phototropic architecture:
intelligent responses to sunlight stimuli
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phototropic architecture:

intelligent responses to sunlight stimuli

a new school of architecture for ogelthorpe university, atlanta, ga

josh vermillion

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abstract:

In 1968, Jan Rowen wrote, “surely our present task is to unfreeze architecture—to make it a fluid, vibrating, changeable backdrop for the varied and constantly changing modes of life. An expanding, contracting, pulsating, changing architecture would reflect life as it is today and therefore be a part of it.” Nature is in a constant state of change. As architects become more aware of environmental sensitivity, so must built form be more responsive to these environmental variables.

All natural systems are flexible enough to respond to these changes in order to survive. Plants, for instance, react to the changes in daylight by opening and closing petals, twisting stalks, sprawling leaves, etc. These responses to light stimuli are known as phototropes. Natural forms such as plants and their kinetic behaviors can demonstrate important principles to designers for the production of a phototropic architecture.

My goal was to create an architectural solution that behaves with respect to daylight. The design project was a new school of architecture at Ogeilthorpe University in Atlanta, Georgia. Through everyday experiences, students will see the benefits of a phototropic building at work.
a plant's very survival depends on capturing the
and converting it to energy in
order to produce food and nutrients. In order
to efficiently capture this light plants must
respond to changing sun conditions. some
open their petals or leaves. others grow
specifically in a direction that is advantageous
to catch sunlight. still, others twist throughout
the day along the path of the sun. these
responses to light stimuli by plants are known
as phototropes. these dynamic capabilities to
maximize efficiency—both day lighting and kinetic
change capabilities—are lessons that designers
can learn from. the intentions of this project are
to explore the creation of a

the reasons for day lighting a building are many,
but, the main reason is that it simply makes
sense to make use of a readily available,
renewable resource directly from
its source. as stewards of the environment,
designers should use day lighting to cut a
building's energy consumption, minimizing that
building’s impact on the environment. less
money is spent cooling the building and less
moisture from cooling systems is produced that
contributes to run-off in our cities. this idea,
then, is desirable from an environmentally
appropriate standpoint, as well as from a building
user’s health standpoint...
most would agree that natural light provides a much better work environment than artificial lighting. In fact, Dr. John Ott would argue that a day-lit environment is much healthier than an artificial lit space. Over the last thirty years, Ott’s articles about fluorescent lighting and its unhealthy effects have been published in leading research journals. From his research one could conclude that, “some of the causes of health problems from regular, extended exposure to fluorescent light could include: lack of shielding for certain types of radiation, fluorescent light spectrums are far different than natural lighting, and the lack of natural levels of ultra-violet light exposure from fluorescent lighting...” Case histories were presented showing how the lack of natural lighting and/or exposure to fluorescent lighting might contribute to health conditions such as infertility, tumors, etc. More recent research has shown the importance of light on the pineal gland, which affects the brain and hormonal system. Because of this, one should expect that regular, extended exposures to fluorescent lighting may contribute to health problems.” This work and his first book, *Health and Light: the Effects of Natural and Artificial Light on Man and Other Living Things*, gained Ott the grand honors award from the National Eye Research Foundation, as well as, an honorary doctor of science degree from Loyola University.
others argue that it is essential for workers to be close to a window in order to maintain their internal, biological clock. An excerpt from Christopher Alexander's *A Pattern Language* helps elaborate this point: "first, all over the world, people are rebelling against windowless buildings; people complain when they have to work in places without daylight. by analyzing words they use, Rapoport has shown that people are in a more positive frame of mind in rooms with windows than in rooms without windows. Edward Hall tells the story of a man who worked in a windowless office for some time, all the time saying that it was 'just fine, just fine,' and then abruptly quit. Hall says, 'the issue was so deep, and so serious, that this man could not even bear to discuss it, since just discussing it would have opened the floodgates.'...since the cycle of daylight somehow plays a vital role in the maintenance of the body's circadian rhythms, and that change of light during the day, though apparently variable, is in this sense a fundamental constant by which the human body maintains its relationship to the environment. if this is true, then too much artificial light actually creates a rift between a person and his surroundings and upsets the human physiology."

Optimal daylight conditions for a particular space are determined by the space's users and the tasks performed by the users. daylight distribution and intensity depends on geometric factors of the space. for my purposes, i have identified two day lighting scenarios that might be desirable to particular spaces:
evenly distributed daylight would be a desirable scenario for spaces that accommodate daily tasks such as offices, studios, libraries, and classrooms.

unevenly distributed daylight that would provide contrast between light and darkness might be desirable for some display/exhibition spaces, atriums, lobbies, reception halls, circulation, etc. contrast can create drama within the space, define sub-spaces, or simply make the space more accommodating to activities that require both lightness and darkness.

throughout the day and year, the sun changes its position. consequently, the quality of light coming to a window is constantly changing. it is apparent, then, that a “kinetic building”—that is to say, one that can respond to these daylight changes—could become much more efficient than a “static building.” my goal was to create an architectural solution that demonstrates responsive and intelligent behaviors with respect to varying daylight—a phototropic architecture.

to put it simply, the question I addressed was, “how can a kinetic design provide for efficient responses to constantly changing environmental conditions in order to facilitate the two day lighting scenarios stated above (even distribution/uneven distribution)?” the aesthetic of phototropic architecture clearly shows the evidence of daylight design while informing people of what parts of the building are in use (alive) throughout the day and night.
typological uniqueness:

the thesis project was a new school of architecture building. the second question i posed throughout the design process was, "what is special about an architecture building and the activities it houses?" truly, an architecture school is unique to all others. Students draw, build, question, present to juries, use the computer, and live in the building. these activities should be showcased to any visitor in the building. buildings should be active and alive, and academic buildings should promote collaboration, chance meetings, and views of the various academic activities for all. people learn from seeing and experiencing, and hopefully, they learn from other's experiences, also.
located in atlanta, georgia, oglethorpe university is an independent, highly-selective, coeducational liberal arts institution of 1,230 students from more than 30 countries emphasizing the preparation of the humane generalist needed by a complex and changing society. while the university has was founded in 1835, it has used its present site since 1915. located just ten miles north of the heart of atlanta, students are encouraged to use the city as a learning laboratory, in addition to traditional classroom training.

