FINAL PROJECT REPORT - RA.141581

WIND TUNNEL APARTMENT

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APPROVAL

WIND TUNNEL APARTMENT

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Thus statement I created with full consciousness and will be used as a requirement to complete the final project RA. 141581

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ABSTRACT
WIND TUNNEL APARTMENT:

By

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The warm humid tropical climate in Indonesia and the conditions of urban area make a lot of people depends on the mechanical ventilation, especially people with middle-upper economy level. With design approach of bioclimatic architecture, this final project attempts to offer design alternative of the apartment for the middle-upper income community by promoting natural ventilation. The goals of this apartment is to apply both natural ventilation system and accommodate the needs of middle-upper urban community

By applying the Evidence Based Method the proposed apartment design follows the rules from the researches available from studies of thermal comfort and residential architecture. The design problems while designing this passive apartment are to promote the thermal comfort and facilitate the needs of middle-upper economy people such as high level of privacy and security. These two problems are contradicts to each other, because on one hand applying the design of natural ventilation means to live more with openness, but on the other hand the occupants need privacy and security. The Wind Tunnel Apartment facilitates these two contradictive design problems by integrating the concept of passive design and explores the design elements.

Key words : warm humid tropics, evidence based design, passive design, apartment

ABSTRAK
APARTEMEN LORONG ANGIN

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Iklim tropis lembab di Indonesia dengan temperatur dan kelembapan yang tinggi membuat masyarakat Indonesia sangat bergantung kepada penghawaan buatan terutama masyarakat kalangan menengah keatas. Dengan pendekatan desain bioklimatik arsitektur, desain apartemen yang diusulkan mencoba membuat alternatif desain apartemen menengah keatas yang ada selama ini yaitu dengan menerapkan penghawaan alami. Tujuan dari tugas akhir ini adalah membuat apartemen dengan pengahawaan alami dan juga mengakomodasi kebutuhan masyarakat urban.

Dengan menerapkan metode *evidence based design* desain apartemen yang diusulkan mengikuti riset yang ada dari studi kenyamanan termal dan arsitektur residensial. Permasalahan dalam mendesain apartemen adalah dalam memenuhi desain penghawaan alami dan juga memfasilitasi kebutuhan masyarakat menengah keatas yang membutuhkan privasi yang tinggi. Kedua masalah ini bertolak belakang satu dengan yang lain dikarenakan di satu sisi menerapkan penghawaan alami berarti membutuhkan tingkat bukaan yang tinggi, sedangkan kebutuhan penghuni akan keamanan dan privasi tinggi. Apartemen Lorong Angin ini berusaha menjembatani kedua permasalahan desain yang bertolak belakang dengan menyatukan konsep pasif desain dan eksplorasi elemen desain.

Kata Kunci : Iklim tropis lembab, evidence based design, desain pasif, apartemen

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I. INTRODUCTION

I.1 BACKGROUND

Indonesia, which is located in the equator, is one of the countries with tropical climate, specifically the warm humid tropical regions. A climate condition of an area can affect the way a building is designed. Building in warm humid tropical regions means battling with the high sun radiation, and high humidity. (Lauber, 2005)

From long time ago our ancestors had designed vernacular building, which showed architectural response toward the climate. In the warm humid tropical climate, it is often found building with large windows, large overhangs, and low mass. Where possible wall are minimized. Sometimes buildings are set on stilts to catch more wind and to rise above the humidity near the ground. High ceilings allow the air to stratify, and vents at the gable or ridge allow the hottest air to escape. These principles created a lightweight houses structure with openings everywhere allowing the building to cool off (Lechner, 2001)

However after the era of modernization, the ideal tropical design, which appeared in

Figure 1-1 Issue Diagram

Indonesian traditional architecture is not simple anymore to be adapted in the present situation, especially in the urban regions. In the tropics, the idea of using natural environment as positive elements, makes living with openness is possible throughout the whole year. However this idea becomes viable only if the external environment is relatively, dust, insect, and noise free. (Tay Kheng Soon, in Tzonis et al, 2001)

I.2 ISSUE & CONTEXT

The basic strategy for architect to tackle the problem in the tropics is to design building with shade and create opening (usually windows) for air exchange. However in the context of urban area like in city of Surabaya, the

second largest city in Indonesia, the availability of land is limited and sometimes rooms are not designed with openings facing outdoor for air exchange

The opening, which is usually in the form of windows, makes the occupant's window opening behavior important in maintaining the thermal comfort. However in the urban area, such as Surabaya, there are many reasons for closing the window. Based on field survey of 437 households in public and private apartments in Surabaya, the top reasons for not opening windows or doors are privacy, insects, and security (Arethusa et al., 2014).

After the invention of technology, especially air conditioner, reaching thermal comfort inside the room temperature become simple without compromising between thermal comfort and privacy, security, insect, and noise. As a result, many building in the tropics seems to forget the basic strategies of climate response, and rely on technology only to solve the thermal comfort. People will buy air conditioner as soon as they can afford it. Lack of knowledge of building science also contributes to the unawareness that a building design also contributes to the thermal comfort inside the building.

I.3 DESIGN PROBLEMS

The design problem according to the issue reviewed above is mainly about the contradictive between the ideal condition of passive tropical housing and the present urban conditions.

- The city density and land available

  The density and limited land available in the urban area result in the proximity of private space between one occupants and other.

  This also challenge architect to create housing which can accommodate a lot of people but still be able to maintain thermal comfort
- Unsuitable environmental and social condition, despite the need of openness for comfort

  Comfort ventilation is the main strategy of passive cooling in the hot and humid region. However, factors of security, privacy, insect, and noise affect the occupants to close the window.
- Low velocity of wind

Although wind plays important role in cooling building off, in the hot and humid tropical region the wind is usually characterized by the low velocity and not always available

I.4 DESIGN CRITERIA

- The design should be able to accommodate the needs of urban community
    - Efficient land use
    - Respect privacy and security
- Design should be able to make the occupant live in harmony with nature

  Comfortable during dry and rainy season
- Design should be able to apply passive cooling strategy in the urban area

I.4 PROPOSED DESIGN

To response from the present issues and condition, this design proposal aims to create a new alternative of housing block in the urban warm humid tropical region by adapting passive cooling strategies. By living and having experience in this passive housing hopefully in the future rather than buying air conditioner people will start to concern about the shape of their home as it affect thermal comfort.

Middle-rise scale buildings is chosen for the response because this type of buildings are relatively easy to be climate responsive but still optimize land usage

II. SITE & PROGRAMMING

II. 1 SITE

II.1.1 Site Location & features

The site is located in the city of Surabaya, province of East Java. The site is curently an empty land, and is situated in the Penjaringansari Area. The site is located next to the Middle East Ring Road (MERR)

Figure 2-1 Site Location

The site boundaries are described as below:

- North side: empty land which will be a road & River with the width of 15 m
- East side : Small creek and empty land
- South side: Empty land with some built building with 2-story height
- West side : Main road access

Figure 2-2 Site Area

The total surface area of the site is 9.135 m^2 with an area in the form of trapezium. The site is equipped with access of electricity, water supply, and drainage.

The site is currently an empty flat land with no contour. The vegetation of existed on the site is grass. There is no particular natural physical features which need to be preserved.

II.1.2 Access

The site is mostly surrounded by residential areas with height about one up to two-story height. The site is located in the middle to upper income residential area.

The site is currently accessible from one road side only which is the west side, but according to the municipality planning regulation the part of the empty land on the north side will be developed for the new road access.

The road access in the west ride is one way access only.

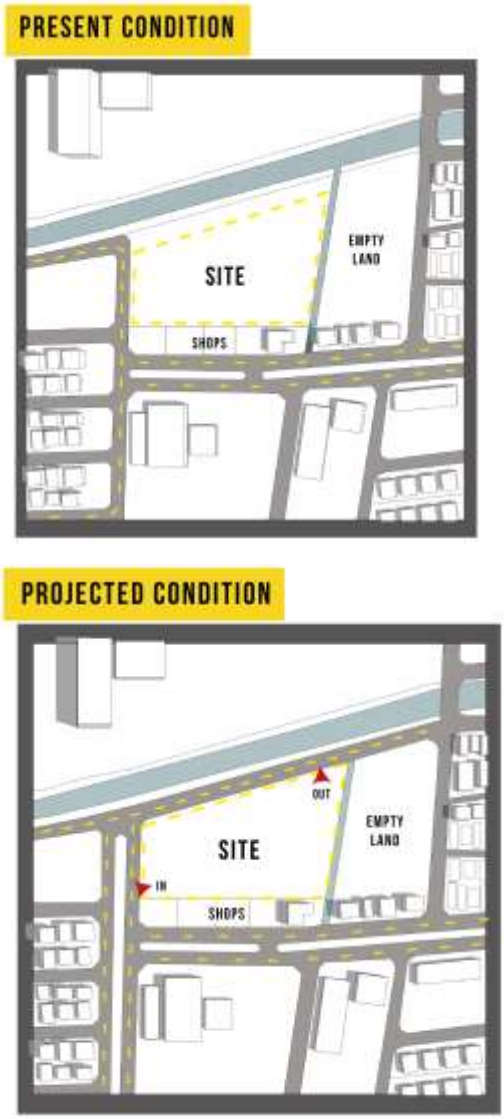


Figure 2-3 Projected Site Development

II.1.3 Site Climate

Surabaya weather features lots of rain and high humidity, but with little variation in daily temperatures. There are two seasons in Surabaya: the rainy season (November to June) and the dry season (July to October).

