

Zoomorphic Architecture: The Carolina Coastal Museum

Todd G. Christopher

Zoomorphic Architecture

The Carolina Coastal Museum

by Todd G. Christopher

ABSTRACT

Throughout the evolution of man, the ocean has played an integral part in his survival. As technology has advanced so has man's use of the ocean. In order to preserve the history of these advancements for future generations, museums have been erected. The Carolina Coastal Museum is dedicated to the nautical history of the Carolinas. The project is fueled by the theories and philosophies of zoomorphism and anthropomorphism. The building is based upon the skeletal structure of a fish, the main element being the spine. Other natural elements such as ligaments, cartilage, respiratory system, and circulatory system were also explored and utilized within the project.

ACKNOWLEDGMENTS

I would like to thank the following people for their unconditional support and guidance:

My committee for their wisdom, suggestions, and their understanding of my ideas.

My classmates for their criticisms, company, and humor.

Two of the best roommates I've ever had, Phil and Ben for a great graduate school experience.

Dr. George for your mentoring, guidance, and friendship over the years.

Uncle Charlie for your support and help through my thesis year.

Gran Anne for letting me turn her house into a print shop.

My mother who always believed in my abilities and was my confidant through all of this.

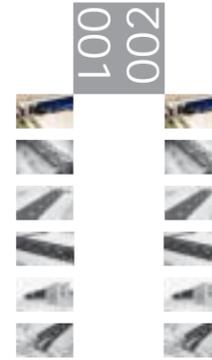
And to Pops, without you I may have never chased this dream. It was from you that I learned much of what inspired me to become an architect.

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What then does representation mean in terms of architecture? For me, it is architecture's physical or carnal quality, or to put in another way, the labyrinthine quality of the body. I am reminded of the etchings of the imaginary prisons by Piranesi entitled *Carceri*. Their overwhelming power and extraordinary sense of space have long remained vivid in my memory. The oneiric and fictional prison of Piranesi, so like the trick pictures of Escher, are precisely what I imagine the maze of the body to be.

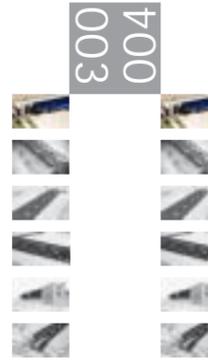
-Tadao Ando

INTRODUCTION

Since the introduction of humans into the world, the ocean has played a vital part in the lives of those geographically close to it. At first the ocean was an avenue for hunting or gathering food, but as society and man became more advanced, man's use of the ocean evolved as well.

The ocean was once the only way for traveling from one continent to another and today still plays a major role in the transportation of mercantile goods from country to country. It has played a major role in man's existence bringing both joy and sorrow. The ocean has helped in creating some of the world's electrical power and it has been used for recreation, but with the good things have also come a variety of dangers for mankind. Tidal waves, typhoons, hurricanes, and other natural disasters have often brought death and destruction to man. So with these horrors in mind, man started to devise ways to cope with these scenarios and also to help avoid them.

Over the years there have been many ways to help man in his adventures involving the sea. The ancient Greeks would burn fires on top of mountains to help ships both see the land and also avoid running aground. Later, lighthouses were strategically placed in areas where ships needed both a landmark and a reference point for navigation. Early ships were hand-made wooden craft that moved by the power of oars rowed by man. Later ships became monstrous, combustion powered, steel vessels that sped across the roaring ocean. As ocean technologies rapidly improved, it became clear that the ideas and inventions of the past should be preserved for future generations. It is this desire that leads modern man to build structures to house the knowledge and artifacts of generations past and often in the form of museums.



The proposed project is for a 30,000+ square foot maritime museum. A large building is needed to accommodate the immense height and width of certain relics, such as a portion of a ship's hull or a large mast.

In developing the program for the building, accommodations for artifacts of diverse sizes needed to be addressed. The building also has to provide secure areas for staff use as well as public spaces.

The program includes:

PUBLIC SPACES

- 24 small exhibit rooms (448 sq ft each)
- 4 medium exhibit rooms (1,270 sq ft each)
- 1 large exhibit room (17,540 sq ft)
- Public restrooms
- Gift shop
- Ticket booth
- Outdoor walkway extending to an overlook of the harbor
- Indoor walkway extending to an outdoor overlook of the harbor
- Stairs
- Elevator
- 169 Parking spaces

STAFF & SUPPORT SPACES

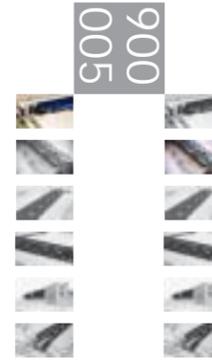
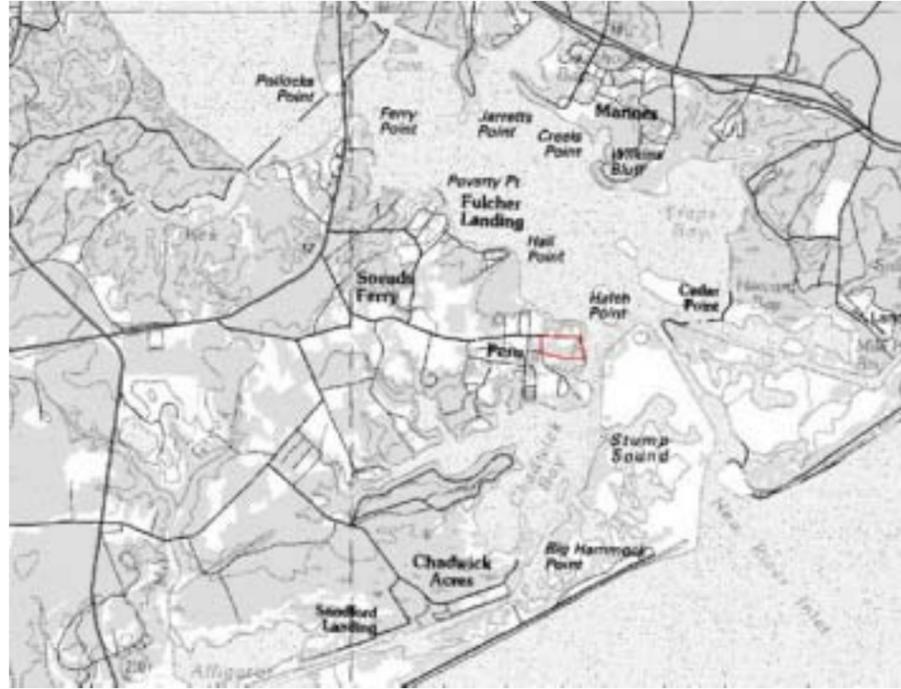
- 2 offices
- Conference room
- Kitchenette
- Storage
- Janitors closet
- Mechanical & Electrical rooms

LOCATION

The site is located in Peru, North Carolina. Peru is located approximately 60 miles southwest of Jacksonville, North Carolina. The site rests adjacent to a narrow inlet between Chadwick Bay and Waps Bay. These bays are only accessible through the New River Inlet which is perpendicular to Onslow Bay in the Atlantic Ocean.

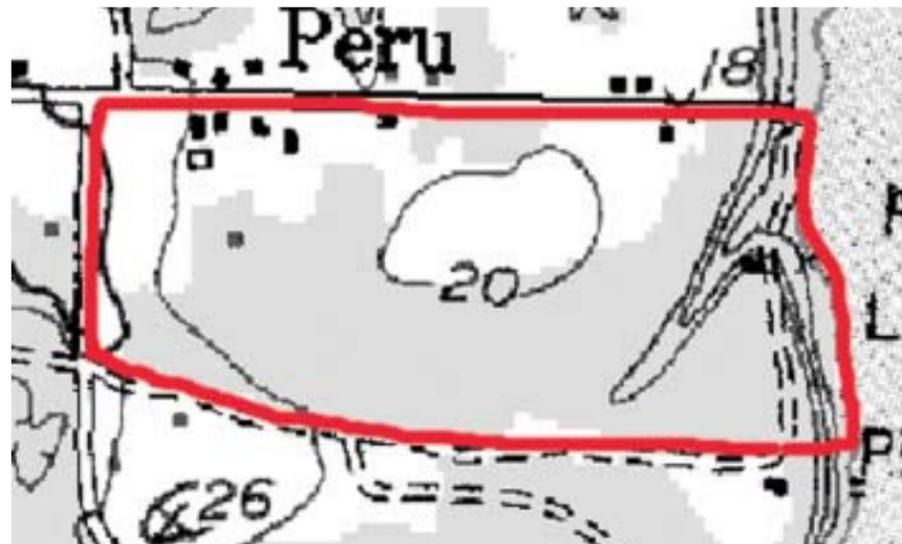
Peru is an area known for its recreational locations. The beaches of the bays are accessible via public roads and jeep trails. The area provides boat launches and docks for public use, picnic facilities, and other amenities.





We wish to see *ourselves* translated into stone and plants, we want to take walks *in ourselves* when we stroll around these buildings and gardens.

-Friedrich Nietzsche, *The Gay Science*



ANTHROPOMORPHISM & ZOOMORPHISM

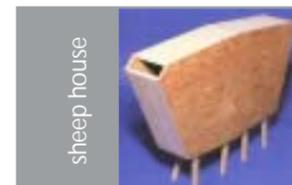
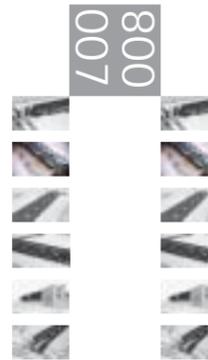
As anthropomorphism attributes human traits or qualities to inanimate objects such as cars, buildings, etc., zoomorphism uses animals as a metaphor between the living and the inanimate.

Anthropomorphism and zoomorphism have been attested since the beginnings of man. Its earliest form was man's sacrifice of other humans and of animals on structures that had been built. There are many other applications of these metaphors, from buildings that may have a statue of a human or animal on them, to buildings that derive their shape, structure, and skin from these ideals.

Renaissance architect Antonio Averlino, also known as Filarete, stated that buildings are like human beings. The mother being the architect, the father being the client, and the finalized design being the child. The transition from model to completed building, Filarete says that can be compared to a baby growing into adulthood. He notes that if these two do not know one another that it is impossible to deliver a design.

The ideas of Filarete can be applied to anthropomorphism as well. Anthropomorphism and zoomorphism have many different translations into the realm of architecture, whether it be a literal translation such as skin and bones or a theory like Filarete's. It can be considered that within anthropomorphism and zoomorphism that there are several layers of complexity to be applied to the design process.

Even with the evolution of technologies in an ever advancing society, many architects are still reaching back to these theories to create many forms and articulations.

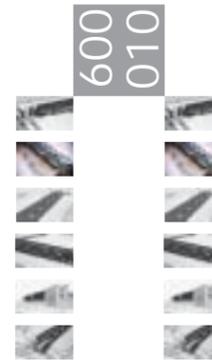


Michael Sorkin has done numerous studies on how the shape of an animal's exterior could be translated into a building's form.

Sorkin is primarily interested in the experience of the form from the outside. He understands that most humans very rarely get to appreciate the internal structure of a body.

This does have its limitations. Since Sorkin is only interested in the outside appearance, the interior becomes ambiguous in its form. The interior spaces are derived based on their functional responsibilities and not based upon the ideals of zoomorphism.

The structure also has limited reference back to its zoomorphic roots. Sorkin incorporates whatever methods needed to achieve the outside appearance and shape. There is no consideration given to the structural form of the study animal in the translation to a building form.



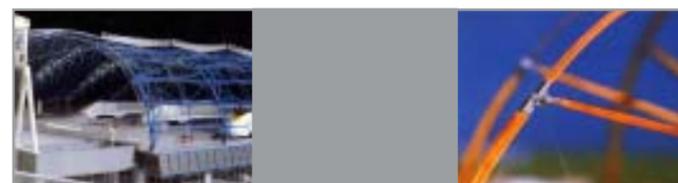
Nicholas Grimshaw's addition to Waterloo station is based on the idea of a human hand. The cupped "hand" reaches across the track to make an enclosure of the space.

Grimshaw's design is more true to anthropomorphic ideals but in the translation loses much of the principles of the human hand.

Looking at the conceptual sketch of the hand reaching across the track, one can see the correlation of the skeletal structure to the structure of the building. However, much of this idea is lost in the final structural configuration.

In the human hand the larger bones are found near the wrist; as the bones extend to the fingers, they become thinner and lighter. Looking at the section of the station, Grimshaw puts the bulk of the structural support towards the "finger" area and makes the "wrist" area thinner.

From the conception of the hand idea to the finished product, many of the rules of the structure of the human body are broken. Grimshaw more than likely had to break these rules in order to be able to provide the large span across the tracks and have a sound structural system that could be manufactured and installed at reasonable cost.

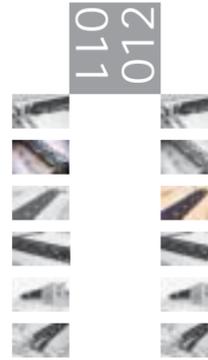


The IBM Traveling Pavilion by Renzo Piano is based upon the skeletal structure of winged animals. Piano looked specifically at the wings of ducks, pterosaurs, and bats.

Since the pavilion was to be moved, it needed to be designed for easy disassembly and transport. To allow for movement, Piano used pin connections between the members. The idea for these connections came from the joints in wings.

To allow for movement, wings have a condition much like a pin connection. Ligaments and tendons encase the bones and prevent bone on bone contact which could erode the surfaces of the bones and lead to premature damage. In the pavilion, Piano understood that the repetitive assembly and disassembly of the structure could also lead to the surfaces becoming damaged. To solve the problem a membrane was used between the pieces to prevent any contact.

The wings use varying sizes of structural members and connections. This is because the wing becomes thinner as it protrudes from the body. In the pavilion one size of connector was used. This lowers production costs and also makes all the parts of the various joints interchangeable which allows for a smaller number of replacement parts to be carried along with the pavilion.

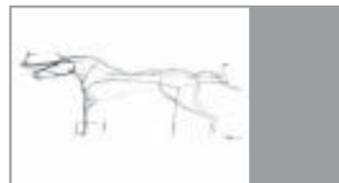


Santiago Calatrava has used features of an animal's shape and skeletal structure in many of his bridge and buildings projects.

Calatrava understands the opportunities that zoomorphism can present and also its limitations. In nature, the structure of a body becomes smaller as less force is applied upon the member. As we build, the repetition of parts becomes more practical. Identical pieces are less expensive to produce and can carry uniform loads throughout the structure.

Calatrava understands how a body varies in order to accommodate its various parts and forces. He also understands that in order for construction to be economical and finished in a timely manner that exceptions must be made to the rules of nature.

Understanding the harmony between nature and man's creations are what make Calatrava's works successful. He has successfully applied his ideas to numerous projects throughout his career. Calatrava could possibly be considered the master of today's zoomorphic architecture.

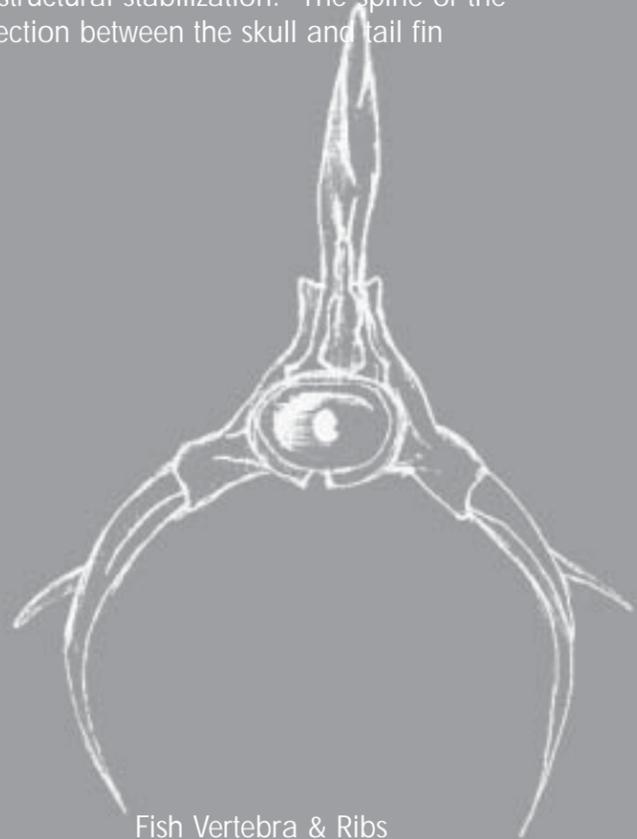


Fish are ideal research subjects because they are symmetrical but only until they wiggle. Our effort is to measure the space between the fish and the wiggle. This is the study of a lifetime.

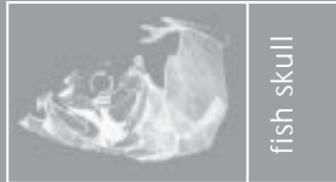
-Michael Sorkin, *Wiggle*

THE SKELETON

The skeletal structure of a fish is amazing in the amount of pressure it can withstand considering its thinness. Nature utilizes an elaborate system for the bone structure to allow for the variance in stresses at different parts of the body. Although the elements of the skeleton are repetitive, they vary in size based upon the forces exerted at their location. The bones in a fish are also rather flexible, allowing the fish's body to contort and propel itself through the water. The skeleton is comprised of numerous bone types, but it is the spine and ribs that perform the majority of the structural stabilization. The spine of the fish is the connection between the skull and tail fin bones.



