Performative Architecture

A Processed-Based Approach &
A Way Beyond Static Permanence Of Architecture

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Project Intent

Performative Architecture, A Processed-based Approach, & a Way Beyond Static Permanence in Architecture

Background

Today's architecture is becoming more and more intertwined and co-mingled with sustainable design concepts, and an increasing emphasis on building performance is influencing building design processes. There is an emerging approach to architectural design in which building performance is becoming a guiding principle for the development of design ideas.

Topic Statement

The main objective of this research topic is the investigation of the new ways that buildings are perceived and visualized. Performative architecture is a new approach in architectural form-making and a shift in architectural practice and theory which perceives a building as a living organ that has the capability to adapt itself to Nature's extreme manifestations and impacts. Process-based architecture is also based on a new approach in data collection, and on simulation techniques.

Process based architecture focuses on building performance as a tool towards development of design concepts and architectural form making. It is a comprehensive approach for development of the built environment, and a novel way of thinking in architectural design that necessitates more collaborative participation of architects, consulting engineers, and other specialists. It is an architectural design procedure that integrates design and analysis of the building and in the physical sense, requires integration among building systems and components, as well as selection, deployment and configuration of building elements in ways that can satisfy both visual and functional objectives.

Performative architecture is an approach in building design that blurs the boundaries between poetics and tectonics, with a meaning that spans different realms and boundaries, from social and cultural, to environmental and technical. It is an approach that is based on performance simulations of combined qualitative and quantitative manifestations of original architectural ideas. It allows the idea of the building's architecture to take shape and form, through the perceived as well as anticipated operation of the building. It is an approach in design that is process and product based, and that is concerned about peoples, places and spatial and environmental qualities, and that is interested in the changes a building tolerates and undergoes as a result of external contingencies. In other words, a building is charged with an anticipated capacity to withstand or respond to both foreseen and unforeseen impacts. In reality, the building design is an act of creating a paradigm of interplay between a building's interior and exterior spaces, and its working with and against its site. Therefore, performative design focuses on sketching out the guidelines of the building performance. Performative architecture not only provide opportunities

for the building's social, physical and environmental conditions to contribute in the architecture's form-making process, but also outlines strategies of adjustment for building's performance based on these varying factors.

The main objectives of this research document will revolve around outlining and analyzing the ways that a building manifests itself through its operation and expected future performance in the context of its virtual reality. This is a novel approach that allows the building to be perceived, made and experienced before has been determined its tangible presence and physical reality within its chosen context.

The key features of "performative design" as the primary goals of this research include the following discussions in development of the design concepts and methodology:

- Design solutions that are customized for a place, purpose and climate----an organic development of place through an organic design process. Organic design process refers to organic techniques for the generation of the building forms, which originates from structural diagrams, function charts, and from wire frames and digital animation software.
- Building systems' performance as the basis for design ideas---engineering in a performative architecture---a generation of freeform designs and non-standard architecture.
- Paradigm of architectural performance----strategies for adjustment.
- A comprehensive approach in integration of design and production processes---a product and process-based design for the building's DNA.
- Implementing advanced information technology---a digitally driven design and production by virtual prototypes and working models for testing.
- Non-traditional and non-conventional approach in integrating with other disciplines---interdisciplinary teamwork and close collaboration with other professions and practices.
- Biological principles----Biotechnical, Biomimicry, and Morphogenetic practices, which surpass the established concepts of a climatically responsive architecture, and model the entire spectrum of a building's performative lifecycle.
- Architecture as a form of communication----performative skin and expressive architecture.
- Shared vision and "mutuality" with sustainable design goals and solutions.
- Transparency of the process of design and production.
- Performativity and optimization in architecture practice. A Pre-Post Occupancy Evaluation ---Design process for high-performance buildings.

Project Intent - Research Components

The main intent of this project is to become engaged in an act of comprehensive research on the many facets, boundaries and instruments of "performative architecture." Performative architecture, as a new approach in architecture practice, is also a novel concept in the theory of architecture. Therefore, there is not a defined definition about the meaning of "performative" in the dictionary of architecture. Nowadays, those architects engaged in performance-based practice, as a result of their own desire and interest to create permanence in their architecture, have established a personalized approach towards a processed-based, performative design solutions. The goal of this project is not only to appreciate the meaning, scope, and instruments

of performative architecture, but also establish a paradigm for performativity. The paradigm for performativity incorporates a list of performative concepts, goals and approaches, which have been adopted, undertaken and performed by certain interested architects engaged in this multi-faceted realm of practice. The compilation of the performative concepts and approaches will lead to the development of a performative prototype based on the concepts that have origins in performativity.

Project Components – Expected Outcome and Methodology

The research document will be composed of three main parts, which have been distributed between Arch 507 and Arch 508 studios, as the following:

Part I (Arch 507) – Part One will be dedicated to the theoretical aspect of "performative architecture." The intent of this section of the research will be to formalize the meaning, scope and instruments of performativity. This phase will involve comprehensive research, which will be on one hand focusing on the methodology of performative design approach from the standpoint of poetics as well as tectonic of architecture, and on the other, it will be an analysis of the theory of design and science of performative buildings, as well as professional practice of performative architecture.

Part II (Arch 508) – Part Two will be dedicated to the appreciation of the performative philosophy of the actual works performed by architects interested in pursuing a performative architectural design and practice. In this part, the goal will be to review and analyze the process and performance-based architectural practice through the works of three architects – Renzo Piano, Nicholas Grimshaw, and Thomas Herzog. The objective of this phase is to identify and analyze the various methodology of performative architecture adopted by these three self-motivated architects through the analysis of the architecture of their buildings.

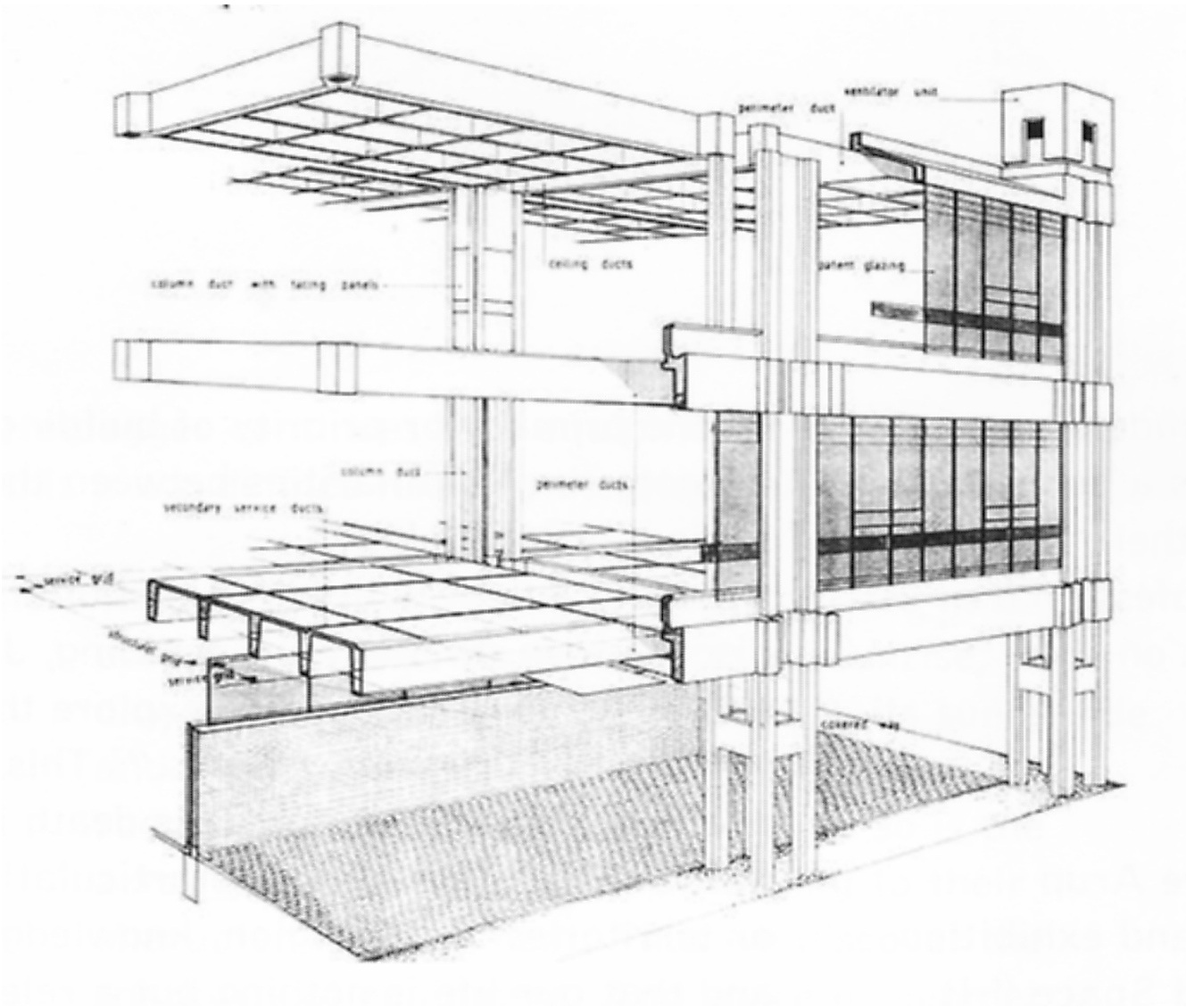
Part III A & B (Arch 508) – Part Three is the synthesis, consisting of Part 3A & Part 3B, in which the theory of the performative architecture discussed in part one, as well as the precedent studies and analysis of part two will be substantiated through the application of performative ideas in the design of a prototype performance-based work-live habitat. The main concepts of the prototype will be analyzed and discussed in Part 3A which contains the predesign, and Part 3B is dedicated to the actual performative design proposal, which will be an exercise in pursuit of the performance-based and product-based design procedures.

In part 3 as a whole, the review of the performance measures including technical, functional and behavioral factors will conclude with the introduction of the concepts of a prototype. The goal of this phase is to arrive at a design proposal for a work-live loft habitat. Design of the habitat is based on the performative view of considering a building as an organism of nature, and will focus on the concept of ultimate "flexibility" and "adjustability". The overriding concept is based on the fact that the habitat is considered to be an organism of nature, which is expected to act similar to a plant, in reaching out to the sun as its stimulus and as the source of dynamism. All throughout, the focus of the proposal will revolve around integration of various aspects and principles of "performative architecture." This will happen through application of certain device paradigms and the building's systematic elements as instruments of performativity. In addition to conducting simulations and analyses specifically to formulate the form and architecture of the building, the project will also rely on precedent studies and the lessons learned from the analysis of projects which are considered to have followed performative design approaches. The final product of the design will be an attempt to provide responses to the following questions: To what extent has performance influenced design, and what does performance truly mean in architecture?

Project Components

Existence is the extent of matter in space.

- Descartes



The geometry of multiple grids for services, space planning and structure -----the network are related but not coincidental.

Credit: Kolarevic, Branko, Malkawi, Ali: Performative Architecture, Beyond Instrumentality, (London: Spon, 2005)

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Meaning & Methodology

PART 1

ARCH 508
Doctorate of Architecture

Mitra Kanaani

With special thanks to David Leatherbarrow Chair of Graduate Department of Architecture, University of Philadelphia, for his generosity of thoughts and many hours of valuable mentorship and debates.

Introduction

Today's architecture practice and design due to sustainable design influences are increasingly becoming process-based, and thus building performance is becoming a guiding principle for the development of design ideas.

Performative architecture is a new approach in architectural form making and a shift in architectural practice and theory, which now perceives a building as a living organism that has the capability to adapt to Nature's extreme manifestations and impacts. It is also a process-driven architecture which is based on new approaches in data collection, as well as on simulation techniques and computer modelings.

Process-based architecture focuses on building performance as a tool towards the development of design concepts and architectural form making. It is a comprehensive approach for the development of the built environment, as well as a novel way of thinking in architectural design that necessitates more collaborative participation between architects, consulting engineers, and other specialists. It is an architectural design procedure that integrates the design and analysis of the building, and in the physical sense requires integration among building systems and components, as well as the selection, deployment and configuration of building elements in ways that satisfy both visual and functional objectives.

Performative architecture is an approach to building design that blurs the boundaries between poetics and tectonics, with a meaning that spans different realms and boundaries, from social and cultural to environmental and technical. It is an approach that relies on the performance simulations of combined qualitative and quantitative paradigms of architectural elements as devices for performativity. It allows the idea of the building's architecture to take shape and form through the perceived as well as anticipated operation of the building. It is an approach to design that is process-and product-based and is concerned about peoples, places, spatial, and environmental qualities, as well as the changes that a building undergoes as a result of external contingencies. In other words, a building is charged with an anticipated capacity to withstand or respond to both foreseen and unforeseen impacts. In reality, the building design is an act of creating a paradigm of interplay between a building's interior and exterior spaces – not to mention its working with and against its site. Therefore, performative design focuses on sketching out the guidelines of building performance that allows for its spontaneous qualifications to be subject to varying social, physical and environmental conditions, while incorporating strategies for adjustment.

The main objectives of this research document will revolve around outlining and analyzing the ways that a building manifests itself through its operation and expected future performance in the context of its virtual reality. This is a novel approach that allows the building to be perceived, made, and experienced before it has found its tangible presence and physical reality with respect to its intended contextuality.

The main pillars of "Performative Architecture" as the primary goals and guiding principle for Part One of this research will be based on three main areas of architecture:

1. Theory of Architecture: Design concepts, and form making, poetics of architecture—Various aspects of the performative form.
2. Building Science: Technology and tectonics of performative architecture.
3. Professional practice of Performative Architecture: Efficiency and optimization in architecture.

Part One
Performative Architecture
Meaning --- Methodology

1.1 Theory of Performative Architecture, Performative Design Concepts and Form Making, Poetics of Performative Architecture

1.1.1 The meaning of architectural performance

The word "performance" means carrying out a task or act and enacting a role. Architectural performance refers to the way the building acts and what the architectural work is carrying out.

Undoubtedly, the building acts to house activities and functions, while also providing opportunities for experiences. Architecture is the only branch of art that undertakes functions within its broad realm. It is the utilitarian aspect of architecture that distinguishes it from other fields of art. Architecture has a life that is predicated on its use, which is undoubtedly a *borrowed* existence. A building's expected role and responsibility is manifested through its interior use and recognizable by its exterior expression and vocabulary, which is the result of the creative efforts of its designers as well as the inputs from its prospective users.

On the other hand, the building's undertaking and assumed responsibility is not a constant matter. This is a role that is granted by the users to the building. As inconstant as this role is, according to Aldo Rossi, use is not a criterion to define a building, whereas it is the building type that gives definition and meaning to architecture (Critique of Functionalism 1982).

Today's definition of architecture is shifting toward its performance and the way the building addresses certain expected functions. This is not by any means a new concept. It is as old as the history of architecture. Over two millennia ago, Aristotle defined architecture as "what imitates human action and life" (Nichomachean Ethics, book 1, chapter). Also, the architect of antiquity, Vitruvius, who lived at the time of the founding of the Roman Empire, identified in his writings the three basic components of architecture as, *firmitas, utilitas,* and *venustas*. Centuries later in the seventeenth century, it was Sir Henry Wooton who translated these three concepts as *firmness, commodity* and *delight.* There have also been more theories that have proposed different systems by which buildings may be analyzed, their qualities discussed, and their meaning understood. Firmness is concerned with the ability of the building to preserve its physical integrity and sustenance, when in confrontation with the force of nature as a physical object. Delight has to do with the effect of the building on the aesthetic sensibilities of those who come into contact with it. The aesthetic qualities of the building might be associated with several factors. The aesthetic qualities and ordering of shapes, colors and textures, as well as the symbolic meanings of the adopted forms and the elegance with which the programmatic requirements of the building and practical necessities of the building have been addressed and solved, constitute the aesthetic component of the building. Commodity refers to the practical

functioning of the building. It requires that the set of spaces that are provided are actually useful, and serve the intended use of the building. To this day, the Vitruvian theory has provided a valid basis for the examination of the building components from the stand point of use, effects, and performance. Throughout the ages, especially in modern times, there have been debates about the relationship between the useful and the beautiful, and how these two main factors give meaning to architecture and building performance. Nonetheless, it is essential to know that at the onset of this millennium, while sustainable design ideas are becoming a vital necessity, the theme of performance is becoming a key factor to the building's definition and its true purpose of existence.

When speaking of the performance of a building, the question arises as to how it would be possible for a building to "perform." Performance is a dynamic act. After all, a building is an object that due to the necessity of its function and use as well as to its relationship with the elements of nature and the surrounding cosmos, has to remain in static equilibrium. This has become a redundant question when comparing architecture with other fields of art. Architecture, in comparison to other branches of art such as dance, film, and music, seems too static, inert, and motionless. No wonder Frederick Schelling referred to architecture as "frozen music" (Eco-Tech 7). How is it possible for an object as rigid and massive as a building to assume perfomative responsibilities that require a dynamic behavior? As we move toward finding responses to this very in-depth and heavily impacted question, shouldn't we ask ourselves whether a building has to be necessarily an object at rest? Does it have to really remain as that which we make of it? Obviously, a building's constituents are all derived from nature. Therefore, can the building become as adaptive and as flexible as other elements of nature in relation to the cosmos? Undoubtedly, there is more to a building than just serving a purpose and addressing a use and a need. As David Leatherbarrow observes: "One suspects there must be something more to it (*building*) because if it were only the consequence of an inhabitant's intentions, it would be impossible to understand why we often feel the need to habituate ourselves to buildings, and also why they can alternately depress and delight us" (Performative Architecture 10). Nonetheless, the building is known through its effects, through its actions and its performances. The question yet to be answered is: Can a building's performance be measured like other objects in the world, and will it yield itself to techniques of sizing, weighing and computing? How will the building's performance be considered over time?

Buildings, like human beings, establish their own unique characters. We get to know the character of the people around us by the way they act and perform actions. With regards to buildings and their architecture, no matter what character they have created in our minds through seeing their photos, visiting buildings will either corroborate the initial developed character or transform it to something else. It is all about the space and the sense of place, the effects, events and the character that the building constitutes and conveys to its occupants and inhabitants. The true character of the building is only revealed through an action or event and the subsequent perception or feelings which arises from it. This might be entirely different from the signs of identity a building has

established originally in the minds of its beholders. Obviously the most important determining factor in the establishment of the building's character and its performance is "time." It is through time and its passage that the building's true performance will become meaningful and sensible. This brings us to the fact that in architecture there are two types of performances: First, performance *of* architecture as an objective act, which yields itself to techniques of measuring, sizing and computing. This has a direct relationship with the physical set up of the building with respect to its cosmos and its constituent systems and materials. Obviously, the adequacy of this act will be revealed over time.

The second type is performance *in* architecture, which has to do with demonstration of architecture through the interests that we bring into it by experiencing it. Performance can be described objectively combined with permanence and stability, which David Leatherbarrow refers to it as, "permanence in waiting." Thus, he refers to, as a motionless, unanimated, and objective act of architecture performance, which is insufficient to convey the building's full actuality. Undoubtedly, buildings are not just what we make of them. When we make them, they become part of the cosmos and find their own unique sense of existence, which is beyond our full control. Buildings might be considered magnificent, marvelous, depressing, dull or exuberating. What is it that conveys these feelings? Buildings impose themselves on us in an unknown, unexpected and surprising way. This is different from operation and function or use, which can be estimated, managed and scripted. This is a state that David Leatherbarrow calls an "event," whereas I am more inclined to call it "feelings." Since, events or feelings with all their subjectivity are not the outcomes of technique or technical knowledge. This is a state that requires foresight, on the contrary to technique which builds on our preoccupations and brings preconceived endings. Foresight is a step above and beyond knowledge. The fact of the matter is that performative architecture is not the result of building technology and does not lead to preconceived results. It is important to appreciate the existence of this fine line. All technology is doing in this process is to enhance functionality and support the use of the building. Performative architecture does not focus only on how a building's different spaces present themselves on a given occasion. In performative architecture, the building spaces' actuality is imagined in their subsistence between various events as well as during particular events. Therefore, by paying in-depth attention to the instrumentality of performative architecture, one has to grasp the meaning of "space actuality." This is one step above and beyond "space virtual reality." In space actuality, a wiser procedure is required to observe, percept, and describe the particularity of a space in any specific and given segment of time. The workability, functionality and adequacy of a space are only revealed when the intended event is unfolding itself. And even then, its occupant might encounter surprises and unexpected peculiarities. Due to the temporality of the space, it is only by viewing the event unfolding itself in the present that one can truly discern the essence of a space setting and the true meaning of the space. There is no definition of a truly discernible space phenomenon, due to the temporality of the mood within the space. Typically, for the purpose of defining the functionality and performativity of a space, the measurable means and quantifiable techniques would be helpful in revealing

the objective character of the space. On the other hand, there are certain architectural theoreticians and philosophers, such as Leatherbarrow who believe that the answer is in combining measurable and immeasurable qualities, or in other words, objective and subjective descriptions. According to him one without the other cannot provide and give a meaning to the whole of architecture. Leatherbarrow explains about this aspect of the performance of the space in his article, "Put differently, the performance of a setting can only be known on its own terms, or, as I suggested earlier, pre-predicatively. Events cannot be defined, organized or scripted because their beginning, middle and end resist objective comprehension. This leads to a first conclusion: to understand architecture's performative character we can not rely on a transparent and objective description, alone, or on techniques of quantification and measurement." (Performative Architecture 11-12)

1.1.2 Place and People---Ways of perceiving space and the act of place-making in a process-based design

1.1.2.1 Element of space and its perceiving mechanism

If we believe that architecture is the art of space-making, then space can be considered the essence of architecture. Many design theoreticians and critics believe that architectural space is entirely an abstract substance. Space is a central element in everyone's daily life. It is a phenomenon that goes beyond technical, aesthetic or even semiotic interpretations. Ironically space is what brings us together or sometimes separates us from each other. No matter what its intended use is, space imposes itself on us. The elements of space, including ideas such as form, proportion rhythm, and color are part of the tools that designers use to create space. Creation of space is the reflection of deep-rooted needs of the individual's psyche and his or her characteristics. An individual's psyche is in direct relationship with his or her un-built, instinctive, and acquired or adopted behavior. It is the balance between the instinctive, meaning what is bred into us, and our experiences, or what is acquired and adopted by us, that constituting the make-up of our psyche. We as human beings, in our daily activities, establish a direct relationship with our surrounding spaces, from which we receive direct and less direct effects from. Rather more influential is a less direct effect of space and the way it mediates our daily private and social lives. A large part of this interaction with space is related to our senses and the way they in turn structure our perception. Therefore, it is the combination of what our senses are telling us, meaning instinct combined with our attitudes that establishes our perception. As was also mentioned, attitude builds on the way we have acquired or adopted behaviors, of which culture is also a main contributor to the development of our behaviors.

Before modern times, and even to this day, in some parts of the world the design and creation of space has been a social and vernacular process, integrated and associated with all aspects of its related culture. This means that human use of space has a direct relationship with culture. Spatial manners, meaning the way people behave within their spatial environments, are ultimately a cultural phenomenon that is an inherent part of the design of vernacular spaces.

Nonetheless, in recent decades, spatial manners, and the relationship of space to the senses are increasingly attracting attention in architectural design and place-making.

1.1.2.2 Space, as behavioral settings

Space in its ultimate essence is an abstraction of a behavioral setting. “Setting” is the derivative and by-product of space and the forum within which we behave and function. It consists of space and its surroundings and contents, which include people and their activities. The key feature of the behavioral setting is the element of time and the way our behavior is influenced, inspired, or constrained by the setting. With respect to the element of time, Bryan Lawson refers to the Dutch architect Aldo Van Eyck and his famous saying: “Whatever space and time mean, place and occasion mean more. For space in the image of man is place, and time in the image of man is occasion.” (*The Language of space 23*) Therefore, behavioral settings are created by people’s activities on specific occasions within the forum of a space, which in our image is a place. The best way to appreciate this notion is by visualizing a stadium both full and empty. Although in both situations it is the same space, it is undoubtedly not the same place! Each setting is different and has its own unique needs and norms, while each place is used for performance of certain rituals of daily life. For space, in order to become a place, it not only has to serve a function, but also has to convey the appropriate appearance and create the reassuring image of the function. It should provide the occupants with an awareness of the outside world and at the same time, a sense of security by remaining in contact with the elements of nature and the passage of time. Throughout history it has been proven that there is a special link between space and time. Places that are marked with the passage of time and its resemblance—including vernacular and traditional architecture—have been highly regarded and treated with special affection.

Additionally, the role of space is to create settings that allow for the expression of a sense of identity. As much as people are instrumental in creating that sense of identity, architects play a major role in facilitating and paving the path for such opportunities. With regards to the need for a sense of identity, Desmond Morris writes: “One of the important features of the family territory is that it must be easily distinguished in some ways from the others. Its separate location gives it uniqueness, of course, but this is not enough. Its shape and general appearance must make it stand out as an easily identifiable entity, so that it can become the ‘personalized’ property of the family that lives there. This is something which seems obvious enough, but which has frequently been overlooked or ignored, either as a result of economic pressures or the lack of biological awareness of architects” (*The Language of Space 32)*. The need for identity is also indicative of the values, priorities, and norms of the occupants, inhabitants and the user groups of the space, and must be a major generator of ideas for how space is designed.

Spaces, in one way or another, should always contribute to the three requirements of perception, meaning sense of identity, security and stimulation. Nonetheless, as Lawson argues to, "Not only can space counter the distortions of life, but it can also help us celebrate events and heighten experiences...Traditional and vernacular architecture often got things right simply by enough trial and error for us to find out what worked well. There was no need for theory, rather myth and rituals. As we move into the modern, fast moving and changing world, we seem often to design spaces in a more abstract way, and so more frequently get them wrong. A common mistake is to concentrate too much on the central purpose of a space and thus to forget the rest of the human condition. Such a way of thinking leads us to the wonderfully efficient and clinically sterile hospital that treats the body and yet numbs the spirit! Another mistake is to copy the conditions of the past when they are no longer appropriate, but have become stereotype." (*The Language of Space 40-41*).

Nonetheless, there are close similarities between the concept of vernacular, and performative architecture in that both focus on the concept of the human condition as the central purpose of the design of space. In performative architecture, subjective requirements of perception, including sense of identity, security, and stimulation as well as human comfort, are considered fundamental elements of the performativity of space.

1.1.2.3 Mechanisms of perceiving space

Perception is an important feature of the way we observe, perceive and associate with the world around us. This is not a passive process but rather an active one. There are fundamental requirements with respect to the way we perceive space and even sense presence of others in the space. Perception is activated by the direct connection of the senses and the brain through an act of analysis, decomposition, and structuring of the scene. A designer internalizes a building in his mind; movements, balance, distances and scale are felt in his subconscious mind through his senses. Eventually, when the building materializes, architecture starts communicating with the inhabitants of the building through their senses. In reality, the entire essence of architectural experience takes place through our senses. We behold, hear, touch, feel and appreciate the spaces of a building with our entire bodily existence. As we step into a space, we start communicating with its environment to the degree that it becomes impossible to detach ourselves from its spatial existence. As the poet Noel Arnaud has written, "I am the space, where I am." According to Juhani Pallasmaa, co-author of *Questions of Perception, Phenomenology of Architecture*, "In memorable experiences of architecture, space matter and time fuse into our single dimension, into the basic substance of being, that penetrates the consciousness. We identify ourselves with the space, this place, this moment and these dimensions, as they become ingredients of our very existence. Architecture is the art of mediation and reconciliation." (37)

With regards to the active process of perception, Bryan Lawson indicates: ”We may not even be aware of the extent to which impressions we have of a place depend on the various sensory channels we use, such as sight, sound, touch and smell. So when we look at Vanbrugh’s architecture or listen to Telemann’s music we are continually but unconsciously taking apart its constituent elements and predicting how it will behave next. In fact, without such a process the world around us would simply generate too much information for us to deal with.” (*The Language of Space 71-72*)

In pursuit of the mechanism of perception it would not be an exaggeration to say that a building speaks to us through the phenomenon of perception, and typically there is a relationship between perception and sensation, or expectation based on memory. Many people mistakenly consider perception and sensation to be the same thing. In other words, perception in a real sense is an experience that involves an analytical process by the brain system, and underlies questions of intention. There are certain factors that affect our perception, such as distance, size, scale, foreground and background, geometry, verticality, horizontality, symmetry, color, repetition, order, concept, context, and more. Architecture, by unifying and relating, foreground, middle ground, and background, as well as other factors, creates a coherent whole, which only at that time becomes comprehensible to our perception. The following factors are contributors to the mechanisms of perceiving space, as described by Brian Lawson in his book, “The Language of Space.”

Distance and Size of the object

Our human brain has the ability to analyze and estimate the distance of an object in space from its size and from the way it seems to move in space, through the movement of our eye and head. Our brain has the ability to do the analysis to allow us to appreciate the size and distance of the objects. This is, however, not a reliable means of perception. True perception can only happen through relative comparisons.

Scale

There are different ways that we maintain a constant perception in the face of changing visual sensations. By looking at the world around us we perceive that as we move the size, shape, and color of the objects around us, they remain constant and unchangeable. However, our visual sensation demonstrates them as constantly changing. This understanding is based on the notion of the “scale” of objects. Scale has to do with the relative rather than absolute size of the building and the effect that the size of the building has on us. According to Lawson, “it is the features of the buildings that appear to be provided specifically to accommodate our shape and size that also attract our attention. If these features seem rather too small or unnecessarily large, we notice it immediately.“ (*Language of Space 48*)

There are many elements of the building that are speaking to us of the scale. For instance, the door reveals the purpose of allowing the standing human form to pass through. Doors and many other elements of the building, in small scale on the

architectural drawing and the façade of architecture, are representative of our height. In reality, scale is not an abstract concept. Rather, it is about humans and their social relationships. Scale relates to humans rather than buildings and is one of the most fundamental components of spatial requirements and their effects.

Repetition

Repetition of an element, a subject, or a theme simply camouflages the main object. For instance, the repetition of columns creates a colonnade, which overshadows the individual columns. Research on short-term memory has revealed that our apprehension starts declining as the number of repetitions increases. It is through arrangement and order, or clustering, that we tend to get a handle on the meaning of the individual elements.

Geometry, Verticality, Horizontality

New research on the human brain has revealed specialized areas, and a specific location that responds to certain geometric stimuli. The brain is capable of processing visual information through some kind of hierarchical modular structure, that enables organization. Lawson has a unique approach in referring to this phenomenon, indicating, “The brain can thus be seen to be a sort of bureaucracy with departments responsible for straight lines, curved lines, triangles, squares, the colors red and green and so on. As with bureaucracies, not all departments are equally powerful. It has been found that the vertical and horizontal line departments are particularly influential.” Nonetheless, it is important to keep in mind that every person’s brain is unique, and every individual’s brain has a unique and particular layout of specialized departments within compartments.

Foreground and Background

Foreground and background provide a clear example of a distant object to be framed by the nearer objects, and consequently the distant objects remain in the background of our perception regardless of their proximity. The notion of foreground and background is one of the essential mechanisms of our perceptual system. One of the interesting phenomena about our brain is that we have the ability to look at the whole of a scene with our mind’s eye, retain it in our memory, and recall it when we need it. The most interesting part about this process is that our minds are selective about perceiving and retaining the observed elements--meaning certain elements are retained in the “foreground” and certain others in the “background.” In fact, this has become a known fact with some predictable rules in the visual field. These rules help to define the visual qualities of an object as having foreground characteristics as opposed to the rest of the object, which tends to become the background. It is important to differentiate between the closeness and stature of the element, meaning it is not abnormal to ignore the items that are near to us for the sake of items and elements that are farther away. It is up to the selective taste and mood of the designer to recognize

the concept and situation, and thus provide the foreground and background quality of the elements.

Symmetry

Symmetry is another tool for providing foreground effect. Throughout the history of architecture, symmetrical geometrical shapes, such as spheres in the form of domes, have created the most attractive and the most fascinating spatial climaxes.

Color

In recent decades, there has been extensive research on the effects of colors on our emotions, which has somehow proven inconclusive. But it is proven that warm colors such as red and yellow demand more foreground attention, raise a higher level of alertness, and enhance performance, while on the other hand, they also create higher levels of stress and anxiety. However, colors such as blue and green are considered cool and receding. A space painted blue appears to be larger than a space painted in red.

Meaning and Concept

It is interesting to know that we all seek meaning and concepts from our surroundings. Our long-term memory appears to be working by using concepts and meanings instead of images. In fact, we see what we desire to see! As our recollection goes to farther distances, we accumulate ideas, concepts, and words in our memory and train our perception to describe the space we have experienced and with which we have dealt. These words and concepts become substitutes for the images. The architect is taught about concepts and meanings related to the built environment, which due to the same training must be able to make more meaning than ordinary people. Thus for architects, concepts with words and meanings attached to them normally have foreground effects.

Context

The context of a situation is an important way in which meaning and concept attract attention. Obviously, attention is directed by our motivation in a given context and with a given concept. What commands our attention and what we retain and recollect about places depends as much on us as on the physicality of the objects and places themselves.

1.1.2.4 Ways of Perceiving Space

There are multitudes of known mechanisms that can be utilized as stimuli to raise our level of perception of a space. Looking through the various eras in the history of architecture---i.e., Classical era---reveals that the grammar of a formal visual language drove the whole conception of design. For instance, symmetry about a dominating axis with all its foreground qualities was strongly enforced and maintained.

The Greeks were also concerned with spatial perception and not just geometrical mathematical perception. For the Greeks, the element of proportion was at the center of their architecture creation and the organizing principle for spaces, surfaces, volumes and lines.

As it was indicated earlier, it is through the direct connection of the eye and the brain and other senses that the act of perception occurs. Also, it is through the analysis, decomposition and restructuring of the observed and perceived space that the essence of perception manifests itself. Nevertheless, this is largely an unconscious process, and our actual experience of perception is by no means an analytical one. The experience is rather integrative. On the other hand, research has proven that people's response to a whole series of situations is in close correlation with certain mathematical measures of structure and the redundancy of architectural elements. Certain experiments have revealed that the capacity of our short-term memory depends directly on the level of the redundancy of the object being remembered. In certain styles of architecture, for instance in the classical vocabulary, not only the shapes, forms, and elements are repeated, but also the relationships. Additionally, classical vocabulary relies on a series of proportions called "Golden Section." These proportions were used centuries later by Le Corbusier to advance a theory of architecture called "Le modular," which was based on the same proportioning system. Le Corbusier modified the repetition of elements and devised a system of redundancy of use in architecture, based on the proportions of elements and their spacings.

Another means of perception is through appreciation of the meaning of different styles of architecture. Different styles have emerged in different fields of art and architecture through introduction of certain redundancies. Nonetheless, redundancy is a fundamental necessity in development of different styles of architecture.

A number of mechanisms of perception contribute to the phenomenon of buildings' external reference, or their iconic and symbolic representations. Additionally, buildings may carry meaning, represent ideas, and convey feelings in a literal or metaphorical way; this is manifested through the constituent properties that the building possesses.

Nonetheless, it is important to bear in mind that the act of design is quite different than scientific experiments or philosophical thinking. Design is a purely prescriptive approach rather than a descriptive one, which requires conscious decisions and involves the thoughtful and sensitive interaction of the senses, even in the face of insufficient time and knowledge.

1.1.2.5 Place and people, Unseen influences

As Christopher Day indicates: "….the qualities around us resonates within us" (*Spirit & Place 113*). Undoubtedly the influence of space on its inhabitants is undeniable. Throughout the centuries, in the history of architecture, for instance during the Renaissance, the five senses were understood to form a hierarchical system,

from the highest sense of vision down to the lowest sense, touch. With regards to the relationship of space and senses, as Juhani Pallasmaa points out, “The system of the senses was related to the image of the cosmic body; vision was correlated to fire and light, hearing to air, smell to vapor, taste to water, touch to earth” (*Question of Perception 29*). It is through the interaction of the senses that our intellect finds the potential to mediate information for its act of judgment; change to this interaction is also a means for articulating sensory thoughts.

Nonetheless, place, through the element of perception, penetrates into our psyche and creates its influences. Through the phenomenon of perception, the occupants of a space will convey psychological responses. Psychological responses are to a great extent complicated, highly individual, and sometimes culturally conditioned. Undoubtedly, all aspects of a space work on us, through all our senses and on all levels of our being. In a simple way, this is what affects our mood. There are also common physiological reactions, for instance to color, noise, air quality, temperature, light and more. In recent years, it has become known that these factors affect our health and well-being through our relationship with the built environment.

It is not inappropriate to define places as spaces with identity. Places have some degree of spatial containment with boundaries, and some degree of influence, as well. This is what we call in a simple way “spirit,” or sometimes “heart.” Regarding the spirit of the place, Christopher Day has an interesting discussion, which describes the spirit of the place as the first impressions and messages that are exchanged between the occupant and the place, as following: “The physical substance of the place, fluidity of its living relationships, its soul and spirit, is the inspiration underlying everything happening there. The soul moods of each activity needs to support this; the relationships that unify these and what this implies in physical substance. We’ve worked through matter, life, soul and spirit—or earth, water, air and fire, and worked with the different levels of our own being as well as those of the place itself. Every place speaks. In default of a chosen message, others, much less desirable, fill the gap. Are these messages in conflict with what goes on there, compromising and diverting it? Or, are they supportive, building a wholeness to nourish at all levels and resonate more than its walls? Places, built or grown for other activities rarely match new needs---neither practically nor spiritually. But with sensitivity attuned, inexpensive modifications, their message can coincide with the spirit of the activity they house. We don’t build buildings just to keep off the rain but to house activities. At the heart of every activity is a motive, an ethic, and a spirit. This is what we house, and it is of this spirit that places need to speak” (*Spirit & Place 161-162)*.

This discussion brings us to the important questions about perception and its association with the phenomenology of architecture: How is it that the quality of a place has so much effect on us as its inhabitants? The answer lies in the fact that architecture, through its elements, in an unseen way holds the power to inspire and transform our day-to-day existence. More than any other forms of art, it engages with our sensory perception. Certain natural elements such as, light, shadow, and

transparency, as well as phenomena of color, texture and passage of time, in addition to material, all to contribute experiences of architecture. The ability to relate with the element of form through these phenomena, and the effects they have on space—and consequently on place--assist in the development of the consciousness of perception. Consciousness of perception is the magic tool in this whole process. Equipped with this tool, it is possible to pursue a design approach which listens to our feelings, spirit of place and community. Throughout the ages, architects have had to anticipate the effect of their design, only to find later after the building had come into existence, whether they got it right. In recent decades certain researchers, such as John Eberhart have envisaged how neuroscience findings could inform and enrich architecture. Through the concept of neuroscience in architecture, it is possible to detect our own subjective responses and unconscious reactions to the material world, while providing an opportunity to make better predictions about the effect of the design. In conjunction with the same philosophy of design, performative architecture is also focusing on an architectural thought process that brings into consideration human responses to the built environment, through the evolutionary process of form-making. This is a design solution that possesses an innate tendency to convey what is right for individuals, community, and place, as well as the related environment. Undoubtedly, if we are able to arrive at such a design approach, we have in all probability attained to the most performative, sustainable, long lasting, adaptable, efficient, and operable design. Such an act of design will undoubtedly lead to an architecture that has the capacity to comply and perform in response to the needs and expectations of its inhabitants.

1.1.2.6 Place making in a Process-based design

By focusing again on the mechanisms of perception and their contributions to the phenomenon of architecture and the act of place making, it would be helpful to consider the concept of space, on one side as the container, and on the other, as what uses or fills the container, meaning people or inhabitants.

In a simple explanation, the relationship of buildings as places and their occupants. In other words, it is about effects that are created, as well as events and actions that are perceived to take place. Space is undoubtedly expected to serve a purpose and allow for the fulfillment of an intended function. Additionally, the role of space is to create settings that allow for the expression of a sense of identity for its users. On the other hand, the occupants, expect to be able to perform and function appropriately within the allotted spatial boundaries. This expectation has a direct relationship with the level of occupants' perception, which is a combination of instinct with attitude, and can be considered a cultural phenomena. It would be appropriate to refer to Aldo Van Eyck's indication: "Whatever space and time mean, place and occasion mean more." (*Architecture in Use 68*) This indication corroborates the concept of "space actuality," which refers to the need to observe, perceive, and describe the particularity of a space in any specific and given segment of time. These are the facts that on one hand, make the process of place making a delicate act of design, and on

the other, augment the critical role of its creator.

In a true sense, "space—actuality" and "process-based" design are two different concepts with the same viewpoint. Process-based design allows for visualization of the realities of a space with all its layers of being and its present time actualities, before they have come into existence. As Christopher Day points out, "A place like a person has layers of being: its substance; its life (and everything that has to do with time); its moods and finally, its indefinable, but palpable, "spirit"" (*Spirit & Place 160*). The goal of performative architecture is to capture the layers of being within a frame of time, however prior to its happening. The pursuit of this goal is the essence of this research topic!

1.1.3 Design methodology and meaning of Performance-based Architecture

Performance and performativity are not new concepts. For the first time in the 1950's, the idea of performance was introduced in the humanities—in cultural anthropology and linguistics—and in some other fields as well. The root of the concept revolved around a change of attitude, meaning the shift in the perception of culture. Rather than a static collection of artifacts, this shift emphasizes an interactive and dynamic network of intertwined and multi-layered processes that defy predetermination and rigidity of form, structure, and meaning. The performative concept in architecture, as a new paradigm in form making revolves around adaptability and defiance of rigidity of form. In the 1960's and early 1970's, various architectural movements had their origins in the performative concept. The Utopian designs, architectural avant-garde, Archigram's soft cities, robotic metaphors and organic urban landscapes were influenced by theories originating from performative acts, which intended to locate meanings in their true sense. Thus, performative architecture can be described as a new design methodology that has the capacity to arrive at design solutions that can constantly reformat themselves. It is a new approach in design methodology that acts as an interface for new and emerging cultural forms and models. Performative architecture focuses on an approach to form-making that involves fluidity and dynamism. Its ambiguous program reflects technological, cultural, and socio-economic transitions. In performative architecture, as Branko Kolarevic argues, "…culture, technology and space form a complex, active web of connection, a network of interrelated constructs that affect each other simultaneously and continually. In performative architecture space unfolds in indeterminate ways, in contrast to the fixity of predetermined programmed actions, events and effects." (*Performative Architecture, Beyond Instrumentality 205*) Interestingly, there are multiple meanings associated with the concept and meanings of performative architecture. It is increasingly becoming a paradigm for the type of designs and developments that are also making connections to sustainability and cultural theory. The meaning of performative architecture is broad and expansive. It has a wide and active web of connections, linking different disciplines and realms from purely technical—structural, mechanical, thermal, and acoustical, etc.—to social, cultural, economic, and financial, as well as spatial and formal. Interestingly

performative architecture brings a new attitude to architecture design methodology, which extends beyond aesthetics (venustas) and or the utilitarian (utilitas), to the tectonics (firmitas) inherent in the other two.

1.1.3.1 Performative Architecture and its device paradigms

In general, architecture operates between the two opposing contexts of "soft or smooth" and "landmarks"—meaning blending in and standing out. Contemporary architecture uses the urban setting to showcase the artistic performance of architecture as a performing art stage.

On the other hand, performative architecture utilizes certain building elements and devices as tools to demonstrate its performativity. Its operational tools are the building parts that are movable, including operable mechanisms such as screens, apertures, etc., with different ranges of motion. Their movements can be initiated and controlled by manual, electric, mechanical or digital mechanisms called "device paradigms" in order to modify, acclimatize, and mediate the environment, as well as human behavior. The highlight of this issue in performative design is the capacity of the device to *adjust* itself to the foreseen and unforeseen situations. It is the spontaneity of the device, or its spontaneous qualifications that warrants flexibility and adjustability. According to David Leatherbarrow, "The first step in the development of a performative architecture is to outline strategies of *adjustment*." The strategies of adjustment can take place through measurable means

There are also other elements of the building, such as the building structural system, enclosure and cladding, and thermal and material components, that are considered to have "behavior." Obviously, a building subject to all predictable loads must remain in equilibrium. It is not uncommon to anticipate and predict the way different elements and components of the building's behavior are subject to ambient conditions such as sunlight, precipitation, wind and gravity. The term "economy of performance" in performative architecture refers to the demonstration of awareness in efficiency of the design, subject to various ambient and natural elements. A well-sited building is demonstrative of an efficient design and the economy of performance. As Leatherbarrow points out, "The economy of performance—in a site, as if on a stage—is always an exchange between forces and counter-forces. To act is to counteract. The building's labor is quite simply the amount of effort it takes to sustain this economy, to keep up or play its part. The term we must use frequently for this work is *resistance*" (*Performative Architecture Beyond Instrumentality 16*). Certain building elements and systems of the building have to demonstrate the capacity for resistance. For instance, the materials of the building enclosure system should be able to resist ambient forces. The changes that the building is going to undergo due to external contingencies must be predicted. Therefore, a performative building has the capacity to respond to both foreseen and unforeseen, or predictable and unpredictable situations. The more attuned the performative design, the more responsive to the unforeseen situations; and the greater the likelihood for a building's contingencies, the more expectation there is for

active performative requirements. According to Leatherbarrow, performative labor has no end, "for it is a task that continually present itself anew" (*Performative Architecture Beyond Instrumentality 16).*

1.1.3.2 Context of Performative Architecture

Performative architecture takes place within a context, which is not from the same make-up and not of the building's making. This context is called "topography," which consists of the built as well as the un-built world. It is the topic, framework and place that provide the ground for architecture to contribute to contemporary culture. It not only incorporates context, terrain, and built and un-built, but more it includes practical affairs and their traces. The word "topography" brings to mind the notion of a physical phenomenon, but it incorporates the many and various performances of everyday life. It also has the capacity to continuously present the residuals and traces of past performances that have been sedimented in the morphology of a specific context.

According to some contemporary architecture theoreticians, there are three characteristics of the topography that sustain the performativity of the building: its outwardly broad scope or wide ambience, its various contrasting components, and its capacity to manifest inherent and latent potentials.

The scientific theory of space, which was discussed and reviewed before, considers space as a phenomenon which is unlimited, all embracing, and contains every possible and particular circumstance. Moreover, it possesses a conceptual character with certain attributes of homogeneity, which allows for demonstration of individual intellectual mastery. Whereas according to Leatherbarrow, in the context of performative architecture, the topography in which the building performs "…. Is just the opposite of space: polytropic, heterogeneous, and concrete; its regions contrast, conflict and sometimes converse with one another. Yet it is not a field of infinite difference either, for it continually offers experience of both unexpected and familiar situation" (*Performative Architecture Beyond Instrumentality 16)*.

Nonetheless, this is the concept that directly relates to the notion of space actuality, because in performative architecture, the actual topography manifests its characteristics through the passage of time—in any given site at any given moment, it provides the opportunity for some of its regions to be recalled, and some of the others to be anticipated. Topography with its ambient constituents create interconnectedness between building and site. Undoubtedly, architecture without contingency and dependency on its topography cannot be substantiated. Topography not only supplements the architecture but also enliven it. By the same token, architecture can be defined as a topographical art, which accommodates and demonstrates the patterns of our lives.

1.1.3.3 Performative Architecture, as an Organic Design Process

Performative architecture and organic architecture share common grounds. Frank Lloyd Wright, in his book, *Organic Architecture, The Architecture of Democracy,* wrote: "Garden and building may now be one. In a good organic structure it is difficult to say where the garden ends and the house begins—and that is all as should be, because organic architecture declares that we are by nature ground loving animals, and insofar as we court the ground with what it has to give us and produce what we do to it, we are utilizing practically our birthright…" (47).

The word "organic" comes from biology, which means organization as it is related to the plant kingdom and animals, which were eventually brought into architecture. The words "organism" and "organization", both describe a harmonious combination of parts. In architecture, the word "organic" means a part of the whole and all of the part. We humans are integral and indivisible wholes; change of one part of our whole will affect all the other parts. The architectural whole is viewed as an absolute, with the individual parts independently created and put in exactly the right place to achieve the desired unity. Obviously, the assumption is that the whole is not the sum of all the parts. According to Frank Lloyd Wright, the word "organic" refers to an entity, meaning, a part of the whole, and all of the part.

In order to assume an organic quality with the desired unity of the whole, there first needs to be a correlation between all the parts. Second, there must be subordination of characteristic features. In comparison with the human body, some of the organs or systems of the body have more functional significance than others. The organs or principle elements form a basis for the integration of the rest. In architecture, there are spaces that are primary and are governing the functionality of the entire building, as well as dominating the composition as a whole. There are also accessory spaces that complement the essentials parts.

In modern times, among the different points of views being disseminated by different architecture theoreticians, the concept of organic architecture has gradually gained more attention. This concept is not based on promoting the copying of nature. Certain architects of this era, including Alvar Alto, have conceived structure as an organism, whereas there are rationalist architects who perceive it as only a mechanism. The former group considers buildings to have life.

So far, most of the organic forms that have literally copied nature have turned out to be superficial replicas of nature, although they have tried to bring natural principles into account. Undoubtedly, by deep submersion in the process of organic evolution in architecture, one can create meaningful constructs that are the traces of the natural shapes existing in nature. However, the true concept of organism has a deeper meaning, which exceeds far above and beyond form.

According to Javier Senosiain, in his book *Bio-architecture*, there are three integral aspects to the design of organic forms: First, the functional, which implies the process and mode of its evolution; second, the constructive, which embraces the material

and technology of its constituent; and third is the aesthetics, in which ideology and emotion or the poetic, transcends the building to the work of architecture. There is also a mercantile architecture, which overlooks the third aspect and only considers the first two as the over arching objectives of the design process. On the other extreme, when aesthetics becomes the dominant objective, it becomes formalism, which might be called the deformation of the architectural image or creation of a stage-set.

Nonetheless, organic architecture is characterized by bringing into consideration not only the natural elements related to the geographic environment, but most importantly the human aspects, and the factors related to their cultural identity.

Performative architecture shares the same views about the fusion of man and nature and the emphasis on societal values. It inherently has an inclusive approach in establishing a three-way harmonious relationship between humans and their surrounding built and un-built environments.

1.1.3.4 Performative Design, as an Organic Approach for Creation of Humane Spaces

Undoubtedly, in architecture the goal is to create spaces for the purpose of accommodating people for different functions and activities. There are different factors that contribute to elevating the occupants' quality of life within the space, other than the three known dimensions. "Time" makes a direct impact on the status of the occupant within the space. The more in tuned our perception with the space, the more we will understand time and the rhythm of life within the place. This is a main factor in improving quality of life and a key ingredient to the conversion of a space to what is called "a place." Undoubtedly, an occupant of a building has different spatial experiences depending on where in the building he or she is situated. As the person moves around the experiential quality changes, as will his or her views. The factor of time is what has been referred to as the fourth dimension. The element of "time" has a direct relation with perception. Design process for creation of space requires the inner eye of perception. Perceiving the occupant's interaction within the space, and capturing the occupant's various views need to be integrated in the methodology of the design process. As Senosiain points out, "Architecture that neglects time and space creates merely things, not homes." Inclusion of the factor of time in the design concept of space is a methodology for architectural dynamism. Fredrick Kiesler refers to architectural dynamism as follows, "The dimension and the arrangement…are determined by the different activities and personal experiences of those who inhabit it. Its free form comes from the fact that each section of the house are determined by the usual measurements of height, width, and depth required for the necessary activities of eating, sleeping, walking, and working. The well-defined functional areas can be opened or closed to the other areas, thereby creating a continuous space" (*Bio-Architecture 136)*.

In some occasions, architects in pursuit of organic forms have found guidance in finding the appropriate form through Michelangelo's ideal, which refers to *finding* the shape rather than *giving* the shape. Michelangelo also talks about *freeing* the shape

rather than *imposing* it from outside elements.

Performative environment shares the same characteristics as organic space in the establishment of a harmonious human space, which is simply more than a space with a heating system, doors and windows for access and ventilation, a strong roof, etc. On the other hand, an organic architecture defies the existence of a building as a mere appliance. The difference concerns the limitation of static, versus ecstatic freedom of space. The ecstasy of space, as Lao-Tse writes, "is what takes the observer through a series of sequences, which prove that the building is an organic whole and to design a model of rhythm, effects, and ordered sequences, finally coming to a climax" (*Bio-Architecture 137*).

1.1.3.5 Performance-based Design as an organic approach to form-making, A Morphogenetic Practice

There is an interesting term in the German culture, "Gestalten": form finding analog to nature. In German culture the term "Gestalt" is used in all topics concerning existence, especially in art, bio-morphology, theology and mythology.

With regards to the organic approach in Gestalten, Haring has made the following remarks:

"Organ like nature has her own form ideas, she makes organs that serve the fulfillment of a living process, she does not content herself with the abstract space arrangements of geometry. In this space arises a new concept of form-creation: the living as a changing process, no static state. It is moved and moving, not rigid and dead. It is bound up with the secrets of creative life, it runs according to the life-effecting secret energies of the spiritual world" (*The Organic Approach to Architecture 30*) .

Goethe in one of his essays "On Morphology" makes reference to Gestalt and the complex existence of the physical organism:

"With this expression they exclude what is changeable and assume that an interrelated whole is identified, defined and fixed in character. But if we look at these "Gestalten," especially the organic ones, we will discover that nothing in them is permanent, nothing is at rest or defined—everything is in a flux of continual motion. This is why German frequently and fittingly makes use of the word "Bildung" (formation) to describe the end product and which is in process of production as well" (*The Organic Approach to Architecture 30*).

On the other hand, morphogenetic properties, or in a better word, morphogenomics, is a term referring to the location or exact spot of each structure within the universe. Let us visualize an infinite and open-ended universe with different levels of all possible morphologies of past, present, and future structures. This is a universe where we have the possibility of accessing and navigating through it, from any level and any type of architecture with the opportunity to transform, transcend, digress, or simply move from one state to the other in a continuum of time and space. This is a highly structured universe. As Halvani describes:

"In this morphological hyper-universe, different types of morphings are encountered. Simple forms can transform to complex, regular can transform to irregular, periodic to non-periodic, symmetry to asymmetry, static can become dynamic, solid can become void, tension can become compression, inorganic (geometry) can become organic (geometry), and so on, all in a continuous manner. In this universe of continuous transformations, all dialectics disappear. Within this universe, topologies are created and destroyed: elements (points, lines, planes and cells) are added and subtracted or simply appear and disappear; open lattices transform to finite closed objects; genus is created and transformed, closed becomes open, and inside becomes outside; and Euclidean space changes to non-Euclidean space. This universe is a continuum where every form can transform to another continuously. This metamorphosis follows systematic transformation pathways within the hyperspace. The structures can also undergo points of singularities in this space to enable dramatic topological transformations. Further, this universe itself evolves and grows as new morphological possibilities are discovered or invented by humans or nature" (*The Organic Approach to Architecture 117*).

Morphs within the universe have code (morph-code), which identifies the genetic code of the form. The genetic code of form in conjunction with other aspects of architecture defines the genetic code of architecture. In a sense, what the morph-code does is to encode all formal design possibilities that exist in the natural, artificial, and human-made environments.

For over a century, various architects have pursued organic techniques for the generation of building forms. This technique has derived and originated from structural diagrams, function charts, and currently from wire frames and digital animation software. This is a new morphogenetic characteristic that is developed from animation of "isomorphic poly-surfaces." Isomorphic poly-surfaces are used in the animation industry for special effects with the terms "meta-clay," "meta-ball," or "blob" models.

In a 1996 article entitled "Blobs (or Why Tectonics is square and Topology is Groovy)," Greg Lynn makes the argument that although the mobility, multiplicity, and mutability of body is not a novel concept, it however remains a continuous novelty due to its continuous regenerative properties. As Lynn explains: "In blob modeling objects are defined by monad-like primitives with internal forces of attraction and mass. Unlike conventional geometric primitives such as a sphere, which has its own autonomous organization, a meta-ball is defined in relation to other objects. Its center, surface area, mass, and organization are determined by other fields of influence. Those 'field of influence' can be used to simulate anything from the motion of the sun to the movement of people to changing brand identities, anything whose influence can be assigned a value" (*Performative Architecture. Beyond Instrumentality 59*).

In the course of the evolution of such aggressive philosophy of design, other conflicting points of views emerge. Undoubtedly, an undeniable fact is the contradiction between the responsive dynamism of the animated objects and the inherent static nature of buildings. Some critics including Michael Speaks have used this idea in the

practice of architecture, due to the fluid demand of the market.

There are many forms of architectural practice that deal with the demands and forces of the market. I am concerned with morphogenetic practices, which are based on methodologies of describing the flows, forces or elements influencing the production of the buildings.

1.1.4 Bio-Technical, Bio-mimicry & concept of performativity

During the 1930's a set of practices emerged from the theory of general system's operations and cybernetics. This was based on a scientific method of analysis of functional requirements, which involved "psychological and aesthetic needs," as well as physical measurements of performance. The interest in performance was based on a long history of functionalism and determinism in architecture that was mainly focused on mechanical and organic analogies, which were to a great extent originated in the latter years of the previous century. What Le Corbusier's famous "Machine for Living" truly meant was that "all the objectivity of the functional methods depend on the assessment of subjective needs, of quantified and temporarily stabilized desire" (*Performative Architecture, Braham 57*).

In 1939 Frederick Kiesler came up with his provocative term "biotechniques," with all its implications related to equivalence between biology and technology. Kiesler, in his biotechniques, focused on man as a combination of heredity and environment. In his famous diagram on "Correalism and Biotechniques," Kiesler expressed the continual interaction of both the total environment on man and the continual interaction of its constituent parts on one another.

In the context of current research on this topic, biotechnique is best described as the biological analysis of technological systems. As an affiliate of Buckminster Fuller's Structural Studies Association, Kiesler, in his studies on equivalence between biology and technology, used the term to convey the depth of the meaning and the difference of his philosophy from other ways of thinking. He used the term, 'equivalence between biology and technology' to distinguish his thinking from other direct imitations of biological forms or processes. This is what today is called "biomimicry." During his time some other philosophers such as Louise Mumford, Patrick Geddes and Karol Honzick, called this approach "biotechniques." Nonetheless, Kiesler, in his "correalism" concept, was referring to the dynamics of continual interaction between man and his natural and technological environments.

Kiesler's point of view, as well as that of some others in architecture and other fields, was based on several facts and assumptions. With regards to its implication in architecture, William Braham refers to three following prepositions: "First, that technology was and still is based on steadily evolving human needs; second, that despite their origin in human needs, technological systems develop according to their 'laws of heredity,' and third, that the final criteria of technological design is not technical performance, but human health" (*Performative Architecture 57*).

Nonetheless, biotechniques can be any method through which buildings are

evaluated as part of a dynamic and "living" system. This system can be either the biosphere or technical, social or financial systems. Biotechniques may or may not bear results that appear to be biological. However, they may be initially deployed metaphorically, to explain or understand how buildings or artifacts are being transformed or adapted through time. Through application of biotechniques, performative design examines the environmental performance of contemporary buildings as biospheres with complex and dynamic systems.

1.1.4.1 Bio-Technical design as a process-based design

The concepts of biotechniques and morphogenetics are not completely new. For over a century, architects, while generating building forms, have focused on ideas that required pursuing organic techniques. These techniques derived from structural diagrams and charts of functions, and these days, from a flow of data manifested with digital animation software. The application of the biotechnical approach in process-based designs is practically identical to the morphogenetic properties technique. Nowadays, this technique is made possible by the development and animation of "isomorphic polysurfaces," and the approaches that are pursued in the special effect and animation industry. A great deal of this effort is diverted to forms of architectural practice adapted to market forces, from corporate design-build to other related aspects of the professional practice of architecture. The most critical aspect of these morphogenetic practices involves the techniques for describing the flows, forces, or elements that affect the production of buildings.

In bio-tech, architecture is the concept developed by the architects who exploited the new generation of "organic machines," which has its basis in progressive technologies. Advances in the technology of architectural production have been accompanied by major advancements in energy efficiency techniques, driven by on-going and increasing concerns with global warming and related environmental issues. This has resulted in the design of buildings called "intelligent buildings" as forerunners in application of energy efficiency standards. The best example is the Hong Kong Bank, completed in 1980's with a fully incorporated computerized building management system, which is capable of monitoring climate control systems and the maintenance schedule of the building. The computerized management system functions similarly to a human's nervous system. Additionally, hybrid environmental systems involving both active—mechanically driven—and passive through non-mechanical elements are also widely used in all forms of buildings in different parts of the world, particularly in the tropical regions.

The most progressive architects are receiving support by equally creative engineers, who offer a full range of advanced environmental and engineering design services, backed up by advanced computer simulation techniques for performance testing. The outcome of these activities has been the emergence of new, innovative, and unprecedented building forms unlike. Development in energy saving techniques and

performance testing also have occurred and are paralleled by further advances in computerized visualization and progress in production. Techniques in virtual reality, digital modeling, and rapid prototyping have allowed architects to share their creative thought process with their clients. These techniques have opened the door for new possibilities in spatial and sensory visualization. Among the recent advances is the production of solid models of components from CAD data that is shortening the time needed for design development. Undoubtedly, in this era of transformation the most important and recent innovation in architecture design and practice has been the development of the Internet and specialized web-related networks that have already made an astonishing impact on the collaborative aspect of architectural practice. As Chris Abel indicates: "The key to the complex and unpredictable process is the "virtual prototype," which functions both as a test bed and as a communication medium, providing instant feedback to everyone involved on the effects of their proposed decisions. Like the networks themselves, the thought processes involved are more likely to resemble analogical thinking than linear logical thinking with a premium on participants' ability to jump professional and technical boundaries and to make new connection" (*Architecture, Technology and Process 84-85*).

Nonetheless, it is important to keep in mind that biotech architecture is not a style. It is a computer-centered process of architectural design, production, and use. Biotech architecture combines global technologies with local responses to site and social conditions. It is an information-based not a form-based process of design that does not prescribe how a building should look, rather it focuses on how it should behave. It uses smart technologies, in addition to smart materials, to achieve a dynamic interactive relationship between a building, its users, and the environment. This is what altogether categorizes the building as what is called an "intelligent building." Additionally, bio-tech architecture customizes the building design from the molecular level or the DNA of the building to all levels, components, and systems of the building. As Chris Abel indicates, "it is self-organizing, and is not a fixed or final product, but is more like a biological organism, which continuously learns about itself and its surroundings, adapting to changing conditions and improving its own performance. Diversity is also important to Bio-tech architecture as biodiversity is to nature" (*Architecture and Identity 76*).

Bio-tech architecture design is basically a design approach that is continuously monitoring feedback from the design process to the production process and vice versa. It is multi-disciplinary and network-based, which involves simultaneous dialogues, rapid prototyping, and virtual memory. Bio-tech architecture allows active, full and open participation in design, and demands radical changes in architecture education and practice.

1.1.5 Functional quality, Architectonic quality and Performance of the building

So far, a great deal of discussion is made revolving around performance of the building; however, the meaning of the word "function" has direct association with the "use" or activity. In psychology, the meaning of the word "function" conveys "power

or ability" to execute certain action. In architecture, the function, as is identified by Zeeman, has various associations as follows:

Protective function: Building provides protection for its occupants against harmful and dangerous outdoor elements, such as wind, rain, predators, and interferers.

Domain or territorial function: Building provides a domain or territory and create a sense of satisfaction for territoriality and ownership, as well as a sense of privacy, security and safety.

Social function: Buildings provide opportunity for people to gather, communicate, and carry on activities with quality, health and endurance.

Cultural function: Buildings become part of the legacy, culture and civilization of a nation. Building form and character is the derivative of the lifestyles, beliefs, notions, and traditions of its people.

Obviously with respect to the domain of territoriality and social and cultural functions, a building is not substantial on its own terms, nor is it self-sufficient to address certain aspects of functionalities. A building is contingent and dependent on its context. Functionality and contextuality are inseparable aspects of performativity. Thus it would be appropriate to reintroduce the principal characteristics of topography as they integrate context, landscape and architecture, with the practical situations they provide and represent. Context provides the conditions for the building to satisfy the intended functions.

According to Dirken, there are primary and secondary functionalities for buildings. Primary functionality means the utility value or effectiveness of a product. Secondary functionality is concerned with function as a bearer of meanings, as for example a building as a means of expressing status, evoking a sense of beauty or representing the kind of experiential values that are described in terms such as "pleasant," "pleasing," or "attractive" (*Architecture in Use 3*).

Nonetheless, performance of the architecture in most cases refers to the ultimate or most active and utilitarian state of the functionality of a building, when the different aspects and systems of the building's use and functions are reaching their highest state of fulfillment.

1.1.5.1 Functional Quality

Functional quality is the state when a product, a component, or a system of the building fulfills its functional duty. When a building is functional, it has the ability and the potential to render or perform its expected mission and envisaged use or uses. Functional quality is practically equivalent to performance. Today, there are serious issues related to environmental complications due to global warming and green house effects and their health and economic ramifications. There are also issues related to globalization, regionalism and the symbolic role of the building that has augmented the responsibility of the building to represent itself as a cultural object. The direct impact of these serious expectations has more than ever been posing burden on the functionality of the buildings and the practice of architecture. Nonetheless, the end result has been increasing numbers of functions and more expected functionality

for the building. The climatologic function, economic function, as well as symbolic function are among those added expectations, which every building, in one way or another, must fulfill.

In essence, the functional quality of the building makes direct references to its efficiency, usability, meaning, and value. It is a warrant for its success to ensure that it has provided a pleasant, safe and healthy indoor environment.

1.1.5.2 Architectonic Quality

Architectonic has to do with the science of architecture. Architectonic quality has a direct relationship with visual vocabulary and its grammar of architecture, as well as with compositional characteristics of the building. Undoubtedly, the role of the dominating culture and affordable technology in manifestation of this quality is unavoidable. A building might have a high functional quality and perform well for its intended use, but architectonically it might perform poorly and not attract interest. According to Van Dijk and De Graaf, "a building only becomes architecture when it is discussed; i.e. when it plays a part in cultural discussion" (*Architecture in Use 4)*. With respect to the architectonic quality of the building, the professionalism of the building with regard to the way it is built is not an important matter of consideration. The building takes on architectonic qualities when it plays a part in cultural discussions and debates. For a building to assume architectonic quality it has to possess various qualities, which include more than just aesthetic quality or cultural value.

Obviously, it will be difficult for a building to meet its architectonic qualities when the functional quality is insufficiently addressed or even not addressed at all. However, the functional quality or quality of use can be assessed, analyzed, and defined on its own terms, although it is an inseparable part of architectonic quality. Voordt and Wegen, in their book, *Architecture in Use*, make references to a study by Van Rossum and de Wildt, 1996, of the architectonic quality of 18 buildings based on groups of questions that emphasizes on various important factors. In the study the architectonic quality depended on the relationship between form, function, and construction, as well as consistency and context, and was analyzed based on series of questions such as:

1. **Building function and context:** What was the context in which the building had to be completed? What was the quality of the site and did it impose special requirements, tacitly or otherwise? Was there any conflict between the program and the site? Is the building addressing a true or faithful translation of the intended function? Is it offering more than just the function, and does it possess expressiveness and spatial quality? Does it elevate the required functions to a more poetic level, thereby creating new association and meaning?
2. **Internal consistency:**
   How does the building's function reflect its spatial organization? Does it conform to the particular typology and convey the identity of its type? Does the visitor maintain a sense of direction and clearly navigate the different functions as well as the entrances and exits of the building? Do important

rooms perform their important functions?

3. **Form, Function and Meaning:**
Is the form a translation or expression of the internal spatial structure? Does the external form live a life of its own, independent of what goes on inside? Does the form say anything about the content? Does the building as a whole display a consistent form? Is the chosen formal vocabulary worked out consistently in all its components? What part is played by the construction technique? Does it determine the form or serve it? Is it emphasized or hidden away? Does it use its own metaphors based on its own logic, and if so does it evoke some relevant meaning? Does the form give the building a meaning that is legible to all? Does the form express what it is? How does the building relate to its surroundings? Does it act in this relationship as a subordinate or coordinator? Does it allow itself to dominate or does it fit in discreetly? Does all of this tie in with the meaning of its function in the given context? Does it achieve a synthesis of complex content with clear expressive form, a simple form in which complexity is nonetheless perceptible?

In performative architecture the experience of quality, as a combination of function and architectonics, is a dynamic requirement. This dynamism originates in the confrontation between the individual and the building as the place, as well as the building with its associated context, meaning man-made and natural environment, in movement and in the passage of time.

1.1.5.3 Form, function and architectural performance

Throughout the history of architecture in conjunction with various emerging movements and ideologies in the field, the relationship between form and function has assumed different meanings. Nonetheless, it is a known fact that the final form of the building must be the consequence of adopted goals and objectives and of the decisions established on the basis of particular strategies and premises. Obviously at the outset of any design process, the designer must investigate the initial premises and rationale behind the proposed design, and decide on the nuances of the engagement. It is unanimously agreed that the form of the building must be in harmony with the building's intended use and function. Undoubtedly the context for which the design is envisaged, plays a major role in the suitability and choice of the form. There are certain factors, such as quality of the context, location, legal restriction, economic and financial conditions, social and cultural situations, as well as environmental and ecological conditions, that need to be reviewed and analyzed before the goals of the design are set and the decisions confirmed. The process of interrogating the goals for the design is critical before a design assignment is made, since a questionable rationale may eventually lead to an unfavorable design outcome.

Moreover, as previously was indicated, in the context of today's architecture, a building must not only perform to meet the expectation of its use, but is also required

to provide other qualities such as climatologic, cultural, and economic functions. Additionally, visual quality, symbolic aesthetics and expression of meaning, as well as the experiential quality of the form are just as important. Nonetheless, although a suitable form is established based on the building's function, an attractive form will be judged in light of certain considerations other than those directly derived from its use value.

In performative architecture, the "form" is not pre-determined, but created. It is dependant on the use, which is the result of a design process, resulting in a "performance form." Thomas Herzog is a practicing architect in the U.K., who for the past thirty years has been committed to exercising social responsibility through his projects, and actively pursuing scientific and technological advances, while addressing the concerns of the environment in multiple ways. With regards to form, Herzog indicates: "the development of 'performance form,' is the modus operandi—mode of the operation—of our architectural practice. The problem and specific marginal conditions are examined and interpreted systematically. Different alternatives and solutions are formulated on the basis of the philosophy of the architectural practice. In the case of building projects, the local climatic data are recorded in addition to the usual information gathered from investigations, such as the access and positioning of the building in the urban context." And also, with regards to the decision on the overall building composition, he indicates: "An important factor which dominates the scope of the practice, is the development of an overall composition that includes building structures as well as the surrounding landscape and public spaces in order to achieve optimal harmony in the architectural design. Using physical models and computer simulations, the effects on the form of the buildings, the positioning, and the possibility of using solar energy for heating purposes, cooling, ventilation, power generation and comfort are investigated. The solutions are found gradually in workshops, together with other members of the design team. The client is also involved in this process, making the decision-making process transparent" (*Performative Architecture 73)*.

1.1.5.4 Contextual Characteristics and relation to the building's form and function—Performance based architecture

In conventional architecture, context indeed plays an important role in the choice of building form. This influence occurs in a number of areas. Often in the process of design there are situations that demand adjustments to be made to the size, scale, rhythm, mass, use, vocabulary, and façade treatment, as well as to the choice of the materials in order to accommodate the surrounding buildings. This is mostly due to the demand for harmony and continuity by local building planning authorities, or by design review committees.

On the other hand, sometimes there are deliberate decisions in favor of contrast. Contrasting with the existing context is sometimes used to break away with the past or to allow the building to stand out and be recognizable within its surroundings. During the twentieth century, architecture witnessed movements such as traditionalism, critical

regionalism, and neo-rationalism that according to Voordt and Wegen, were based on establishing links between design and the sociocultural, historical and spatial contexts. The most vivid examples of contextual influence on the form, function and vocabulary of buildings are found within a multitude of vernacular buildings around the globe that are symbolically representing the influence of their climate and contextual demands and cultural preferences. This by no means indicates that functional and constructional efficiency were not important to the traditionalists. However, it is important to bear in mind that limitations in technological means and materials have been the driving force for compliance with the laws of nature. It also has worked as a safeguard for creating the most enduring forms.

Some of the architectural movements such as "critical regionalism" are worthy of more detailed analysis and attention, since they have tried to follow design strategies that comply with the contextual characteristics and potentials of the site. The goal was to create a form that would provide the opportunity to make the site unique and different. The movement's main characteristics with regards to the elements of local architecture were:

- Giving more preference to local materials and methods of building construction and local vegetation.
- Promoting a sense of intimacy with nature and concentrating on ecological and sustainable building.
- Promoting historical vocabularies by studying, analyzing, transforming, and applying the historical themes and motifs.
- Promoting and supporting the use of local craftsmanship.

As was discussed earlier, with regards to performative architecture, performance unfolds within a cyberspace context called "topography" which incorporates both built and un-built environments. This is a widely open and encompassing polytropic context, which allows the elements of the site, landscape, and changing topography to be participate in the creation of the building form. It also provides opportunities for the architectural form of the building to assume fluidity and synergy in conjunction with its siting, or if appropriate, to nestle in to its environment. This challenging and exciting process, involves creating a computer model of the topography along with the 3D model of the building, and then intersecting them to find the most suitable and functional adaptation. Cutting through the model provides a changing fluid form as the topography of the ground and the form of the enclosure of the envisaged 3D model changes. Through this process the best-suited geometry will be attainable. At this time there is the designing team can step back from the form and learn more from nature in order to allow the structure to follow the most efficient path and to find the most suitable adaptation, rather than imposing on the building a structure that is not inherently efficient. Final assessments are made at this time with respect to the form of the enclosure, its materiality, structural viability, and pricing. This is becoming possible through engaging computers in design, which allows the designer to follow the laws of

nature, and also to explore various design ideas in a much more creative way.

1.1.5.5 Flexibility, multi-functionality, and strategies for adjustment, as paradigm of architectural performance

It has been a common saying that "one size fits all does not work in architecture," and the functional solution for one space is not necessarily going to be an appropriate solution for another. However, by looking at the world around us, we have to admit that users as well as the element of "use" are constantly transforming and evolving. With this regard there is an article written by Herzberger in 1963, and quoted by Voordt and Wegen as follows:

"To allow to stand up to change, forms must be built to allow a multitude of different interpretations. They must be able to take on several meanings, and then abandon them again without harming their own identity. This means searching for primary forms, which can not only accept a program but also liberate it. Form and program inspire one another. The impossibility of creating an individual environment to suit everyone makes it necessary to allow individual interpretation by designing things in such a way that they are indeed capable of interpretation." (Architecture in Use 32-33)

Herzberger is arguing that the appropriation of space must be done by the user. Therefore, flexibility and consideration of multi-functionality is a necessity for a successful design solution. Many architects of this era have taken steps toward this direction with the idea to open the door for individual interpretations and interventions. One of the best examples of modernist design practices with this focus can be found in the famous designs of Mies van der Rohe. Mies's designs were examples of attempt to achieve independence from function and program, as well as climate and location. He believed that good architecture has to accommodation a variety of different functions. Design must introduce simplicity and generosity of space, in order for its user to appropriate the space for the intended use.

In recent years, some architecture educators and practitioners, who believe that functional analysis does not and must not define space, have introduced the concept of the "function-neutral" building. The followers of this concept believe that the form of a building has several potential uses and must be capable of accommodating constantly changing activities.

Flexibility and multi-functionality accompany generosity of space. While generosity of space works well toward achieving multi-functionality, in most occasions, however, it requires over-dimensioning and over-sizing. In the neutral-form, it is through the less direct linkage to one particular function that the negative side effect of this design approach can be overcome. In recent years we are witnessing the rapid emergence of functions that are constantly evolving. Therefore, it is becoming necessary to design buildings that can adapt themselves to change and accommodate a range of functions by maintaining fluidity.

Some of the most notable themes of twentieth century architecture have been linked to the adoption of mass production and information technology, which has

revolutionized the practice of architecture. Architecture involves design productions that necessitate careful analysis and creative thought processes. The key to responding to this need lies in combining intellectuality and manufacturing capabilities, or in other words, combining creativity with know-how. Essentially, what it means is that creation and development of idea must be combined with the development of a process for achieving the final product. This is what performative architecture is all about. Architects engaged in performative design such as Grimshaw have an in-depth appreciation of how things go together. Although it might appear to be pragmatic and overtly functional, in their perception, in performative terms and out of functionality, a great deal of poetics is found in the final design constructs.

Nonetheless, in performative architecture, by inclusion of the factor of "change," the practice of architecture is performed within the context of time and technological development. Thus, buildings behave like organisms that can adapt to suit different demands. By embedding adaptability into the design, the building and its systemic elements create an architecture that not only can perform over time, but also can constantly improve the quality of life for its intended users.

1.2. Building Science and Technology, Tectonics of Performative Architecture

1.2.1 A product and process-based design

In recent decades, some prominent architects around the globe have been engaged in a performative design process in architecture that utilizes a process and a product driven practice.

As was previously mentioned, in a process-driven practice of architecture, there is no preordained stylistic solution. The essence of practice revolves around the exploration of ideas, which ideally results in a strong and transparent concept. In order to arrive at a viable solution in design, there must be a broad investigation and in-depth research engagement. Typically, the investigation explores the design to its smallest details, and systematic implementations. Such integrative approach in design, starting with the concept and narrowing down to the details, is truly a harmonious and balanced act. It allows for the concept to manifest itself in the smallest of design details. Performative architecture is also a product-driven approach that revolves around the appreciation of manufacturing and tectonics, as well as knowledge of how details work and elements fit together.

Grimshaw architect, a notable architectonic designer, is one of the promoters of performative architecture. His methodology of architectural practice is a product-process-driven approach. One of his early designs in 1976, the factory in Bath, U.K. for Herman Miller, the furniture manufacturer, is an obvious and befitting example of the performative approach in architecture. Whalley quotes some of Grimshaw's account of the methodology of design he pursued for this building, as follows:

"The client, wanted a factory with the potential for change, because it did not know what lines it would bring out over the next twenty or thirty years. The solution was an early use of fiberglass paneling to provide a very flexible, adaptable skin. Along with

this adaptive cladding system on the outside was a very flexible servicing strategy inside… Over fifteen years of use, the factory has been rearranged five times. In the most recent change, the occupants moved the canteen to an area that was formerly used for manufacturing and so it had an opaque skin. By moving glazed panels to that area, views onto the river were opened up" (*Performative Architecture 23*).

By embedding the concept of adaptability and flexibility into the Herman Miller architecture, as it became necessary, the building was able to respond favorably and appropriately to its arising needs. Grimshaw describes, the second Herman Miller project at Chippenham, as follows: "*He* wanted a building that could anticipate change. It had to have a large span and be essentially a big warehouse, but one with the scope for conversion to office use in the future. Long-term flexibility had to be anticipated. We designed a whole cladding system that would meet those performance criteria, because a warehouse is essentially about a skin. An office, however, is something more sophisticated—you have to have windows, doors and natural ventilation. The solution was to try to design a skin that would foresee that change could be adapted to suit its use" (*Performative Architecture 23)*. Throughout the years, Grimshaw has been able to design his own details. One such example is the design of his cladding system of pressed aluminum, which he subsequently improved throughout the years. To grasp the knowledge of how elements such as cladding are made, one has to go to the factories and explore the materials, their properties, and their possibilities for manufacturing. At Grimshaw's design firm, a motif or a key detail, such as large glass wall, is consistently followed so that one can observe and appreciate the larger picture through the derived smaller elements. In the design of the component of a detail, the approach is to make a prototype of that detail in the office from different applicable materials such as foam and wood. This prototype is considered the DNA of the building. It is the arrangement of the DNA of the building that constitutes the make-up of the entire building. This is how Grimshaw has applied his details and designs of the building skins and thus has developed his buildings' architecture vocabulary. He believes that it is through this intense and rigorous pragmatic approach that beauty can manifest itself. One of the best examples of performative architecture is the Waterloo Station, Channel Terminal, designed by Grimshaw and built in 1993, which vividly reveals the transition to a more dynamic architecture, and will be reviewed in detail in the section of case studies.

Performative architecture, is an approach to architecture design that is unique and different in its application. The most important aspect of performative design is the fact that architects are no longer constrained by the limitations of traditional and conventional techniques. Designs can now be fully envisaged, manipulated, articulated, and adapted to concepts in three dimensions. Moreover, architects can be fully directed and guided to follow the laws of our surrounding cosmos, which shapes and forms all the natural elements around us. Therefore, buildings are inevitably becoming organic entities that are adapted to their context, the same way that all natural elements comply with nature's rule of law and order. In performative designs, buildings are designed based

on the dynamic and organic approach exploring solutions through performance and functionality. In some cases, the answer comes from physics. As Whalley points out: " A Stradivarius violin is a functional object that produces the most beautiful range of sounds; it is this dedication to performance criteria that results in an object that is also intrinsically beautiful to look at." (38)

Undoubtedly, by responding logically to functional requirements and by following the law of physics and nature, it is possible to arrive at the most innovative, creative and yet poetic design constructs.

1.2.2 Building systems' performance as the basis for design ideas---engineering in the performative architecture, structural integration in the evolution of architectural form

Engineering has been considered a field that incorporates analytical processes, where one finds technical solutions for concepts. The practice of engineering has been moving from concepts and ideas towards concrete objects. A prescriptive method is the most commonly adopted approach in engineering design. It pertains to a set of rules adopted, outlined, and enforced by certain codes that need to be followed. Adopted rules are based on scientific knowledge. New developments in performance-based designs are providing rapid and technical alternatives to even the most unique situations—the appropriate and timely application of these methods and tools in the design process by knowledgeable design engineers can result in quality performing designs. This is above and beyond today's output of prescriptive methods. The latest advancements in CAD modeling software have assisted in the development of more daring structural forms. For more specialized areas of structural engineering, many firms have nowadays developed performance-based software suitable for specialized uses. With the use of rapidly evolving computational tools, the realm of performance-based design ideas in engineering is rapidly growing.

Today, with all the advances in technology and engineering, the analytical process tends to be shifting to the direction of "modeling." Problem solving by routine analytical processes is rapidly being replaced by more complex simulations of complete built constructs, with the inclusion of their various systems and components. However, at the core of the design, the most important consideration in this whole process is the choice of the right set of criteria, by which the simulated project can be appraised.

Performative design is a holistic approach that provides a monolithic and integrative process for both architectural and engineering aspects of design. In performative approach, form of the building takes shape in the process of decision being finalized on materiality and the constituent of the systematic constructs. The most important aspect of this process is the opportunity to distinguish and separate the successful and unsuccessful experimental models. This is an approach that can be applied to the development of both architectural and technical elements of design. Moreover, since monetary aspects play a major role in engineering decision-making and establishment of technical determinants, simulation and modeling techniques are also useful tools

for guiding the design to the most economical direction, and economization of design.

From a monetary stand point, there are different terms for economy, including economy of materials and matter, economy of means, as well as economy of time. If the twentieth century was concerned with the economy of labor and time, the twenty first century is concerned with the economy of the building industry and its direct relation to the economy of energy. With regards to the economy of energy, obviously, the two aspects of energy, embodied energy and direct consumption of energy through commissioning of buildings, have caused serious concerns around the globe. Blassel, with regards to energy, indicates: "not only the drain on resources induced by the design during its useful life but also what is embodied at construction, and, of course, what happens after the design is no longer useful. These two aspects of the changing conditions in which we design seem to influence the way in which buildings are made on at least two levels--where technology and architecture converges" (126). Nonetheless, buildings are concurrently evolving the way other technical objects are evolving. In fact, all aspects of technology help to move each other forward. For instance, advances in aerospace engineering have also been helping many aspects of the building industry to grow and progress. Today's advances in the building industry have provided opportunities for the various elements and components of the building to play multiple and complementary roles in their physical usefulness, above and beyond their original functions. Technology has also influenced the external building's morphology. Building skin as the enclosure system of the building is the medium for the exchange of energy between the building and the exterior. Modeling tools, by focusing on the skin morphology and energy requirement of the interior spaces, allow the surreal exploration of form for achieving the more coherent technical and poetic response to each unique design problem.

1.2.2.1 Structural Engineering

Among the branches of engineering, structural design contributes to the formation of final architectural constructs, and maintains direct link with the building industry. Structural design means moving from geometrical form developed in architectural design to structural systems. This occurs through connecting the formal architectural ideas with the rules of physics and stress flows. The existing software tools for engineering and the three-dimensional design modeling used by architects do not share a common digital database. As the result, it is up to the engineers to develop so-called "post processing methods" that are capable of transposing the geometrical data to a more useful form of data. Of course, transferring and inputting manually is time-consuming and somehow impractical, especially for complexly shaped design structures. The important issue is to be able to import data files accurately and quickly. As Kloft recommends, "this is an important aspect of accelerating the act of design, which allows the engineers to directly apply finite elements and spatial vector programs to problems that need to be solved during the early design phase" (141). One of the important steps towards the structural design of the buildings would be to develop the "master geometry." At this phase there is no specification for skin's material and thickness. With "master geometry" the aim is to direct the process of form-making in converging its influential forces to diverge into a

dynamic balance and to express the idea of the form as only a frozen or static instance in multiple series of possible geometric constructs. The interesting part of the master geometry is that it can reveal whether the structural system is optimized.

Nonetheless, nowadays, for previously indicated reasons, there is a great desire towards adoption of free forms. The translation and transposition of free form, meaning non-standard architectural designs into built structures, requires the development of new modes of thinking from all project participants. The emergence of digital design combined with novel production environments and new materials, as well as modern technologies, offer infinite possibilities for architecture. While today's architecture is swiftly moving toward adopting conceptual, technical, material, and financial meanings, engineers are also finding unique opportunities to participate in the creative context of the design discipline. This means that they are not expected to solely support the architects with calculations. Engineers can support the creative aspects of design by utilizing digital form generation to explore different possibilities for structure and material, and to become an active participant in the creative part of the design process. Performative architecture is providing opportunities for new collaborative design activities for architects and engineers.

1.2.2.2 Mechanical Engineering

In recent decades, there has been a major adoption of new computational tools in the field of mechanical engineering, after a long period of resistance. Design of HVAC for the building industry in particular has been very slow in making the transition to more innovation in this field. Nonetheless, in recent years, advances have been made in computational fluid dynamics modeling software, which have made it an important tool in building engineering. This software is a useful tool for spaces where the conventional prescriptive method is not effectively and appropriately performing. The CFD models, for example, have been used to refine the HVAC strategy and to ensure that internal comfort was maximized for the system. Other examples include conditioning of large lobby spaces and double façade cavity wall systems for multiple story buildings and various large research and specialized science facilities with special needs and requirements. CFD modeling is used extensively to underpin the environmental strategies put forward by the architectural design team for the projects. Another interesting opportunity for the use of CFD simulation, for example, is in the review and assessment of pollution generated by the power generation equipment.

Moreover, in addition to CFD there are energy modeling software and thermal and lighting simulation techniques that are rapidly becoming useful parts of the building's HVAC design and calculation. One of the important aspects of energy modeling is the possibility of testing the "environmental effects" at both the micro and macro levels for critical design decisions and simulations.

Undoubtedly, today's performance based approach is tomorrow's prescriptive calculation to design problems. The only constant in this world is "change."

1.2.3 A digitally-driven design and production --- virtual prototypes and working models for testing

As was indicated, engineering has been considered a field that incorporates analytical process; one can find technical solutions for concepts through engineering. In this age of technology, computers have provided astounding opportunities for advances in the sciences and for assisting with engineering analytical processes, as well as finding appropriate technical solutions. In architecture in particular, architects and designers have found opportunities to follow the laws of nature and to explore and envisage objects and buildings in three dimensions. Computer systems are developed to virtually define space and allow for the space to be manipulated. CAD/CAM assists with visualization of the most complicated forms, and effectively allows for rapid prototyping and mass production. Through computer simulations for instance, it became possible in the design of the Eden project by Grimshaw to make different pillows, without any prohibitive cost implications. There are numerous examples of CAD system involvement in architecture that have allowed inspirational organic forms to become a possibility. For instance, the concept of transpiration, which is the way a tree uses energy, was used by Grimshaw for the Education Center, during phase four of the Eden Project, based on the idea that the building would tell the story of transpiration. The resulting building is a tree-like shell that follows a logarithmic geometry in the form of a spiral. For this project and projects with similar sophistication and complexity, the computer made major contributions. It is the computer that allows for the final geometry, connections, size of the elements, and many more building components to come together and be finalized in a coherent way. The rapid prototyping is a way to swiftly investigate the shape, as well as the performance and function of the building and its component. It is a fast way to investigate and explore the form and shape of the building and decide upon its skin, its functionality, and the light admittance into the building. In certain projects, rapid prototyping through a series of changeable components and elements has allowed the skin and structure to interplay and thereby assist in the experimentation with creating innovative formal effects and outcomes. Computer prototyping is truly assisting performative architecture in its notion of flexibility and changeability. Another computer influence is the Environmentally Viable Architecture (EVA) design guide—a software tool that allows a building's potential impact on the environment to be measured. This is another tool in promoting the performance-led approach in design. Through this tool, architects are constantly updated on the viability of their decisions by receiving scores that measure the process, and receive feedback on the impact of the design and materials. EVA software is a useful tool for staying updated on the environmental strategies that are extremely critical for any sustainable design project.

1.2.4. Performative skin and expressive architecture— A communicative architecture

The relationship between a building and its exterior surface is one of the oldest and most essential as well as time consuming and controversial aspects that define architectural thinking. Generations of architects and engineers have been working on creating buildings that can instantly adapt themselves to the varying needs and demands of the environment by transformation, change of the physical appearance, spatial and functional configuration, levels of natural and artificial light, etc. In recent decades, the idea has also expanded to include robotic technology by which the physical appearance of the building becomes a communicative skin with changeable qualities. The skin of the building is the first element that comes into contact with its micro climate and environmental elements. Therefore, the exterior morphology of the building, like the human skin, plays a major role in the life and well being of its occupants in addition to its architectonic quality and aesthetics. The idea of changeability of the skin as a media façade, or its transformability based on environmental needs and demands as well as artistic expression will have serious impacts on its relationship with interior building arrangements.

In recent years, technology has provided opportunities for the skin of the buildings to play an interactive dynamic role in the exchange of energy with the surrounding environment. By exploring the multiple realms of building performance—from spatial, social, cultural, to purely technical—the concept of performance with all its multiple realms of involvement becomes manifested through the skin and the enclosure system of the building. The realm of the technical in particular, which includes structural, material, thermal, and acoustical features, reveals the critical role of the skin as a major determinant in building performance strategies.

Computer software tools have been available for simulations and data processing of the technical issues related to the skin of the building such as thermal insulation and transparency. In recent years, more new components are being developed and tested in these areas. They include vacuum thermal insulation, new types of glass that can react to the changing needs of insulation, such as switchable glass with an inert-gas filling and with U-values of around 1.0, as well as electrochromic and thermotropic glass.

Obviously, the morphogenetic potentiality of the skin and enclosure system, where the choice of form is initiated and finalized, is largely related to the building's quantifiable performance objectives and the designer's aesthetic and plastic sensibilities.

Nonetheless, the use of digital techniques in the design of the skin of the building, is accomplished through the designer's simultaneous interpretation and manipulation of a computational construct, have not yet reached their optimal level of usability. This is due to their high level of sophistication and their overlap with other areas of science. The process of change could be animated from the given condition to the optimal condition, with the assumption that the designer could reach the most interesting condition through pursuing and experiencing various conditions. However, the most

interesting condition might not be the most optimal solution.

In recent years the concept of interactive facades has been facilitated by some sensor-driven computer software. This is based on the concept of making buildings as media surfaces, which need valid dynamic aesthetic concepts as a continuation of the architectural culture that is still in the process of development.

1.3 Professional Practice of Performative Architecture: efficiency and optimization in architecture

1.3.1 Practice of Performativity – a Transparent process

Any entity, object, or building, by coming into existence and subsequently evolving in its related context or environment, will be charged and susceptible to impacts. In architecture, there are different and separate paradigms for performance that ultimately need to come together and be considered as a whole. The practice of performativity requires cognition, innovation, and new skills that can lead to more innovation and proliferation, as well as to new architecture practices. The concept of performativity demands and enforces major shifts in the practice of architecture in its various stages. There is an underlying and yet vivid magic in the concept of performative architecture that is the result of the influence of animation techniques.

In essence, through the power of animation, the practice of performative architecture is a transparent process from pre-design to post-occupancy evaluation. The key to its magic lies in capturing the factor of “time,” which makes the entire practice of architecture a dynamic one. This is due to the fact that performativity has the power and the potential to produce effects at any moment in time. It has a mechanism that allows for the flexibility and predictability of the outcome in its present moment, and has the potential to avoid future negative consequences. Performativity in architectural practice allows for more coherencies by bringing all fragmented aspects of architecture into one transparent act.

Ali Rahim writes, “The material, organizational, and cultural change that occurs as a result of this perpetual feedback and two-way transfer of information is performativity. Here, models developed in one research paradigm can be appropriated by another. These paradigmatic readings not only have the ability to generate, describe and evaluate performances, they also cite and re-cite them, breaking apart the evaluative forces that bind together their discourses and practices. More importantly, they can recombine and re-inscribe these forms, deploying them elsewhere while incorporating, ignoring or re-evaluating their values in other ways” (*Transformable Architecture 179*).

This is a required and recommended part of any sustainable design practice to learn from operation, steward the operation, document the findings, and complete the full course through the phase of post-occupancy evaluation. The full life-cycle operation of a building is a primary concern of sustainable design practice. In performative architecture practices, through paradigmatic readings and the transparency of the

entire operation, the architect is empowered to evaluate performances and adjust outcomes. If appropriately performed, is a major step forward in architecture practice. Performativity liberates the architect, from many present complications and entanglements of practice. Why? The answer is in the palette of performativity, which is the utilitarian and measurable aspect of the entire process. As Rahim points out: "Performativity influences the outcome of habitational, material and ambient effects perceived by users and the effects they have on their milieu by reconstructing our sensibility of architecture" (180).

Nonetheless, performative architecture is a non-traditional and non-conventional approach the practice of architecture, which due to its highly integrative approach in working with other disciplines and fields, rich palette of possible interactions, requires adoption of novel skills, strategies, and approaches in the practice of architecture.

1.3.2 Efficiency and optimization of performativity in architecture practice –and pre-post occupancy evaluation

The word "optimum" refers to the highest state or level of efficiency. In other words, optimization often points out to the most efficient, along with the shortest or fastest and the least involved solution.

In performative architecture, through available non-linear analytical software at the schematic phase of the project, and in particular at the design development phase, it is possible to determine the viability of the mechanical and structural systems of the proposed design solution. The optimization model is always exploring ways to maximize the efficiency of form by searching for the purest design idea and form. The maximization of efficiency on one hand relates to the material of the construction and on the other to the labor intensification of the project. Searching for the purest design solution is an attempt to do more with less material. There is multitude of questions to ask—How much more can the material be reduced to bring its quantity to a minimum? How can air be better moved? How much thinner the cable, or smaller can the beam get? —And much more. We can imagine that the answer to many of these questions is made due to advancements in material science. Software is being developed by engineering firms that are able to generate and test forms dynamically. The engineering software is less focused on the spatial-temporal quality of the space. The ideal is to attain a model of performativity for all behavioral aspects of the building. This means the ability to pursue and explore all aspects of the evolution of a building's performativity, while simultaneously being able to monitor its effectiveness in different social contexts and conditions. Thus, the building would receive pre-post occupancy evaluation in real-time without having undergone the real test of time. This would allow the designers to immediately and fully comprehend the effects and ramifications of their own formations. It would allow them to explore forms with most ideal habitational potentials, while not being obligated to wait for the real tests of time. Tests of time are the most accurate and real, but they are much more expensive and not the most efficient! Therefore, through the software in real-time, it would be possible to forecast

unforeseeable and unpredictable circumstances and become informed of all the formal and ambient effects—and be able to respond accordingly.