Surabaya is categorized as warm humid tropical climate city, with monthly average temperature ranging from 27.2-29.0°C and monthly average relative humidity ranging from 65.9-80.9% (Fig.1). The city receives monthly average wind speeds of 2.12-3.10 m/s (NCDC, 2014). Although Surabaya has two seasons (dry and wet seasons), the monthly average temperatures and humidity of both seasons do not show significant differences.

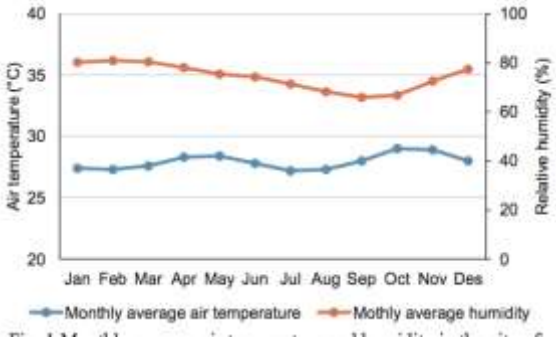


Figure 2-4 Monthly average air temperature and humidity in the city of Surabaya (1993-2013)

II. 1. 4 Wind Analysis

There is no wind data, which based on observation on the current site. However based on the observation by the Meteorology Board, the lowest speed of wind was on April: 5.8 knot, and the highest one was in January: 8.8 knot while the maximum speed was 22 knot and most of them came from the Eastern side.

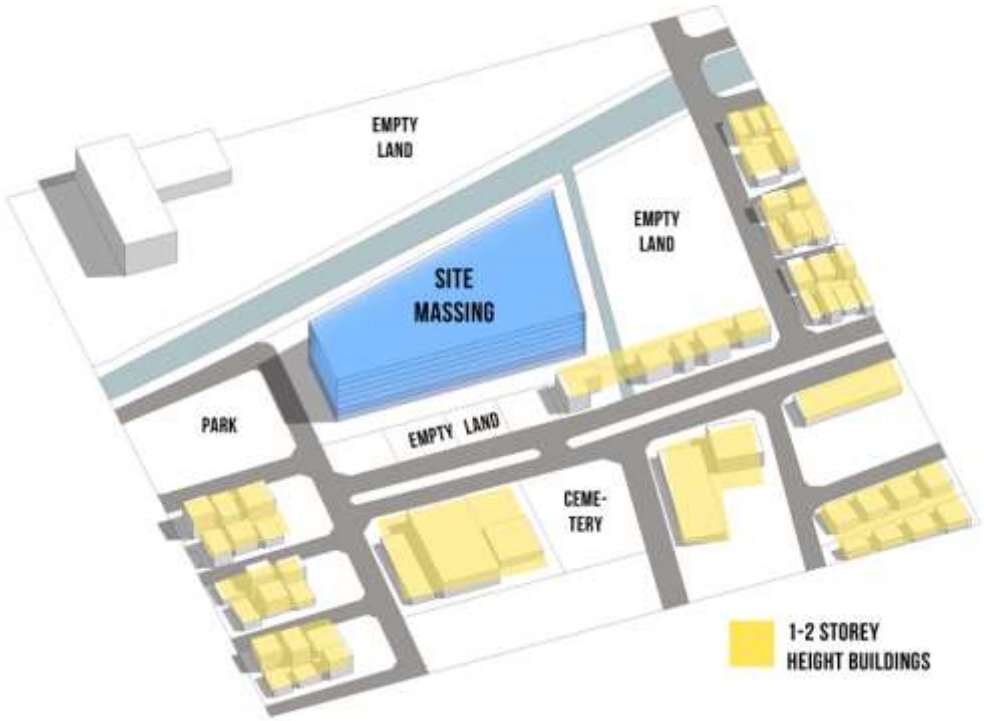


Figure 2-5 The massing surrounding site which affect the upcoming wind

The wind data available are measured in two areas of Surabaya, which are the Juanda International Airport, and from the Perak Harbour. The diagram of the wind rose below shows the direction of the wind in these two areas in Surabaya.

Based on these data above, the wind is projected to come from east and west side, of the site.

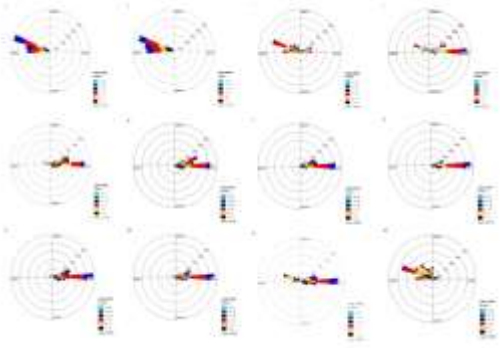


Figure 2-6 Wind Rose in Perak Harbour

Figure 2-7 Wind Rose in Juanda Airport

In addition, the wind is also relate to the surrounding area of the site, as shown by figure 7, the wind is available in the site because the building in the existing site are almost all about 2-story height and the site's boundary are detached from neighbor buildings except in the south side.

II.2. PROGRAMMING

II.2.1 Users

The users in the proposed design object are :

- Middle-upper income families

  Based on the issue of high-energy consumption for cooling building in the tropic, the apartment is intended for middle-up income people because these economic groups often use air conditioner in their home

- Visitors

  The visitors in the vertical housing are the relatives, of the occupants.

- Administrative personnel

  The administrative personnel in this housing complex are the person working on the management office, janitors, tenant's officer, and security.

II.2.2 Spatial Program

Based on the literature study, the programs in the apartment are categorized as main facilities, supporting facilities, management facilities, and service facilities

II.2.3 Main Facilities

The apartment units are divided into 3 kinds, units with one bedroom, two bedrooms, and three bedrooms. Each of this categorized unit has plan variation with different size

Facilities	Notes	Total Area
1 Bedroom Units	34 units / each 40 m^2	1360 m^2
2 Bed Rooms Unit	50 units / each 64 m^2	3200 m^2
3 Bed Rooms Units	12 units / each 100m^2	1200 m^2

Table 1 Area of Main Facilities

II.2.4 Supporting facilities

Facilities	Notes	Total Area
Lift Lobby	-	64 m^2
Mailbox room	-	64 m^2
Swimming Pool	-	238m^2
Gym	-	134 m^2
Restaurant	-	924 m^2
Clinic	-	64 m^2
Laundry	-	92 m^2
Tenants	3 available rent space	348 m^2

Table 2 Area of Supporting Facilities

II.2. 5 Management Facilities

Facilities	Notes	Total Area
Management office	-	128 m^2
Multi purpose room	for residents meeting	148 m^2
CCTV Room	-	16 m^2
Men's locker	For the	32 m^2

room	workers	
Women's locker room	For the workers	32 m^2
Worker's canteen	For the workers	286 m^2

Table 3 Area of Management Facilities

II. 2.6 Service Facilities

Facilities	Notes	Total Area
Security Post	-	9 m^2
Car Park area	145 car parking space	3850 m^2
Motorcycle Park Area	100 motor cycle parking space	128 m^2
Kitchen	-	128 m^2
Rest room	In the first floor& second floor	64 m^2
Men's shower Room	For the swimming pool and gym	58 m^2
Women's shower	For the swimming pool and gym	58 m^2

Table 4 Area of Service Facilities

II. 2. 7 Utility Facilities

Facilities	Notes	Total Area
Fire Stairs		96 m^2
Generator room	-	64 m^2
Circuit Breaker Room	-	16 m^2
Lift Machine Room	-	40 m^2
Pump House	-	40 m^2
Upper water tank room	The upper water tank separated into 4 area in the roof	120 m^2
Trash Chute	3m2 in every floor	18 m^2
Dumpster room	For collecting trash in the ground floor	64 m2
Janitor room	5 m^2 In every floor	35 m^2

Table 5 Area of Utility Facilities

III. DESIGN APPROACH & METHOD

III.1. DESIGN APPROACH

Based on the resulting issue and response to create vertical housing which apply the passive design. The design approach which is suitable in handling such condition is called "Bioclimatic Architecture."

The term 'bioclimatic' has traditionally related to the relationship between climate and living organism. In the context of architecture, it is building designs that take into account climate and environmental conditions to help achieve optimal thermal comfort inside. It deals with design and architectural elements, avoiding complete dependence on mechanical systems, which are regarded as support.

Bioclimatic architecture can be conceptualized as building design that utilizes a range of biophysical elements, such as heat, light, landscape, air, rain, and materials.

III.2. DESIGN METHOD

According to the issue, which is related to the building science, the appropriate method used is called "Evidence Based Design".

Figure 3-1 Method Diagram

Evidence Based design is design method which make use of current best evidence from research and practice in making critical decision. Cama (2009) states that Evidence Based Design consists of 4 steps which are research, analyze, implement, and evaluate.

Research In this step the designer will gather data, such as literature review, precedent analysis, and select which data that will be applied in the design strategies.

Analyze is the step to integrate the strategy from the data gathered in the first step with the programmatic requirement (Define needs), this step also include determine goals for the designed object

Implement phase consists of interpreting and understanding the data, and then creating hypotheses of the result from the design decision according to the date. Based on this

hypotheses designer make design decision.

The last step is to measure from the data gathered whether the design decision meets the requirements and goals.

