changed that and severed this fundamental principle of integration and "multi-valency." The invention and development of the triple systems of air conditioning, fluorescent lighting and the acoustic ceiling before and shortly after the 2nd World War clearly severed the relationship and control by the architect of environmental technology, a tale that is eloquently explained in Banham's "Architecture of the Well tempered Environment."[11] It certainly allowed the architect to be "liberated"—plan and section divorced from climate—to consciously generate internal space of any size and configuration separated from the integrated technology theme of the past. Buildings became systems and assemblages, integrated in construction and parts but not in conceptual intention. It led quickly led to the sealed environment, the *grand refrigerator,* being the desirable commodity and one that has been exported as the "international style," carrying with it the inevitable consequences of high energy consumption and environmental pollution. However, the central theme of collaborative interdisciplinary design and a "multi-valent" use of design ideas that is the continuing link between the technological agendas of the late 1960's through to the environmental concerns of the 1990's.

AGENDAS FOR THE 1990'S

Following the commercial excesses of the 1980's, the explosion of growth in the financial trading floor and the advent of the PC, the 1990's have seen the emergence of a new agendas; a switch from anonymous developer space to buildings where the client is the inhabitant, a redefinition of the workplace based upon the ability of the user to gain greater control their own environment—the "intelligent building": social and political demands to use resources and energy more efficiently and for buildings to be more environmentally conscious and sustainable: a focus upon the relationship of architecture to the processes of nature and it's inherent systems; the integration of architecture with the sciences and engineering leading to the exploration of natural phenomena—light, air and heat—to the process of form making; the emergence of computation and digital based medium into the design process; and the potential to redefine "making" and craftsmanship through computer based fabrication and assembly. All become ingredients for Piano's "new architecture" in which architectural technology discovers new layers of meaning and purpose. Quote: Renzo Piano: *"At the beginning of the century, technology was like a train breaking everything—a killing machine. It really was an adversary to nature. But today you can begin to see technology and nature are not so far apart."*[1]

The products of this shift to environmentally responsive technology—an "enviro-tech"—technology informed by an "idea" about environment—are still emerging through a new generation of forms, structures and technological prototypes. It is still early days in the movement to establish a new set or relationships that melds craft and assembly to natural systems, ecology and natural phenomena. However what we see are several new directions in architectural form and technology. Technology becoming increasingly sophisticated but less visible. Technology, instead of being deterministic, becoming the "enabler" of what Jencks refers to as *"another idea."*[12]

Several contemporary projects and buildings serve to illustrate this significant shift in focus:

• The deployment of form and material, nature and light in visual and energy efficient integration : Piano at Menil and the Building Workshop office in Genoa;

• New forms of environmental control and interpretations of the wall as an interactive boundary: Foster at Dusseldorf and Hopkins in London;

• Tectonic expression of passive climate control: Grimshaw at Seville, Yeang in Malaysia, Murcutt in New South Wales;

• Advanced integration of renewable energy technologies: Rogers in Japan, Battle Mc.Carthy in Brussels, Foster in Duisberg;

• Natural ventilation and daylighting combining with the bio-morphically shaped floors and ceiling components: Hopkins at Nottingham, Bennetts at Coventry;

• Computer modeling of air flow supporting propositions about spatial form: Ove Arup at Kansai and Munich, Rogers at Nottingham and Bordeaux.

The criticism of "Hi-Tech" again by Charles Jencks[12] as the "propensity to repeat good solutions ad naseum—'Monothematatis'—from reductivism, mechanism and functional determinism," confirms what he see as a technical determinism in the work where he affirms the "Hi-tech architect" believes that "design must happen automatically." Historically there may be some truth to this perception although I disagree with the view of naseum of the singular theme. The dependence upon the structural bay and repetitive detail that formed this opinion can clearly be seen to developing into a richer, more fluid—even biomorphic—language of space, technology and enclosure, but one that supports an primary environmental objective. Contrast this if you will, with Frank Gehry's approach to his recently completed Communication and Technology Center at Bad Oeynhausen in Germany which, while attempting to demonstrate energy and environmental responsiveness, shows no yielding from that dynamic but limiting expression of form: Quote by Frank Gehry: "We tried to let the energy question generate the form...but we failed. In this sense the building does not have the clarity we would have liked."[13] Please draw your own conclusions. Who is playing the determinist game now?

A CASE STUDY: THE TECHNICAL SYNTHESIS

In order to illustrate my central theme concerning the evolution of architectural technology as a response to environmental concerns, I turn to a design research project that I recently completed together with architect and engineer Paul Donnelly. The project was centered upon a national competition titled "Building Integrated Photovoltaics" sponsored by the American Institute for Architectural Research and the National Renewable Energy Laboratory under the support of the US Department of Energy. The project was for a Pavilion for American Sport in Washington, DC and was awarded a first prize.[14]

Our central objective for the design was to achieve a holistic integration of an urban strategy, building form, passive based environmental criteria and a supporting technology that was seen as "enabling" and giving meaning to a technical and formal synthesis. The renewable technology, the photovoltaics, was an important focus but was regarded as (in Piano's words) "sophisticated but less visible." The significant aspects of the design, without discussing specifically the response to program and use, can be explained firstly by the "theme in plan" followed by the "idea in section."