As we proceed toward the evolution of a building performance concept, the trend moves toward incorporation of manufacturing within the existing model, which according to Rahim would curtail the shift of "production processes from mass production and mass customization to one where the dynamic evolution and production of non-prescribed possibilities is possible" (186). The automotive industry, offers a possible direction for developing better techniques in the building industry. For example, the automobile crash-testing model is both virtual and physical, with the possibility of multitude scenarios. In this regard, as Rahim argues: "Automobile designers employ an iterative process and come across effects that they can predict and others they can not foresee. These effects are generated by the variables that produce them and it is this outcome of effect that highlights these virtual techniques and reveals the potential for them to be applied in architecture …" (186).

Undoubtedly, with the progress in technology and computer simulations, through the context of real-time and with precise calibrations of evolving performative design feedbacks, it is becoming possible to generate and test emergent effects on users throughout the design and manufacturing processes. This is a process that is making "optimization in architecture" an attainable objective.

In all likelihood, it is through the properties of flexibility, transparency adjustability, and changeability of performative architecture that architecture practice and the building industry will be able to achieve their highest goals and most accurate objectives in "optimization of performance" and "optimum post occupancy evaluation."

1.4 Shared vision with Sustainable design objectives and methodologies

Throughout the last decades of the twentieth century, the interest in building performance as a new approach in design paradigm was augmented. This has been largely due to the emergence of sustainability as a socioeconomic issue and more awareness of cultural theory, as well as to the recent developments in technological means and methods, which make direct connections to the vitality of sustainability.

Among the key concerns of performative designs are new interpretations of spatial and functional concepts by coordinating the form of buildings and their construction with the energy concept, as well as application of sound principles of building physics and exploitation of locally available forms of environmental energy. Additionally, taking into account environmentally relevant issues, the high quality of the workplace and flexibility of use are among the main criteria for sustainability, which ensures that over time the building can adapt to changing working needs.

There are multiple performative design solutions that share a vision with sustainable design concepts. The performative features that reinforce sustainability objectives addressing efficient use of energy and a high degree of indoor comfort include but are not limited to: natural ventilation through operable windows, double skins on the

facade, supplied fresh air opportunities via inlets incorporated in the inner façade skin, vitiated air extraction by means of thermal uplift of warmed air in internal spaces and channeling through a central duct system with vertical shafts leading up to a rotary heat-exchange unit, heating and cooling laid in monolithic screeds, thermo active floor slabs to reduce temperature extremes and ensure a balanced indoor climate, and more.

Of course, the role of computer tools in the simulation of various elements and components of a building, such as thermal or lighting balance and providing multiple sustainable performative design concepts, is undoubtedly critical. Also, new components developed as such, vacuum thermal insulation and new types of glass were already mentioned regarding the issue of skin. There are also performative sustainable alternatives with regards to environmental forms of energy for a variety of purposes—such as natural lighting, ventilation, heating and the generation of electricity via photovoltaic systems. The concept of "intelligent building" is a perfomative methodology. As conditions change according to the season, the time of day, the weather, and the type and duration of use, conflicting needs can arise. These systems could respond to changing conditions and could be used to control different functions. Thomas Herzog has used various multi-functional and multi seasonal devices for the purpose of heat generation, distribution and output, the operation of sunscreen blinds, coordination of day-lighting and complementary artificial lighting, ventilation flaps, and humidifiers in his various sustainable design projects.

Nonetheless, in performative architecture, sustainable design concepts enable human beings experience a high quality of life within their indoor environments—while all their senses are nurtured. Thus, people will be shielded from the drawbacks of mental and spiritual atrophy. This will also elevate their sense of well-being and promote health and happiness. At this time the question should be: isn't this what architecture is supposed to provide for the masses?

1.5 Epilogue One–

Extract of the Argument – As the main topic of this research, the foremost argument has revolved around the ways that a building discloses itself through its operation or performance. This is mainly an attempt to appreciate the building through its performance rather than its existence.

To define the meaning of architectural performance as looking at a building as what houses certain activities and experiences is not new in architectural discourse. The ideal achievement of this research could have been to find a way to comprehend and evaluate the building apart from its use and irrespective of its programmatic requirements, based instead on the users individual desires and the cultural impacts. Nonetheless, the working hypothesis is that performance is the key to the building's pre-declared existence and internal functional definition.

The guiding principle in this research analysis and its subsequent synthesis stage is to consider the reality of architecture work as a combination of:

1) A system of components intended in design and manifested through their construction—measurable components, and

2) A system of portrayals outlined in spatial composition and experienced through perception—immeasurable components.

One system without the other will not convey the realities of the architectural work. It is through the combination of both systems—technical accounts, as well as evidence of aesthetical anticipations and concerns —that building manifests itself as an object. Of course, this is the repetition of the old Vitruvian's debate between the architecture that works and is useful, and the architecture that is poetic and beautiful. As David Leatherbarrow in his article on "Architecture's Unscripted Performance," writes, "…It may be helpful to ask not about the work but about the way the work *works*," (Performative Architecture 5). This argument brings us to the first question that needs to be answered:

Is there an action in building's evident dormant and inert mode and in its anticipated static permanence?

In response, as it was indicated before, architecture, compared to other areas of art, is very inactive, frozen, and motionless. Without getting too deep into metaphysics, as Gaston Bachelard believes, a building that has been experienced is no longer an inert box, and an occupied space transcends geometrical space (*The Poetics of Space 47*). This is the main reason behind why buildings can make us sad, depressed, agitated or delighted.

But how is it possible to measure the phenomenological effect of spaces?

Undoubtedly a building is the result of a technical and aesthetics (firmitas and venustas) work, which manifests itself through its operation, through its instruments, and through its effects. The undisputable factuality of a building such as its enclosure system, structural elements, air handling equipment, floors and roof, as well as interior spaces and their admitted natural lighting, are among the elements that provide static

permanence to the building. This brings us to the next series of questions:

Can building performance be measured like a machine? Can building performance be calculated through the performance of its components by sizing and other appropriate techniques of measurement? What is the impact of time on the building's elemental performance, and how is the building's performance is considered overtime?

The response to the above posed questions is found in the application of the principles of building performance criteria. Principles of performativity include but are not limited to measurement, evaluation, comparative analysis, documentation and provision of systematic feedback in design, construction and maintenance of the buildings. Performance evaluation requires a form of systematic feedback that relates client goals to the expected and appropriate performance criteria for the building type. Performance criteria are quantifiable through the application of certain parameters and measures, applied to the three main aspects of the building, including:

1. Technical: This involves building components and systems, such as structure, enclosure, acoustics, finishes, sanitation, fire safety, heating, ventilation, and lighting. This is the most tangible aspect of the building, which lends itself to more quantifiable evaluation processes. Technical needs and expectation of the building based on the building type may change insignificantly over time.
2. Functional: This relates to the ways a building supports certain activities within itself. These activities include but are not limited to required primary spatial capacity, interior circulation, exterior access, parking, utilities and equipment, capacity for expansion and adaptability to change over time. Functional needs are specific to building type, and differ from one building type to another.
3. Behavioral: This relates to the psychological and sociological, perceptual, aesthetic and cultural satisfaction and well being of the occupants. The behavioral aspect contributes to the level of satisfaction of the individual occupants within the space, and the image and the meaning that they develop in their minds about the building. Behavioral aspect is measured through assessment of occupant responses, which sometimes are different from those of the building architect.

The three aspects of building performance were discussed in more depth in prior related sections of this part of the research.

1.6 In Search of a Guiding Criteria – Measuring Performativity of the building

Performative architecture is an integrative approach, and an interweaving web, which is not just the outcome of a building's technical aspect or design technology. While technology mostly improves the functionality of architecture, it is the setting that stages the event and allows the building to serve the aims of the users. A building generally reveals its adequacy when the event takes place. Events may

or may not mean happenings, and cannot be defined and planned, since they are above and beyond objective comprehension. As David Leatherbarrow, in his article, "Architecture's unscripted performance" indicates, "to understand architecture's performative character we cannot rely on transparent and objective description alone, or on techniques of quantification and measurement" (5). Therefore, how is it possible to measure the performativity of architecture in its true sense?

It is possible to evaluate a building's performativity, with regards to the three above indicated categories. However, there are certain building aspects that are quantifiable and certain others that are not. There are different approaches and tools for evaluating the quantitative aspects of the building versus qualitative ones. The qualitative aspects of the building, including behavioral and functional performative aspects that are not directly measurable, such as issues related to aesthetics, beauty and poetics, are more complicated and difficult to assess and evaluate. The technical and functional performative aspects of the building are directly quantifiable. The quantifiable performative aspects of the building, which incorporate the performance of various building systems and elements, include ventilation, temperature and humidity, lighting, acoustics, distribution of programmatic spatial volumes and areas as well as the durability of the materials.

One way to discern the setting for architecture performances is by focusing on a building's movable mechanisms. This is literally an action that can be ignored or avoided. This is the action of certain movable parts of the building that have their own range of motion, which can be manually, mechanically, electronically or digitally regulated, repositioned or controlled. Overall, these mechanisms have the ability to mediate and adjust the environment, from climate to human behavior. The range of movements that a mechanism's devices can undertake and their adjustability to foreseen and unforeseen circumstances reveal their level of intelligence. The important issue would be to assess the reaction of the architectural setting to the unforeseen conditions and their capacity of adjustment. Therefore, one tangible approach in measuring the performativity of architecture is through outlining strategies of adjustment of building devices. Performative architecture relies on the philosophy of "architecture of change" and "adjustability." While it defies the stagnation of design ideas, it also challenges creativity and encourages innovation in practice of architecture within the context of time and technological development.

Another area of performativity is a building's requirement for structural equilibrium, as well as its thermal and material stability. This includes the behavior of certain components of the building such as floors, roofs, foundations, and retaining walls, as well as beams, columns and cladding. It would be ironic to talk about the behavior of these components, when the building is expected to be an object at rest. A building is expected to work with its ecosystem and its ambient conditions, as well as against forces of nature within its context. In this case, movement of the elements is not a change of position, but a change of status. It is the interaction between force and counter force that results in alteration or change of the physical body and demonstration

of a building's physical capacity to function within its contextual and ambient conditions. Such action or performance must inevitably be within the range of static permanence of the building's elements. Nevertheless, a building's intelligence and preparedness will only be manifested through its demonstrated capacity to confront foreseen and unforeseen conditions, and through its tendency to withstand external contingencies.

Another important aspect of consideration and evaluation in the qualitative aspect of performativity is the search for evidence of building engagement in what is and what is not constructed, and its flexibility to be part of what is not. As vague as it might sound, it directly relates to the original definition of performative architecture, which is engaging nature in architecture and allowing the architectural beauty of the building components to be the result of natural elements and the related ambient setting, rather than the building's design or its construction techniques. In this situation, natural elements become an inherent part of the building's architecture. It would not be wrong to suggest that through the liberation of the building from technological deliberations and entanglements, we will be able to fully discover its social and environmental connections, as has been the case with various ranges of vernacular buildings around the globe. When the building has a harmonious association with its immediate social and natural environmental context, it comes close to resembling an organism of nature, which rather than exploit of the nature's resources, works in rhyme and integrated with the entire ecosystem and its elements. Nonetheless, the fact of the matter is, while a building's association with its immediate environmental and social context will augment its performativity, as an inert and isolated object from its ecosystem, it will be deprived of the constancy of the qualities that nature would offer.

The performativity of architecture unfolds within the built as well as the un-built context with unforeseen potentials, capacities and with various manifestations. In reality, the context in which architecture performs, may or may not reveal the intention for its formation, but serves as the ground for that formation. Obviously, the site is surveyed at the early phase of design and all the existing conditions are described, assessed and documented. Therefore, evaluating the performativity of the design is a way of assessing the building's response to all detected and even undetected contingencies and contextualities. The key to the performative solutions might lie in the word "re-adjustment." Nowadays, as design-thinkers and architecture theoreticians, in pursuit of a performative design paradigm, believe that the building's approximate dis-equilibrium animates a life and a history of ever-new performances. In this era of change, the underlying concepts of adjustment, re-adjustment, flexibility and adaptivity are opening the doors to many exciting opportunities for designs.

In Search of a Guiding Criteria - Measuring Performativity of the Building

In embarking on the next phase of this research, the main objective will still remain to establish the boundaries of performative architecture, as well as to pursue and inquire about instrumental reasoning and rationality for the paradigms of performativity. The phase of the precedent study will be an inquiry into the realm of performativity by conducting a search for rationality of building performance. It is an attempt to discover the particularities of performative architecture and the complexed web of conditions that have prompted, animated, and concluded a building's performance.

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1.7 Performative Paradigms --- qualities and Characteristics

The paradigm of "Performative Architecture" is broad, inclusive and multi-faceted. It has a wide and active web of connections, which establishes a coherent relationship between aesthetic, utilitarian and tectonic aspects of architecture. Performative architecture can act as a forum for linking different disciplines and realms of information, from purely technical, structural, mechanical, thermal, acoustical and more, to social, cultural, economic and financial. For the purpose of this study and based on the analysis made in the first part of this research document on performative architecture, the following list of the gathered qualities and characteristics as performative paradigm will be used in establishing the scope of the performativity of the selected buildings. Performance-based buildings are required to have certain characteristics and qualities, which are gathered in a list and categorized under: **concept & design**, **context & technics**, & **practice**. The following list will become the basis for the entire analysis of both case studies, as well as the synthesis, which is development of the design proposal. In reviewing the items of the performative paradigms with David Leatherbarrow, Chair of the Architecture graduate program of the University of Philadelphia, one of the few architecture philosophers who have done extensive research on performative design, commented about the following list of the performative paradigms, as both interesting and rather exhaustive. His comments were that there is much that is positive in it, but some parts (measures) seemed to be too objectivizing, as if it were the performance of a machine that was being measured. He also indicated that, on the matter related to performance, he always tries to think of a musical or theatrical performance as an analogue for architecture, as if the building were a violin or voice, the parts of which must be precisely determined when it is built. Some aspects of those sorts of performance (musical, vocal, or theatrical) can be objectively measured, but not all. To corroborate his argument he refers to one of his writings, which makes reference to Aristotle:

"Aristotle once advised that the mark of a wise individual is to strive for the degree of exactitude in descriptions that is appropriate for the given subject" (*Nichomachen Ethics, book 1, chapter 3*). The same exactness, he said, must not be sought in all departments of philosophy alike, any more than in all the products of the arts and crafts: 'it is the mark of an educated mind to expect that amount of exactness in kind which the nature of the particular subject admits.' For this reason it is equally unreasonable to accept merely probable conclusions from a mathematician and to demand strict demonstrations from an orator. In a similar vein he recommended that when building a house, sketches of basic (configurational) principles be made in outline form only, so that they can be gradually filled in as unforeseen exigencies and opportunities arise. The carpenter and geometrician both seek after the right angle, Leatherman said, but in different ways: "the former is content with an approximation to it which satisfies the purpose of the work, the latter looks for the essence or essential attributes." Leatherbarrow also indicated: The key question in "measuring" performance is the kind of "ruler" applied to architectural subject matter. This ruler as "Aristotle" recommends has to be a flexible ruler for consideration of equity. In reality Aristotle advise, leads to the idea of "bending the rule," (Nichomachen Ethics, book 1, chapter 3). The purpose of this procedure is by no means to weaken standards, but to remain close to the particularities of the case, and to be more exacting than rigidly adhered to the "objective standards", as Leatherbarrow recommended. Nonetheless, the following, comprehensive and somehow exhaustive list of the characteristics and qualities are gathered as an attempt towards establishing some tangible measurable means, for case study analyses and for establishing the basis for a proposal which is going to be made for the design of a performative habitat project.

Performative Paradigms: Qualities & Characteristics

CONCEPT & DESIGN : Performative qualities and characteristics with respect to an abstraction of architectural concept, form, and design, as well as program and spatial requirements:

1. It involves an architectural design that has the capacity to reformat itself.
2. It involves a formal characteristic that has fluidity and dynamism.
3. It reflects a program, which involves technological, cultural, and socio-economical transitions.
4. It incorporates a space that has the capacity to unfold itself in an indeterminant way, in contrast to the fixity of pre-determined programmed actions, events and effects.
5. It incorporates device paradigm: it utilizes certain building devices that are movable, including operable mechanisms such as screens, apertures, etc, as its tools to demonstrate its performativity. The operation of these devices can be controlled by certain manual, electrical, mechanical, or digital mechanisms, in order to modify, acclimatize and mediate the environment, as well as human behavior.
6. It adopts strategies of adjustment to foreseen and unforeseen external contingencies.
7. It creates a web of interrelated realms linking purely technical disciplines, to social, cultural, economical, and financial, as well as spatial and formal disciplines.
8. It creates an opportunity for a building's architecture to be able to transform, transcend, digress, or simply move from one state to the other in the continuum of time and space, allowing for different types of morphing encounterment.
9. It incorporates architectural designs that are involved with morphogenetic practices, which are based on methodologies of analyzing flows, forces and elements that are influencing the production of the buildings.
10. It involves programs that reflect technological, cultural, and socio-economical transitions,
11. It allows the form to stand up for change and different interpretation, which allows for appropriation of the space by the user through flexibility and multi-functionality.

CONTEXT & TECHNICS: Performative qualities and characteristics with respect to technical, environmental, social, cultural and technological issues:

1. Performance-based buildings are to be evaluated as part of a dynamic and living system, which can be biosphere, technical, or even social and financial.
2. Performance-based buildings focus on energy efficiency and creation of intelligent skins, which is capable of controlling and monitoring climate control systems and the maintenance schedule of buildings, similar to a human's nervous system. It also involves hybrid environmental systems including, both active, mechanically driven, and passive, as well as computer simulation techniques for performance testing.
3. Performance-based buildings use techniques in virtual reality, digital modelling and rapid prototyping to allow creative thought process to be shared with consultants and clients, as well as any analogical rather than linear logical thinking. This allows technical and professional boundaries to be surpassed.

Performative Paradigms: Qualities & Characteristics

4. Involves any information-based, not just form-based process that does not prescribe how, a building should look, but how, it should behave and operate.
5. Uses smart technologies, as well materials to achieve a dynamic and interactive relationship between a building, its users, and the environment.
6. Customizes the building design from the molecule level or DNA of the building to all levels, components, and systems of the building.
7. It is an architecture, which is self organizing and not a fixed and final product, but more like a biological organism, which is continuously is transforming and adapting to changing conditions and improving its performance.
8. Involves an architecture design in a which, building has been allowed to reach to its highest level of functionality, or buildings that have reached to the highest level of fulfillment in their operation or in their utilitarian state of functionality.
9. Incorporates functional quality toward environmental issues addressing the pressing needs of current global problems and complications, as well as addressing cultural values and globalization issues.
10. Performs, by allowing users to pleasantly and efficiently experience a combination of functional and architectonic qualities of created places within the building, as well as in the context of built and natural environment and the passage of time.
11. Involves form which is created based on the combination of climatic, social, cultural, economic, programmatic, contextual, and functional factors.
12. Involves development of the form which is based on a philosophy of architectural practice and architect's mode of operation, involving experiments, analysis, trial and error, use of computer simulations, teamwork, and client participation, toward gradual arrival of the most efficient architectonic form.
13. Gives more preference to local materials, method of construction, craftsmanship, and vegetation, as well as promoting a sense of intimacy with nature.
14. It is a process-driven, and product driven approach in architectural design, which revolves around appreciation of manufacturing, tectonic, and art of detailing.
15. It is an architectural design that is not limited to the constraint of traditional and conventional techniques, instead, is envisaged, manipulated, articulated and adapted to the concept in 3-Dimemsional experiments.
16. It is an approach in design practice, in which architects are fully directed and guided to follow the laws of physics, cosmos and natural elements.
17. It is an approach in design, in which provides an opportunity to distinguish and separate successful and unsuccessful experimental models in the engineering of the building.
18. It is an approach in design, in which form of the building evolves while arriving at the right choice of the materials and methods of construction.
19. It is an approach in design, in which the development of a "master geometry" in structural engineering brings the forces into a dynamic balance by arriving at a structural system which is optimized with respect to the architectonic form.
20. It involves an approach in design, through the usage of computational fluid dynamics (CFD) modeling software, which refine HVAC strategies and ensure maximization of human comfort.

21. It is a design strategy, which emphasizes on the exterior morphology of a building, and promotes application of performative skin, transparency and transformability of the skin, based on environmental needs and demands.
22. It use computer simulation techniques for daylighting effects and new types of glass and synthetic materials.
23. It makes connections to sustainability and cultural theory.

PRACTICE: Performative qualities and characteristics with regards to professional practice of architecture. The strategies for a performance-based design practice involve the following:

1. It is a transparent practice of architecture from pre-design to post-occupancy evaluation, which ensures coherency of performance of different and separate paradigms, by bringing all fragmented aspects of architecture into one transparent act.
2. It is a non-traditional, non-conventional practice of architecture, which requires novel skills, strategies, and approaches in the practice of architecture.
3. It is a practice of architecture, which allows for maximization in efficiency of the architectural form, through efficient usage of materials and labor.
4. It is an approach in design which is constantly maintaining a shared vision with sustainable design goals and practices.

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Performative Architecture

Case Studies

PART 2

ARCH 508
Doctorate of Architecture

Mitra Kanaani

2.0 CASE STUDIES - A Historical Overview

The architecture of the last decades combined with industrial design are both a response to and reflection of the society in that we live. The increasing emphasis on building performance from the cultural and social context to building physics has drastically influenced building design, process and practice of architecture of this era. It also has considerably blurred the distinction between geometry and analysis as well as the relationship between appearance and performance. Some prominent architects of this era, through the application of digital technologies and modeling, have been able to integrate the design and analysis of buildings, and provide a seamless digital collaborative enterprise with their team of consulting engineers from the earliest conceptual stages of their design.

Hugo Haring (1882-1958), a German architect and theorist who, along with Le Corbusier and Siegfrid Giedion, had a part in the creation of the Congres International d'Architecture Modeme (CIAM), rather than understanding architecture in terms of economy and repeatability, saw the building as a singular event emerging out of the particularities of place, program, material and culture. Therefore, instead of treating the building as a container which is very insensitive and indifferent to what it holds inside, he saw it as a specific response to the individuality and uniqueness of design conditions. Haring refers to the condition of a house as an organic structure, which he describes as, "It still seems to many people inconceivable that a house too may be evolved entirely as an organic structure, it may be bred out of the form arising out of work performance; in other words that the house may be looked upon as man's second skin", and hence as a bodily organ. (*Rethinking Technology 56*)

In recent decades, certain inquisitive architects have developed the form and skin of the buildings creating unprecedented and complex geometries. In contemporary architecture, there have been experiments on the relationship between contemporary techniques, culture and architecture. Architects, in pursuit of performative architecture, have used techniques of design that are animated and process driven, which can provide new transformative effects on cultural, social, and even political conditions. By sculpting the building into novel forms that respond efficiently to planning requirements through the new performative methods of architectural form making, there have been evolutionary traces of influence on human behaviors and technical performance. Undoubtedly, in every society the common application of techniques has always contributed to the production of the human and cultural artifacts. As Ali Rahim in his article indicates: "Technology in this sense is not an efficiently oriented practice measured by quantities, but a qualitative set of relations that interact with cultural stimuli. .....In fact, contemporary techniques themselves are new effects of previous techniques that result in further cultural transformation through a complex system of feedback and evolution. (*Architecture in the Digital Age - Design and Manufacturing 201*)

Nonetheless, contemporary techniques have developed a new sensibility and geometric ambiguity, as well as new composite forms and new ways of occupying space. Obviously the effect of all these novelties has ultimately been the transformation of culture, altering cultural development and reformulating consequent effects to produce new techniques.

The evolution of the last century's design in modern architecture is signified by dominant themes, mainly information technology and mass production. There has also been major evolution in the condition of public nodes of connection or transportation and work environments, along with the expression of technological achievements. A high regard for technology as a transforming force for change in modern architecture began with Behren's 1909 Turbine Hall for AEG in Berlin through Mies van der Rohe's 1958 Seagram Building. This was a sensibility that evolved in to a high-tech architecture, especially in the 1960's with the aerospace industry putting man on the moon and the provocative work of Archigram architects.

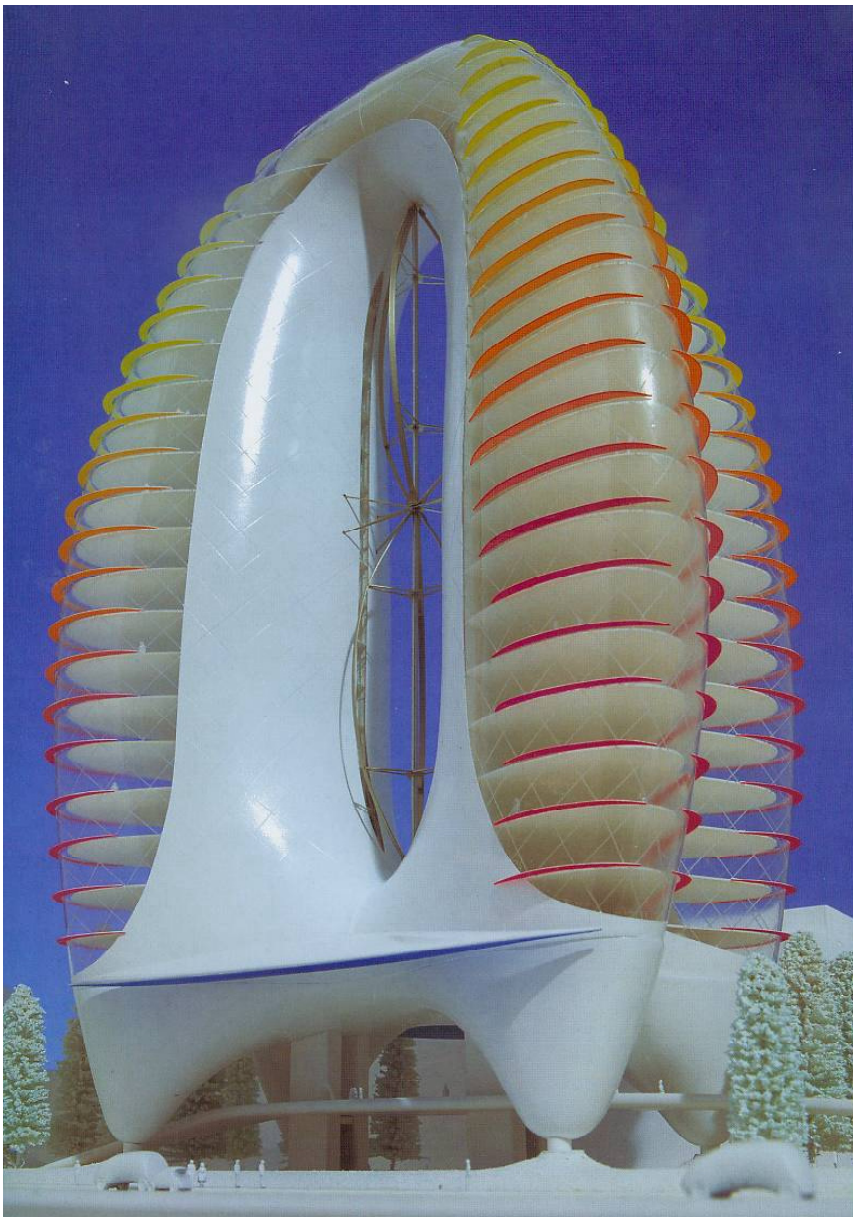
The search for an Earthly Paradise – A Utopian vision

Archigram's walking city and organic urbanism were extreme visions predicated upon the notion of migrating species and the integration of complex ecological and architectural orders. It was an obsession with high technology and a preoccupation with the altered environment, was as an extreme green vision of environmental resurrection.

Above: Walking City project and organic urbanism, Archigram's fantastic imagery of the early 1960's by Ron Herron, were extreme green visions predicated upon the notion of migrating species and the integration of complex ecological and architectural orders.
Credit: Edwards, Brian, Green Architecture, AD. Wiley-Academy, London, 2001,

CASE STUDIES - A Historical Overview

A number of stimulants rooted in contemporary techniques have become the driving forces behind the emergence of an entire generation of architects and influential practitioners such as Nicholas Grimshaw, Richard Rogers, Renzo Piano, Michael Hopkins and several others who have paid attention to the notion of technological concern in their form-making. Catherine Slessor articulately refers to the particularities of this evolving phase of architecture as follows:
" A critical aspect of the interaction between architecture and technology is the way in which they have continually redefined each other. High-tech has moved on from an early preoccupation with the arid logic of mass production wedded to extreme functionalism. What began as the introduction of rationalized industrial processes into building construction to create neutral, flexible, expendable environments has evolved into an increasingly diffuse and complex styles. This sensibility now embraces wider concerns, including place-making, social responsiveness, energy use, urbanism and ecological awareness. "Eco-tech" as opposed to High-Tech. Instead of being unthinkingly glorified, technology is more selectively exploited to achieve particular ends." (Sustainable Architecture and High Technology, Eco-tech 7)



An innovative and imaginative design for a mixed use building applies both high-tech and low-tech solutions. Including natural ventilation and light, the form and design are contrived so as to maximize the wind and the sun as free energy sources. Over the course of a year the building would be almost entirely self-sufficient in energy terms. The building design is formed around a central opening which act as a wind concentrator.

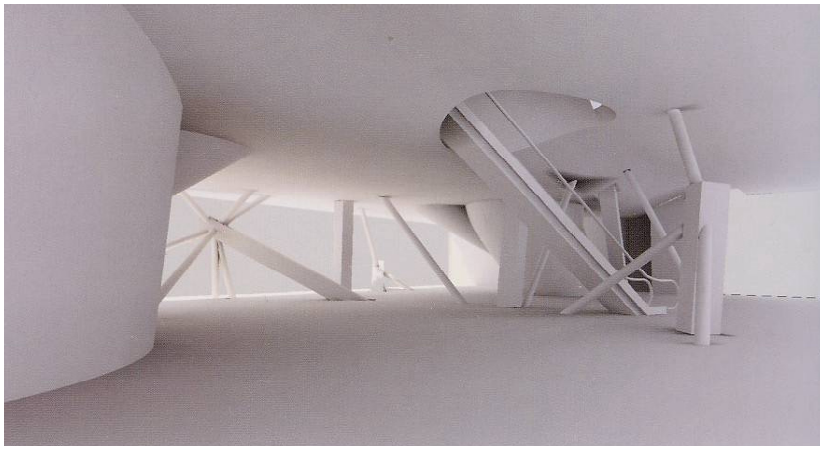
Its wind turbines and integrated photo-voltaics designed into the external shading fins generate a significant of percentage of the free energy.

Future Systems, Project Zed, London, 1995

IEdwards, Brian, Green Architecture, AD, Wiley Academy, London, 2001

Undoubtedly the advances in technological means have characterized the architecture of this era through new concepts in fluidity of form and perception of space. The creation of the most novel, complex and spectacular forms has only become possible due to the advances in structural and building services, as well as engineering, materials, computer and the ecological sciences. The new architecture has demonstrated a realm of innovative ideas that previously did not seem possible. On this note, Catherine Slessor, in her book on eco-tech, refers to Richard Rogers and his argument as follows:

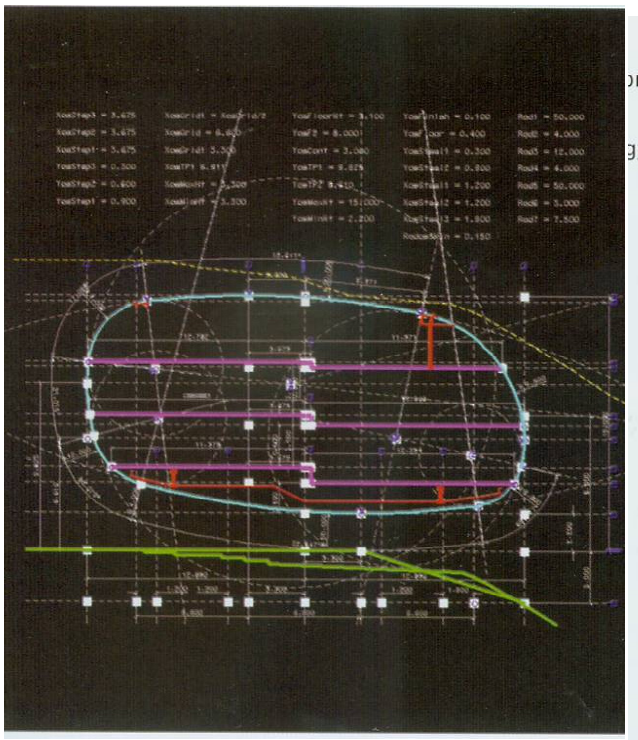
"The creation of an architecture which incorporates new technologies entails breaking away from the platonic idea of a static world, expressed by the perfect finite object to which nothing can be added or taken away, a concept which has dominated architecture since its beginning. Instead of Schelling's description of architecture as frozen music we are looking at an architecture more like some modern music, jazz or poetry, where improvisation plays a part, an indeterminate architecture containing both permanence and transformation." (*Eco-tech 7-8*)

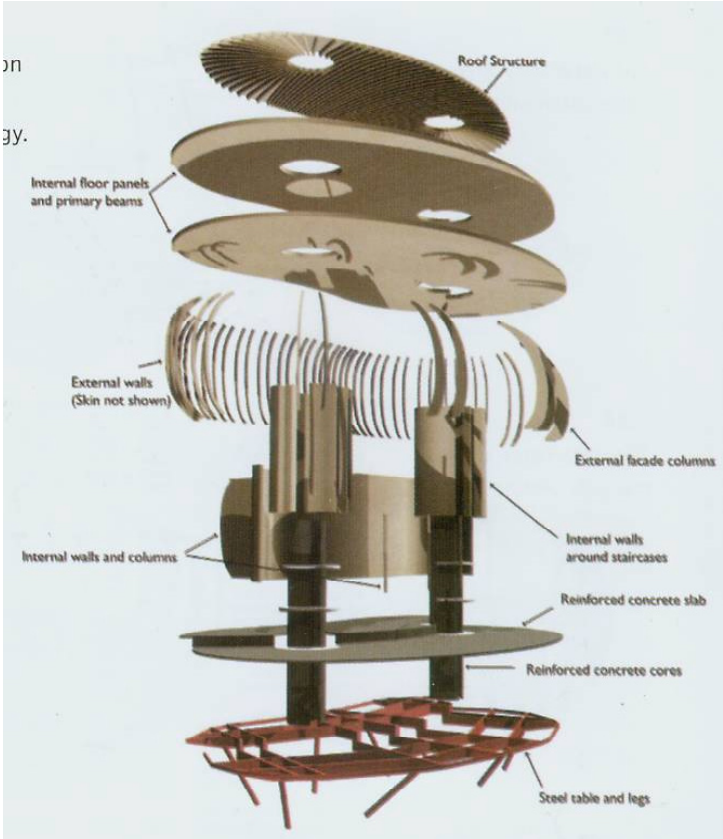


Kolarevic, Branko, *Torus House (2001), Old Chatham,* New York, Architect Preston Scott Cohen, Architecture in the Digital Age- Design and Manufacturing, New York, Taylor and Francis, 2005

In recent decades, an increasing number of contemporary architects have put aside pre-ordained stylistic solutions and have demonstrated a vast knowledge of manufacturing skills and understanding of complicated details. Additionally, by following a process-driven practice, they have proven to possess the ability to combine intellect and knowledge of manufacturing, thus arriving at strong conceptual ideas and formulated design diagrams. Architects have been able to investigate and formulate a design program, and subsequently generate and establish the appropriate conceptual ideas to pursue the appropriate process and methodology of design and finally to develop the product.

The development of the elements of design in the architecture of these architects is based on the investigation of the finest and smallest details and motifs. Thus, the overall concept is vivid to the smallest detail of the building due to the appreciation of the way things go together. These architects believe that there is beauty out of functionality and performativity, and the increasing potential of expression of details is an obvious embodiment of the symbiosis between architecture and technology. Their architecture involves forms that are the result of creation rather than predetermination. The outcome of the design process is a “performative form”, which is also called “performance form.” For these architects “performative form” is their *modus operandi* (from Latin, a particular method of working) of their architectural practice.





Chesa Futura-ST Moritz : Parametric definition of the section of the Chesa Futura. And, the construction process and phasing strategy. Switzerland, Architect Foster and Partners. Whitehead, Hugh, *Laws of Form*. Kolarevic, Branko, *Architecture in the Digital Age- Design and Manufacturing*, New York, Taylor and Francis, 2005.

CASE STUDIES - A Historical Overview

For the purpose of this study, the philosophy of architectural design of the three architects Renzo Piano, Nicholas Grimshaw, and Thomas Herzog will be reviewed, and analyzed with respect to identification of the performance-based aspect of their architectural works.

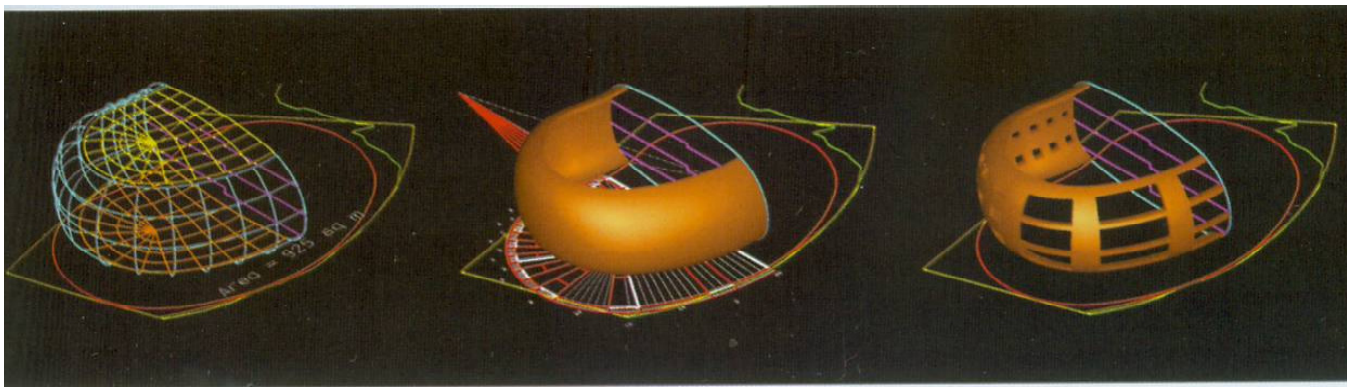
The purpose of this case study is not the analysis of particular buildings. Rather, it is an investigation of particular architects and their firms' philosophies in pursuit of performative architecture.

Selection of the architects and the firms of Renzo Piano, Nicholas Grimshaw and Thomas Herzog is based on their proven ability in performative architecture as well as their involvement with process and product-driven practices. In order to appreciate the work of these architects and their design philosophies, in addition to their performance-based architectural practice, it is important to situate their works within the historical, as well as technological context. The focus of this analysis will be on the creation of performative buildings through the development of the smallest design motifs and their building DNA. Additionally, the concept of the architecture of change and the process of the design of buildings through the design of their components will be investigated and analyzed. Moreover, the selection of these architects and their works will be based on their negotiation of imparative issues related to:

- Place making,
- Social responsiveness,
- Urbanism or urban responsiveness,
- Energy matters and use,
- Ecological awareness, as well as,
- Performativity of building's device paradigms.

In modern architecture the combination and reconciliation of these imperatives have created opportunities as well as challenges and problems for architecture practice. Today's architecture has highly redefined itself, and addresses a broad spectrum of issues from ecological and cultural, to enhancing public and private life. These factors, based on the type of projects, provide unique performative potentials, and illustrate various forms, functions and design influences.

Nonetheless, one common approach in the works of these three architects is the pursuit of performance-based architecture, which has potential for change and flexibility within the context of time.



From left to right: 1) The initial surface model with the slice plane. 2) The model of the exterior wall as a shell, with associated polar grid. 3) The perforated design surface shell.

Credit: White-head, Hugh, *Laws of Form*. Kolarevic, Branko, *Architecture in the Digital Age-Design and Manufacturing*, New York, Taylor and Francis, 2005.

Case Studies

Renzo Piano Building Workshop

Product and Process:
Performance-based Architecture

2.1 About Renzo Piano's Performative Architecture

In an interview Renzo Piano was asked to respond to his statement that architecture should be thought of as merely a service profession similar to baking bread. Yet bakers do not feel compelled to invent a new loaf each time as architects do.

Renzo Piano responded:

" Talking about baking bread is more about behavior, it is a provocation against the pompous attitude of the real artist,……But I totally agree that architecture is not baking bread, every day doing the same thing. The baker is proud to do his job correctly, but every day is a repetition. Every day in architecture, though, is a new adventure. But baking a bread is about reality, normality, and that is important for an architect not to lose touch with……

That my works show the way they are constructed comes from my personal history. Making is biologically imprinted in me. ….I stress the making part of architecture, it is not because it is the most important, but because this is the origin.

When I go shortly to speak to people at the drawing board, it is not going to be about making . The Berlin Potsdamer Plaza project is not about making---though of course it will become so. For instance, we will start to work this afternoon on the construction of the shell roof over the theater and casino, on the problem of how to interconnect the rigid individual components of the roof so that it becomes the curving shell…….Making has now become part of a much bigger vision in our work, that now includes as equally important such things as history and space….."

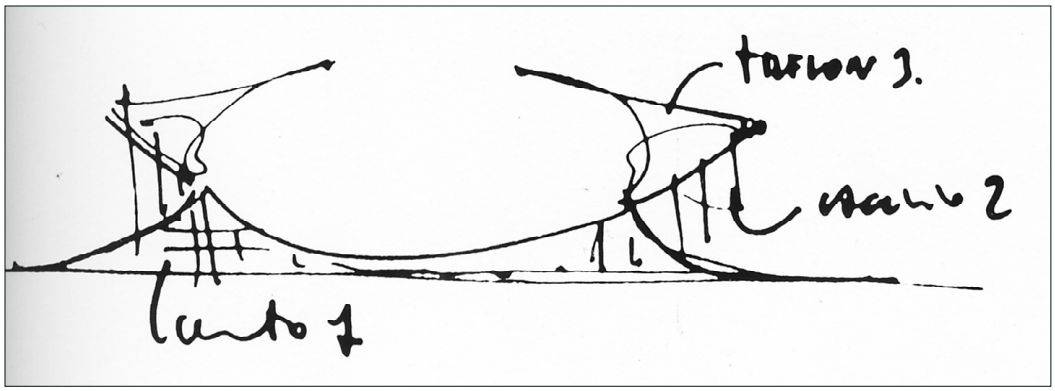
He also iterates:

"Architecture is a contaminated art on which everything impinges, it is not about drawing but about the making of things, it requires a balance between science and craft, head and hand experiment and memory; it is not necessary for technology to be incompatible with nature or history." (Renzo Piano Building Workshop 36)

The architecture of Renzo Piano is concerned with lightness, and an honest and yet innovative expression of structure and construction. He belongs to the Functionalist stream that sees equivalences between the organic and the mechanistic. He also subscribes to the social ideals that are part of this strand and the assumption that authenticity lies in the honest and innovative expression of tectonics. He has an in-depth fascination with building sites and especially with the intricacies of how buildings are put together. Renzo Piano is concerned with the making of architecture. His designs are concerned with organizing, making, and design development. They are also about physical mocking-up and testing. Drawing has value in that it only serves these processes. For Piano, making a building is not a solitary process. His designs pass sequentially through a series of specializations, to which each one make their own contributions. His consultants contribute right from the beginning and all the way through the design process as integral members of the team. "During the design process Piano mentally plays the roles of scout, actor, and editor-- as well as the more obvious ones of creator and refiner of form and space, and inventor and maker of their physical manifestation. The scout looks at the surroundings to find clues to generate the formal disciplines of the design. This often arise by extending elements he finds in the surroundings into the site and building.

Piano the actor imagines himself as the kinds of people who will use the building. He conjures in the mind's eye the mood, speed and sense of expectation with which they will approach the building, and the kinds of things they would like to do in the building. "...Another one of Piano's greatest skills is as an editor of other people's elaborations of his ideas. Not only can he sense the most promising directions but he is also good at whittling away the unnecessary.." (*Renzo Piano Building Workshop 36*)

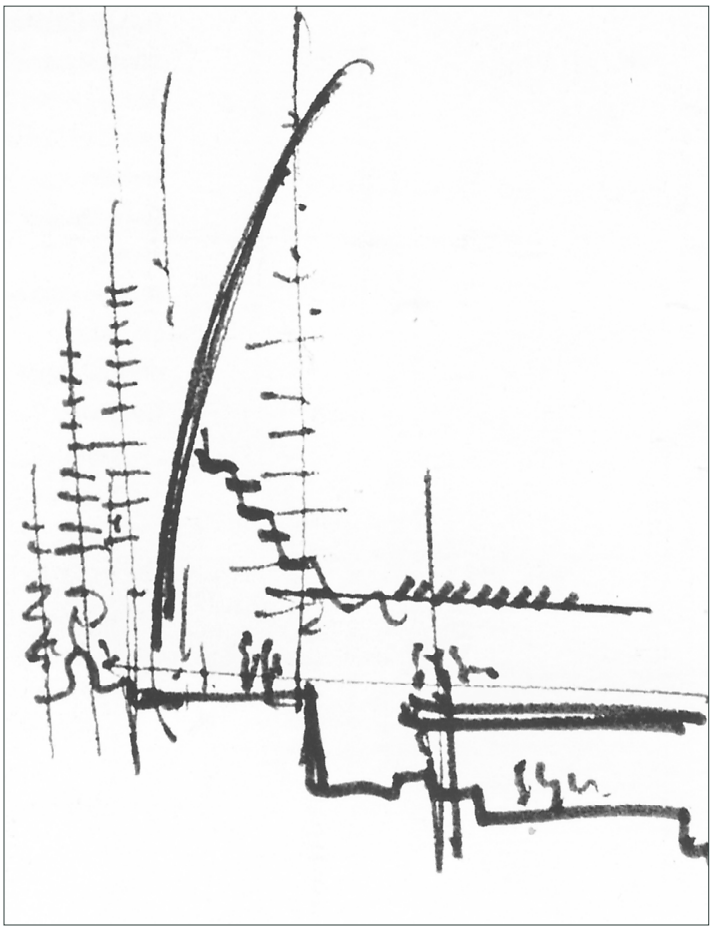
About Renzo Piano's Performative Architecture



The Renzo Piano Building Workshop has been committed to hands-on experiments and engagements with all aspects of the making of architecture, the intensity of this immersion in process being essential to the qualities sought in the built end-product. This process has been highly collaborative.

Renzo Piano neither follows fashions of form or theory, nor is he limited to personal idioms. Instead, he is concerned with specifics and potentials of a particular situation and moment, meeting the challenges of the program, pushing the limits of technology, but always responding sensitively to the topography or urban fabric of the building's site.

Renzo Piano's works range from the urban such as the Potsdamer Platz master plan, a science museum in Amsterdam, high-rise towers in Rotterdam and Sydney, and the acclaimed Beyeler Foundation and the Jean-Marie Tjibaou Cultural Center in New Caledonia. His works exemplify the architect's sensitivity to site and local tradition, combining traditional materials and techniques with those from the cutting edge of technology.

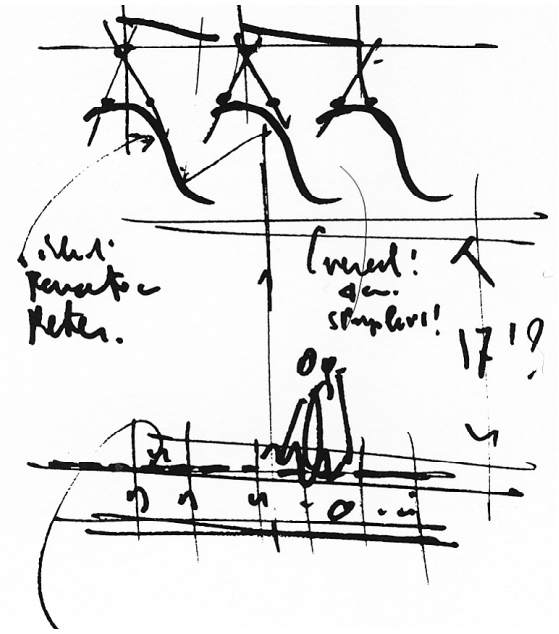


Renzo Piano works' photos credit :
Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London

2.1.1 CASE STUDY ONE - Menil Collection – Houston, USA - Renzo Piano

The bio-morphic shapes and openness to the surrounding landscape seen in many of Renzo Piano's works reinforce another consistent trait of his architecture. Wherever possible, it establishes an intimate relationship with nature, settling itself into natural or landscaped surroundings and inviting inside plants and ever-changing natural light as pervasive and potent presences.

The bio-morphic light diffusing "leaves" and trusses of the Menil exemplifies the way that components can emulate form and the close fit of form to function, as it can be found in nature. Leaf and truss together constitute the characteristic "piece" of the Menil. The architecture of the Building Workshop consists of assemblies of tailor-made pieces, the identities of which are as intrinsic to that of the building as is that of a leaf to a tree. The building is similarly recognizable from its pieces alone. The aim of the design was to create a space facilitating a direct and relaxed relationship between visitors and the exhibited object by creating a non-monumental and familiar environment open to contact with nature.

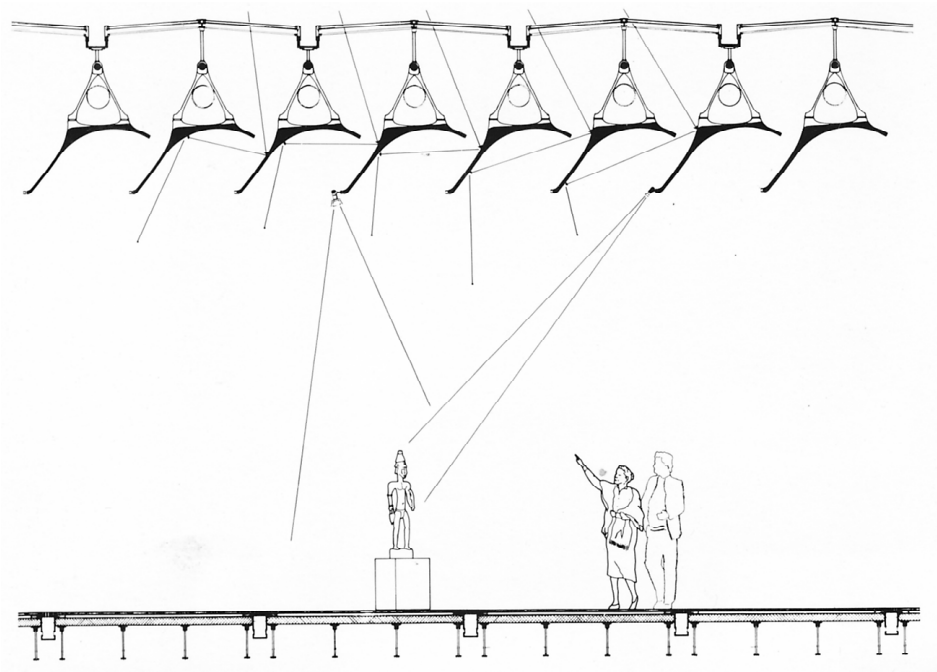


photos credit :
Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London

The leaf plays a structural role as an integral part of the roof truss that helps with passive climatic controls. Besides controlling the amount of light and diffusion, the leaves are shaped to achieve stable temperatures. The model of the canopy of leaves is being tested to varying conditions. The final design of the leaves blocks out direct sun and reflects and diffuses the light they admit. The leaves also trap an insulating layer of warm air above them.

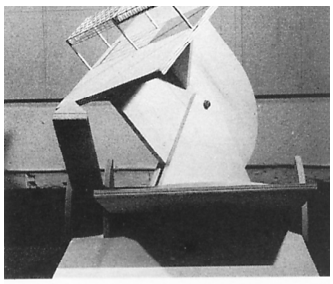
Piano plays the role of scout by looking at the surroundings to find clues to generate the formal disciplines of the design, which often arise by extending elements he finds in the surroundings into the site and building. The Menil Collection is a good example of this, as the structural grid of the roof canopy is a microcosm of the suburban street grid. This canopy is supported on exposed steel columns derived from those of a nearby Philip Johnson building which are in-filled with the clapboarding of the surrounding bungalows. Together with the othersexisting buildings, it forms a sort of "village Museum." The main building harmonizes with the other smaller houses because of its low outline and similar treatment of the outside walls. Paul Klee's painting, "Blossoming", furnishes a good analogy of the way elements are drawn into and intensified in a design.

CASE STUDY ONE - Menil Collection – Houston, USA - Renzo Piano



Besides controlling the amount of light and diffusing it, the leaves are shaped to help achieve stable temperatures in the galleries.

Partial section through the gallery shows the final design of the leaves, which block out the direct sun and reflect and diffuse the light they admit. The leaves also trap an insulating layer of warm air above them. Their lower edge also supports the artificial lighting.



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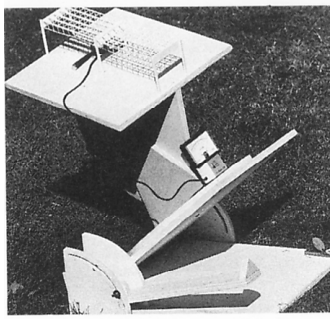
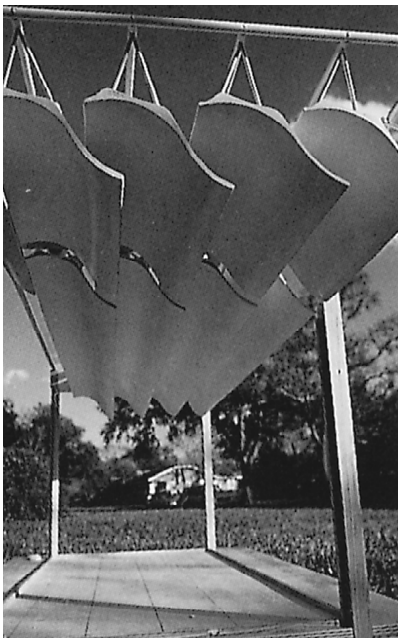
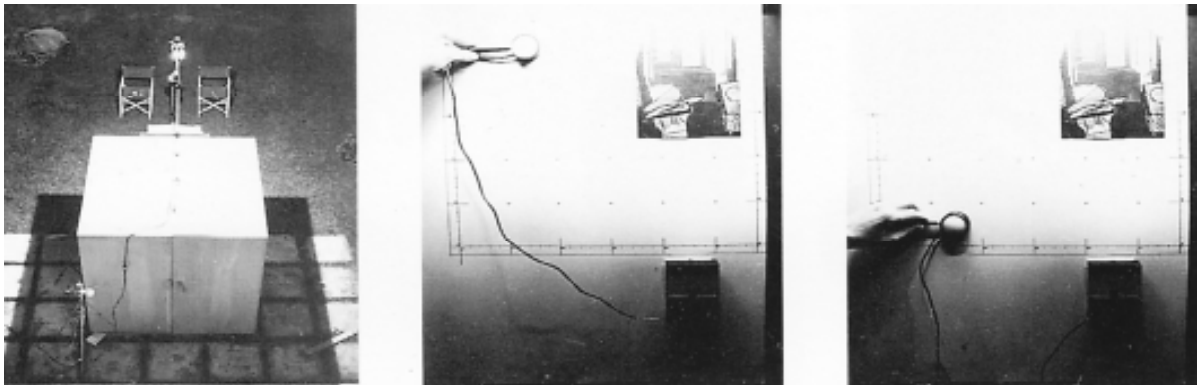
Models of the canopy of leaves being tested in varying conditions to simulate those in Houston.



Models being tested on site in Houston.
photos credit :
Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

Models and test results used in checking the quality and intensity of internal lighting with variations outside.

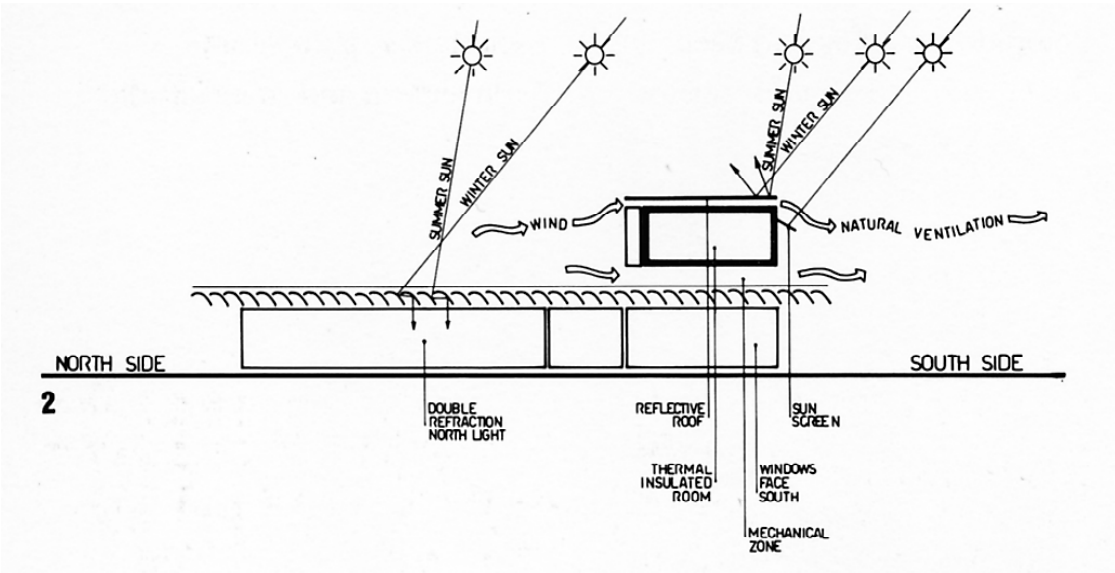




CASE STUDY ONE - Menil Collection – Houston, USA - Renzo Piano

The north-east corner of the colonnade, and the projecting canopy of leaves.

The ever-changing day-lighting admitted by the leaves, but not overpowering what is below.

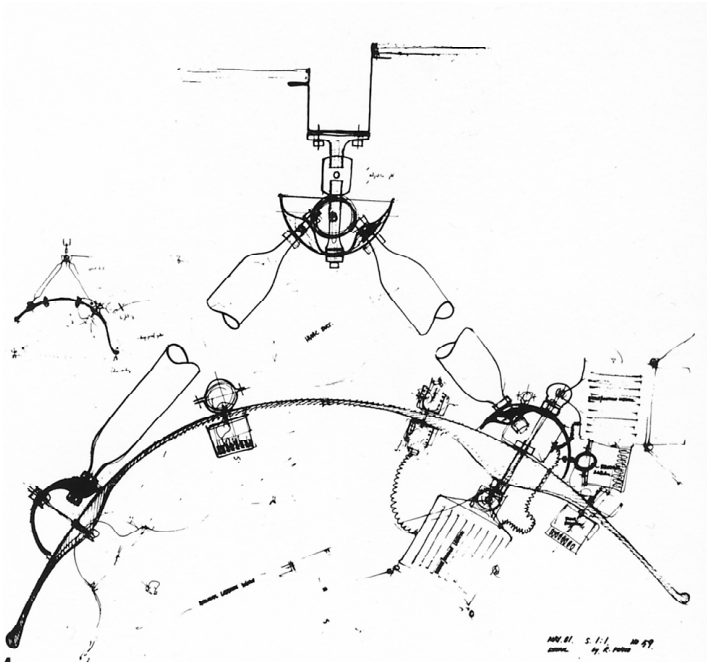


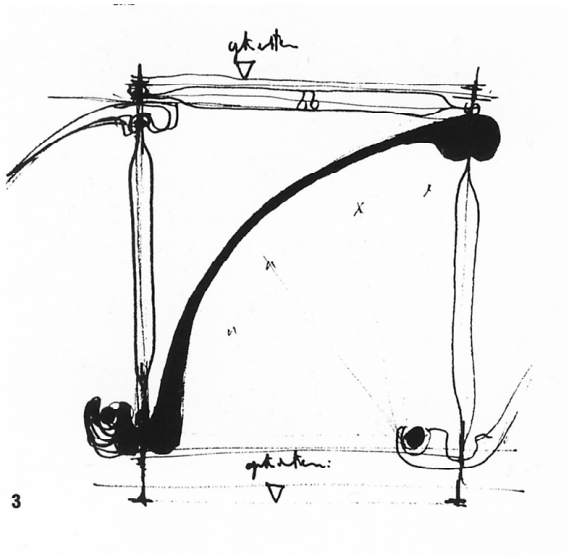
Diagrammatic cross section showing passive climatic controls

photos credit :

Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

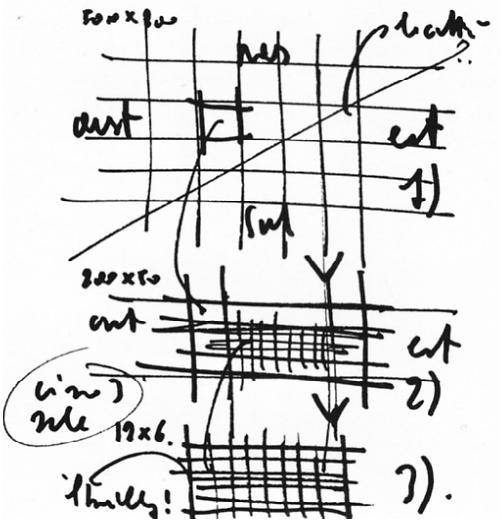
CASE STUDY ONE - Menil Collection – Houston, USA - Renzo Piano





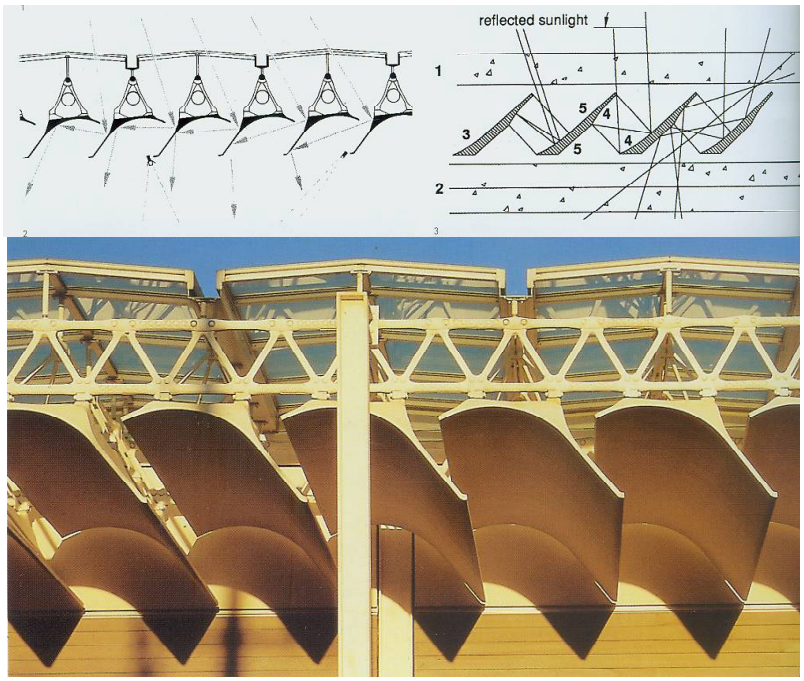
Early studies of the leaf, the initial idea was of the curved ferro-cement element that would reflect and diffuse both and natural and concealed artificial lighting and would also provide diagonal bracing for a tubular steel truss, at an intermediary stage.

photos credit :
Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.



Piano's sketch showing how the structural grid of the roof canopy was conceived of as a microcosm of the street grid.

Piano's idea of optimizing the relationship of shade and daylight guidance leads to new forms



Performative Paradigm and Characteristics: Menil Collection

In performative architecture, environment means climate, culture, and context, which is referred to as “topography.” It emphasizes on an “open” design, which allows for the fusion of man and environment, while building on those aspects of a place already exist.

Menil Collection reveals Piano’s shift toward natural design solution. Unlike his other work the Pompidou Center, which juxtaposes with its surrounding context, Menil Collection is in perfect harmony with its local conditions, humbly blends with them, and based on the client’s wishes does not look overbearingly large from the outside. The design concept was heavily influenced by the client Mrs. Dominique Menil, whose foremost requirements for this project was that all art in display must be seen in natural light, and that light be handled in such a way that visitors are alert to its constant changes with time, seasons, and weather. Living with art works, she knew to what degree this critical requirement could transcend both the gallery and the display of art to a higher level of perfection.

The architecture of the Menil Collection started with the concept imposed by the client, which drove Piano to a bio-morphogenetic design, with a structure that is conceived of as the microcosm of the street grid. The design of leaves as the performative motif for daylighting is an utterly novel idea. Together with Rice, who was Piano’s structural engineer, they developed the most unique device paradigm for the performative objective of the building. Operation of the leaves can be controlled by certain manual, electrical, or digital mechanism for adjustment of the light and air circulation, as well as acclimatization and mediation of the environment.

The performative objectives of the leaves in their most novel design require testing and experimentation; Piano and Rice sought usage of modeling and rapid prototyping, which helped them with ways to integrate the leaves with structural trusses. In order to analyze the function and performativity of the 12 meter trusses, which are a combination of ductile iron and leaves, they made prototypes and tested them at the site. This was also an attempt to eliminate redundancy.

Nonetheless, the design outcome is a building that to start with makes strong connections to its context, which to some extent is almost camouflaged by its context, while creating a very fluid and dynamic form to fully serve the objectives of its concept and intended function.

The Menil Collection is a morphogenetic form which not only deals well with its local forces and flows, but is constantly self-organizing and continuously in transformation, adaptation, and change of condition to fit with its contextual setting and its intended use.

The form of the Menil Collection building evolved through, while arriving at the right choice of the engineering system and material and methods of construction, focusing on energy efficiency and monitoring climate control. The form was not pre-determined, or pre-ordained, but was created through a creative process by testing and prototyping, which was focused on climatic conditions, and social, economical, cultural, and contextual studies; the final form arose out of a process of continuous revisions and analysis.

Design of the Menil Collection is a product-driven approach, revolving around appreciation of manufacturing and tectonics, as well as the art of detailing, while sharing a vision with sustainable design. The logic of the building is related to nature, by providing pedestrian paths sheltered from sun and rain and tropical gardens that allow plants and trees to grow through the building. The design of leaves is innovative and fully performative for the intended need of the interior as an art display area, which makes one wonder what would be the intended function for the exterior other than aesthetically helping its architecture vocabulary.

2.1.1.1 Performative Paradigm and Characteristics: Menil Collection

Nonetheless, development of Menil Collection's performative form is the architect's Modus Operandi, which took place as a teamwork activity through experiments, trial and errors, use of computer simulations, and client participation.

Lessons learned from Menil Architecture:

• Architect have used the natural terrain as a cultural topography for addressing social, ecological, and even economical factors that are latent in place-making. In other words, the latent and positive aspects of the context were understood to constitute and conform to a morphology that is fully compatible and in harmony with existing conditions. It resembles an architecture of social concerns.

• An architecture that in addition to blending with the morphology of its context, is able to stand out and express its own unique character and originality.

• An example of performative practices, in which architecture has allowed the building to work in direct relationship with the forces and flows of its context and the microcosm of its environment.

• A performative architecture in which the instrument of its system (mainly leaf) is successfully contributing to the aesthetics of the building and the poetics of its architecture.

• A fruitful collaboration and thorough communication between the architect and the client.

• A full integration and successful marriage of structural and environmental systems.

• A successful and innovative marriage of natural and artificial lighting, where the leaf elements act as filters to solar heat and light.

• Creati of an ever-changing adaptable environment that reflects the outside's natural conditions.

• A successful blend of art and science, and an innovative approach to sustainable design practices.

• A productive performative design from the stand point of its settings which supplies what the inherited context is unable to give on its own, for instance, ambient light. Architecture's real accomplishment is alteration and adjustment of a latent phenomenon that is already there, to a more prevailing and useful condition for the interior ambient light. In short, the conversion of daylight to ambient light, which is suitable for exhibiting the artwork.

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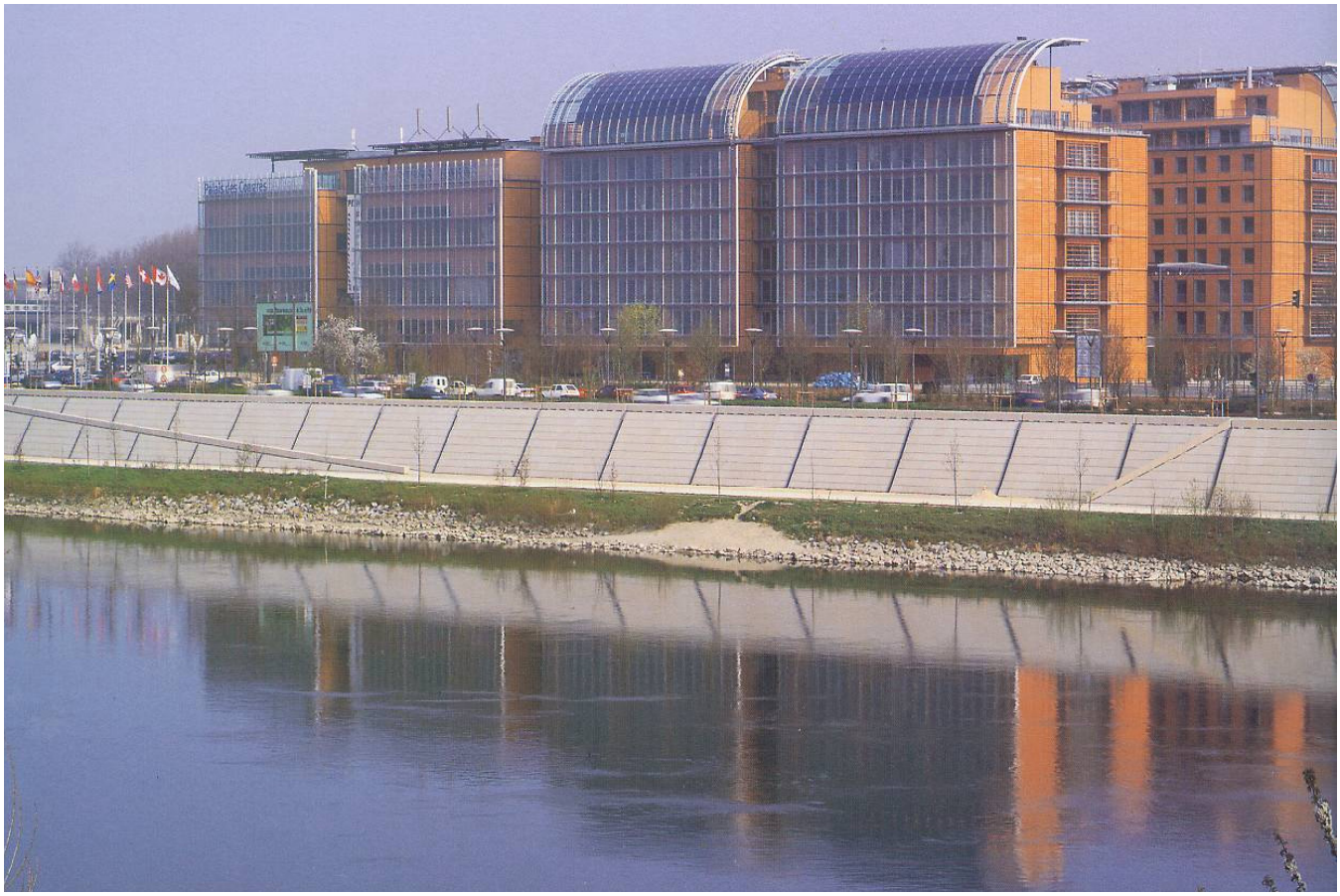
2.1.2 CASE STUDY TWO - Cite Internationale de Lyon–Renzo Piano

These buildings are the first in a series to have used the system of a double façade. The outer glass panes break the force of the wind and intercept the rain so that the conventional windows behind them can always be open.

In summer, the night air cools the buildings, while during the day the gap behind the outer glass layer acts as a thermal chimney, with warm air rising to escape through open louvers at the top while drawing in cool fresh air behind it through louvers lower down the façade. In winter, the louvers are closed to trap air, warmed by the sun. Consequently, heat will escape from the inside at a temperature that is immediate between indoors and out, forming an effective insulating layer and thus cutting down heating loads.

These outer ventilated glass skins are not used on the sheltered façades along the pedestrian spine, and only face the park and the river.

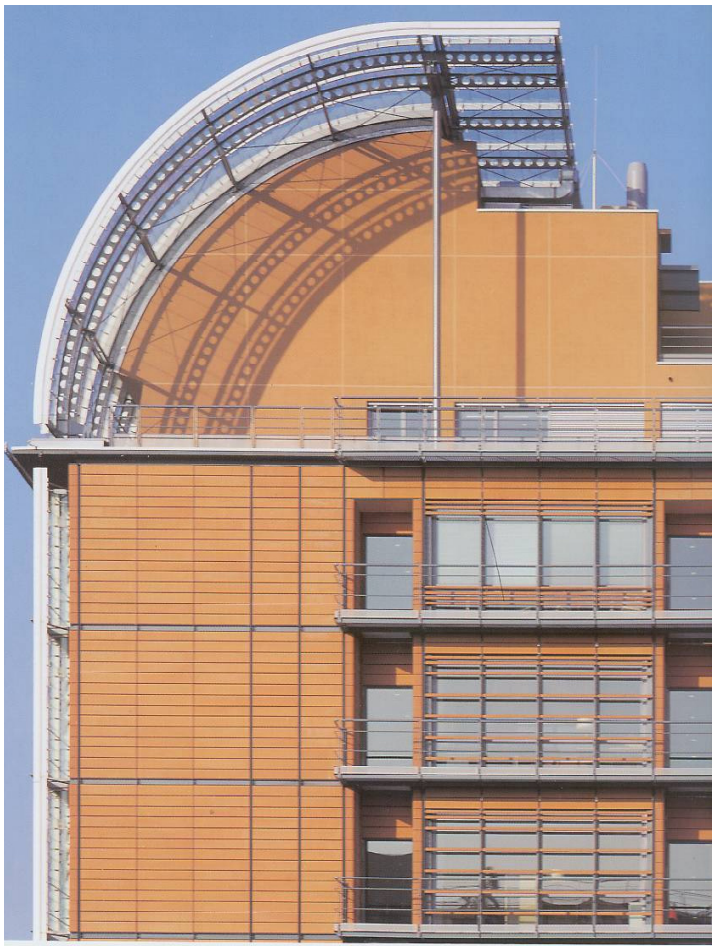


A multi-use combination of offices, retails and residentials. Offices seen from across the Rhone River.

photos credit : Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

The project consists of a rhythmic system that disciplines the layout of the blocks along the central spine between the blocks and the open cross routes that link the river and the park. Mid-block lobbies between the two wings, which make up each block, form the cross routes between them. To unify the whole block with different heights, functions and fenestrations, they are clad in the same components. The most innovative aspect of this project is the application of an exterior finish -- size and fixing of terra-cotta units-- and the use of another layer of glass units outside to give coherency to the whole of the architecture.

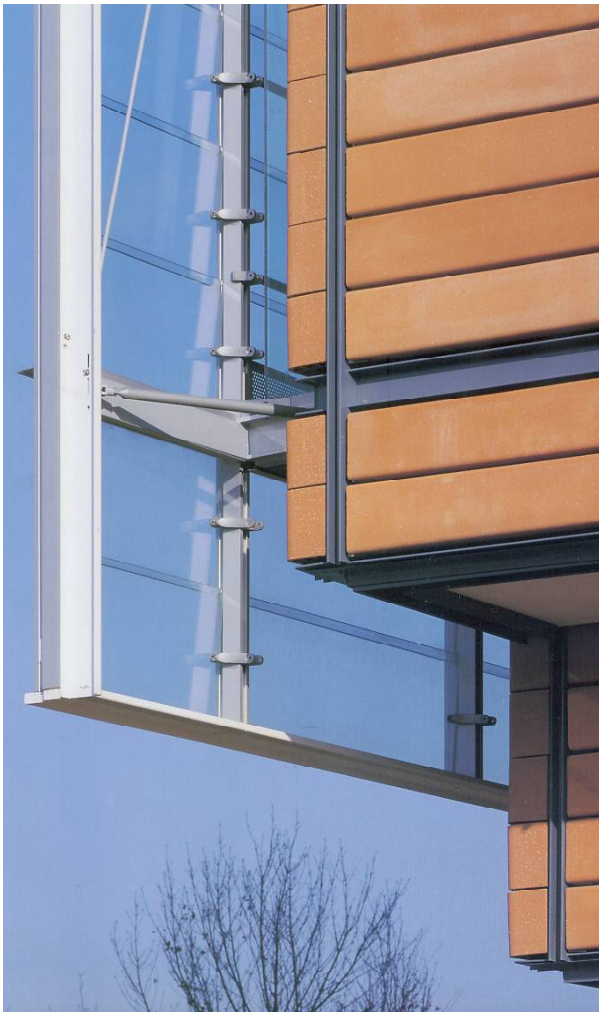
CASE STUDY TWO - Cite Internationale de Lyon–Renzo Piano



Upper corner of the office block, facing south and overlooking the park and the river. The outer layer of glass louver serves several purposes. It breaks the forces of the wind and rain and provides flexibility for the windows behind to be left open at all times if needed. The air in the gap between the louvers and building is warmed by the sun in summer and thus heat rises and escapes from the top, while drawing cool fresh air up into the windows. In winter the warm air is trapped to create a thermal jacket for the building.

The outer layer of glass louvers sails past the main façade. Clearly visible are the elements of terra-cotta cladding system with supporting rails and recessed channel string course.

The buildings' double facades have been the main aspects of energy efficiency for this project, while still allowing the occupants of the building to maintain a feeling of contact with the outdoor environment. For the same reason, these outer ventilated glass skins are not used on the sheltered facades along the pedestrian spine, and only face the park and the river.



photos credit :
Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

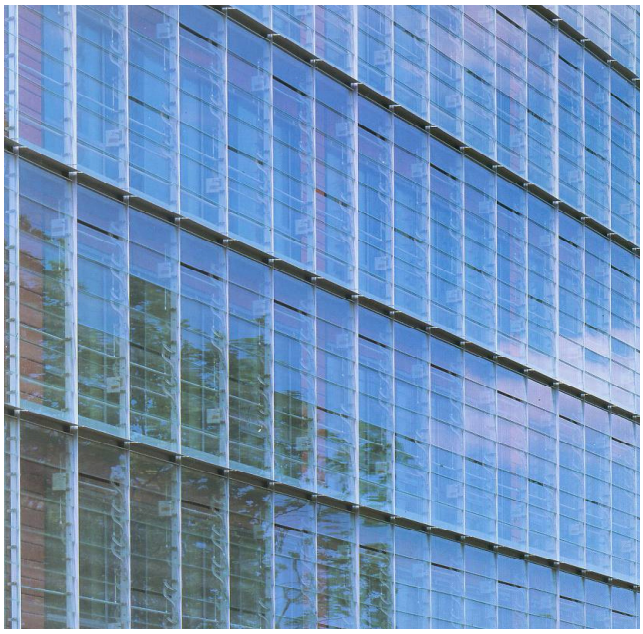
Looking east along the park-facing facades of the office blocks and beyond them, the conference center. The basement of the latter extends under the office blocks and can be reached via the sunken court onto which opens a large lobby.

photos credit :
Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

External view of louvers, some of them wide open with shading venetian blinds in cavity behind.

Office façade with all the louvers closed.

CASE STUDY TWO - Cite Internationale de Lyon–Renzo Piano



Glass roofed mall flanked by office blocks leading to the lobby of the conference center. Detailing and finishes are kept low-key so that the mall should not resemble a slick shopping center but seen as a normal part of the public realm.

This is a built environment that has elaborately and cohesively brought climate and culture together. A true argument for a design as "open"--- meaning open to light, air, movements to both place and people-- which endows architecture with greater social relevance.

Office façade with all the louvers closed for climatic reasons.

Photos credit : Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

2.1.2.1 Performative Paradigm and Characteristics: Cite Internacionale

Cite Internacionale is a cultural/leisure facility, which is not only adding to the resources of Lyons, but is also an attractive international business center for foreign visitors. Located on a very attractive site, this urban microcosm is a dense linear development, with chains of buildings of different uses at either side of a central pedestrian spine on a prominent site between the River Rhone and the Parc de la Tete d'Or. Like most of Piano's work, as the first aspect of performativity, the project makes a direct connection with its surrounding natural elements. In the case of this project it has been cementing new links between park and river, in order to bring contemporary life in harmony with nature. The usage of terra-cotta cladding provides a protective finish that conveys a sense of warmth and an enlivening delicacy of "grain" with a horizontal emphasis, and adds an attractive shimmering effect. Piano has been meticulously using glass in conjunction with terra-cotta as a gesture of affinity with the glass houses in the park. Piano's design of the Cite focuses on energy efficiency and the creation of intelligent skins, which arecapable of controlling and monitoring climate control systems and the maintenance schedule of the building while still allowing occupants a feeling of closeness with outdoor elements.

The performative design consists of the incorporation of device paradigms by implementing operable and mechanical building devices as tools to demonstrate performativity. Operation of the devices can be controlled by manual, electrical, or digital mechanisms in order to modify, acclimatize, and mediate the environment. The outer glass panes break the force of wind and intercept the rain so that the conventional windows behind them can always be open. In summer, the night air cools the buildings, while during the day the gap behind the outer glass layer acts as a thermal chimney, with warm air rising to escape through open louvers at the top. Consequently, this event draws in cool fresh air through the louvers at the lower part of the facade. In winter, the louvers are closed to trap air warmed by the sun, while heat escapes from the inside at a temperature that is between indoor and out, forming an effective insulating layer and thus cutting down the heating loads. Depending on the orientation, the transparent glass facade is different. The ventilated glass skins are not used on the sheltered facades along the pedestrian spine, and only face the park and the river. Glass facades on the seven story building curve back above the roof. Above the eighth floor they give way to weather tight double glazing that curves to form flat glazed roofs. These facades represent Piano's concern with the performative natural passive system.

Piano, by usage of modeling and rapid prototyping, has customized the building design from the molecular level to all other levels, components, and systems, while creating a morphogenetic architecture practice that has successfully resolved its contextual forces. Performativity of the Cite's design includes a performative transparent skin tested with computer simulation techniques for day-lighting effects, and usage of new types of glass with integrated venetian blinds in the cavity behind. Performativity has created an architecture which is constantly self-organizing and is continuously transforming, adapting and changing conditions. Undoubtedly, the buildings have adapted well to their intended use and expectations, as well as to their contextual circumstances.

Projects have been successful in structuring and modulating a flow for the interior spaces and movement of the people within them. It is truly an architecture of social concerns, while it is receptive to various moods of nature. Considering that receptivity is a matter of choice, it allows the occupant the freedom to be unreceptive to what is around them, if they so choose.

Performative Paradigm and Characteristics: Cite Internacionale

The development of this project, based on performative design concepts, is another of Piano's modus operandi, along with teamwork activity, experimentation, trial and errors, use of computer simulation, and client participation. The form was not pre-determined, but was created based on climatic, social, economical, cultural, and contextual conditions, and in a process of continuous revision and analysis. This project can be considered a product-driven approach, revolving around appreciation of manufacturing and tectonics and an elaborate merger of tectonics and poetics. The form of the building evolved through the right choice of the engineering system and materials and methods of construction. It is a shared vision with sustainable design concepts and principles.

Lessons Learned:

• A large mixed-use complex can be homey for the residence, while also attractive and convenient for public use.

• A successful marriage of private and public types, where each are expressing their own identity and type.

• A proper and creative usage of topography is added to the dynamism, convenience and efficiency of the design.

• A fusion of man with environment; considering that environment is an intertwining of climate and culture.

• A proper usage of energy controlling devices or performative instruments, which serve the needs of different orientations, and yet introduce variety and identity.

• An efficient and proper juxtaposition of materials to introduce identity and variety, as well as an affinity with the surrounding context.

• A true example of how contextual forces, as well as social, cultural and economical needs, influence the design and vocabulary of the building.

• A successful and elaborate integration of arts and science, or poetics and tectonics of architecture, which is interestingly not a cause for conflict between figurative and functional performance of the building. In other words, environmental performance can be used as a topic of representation or a matter of operation, while that operation has aesthetic qualities as well.

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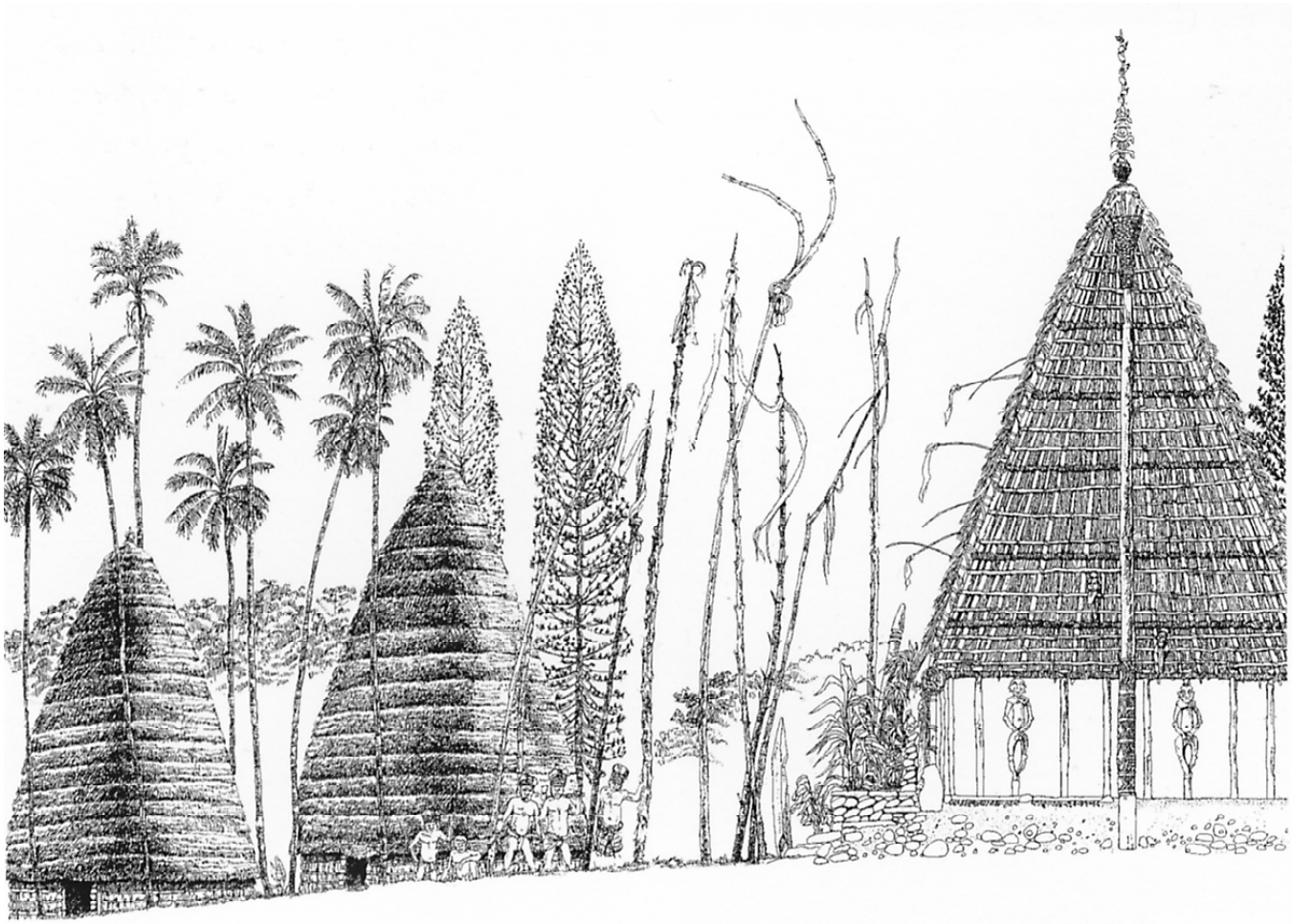
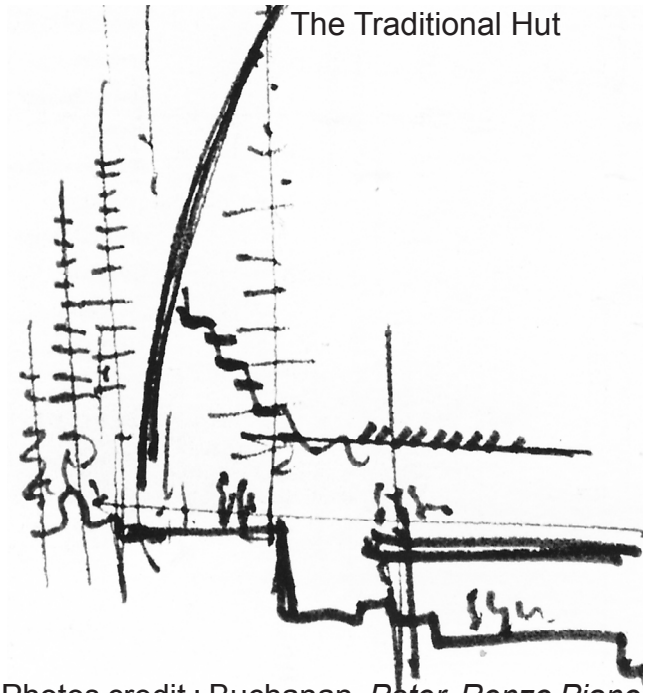
2.1.3 CASE STUDY THREE - JM Tjibaou Cultural Center, New Caledonia - Renzo Piano



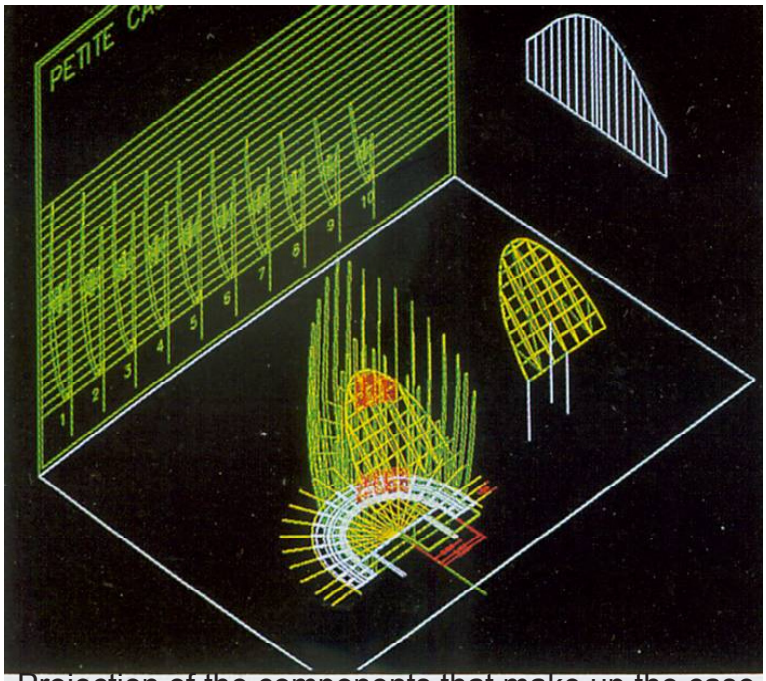
The cultural center, an enchantingly evocative and seductive design, which commemorates both the traditional society of the Kanaks and provides a focus on the inevitable evolution of its culture. Aspects of this traditional culture inspired parts of the building's design and also the treatment of the surrounding landscape. It encapsulates a vision of coexistence in close harmony with nature through an imaginative fusion of contemporary technology and reinterpretation of traditional local forms.

The design of the major spaces of the cultural center consist of repetition of the motif "cases" as man-made vegetal husks which, like the huts and the artifacts of the Kanaks, establish an intimate visual connection with the surrounding vegetation, particularly with the tall pines of the island.

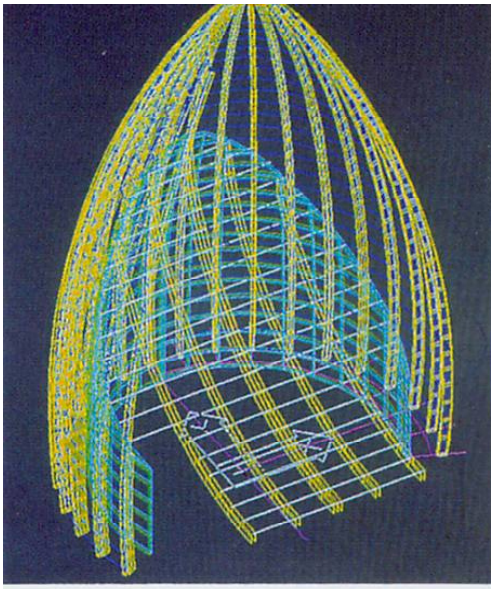


The Traditional Hut

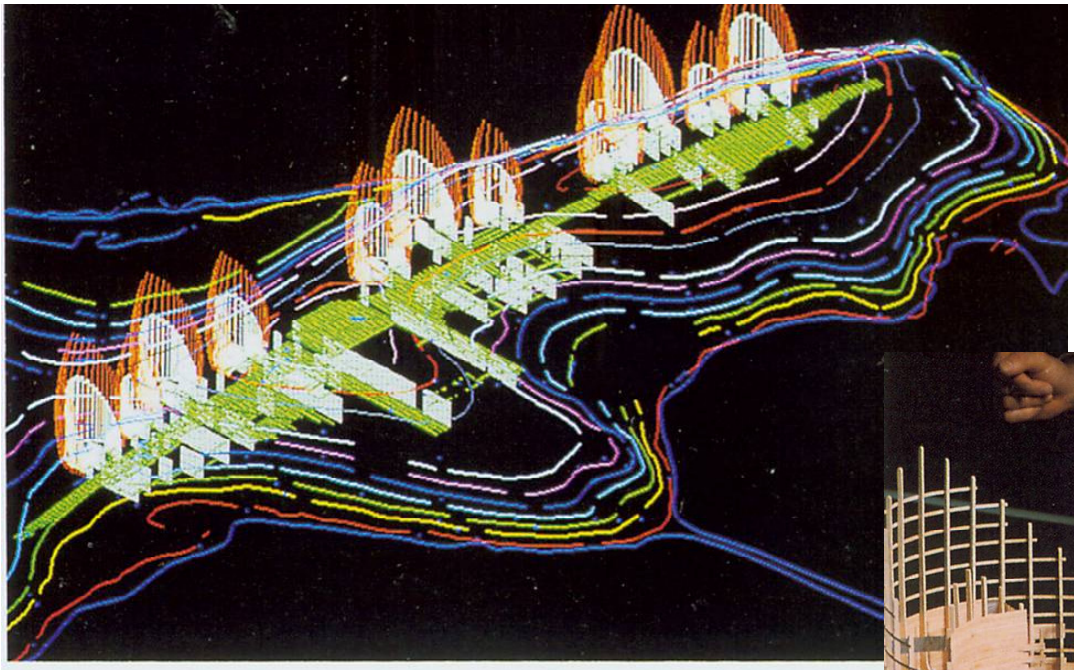
Photos credit : Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.