III. 3. DESIGN CONCEPT

In order to answer the question in the urban tropical climate, the main building concept is to maximize the usage of wind in the form of middle rise apartment. Wind is useful for passive cooling in the hot and humid tropical climate because air movement surrounding the human body will transfer the heat from our body through convection and evaporation into the air molecules.

This passive cooling technique is very appropriate in hot and humid climates, where the air temperature and relative humidity are out the comfort zone. (Lechner, 2001)

To integrate this concept of maximizing the wind and another factors that affect thermal comfort in a building, the strategy is to create cooling strategy in every architectural element, from the architecture neighborhoods down to the building elements. Integrating these strategies are adapted from the book, Sun, Wind & Light (Dekay, 2014)

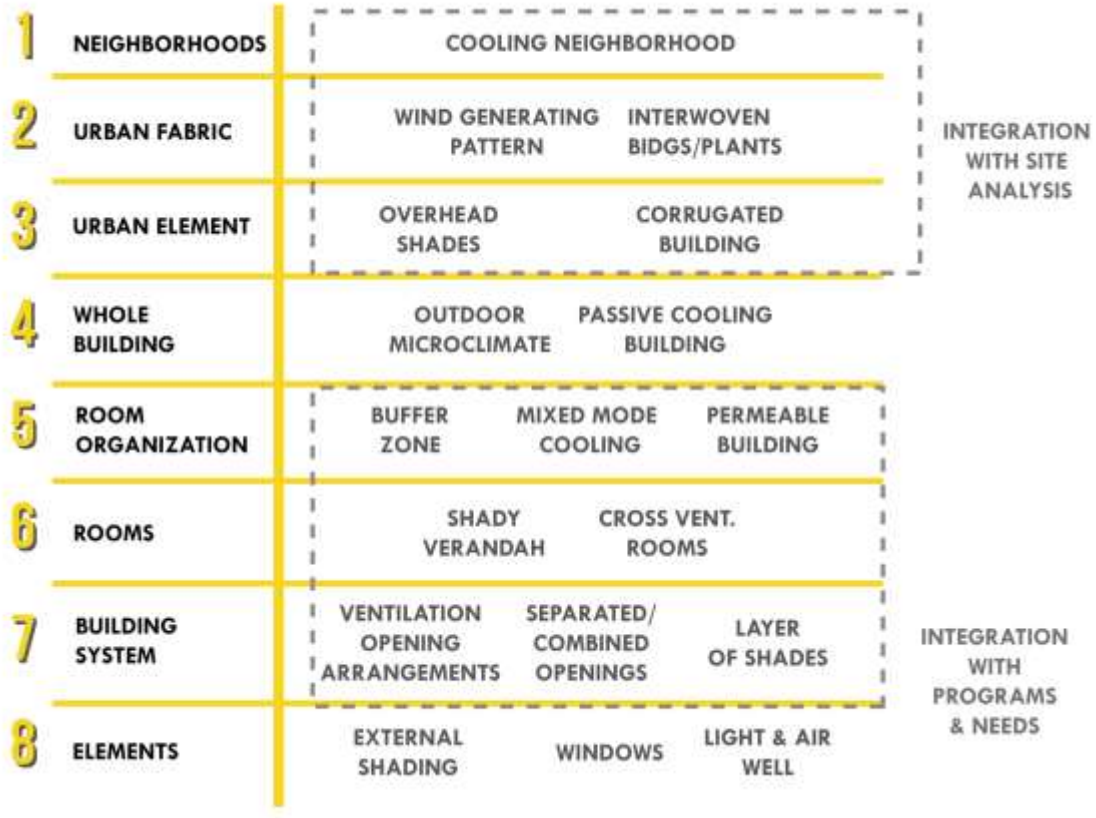


Figure 3-2 Concept Diagram

IV. DESIGN EXPLORATION

IV. 1. FORMAL EXPLORATION

IV. 1. 1 Site Access & Circulation

Considering the road development in the future (based on the municipality regulations ,RDTRK Surabaya), the entrance of the apartment is located in the area with wider road, which is road in the west side, and the exit in the site will be on the north side of the site

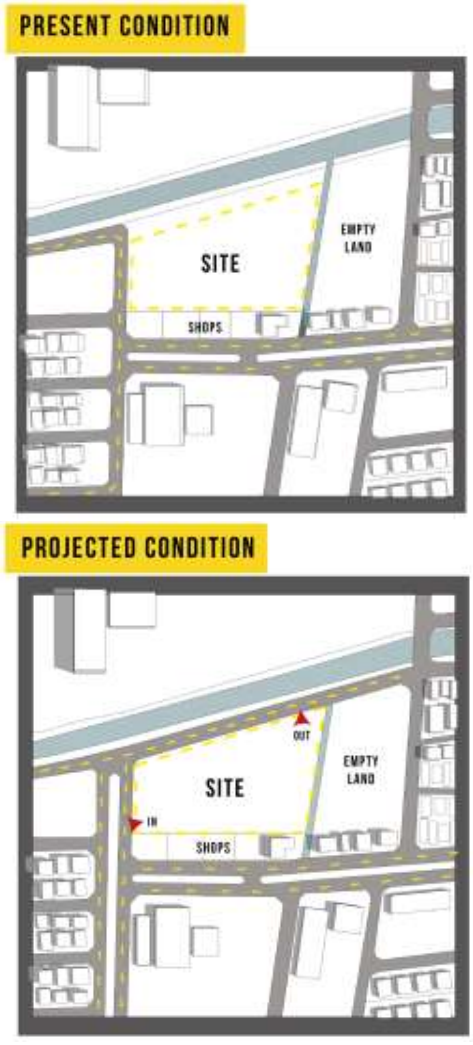


Figure 4-1 Projected road development

The road with the width of 5 m is designed in the perimeter of site as the main vehicle circulation in the site. This circulation is not only beneficial for the resident's vehicle access but also for the service vehicle such as dustcart and fire truck

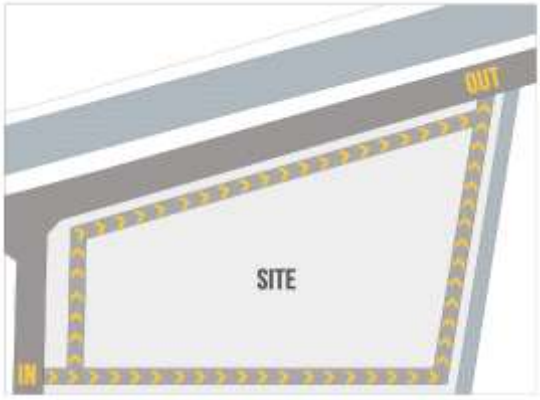


Figure 4-2 Site entrance and exit

IV. 1. 2. Program Zooning

Based on the building program, and the usage, the program in the Wind Tunnel Apartment is arranged as the diagram below.

The facilities such as restaurants, clinic, laundry, and tenants, which can be accessed by the non-residents are located in the first floor. The location in the first floor also beneficial for tenants who seeks for profit. These facilities also accompanied by services facilities such as car parking space and motorcycle parking space.

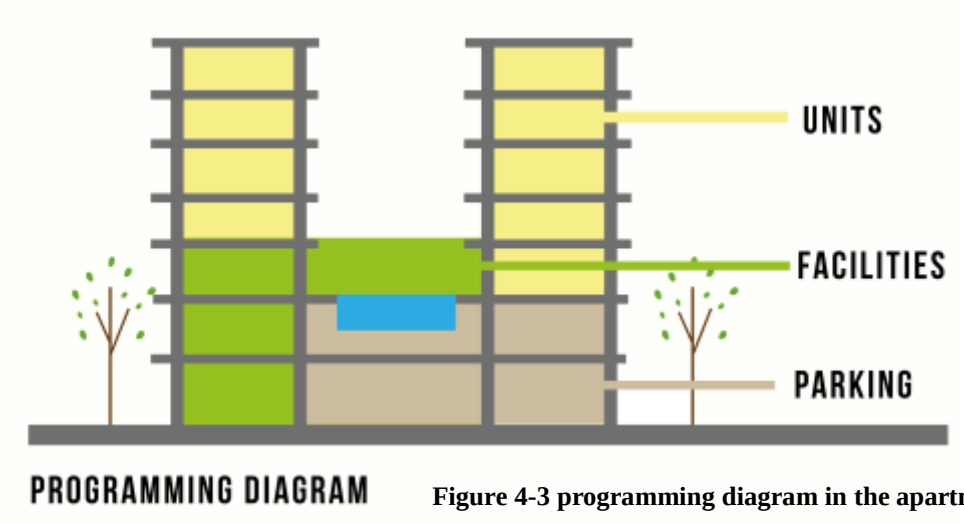


Figure 4-3 programming diagram in the apartment

In the Second floor the management facilities is located, as well as facilities for the workers such as the worker's canteen.

The units are located from the third floor to the seventh floor because the wind will be higher in this level and according to the wind analysis the ; the swimming pool and gym are located in the third floor next to the units because these facilities are intended for the residents only. Locating the swimming pool in the third floor also beneficial for some units to have view of the pool.

