MSc4: P5
June 24, 2010
Architecture: Hyperbody

Motion Environment

Flows of Movement, Social Diversity and Natural Ventilation Integrated in a Wind Pressure Based Parametric Building Design

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Bottom-Up Parametric Building Design

Flows of Movement
Any site for an architectural project requires the knowledge of the flows of movement: how do pedestrians get from one place to another, what hierarchy do the roads present to the city, and what is the contribution of the public transportation to the city and in particular to the site.

Social Diversity
A city is not merely the collection of roads and means of transportation, a city is used and designed for its users. The social diversity is a given and can be used in positive manner to stimulate the interaction of different social groups in any given place. While residents from the neighborhood start their journey, commuters use the same places as a transportation hub, visitors have a particular point of interest, and business man come to work. All these different groups require different functions and the intertwining of these makes up the interesting design of social integration and social collaboration.

Energy Efficiency
In these modern times the emphasis in many architectural designs lies in the energy efficiency of the building, and how that sometimes even contributes to the nearby environment. Energy eficiency can be thrived in many manners: using wind energy or solar energy to gain power, using wind to create a natural ventilation, catching rain to use elsewhere, using environmentally friendly materials, using energy reducing building components, etc.

Wind Pressure Performance
A building has a big influence on the wind flow and the turbulence zones around it. Modern business areas deal with a lot of negative influence of the wind upon the pedetrian area, which leads to these people to spend minimal time as possible in these public areas. A building design can use its form and curves to determine the placement of turbulence zones directly around the building to use this knowledge in a positive way. It becomes possible with several design tools to create a desired urban environment for pedestrians in winter time, when wind brings cold air to the streets, and in summer time, when the air can bring much needed ventilation.

MSc3: Pressure Based Facade Component
MSc4: Pressure Based Building Dvesign

Facade Component
In my MSc3 I have designed an adaptive facade component that uses pressure difference, created by the wind forces upon the building and the temperature difference between inside and outside, to filter carbon dioxide and nitrogen oxides from the desired oxygen and to change the temperature to a desired level. This research has been extended to the entire building, which is optimized in shape to deal with changing wind directions throughout the year to create a minimum amount of turbulence zones around the building and to set up a system for natural ventilation on the building scale.

Reducing Turbulence Zones
A minimum of turbulence around the building is desired to enhance walking opportunities in a city that is known as the Windy City. This is achieved by adding curvature to the entire body of the building and placing sharp edges on strategic points to maximize the influence on each wind direction. Entrance zones and walking routes around the building turn into more pedestrian friendly environments.

Maximizing Pressure Difference
The shape of the tower is modeled to maximize the pressure differences upon the facade to use the facade components to their full capabilities. The obtained shape minimizes the air streams downwards when hitting straight upon the facade, which increases the amount of turbulence on ground floor. (Something that is seen here in Delft at the EWI building, which constantly creates turbulence zones at walking routes.) The air entering through the facade components is distributed around the building before entering the individual functions. The outlet of air is in the middle of the building where the heated air rises up to the grand openings in the building. These two openings decrease even more the amount of air traveling to the ground floor and accelerate the air passing through them. The acceleration of air implies a decreasing in pressure and through this suction the heated air is drawn out of the atrium.

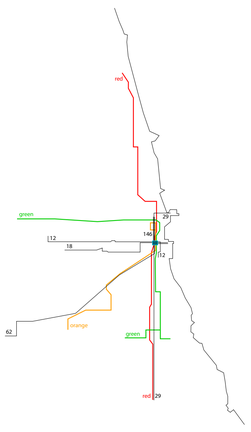
Wind Velocity to Pressure Difference
With the increasing wind speed being directed linked to the decreasing in pressure, it is seen that there is only a limit to the amount of overpressure on the building to 1 when wind speeds decrease to 0, while this doesn't go for the amount of suction, as the wind speed could increase to infinity.