Fish Vertebra & Ribs



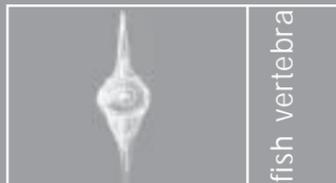
fish skull



fish vertebra



fish vertebra



fish vertebra



THE SPINE

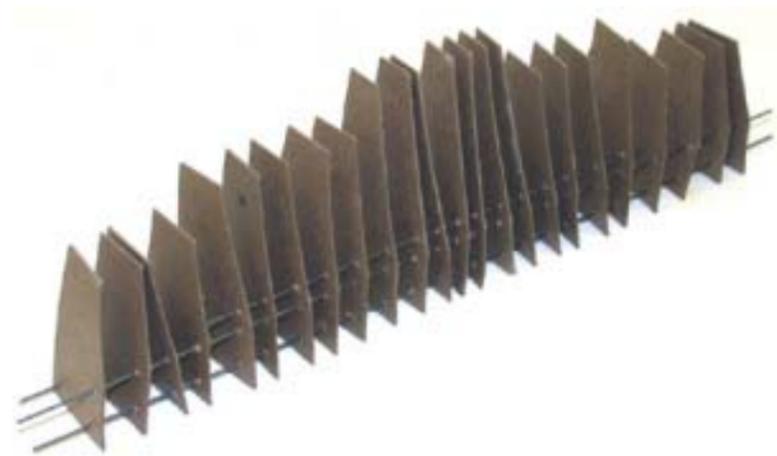
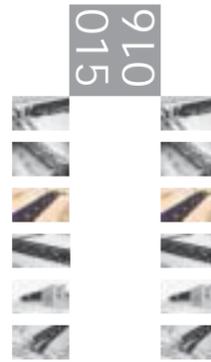
The idea of the "skeleton" as the structure of the building became the emphasis for the project. In a mammal's body, the spine is one of the most important structural elements. Applying this idea to the building was the preliminary exercise. What form should the spine translate into? How should the spine be made to become the dominant hierarchical element? These two questions fueled the idea of the spine and the development through the study models.



11th & 12th Human Verebra

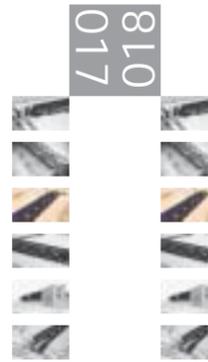
STUDY MODELS

The first model was to study how planes could be arranged in order to create a spine-like element. The planes, which are a correlation to a vertebra, vary in size and shape. The pieces can be moved along the steel rods in order to study the relation of the elements to one another.

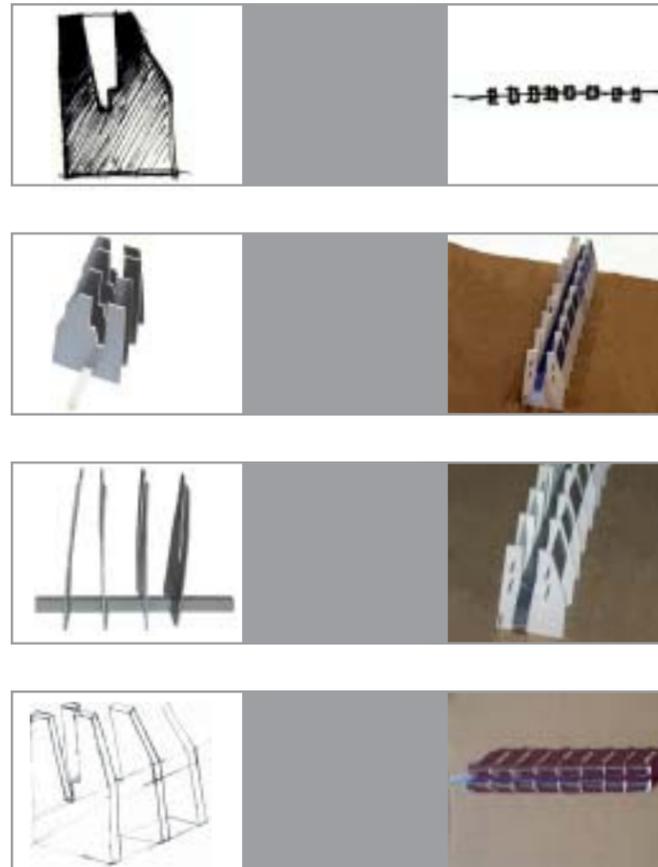


This is a variation of the preliminary model, made to study the spine elements in a different material. Reflective material was used to simulate stainless steel giving the panels a reciprocal mirror effect making the pieces seem to extend forever.





The third model of the series was made to view the planes as a different, more complex shape. How could the planes be altered to give an indication of pathway? Also a different type of connection idea was explored as well as a different material. In this case, paper was used to represent anodized metal.



How the planes could be used to begin to define enclosure was the emphasis of this model. Also how the elements could be used to define circulation, the differentiation of public and private spaces, and how different sizes and types of exhibit halls could be specified based upon the relationship and spacing of the planes.

Another function of the spine element was to support both an interior and exterior walkway that would extend out from the eastern side of the building to offer patrons a view of the harbor and recreational areas.



THE RIBS

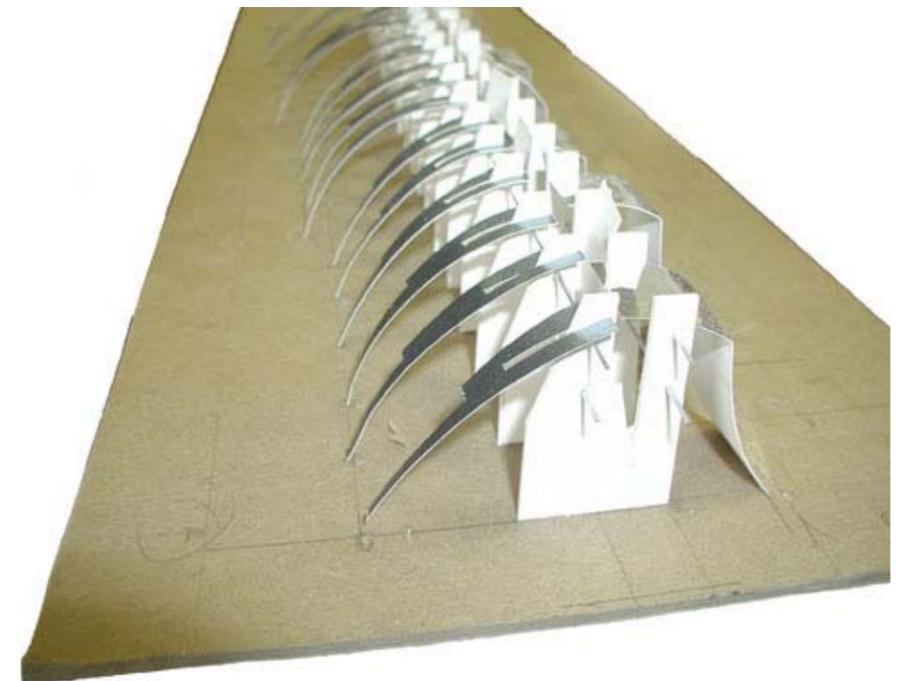
Since the main structural element of the building is based on the spine, it seemed sensible that another less dominant structural piece should be based upon the ribs. In nature the spine and ribs work in conjunction with one another to provide support and protection. This idea seemed plausible for the building. The ribs provide support for the roof and create enclosure, or protection from the elements, in the form of a building. The ribs are structurally dependent on the spine much as inside a mammal. The hierarchy of elements was now beginning to develop with the spine as the main element and the ribs becoming the second most important element.

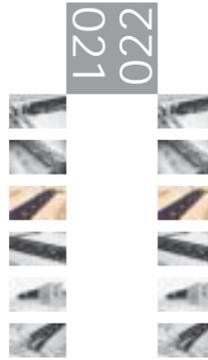


The Ribs of the Human Body

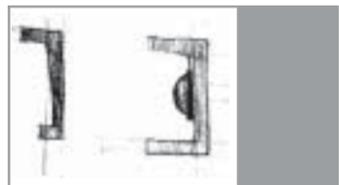
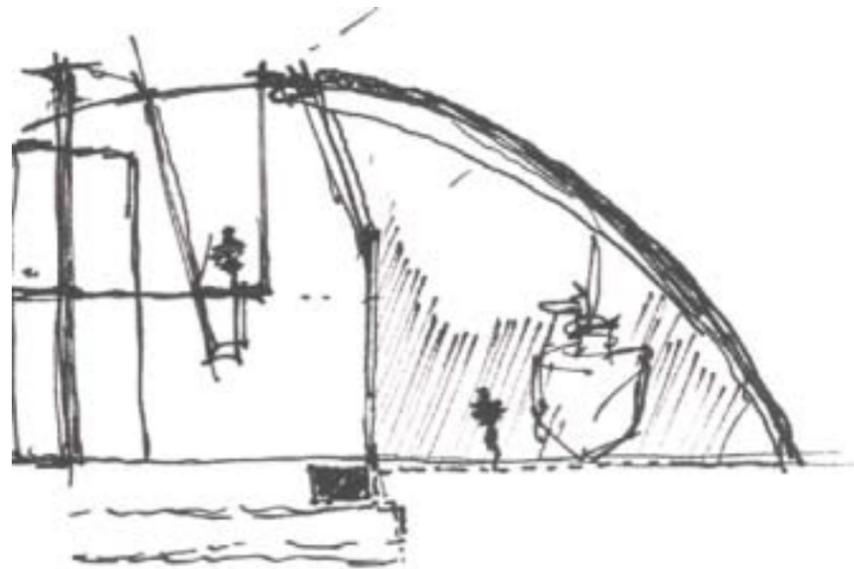


The use of ribs was first explored in this model, with particular attention to how they could start to define the main exhibit spaces. The study raised many questions, such as what form the ribs should take, what material should be used, how the rib should connect to the spine, and how they should terminate on the north side of the building.





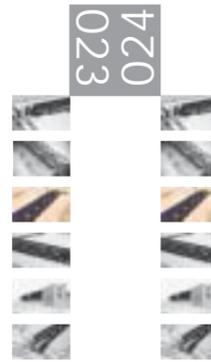
In this regard, the question of how the north side of the building should be enclosed became significant. In a body the ribs are symmetrical on either side of the spine. In this case, the ribs on the south side were creating a space for larger exhibits. On the north side the spaces would be used primarily for the service and support areas. Since the two sides differ in size and also in their hierarchical function, the north side should not compete with the ribs of the south side.



NORTHERN ENCLOSURE

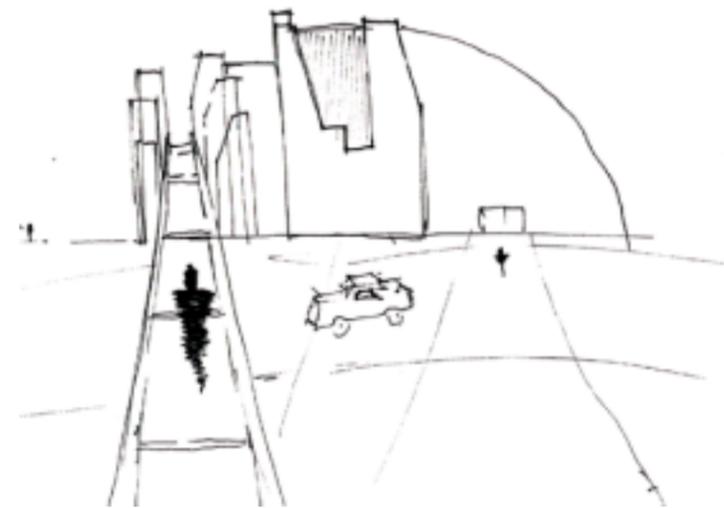
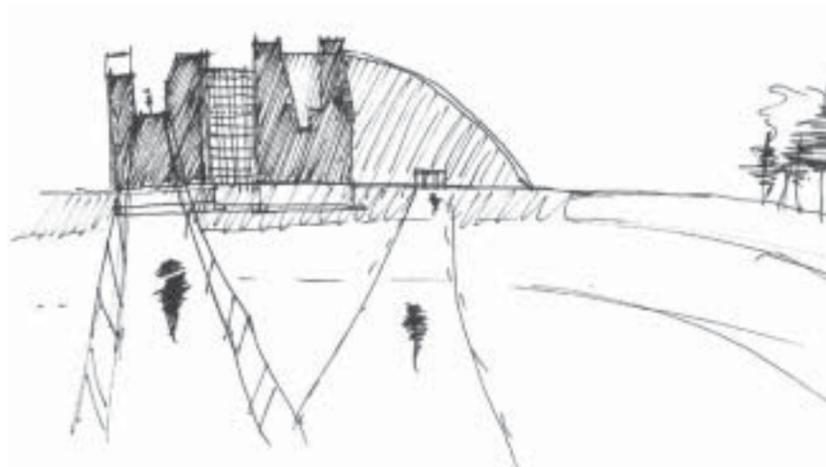
The subordination of the northern enclosure became one of the most challenging aspects of the project. The southern side of the building was enclosed with the rib structure. This enclosure created the main exhibit area. On the northern side, the spaces would be used for smaller exhibit areas, staff areas, and support spaces such as mechanical and electrical rooms. Since the southern side was housing the main exhibit area, it was decided that the northern side should not compete with the southern side.

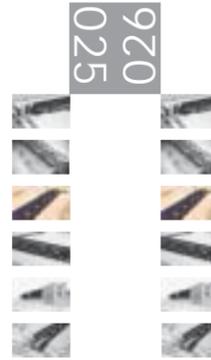
Then the question was how should the northern side be enclosed? Other questions also arose, such as how to introduce light into the space, how the ribs should connect to the spine, what materials should be used, and how the forces acting upon the elements should be resolved.



It was decided that the shape of the spine element should change to accommodate the north spaces. By changing the spine, the northern spaces would not be a distraction to the structural dominance of the spine but rather would become a secondary structure dependent upon the it. The spine should also support and offer protection to the north spaces much like the way the skeleton protects the body's vital organs. These service areas could be compared to organs of the body. They house necessary machinery to assist the building in "life like" functions.

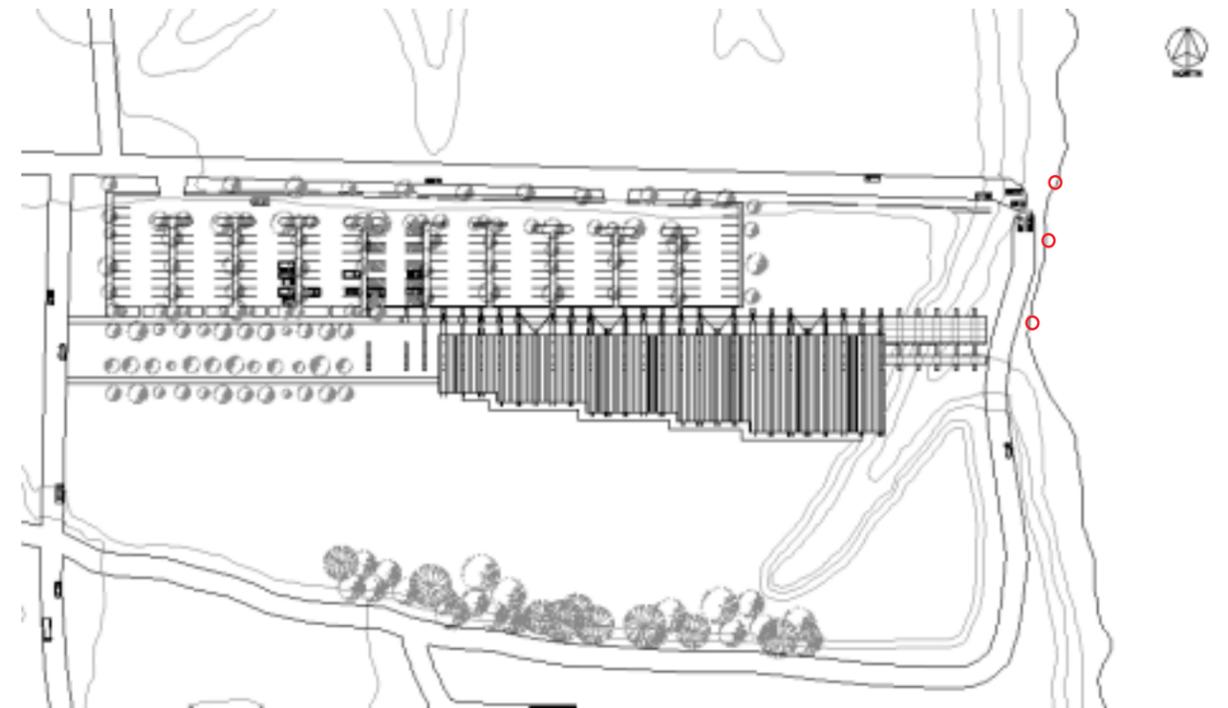
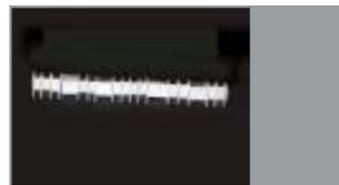
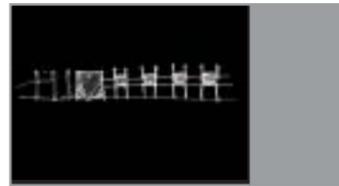
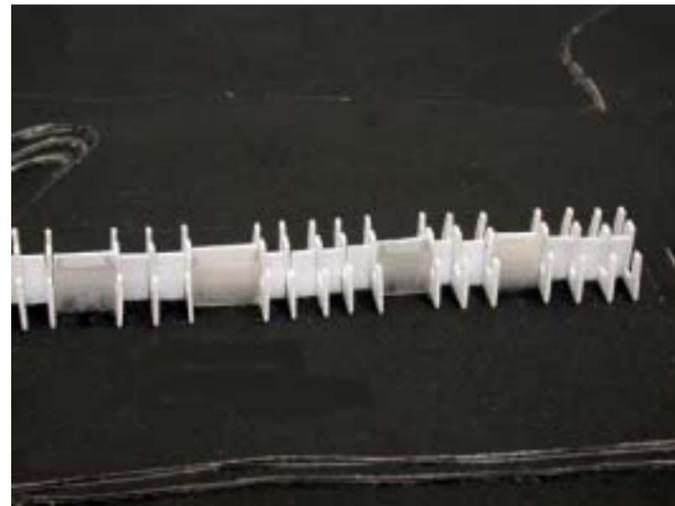
The term "life like" refers to situations in the building that are much like the living counterparts. The building must be able to "breathe" or ventilate. It also must have a "circulatory system" that allows HVAC duct work, electricity, and other utilities to be distributed around the interior.