IV. 1. 3. Mass Transformation

Because of the main design concept, which is to maximize the wind flow in the building, the principle to maximize the wind flow is adapted from the book of Tropical Architecture by Wolfgang Lauber, which state in order to maximize the wind flow there

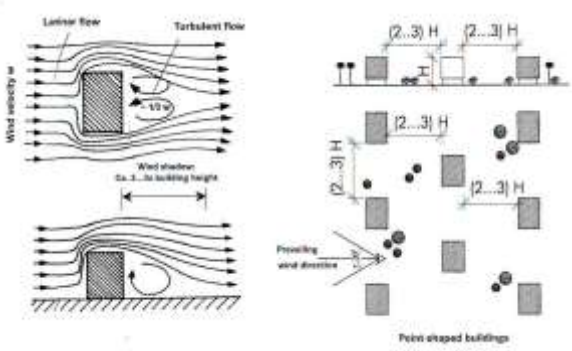
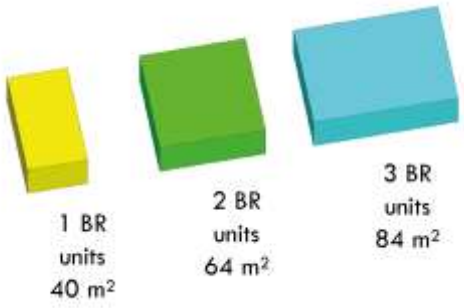


Figure 4-4 Distance required for maximizing wind flos. Source: Lauber

has to be minimum distance between one building and another, which is 2-3x the building height.



In this form transformation the building are assumed as the units of the housing, so that every unit can get adequate wind flow to obtain thermal comfort. The units are determined according to the size before arranging the units. Then these units are arranged

in the 8x8 m grid in the site. This 8x8 m grid is based on consideration of the parking size beneath the unit and the unit size itself.

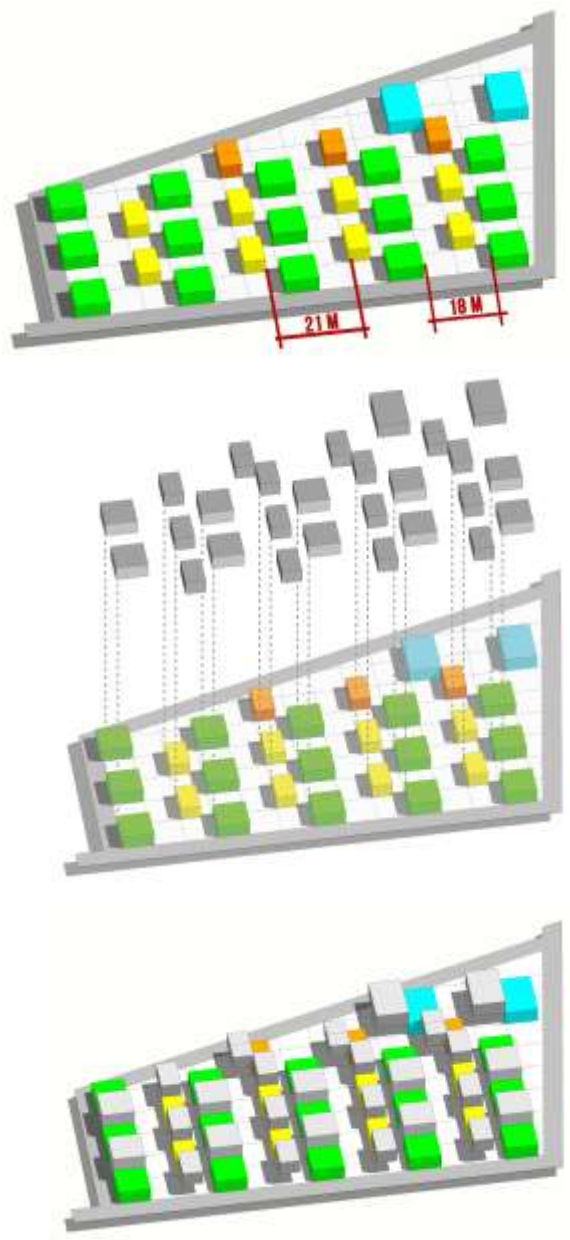


Figure 4-5 Process diagram of the massing arrangement

After that, the layer above are arranged in opposite direction, so that it create a form like a square with checkered hole. The masses in the middle of these form are replaced by the swimming pool.

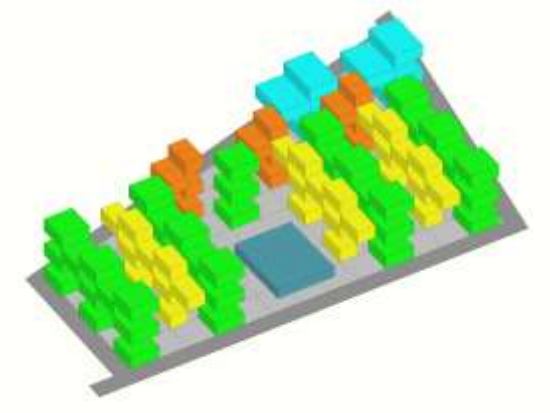


Figure 4-6 Placing the swimming pool

This form will be developed further which turned to be the final form of the design.

IV. 1. 4. Circulation

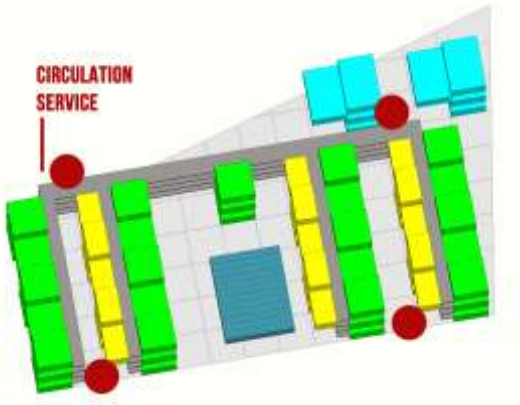


Figure 4-7 Circulation between the mass arrangement

After defining the mass of the form, the circulation between the units is formed. The circulation forms two blocks of housing units. By defining the circulation the point which the vertical circulation and services such as fire stairs, trash chute, circuit breaker, can be defined.

IV. 1. 5. Sky Verandah

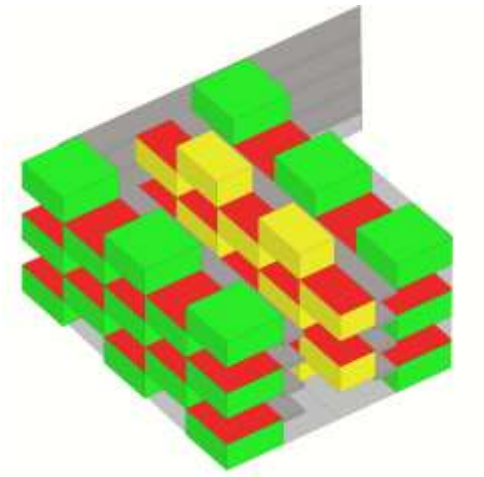


Figure 4-8 Red color shows empty spaces between the masses

Because of the mass arrangement, which is maximizing the wind, as a consequences there are empty spaces existed between the units. These empty spaces will be function for the unit's verandah adapting the concept of Indonesian traditional houses which has verandah for socializing as well as migration zone for the thermal comfort. Migration zone is room/court which the activities can take place in cooler areas during warm periods and warmer areas during cool period. (Dekay, 2014)

This concept of sky verandah was applied in one of apartment in the Singapore and had been researched further the beneficial of the sky verandah (Bay, 2006)

The veranda will encourage the residents for gardening and increased planting will lower the ambient temperature.

Activities in the verandah can influence the residents to know more neighbors and have a higher sense of community.

Figure 4-9 Different type of units with their verandah

IV. 1. 6. Air & Light Well

The main problem of the mas is that some area will be over shadowed and the air movement inside the building is facilitated horizontally only. As explained by the diagram on the right side, creating an air & light well, the light can comes in and the air movement inside the building will be more facilitated. The figure of floor plan below shows the location of the air & light well in between the apartment units.

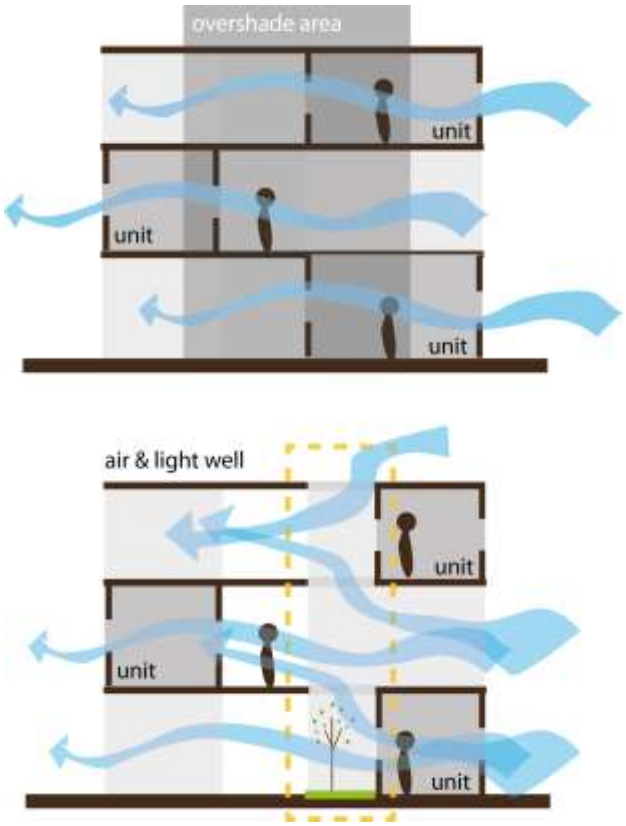


Figure 4-10 Illustration of the lightwell

Figure 4-11 The green boxes show the location of the air & light well

IV.1. 7. Unit Transformation

Based on the form transformation before, every unit is detached from each other and each has veranda and at least in every two units there is a light & air well. The air movement inside a building can works better if there are fewer barriers between the windward side and leeward side. As a result, the rooms arrangement inside the units are designed for the wind to cross ventilate especially in the east and west side where the wind mostly come from.

