ATMOSPHERIC APPARATUS
The Production of Another Comfort Paradigm

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B.S.Sc (Architectural Studies), 2006
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Submitted to the Department of Architecture
in Partial Fulfillment of the Requirements for the Degree of

Master of Architecture

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ABSTRACT

Nowadays, being thermal comfort is no longer a challenging problem for modern living. With the aids of the modern environmental control technologies, a fast, convenient and effective thermal comfort experience can be easily obtained with less effort than ever before. And due to the technologies’ capabilities, this comfort experience can be universally adopted anywhere regardless of the physical location and climate condition.

However, this widely adopted comfort experience has been proved to be problematic due to its nature of producing comfort. The highly technological dependent and the energy reliance approach are not suitable for a sustainable development.

Therefore, the goal of the thesis is to challenge this modern comfort experience and argue there exists "another comfort paradigm" in which a new kind of atmospheric experience is obtained by architectural intervention. And, the thesis proposes Atmospheric Apparatus as a new architectural typology to generate alternative thermal experiences for new comfort paradigm. In order to define the "another comfort paradigm," the thesis examines the current modern comfort phenomenon on its production, impacts and experience. Then, the thesis studies the scientific knowledges of thermal comfort and the thermodynamic relationship between human body and the atmosphere. Lastly, there are architectural proposal of the Atmospheric Apparatus for "another comfort paradigm."

Thesis Supervisor: Nader Tehrani
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HEAT | °C, °F
HUMIDITY | %
WIND | m/s

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BIBLIOGRAPHY
01 | INTRODUCTION -- TWO COMFORT PARADIGMS
MODERN COMFORT

In 1902, when Willis Haviland Carrier invented the world’s first modern electrical air conditioning unit, it symbolized the environmental condition technology has entered the modern era. The modern paradigm guaranteed convenient, effective and fast comfort experience. Actually, the modern comfort experience is highly constituted of the premises of technologies applications and energy consumption. While these two premises have gradually transformed the modern lifestyle and eventually reflected on architecture design, building industry and energy practice.

In the modern comfort, technology plays an important role to maintain a stable and comfortable living environment. For example, the modern air conditioning regulates the atmospheric condition to control air temperature, humidity levels and air ventilation. The air conditioning simply resolve the complex thermal comfort challenge for people. As a result, he modern skyscrapers and shopping malls are specific architecture typology benefited from the use of air conditioning. And gradually, the modern comfort became highly reliance on technologies.

In addition to technologies basis, the modern comfort experience is constructed on energy oriented approach. As a consequence of the employment of the active condition system, high energy input is required to support the system operation and performance. According to Reyner Banham in his The Architecture of the well tempered environment, he regards this approach as “power-operated solution”.
ANOTHER COMFORT PARADIGM

The modern comfort promises us with a favorable living environment for comfort's desire. However, the technological and energy oriented paradigm of modern comfort have become frictional resistance to pursue a sustainable future. The persistent technological failure, the irreversible energy crisis technological as well as the severe climate change have revealed the fact that the promises of modern comfort may fail some days.

Therefore, the goal of the thesis is suggesting there exists another comfort paradigm, in which the thermal comfort experience is obtained differently from the existing modern approach. The focus of this another paradigm is shifting from the technological and energy basis towards the inter-relation between the human body and the situated atmosphere. Thus, the human body, the atmospheric condition and the accommodating architecture are the critical re-considering subjects of the thesis.

Within the new paradigm, three architectural experimental type are proposed as Atmospheric Apparatus in responding to the production of another comfort experience. The three experimental types are designed according to three primary atmospheric factors: temperature, humidity and wind in order to induce respective atmospheric experiences.

02 | PHENOMENON -- MODERN COMFORT
MODERN COMFORT DEVELOPMENT

1902 – Willis Haviland Carrier invented the world first electrical air conditioner
1906 – Stuart W. Cramer used the term "air conditioner"
Carrier received U.S. patent No. 808,697.
1907 – A.H. Barker developed "radiant panel".
1906 – Larkin Administration Building,
1st office building designed for air conditioning by Frank Lloyd Wright.
1902 – New York Stock Exchange building,
1st building equipped with comfort cooling system.