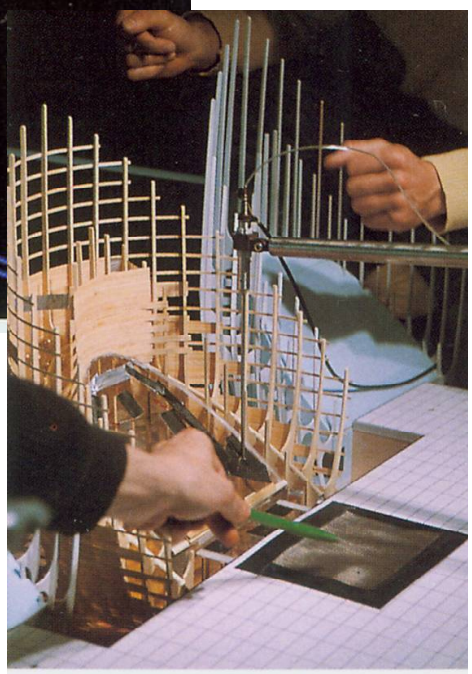
Projection of the components that make up the case



Projection of competition case



Study of intermediate scheme and its relationship to the site



Setting up for wind testing

Photos credit : Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

Computer and Wind Studies

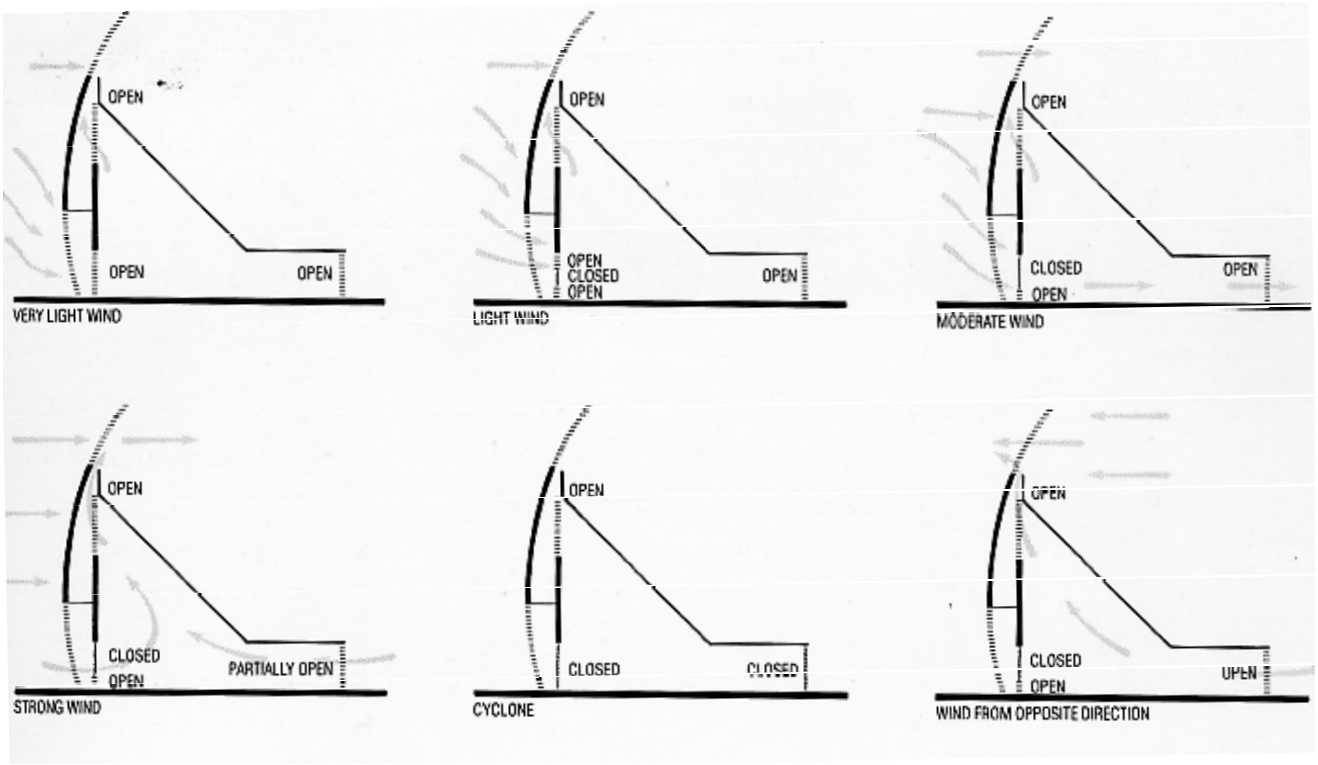
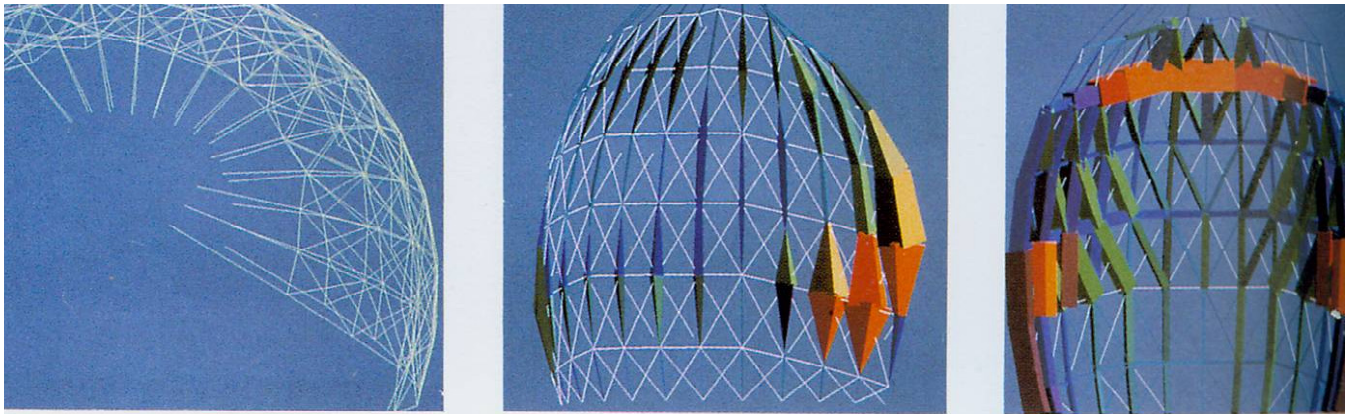


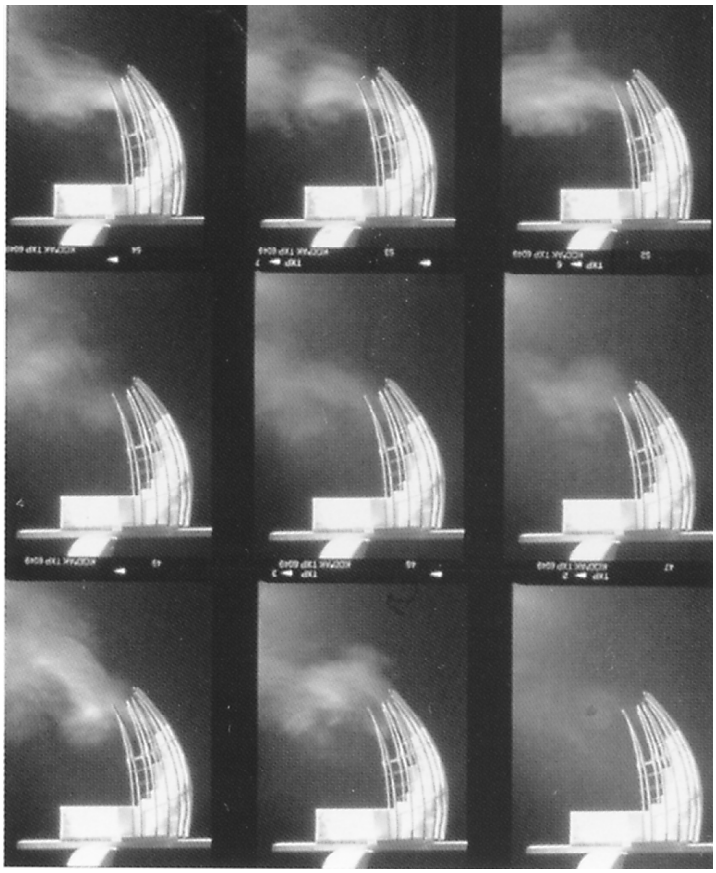
Diagram showing how ventilation is adjusted in response to different wind speeds and direction by opening and closing louvers at the head, base, and entrance to a case.
In performative architecture this study is used as a tool for evolution of the architectural form.

Photos credit : Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

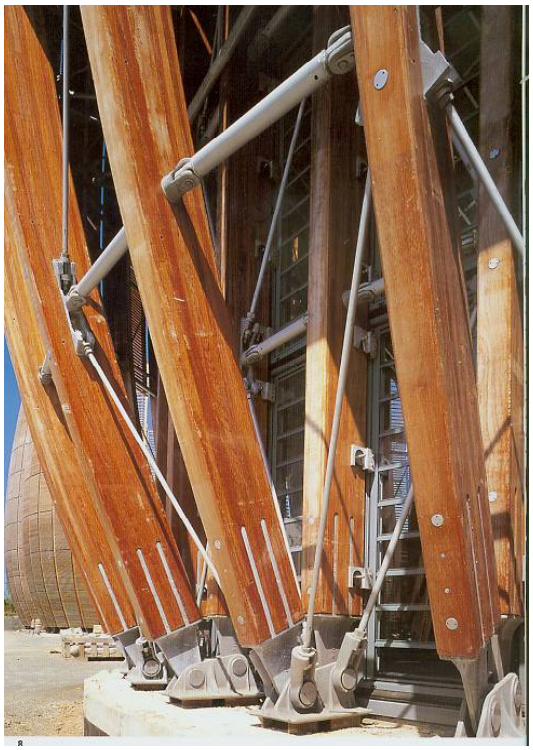


Studies of structural loading on case. Color indicates type of force, and thickness, as well as its amount. Load distributions are used in performative architecture as a tool towards evolution of the form of the building.

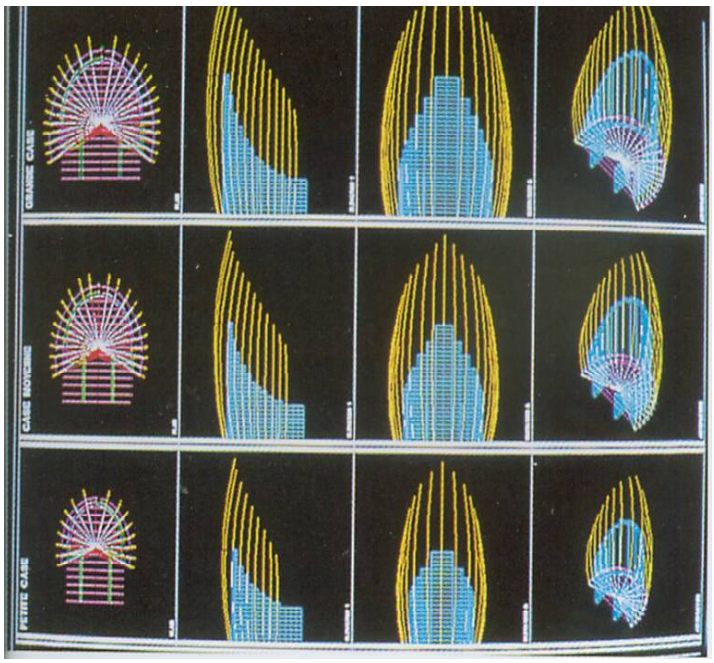
Computer and Wind Studies



Wind tunnel testing with smoke.



The structure and internal cladding in place. Only the outer layer of wooden slab is missing.



Comparison of the three sizes of case.
Because the spacing of the structural ribs is constant, the larger cases have more ribs than the smaller ones.

Photos credit : Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

Computer and Wind Studies

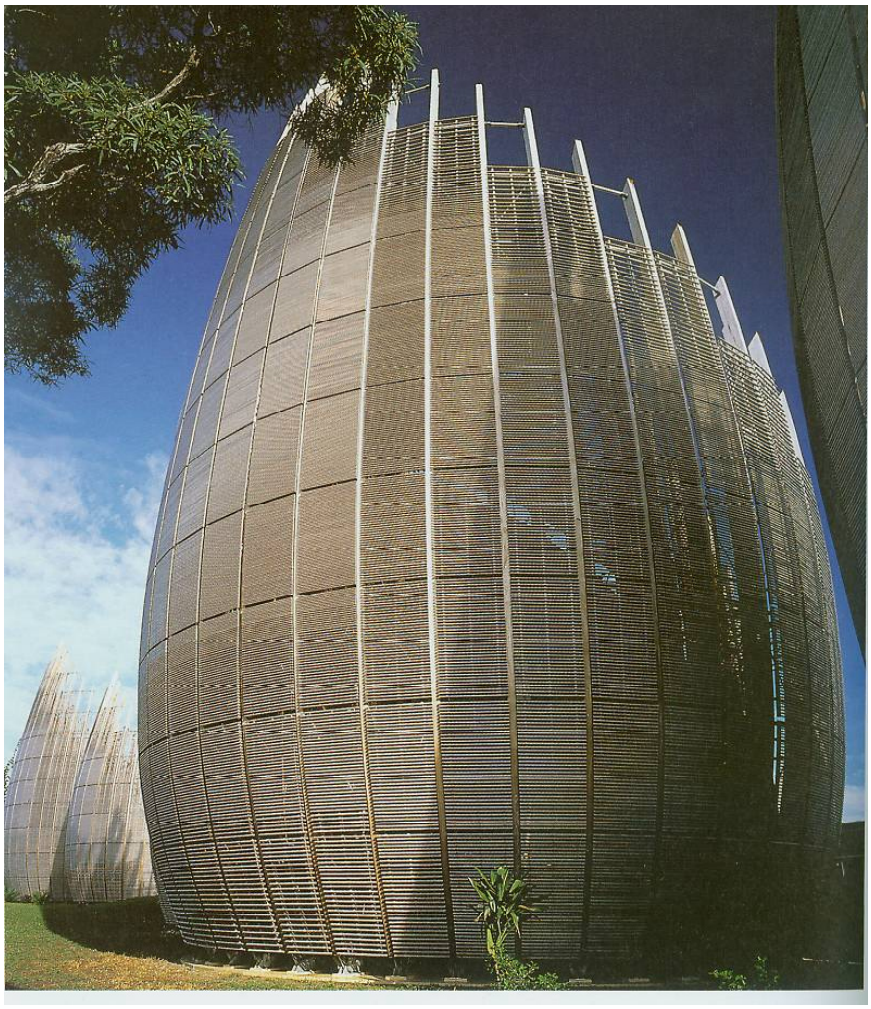
CASE STUDY THREE - JM Tjibaou Cultural Center, New Caledonia - Renzo Piano

Front of cases from lagoon

Photos credit : Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

Contrast between the cases cresting rise in foreground and flat-roofed parts on gentle slope to lagoon

CASE STUDY THREE - JM Tjibaou Cultural Center, New Caledonia - Renzo Piano



Our present age of Information and Ecology suggests an architecture of less substance and more information, less intrusion and more inclusion, less objectification and more fragmentation, less Euro-centrism and more cultural diversity. Renzo Piano is nearly alone in combining all of these progressive elements in one building. ***James Wines Green Architecture***

Photos credit : Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

Manifested in the works of Renzo Piano has been a great sensitivity to site and the increased use of terrestrial materials and vegetations.

2.1.3.1 Performative Paradigm and Characteristics: JM Tjibaou Cultural Center

This is an archaic and yet futuristic design that simultaneously evokes the indigenous Kanak culture and forms of the local tradition, whose artefacts include huts that are mostly made and woven from vegetal matter, while signifying a sense of cosmic awe and an intimate visual connection with the surrounding vegetation. The tops of their tall vertical ribs comb the Alize, the predominant trade wind on which the kanaks sail their outriggers, and which sighs as it blows through the slatted cladding to ventilate the building. Nonetheless, it is reflecting a program that involves technological, cultural, and socio-economic transitions. The design and its program evolved organically from site and climate conditions, the Kanaks' traditional culture, and social aspirations, in addition to the design skills and technological expertise brought in by Piano's team. The resulting scheme of the building establishes an intimate relationship with all aspects of its natural setting, but it also evokes a dream of living in harmony with its natural setting and its local ecosystem. The outcome is a design that makes connections to sustainability and cultural theory, and an architecture that has adapted well to the building's intended use, expectations, and contextual circumstances.

The performative form is the result of wind tunnel testing that allowed the team to arrive at the most functional form, wind scoops. The final form has an inner as well as an outer ring of vertical ribs, none of which meet on the top. The space between these rings of ribs has proven to work as a convection chimney for the purpose of natural ventilation. Thus, it has become an architecture of morphogenetic practices developed from modeling and rapid prototyping, in addition to computer simulations, which deal with flows and forces that focus on energy efficiency and monitoring climate control strategies. Although form has a great deal of cultural resemblance, it is a processed-based design that by no means has pre-ordained form qualities.

The huts, possessing sloping ceilings with inner and outer enclosures in conjunction with their related patios, work as one system in coping with different wind conditions. The wind passes through horizontal slats with wide gaps at the bottom part of the hut. Slats are closely spaced mid-way up, thus trapping the air by forming a chimney and allowing the air to rise up and get sucked out. The inner walls of the huts have fixed louvers, which lie below the highest part of the ceiling and a larger area of adjustable louvers. There are more adjustable louvers between the huts and the promenade. The design of the huts was tested and further refined through erecting two full-size prototypes. The double roof consists of an I-section of steel over aluminum, which maintains the inner temperature at 30 degree when the outside temperature is about 50 degrees. Nonetheless, the make-up of the huts incorporates building devices that are tools for its performativity. The architecture of Tjibaou is the customization of a building design from the molecular level to all other levels, components and systems of its construct.

It is also an architecture that is constantly self-organizing while being continuously transforming, adaptating and changing. The form was not pre-determined or pre-ordained, but was created based on climatic, social, economical, cultural, and contextual conditions within a process of continuous revision and analysis. Development of performative form is the Architect's *modus operandi,* which includes teamwork activity, experiments, trial and errors, use of computer simulation, as well as client participation, in this particular case from the Pacific Islanders.

Performative Paradigm and Characteristics: JM Tjibaou Cultural Center

Tjibaou design was a fully product-driven approach, revolving around appreciation of manufacturing and tectonics, as well as the art of detailing. The form of the building evolved while arriving at the right choice of the engineering system and material and methods of construction, both of which share a vision with sustainability.

In the design of the Tjibaou, a great deal of attention was paid to cultural heritage as a positive vital element of the place. The latent flows and positive aspects of the context were understood to constitute a foreground for the design of a cultural center, which was supposed to be the reflection of the ecological, social and even economic aspects of this society. Additionally, the real flows --air, light, temperature, fragrance of the natural environment, as well as the views and movements of people in varying intensities, regularities, and spontaneity-- have been analyzed and considered.

Nonetheless, in the performative design process, environment along with climate, culture, and man are fused to arrive at the most appropriate and suitable design solutions.

Lessons Learned:

Design of the Tjibaou is

• A true traditional and indigenous form, that can also be reflective of modern technological advances, having no pre-ordained formal undertakings.

• An example of morphogenetic practices, working with flows and forces of nature.

• An intimate relationship with all aspects of nature and the surrounding ecosystem, and yet maintaining its own originality and genuineness.

• A modernized simulation of old traditional convections of chimneys.

• A great example of computer simulation and rapid prototyping techniques.

• Development of elaborate full size prototypes, which are always invaluable eye-openers in the identification of the strength and weaknesses of a design construct.

• A product of driven design that reflects the harmony of the form and the artistic development of its detailing.

• Performative architecture sharing similar visions with sustainable goals.

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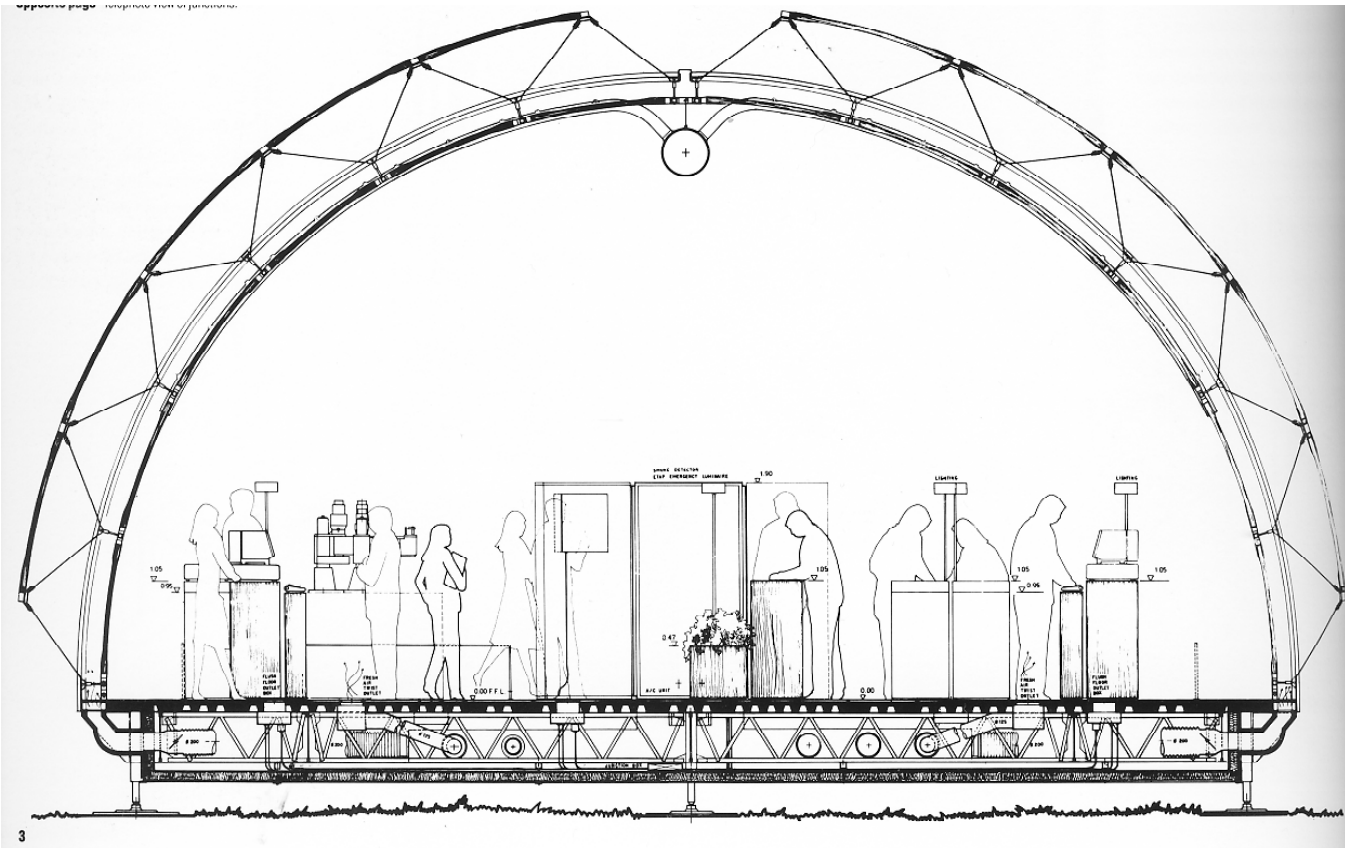
2.1.4 CASE STUDY FOUR - IBM Travelling Pavilion - Renzo Piano

Photos credit: Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

The IBM Travelling pavilion was designed for an exhibition, touching twenty European towns between 1982-1986.
Like a modern-day equivalent of the circus, the demountable IBM traveled from city to city in a fleet of specially-built and emblazoned trailers.
In this project, the concept of nature was of utmost importance, using as a pavilion a translucent structure that could be readily disassembled and transported.

CASE STUDY FOUR - IBM Travelling Pavilion - Renzo Piano



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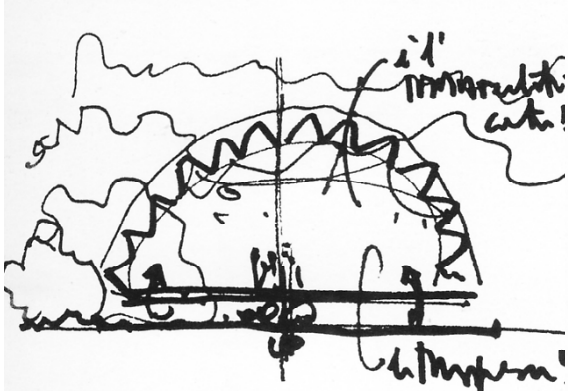
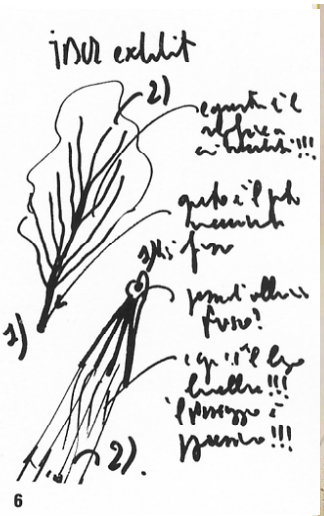
The Travelling Pavilion is a continued theme from Piano's earliest explorations of lightness, transparency and construction with repetitive units. Yet the Pavilion differs from Piano's earlier works both in the rich variety of materials used in a single work and in the celebration of workmanship.



"IBM is very organic, because of course everything becomes organic when you look for extreme optimization, lightness and perfection."

Renzo Piano

Photos credit: Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.



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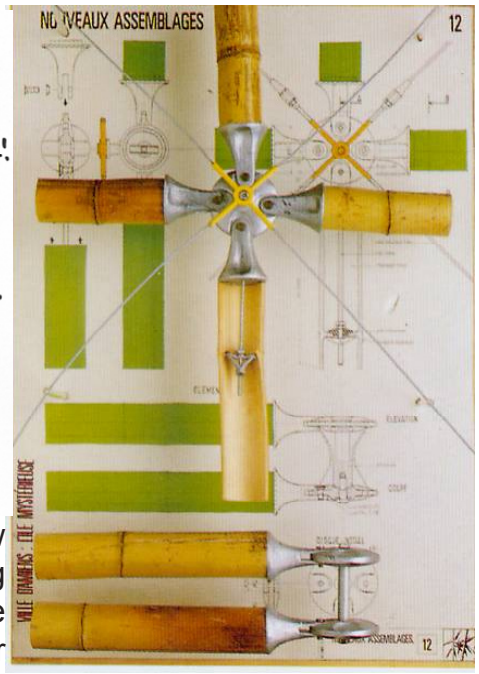
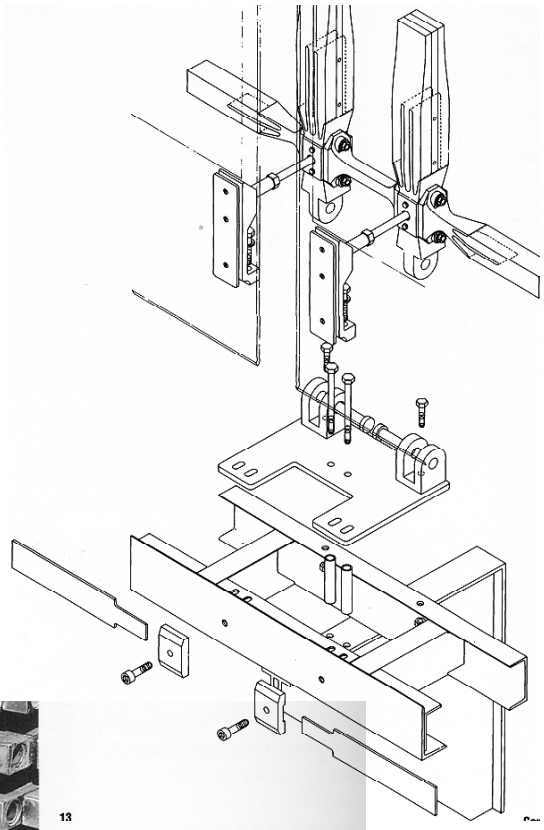
Piano's sketch of how the stalk and veining of a leaf inspired the aluminum connector that was finger-jointed to the wooden strut



CASE STUDY FOUR - IBM Travelling Pavilion - Renzo Piano

Piano's sketch and isometrics as well as finished struts. Pinned-joined junction of inner chords of adjacent arch-trusses at head of vault



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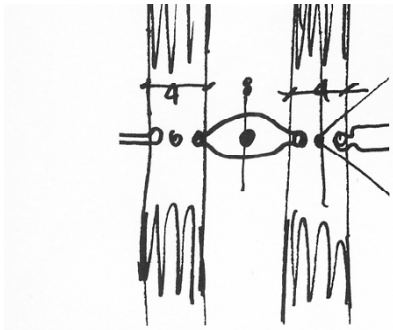

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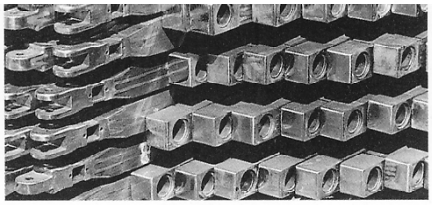

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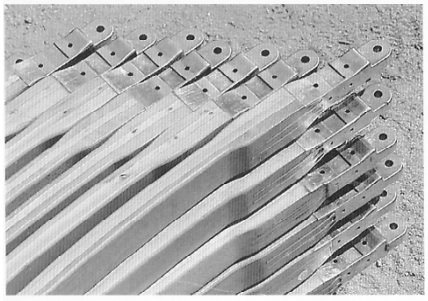
Photos credit: Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.



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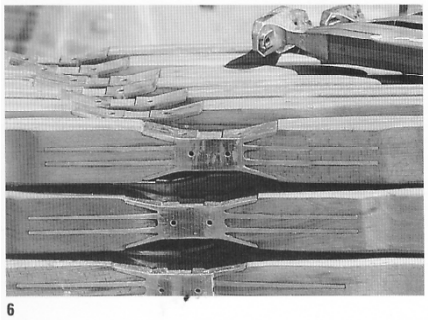

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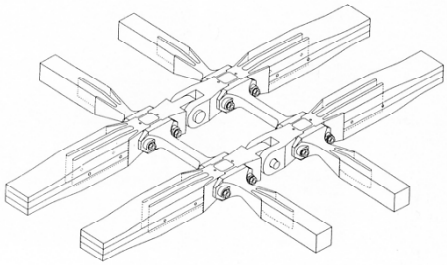

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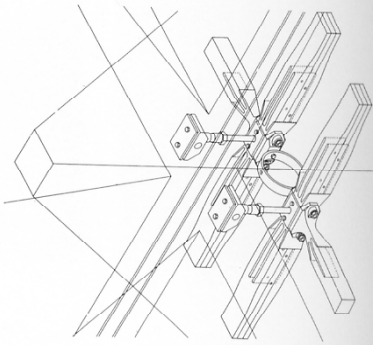
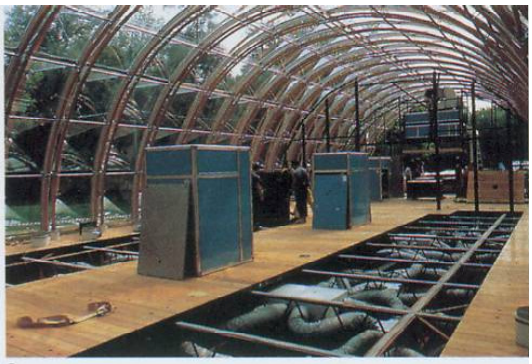


CASE STUDY FOUR - IBM Travelling Pavilion - Renzo Piano

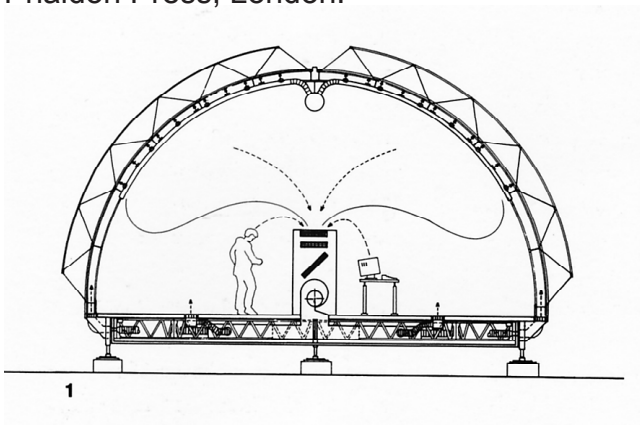
Piano and his assistants used a new plastic made of poly carbonate, and new glue to bond wood and metal.
A technique was used to bond the apexes and bases of the poly carbonate pyramids to metals. Glue was also used in the finger joints between wood and cast aluminum.
Poly carbonated pyramids held together by laminated timber struts with cast aluminum joints.
Photos credit: Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

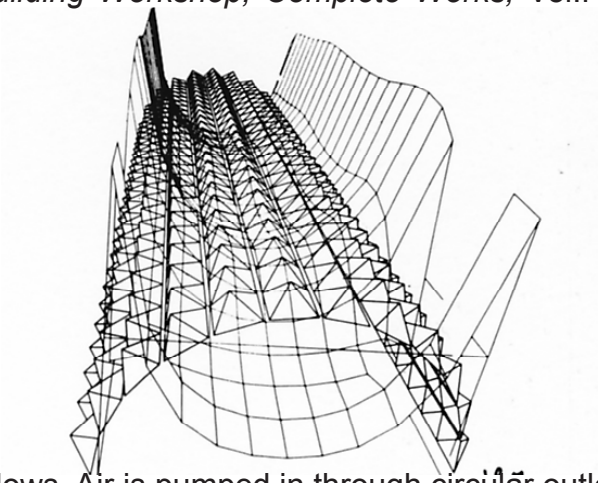
A transparent vault acted as cladding and structure, 48 meters long and 12 meters wide



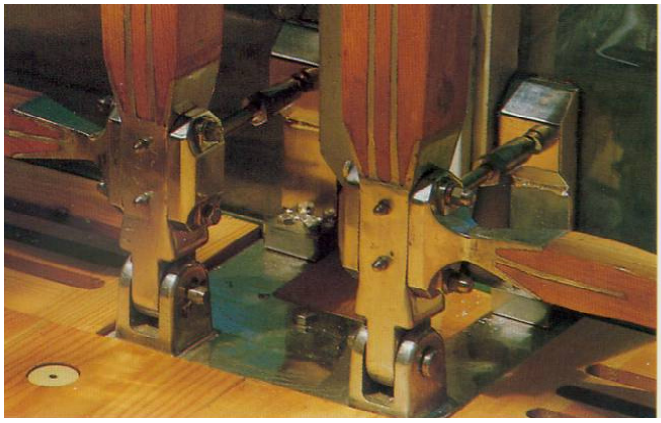
For different rate of expansion between wood and metal a solution was devised to take up these differential rates by a spacing bolt between the base of the pyramid and the inner chord of the truss where it was flexibly mounted into the cast aluminum element that connected consecutive wooden struts.

Photos credit: Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.





Cross section showing mechanically assisted air flows. Air is pumped in through circular outlets in the floor and grilles along its outer edges as well as from nozzles set in small ducts branching off a central overhead duct. It is extracted via freestanding elements along the center of the pavilion.



Pre-joined junctions of inner chords of adjacent arch-trusses to edge of structural chassis

Junction between struts of inner chords of truss and webbing strut, with spacing bolt securing poly carbonate pyramids

CASE STUDY FOUR - IBM Travelling Pavilion - Renzo Piano

In the Parc du Champ de Mars in Paris

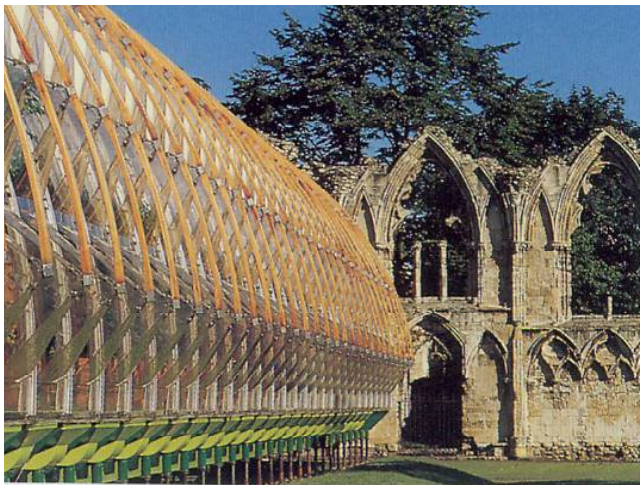
Outside the Natural History Museum in Paris

Looking over the pavilion at central Lyon

Photos credit: Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

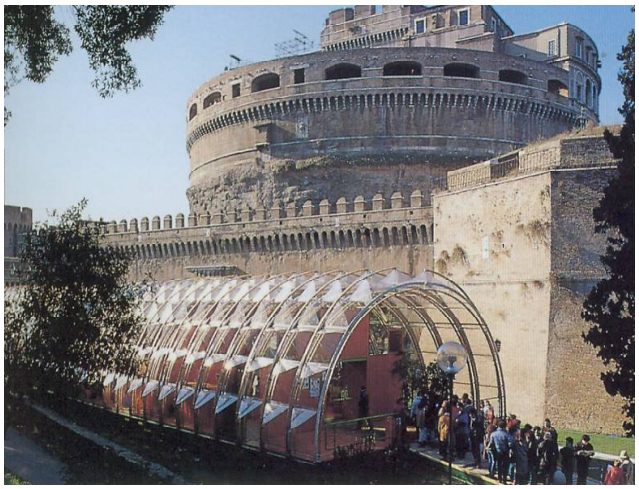
CASE STUDY FOUR - IBM Travelling Pavilion - Renzo Piano

Against the medieval and leafy backdrop of Stuttgart's Schlossplatz

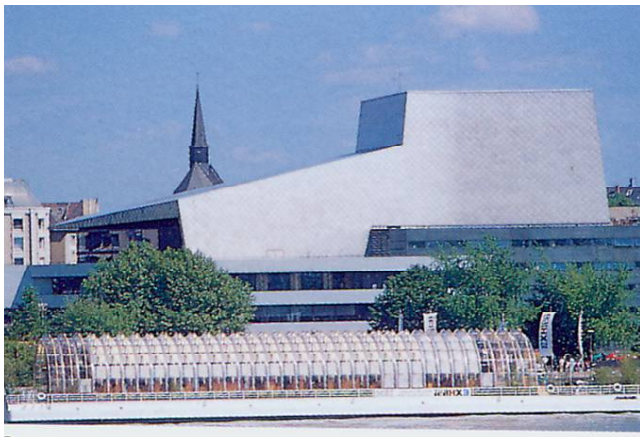


Juxtaposition with Gothic ruins in York, emphasizes how the pavilion belongs to the bio-mechanical strand of modern architecture that originated in Neo-Gothic

In Amsterdam's Vondel park



In front of the Castel Sant Angelo in Rome



Photos credit: Buchanan, *Peter, Renzo Piano Building Workshop, Complete Works,* Vol.I-IV, Phaidon Press, London.

On a barge in Bonn, the only place where it had no shade from adjacent trees

2.1.4.1 Performative Paradigm and Characteristics: IBM Travelling Pavilion

The IBM Travelling Pavilion is like a modern-day circus, a demountable building that is reflecting a program that involves technological, cultural, and socio-economical transitions.

It is an architecture design in that the building has been allowed to reach its highest level of functionality, while also attaining a state of fulfillment in its active or utilitarian state of performance. It is an architecture that is showing off the more intellectual and abstract capacities of machine through a pristine barrel vault of transparent poly-carbonate pyramids. It has shapely wooden struts and metal joints that are on a raised structural floor system. Piano, by using precision in the repetition of components, sculpted a bio-morphic form in the architecture of this building. Thus, he customized the building design from its molecular level to all other levels, components, and systems.

The Travelling Pavilion is an exploration into lightness, transparency, and construction with repetitive units, which have resulted in a performative form that has the capacity to fuse man and his environment in various contextual settings. It alludes to the argument of architecture as “open” to light, air, and movement. It endows architecture with greater social relevance and concerns. It is also a single work of art that celebrates craftsmanship in its most elaborate way.

The performative skin has tested well with computer simulations, modeling, and rapid prototyping for daylighting effects, while also being involved in the usage of a new type of transparent material. From the stand point of its spatial program, it has the capacity to unfold itself in an indeterminate way, much in contrast to the fixity of the pre-determined program, actions, events, and effects.

IBM Pavilion’s architecture of morphogenetic practices deals with flows and forces, while consisting of details that are inspired from nature in combination with the application of a new type of plastic cladding. The enclosure system is designed in an ingenious way to act both as the cladding and the structural system of the building. The combination of wood and metal along with their respective rates of expansion performs very well due to its appropriate detailing. It has arrived at an architecture that is constantly self-organizing and continuously undergoing transformation, adaptation, and changing conditions. The building has adapted well to its programmatic intended use and expectations, as well as to various contextual circumstances. The design is most definitely process based and not a pre-ordained one. It has developed with the idea of a performative form as the architect’s *modus operandi*, through teamwork activity, experiments, trial and errors, use of computer simulation, and client participation. It also has responded well to its intended use and expectations.

From the stand point of performativity, once the Pavilion is erected in a new location, computers start scanning and analyzing the new geographic and climatic conditions. It takes about three weeks for a computer simulation to lay out the outside light and thermal conditions. This is done by taking into account the orientation of the pavilion, the position of the shading trees, and other built and natural elements. This will determine the exact placing of the opaque pyramidal elements that are fixed inside the transparent ones, as well as that of the mesh screen, which is created by the computer in simulation drawings and diagrams. The computer will reveal how to control glare through a series of simulation diagrams and decide, the necessary amount of heating loads. Throughout the years and at different geographical and site conditions, computer-generated simulation diagrams have assisted in various approaches and methodologies for dealing with the human comfort aspects of the interior spaces of the Pavilion.

At one stage photo sensitive gas was proposed to overcome heat with. However, the idea did not manifest itself into a successful outcome. During the cold seasons, condensation on the pyramid's interior shell was prevented by blowing warm air into them through nozzles identical to the ones used in aircraft. These nozzles are set into small ducts that are branched from either side of a large duct that runs along the length of the pavilion and is suspended from the central pins of the arches. Other air-conditioning ducts and cables are located within the structural depth of the floor that was raised via jacks. Nonetheless, the performative design of the IBM Pavilion whose focus was on energy efficiency was not as successful as its product-driven approach. It revolves around the appreciation of manufacturing and tectonics, as well as its innovative detailing. The form of the building evolved arriving at the right choice of the engineering system and material and methods of construction. The building could definitely be categorized as part of a dynamic and living system in the sense of a biosphere with technical, social and even financial strongholds.

Lessons learned About the Pavilion:

• It is an elaborate and innovative example of craftsmanship.

• It is a solid example of the pursuit of the application of new materials and the art of detailing.

• It is an example of the successful adaptation of programmatic requirements and their intended use.

• It is an elegant example of mass production for the purpose of transportability.

• It is an example of lightness and transparency.

• It is an example of the merger of science and art.

• It is an example of a computer application in a hybrid environmental system, whose purpose is for adapting to the uniqueness of different contextual micro-climates.

• It is a great example of prototyping.

• It is a true example of a dynamic and living biosphere.

• It is a successful design attempt fusing man with environment.

• It is a successful exercise in integrating and utilizing, as well as mitigating, the flows of the context for the purpose of creating a quality indoor environment for the occupants.

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Case Studies

Nicholas Grimshaw

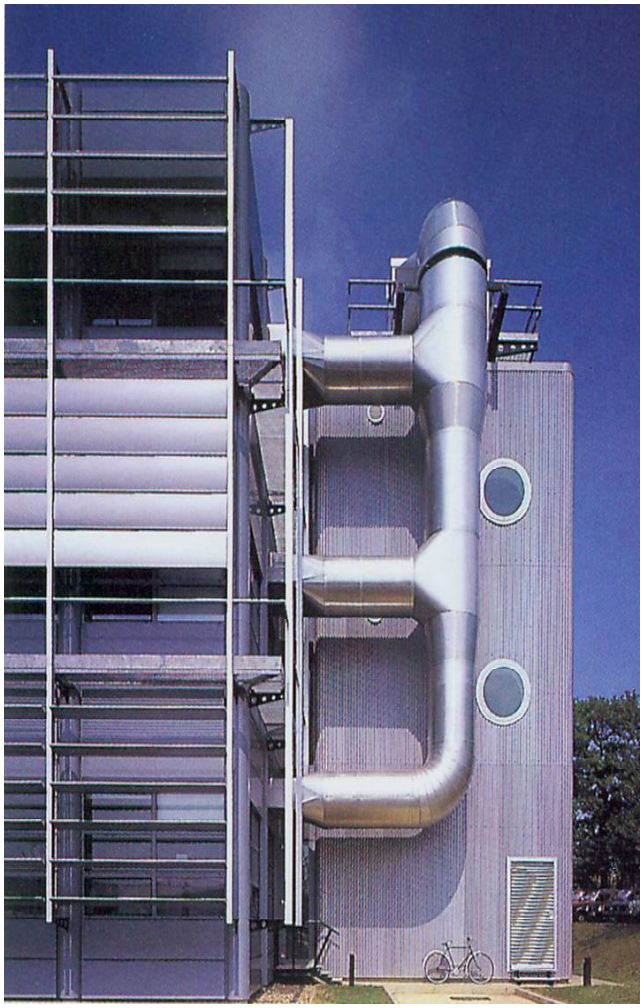
A Process-Driven
&
A Product-Driven Pratice

2.2 CASE STUDY ONE - IGUS Factory, Cologne - Nicholas Grimshaw

Grimshaw's practice of architecture is based on highly process-driven designs, which have no pre-ordained or pre-set stylistic objectives. This practice involves a rigorous exploration of ideas and the achievement of strong and meaningful concepts.

Grimshaw's firm's philosophy is established based on a practice founded in industrial architecture, which has manifested itself throughout the past three decades in relation to changing technological development. Therefore, Grimshaw's practice is synonymous with an architecture of change.

Grimshaw's pragmatic approach to architecture makes for a product-driven firm. This is based on the demonstration of a high level of understanding of manufacturing and an appreciation of how things go together. According to the firm's philosophy, "out of functionality, understood in performative terms, beauty arises." On the other hand, Grimshaw's wide array of public works, from railway terminals and airports to city-center buildings, factories, and exhibition pavilions, have all produced schemes that are as humane as they are technically advanced. History matters profoundly to Grimshaw, as he is acutely conscious of the precedents for his own creations. His vision of history is based in engineering, which is the family tradition.

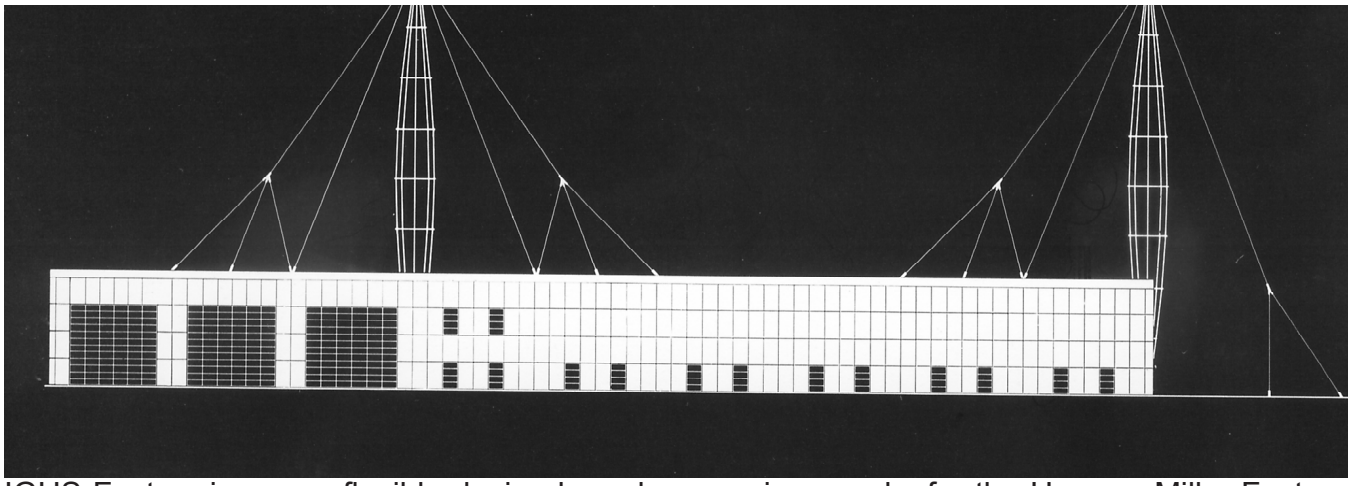


Grimshaw's key concepts are followed to the finest and smallest details. By looking at his buildings, one can find the concept in the smallest detail, or as he calls it, the DNA of the building, while understanding the larger picture from the finest elements.

Grimshaw believes that modern architecture, through the use of new technology and materials, is today's vernacular architecture, which is the most natural and obvious way of creating architecture for this era. Grimshaw once declared: "Fitting in, is to do with things like scale and height, light and shade, the feeling that the building has at ground level, at people level....It's not to do with just matching the building next door" (*Powell / Moore 11*).

Photo credit:
Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001)

2.2.1 CASE STUDY ONE - IGUS Factory, Cologne - Nicholas Grimshaw



IGUS Factory is a very flexible design based on previous works for the Herman Miller Factory and a vocabulary of skin that was developed with inspiration from Jean Prouve.

The Igus factory is a plastic manufacturing plant with a power image of structural masts. The two pylons not only lend the project a an exciting image but they also provide a great deal of internal flexibility. The "hand" detail of the pylon structure and the two rods are fixed to the top of the pylon, while the assembly allows individual rods to be connected to the main steel structure in the appropriate locations. Grimshaw drew on his past experiences of using plastic panels for cladding, with added refinement, to make the installation easier and more convenient. The roof domes, with their north-facing roof lights, provide very efficient studio-quality light to the workplace. Grimshaw's projects are process-driven, and his in-depth understanding of structure and detail have helped him to arrive at very attractive forms.

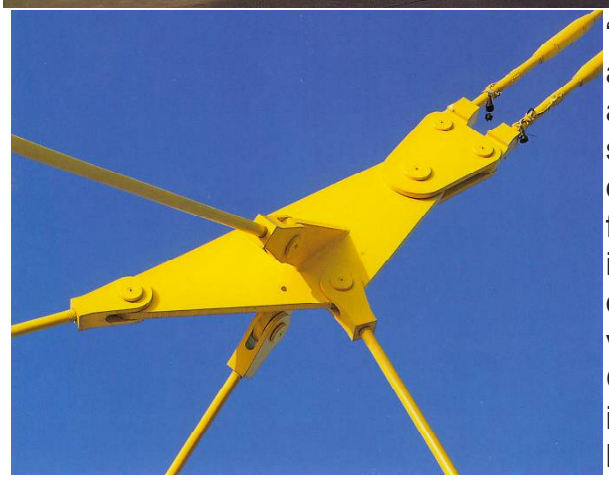


Photo credit: Powell, Kenneth, & Moore, *Structure, Space, and Skin*, NY, Phaidon, 2001.

CASE STUDY ONE - IGUS Factory, Cologne - Nicholas Grimshaw

IGUS Factory's flexible façade detail

One main performative aspect of this building is its interactive and flexible skin. In this photo, the physically expressed clamps show how the skin works and how the panels are pressed back onto a framework.

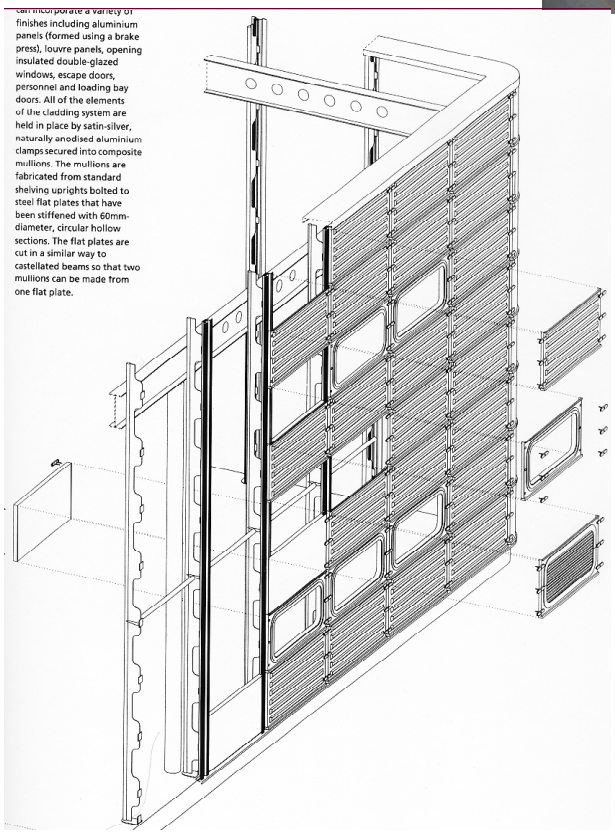
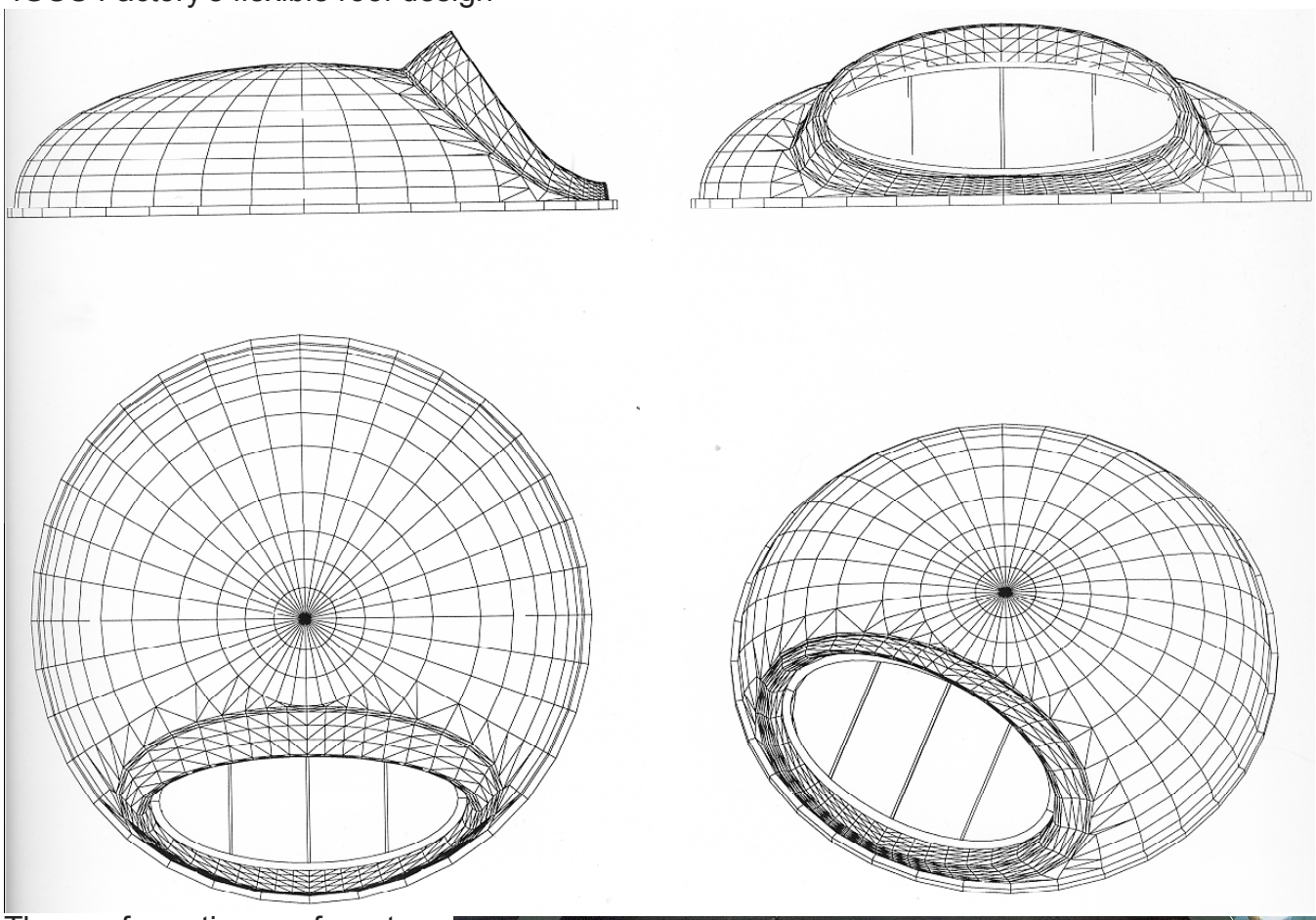


Photo credit:
Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

As with all performative designs, computer plays a major role in identifying and simulating different systems and components of the building for the purpose of identifying their relationships and performativity. The computer generated axonometric of the flexible cladding system shows how the system can incorporate a variety of finishes including aluminum panels, louver panels, opening insulated double-glazed windows, personal and loading bay doors, and escape or exit doors.

IGUS Factory's flexible roof design



The performative roof system with the sculptural "eye ball" domes, brings light deep into the building. The uninterrupted volume of the interior space of the factory is another aspect of the building's performativity.

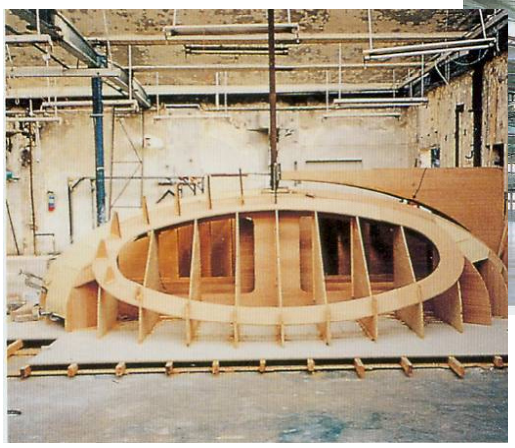


Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

Wooden pattern of roof domes from which the molds were taken.

IGUS Factory's flexible interior spaces

The performative interior contains a series of modular elements that float inside the building, which can incorporate a variety of functions, such as office spaces or restrooms and showers. The theater technology of pressurized air is used in the pad units under modules so each can be moved manually around the factory floor.

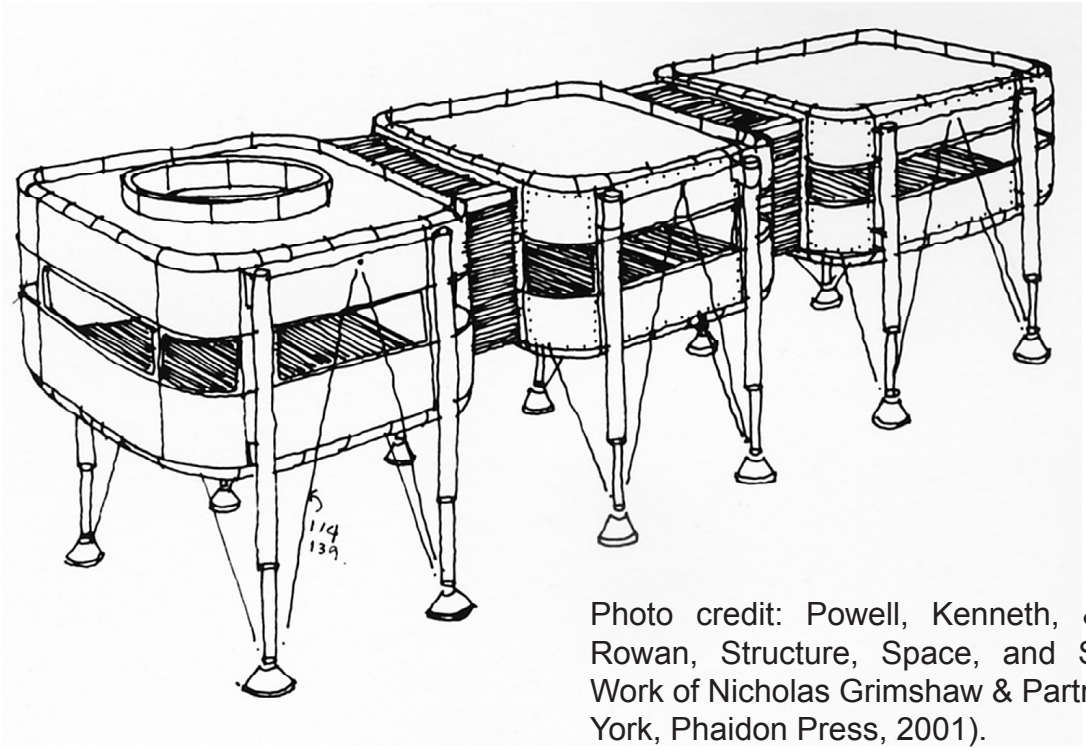


Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

IGUS Factory's flexible interior and exterior opportunities

Interior view of the cladding system looking out into the courtyard

View looking along the vertical junction between cladding panels

The performative skin construction allows for inherent interchangeability of the enclosure system of the building. The cladding panels are secured with anodized aluminum clamps fixed to the mullions, made from standard shelving uprights, stiffened with flat steel panels.

Note:
The building is now grown up to phase five, to about 400% of its original size, which has been possible because it was built around courtyards and based on a design that anticipated change.

Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

2.2.1.1 Performative Paradigm and Characteristics: IGUS Factory

The Igus Headquarter acts as a landmark, while being a totally flexible design that has the capacity to reformat itself with a great deal of fluidity and dynamism. Masts not only perform a structural role but also convey a powerful image in creating a landmark. The architecture of Igus is as much an approach or a process as it is a finished object. It is a performative architecture design in which the building has been allowed to reach its highest level of functionality, as well as a state of fulfillment in its active or utilitarian state of performance. The only insertions into the interior flexible space are the elevated walkways and the movable pod for the offices, restrooms, and recreational rooms. The distribution of services, including the pumped drainage, also happen at overhead. The office pods can be dismantled and assembled in two weeks. Grimshaw's team has been working on the development of a system of moving pods on air cushions so that pods can be moved in one weekend. Each pod, like a self-sufficient structure, has splayed feet to spread apart and does not need any localized foundations. Also, each pod has its own service box, which can be plugged into the building's overall system through flexible ducts. At the core of the factory space is a couple of courtyards that allow daylight to wrap around interior spaces. It is through the arrangement of the roof domes, windows, and interior courtyards that natural light and ventilation are available at all areas of the building.

The factory's building enjoys not only a fully adaptive design, but also a performative skin and roof. The interchangeable exterior synthetic panels, along with the transparent materials, allow a great deal of flexibility for the rearrangement of interior functions within the building.

The Igus factory is customized from the molecular level of the building to all other levels, components and systems. These factors categorize the architecture at the highest level of performativity for this building type. Space has the capacity to unfold itself in an indeterminate way, in contrast to the fixity of pre-determined program, actions, events, and effects. It is the morphogenetic practice of architecture that has had the potential to deal with the flows and forces of its micro-climate. The most efficient energy consumption is achieved through modeling, computer simulations, and rapid prototyping.

This is an architecture that is not only process based, reusable, and flexible, but is also constantly self-organizing and undergoing continuous transformation, adaptation, and changing conditions. The building has adapted well to its intended use and expectations, as well as to its contextual circumstances. Undoubtedly, the development of performative form has been the architect's *modus operandi* through teamwork activity, experiments, trial and errors, use of computer simulation, and client participation. It is a product-driven approach, which revolves around the appreciation of manufacturing and tectonics, as well as the art of detailing. The form of the building evolves while arriving at the right choice of the engineering system and material and methods of construction.

The building can be evaluated as part of a dynamic and living system, it is a biosphere with technical, social and even financial aspects. The only rigid element in the building elements is the fixity of the domes with their windows facing the north. The design of the roof domes' windows has allowed the capturing of sun angles in different directions, while also admitting sun rays into and around the interior spaces. This revolution of the sun happens at 180 degrees or more throughout the summer season, which could be a boost for energy conservation and the reduction of artificial lighting loads.

Nonetheless, the existing design of the Igus is an opportunity for a performative architecture, which is able to transform, transcend, digress and/or simply move from one state to the other in the continuum of time and space. At the same time, it also allows for different types of morphing encounterment. The building's performativity definitely shares a vision with sustainability concepts.

Lessons Learned:

The design of the Igus Factory represents:

- A harmonious marriage of architecture and structure or poetics and tectonics, to achieve the same concept and objectives.

- An elaborate design of the building enclosure (roof and walls), which uses daylighting to provide efficient studio-quality light.

- A design with the most flexible cladding system.

- The design of floating modular elements for the interior, which, can be moved manually around the factory. This is an innovative concept for the maximum flexibility of the interior spaces.

- A building with a high utilitarian state of performance.

- A true example of an adaptive design and a performative enclosure.

- A great example of architecture that focuses on the goal of permanence through the utilization of transformability concepts.

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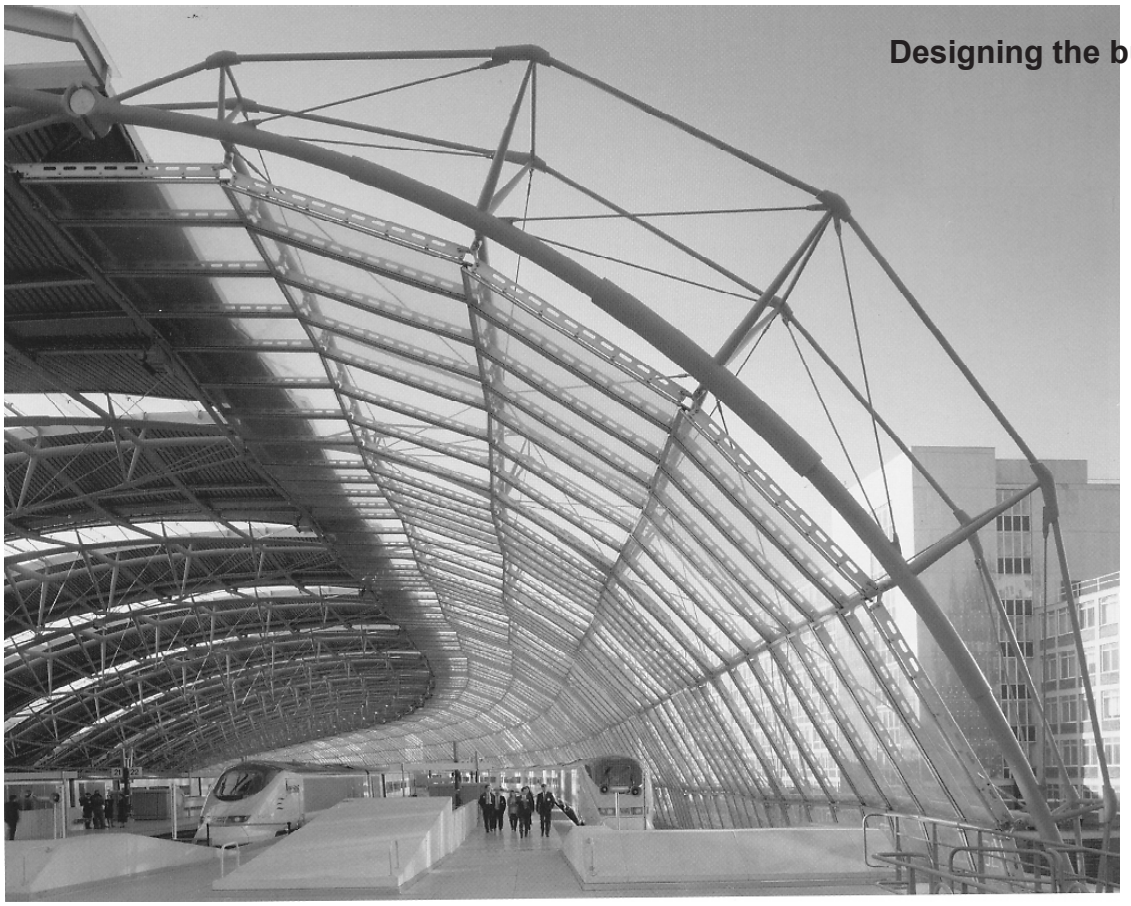
2.2.2 CASE STUDY TWO – Channel Tunnel Terminal at Waterloo- Nicholas Grimshaw

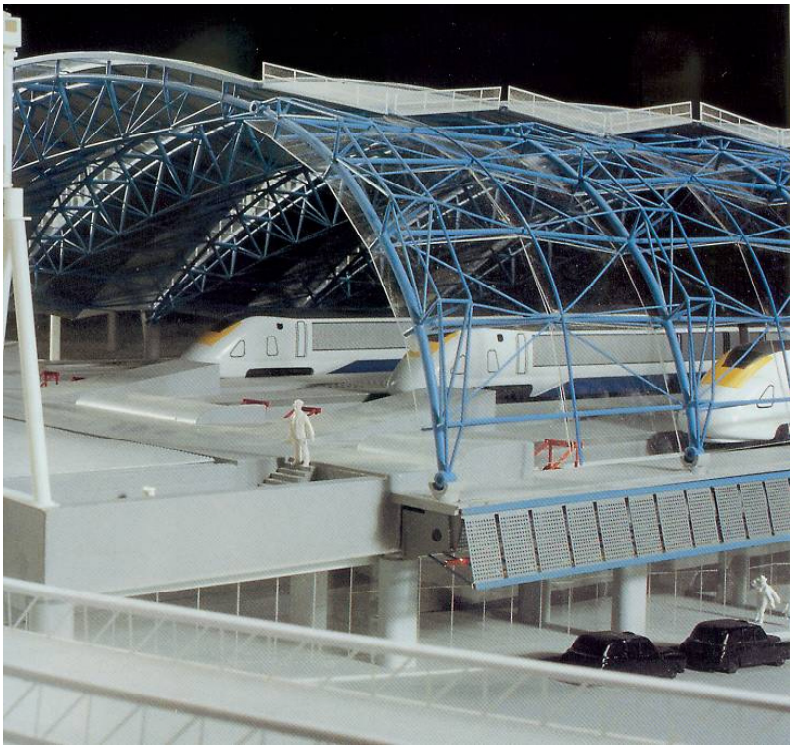


Designing the building's DNA

The architecture design is a performative solution to a complicated contextual puzzle. The railway engineers produced a complex footprint to allow for the trains coming into the station. The design of the project was about creating an indoor space snaking its way to the terminus.

A spectacular reinterpretation of the glass train shed using contemporary technology and circulation management, which takes the form of a great glazed, bio-morphic funnel that gently curves in two directions in response to a particularly awkward site.

Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).



Designing the building's DNA

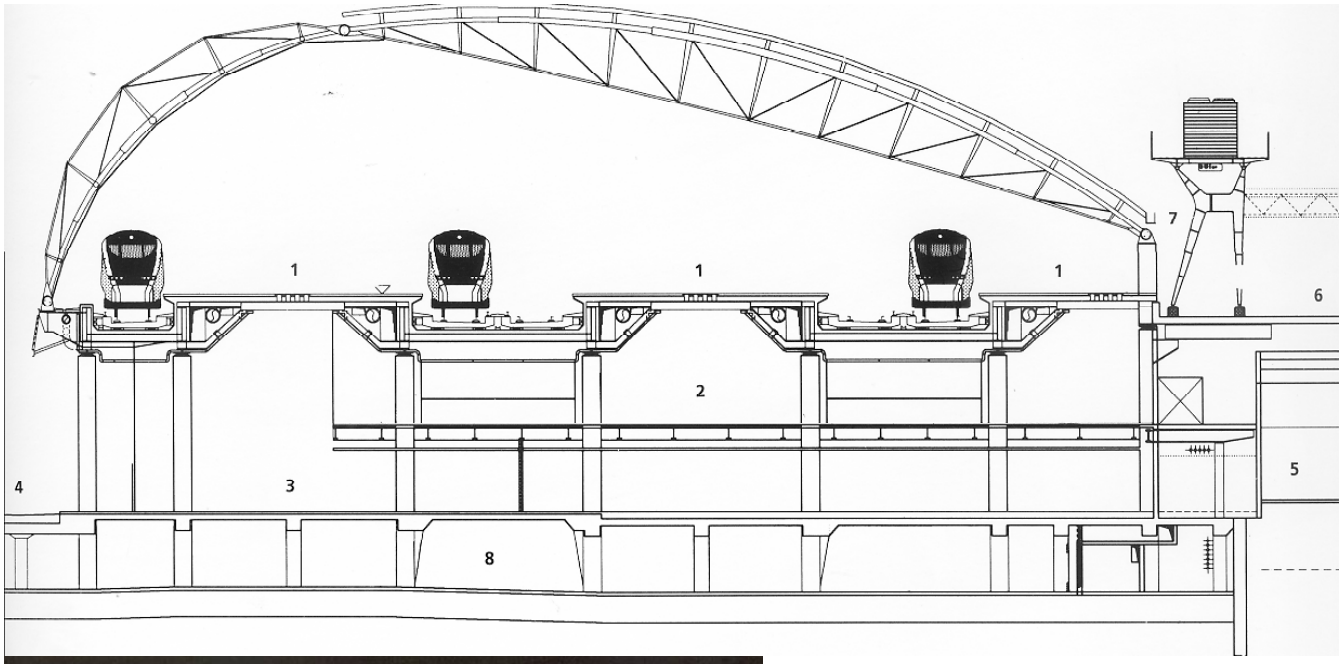
One entire bay of the roof was fully built with glazing and cladding, and was erected at Yorkshire. The exercise proved invaluable as a means of validating the performativity of the design idea and as a learning tool for erection crews, as well as a pretext for an office outing.

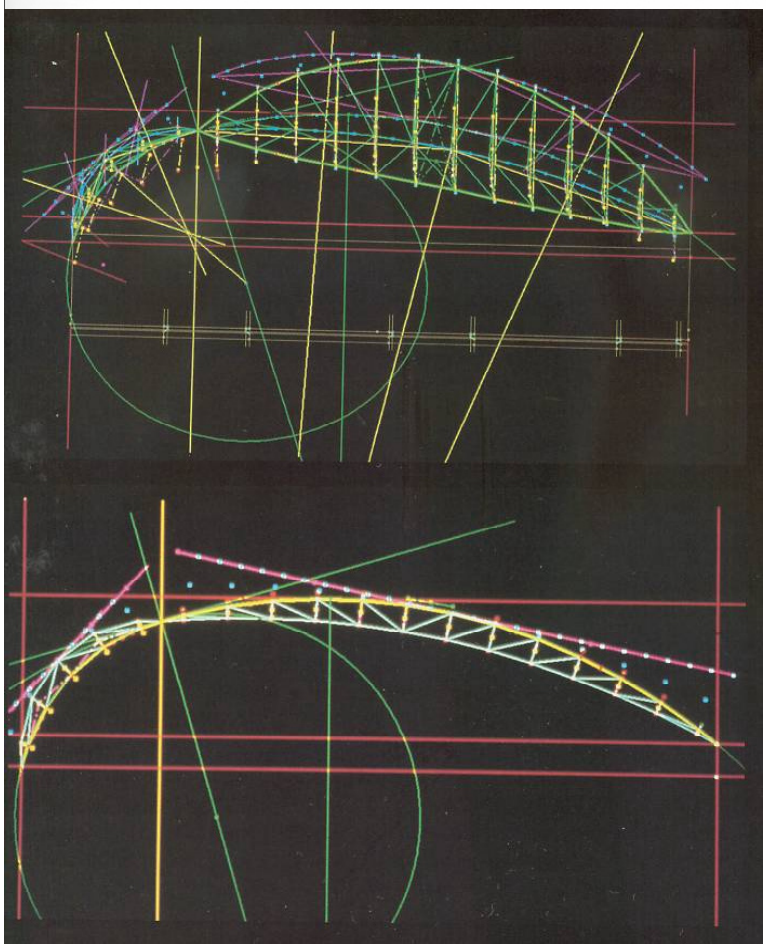
In design of this building a considerable amount of time was spent looking at the manufacturing of the constructs as ideas were developed. This was done by making a series of models as a way of visualizing and understanding the space and structure.

A considerable amount of time was spent designing a single component, specifically a joint element that could pick up the skin anywhere in space. The overall effect is the creation of an organic and fluid architecture. Although the entire roof glazing is made out of rectilinear pieces of glass and tubular elements, the design of the individual elements allow for the creation of a very coherent and performative whole.

Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

CASE STUDY TWO – Channel Tunnel Terminal at Waterloo- Nicholas Grimshaw





The reverse compression and tensile elements are used to invert the relationship of interior to exterior structure.

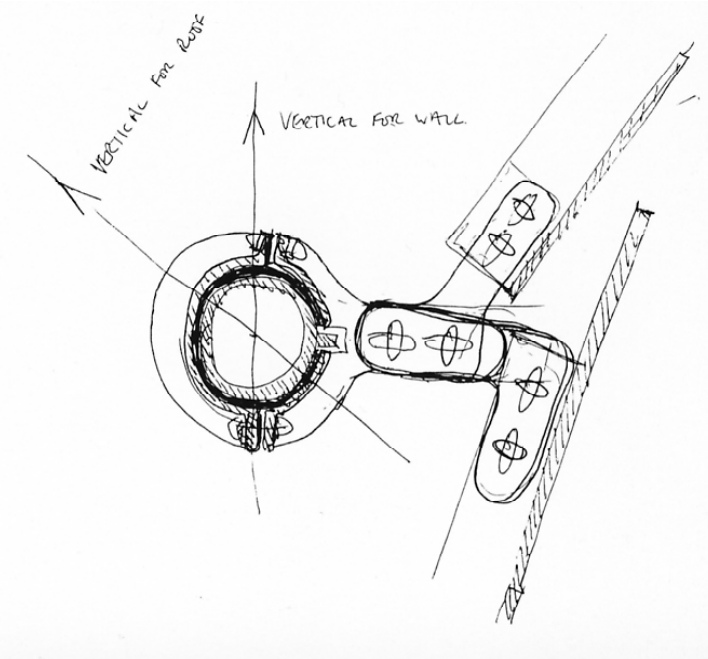
The final roof form is the result of a performative design concept; a three-pinned arch, with its central pin displaced to one side, reflects the asymmetrical configuration of five tracks and three platforms. The tension cord is on the inside of the major truss, and then on the outside of the minor truss, flipping over at the point of contra-flexure. The complex geometry of the roof structure was mastered using computer assisted design.

Designing the building's DNA

Photo credit:
Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

CASE STUDY TWO – Channel Tunnel Terminal at Waterloo- Nicholas Grimshaw

Views of prototype assembly of the stainless-steel rotating arms for the glazing structure



Early Grimshaw's sketch of the glazing overlap detail

Conceptual sketch exploring the form of the glazing bracket

Designing the building's DNA

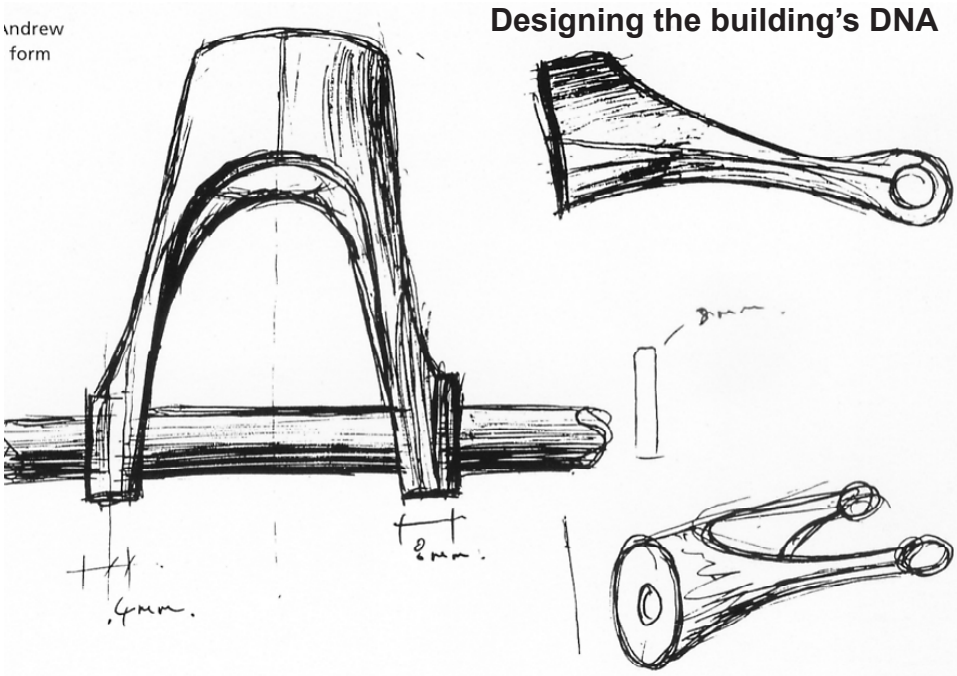


Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

The problem was how to create a glass envelope that could move and snake around the irregularly shaped site; the solution was to keep all of the glass as a set of standardized rectilinear sheets, and design individual elements that would create the whole (the concept of DNA). The joint is the key element that allows the different geometries to be used by letting each sheet slide, like the scales on a snake's skin.

CASE STUDY TWO – Channel Tunnel Terminal at Waterloo- Nicholas Grimshaw

Waterloo's performative approach in resolving the challenges of adapting to the site has been unique and innovative. The design solution includes a tapering span and narrow sinuous plan which is an ingeniously engineered response to the site and track layout. The complexity of the roof structure, which curves in two directions, necessitated 229 different sizes of glass sheets out of a total of 1680 used --yet much more would have been required if a tight carapace had been adopted instead of a loose-fitting skin.

The roof glazing is made out of rectilinear pieces of glass and tubular elements meandering through the site.

Grimshaw's early sketch explores the organic, asymmetric properties of the station vault.

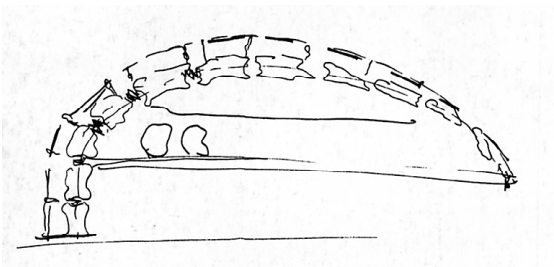
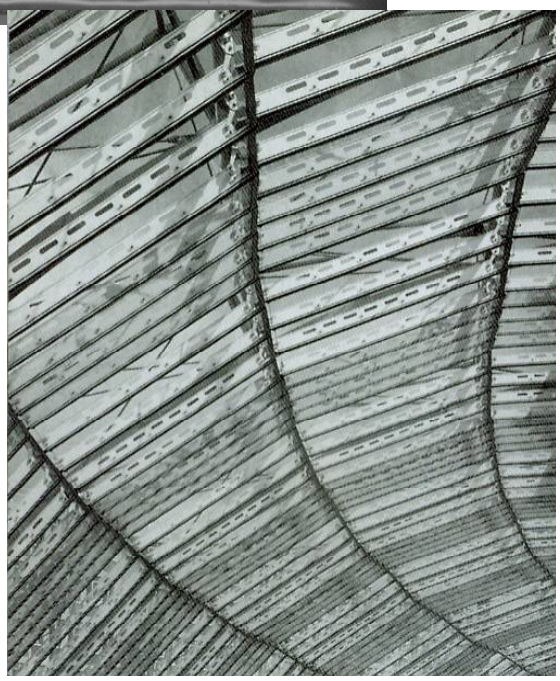


Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

CASE STUDY TWO – Channel Tunnel Terminal at Waterloo- Nicholas Grimshaw

The performative construct of the vault spans 48.5 meters at its widest point, reducing to 32.7 as the track narrows.



Detail of the station canopy, an ingenious work of art and tectonics, and a performative design DNA. Rectangular sheets of glass, overlapping at the top and bottom like roof tiles, are joined at their sides by concertina-shaped neoprene gaskets that can flex and expand to accommodate the curved configuration.

Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

2.2.2.1 Performative Paradigm and Characteristics: Train Station at Waterloo

The Train Station at Waterloo is a true process-driven design that has fully risen out of its site with a tapering span ranging from 50 m to 35 m. The building possesses the capacity to reformat itself with the utmost fluidity and dynamism. It is an architecture design of great technical innovation for a performative roof, in that the building has been allowed to reach its highest level of functionality. The building has been charged with performing an active or utilitarian. This is partly due to the asymmetry of the trusses.

Trusses derive their elegance partly from the inversion of their structural geometry. At the same time, trusses also derive their elegance from their tension and compression members and their tapering. This allows the members to respond to the distribution of forces in each truss with the utmost economy in the application of materials. This innovative solution for the irregularity of the site has been the design of a roof consisting of grid panels that can adjust themselves similarly to the scales of a snake. They are joined at their sides by concertina-shaped neoprene gaskets, which can flex and expand to accommodate turns and varying widths. Another performative aspect of the train station design is the admittance of natural light through the glazed western wall and by the generous hollowing out of spaces in the confined section. Services and shops are concentrated under the deep structures that carry the tracks, while leaving more space under the platform for circulation. Thus, the roof enclosure has turned out to be a fully performative enclosure for both daylighting and the creation of the most generous space within the interior. The transparency of the enclosure has added a new dimension to the performativity of the interior space, and has captured the most spectacular view of the park and river. Waterloo station is undoubtedly a customized building design from the molecular level of the building to all other levels, components and systems of its construct. Space has the capacity to unfold itself in an indeterminate way. This is in contrast to the fixity of the pre-determined programs, actions, events and effects. It is an architecture of morphogenetic practices, dealing very efficiently with the flows and forces of its context. The designers of the station sought a great deal of assistance regarding the performance of the building structure and enclosure through the usage of modeling and rapid prototyping. Undoubtedly, this is an architecture that is constantly re-organizing itself and undergoing continuous transformation, adaptation, and changing conditions. It is a performative design that has adapted well to the building's intended use and expectations, as well as to its contextual circumstances. The glass of the western wall has to form a weatherproof barrier while accommodating civil engineering tolerances and deflections of up to 6 mm caused by moving trains. Its panels are held together by the most sophisticated stainless steel castings, which allow them to have substantial movement in all three dimensions.

The performative design of Waterloo station is the reflection of its purpose of fusing man with environment and its contextual circumstances. It is an intriguing artifact, but one that could not have been pre-ordained. Grimshaw's performative design of Waterloo Train Station is based on the architect's *modus operandi,* which is conducted with teamwork activities, experiments, trial and error, use of computer simulations, as well as client participation. It is a product-driven approach that revolves around the appreciation of manufacturing and tectonics, as well as the art of detailing. The form of the building evolved, while arriving at the right choice of the engineering system and material and methods of construction. From the stand point of performativity, the building can be evaluated as part of a dynamic and living system. The construct is thus a biosphere with technical, social, and even financial functions.

Performative Paradigm and Characteristics: Train Station at Waterloo

The highlight of the performativity aspect of this design is the creation of the opportunity for an architecture to emerge out of its DNA constituents, while maintaining the potential to transform, transcend, digress and/or simply move from one state to another in the continuum of time and space. In addition, it would allow for different types of morphing encounterment. For obvious reasons it shares vision with sustainability.

Lessons Learned:
The Train Station at Waterloo offers Important Information:

• About the creation of a biomorphic architecture, which is an ingenious engineered response to both site and track layout.

• About the development of a DNA construct that allows for different geometries of the enclosure panels to slide side by side. At the same time, the creation of an innovative DNA construct provide an opportunity for the building to transform and change shape as the site situation demands. This is a great learning experience about an architecture that has the capacity to unfold itself in an indeterminant way.

• About customization of a building from its molecular level to the whole.

• About performative roof enclosure with the highest level of functionality.

• About when skin and structure become an ingenious work of art.

• About a harmonious marriage of architectural form and structure.

• About the use of full-size prototype models for daylighting experimentation, flexible detailing of the enclosures, and computer simulations.

• About a challenging morphogenetic practice, which has been able to efficiently deal with the flow and forces of its context.

• About an efficient fusion of man with environment

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2.2.3 CASE STUDY THREE - British Pavilion - Seville - Nicholas Grimshaw

View from the north-east

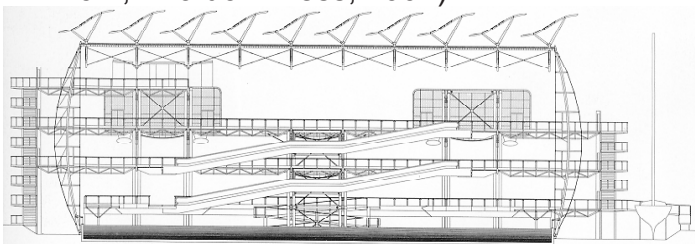
The design of the building enclosure was based on the design of DNA for the building that could be expanded to the whole of its architecture.

The most ingenious performative concept of this building is using sun to cool the building. The architectural construct of the building is a true marriage of art and science for the purpose of fusing man with environment.

The project involved a program for creating an environment suited for an expo while demonstrating a high degree of sustainability in the most intense climate.

The building enclosure was designed to temper and control the environment with a number of highly conditioned pavilions that provide flexibility of use for the exhibitions.

Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).



CASE STUDY THREE - British Pavilion - Seville - Nicholas Grimshaw

Designing the building's DNA

In the design of this building William Pye, the sculptor, was also involved in the development of the project's sculptural elements. He turned the water into droplets, which visitors could hear falling down as they walked through the space – they actually hear, see and understand what is cooling the building.

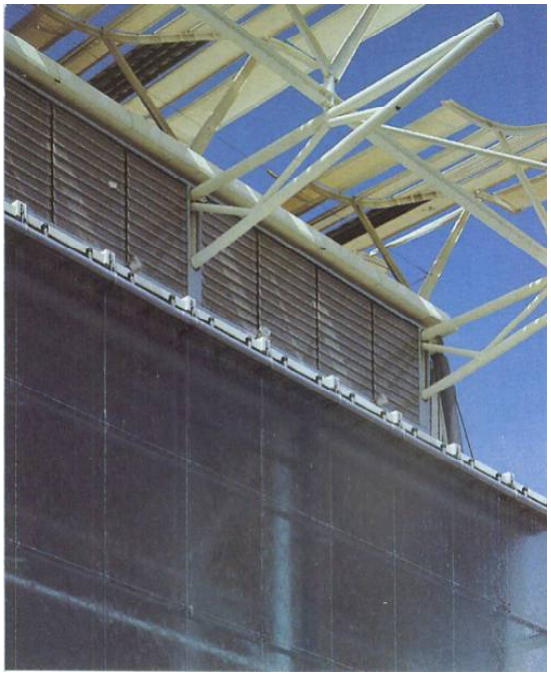
Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

The water wall, powered by the solar panels on the roof, creates two zones of coolness: outdoor for visitors awaiting admission as well as indoor.

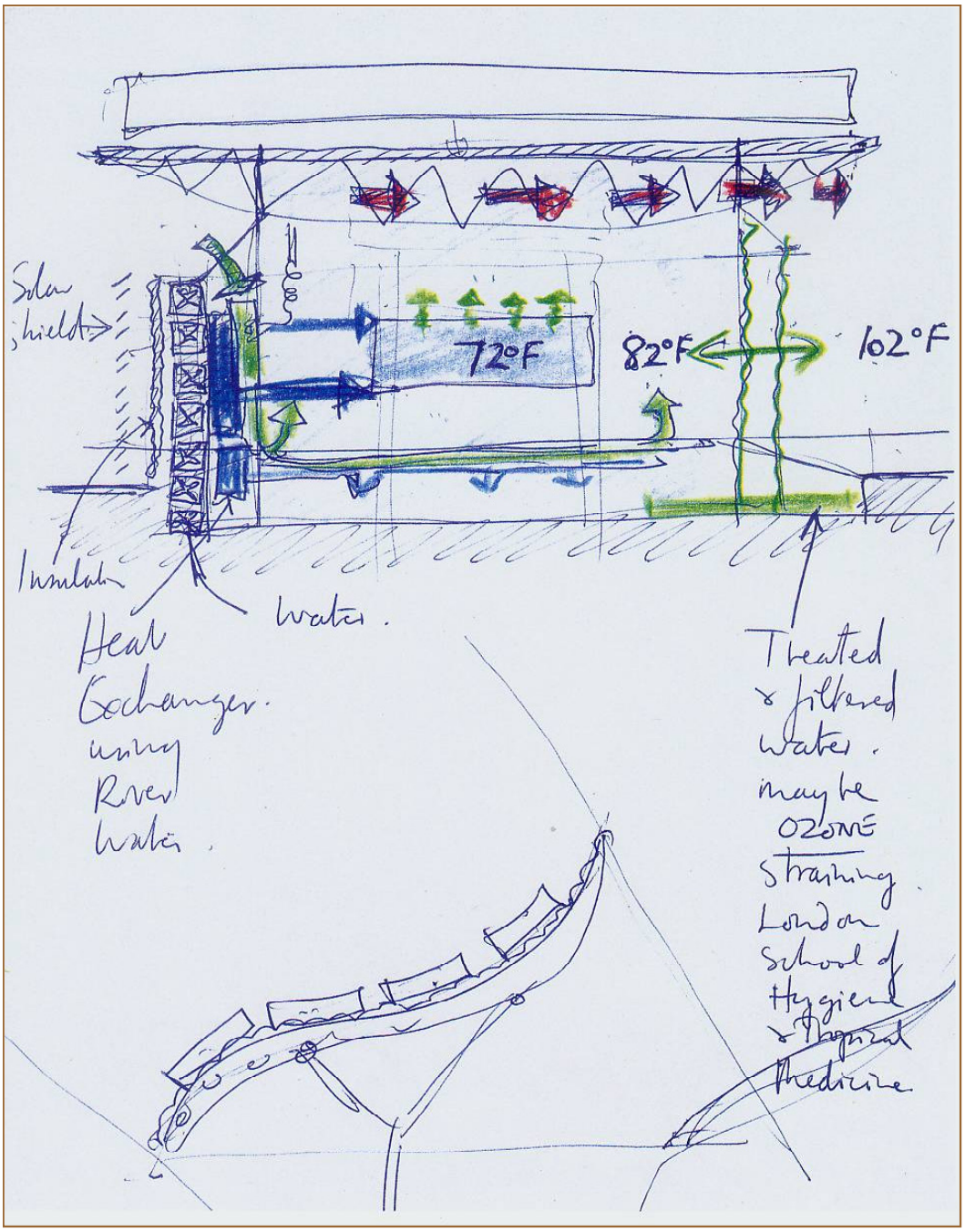
The roof is covered with photo-voltaic cells and together with the fabric sails shields the enclosure from the heat. The resulting generated energy pumps water and pour it over the glass, for moderating and lowering the temperature and keeping the building cool.

A reasonable thickness of water absorbs almost all the infrared (heat) components of light, while still allowing the rest of the visible spectrum into the building.

The idea of functional performance is manipulated further in its most innovative ways, to give the space exceptional qualities that warm or cool the senses.



Designing the building's DNA



Grimshaw's sketch demonstrating a passively moderated space between the extreme outside temperature of Seville, and the air conditioned pods within. The sketches reveal the inception of the performative concept started at the early stages of the design of this project.