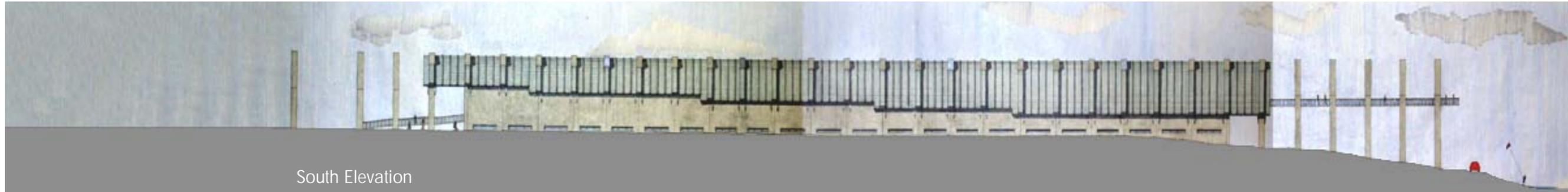




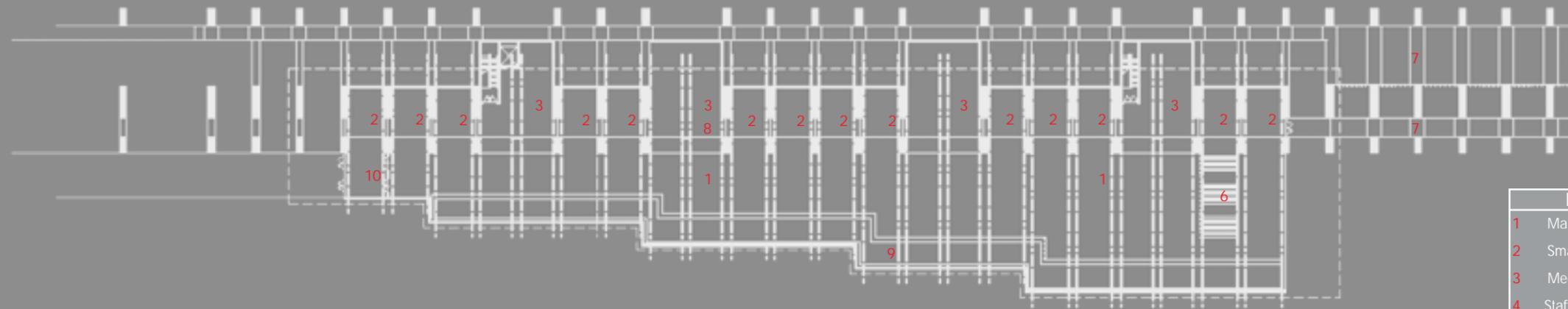
At this point it was important to see how the spine element would interact with the site. This model was the first that actually addressed this situation. The issue of how the building should react on both the north and south sides to create enclosure was still being considered so only the spine elements were used.

SITE The area already has several recreational areas (designated by ○) where people gather to enjoy various beach activities. The local government has provided roads that lead to these areas. It was important for the building not to encroach on the recreational areas or access roads. Part of the viewing experience from the overlook would be to enjoy a different view of people partaking in various beach activities.



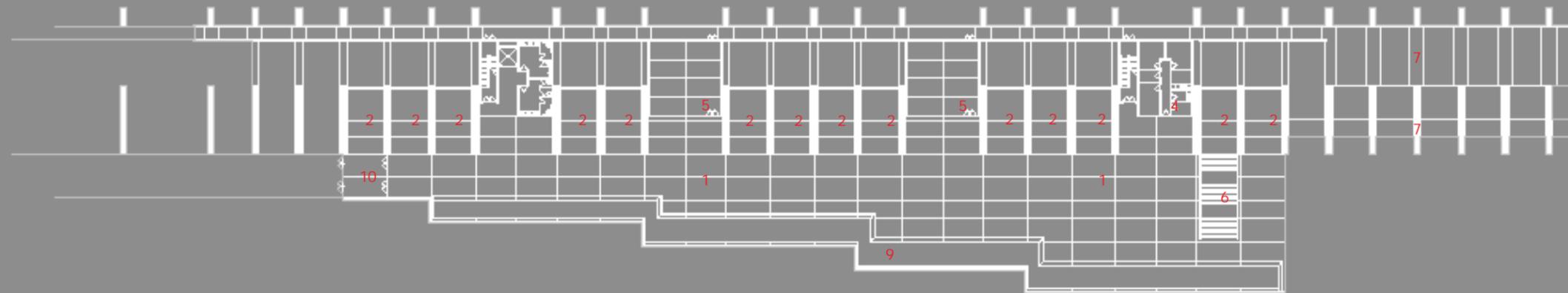


South Elevation

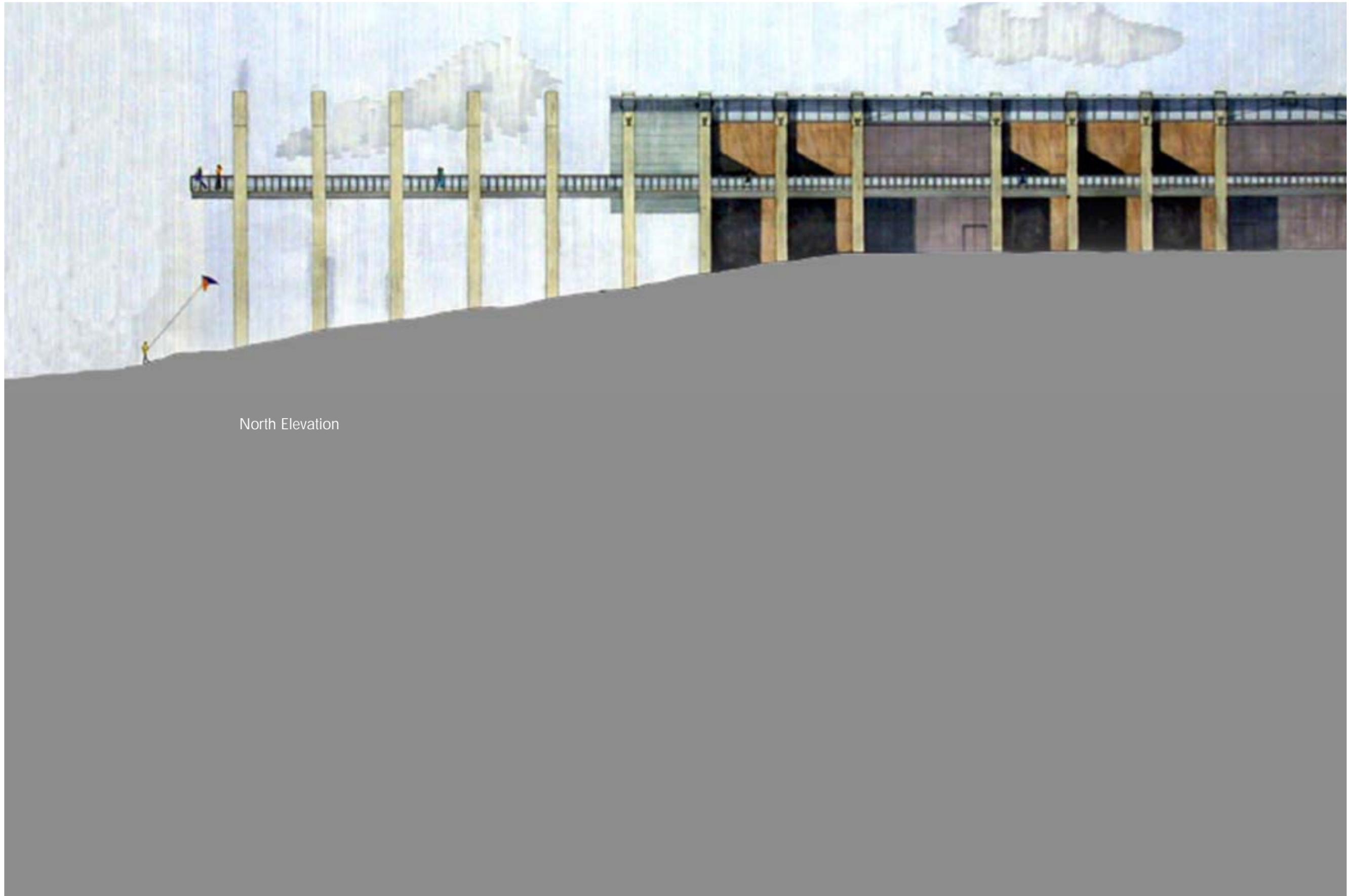


Second Floor

LEGEND	
1	Main Exhibit Hall
2	Small Exhibit Hall
3	Medium Exhibit Hall
4	Staff Offices
5	Mechanical Room
6	Interior Stair
7	Overlook
8	Second Floor Walkway
9	Reflection Pool
10	Entrance



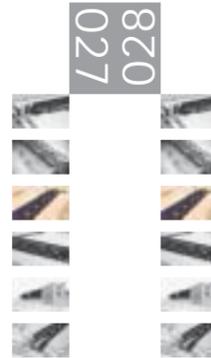
First Floor



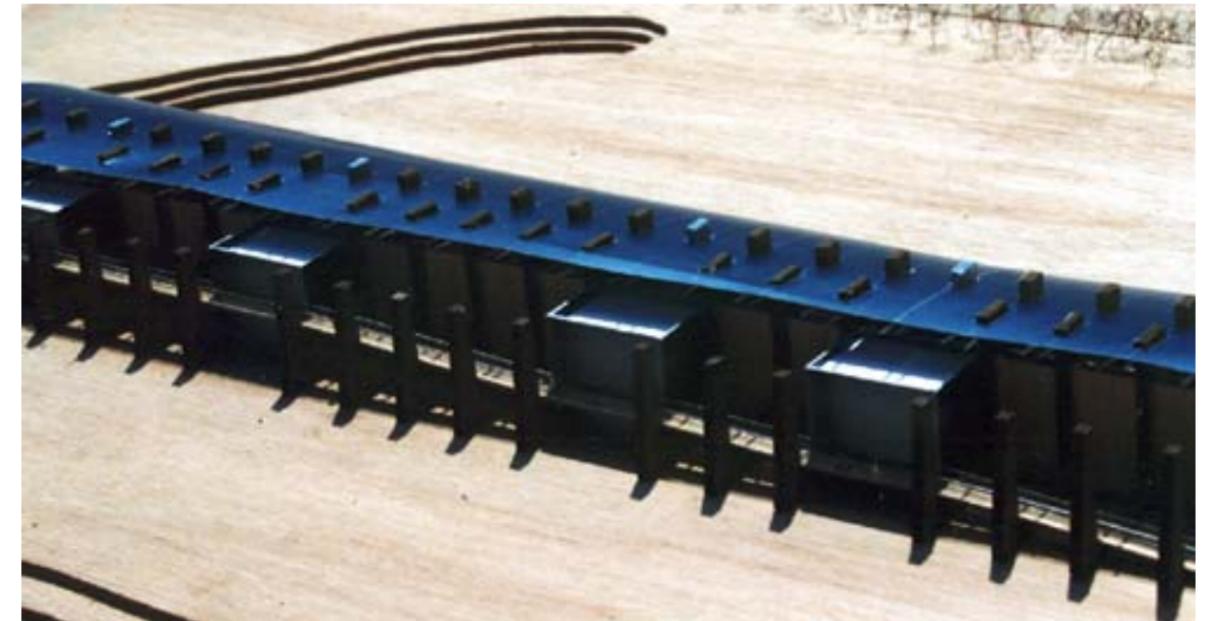
North Elevation



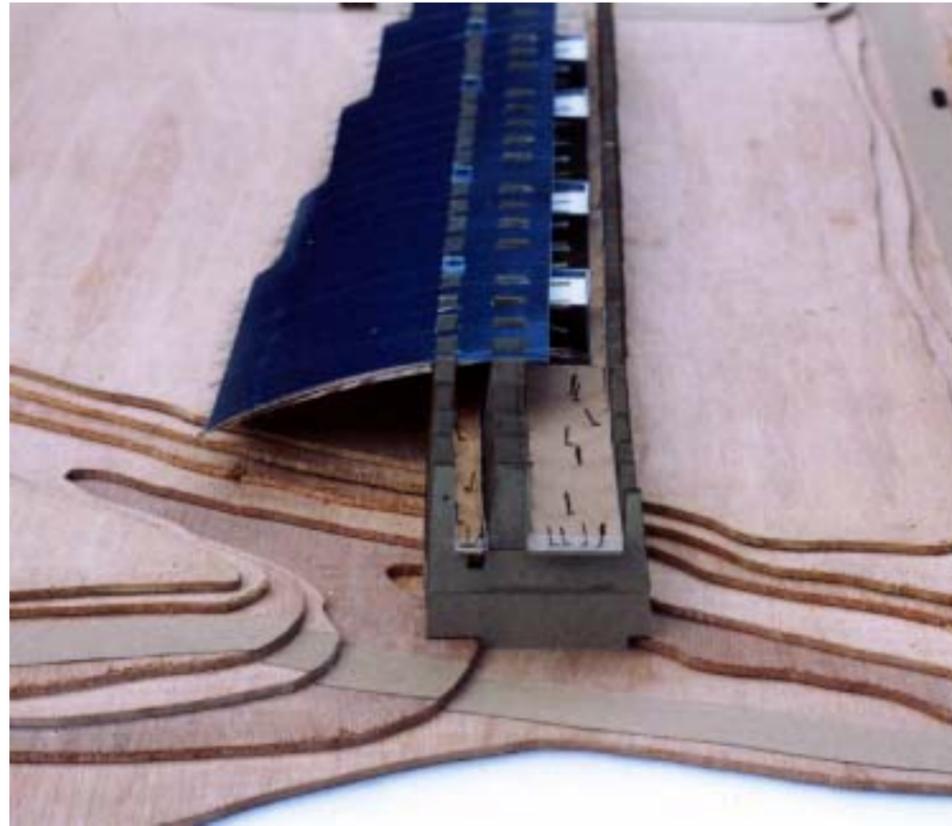
Exterior view of the overlook walkways.



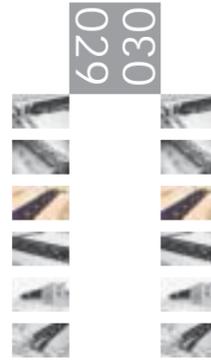
View of the "organs" on the north side of the building protected by the spine elements.



Northern view of building showing the exterior walkway and the "organs."



The overlook of the harbor.

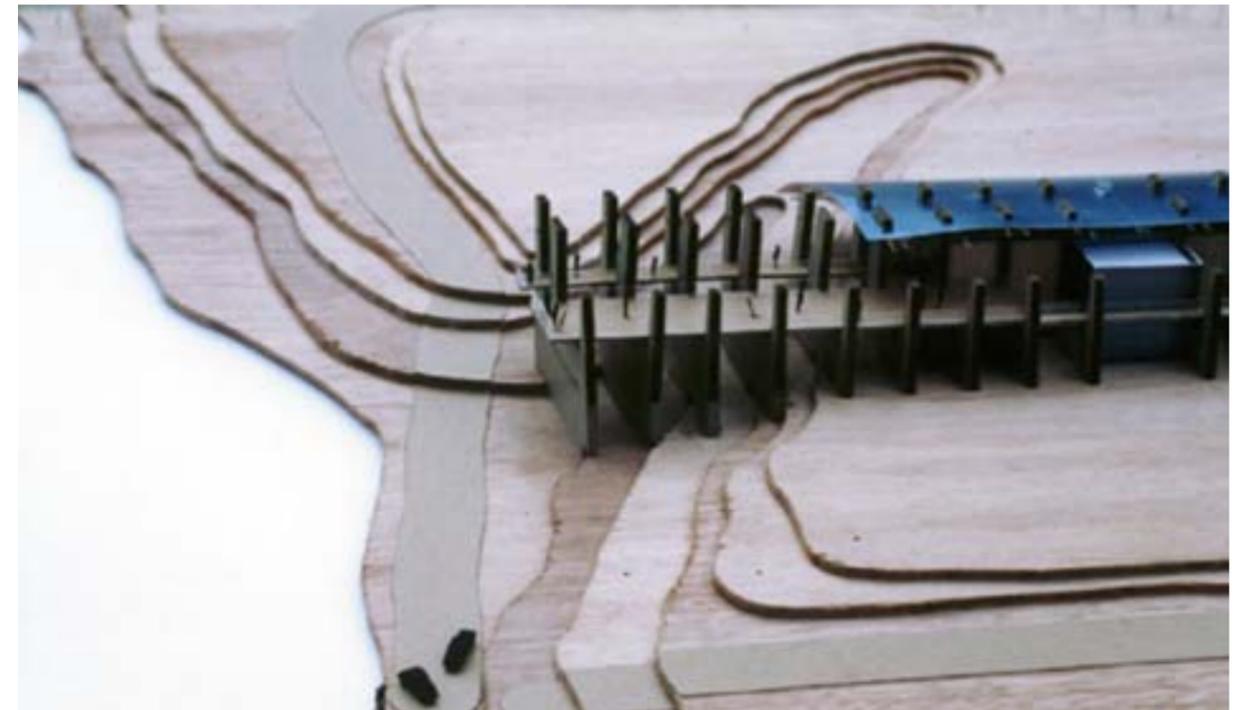


Interior view of the spine elements.