In addition, the floor level on every unit is raised in order to create more privacy for the occupants, and encourage occupant's window opening behavior. The occupants will be more comfortable doing activities inside because the floor level also create more distance between public and private space.

Figure 4-12 Internal Room Arrangement which maximize cross ventilation

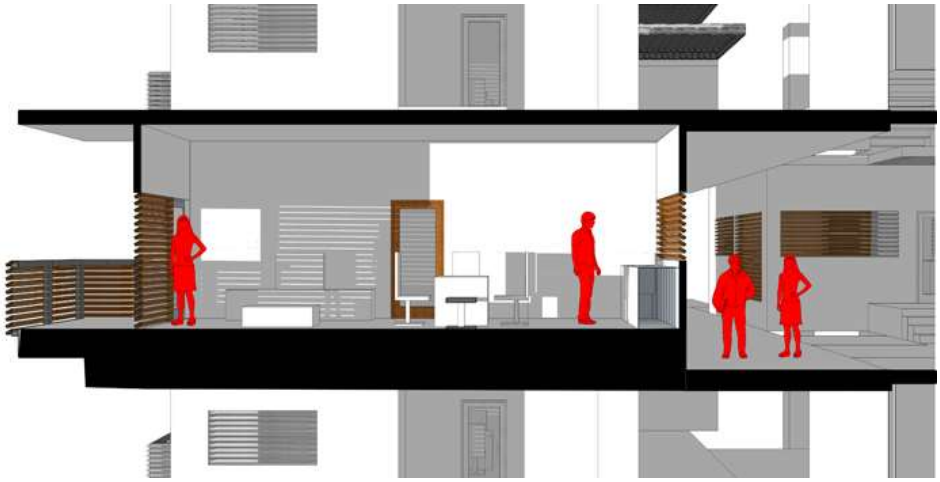


Figure 4-13 Section diagram of raised floor level

IV. 1. 8. Opening System

The main issue in the urban area while addressing apartment with natural ventilation is the privacy and security. To obtain opening but also maintain privacy and security, the opening system is designed differently with the normal windows.

There are layers of opening to facilitate the natural ventilation, which the occupant can choose. The outer layer is opening in the form of jalousie or sun louvre, which is useful for shading the entire opening from the sun radiation and also the openings are equipped with louvre allows the occupants inside to view outdoor but people outside are unable to see the indoor. The second layer is the insect net to prevent the insects such as mosquito from coming in. The indoor layer is the operable window that can be opened and closed depends on the occupants.

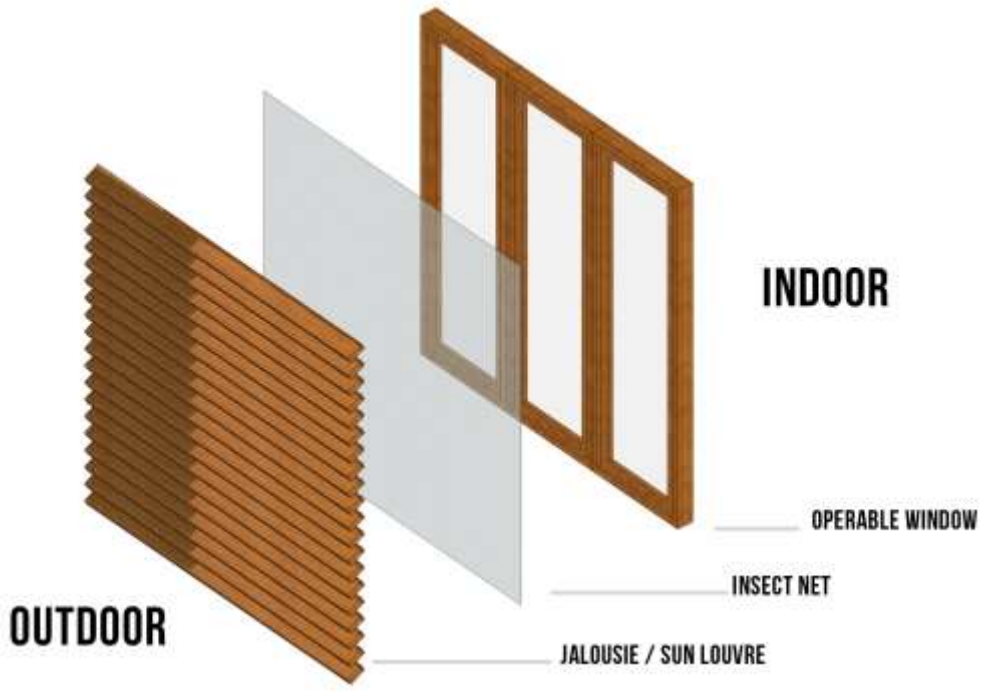


Figure 4-14 Scheme of the opening system

IV. 2. TECHNICAL EXPLORATION

IV. 2.1 Water System

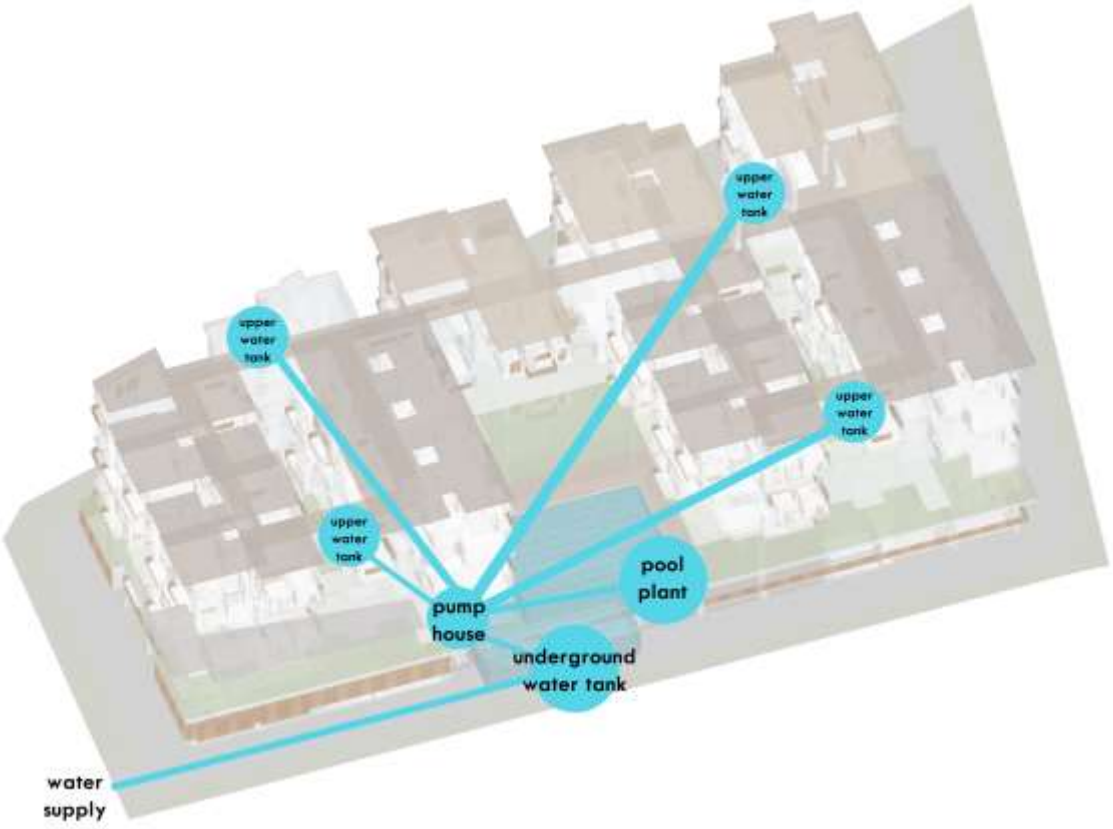


Figure 4-15 The water distribution diagram system

The scheme for the water system starts from the city water supply to the underground water tank then goes to the pump house (in the first floor) up to upper tank (next to the structural core of fire stairs & lift) and down to the units by the gravitational system

IV. 2. 2. Swimming Pool System

The water in a swimming pool needs to circulate through a filtering system, to remove dirt and debris. Because of this system requirements there is a room called the swimming pool plant in the second floor, located right beneath the floor to accommodate this needs.