Fig. 3. Modern conditioning technology development
84

1937 — “Critical” System in Switzerland

1950s & 60s — Failure of Metal Tube Hydronics

1968 — Thomas Engel developed cross-linked polyethylene tubing (PEX)

1930s

Frank Lloyd Wright’s Usonian House Design

1906 — Openluchtschool (Open Air School), designed by Johannes Duiker

1986 — “Sick Building Syndrome” was coined by World Health Organization

2009 — Philippe Rahm’s Domestic Astronomy

2002 — Diller Scofidio + Renfro designed Blur building for Swiss Expo 2002

PURSUIT OF TECHNO-COMFORT

Due to the natural comfort desire, pursuing thermal comfort has become an important cultural activities. And this pursuit has been significantly influencing architecture and technologies development. Various thermal comfort technology has been employed and integrate to building construction to favor interior habitation. For example, the Chinese Kang, the Korean Ondol and the Roman hypocaust as well as many other vernacular architecture around the world. All these architecture were reflecting the their respective knowledges on thermal comfort technology and actualizing them in building.

Then, until the Industrial Revolution, people began the Industrial Age and followed by Machine age in history. The science knowledges and technologies advancement have been resulted in a paradigm shift for the pursuit of thermal comfort and architectural design. In this paradigm, seeking for comfort has been engineered towards a scientific approach. For example, the Franklin stove, invented in late 18th century, with better performance and effective solution for smoke problem has dramatically transformed the heating for domestic living. Then, during the early 20th century, people were further fascinated by various spatial conditioning technologies developed and devote to live in a conditioned interior environment. Due to the desire and technological development, these conditioning technology had been widely applied to domestic space in which, a well conditioned living was perceived as luxury. As a result, living in a conditioned interior was regarded as a modern existence.

In the entire 20th century, people were enjoying the thermal comfort achieved by these modern technology, however, when these conditioning technologies became more widely adapted, various problems and related consequences emerged. Since these technologies required to maintain a stable
condition, much energy were consumed to maintain a steady thermal performance, which results in energy and economics problem followed with inter-country relations. Since 70s, the over demands of energy has turned to energy crisis in major industrial nations and eventually developed further to an international global problem. Meanwhile, these technologies have performance problems which consequently became various critical issues when these technologies lack of maintenance or even fail.

In recent decays, debate have been started over this technological determinism, the discussion has related to global sustainable topic in which the more adaption of technology, harder for human's survival in the future due to climate change, energy shortage, political conflict resulted due to these impacts. People begin questioning and doubt the necessity on technological solution to condition living environment, thus various "green" movements, which encourage sustainable technologies or restore to basic and learn from the tradition and history, emerged to reconsider the technologies application on conditioning living environment.

In summary, modern conditioning technologies provides many effective and solutions to achieve thermal comfort in modern time, however, their energy consumptions and inadequate application may results in un-desirable condition to the users in the building. Thus, regardless users or building industry, it is requires a new mentality and attitude to re-consider the applications of technology and avoid over reliance on them in order to foresee a sustainable comfortable future living.

