REVISITING THE SKYSCRAPER:
HOW ECOLOGICAL ARCHITECTURE AFFECTS SPACE

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Designers should take responsibility for their buildings, both inside and out. Every decision that is made should be weighed against the health benefits of the people and the Earth. One building may not be able to solve all of the ills of one city, but it can pave the way for a new style of architecture and ultimately a better lifestyle.

Unfortunately with the ever-growing population, and our dislike for urban sprawl, the need to reach up instead of out has become pressing and will soon be imperative. I feel that "ecological designers" have mostly overlooked the skyscraper because of its immense scale. We, as designers, should look at the large size as an opportunity to make large impacts.

This skyscraper responds to its surrounding environmentally and contextually. It respects the scale of the city while reacting to the path of the sun. Natural day lighting and natural ventilation strategies create a better living, working and playing environment.

"THE DESIGNER'S CURRENT RANGE OF EXPERTISE NEEDS TO BE CRITICALLY EXPANDED. THE PRINCIPLES OF ARCHITECTURE HAVE TO BE WIDENED TO INCLUDE AN ECOLOGICALLY SENSITIVE ANALYSIS OF THE BUILDING'S CONSTRUCTION, OPERATION DURING ITS USEFUL LIFE AND FINAL DISPOSAL."

- KEN YEANG, THE GREEN SKYSCRAPER
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This thesis started out by looking at the office tower. I felt that the office tower could be changed so employees weren't plagued at the end of each working day with aching eyes from poor lighting, runny noses from poor ventilation and aching backs and thighs from poor seating. The best avenue of action I saw was to incorporate elements from "environmental architecture" into the design. If at the end of the project I was helping the exterior environment as much as the interior environment, then it would be a success.

At the time of this decision, I was not aware of the true meaning, or more specifically my definition, of such words as environmental architecture, ecological architecture, sustainability, green architecture, and environmental friendliness.

Designers should take responsibility for their buildings, both inside and out. Every decision that is made should be weighed against the health benefits of the people and the Earth. By creating a design that nurtures the lives inside, the building can operate as a whole system to nurture the lives outside. What would

"Once you understand the destruction taking place, unless you do something to change it, even if you never intended to cause such destruction, you become involved in a strategy of tragedy."

- William McDonough, Cradle to Cradle
be the point of allowing natural air in if the natural air is polluted? One building may not be able to solve all of the ills of one city, but it can pave the way for a new style of architecture and ultimately a better lifestyle.

Unfortunately with the ever-growing population, and our dislike for urban sprawl, the need to reach up instead of out has become pressing and will soon be imperative. I feel that "ecological designers" have mostly overlooked the skyscraper because of its immense scale. We, as designers, should look at the large size as an opportunity to make large impacts.

Those designers that have tackled the skyscraper were always missing that one piece to make it truly functional. The designer may have haphazardly added a few touches after the design was finished, thus selling the idea as "environmentally friendly," but in reality, only one aspect may have been taken under consideration. The designer may have thought through the idea of a central atrium as a means for ventilation, but the users have problems with suction, sun, or heat on the upper floors. The designer may have worked diligently to create a building that is environmental, though the materials may have been imported from halfway around the world, negating through transportation energy, the positive effect that building ever had on the environment. The designer may have done all of the aforementioned correctly, but because of some poor design decision, created an interior space climatically only slightly better than the exterior elements.