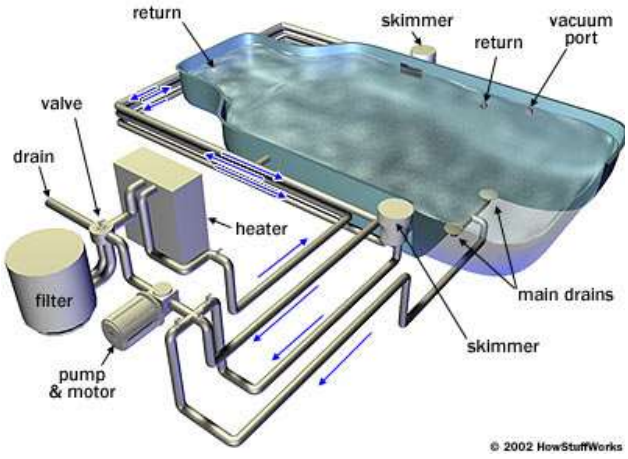


Figure 4-16 The swimming pool system. Source : howstuffworks.com

IV. 2. 3. Trash System

The trash system is collected via trash chute, in every floor there are two trash chute available. In the first floor the trashes are collected in the dumpster room, where it will be transported. This trash chute is located next to the fire stairs because the trash chute should be fire resistant.

IV. 2. 4. Sewage System

The grey and black water from very units is transported into the Sewage Treatment Plant in the first floor through shaft located next to the column

Figure 4-17 Trash chute system and the locations

Figure 4-18 The Scheme for the sewage system

IV. 2. 5. Fire Protection System

Figure 4-19 The Location of Fire Stairs and Fire Extinguishers

The fire protection is divided into two the fire protection system for the outdoor and indoor. The indoor system consists of fire stairs, sprinkler, and fire extinguisher. The sprinkler is only available in the first and second floor.

The outdoor unit consist of outdoor hydrant which is shown in the layout diagram.

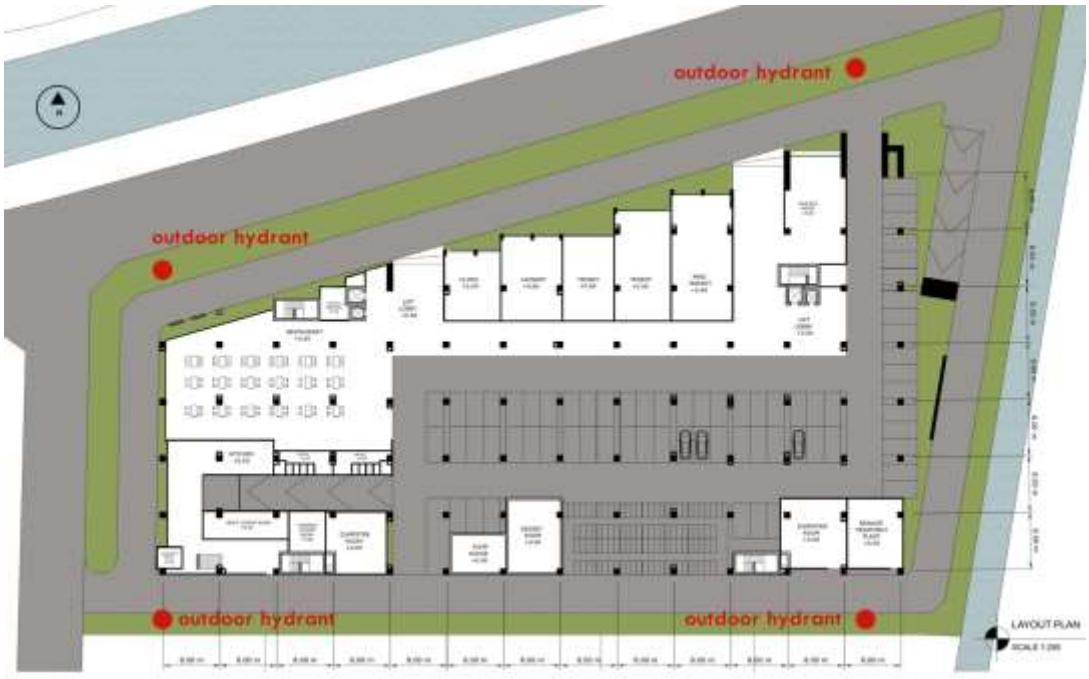


Figure 4-20 The Location of Outdoor Hydrant Units

IV. 2. 6. Electricity System

The electricity system in the proposed designed object is based on the the scheme explained in the figure below. The main electricity supply from the PLN, and then it goes to the transformer and generator set (genset) room in the first floor, and then the electricity supply is distributed floor by floor via the Circuit Breaker, lastly each of the apartment unit is equipped by the Fuse to control the electricity.

IV. 2. 7. Structural System

The structural system in the designed object is 8x8 m grid with concrete composite column and two way waffle slabs. The module of 8x8 m is chosen based on two considerations : the effective car parking size and the units size.