Social Interaction
Another theme determining the architecture of the building is the social interaction that is obtained by the placement of functions throughout the building. The social interaction is achieved by the different groups using various functions in the building, which also functions as a transportation hub to the city. The users are varying from residents to commuters and from employees to visitors.

Intertwining Levels
The amount of social interaction has different gradations according to the functions placed on various heights with peaks on the first few levels and the shopping mall with food court from the 16th floor up. The interior architecture is focused on its place in the natural ventilation scheme and the different functions defined for the building. Functions are not merely linked by elevators, but mainly by the spiraling inner organization that links different floors together and allows for social interaction. The placement of each individual function is determined by its interaction to other functions, its need for daylight and its need for speed.

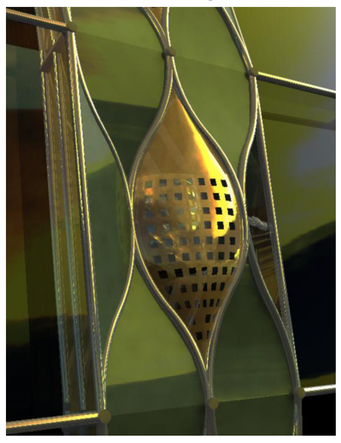
Roosevelt Ave. & State St., Chicago, IL, USA

