Climate Responsive Architecture in Jakarta’s Apartments

C Tjie1*, F Lianto1#, and N W Priyomarsono1
1 Department of Architecture, Tarumanagara University, Jakarta, Indonesia

*Email: christine_tjie@yahoo.com
#Corresponding Author: fermanton@ft.untar.ac.id

Abstract. Almost every day, apartment buildings in Jakarta have to face a long hour exposure of solar heating which caused temperature gain inside the building. It creates a high room temperature and requires an air-conditioning system to reduce room temperature. This problem arises from the ineffective function of architecture design elements used. The method used in this research is literature study and analyze it with the case study of three apartments located in Jakarta. The principal design of climate-responsive architecture in Jakarta (tropical humid climate city) is a passive cooling strategy which used to prevent/avoid solar heat exposure and to release heat inside the building. There are two categories of design elements function used: 1) as building envelope/façade (such as shadings, ventilation, roof, and building materials) and 2) as building placement (such as building thickness and orientation, ventilations, building landscape, etc.). Three apartments located in Jakarta were analyzed with the findings, and the design elements used were found ineffective as climate filter in Jakarta (the three apartments still rely on air-conditioned systems-active cooling approach to reduce the transmitted solar heat and cooling rooms). The result of this study is a solution/recommendation for designing architecture elements that functioned as climate filter and have better respond to Jakarta’s climate.

1. Introduction
The research started with a phenomenon found in the architecture of Jakarta’s apartments, the design styles are so modern using glasses as building envelope/façade makes us wonder, are they suitable for Jakarta’s climate? Are they inspired by international/global modern architecture? Why the used of Air-conditioned is a must to create a comfortable interior in apartments? These questions lead to one research question on how to design a residence that suitable to Jakarta’s climate with minimal use of air-conditioner? The focus of research is to understand Jakarta’s tropical humid climate, its problems to buildings, especially apartments, and the potential of using architecture design elements as climate filter.

2. Material and Method
2.1 Method of Study
The method used in this research is a literature study concerning climate-responsive architecture theory, a passive cooling strategy that suitable for the humid tropical climate in Jakarta, and the effective design elements used in achieving it. The findings in the literature study will be used to analyze the case study of three apartments located in Jakarta. The interpreted result will answer the question of whether architecture apartments in Jakarta are designed with climate consideration, and if not, what kind of solution/recommendation for creating a climate-responsive apartment in Jakarta with optimal climate filter, and energy usage (especially in aircon usage).
2.2 Theoretical Review

The literature study started with understanding what architect and architecture mean to the world. Architect derives from Greek etymology, arkhiteton. Arkhi means chief and tekton means builder [1]. Architecture has to characterize its esthetic (Venustas), strength (Firmitas), and function (Utilitas) [2], architecture is the coordination and balance of three. Now the definition of architecture evolves as of a holistic design thinking process of an architect that consider all esthetic, strength, function, and sustainability of architecture for human and its environment. The proper structuring and balancing of buildings in architecture, structure, and interior can provide the best benefits for users [3].

With a holistic meaning of design architecture, the study goes further to finding what climate-responsive architecture is. A climate-responsive architecture is a design practice that focuses on designing buildings that function effectively with its environment (microclimate) [4]; Architecture has to represent its climate, the condition of atmosphere will influence the design, materials, and construction methods used [5]; and architecture connecting place, environment, and human life. There is three principal of climate adaptation/responsive architecture are passive design, active design, and the combination of both [6].

Jakarta’s climate is a humid tropical climate with its characteristic such as an everyday average 10-12 hours sun hours [7]; average temperature 28°C, deviation 7°; average humidity 70%; average wind speed 1 meter/second); and average precipitation 3000mm/year). With this kind of climate statistic, everyday Jakarta’s people and its building (include apartments) have to face a hot temperature and be adapted with it.