Photo credit: Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

Designing the building's DNA

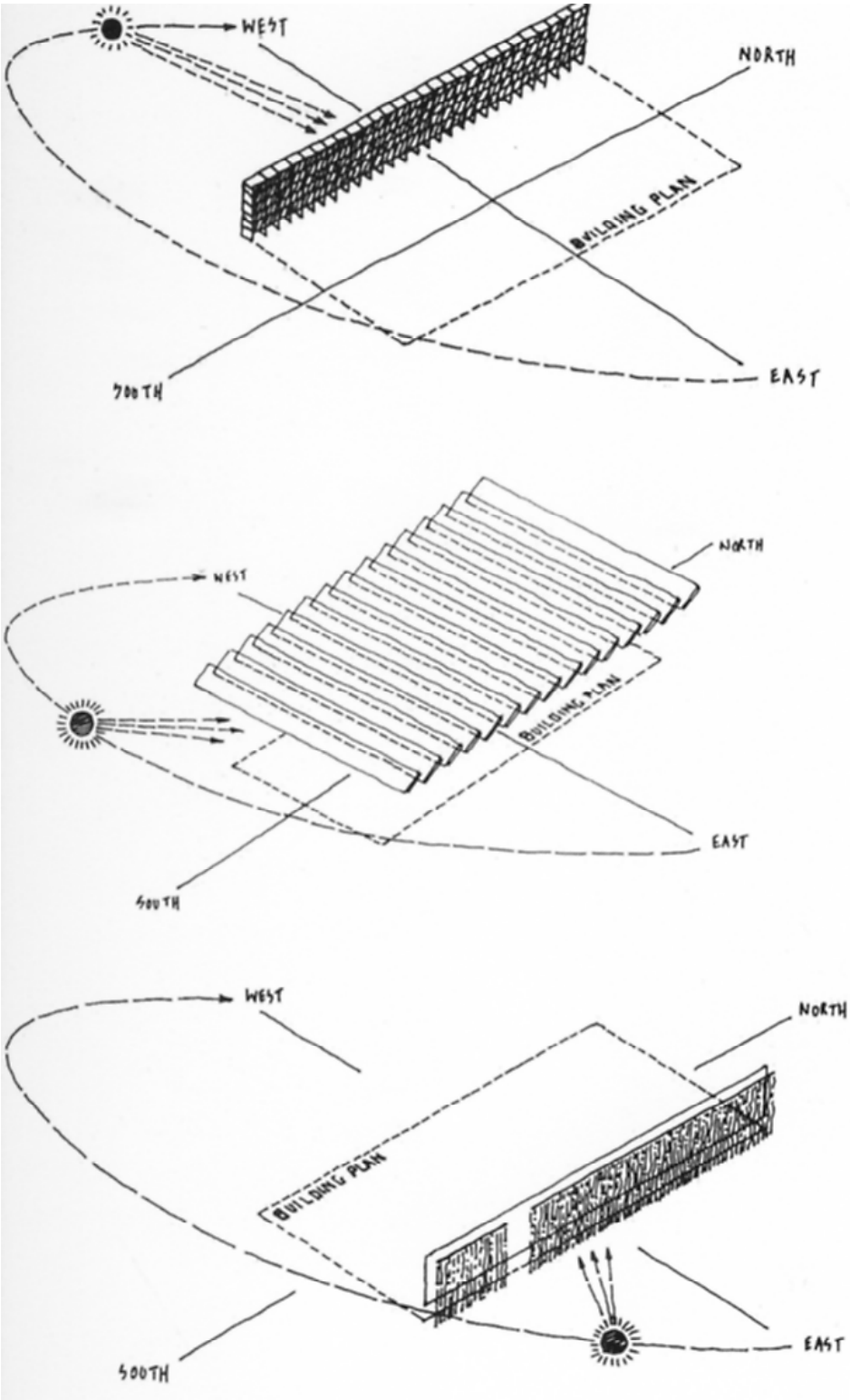


Diagram showing different surfaces of the building in response to the orientation of the sun. The performative enclosure was ultimately developed as the result of ecological and climatic analysis and studies.

Photo credit:

Powell, Kenneth, & Moore, Rowan, Structure, Space, and Skin, The Work of Nicholas Grimshaw & Partners (New York, Phaidon Press, 2001).

2.2.3.1 Performative Paradigm and Characteristics: British Pavilion - Seville

The British Pavilion's design involves technological, cultural, and socio-economic concerns, which are meant for the creation of a web of technology and space that constantly affects each other. According to Grimshaw, the main theme of the design for this building was "climate" and "energy." The British Pavilion is an affirmation of technology, but is mainly about the demonstration of its more environmentally benign applications. Except the foundation, it is an entirely prefabricated building that harnesses its contextual resources of water, air, and sun. The building acts as a container with a fully flexible interior, which accommodates the freestanding exhibition pods within its large single volume along with the shading louvers on the roof. Therefore, it is a true process-driven design that has the capacity to constantly reformat itself. Architecture involves fluidity and dynamism, while its construct has allowed it to reach the highest level of functionality. The architecture of the British Pavilion has reached a state of fulfillment in its active or utilitarian condition of performance. This type of architecture has the capacity to unfold itself in an indeterminate way. This is in contrast to the fixity of the pre-determined program, actions, and events that take place within its interior.

As a fully sustainable, energy-conscious design, the building has been able to perform well in creating cool indoor and surrounding outdoor spaces. This is accomplished without the consumption of large quantities of energy. The performative and intelligent enclosure (roof and facades) has allowed the skin of the building to actively take charge in working with the sun and other natural elements. The result is the creation of pleasant spaces within the building. The architecture of the British Pavilion was customized from the molecular level of the building to all levels, components and systems of the construct. This is accomplished through the usage of modeling techniques, rapid prototyping, and diagrams that show different surfaces of the building in response to its orientation to the sun. It is truly an architecture of morphogenetic practices, which deals with the flows and forces of nature.

The most performative aspect of the architecture of the British Pavilion is the water wall running down the glass, which acts as a device paradigm for performativity and a curtain of "free-falling rain." The environmental role of the water wall is to create two zones of coolness powered by solar panels in the roof. In reality, the building is seeking help from the sun for cooling down the building. Additionally, the S-shaped shades carry the solar panels while keeping the sun away from the sheet-metal roof. The western wall receives sun during the hottest part of the day, while stacks of shipping containers filled with water provide the thermal capacity and the ability to absorb heat. This task would normally be achieved through the use of masonry. On the north and south walls, another traditional concept is imported into the technology. PVC-coated polyester fabrics, made in a manner similar to that of yacht sails, are fixed to bowed steel tubes by luff grooves. This action is reminiscent of sails being fastened to masts. On the south side, a second layer of sail cloth in the form of angled louver-like strips provides additional protection from the sun.

Undoubtedly, the architecture of the British Pavilion is constantly self-organizing and undergoing continuous transformation, adaptation, and change. It is a product-driven approach to architecture design, revolving around the appreciation of manufacturing and tectonics, as well as the art of detailing. The building has adapted well to its intended use and expectations and also to its contextual circumstances. The form and vocabulary of the building evolves through, while arriving at the right choice of the engineering system and material and methods of construction. The development of the performative building can be evaluated as part of a dynamic and living system. Thus, the construct becomes a biosphere with technical, social, and even financial functions.

It is truly an ingenious performative design that has been able to respond well to climatic influences. There was no predetermination in the development of its morphogenetic construct. It only evolved through methodical and thoughtful analysis in response to climatic factors.
The design of the British Pavilion is the creation of an opportunity for a building's architecture to be able to transform, transcend, digress and/or simply move from one state to another in the continuum of time and space. At the same time, different types of morphing encounterment along with shared visions of sustainability have all been involved the architect's *modus operandi*.

Lessons Learned:
The British Pavilion offers important information:

- About environmentally benign applications of technology.

- About using the sun to cool a building.

- About performative responsive facades and surfaces of the building that react according to their orientation to the sun.

- About a passively moderated design that is efficiently working between the extreme outside temperature and the air-conditioned pods within.

- About creating innovative zones of coolness for the outside and inside of the building. This is accomplished by the usage of the element of water as the moderator (water wall).

- About the usage of PVC-coated polyester fabrics made in a manner similar to that of yacht sails. This is an example of yet another thoughtful concept imported into the arena of building technology.

- About creating performative architecture. The result is essentially a technical biosphere, which has created a successful precedent in fusing man with environment.

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Case Studies

Thomas Herzog

Development of Performative Forms

2.3 About Thomas Herzog – Herzog and Partners' Performative Architecture

There are a lot of lessons to be learnt from nature, especially with regard to the efficiency, performance, adaptability, variety and tremendous beauty which most organisms display under close observation. Considering that nature has to obey the same physical laws as man-made objects, this should be seen as very encouraging for us, making it worthwhile to study its principles and mechanisms.

Thomas Herzog
Green Questionnaire
Green Architecture

Thomas Herzog's architecture has unique performative qualities and approaches as outlined below:

Herzog's architectural forms are, in general, not predetermined but created.

The projects imbue a special aesthetical quality, and are a thoughtful integration of the poetics and tectonics of architecture.

Herzog emphsises the development of an overall composition that includes building structure and the surrounding context and public spaces in order to achieve optimal harmony in the architectural design.

Herzog, in collaboration with research institutions and universities, has been able to develop new and innovative concepts and prototypes of building systems and components. The development of performative forms is the *modus operandi* of Herzog's architectural practice.

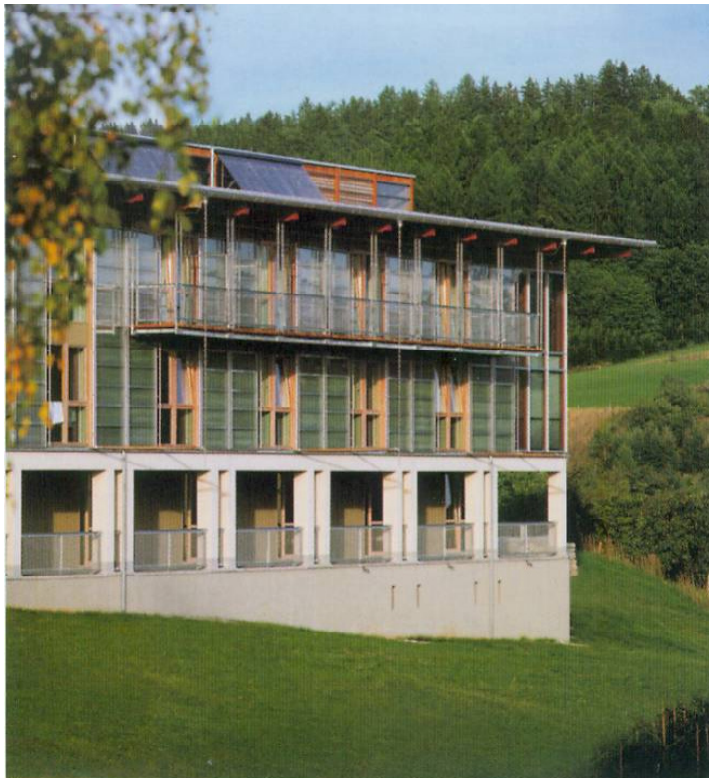
He has been using physical models and computer simulations to investigate the effects of architectural form and constructs, the siting of the building, and the role of the enclosure in the production of passive solar energy for heating, cooling, ventilation, power generation and comfort.

He has conducted extensive research on the design of "intelligent building" systems.

Herzog has also been involved in research for the development of renewable energy sources and sustainable building products. In 1995 he drafted the European Charter for Solar Energy and Planning, which was supported by the European Commission, in setting new objectives for energy use in architecture, planning, product development, materials, and supply systems.

Herzog's buildings are thoughtful resolutions of functional, aesthetic and ecological concerns. Nicholas Olsberg, director of CCA, refers to Herzog's architecture as follows: "they look on from the threshold between the fanciful and the scientific, the playful and the reverent, the material and the metaphysical" (*Herzog and De Meuron, Natural History 8*).

2.3.1 CASE STUDY ONE - Youth Education Center, Windberg, Germany - Herzog



Top: South-facing facade, cladded with translucent thermal insulation. Bottom: East face
Photo credit: Kolarevic, Branko, & Malkawi, Ali M., Performative Architecture, Beyond Instrumentality (New York, Spon Press, 2005)

The design of the Youth Education Center mainly revolves around the allocation of interior spaces. The exterior vocabulary and choice of the materials are divided into two sections, which are based on the north and south exposures of the building. The south tract houses, the lounge areas, and the bedrooms are identified with broad full height glazing for view and sun exposures. It is a direct exploitation of solar energy and daylighting strategies for heating and lighting the spaces.

Opaque areas of south-facing external walls are clad with translucent thermal insulation, which allow solar radiation to pass through while minimizing thermal losses. The south-facing external wall is thus heated during the day and passes on the thermal energy to the internal spaces after an interval of five to six hours, beginning in the early evening.

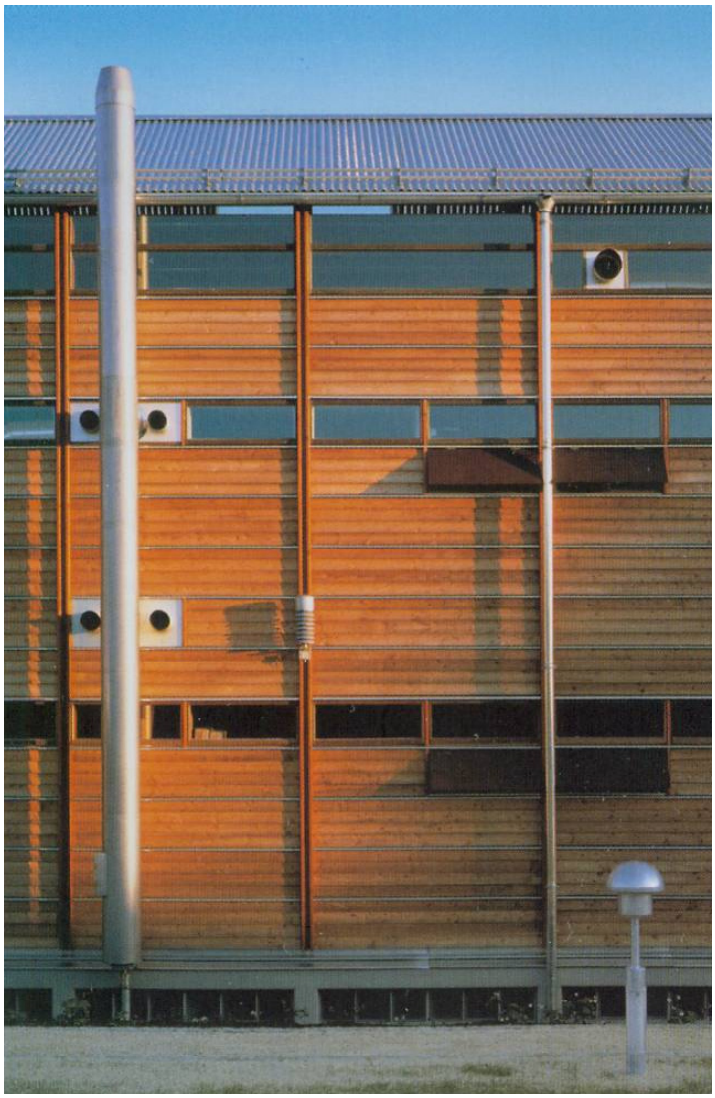
During the night when external temperatures are at their lowest, the outer wall functions as an inward-facing solar heating area. During the summer months, overheating is prevented by the broad roof's projection and external louvered blinds.

The nature and duration of the use of the various groups of rooms plays an important role in determining the energy concept for the building.

Part of the teaching program of the youth education center is to make the functioning of the building comprehensible to the young guests. This is done by providing them with an insight into the use of environmentally sustainable forms of energy through "passive" and "active" construction systems. However, mechanical installations also play a role in the energy balance as well.

The architectural effect of the newly developed south-facing heating wall is immediately visible in the facade, while also being tangible internally.

CASE STUDY ONE - Youth Education Center, Windberg, Germany - Herzog



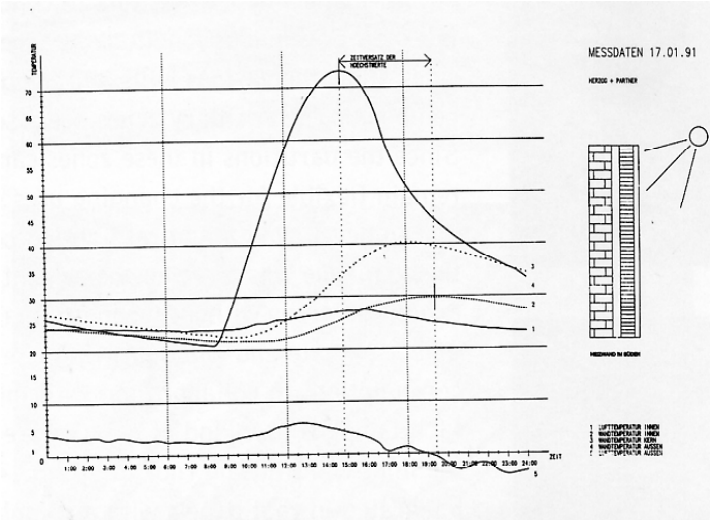
Timber boarded front facing the village

The northern tract contains the sanitary facilities and storage spaces, as well as the circulation route through the building. These spaces are distinguished by the fact that they have a generally lower average temperature. This is the result of using them for only short periods of time during the day.

In the shower rooms, a higher temperature level is required for only two to three hours a day. This tract was therefore equipped with a quick functioning warm-air heating system. To minimize heat losses through ventilation, a heat recovery unit was installed in the attic space.

The hot water supply is provided largely from solar energy by means of vacuum-tube collectors on the roof.
On the south-facing heating walls, the service lines, solar storage units, and collectors are exposed to the view. There is also a display panel, which is installed in the entrance area and shows changes in the temperature.

Photo credit: Kolarevic, Branko, & Malkawi, Ali M., Performative Architecture, Beyond Instrumentality (New York, Spon Press, 2005)



On the left is the temperature curve of the south-facing external wall on a clear January day. The temperature curves is of the external wall with translucent thermal insulation on a cold winter day with high insolation levels. The time lag between the absorption of solar heat and its release into the rooms is clearly recognizable. The inner surface of the wall reaches its maximum temperature towards 7:30 p.m., in other words, long after sunset. The wall continues to give off heat into the rooms until well into the night.

2.3.1.1 Performative Paradigm and Characteristics: Youth Education Center

The Youth Education Center is a true process-driven design, with a focus on energy and human comfort. The architecture vocabulary is the result of an analytical design process, which is based on the choice of the materials for different orientations and allocation of different interior functions to different exposures of the building. The design has charged the building with the capacity to reformat itself with a great deal of dynamism and functionality as the situation demands. The type and duration of the use of the different groups of rooms within the interior spaces has played an important role in determining the energy requirements of the building. The rooms that are used for longer periods of the day are separated from those that have shorter durations of use. For the same reason, two separate sections of the building meant for respective day and night usages have received different material treatments and constructs. Their treatments are appropriate to their particular use and function. The southern tract houses, the lounge areas, and the bedrooms have a more attractive view of the outside landscaping through their broad glazings. Undoubtedly, there is a direct exploitation of solar energy and daylight strategies for the heating and lighting of the spaces, particularly for the section that does not have daily usages. It is an architecture design in which each of the building spaces has been allowed to reach its highest and most efficient level of functionality. Each of the building spaces also attains a state of fulfillment in its active and utilitarian state of performance.

The different facades of the building are designed with appropriate performative and intelligent enclosures, which are based on their various exposures. The skin of the building is actively taking charge in working with the sun and other natural elements for providing comfort within the building. Additionally, certain building devices have been used as tools for performativity. Their operations are controlled by certain manual, electrical, mechanical, or digital mechanisms in order to modify, acclimatize, and mediate the environment, human behavior and comfort.

In the Youth Education Center, the architecture of the building is used as a guiding tool towards providing insight in to the use of environmentally sustainable forms of energy. This includes passive and active systems as well as the mechanical installations that play a vital role in the energy balance of the building. It is an architecture, which is constantly self-organizing and undergoing continuous transformation, adaptation and change in response to the nuances of nature. It is also an architecture of morphogenetic practices that deal with the flows and forces of its immediate context. The formation of the architecture has been through the usage of 3-D modeling and rapid prototyping. The building has adapted well to the programmatic requirements and expectations, as well as to its contextual circumstances. The architecture effect of the newly developed south-facing thermal wall is immediately visible from the facade and is directly sensible internally. Thus, the building can be evaluated as part of a dynamic and living system. It is thus a biosphere with technical, social and even financial functions. It is a product-driven approach revolving around the appreciation of manufacturing and tectonics, with a focus on intelligent building enclosure.

The development of performative form, especially the performative enclosure, was the architect's main *modus operandi.* This was implemented place through teamwork activity, experiments, trial and errors, use of computer simulation, and client participation. The architecture design of the Youth Center is definitely process based and not pre-ordained or predetermined one. The form and vocabulary of the building have evolved, while arriving at the right choice of the engineering system and material and methods of construction.

CASE STUDY ONE - Youth Education Center, Windberg, Germany - Herzog

The performative construct of the Youth Education Center has created an opportunity for the building architecture to be able to transform, transcend, digress or simply move from one state to the other in the continuum of time and space. This is accomplished by allowing different types of morphing encounterment to take charge of the building. Undoubtedly, the performativity of the architecture of the Youth Center has a shared vision with sustainability.

Lessons learned:
The Youth Education Center offers important information:

• About making the functionality of the building comprehensible to the users, while providing insight into the use of environmentally sustainable forms of passive and active energy systems.

• About creating a transparent effect by allowing the energy features and elements of the facades to become part of the architecture vocabulary. At the same time, these features are being expressed on different building elevations, particularly the south-facing thermal facade.

• About using the expected human comfort functionality of the various interior spaces as a criteria for establishing their energy requirements.

• About segregating long-period use spaces from short-term Spaces. This is done for the purpose of establishing different energy zones and thus, design according to the demands of each zone.

• About proper exploitation of solar energy and daylighting for the heating and lighting of long-term use spaces.

• About proper space planning by creating clusters or zones for interior functions of the building, as well as their allocation to different orientations.

• About the appropriate integration of technology in design and creating aesthetically pleasing technical building constructs. The result is an elaborate marriage of poetics and tectonics (i.e. an elegant trombe-wall system on the south-facing facade).

• About a truly intelligent and sophisticated building design from which to derive inspiration.

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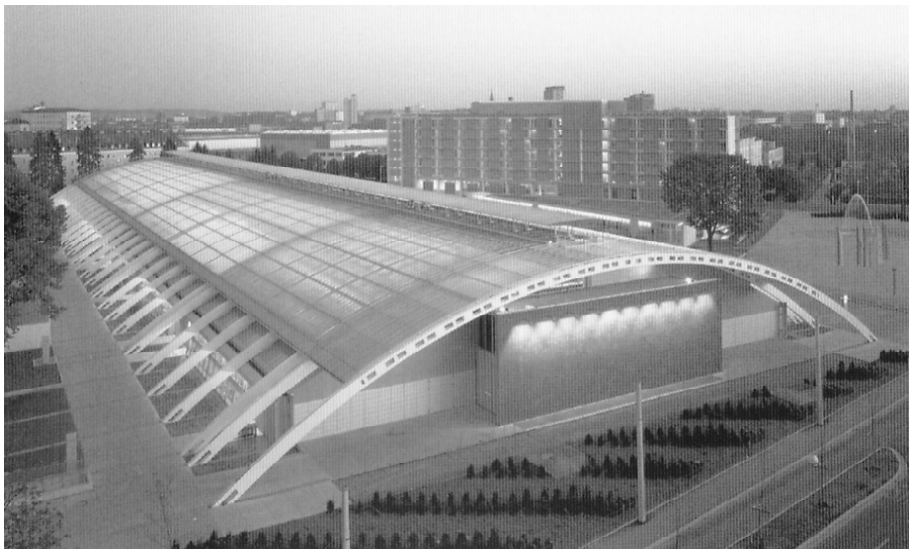
2.3.2 CASE STUDY TWO – Congress and Exhibition Hall, Linz, Austria - Herzog



Linz Exhibition Hall is a creation of an immense gestural architecture, which demonstrates Herzog's rigorous concerns for materials and how they are put together. The underlying factor in development of the program was **flexibility**.

Photos Credit:
Slessor, Catherine, Sustainable Architecture and High Technology, Eco-Tech (London, Thames & Hudson, 1997)

Detail of steel arch structure -- each arch is made up of four 900x600 mm box sections which were welded together on site and finished with an epoxy paint treatment.

The architecture vocabulary of the Linz Hall incorporates the rhythm created by the exposed steel arches. Meanwhile, the structure is articulating the monolithic volume of the barrel vault that is situated amid nondescript surroundings. The Exhibition Hall makes a powerful statement in its existing context. The performativity of this building initiates a strong association with the site and its ability to fuse man with environment.

One of the goals in planning the Linz Design Center was to reduce the interior volume to a minimum. The analysis of the interior volume resulted in limiting the height of the interior spaces to 12 meters. Since this height was not required everywhere in the hall, the roof structure was designed in an arched form with flat glazed coverings.

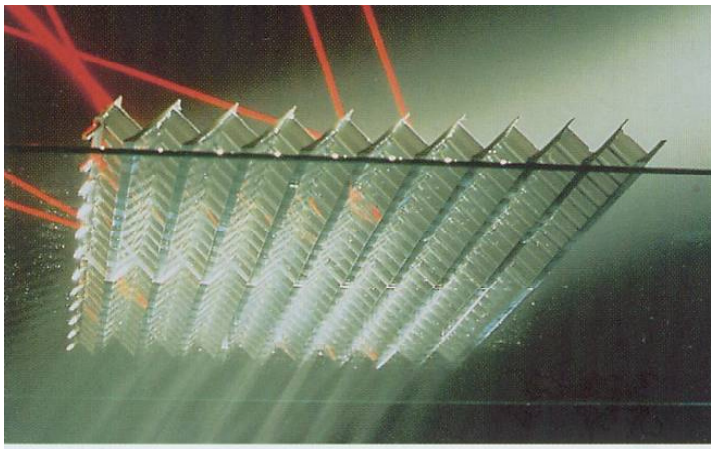
CASE STUDY TWO – Congress and Exhibition Hall, Linz, Austria - Herzog

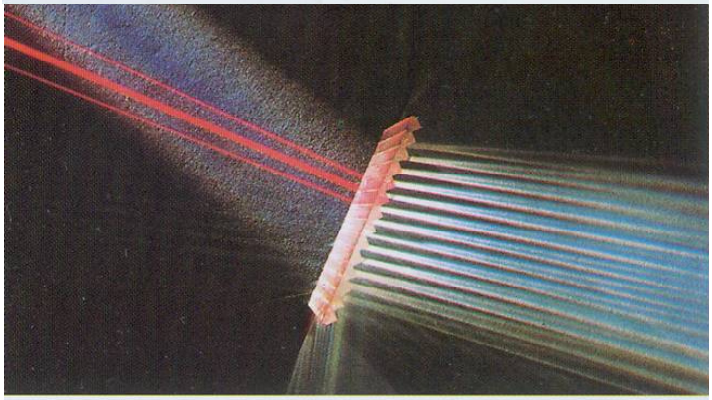
The performative approach to architecture design of this building involved a rigorous approach to choices of materials and their detailing. One of the main details is the detail of steel arch structure. Each arch is made up of four 900x600 mm box sections, which were welded together on site and finished with an epoxy paint treatment.

One main performative aspect of this building is controlling the excessive heat gain of the internal spaces in the summer, which is controlled by a 16-mm deep retro-reflecting grid thinly coated with pure aluminum, and inserted into the cavity between the panes of the double-glazings over the roof.

Photos Credit:
Slessor, Catherine, Sustainable Architecture and High Technology, Eco-Tech (London, Thames & Hudson, 1997)

CASE STUDY TWO – Congress and Exhibition Hall, Linz, Austria - Herzog





The translucent volume of the Exhibition Hall.

Another performative aspect of this project is the admittance of natural light, which is filtered through specially developed glazed roof panels containing grids that diffuse natural light.

In collaboration with Bartenbach LichtLabor, a new kind of building element was developed for the light transmitting roof. A plastic grid was integrated in roof panels with a complex performance, allowing indirect luminous radiation from the northern hemisphere of the sky to enter the building, while direct sunlight is screened off.

Left: a simulation of the light transmitting roof.

The combination of the vault's sleek transparency and precise detailing has created a functional, monolithic form, with a high level of refinement. Natural light is exploited as much as possible to avoid reducing the interiors to featureless large spaces. Like a huge greenhouse, the building is covered in glazed panels that were specially developed for the project.

A performative detail, consisting of a sandwich of two insulating glass sheets, encloses a 16-mm thick retro-reflecting grid while enabling the indirect light to pass through the panel. Direct light is blocked, so the effects of overheating and glare are minimized.

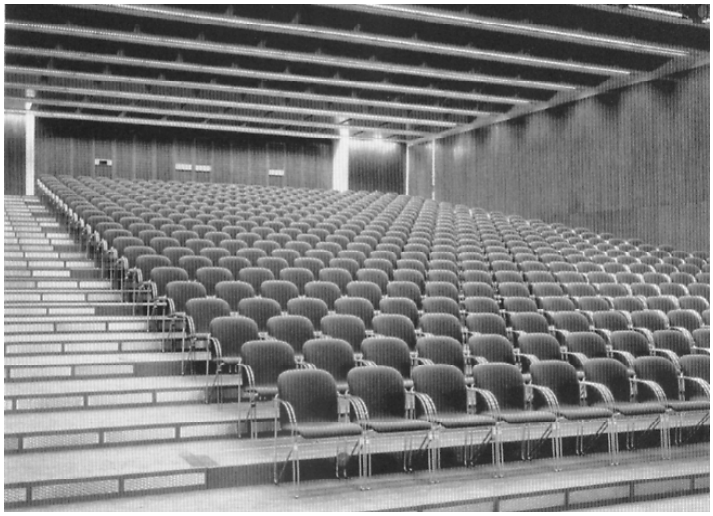
Left: Steel girders framing the roof structure

Photos Credit:
Slessor, Catherine, Sustainable Architecture and High Technology, Eco-Tech (London, Thames & Hudson, 1997)

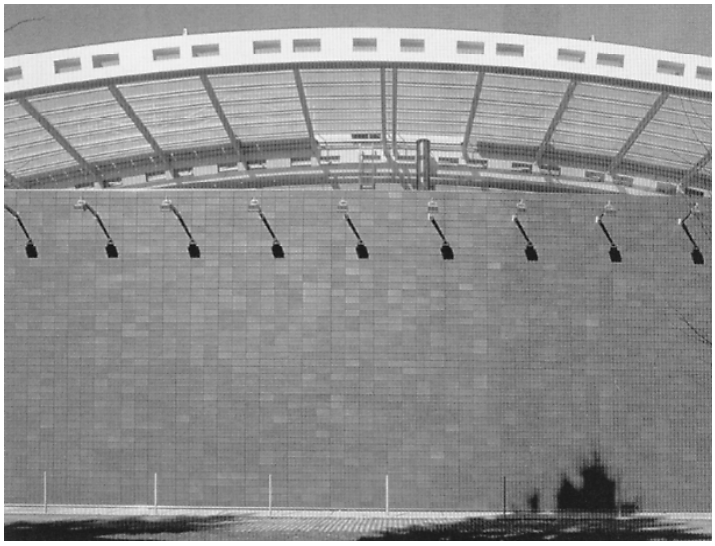
CASE STUDY TWO – Congress and Exhibition Hall, Linz, Austria - Herzog

A performative space planning, the points of access are laid out in such a way that visitors to concurrent events do not interact.

Continuous longitudinal access routes along both sides allow the various halls and the gallery space to be combined. The ancillary zones are also laid out in linear form. Since the partitions in these zones can be moved, the spaces remain flexible for the changing uses.



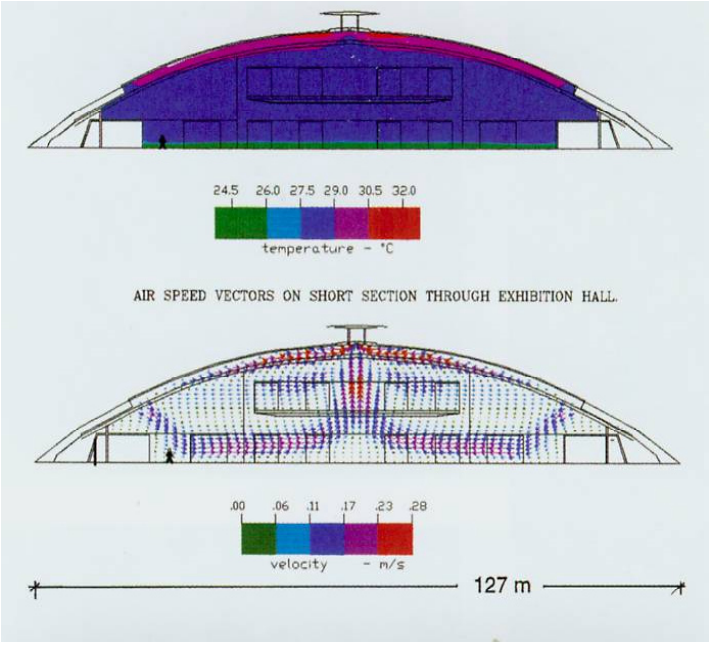
The Congress Hall



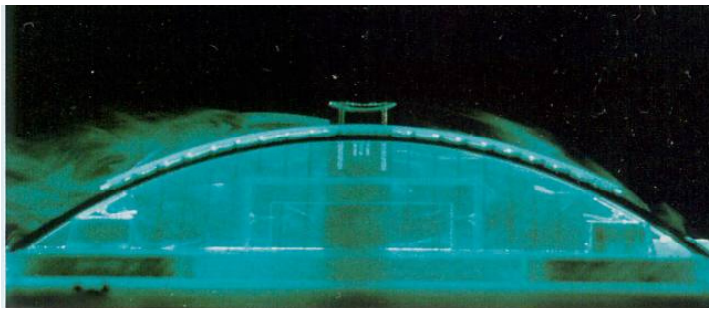
End wall with clay-tile facade

Photos Credit:
Slessor, Catherine, Sustainable Architecture and High Technology, Eco-Tech (London, Thames & Hudson, 1997)

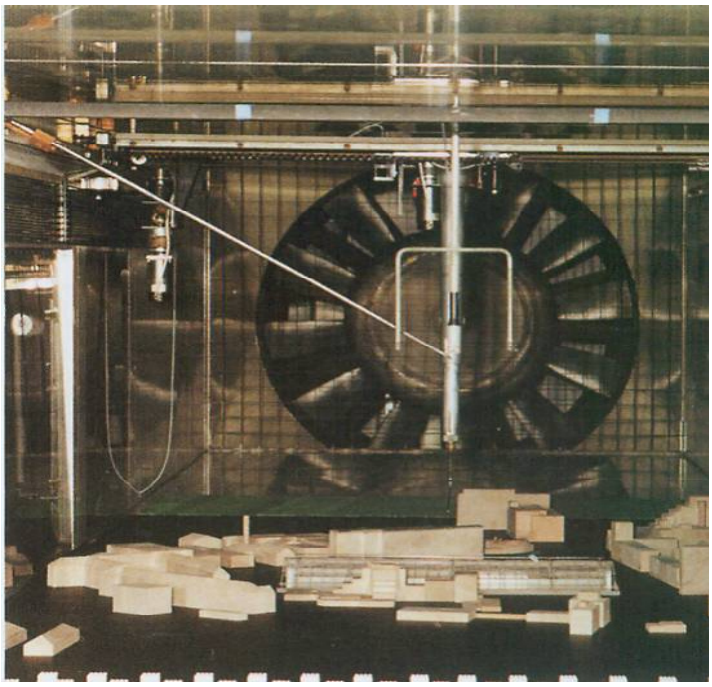
CASE STUDY TWO – Congress and Exhibition Hall, Linz, Austria - Herzog



Performative design process involved modeling and simulations of temperature curves and airflow patterns.



Performative design process involved simulations using the wind tunnel, as well.



The final performative construct of the ventilation flap and building envelope was determined in wind-tunnel test.

Photos credit:
Flagge, Ingeborg, & Herzog-Loibl, Verena, & Meseure, Anna, Thomas Herzog, Architecture & Technology (Frankfurt, Prestel, 2002)

CASE STUDY TWO – Congress and Exhibition Hall, Linz, Austria - Herzog

Another aspect of performativity is to address the challenges for air change in a building with a flat and deep volume, in which fresh air enters via floor inlets and ventilation flaps at the side of the hall. The warm air rises up, and the exhaust air escapes at the crust of the roof via a large and continuous opening that is fitted with closable louver flaps.

A 7-m wide element on the roof with a convex underside exploits the "Venturi effect."

The final form of the roof ventilating element was determined in wind-tunnel tests, as part of the project's adopted performative methodology of design.

The system is protected from dirt and pollution, particularly for the use of elements with sensitive and highly reflective surfaces for daylighting redirection. With an element such as the micro-grid and prism system, which works as an effective performative device installed into the cavity between insulated glazing, the cleaning and maintenance effort is potentially reduced even more, and the life cycle is increased.

In light of these developments, one sees that building envelopes are subject to changes in their technical functioning and construction when, in addition to performing their traditional protective role, they are required to control indoor temperature and the ingress of daylight.

Photos Credit:
Flagge, Ingeborg, & Herzog-Loibl, Verena, & Meseure, Anna, Thomas Herzog, Architecture & Technology (Frankfurt, Prestel,2002)

2.3.2.1 Performative Paradigm and Characteristics: Congress & Exhibition Hall

The Congress and Exhibition Hall is designed with the maximum flexibility of use for its interior spaces, while possessing a dynamic and fluid form. Its space-planning allows the Hall to entertain several events concurrently, while visitors of different events maintain their independence. The design of the hall reflects a program which involves technological, cultural, and socio-economical transitions. The ancillary zones are laid out in a linear form, while movable partitions allow for the flexibility of changing uses. It is an architecture design in which the building has been allowed to reach its highest level of functionality and state of fulfillment in both active and utilitarian conditions of performance.

The development of the natural lighting concept through the interactive transparent roof has provided excellent light quality in the exhibition areas. However, this is done without having to make sacrifices in the indoor climate, and without giving rise to excessive energy consumption. Therefore, the performative and intelligent roof enclosure allows the skin of the building to actively take charge in working with the sun and other natural elements, while creating comfortable spaces within the building. One performative aspect of the building is the usage of a building device in the light transmitting roof system. This is meant to control its operation by certain manual, electrical, mechanical, or digital mechanisms. A plastic grid integrated in the roof panels allows indirect luminous radiation from the northern hemisphere to enter the building. Direct sunlight is screened off and excessive summer heat gain is avoided in the internal spaces. The performative roof efficiently modifies, acclimatizes and mediates the environment. It has also affected occupant's behavioral, emotional and physical well-being. Thus, it is an architecture of morphogenetic practices, which focuses on the use of the flows and forces of the immediate micro-climate and surrounding context. It is also an architecture that is constantly self-organizing and undergoing continuous transformation, adaptation, and change.

The geometry of cutting the grid was determined by computer programs, while taking into account the angle of the sun's elevation, azimuth angle at various seasons, the orientation of the building, and the slope of the roof. The performative enclosure was designed as a process of testings and evaluations in addition to the usage of various simulation techniques. This included wind-tunnel simulations of temperature curves and airflow patterns. The final form of the building was determined in wind-tunnel tests. The development of the Venturi capping on the roof is another performative aspect of the form. During the heating period the warmed, used, and internal air rises to the top of the building, and then is borne by large ducts to a heat recovery plant. During the rest of the year the exhaust is allowed to escape at the crest of the roof via a large opening that is fitted with closable louver flaps.

The development of the performative form is Herzog's *modus operandi*. This is accomplished through teamwork activity, experiments, trial and error, use of computer simulation, and client participation. The architecture of the Hall has been process based and not a pre-ordained and predetermined form, and it was developed through close collaboration with manufacturers and consulting engineers. The form and vocabulary of the building evolved, while arriving at the right choice of the engineering system and material and methods of construction.

The building of the Hall through its interactive and performative enclosure can be evaluated as being part of a dynamic and living system. The structure is thus a biosphere with technical, social and even financial functions. Exhibition Hall provides an opportunity for a building architecture that is transforming, transcending, digressing or simply moving from one state to the other in a continuum of time and space. At the same time this allows for different types of morphing encounterment. In this architecture, there is a wide range of shared vision with sustainability and a fusion of man with his environment.

Lessons Learned:
The Congress and Exhibition Hall offer imoprtant information:

• About when science becomes a major contributor in developing the form and vocabulary of an architecture.

• About the building envelope, which in which addition to performing its traditional protective role, has the potential to control temperature and the ingress of daylight.

• About the use of scientific methods in architectural design and form making in order to provide adequate air change. The process starts when warmed, used, and internal air rises as a result of thermal buoyancy to the top of the building. During the heating period, the air is then borne by large ducts to a heat recovery plant. During the rest of the year, the exhaust air escapes from the building at the crest of the roof via a large continuous opening fitted with closable louver flaps. To guarantee the extraction of the used air under unfavorable air-pressure conditions, a spoiler capping was developed and assembled over the crown of the roof. This a 7-m wide element that has a convex underside, which supports the extraction of air from the building.

• About the geometry for cutting the grids, which was determined by a computer through taking into account different factors, including the angle of sun elevation and the azimuth at various seasons.

• About the thoughtful layout of the interior spaces with their points of access and maximum flexibility of use for concurrent events.

• About a project that is the essence of a performative form.

• About a great example for the use of performance simulation in architectural design and computing power, which is predominantly for analysis purposes.

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Case Studies

A Search For A Revised Thinking In Architecture Of Habitats

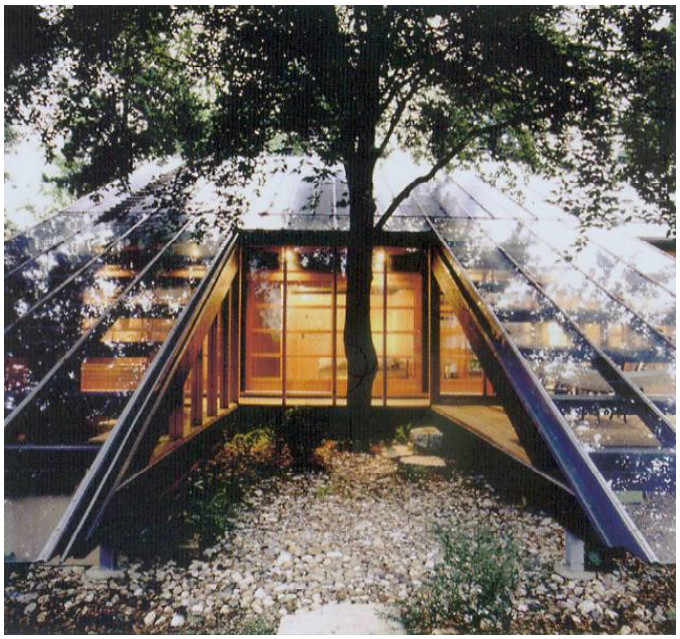
Toward Development of Performative Forms

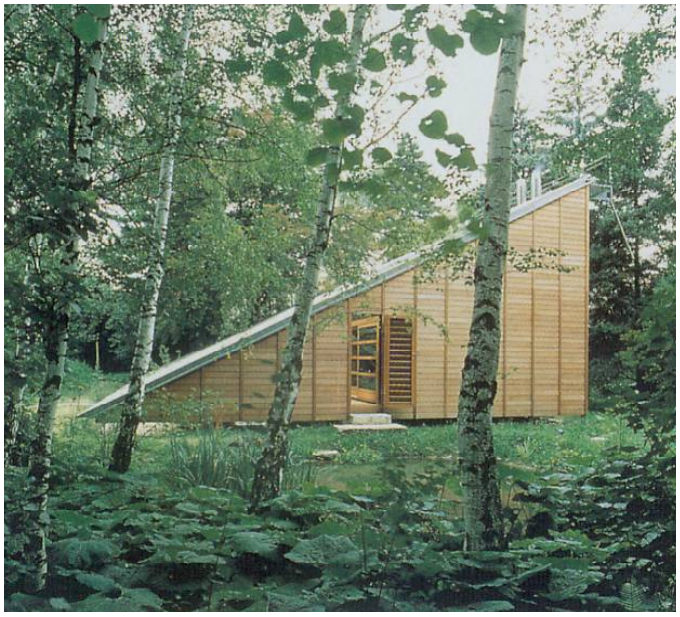
2.4.1 CASE STUDY ONE on Habitats – House at Regensburg, Thomas Herzog, West Germany, 1979

The house at Regensburg is Thomas Herzog's first low-energy house, but it is a new invention and a logical design, which owes more to science than to sentiment. Its pure prism form and rational plan make it almost like a machine. Its triangular shape is designed to collect free solar energy and use it to heat the house, which was a relatively new idea in the 1970's. Herzog's goal was to integrate energy-saving features into a new environmentally responsive architecture.

Energy saving is not the only goal of the design of this house. Another main goal is flexibility and regularity. The plan is a system of abstract grids that divide or distribute the space by combining the cells horizontally and vertically in different and yet meaningful ways. Between the high north wall and the sharp point of the triangle on the south, there is a conservatory. The house in its east-west direction has double bay and double height spaces. In the conservatory area, the roof over two of the bays is omitted, to preserve a beautiful beech tree and to accommodate a patio next to the dining room.

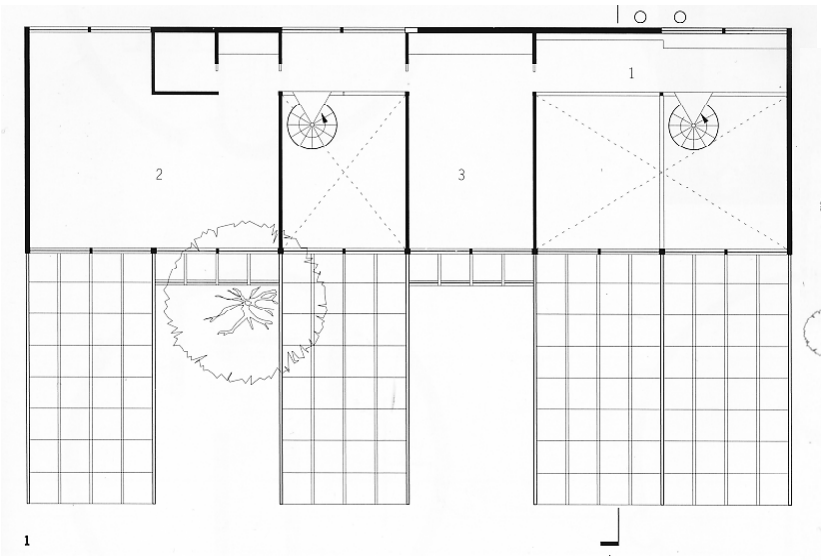
Herzog has chosen wood in various forms for different elements of the building, as laminated beams and columns and veneered chipboard and plywood sheets for the internal walls, and as horizontal boards for the external cladding. He has also used double-glazed windows and insulation in solid walls, as well as titanium-zinc sheeting for the roof.

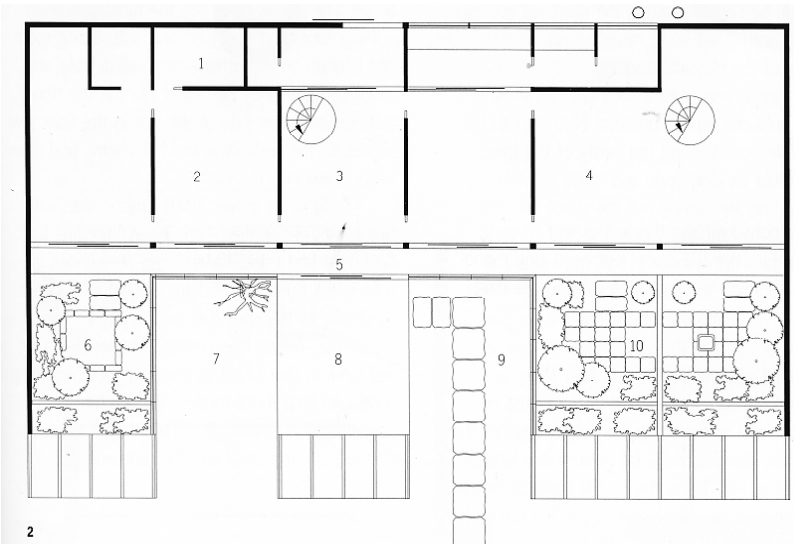


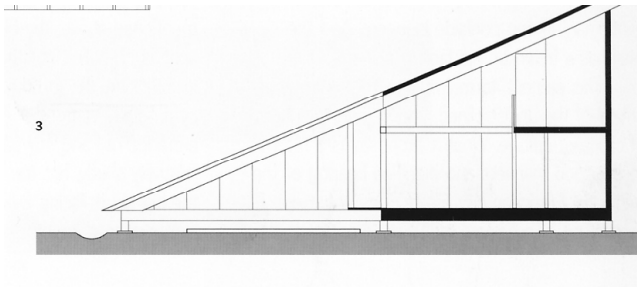


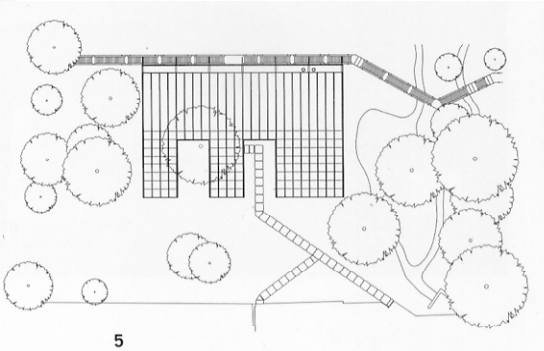
Photos credit:
House at Regensberg
Davies, Colin,
Key Houses of the Twentieth Century, Plans Sections and Elevations, (New York: W.W. Norton & Company, 2006)

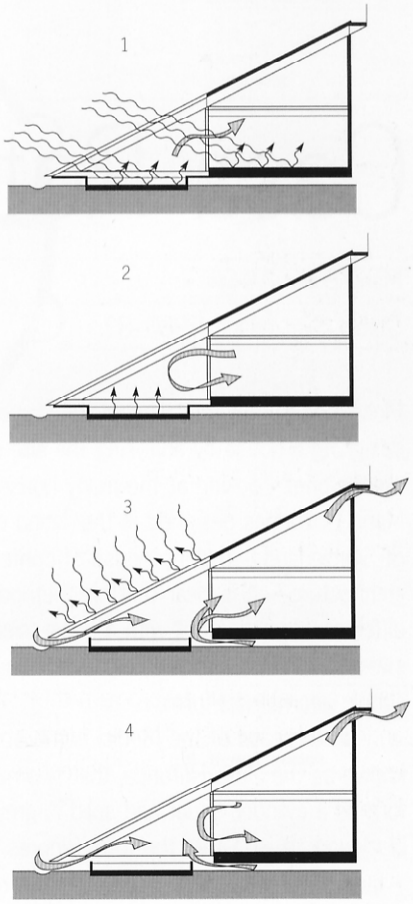
CASE STUDY ONE on Habitats – House at Regensburg, Thomas Herzog, West Germany, 1979











Photos credit:
House at Regensberg
Davies, Colin,
Key Houses of the Twentieth Century, Plans Sections and Elevations, (New York: W.W. Norton & Company, 2006)

Left to Right, Top to Bottom:
1. Upper floor Plan
2. Lower floor Plan
3. Section A-A
4. Site Plan
5. Sections, from top: Winter day, Winter night, Summer day, Summer night

Performative Paradigm and Characteristics: House at Regensburg

The house at Regensburg is a true process-driven design that has the capacity to reformat and adjust itself with the nuances of its microcosm and context. It employs an architecture that is constantly self-organizing and is continuously transforming, adapting and changing. It involves a very fluid and dynamic form, which is developed and evolved based on scientific inquiries. Its rational plan and form resembles the concept of the machine for living, which has the capacity to be responsive to its immediate surroundings. It employs an architecture of morphogenetic practices, which is prepared to deal with the flows and forces of its microcosm. It acts as a medium in resolving the flows and forces of energy within its construct. The building has adapted well to the project's intended use and expectations, as well as to its contextual circumstance.

The house at Regensburg is a design in which the building has been allowed to reach its highest level of functionality, and a state of fulfillment in its active or utilitarian state of performance. The plan of the house was developed on an expandable grid system, which allows for a great deal of flexibility and functionality. The house incorporates a performative and intelligent enclosure (facades), which allows the skin of the building to respond to the sun and other natural elements to create pleasant spaces within the building.

The architecture of the Regensburg House includes certain devices as tools for its performativity. The operation of the device paradigm of its performativity can be controlled by certain manual, electrical, mechanical, or digital mechanisms in order to modify, acclimatize and mediate the environment. The positioning of the house and the choice of the enclosure system were driven by the principles of environmental psychology and human behavior. The building can be evaluated as part of a dynamic and living system, or a biosphere, with technical, social and even financial ramifications

Development of Regensburg architecture, as the architect's *modus operandi* for a truly performative design, was based on teamwork activity, experiments, trial and error, use of computer simulations and prototyping, as well as client participation. It is a process-based rather than a pre-ordained or predetermined architectural form. It is also a product-driven approach, revolving around appreciation of manufacturing and tectonics, as well as the art of detailing. The form and vocabulary of the building evolved, while arriving at the right choice of the engineering system and material and methods of construction. Herzog has created an opportunity for architecture to be able to transform, transcend, digress or simply move from one state to the other in a continuum of time and space by allowing for different types of morphing encounterment. It is truly a performative design that has a shared vision with sustainability.

Lessons Learned

• **The** use of energy saving features can be incorporated into a fully environmental responsive architecture.

• Energy saving goals and flexibility of interior plan and spaces can effectively intertwine and work together.

• Efficiency of the abstract grid used for the plan of the house for the distribution of the spaces, both horizontally and vertically, allows for more spacious volume in some parts of the house. The larger volume helps with better natural ventilation, air circulation, and daylighting.

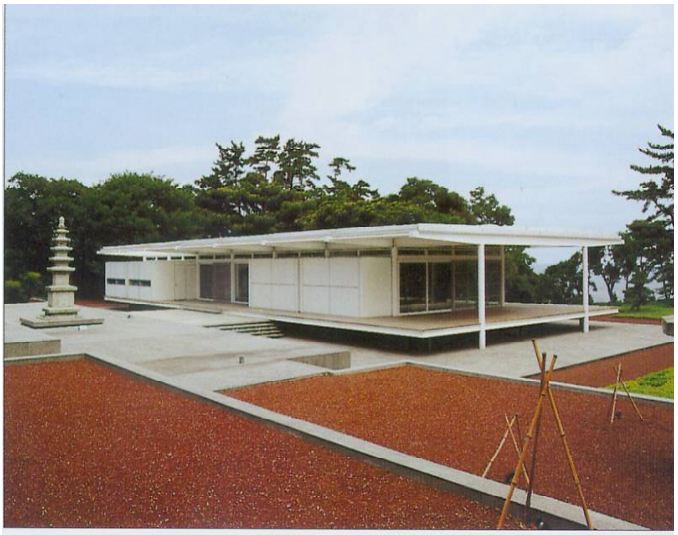
• A thoughtful and elaborate integration of outdoor and indoor spaces, has become possible by allowing nature to penetrate within the interior volume.

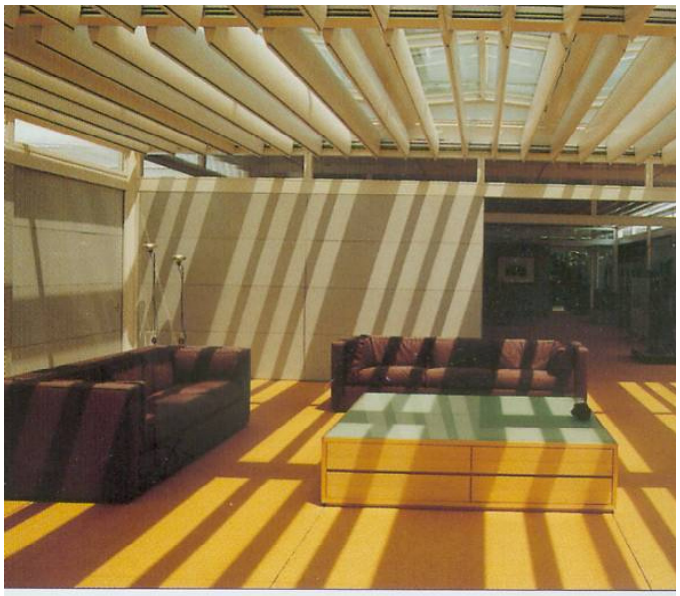
2.4.2 CASE STUDY TWO on Habitats – Cho en Dai House, Norman Foster, Kawana Japan, 1994

The house is an approach to the expression of high tech style. It emphasizes flexibility rather than spatial arrangements. Rather than usage of natural materials such as wood and brick, it showcases a combination of bolted glass and metal, in a Miesian style.

Rather than hanging, the house sits on a cliff-top with a scenic view of the pine trees, and is composed of rectangular geometry that organizes the shape of both the house and the outdoors. The house is a single story with a flat roof hovering over steel tube posts. The wooden deck of the outdoor terrace is very thin and raised up, as if there is no support element holding it. External walls are mostly glass, and all the panels slide open, reminiscent of shoji screens. There are modules that contain the kitchen, storage and space to accommodate an air-conditioning unit. The interior spaces between the columns are entirely free, and through sliding partitions the spaces are divided onto two double and two single bays which are arbitrarily divided into the living room, dining room, entrance hall and bedroom.

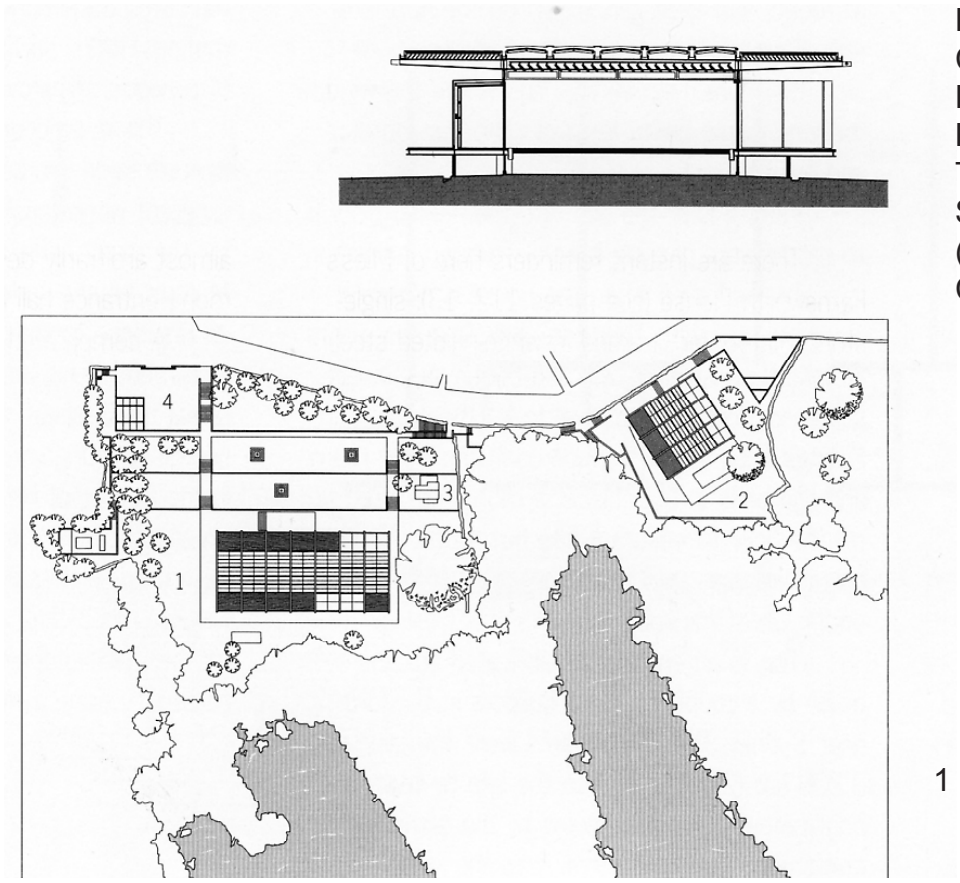
Another interesting feature of this house is the array of shading devices over the roof. The roof over the main living areas acts as a machine that can modify natural light and heat. There are external roller blinds that can shade the shallow-pitched glass panels. On the inside, the ceiling has large motorized louvers that are adjustable as well. It is through the outside roller blinds and inside louvers that the daylight and sunlight can be fully controlled, and heat loss and heat gain are mediated through the roof.





Photos credit:
Cho en Dai House
Davies, Colin,
Key Houses of the Twentieth Century, Plans Sections and Elevations, (New York: W.W. Norton & Company, 2006)

CASE STUDY TWO on Habitats – Cho en Dai House, Norman Foster, Kawana Japan, 1994



Photos credit:
Cho en Dai House
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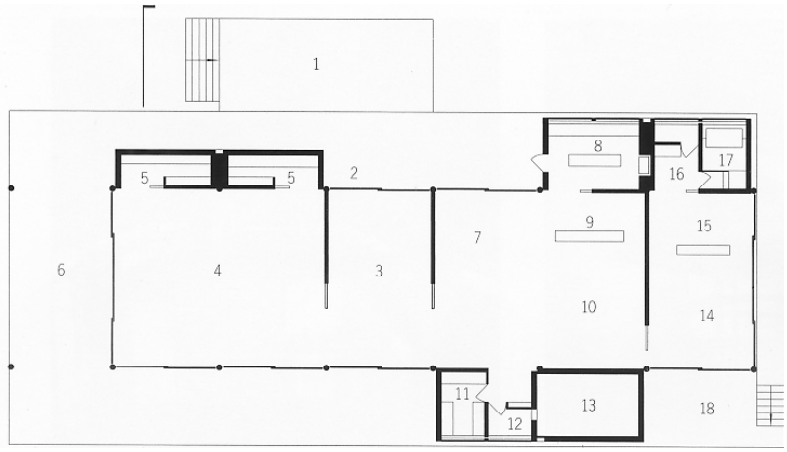

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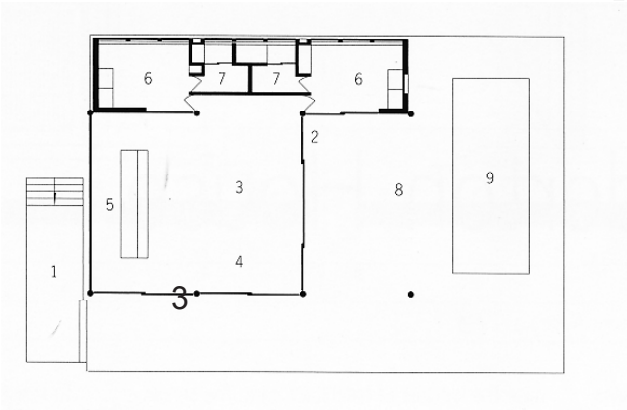


3

Top to Bottom:
1. Site Plan
2. Main House
3. Guest House

Performative Paradigm and Characteristics: Cho en Dai House

The performative design of the house is rooted in a Miesien expression of a high-tech approach resembling dynamism and incorporating fluidity of form. It reflects a program with the utmost flexibility, which is able to adjust to the immediate needs of the inhabitants. The program reflects technological, cultural, and socio-economical transitions. It is an architectural design in which the building has been allowed to reach its highest level of functionality, and fulfillment in its active or utilitarian state of performance.

Influenced by performative design concepts, the design of the building form, massing and siting, as well as the design of the flexible interior layout and selection of the materials, are reflective of an intelligent biosphere that can interact with its immediate microcosmos, rather than becoming an imposition. The house is designed with a performative and intelligent enclosure (roof), which allows the skin of the building to respond to the sun and other natural elements and create pleasant spaces within the building. The house is also charged with the use of certain building devices as tools for performativity, and their operation can be controlled by certain manual, electrical, mechanical, or digital mechanisms. Performative devices allow the building to modify, acclimatize to, comply with and mediate contextual conditions, or adapt itself to the specific nuances of its immediate environment. The flexibility of the interior layout and the ability to adapt to daylighting requirements address the nuances of human behavior and comfort within the building.

Undoubtedly, it is an architecture of morphogenetic practices, which is based on methodologies involving flows and forces. The array of shading devices on the roof has transformed the roof to an adaptable machine. It has created an architecture that is constantly self-organizing and is continuously transforming, adapting and changing. The building has adapted well to the intended use and expectations, as well as to its contextual circumstance. It involves an architecture, in which the development of its performative form is the architect's *modus perandi,* involved in teamwork activity, experiments, trial and errors, use of computer simulation and client participation. It is a process-based rather than a pre-ordained or predetermined form. It is also a product-driven approach, revolving around the appreciation of manufacturing and tectonics, as well as the art of detailing.

Foster, in the design of Cho en Dai House, created an architecture that has the capacity to transform, transcend, digress or simply move from one state to the other in a continuum of time and space while allowing for different types of morphing encounterment.

Lesson Learned:

- It is a very sophisticated high-tech design, yet simple and minimalist in the usage of materials and detailing.
- It emphasizes flexibility, rather than a rigid pre-defined arrangement of space.
- The siting of the house has minimized the impact on its contextual environment.
- The interior auxiliary functions consist of modules that allow for transferability, and inter-changeability of the functions, and thus overall flexibility of the interior spaces.
- Flexibility of the exterior facade, which is designed so that the exterior panels completely slide open for the possibility of an indoor-outdoor relationship as it becomes necessary.
- An innovative roof system which acts as a machine between the exterior roller blades and interior motorized adjustable blades, for modifying the natural light as well as controlling heat loss and gain through the roof.

2.4.3 CASE STUDY THREE on Habitats – The Malin Residence, John Lautner, Los Angeles, USA. 1960

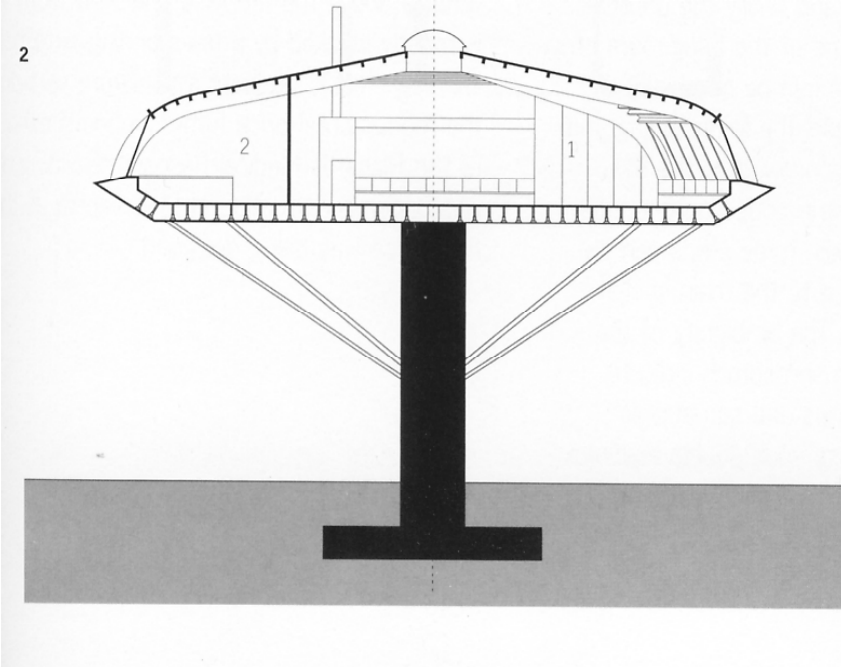
The Malin Residence is located in the Hollywood Hills, known as Chemosphere. This futurist-looking design has been a practical solution to a challenging, steeply sloping site. The house is elevated and held up on a single concrete column. The concrete column has a large footing that is buried down in the sloped hillside.

The house itself consists of an octagonal one-story structure. Like an umbrella, the floor of the building is supported by diagonal struts. The concrete column does not penetrate inside the building to support the roof. Instead there is a roof skylight at that location that brightens the deep interior spaces.

The structure is a combination of wood and steel, and the steel struts support the end of the floor beams radiating from the concrete column. The roof is supported by the curved laminated portal wood frames that on one end tie to the ends of the struts and on the other to the ring around the opening of the central roof skylight.

Photos credit:
Malin House
Davies, Colin,
Key Houses of the Twentieth Century, Plans Sections and Elevations, (New York: W.W. Norton & Company, 2006)

The whole interior is column free and flexible. The plan is divided into two halves. One half is dedicated to the kitchen, dining and living spaces, with a fireplace alcove and sitting area under the roof skylight, and the other half is divided into bedrooms. The treatment of the perimeters and where the floor meets the upside down saucer of the roof is elaborately detailed. The windows are recessed in exception of one location that allows for the view of the carport.



For accessing the house from above a narrow bridge spans from the solid ground to an entrance near the kitchen, in an area like a balcony. From below, visitors climb into an open topped lift, which takes them from under the house to the end of the bridge.

Photos credit:
Malin House
Davies, Colin,
Key Houses of the Twentieth Century, Plans Sections and Elevations, (New York: W.W. Norton & Company, 2006)

Performative Paradigm and Characteristics: The Malin Residence

The dynamic design of the Malin Residence is a functional, practical response to its contextual condition. It is an architecture design in which the building has been allowed to reach its highest level of functionality and to fulfill its active or utilitarian state of performance. The design accommodates a program that responds to the technological, cultural and even socio-economical transitions. The building has adapted well to the intended use and expectations, as well as to its contextual circumstances.

The structural system of the building is somewhat of a novel and performative solution to achieve the goal of making the least impact on the existing site. The choice of the materials for the structure and enclosure of the building is fully process based. The performative and intelligent enclosure of the building, and its detailing, as well as the angle of the windows are all responses to the contextual conditions. The architecture allows the skin of the building to actively respond to the sun and other natural elements to create comfortable spaces within the building. The project is designed to use certain building devices as a tool for performativity, and their operation can be controlled by certain manual, electrical, mechanical, or digital mechanisms in order to modify, acclimatize and mediate the environment as well as human behavior. It is the architecture of morphogenetic practices for the creation of a biosphere that is based on methodologies for involving the flows and forces of its microcosm.

Architecture of Malin Residence has been successful in creating a fully flexible and performative interior environment, adaptable to the specific needs of its inhabitants. Development of the performative form is the architect's Modus Operandi, started as an experiment, with trials and errors, use of computer simulation, and with client's participation and involvement. It is a process based and definitely not a pre-ordained and predetermined form. It is also a product driven approach, revolving around appreciation of manufacturing and tectonics, as well as art of detailing. The form and vocabulary of the building evolved, while arriving at (somehow) the right choice of the engineering system and material and methods of construction.

Lessons Learned:
The Malin Residence offers important information for:

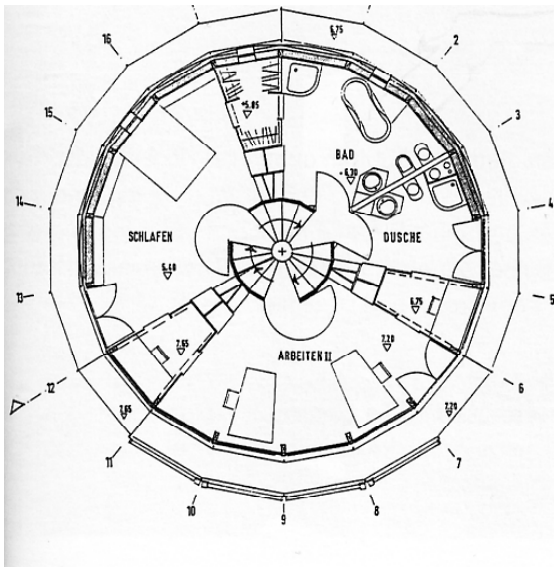
• The challenges of a site which has been pushing the boundaries of conventional design to more novel ideas for creativity and innovation.
• A design solution that allows for the least impact on an otherwise very challenging site condition.
• An interactive enclosure -- a design, which is focusing on provision of panoramic views.
• A process-based form and definitely not a pre-ordained one. The octagonal form allows for more efficient usage of space than a full circle.
• A form fully integrated with the flows and forces of its microcosm --- particularly with respect to daylighting considerations.

2.4.4 CASE STUDY FOUR on Habitats - The Heliotrop: Residential/Studio office Prof Rolf Disch Architekt, 1994

The lightweight tree-house has been named after the word heliotropism, which refers to plants that grow in response to the stimulus of sun. The wooden structure is cantilevered from a central stair shaft which can revolve the 100-ton house to track the sun, maximizing passive solar gains to the indoor spaces and active gains to the evacuated solar collectors mounted on the balustrades. Independent of the main house is a tracking of photovoltaic array, which is mounted on the roof. This house was a prototype designed and funded by Professor Disch.

The house can vary its orientation in response to the sun's position. Other features include solar water heating, photovoltaics and an earth heat exchanger. The ventilation and heating for each room is accomplished by an "occupancy switch" which tells the BMS that the room is in use.

The cylindrical timber stair shaft rises from the plant room in the basement, creating a sheltered entry with the main accommodation tower 14.5-m above. The principal living spaces are arranged around the central trunk within the 10.5-m diameter, spiralling up the building to a roof garden at the top. One half of the revolving living tower is highly glazed, and the other is well insulated with few window openings.



Site and Climate

Freiburg is situated at the bottom of the upper Rheine Valley and lies on the edge of the Black Forest. It is the hottest place in Germany, with an average temperature of 10.3 C and 4.8 average sunshine hours. The typical climate is hot and moist in summers and cold and foggy in winters. The steep sloping site had previously been regarded as unusable and the new tower utilizes the site effectively, giving beautiful views over vineyards toward south.

Photos credit: Wiggins, Michael, Intelligent Skins Skins. Italy Architectural Press, 2002

CASE STUDY FOUR on Habitats - The Heliotrop: Residential/Studio office
Prof Rolf Disch Architekt, 1994

Energy Strategy:

The energy strategy aimed to attain all of the energy for the house from the sun. It is able to adjust its position according to the need for maximum solar gain, or to turn itself away from the sun for protection. The building has the rotation capability of 400 degrees, meaning 20 degrees in both directions. The building is programmed to follow the sun by rotating approximately 15 degrees each hour. It stops rotating at sunset, and returns to the sunrise position at 3:00 AM each morning. A full 400-degree rotation takes about one hour. The electric motor that turns the house uses about 120 W at maximum speed, equating to a yearly power consumption of about 20 kwh.

Construction

The timber framework is insulated with 300 mm of mineral wool, and the opaque elements are covered with with corrugated metal cladding. The 2.6-m diameter central column was prefabricated and is made with a faceted array of 18 sheets of laminated timber panels 111-mm thick. The laminated panels are joined together with an epoxy resin and steel ties.

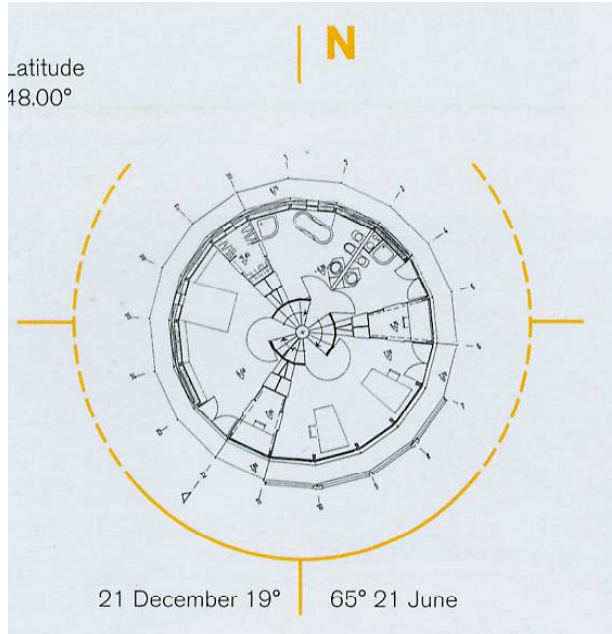
Glazing

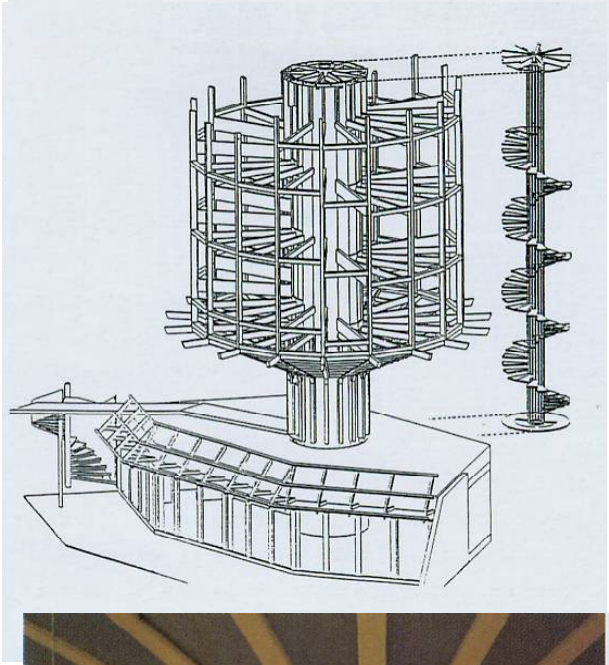
Different types of glazing were used in the building for experimentation. The predominant glazing is triple glazing with krypton-filled cavities, low-e coatings and insulating blinds.

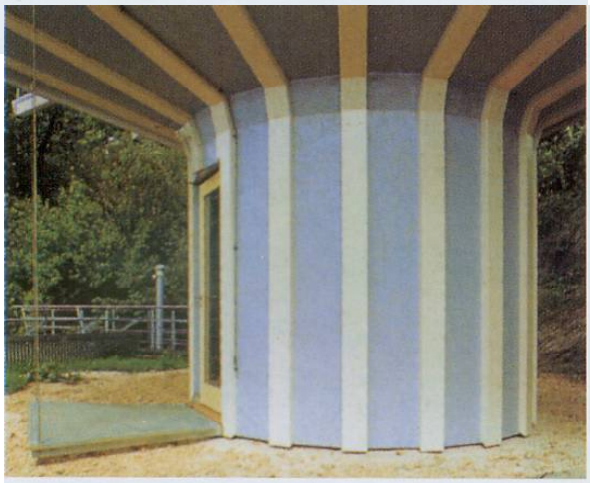
Heating

Evacuated tube collectors installed on the balustrade of the perimeter balcony provide hot water and meet part of the heating energy demand. The solar heated water is fed into tanks in the basement with up to 1200 liters of storage capacity. Fresh air supplied mechanically to the space can be warmed in winter by the earth heat exchanger in the basement. Heating is only required in November and February.

Credit: Wiggins, Michael, Intelligent Skins Skins. Italy Architectural Press, 2002







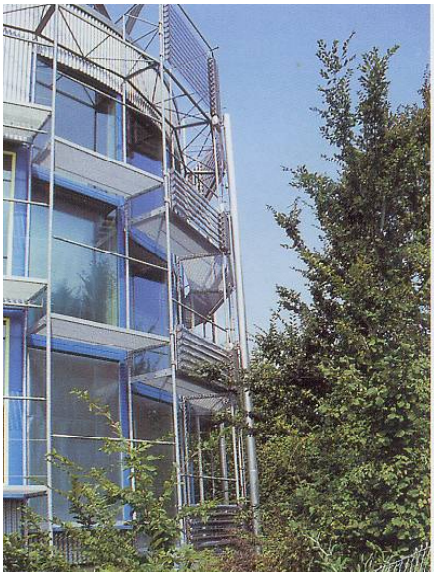
Cooling:

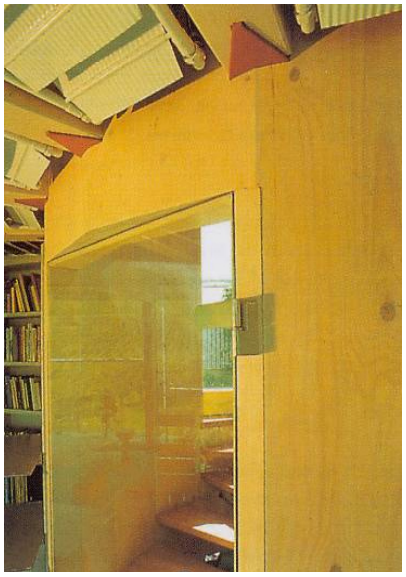
Ventilation air can be pre-cooled by passing it through the earth heat exchanger that is buried into the bank. The glazed side of the building can be turned away from the sun , or programmed to offset its revolution by 180 degrees to prevent unwanted solar gain.

Ventilation:

Both the basement and the top of the house can be mechanically ventilated with low-level inlets and a high-level extract. An earth heat exchanger in the basement that maintains year-round temperatures in the range of 8 degrees C ensures that the air is pre-heated or pre-cooled depending on the season. In the winter, air is heated further by passing through the heat exchanger containing solar-heated water. Outgoing air is also passed over a heat exchanger for the recycling of waste heat. In summer, open windows can be used for ventilation.

Photos Credit: Wiggins, Michael, Intelligent Skins Skins. Italy Architectural Press, 2002





Electricity Generation

A photovoltac array on the roof is also programmed to follow the sun on a two-axis tracking system (in response to the Azimuth and elevation, which operates independently of the house. Unlike the main living areas, the photovoltaic panels should always be positioned for maximum exposure to the sun.

Daylighting

All perimeter rooms are provided with windows for natural light and views. Rooms that are positioned on the south side have full-height glazing.

Solar Control

Metal balconies, which spiral around the perimeter of the tower allowing maintenance access and fire escape, also double as external sunshade, and internationally aluminized fabric blinds can be raised from the floor level to reduce unwanted solar gain. The U-value of triple-glazed windows is improved when the blinds are closed.

Controls

The building is programmed to turn every ten minutes according to a calculation that determines the Azimuth and the elevation of the sun. Each room is fitted with a temperature sensor and an occupancy switch (activated manually), which help the computer to determine the room inputs in terms of heat and air.

User Control

The rotation of the building can be manually overridden. For instance the occupants may desire to rotate the dinning room to overlook the vineyards during a dinner party, or the building may need to be turned out of the sun when the occupants are on holiday. A manually activated occupancy switch is used to tell the computer which spaces are occupied and the temperature of vacant rooms is kept lower.

Operating Modes

In the summer, the house can be turned away from the sun to prevent heating, and by rotating the house to face northeast and

Photos Credit: Wiggins, Michael, Intelligent Skins Skins. Italy Architectural Press, 2002

opening the windows at night, temperatures can be maintained at 25 degrees C. In the peak of summer, the house can track the sun with an offset of 180 degrees to avoid solar penetration to the glazed living areas. For the remainder of the year the house is rotated to take maximum advantage of passive solar gain and active solar water heating.

Performance Delivered Energy Consumption

Measurements have shown that the actual heating energy demand of the Heliotop lies close to the heating energy demand of 27kw/h during the design stage.

Design Process

Dynamic computer simulations calculated energy lost by heat loss and infiltration and heat gain from internal sources and the sun.

Lessons Learned:

Every aspect of this prototype attempt is a lesson to learn from.

2.5 EPILOGUE TWO

Looking into Performative Design Types
General Overview

By looking at examples of performance-based design practices, it is important to note that performative architecture should not be seen as simply a way of devising a series of practical solutions to a set of architectural problems. Review of the various works of performance-based architects reveals that performative architecture is not a kind of neo-functionalist approach, and must not be mistaken as such.

The interest in building performance and performance-based design was probably initiated due to the emergence of sustainable design and its wide paradigm. This ranges from socio-economic and cultural issues to recent developments in technology. It's broad range of inclusive context includes spatial, aesthetical, cultural, social and even purely technical issues (i.e. structural, mechanical, acoustics, etc). Thus, performative architecture incorporates a wide range of meanings and operates beyond aesthetic or utilitarian intentions.

Looking more carefully into the work of the architects involved in the performative approach was itself a "paradigm," whose performance could be understood with respect to an origin that was rooted in social, technological, and cultural conditions. The examples of performative architecture in the buildings could be looked at as an index or interface to new patterns arising out of temporal dynamics, as well as cultural and technological changes. Thus, the buildings act as an active web of connections or networks of interrelated constructs that continuously and simultaneously affect each other. The performative buildings, as dynamic living biospheres, revealed the capacity to continuously reformat and adapt themselves to foreseen and unforeseen contingencies. The examples revealed that they are able to continuously update and transform themselves to the nuances of their surrounding conditions. In other words, they are charged with the capacity for self-organization.

In all the contemporary architectural designs that were examined, the effect of various digital generative and production processes was the opening up new territories for conceptual, formal, and tectonic explorations. The performative designs also articulates an architectural morphology, which focuses on the newly developing and adaptive properties of form. The emphasis in these buildings has typically shifted from the making to the finding of form. Each building reveals a well -detected aspiration for the manifestation of the invisible dynamic processes that shape the physical context of its architecture. Additionally, the context of design predominantly acts as active abstract spaces. On the other hand, the current of forces that was continuously emerging out of the buildings affect their architectural form.

Case studies reveal that the usage of computer analyses and digital processes, as well as the introduction of the dimension of time into the process of conceptualization, are ways to visualize the dynamic forces that affect architecture. The computer program has guided the designer on how to change geometrical or constructional information, and even how to modify design in order to reach the optimum design solution. In almost all cases, building performance has become a guiding design principle for form making, while the performance-based generative design tools are a source of creation for the new synergies between their poetics and tectonics.

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Device Paradigms for
Performative Architecture

A Search For Performance-Based Design Concepts

PART 3A

ARCH 508
Doctorate of Architecture

Mitra Kanaani

3A.0 Conceptual and Operative Performativity - Towards formulating a design methodology or a guideline - Initial Overview:

In the first two parts of this research, an effort was made to establish the different views of performativity and the meaning of performance in architecture. The main challenge has been to introduce an overall coherency to the notion of performativity or performance in architecture. Through an in-depth look into its thematic realm, two main domains became distinguishable, at one end the conceptual domain, and on the other the operative. This is directly related to what was discussed in part one, as the subjective versus the objective aspects of performativity. Interestingly, neither of these two aspects negate the importance and essentiality of the other.

In Part Two of this research, by looking into the works of three architects, Renzo Piano, Nicholas Grimshaw, and Thomas Herzog, it became apparent that performative architecture is not stylistically predictable. It is a process-driven approach that is also driven by the programmatic requirements of a particular project. The review of performative projects signified that the designs have taken on broader aspects in addition to being purely functional. The issues of beauty, contextuality, materiality, durability, permanence, weather-resistance, and much more are brought into discussion and consideration. Performative design has an inclusive trend that is unique to the project type. In the pre-design phase of the project, the various architectural issues pertinent and unique to the project are brought into consideration, including the issues of beauty and aesthetics. For instance, in the case of the British Pavilion project, the stated purpose of the water wall was to create a cooling element. In reality, the project is also about the senses and creating the feeling of a cooling oasis in the midst of a hot climate. It is about a sensuous experience with water. Therefore, the design methodology is not only performative, focused on cooling and lowering the temperature of its micro-climate, it also intends to create an oasis. In reality, it is working on the poetics and objective aspects of architecture. The building is truly optimized and charged to meet conceptual and operative goals, in both objective and subjective ways, through architects' foresight and ingenuity. This is a process that brings the two extremes of art and science, or artist and scientist, to a middle ground of compromise.

Another aspect of performative architecture, as it was previously discussed, is its non-static mode. Performative architecture is an active and dynamic process. It provides opportunity for the building to constantly update itself with the flows and forces of nature. Performative design, similar to that of traditional vernacular architecture, uses its own devices to address objectives of adaptability to the related context and environment.

A true performative approach is when objectives of performativity, with certain measurable goals and expectations for results, are combined with subjective performative objectives. In this case, measurable goals as well as the psychological and physiological needs of the occupants are brought into consideration in a coherent way. One of the common goals that includes both the the psychological, as well as physiological needs of the occupant is 'human comfort.'

Nowadays, computer simulation and diagrammatic techniques provide opportunities to address performative design expectations. Computer simulations allow measurable solutions to work towards the achievement of performative goals. Ideally, in order to have a true performative design process, there is a need for sophisticated simulation tools and software. Through pre-configured computerized techniques, the virtual experiments find the appropriate platform for performance. Nonetheless, computer simulation and diagrams provide an array of tools and techniques that provide a benchmark that allows the designers to compare and analyze solutions. There is no doubt that every project starts with analysis and with the weighing of data. At the end, the project concludes with certain weighed facts as well. It is the in-between that incorporates

certain non-metric and non-quantifiable facts and abstractions. This means that there is a whole world of organizations and diagrams in the design that can be quantified. However, there is a point in an abstraction at which everything has to go through a stage of order and qualification. By using the tools in the generative part of the design, it is possible to address the most interrelated architectural problems. Tools allow us to get to the root of the problems and address the more in-depth issues. It also gives us an opportunity to visualize the solutions.

The most challenging obstacle in this whole process is alternating between the different tools, from the analytical ones to the tools that can truly synthesize, integrate, and reach an abstract level of design. Today, there are opportunities for the designers to appreciate the collaborative process of the inter-operability of the systems. This is accomplished by using the appropriate simulations to look at different scenarios, while not getting too involved in the functioning of undefined tools. Nonetheless, in performative architecture it is up to us in the end to interpret the results through the plurality of our knowledge. The plurality of knowledge does not mean that the architect is empowered to do the engineering work. On the other hand, the engineer would be allowed to assume an efficient and collaborative role relatively early in the conceptual design process.

Regarding the purpose of project delivery in architecture practice, and whether the architect would like to continue playing the role of the project architect and manage the design process, he or she has to have the appreciation of the tools and representations. This allows the architect to monitor the ways that the consulting team of engineers will render their share of expertise in their collaborative efforts, and thus bring a considerable degree of oversight expertise to the collaboration. On the other hand, based on the necessities of today's economy, according to Gordon Chong, FAIA, principle of Chong Partners and recipient of the 2005 Latrobe's Fellowship, "As architecture becomes a more complex and knowledge-based profession, clients will begin looking for more intuitive, experiential, evidenced-based design." By the same token, performative architecture demands that the architect's current skills be developed to form a layer of evidence-based design that is more predictive of human responses to spaces and designs. This could be accomplished by adding science to the art which would also create more coherency.

From the stand point of the project itself, the concept of post occupancy evaluation can be applied to the performative design project as a "pre-post occupancy evaluation," which can incorporate the same perspectives. The NCARB Monograph on "Improving Building Performance" is referring to Post Occupancy Evaluation, as one sub-phase of a more systematic analysis known in the field as *building performance evaluation.* This in turn relates to broader idea of *performative*

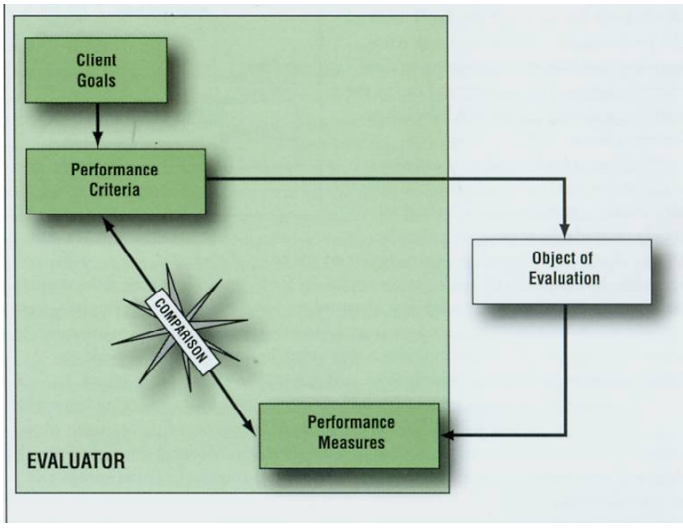


Photo Credit: AIA Continuing Education, Professional Development Program, Improving Building Performance, (Washington, DC: NCARB, 2003)

The Performance Concept
Source: Architectural Research Consultants, Albuqurque, NM.

*concep*t (15-16). Using the principles of performativity is critical to the achievement of performative concepts--measurement, comparison, evaluation, and feedback-- toward the design, construction and maintenance of buildings. This is a systematic approach that warrants the building's responsiveness to the functions they support and to the needs of their occupants.

The performance concept applies to various performative evaluations, ranging from the success of a particular typology to the appropriateness of a particular design solution. In the act of such evaluations, performance measures are analyzed and compared with the appropriate performance criteria, and with a conclusion about the success or failure of the building performance. This is then combined with recommendations for future improvements.

3A.01 Qualitative and Quantitative:

The manner in which these two aspects of performative architecture are measured is different. There are certain building elements that are measurable, such as the volume of interior spaces, distribution of live and dead loads, and stresses in structural elements, as well as sound distribution, acoustics, humidity, air, daylight, requirement for energy, quantity, the size of the materials, and more.There are manual and computerized techniques for measuring quantitative aspects of the building.

The qualitative aspects of the building are more difficult to evaluate. They relate to sensory issues such as aesthetic beauty, visual quality, development of certain psychological and behavioral manifestations, and well-being. Regarding the qualitative elements, in most cases, the experts and evaluators render judgements. Nowadays, there are scientific techniques and methods of research that have developed to measure the physiological and psychological, as well as sensory impacts of the space on its occupants. Obviously various computer software are major contributor to all these research processes.

3A.02 Building Performance Evaluation:

Building evaluations are based on scales, users and appropriately adopted criteria that in turn relies on measurement technologies, information systems, and performance guidelines.

- Measurement Technologies: refers to all techniques that are used in collecting data, including interviewing, questionnaires, direct observation, and mechanical recording.
- Information Systems: refers to the data fed into the computers for use in computerized reports, which can be helpful to improve state-of-the-art knowledge. The data can also be used for the development of performance criteria and design guidelines for future and similar buildings.
- Performance Guidelines: are a helpful tool to establish a set of criteria or standards for a building type and its occupants. In most cases the criteria are formally documented in technical manuals, design guides, and specialized data-bases, or simply are developed in-house by architects from available information systems and various sources. These sources could possibly include published literature, analogues of precedent studies, as well as reports of previous buildings' post-occupancy evaluations and resident experts.

3A.03 Performance Measures:

Performance measures quantify the elements of the building that are measurable, including functional, technical and behavioral aspects.

- Technical: involves structures, mechanical (heating, cooling and ventilation), electrical, acoustics, lighting, enclosure, fire safety, plumbing, and sanitation.

There are measuring methods and performance criteria as well as evaluation approaches for the specific materials, assemblies, and components of the building. A drawback to this procedure is the fact that most of these evaluations are taking place in the forum of laboratories, rather than in their actual settings. This subsequently lowers their testing precision and importance.

• Functional: There are a series of functions that a building can house. These including residential, commercial, institutional, religious, and others, which establishes the building typology. Each function incorporates certain requirements for spatial capacity, interior circulation, utilities, exterior access, parking, communications, security, equipment, consideration for future expansion, and adaptability for change over time (if required).

In performance-based architecture, the building design must support the specific psychological and physiological needs of its occupants as both in a qualitative and quantitative way toward building's intended function and type. Some functional needs tend to change over time and some are specific to the building type.

• Behavioral: In recent years it has become known that building design can have serious effects on occupants' physiological and psychological well-being. The issue of sick building syndrome has proven to be a known fact. Additionally, the issues related to territoriality, social interaction versus privacy, frequency of use, visual quality and clarity, environmental perception, and the creation of an understandable and stimulating persona for the building are seriously considered in environmental psychology.

3A.04 Building Scale and Users:

Based on the appropriate performance criteria, the evaluations are conducted at a different ascending order of scales with respect to different types of users/occupants. It is important in the evaluation effort to identify the needs of the different user groups of the building.

3A.05 Positive Outputs of Performative Design Concepts:

• Performative Design Concepts promote objectivity and allow measures of performance to substitute mere opinion and ideas.

• Performative Design Concepts reveal the important and relevant factors toward decision - making.

• Performative Design Concepts promote proper and effective collaboration between the architect and the team of consultants.

• Performance Design Concepts promote a range of design solutions and alternatives pertinent to related performance criteria.

• Performance Design Concepts promote a higher level of professionalism.

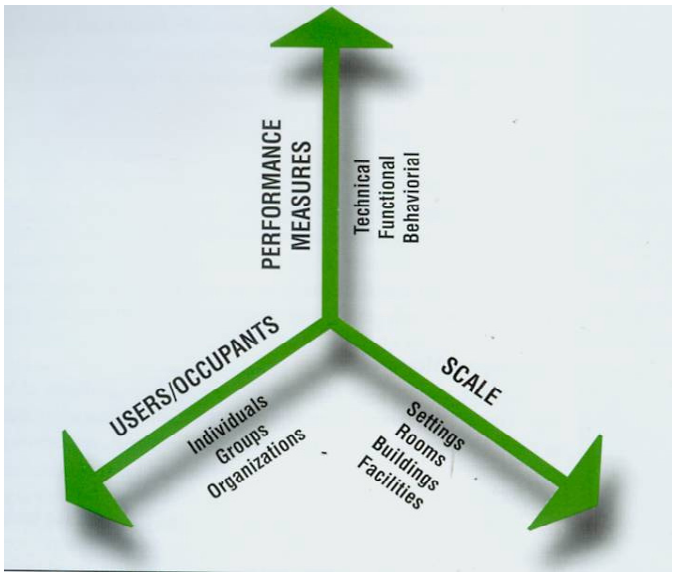


Photo Credit: AIA Continuing Education, Professional Development Program, Improving Building Performance, (Washington, DC: NCARB, 2003)

Building Performance Variables

Nonetheless, the building performance evaluation has an integrative framework that embraces all aspects of a project's delivery. These range from strategic planning, to programming, to all phases of design, construction, occupancy, and to the recycling of the building. During the design phase, it effectively brings the members of the design team as well as the client and user groups together. Through knowledge based and computer simulation and modeling techniques, architects in collaboration with teams of experts have the most suitable opportunity to make appropriate decisions regarding the design and modification of a project. Obviously, the appropriateness of the decision will be manifested by the building's users over time.

