Kinetic Tower

"The Harmony of Nature and Culture"

Team 3703

Ta Min Song 733036651
Sung Kyeng Song 1853072
Kang Min Yoo 670482936
Jin Woo Kuk 804584082
Jun Sun Baek 114667833

The University of Auckland

1. Intro

As a tropical region Manaus' climatic conditions play a major part in residential and commercial design. Being situated in the tropical zone near the equator, Manaus experiences sudden climatic changes with high humidity, precipitation and constant solar heat gain. Manaus is a metropolitan city that pursues the preservation of its cultural and natural assets. An exemplar measure taken by the council to achieve this was to limit the primary means of access to the city as by ferry and airplane.

However a problem Manaus hasn't been able to avoid is the rising population density and high annual tourist traffic. A by-product of large-scale urbanisation is the zoning consequences that come from corporate development of port districts. Following the Amazon River, port activity was the city's main means of growth. Still today, the port offers many jobs to the local people, however due to urbanisation of port districts the residential area has been pushed back resulting in additional transport needs for much of the working force. Due to this, together with high tourist traffic, the pollution rate has been increasing steadily over the past few decades.

The current 'solution' to these problems are to adapt to the population increase at the expense of the environment, focusing on meeting the needs of rapid urbanisation rather than the efficient energy use in response to climatic variations. Rapid urbanisation results in rising pollution rates, consequently disabling the preservation of both the cultural and natural assets unique to Manaus. This situation is a blatant contradiction to the city's intentions.

2. Design Concept

In light of this, the aim of our design is not to create a building that has to adapt to fluctuating human conditions at the expense of Manaus' assets but rather one that faces both problems of rising density and pollution at once. Aiming for a 'zero-energy' design that responds primarily to natural conditions, then addresses the human needs within the framework. This way, the design presents a new paradigm of architecture that is flexible at any scale, with application potential in small to big, corporate, and residential housing complexes.

Not only this, we aim to design architecture that enables the preservation and enrichment of Manaus' cultural assets. Hence producing a comprehensive solution to achieving Manaus' original intentions: both cultural and natural sustainability.

3. Design Strategy & Features

1. Site

Currently the working population commutes between the residential area and the commercial hub of Manaus generating extra pollution. On top of this, the city acts as a main entrance for visitors who wish to explore the flora and fauna of the Brazilian Amazon, this means high tourist circulation. By choosing to situate our building near the port the advantage is two-fold as it is possible to provide permanent accommodation for the working population right in the hub of the city and temporary accommodation for tourists who arrive by ferry. Building by the free port has limitations regarding land size, however this itself is an advantage. Designing high-rise, compacting commercial and residential sectors within one building solves land scarcity problems. Furthermore, by replacing previous residential areas with native flora plantations, the city's land is optimised, enabling it to preserve its natural assets at no expense to functional capability.

2. Climate

Manaus has a tropical monsoon climate according to the Köppen climate classification system, with reasonably consistent temperatures all year round. First off, the Outer shell acts as a radiant barrier, effectively mitigating the overheating problems from high levels of solar insolation. The driest month, August, sees less than 60 mm of precipitation. However, despite this Manaus experiences sudden heavy rainfall which causes floods in urban areas. So the city at times, has huge greywater run off that is taken out to sea through the city's storm water system. By re-routing some of this greywater to the building, we are able to use this in the building.

3. Vegetation

The Amazon consists for over half of the planet's remaining rainforest and is the largest and most species-rich tract of tropical rainforest in the world. Wet tropical forests are the most species-rich biome, and tropical forests in the Americas are consistently more species rich than the wet forests in Africa and Asia. As the largest tract of tropical rainforest in the Americas, the Amazonian rainforests have unparalleled biodiversity. More than one-third of all species in the world live in the Amazon Rainforest. We have installed small 'rainforests', a native plantation at every level. This has several cultural advantages. Firstly, it creates spaces that cultivate social activity and also reinforces local identity, preserving Manaus' unique identity within the urban cityscape.

4. Accessibility

We designed the site to be accessible via walking, cycling and ferrying as the free port is close by. The building site is largely open, offering easy accessibility to pedestrians and cyclers to encourage both locals and tourists to be eco-friendly, becoming a campaign in itself against polluting means of transport. On top of this, being largely human powered, the area fosters relationships at a personal level, becoming an opportunity for positive and lively community development.