A passive design strategy means a design that regards climate. Designing building envelopes/façade as building climate filter is an approach of passive design strategy [6]. Passive design charts are straightforward to use for architects in designing apartment because direct results can be adjusted using the graph without difficult calculations [8]. The effort to control interior thermal comfort without consuming too much energy (fuels); to arranged building orientation, layout, façade that control heat, wind flow, humidity; the use of selected materials that insulate building from heat/sun exposure; to maximize the use of sunlight for natural lighting; to maximize the opening for passive cooling; the use of shadings to control sun heating [9]. There are two passive design strategies: passive cooling and passive heating design. A passive cooling design approach suitable for humid tropical climate. The policy is to release heat in the building with opening quickly, and natural ventilation [5] with the most effective design elements functioned as ventilation and sun-shadings [10]. The heat avoidance strategy is sun-shadings and the design arrangement of opening and cross ventilation [9]. The design of flats should follow to natural ventilation requirements for comfort, occupant health, and energy savings [8].

The architecture design elements responsive to passive cooling designs are: 1) building mass thickness, and orientation to the sun (source of heat and radiation); 2) roof design; 3) opening/ventilation-ratio between transparent wall and massif wall; 4) building materials; 5) green and vegetation; 6) building shade designs [5] [9] [10] [11].

1) Building mass thickness, and orientation to the sun (source of heat and radiation). Optimization of building envelope/façade design can reduce the usage of air-conditioner [12]. The building mass thickness means the shorter side of the building. In a humid tropical climate, the slimmer building mass means the faster movement of air flowing in-out, releasing heat inside the building [5]. The building and opening/ventilation not facing direct East-West sun orientation are more effective in tropical climate [13].

2) Roof design. The roof is the first defender/filter from sun’s heat and radiation. Architecture that pays attention to its roof design and a non-transferable heat-materials will give a significant impact to heat release-passive cooling strategy.
3) Opening/ventilation-ratio between the transparent wall and the massif wall. The right design of opening/ventilation ratio and its position will filter and release heat in-out the building. Two tables of natural cross-ventilation, room depth to ceiling height ratio, and one illustration of a window to wall ratio (WWR) required to design a climate-responsive building/apartment [11, pp. 41-43]. Window to wall ratio (WWR) is a guideline of façade transparent wall and massif wall ratio [11, pp. 20-21]. A maximum of 30% façade opening is required in tropical humid climate building/apartment [11, pp. 26-28].

4) Building materials. As building materials develop extensively, it is essential for architects to have knowledge of materials used for the building design. The right materials can filter heat from entering the building and help release the heat from inside the building.

5) Green and vegetation. Creating a micro-climate is essential, positioning and choosing vegetations can create a good filter of climate and reducing heat from the building site.

6) Building shades. External shading devices are important design elements to avoid and reduce heat from entering the building. To design the effective sun-shading/external shading devices, architects must understand the orientation and the ratio of sun-shading.

The theoretical review on how to design a climate-responsive architecture in Jakarta’s apartments above is a passive cooling design where the main issue is to avoid heat and releasing heat as fast as possible so the room temperature can be cold and minimal use of air-conditioning. The figure summary is shown below (Figure 1).

![Figure 1. Summary/Schematic Theories of Climate Responsive Architecture Jakarta’s Apartments.](image-url)

2.3 Case Study
The study conducted at three apartments (Figure 2,3,4 and Table 1): Regatta Pantai Mutiara-London Tower (North Jakarta); Thamrin Executives Residence (Central Jakarta); and La Maison Barito (South Jakarta).
Figure 2. Regatta Apartment
London Tower.

Figure 3. Thamrin Executives
Residence Apartment.

Figure 4. La Maison Barito
Apartment.

Table 1. Analyses on Case Study of Three Apartments with Climate Responsive-Passive Cooling Design Strategy-Elements/Parameter.