3A.1 Phenomenology of Performative Buildings - Free Forms

INTRODUCTION:

Undoubtedly, architecture is an artifact that has to respond to the context in which it is constructed. Additionally, it is also expected to respond to the physical, spatial, social, and cultural spatial needs of the communities. Aaron Betsky in his article, "Architecture in Limbo," points out: "Architecture must be an unfolding of the landscape, rather than the placing of an object upon it" (*Archilab 32).*

It is no longer acceptable for the architects of this age to create a collage of forms gathered together from around the world, rather than creating an artifact that emerges out of its context and is woven with its environment. The form of the building should follow the forces of its context, while flowing with and not against the dynamic forces of nature.

Performative architecture, which possesses the concept of the "free flowing form," builds on the organic philosophy of design. The roots of this design refer to nature as the fundamental inspiration for architecture. It is also based on living organisms, both in their exterior forms and in their constituent structures, thus allowing for endless design concepts to emerge. In performative architecture, design embraces the process of growth, change, and adjustment. Buildings are seen as organisms that, when they come into existence, they also become elements of nature. Ecological concerns have become an over-arching part, as well as the focus of the development of design concepts. With today's advances in science and technology there are opportunities for creativity and inspiration from nature's limitless source of ideas. David Pearson, in his book, New Organic Architecture, the Breaking Wave, quotes from Sim Van der Ryn: "But I do know as a designer that, when we approach the design of buildings and places by working with dynamic flows as well as static forms, when we think of the building as an organism as well as an object; when our clients become true partners rather than masters or victims, then we have a possibility of building an ecological present that increases our children's chances to create livable futures" (*New Organic Architcture 1*4).

Nonetheless, an efficient performance-based architecture flows with and not against the dynamic forces of nature, and applies to all forms of energy: gravity forces, seismic and wind forces, flow of heat and water, earth energies, electric and magnetic fields, as well as the energy disseminated from the occupants. By reviewing the phenomenology of performative buildings we conclude that on many occasions, the unusual and irregular forms are the result of adaptations to external forces. In some instances, the discontinuity between part and whole, external forces and internal requirements, provides a complex and yet compliant character to the smooth fluidity of the building.

On the other hand in current years, with the fast-forwarded process of globalization, architecture has slowly been absorbed into the turbulent flux of changing urban conditions. Many of these conditions are not defined by local factors, but by the increasing forces of global economies. Undoubtedly, the globalization of our living environments is creating internal-external stimulants, which call for some kind of mechanism to accommodate and integrate these cultural shifts. In this whole process, science has been extensively incorporated. Currently, there is a strive toward the realization of this multi-layered complexity and the demand for a new spatial order.

In these years of transition, architecture has had a critical role of identifying the many facets of the new globality by extracting and transforming its many systems into a spatial construct. For architecture the study of science, similar to that of philosophy, mathematics, and microphysics, is gradually becoming critically important. This will allow architects to acquire the means to affect a transformation from a mechanistic approach to one that is organismic and process-

oriented. A shift in orientation has already taken place in science with relativity and quantum theory. However, now systems theory is reinitiating this transition. This notion of the organismic approach affects architecture through the knowledge that an organism is characterized by its immanent patterns of organization. The organismic approach is process oriented; it develops a space in the way a scientist works--based on research.

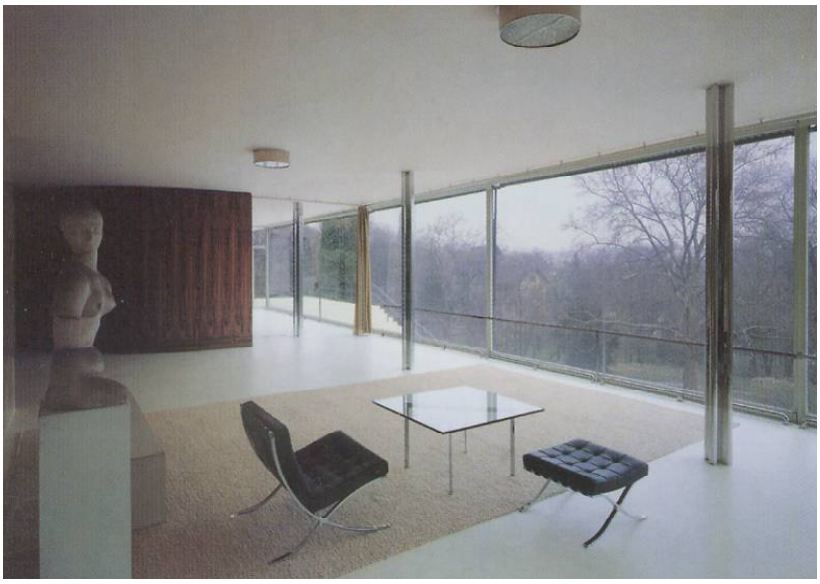
Undoubtedly, the current demand of global forces will affect architecture in a more drastic way. Architecture will transcend the notion of just “a machine for living.” Architecture has already begun moving towards a direction where the act of creativity and scientific inquiry work hand in hand. The act of design has started demanding research, resulting in a set of parameters that are traced, graphed, and mapped to reflect the complex behavior of urban context forces, programmatic elasticity, and the multiple layers of demands of current modern architecture.

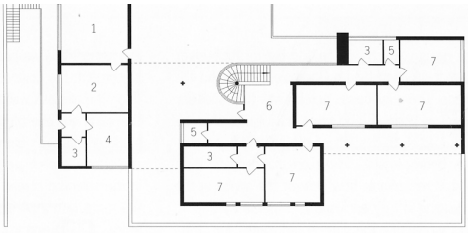
In performative architecture, buildings are divided into several systematic elements. Each system contributes to providing more performative roles for the architecture. Based on the performative roles, building systems are classified as the following:

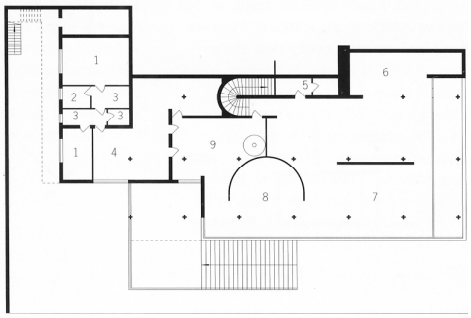
- Interior Spaces
- Building enclosure
- Structural System
- HVAC System
- Lighting/day-lighting System
- Acoustical System

In performative architecture, the assertive roles and interplay of each one of these systems, along with the dynamic flows of nature, create an active organism that allows the building to become fully adaptable and integrated with its microcosm. As a result, the practice of architecture in current times is shifting to a direction that demands the architect have acquired sufficient scientific knowledge, as well as a high level of creativity in the development of highly complex and yet free-flowing spaces. In general, the phenomenology of performative forms is complex and demand unusual geometries adaptable to the forces of nature. As a result, these forms require interior spatial fluidity and openness as well. This concept has its root in the Twentieth Century’s concept of “free flowing spaces.”

Photos credit: Tugendhat House in Brunn, Davies, Colin, Key Houses of the Twentieth Century,





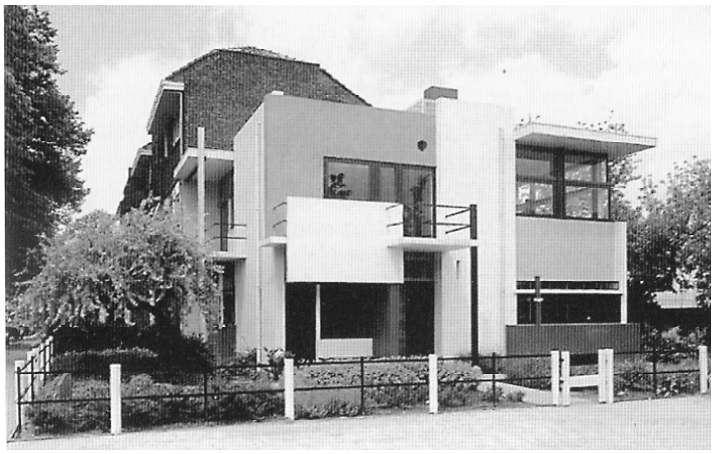


Plans Sections and Elevations, (New York: W.W. Norton & Company, 2006)

3A.1.1 A Historical Overview of Free Interior Spaces in Modernity:

In the early part of the Twentieth Century, the prominent architects of that era initiated the concept of “open plan” and “free flowing” space. In the plan of Mies Van der Rohe’s works, the traditional box-like character of the room was completely dissolved. His idea was that the individual and the family should no longer dwell in a “cave” sealed off from nature. According to Mies, people must be liberated from their caves and face the surrounding landscape to integrate it with their lives. The Tugendhat in Brunn is a practical realization of the same concept. The glass wall, which is integrated with the garden, allows nature to be accessible across the raised pedestal base.

In the early decades of the 1900s, the tension between the interior and exterior, the flexible use of the interior spaces, and expansion into the third dimension were among the issues addressed by modern architects. Gerrit Rietveld’s Schroder House in Utrecht (1924) features a core from which the rooms fan out. In the case of this house the core is not the chimney, but the stairs. The upstairs level can be used in a variety of ways by means of a foldable and sliding wall, creating a division into four separate rooms or a common living area. The innovation in the spatial transformations shows that the idea of a room as a cell has been abandoned for the benefit of a lifestyle that privileges openness.



At the same time, the concept of breaking the box and the dissolution of the floor plan in the Schroder House corresponds to a façade whose, its traditional isolation from the outside and the barrier between the interior and exterior have been relinquished in favor of a new balance of horizontal and vertical lines and surfaces in primary colors.

Photos credit:
Schroder House
Davies, Colin,
Key Houses of the Twentieth Century, Plans Sections and Elevations, (New York: W.W. Norton & Company, 2006)

3A.1.2 Space & Functional Flexibility - 3A.2 Role of the Structural Elements in Defining Spaces & Functions

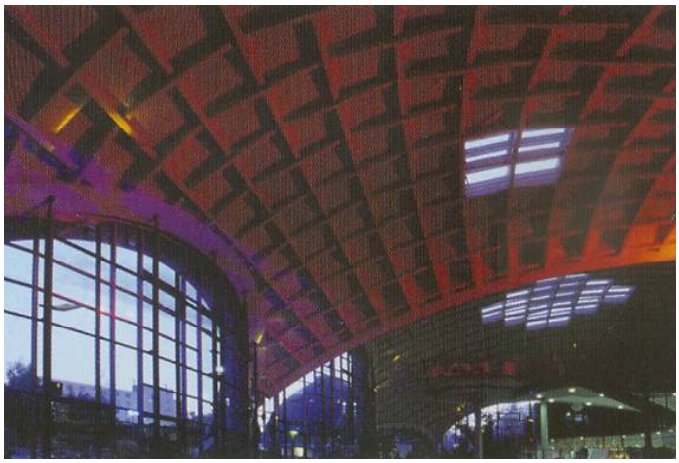
Space & Maximizing Functional Flexibility

Modernization, which signifies advances in industrialism and technology as well as freedom from, specifically structural constraints, resulted in the maximum flexibility of space planning and building function. Maximum interior architectural flexibility is achieved by positioning the primary structural elements outside the building's envelope, or by centralizing it in one location. This approach is not always the answer, due to excessive structural depth and other structural implications, particularly costs associated with spanning the width of a building. Therefore, a far more common and realistic approach to achieving a high degree of planning freedom involves adopting the "free plan"--being integration of structure with interior space inherited from the modern movement. It is only through advances in industrialism and technology, that have enabled the spaces that once would have been enclosed by load-bearing walls, now find the opportunity to flow almost completely unimpeded around and between columns that are usually located on an orthogonal grid. The new widespread concept is about the spatial neutrality of structures that allows for a "free-plan". On the other hand there is a debate about the neutrality of the structure. Locating structure, within a building envelope can reduce the net usable area, as well as restrict the usage of space in its surroundings. In the above indicated case of the Tugendhat House designed by Mies van der Rohe, one might interpret positively the architect's use of column by arguing that he used columns to help identify places and define the living and study areas. On the other hand, one could conclude that columns positioned close to walls play no particular spatial architectural roles and definition. Therefore, spatial efficiency might have been improved, if the columns were substituted with alternative load-bearing walls in designated locations. This could also have been implemented by relocating the columns to the periphery of the space. Maximum planning freedom occurs when the area of the vertical supporting elements of the building is reduced to the minimum possible, while being situated on the building's perimeter. Obviously, this approach has its own restrictions as well.

3A.2 Role of the structural elements as device paradigm in defining spaces and functions

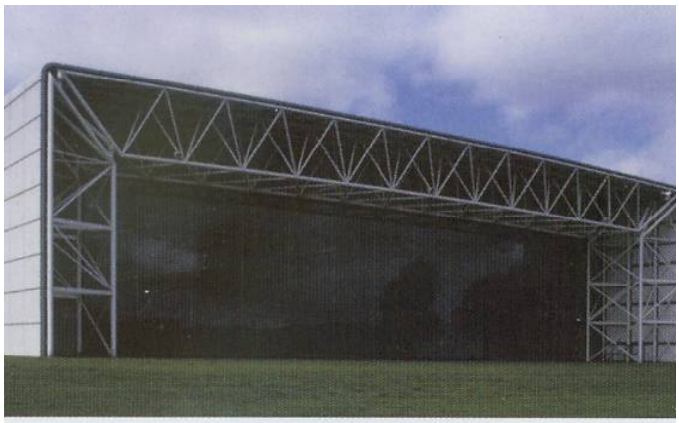
In performative buildings, structures can have a profound influence on building function. In addition to its role of providing firmness and stability, the structure could also play a significant role in providing spatial organization. It can horizontally or vertically define and articulate interior and exterior circulation within spaces, as well as separating and defining the primary functions. Additionally, the structure, through a combination of walls and columnar elements, as well as through its rhythm and hierarchy, has the potential to introduce variety and meaning to the spaces. The structure contributes not only in giving definition, but also in conveying meaning and enriching the architecture of the interior, while establishing a vocabulary for the architecture. The structure, by virtue of its permanence, defines and limits the activities within a building. Nonetheless, in performative architecture, the structure is one of the design tools that can have a profound influence upon building function and appearance. On the other hand, the degree to which the architect would like to utilize the structural elements to define and /or limit the functional activities within a building, and the extent of a structure's physical presence and participation in both plane and volumetric aspects of the space, will make a difference in the structural performativity of the building. Depending on the degree of integration of the structure, it can maximize or even disrupt functional flexibility, subdivide the space, or articulate the functions. Nonetheless, in performative architecture, the structure of the building must be thoroughly integrated both in the conceptual design process and in the functional performance of the building.

Role of structural elements as device paradigm in defining spaces and functions

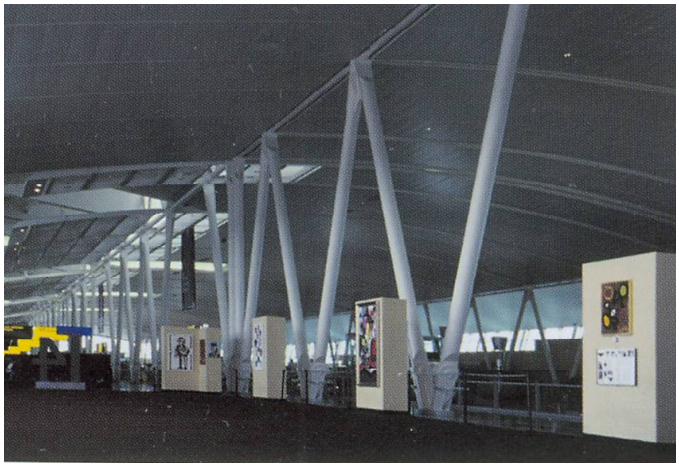


In performative architecture, structure is one of the tools that enables performativity of the building. The structure can give definition and meaning to the space and allow for flexibility and functionality.

Toscana Thermal Pools, Bud Sultza, Germany, Ollertz & Ollertz, 1999. Timber shell structure. Open structure free space under the shell roofs.

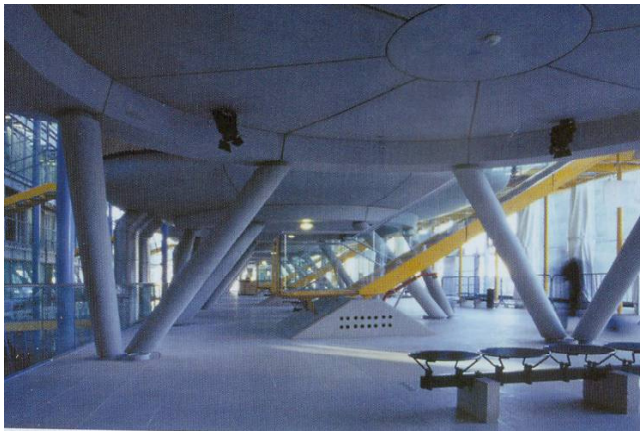


Sainsbury Center for visual arts, Norwich , England, Foster & Associates. 1977. The vertical wall structure that is visible on the end elevations houses support functions.



Law Courts, Bordeaux, France, Richard Rogers and Partnership. 1998. A waiting area under a courtroom pod.

FK Airport terminal 4, New York, SOM. 2001. V struts separate ticketing areas to the left from a circulation area and retail outlets on the floor beneath.



PhotoCredit:
Charleson, Andrew W. Structure As Architecture (Italy: Elsevier, 2005).

Museum of Roman Art, Merida, Spain Rafael Moneo, 1985.
Nine cross walls subdivide the main space horizontally into separate galleries. This view shows the nave, and the floor slab dividing the span vertically.
Photo Credit:
Charleson, Andrew W. Structure As Architecture (Italy: Elsevier, 2005).

Structure, in performative design, is a tool to generate spatial fields and boundaries, and a means to affect the occupants' senses and perception. Structure creates possibilities for different ways of place-making. Interior structure, offers many diverse spatial and visual experiences. Structure can also play an important role in ordering spaces and imposing a sense of spatial hierarchy. In performative designs, the choice of structure typically demonstrates a high-tech, progressive concept of making places. The proper application of structure accentuates building geometry in such a way that it can lead to additional architectural enrichment.

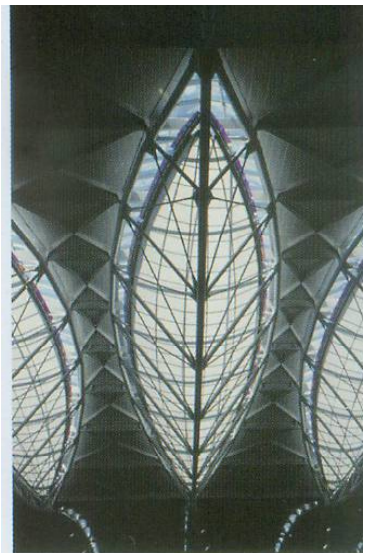
3A.2.1 Structures as the modifier and a source of light

Part one of this research, discussed the mechanism of perceiving space, specifically that architectural space exists when it is experienced by the senses, particularly sight. Modern architecture is considered to be the art of placing and controlling light sources in space. Nonetheless, in performative architecture, control and dissemination of light are the responsibilities of the enclosure and the structural system of the building. The structure of the building in performative design can be potentially a medium and a source of light. The structure allows for the penetration or illumination, as well as control, obstruction, and dissemination of light within a space. Depending on their geometrical configuration, structures either inhibit or facilitate the penetration of light. From the stand point of performance, structure, relate to light in four different ways:

1. As a source of light
2. As a maximizer of light by minimizing the shadow effect of the structure
3. As a modifier of light by reflecting and diffusing it, and
4. As a mechanism of perceiving space for light to affect our perception of structure.

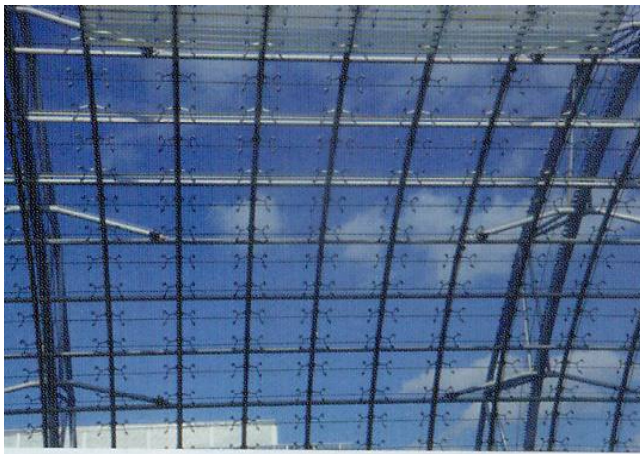
Some structural forms are far more receptive to daylight penetration into building interiors. For instance, the skeleton quality of structural moment-resisting frames has more potential to light, than opaque structural walls.

3A.2.1 Structures As the Modifier and a Source of Light

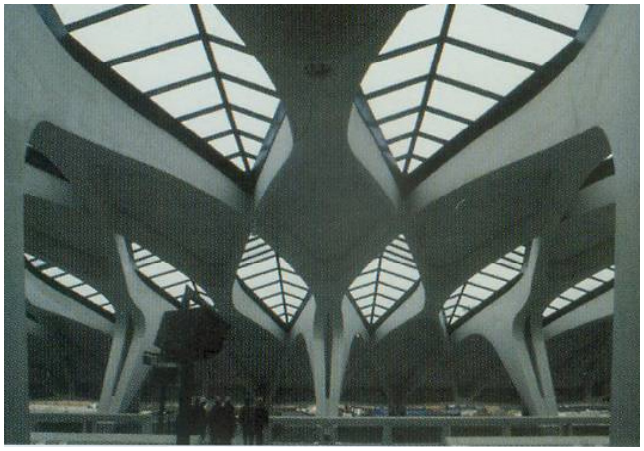


San Francisco International Airport. SOM, 2000.
Light passing through a 3-D truss. The 2-D truss transforms into 3-D over the central span of the terminal.

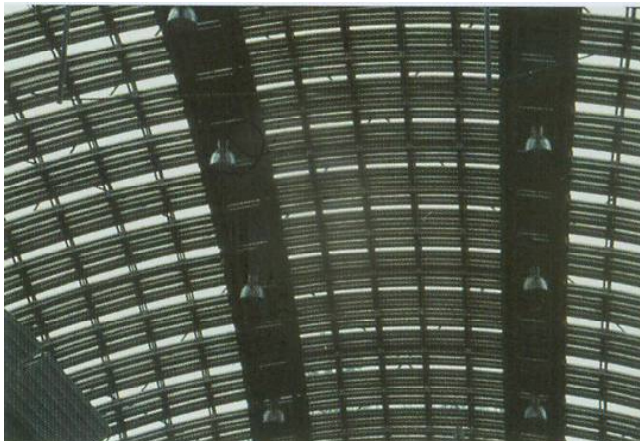
Burrell Gallery, Glascow , Scottland Bary Gasson Architects 1983. Repetitive and yet attractive glass and timber restaurant.



Trade for Glass Hall, Leipzig, Germany, Ian Ritchie Architects, 1996. Trusses and the grid-shell as seen from within the hall.



Railway station of Lyons Airport, Santiago Calatrava, 1994. A view across the concourse, glazed area are integrated with the pattern of ribs.



Seed House and Forestry Center, Marche-en-Femenne, Belguim, Samyn et Associes, 1996.
Shading increases at the splice positions of the transverse arches.

Photos Credit:
Charleson, Andrew W. Structure As Architecture (Italy: Elsevier, 2005).

3A.2.2 Structure as a Mechanism of Perceiving Space

Part one of this research referred to the elements affecting our perception, including distance, size, scale, and more. An individual's mind inherently has the potential to develop the process of perception. The mechanisms of perception are used as stimuli to raise the level of perception in such a way as it relates the occupants of the space to the interior as well as the exterior of the building. In performative design, elements of structure, including walls, slab, beams and columns, are given the potential to be utilized and to participate in ordering the facade thereby affecting one's perception of the building.

3A.2.2.1 Modulation:

Generates patterns that potentially introduce variety, rhythm, and hierarchy, and generally creates interest. If modulation is too repetitious, it ceases to be an attractive architectural feature. Where beams and columns modulate a façade, they visually subdivide the skin, horizontally and vertically, creating a rectangular ordering pattern over the building surface. Within these structural modules, secondary structural members---including supportive elements of glazings--- which in order of magnitude are smaller than primary structural modulators, may further subdivide the surfaces.

Yerba Buena Lofts, San Francisco, Stanely Sattowitz Office/ Natoma Architects, 2002.

88 Wood Street, London, England, Richard Rogers, 2000. Columns introduce rhythm and modulation.

Walls and slab, while modulating and ordering the facade, also alter one's perception of the building's scale. Concealment of the mezzanine floor structure behind glazing in each double-height apartment means that the ten-story building is read as five stories.

In Richard Rogers' design, perimeter columns are setback 1.5 meters from the street frontage to reduce the span and structural depth of the interior floor beams. By minimizing structural depth, the developers gained an extra story height within a restricted building volume. On the upper floors, a floor to ceiling glazed skin extends in front of the structural grid concealing it from the outside.

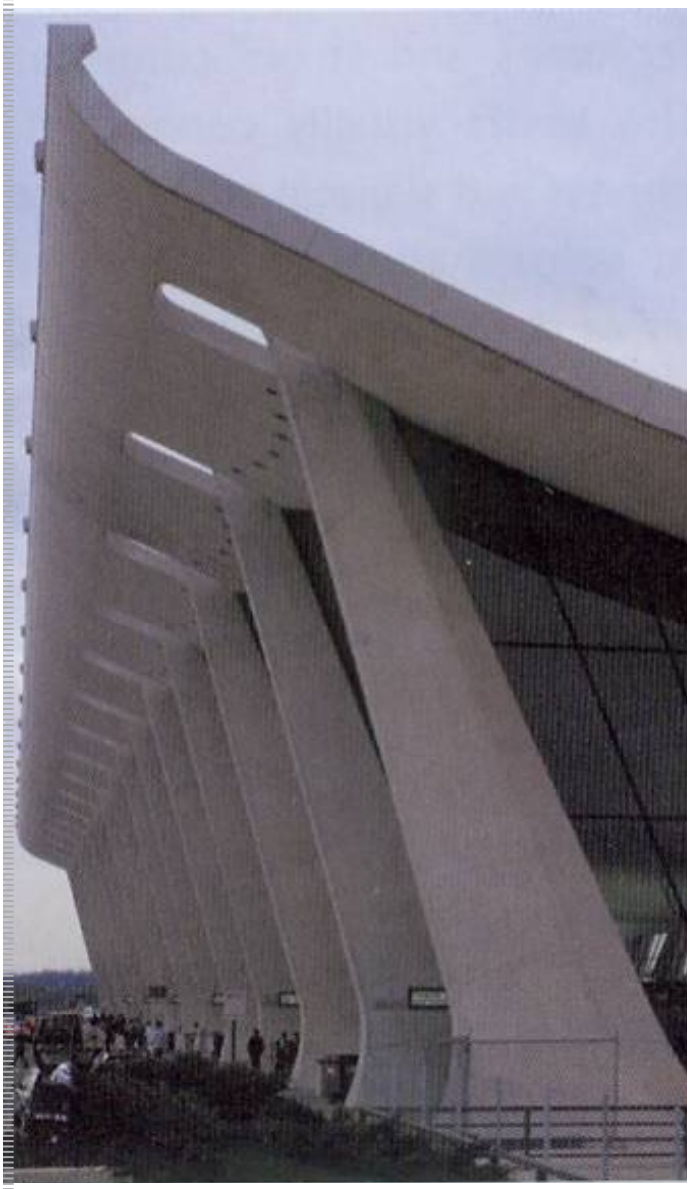
The resulting double-height colonnade, whichvisually functions as a base to the building, runs at the street frontage until the skin moves further back into the building to accommodate stairs and a ramp to the main entrance. Above the level where the columns disappear behind the skin, the articulation of the suspended floors and vertical joints between the story-high glazed units modulate the facade at a finer scale.

Photos Credit: Charleson, Andrew W. Structure As Architecture (Italy: Elsevier, 2005).

3A.2.2.2 Depth and Texture:

Although a tructure can modulate the surfaces around it by means of its distinguishing color or materiality, structural depth is a prerequisite for and major contributor to modulation. In performative design the variation of surface depth is a useful tool that relieves plainness, and in conjunction with natural and artificial light, creates opportunities for contrasting bright and shadowed areas to visually enliven a facade.

Unlike Gothic buttresses that resist compression thrust, originating from masonry roof vaults, the terminals' piers resist tension forces arising from a reinforced concrete catenary roof.



Dulles International Airport, Washington DC
Saarinen.

The elegant tapering of slanted columns reflects both structural actions and the architect's desire to express the movement and excitement of modern "travel by air."

Piers create deep bays along the facade, which certainly add a great deal of dynamism to the building's architectural vocabulary.

From almost every view point, the piers visually dominate the exterior of the terminal and provide depth and rhythm to the front facade.

By curving the glazed walls, in-plan additional façade depth is gained. Architecturally, the facade gesture accentuates points of entry and bays between the piers are places for people to meet and wait.

Photos Credit:
Charleson, Andrew W. *Structure As Architecture* (Italy: Elsevier, 2005).

Structure as a Mechanism of Perceiving Space - Depth and Texture

As a mean for design performativity, structure can modulate the surfaces around it by way of its distinguishing color or materiality. Structural depth is a prerequisite for and major contributor to modulation.

World Exhibition Center, Hanover, Germany, Herzog and Partner 1999.
An example of textured soffit surface

Although the main members, the masts and cantilevering ribs are themselves textured, the fine ribbed shell structure, spanning between the cantilevers and covered by a timber lattice as a white waterproof membrane appeals to the eye.

PhotoCredit:
Charleson, Andrew W. *Structure As Architecture* (Italy: Elsevier, 2005).

3A.2.2.3 Screening & Filtering:

The exterior structure can be read as a screen or a filter depending on its depth, density in plan and elevation, and spatial relationship to a building envelope.

In a performative design, this is another means of providing aesthetic qualities for the facade, and adding to the building's architectural vocabulary.

Exhibition Center Melbourne, Australia, Denton Corker Marshal.

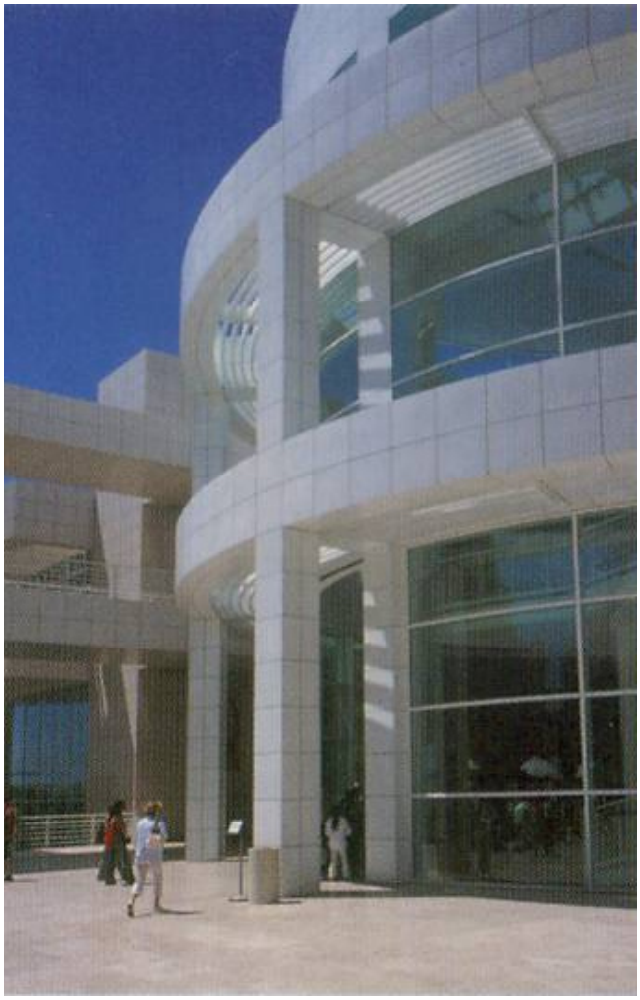
A multitude of slender steel posts, on a close 3x3 grid support.

A wide verandah that slopes away from the main building.

A promenade along the building edge through the posts yields a final delight--their slenderness, close spacing, and uniform tilt recalls walking through the saplings of a windblown forest.

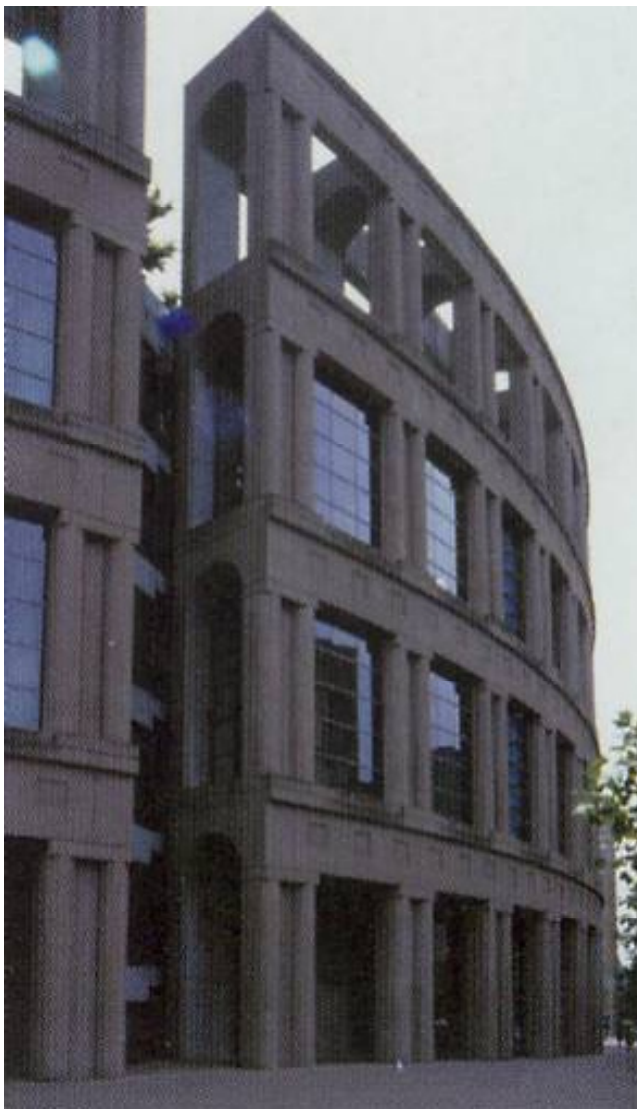
Photos Credit:
Charleson, Andrew W. *Structure As Architecture* (Italy: Elsevier, 2005).

Structure as a Mechanism of Perceiving Space - Screening and Flitering



Getty Center, Richard Meier, LA, Ca

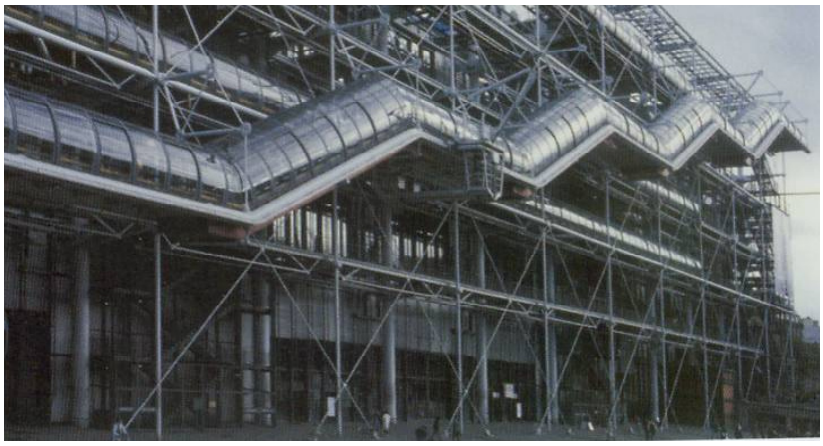
By varying the relative position of structure and skin in plan, structure projects beyond the building enclosure to contribute to depth and to some extent screen of the façade.



Library Square, Vancouver, CA Safdie, 1995

A gap reveals the cross section of the screening frame and a glimpse of the main library block behind

Photos Credit:
Charleson, Andrew W. *Structure As Architecture* (Italy: Elsevier, 2005).



Centre Pompidou, Paris, Piano and Rogers.

Screening effect of structure on the main façade.
Most screening structures on the main facade, are located within one plane.

Photos Credit:
Charleson, Andrew W. *Structure As Architecture* (Italy: Elsevier, 2005).

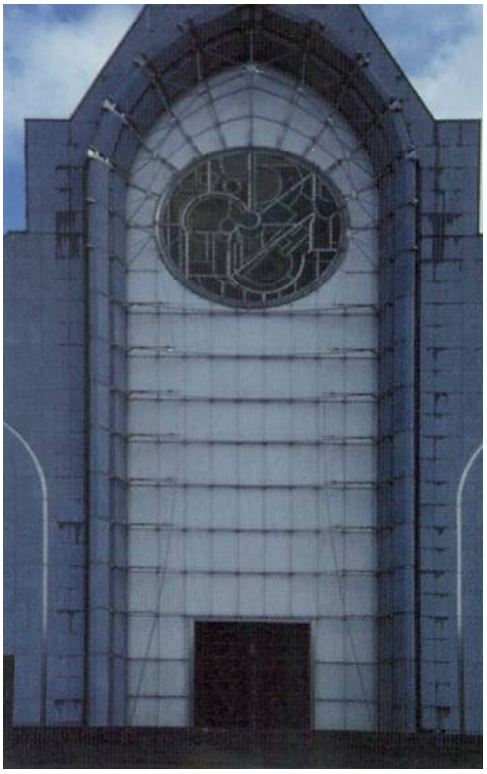
Mexican embassy, Berlin Germany, Gonzalez de Leon and Serrano, 2000.

Exterior structure functioning as a screen.

3A.2.2.4 Structural Scale:
The structural scale strongly influences how the exterior structure contributes aesthetically to a facade. The dimensions of structural components can lie anywhere on a continuum between the extremes of mesh-like fineness and massive monumentality.

Where steel is used efficiently, structural members in tension, invariably fall into the category of small scale.

A stainless steel rod and tube structure, reminiscent of a spider's web, supports a new exterior nave wall.
Cathedrale Notre Dame,
de la Trielle, Lille, France,
Pierre-Louis Cartier



Structure as a Mechanism of Perceiving Space - Structural Scale

Law Court Bordeaux, France, Richard Rogers. 1998.

Where steel is used efficiently, structural members that are in tension invariably fall into the category of small scale.

A stainless steel rod and tube structure, reminiscent of spider's web, supports a new exterior nave wall.

Exposed five-story-high columns are relatively slender given their height and the size of the building behind them.

Their modest diameter acknowledges the light loads from the delicate steel trusses they support and their independence from suspended floors supported by interior columns.

The lateral load resisting system consist of exoskeletal braced frames that wrap around each corner of the building.

Frame members are considerably smaller than the glazing panels behind them, and appear rather frail.

Hotel de las Artes, Barcelona, Spain. S.O.M.

In performative design, adoption of structural elements to give a sense of scale to the facade has become a common strategy in modern high-rises as well as long-span structures.

Structure as a Mechanism of Perceiving Space - Creating a sense of indoor-outdoor relationship

Creating a sense of indoor-outdoor relationship:

In performance-based design strategies, one of the design objectives is the celebration of a direct and indirect relationship between the interior spaces and the external environments. Obviously, the concept of transparency goes hand in hand with this goal, and is a main contributor to achieving of this objective.

Connecting the Exterior to the Interior:

In contemporary architecture, a structure that is exposed on an exterior elevation is the continuation of the interior structure. This may be the consequence of a design process that begins by focusing on the interior structure and then includes it with other goals and ideals like transparency to inform the exterior design. However, the relationship between exterior and interior structures may also have deeper roots. There may be a conscious reaction against the practice of facadism, where a façade bears little relationship to the rest of the building, or a concern for a holistic and integrated architecture with a demonstrable coherency between exterior and interior. An outside-inside connection need not be literal but might entail external expression of the interior structural qualities, rather than the exposure of actual members and details.

Photo Credit:
Charleson, Andrew W. *Structure As Architecture* (Italy: Elsevier, 2005).

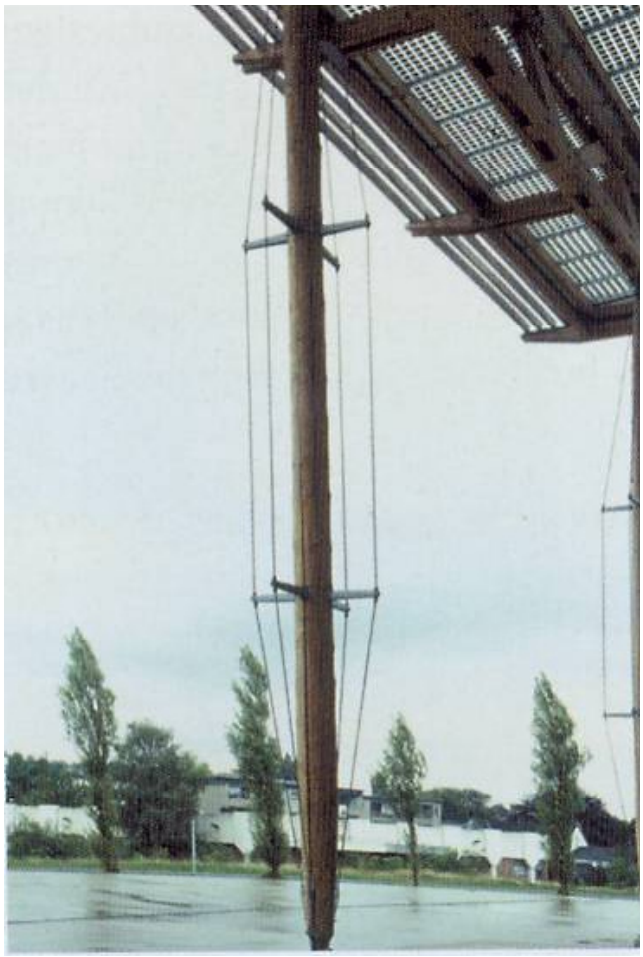
Stansted Airport Terminal, Essex, England. Foster Associtess, 1991.

Portico trees are extension of the interior structural motifs.

Portico trees are an extension of the interior structure.

The structural motif of the trees are repeating themselves inside as well as outside of the main roof canopy.

Structure as a Mechanism of Perceiving Space - Creating a sense of indoor-outdoor relationship



Mont-Cenis Academy, Herme, Germany 1999. Jourda & Perraudin

The front canopy structure is almost identical to that of the interior, which presents glimpses of the interior structure on the exterior. The timber posts and roof structure that supports a full-width entrance canopy are the genuine expression of the structure, located inside the building envelope.

From stand point of performativity, due to the long span of the roof canopy, the added steel rod composite action supplements the vertical load-bearing capacity of the posts.

Public University of Navarra, Spain, 1993

The pair of exterior columns are precursors to columnar interior architecture.

Photos Credit:
Charleson, Andrew W. *Structure As Architecture* (Italy: Elsevier, 2005).

3A.2.2.6 Entry:

Provision and articulation of entry are very important aspects of architectural design, which provide endless opportunities for structural participation.

At a basic level, a structure might contribute little more than the support of an entry canopy. Yet in another building, a structure might function as the architectural element that creates a sense of entry, and contribute to its expression and celebration. In performative designs, creating a sense of entry is achieved through the direct expressive usage of design motifs and of structural detailing.

Millennium stadium, Cardiff, Wales, Lobb, now HOK sports, 2000

The main entry is under the beam between the mast legs.

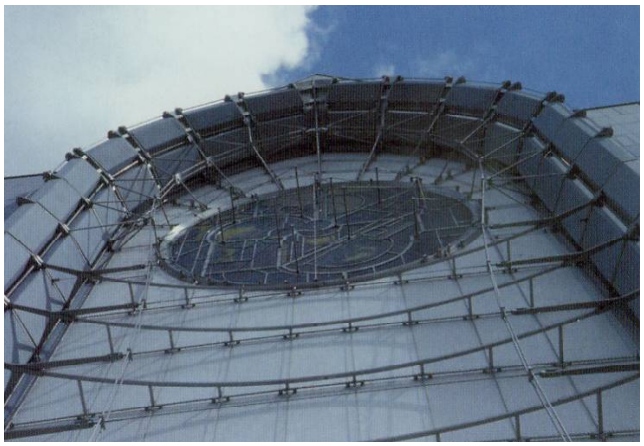
Charles de Gaulle Airport Terminal 2F, Paris France, 1999

Photos Credit:
Charleson, Andrew W. *Structure As Architecture* (Italy: Elsevier, 2005).

Semi-circular columns signal entry.

3A.2.2.7 Expressive Role:

Throughout history, exterior structure has long played expressive roles in the architectural vocabulary of buildings. However, in performative design, contemporary exterior structure continues this expressive communicative role, with more added meaning and performative qualities. Exterior structure can express various architectural ideas. The clarity with which such an idea might be communicated and the efficiency of the integrative design are two different matters. The efficiency of its integrative design is certainly dependant on the architect's skill and his focus on performative design processes.



In performative processes, exterior structure conveys not only a sense of protection and enclosure, but also demonstrates architectural ideas metaphorically and physically.

3A.3 Roles of Building Enclosure

3A.3.1 Concept of Interactive Skin:

In performative design the skin of the building undertakes an interactive role. It acts not only as a transitional element between the inside and outside to moderate indoor and outdoor climates, but also has an active role in imparting permanence, strength and durability to the building. In a performance-based building, the aesthetic and cultural function of the skin, as well as its urban influence, are just as important. A performative building conveys a sense of identity through its enclosure. The ideas that the external appearance of a building should reflect its internal life and that there must be an inherent harmony between the form and function of the exterior elements of the building are strongly reinforced in performative architecture. Due to the advances in modern technology, the skin of the building has found opportunity to liberate itself from the task of carrying the load of the building. Therefore, in many design forms, the interactive role of the skin has been transformed to that of a curtain or a cladding. In performative designs the concept of a skin that interact with its environment are developed and tested through modeling techniques and computer design simulations. Computer software provide opportunities for the appropriate integration of the building form and the most efficient skin. It is through computer analysis that skin has found the opportunity to be investigated in its various and multi-functional roles and responsibilities. In performative architecture, the skin of the building is subject to tests for maximum efficiency of multitude of functions. Although in performative design the aesthetic role of the skin is vitally important, the creation of a responsive and functional skin which interacts with its surrounding overrides its ornamental role.

As technical requirements are becoming more complex and challenging, especially in the area of insulation, nearly every external skin, in performative ways, is becoming a multi-layered system. True process-based, performance-oriented designs allow for interchangeability, adjustability, and replacability of skin, when uses change over the life cycle of a building. This issue is becoming more and more vital, as the clients' demands for more flexible spaces and different uses are increasing. Therefore, in the increasingly expanding context of the virtual world, performative design architects look at the design of the building skin as an element that not only architecturally satisfies the aesthetic, communicative and expressive roles of the skin in establishing a vocabulary, but also plays a major part in establishing the sustainable, low-energy objectives of the building. The skin of the building has become a hybrid element that combines high and low technology for more efficiency. Nowadays, skin can consist of simple folding and sliding shutters, or it can include the popular movable louvers. It can also culminate in multi-layered glass facades, which are equipped with a multitude of devices for shading and glare protection, light deflection, as well as heat and energy gain. Today's performative facade design is constantly in search of newly emerging and innovative skin materials, while avoiding the risk of creating superficial ornamentation.

Performative design creates an architecture that is guided by reason rather than the pure art of invention. In order to have an architecture of reason, design must adhere to the universal laws of nature and the mechanical laws of materials. There are four aspects that need to be met in order for the skin to have been guided by reason. These four aspects are vitally important to the theory and analysis, as well as to the planning and design of the skins:

1. Function: What is the practical purpose of the building skin?
2. Construction: What are the constituent components of building skin, with respect to all the other components of the building itself?
3. Form: How does the building skin look like?
4. Ecology: What is the energy consumption of the building skin during construction, use,

and demolition.

Nonetheless, building skin has to possess certain physical and aesthetic requirements as well as functional properties in coherency and harmony with the rest of the building components.

3A.3.2 Building skin as a separating and linking element between indoos and outdoors

In performative design the skin of the building must fulfil a multitude of vital functions and is a principal factor in the energy consumption of a buildings. Some of these functions are as follows:

- Energy gain (Thermal Filter)
- Lighting (Light Filter)
- Fire protection (Barrier)
- Ventilation (Air Filter)
- Noise protection (Barrier)
- Sun protection (Barrier)
- Wind protection (Barrier)
- Protection from humidity (Barrier)
- Glare protection (Barrier)
- Insulation against heat/cold (Barrier)
- Visual contact (Visual Filter)
- Visual protection (Barrier)
- Safety / security (Barrier)

The expected functions of the skin, which are not limited to the above list, establish the number of experts required for this important system of the building. In a performance-based architecture, the skin must have the capacity to mitigate prevailing conditions, while being able to regulate and adjust itself to ensure a comfortable condition for the interior.

3A.3.3 Comfort factor requirements for the building skin:

The direct link between building skin and room climate calls for a precise definition of human comfort. The comfort factor works in conjunction with various other factors. Considering these factors in isolation will not bear ideal results.

3A.3.3.1 Indoor Air Temperature

Indoor air temperature as low as 18 degree C and as high as 27 degree C in the summer is perceived comfortable. Typically the comfort range is within 20-25 degree C.

3A.3.3.2 Air Change and Air Movement

A minimum of .3/h is sufficient for an unoccupied room. During work hours this value rises to 1.1/h. This corresponds to a fresh air intake of 40-60 m3/h per person.

3A.3.3.3 Relative Indoor Humidity

Depending on the room temperature the comfort zone for relative indoor humidity ranges between 30 and 70 percent.

3A.3.3.4 Average Surface Temperature

Typically these temperatures should not differ by more than 2-3 Kelvin from the indoor temperature.

3A.3.3.5 Luminance

The standard value for luminance differs depending on the work activity, room layout, and proximity of workstation to windows. A typical value falls in the region of 300lx for a workstation near a window, 500lx. for a standard office cubicle and 700lx for an open plan office, or 1000lx for an open plan office with medium surface reflection.

:

3A.3.4 The Roles of Building Facade and Roof Enclosure in Interior Comfort

There are strategies to increase human comfort and reduce energy consumption in building. Typically, the strategies revolve around reduction of cooling loads by means of optimal sun protection, improved daylight use and daylight-dependent regulation of artificial lighting. Additionally, excess heat gains should be extracted via night cooling, a process that can be greatly facilitated with the corresponding building skin design and exposed thermal masses in the building interior. This combination is equally effective for reducing transmitive and ventilative heat losses. Certain building elements that are flexible, both in design and in use, are essential tools for establishing such strategies. Depending on the situation, room heat gain or thermal transmittance losses in the facade can be minimized through application of shade, glare protection devices and insulating systems, as well as daylight deflecting devices. In performative architecture basic strategies for heat insulation, as well as shade and glare protection devices are both considered effective ways to reduce energy consumption in buildings, particularly in the summer.

3A.3.4.1 Performative Sun Protection Systems

In addition to the heat insulation factor of a transparent facade, the placement of the sun protection systems, has a major influence on the energy consumption of the building. Calculations performed on conventional facades with east-west orientation have shown that the energy consumed for cooling can be halved when external blinds are used, versus a glass facade without sunscreen elements. This is also compared to the use of internal blinds, which reduces energy consumption by no more than 20%. Sunscreen elements are required to prevent overheating in all building types, especially for buildings with high internal cooling loads or a high percentage of glazing. Moveable systems can be adjusted to respond to changing solar altitudes over the course of a day in different seasons, allowing for individual control of sunscreen elements, optimal shading, and maximum use of daylight. There is one main disadvantage with internal sunscreen elements, which is related to their tendency to absorb and store solar radiation and transmit it into the room. In summer, this results in unwanted additional cooling loads, and in winter, the potential heat gain may be used to increase room temperature. Those systems mounted behind glass and thus protected from the elements are easier to build and to install. This is equally true for double-skin facades. With elements such as micro-grid and prism systems, installed into the cavity between insulated glazing, the cleaning and maintenance effort is potentially reduced even further. Despite the advantages offered by weather-protected shading systems, external sunscreen elements are still the most advantageous option due to the direct convection of heat gain to the outside. Nevertheless, it is important to consider climate conditions and wind resistance when selecting the relevant components, since high wind load can lead to a temporary system shutdown.

3A.3.4.2 Anti-Glare Systems

The principle difference between anti-glare and sun protection systems is to prevent extreme contrasts in lighting intensity. In performative design solutions, a variety of different systems can be used to mute and scatter the intense light. These are: curtains, horizontal blinds, venetian blinds, screens, translucent glazing, and electro-chromic glazing. In use of these systems, it is important to avoid reducing daylight transmission to the point where artificial

light has to be used or to impede visual contact between inside and outside. Textile anti-glare systems, screens and perforated aluminum louvers are practical options. The position of an anti-glare system in relation to the internal glazing layer determines the amount of heat, which is in the interior as a result of radiation.

3A.3.4.3 Daylight Use

In performative design the use of natural daylight is increasingly important both in terms of comfort and user satisfaction, as well as reduction of the need for artificial light. Daylight strategies combined with artificial lighting are particularly useful in the interior spaces where significant room depths preclude direct use of daylight, and or where the quality of lighting is a high priority. Moreover, daylight-dependent artificial lighting offers additional savings potential. Measures to optimize the use of daylight should always be closely integrated with any sun protection systems to keep the daylight component of transmitted solar radiation as high as possible. Conversely, the short-and long-wave spectrum of solar radiation needs to be reduced to as low as possible. The following systems are suited to meet these requirements:

- Glazing with selective coatings
- Reflectors that deflect daylight into the depth of a room
- Micro-grid systems with high reflective coatings
- Prism systems
- Light diffusing glazing
- Glass louver systems
- Holographic defractive system (HDS)

3A.3.4.4 Thermal Insulation Systems

Employing materials and components capable of reducing heat loss through transmittance, convection or radiation is an option for regulating the resistance to thermal transmittance in a facade or roof structure. The usage of building enclosure as a regulator for thermal transmittance must be in response to internal requirements and external weather conditions. The common approach is to use materials with low thermal transmittance factors, low emission properties to decrease heat loss by radiation, and also high reflective foils or surface coatings to reflect heat radiation. Aside from reducing heat loss by transmittance, these measures can also help to increase the internal surface temperature of the exterior wall. Fixed systems, such as combined heat-insulating systems or rear-ventilating facade systems, do not allow the insulating properties of the building skin to adapt to seasonal and daily fluctuations of external temperatures and radiation conditions. This may become problematic when transparent or translucent insulating components are used, and when there is a need to avoid summer overheating. In movable systems such as sliding and folding shutters, the insulating material or component is installed either on the inside or on the outside of the existing skin structure. Transparent and translucent building components can be used for heat gain in the winter for preheating the air in the facade cavity, while evacuating the heated air via facade openings in the summer. Opaque insulating systems do not offer this advantage for utilizing solar gains.

3A.3.4.5 Natural Ventilation

In performative buildings the performance of the building skin in terms of natural air

exchange is an important expectation. Meeting the requirements for air hygiene is the key factor in this approach. The need for air hygiene must be in conjunction with maintaining the correct amount of ventilation, that is, to minimize heat loss by ventilation due to cool outside temperature. Free ventilation through existing openings in the building skin is generally sufficient for rooms whose depth does not exceed the height by more than 2.5. Depending on the type of opening, as well as on the location and position of the operable element, this solution achieves air changes between .2 and 50 /h. Designing the building skin specifically with these natural principles in mind --such as stack effect-- can help to achieve natural ventilation even in the case of great room depth.

3A.3.5 Role of the Envelope With Respect to Building Vocabulary and Perception

Part one of this research, discussed the types of architecture performance. As was discussed, there are two types of architecture performance: First, performance of architecture as an objective act, which involves techniques, measuring and sizing. The second type is an experiential one that has to do with architecture manifestations and their impact on our senses. This is a motionless and unanimated act of performance as it directly relates to our perception. Perception has to do with the type of impression that one will have by seeing, touching, and developing certain feelings about the building's vocabulary and expression. Nonetheless, the meaning that people read into a building is largely a function of what is expressed by its envelope. This is the same as the meaning or perception that one develops by experiencing the interior spaces. The most predominant visual component of a building from the exterior is the envelope. The envelope also functions to connect or even separate the building from its surrounding built and un-built contextual environment.

Nonetheless, the envelope of the building plays a vital role in our perception about the built environment.

NCARB's Professional Program on Building Envelope (10) recognizes eight strategies or concepts that can influence the aesthetic of a particular building envelope and in turn generate certain intellectual and emotional responses in the mind of the beholder. These concepts are:

- Structural expression or concealment
- Opaque, transparent, or translucent
- Natural or man-made materials
- High-tech or low-tech
- Temporal or permanent
- Background or foreground
- Graphic device
- Iconographic entity

Most of these concepts and strategies are discussed in different sections of this research. In performative architecture, the choice of each concept will be substantiated through reasons that tie the design to the program and to the site. In performative architecture, different components and systems of the building are utilized to create the expected coherency between the three elements of design, program and site. The choice of design concepts facilitate bridging between the three elements of design, program and site. Undoubtedly for a given project based on a given site and a program, the architect must decide which one of the potential concepts best suits the project. It is possible to combine more than one concept and develop a hybrid solution,

3A.4 Towards a Futurist Live-Work Performative Habitat - Developing Design Concepts - Search For Performative Concept

"I believe that the original intention of our architecture was to create an architectural connection between the sky and the earth, a connection which enlightens and expresses man's movement and position, to create a magic, weaving an invisible spell on its surroundings."

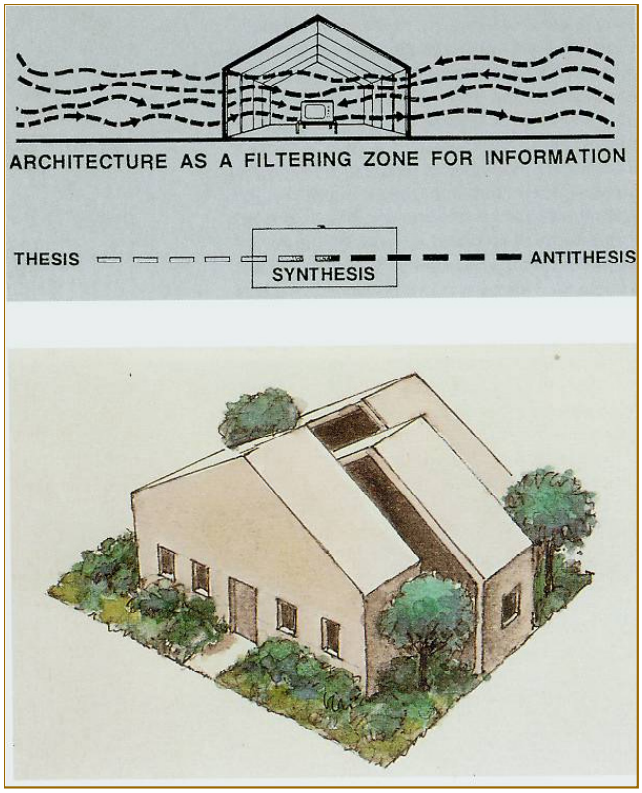
Imre Makovecz: Building with Soul
(Bio-Architecture 121)

3A.4.1 Search For Performative Concept - Introduction:

The discussion of performative architecture leads to the interpretation of architecture as a system of "passages" for the flows of the forces, that are constantly impacting it. It is a concept that links building, landscape, and elements of social, contextual, and environmental communications. Architecture in its physical sense, meaning as a tangible construct, consists of a combination of systems, which in their totality serve the building functions and intended use. Passages allow the building to become inherently adaptable to its natural setting. Should they function properly, the building establishes a coherent association with its natural and even man-made environment.

If we agree with the concept of the earth as one living organism, a truely responsible architecture must function as an intrinsic part of the ecosystem. Until the day that technology can provide the opportunity for the buildings to become true organisms of nature, a hybrid solution and an efficient system of passages can provide a compromise.

This means that the communicative role of the building suggests shifting the aesthetic focus of architecture from a sculptural object to an organism of nature that has the capacity to absorb and transmit messages, while adjusting itself to the manifestations and nuances of the ecosystem. As it was described in part one of this research, the more attuned the building is to the foreseen and unforeseen external contingencies of nature, the more the working system of passages are in effect between the building and its surrounding ecosystem.



In performance-based architecture designs are involved with morphogenetic practices, in which the elements influencing the production of the buildings are based on the flows, forces and elements of the surrounding cosmos. In this architecture, the system of passages is inevitably in effect and in practice. This is what makes a building a dynamic and living system. Indeed, the designs' of process-based buildings focus on energy efficiency and the creation of intelligent enclosure systems. Such buildings have the capacity to control and monitor the climate, while maintaining the appropriate schedule of adjustments with the necessary established system of passages that allow the buildings to link and communicate with the entire surrounding landscape, and to social, contextual, and environmental elements.

According to James Wines: "…walls as being seen mainly as barriers of enclosure or compositional elements, can serve as information-filtering membrane or points of passage that fuse and dissolve traditional inside/outside relationships…" (Green Architecture 223-224).

The concept of passages in terms of performative architecture can also relate to the integration of trees, vegetation, water and other combinations of atmospheric and terrestrial elements such as shelter. Even from an aesthetic standpoint, the objective is to look at the fusion of structure and landscape as a kind of interactive dialogue visually describing their mutual origins in nature.

"Trees are the most complete representation of life. Branches are supernatural aspirations and roots represent the mysterious unconscious."

Imre Makovecz,
Building with Soul (Bio-Architecture 121)

Photos Credit:
Wines, James, Green Architecture, (London: Taschen, Verlag, 2000)

3A.4.2 Developing Design Concepts - Programmatic Goals & Objectives

Factual assumptions, and goals for the development of the project program and conceptual design ideas:

1. A performance-based design approach, in which the expected building performance becomes a guiding design principle toward its architectural form making.

2. A design attempt towards an Inevitable future, where all human enterprises will be modeled upon the behavior and characteristics of natural systems. This fact will entirely affect our socio-economic structure as well.

3. A design that is driven by the increasing demand for short-term structures in response to changes in families' structures and socio-economic circumstances, in addition to technological changes and the increasing desire for flexibility.

4. Where socio-economic circumstances are blurring the boundary between work and home life. The home office notion at this point in time is a common fact of life for many individuals. Subsequently, it is imposing a demand on the design of the homes to be readily flexible and convertible to all sorts of rising changes in the family's structure and status.

5. A design striving to capture the occupants' various work-live needs, the house will adopt a modular and open layout with a simple structure to adapt itself to changing lifestyles and circumstances. The interior of the house will assume a continuous and free-flowing layout and form. The occupants have the opportunity to determine their own interior arrangements and dimensions based on the type of desired activities. The free form allows each section of the house to become adaptable to the needed height, width, and depth of the desired activities of eating, sleeping, working, studying, entertaining and socializing. The well-defined functional areas can be opened or closed to the other areas, thereby creating a continuous space. Nonetheless, the interior open spaces have the capacity to unfold themselves in an indeterminate way, as will ultimately be needed. This will be in contrast to the fixity of other predetermined actions and events.

6. The house will be a fusion of high-tech & low-tech design solutions, striving to embrace a hybrid design of ecological technology. In this house, in order to acclimatize the environment to human behavior, the operation of certain building devices, which are also tools for the performativity of the building, are controlled by manual, electrical, mechanical, and/or even digital mechanisms.

7. The goal will be to adopt a design for the house that is in harmony with nature, while acting as an organism of the ecosystem. This will be accomplished by creating a paradigm and an active web of low-tech and high-tech mechanisms and spatial dynamisms that are constantly affecting each other.

8. The movement of people around and through the building at different levels and conditions, as well as the experience of the architecture's spatial presence and materiality, engagement of the eye and body, and dynamic display of light, will provide the architecture of the house with certain performative capacities that will undoubtedly be unique to this house based on different contextual circumstances.

9. The ultimate goal for the architecture of the house is to provide the opportunity for the building to transform, transcend, digress, or simply "move" from one state to the other, within an allotted range in the continuum of time and space.

3A.4.2.1 Adaptive and Responsive Objectives - Exploring solutions through performance:

1. The house will act as an "Intelligent Home," which has the capacity to perform similar functions to those that characterize the behavior of a living organism in nature. For example, this could mean following the path of the sun. Intelligent buildings utilizes high technology, which for the sake of efficiency are combined with manual devices.

2. The operation of the house through automatic controlled devices will be adaptive and responsive to the special needs of the disabled.

3. The house will be provided with an enclosure that possesses a thermo-regulatory skin. This is similar to a human skin's power, which has the capacity to adapt itself to the fluctuations of temperature and the moisture content of the air. The seasonal changes of skin for many animals, as well as the closing and opening of flowers in response to sunlight, are examples of nature's responsive power and performative behavior.

4. The building will act as an interface between the occupant and the varying climatic conditions throughout the day, as well as serving as a medium between the seasonal changes. It is also acting as a means of protection from the extremes of climates, while also fulfilling ventilation requirements.

5. The building will act as a dynamically animated object that moves not only as a static object in response to structural and thermal stresses, but also makes movements that will emulate systems seen in nature. It will also respond to occupant's needs. Such dynamism will include automatic and manually retractable opening and closing windows, as well as various levels of insulative membranes on the south-and west-facing facade glazings. The presence of these features will allow for daily and seasonally controlled passive solar gain.

6. The glazing elements are designed for adjustment, flexibility and adaptation to the different season's, the same way that human beings react to temperature by adding or reducing layers of thermal clothing. The dynamic system will be able to avoid unwanted solar gain in summer and protect the interior in winter, as well as providing a naturally ventilated environment within the building.

7. The planning of the interior spaces will be based on maximum flexibility, which will address the current and future needs of the residents.

8. For the purpose of this exercise, the modular approach to the design of the house is based on a flexible layout for a one-bedroom unit, which is more popular and in great demand in many regions. This idea lends itself to various forms of repetition and configuration in order to provide more bedrooms and meet programmatic requirements.

9. Typically, daytime living and working spaces are located on the south side of the house, while circulations and more private and fully enclosed spaces are situated to the north. The house, due to the circumstances of its location, will have a panoramic view of its entire site and outdoor context. Obviously, the rotational mechanism of the building allows for choices based on either the capturing the desirable view, or the invitation or avoidance of the heat and glare in certain areas of the house.

3A.4.2.2 Energy Objectives:

1. The Live-Work Habitat functions by sensible energy use combined with a passive system. The geothermal-activated heating and cooling system will be fed through the main shaft of the house, and runs through the metal panels in the ceiling of the first floor, maintaining a constant temperature with coils that carry cool or warm water as appropriate for the season. This system is supported by the easy-to-use control systems with maximum use-control provision.

2. Due to the high cost of energy in the region and the desire for energy conservation, the heating and air conditioning system will draw its primary energy requirements from an array of facade–mounted photovoltaic panels as well as a sophisticated geothermal system. When solar gain through the photovoltaic panels is not sufficient, space heating can be supplemented by geo-thermal heating. At the highest peak of demand, a movable solar burning fireplace can add to the heating demand of the space. The fireplace will be located according to the needs of different interior arrangements. The geo-thermal unit takes the heat from the ground and releases it as useful warm air in the house.

3. Based on a vision of sustainability objectives, provision for a large roof-mounted photovoltaic panel, as well as a wind generator will be made integral to meet the primary source of the household electricity demands. An array of rectangular panels on permanent scaffolding due south, south-east and south-west provided different daily sun angles for provision of additional solar support.

4. High-performance glazed, adjustable window panels within the retractable fenestrations on all four facades will help to minimize heat loss and heat gain from the building, as well as reduce the dependency on the artificial heat intake. The double-glazed glass with metal-coated plastic foil and inert gas between panes reduce the long-wave sun rays, thereby reducing heat gain in the home.

5. A sophisticated array of shading devices protect the interior from heat gain and the intense glare of the ocean, particularly on the West-and South-facing facades. The retractable panels of the four facades modify natural light and heat. On the exterior, horizontal rows of photovoltaic roller blinds modify natural light and heat, and act as the source of energy production, while adding to the dynamism of the architectural vocabulary, aesthetics and overall enrichment of the facade. Additionally, each operable window pane consists of two layers of double-glazed glass with incorporated motorized, adjustable louvers. The entire system of the facades thus operates according to the needs of each individual facade and its related orientation.

6. The house will benefit from sensor technology, which allows temperature and lighting levels to be controlled with touch screens. Water flow is also controlled by the sensor technology as well as by manual mechanisms.

7. A core of cables and flexible plumbing pipes run originally in the main shaft of the house and subsequently through surface-mounted and accessible ducts, which will be visible in the design components of the house.

3A.4.3.1 Materials of the form: Polymer specifications and characteristics

One of the main structural materials of the house is a site-cast shell module made of polymer (POMA). There are aesthetic and structural reasons for the choice of this type of concrete material.

The interesting and yet challenging aspect of working with polymer materials is the integrative aspect of structural and architectural decision making, since form and structure are no longer categorically distinct but may flow in and out of one another. With respect to the form of this house, the four curved corner panels are made of polymer concrete. In 3-dimensional form, at the top part of the corner panels, two opposing curves have to merge to create the doubly curved corners of the building. Polymer's ease of construction will be the most suitable for such complicated morphology in which form and structure are not separable. Additionally, the translucence of the polymer in conjunction with the adjustable louvers of the four facades will provide different arrays of interplay of textures of daylighting within the free-flowing form of the interior spaces, and will create a spacious cathedral of light from the 25 cubic feet form of this house.

Polymer composite materials have a relatively high strength to weight ratio with a vast potential for novel aesthetic effects. Polymer materials are highly moldable and require minimal maintenance.

Typical matrix materials for architectural PMC (Polymer Matrix Composite) are polyester and epoxy. Matrix is made from substances that consist of giant molecules formed from smaller molecules of the same substance.

The reinforcement, such as fiber of various type, is embedded in the matrix, which acts as an adhesive. In addition to the two principal elements, reinforcement and matrix, a composite can also contain additives and fillers. The latter are often employed to add volume with minimal weight gain. The former can be chemical compounds that yield color, for instance, or improve fire-resistant performance.

While additives and fillers can influence the strength of the composite, it is primarily the choice of the composite, and the interface between the additives and fibers, that determines the properties and performance capabilities of the product.

Although there are a number of inorganic and organic fibers, due to cost, fiberglass fiber is the standard type of reinforcement in architecture.

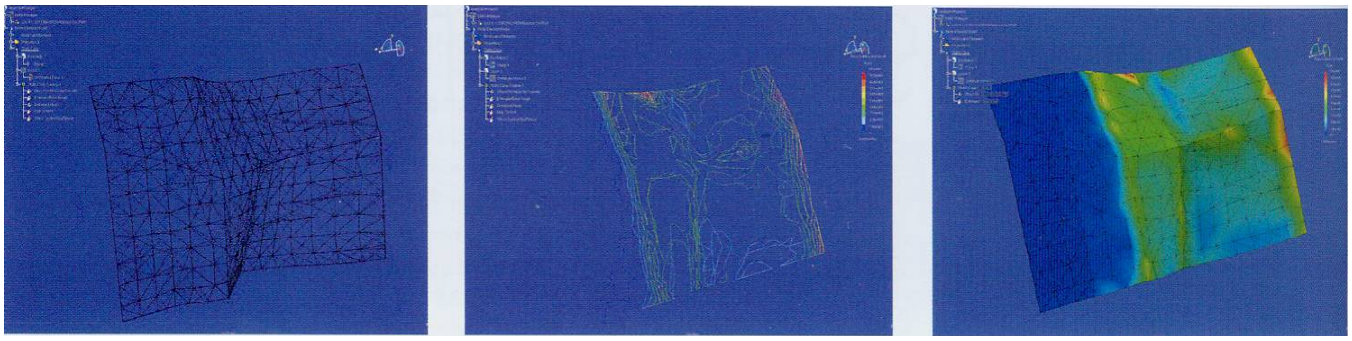
The most advanced fiber-based products are knitted and woven fabrics. Industrial knitting and weaving machines allow for an additional degree of variability, including the mixing of different types of fiber. The result is a two- or three-dimensional arrangement that is based on the yarn's array of knots, in the case of knitting, and a pattern of interlacing in the case of weaving.

There are numerous ways to produce the composite itself. It consists of layers of reinforcement that, through the action of the matrix material, are laminated on top of one another.

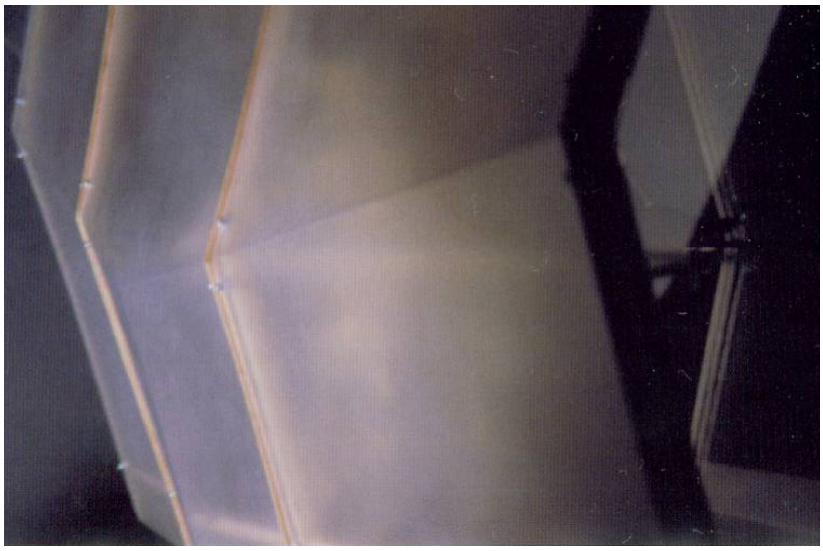
A mold is needed even for a flat, open surface. In the automotive industry, the matrix material is transferred into a closed mold with the help of a partial vacuum and pressure. Façade panels are produced either with resin transfer molding or continuous lamination processes on a rolling band.

Polymer allows for a performance-based design approach, and opportunity for analysis, modifications and evolution of the form in the process of its construction, which is beyond the scope of this research.

Materials of the form: Polymer Specifications and Characteristics: Continued

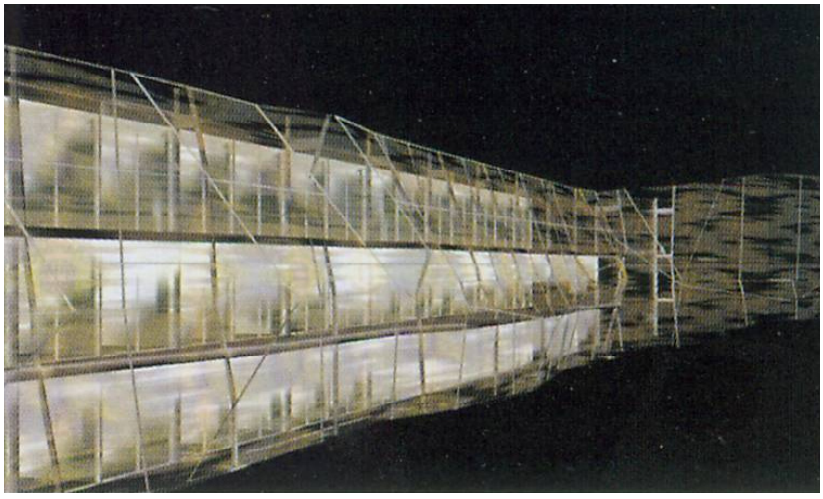


Display of localized stress distribution in the façade panels. The highest amount of stress is displayed as red. Depending on material tolerances, the analysis will indicate where the design needs to be modified

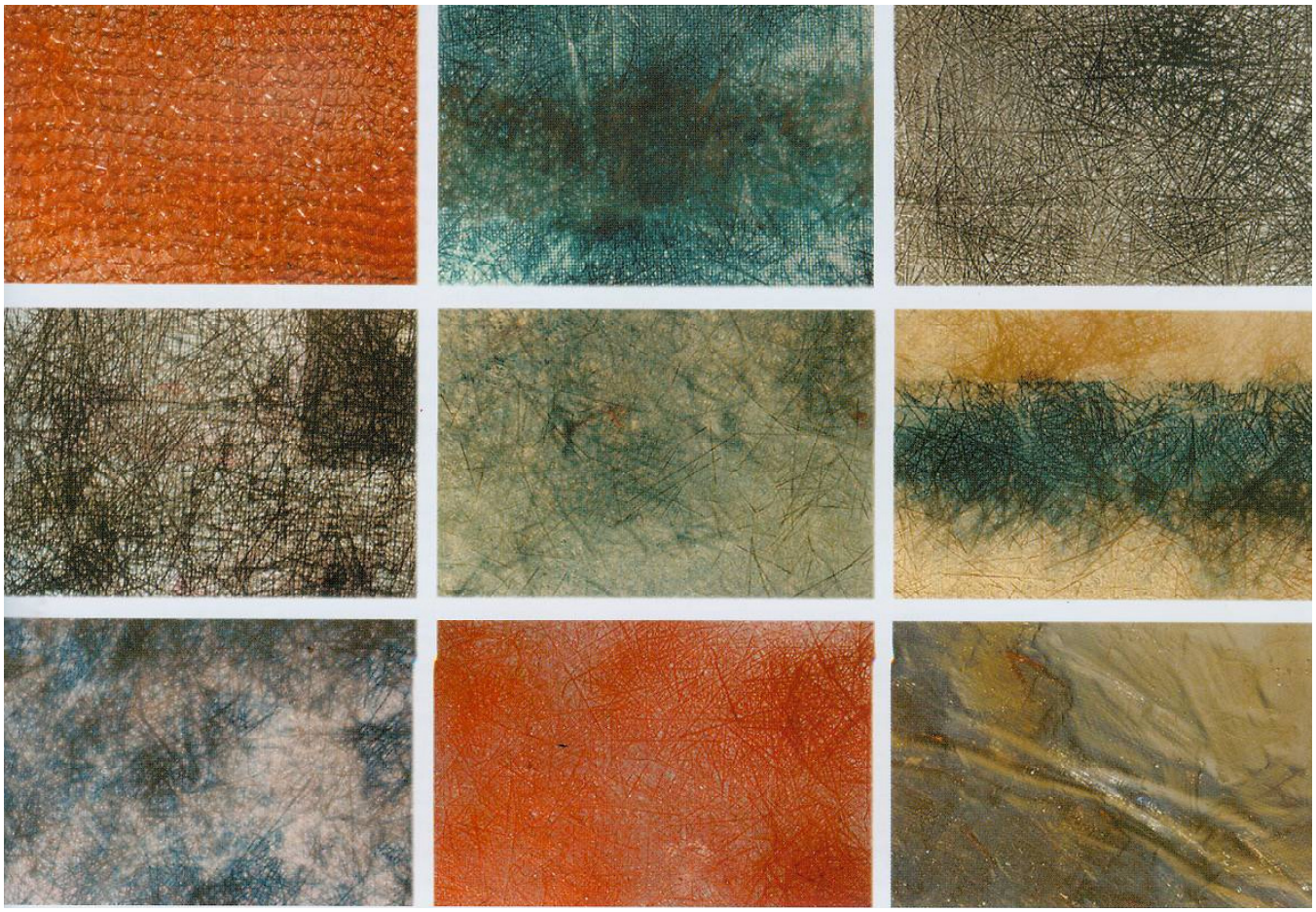


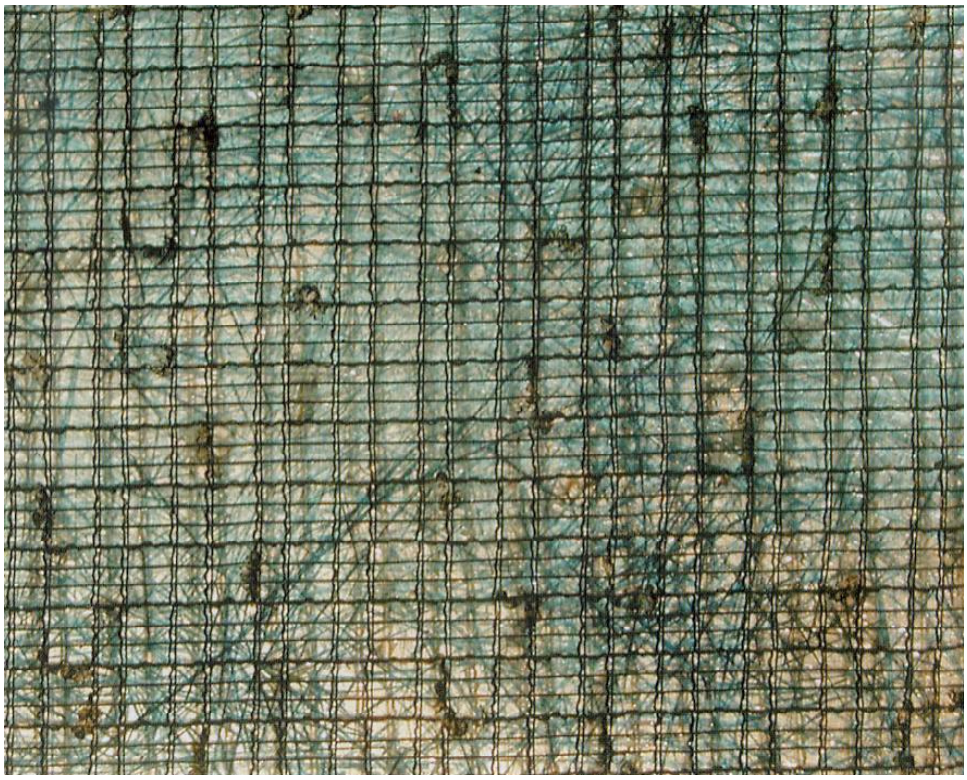
Credit for all Polymer Photos, this page and next:
Rahim, Ali, *Contemporary Techniques in Architecture, Skin Deep, Polymer Composite Materials in Architecture*, (London: AD, Wiley-Academy, 2002).

View of polymer composite panel in its initial manifestation.



Outside view towards service entrance area, Holiday Inn Express, International Airport, Norway.





Material test exploring different graphic patterns and degrees of light transmission resulting from a clear polyester and various reinforcements and additives. Material elements used include transparent polyester, different mixes of woven polyester mesh, chopped glass-fiber rovings, glass-fiber mats, paper and color additives.

Material test image.

3A.4.3.2 Materials of the Structure:

Steel beams and tubes, composite polymer walls, composite corrugated steel concrete floor and roof decking

Today, house building can be broken down and reinvented by a method not normally associated with the construction industry: the transformation of building technology through the reassessment of the physical nature of construction.

Jonathan Bell
The Transformable House
Introduction

3A.4.3.2.3 Building Skeleton & Structural Elements:

1. The proposed concept of a performance-based house, the modular structure, is an experiment that integrates a polymer shell with radial steel girders welded and bolted to the off-centered central shaft and to the perimeter steel tube beams.

2. Diagonal bracings, which connect the central shaft to the floor radial beams, tend to reduce the intensity of the moment generated at the connection of the radial beams and shaft.

3. Bracings, holding up the central shaft, lay flat as the structure lands on the grade.

4. Composite corrugated steel decking and polymer constitute the first and second floors, as well as the roof plates.

5. There will be no internal load-bearing partitions, except the fiberglass compartment for the bathroom and shower, which is transportable to different locations of the house based on the different arrangements of the floor plan.

6. The second floor loft hangs through perimeter beam to the polymer shell on one side, and to the central shaft on the other, while the roof deck is constructed in the same way. The loads of the second floor and the roof deck are carried by the polymer corner walls to the first floor plate, and eventually to the main, slightly off-centered central shaft. Knee-bracings are extremely vital to provide stability and prevent torsion. There are two major openings in the second floor which allow the provision of two stories volume. The second floor loft has openings to the first floor, which provide a more spacious volume for the interior. Openings will be secured by an addition of railings, without obstructing the view to the exterior.

7. The foundation consists of concrete raft footing, with surrounding retaining walls, which will hold up the shaft of the hydraulic elevator for the vertical and rotational movement of the house.

8. There is a slab decking at the grade level, which covers the underground mechanical storage. Underground storage is accessible through a movable grilled panel and a ladder. The slab decking on the grade provides a large exterior open space for desired outdoor activities when the house is lifted up.

9. The modular layout provides a simple structure, designed to enclose flexible space, which can be adapted over time to suit changing lifestyle and different living circumstances.

10. A spiral staircase provides access between the first and second floors, as well as to the roof deck. When the first floor of the building is in a position above the ground, a folding or stacking staircase provides access to the ground level.

11. The house materials and components, including the polymer walls and the adjustable full-height fenestration system, as well as the glass treads of the stair and perforated steel and polymer composite floor system, allow for an interplay of layers of transparency and light penetrations.

3A.4.4 Integration of Solar Energy in Design

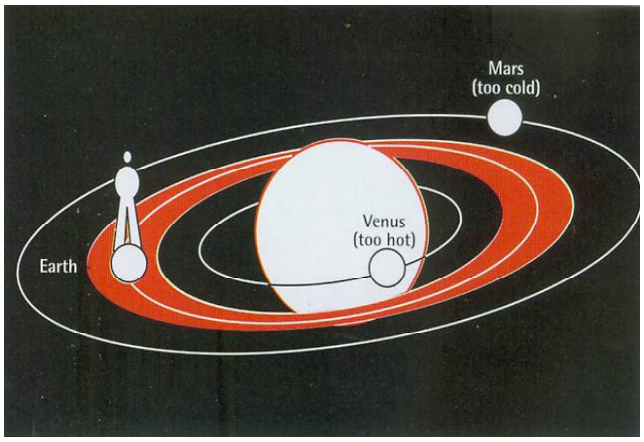
An Overview:

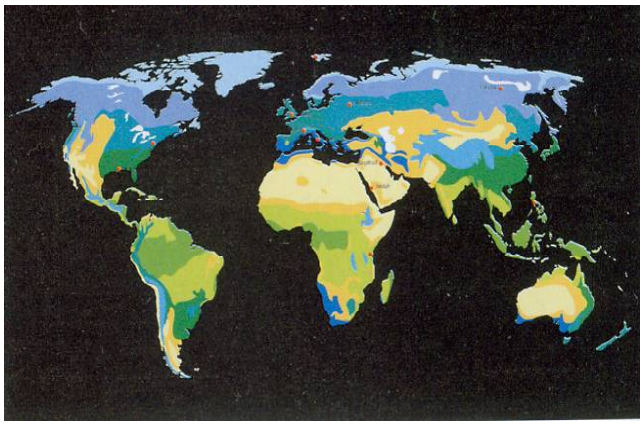
In our solar system, the planet Earth orbits around the Sun in a range, that is within the comfort zone. The comfort zone is a narrow path in the solar system capable of sustaining life, which is considered not too cold and not too hot for the inhabitants of the planet Earth.

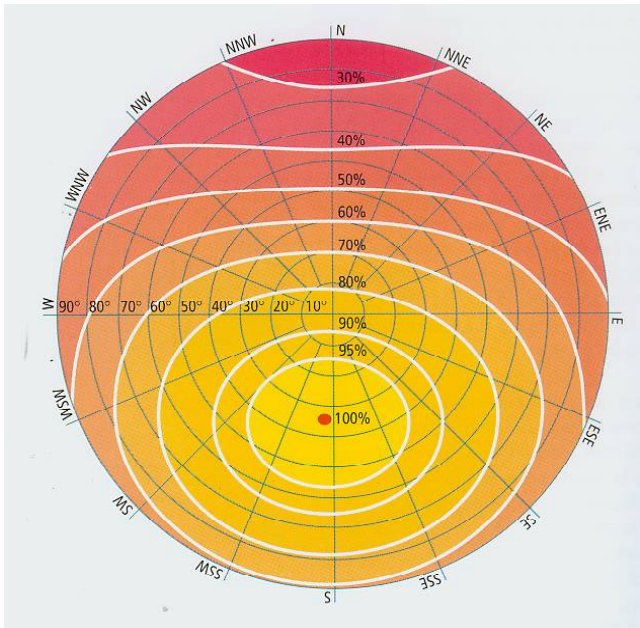
Regions vary in climate according to their position on the Earth's surface. Each type of climate is determined by how near a region is to the equator and by its distance from the sea. The earth's radically different climates are always changing. Changes of weather occur because the heat from the sun keeps the air constantly moving. Solar energy reaches the atmosphere in various forms. The sun is a non-polluting source of renewable energy and is essential to the formation of wind, clouds, thunderstorms, rain, and some other weather conditions, some of which can be converted into usable energy.

The first law of thermo-dynamics states that all energy in a closed system remains constant. The second law states that in any transformation of one form to another, some of it dissipates and is no longer available for use. The Earth and its atmosphere form an open system dependent on the sun. Any form of solar energy can be converted into heat. But heat energy can never be converted into other forms of energy. All radiation coming from the sun is transformed into different forms of energy on Earth.

Solar radiation controls our climate. Some amount of radiation does not penetrate to the ground; some amount is reflected off the atmosphere, back into space. The oxygen, ozone, and water vapor in the atmosphere absorb some of the radiation, which warms the atmosphere. Some of this energy reaches the Earth, and supports life on this planet.





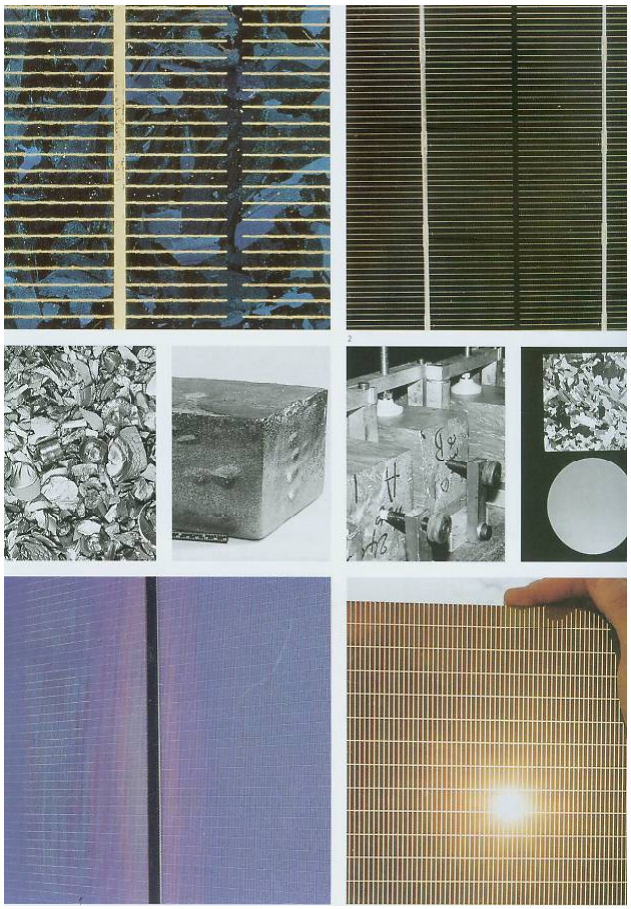


Photos Credit:
Behling, Sophia and Stefan, Solar Power, (Germany: Prestel, Verlag, 2000).

Objects in space are powered by solar energy through photovoltaic system.

On the Hubble telescope, non-crystalline PV cells are used.

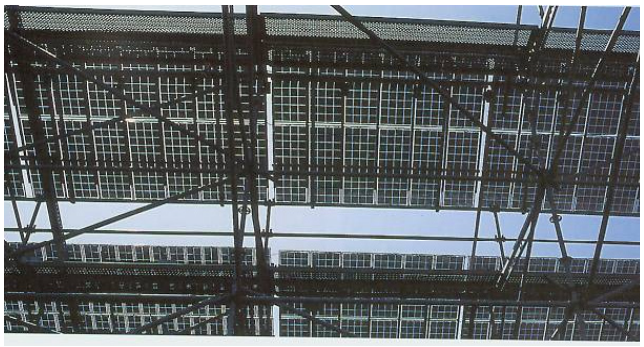
It is possible to harvest solar heat as a viable source for energy, through the use of collectors and generators. New transformation processes, such as photovoltaic methods are now capable of converting the renewable energy of light into electric current. Photovoltaics can produce energy from light by an artificial process similar to photosynthesis.



The production of photovoltaic cells begins with silicon crop, which is a byproduct of the computer industry. Silicon is melted and formed into ingots, which are then trimmed into blocks and sliced into thin wafers. There are two types of photovoltaics. Crystaline photovoltaics come in thin wafers, and each panel of cells varies in size and output. Amorphous silicon is easier to produce in large quantities per area, and is cheaper than CPV. With Amorphous silicon, it is possible to make a film in order to create translucency.

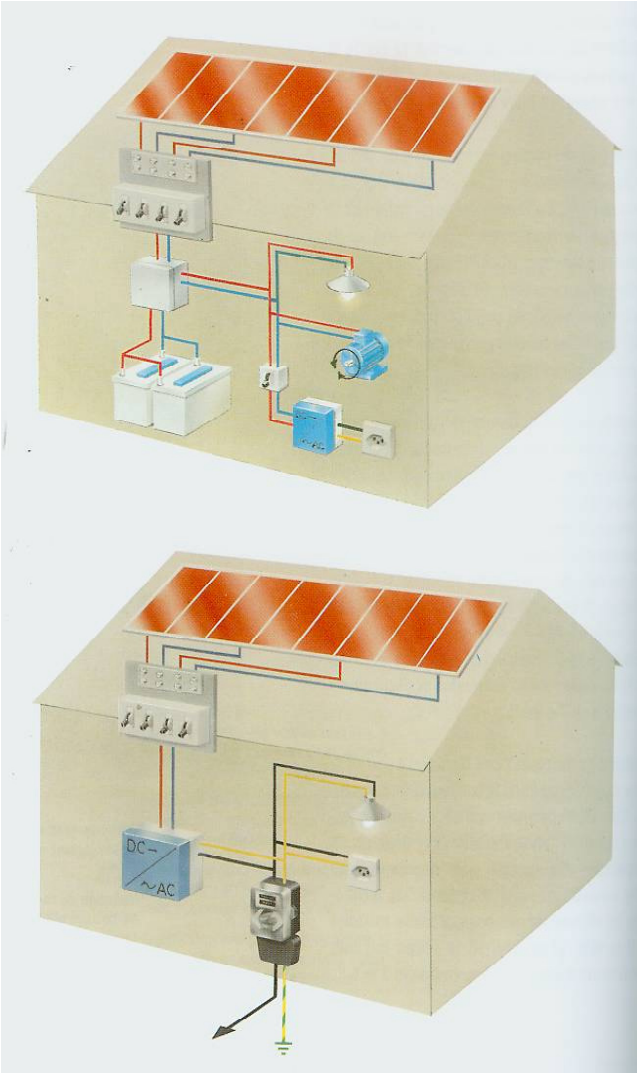
3A.4.4 Photovoltaic:

Photovoltaic panels, ideally have to be focused on the sun as long as it shines. As the sun's position changes, panels must be tilted according to the altitude and then pointed to the most advantageous direction. Obviously, it is also possible to place PV panels flat or vertically on roofs and facades, with some reduction in the efficiency and output of the cells.