Flows of Movement

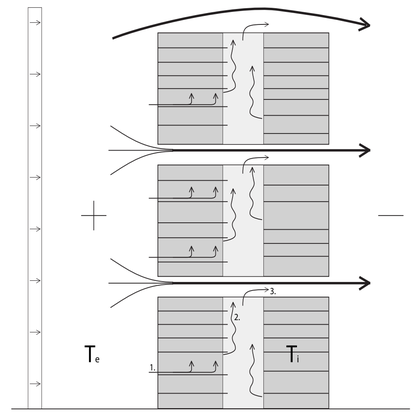


Social Diversity

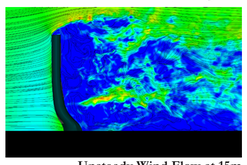
Pressure Based Facade Component



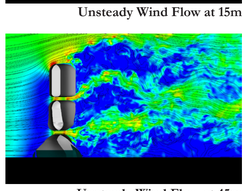
Natural Ventilation Scheme



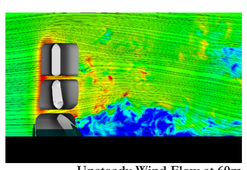
Vertical Slice of Velocity Magnitude



Unsteady Wind Flow at 15m

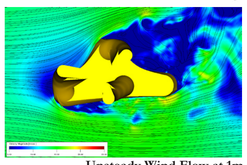