Eastern window that gives a view of the harbor which changes while moving along the interior stair.

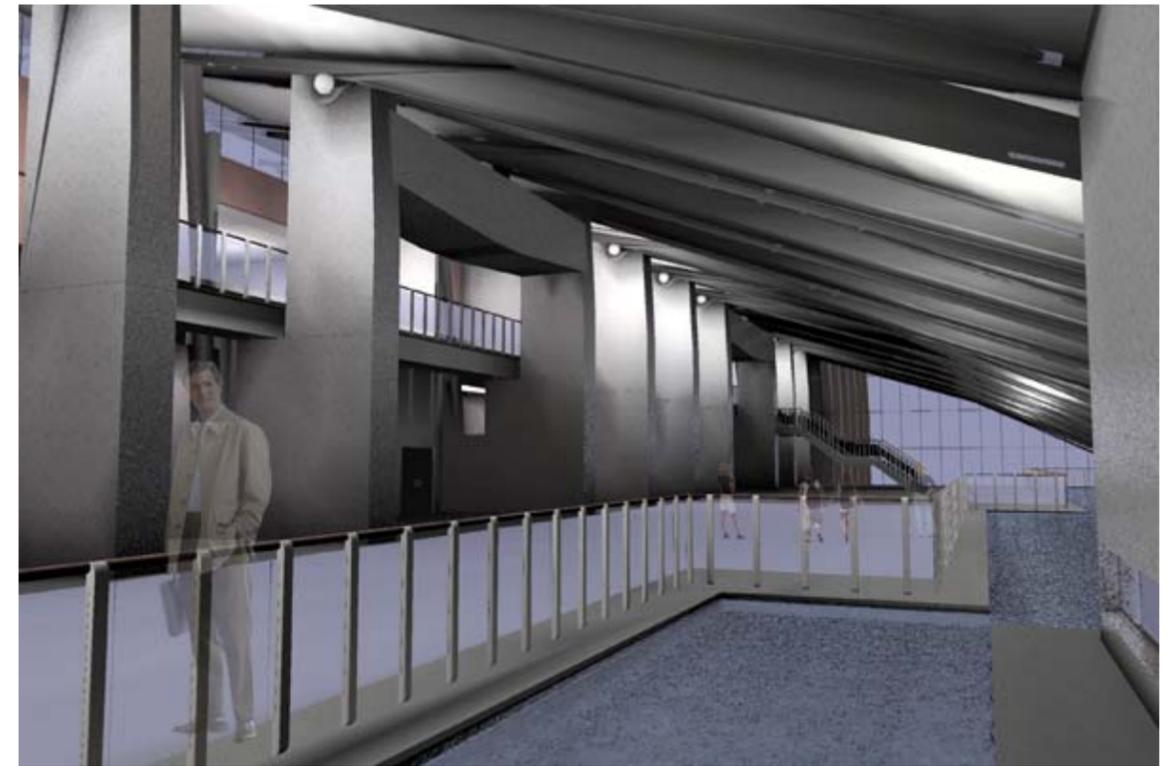
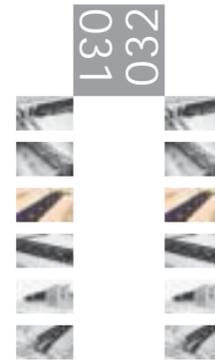


Spine elements and walkway in relation to the harbor and recreational areas.





An interior view looking down the second floor walkway at the transfer beam.

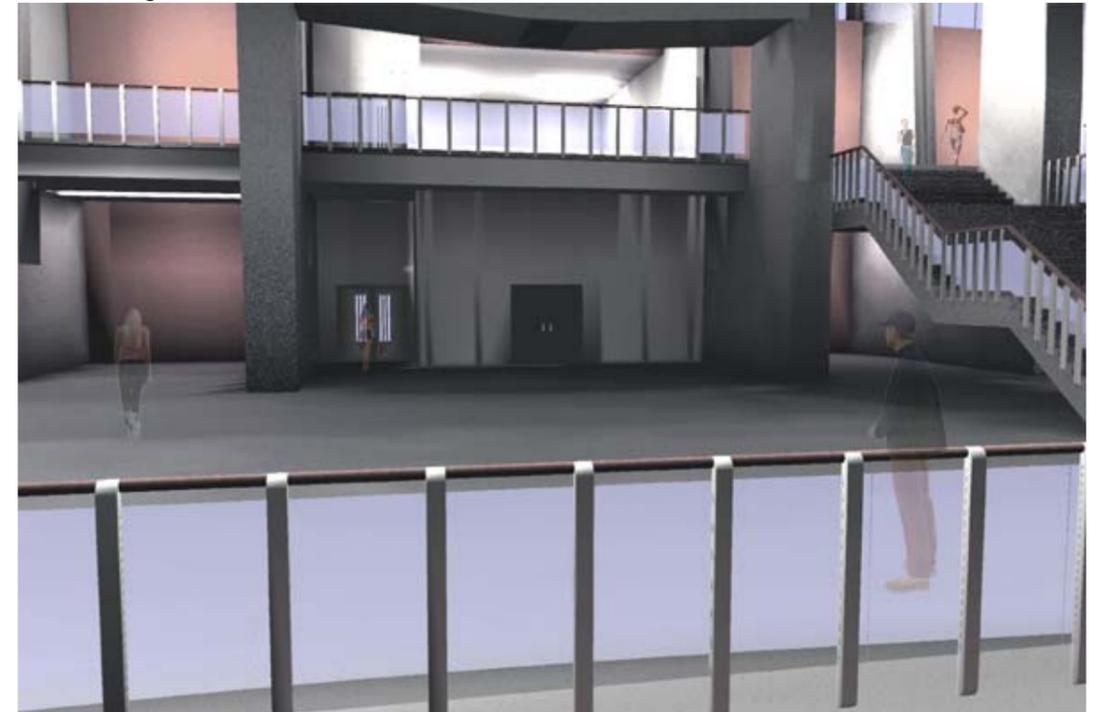


Interior view of the reflection pool.

The spine elements supporting the second floor walkway.



View showing the interior stair.



CONNECTIONS

The spine and rib structures of the building needed to be connected some way that not only fulfilled the zoomorphic ideals but that also performed the required function. Throughout the project, there were three critical connections which needed to be addressed. The most crucial was the actual connection of the rib element to the spine element. Secondary to this, but nonetheless important, were the connections at the northern and southern sides of the building.

Bone and Cartilage Composition of the Human Knee



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034

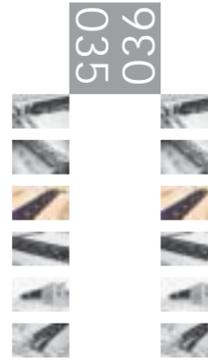


RIB TO SPINE

Attaching the rib element to the spine proposed some challenging questions. The concrete spine and the stainless steel rib were to be joined via a pin connection, but these two materials needed to be separated by a buffer to allow for the different expansion and contraction rates of each material.

Nature must address similar conditions within the skeletal system. Even though the skeleton does not utilize varying materials, the pieces can not function properly without cartilage between them. The cartilage provides the necessary elasticity between bones to prevent erosion from occurring.

In the project, the "cartilage" between the elements would be a semi-rigid plastic membrane that would allow the pieces to expand and contract but not to abrade one another. Each rib element could be temporarily supported while the pin was removed and a worn membrane replaced.

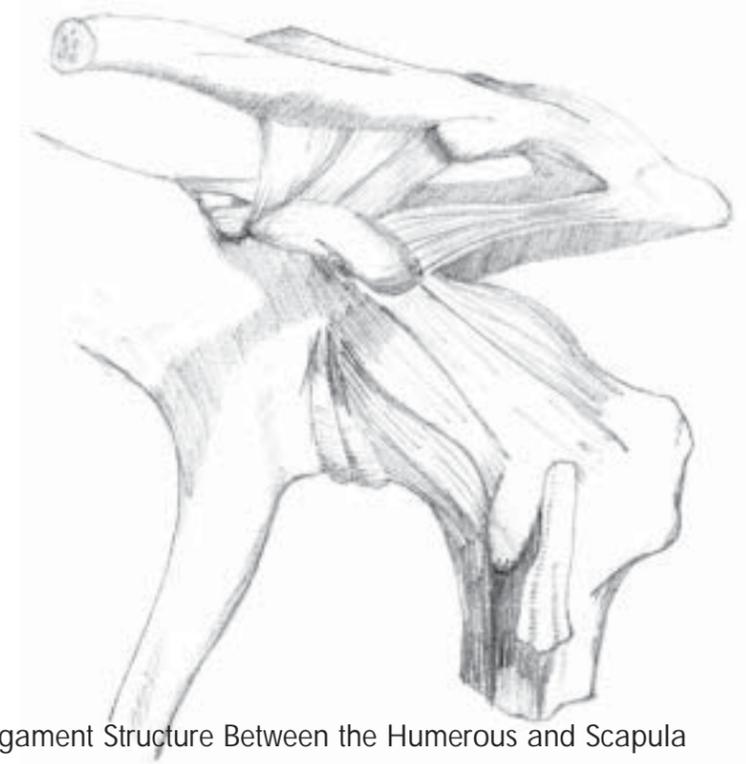
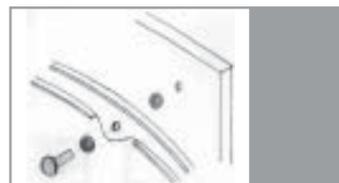
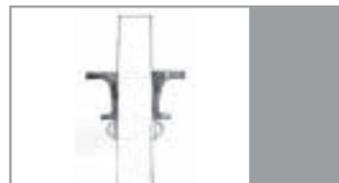
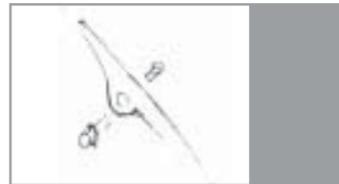
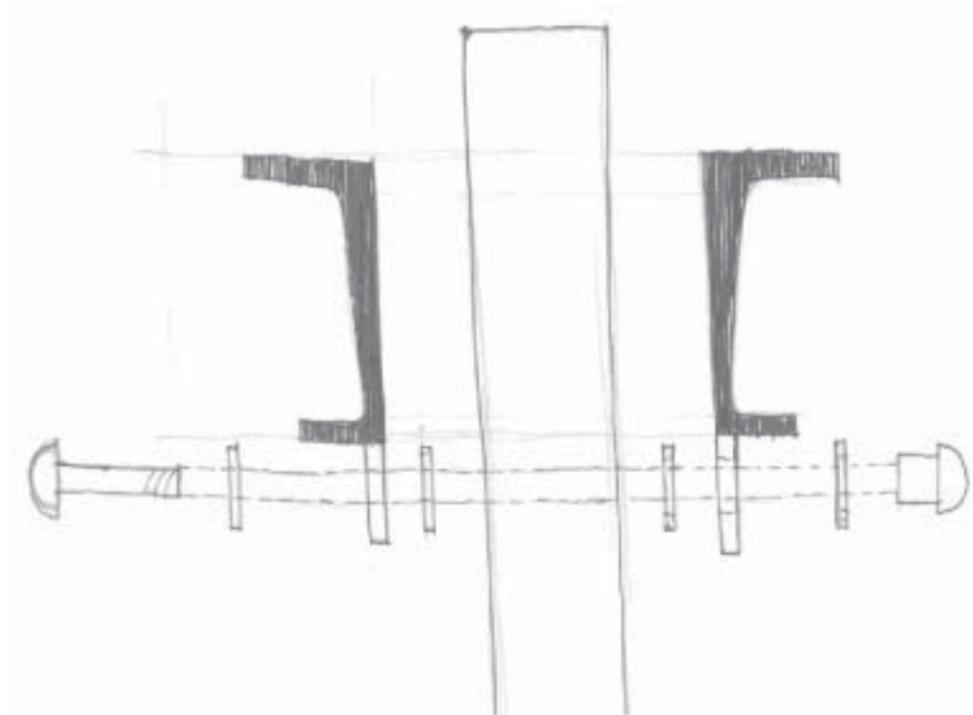


NORTHERN ELEVATION

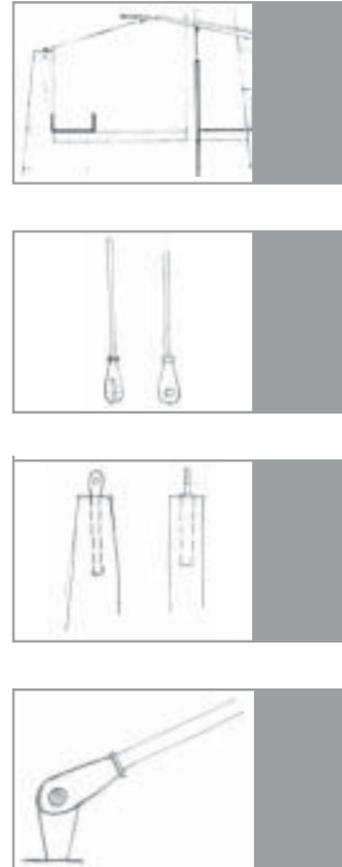
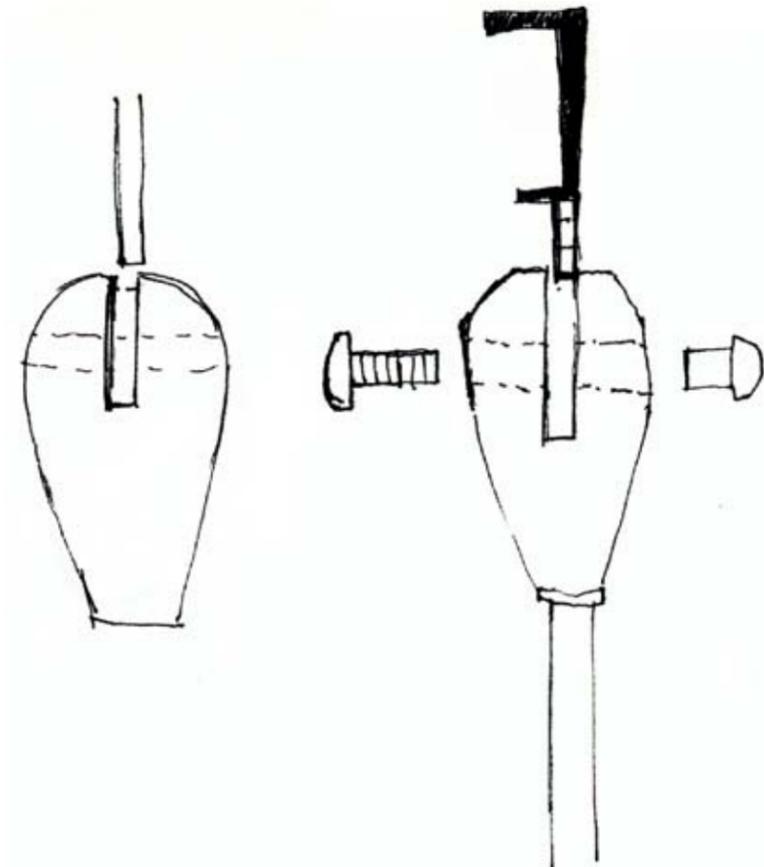
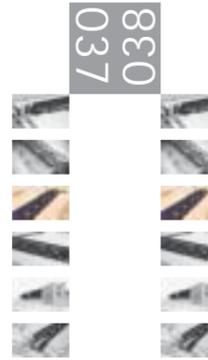
The rib needed a secondary connection to prevent it from rotating at the pin in the event of a hurricane or other high wind conditions. To solve this problem, a tension rod was used on the northern side of the building.

On the north side where it protrudes from the building, each rib has a flange to which the rod connects with a clevis and pin. At the northern portion of the spine a rod is embedded into the concrete and accepts the clevis connection for the opposite end of the tension rod.

The tension rod at the north side of the rib keeps it from rotating about the axis of the pin and also helps reduce the amount of weight that is placed upon the southern wall. This could be compared to how ligaments and tendons function in a body: they serve both as connection agents but also help to disperse the loads of the particular structural elements.