"Every country builds its houses in response to its climate. At this moment of general diffusion, of international scientific techniques, I propose: only one house for all countries, the house exact breathing... I set up the factory for the production of exact air. It is a small establishment, a few small space; I produce air at 18 °C humidified according to seasonal needs. With a ventilator, I blow this air through carefully laid-out conduits. Means of expansion for this air have been invented to avoid drafts. Air comes out. This system at 18°C will be our arterial system. ... The Russian House, the Parisian, at Suez or in Buenos Aires, the luxury liner crossing the Equator will be hermetically sealed. In winter it is warm inside, in summer cool, which means that at all time there is clean air inside at exactly 18 °C"
As previously mentioned in "Pursuit of (techno) Comfort," the modern conditioning technologies development provided effective thermal comfort solutions for domestic living. Meanwhile, these technological approach amazed architects and inform the Modernism Architecture development in the 20th century. The sketch on the opposite page is sketch once proposed by Le Corbusier during one of his lectures at Buenos Aires. During the lecture, he once suggested “one house for all countries,” in he would imagine it acted like a human “breathing pure air, at a constant temperature and a regular degree of humidity” with the aids of international scientific techniques. In the house, it was serviced by modern conditioning technology to provide air at a constant temperature of 18 degree Celsius to operate the interior space. And this air was continuously circulating within the building with the helps of machine for cooling, humidifying and purifying. The entire system was regulated with standard and scientific quantity. Furthermore, he even proposed an architectural intervention called, Neutralizing Wall, when he was questioned how to maintain the constant temperature when outside temperature were forty degree higher or lower. Therefore, his neutralizing wall, a glass envelope wrapping around the building, would prevent the “air at 18°C” from any external influence. And in between the glass and building, heated air will circulate to maintain the interior condition stable. Lastly he provocatively suggested to hermetically seal this house, so it could be build around the world, such as at Russia, at Parisi and at Bueno Aires with “clean air exactly 18oC.”

In fact, the “one house for all countries” by Le Corbusier has been generally adopted in following Modernism Movement and become the hermetically sealed typology referred here. This universal and generic architectural proposition consisted of three important notions to shape Modernism Architecture spatial configuration: 1. Hermetically Sealed: Building is totally isolated from its external climate and environment to maintain an uninterrupted internal space; 2. Constant Interior Condition: A standardized and universal atmospheric condition was maintained with regulated temperature and humidity, the modernists believed this constant and stable condition will provide the maximum comfort for the occupants; and lastly, 3. Machinery Servicing Dependent: Intensive mechanical servicing and conditioning machineries are required to achieve the interior condition, it reflected the Le Corbusier’s philosophy of The house is a machine for living in.

5. Ibid, 64
6. Ibid, 66
7. Ibid, 64
Fig. 6. Global location map
INTERNATIONAL STYLE

As a result of this hermetically sealed typology, international style has benefited from the technology and energy base modern condition approach. And the skyscraper typology has spread all over the world.
According to the Building Data Book from US Department of Energy, the energy consumption for thermal comfort conditioning including heating and cooling in domestic context have been over 50% of total residential energy use, and this percentage is equivalent to 11.6% of total energy consumption in United States annually.
03 | INQUIRIES -- THERMAL COMFORT
HUMAN COMFORT

Basically, human comfort is referring to both physical and psychological ease, and these comforts can be easily achieved through various means, psychological comfort can be achieved by recalling of previous experience from seeing an object, the appreciation of an art piece and the intake of food. And the body physical comfort is more related to the situated environment and its corresponding atmosphere including temperature, humidity, lighting and odor. These various conditioning factors will create stimulation on body sensation system and developed a overall perception of comfort.
COMFORT

1. "A sense of physical or psychological ease, often characterized as a lack of hardship. Persons who are lacking in comfort are uncomfortable, or experiencing discomfort." (Wikipedia of Comfort)


THERMAL COMFORT

1. Not too hot or not too cold (Spontaneous Human senseation)

2. "The state of mind in humans that expresses satisfaction with the surrounding environment." (ANSI/ASHRAE Standard 55)

THERMAL COMFORT

Human body has an amazing sensibility for thermal comfort, it is a simple and reliable sensational ability to tell body its physiological feeling within a thermal condition. However, this sensation is always rather difficult to describe and define. For example, "Comfort is best defined as the absence of discomfort," for example; human will tend to describe it as not too hot or not cold when defining the comfort state. In other words, positive comfort conditions are not distracted by causing unpleasant sensations of temperature, drafts, humidity, or other aspects of the environment. According to Bradshaw in his The building environment, an ideal thermal is that state of mind that is satisfied with the thermal environment.