Unsteady Wind Flow at 45m

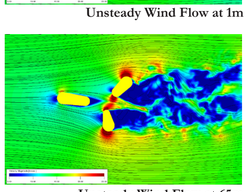


Unsteady Wind Flow at 60m

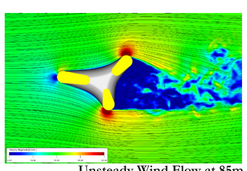
Horizontal Slice of Velocity Magnitude



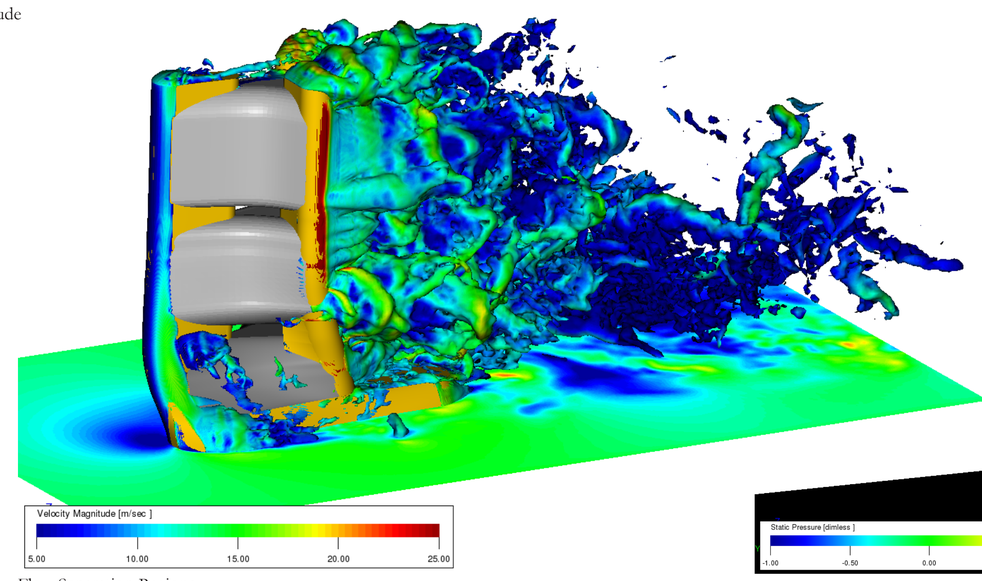
Unsteady Wind Flow at 1m



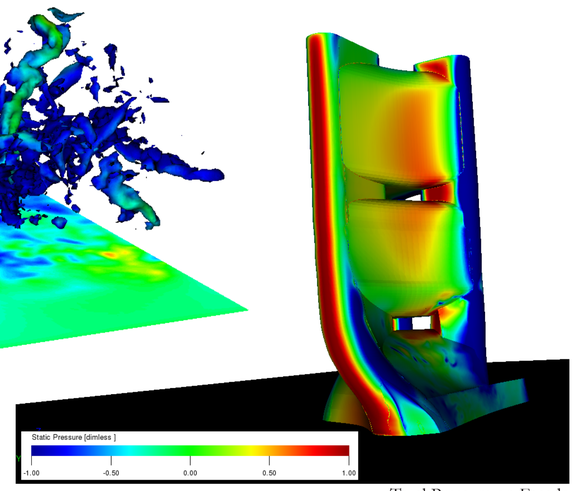
Unsteady Wind Flow at 65m



Unsteady Wind Flow at 85m

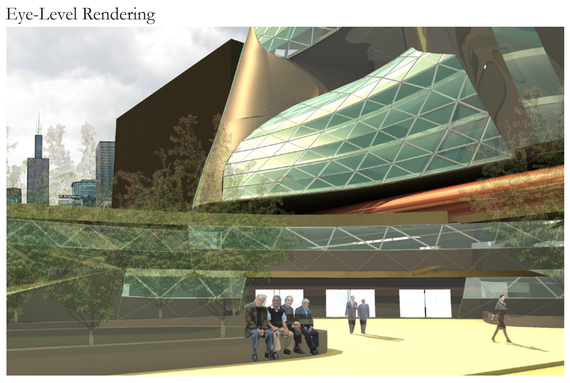