5. Cross Ventilation

Cross ventilation is the circulation or flow of air through openings, such as doors, windows, or grilles that are on opposite sides of an enclosure. Cross ventilation is very effective in our kinetic tower because of following reasons. The building is:

- Narrow.
- On an exposed site.
- Perpendicular to the prevailing wind.
- Free from internal barriers to air flow.
- Provided with a regular distribution of openings.

This is the key component of our passive building system. Fresh air is pulled through the space between the inner core and outer shell during the daytime which become large 'vents' that reduce humidity and fungi growth rate inside the building. Also, by the use of the radiant cooling system, air captured during the day is cooled to control the building temperature of the next day. This passive system negates the need for mechanized AC systems.

6. Cultural-friendly community centre

To preserve and enrich cultural assets of Manaus we have integrated cultural hubs within the lowest levels of the building. This area becomes a big melting pot of different cultures and people who come from all over the world that enriches the local cultural identity.
The cultural sector includes the following facilities:

1. **The ferry terminal-** direct access to the building
2. **Cafeteria**- viewing over the Amazon river, putting the whole scene into context
3. **The community centre & Cultural event centre-** becomes a cultural hub for native performances and integrated community events
4. **Grocery store & food court-** grocery for tenants/native food
5. **Shopping mall & Retails-** jobs for locals/souvenirs for tourists.

By providing employment opportunities for locals and offering cultural attractions to experience for the tourists, both could be harmonized through this building.

7. Rain collection

Manaus is an irregular but heavy rainfall site. To adapt to this natural condition, we designed three kinetic panels that can open and close according to the climatic changes. The kinetic panels are inclined at angle towards the centre. When rainfall occurs, the panels will close to create rain shelter for tenants and at the same time, the rainwater will flow into the rainwater collector installed at each kinetic system. One of the best features of this building is that the top panel can close for shelter, but the other two panels can still open for further rainwater collection and also for ventilation purposes. The average amount of rainwater collectable is 8.43m^3/day which is expected to provide for 62% of water supply over the year.

8. Outer Shell

8.1 Curved Façade

The Outer shell works as a defensive tool against the climate in Manaus. The Outer shell's façade consists of smart double-glazed glass, efficiently filtering UV rays and varying its opacity to stop overheating which is a very real problem for buildings of Manaus. The wind loads in Manaus is not very high but a constant breeze. As our building is a high-rise, we had to consider wind resistance against the constant wind load. Regarding this problem we designed the façade of the outer shell with curvature so that when the wind loads are applied, the curved façade will allow wind to flow about the curvature, successfully reducing wind resistance and hence wind load the building experiences.

8.2 Natural Lighting

We also used electrochromic glass for the Outer shell which also known as Smart glass. The Smart glass is a sustainable and upgraded version of the traditional material. Smart glass effectively deals with solar heat gain. By using a very small amount of electricity, the Smart glass charges ions to control the amount of light it reflects. In effect, the glass tints during the peak sun-hour and returns to transparent at night. As the glass' functions are fully controllable, those floors where they want to completely cut off sunlight (e.g. for cultural performances), they can operate the Smart glass, in contrast, for the rest of the building they can switch it off depending on usage. Through this active and passive system, the usage of natural light will be maximized to greatly reduce any electricity used

for lighting purposes during the day which is expected to save more than 82.6% electricity, and also provide for the most required natural resource to the inner garden vegetation.

9. Kinetic system

The Kinetic panels have four functions.

9.1- Water Collection

The inclining slope of the panels allow for rainwater collection high above the urban city pollution. Once collected into the water tank below, some of the water is filtered and channelled throughout the building for consumption, the rest is treated for greywater uses such as vegetation maintenance, washing machine use and the like.

9.2- Solar panels (solar energy accumulation)

The panels act as a photovoltaic system that is capable of producing up to a maximum of 6,228kWh a day, over a year this calculates to a potential production of 66.4% of an average 300 households' yearly energy consumption in Manaus.