The electrical production of a photovoltaic cell, as a percentage of the maximum value, depends on the tilt and orientation.

The most important components of a photovoltaic unit: Photovoltaic unit cell module (above), connector box, (middle) and inverter (below).



The two types of photovoltaic cell units: stand alone system (top) and utility interactive system (below).

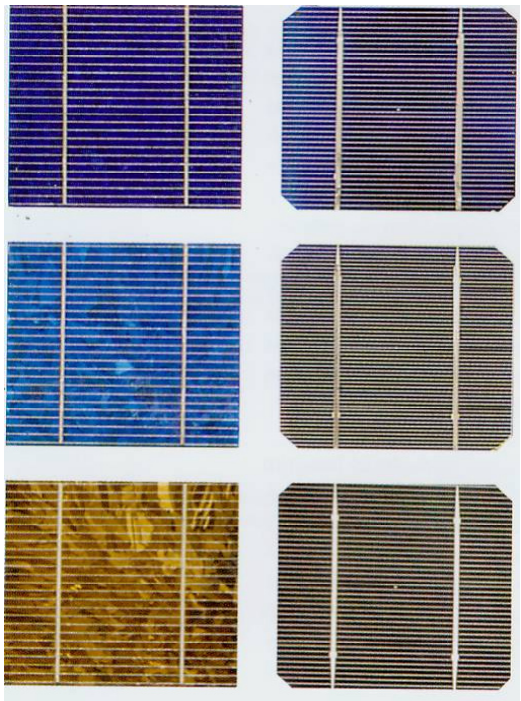
Photovoltaic cells are not only available in different technical versions for application on roofs in flat and tilted forms, as well as on facade, but are also in various colors.

In practice, under coordination by the architect, two specialist teams participate in decision making about the procedure for integration of the photovoltaic system. Those considered to be the authors of the roof/ facade project and those involved with the electrical aspect of the project work together with the architect's coordination. Aside from the actual permit for the building, the approval of the relevant electricity supply company is required for grid-parallel operation. For independent systems, various authorities, including the local electric supply company, are responsible for the regulation.

The solar module or panel consists of several individual photovoltaic cells connected in a series or parallel to a metallic material. The energy produced by a solar module is influenced primarily by the number of cells within a module and how these cells are arranged. When the cells are connected in series the total voltage is the sum of the voltage from each individual cell.

The size of the photovoltaic system will be dictated by the amount of daily energy required (loads) and the amount of energy available at the location.

The output current in this configuration will remain the same as that produced from a single cell. When the cells are connected in parallel the total current is the sum of the currents from the individual cells and the output voltage is the same as that produced from a single cell. Each cell in a module typically produces anywhere from 2 to 5 ampers and approximately 0.5 volts. The cells can be arranged in a module to produce a specific voltage and a specific current to meet electrical requirements. By multiplying the output voltage by the output current, one can calculate the total electricity produced in watts. Typically cells are arranged in a module to produce voltages in increments of 12. Most modules in the market are 12, 24, and even 36 volts. By connecting solar panels in certain configurations called a solar array, one can dictate the current and voltage of the array, thus dictating how much electricity the system produces.

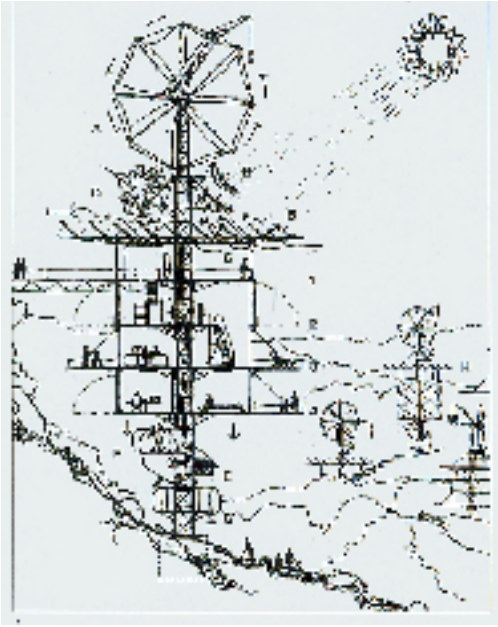


Selected patterns of colored Photovoltaic cells.

Photos Credit:
Humm, Peter & Toggweiler, Peter, Photovoltaic in Architecture, (Germany: Birkhauser, Verlag, 1993).

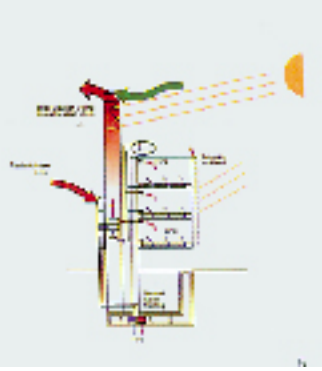
3A.4.5 Using Wind for Electricity and Natural Ventilation:

Wind is crucial for natural ventilation and fresh air supply. It also can be used for energy generation. Wind can be harnessed by a building, through integrated wind catching devices or turbines. On the other hand, the draft caused by wind adds additional wind load to the building.

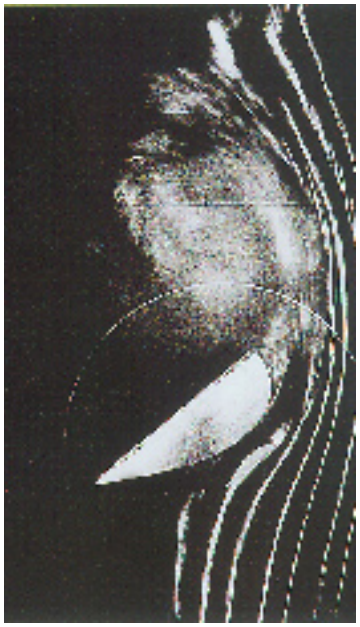


In this visionary scheme by Richard Rogers, windmills, as an imaginative approach to using wind power, have become part of the buildings.

It shows how flexible the building is to varying wind conditions.



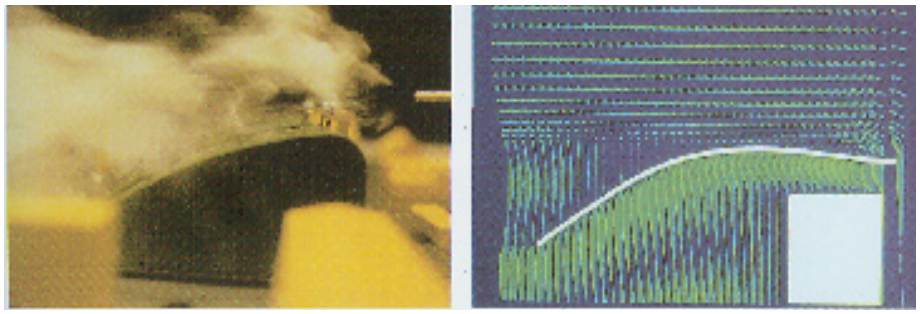
Turbine Tower by Richard Rogers in Tokyo is capable of generating enough energy to sustain itself. Wind tunnel tests have neen performed to analyze wind condition.



Photos Credit:
Behling, Sophia and Stefan, Solar Power, (Germany: Prestel, Verlag, 2000).

The Duisburg Microelectronic Center has the capacity in its building performance to optimize the flow of natural ventilation and smoke extraction through the two atria.

The wind behavior with respect to the aerodynamics of the building's performance was tested in a wind tunnel and with computer simulation using fluid dynamics.



3A.4.6 Thermal Comfort and the Need for an Adaptive Approach

Theory into Practice:

Based on scientific facts, people are not passive receptors of their thermal environment, and they take actions in order to improve their thermal comfort. These actions or adaptations include modifying the rate of internal body heat generation, modifying the rate of body heat loss, modifying the thermal environment, and even selecting a different environment. The constraints that act parallel with adaptive processes result in particular temperatures for thermal comfort for an individual. Climate by itself is an over-arching constraint, which together with the intended function of the space, will provide the suggested temperature for the inhabitant of the space. Obviously there are adaptation measures and remedies, from the human body itself, to the building components that can rectify and reduce the intensity of each circumstance. Therefore, as it was mentioned, the adaptation measures can fall into four main categories:

1. Modifying the rate of internal heat generation
2. Modifying the rate of body heat loss
3. Modifying the thermal environment
4. Selecting a different thermal environment

If all the avenues of adaptation were freely available it would not be possible to predict how people would choose to get comfortable. However, the items 1 through 3 of the above list reveals that "ventilation" is a major contributor to those modifications. Nonetheless, from the point of view of building design and operation, the comfort temperature is the "answer," "result", or "solution" of the adaptive performative processes. This temperature would be ideal for our design purposes. On the other hand, since not all options are always available, it would be wise to gather knowledge of the constraints. A knowledge of constraints can to a great extent lead to a knowledge of the solution for comfort temperatures.

3A.4.6.1 Energy Conscious Design and Thermal Comfort Strategies

Studies and researches on the issue of human comfort within buildings have revealed that adaptive actions are not always practical in certain prevailing conditions because there are always certain operating constraints that dominate the condition. These constraint might arise from climate, social context, culture, conscience, economical conditions, fashion, body physiology and required activities, as well as from the type of building design. Constraints mostly hinder but sometimes promote achieving the appropriate comfort temperature.

Thus the role of the designer in laying out the objectives for a comfortable thermal environment seems to be extremely critical. In a performative adaptive design, minimizing energy use, combined with thermal comfort entails certain strategies as follows:

- Using air movement (preferably natural air) rather than refrigeration.
- Using the building envelope to provide suitable environments rather than relying on heating and cooling equipment.
- Designing in harmony with the climate.
- Heating or cooling the person rather than the space.
- Allowing seasonal drifts in indoor temperature within prudent limits.
- Using auxiliary heat gains in winter, while extracting heat at the source in the summer.

Nonetheless, heated or cooled individual spaces should be controlled by the occupants, as should devices such as blinds, shutters, fans, etc. Sophisticated and intelligent control systems are only effective when they are under the control of the user.

3A.4.6.2 Visualization of Indoor Air Movement

The pattern of indoor air movement will define the effectiveness of heat distribution and fresh air ventilation, which will relate to indoor air quality and comfort. There are methods to assist in the visualization of indoor air movement. Indoor air movement is quantifiable by experiment, and can be visualized using some form of seeding method, with smoke, balloons, or bubbles, or with some neutrally buoyant particles. Seeding methods refer to the substance that is introduced to the internal air. Visualization involves three stages: seeding the air, illuminating the seed and recording the visualized flow.

Smoke can be used as a qualitative means of measuring air movement. It can be introduced or injected into the space using a smoke generator and then observed and recorded using video or manual sketching methods. There are puffers available for assessing localized air movements. Puffers are small hand-held devices that emit smoke and are particularly useful for locating and demonstrating component leakage, for example, around window area.

Neutrally buoyant balloons or bubbles are used in a qualitative way similar to smoke. Balloons, in particular, are relatively clean, and can be used in sensitive spaces. For a more qualitative measure of air movement, the position of the air in space can be monitored with simple video cameras, which the information can then be computer analyzed to provide and observe accurate three-dimensional velocities and the pattern of air flow in the space.

3A.4.6.3 Prediction of Ventilation Rates

Currently, there are three methods of predicting for ventilation rates:

•••Zonal Models:

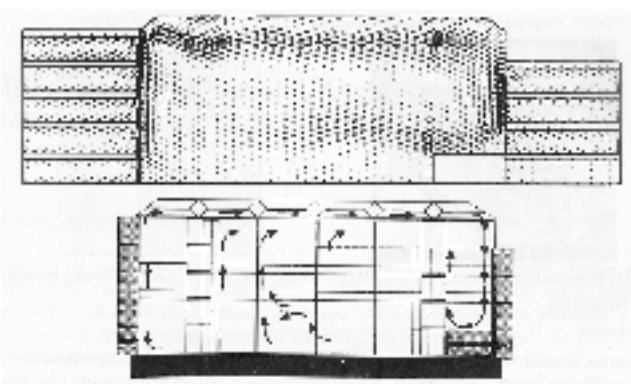
Zonal Models are suitable for the calculation of air between one or more zones and the outside, and are useful for air change rates. This is a good tool for new designs and building forms, but the procedure is fully computer based. Through scientific graphs the models can assess the variation in ventilation rate with leakage area halved and doubled compared to a normal level of leakage.

•••CFD Prediction:

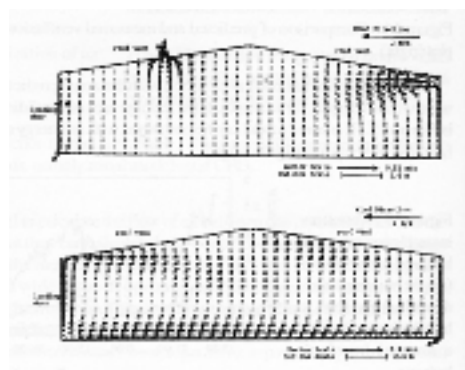
Computational Fluid Dynamics, is used to predict internal air movement and ventilation. It is particularly useful for predicting air flow paths in naturally ventilated spaces, where the building form and space planning are integral parts of the ventilation design, and the prediction can be sufficiently accurate to inform the design process. However, it is a complex method, which requires a level of skill and understanding of ventilation design, physics, and computational numerical techniques to reach to credible solutions.

3A.4.6.4 Wind Tunnel Modeling

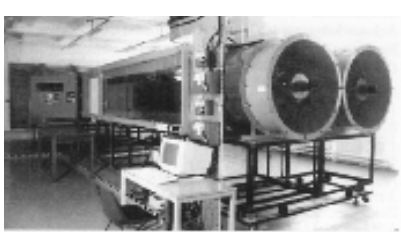
For the purpose of ventilation prediction the wind pressure over the external envelope of the building must be estimated. By building a physical model of the building and its surroundings and placing it in the wind tunnel and subjecting it to a controlled wind flow, the pressure is documented and estimated. Additionally, pressure sensor taps can be installed at various points on the building envelope, in relation to the ventilation openings. The pressure at each opening can be measured using a pressure sensor, which can be related to the free wind pressure, at a point of known height above the surface in order to obtain Cp. The main use of wind tunnels for ventilation studies is the prediction of Cp. However, they can be used for flow visualization by introducing smoke or other substances in to the tunnel and observing its flow.



CFD prediction of internal air flow in a naturally ventilated atrium. Balloon visualization in agreement with CFD Prediction.



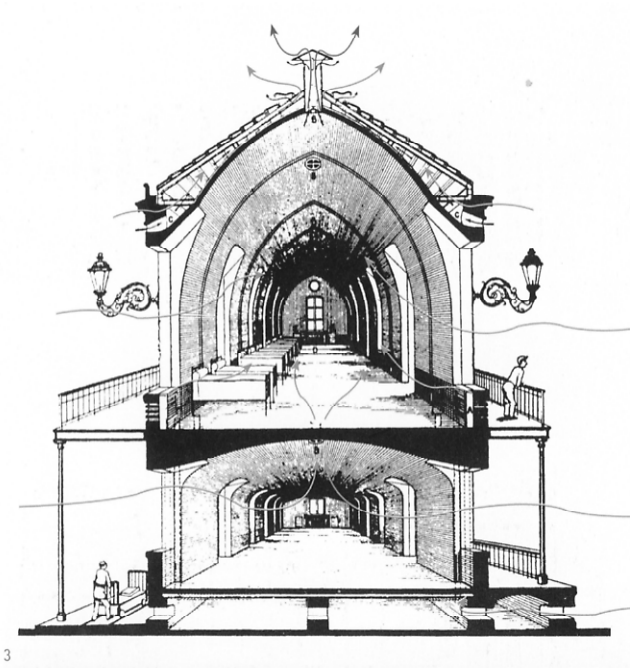
Internal air movement due to wind-induced pressure boundary conditions at leakage around details (top), and combined with internal buoyancy effects (bottom). Internal buoyancy dominates the pattern of air movement.



Boundary layer wind tunnel.

3A.4.7 A Historical Reference - The Rational Approach to Light, Air and Structure

In the 1800's, during the era of industrialism, the quest to find the right way of living, particularly for the dismal conditions of the hospitals, drove architects toward the design of functional layouts for the maximum efficiency of treatment with good daylighting and cross-ventilation in the buildings.



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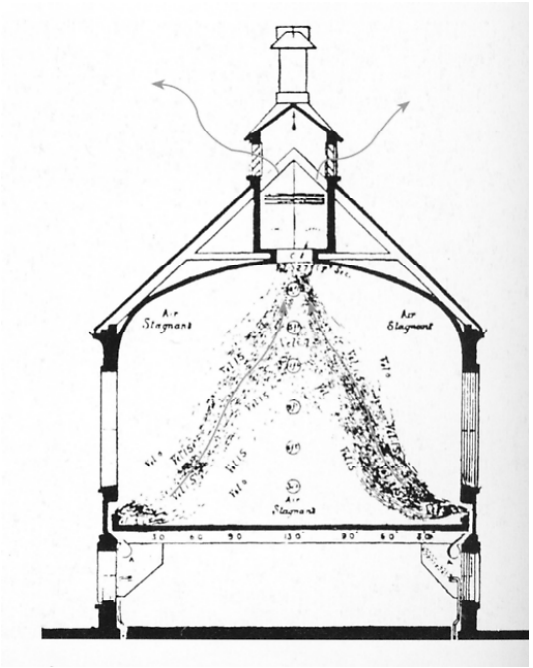


The Rational approach to light, air and structure became a major design concept:

Tenon and Poyet, two nineteenth century's architect, carried out tests on the ventilation scheme of their hospital project and employed concepts related to daylight and cross-ventilation in their design process.

Design of the hospitals had to comply with requirements for provision of the best ventilation possible. Flues conducted air from beneath the floor to grilles besides the beds. Air entering at the eaves cooled the ceiling in the summer.

In the early decades of the twentieth century, architects were trying to find the optimum city and building form to allow maximum daylight, air, and space to each resident. Certain architects who where true solar pioneers tried to optimize land use, density, and ventilation requirements in housing. During this time interesting urban geometries and building types were developed. Some of the housing projects of these decades focused on orientation as the primary concept for capturing the most efficient sunlight.

In the mid-twentieth century Le Corbusier designed buildings with a primary focus on prevailing winds for cross-ventilation and shade. His designs illustrate how shade can be integral to a building, and how there can be perfect harmony between a building and the natural environment. In his 1954 design of the Mill Owners Association building in Ahmadabad, and in several other famous building designs, he incorporated Brise-soleil on the east and west facades. Realizing the insufficiency of the simple glass wall, he developed a wide range of climaticly responsive solutions to incorporate shade as an integral part of the design.

3A.4.8 More Sustainability Considerations

Rainwater falling on the roof will be collected in the oversized downspouts for irrigation of the surrounding landscaping.

Direct energy use will be minimized within the house by reducing the embodied energy of the materials used in construction of the house through specifying local materials.

The house will entertain a hybrid of low-and high-energy technology and embrace appropriate sustainable technologies within the parameters of a contemporary design.

A Staircase serves as the means of access between the two floors and allows light to flood in and illuminate the first-floor spaces.

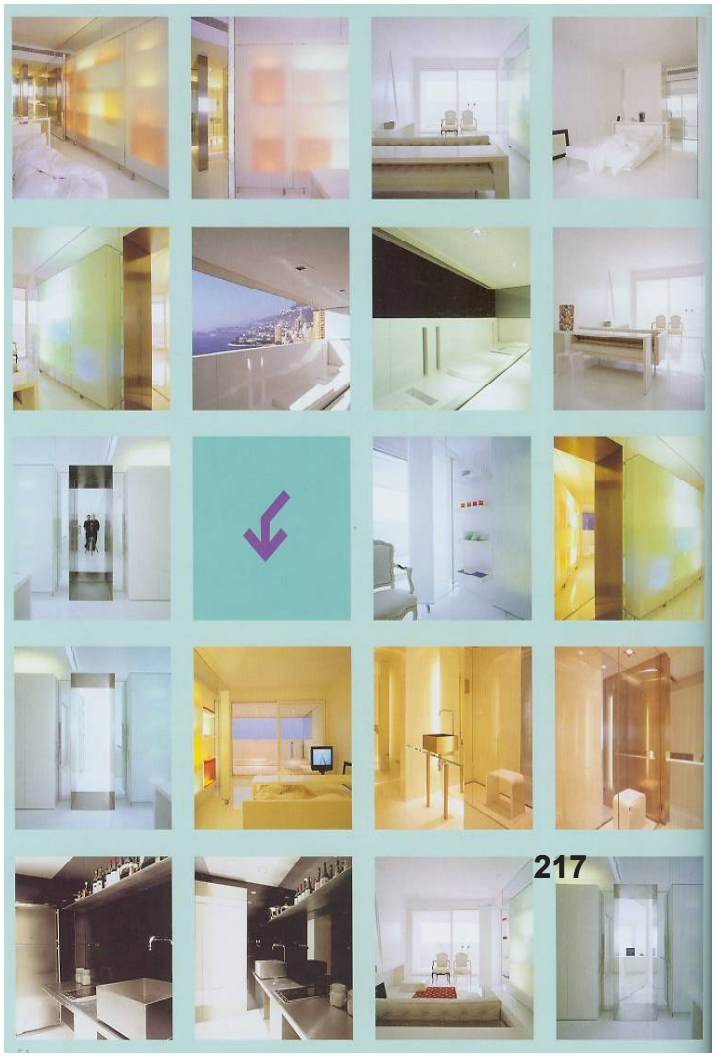
Photos Credit for this page and next: Bell, Jonathon, Goodwin, Sally, *The transformable House,* (London: AD, Wiley-Academy, 2000).

3A.5 Program:
Space Planning & Spatial Requirements:

- First Floor, 625 SQ. FT.
- Second Floor / Convertible Loft, 525 SQ. FT.
- Roof Deck, 400 SQ. FT.
- Kitchenette, 50 SQ. FT
- Bath-Room, 45 SQ. FT.
- Total 1550 SQ. FT.

A spiral staircase connects the first, and second floor, and the roof deck. In the event that the building is raised above the ground a stack-able, unfolding staircase will connect the building to the ground.

A lift connects the first floor to the second and to the roof deck. In the event that the building is raised above the ground, the lift is the accessible means to connect these four levels.

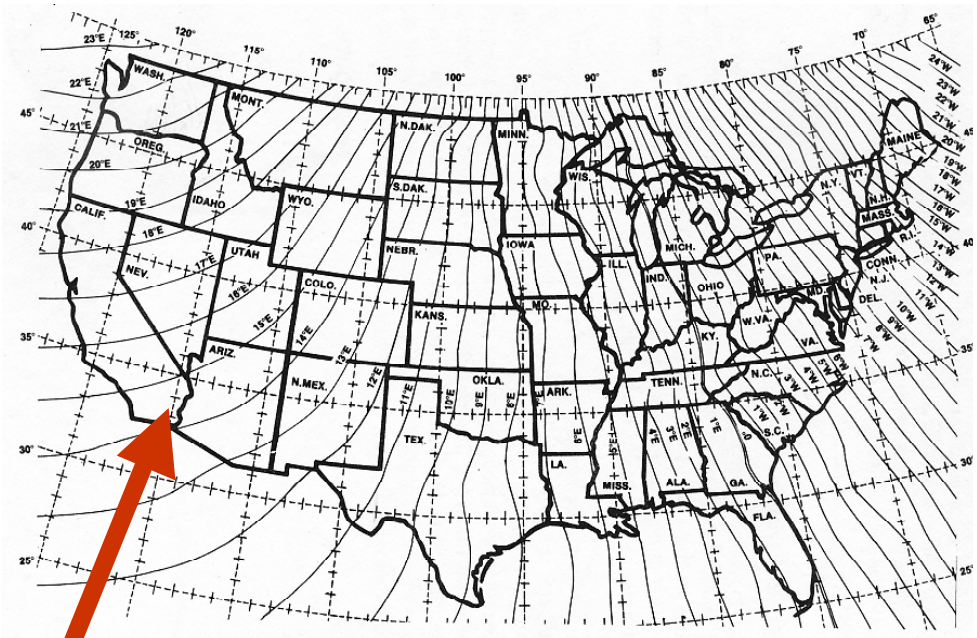


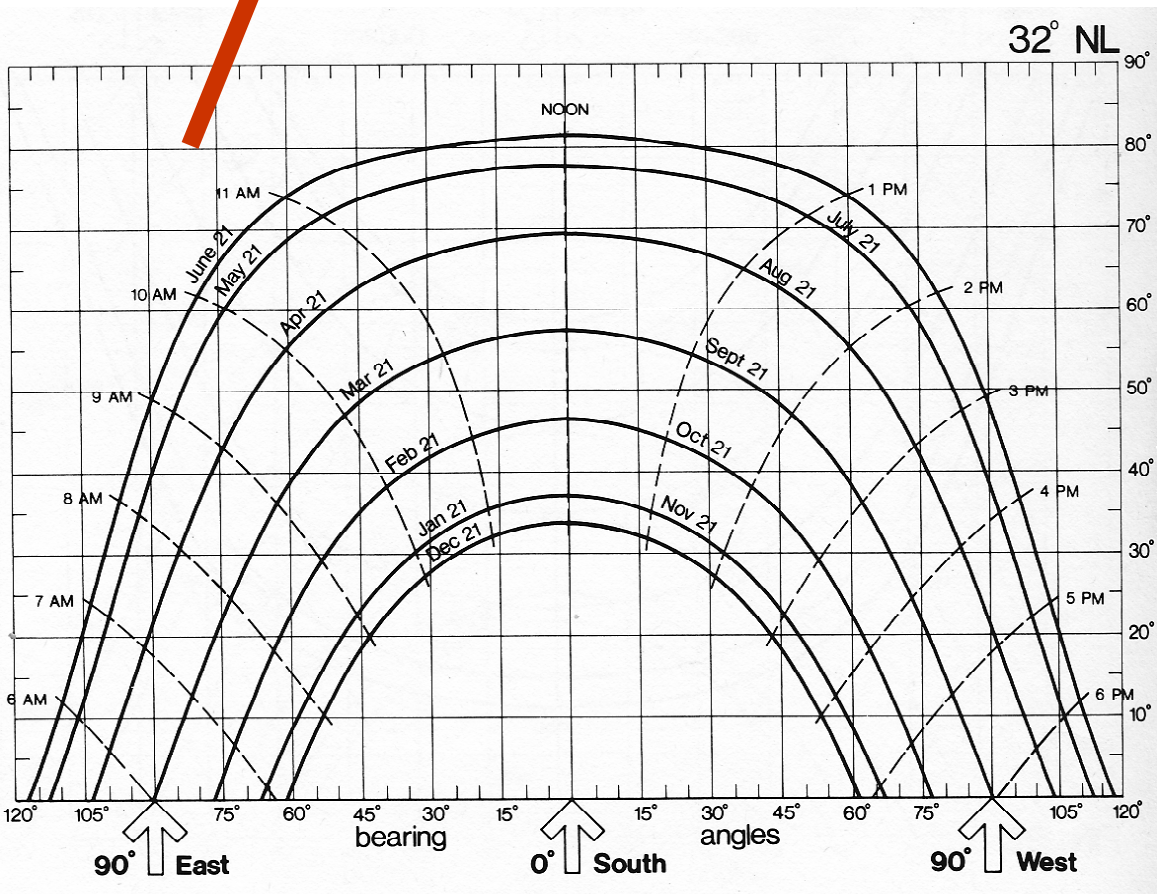
Photos Credit for this page and next:
Bell, Jonathon, Goodwin, Sally, *The transformable House,* (London: AD, Wiley-Academy, 2000).

3A.6 Site's Region & Latitude

Selected site for the purpose of measurable aspects of design will be considered in Southern California:

In 32 degree North Latitude, and in seismic zone 4, which is the highest degree of seismicity.



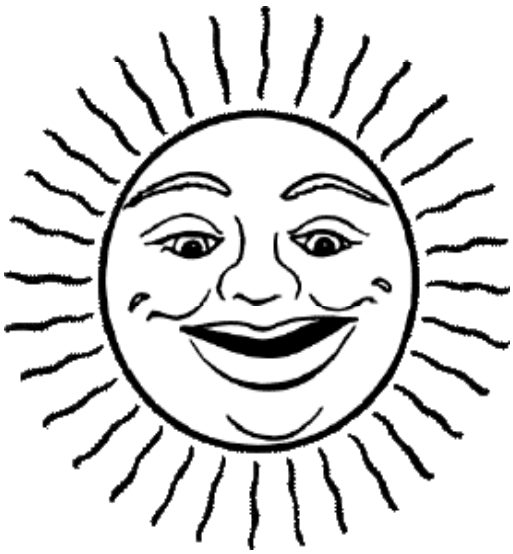


Mapps credit:
Mazeria, Edward, *The Passive Solar Energy Book,* (USA, Roale Press: 1979).

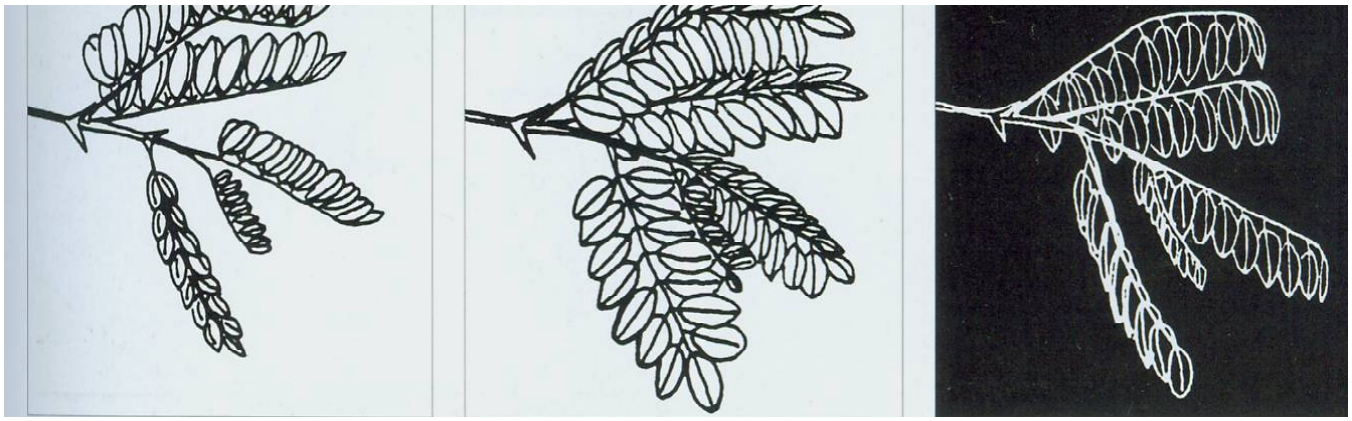
3A.7 Origin of the Main Concept

1. Creating a performative organism compatible and in harmony with nature, similar to plants, flowers, and other biospheres that follow the sun as the source of dynamism.

2. Creating a fluid and dynamic form, which has the capacity to reformat itself through mechanisms that allow flexibility and adjustability.



Survival of flowers and trees is dependent on their full integration and compatibility with their ecosystem.

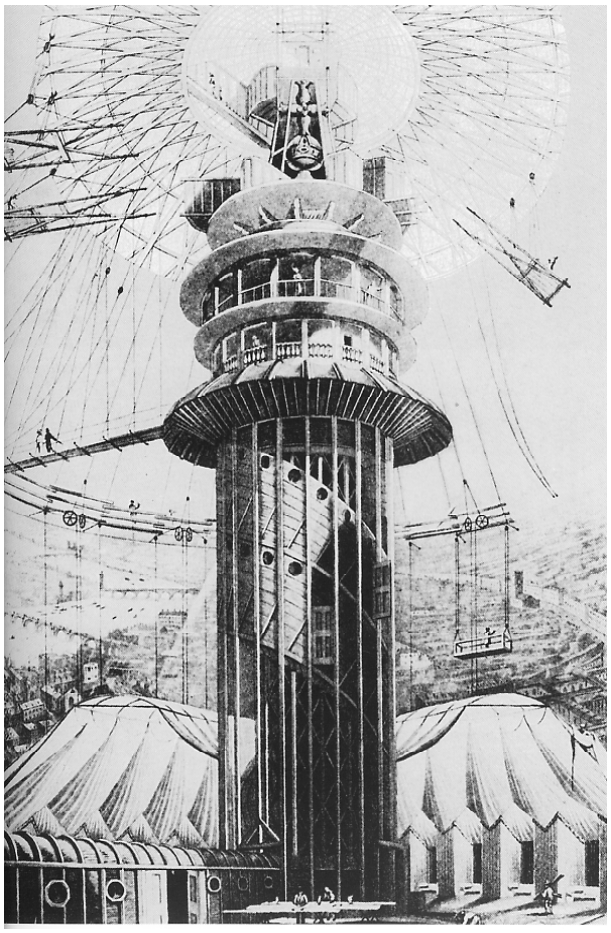


Strong sunlight, closed position | Little Sunlight, Maximum Aperture | No Light Sleeping Position

The leaves of Robina Pseudo-acacia track the sun. With strong solar radiation, the small leaves turn upwards, so the leaf surface is reduced to the minimum. In diffuse daylight, the plant opens up its leaves to the light, so that the incoming light can be used to the optimum. At night, the leaves turn downwards.
Credit: Behling, Sophia and Stefan, Solar Power, *the Evolution of Sustainable Architecture*, (Germany, Prestel Verlag: 2000).

3A.7.1 Why building to rotate and elevate

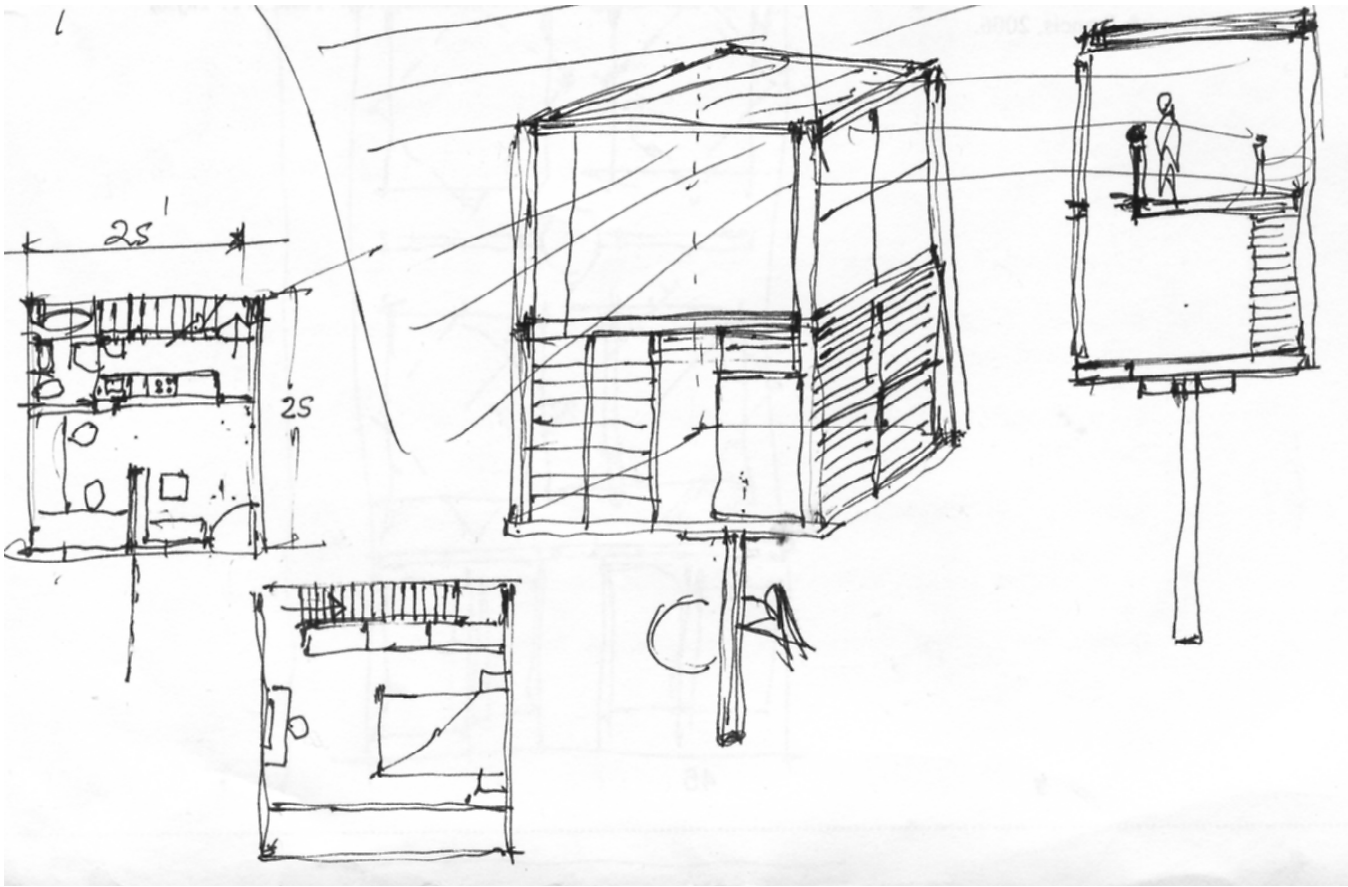
The desire for a panoramic view was perpetuated in the age of Enlightenment, which lifted the human view of the world. This new view was brought to a wider public by the diorama, a darkened room housing a 360-degree panoramic painting. Visitors would pay to enter dioramas and experience these new views. Such structures, with their panoramic windows, anticipated the feeling of fully glazed modernist buildings. The wealthy built themselves belvederes, observation platforms from which women could watch men display their skills in falconry.



Spectators stare out a panoramic window onto an artificial landscape

3A.8 Design - Initiation of the Design Ideas

Initiation of the Design Ideas:



First study of the concept of a modular house that can reach to the sky and follow the revolution of the Sun

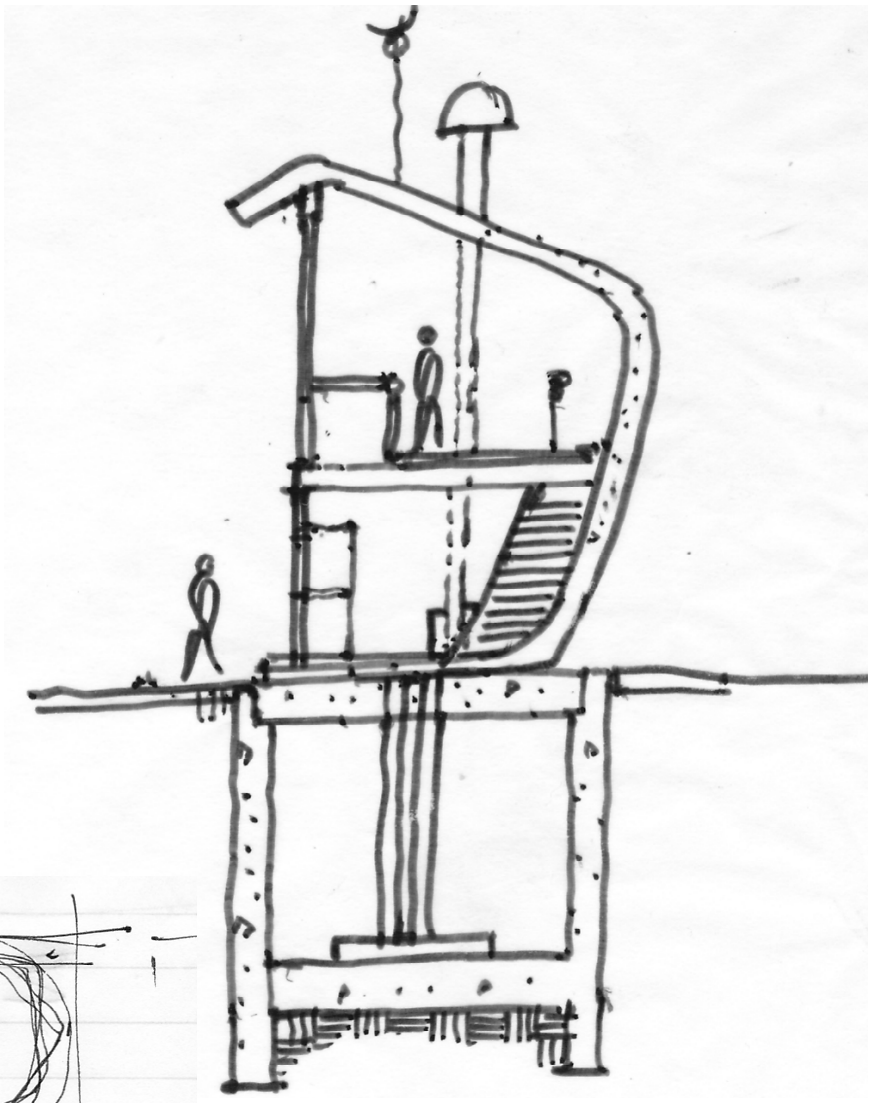
There are Two Main Concepts for the initiation of the form and design of the Live-Work Loft, the Performative House:

1. Creating a Performative organism integrated in Nature

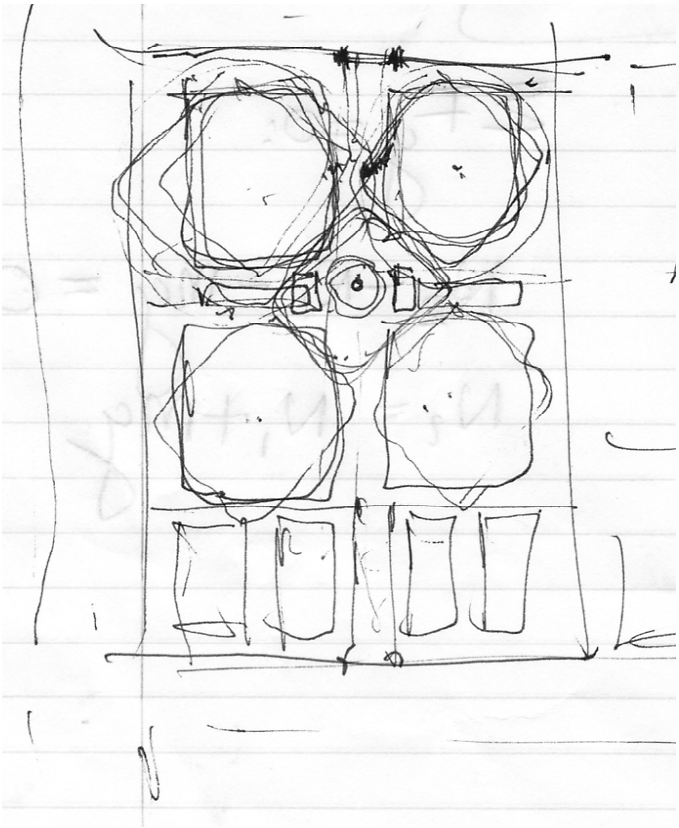
2. Flexibility, Adjustability & Re-adjustability

Study of an organic form shell prototype to act as an organism of nature.

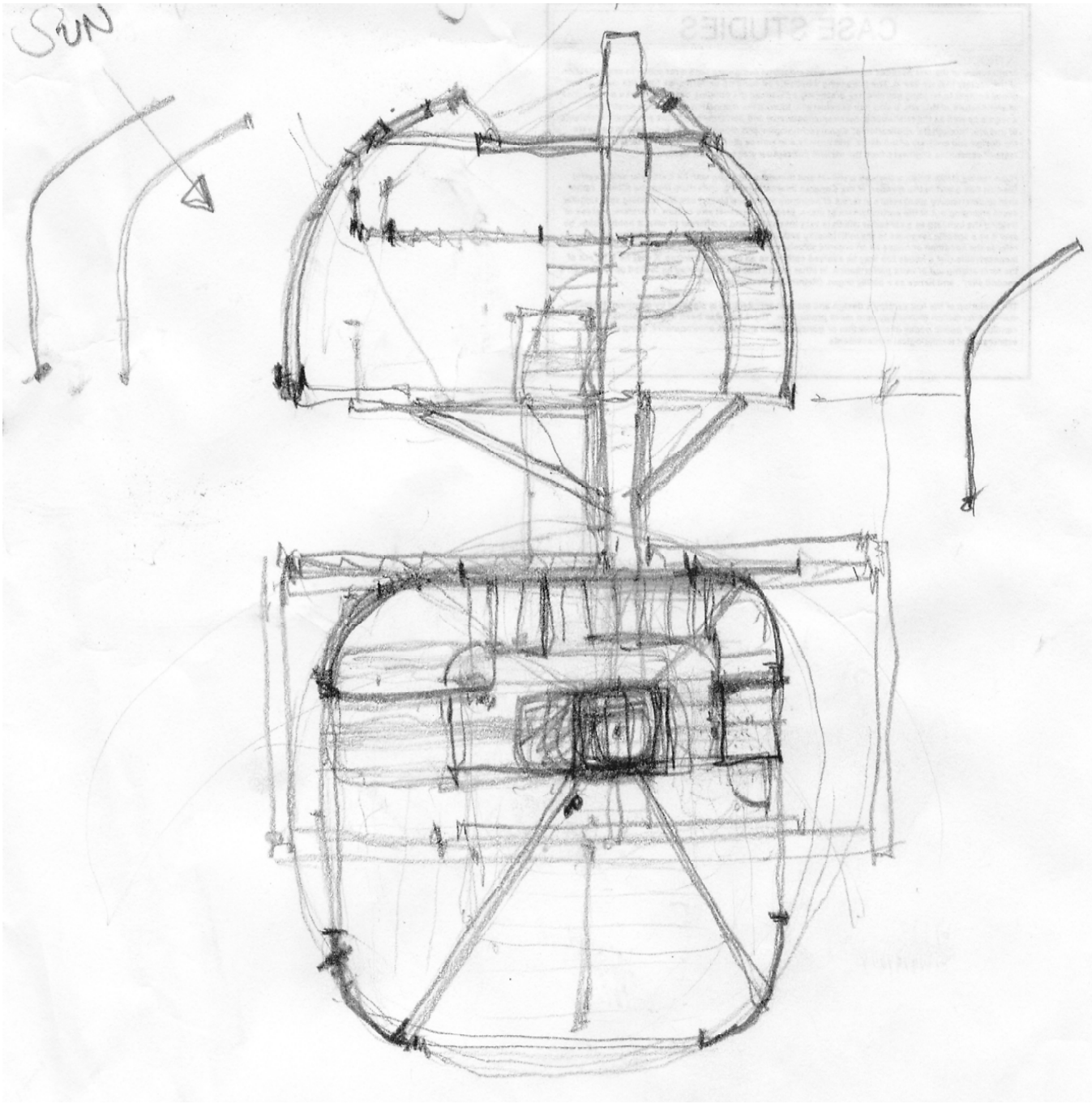
Initial study of the form of the Habitat as a dynamic organic biosphere.



Very initial study of the conceptual ideas of a modular house that can reach to the sky and follow the revolution of the Sun.



Study of arrangement of four protoypes on a site.



A study of the conceptual ideas of a modular prototype residence from plan to section, particularly on the location of the supporting shaft and its relationship with opening up the plan for required functions.

3A.8.1 Study and Development of the Form

The building relies on one main large shaft that is the main source of support. This shaft allows the building to rotate, as well as to raise above the ground within 10 feet, which the assumption is that it provides an opportunity for the interior spaces to have a panoramic view of the surrounding hills to the north and east, as well as of the Pacific Ocean to the south and west. Raised buildings have some tradition along the shores, due to the type of foundation which is appropriate for sites with high water table and sandy soils.

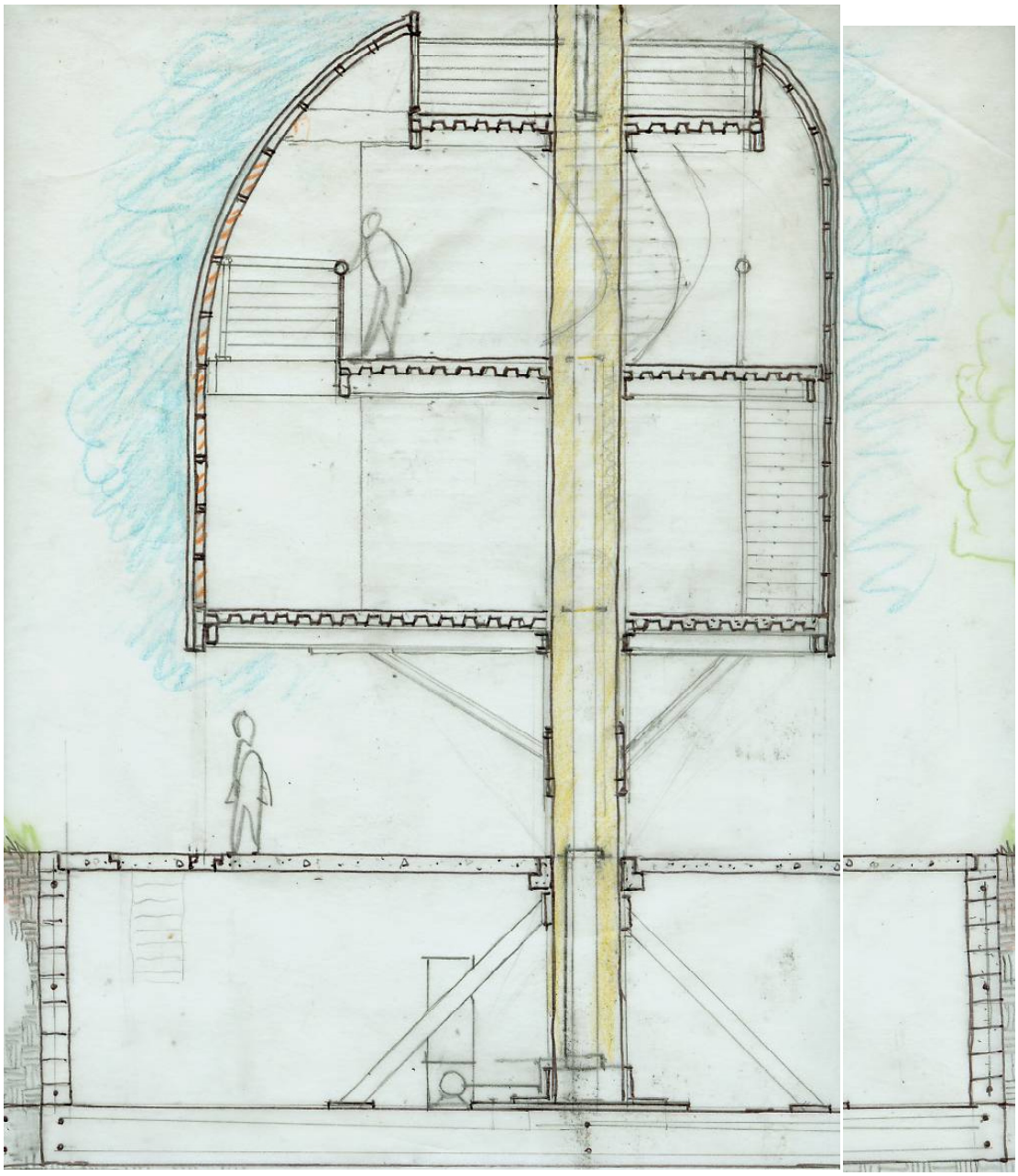
Assumption is that the site planning regulation has a height limitation of about 30 feet, which certain features of the building can extend beyond this limit. The building has a square form with curved corners, which is a derivative of the organic three-dimensional cylindrical shape, and can easily respond and adapt to a site orientation, local weather and micro-climate, as well as to internal spatial requirements. Building floors with the potential to grow a maximum of ten feet taller and its ability to rotate and follow the path of sun, is a response to the concept of full flexibility and adjustability for view, orientation, and sun exposure.

The building is sculpted out of a square within the confinement of a circle. The square is a more efficient geometry in addressing the interior spatial requirements. The solid polymer curved corner walls within the confinement of the circle allow for a more efficient seismic resistivity for the building. The building form allows the windows to wrap around the facade at their full-height, providing the most flexible opportunities for daylight, air and view. The curved form appears to be a simple form, but lends itself to various combination of plan and facade configurations, which have endless possible approaches to the surfacing techniques.

Initially, based on the study of the way complicated three-dimensional images are created with computers, creating an entire wall of the house as a full shell with associated polar grid seemed to be the most logical approach. In the computer digital modeling the enclosure as a shell has an associated polar grid system, which initially appeared to be a viable approach combining the two concepts of flexibility and modularity. Typically the polar grid is an ideal way of locating elements of the building enclosure and determining the window and door locations, as well as other features by providing a great deal of flexibility within the confinement of the grid system. In the case of this house, shells could have been carved out to the extent that only the four corners were physically left to be used as polymer shells for translucency, with the polar grid also becoming the basis for window grids.

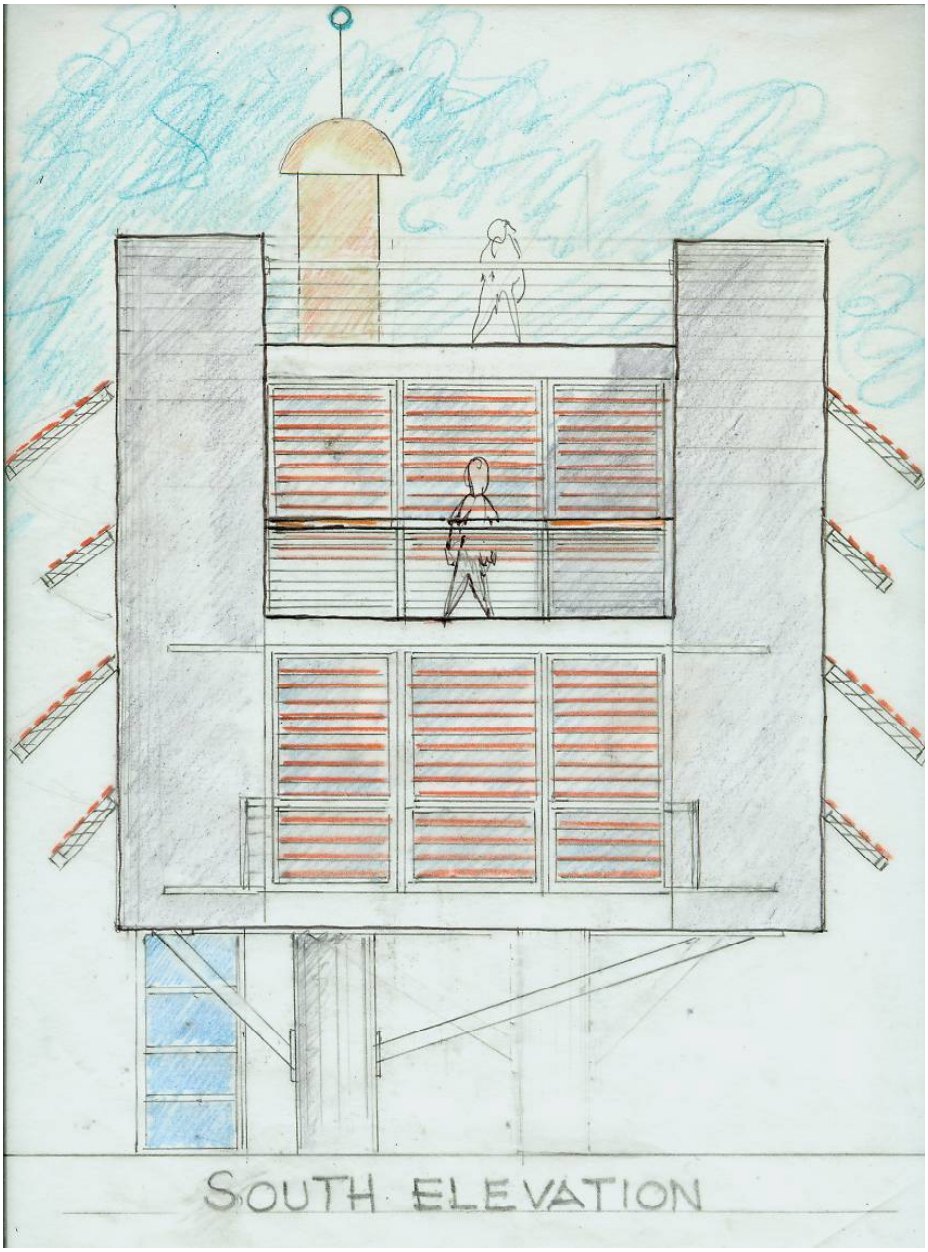
Ultimately, in subsequent studies of the evolving form and its relationship with the structure, the need for a lighter material became critically paramount, and thus demanded a lighter skeleton system. The shift toward a skeleton form as a substitute, which started based on structural necessity, became a viable response to the interactive and morphological demands of the building enclosure.

Study of the Plan to Section



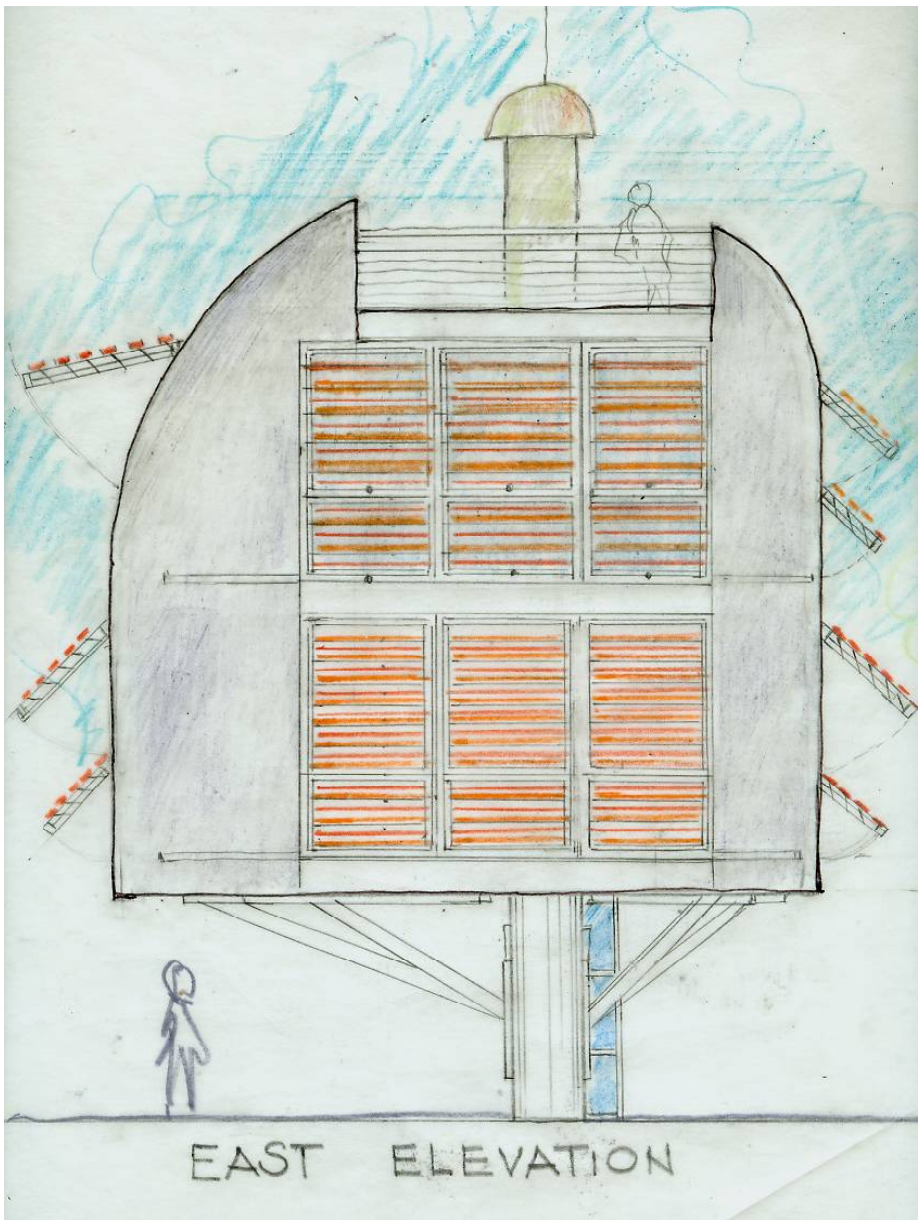
This section, through the north-south axis of the unit, demonstrates the relationship of the first and second floors, the maximum height that the building can assume, the top roof decking, as well as the structural and material constituent of the unit.
The material selected for the building envelope was influenced by several factors. One of the design preferences, was that the overall form of the building to read as a light volume.

3A.8.3 Design - Study of the Elevations



The south elevation initial study, shows the building at its ultimate height, front retractable fenestration with their louvers and exterior photovoltaic blades. In the background is the glass lift, and the bracings that stabilize the unit from rotation. The retractable fenestration panel on each facade can also fold up, which is shown at the two sides of the south facade.

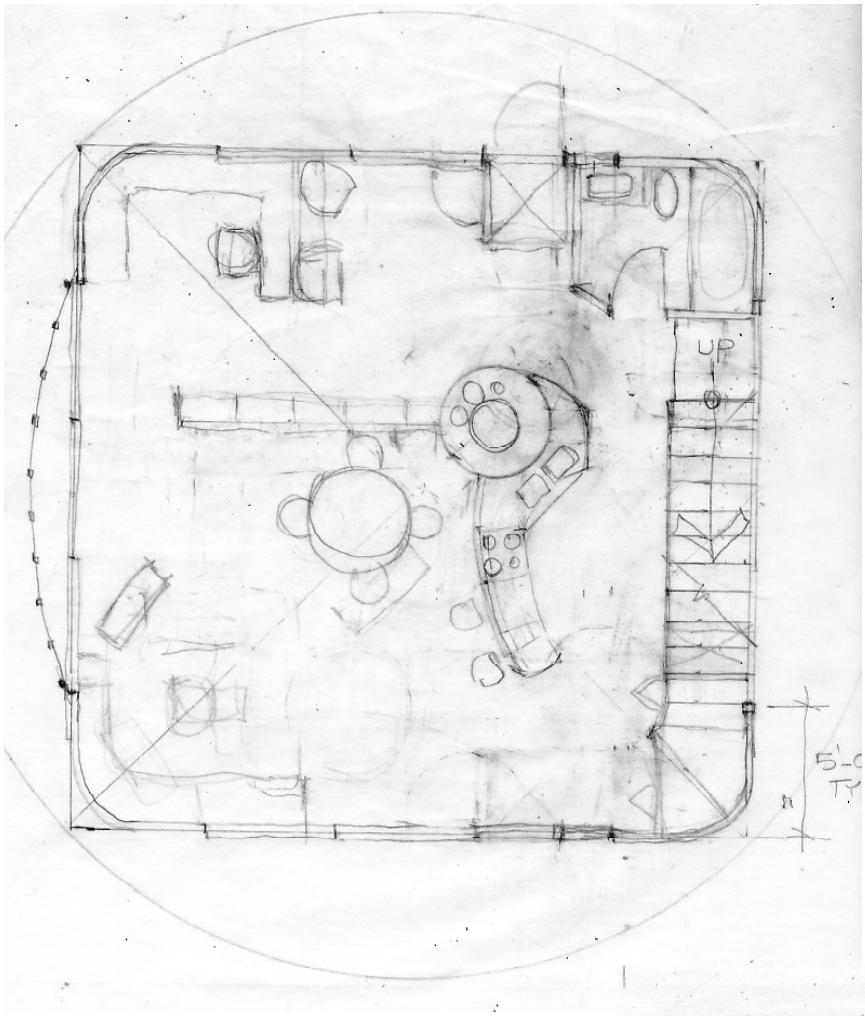
3A.8.3 Design - Study of the Elevations



The east elevation initial study reveals the curvature of the south facade, which is perpendicular to the south sun angle, at noon time on December 21st. in Southern California is 32 degrees NL.

The north elevation curvature is only for aesthetical reason. Four corner panels with double curves are made of polymer concrete, which is translucent.

3A.8.4 Design - Initial Study of the Layout

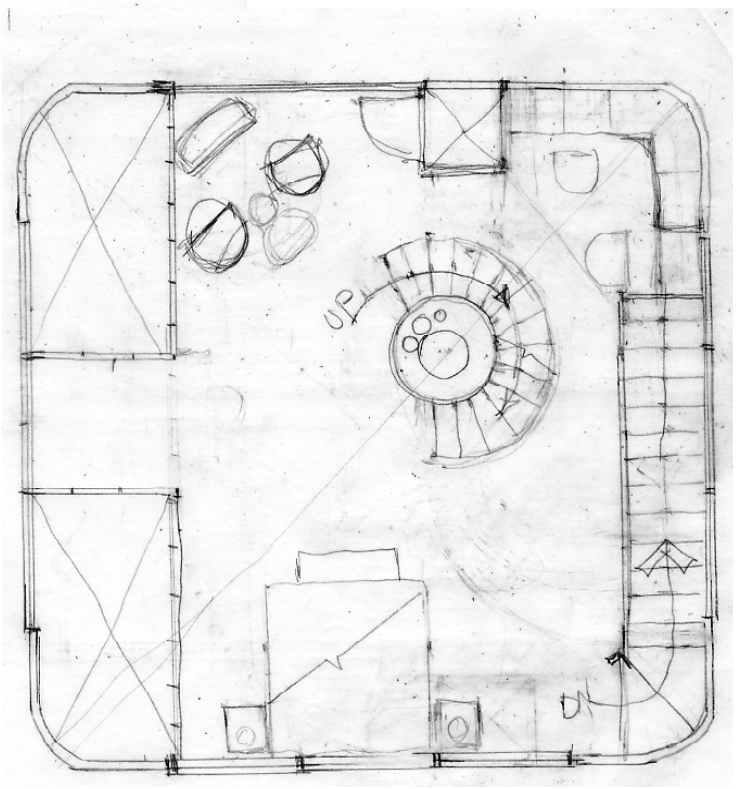


Initial study of the layout:

The initial study for the develoment of the first and second floor plans, focuses on:

- Maintaining openness and flexibility.
- Access to the floors.
- Relationship between the floors.
- Off-centering the main structural support for providing a more efficient usage of space.
- While allowing for flexibility within the confinement of grid, also distinguishing the location of primary and supportive functions of the work-live habitat.

Top: First Foor
Right: Second Floor



Each floor plan reveals the corner curves and free-flowing floor plan. There is a small curved balcony at the south side of the first floor. The second floor has two openings to the first floor, which create a two-story volume at those locations.

3A.8.5 Design - Initial Massing, form, volumetric and Spatial Studies

Initial massing, form volumetric and spatial studies

The Principal living areas are arranged around the off-setted trunk or shaft within an 18 feet radius, spiralling up the building to a roof garden at the top. Almost 2/3 of each side of the revolving cube which also can go up and down within a range of 10 ft. is highly glazed.

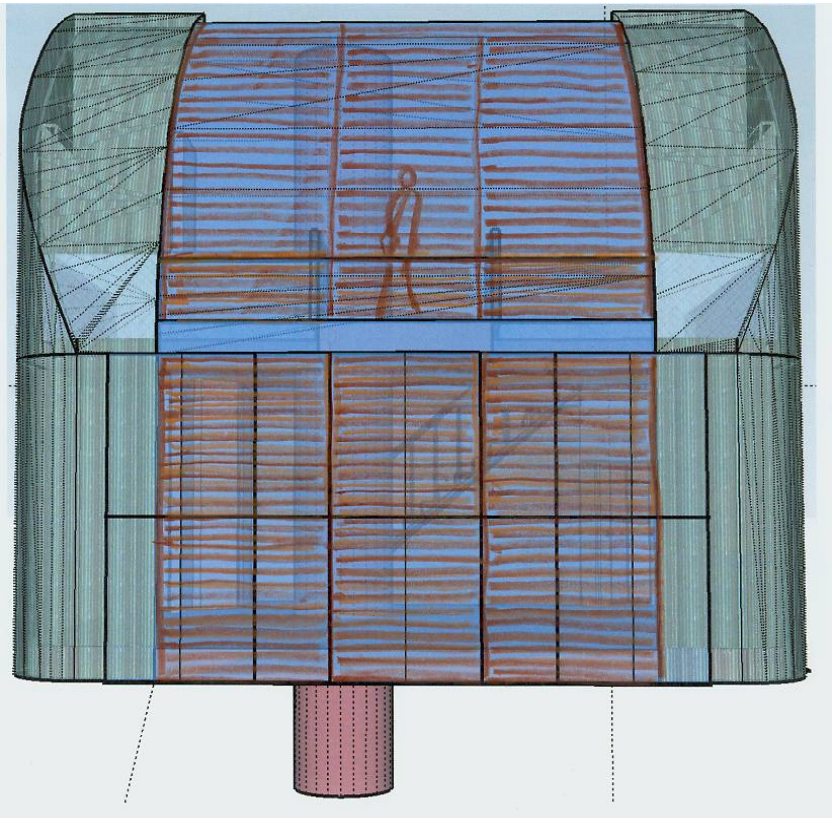
The energy strategy for the house is aimed to be captured from the sun.

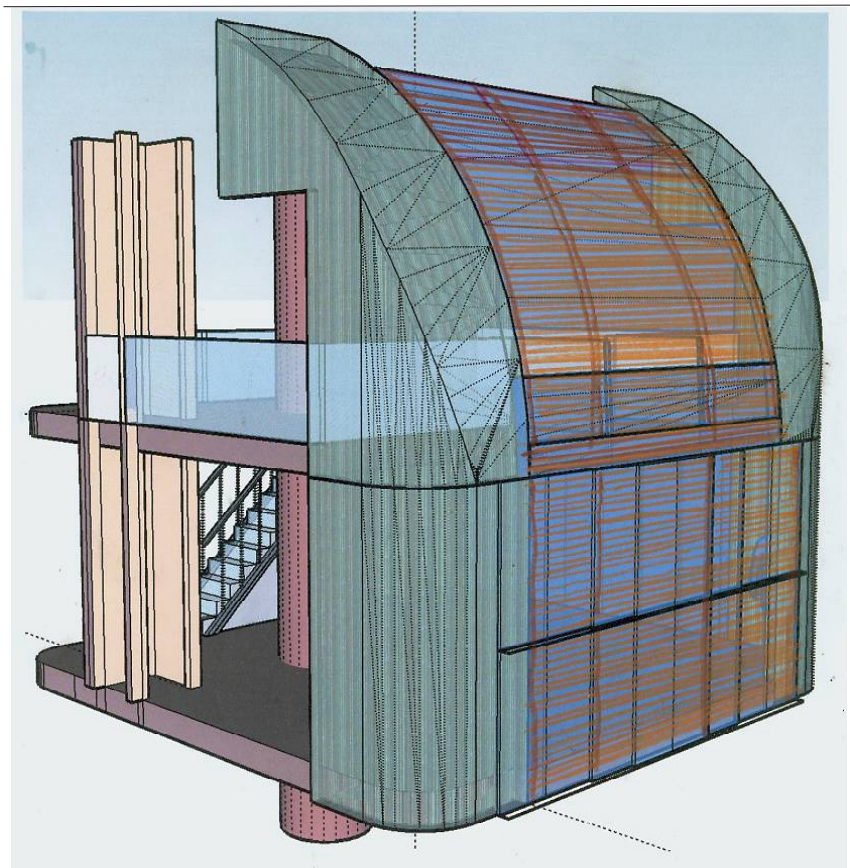
The building has a rotational capacity of 360 degree, and is programmable to follow the sun, until sunset and return to the sunrise position at 5:30 a.m. each morning.

The typical climate of Southern California, on 32 degree latitude, varies from temperate mild to hot humid or dry, in various regions from Pacific shorelines to the inland deserts. Along the shorelines, the climate is mild but with warm moist summers and cold fogs in winter.

The prototype habitat is intended to be possessing a massing and enclosure that is adaptable to various micro-climate within the region, as a biosphere that is able to adjust itself to different extremes and morphological encounterments.

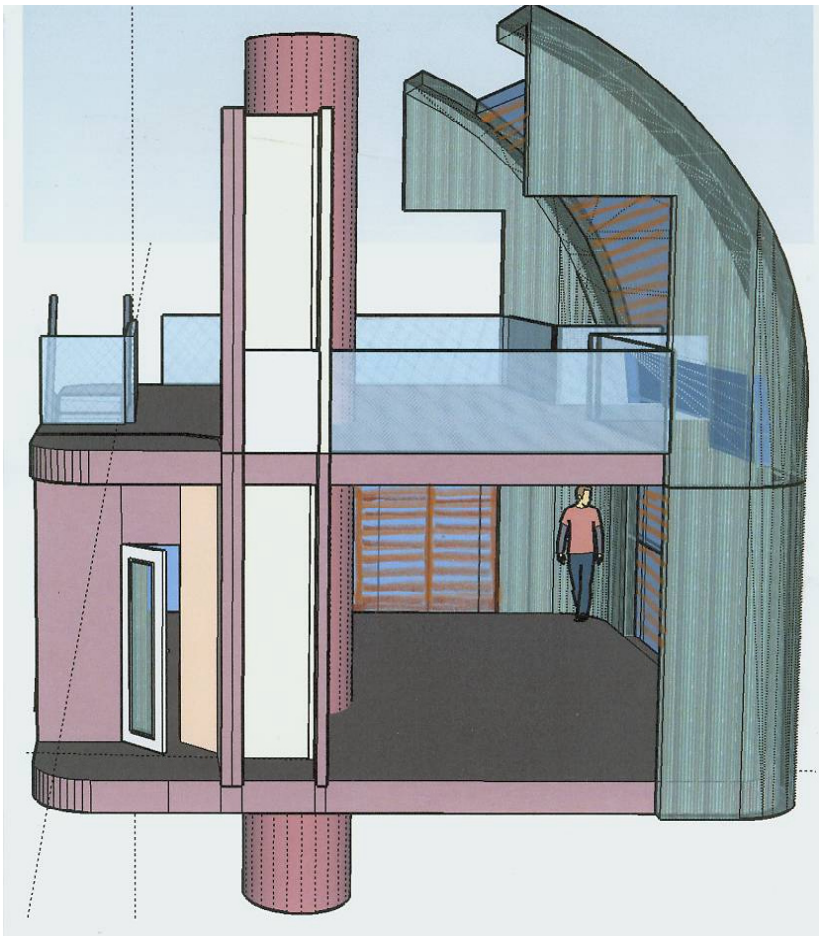
The main enclosure consists of large fenestrations of double glazing windows, with low-e coating and insulating blinds in the middle.

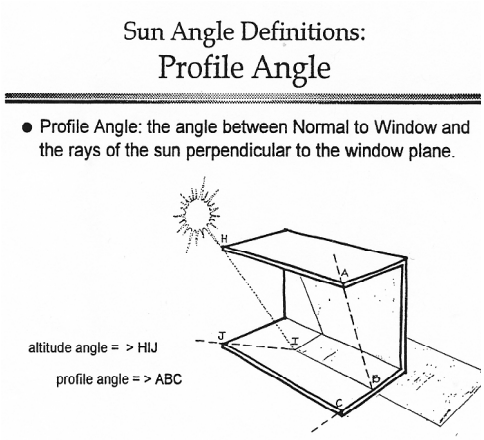


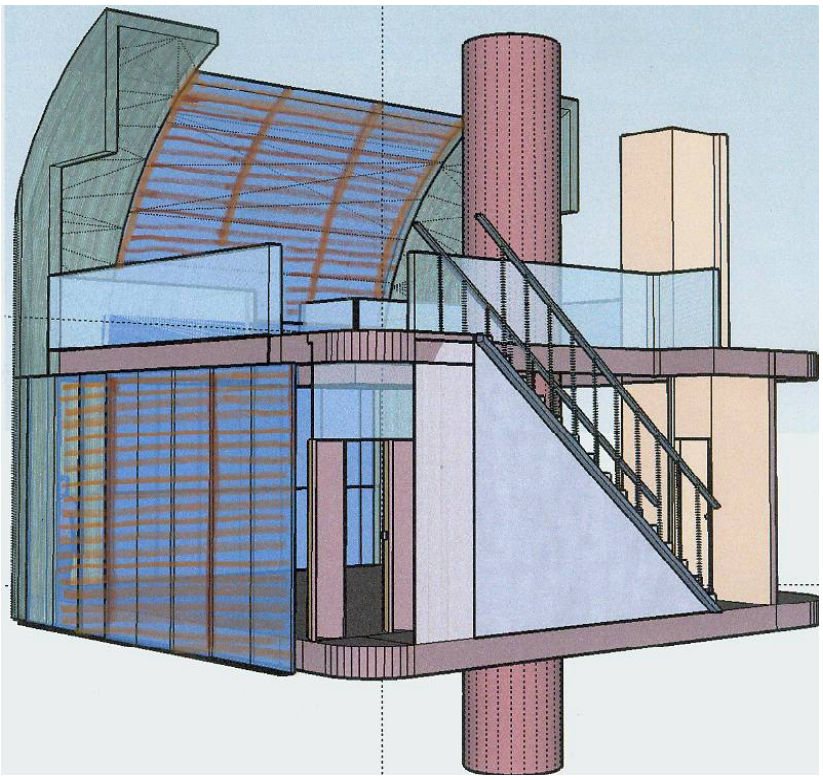


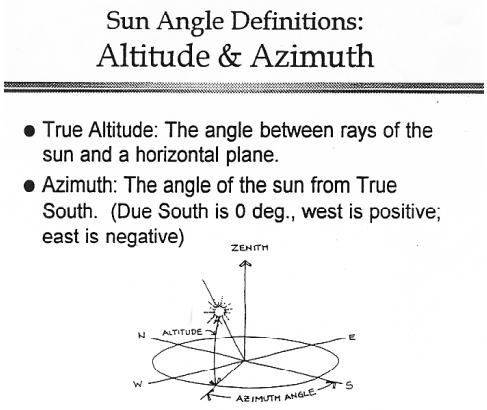
Design - Initial Massing, form, volumetric and Spatial Studies

Arrays of photovoltaic on the louvers outside of the windows and on the roof are programmed to follow the sun on a two axis tracking system. Meaning in response to azimuth and elevation which operate independently of the house. The photovoltaic panels should always be positioned for maximum exposure to the sun.









The initial massing, volumetric and spatial studies

Design - Initial Massing, form, volumetric and Spatial Studies

In the summer the house can be turned away from the sun to prevent overheating. By rotating the house to face northeast and opening the windows at night, room temperature can be maintained at low 70 degree F.

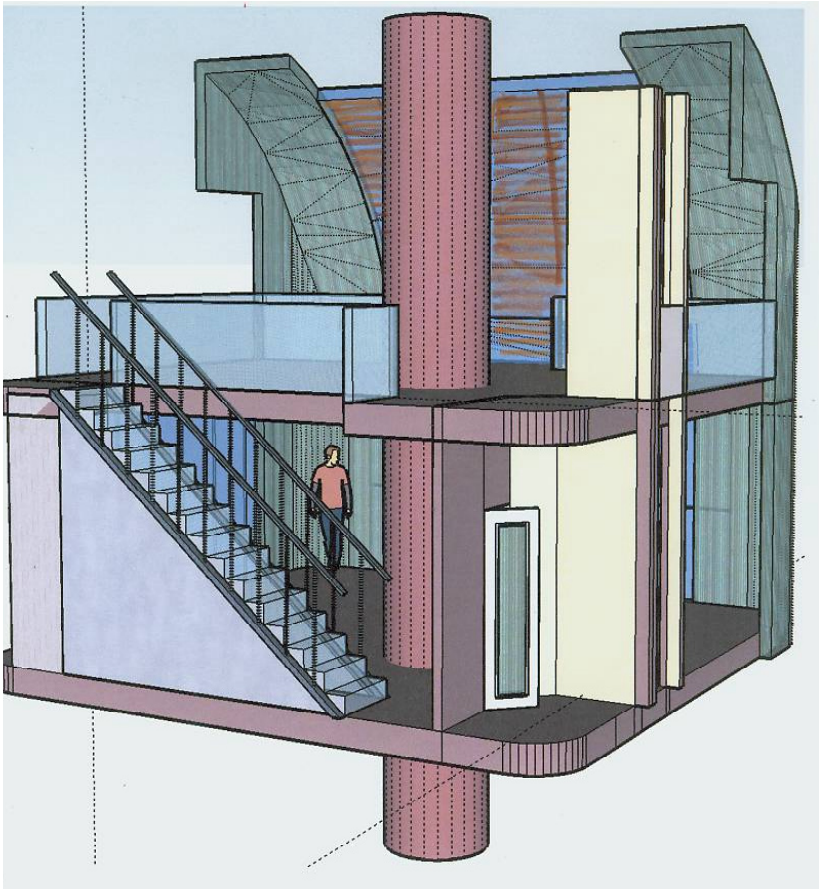
In the peak of the summer the house can track the sun with an offset of 180 degree to avoid solar penetration to the glazed living areas.

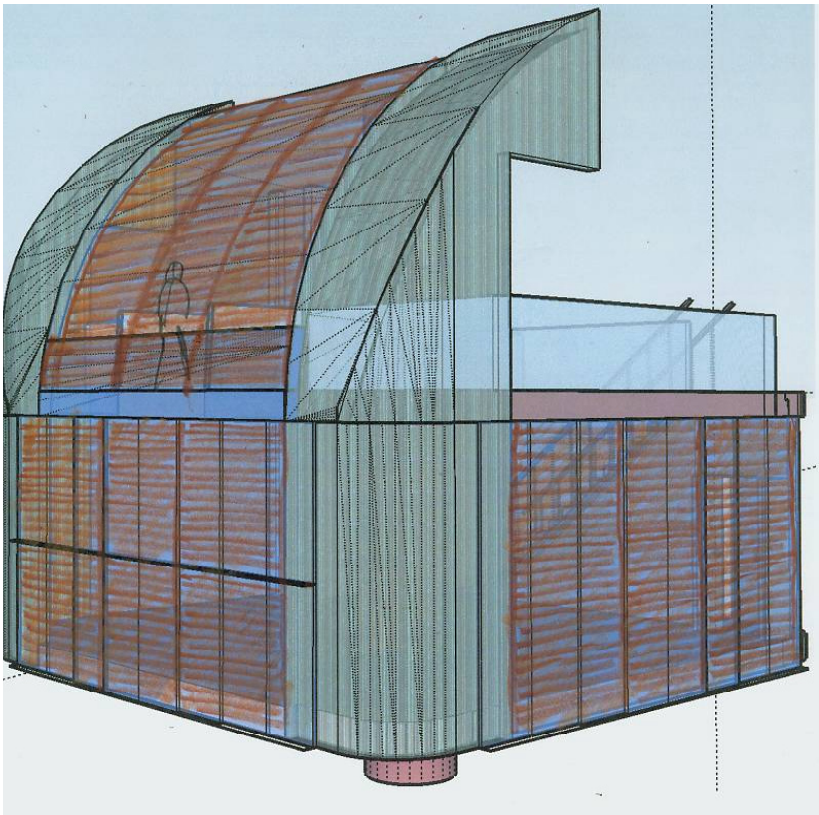
For the remainder of the year the house is rotated to take maximum advantage of passive solar gain and active solar water heating.

All perimeter rooms are provided with windows for natural light and views. Rooms that are normally on the south side have full-height glazing. The facades fenestrations on all four sides consist of full-height retractable glazing integrated with roller blades and shutters.

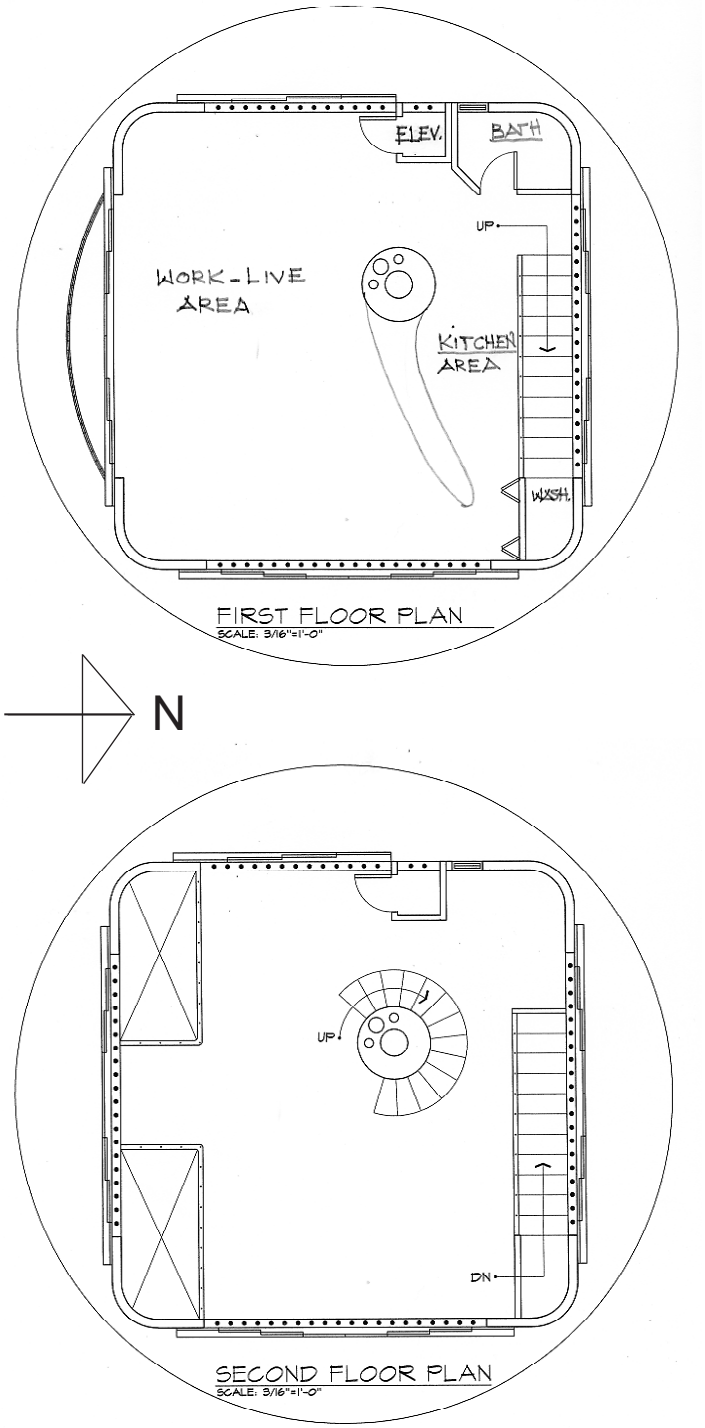
The rotation of the building can be manually overridden. For instance, it may be desired to rotate the living area to overlook a hillside, or the ocean, during a dinner party. Or the building may need to be turned away from the sun when the occupants are on holiday. A manually activated occupancy switch will be used to tell the computer which spaces are occupied and temperature of that zone will be kept lower.

The initial massing, volumetric and spatial studies

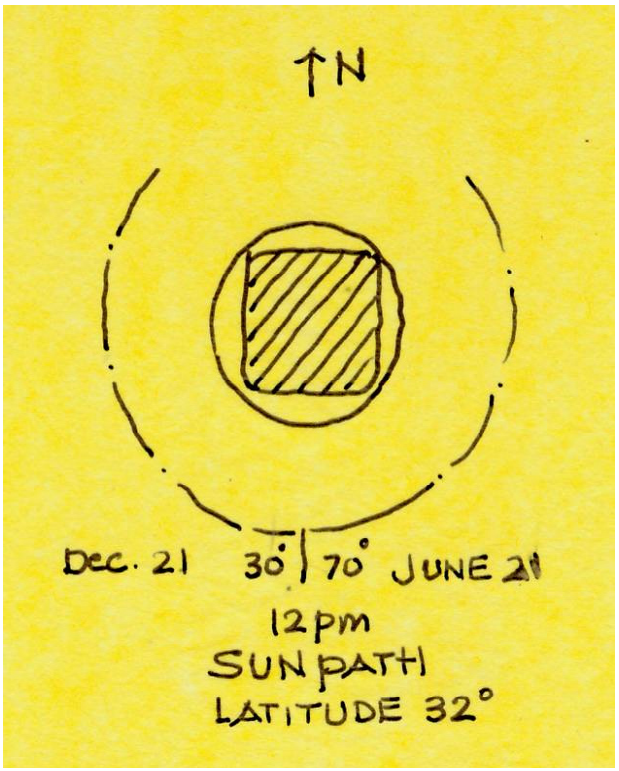


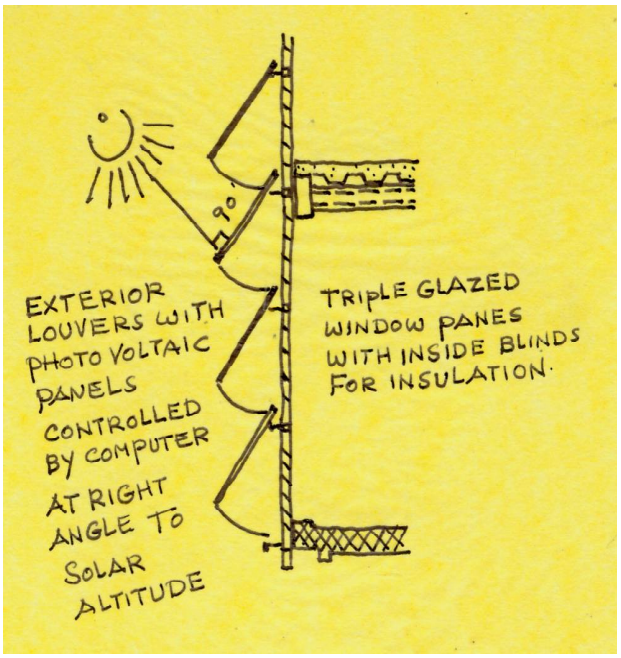


Design - Initial Massing, form, volumetric and Spatial Studies



The initial massing, volumetric and spatial studies - Study on establishing a generic north-south for the building





Sectional study of the exterior louvers with photovoltaic panels, which are controlled by computer at right angle to solar altitude.

Device Paradigms for
Performative Architecture

A Proposal For A Live-Work Futurist Performance Habitat

PART 3B

ARCH 508
Doctorate of Architecture

Mitra Kanaani

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Dan Pulido - Daniel Pulido Engineers
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John Gurski - Sullivan Electric & Solar Energy
CADD and Sketchup Drawings: Haleh Farahmehr
Revit Drawings and 3D Modeling: Linda Nguyen

3B. Simulation Enhanced Prototyping of an Experimental Live-Work Performative Solar Habitat: Toward the Final Design Proposal

3B.1 Review of the performative concepts

Before making any attempt to understand the performative mechanism and techniques applied to this experimental solar habitat, it is important to appreciate the objectives and the architectural meaning, which this futuristic artifact relies upon. Although merely performative and utilitarian, there are still questions as to why certain programmatic requirements are applied to this prototype solar habitat. Aside from the adopted metaphor of a plant, which efficiently harvest solar energy, as well as a desire for panoramic views rooted in history and arising from a social demand, the underlying and over-arching desire to challenge and defy norms is undeniable. Modernity has meant greater technological sophistication, so that people have set higher targets in almost every area. Technological progress has always had an impact on architecture. However, the progress of science in the recent past has been massive, while so has the continuous changes in architectural design. Creativity in architecture for the most part supersedes many other fields. However, due to economic and social norms that create resistance to change, innovation has not made parallel advances. Nonetheless, the question has now arisen as to whether we are now standing at the dawn of a completely new era in performative architecture, by introducing new science in design, bridging art and science, and evoking new paradigms in architecture?

The 1550-sq.ft. solar-powered habitat, operating within a set performative criteria, predisposes the project to push boundaries in design and construction. The habitat is designed with the goal to minimize energy use, while making the house adaptable to almost any type of environmental condition and contextual setting. The design is compatible and in rhyme with performative objectives. It is grounded in the laws of nature, science and the strength of the materials, as well as, the adoption of new and improved materials, structural analysis, natural illumination, human comfort, while at the same time, aesthetics, and beauty have not been overlooked or disregarded. Building materials and their potential performance have formed the starting basis for shaping the building from the very outset. The design and vocabulary of the solar habitat have been heavily impacted by certain systematic performative requirements of the building. The architectural form of the building is informed by a reciprocity between scientific mandates and aesthetics. The central science of the mechanics of building materials, with properties such as stress and strain, stability, buckling, elasticity and plasticity, have contributed to the formation of a geometry and design product that is workable and performative in its entirety. The morphology of the design of the building, and aesthetics, as well as the collection of methods for devising its optimal forms, were initiated from the concept and general study of form in nature, as well as from the way the building is expected to perform in its relationship with the elements of nature, particularly the sun.

The final form of the solar habitat is the result of a close partnership between several engineering experts and an architect. The primary geometry of the building is extracted from a simple cylinder. As the architectural form evolved did so the form of the cylinder. To most efficiently use of interior spaces, the four sides were gradually transformed to straight lines, while the curved corners are reminiscent of the cylinder. The curved corners made out of polymer add a great amount of rigidity and resistance to torsional movements.

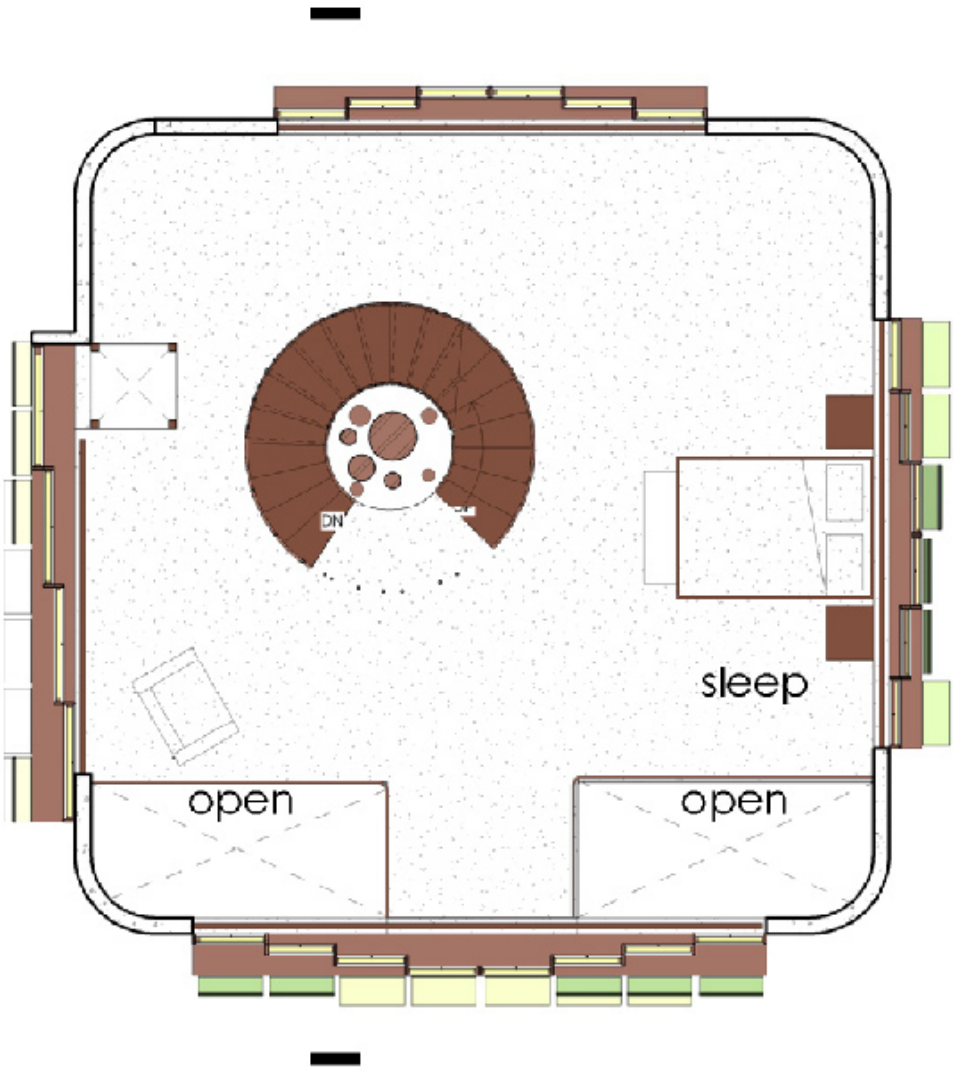
The process of developing this sculptural shape is undoubtedly based on certain priorities and aesthetic preferences, while aiming to solve real environmental concerns. The choice of building materials for the facades is the reflection of the design concept and depends to a great extent on the function of the building.