4 Vaughn Bradshaw, The building environment : active and passive control systems (Hoboken, N.J.: Wiley, 2006), 4
5 Ibid, 5
THERMAL COMFORT

THERMAL EQUILIBRIUM

HEAT GAIN = HEAT LOSS

M = C ± R ± E ± S*
THERMAL EQUILIBRIUM

According to "Design with Climate" written by Olgyay Victor, he stated that the human thermal comfort can be understood according to thermodynamics principles to maintain a thermal equilibrium between the body and the environment. And their respective thermodynamics relations can be translated mathematically into a Thermal Equilibrium Formula, in which the previous mentions comfort parameters are integrate in various heat exchange mechanism in the formula:

\[ \text{HEAT GAIN} = \text{HEAT LOSS} \quad \text{or} \quad M = C \pm R \pm E \pm S^* \]

*where:
M = metabolic rate,
E = the rate of heat loss by evaporation,
R = radiation rate,
C = conduction and convection rate, and,
S = the body heat storage rate.

At the point when heat generated (or heat gained) by body metabolism is equal to the overall heat gained or loss by convection, conduction, radiation and evaporation, a thermal equilibrium state is established within the body. In order word, at this equilibrium point, a human thermal comfort is obtained.

In all, the body thermal comfort give a interesting architectural proposition to relate to spatial configuration in order to induce above influencing thermal exchange mechanisms in order to provide human body a thermally comfortable habitation environment.
Fig. 8. Relation of thermal exchange
BODY TEMPERATURE

EQUILIBRIUM POINT

TABOLISM RATE (M)

EVAPORATION (E)

CONVECTION

MECHANISMS & FACTORS

In order to maintain the thermal equilibrium within the body, there are four thermodynamic mechanisms for the body to have heat exchange between the environment:

**Radiation** is the radiant energy transferred mechanism due to the heat content of an object. Human body is constantly undergoing radiation exchange by gaining heat from or losing heat to its surrounding environment.

**Convection** occurs when air passes over the body skin surface and brings sensible heat to or away from the body.

**Conduction** happens when the body has direct contact to any surface which has temperature difference from the body.

**Evaporation** is the only cooling process for human body to lose heat through perspiration, sweating and respiration by converting liquid to gas.
### HEAT GAIN

<table>
<thead>
<tr>
<th>1a) Basal Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1b) Activity</td>
</tr>
<tr>
<td>1c) Digestive, etc. processes</td>
</tr>
<tr>
<td>1d) Muscle tensing and shivering in response to cold</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>2a) From Sun directly or reflected</th>
</tr>
</thead>
<tbody>
<tr>
<td>2b) From glowing radiators</td>
</tr>
<tr>
<td>2c) From non-glowing hot objects</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3a) From air above skin temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>3b) By contact with hotter objects</td>
</tr>
</tbody>
</table>

| 4) Condensation of atmospheric moisture (occasional) |

### HEAT LOSS

<table>
<thead>
<tr>
<th>5a) To “sky”</th>
</tr>
</thead>
<tbody>
<tr>
<td>5b) To colder surroundings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6a) To air below skin temperature (hastened by air movement-convection)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6b) By contact with colder objects</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7a) From respiratory tract</th>
</tr>
</thead>
<tbody>
<tr>
<td>7b) From skin</td>
</tr>
</tbody>
</table>

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**Fig. 9. Atmospheric Factors**

Fig. 10. Human Body Temperature
Reference: Moe, *Thermally Active Surfaces in Architecture*, 71
OPTIMAL ATMOSPHERIC CONDITION

Due to the complexity of the body structure and the dynamic atmospheric condition, it is impossible to achieve a definite thermal equilibrium, thus, there is optimal temperature and humidity range in which the body obtains maximum thermal comfort. Meanwhile, these optimal atmospheric conditions are also important for human body normal function.
PSYCHOMETRIC CHART

DOMESTICS APPARATUS

DOMESTIC HEATING

Thermostat
Radiator
Air heater
Space Heater
Franklin Stove

DOMESTIC COOLING

Dehumidifier
Ceiling Fan
Stand Fan
Air Conditioner
04 | PROPOSAL -- ATMOSPHERIC APPARATUS
ATMOSPHERIC APPARATUS
THE PRODUCTION OF ANOTHER COMFORT PARADIGM