Flow Separation Regions

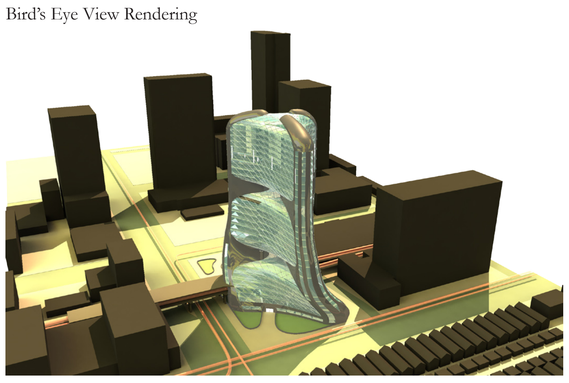


Total Pressure on Facade

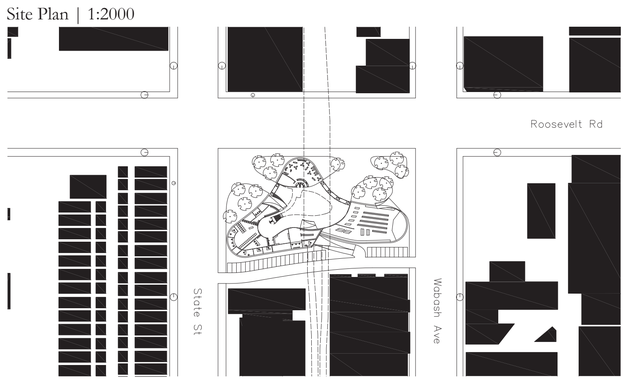
Eye-Level Rendering

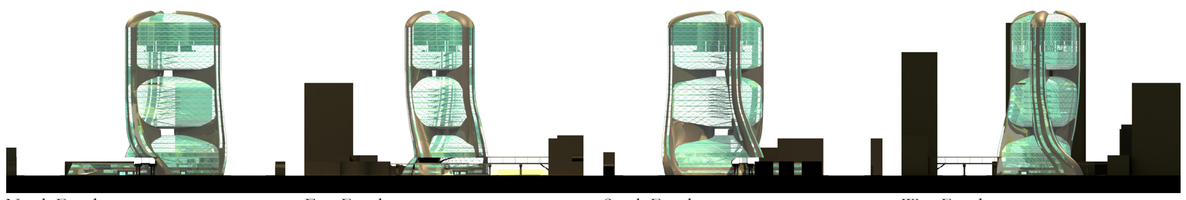


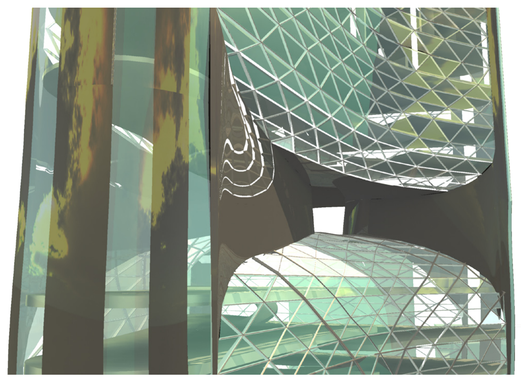
Bird's Eye View Rendering



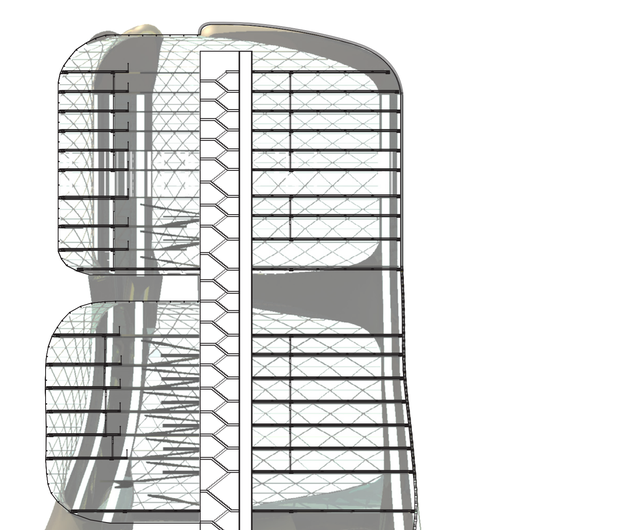
Site Plan | 1:2000



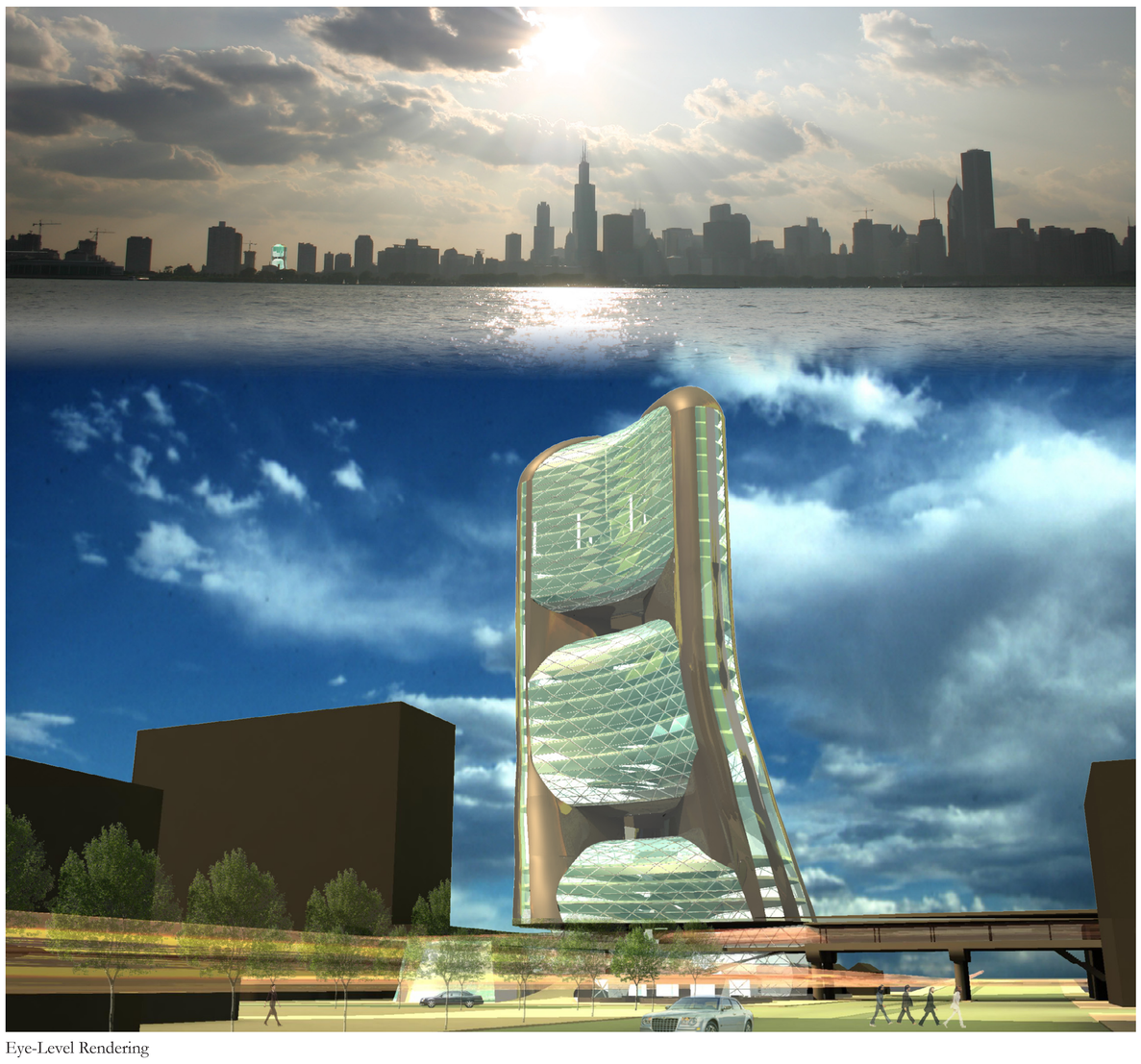