Ligament Structure Between the Humerous and Scapula



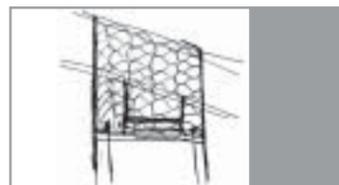
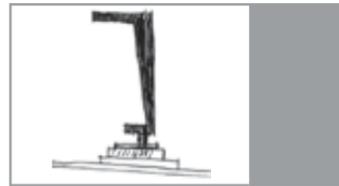
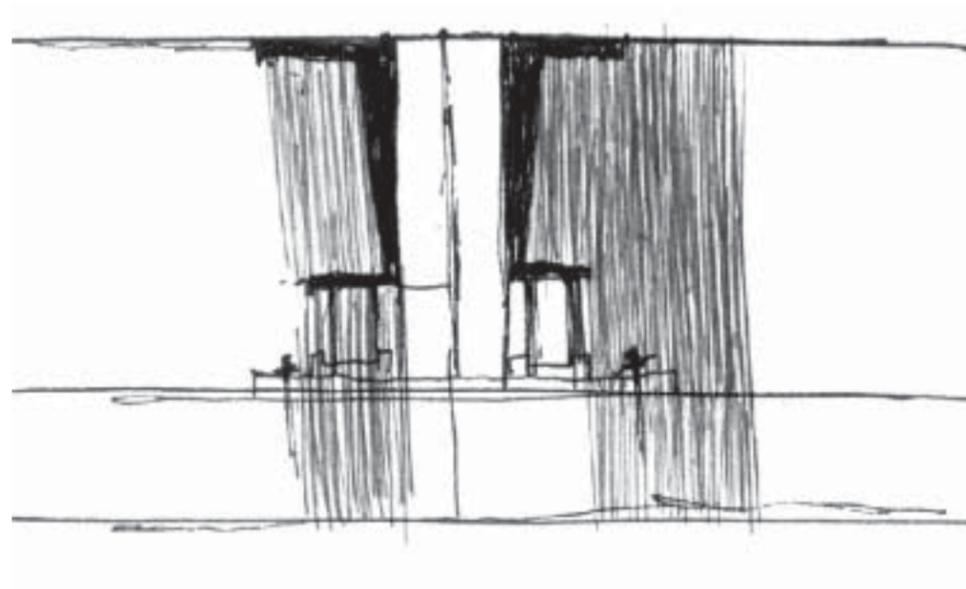
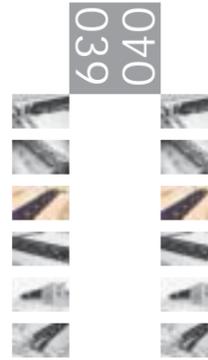
SOUTHERN ELEVATION

At the southern side of the building, the rib element rests against the top of the wall. The rib must be allowed to move in order to prevent buckling of the roof during expansion and contraction.

Where the rib rests, a plate is attached to the top of the wall with anchor bolts that are embedded into the concrete. The rib has a flange and plate combination attached to the bottom so that it can support the element at the wall. Between the plate and the flange plate; is a hard plastic membrane that provides a protective barrier between the two elements, acting as cartilage would in a body. The membrane prevents the two metal plates from continuously moving against one another. Although the movement in the rib pieces would be minimal, over time the pieces would erode away on one another. By using the "cartilage" membrane, the two pieces have no surface contact with one another. In the event the membrane become worn, the rib can be lifted gently and the membrane removed and replaced.



Cartilage Structure of the Elbow



TRANSFER BEAMS

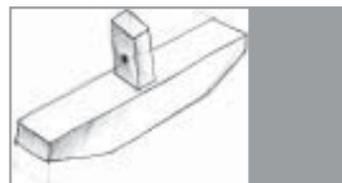
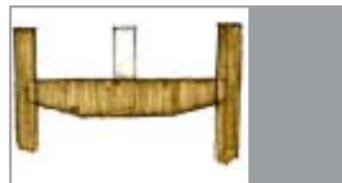
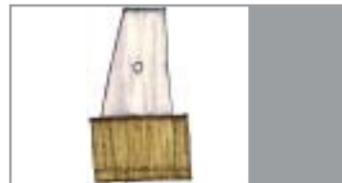
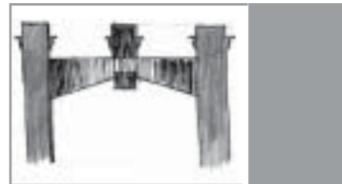
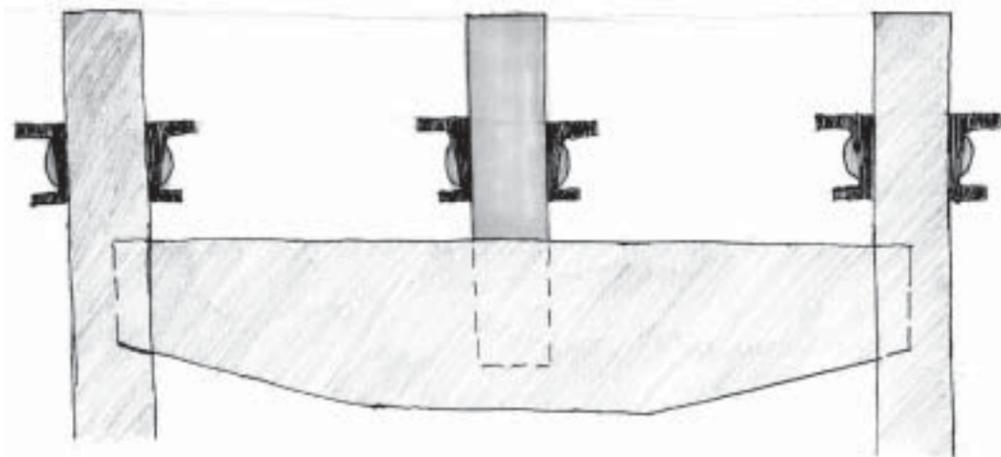
In order to allow for the thirty-two foot span where the four “organs” would reside, a transfer beam was needed to carry the load where the spine element was missing. The concrete transfer beam would hold a stainless steel spinal element to provide the rib members a place to connect. The piece made of stainless steel, is different in both material and shape. This is to denote that at this particular place in the structure that something different is happening. This is more important on the exterior of the building, because a viewer; though unable to see the actual structure of the spine and rib elements, would still be able to infer that this location is functionally different.

In a body, an area of increased loads requires the structure to become large to accommodate the increased pressure. For example, in the human spine the vertebrae become smaller as they descend towards the tail bone. In the building, the spine elements break the rule that “Mother Nature” has set forth. Instead of the spine elements becoming larger than the others, all of the spine elements were enlarged to the three foot wide section needed to carry the transfer beam. While this breaks the rules of nature, it is more feasible for construction in terms of time and cost.

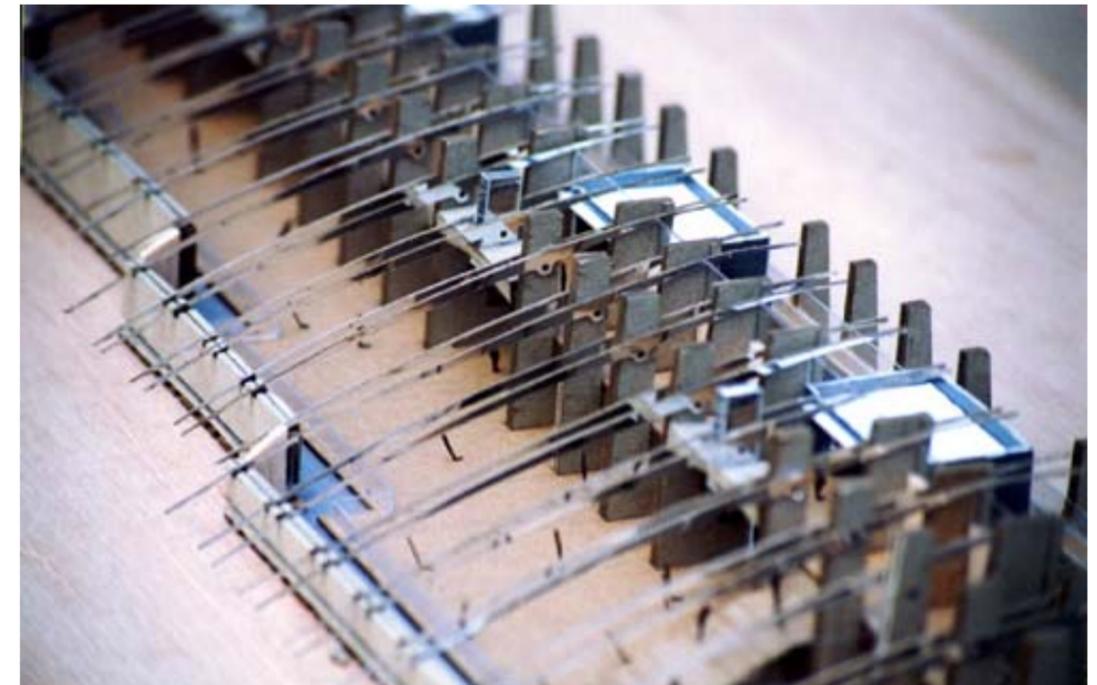
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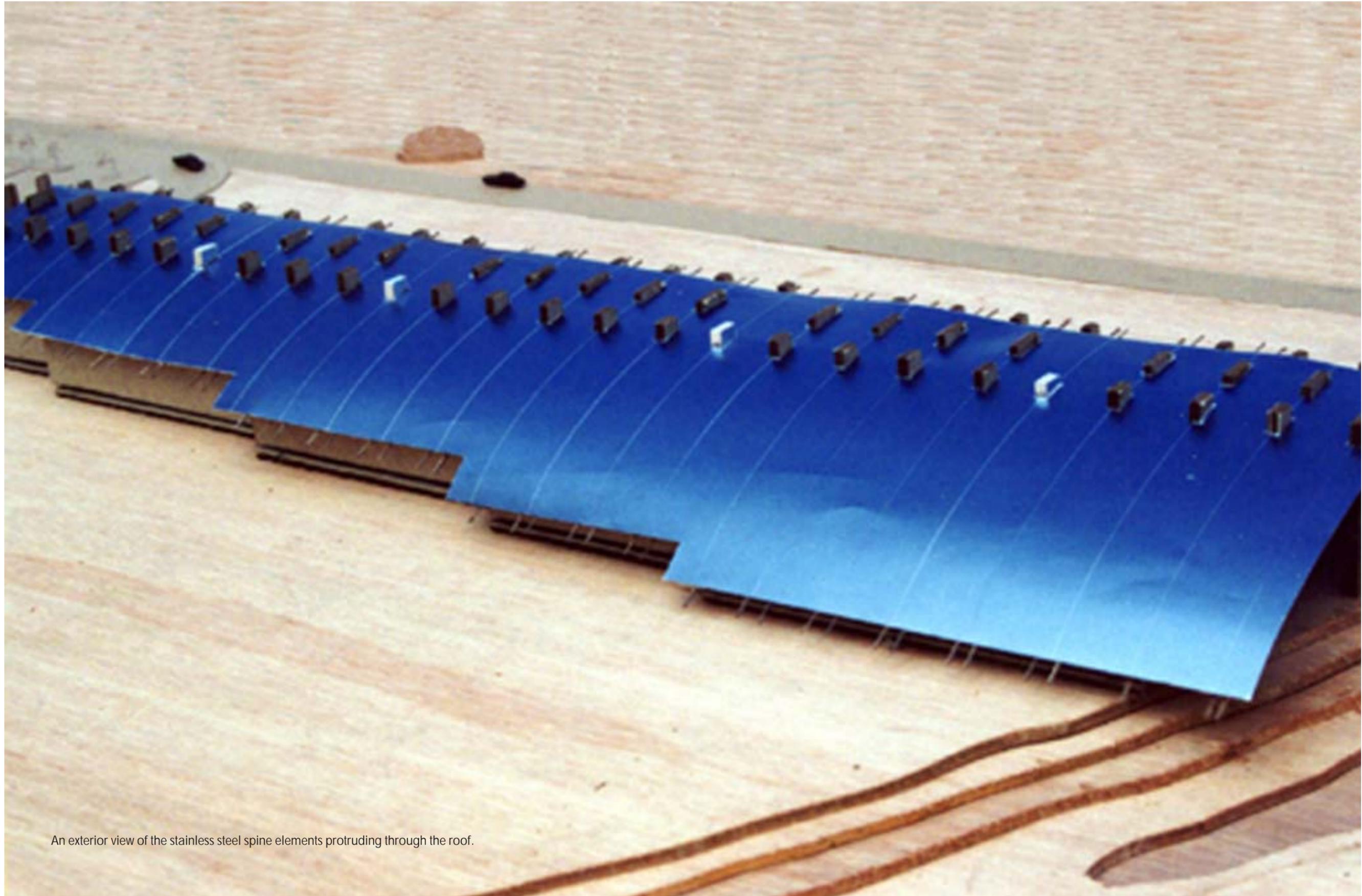


Interior perspective showing the transfer beam.

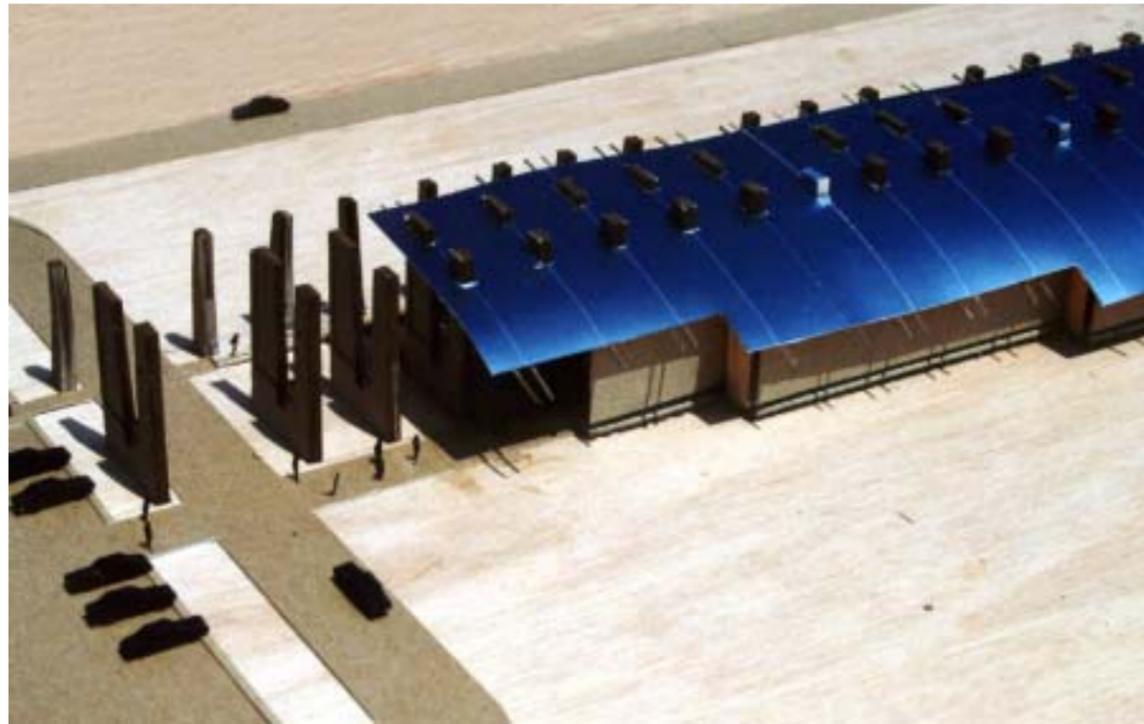
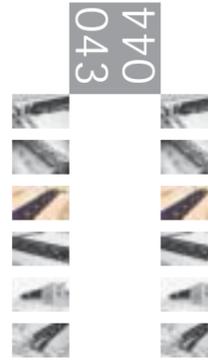


Model photo with the roof removed showing the transfer beam and spine element.





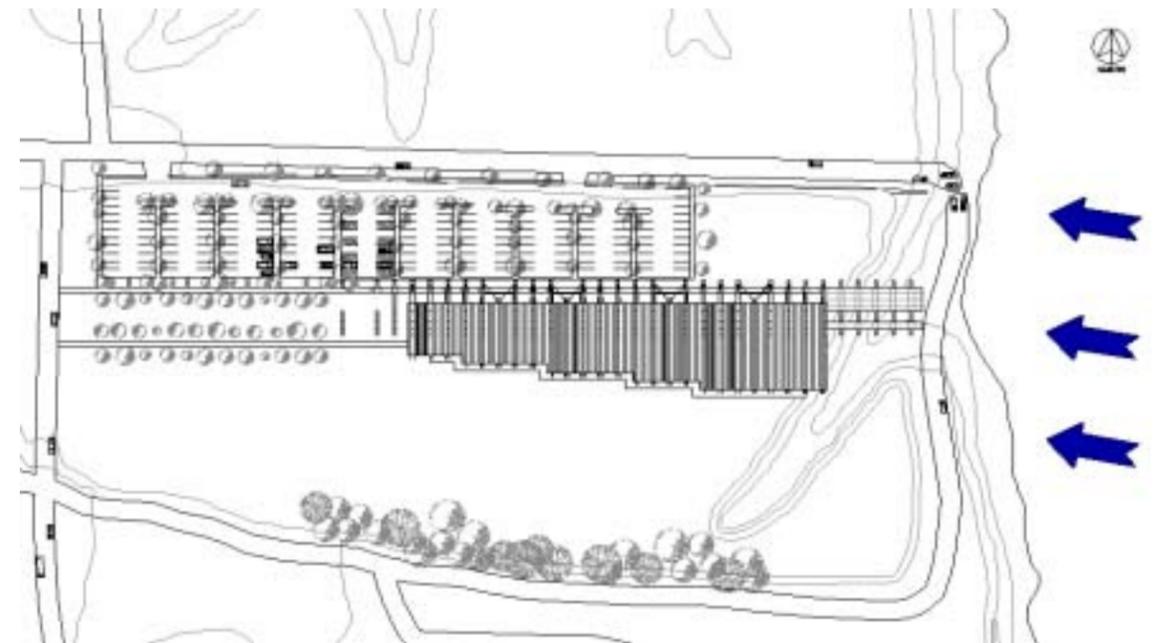
An exterior view of the stainless steel spine elements protruding through the roof.