The architectural proposal of the thesis are three experimental prototypes of Atmospheric Apparatus. The major idea of three prototypes is to induce an alternative atmospheric experience for thermal comfort. Thus, each prototype’s design is driven by a specific atmospheric factor and they are Temperature | °C, Humidity | % and Wind | m/s respectively. In addition to the atmospheric factors, the program, site location and material choices of each apparatus prototype are differently decided in order to further enhance the unique experiences.
°C
SITE

AKUREYRI

ICELAND

CLIMATE

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<th>J</th>
<th>F</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>53.8</td>
<td>49.1</td>
<td>41.7</td>
<td>35.8</td>
<td>34.7</td>
<td>36.1</td>
<td>42.8</td>
<td>45.3</td>
<td>44.8</td>
<td>40.8</td>
<td>38.3</td>
<td>31.3</td>
</tr>
<tr>
<td>Min.</td>
<td>22.1</td>
<td>23.5</td>
<td>24.4</td>
<td>32.6</td>
<td>35.1</td>
<td>33.2</td>
<td>36.7</td>
<td>37.5</td>
<td>35.8</td>
<td>33.6</td>
<td>35.1</td>
<td>28.6</td>
</tr>
</tbody>
</table>

Average max. and min. temperature / °F
Source: Hong Kong Observatory

GEOTHERMAL

Volcanic landscape
Geothermal power plant

Image sources:
Left: http://www.wallcoo.net, Right: http://www.evwind.es
THERMAE
RE-EXPERIENCING TEMPERATURE

THERMAE is the first prototype designed to provide opportunity for re-experiencing the “forgotten” temperature. Nowadays, our living environment is constantly regulated with standard temperature level according to the pre-defined comfort zone derived from modern engineering knowledge. However, the pre-determined have been always proved to be not suitable for everyone’s comfort desire, Thus, THERMAE is designed as a device to produce a spectrum of diverse thermal experience.

Site and Climate
Akureyri, a fishing town in the northern part of Iceland, has a subpolar oceanic climate of cold winter and mild summer. The average temperature of the region is relatively low throughout the year. The average maximum summer temperature is only 58.1 °F, while the average minimum winter temperature is 22.1 °F.

Resource
Due to Iceland’s geological condition, the abundance geothermal power resources from below ground become the major energy source for the country. In 2010, 26.2% of the nation’s energy is generated by the geothermal power, and 87% of the heating and hot water supply are produced by the geothermal heat source. Therefore, THERMAE will take advantage of this abundance resources to generate another thermal experience.

The programatic idea of THERMAE is to produce rich and diverse thermal experiences through various heat exchange mechanisms: **radiation**, **convection** and **conduction**. These heat exchange mechanisms will occur between the human body with specific experience media of surface, air and water respectively.

**Radiation**
The radiation process occurs through heated surfaces with hot water hydronic tubes embedded. They are the stone sauna with a single flat stone slate surface and the solarium with six surfaces inside an enclosed chamber.

**Convection**
While another thermal experience is obtained through the convection process by passing heated air over the body in dry sauna and smoke sauna. Because of difference in air heating methods, the experienced air temperature in dry sauna is higher than the smoke sauna one.

**Conduction**
Lastly, the conduction process happens when the body is in direct contact to the warm water in the hot bath, cooled water in cool shower and steam vapor in the steam bath. Due to the direct body contact, the temperature of the thermal experience will be relatively lower.
FLOOR PLANS

1. Solarium
2. Dry sauna
3. Stone slate sauna
4. Hot bath
5. Steam bath
6. Smoke sauna
7. Cool shower

Roof plan

Ground plan
SECTIONS

1. Solarium
2. Dry sauna
3. Stone slate sauna
4. Hot bath
5. Steam bath
6. Smoke sauna
7. Cool shower
Above: Average max. and min. temperature / °F
Below: Rainfall / mm
Source: Australian Bureau of Meteorology
STRATUS
RE-EXPERIENCING HUMIDITY

In addition to temperature, the atmospheric humidity also plays an important role to induce comfort thermal experience. Thus, STRATUS, the second aparatus prototype, is designed to articulate the presence of humidity within the atmosphere for comfort. At the same time, the STRATUS will help tp to recall the human sensation of the importance of humidity.