My goal is to learn from these past mistakes and improve upon the skyscraper to be something better than an energy giant. I want to use the surrounding environment and resources to create a sustainable environmentally friendly building for the future. By connecting the outside and the inside of the building, a more complete "environmentally friendly" structure will transpire. Not only will the building be giving back (or not taking as much from) the natural environment, it will be feeding the health and emotional needs of those inside.
SITE ANALYSIS

Now the question becomes as to where such a proposed tower should be placed. I feel that Chicago is a prime city for a building of such magnitude. Most "environmentally friendly" skyscrapers have been placed in extreme climates, with the emphasis on warmer tropics. These tend to be easier to design because the extreme temperature swings are not as high. Few towers have been placed in more temperate climates such as the Midwest and it is time we did! When looking at cutting edge culture in modern times, society looks to New York or Los Angeles. Why not Chicago? In the past Chicago was an extremely happening place culturally and technically, and could be again with the help of a truly environmentally friendly skyscraper. New York recently acquired the Conde Nast Building, which is touted as "environmentally friendly" but it too doesn't live up to the expectations I have set. A skyscraper as proposed in Chicago could pave the way for a new way of thinking.

I also feel that Chicago is ready for an environmentally friendly skyscraper because of the support of the local
government. Mayor Richard M. Daley is an advocate of environmentalism, and is working to put rooftop gardens on all buildings. This skyscraper would follow in this thinking, trying to reduce the heat sink of the city.

When picking my site, I was looking for something that was close to the river, but not on it. I tried to choose a site that didn't have a prominent building on it already. The corner of Randolph and Franklin seemed like a good choice. Currently, a Walgreen drugstore resides there, but that could be easily integrated in the commercial aspect of the skyscraper. Randolph Street to the south would allow some opportunity for sun to reach the site, without worry of future obstruction. The view to the west is straight to the river and looking south on Franklin Street you can see the Sears Tower, a true city icon.
"In comparison with other American cities, Chicago offers a broad range of design possibilities, since its pattern is neither as sharply defined as Manhattan's nor as loosely organized as that of Houston and other unplanned cities."

-Robert Mugerauer, "Chicago's Four-Layered Plan"
This portion of the city is very eclectic in styles. There are short historic buildings next to soaring International style office towers next to mid-sized Modern apartment buildings. One common element is a repeating column at street level. This is used to bring the structures to human scale and provide large storefronts for window shopping. Even the parking garages either have commercial storefronts on the first level, or at least repeating columns to break up the monotony. I feel it is important to incorporate this into my design because it is so prominent.

There are no setbacks in the local area, so I also feel it is important to fill the entire site and keep the city density.
Because the focus of my project is environmental issues, I took a thorough inventory of the existing environment. I checked the surrounding obstructions on sun path diagrams (Appendix A) to determine in what locations and at what elevations my site would be in shadow.

A few site sections of the city showed distinct height patterns associated with internal functions.

The sun path diagrams and site sections helped me to determine that the commercial section should be no taller than 150 feet, the office portion should be around 450 feet and the residential portion could extend up as high as needed, but should not exceed the Sears Tower at 1, 454 feet. This would maintain the scale of the city, while providing natural light to the office employees and allow good views from the apartments.
The temperature of Chicago is mostly cold, which will work well with an internally loaded building such as this skyscraper. This does limit the time that windows can be opened traditionally, so other ventilation strategies must be used. All green spaces should be indoors for year-round use, with the possibility of opening large windows to “feel” like one is outside on those few nice days.
Due to site conditions certain design strategies will be utilized in different zones. The commercial zone will make use of stack ventilation because of the lack of cross wind at street level. Little natural light will reach this level because of the large tower directly to the south, so the dependency on artificial light is imperative. The office zone will use a combination of stack ventilation and cross ventilation depending on the conditions of the day and time of year. Natural light will flood this area, so every office should be within 30 feet of a window to make the most of this. The residential zone will make use of cross ventilation as winds are unobstructed and strong at this height. Buffers will be developed to slow the wind to a usable speed though. Natural light will be unobstructed as well, though the typical user hours will not benefit from this. Due to the externally loaded nature of residences, trombe walls and sunspaces will be explored for passive heating and cooling.
THE DESIGN

As determined by my site and environmental analysis, my office tower will have three zones. Each zone will step back to allow natural light to the zones below. This will allow space for an atrium to top out for even more natural light and air to the interior spaces.

The lowest commercial zone should take up the entire site to maintain the fabric of the city and have a center atrium for stack ventilation.