9.3- Passive ventilation (Void space between outer shell and inner building)

The panels work as 'stop-start' plugs for the ventilation system. This enables specific control of living temperatures in different sectors of the building (residential, corporate, social) over different times of the day, according to different needs. On top of adjusting to programs, the panels enable heat retention during the night by reducing ventilation in residential sectors.

9.4- Shelter/Shade/Natural lighting

During warmer days, when the panels are opened for maximum ventilation, the opened panels double as 'awnings', shading direct sun rays. During colder days, the panels are retracted (consistent with ventilation needs) allowing maximum sunlight to enter the building.

10. Renewable energy

Manaus is rich in natural resources that have great potential to be used as renewable energies within the building.

10.1 Electricity resources

Our building generates and supplies electricity from two renewable resources, water and solar energy. The building is located right next to Amazon River and though the river is downstream, the current is rather strong. So we installed water turbines at the lowest level of the building below ferry terminal. The generators are expected to produce 53.8% of annual energy consumption of 300 households. The blades will actively operate to continuously generate electricity, and store water at the same time in the underground water storage.

The solar energy is accumulated through the kinetic panels attached in the Outer shell. Each Kinetic panels save 7374kWh/day, with total of 22122kWh/day (three panels). The Kinetic panels are expected to save 66.4% of annual energy consumption. Both of the percentages are in standard of households but the building also has variety of facilities from basement to underground. Total expected energy save of both residential and commercial is 98.2%.

10.2 Air filtration

When air is trapped between closed panels for heat retention, the air is naturally filtered by the inner garden plantations, constantly supplying fresh air for tenants. This further reduces the need for mechanized systems for air supply, temporal adjustment and filtration within the building.

10.3 Recycled materials and Local materials

Use of recycled materials greatly reduce the construction cost by 40% and carbon emission by 30%. We used gypsum boards from local building deconstructions and fibre glass insulation which is made from broken glass. Pebbles needed for ultra-lightweight concrete can be acquired from the Amazon River.

Taking the advantage of the Amazon rainforest and the direction of the Rio Negro River, timber is transported on rafts which then saves transportation fees and reduces carbon emission by 35%. Steel is supplied from Santarém, the closest steel manufacturing city from Manaus by freighters due to circumstances of Brazil, where most of steel manufacturing companies are located around the international port of Brazil.

11. Flexible accommodation

Each floor is designed carefully for convenience and flexibility for tenants.

11. 1 Short-term tenants

The peak season of tourist traffic in Manaus is between July and September, the driest seasons of the year. Rooms will be available for tourist couples and families. And during the off-peak season (Oct to June), the empty rooms will be opened to working-holiday visa holders and local people seeking for short-term job experiences.

11.2 Long-term tenants

Our research found the characteristic of family culture of Manaus, they are usually made up of a large number of members. We took this into consideration and designed each floor differently for couples, 4 member families, 7 and more. Different room designs for local families are to target all age groups. Each floor is divided according to these categories for kids, adults and elders to live in harmony.

4. Conclusion

4.1 Society- Economy

The kinetic tower is a compacted space for both residential and commercial facilities. By optimizing land use, the tower could hold more than 300 households enhancing land scarcity reduction. Use of sustainable features cost 15% more but by water storage, solar energy accumulation, Turbine electricity generation and natural ventilation/filtration are expected to save total 94.7% energy of the building annually and will return the investment cost within 7 years as well as using local and recycled materials enhance carbon emission reduction by 75%.

4.2 Nature- Environment

We want to create a space where people are still in touch with nature, and hence provide a healthy living environment. The building becomes a massive 'Tree', reversing the idea that 'high-rise buildings destroys nature'. Living with inner gardens benefit the healthy lifestyle of tenants in the building. By encouraging people to make the most of pedestrian walkways and bicycle roads as a form of campaign. The Kinetic tower adapts according to the various climatic changes through passive and active systems such as cross ventilation and radiant cooling systems, and smart glass for and natural lighting control.

4.3 Culture- Community integration

The design of the building enhances the integrated development of the community through a variety of features, encouraging harmonisation between tourist and locals. Both local people and tourists interact in the inner gardens, communal areas, cultural centre, and through outdoor activities, these will increase and encourage well-being, positive relationships between neighbours, and diverse enrichment of cultures.

The GBCI rating of the design has achieved Platinum rate by simulation
Total GBCI Greenship Point: 88