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RESEARCH ARTICLE

Designing for change: The poetic potential of responsive architecture

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Abstract
The integration of responsive components in architecture offers the potential to enhance the experience of the building by giving expression to fleeting, changeable aspects of the environment. Responsive buildings enable a physical response to changes in the environment through specific building elements; in rare cases these responsive elements become an integral and poetic element of a culturally significant work of architecture. In this paper I examine two types of responsiveness, one which concerns the changing environment and another the activities and needs of the building's inhabitants. I look at two examples of buildings that illustrate a potential poetic role for architectural components responding to these two types of change, and propose that architects will need to acquire experience with designing for specific rates, scales and types of change before responsive elements will more frequently appear as a poetic and integral part of the building.

1. Introduction

For the first visitors to the Institut du Monde Arabe in Paris, standing in the open plaza and looking up at innumerable mechanical diaphragms set in the glazed south facade, the spectacle must have been extraordinary and unprecedented (Figure 1). The sight and sound of movement in each mechanical diaphragm across the facade, combined with the realization that this movement was linked to the constantly shifting modulation of sunlight, must have inspired the building's first visitors with wonder. It is now easily forgotten that Jean Nouvel's early implementation of responsive components was remarkable in scale, complexity, and architectural ambition at the time of its construction. What this project promised was an architecture based on change: response to change in the external environment and a corresponding modulation of conditions in the interior. Each of the building's facades, including the translucent panels of the internal courtyard, proposed a different method for daylighting and a different approach to the inevitable variability of natural light. Equipped with sensors, actuators and an array of mechanical diaphragms, the south facade of Nouvel's building

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Figure 1 Institut du Monde Arabe: the south facade. Image *source*: Peter Blundell Jones.

proposed a pattern that would be adjusted in response to variations in the intensity of sunlight.

Many forms of building automation are now commonplace, and in recent years sensor networks have been broadly employed in buildings to monitor and control diverse aspects of the built environment. Sensors are commonly used to track indoor and outdoor climatic variables such as humidity, temperature, and solar radiation; and to recognize patterns in the activities of people. In addition to this common instrumental role, these automated elements of buildings have occasionally played an important aesthetic and cultural role in the design of engaging architectural spaces. The automated diaphragms of the Institut du Monde Arabe offer one example of a dynamic building element which was conceived from the beginning of the design process as an integral, defining aspect of a significant work of architecture.

Responsive components are defined here as all those elements of the building that adapt to the needs of people as well as changes in the environment. These components may be high tech systems that employ sensor networks and actuators to monitor the environment and automate control of operable building elements. I am also using this term to refer to the moveable, operable, often manually controlled elements of buildings which allow the adjustment of the building envelope and interior in order to adapt the building's performance to meet everyday needs. The term is sometimes used to describe only the automated responsive components in buildings, a usage that ignores the strong connection between manual and automated mechanisms. There is also a potential for the relatively new phenomenon of automated building components to be informed by a long tradition of design excellence in manually operated mechanisms, a tradition represented in this paper by the Maison de Verre of Pierre Chareau, where mechanical adjustment achieves a remarkable level of poetic expressiveness.

In this paper I will use the Institut du Monde Arabe and the Maison de Verre to tell a story of the architectural contribution of responsive building components, and to suggest alternative ways of thinking about the elements of buildings capable of movement in response to change. The question I will address in the paper is whether it is indeed possible for the responsive components of architecture to become a poetically expressive part of the building, and if so how why it is that this result has so rarely been achieved in contemporary and recent built work. In other words, I ask whether responsive building components have the capacity to transform, or at least to poetically inform the way that architecture is conceived and experienced. In a discipline as rapidly changing as responsive architecture, it is easy to overlook the roots of contemporary ideas in architecture's recent history, and this paper aims to redress this oversight by recognizing important pre-digital precedent for a current and future responsive architecture.

2. What is responsive architecture?

Every building is in some aspects a fixed entity, static and passive. At the same time, every building is also a changeable body whose permeability, appearance, and affordances for activity are capable of sudden and unpredictable change in response to the environment and the needs of its inhabitants.

The fixed aspects of buildings include location in the landscape and structure, things which change little if at all over the life of the building. And yet, if a building's behavior were entirely static it would hardly be capable of accommodating the range of contingencies that characterize daily life. Shifts in weather, changes in the behavior and needs of people: these require a certain degree of flexibility, a capacity for adaptation and change.

Architecture by necessity contains elements that are static and fixed: human survival depends on maintaining a constant core body temperature and our survival behavior includes the construction of shelters that maintain a stable interior environment. One of the most elemental functions of the building's responsive components is the maintenance of these stable conditions – opening or closing windows, raising or lowering blinds and sunshades, controlling fans and chillers and other air conditioning machines. Although we require stability we design our shelters to actively seek equilibrium using behaviors that involve frequent adjustment in order to accommodate variable meteorology.

Buildings are static, but most buildings also incorporate equipment which allows for a greater degree of 'fit' with variable circumstances. Le Corbusier used the term 'household equipment' to refer to furniture as well as the operable or movable elements of the building. To this list I would add the mechanical parts of a building that allow adaptation of the interior to conditions related to environment and human behavior: windows, doors, movable partitions, operable vents, louvers, sunshades, screens, etc. in other words, all the equipment that permits adaptation of the building interior and surroundings to meet the needs of everyday life. What I refer to in this paper as responsive components encompasses all the parts of the building that are able to adapt and change in response to the environment or to accommodate the contingencies of daily life.

As early as the 1970s, visionary thinkers like Nicholas Negroponte proposed that advances in artificial intelligence and the miniaturization of components would soon give rise to buildings capable of intelligently recognizing the activities of their users and responding to their needs, as well as