The upper residential zone will mimic the Unité d'Habitation by LeCorbusier. Thus the building shape should be long and narrow, allowing easy cross ventilation through one unit.

The middle zone provides the most challenges design-wise to integrate the environmental strategies.

Even though there are three zones vertically, the building's exterior is defined differently. Using the same materials in unique ways creates a tower that is articulated into two "structures". The first "structure" is the residential tower that appears to start at the ground level and stretch high into the air. Pre-cast concrete panels create an angle that adds dynamism and drama to the otherwise traditional tower. A glass curtain wall fills in the revealed façade. The second "structure" houses the commercial and offices. The commercial portion is again clad in pre-cast concrete and curtain walls. The dynamic angle is repeated in this location to highlight the main door. Then this angle is rotated ninety degrees and wraps around the building in green glass to highlight the secondary entrance. Atop this second "structure" is the office portion, articulated in a style reminiscent of the International Style. A rectangle was determined to be the most efficient in business and design, with five story atriums cascading up the sides by curved curtain walls. Photovoltaic panels will comprise the horizontal elements to collect energy for the building.

"...WITH THEIR SEALED WINDOWS, CONSTANTLY HUMMING AIR CONDITIONERS, HEATING SYSTEMS, LACK OF DAYLIGHT AND FRESH AIR, AND UNIFORM FLUORESCENT LIGHTING, THEY MIGHT AS WELL HAVE BEEN DESIGNED TO HOUSE MACHINES, NOT HUMANS."

- WILLIAM McDONOUGH CRADLE TO CRADLE
Before settling on a rectangular shape for the office zone, several iterations were explored.

A. The floor plate would wrap around the north and east sides allowing a breakdown of form to create interesting atrium spaces.

B. Again the floor plate would wrap around the north and east. The breakdown of form would be on an altered grid structural system and would comprise of connecting atrium and sky lobbies.

C. Spawned off of a World Trade Center Proposal, The north side would provide structure that the free form shape could attach to at any point.

D. Overlapping atriums would allow air circulation through the entire building, but large expanses of offices would be without natural light.

Light Blue - Commercial
Orange - Offices
Rose/Red - Residential
Green - Atrium/Sky Lobby
Cascading atriums that tie together would provide good ventilation for the building. The warm morning sun would heat the East side on the cold Chicago mornings. By the afternoon, the internally loaded zone would be warm enough. This atrium would then act as a buffer from the piercing afternoon sun while using natural foliage as a filter. The angled roofs, shown here in blue, would have photovoltaic panels to collect energy for the building.

According to The Architect’s Studio Companion this plan shows the correct number of elevators. After further investigation, I learned how to stack elevators and reduce the square footage of the core. Other mechanical requirements were also investigated and are presented in Appendix B – Research.
Service elevators will stop on every floor for ease of deliveries, mail, and trash removal. All elevators will stop on the ground, Sky Lobby One and Sky Lobby Two. One bank of three elevators will serve as secondary transport, escalators being the first, to the commercial zone. One bank of three elevators will then service five floors of offices above. The residences have their own lobbies and elevators that are inaccessible by other building tenants. The residents will have a private keyed entrance to these lobbies from the commercial spaces.

The Ground Floor is a grand space with two story entrance spaces opening to a ten story central atrium. The main entrance is on Randolph Street and secondary entrances are on Franklin Street and connected to the parking garage. The residential entrance is also on Franklin Street. The corners will be anchored with local restaurants, inviting people to the building.
Having speculative commercial spaces means having to have ultimate flexibility. These are simply proposed plans and would change per store request. The first nine floors will feel like a typical mall. Storefronts that are fully customizable will skirt the outside of the main atrium space. Food courts, indoor plazas or large stores will reside on the corners to anchor the spaces. Smaller stores will fill between these elements with customizable interiors. Three shafts will meet the mechanical needs of each floor. These shafts will allow the opportunity for private bathrooms for commercial store employees. The exterior wall is a mostly glass curtain wall. Spandrel panels could be provided per store request.
As the very top of the building, Sky Lobby 3 is accessible only by the residents. A large area will be available for banquets and receptions or as a lounge and meeting place for residents. It will house a slightly raised pool for diving and casual swimming. A mechanical floor underneath it will allow for the proper depth and water filtration. New pools have been made that use water with no chemicals, only same microbes to filter bacteria. With this technology, the water may be used to fill the fire suppressant system.