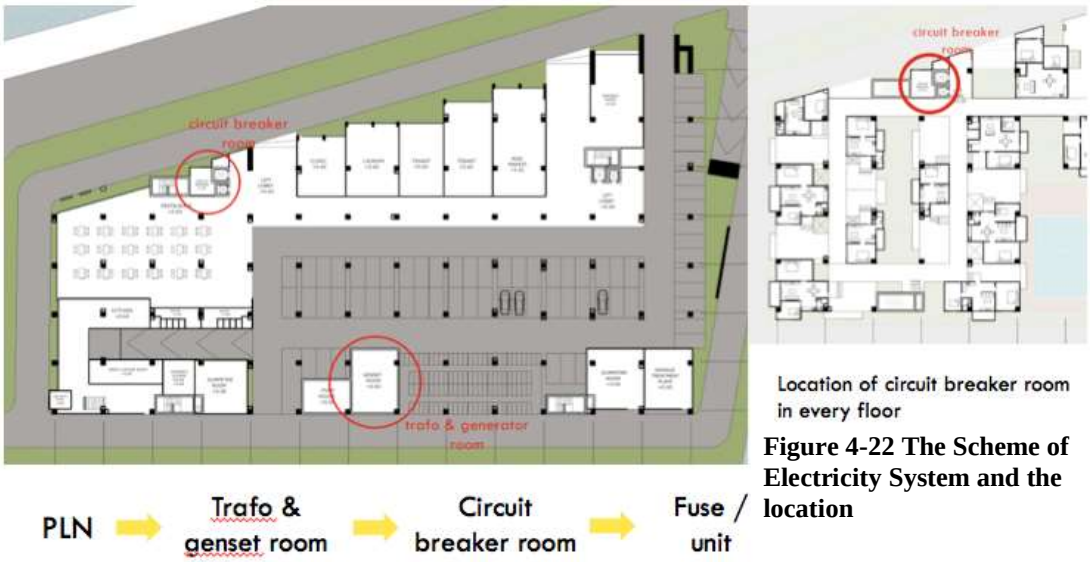


Figure 4-22 The Scheme of Electricity System and the location

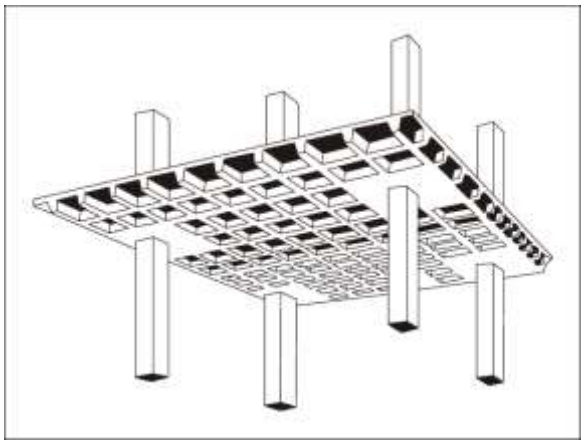


Figure 4-21 The Structure of Twi-way Waffle Slabs

V. DESIGN RESULT

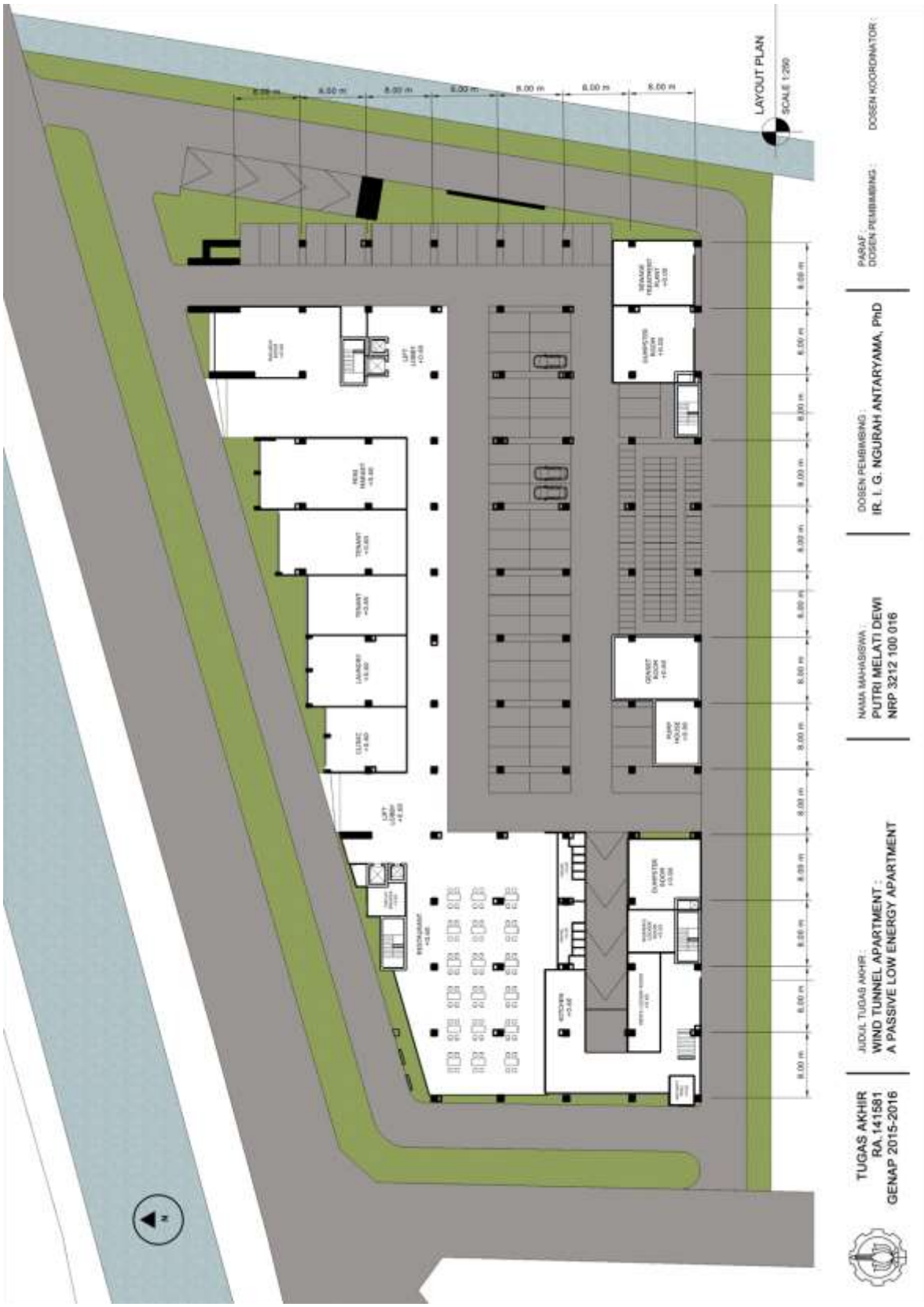


Figure 5-1 Layout Plan

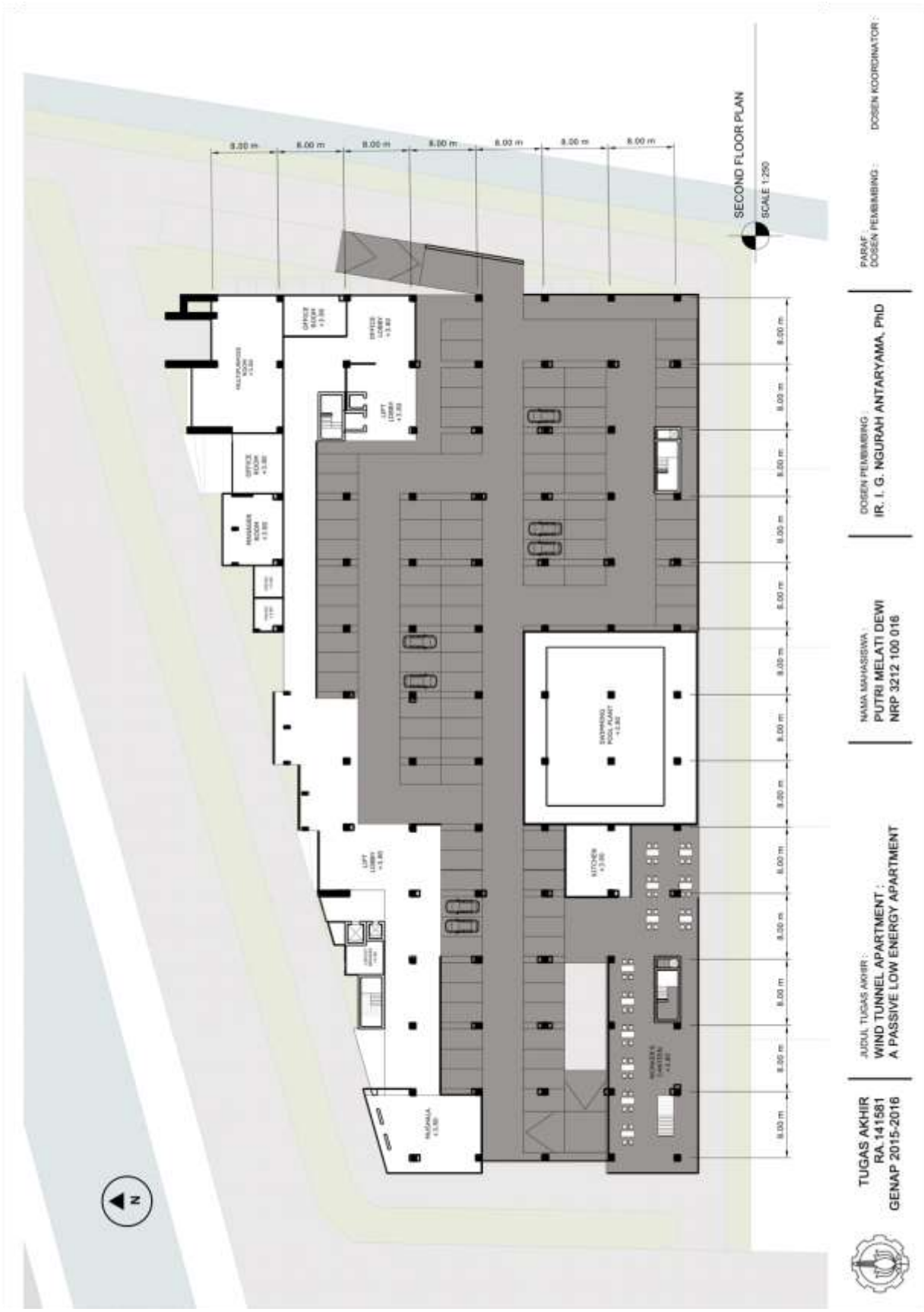


Figure 5-2 Second Floor Plan

Figure 5-3 3rd Floor Plan

Figure 5-4 4th & 6th Typical Floor Plan

Figure 5-5 5th & 7th Typical Floor Plan

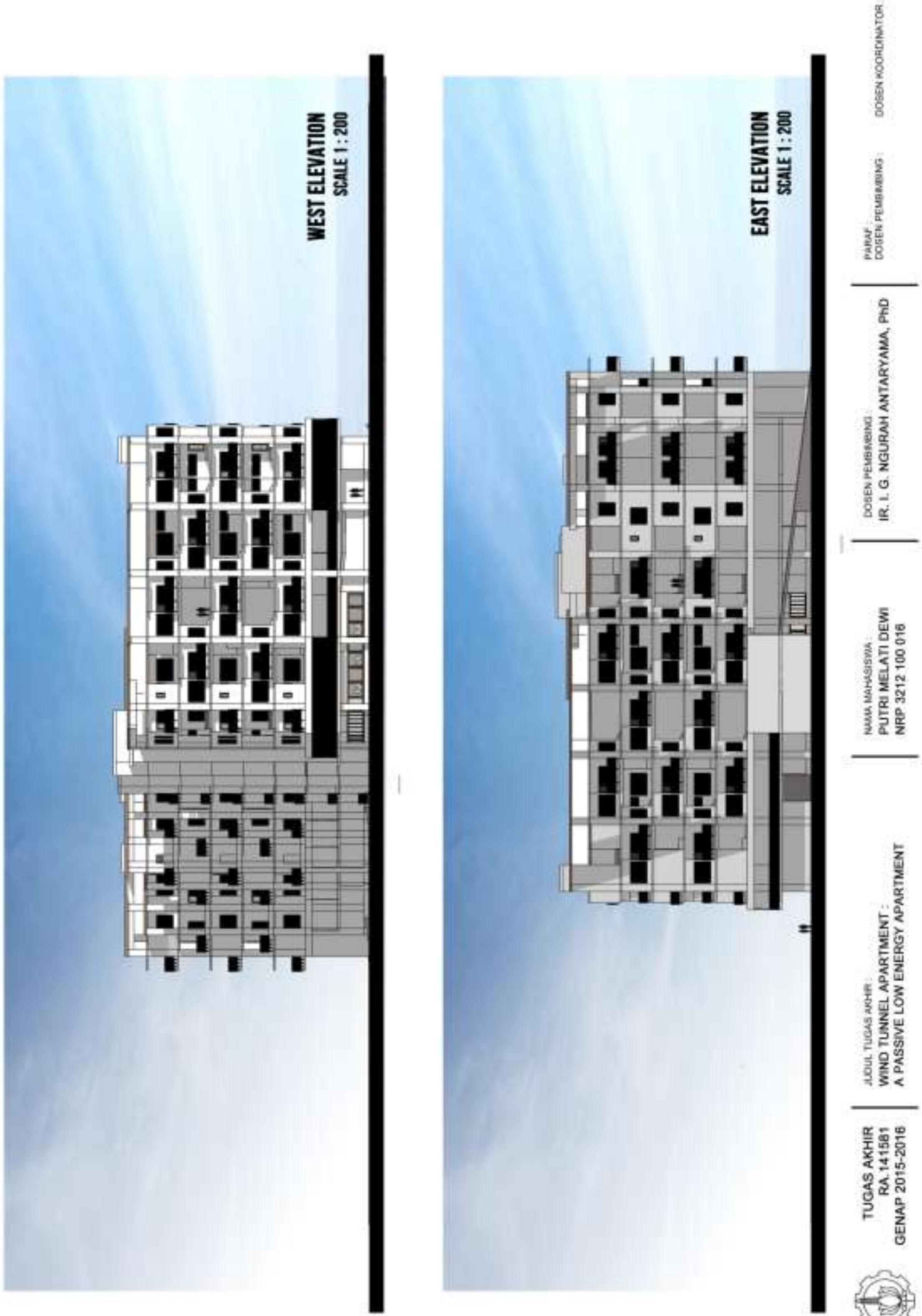


Figure 5-6 West and East Elevation

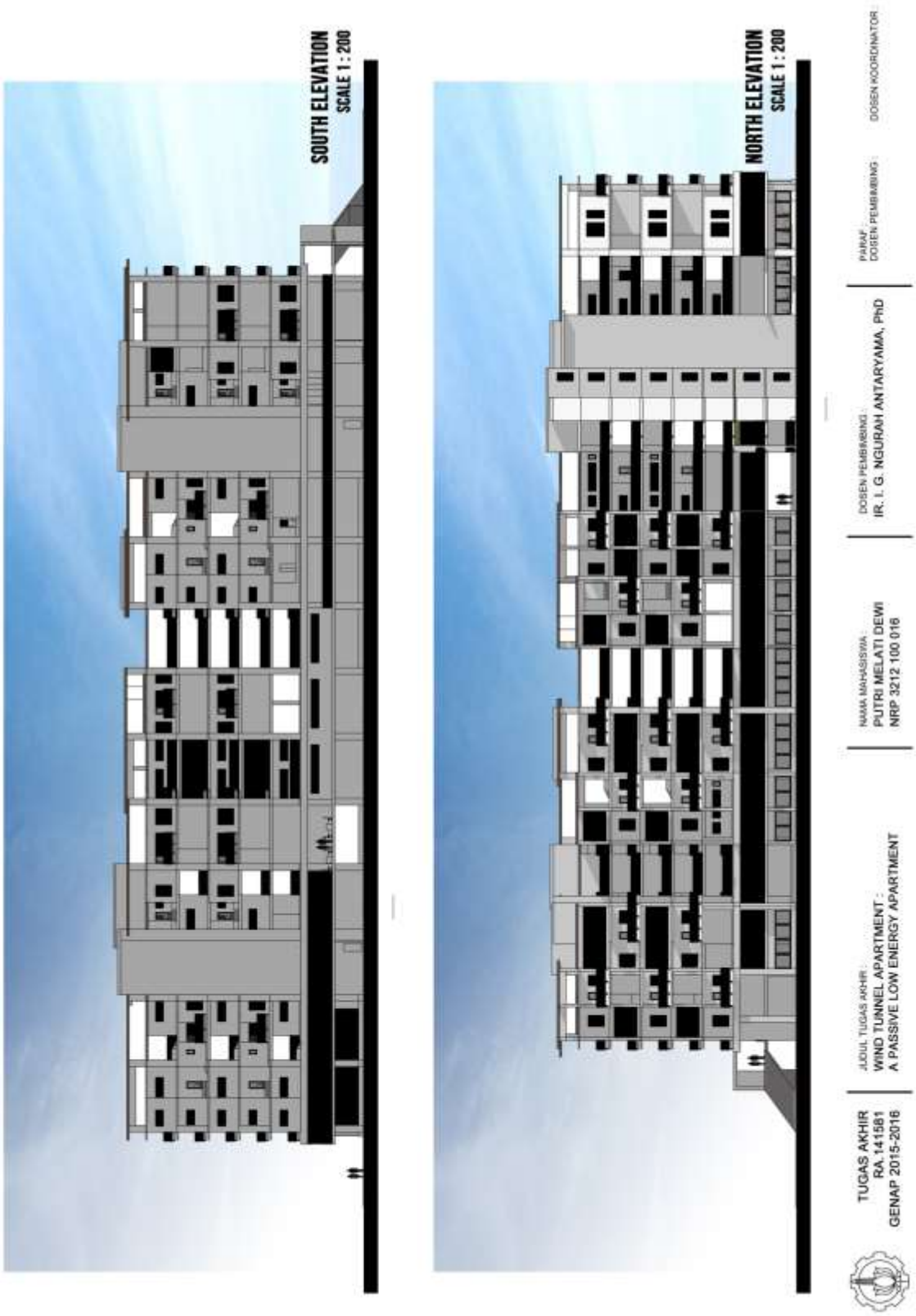


Figure 5-7 South & North Elevation

Figure 5-8 Wind Tunnel Apartment Section

Figure 5-9 One Bedroom Unit Plan Variation and Interior

Figure 5-10 Two Bedrooms Unit Interior

Figure 5-11 Two Bedrooms Unit Variation

Figure 5-12 Three Bedrooms Unit Variation

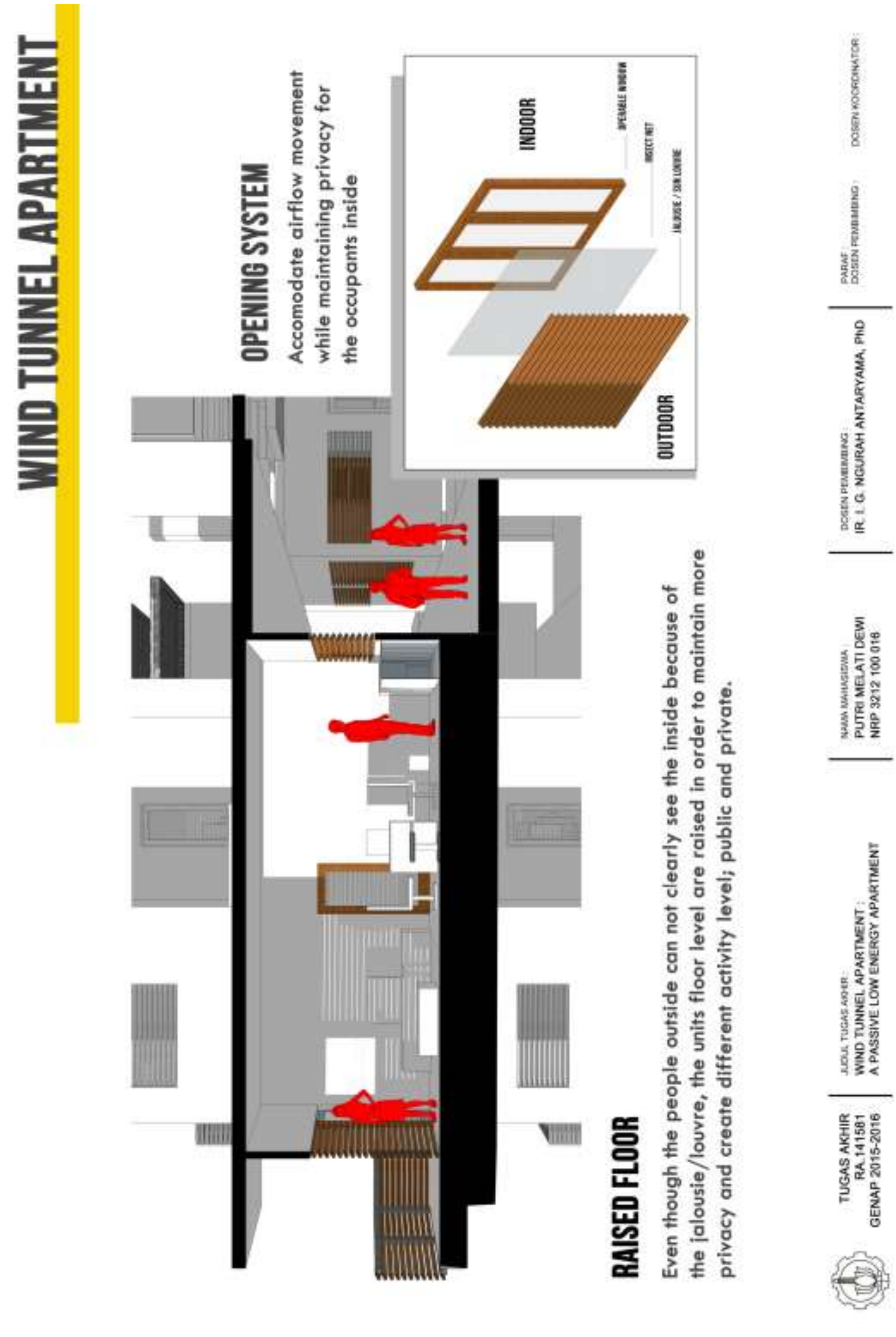


Figure 5-13 Section of unit; shows both accomodate airflow and privacy level

Figure 5-14 Perspective of the sky verandah and the corridor

Figure 5-15 Facilities in The Apartment

Figure 5-16 South Perspective of The Apartment

Figure 5-17 South West Perspective of the Apartment

VI. CONCLUSION

The challenges of designing naturally ventilated apartment in warm humid tropical urban area are contradicts to each other. The reason for that is on one hand naturally ventilated apartment means maximizing openings as much as possible, on the other hand middle-upper income class people need high security and privacy.

Wind Tunnel Apartment overcome these design problems by maximizing the airflow, and explore the design elements. As a result, apartment units in the Wind Tunnel Apartment are detached from each other, creating chessboard-like pattern gap in its apartment block design. The contradictory factors in designing this apartment are solved by explore the design of the opening system. The window system in this apartment can both accommodate the air flow and maintain the occupant privacy because the opening is not see through from the outside. Raising the unit floor level also separates the privacy level between the units and corridor. Creating gap between public space and private space.

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