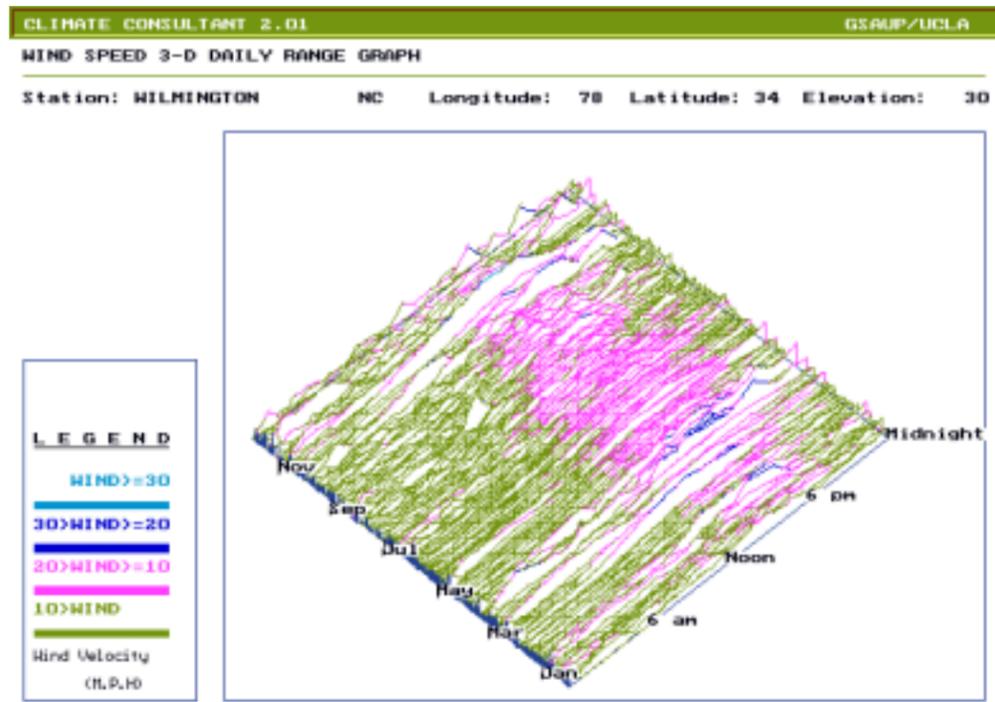
The spine elements at the entrance.

NATURAL VENTILATION

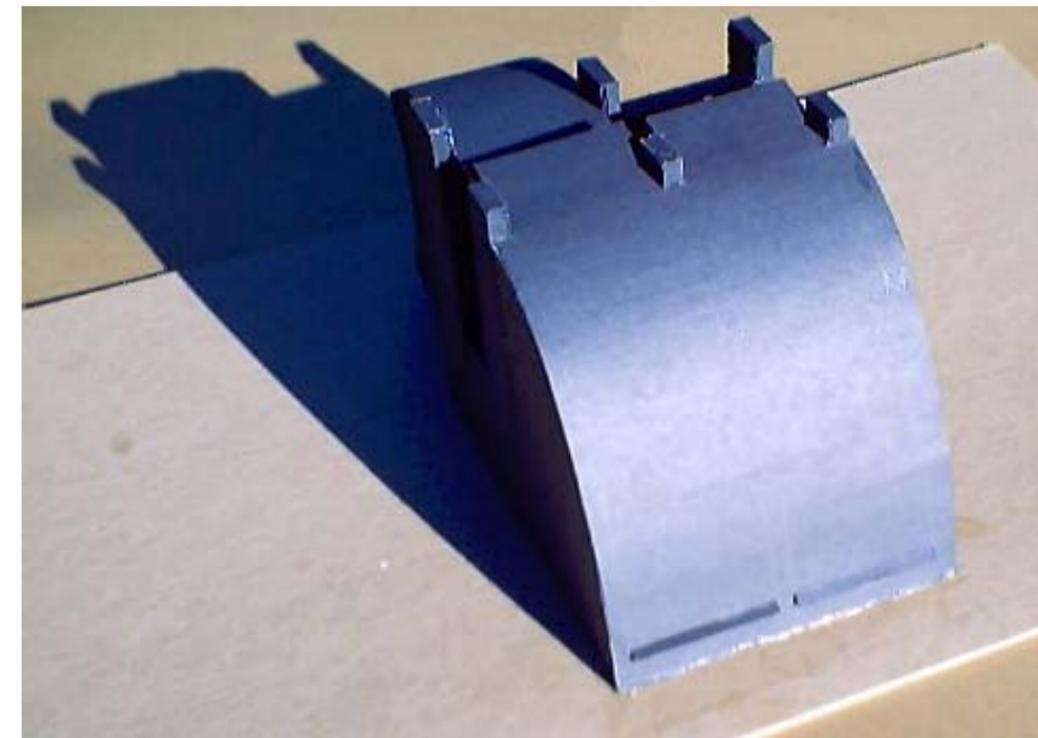
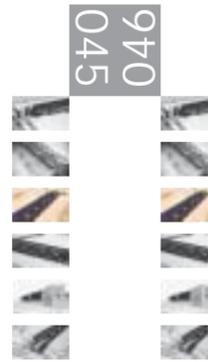
In Peru, North Carolina, the wind speed averages approximately ten miles per hour daily and moves in a north westerly direction. Between the hours of 12.00 pm and 8.00 pm, the average wind speed increases from eleven to thirty miles per hour. This increase in wind speed is most predominate from April to October. In light of this data, which was gathered from the computer program entitled "Climate Consultant," and since the wind moves across the harbor and is cooled by the water, this site is a prime candidate to incorporate natural ventilation into the building.



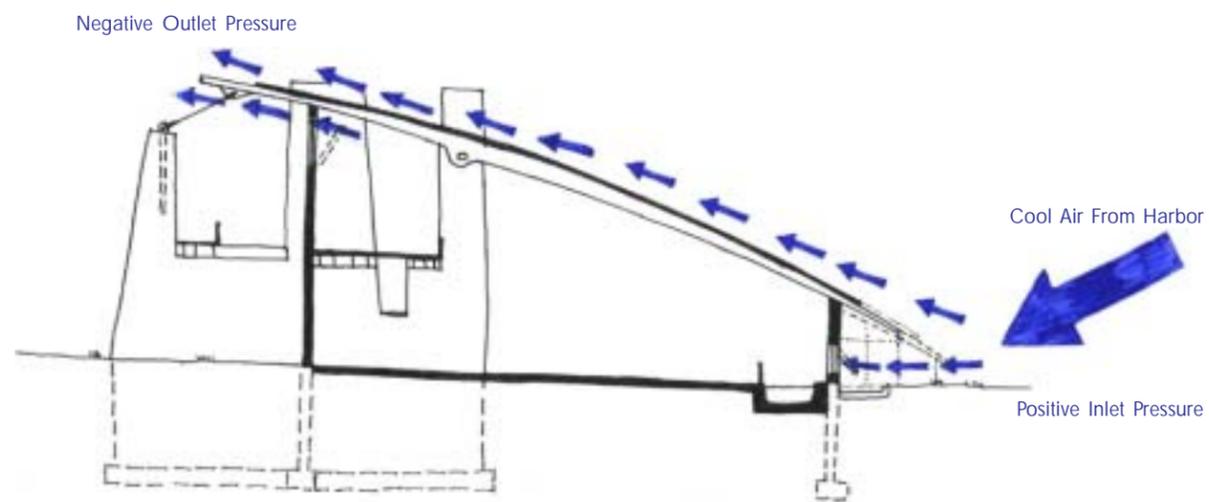
The Air Flow Moving Across the Harbor and Towards the Building



Climate Consultant wind speed data gathered for Wilmington, NC.



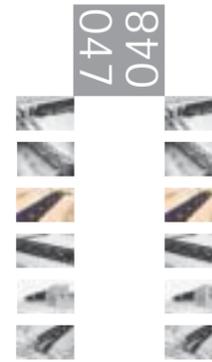
Model used to test the ventilation scheme of the building in the wind tunnel.



Sketch showing the Bournoulli effect on the building which creates natural ventilation.

The air flow was successfully tested in the wind tunnel.



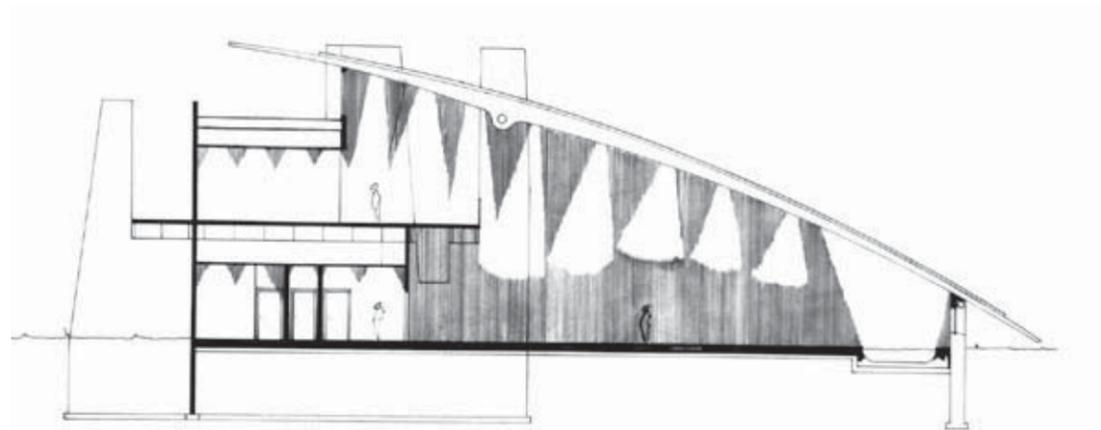


LIGHTING

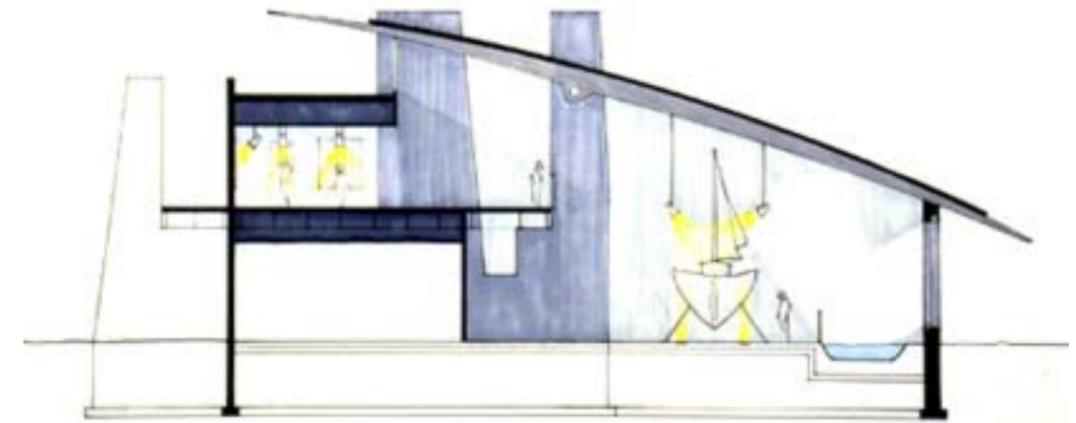
Throughout the project there was quite a bit of deliberation over the use of artificial light and natural light for illuminating the interior of the museum. Artificial light was the first to be explored. Different types of light were studied, as was how different light fixtures could impact the space. Exposed fixtures distracted from the structure within the space, while recessed fixtures did not disrupt the continuity of the structure. The interior pool was also explored for lighting options. Ambient, direct, and up lighting methods were studied.

Natural light was then studied in many different ways. Skylight and window schemes were explored to illuminate the space. The sloping roof over the main exhibit hall is oriented south, so measures needed to be taken to insure that the space did not overheat from the sun's penetration. The northern facade could be used to allow less harmful, indirect lighting into the space. The interior pool could serve as a light reflection element on the southern side, directing light onto the ceiling surface.

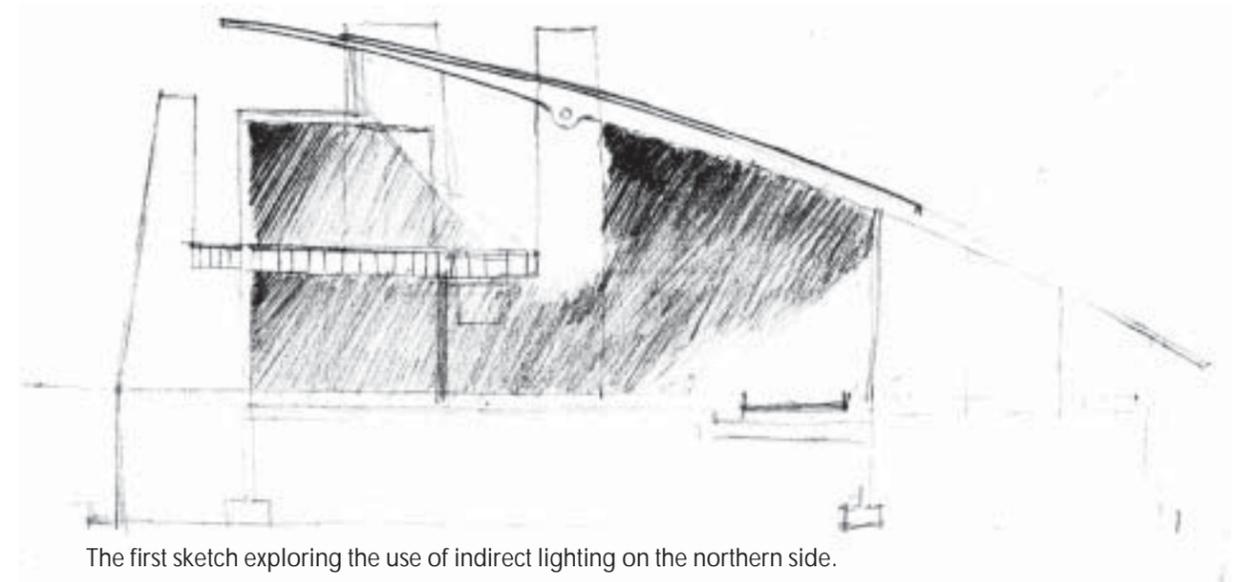
The final scheme was to utilize natural light throughout the day and then supplement artificial light into the space at night through recessed fixtures.



A sketch showing the use of recessed lighting fixtures.

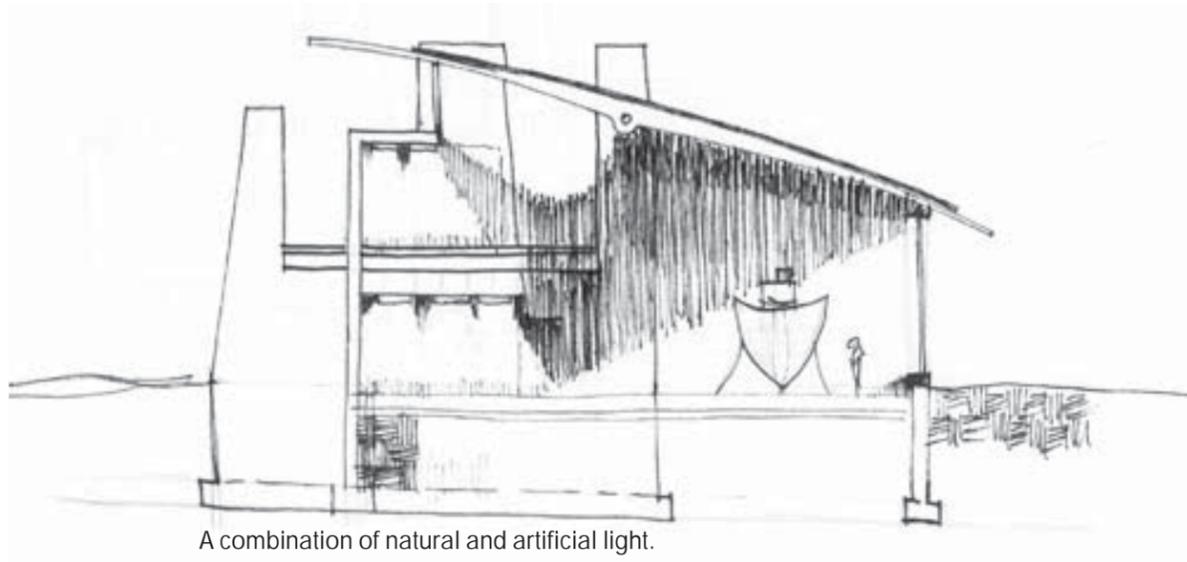


An early sketch showing the impact of exposed fixtures in the space.

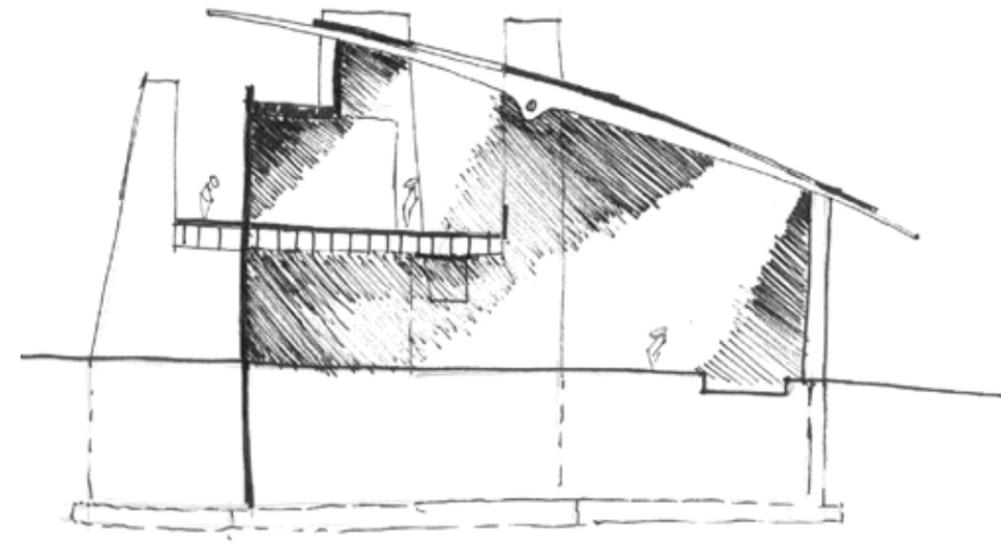


The first sketch exploring the use of indirect lighting on the northern side.