Site and Climate
Alice Spring locates in the center of Australia, where it situats within an arid area surrounded by several deserts. Due to its inland location, Alice Spring has hot and dry desert climate with relatively high temperature throughout the year, the limited annual average rainfall of 285.9 mm\textsuperscript{7} and high evapotranspiration rate prohibit any cloud formation to prevent excessive solar radiation gain during daytime and heat loss during nighttime, therefore, the area also suffers from dramatic diurnal temperature variation everyday.

**DAYTIME**

1. Hot and dry air penetrates in (30%)
2. Incoming dry contacts with water bodies & wet curtain (30%)
3. Cooled and humidified air is dispensed by fan
4. Air is further cooled down and humidified (80%)
5. When air is saturated, cloud of mist forms (100%)

**NIGHT-TIME**

1. Moisture evaporated into the air during day time
2. The humidified air is carried away by wind
3. Wet air condenses when contact with the water tower
4. Condensed moisture is collected and stored
5. Stored water become water supply
ATMOSPHERIC APPARATUS

The design ambition of STRATUS is to produce an ecological apparatus with multiple functions in order to create a unique comfort experience related to humidity. Thus, in order to reflect this intention, the programatic idea of STRATUS is decided to be water related, a water storage, water supply center, water collector and air humidifier are the primary programatic framework for the design of STRATUS. The major goal of STRATUS is to induce decent comfort experience through the water related programs to achieve cooling effect. Actually, the ultimate aspiration of STRATUS is to transform the perception of the place by mimicking the cloud formation to create a new atmospheric condition for the area.
WATER COLLECTION TOWER:
1. Metal mesh provides large condensation surface for wet air
2. Large water tank stores and collect condensed water and provide water for other uses.

TOWER STRUCTURE:
3. Three tower height to capture water moisture at various level
4. The tower is supported with composite columnar system made of beams
5. Underneath sprinklers provide water mist during events and hot day

PODIUM:
6. Fans to further enhance air current to when air movement is low
7. Mesh floor collects water from the mist dispensed by the sprinkler
8. Louver fins to allow hot and dry air penetrates

PLATFORM:
9. Different type of water bodies provide varied experience and function
10. Air Humidification
11. Water fountain
12. Water wall
COMPONENTS

STRATUS is basically constituted of three major components: tower, podium and platform, which enables STRATUS to perform as an ecological apparatus at respective levels.

Water Collection Tower:
The superstructure of STRATUS is dominated by three water collecting tower with various height. The major function of these tower is to provide sufficient cooling surfaces are for air moisture condensation happens during the nighttime. Due to the high thermal conductive property of the surface material, the tower will have lower temperature than the atmospheric air, thus, condensation occurs when the hot air moisture is in direct contact with the surfaces. Moreover, the different tower heights provide enough exposure to each tower for a non-obscured air current. Meanwhile, a water tank is installed withing the taller tower for water collection purpose.

Podium:
The podium of STRATUS provides an decent outdoor space with the aids of the sprinklers system to regulate the humidity level to a comfortable level. During daytime, the sprinkler system will dispense cloud of mist to induce cooling effect for the air, while the mist clouds can reduce radiant temperature by blocking some solar radiation from heating up the surface. As a combine effect of cooling effect and radiation reduction, the podium become a decent outdoor event space even during the hot and arid day at Alice Spring.

Platform:
The platform of STRATUS accommodates mainly the water center program to serve as a public facility and community gathering space for people who come here for water. The covered interior provides shaded to protect from the direct solar radiation of heating up. The interior experience is also further enhanced by the present of water bodies and good ventilation by openness of the peripheral supporting structure.
Above: Average max. and min. temperature / °F
Below: Rainfall / mm
Source: BBC Weather
MONSOON
RE-EXPERIENCING WIND

MONSOON is the third proposed apparatus prototype. Its design intends to induce the comfort sensation through air movement - wind. In addition to temperature and humidity, air movement also plays a critical role to affect the human comfort perception. According to the thermodynamic knowledge, both convection and evaporation processes and their respective processes rate are influenced by the degree of air movement. Thus, the MONSOON is design based on the idea of air movement to induce unique experience.