The plan is concerned with the geometry of the site and the search for a strategy that integrates public space with climate, orientation, and a concept of movement on the site that engages passage inside and outside of the enclosure. This has been formally expressed and interwoven with a sequence of layers or boundaries from south to north. These layers are focused upon the apex of the triangle of the site and structured by a double wall system that acts as a linear "ventilation chimney"—an essential component to the environmental strategy.

The sectional and structural form is derived for the "environmental idea," and demonstrates the principle of the "multi-valent" meaning in design of formal elements that was discussed previously. The section has 2 major parts: the ground based concrete floor, walls and site infrastructure which essentially "grows" for the ground upwards and provides for temperature stability through thermal mass. The sky component is a lightweight tube and cable tensile structure, a fabric membrane and a photovoltaic layer that serve as both energy source and filter of natural light. The meeting of these elements creates the major space. The structure owes its profile to the theme of passive ventilation and an orientation to the optimum solar axis. It was also designed to enable the air to move both over the building and through the section, actions that are essential to the success of the buildings passive environmental ideas. The form of the concrete walls, floors and "ventilation chimney" enables this to happen through air being pulled through the section induced by a negative wind pressure on the leeward side of the building. The photovoltaics were used as a layer of environmental control hovering above the roof membrane and took the form of a cable suspended—frameless—open jointed glass system onto which photovoltaic cells are bonded in varying patterns and densities.

How do we know these sectional ideas work and how may they be tested and tuned as a part of the iterative process of design? This is normally the domain of the infamous architect's arrow—a reflection of his abdication of authority on such issues to other disciplines. In our case we deployed computer simulations of both air flow and natural lighting, based upon computational fluid dynamic and radiosity based software to support our intuitive ideas. The results proved positive and has created a rich field for further design research. This case study, while focusing upon the technological dimensions of the project, illustrates a synthesis of the architectural form and ideas at the macro scale with environmental objectives. In such a case the advanced technology is working hand in glove with nature and natural phenomena.