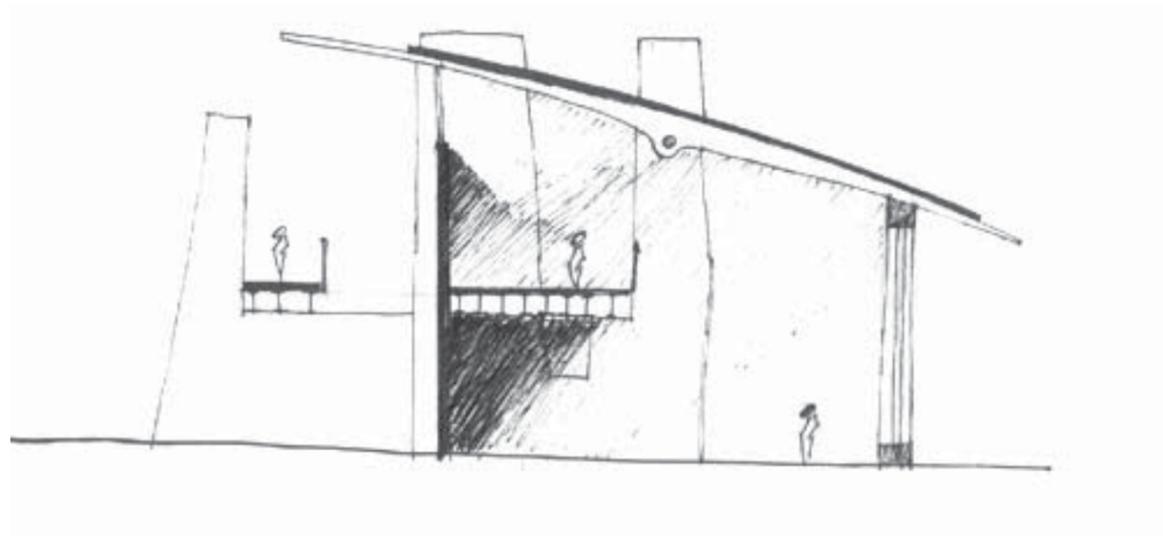
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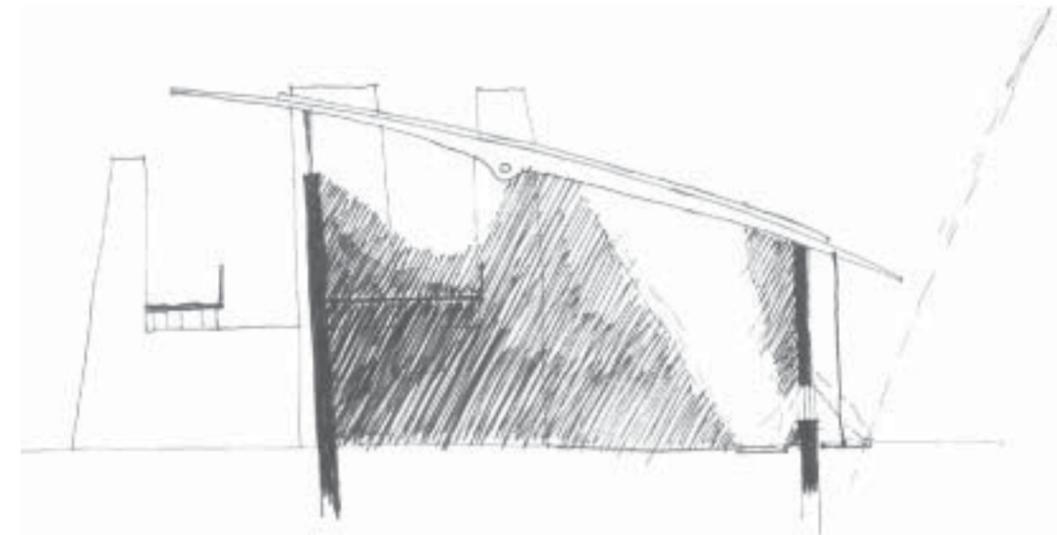
A combination of natural and artificial light.



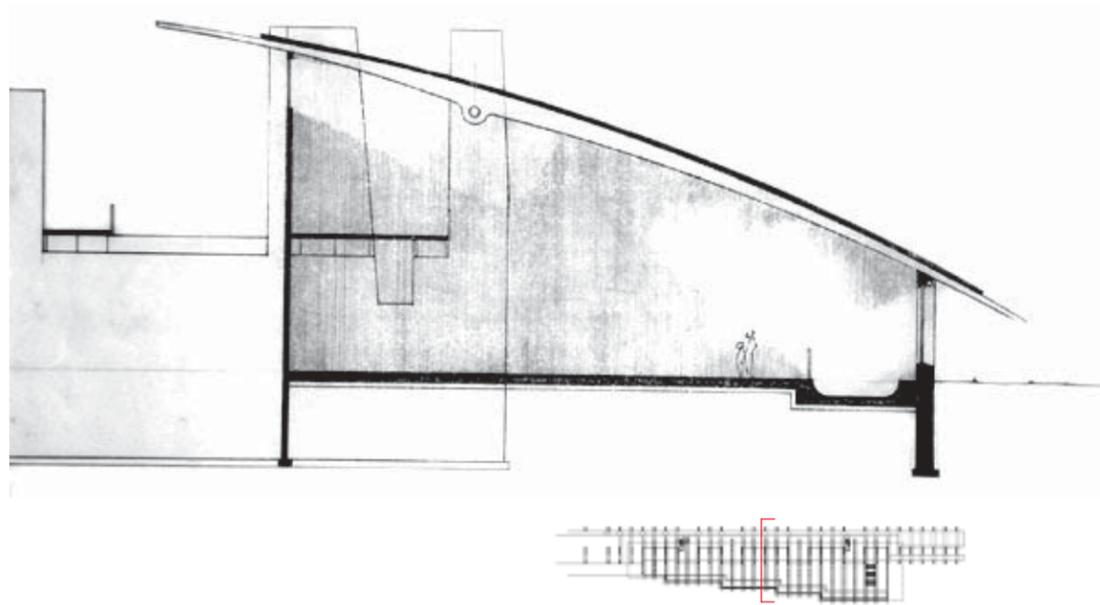
An exploration of a dual sky light system.



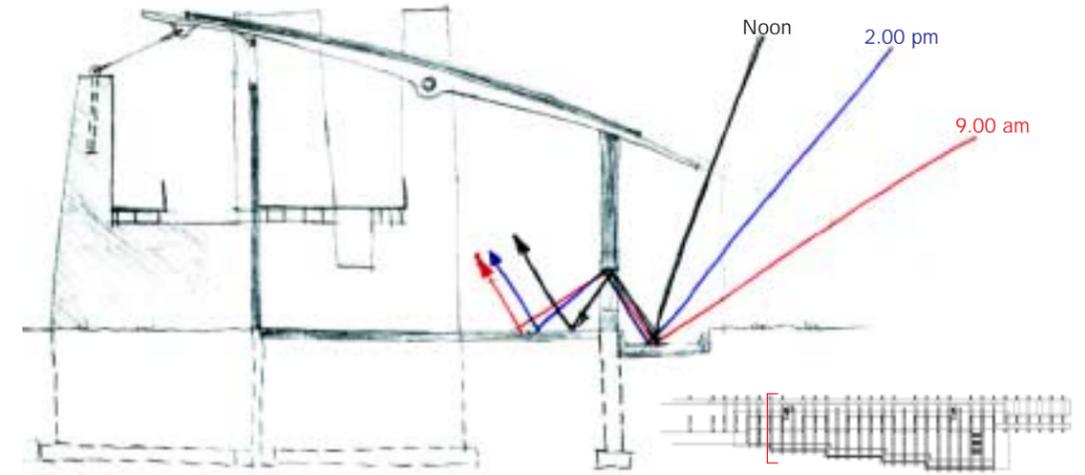
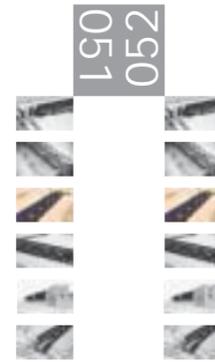
The impact of the light from a large southern facing window.



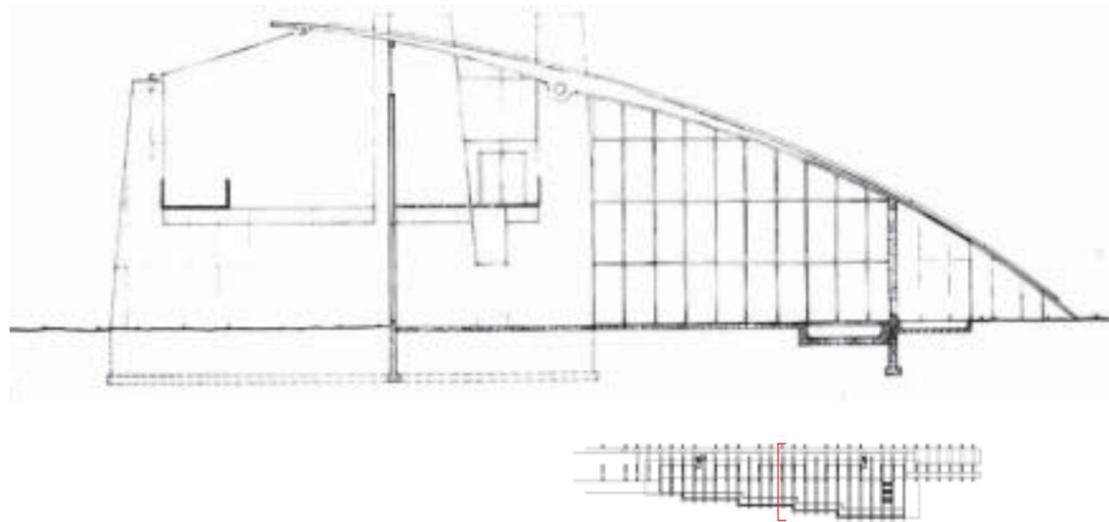
Conceptual sketch illustrating how light could be reflected into the space.



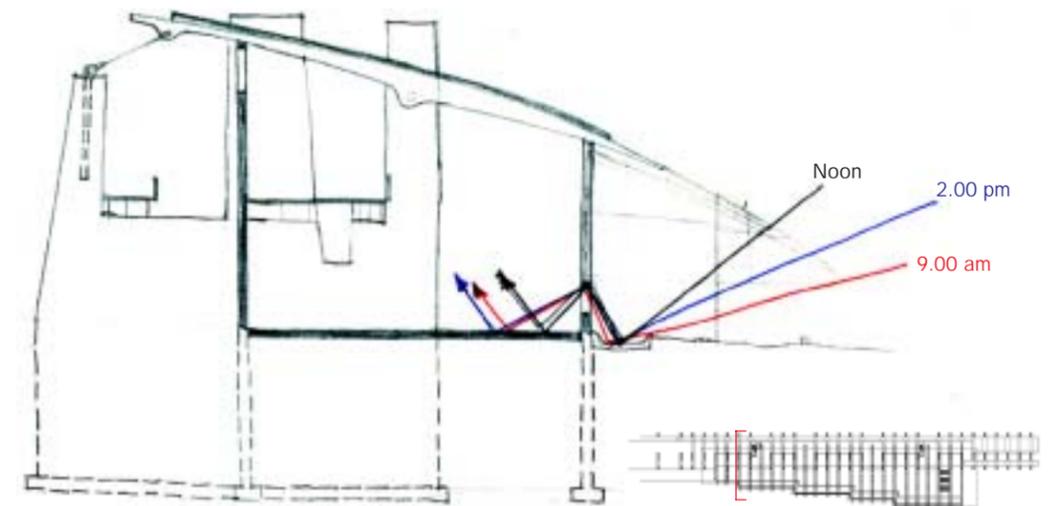
The impact of light through a large south facing window.



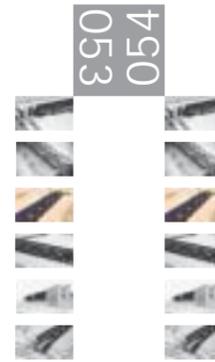
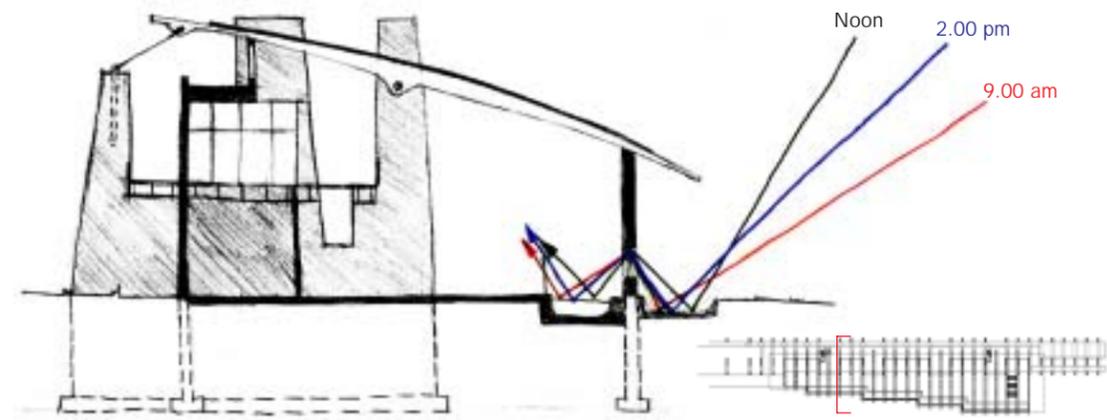
The light effects at varying times of day for the summer months at the twenty foot section.



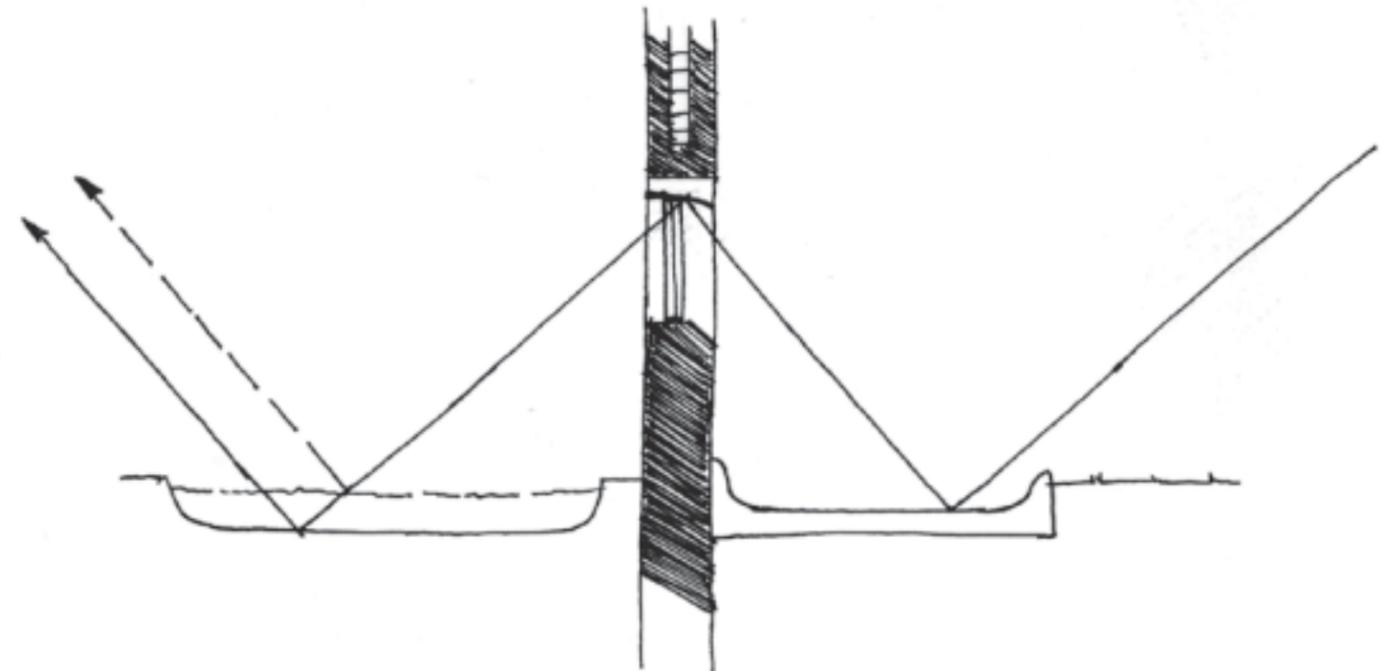
Section of the southern side and the reflection of light through two foot window.



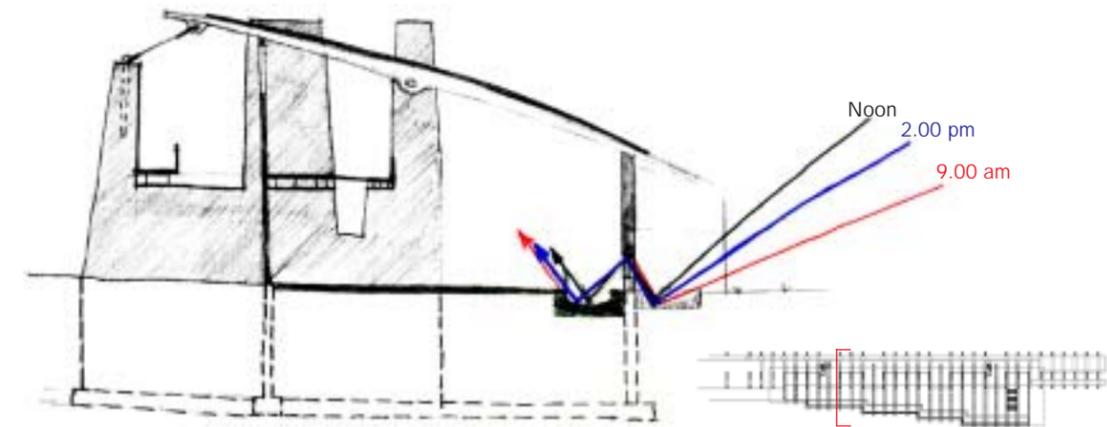
The light effects at varying times of day for the winter months at the twenty foot section.