Sky Lobby 2 is open to all tenants and visitors, and would house a small health club. This follows the principles of sustainability, or being able to work, live and play in one location. Also on this floor will be small vendors including newsstands, small food shops, shoe shiners and dry cleaners.

Sky Lobby 1 is also open to all tenants and visitors, and would house a child care facility. This will eliminate the need for sitters and extra travel, and allow the parents to visit their children for lunch or on breaks. Also on this floor will be more small vendors and serve as an accidental meeting place for office employees in particular.
The offices surround a central atrium that ties to, but is not connected to the central atrium of the commercial zone. This atrium will be surrounded by cross bracing for lateral support of the structure. Five story atriums with operable windows alternate around this center space and allow natural light and air into the interior of the space. Large fans then pull this air to vent through the mechanical floors, which is right under the sky lobby floors. By doing this a combination of stack and cross ventilation is achieved. Chicago temperatures and conditions change rapidly, and must be accommodated through different strategies at different times. Low partitions will be suggested in the building tenant guidelines to allow natural light, though height of walls will be determined by the individual tenants.
The apartments interlock together and with the structural bay of the building. A hallway is on every third floor and all regular apartments enter on this level. Then the rest of the apartment is either up a floor or down a floor, accessible through inter-apartment stairs. This allows for two story spaces, enclosed balconies and the potential for cross ventilation. Handicapped accessible apartments are available on every floor directly next to the elevator lobby.
Overall as a skyscraper, this tower is strong. I have utilized different environmental strategies to slightly minimize the effects of this building on its users and the surrounding environment. The shape, style and design are respectful to the surrounding context of Chicago, Illinois. From a sustainability standpoint it is very good; the functions of daily life are all housed in one structure. The spaces could be changed relatively easy for future purposes.

As a truly environmental structure there are loads more work to do. I wish that more time could have been given to hands-on experiments of the environmental systems. Because of the large scale of the project, individual systems and details were not worked out. The beauty is in the details and I would have liked to work more with materials, constructability and connections. I have some ideas for these things, but they were never brought to fruition because of other issues. During the project, with every small step forward in design, was one large step further back in environmental concerns and concessions were

At present rates of use of non-renewable energy resources, within the next 50 years the world will likely run out of non-renewable fossil fuels.

-Ken Yeang, The Green Skyscraper
made. I am glad to have added the residential portion since my initial proposal, though it took time to work out the rooms and mechanical systems for them. The sky lobbies, and atrium are underdeveloped in plan. Though thought through, they are not addressed to their full extent graphically anywhere.

I am glad to have chosen such a large project because I have always wanted to design a skyscraper. Having now worked on one, I'm not sure if I would work on another. Unfortunately like most architecture of today, the design was dictated by the mechanical requirements of such a large structure. Flamboyant curves and designs became impractical with heating and cooling needs and to meet the square footage needed for the building to pay for itself. With smaller structures, more can be accomplished design-wise.
*Discusses the development of the skyscrapers in Chicago as through a biography of the structural engineer of the John Hancock Tower and the Sears Tower*

*Plans, Sections, Elevations of past skyscrapers for precedent studies*

*Examples of their work on environmentally friendly skyscrapers*

*Traces the history of the skyscraper and style periods through time*

*Guidelines for consideration in designing ecological architecture*

*Theory on ecological design as seen by McDonough. Stretches the imagination and thinking on the way we see the world*