The solar habitat prototype is much more than a live/work shelter. While looking toward the future, it is a signifier of our society and our age of technology, which can contribute to energy production rather than a burden to the local utility infrastructure. Ultimately, the performative aspect of the solar habitat plays a poetic function in the community by uplifting the human spirit.

3B.1.1 FIRST FLOOR PLAN

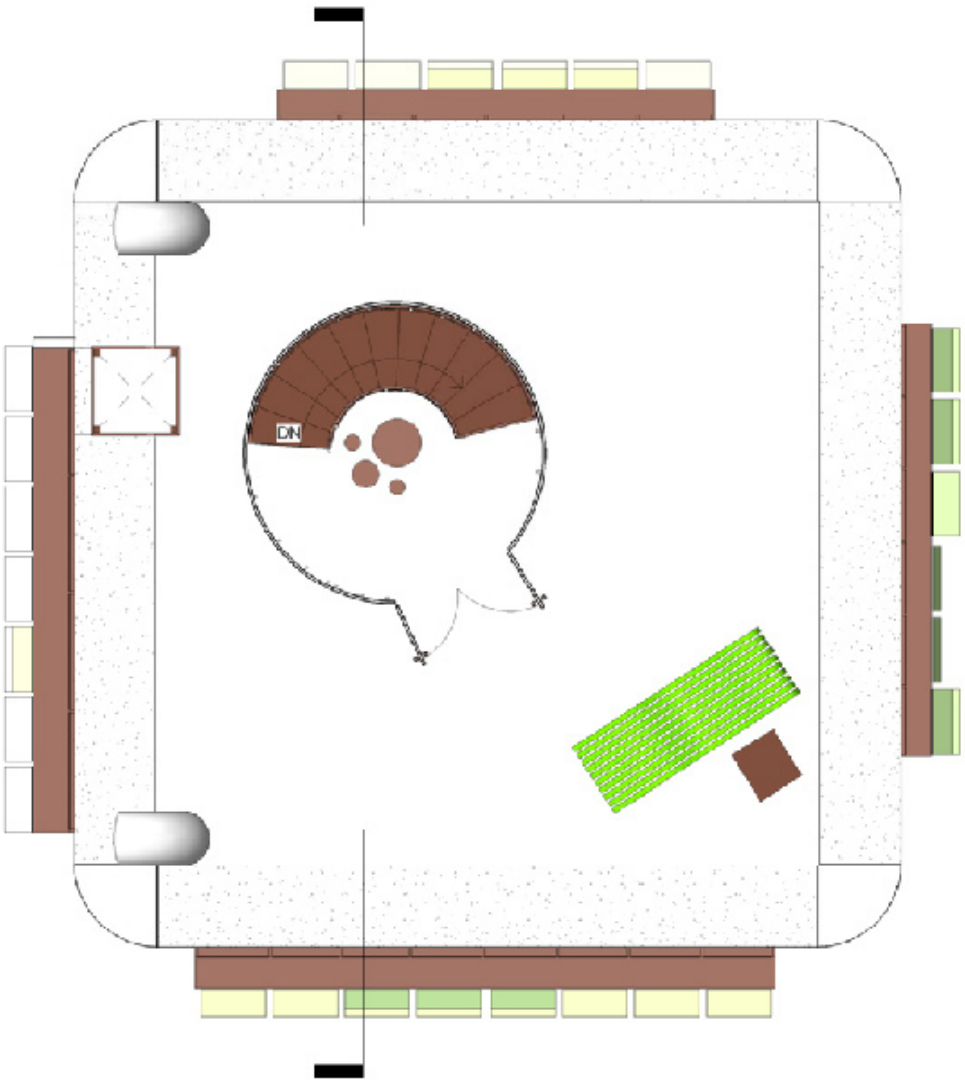
The plan is a fully open layout, with an offset shaft at the center, integrated with a foldable spiral stair, and penetration of a lift for accessibility to second floor and roof decking. Additionally, the bathroom, and washer, dryer modules as well as kitchen cabinets are all movable and relocatable. Credit: Revit 3D Modeling by, Linda Nguyen

3B.1.2 SECOND FLOOR PLAN



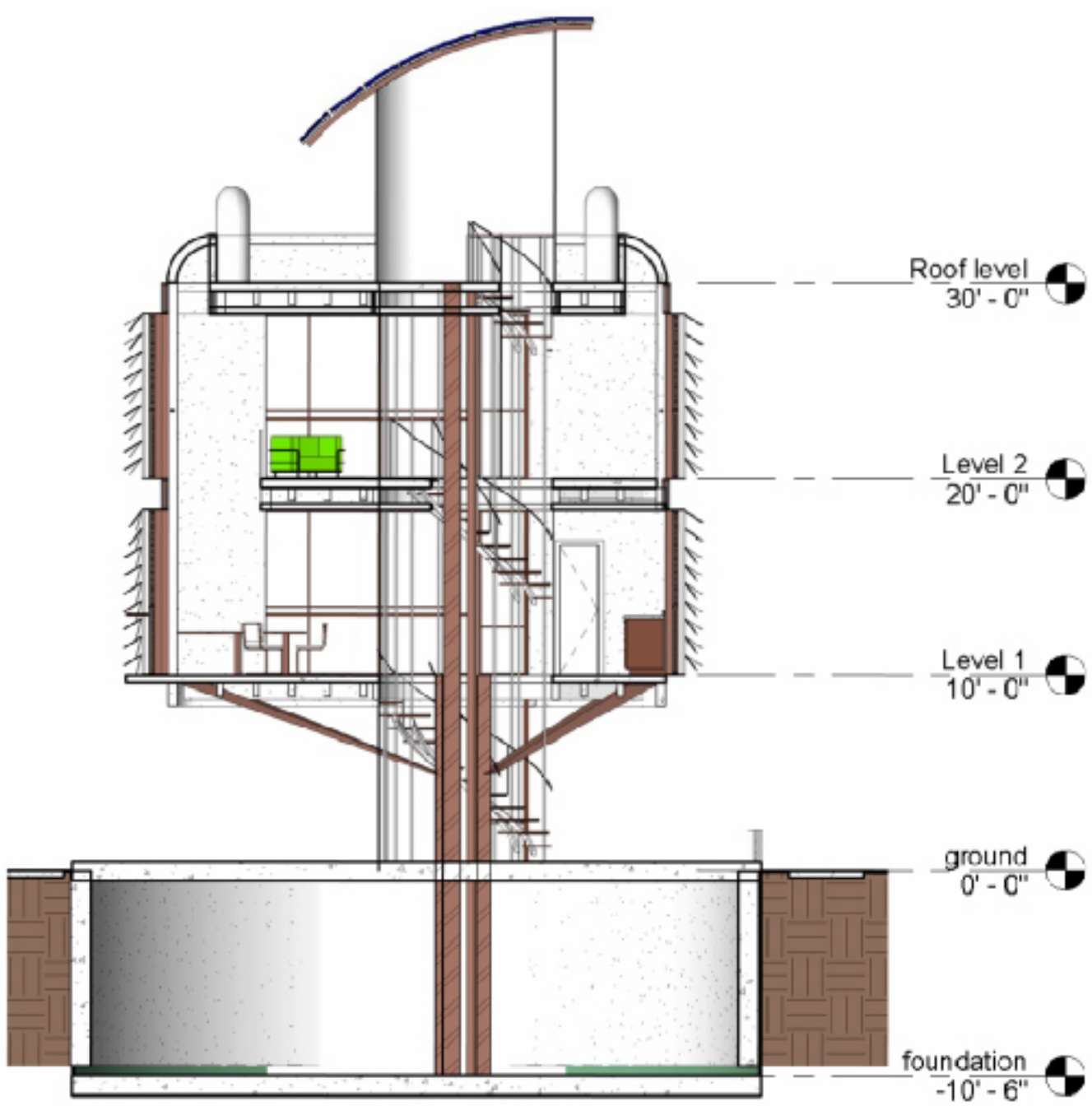
The solar habitat prototype creates an open spatial interior environment. First and second floor plans emphasize flexibility rather than spatial arrangement. Due to large openings in the second floor plate, the house acts as one large, spacious, well-lit volume. There are movable modules that contain a bathroom, and storage for a washer and dryer. The main plumbing pipes run through the shaft, which provides flexibility for the re-arrangement of the modules within the open layout. The location of the only support shaft of the building is a true compromise between the structure and architecture. While the off-set shaft with respect to the center of the square still provides a workable cantilevered structure, concurrently it allows for more efficiency in distribution of the functions within the open layout. Credit: Revit 3D Modeling by, Linda Nguyen

3B.1.3 PLAN OF THE ROOF



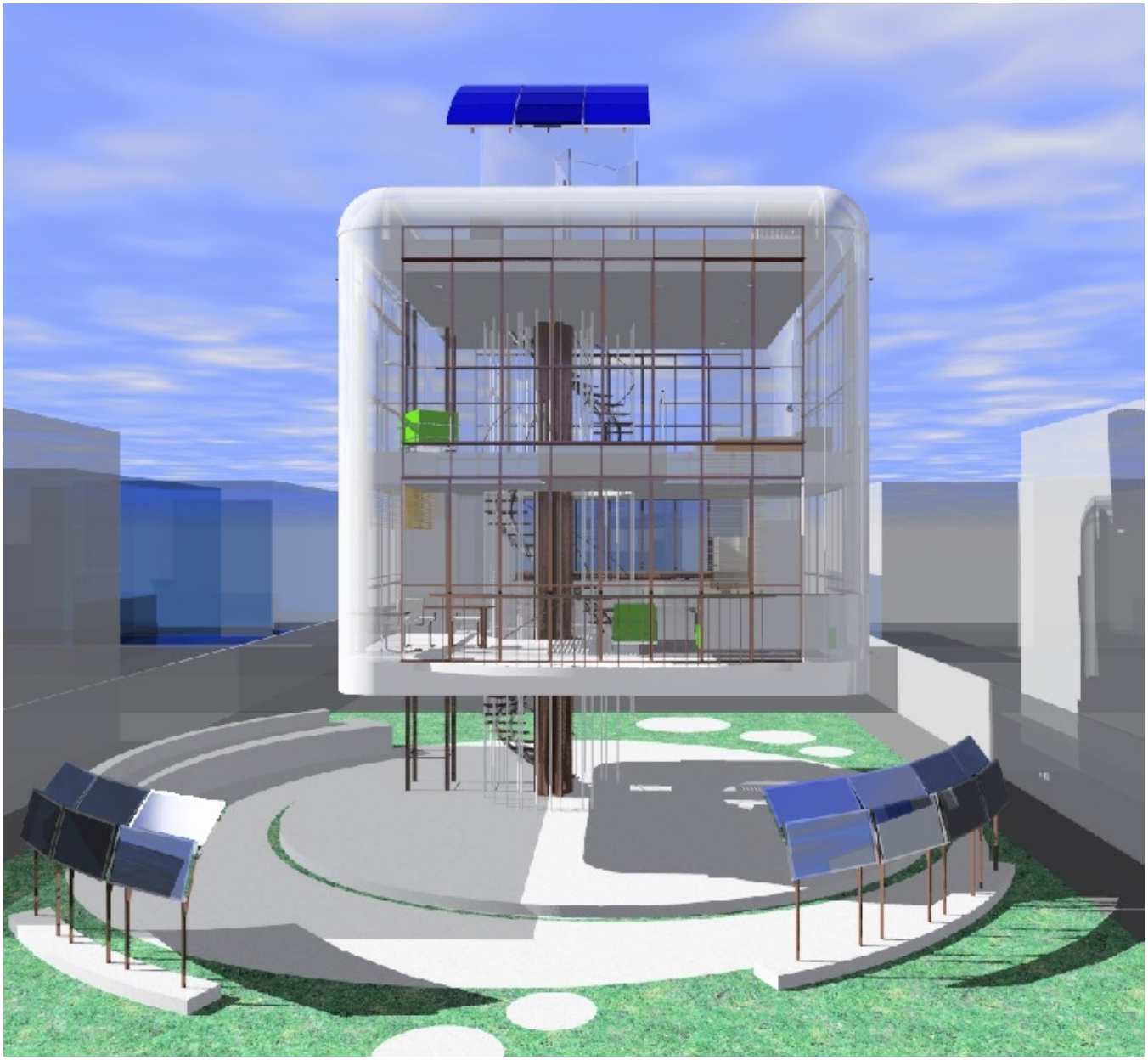
The solar habitat prototype has a flat roof deck hovering over a 3-ft. steel tube shaft. The lift at the left side of the plan, as well as the spiral stair around the main steel shaft, allow access to the roof deck as an outdoor private space, with a 360-degree panoramic view. The habitat benefits from a track solar collector on the roof deck, which follows the path of the sun to keep the sunlight focused on the absorber throughout the day. The track solar panel, while acting as a solar collector, like a large umbrella, provides shade for the users of the deck. The two wind scoops at the left side of the deck allow the air circulated within to be pushed out by the incoming fresh air from the open windows.
Credit: Revit 3D Modeling by, Linda Nguyen

3B.1.4 Typical North-South Building Section



Within a volume of 20-ft. interior space, the house is providing a total of four levels--two levels of indoor and two levels of outdoor spaces-- in the fully raised up position. The access to all levels is provided by a lift and a spiral stair that wraps around the interior supporting shaft. The provision of the basement is for accommodating the equipment and not as a structural necessity, which is solely optional based on the programmatic requirements. The provision of knee-bracings, although helpful for lateral resistivity reasons, however was not found to have urgent structural necessity. The effect of the knee-bracings are more for psychological reasons to create a sense of confidence and security. Credit: Revit 3D Modeling by, Linda Nguyen

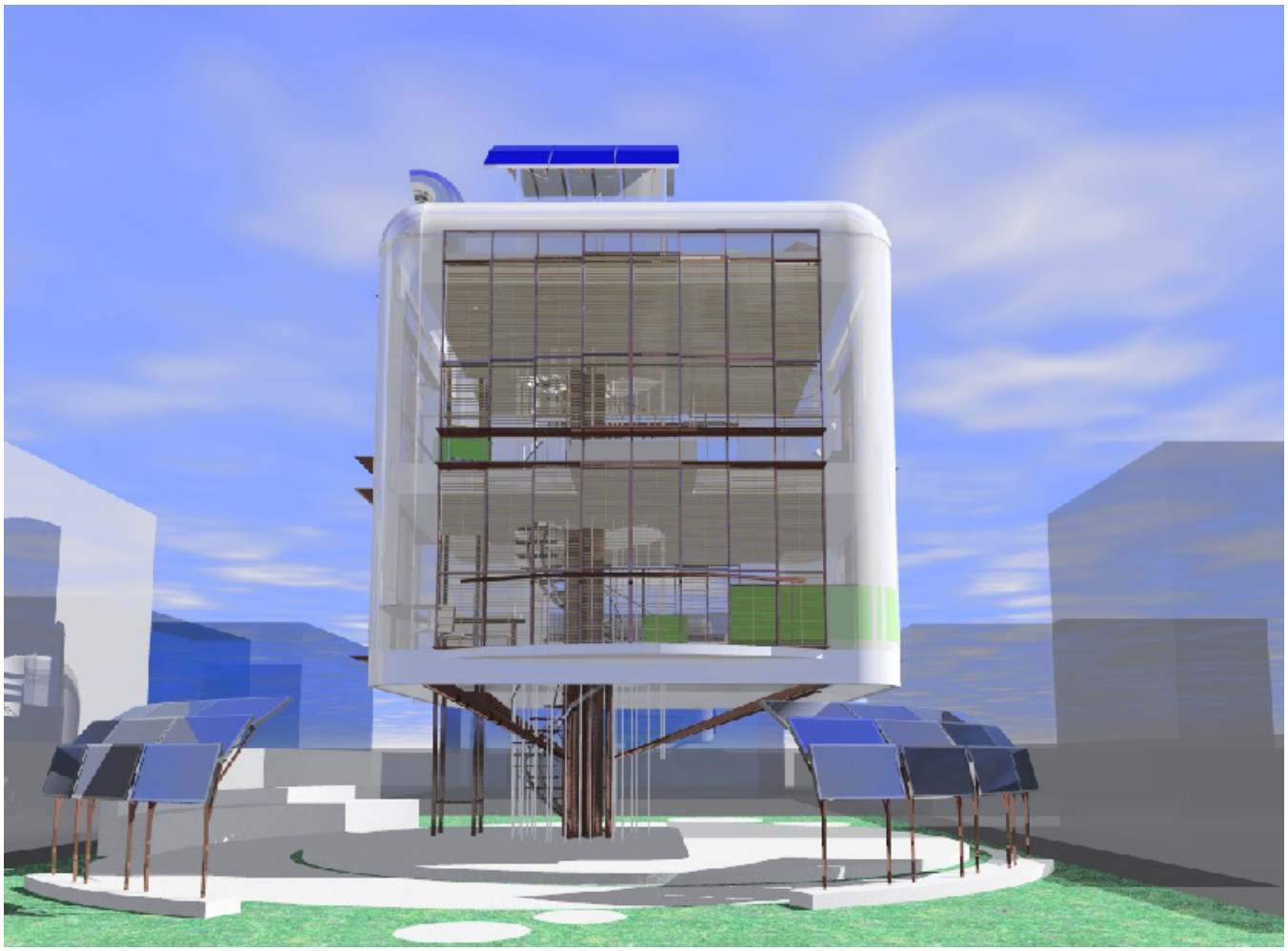
3B.1.5 Typical South Perspective - High



The prototype habitat showcases a combination of glass and metal, in a Miesian style, as well as the composite material Polymer. All four sides of the building enjoy full-height fully operable and tractable fenestration to the extent that the house can convert to an outdoor canopy as desired. The roof deck separation from the edge of the curtain glass wall (as it is clearly represented in the building section) provides a series of windows all around the roof, and allows the roof to look it is floating, while creating a more dynamic look for the building.

The solar habitat prototype also employs an array of fixed situated photovoltaic panels, which add to the provision of the required energy load for the house's daily energy needs. The habitat, in its fully raised-up position, creates a pleasant outdoor environment, which is suitable for outdoor social activities as well. Credit: Revit 3D Modeling by, Linda Nguyen

3B.1.6 Typical South Perspective - Low



There are roller blinds incorporated into the double-glazed windows, which allow the entire building facade fenestrations to act as a machine that can modify natural light and heat. Another interesting feature of this house is the array of shading shutters over the exterior of the facade glazings, which add to the facade mechanism in modifying natural light and heat by providing the photovoltaic panels with the flexibility to adjust to the angle of the sun. (Is not shown on this elevation)

Ground fixed situated photovoltaic panels, along with a tract photovoltaic panel on the roof and on the exterior shutters, provide more than the required energy load for the house's day to day various energy needs.

3B.2 Structural Analysis

The original design concepts for the habitat are structurally challenging and demand the expression of tectonic strategies. Undoubtedly the design of this building is based on the mandate of static equilibrium against gravity and wind, and the structural considerations are one of the most critical and empirical technical influences on the design of this habitat prototype. Based on the design concept, the building has to stand up on one support and demonstrate the workability of structural solution leads for an efficient reciprocity between the architectural form and the structural skeleton. Alternate schemes were analyzed to determine an optimal structure based on the demand of the interior layout to locate the interior support away from the center of the plan.

3B.2.1 Proof Of Performance

The first and most convincing proof of the success and safety of a structure is the placement of the structure into service. Once the structure is in service, its response to expected functional loadings or environmental hazards, such as earthquake and wind loads, must be considered. Accurate predictions of structural response and, or behavior provide the proofs needed to assure that the structure is safe and can be used for its intended purpose. In order to predict structural response, there are five important procedures or tools available:

1. For some types of structures it is possible to test one or more full-scale or prototype structures for extreme loading or environmental conditions. Although the testing program is a great tool, it was not possible for this particular project to build a full-scale prototype structure.

2. For large structures, particularly with unusual design features, small or medium scale tests of the structure may be conducted. While the proof of performance is less convincing than full-scale tests, it provides some physical evidence of the response of the structure to loads. An example of this type of modelling is the testing in wind tunnels of small-scale models of large buildings to determine loads and the effect of the presence of structure on wind patterns in its local vicinity. For all practical reasons, performance of this kind of test was not feasible either.

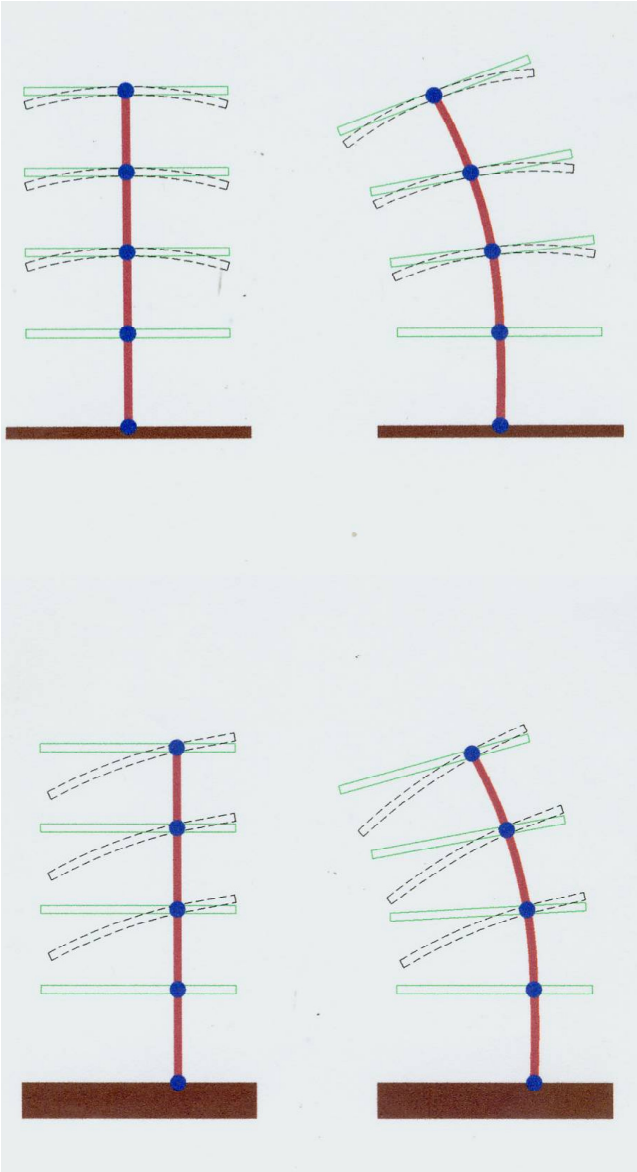
3. When full-or small-scale model tests of a structure are not feasible, tests of a model or prototype of a single member or a small portion of the structure may be conducted. These tests can be used to assess structural performance under expected loads, to evaluate performance under conditions of fire or special dynamic loads, or to learn more about the behavior of the member or assembly of members. Parameters can be varied and designs modified on the basis of the test results. These kinds of tests do not necessarily guarantee the performance of the entire structure, but they improve our level of confidence. For a fully cantilevered building that poses a considerable challenge, this method of performance testing did not seem to be a viable solution.

4. The most universally used and reliable technique these days is to create or simulate a mathematical model of the structure, and evaluate its structural performance by studying the effects of varying parameters in the model. Mathematical modelling of a structure is the most powerful tool for analysis of the alternative structural systems. This is the tool that was adopted for the evaluation of alternative structural solutions for the habitat. The spatial need of the program demanded that the supporting column move away from the centroid of the geometry, while the center of the form, happens to be the most optimized location for the single column. Through computer simulation modeling, the form was modified based on the optimal off centered location for the shaft. Through series of trial and errors, computer simulation modeling revealed the most

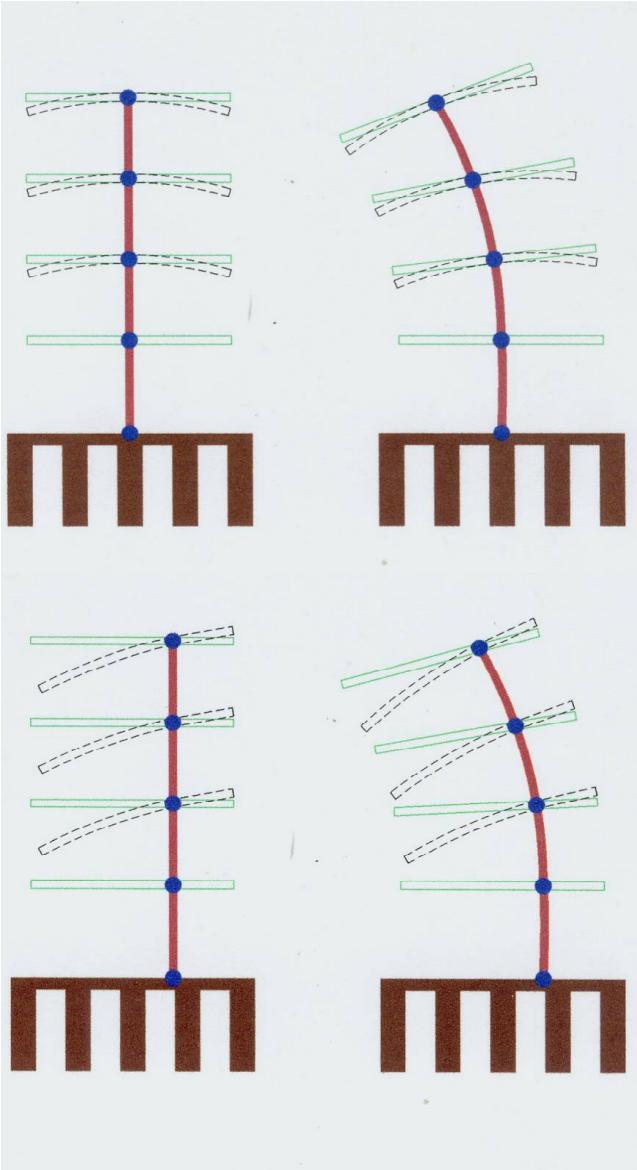
ideal location.

5. The last tool is still known as intuition and experience. Interestingly many structural engineers believe that if you don't know the answer to how your structure will respond, you shouldn't use a computer to analyze it!

3B.2.2 Structural Analysis - Diagrammatic Simulations



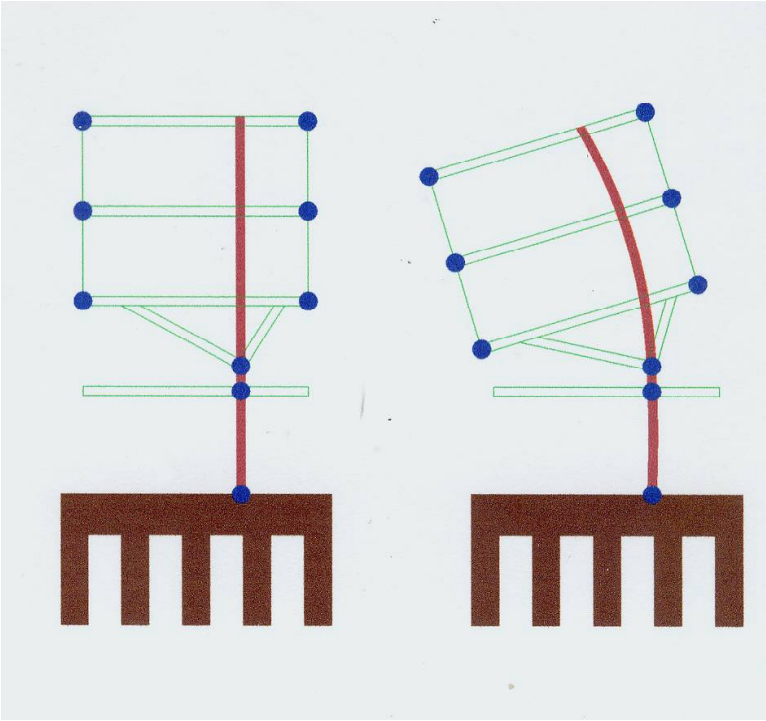
Behavior of the floor and roof plates, subject to live load and dead load (left), and subject to lateral load (right), when central support is off-centered, with *raft* foundation.



Behavior of the floor and roof plates, subject to live load and dead load (left), and subject to lateral load (right), when central support is off-centered, with *pier* foundation.

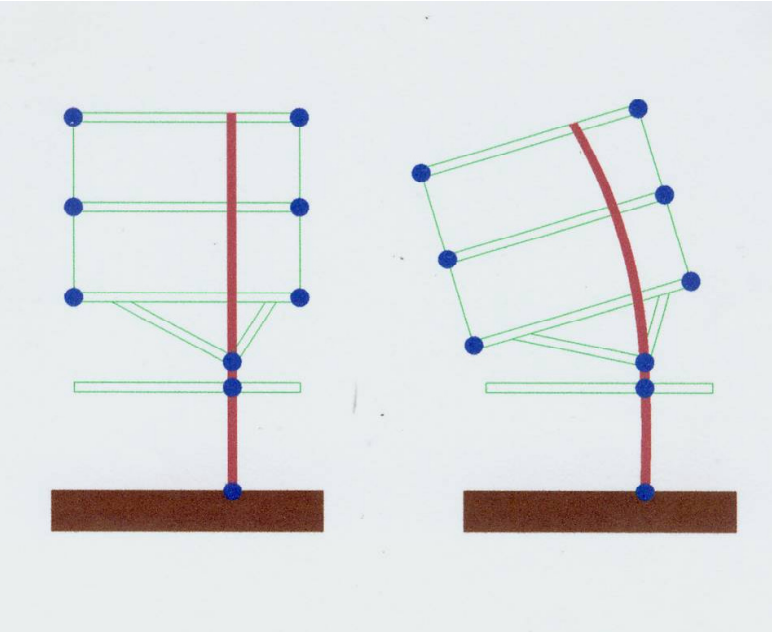
- Blue dots resemble rigid connections.

3B.2.2 Structural Analysis - Diagrammatic Simulations - Continued



Concept of creating a rigid box. In this case the load of the roof and floor plates above the first floor is transferred to the first floor plate and ultimately to the central shaft which is off-centered. The connection of the entire box to the central shaft needs to be fully rigid to tolerate the moment that is going to be induced in that joint.

Frame connection to the pier foundation (in case soil is unreliable) has to be rigid, as well.

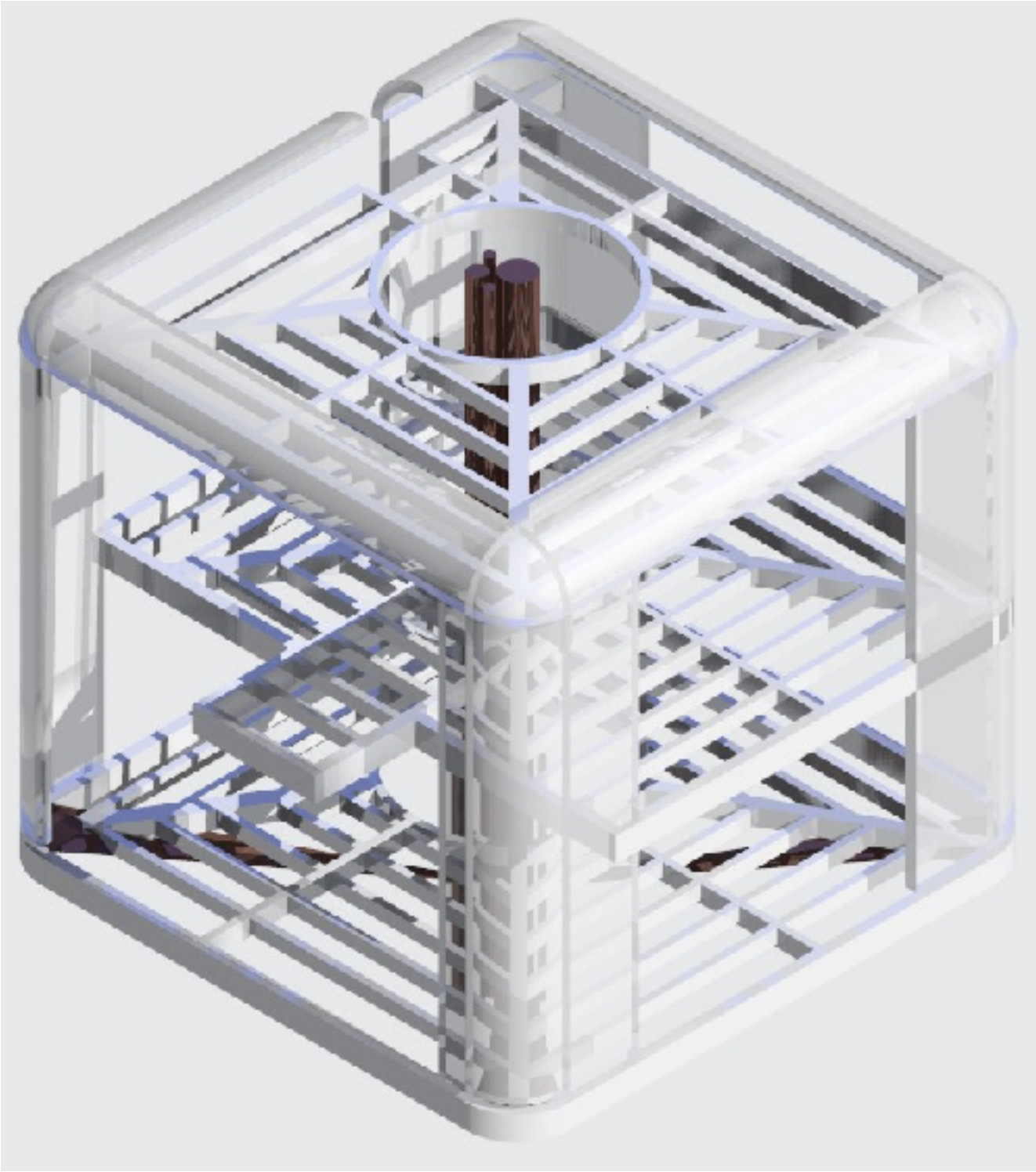


Same situation as above.

Rigid connection to the raft foundation.

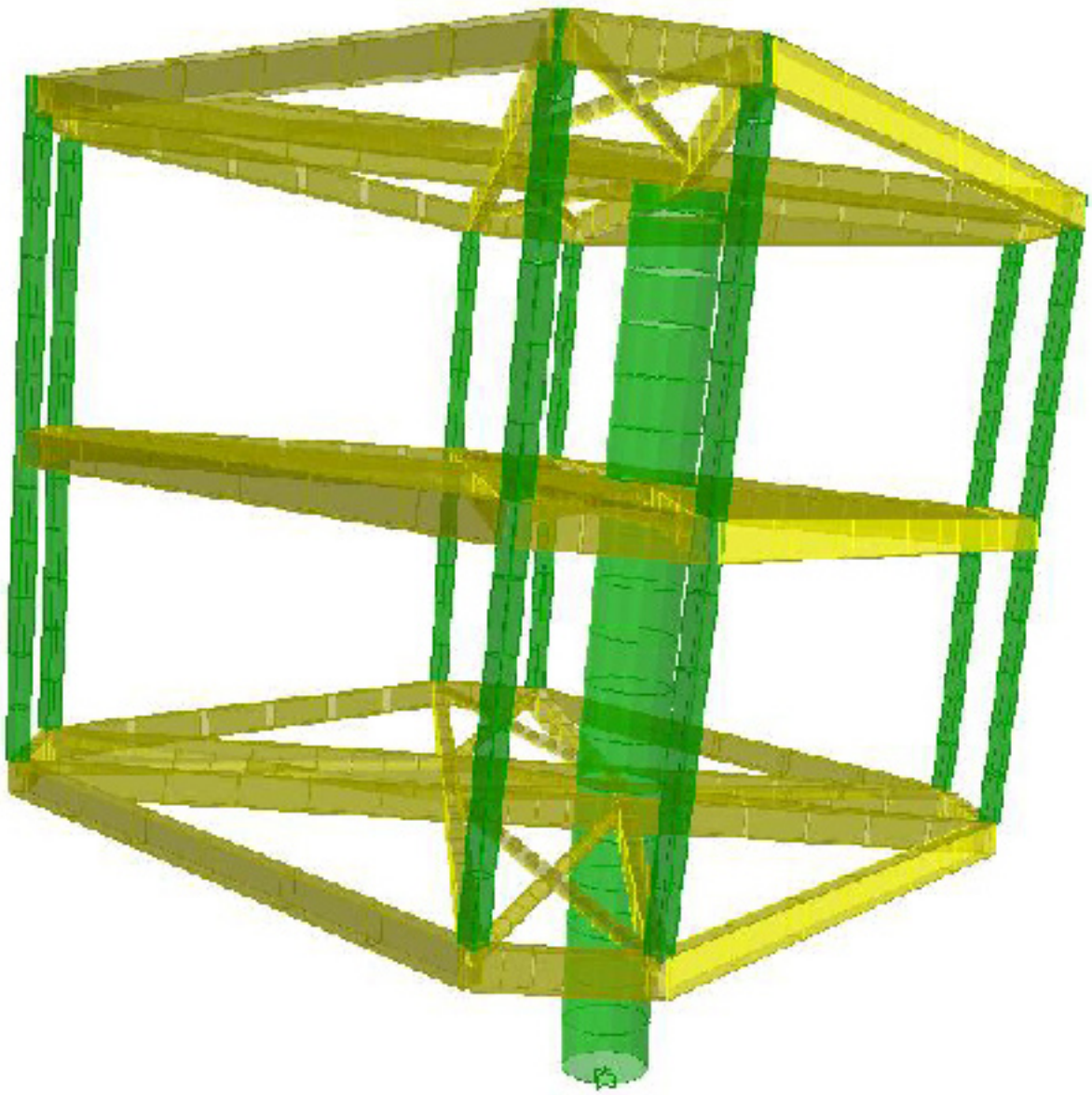
CADD Diagrams by: Haleh Farahmehr

3B.2.3 Initial Structural Simulation with Centralized Support



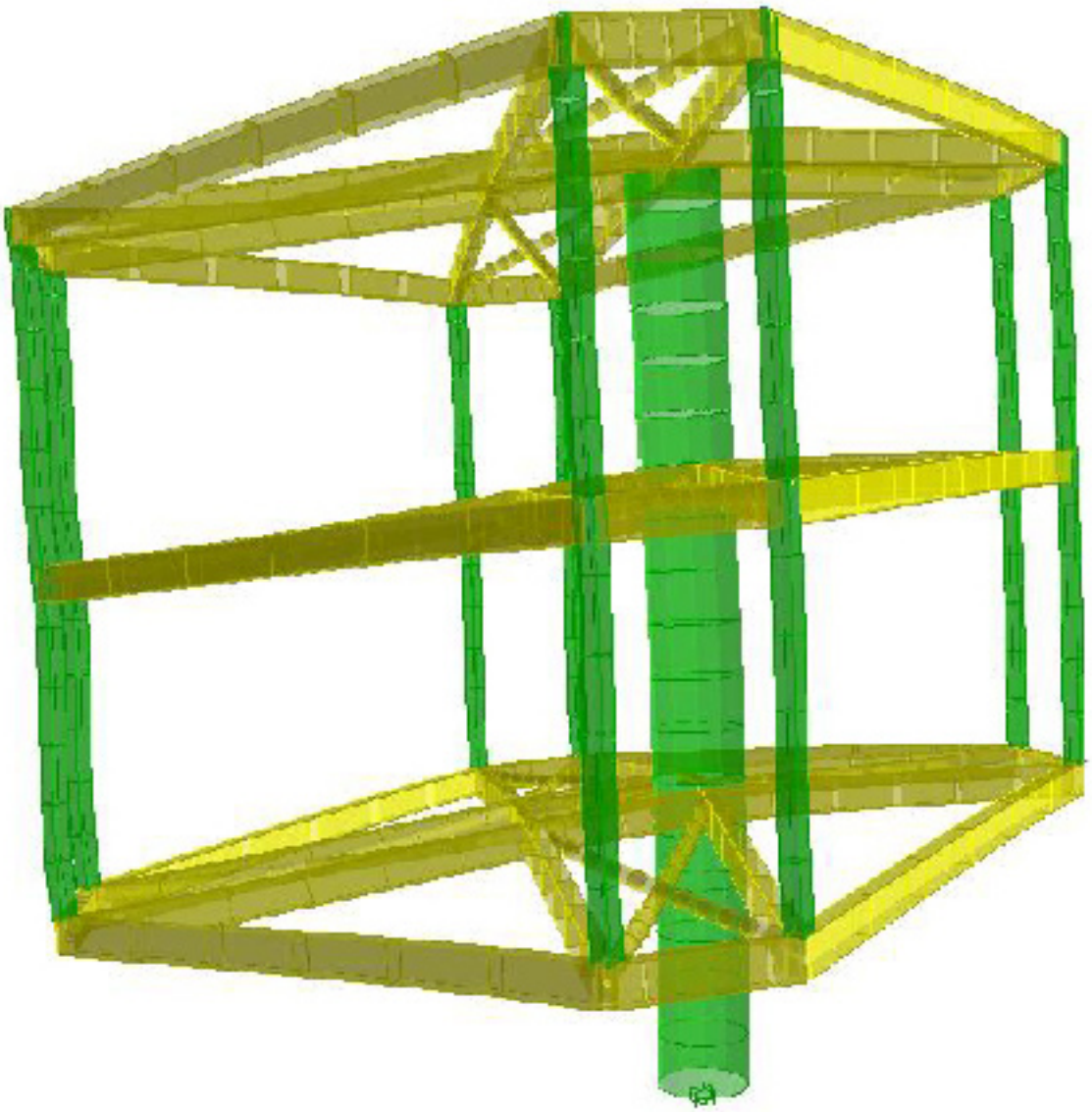
One of the early experiments with the framing of the floors and roof deck diaphragms.

3B.2.4 Final Structural Simulation with Off-Centered Support - Position A



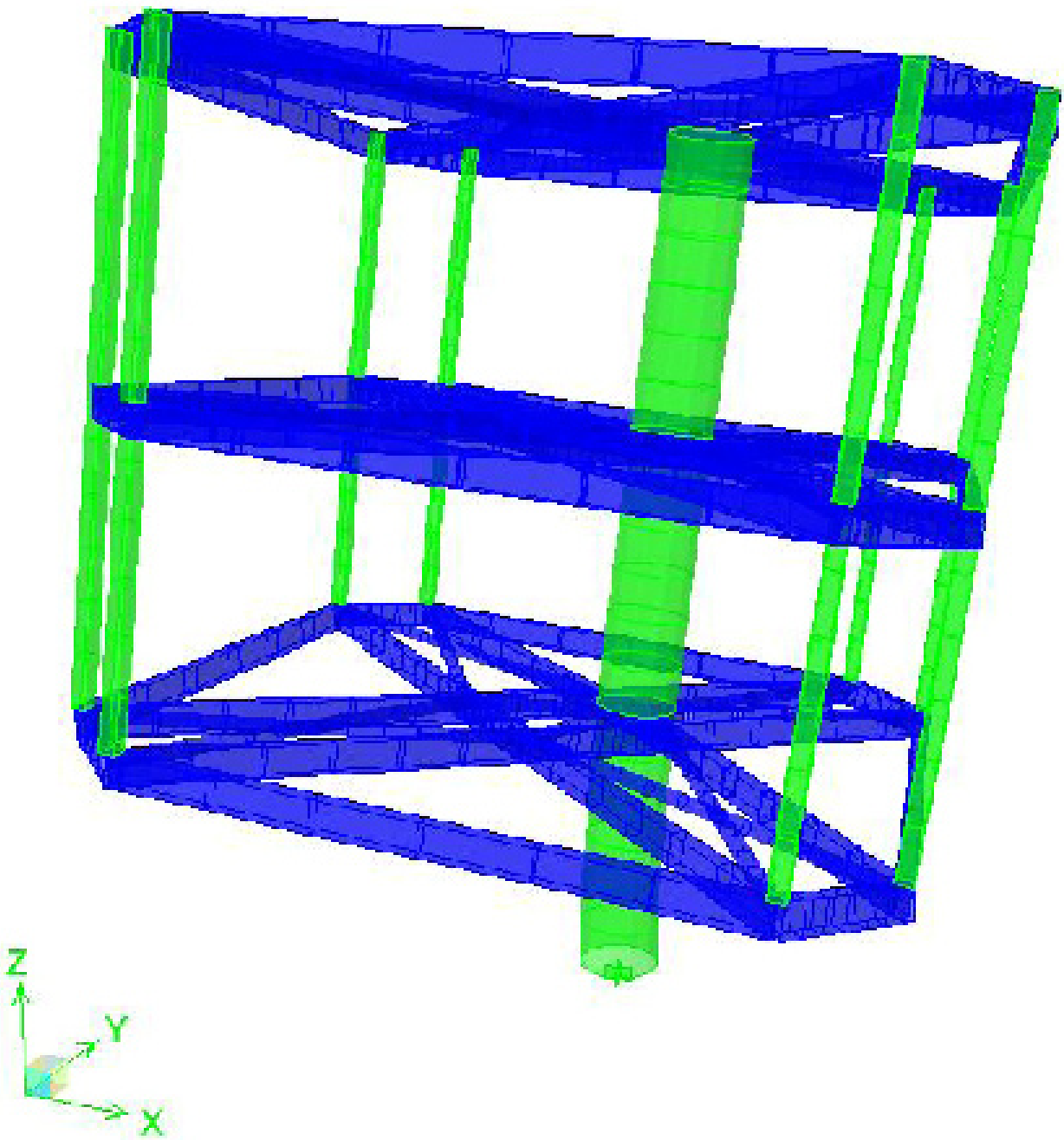
ETAB Structural Simulation of the behavior of rigid box with rigid diaphragm connections to the off-centered central column subject to lateral load.

3B.2.5 Structural Simulation with Off-Centered Support - Position B



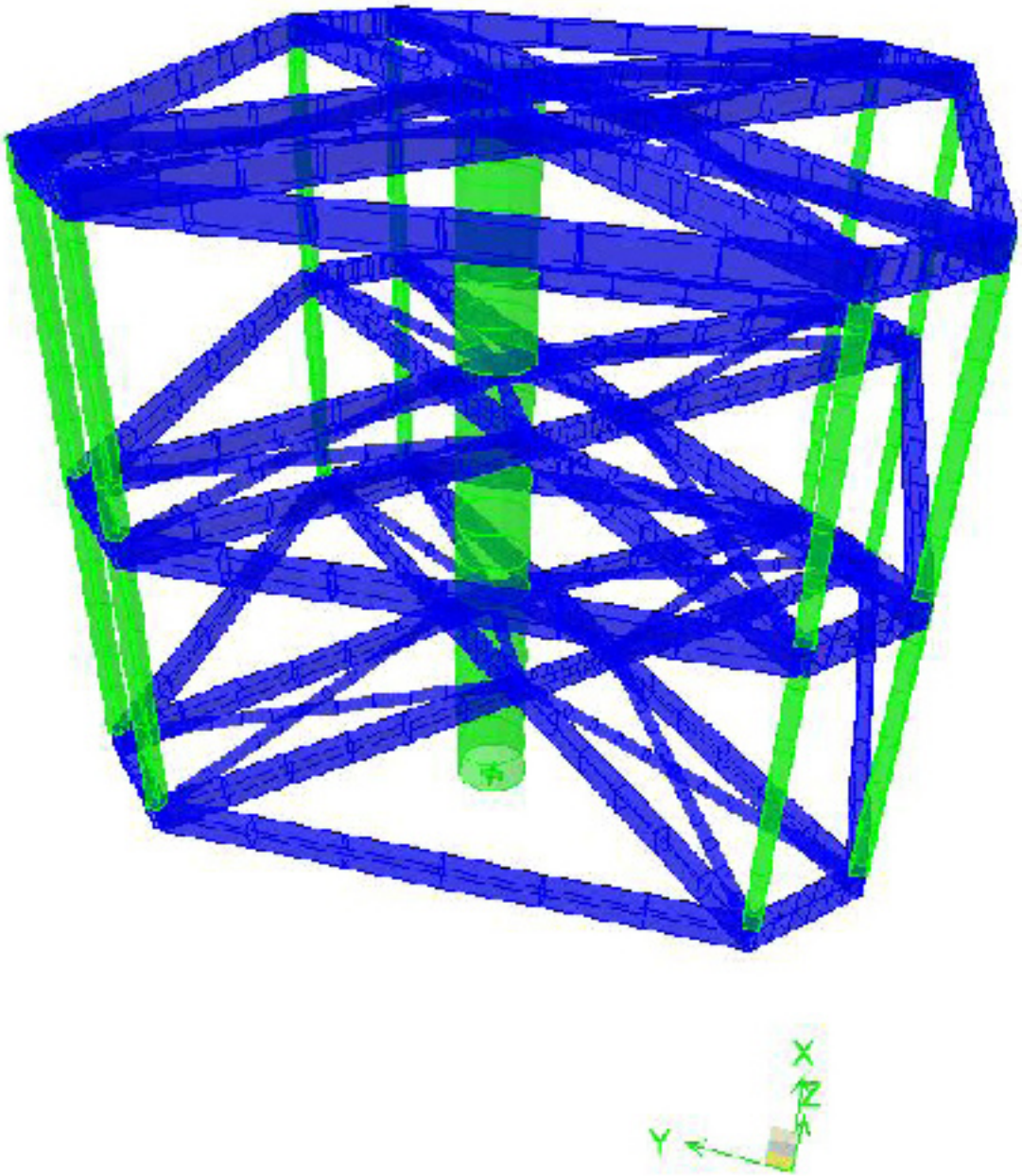
ETAB Structural Simulation of the behavior of rigid box with rigid diaphragm connections to the off-centered central column subject to lateral load.

3B.2.6 Structural Simulation with Off-Centered Support - Position C



ETAB Structural Simulation of the behavior of rigid box with rigid diaphragm connections to the off-centered central column subject to lateral load.

3B.2.7 Final Structural Simulation with Off-Centered Support - Position D



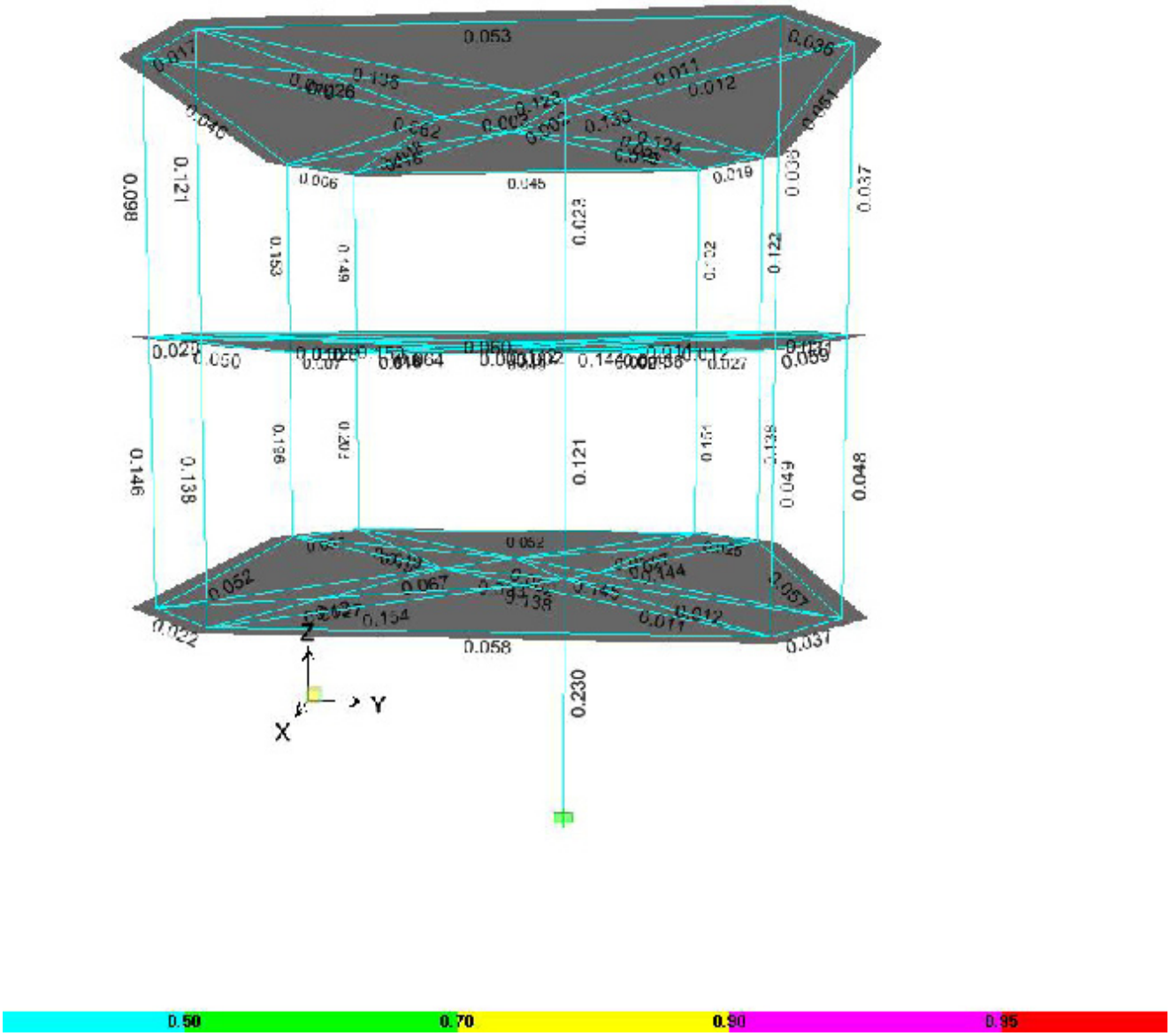
ETAB Structural Simulation of the behavior of rigid box with rigid diaphragm connections to the off-centered central column, subject to lateral load.

3B.2.8 Final Structural Simulation with Off-Centered Support - Position E

ETAB Structural Simulation with rigid floor and roof plates and the three feet off-setted central column.

3B.2.9 ETAB - Strength Diagram

Demand to Capacity ratio - Members are not over-stressed if they are not shown in red

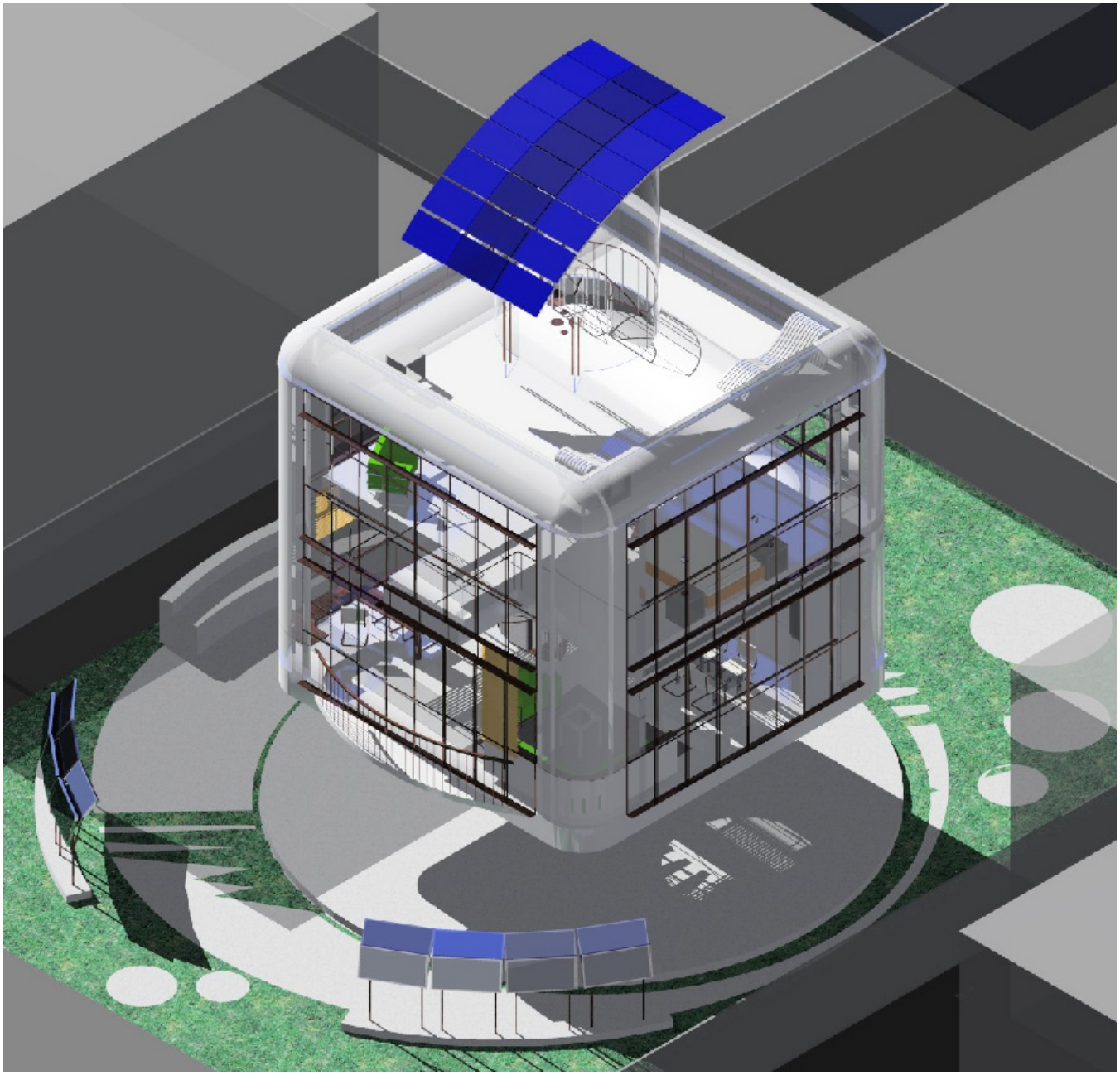


3B.2.10 Report of the Final Conclusion on the Structural Simulations:

To schematically design the members of this project, a 3-dimentional analysis model for simulation of the structural elements was built in ETABS. The model included the seismic mass of the structure's dead-loads along with a static earthquake force applied in accordance with the current code for a cantilevered column-building system. The results required the need for rigid floors and for the central single column to be a **minimum three feet in diameter**. The size of the central column was governed by the displacements and rotations of the structure and not by the stresses. Interestingly the simulation revealed that there is not a critical need for knee-bracings. The structure will require a "fixed" foundation system to be stable along with rigid fixity of the perimeter columns to floors to simulate a rigid box.

Credit: ETAB Structural Simulations Performed by, Michael T. Braund Structural Designer Degenkolb Engineers

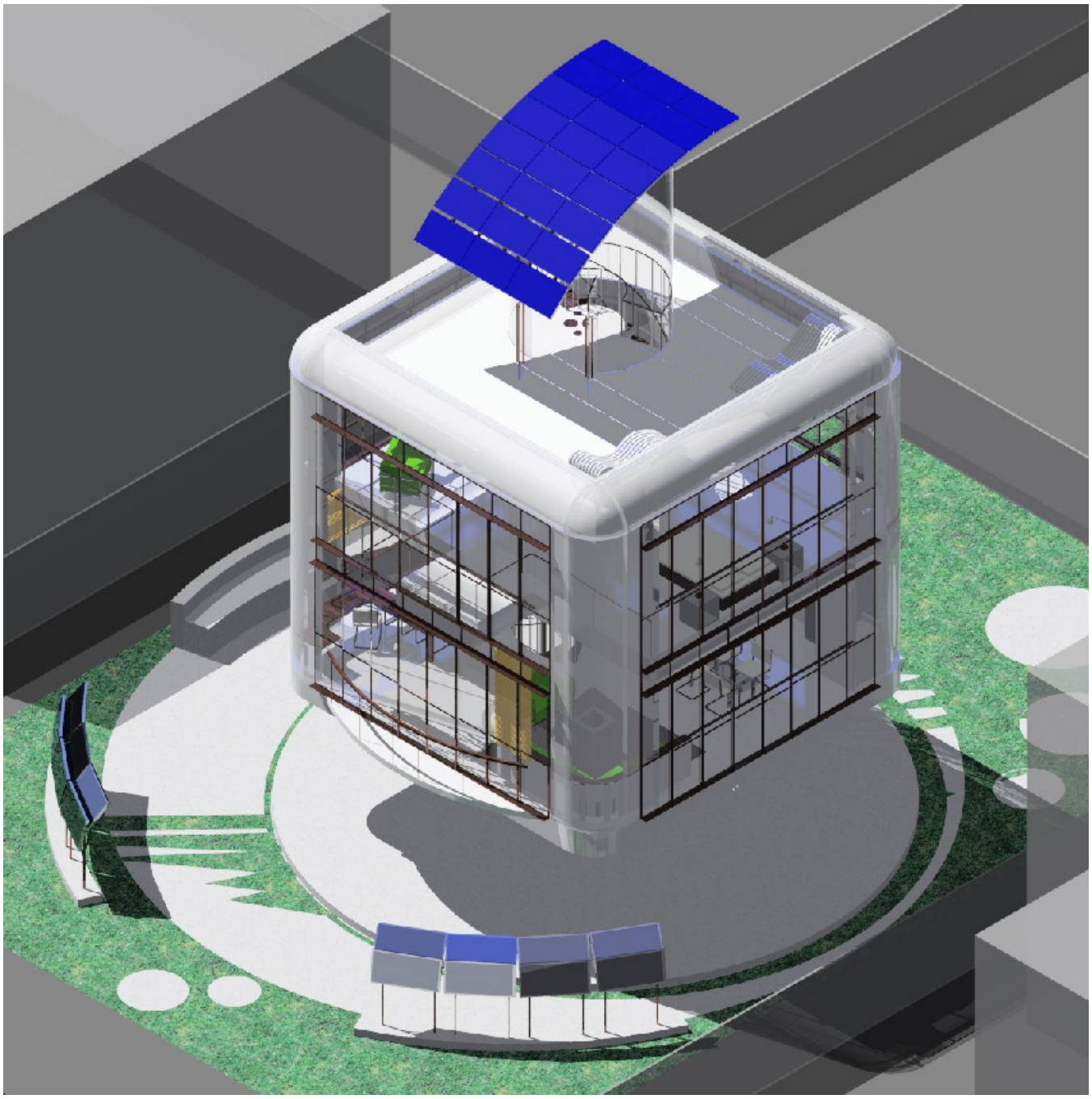
3B.3.1 Initial Study of Daylighting & Shadows - for future repetition and adjacency of modules



Building Shadow Casted at 4:00 PM.

Credit: Revit 3D Modeling by, Linda Nguyen

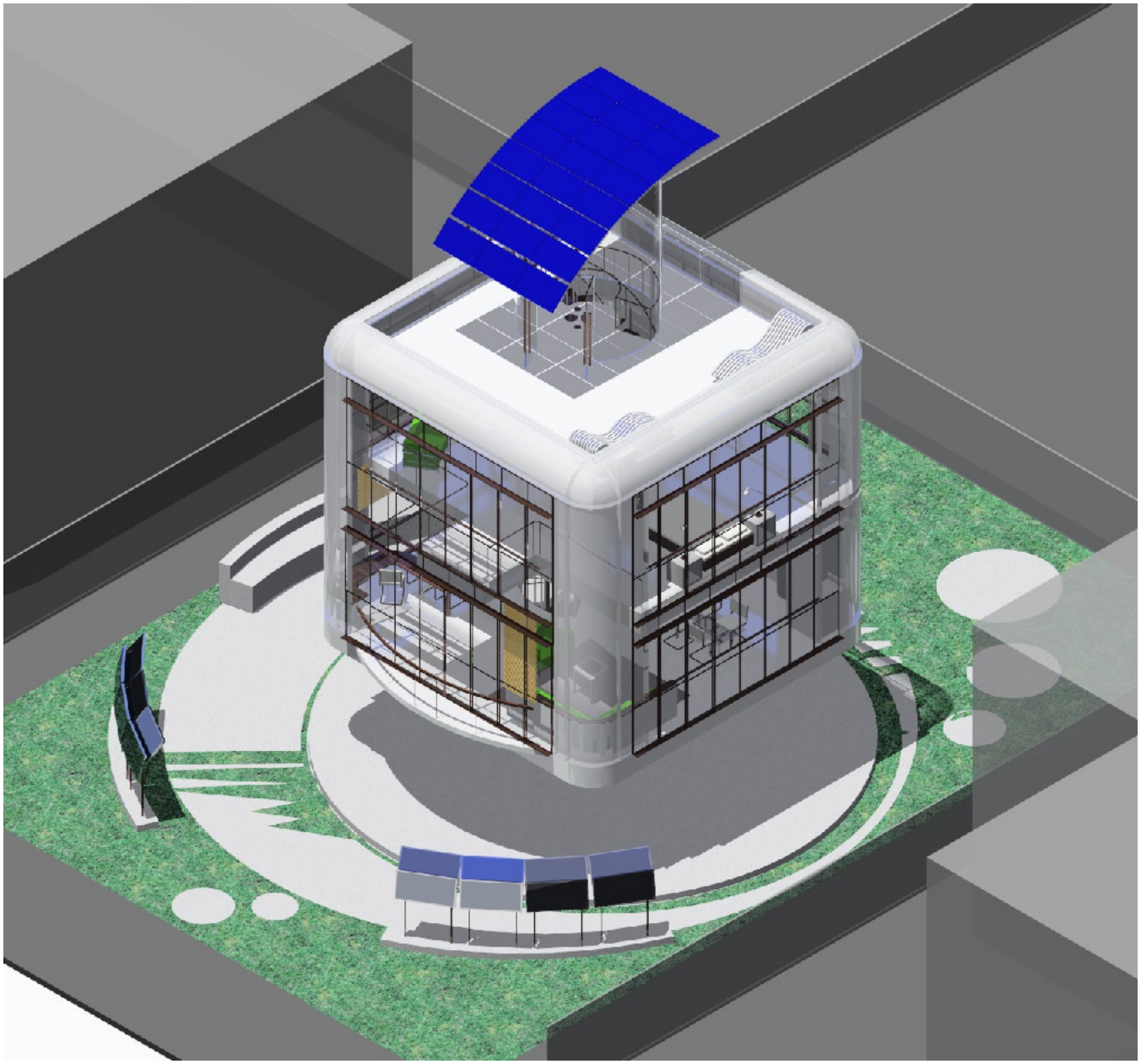
3B.3.2 Initial Study of Daylighting & Shadows



Building Shadow Casted at 2:00 PM.

Credit: Revit 3D Modeling by, Linda Nguyen

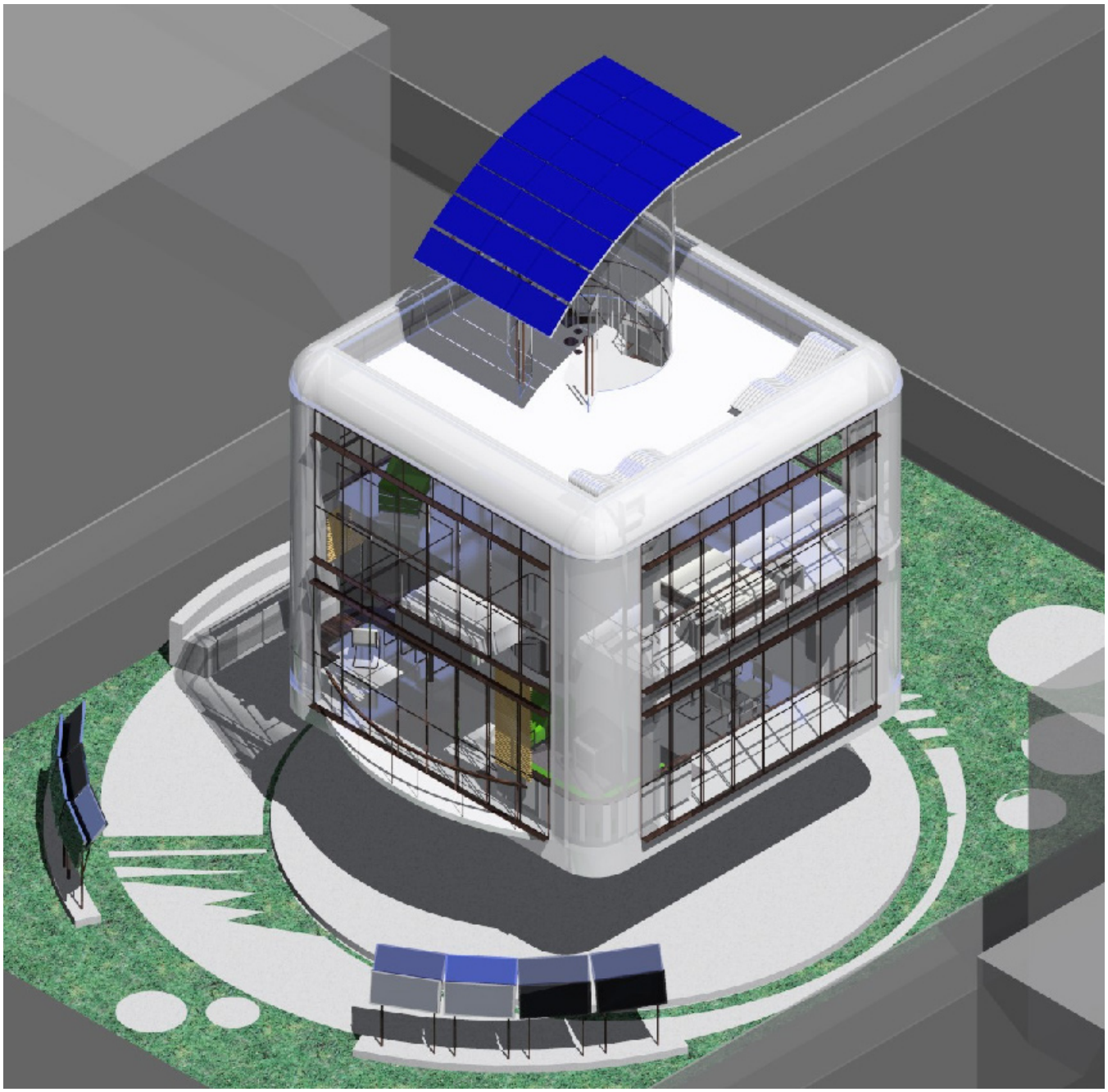
3B.3.3 Initial Study of Daylighting & Shadows



Building Shadow Casted at 12:00 PM.

Credit: Revit 3D Modeling by, Linda Nguyen

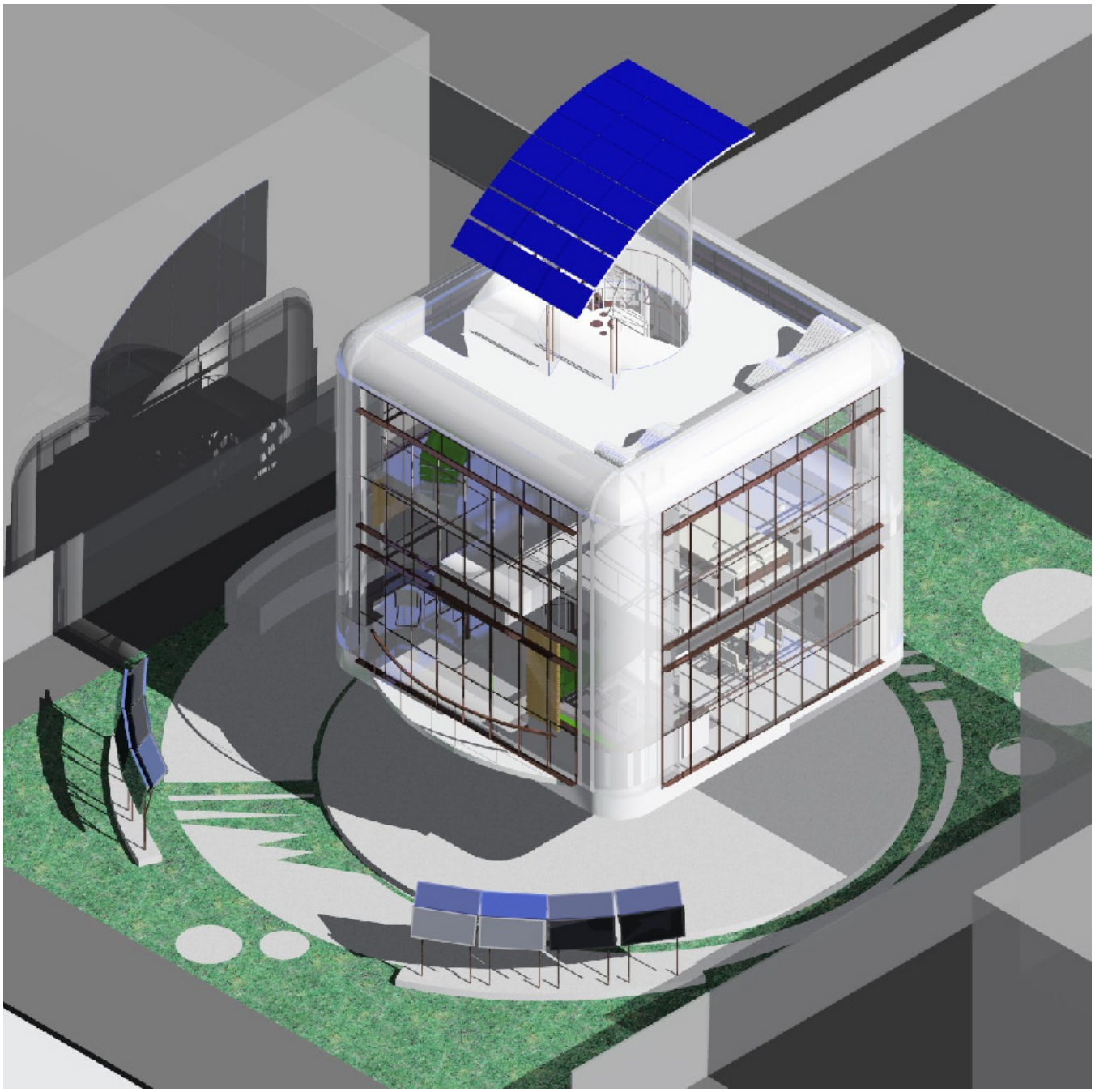
3B.3.4 Initial Study of Daylighting & Shadows



Building Shadow Casted at 10:00 AM.

Credit: Revit 3D Modeling by, Linda Nguyen

3B.3.5 Initial Study of Daylighting & Shadows



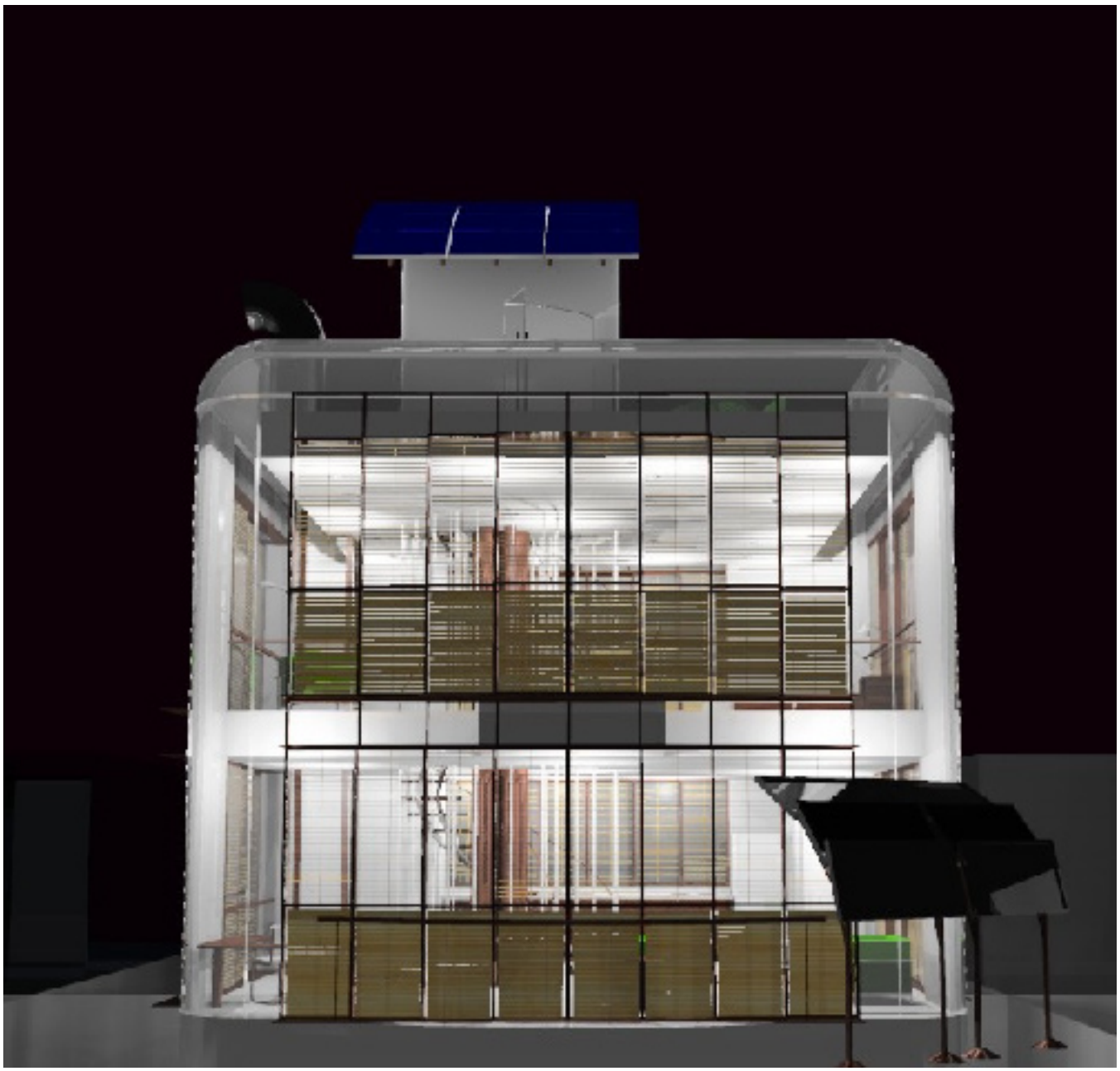
Building Shadow Casted at 8:00 AM.

Credit: Revit 3D Modeling by, Linda Nguyen

3B.3.6 Study of the Facade at Night, with the interior lights glowing the facade

Night view of the Habitat when blinds are semi-closed, while the translucent polymer corner walls glow with the interior lights.
Credit: Revit 3D Modeling by, Linda Nguyen

3B.3.7 Night facade with the building First Floor lowered to the ground

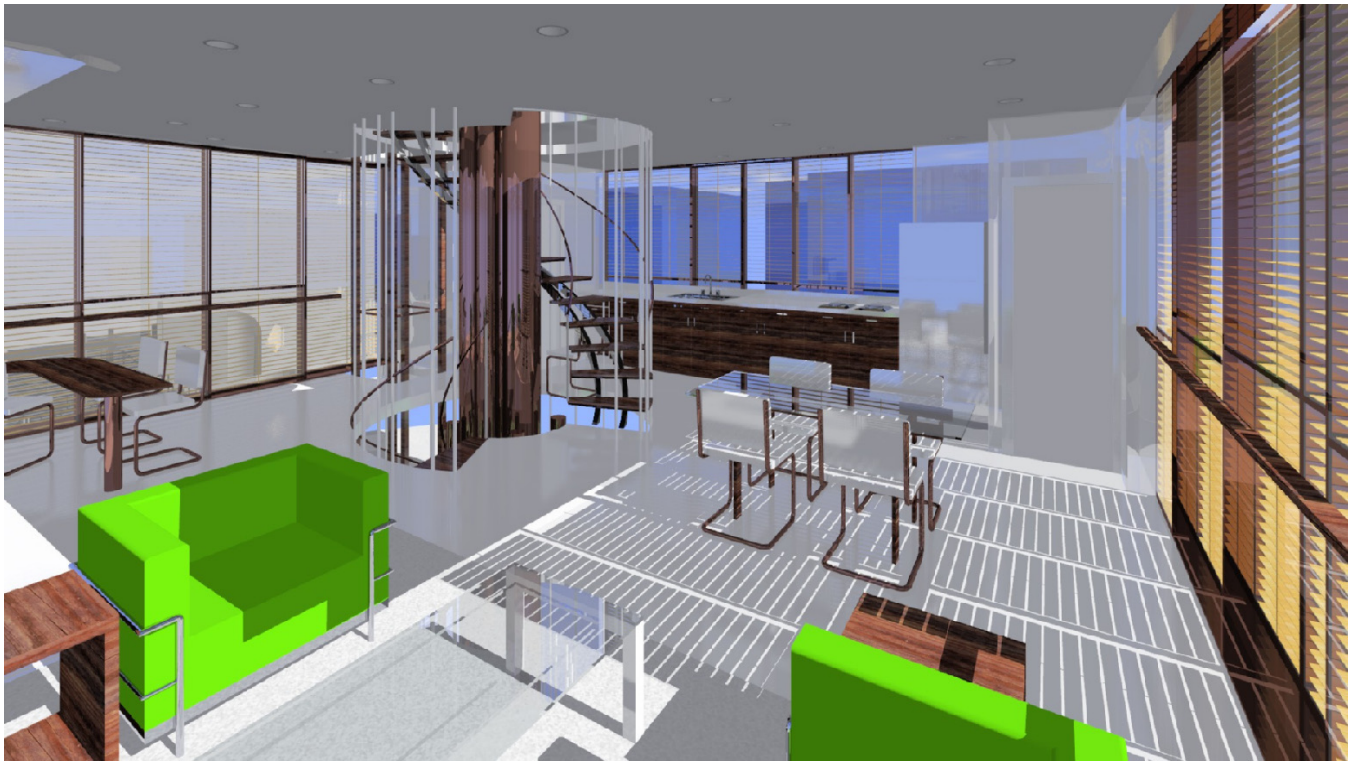


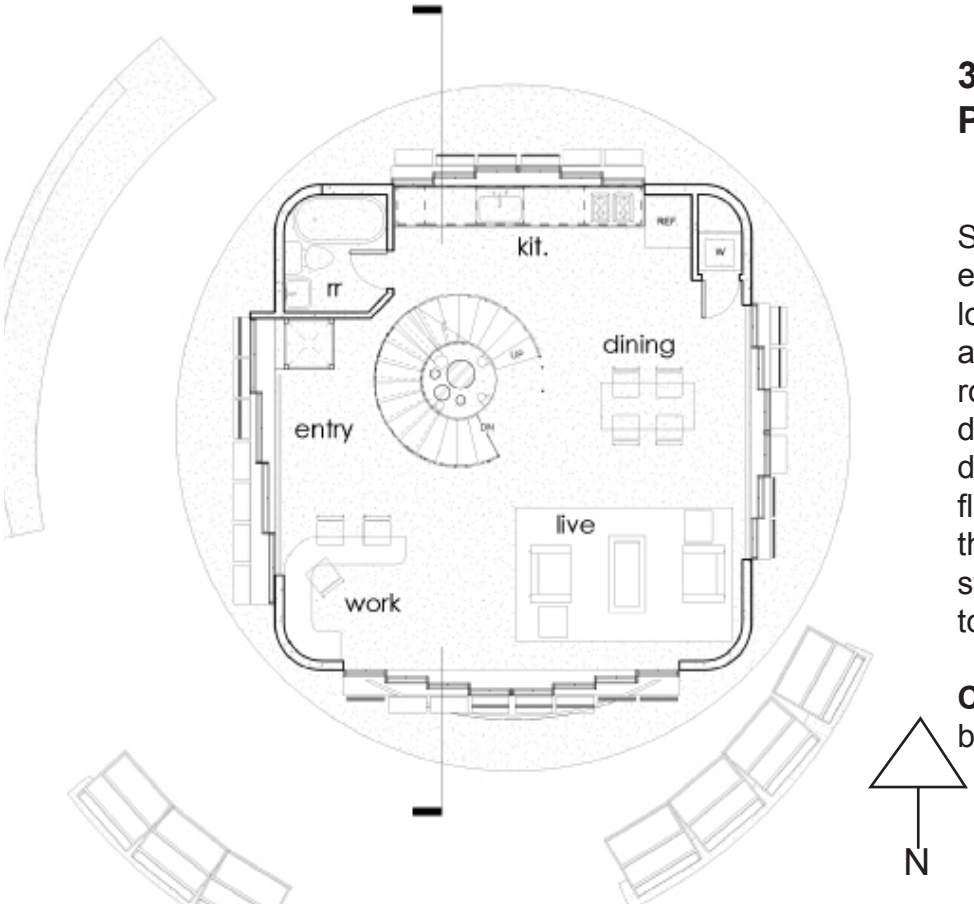
Night view of the Habitat when building is landed on the ground; lower window pane blinds are fully closed, and the top part blinds open. The translucent polymer corner walls glow with the interior lights.

Credit: Revit 3D Modeling by, Linda Nguyen

3A.3.8 Night view of the Habitat in its full landed position and when Blinds are completely open. The translucent polymer corner walls glow with the interior lights and the array of permanent photovoltaic panels are at the forefront.

Credit: Revit 3D Modeling by, Linda Nguyen

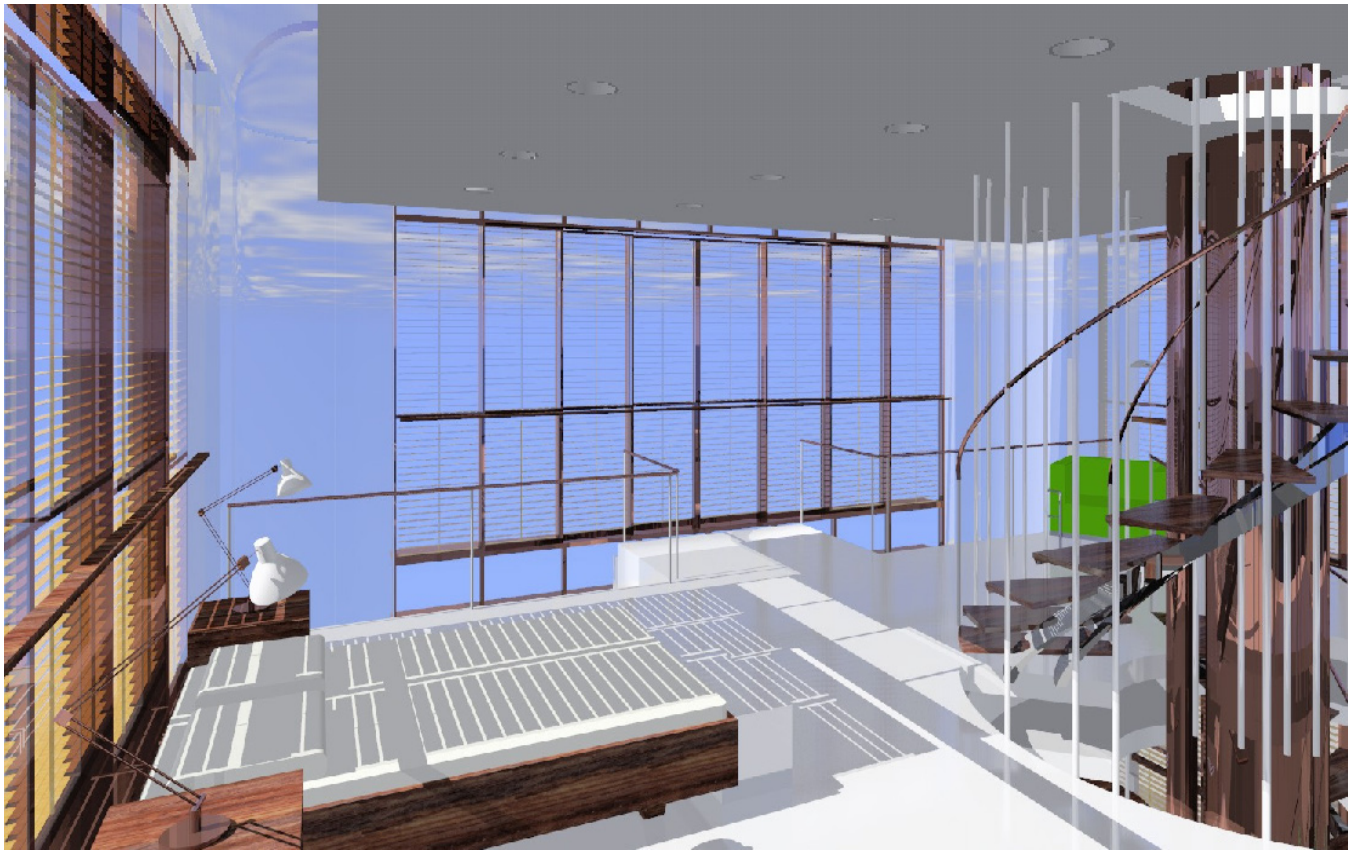


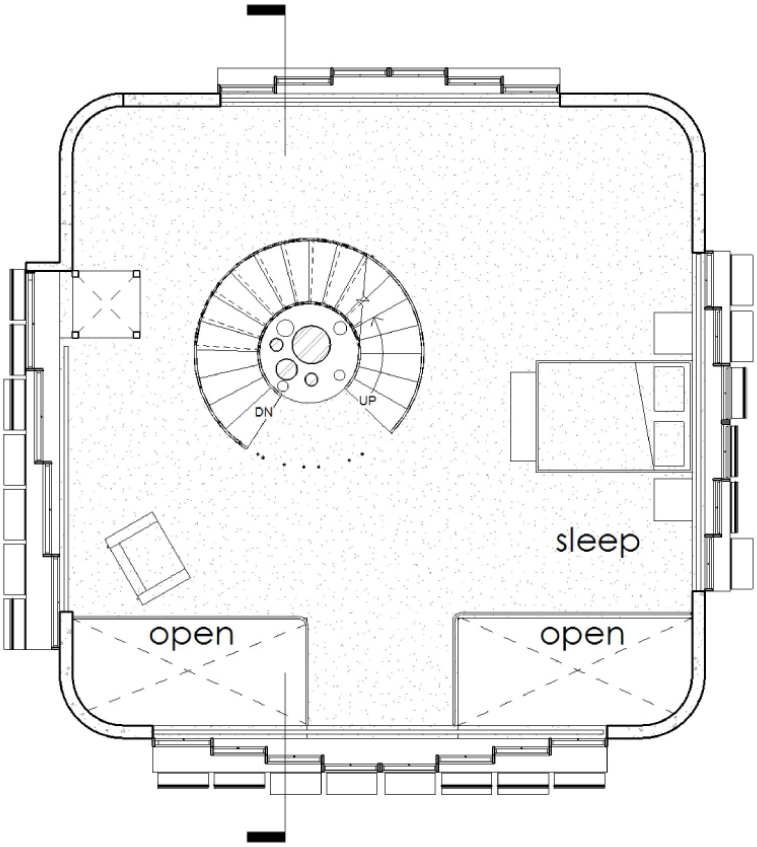


3B.4.1 Interior Perspective

Standing position is south-east corner of the building looking north to the kitchen area. Although building can rotates 360 degree, in both directions, the living and dinning areas of the first floor, which has opening to the second floor with a two story volume, is normally set to the south orientation.

Credit: Revit 3D Modeling by, Linda Nguyen



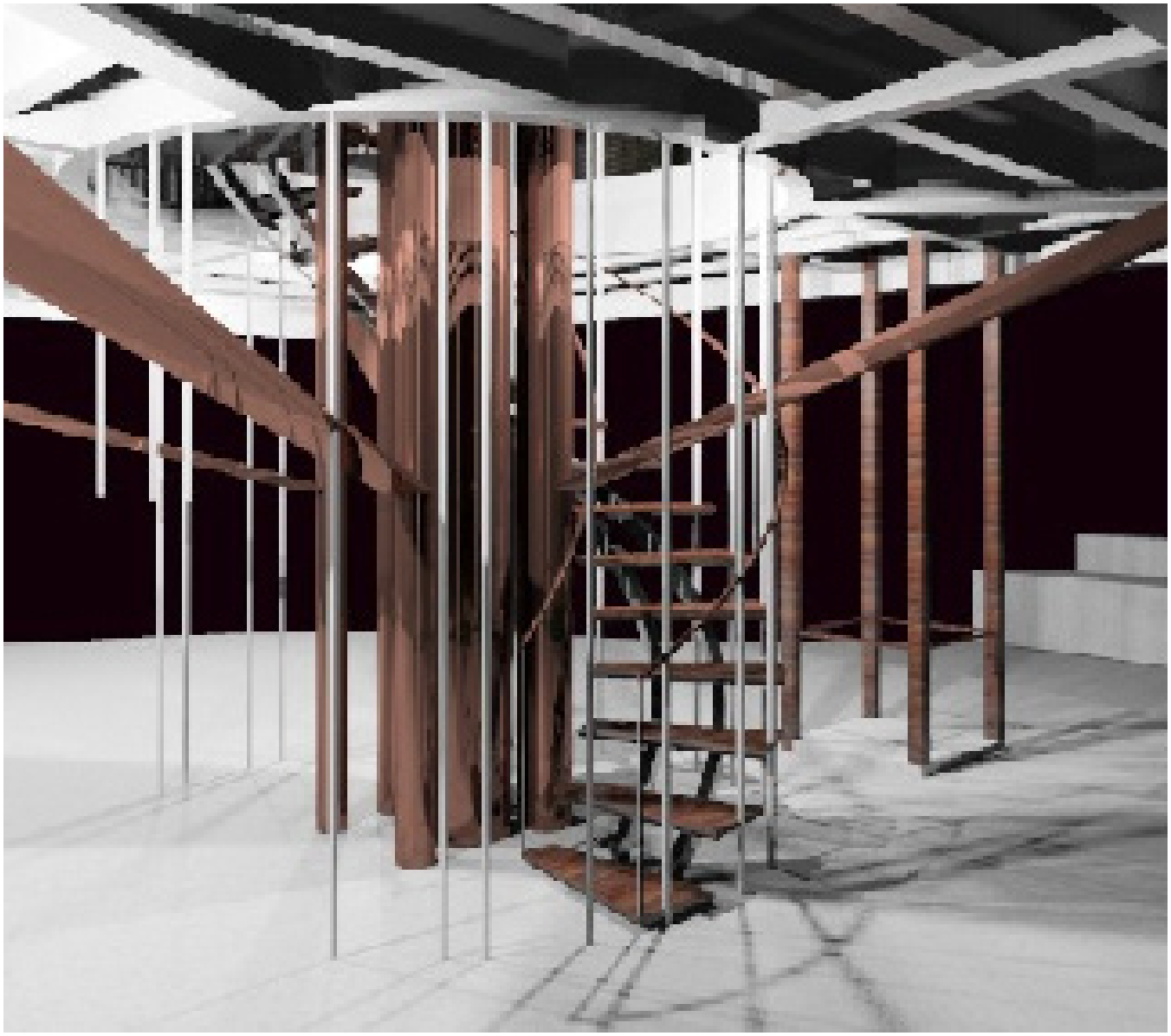


3B.4.2 Interior perspective at second floor, which is mainly the bedroom loft area.

The standing position, at the northeast of the house looking south. Openings to the first floor, as well as the spiral stair opening to the roof deck are shown in this perspective.