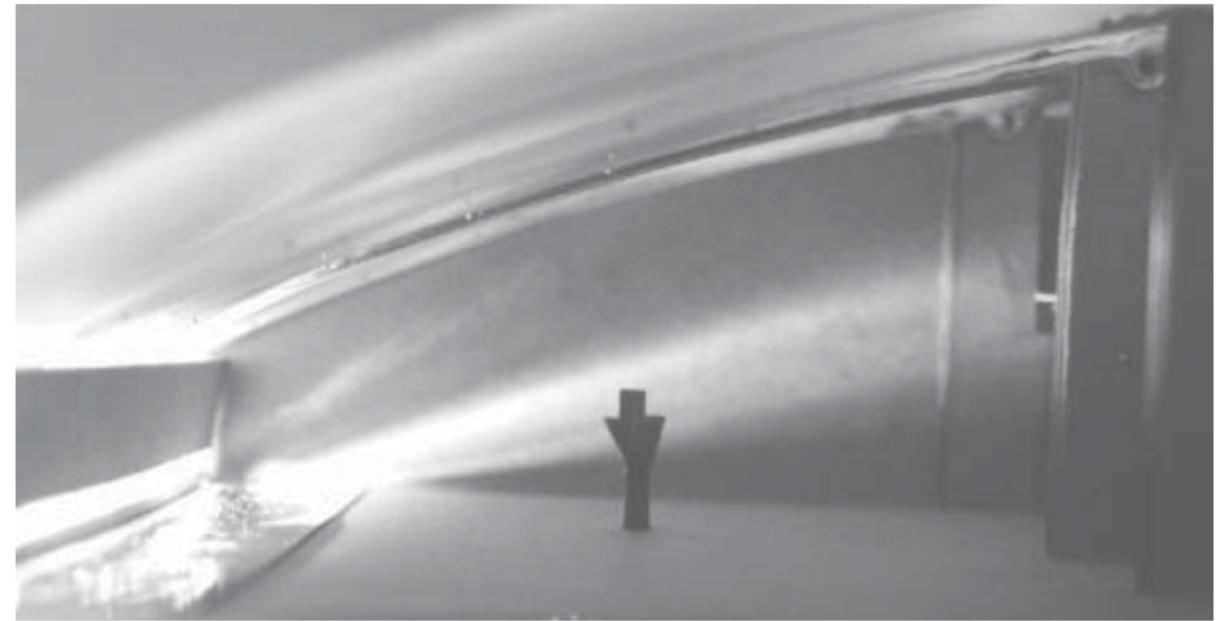
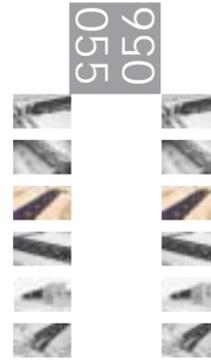
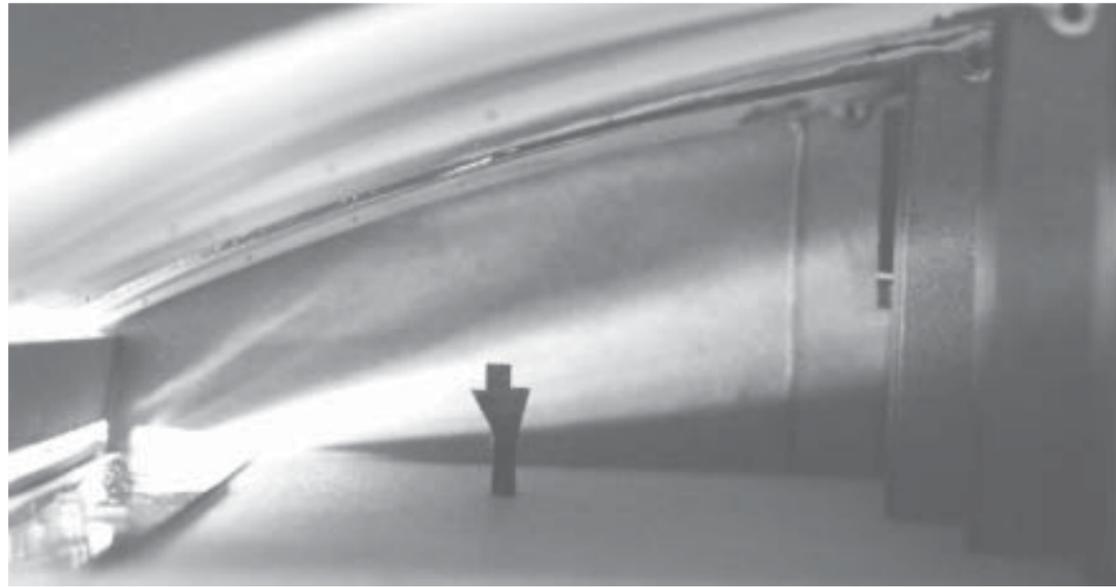
The light effects at varying times of day for the summer months at the thirty foot section.



A drawing of the reflection scheme for interior daylighting.

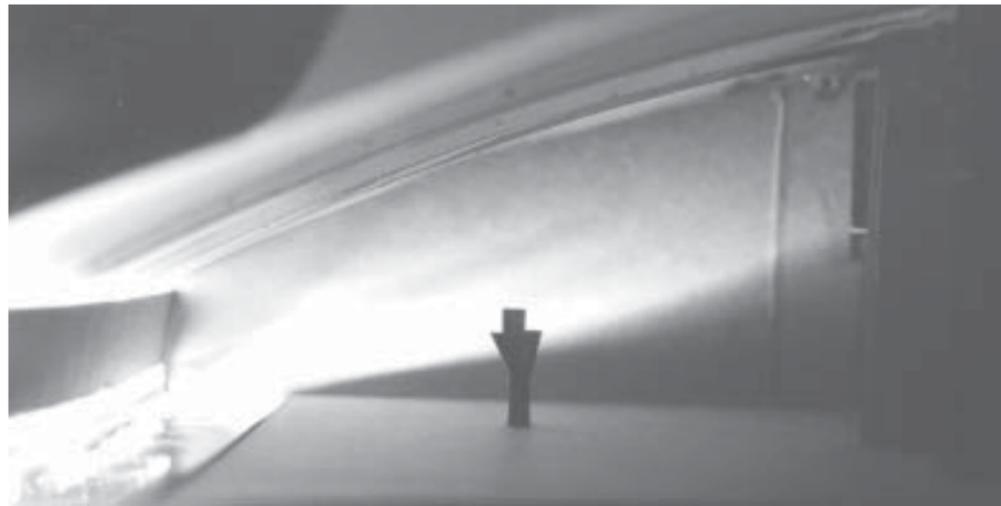


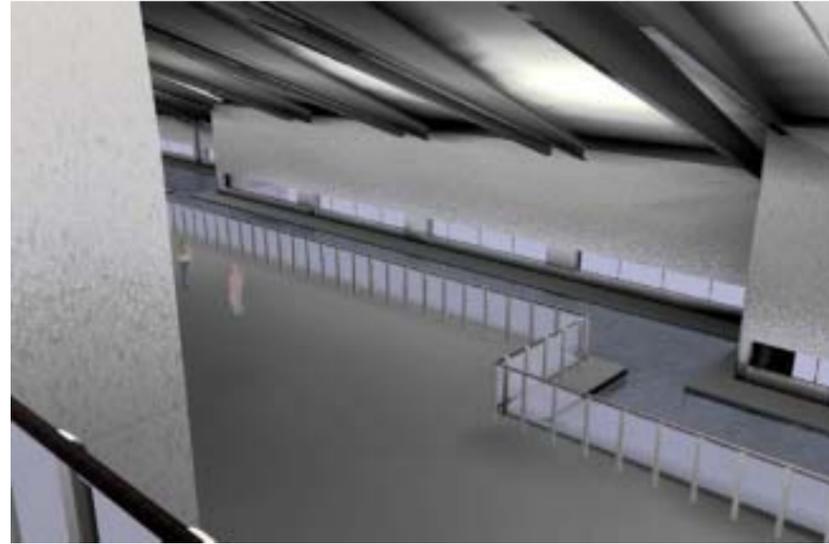
The light effects at varying times of day for the winter months at the thirty foot section.



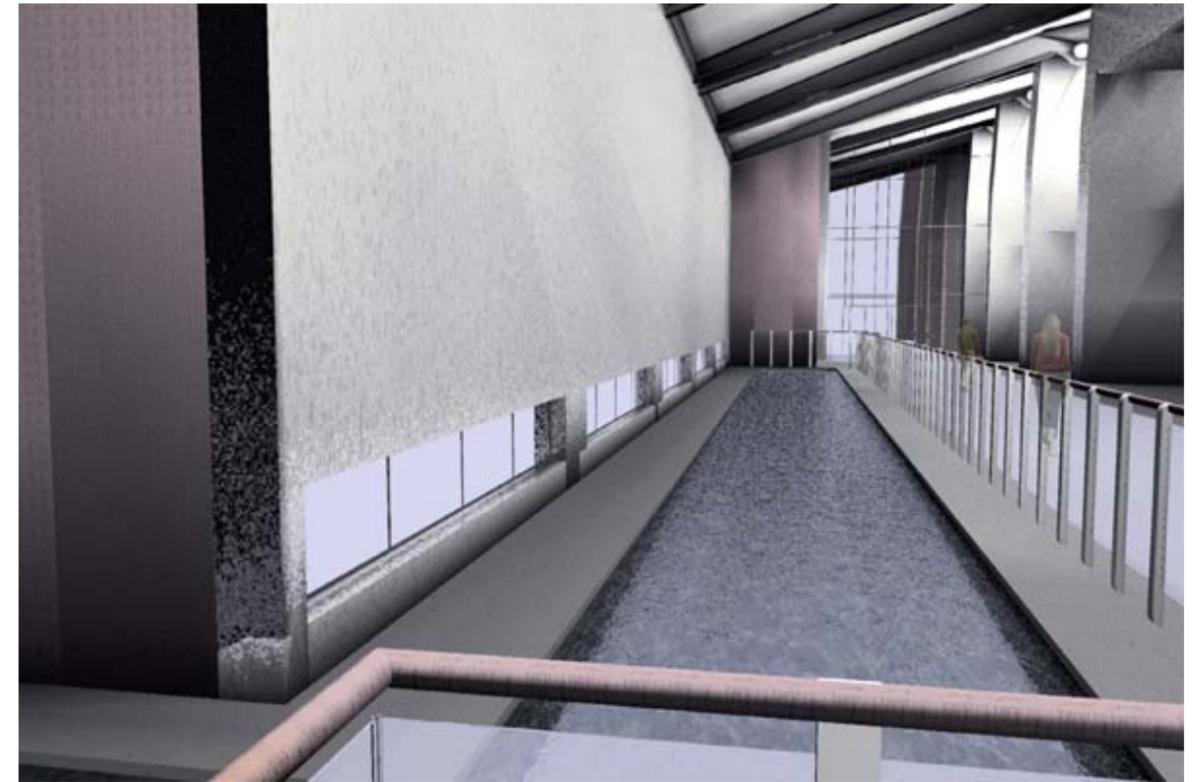
Light study model exploring the reflection scheme.

Light study model exploring the reflection scheme.





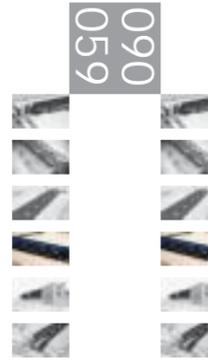
Interior rendering looking at the reflection pool from the second floor walkway.



Perspective looking west.

Perspective looking east.





“It is one thing... to apprehend directly an image as an image, and another thing to shape ideas regarding the nature of images in general.”

-Jean Paul Sartre, *Imagination*

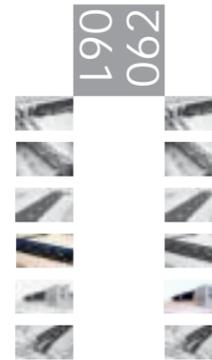
ARCHITECTURAL DISCOVERIES

Zoomorphism and anthropomorphism can have varying levels of complexity. Looking at Michael Sorkin's work one can see perhaps the crudest of these levels. Sorkin is merely using the outside appearance as the basis for his projects. This approach is not “wrong,” but lacks the complexity and substance that architects like Piano and Calatrava bring into their own work. There is much more to the genetic make up of a person or animal than what is visible to the eye. The body is a miraculous entity of various structural elements such as bones, cartilage, ligaments, and tendons combined with an even more vast array of systems which enable a being to live.

An understanding of what comprises the “body” can lead to an even greater complexity in architecture. A layman might categorize the body as “skin and bones,” but in reality there is much more to the picture. Architecture is much like the body. Many people see a building as simply what is on the inside and what is on the outside. Few people, architects included, can appreciate or more importantly understand all of the necessary elements that make buildings into the places suitable for habitation.

There is also a down side to zoomorphism and anthropomorphism. A body has different levels of stress and pressure at various places. “Mother Nature” has derived her own systematic formulae for dealing with these variances. In areas that carry a minimal load, the structure of the body becomes lighter. For areas under heavier loads, the structure increases to handle the higher stresses. In architecture, following these guidelines is not always feasible.

An architect must understand that construction must be cost and time efficient. It is not economical to have too rich a variety of pieces for construction, from both a fabrication and an installation standpoint. Specialized pieces require a greater number of man hours to produce. For instance, each piece must be cut or formed. Installation also requires more time since pieces are designated for specific areas. A worker is no longer able to simply pick up a piece and install it. The worker must first consult the drawings to see what piece goes in a specific area, then find the piece and install it. A project that could financially afford these individualized pieces would be more true to the zoomorphic or anthropomorphic philosophy. However, with the cost of construction today and the immense pressure for buildings to be built as quickly as possible, an architect must strike a balance between the philosophical goals of the project and what can be produced in a cost and time efficient manner.



There are many variables that contribute to the triumph or defeat of a space. Material choice is probably the most crucial. Material texture and color provide the general atmosphere for the room. Another critical variable is lighting. The type and intensity of light and the fixtures or apertures make a direct impact on how the space is perceived.

However other senses need to be acknowledged in architecture. The majority of architects tend to focus only on the visual but there can be much more to the experience. Sound can become a powerful influence on a space though. There are many sounds that could help to make the transition from space to experience, such as the flow of water, the sounds of the wind, and simply the sound rain makes as it falls on the roof.

Touch and smell are equally as important. The visual beauty of a space is non-existent to people with visual impairments. However, their sense of hearing and smell need to be stimulated just as much as a sighted person's eyes.

An architect must take advantage of every opportunity to make an exciting place for as many different people as possible.

When I design a dwelling ... I confess ... it seems that my body is playing its part in the game.

-Paul Valery



CONCLUSION

Anthropomorphism and zoomorphism were the groundwork for this project. Unfortunately, there are not a lot of articles or books published on the subject. Throughout the course of the project I was forced to make interpretations and decisions about the two based on my own judgement and experience.

The most crucial was knowing when to break the rules set forth by the philosophy. There were many instances where following the rules was the more logical solution. However, in the instance of the spinal elements varying in size, the rules were broken. As architects we must ask ourselves what the consequences are of following or breaking the rules. If breaking the rules provides a more reasonable solution and does not complicate other avenues of the project then it is possibly the more logical answer. On the other hand there are instances where following the rules is the more viable solution. The instance where an architect breaks the rules can often be the one aspect of the project that brings greatness or utter disaster. There are no "formulas" for deciding, only the sound judgement of the architect.

The use of the morphic philosophy was the great architectural enlightenment of the project. The project would have never progressed in the manner it did without the invaluable guidelines that nature has given to us.

The role of the architect is to make visible that which is invisible.

-Marco Frascari, *Monsters of Architecture*



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Tzonis, Alexander. *Movement, Structure, and the Work of Santiago Calatrava*. Boston: Birkhauser, 1995.



IMAGE CREDITS

Page 008

From Top:

Aardvark House

Sheep House

Frog House

Dog House

All images from *Wiggle* by Michael Sorkin

Page 009

From Top:

Skeletal Structure of the Human Hand

Conceptual Sketch of the Waterloo Station Addition

Section of the Waterloo Station Addition

Finished Model of the Waterloo Station Addition

All images from *Structure, Space, and Skin: The Work of Nicholas Grimshaw & Partners* by Nicholas Grimshaw and Partners.

Page 010

From Top:

Drawing of a bat's wing

Model of the IBM Traveling Pavilion being erected

The IBM Traveling Pavilion model fully erected

Joint Detail

All images from *Renzo Piano and Building Workshop: Buildings and Projects, 1971-1989* by Renzo Piano.

Page 011

From Top:

Bull Sketch

Merida Bridge, Spain

Horse Sketch

Model of the Tabouretli Theater in Basel

All Images from *Santiago Calatrava* by Klein Bernhard.

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Adobe InDesign 1.5, 2.0

Adobe Illustrator 7.0, 8.0, 9.0, 10.0

Residential and Light Commercial Construction