Site and Climate
Jaipur, a city at the northwestern India, is chosen to be the experiment site for MONSOON. According to the Köppen Climate Classification, the climate at Jaipur is hot semi-arid. During the monsoon period in summer time, the average temperature will rise to over hundred degree Ferinheight and the condition will become relatively humid.

**ACTIVITIES**

**LEVEL**

- Climbing stairs

**CLOTHING**

**BEAUFORT WIND SCALE**

- Hurricane: >32.8
- Violent storm: 28-32.8
- Storm, whole gale: 24.7-28.3
- Strong gale: 20.8-24.4
- Gale, fresh gale: 17.2-20.6
- High wind, moderate gale, near gale: 13.9-16.9
- Strong breeze: 10.8-13.6
- Fresh breeze: 8.1-10
- Moderate breeze: 6-8
- Gentle breeze: 3-5
- Light breeze: 2-3
- Light air: 0-2
- Calm: <=0.3

**RUNNING TRACK**

**WIND SPEED**
APPARATUS PERFORMANCE

The comfort experience induced by MONSOON is totally different from the previous apparatus prototypes. In MONSOON, human body becomes the active agent for obtaining comfort experience by physical exercise. The program of MONSOON is an urban fitness center with a spiral track consisting of multiple ramps. The programatic intention is to offer people with comfort experience at different activity levels. A person who walk up the track will experience differently compared to a person who jogs or runs. When that person walk down the track the experience will be totally different again. Meanwhile the proliferated facade encourages good natural ventilation to provide steady air movement for minimum cooling. Apart from the spiral, there are four contained wind chambers with active mechanics ventilation system for more intensive exercises. As result, the comfort experience obtained in MONSOON is uniquely correlating to the respective body activities levels.
Components

The basic components of Monsoon consists a facade system, a spiral ramp system, four contained wind chambers and a structural frame system.

Facade

As mentioned above, the proliferated facades on MONSOON's long elevations ensure steady natural cross ventilation. At the same time, the highly permeable facades also create shading for the building to prevent overheating during sunny day.

Spiral

The spiral system provides an active exercise surface for experiencing difference body's activity levels. Contrasting to flat surface walking, navigating on the spiral required high amount of body exercise and energy input. As a result, it alerts the body metabolism rate and affects the thermal equilibrium. Thus, the thermal comfort experience is not perceived passively at a constant condition.

Wind Chambers

The contained wind chambers are dedicated for more intensive physical exercises of higher activity levels. Therefore, each chamber is equipped with mechanical ventilation for high thermal comfort requirement.
ATMOSPHERIC APPARATUS
INTRODUCTION OF A NEW MODERNITY FOR COMFORT

MODERNITIES OF COMFORT

PROMISES

FACTS

UNLIMITED DEMAND

ENERGY CRISIS

CAPABLE TECHNOLOGY

TECHNOLOGY FAILURE

PERFECT STANDARD

SUBJECTIVE PERCEPTION

DESIGN ARCHITECTURE OF ATMOSPHERIC COHABITATION

DESIGN ARCHITECTURE AS APPARATUS

DESIGN ARCHITECTURE FOR EXPERIENCE
STRA TUS
RE-EXPERIENCING HUMIDITY

DAYTIME APPARATUS MECHANISM

NIGHTTIME APPARATUS MECHANISM

ROOF PLAN 1:100
FLOOR PLAN 1:100
SECTION 1:50

SYSTEMS

HUMIDIFIER APPARATUS
EVAPORATIVE COOLING EFFECT

WATER COLLECTION TOWER:
1. Water catchment from roof and surrounding landscape
2. Large, permeable tank with high evaporation capacity

TOWER STRUCTURE:
1. A vertical axis with a cross-sectional area at the top
2. Linear tower with a cross-sectional area at the bottom

FLOODING:
1. Water flow through a network of pipes
2. Distributes water evenly across the structure

PLATFORMS:
1. Supports the structural elements
2. Acts as a base for the tower structure
BIBLIOGRAPHY