Credit: Revit 3D Modeling by, Linda Nguyen

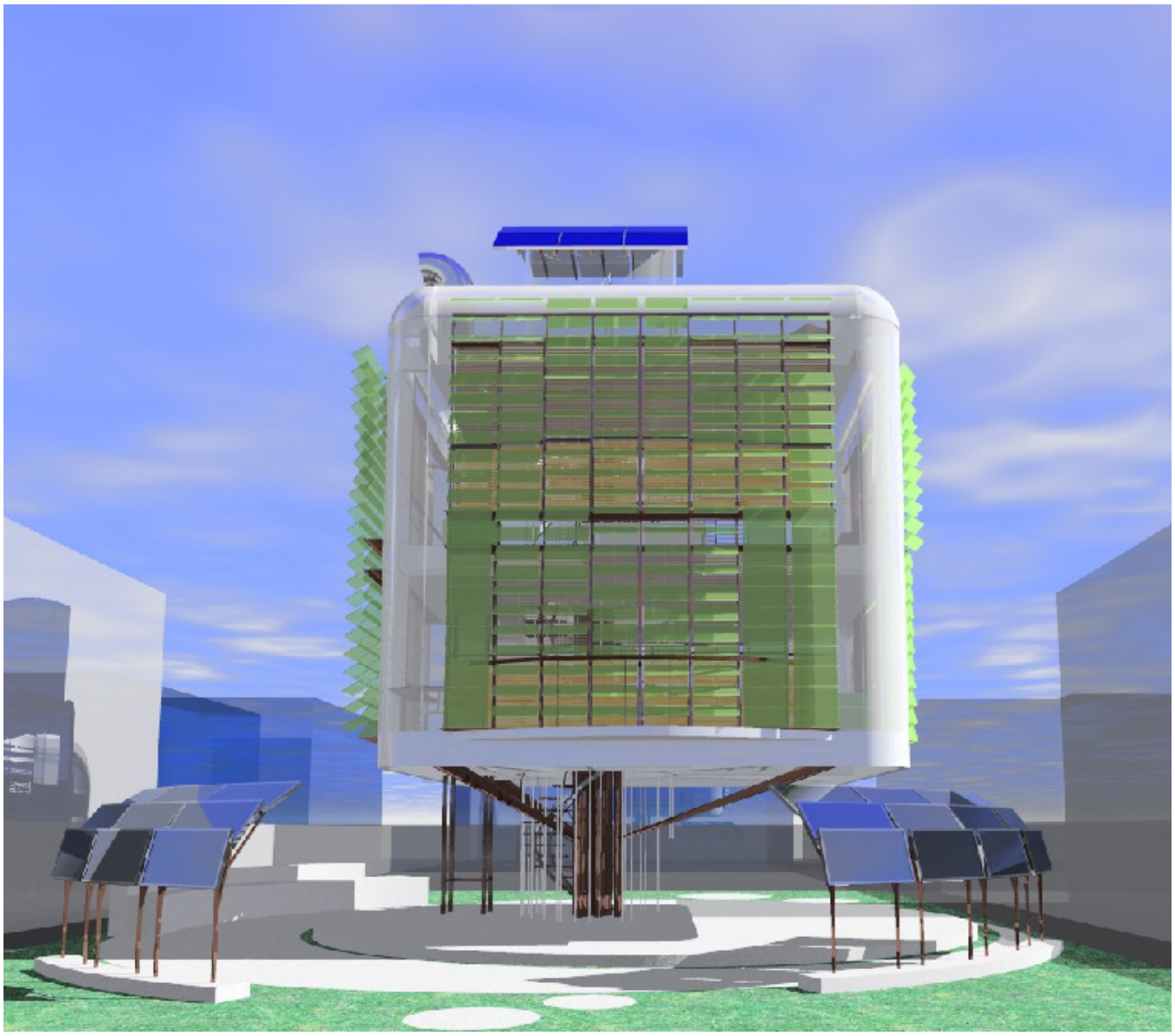
3B.4.3 Ground Level Open Deck



In the situation that the building is raised up to its full height position, the bracings slide off to their actual supportive mode, as well as the stackable spiral stair that by unfolding and providing the required number of treads allows a direct access from the open ground deck to the roof deck. The house, is also made accessible through a lift, which connects the ground level deck to the roof deck.
The central column, is consisted of a bunch of steel tubes that are rigidly tied and connected together to be able to act as one central support.

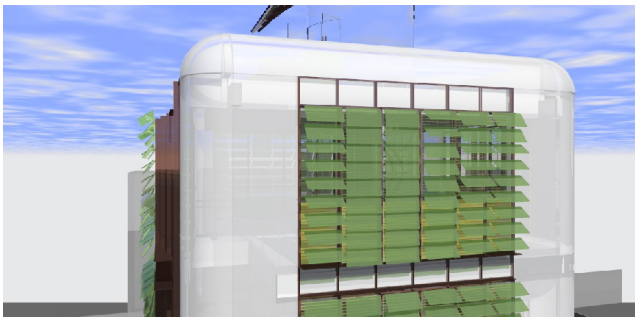
Credit: Revit 3D Modeling by, Linda Nguyen

3B.5.1 Analysis on Integration of Photovoltaic System



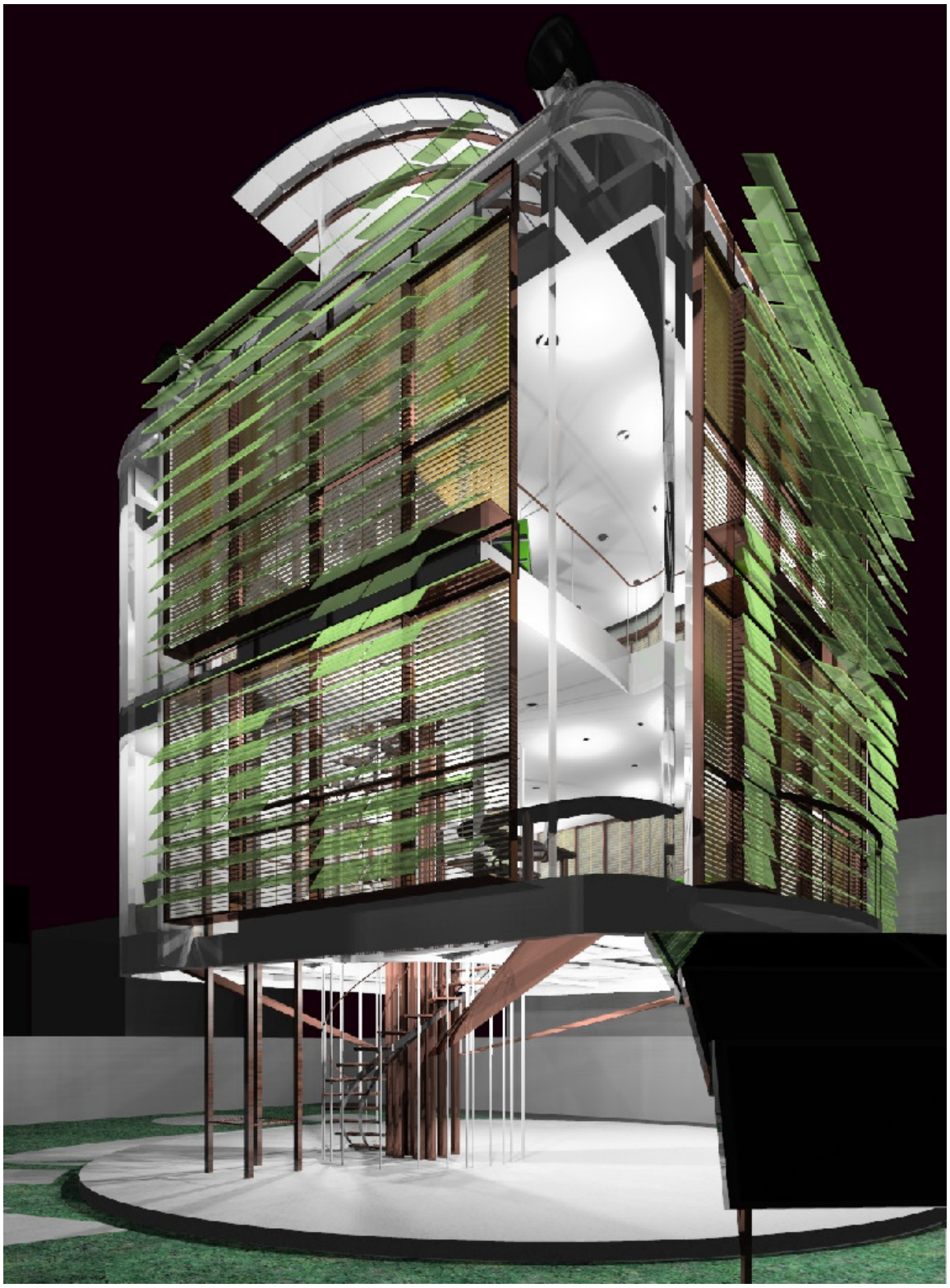
Credit: Revit 3D Modeling by, Linda Nguyen

Exterior South-Facing Facade with the added shutters and their photovoltaic surface.



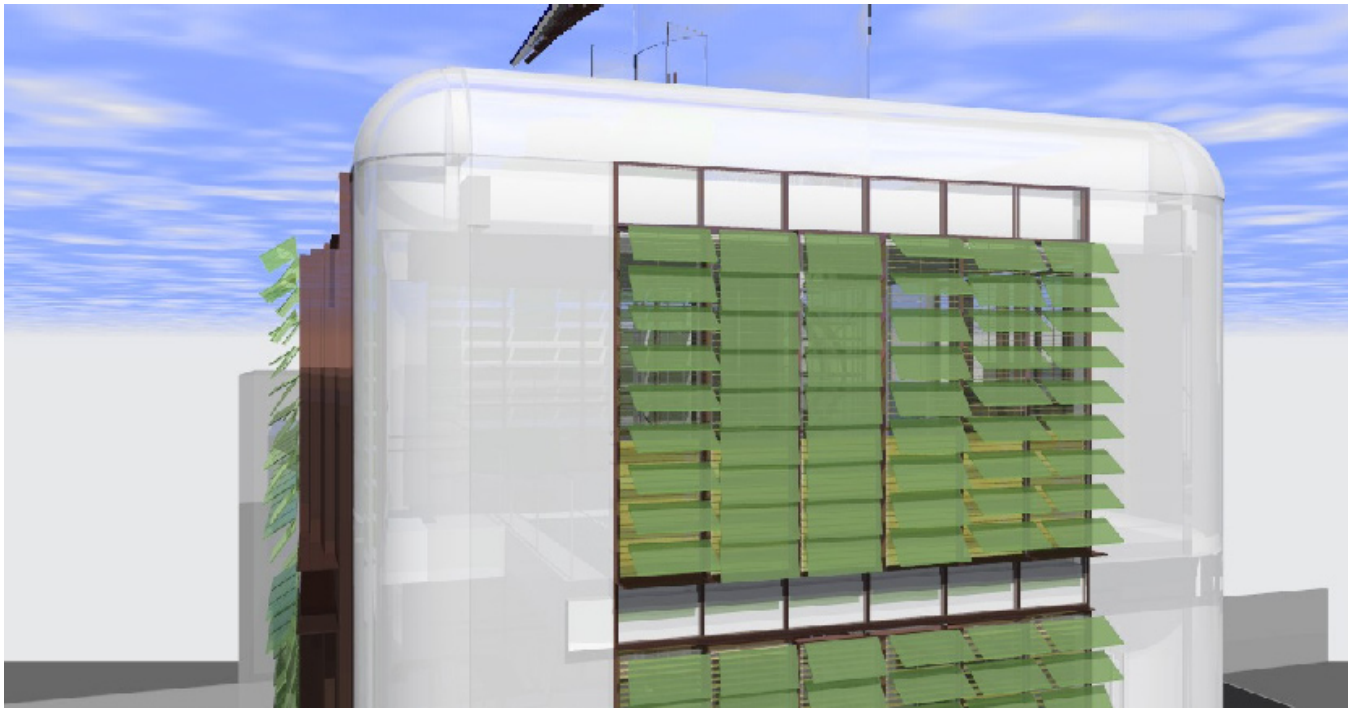
Photovoltaic shutters have the flexibility to adjust themselves with the sun angle depending on the orientation, time of the day and season.

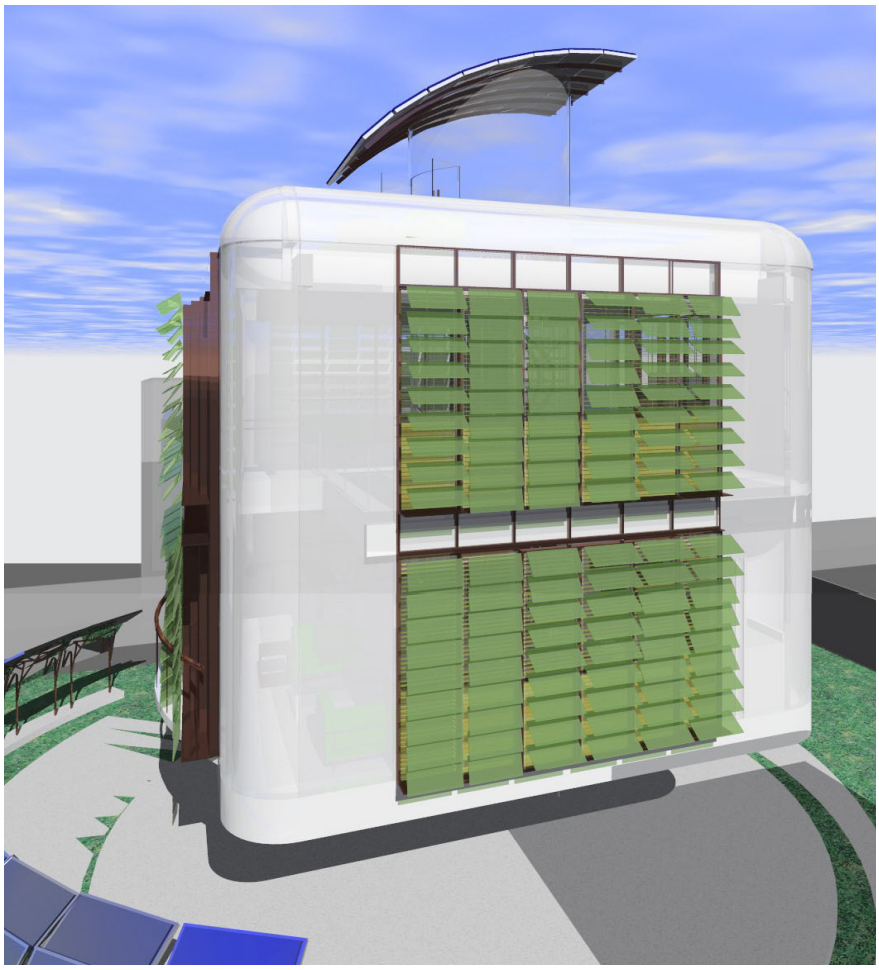
3B.5.2 Analysis on Integration of Photovoltaic System



Night-time image with the photovoltaic shutters randomly open and mostly tilted to the day position toward sun. The material of the curved corners made out of polymer is supposed to be tranclucent. **Credit**: Revit 3D Modeling by, Linda Nguyen

3B.5.3 Analysis on Integration of Photovoltaic System



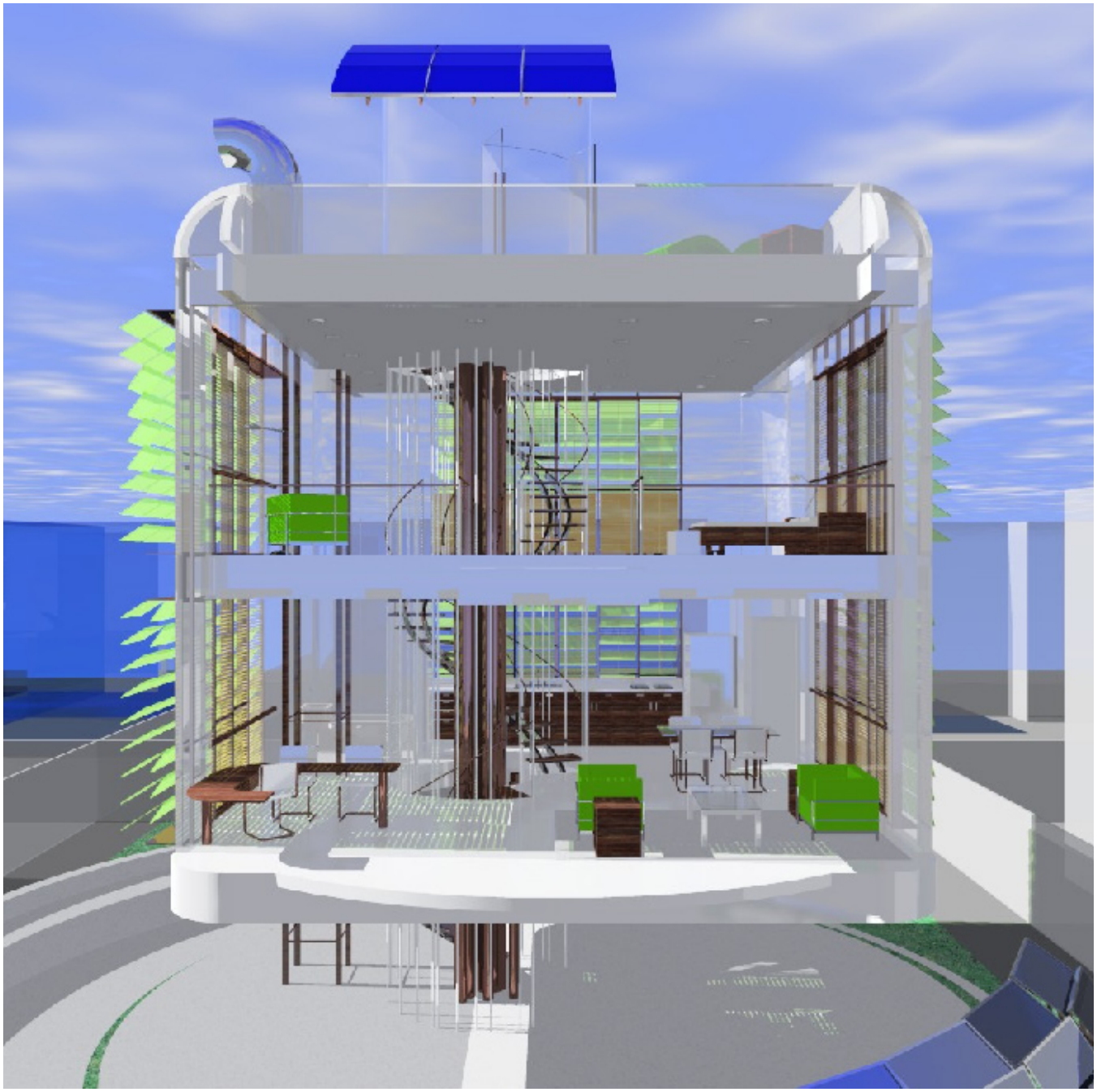


Close-up of the photovoltaic Shutters in different slanted positions.

Photovoltaic shutters as the exterior shading device are helpful toward saving the required cooling load.

Credit: Revit 3D Modeling by, Linda Nguyen

3B.5.4 Analysis on Integration of Photovoltaic System



Photovoltaic Shutters in different slanted positions.

Photovoltaic shutters as an exterior shading mechanism is helpful toward providing more energy. Shutters, as any other element attached to the exterior are more effective for keeping the building cool. If shutters were installed at the interior surfaces, they would have created air traps, and thus would have had opposite effects toward cooling the building, as whole.

Credit: Revit 3D Modeling by, Linda Nguyen

3B.5.5 Analysis on Integration of Photovoltaic System

3B.5.5.1 Electrical Generation

There are three types of design of Photovoltaic panels for this project :

1. An array of fixed panels around the building, which works more efficiently if they are located due south with panels fixed to be perpendicular to the sun in the peak hour.
2. Tracking panel, which is located on the roof deck, and works best when it follows the sun. The intent would be that the tracking panel follow the sun as the building rotates from early sun-rise to the sun-down, while it can also adjust its angle to the sun for getting the most of the sun energy, seasonly as well as daily.
3. Array of photovoltaic panels on the exterior of the windows, acting as shutters.

In the following analysis the amount of energy by each of the three systems are calculated and analyzed. Credit: Project Summery analyzed and prepared by John Gurski -Sullivan Electric.

3B.5.5.2

PROJECT SUMMARY

Ground Mounted System

- Provide and install (20) Sharp NE-80EJEA modules on Ground Mounted Structure
- Provide and install (2) SMA SB700U inverters

Total System Output

- 1,600 W DC
- 1,288 W AC (CEC rated)

Estimated Average Monthly Production

- 200 kWh

Roof Mounted System

- Provide and install (16) Sharp NE-80EJEA modules on Roof Mount
- Provide and install (1) SMA SB1100U inverters

Total System Output

- 1,280 W DC
- 1,025 W AC (CEC rated)

Estimated Average Monthly Production

- 200 kWh

Analysis on Integration of Photovoltaic System

Each Façade System

- Provide and install (48) Sharp ND-62RU1 modules on Façade Mount
- Provide and install (1) Magnetek PVI-3600OUTD inverters

Total System Output

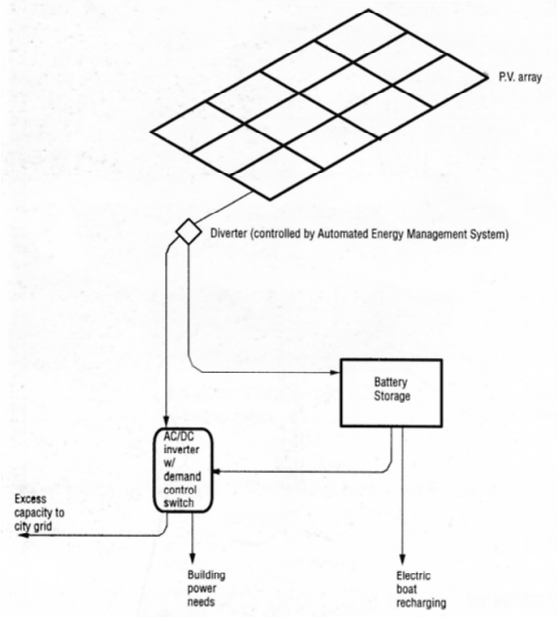
- 2,976 W DC
- 2,498 W AC (CEC rated)

Estimated Total Average Monthly Production

- 355 kWh

The total electric generation of the three types of photovoltaic systems of Poly-Crystaline Silicon modules, with dual power inverter, are 200+200+355= 755KWh, per month, which is more than sufficient for this size residence. Average required energy is typically 10 w/sq.ft.. The total calculated amount of energy serves not only the building's lighting and power outlets, but also stores electricity for the required energy for the operation of the lift, as well as the hydraulic elevator system of the building. The electric motor that rotates the house, uses about 120W at maximum speed, which is equating to about 20 kwh per year. The PV system's battery storage area is accompanied by a DC/AC inverter system. The building was not considered to be designed with independence from the electrical utility grid. Battery storage and inverter system are located in the underground basement. In case the site is not suitable for an underground level, an on-ground storage space will accommodate the necessary auxilliary equipment.

The photovoltaic tracking on the roof is also programmed to follow the sun on a two axis tracking system, in response to the azimuth and elevation, which operates independently of the house. The photovoltaic panels should always be positioned for maximum exposure to the sun.

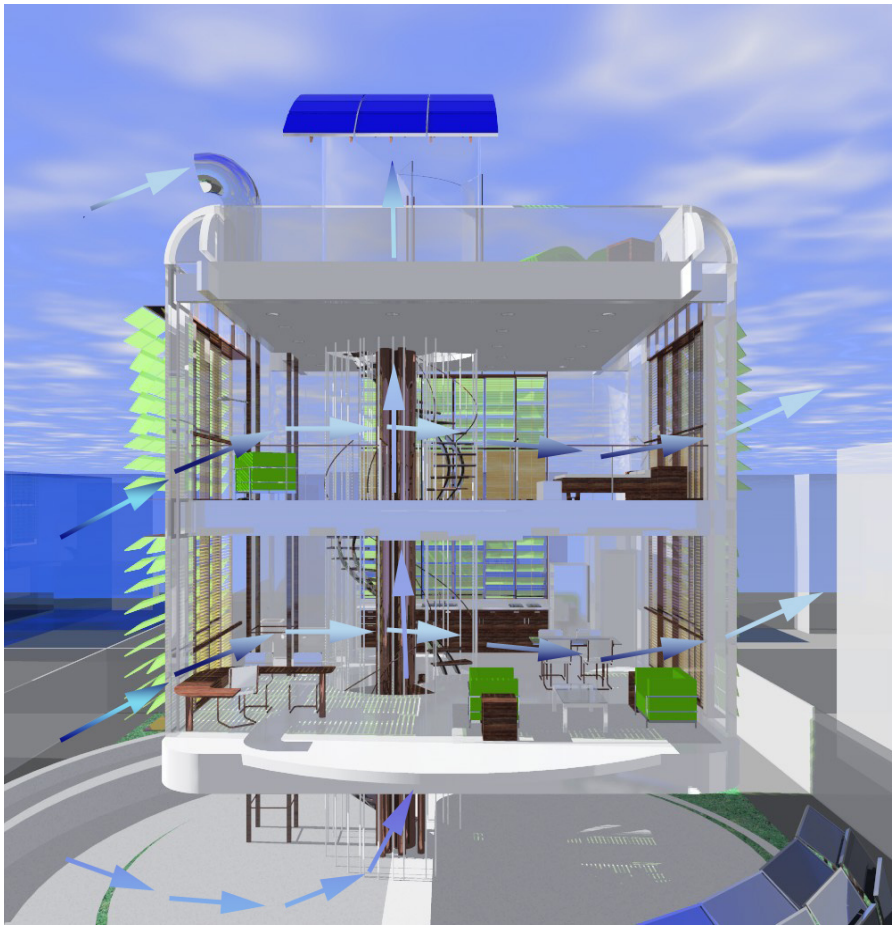


Photovoltaic System Components

The photovoltaic panels in insulated glass are selected with dimensional coordination withe facade fenestration system. The trackinig photovoltaic system on the roof, as well as the fixed array on the ground have more flexibility of area adjustment, which are made of solar harvesting layers of polycrtstalline wafers and with circuitry of a conventional opaque PV panel within the sealed air space of insulated and safety laminated glass unit, except the ones incorporated on the shutters that are translucent.

Credit: NCARB Professional Development Program, *Building Envelope*, (Washington, DC: NCARB, 2004

3B.6 Natural Ventilation - Study on Fresh Air

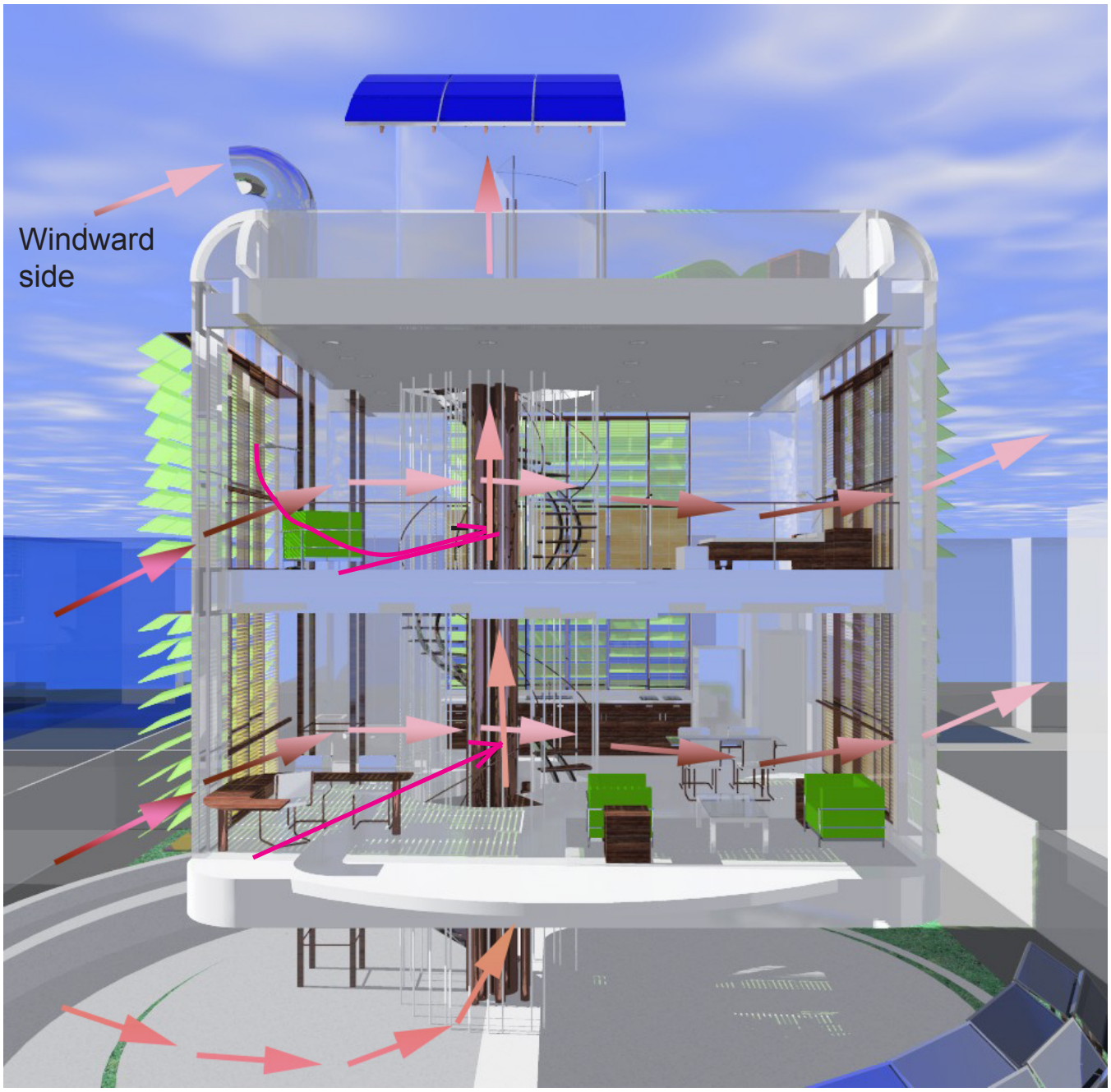


As the wind normally creates areas of high and low pressure around structure, this structure has the flexibility to enhance the cooling effect of cross ventilation by using outside fresh air. The fully flexible fenestration of all four sides of the building, based on the direction of the wind flow by providing the size of the openings, has the potential to create venturi effect, and thus control the volume of airflow, or number of air changes that passes through the structure . The large size of the fenestration allow large size inlets and outlets that make greatest number of air changes possible. Flexibility of the fenestration on all four sides of the building, allows to provide smaller size inlet on the windward side.

It would be easily possible in this building to place opposite inlets and outlets, which the air flow will only cool objects that are in the direct path of the airflow, Even if it is desired to cool a larger area, it would be possible by changing the direction of the air in the room to lower the speed of the moving air.

Of course the pattern of air movement can be accurately visualized by using some form of seeding method, with smoke, balloons, bubbles or some other neutrally buoyant particulate. As it was mentioned before, this study requires a physical model, in which smoke can be used as qualitative means of measuring air movement.

Credit: Revit 3D Modeling by, Linda Nguyen

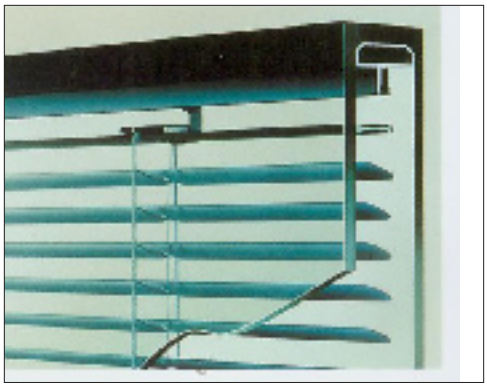


3B.6.1 Natural Ventilation - Fresh Air

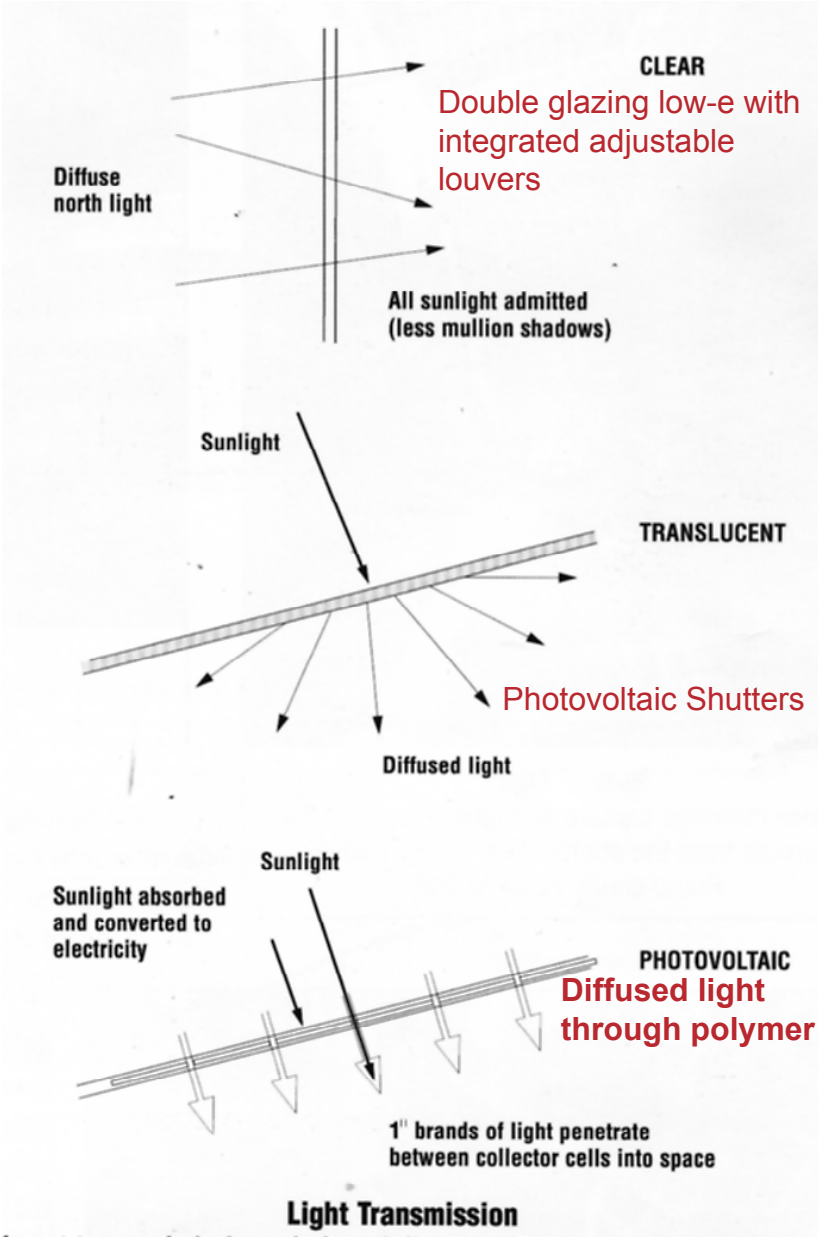
Depending on the direction of the wind, the combination of the operable windows and the adjustable exterior shutters allow for provision of 100% natural ventilation and conditioning indoor temperature and humidity. In hot and humid days of the year, the retractable fenestration of the facades that are away from the sun (mainly at the north facing facade), can fully open itself up to the exterior to allow for a complete outdoor air circulation. Couple of wind-scoops on the roof, as well as the spiral stair openings can act as a wind shaft to help with the air movement, by generating suction and stack ventilation.
Credit: Revit 3D Modeling by, Linda Nguyen

3B.7 Daylighting

Daylighting is used throughout the building envelope through different techniques. Different types of devices and glazing admit and distribute light rays in different ways within the interior volume. The first method involves the use of translucent polymer walls, which envelope all four corners of the building, which is approximately 33% of the entire envelope of the building. Polymer greatly diffuses the light, while avoiding shadows and glare. The second system is the floor to ceiling fenestration on all four sides of the building envelope. The use of shutters and inserted blinds in the two layers of glass allows for full control of each segment of the windows on each wall, without the need for light shelves or other techniques to bounce light to the back of the space. The third method is accomplished by the array of photovoltaic shutters that consist of poly-crystalline wafers and by the circuitry of a conventional opaque PV panel within the sealed air space of an insulated and safety laminated glass unit.



Insulating glass with integrated adjustable louvers for solar control.



3B.8 Heating, Ventilating, Cooling

The house is practically cooled by natural ventilation, through operable windows. In cases of extremely hot climate, ventilation air can be pre-cooled by passing through the earth heat exchanger that is installed in the basement. Heating and cooling are primarily handled by the earth heat exchanger that maintains year round temperatures, and air is pre-heated or pre-cooled depending on the season, climate and locality.

Credit: NCARB Professional Development Program, *Building Envelope*, (Washington, DC: NCARB, 2004)

3B.9 Solar Energy & Loading Analysis

The building is divided into two zones. The live/work zone, which is an all-year-round zone, and the summer zone, which includes all auxiliary spaces. Auxiliary zones includes the bathroom and laundry compartments as well as the kitchen counter, and all their required lines are fed through the main shaft of the building.

The building load calculation is based on two different groups of calculations. One group of analysis includes of insulation for glass and concrete, and the other group excludes insulation from these materials. Each step of the calculation consists of a comparison between the inclusion and exclusion of insulation, and the result is analyzed.

Credit: Energy Load Calculation conducted by Shawn Babaiean, Salehi & Salehi Mechanical Engineering.

ROOM LOAD SUMMARY

PROJECT NAME	DATE
Work Live Area	6/14/2007
SYSTEM NAME	**FLOOR AREA**
Res HVAC	1,150

ROOM LOAD SUMMARY

			ROOM COOLING PEAK			COIL COOLING PEAK			COIL HTG. PEAK	
ZONE NAME	ROOM NAME	Mult.	CFM	SENSIBLE	LATENT	CFM	SENSIBLE	LATENT	CFM	SENSIBLE
1st Floor Zone	1st Floor	1	593	12,812	886	593	12,812	886	368	13,912
2nd Floor Zone	2nd Floor	1	563	12,161	808	563	12,161	808	220	8,300
PAGE TOTAL			1,157	24.973	1,693				588	22,212
TOTAL			1,157	24,973	1,693				588	22,212

Insulated concrete and insulated glass.
Concrete wall R-13, U= 0.00633
R-19 Roof concrete U= 0.0444
Glass U = .31-.24
Sensible Cooling = 24,973, over 3 tons.
Sensible cooling energy is equivalent to 70% of the output for cooling , meaning there is a need for 30% more energy to run the equipment.

Load Calculation and Analysis

ROOM LOAD SUMMARY

PROJECT NAME	DATE
Work Live Area	6/14/2007
SYSTEM NAME	**FLOOR AREA**
Res HVAC	1,150

ROOM LOAD SUMMARY

			ROOM COOLING PEAK			COIL COOLING PEAK			COIL HTG. PEAK	
ZONE NAME	ROOM NAME	Mult.	CFM	SENSIBLE	LATENT	CFM	SENSIBLE	LATENT	CFM	SENSIBLE
1st Floor Zone	1st Floor	1	712	15,361	886	712	15,361	886	592	22,360
2nd Floor Zone	2nd Floor	1	681	14,711	808	681	14,711	808	443	16,748
PAGE TOTAL			1,393	30,072	1,693	1,035	39,108			
TOTAL			1,393	30,072	1,693	1,035	39,108			

Default dual glass U 0.79 - 0.70
with insulation
Sensible energy 3.5 tons

ROOM LOAD SUMMARY

PROJECT NAME	DATE
Work Live Area	6/14/2007
SYSTEM NAME	**FLOOR AREA**
Res HVAC	1,150

ROOM LOAD SUMMARY

			ROOM COOLING PEAK			COIL COOLING PEAK			COIL HTG. PEAK	
ZONE NAME	ROOM NAME	Mult.	CFM	SENSIBLE	LATENT	CFM	SENSIBLE	LATENT	CFM	SENSIBLE
1st Floor Zone	1st Floor	1	713	15,399	886	713	15,399	886	820	30,984
2nd Floor Zone	2nd Floor	1	683	14,749	808	683	14,749	808	672	25,372
PAGE TOTAL			1,396	30,148	1,693	1,492	56,356			
TOTAL			1,396	30,148	1,693	1,492	56,356			

Single tinted Glass 1.280 - 0.67
with concrete insulation
Sensible energy 3.5 tons

Load Calculation and Analysis

ROOM LOAD SUMMARY

PROJECT NAME	DATE
Work Live Area	6/14/2007
SYSTEM NAME	**FLOOR AREA**
Res HVAC	1,150

ROOM LOAD SUMMARY

			ROOM COOLING PEAK			COIL COOLING PEAK			COIL HTG. PEAK	
ZONE NAME	ROOM NAME	Mult.	CFM	SENSIBLE	LATENT	CFM	SENSIBLE	LATENT	CFM	SENSIBLE
1st Floor Zone	1st Floor	1	713	15,399	886	713	15,399	886	820	30,984
2nd Floor Zone	2nd Floor	1	683	14,749	808	683	14,749	808	672	25,372
		PAGE TOTAL	1,396	30,148	1,693	1,492	56,356			
		TOTAL	1,396	30,148	1,693	1,492	56,356			

Single Glass 1.280 - 0.80
with insulation
Sensible energy 3.5 tons

ROOM LOAD SUMMARY

PROJECT NAME	DATE
Work Live Area	6/14/2007
SYSTEM NAME	**FLOOR AREA**
Res HVAC	1,150

ROOM LOAD SUMMARY

			ROOM COOLING PEAK			COIL COOLING PEAK			COIL HTG. PEAK	
ZONE NAME	ROOM NAME	Mult.	CFM	SENSIBLE	LATENT	CFM	SENSIBLE	LATENT	CFM	SENSIBLE
1st Floor Zone	1st Floor	1	674	14,542	886	674	14,542	886	480	18,141
2nd Floor Zone	2nd Floor	1	934	20,155	808	934	20,155	808	458	17,302
		PAGE TOTAL	1,607	34,697	1,693	938	35,443			
		TOTAL	1,607	34,697	1,693	938	35,443			

No insulation for glass and concrete,
Glass: U =.31 - .24 SHGC, Wall: U = .36, Roof:: U = .283, Floor: U = .315
Sensible energy: 4 tons

Load Calculation and Analysis

ROOM LOAD SUMMARY

PROJECT NAME	DATE
Work Live Area	6/14/2007
SYSTEM NAME	**FLOOR AREA**
Res HVAC	1,150

ROOM LOAD SUMMARY

			ROOM COOLING PEAK			COIL COOLING PEAK			COIL HTG. PEAK	
ZONE NAME	ROOM NAME	Mult.	CFM	SENSIBLE	LATENT	CFM	SENSIBLE	LATENT	CFM	SENSIBLE
1st Floor Zone	1st Floor	1	792	17,091	886	792	17,091	886	704	26,589
2nd Floor Zone	2nd Floor	1	1,052	22,705	808	1,052	22,705	808	682	25,750
PAGE TOTAL			1,843	39,796	1,693	1,385	52,339			
TOTAL			1,843	39,796	1,693	1,385	52,339			

No insulation for glass and concrete,
Default Dual Glass: .79 - .70
Sensible energy: 4.5-5 tons

ROOM LOAD SUMMARY

PROJECT NAME	DATE
Work Live Area	6/14/2007
SYSTEM NAME	**FLOOR AREA**
Res HVAC	1,150

ROOM LOAD SUMMARY

			ROOM COOLING PEAK			COIL COOLING PEAK			COIL HTG. PEAK	
ZONE NAME	ROOM NAME	Mult.	CFM	SENSIBLE	LATENT	CFM	SENSIBLE	LATENT	CFM	SENSIBLE
1st Floor Zone	1st Floor	1	793	17,129	886	793	17,129	886	932	35,213
2nd Floor Zone	2nd Floor	1	1,053	22,743	808	1,053	22,743	808	910	34,374
PAGE TOTAL			1,847	39,872	1,693	1,842	69,587			
TOTAL			1,847	39,872	1,693	1,842	69,587			

No insulation for glass and concrete,
Single + tinted Glass: 1.280 / .67
Sensible energy: 4.5-5 tons

Load Calculation and Analysis

ROOM LOAD SUMMARY

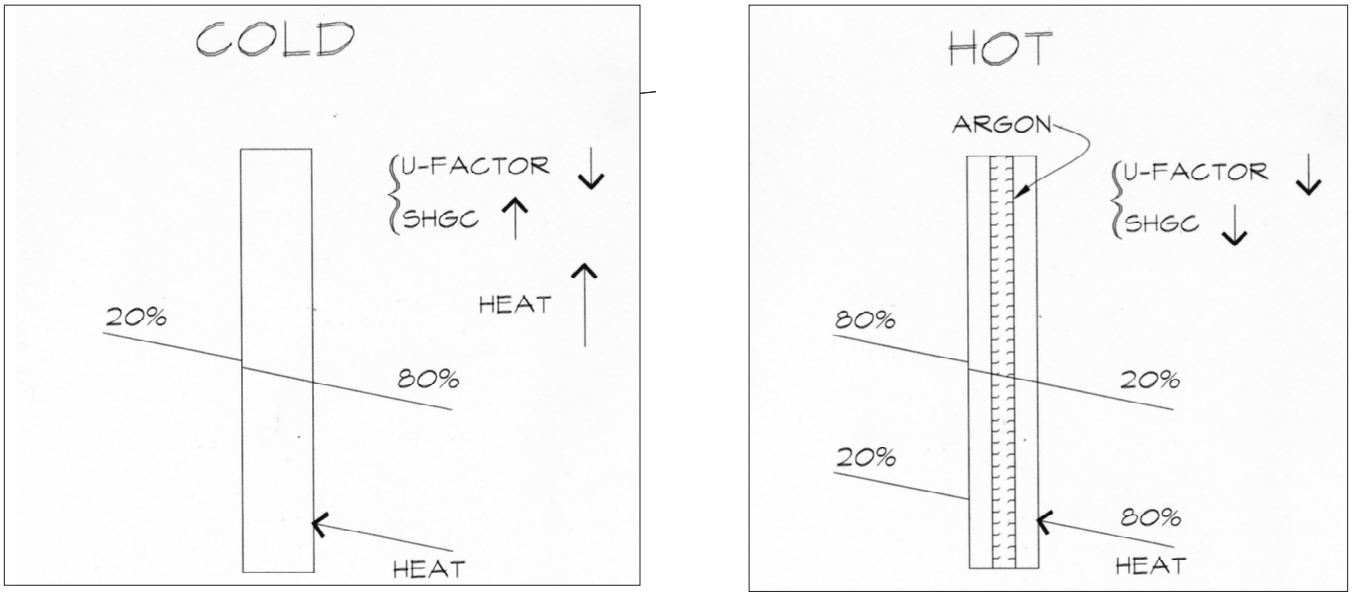
PROJECT NAME	DATE
Work Live Area	6/14/2007
SYSTEM NAME	**FLOOR AREA**
Res HVAC	1,150

ROOM LOAD SUMMARY

			ROOM COOLING PEAK			COIL COOLING PEAK			COIL HTG. PEAK	
ZONE NAME	ROOM NAME	Mult.	CFM	SENSIBLE	LATENT	CFM	SENSIBLE	LATENT	CFM	SENSIBLE
1st Floor Zone	1st Floor	1	813	17,549	886	813	17,549	886	932	35,213
2nd Floor Zone	2nd Floor	1	1,073	23,162	808	1,073	23,162	808	910	34,374
PAGE TOTAL			1,886	40,710	1,693				1,842	69,587
TOTAL			1,886	40,710	1,693				1,842	69,587

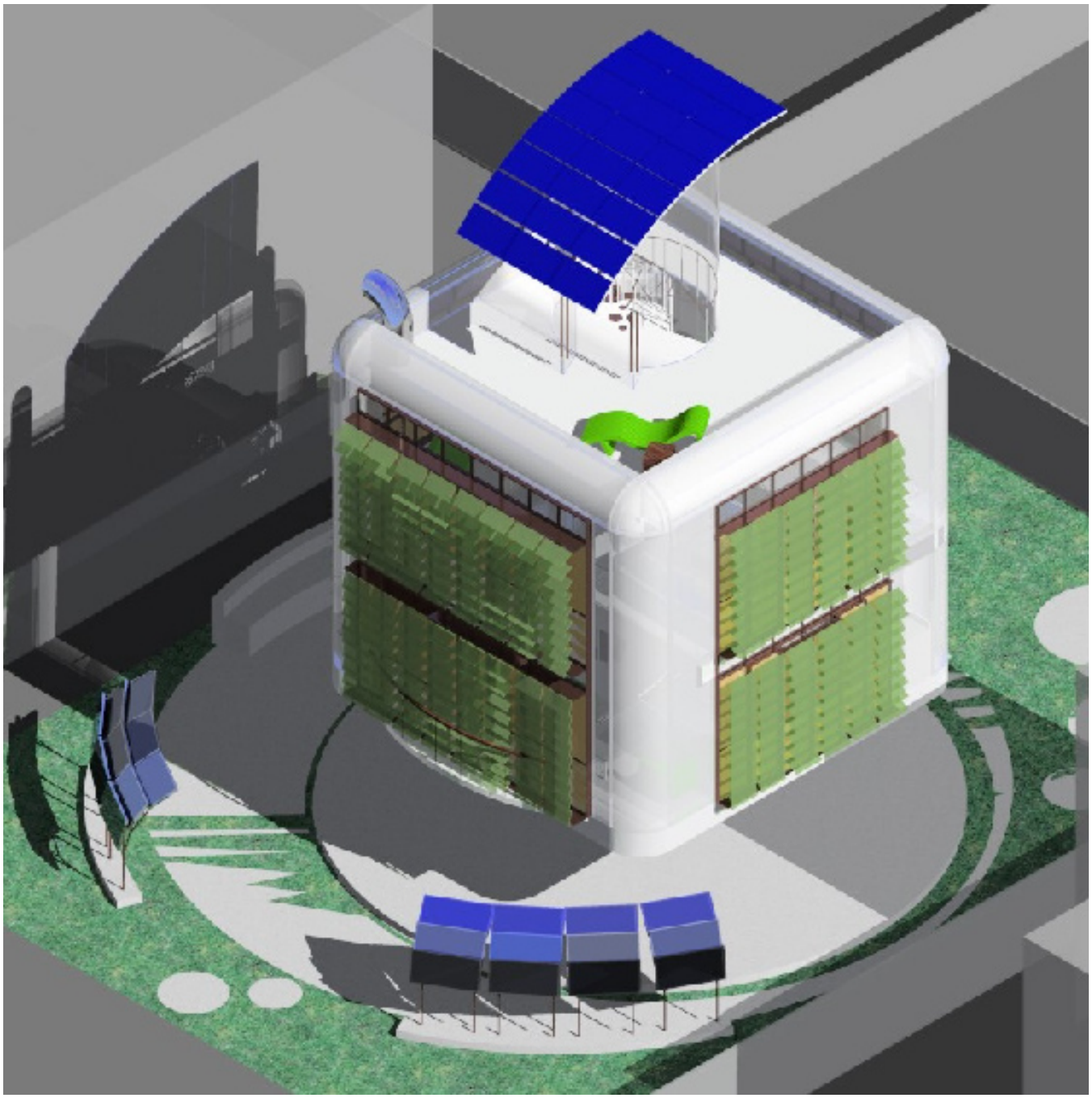
No insulation for glass and concrete,
Single: 1.280 / .80
Sensible energy: about 5.5 tons

Lesson Learned from comparing the first and last analysis: lack of insulation approximately doubles the energy load.



The relationship of U-Value and Solar Heat Gain Coefficient (SHGC), comparatively in Hot and Cold climates

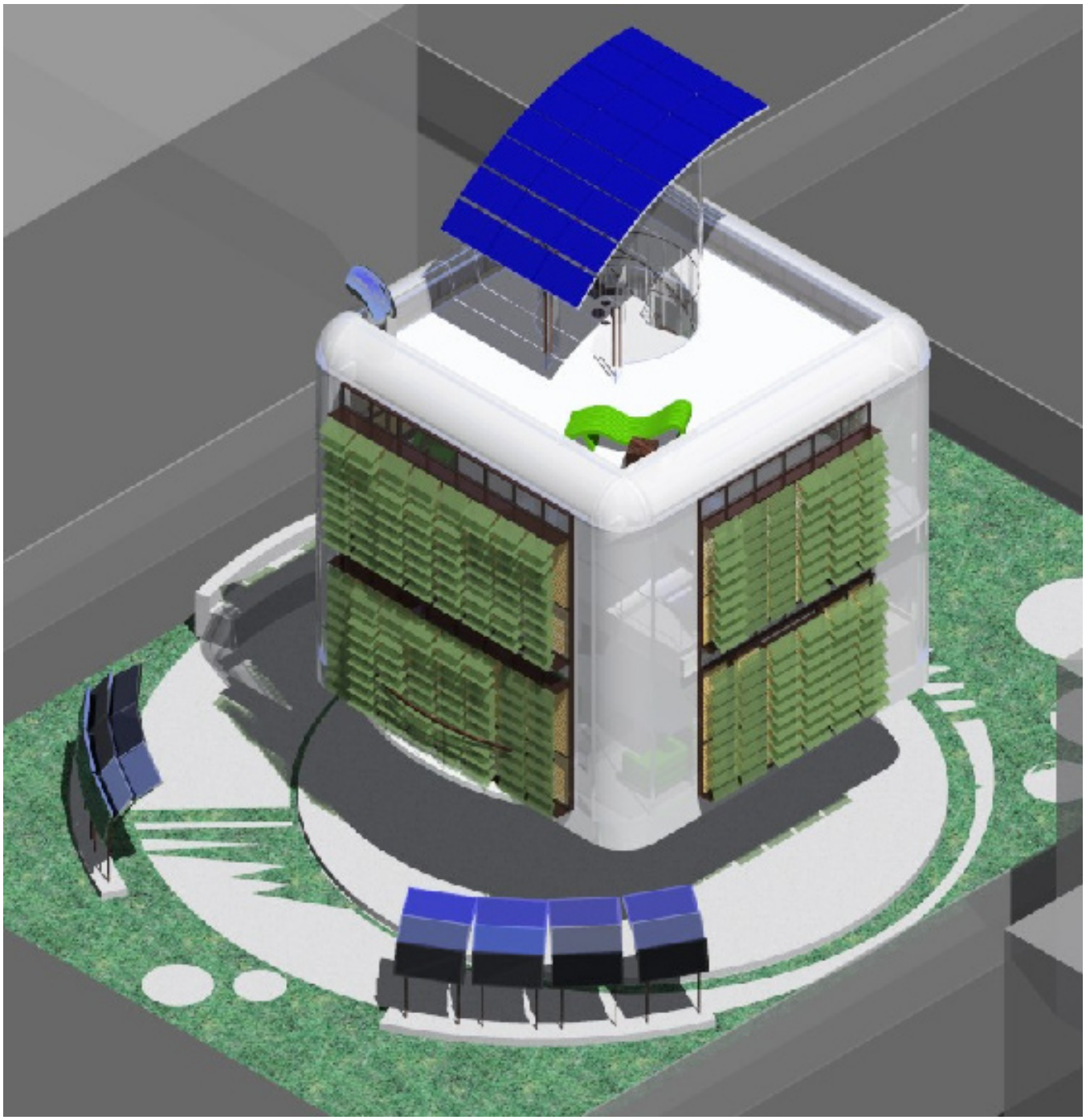
3B.10.1 Daylighting - Shadows



Daylighting - 8:00 AM Shadows

Credit: Revit 3D Modeling by, Linda Nguyen

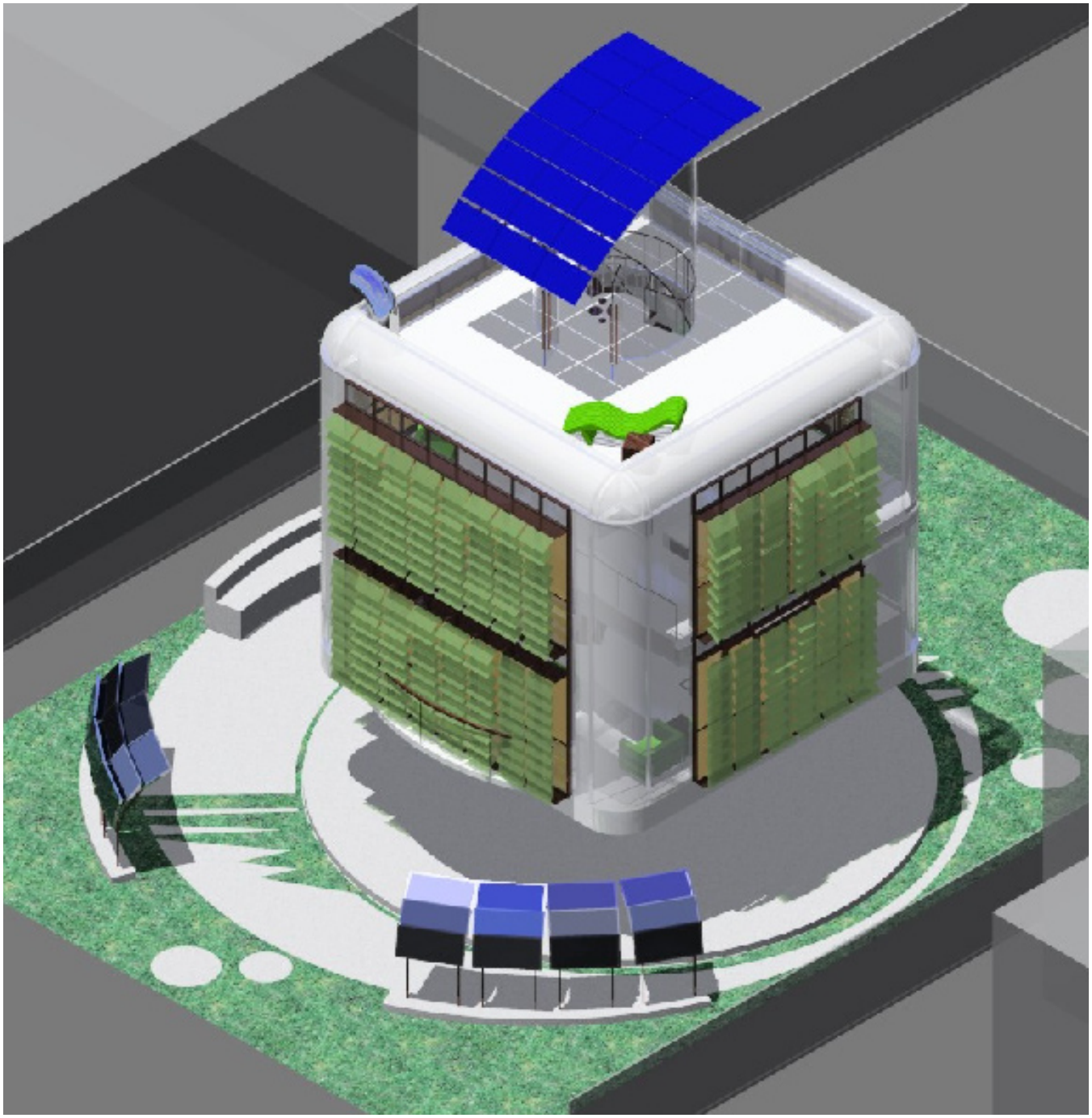
3B.10.2 Daylighting - Shadows



Daylighting - 10:00 AM Shadows

Credit: Revit 3D Modeling by, Linda Nguyen

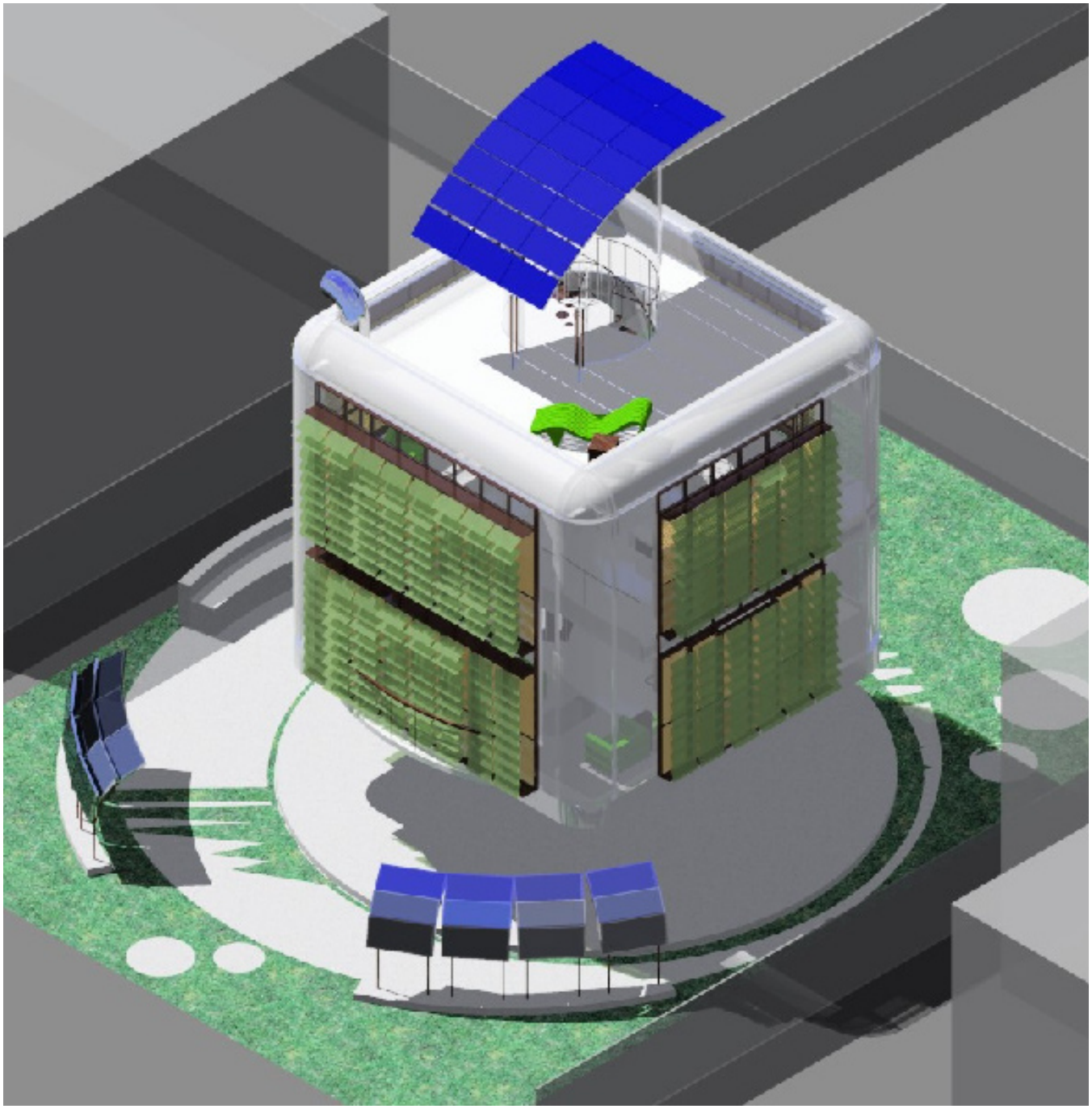
3B.10.3 Daylighting - Shadows



Daylighting - 12:00 PM Shadows

Credit: Revit 3D Modeling by, Linda Nguyen

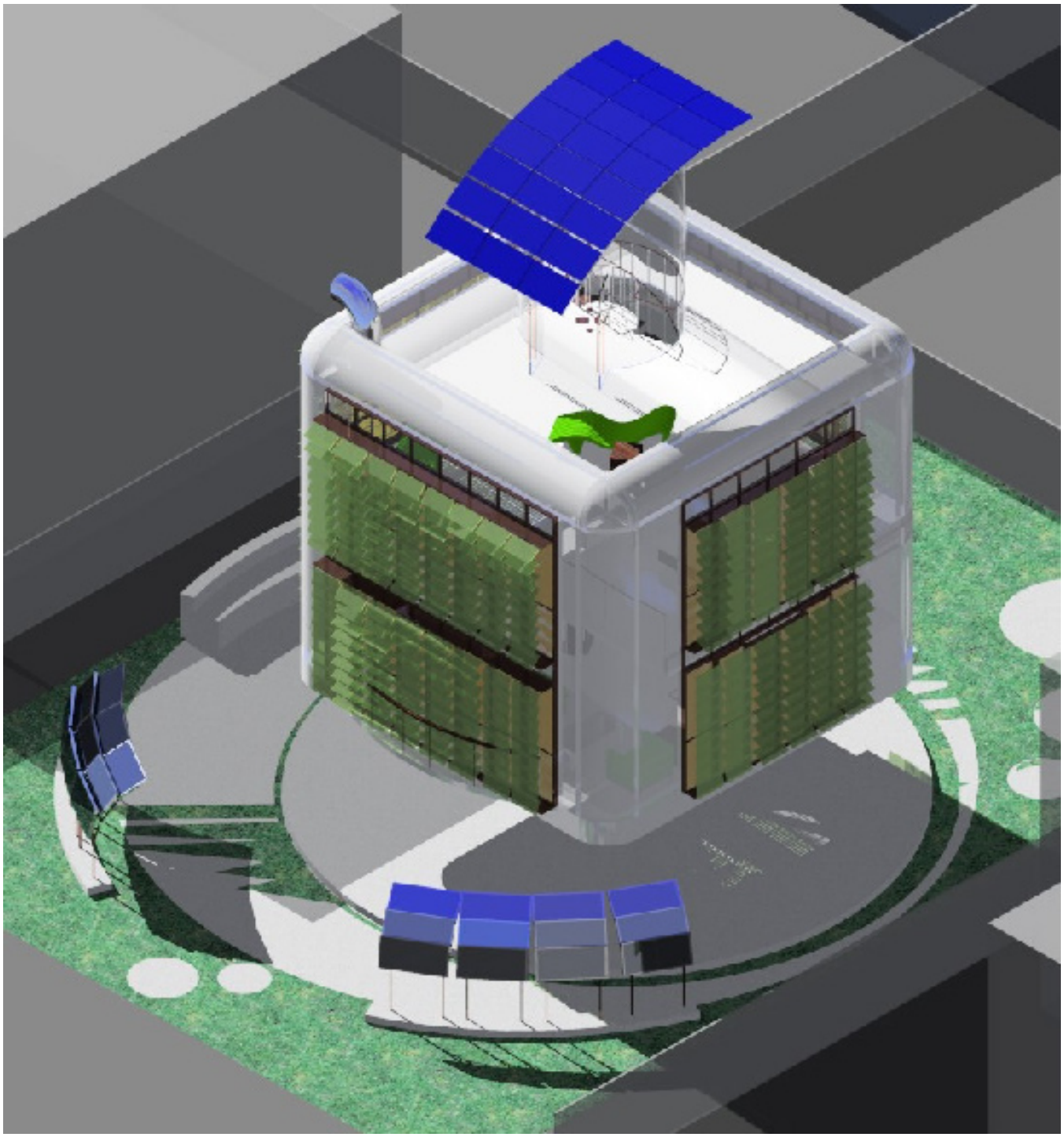
3B.10.4 Daylighting - Shadows



Daylighting - 2:00 PM Shadows

Credit: Revit 3D Modeling by, Linda Nguyen

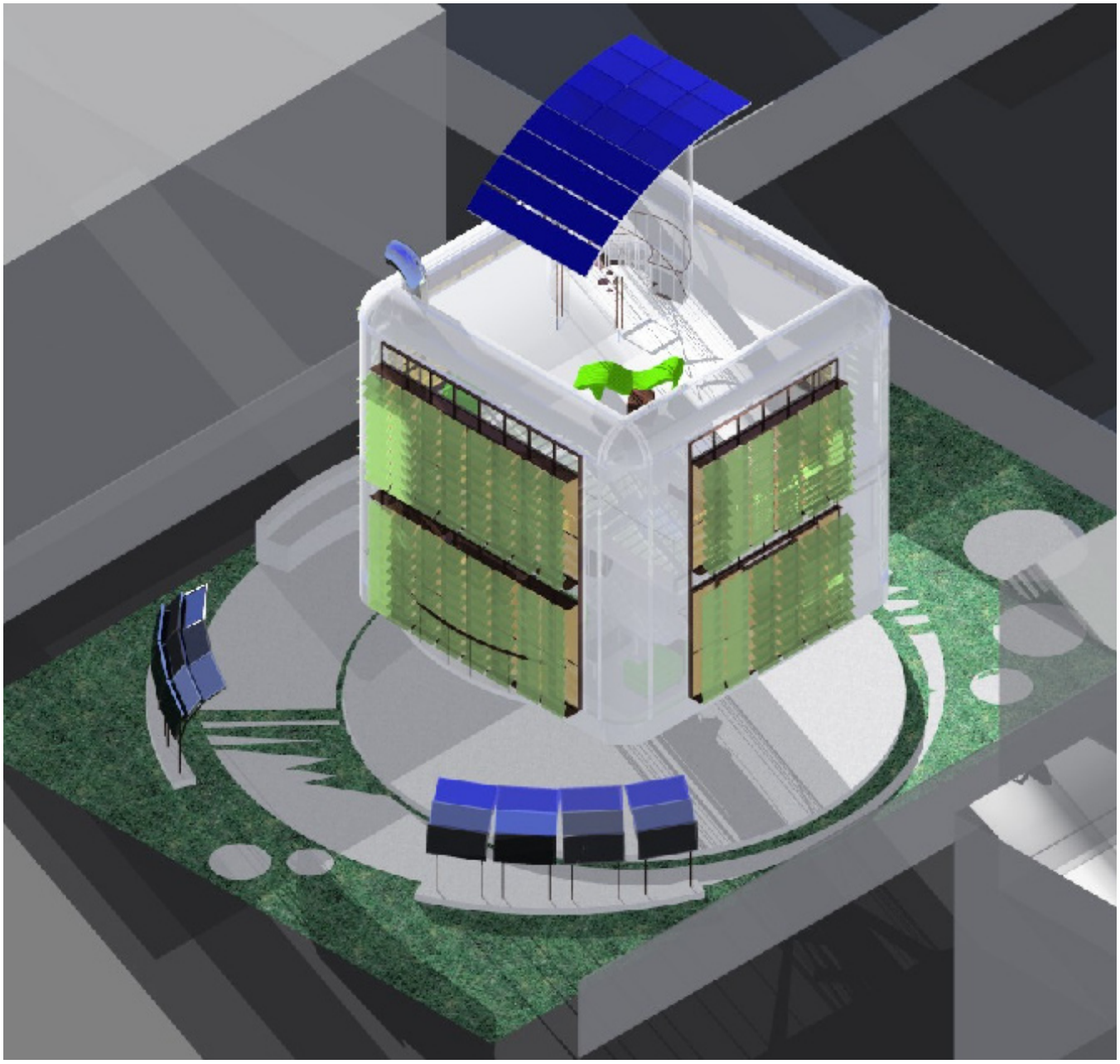
3B.10.5 Daylighting - Shadows



Daylighting - 4:00 PM

Credit: Revit 3D Modeling by, Linda Nguyen

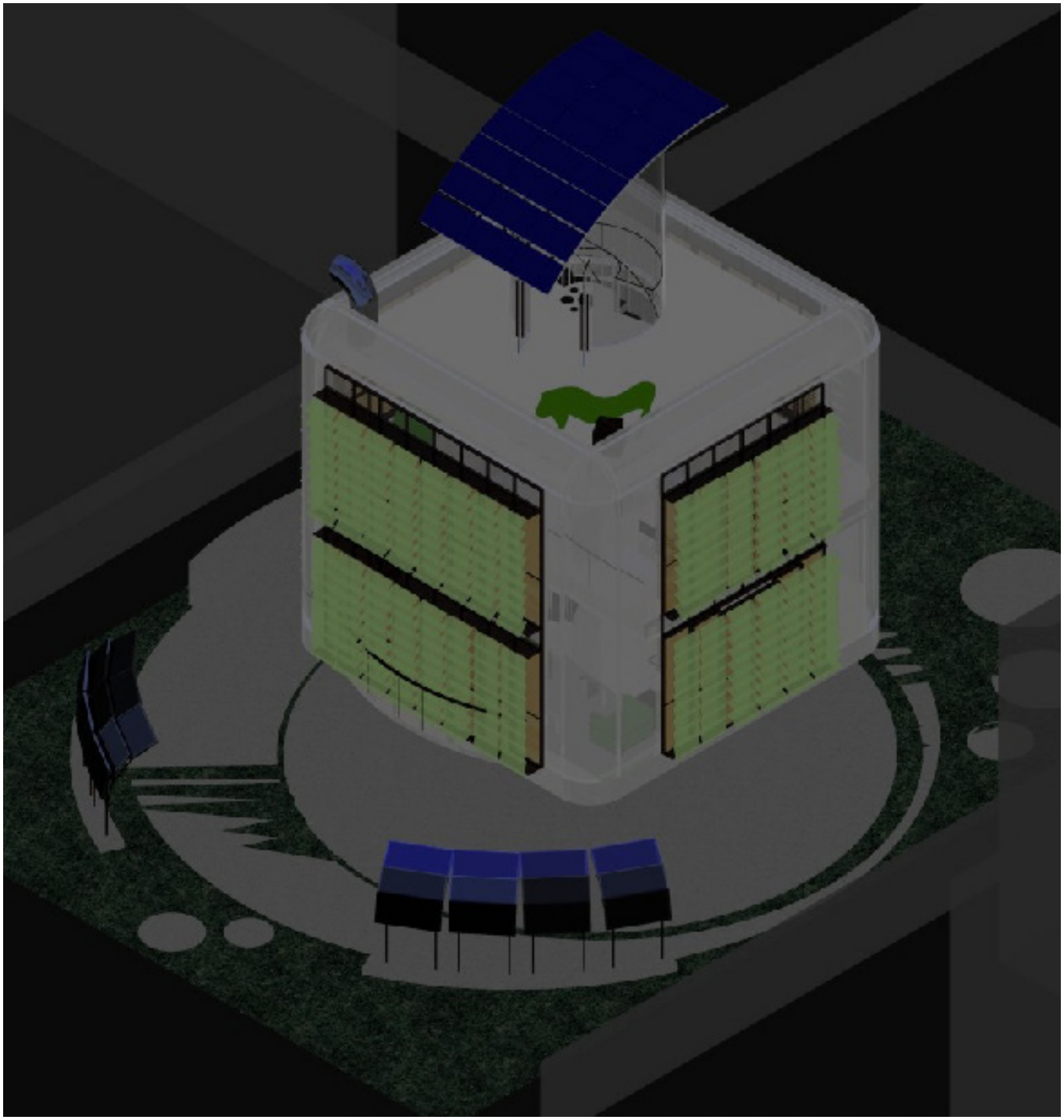
3B.10.6 Daylighting - Shadows



Daylighting - 6:00 PM Shadows

Credit: Revit 3D Modeling by, Linda Nguyen

3B.10.7 Daylighting - Shadows



Daylighting - 8:00 PM Shadows

Credit: Revit 3D Modeling by, Linda Nguyen

3.11.1 Interior Lighting: Interior images looking north-east toward the kitchen area, at six different times of the day for the dylighting effects

8:00 AM. with minor daylighting difference with 10.00 AM.

10:00 AM.

Credit: Revit 3D Modeling by, Linda Nguyen

Interior Lighting

12:00 pm

2:00 pm

Credit: Revit 3D Modeling by, Linda Nguyen

Interior Lighting

4:00 pm

6:00 pm

Credit: Revit 3D Modeling by, Linda Nguyen

3B.12 A Conclusive Synopsis on Exemplifying the Habitat's Design Concept Decision-making Process -

Throughout this research project the attempt was made to clarify the role and meaning of performative architecture. In performative designs, architectural forms are not only meant to be a manifestation of their internal relational logic, but also a response to the dynamic and variable influences of their environmental and socio-economic context. The Live-Work Habitat prototype is based on a design philosophy that introduces a living architecture in conscious harmony with varied manifestations of different natural and man-made settings. The design proposal was initiated with the concepts that were in rhyme with the "Performative Design" objectives. Greg Lynn who was one of the first architects that used animation software not as a medium of representation, but of form generation, in his book Animate Form, observes "the context of design becomes an active abstract space that directs from within a current of forces that can be stored as information in the shape of the form" (Architecture in the Digital Age, Design and Manufacturing 19). He also indicates, "it is important in any parameter-based design that there be both the unfolding of an internal system and the infolding of contextual information fields" (19). There were many internal and external forces that contributed in the shaping up of the Habitat Prototype's form. For the purpose of summarizing the decision-making process, it is important to go back to the categories listed in the original list of the characteristic paradigms of performative architecture, which were presented in part one of this document. This synopsis is based on the following categories:

Choice of the Concept and Design –
Flexibility

We live in a world where the only constant is change. Our dynamic societies are demanding the change of functions and activities, or reorganization of current activities and potentials for their adaptability to new lifestyles. By the same token, the main concepts of flexibility and adjustability are dominantly influencing almost every aspect of the design of this prototype habitat. While flexibility conveys the meaning of the ease of the adjustments to suit changing circumstances, adjustability and adaptability refer not to specific advance adaptations, but rather designed in such a way that later adaptation can be a possibility.

Although buildings are typically designed and expected to remain as static objects, the design of the Solar Prototype Habitat attempts an initial defiance of static equilibrium, and a full demand for "flexibility" and "adjustability." The concept of flexibility embraces all other concepts of 'strive for panoramic views,' as well as the 'pursuit of sun,' as dominant design ideas. The main objective has constantly been to meaningfully bring man as close as possible to his natural setting, and fuse him with his environment. Thus, the choice of the concepts that were inherently performative became the guiding principles for the development of a design project that involves fluidity and dynamism.
To address the concept of dynamism, the building must be flexible by opening up, both internally from within and externally to the outside, while being also capable of expansion and contraction. This is the concept of the adoption of strategies of adjustment to the foreseen and unforeseen external contingencies for different types of morphing encounterment. In essence, adopting a design based on the methodologies of analyzing nature's flows, forces, and elements that are

influencing the production of the building, can be accomplished by letting the form to stand up for change and allowing it to assume different roles and interpretations in various conditions. The design is an active and dynamic process, which uses certain devices to address objectives of adaptability to the related environment. For the purpose of visual dynamism, the design of the prototype has also sought creating visual tensions with an inherent strive to resolve the intensity within the whole of its architecture. The choice of this concept influenced the design of the building in various ways. This concept to a great extent affected the choice of the materials and its related structural system, through the combination of polymer and steel, while also drastically influencing the design of the building enclosure.

Choice of the Concept and Design –
Form & Interior Layout – Building Enclosure and Structure

In today's arguments about design, the inclination is towards function-neutral buildings, which are suitable for various typologies. Considering that the building consists of six major components: site, structure, skin, space plans, and building's content, the design of the solar prototype habitat keeps a keen eye on providing flexibility on all these six components.

A selected building façade is programmed to follow the sun from sunrise to sundown. This can occur according to the calculation that determines the Azimuth and the elevation of the sun. The building is equipped with a sensor as well as a manual switch to activate or neutralize the sensor's operation in its automatic pursuit of the sun. In the summer, the living areas can be turned away from the sun—mainly toward northeast—to prevent overheating. In fact, the prototype habitat has the flexibility to revolve 180 degrees in every direction around its off-setted shaft, which can work for both avoiding solar penetration in unwanted areas, and taking maximum advantage of passive solar gain. In the initial experiments for the selection of the building form, attempts were made towards organic shapes, which are more adaptable to natural elements. Nonetheless, for the sake of buildability and the ease of the construction of the habitat as a prototype, the ultimate decision landed on the form, which is a genuine defined geometry with curved corners for added rigidity and lateral stability.

The selected program of the prototype is also a reflection of the existing demand arisen from the cultural and socio-economical shifts in housing, which require the pursuit of technological advancements. The shift in the lifestyle of many existing societies and the desire for mobility and flexibility demands the types of housing that are transportable and transplantable. Thus, the design of this prototype is also based on modularity and the possibility of creating new opportunities in design through repetitions, while providing ease of adaptability to various contextual settings and pursuing the highest level of functionality in an active and utilitarian state of performance.
Among the conditions that have guided the design of this habitat prototype is the adoption of a performative and intelligent enclosure for the facades, as well as the roof deck. Thus, the skin of the building is actively taking charge in various contingencies by working with the sun and other natural elements, while creating an adaptive condition with its ecosystem. This condition creates a balanced environment for experiencing comfort within the interior space of the prototype, and is a process that demands the building to become a proto-bio-sphere in its ultimate mode of adaptivity to its micro-system. The adjustable array of shading devices, including the blades and shutters, make the building act as a machine that can modify natural light and heat. The external shutters integrated with photovoltaic panels can not only shade the full-height window glass

panels, but also contribute to the production of energy. It is through the inside louvers and outside shutters that the daylight, as well as heat loss and gain can be fully controlled. With respect to the performativity of the building, the entire glazing sections of the facades are fully operable. In essence, the entire full-height glazing panels with integrated adjustable louvers and the added array of shutters with polycrystalline wafers of photovoltaic, are foldable such that the entire façade could open up to the exterior. Simultaneously, certain building devices are used as tools for the performativity of the building. The operation of these building devices can be controlled by certain manual, electrical, mechanical, or digital mechanisms. This is to modify, acclimatize, and mediate the environment for the occupants' physical and emotional well-being.

The architecture of the prototype, although appearing to be a generic design exercise, is an attempt for the architecture of morphogenetic practices. This is based on methodologies for involving the specific contextual flows, forces and circumstances, as well as considerations for adaptability. It involves a latent condition common and expected in a performative building, which demands the architecture to be constantly in a state of self-organizing transformation. Self-organizing transformation refers to guided design solutions that possess a state of adaptability to all sorts of foreseen and unforeseen contingencies and events that might affect the building's architecture. Nonetheless, the prototype habitat is a fusion of high tech and low-tech design solutions striving to embrace a hybrid design of ecologically driven technology.

The form of the building and flexibility of the spaces within allow the prototype habitat to stand-up for change, comply, and adjust with different interpretations and vocabularies. On the other hand, although the prototype is designed as a hybrid system, it is also providing opportunities, as demonstrated in the analysis, to perform as a self-sufficient biosphere with no or minimum dependency on the local utility systems. The ultimate design of the building is the final product of an evolution of a process that does not prescribe how and what the building should look like. Rather, it was based on how the building should behave and operate. This has been the mind-set from the initiation of the design of the building, since the concept was first selected and throughout the form-making process. The systematic analysis of the building became the true form-giver. Its form-making process, assisted step-by-step in the ultimate formation and vocabulary of the building. It involved a performative design that through the development of a computerized master geometry in structural engineering brought the forces into a dynamic balance and an optimized architectonic form. Additionally, the usage of computer software for HVAC strategies also assisted with the development of a form that ensures maximization in human comfort strategies.

Habitat is an architecture that alludes to the argument for "openness," which invokes terms and concepts that have been used in the past century in buildings designed by Le Corbusier, Bruer, Nuetra and some of the others. The idea of the room as a cell has been abandoned for the benefit of a new openness. The concept of the dissolution of the floor plan corresponds to fully operable facades, where the barrier between the interior and exterior are fully relinquishable for the sake of establishing an outdoor-indoor relationship. Thus, the habitat's architecture is representing flows, plasticity, and continuity. The design has incorporated a skeleton structure, ample opening, and movable enclosure, which open the entire volume to light, air, views and the movements of people in varying regularity and spontaneity.

The location of the single shaft is off setted for the purpose of providing more usable space within the openness of the entire interior spaces. The performative interior contains modular elements for bathroom, washer, and dryer compartments, as well as the kitchen cabinets that can be moved around and situated in different arrangements. For the sake of flexibility in rearranging the modular compartments, all the plumbing and electrical conduits run through the main central shaft and are distributed radially through the entire floor system. The structural system works as a hydraulic elevator, which allows the building to have full flexibility in ascending and descending movements within a range of "ten feet," in addition to 180-degree revolutions in both directions. In the case that the prototype is desired to be in a full landing position, the hydraulic bracing elements and the spiral stair tread panels are stacked up and folded together to provide a flat position for the first floor platform to land on the ground. Thus, this is an opportunity for maximum adjustability and flexibility to the nuances of the context, which includes climate, sun, and view. In the true sense, the design of this habitat is using environmental performance as a topic of representation for operation, as well as aesthetic qualities. Plasticity can be seen in the expressive translucent corner polymer flesh covering of the surrounding skeleton, as opposed to the articulation of the skeleton itself. The construction of the polymer appears less like an architectural structure than an exterior curtain wall or drapery. It also tends to modify ambient lighting. Within its wide uniformity, a full range of contrast can be observed (refer to interior perspectives).

The architecture of the habitat in a true sense represents performance and operations. Movements and exchanges take place in every aspect of the building, from the use of elements, blinds, shutters, and enclosure panels, to the entire building as a whole. The facade consists of permeable horizontal elements to shield the interior from solar gain, yet also admits light and fresh air into the building and contributes to the architecture's iconography. In the design of the Prototype Habitat, the elements of composition are working as the device paradigms for performativity. The full height louver devices allow air, light, and views to pass through the building. The facade's louvered walls introduce the continuous planarity of solid walls, while affecting the interior by allowing more interconnectivity between indoor and outdoor. The angling of the openings allow for the facade to express more depth. Meanwhile, the rhythm of the repetition of the screens at a smaller scale reduces the large pattern of the whole facade to a smaller or more human scale. Lastly, the single load bearing column, as the only solution to structural support, is also an instrument that works to define the way the building engages the pattern of movement with its outside world. The building reacts to the impacted flows and forces as a single box, rather than individual plates. The design of the habitat is undoubtedly incorporating a non-traditional, non-conventional performance, which requires novel skills, strategies, and approaches in architecture practice. It has maintained shared visions with sustainable design goals for permanence. This is an architecture that is breathing an air of freshness and originality.

In practice, the development of the performative form was adopted as the architect's Modus Operandi, which involved teamwork activity, experiments, trial and errors, use of computer simulation, and finally client participation, being in this case the architect. The final morphology, form, and architecture of the building is a process based approach and not a pre-ordained and predetermined one. The design of this project followed a product driven approach revolving around the appreciation of manufacturing and tectonics, as well as the art of detailing. The form and vocabulary of the building is step-by-step demonstrated in this research document, which evolved through while arriving at the right choice of engineering systems and materials and methods of construction.

3B.13 EPILOGUE THREE

This project should be regarded as an attempt to establish the meaning, scope and application of the newly implemented concept of performative architecture. The work in this project is a limited representation of the methodology of an architecture practice, which relies on the investigation of concepts as opposed to a method relying on a priori ideas and adopted rules. The intent was to remain process-and-performance-driven. Process-driven, in terms of adaptability, and creating an architecture that has the capability to speak to and interact with nature, as well as the potential to change the way we live and work; and also performance-driven, in terms of the use of resources, and its implications on the lifestyle of its occupants and its context. Therefore, the main adopted concept is centered on a generic prototype to allow adaptability to different contextual circumstances for various ways of live and work lifestyles.

The most important aspect of this attempt is its adopted process, which is a reiterative one; whereby in every step of the development of the design the initial assumptions have been questioned and reviewed, and have continued to be investigated, and reinvestigated. The adopted process is a way of attunement of the conditions between contradictory realities, for example, between indoor-outdoor, public and private, and between architecture and its contextual environment, which I tend to call a hybridization process. Therefore, the entire intended attempt for the development of this project is driven by process, which relies on operational procedures that have unraveled themselves at every step of the design development. In this project, the process of hybridization is mainly centered around the analysis of the structural system, as well as energy calculation, usage of solar energy, and indoor air quality requirements that affected the overall form and enclosure of the building, as well as the vocabulary of its architecture. Certain decision such as maintaining the bracings of the shaft have been made only for the aesthetical reasons, which undoubtedly work contradictory to the concept of efficiency, and were not pursued and considered in this project.

In general, in engineering a fundamental requirement is the economy of means that must be brought into consideration, and the overall level of resources that are utilized in the project should be as small as possible. This has to do with the sensible balance that needs to be maintained between high structural efficiency, and the ease of the design, construction and maintenance of the building. The efficiency of the means and materials has not been a consideration in this project. In general, performative buildings are sophisticated and complicated buildings. One indicator of the extent to which the correct balance between complexity and efficiency has been achieved is cost. Cost as a factor in measuring the level of the economy of means for the project, and as an important factor in determining the balance of efficiency and complexity, is not brought into consideration in this project.

In this attempt towards a performative architecture, in addition to the issues such as the volume and weight of the materials required for a structure, with respect to the overall form and pattern of the applied load, other subjective aspects, such as the psychology of the space and the senses are major determining factors, particularly on the decisions made on the interior and exterior elements of the building. To address the issue of performativity required a process of hybridization, which was definitely a compromise towards addressing the objective and subjective aspects of the building's architecture.

EPILOGUE THREE

In part one of this research project the discussion was made that Performative architecture as a hybridization process, although as old as the history of architecture, in this era of emerging modes appears to be a novel concept in the theory of architecture practice. It was also discussed that in recent decades, globalization, the development of global societies, as well as global warming and the need for green and sustainable built and natural environments has brought novel meanings and new requirements to the current design and practice of architecture. On the other hand, the emergence of new architectural trends, along with architects' desires to reflect changing aspirations, have created more complications, which are even augmented by the tremendous diversification of functional requirements.

The design of this project was also involved with an ambition to satisfy various aesthetic requirements, as well as the critical need to bring the characteristics of building in harmony with its contextual environment. Therefore, the idea of proposing a site-less prototype was demanding more of the flexibility and adjustability of the design to any given contextual condition and circumstance. This particular issue demanded a design that could remain disciplined in the face of multiple constituencies and interests, with a broader scope work requirement and an early selection of the design trajectories and concepts, from what typically in performative project must take place. Therefore, this circumstance drove the design towards the development of elasticity in the spatial concepts that are capable of performing in an optimally responsive way. As a result it demanded a non-static architecture, and an exaggerated, non-discrete and daring form and concept of what is typically being pursued and followed in performative designs.

Several abstract and experimental works of architects that have sought the aid of computer software packages were reviewed and analyzed. It became obvious that through the application of sophisticated 3D modeling techniques and computer simulations, designers in the pursuit of performative architecture have practically been able to heighten the boundaries of the imagination to sophisticated conceptual diagrams of novel forms, which are at the same time practical and performable. Additionally, the participation of the clients and future users, as well as the possibility of the interim review of design in its various stages, has also opened the door for the emergence of new performative forms. Therefore, on one hand, the recent developments in the fields of computer-aided design, virtual reality, fluid dynamics, and light modeling allow the visualization of the invisible performative aspects of the building. On the other, the demand for achieving higher quality and efficiency in the design of the buildings calls for the adoption of a methodology of design with a warrant for performativity, which can dominate the entire design process and practice of architecture.

Obviously, the pursuit of this path with limited resources was not going to bear fruitful results. The solution became obvious to focus on "performance integration," which demands an integrative approach to the design process. Considering that a building consists of an interwoven whole, composed of an ensemble of devices, this became a concept toward adopting a shared function between the components of the building. The design of the performative methodologies was pursued through the unification and meshing of the building systems and components, with the idea that efficiency will be attained by thoughtfully following such path.

EPILOGUE THREE

In analysis of certain selected performative designs and the lessons learned from them, it became obvious that in these projects the goal exceeds the minimum interweaving or integration of physical, visual, and functional aspects of the building. In fact, the message was loud and clear that in performative architecture, the design establishes the major architectural goals of the project and then directs the process of attaining the goals. Therefore, performativity is a broad and all-encompassing process, which embraces all aspects of design and practically includes everything involving the design of architecture. It is the pursuit of this approach that demands the architect to be also a problem solver, and act on one hand as the artist who is able to use technology as a means to attain aesthetic and formal ideals, and on the other act as the scientist who has the knowledge and the know-how to pull the components of the building together and allow it to perform to the expectation of its design goals. That is why in performative design more than ever, teamwork is essential within the design group, which is expanding to include many different kinds of expertise. On these basis the goal and methodology of the design project was established and pursued. Due to limited resources, the focus was only centered on structure, building enclosure, and human comfort, as well as the adoption of solar energy.

As the analysis and research for the project progressed, and while the design of the project unfolded itself, a message became louder and clearer, that performative architecture must transcend such descriptions as “functional”, “integral”, “efficient”, “adaptive”, “process and product-based”, “user-based”, “scientific”, “futurist”, and even “productive.” The idea of creating a productive architecture, which is endowed with the potential and is equipped with certain capabilities, was reinforced more than ever before. This was to introduce change of position and even state, as well as creating an inherent adaptability to unforeseen contingencies. One of the lessons learned from performative designs, which has charged the Solar Habitat with change is also sometimes done to block or retard, while other times used as a welcoming gesture for function and use. In the case of the Solar Habitat, this process took place through moderating, modulating, or filtering the external flows and through the function of its instruments of change or the ensemble of its device paradigms, which are parts of its systematic and elemental make-up. Typically the building’s elements are passive, and in most cases they do not change positions. In the case of the Solar Habitat, Certain device paradigms are active and adjustable. As Leatherbarrow, in his article and analysis about the architecture of Klumb writes, “but they can also be seen to be active if their ‘behavior’ is seen to result in the creation of qualities the world lack” (“Henry Klumb’s Work at Work“ 47). This prompted the conceptual idea of a daring design, which promoted a fully dynamic building.

The fact of the matter is that the architect, in pursuit of performative design philosophy, will allow the latent ecological, social, and economic conditions as well as the positive and vital element of cultural heritage, to guide the design solutions. In performative design, the concept of the building’s productivity allows the building to demonstrate certain qualities that are not originally given in the design, but are inherently present. This is when the building has become a constituent of its context, and the environment is not external but internal to it. In this regard, Leatherbarrow, while explaining about the architecture of Klumb, indicates that: “The building is not part of the environment—no one can sensibly deny that it was added to it—but in its passive activity it presents itself as though it were part of a work that was never designed. This is how architecture enters in to the “atmosphere” of a situation, through its enactment, operation, or performances. Already in its mere functionality, then, the building finds itself taking on a role,

acting a part that is not its own, representing itself as something other than it is. This is as much a theatrical as a practical performance" ("Henry Klumb's Work at Work" 48).

Nonetheless, The design of the Solar Habitat is only focused on generic ideas irrespective to specific social, economical and even ecological factors. In this performative solar habitat, the building tends to act as a symbol as well as a system of references beyond itself. It is a living architecture that only evolves through expressing its occupants, a way of life, and their fusion with the various adopted environments. The thought has been to create a state of balance and harmony between the building and the various manifestations of nature, as well as establishing a relationship between natural and conventional symbolism. The idea has been to allow the building's parts and constituents to generically enmesh and intertwine with their related context, in order to utilize and benefit from the available energies of the surrounding nature. This was becoming possible by creating an architecture, which possesses absolute freedom and independence, and is receptive of the external flows and forces without being affected by the constraints of its context.

In the end, performance has played a major influence in the design and meaning of the Solar Habitat's architecture. The performance influence entails the direct use of the materials in their raw forms and condition, and their application into a sympathetic tectonics, as well as development and integration of passive strategies into an artistic vision of the building, and by understanding and enriching the buildings enclosure and the architecture expression through the flows and forces of nature, and a merger of tectonic and mechanical means that marks the originality of the Habitat's synthesis. The role of performance in the design of the Habitat is a weaving of form and behavior, in which along with maintaining its aesthetical balance of the form, its dependency and dramatic influence on the natural environment is not overlooked.

Considering that the architect through the act of design bridges art and the sciences, while making a creation that relates to our daily lives, particularly with regards to the inherent objectives of performative architecture, it would be appropriate to quote from Albert Einstein and sum up our central thrust:

"The whole of science is nothing more than a refinement of everyday thinking. It is for this reason that the critical thinking for the physicist cannot possibly be restricted to the examination of the concepts of his own specific field. He can not proceed without considering critically a much more difficult problem, the problem of analyzing the nature of everyday [living]" Einstein, (pg. 290). Dealing with everyday nuances of nature has been the origin of the development of the concept and the related Solar Habitat's thought process.

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