excerpt from asca competition book:
the southeastern region of the u.s. is one of the fastest growing areas in the country. this growth has fueled an increased demand for degreed architects. as a result of this increasing demand, many of the existing architecture programs in the region are experiencing increased enrollment and are required to plan additions to existing facilities or construct new, larger facilities. other universities, realizing this opportunity, are considering expanding their educational offerings by incorporating architecture programs into their curricula.

oglethorpe is one such university and is in need of a new school of architecture facility.

wind rose analysis of atlanta
design studio
project spaces (4)
student lounge
student resource library
office for student organizations

gallery
storage
kitchen
resource center
resource librarian office
project photo room
project archive room

jury space
jury viewing gallery

faculty offices (8)
classrooms (36)

shops + labs
building systems lab
wood/model shop
student project storage
finishing area
shop instructor office

administrative offices + support

exterior
design build yard
Objective 1

to demonstrate how a phototropic building could adequately respond to the lighting needs of both even and uneven light distributed spaces

to resolve ways in which kinetic devices (changing skins, light scoops, vegetation, etc.) could further help with day lighting strategies. ways that kinetics could help include efficiency by responding to the constantly moving sun, or by helping to bring in daylight to deep spaces.

to create a piece of architecture that respects the campus, but, also gives the school of architecture it’s own identity.
explore different ways to daylight spaces
explore

match research findings with programmed spaces

develop modules/bays

develop massing + design
resolve contextual issues
refine interior layout

refine design
research:

nouvel's skin is fantastic in the way it responds to time and light. visitors are constantly aware of the time of day as a result of the magnificent and shadow patterns produced by the skin apertures. the energy created by the play and contrasts of light is like walking through a film shot.

the on the south facade of the institute are very impressive in the way they imitate the similar patterns of mosquessuch as the alhambra. more impressive, though, is the lighting effect of the skin from the interior. the skin is a dark veil, pierced in dramatic contrast with bright pupils. if one draws closer to the skin, the whole facade is revealed as a wall of
"I began to consider the question of light at the Institute du Monde Arabe. The theme of light is reflected in the southern wall consisting entirely of camera shutters, in the stacking of the stairs, the blurring of contours, the superimpositions, reflections, and shadows."

Nouvel, lecture in London, 1995
"the sequence of changes between different volumes and different light levels, according to different trajectories through it can be seen as a series of camera angles and appertures."

nouvel
The building consists of two wings of offices that are bring indirect light into the space. These baffles prevent excessive heat gain. This controlled heat from the sunlight helps pull air through the building for daylit atrium.
milwaukee museum of

an art museum with indirect daylighting and views out to lake Michigan. Calatrava created expressive forms that relate to structure and sun. The main lobby extends to the sky and lake while kinetic wings sprawl from the central spine.
excerpt:
"This building was conceived as a sequence of events, responding dynamically to internal demands and

. the roof opens up in the heat of the day to release a

which hovers above the pavilion and deflects the sun's rays. at night its underside can be used as a projection screen. the main exhibition area has a transparent glass-block floor with fountains below; an internal courtyard contains a continually circulating, four meter wide channel of water; the hull-shaped audio-visual dome is cooled by the water running down its curved timber wall. the east wing of the pavilion has an 85 meter long external wall which lifts entirely, allowing the space to act as a stage for concerts or fashion shows and providing means of entry without queues."

siting studies
some preliminary studies were
done to determine basic massing
and site placement

south scheme

curved scheme

north scheme
section studies
grand space where steel + light are showcased along with all of the special work spaces that make the architecture building what it is - special
curved trusses

on interior - hold up double skin with shades
pv paneled louvres

trusses become a contextual gesture
the new school of architecture for college university is about two things:

showcasing all of the activities that set it apart from the rest of campus

allowing these activities to utilize the sun for task lighting; the daylight factor being adjustable to accommodate the many different activities in different parts of the building
the space:
work spaces, lounge spaces, jury spaces, gardens, galleries: everything that is special about an architecture school
the skin:
these spaces are enclosed by a steel +
glass skin which generates electricity,
separates heat from light, allows indirect
light to pass through, & adjusts the lighting
factor on the interior.
the skin isn’t an ambiguous facade, but carries on the compositional between the two adjacent campus buildings. the triangular roof peaks of the nearby buildings are continued by the tops of the trusses.
north facade:
thm of the campus
the [ ] is located on the north side of the building, overlooking the main quadrangle of campus. It is one large two-story space, the second level lofted above the first. The studio opens out onto outdoor spaces. Skylights help light the space from the top.
reflections

"nothing is permanent. everything is in a
  . through day and night, through summer and winter,
year after year, from birth to death, life flows in a timeless cycle—
life in the soil and on the ground, in water and air, life of man and
animal and plant—always in

, in rise and fall, in growth and decline, so

that

.

andreas feininger

as i look back to the beginning of the semester, i have realized
that i have had a lot of fun. i really enjoyed studying daylighting,
kinetics, etc. for my thesis project. if i had the time, further
explorations would include:
detail studies
different ways to wrap the skin around a corner

but i don’t have the time, i have already spent 43800 hours in
architecture school. these hours were fun, tough, frustrating,
enlightening, character-building experiences that i will never forget.


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