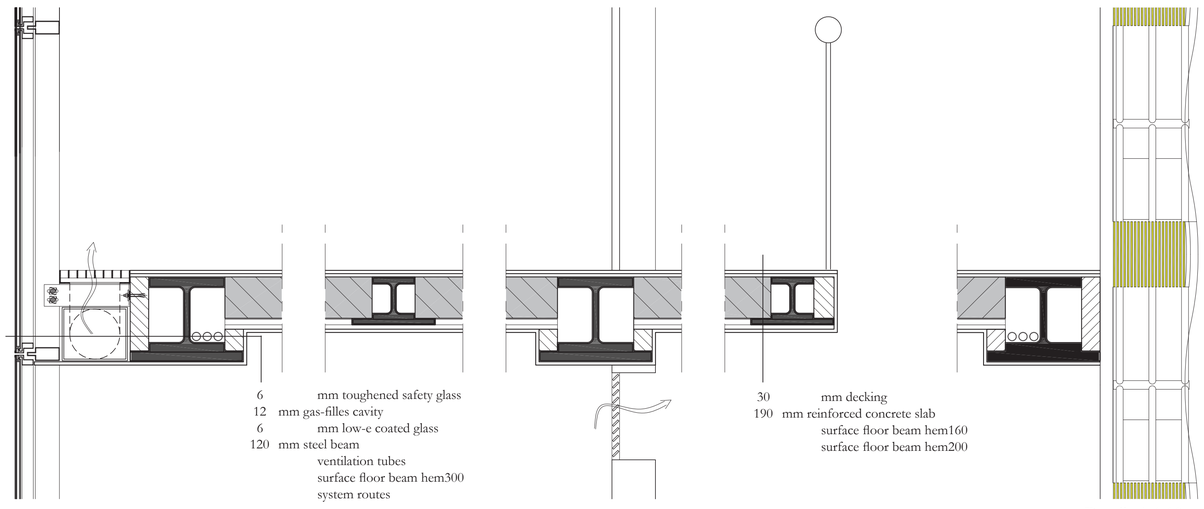
Facade Rendering



Section | 1:200

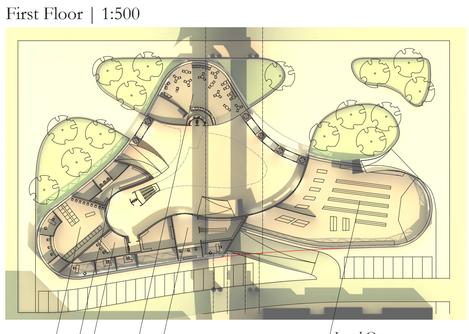


Eye-Level Rendering

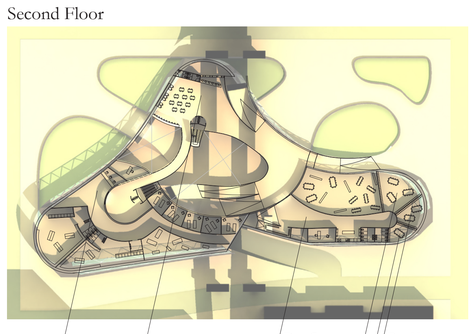


Details | 1:10

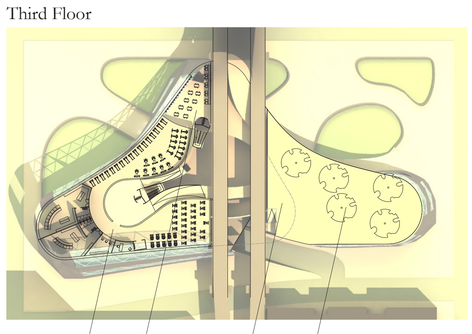
First Floor | 1:500



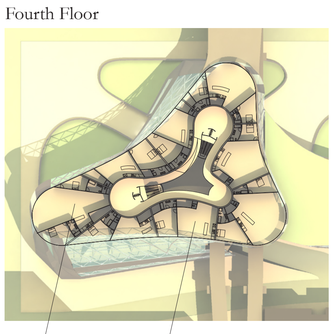
Second Floor



Third Floor



Fourth Floor



Nineteenth Floor

Twentieth Floor