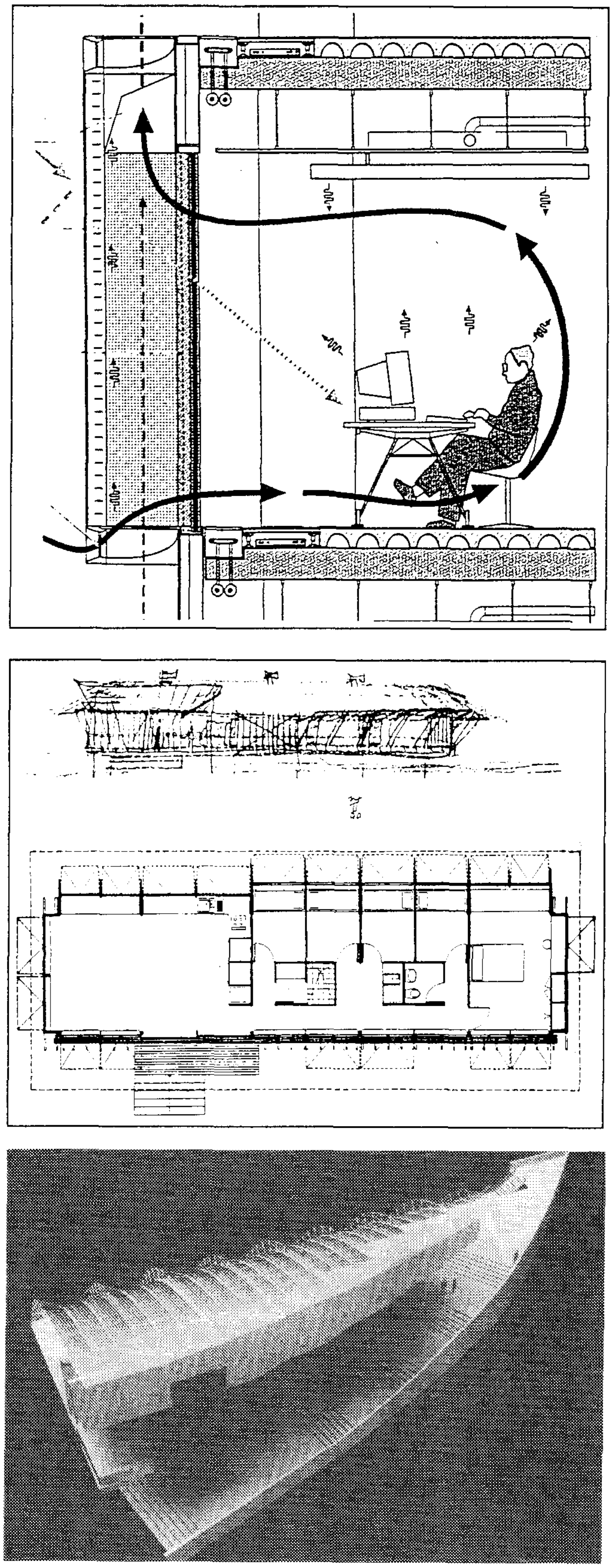


Figure 4: Context and technology. Pavilion, Washington, DC. Scott + Donnelly

NEW DIRECTIONS

Renzo Piano's call for a new architecture, or maybe an "evolving architecture" is a more appropriate definition, from

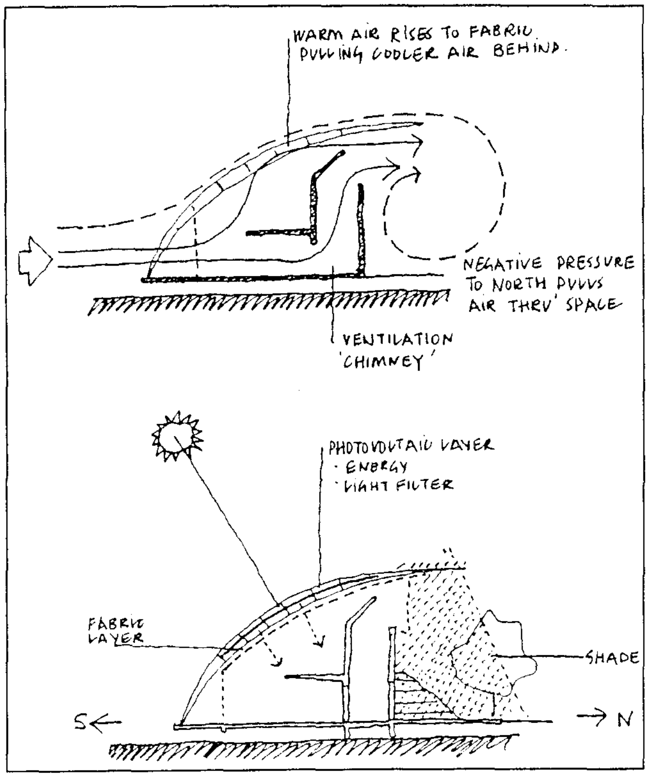


Figure 5: Ventilation, structure, and enclosure. Pavilion, Washington, DC. Scott + Donnelly.

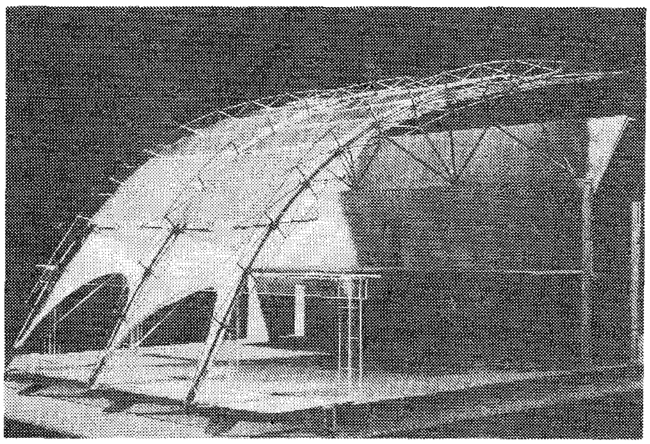


Figure 6: Photovoltaics integration. Model. Pavilion, Washington, DC. Scott + Donnelly

new technologies, processes and aesthetics is emerging. In so doing it is suggesting that architectural technology—not simply as a theory, historical revue of applied science—is becoming more synthetic with ideas of fluid spatial form, phenomena, ecology and the natural world. The connection form the past, to the present and on to the future—"hi-tech to enviro-tech"—becomes the process of innovation through collaborative design and harnessing the ability for technology to "enable and ennoble" an idea—in this case the environmental or "sustainable."

The next stage in the movement of architectural technology—"enviro-tech" as I have described it—will likely reveal a far greater understanding of the symbiotic relationship between the spatial form, habitation and change, fluid (non-orthogonal) geometry and interactive building elements. Assisted by a "technology of design" in the form of modeling (computer) techniques for simulation and craft oriented production (CAD-CAM), and a "technology of assembly" in the form of industrially produced elements oriented to a specific environmental task, an architecture will evolve that can accommodate the variable demands of our contemporary society for shelter and workplace, but with a new understanding to a "sustainable" world that, sooner rather than later, must learn to use less but harness more.

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