*A look at why skyscrapers are built and societies that inhabit them*

*Hard book to understand, that discusses the decline of society, and Soleri’s solution to it*

*Criteria established and to judge ecologically friendly products*

*Wine’s view of others built ecological architecture*

*Discussion of office plan layouts*

*Theory behind green skyscrapers, as defined by Yeang. Raises issues to be considered in design*

*Textbook notes on how to design systems for bioclimatic skyscrapers*
APPENDIX A - SUN PATH DIAGRAMS

MAP KEY TO DIAGRAMS
NORTHWEST CORNER AT GROUND LEVEL

SOUTHWEST CORNER AT GROUND LEVEL

NORTHEAST CORNER AT GROUND LEVEL

SOUTHEAST CORNER AT GROUND LEVEL
NORTHWEST CORNER AT 150 FEET ABOVE GROUND

SOUTHWEST CORNER AT 150 FEET ABOVE GROUND

NORTHEAST CORNER AT 150 FEET ABOVE GROUND

SOUTHEAST CORNER AT 150 FEET ABOVE GROUND
This tower will use the services of Exelon Thermal Technologies, which provides cooling solutions for large scale projects. The idea is to limit the CFC's used in cooling systems by cooling air offsite and sending it to the project. The temperature is always constant, and no cooling towers, water plants or chiller rooms are needed in the structure. It was first tried in Chicago and is not spreading to other cities.

The following charts and numbers were found in The Architect's Studio Companion Second Edition by Edward Allen and Joseph Iano. This helped me to determine that my mechanical floors were large enough, and the size of shafts needed to penetrate the floor planes.

The Emergency Electrical Service Room is 12ft x 12ft and located 2 floors underground.
The Telephone Switchgear Room is 20ft x 20ft and located in the basement. A 4ft x 7ft Telephone Closet is on each floor to service that floor.
The Trash Compactor Room is 150 sf and adjacent to the loading docks.
The Water Pump Room is 16ft x 12ft and located on every mechanical floor.
The Fire Pump room is 20ft x 12ft and located on every mechanical floor.
Major Electrical Closets are 7ft x 12ft and normally one per floor. Minor Electrical Closets are 5ft x 3ft and are located where needed.
UNITÉ D'HABITATION

Designed by LeCorbusier as an alternative to low income housing, the principles behind it are interesting. Each unit would have a two story space and windows on opposite sides of the building for cross ventilation. The project has become a slum through poor management and misconception of ideals.
The circulation scheme in comparison to the floor plan really opened up the idea of stacking elevators and how to go about doing it correctly. The tower’s 9 section plan was innovative for its time and works well. The office zone on my tower mimics this form. It was designed to be seen from afar, rising above the skyline. Up close, the curtain wall system is not very aesthetic.
This proposal because it is based off of the 9 section plan like the Sears Tower. However, this design takes liberty with the plates that connect the structure together, thus creating almost organic shapes. This is a good example of how to be creative with structure while still being stable. For my project, I just don’t think I will do this though. The sky lobby safe floors were an interesting idea as well. I have incorporated something similar in my design.
This building captivated my attention when I saw it last spring, well before I learned of its environmental ramifications. Towering substantially above the rest of the city, its partially organic shape and rotating glass atrium were pleasant to the eye making its sheer height acceptable. The organization of the plan is genius. I only wish Lord Norman Foster had dealt with water collection and a more clever way to cap the top.
RENAISSANCE CENTER, DETROIT MICHIGAN

The glass on the elevator pods versus the curtain wall of the buildings creates a good contrast. The real details are on the interior. The several story spaces create layering that is really nice, with overlooks that are captivating.
The cascading three story tall skycourts intrigued me. By wrapping around the building it creates a wind path for natural ventilation while the vegetation filters the air. The gymnasium and pool on the roof seemed like a good health welfare issue to include. The sun shading louvers were a nice touch as well. I wish that Yeang would design a building in an urban setting in a more temperate climate.