| Jakarta’s Climate Responsive Design Elements/Parameter | Regatta Menara London 2017 | Thamrin Executives Residence 2012 | La Maison Barito 2017 |
|-------------------------------------------------------|-----------------------------|----------------------------------|----------------------|
| Building Mass & Thickness                            | Tower                       | Slab-L shape                     | Tower                |
|                                                       | High-rise-24 floors         | High-rise-35 floors              | High-rise-24 floors  |
|                                                       | High-end                     | Medium to High-end               | High-end             |
|                                                       | Family                       | CBD Area                         | Family               |
|                                                       | 2-3 bedrooms unit-type       | Studio, 1-2 bedrooms             | 2-3 bedrooms unit type |
|                                                       | Double-loaded corridor       | Double loaded corridor           | Double loaded corridor |
| Building and Units Orientation                       | North East                   | North, South, East, and West     | East                 |
|                                                       | South West                   |                                  | West                 |
| Roof Design                                           | No design- standard RC deck-utility area | No design- standard RC deck-utility area | No design- standard RC deck-utility area |
| Materials for Building Envelopes/Façade             | 83% reflective glass+ opaque | 80% solid wall as facade         | 90% reflective glass+ opaque |
|                                                       | 15% solid wall as facade     | 20% windows and balcony          | 10% solid wall as facade |
| Green Space Design & Vegetation                      | At ground level-mural. No impact on micro climate | At Podium level-mural. No impact on micro climate | At ground level. No impact on micro climate |
| Shading                                               | Not designed                 | Designed, less than ratio required | Not designed         |
|                                                       | Designed                     |                                  |                      |
| Corridor as Facade                                   | Not designed                 | Not designed                     | Not designed         |
| Window to Wall Ratio-WWR                             | Designed: 85% WWR            | Designed: 30% WWR                | Designed: 90% WWR    |
| Natural ventilation (1 room)                          | Designed                    | Designed                         | Designed             |
| Cross Ventilation in 1 room                          | Designed for corner units    | Designed for corner units         | Designed for corner units |
| Cross Ventilation-2 rooms connected                  | Not designed                 | Not designed                     | Not designed         |
| Stack Ventilation                                    | Not designed                 | Not designed                     | Not designed         |
| Air-conditioned (AC) in unit apartments               | Designed (VRV system)        | Designed (Split system)          | Designed (VRV system) |
3. Results and Discussion
The result of analyses on three apartments with climate responsive-passive cooling design strategy-elements/parameter are as follow:

1. Building mass thickness, and orientation to the sun (source of heat and radiation). Regatta and La Maison Barito were designed with massif, and thick building mass resulted of slower heat release. Thamrin Executives Residence’s building thickness is less than 17 meters, it is slim and have opening on both corridor end (although the distance is more than 15 meters-not an optimal distance according to room to ceiling height ratio of cross ventilation) which can release heat better, especially in the higher level where the wind blows stronger. On building and rooms orientation, the three apartments were not following ‘avoid East-West orientation design parameter.’ They follow site orientation with maximum numbers of units and maximum view. As a result, some apartment units have to face heat and use aircon to reduce room temperature. The three-case study was showing the un-effective passive cooling design in building mass thickness, and orientation to the sun.

2. Roof design. The three case study did not have any special design and materials for their roof and functioned as a utility area. So the roof is not designed as the first defender/filter from sun’s heat/radiation and does not implement a passive cooling design strategy.

3. Opening/ventilation-ratio between the transparent wall and the massif wall. The natural ventilation and cross ventilation in the three apartments are not functioned effectively due to poor positioning of ventilation/windows, the room to ceiling height ratio is not effective, and the window to wall ratio for Regatta apartment is 85%, Thamrin Executives Residence is 30%, and La Maison Barito apartment is 90%. The higher WWR means the internal building receives more heat. The analyses show that only Thamrin Executives Residence have better WWR, so they only rely on split system aircon to adjust room temperature. The right design of opening/ventilation ratio and its position will filter and release heat in-out the building.

4. Building materials. Regatta and La Maison Barito apartment were designed using wall-cladding system with reflective glasses while facing East-West orientation, resulted in ‘glasshouse effect’ and have to use the VRV aircon system to achieve desired room temperature. The passive cooling design on building façade materials of these two apartments are not applicable. Thamrin Executive Residence was designed with better WWR (30%) and using pre-cast massif wall, and glass/transparent window ventilation have better heat filtering. The right materials can filter heat from entering the building and help release the heat from inside the building.

5. Green and vegetation. The three apartments were not designed with effective and optimal green and vegetation, resulted in no significant filter of climate and reducing heat from the building site.

6. Building shades. La Maison Barito was not designed with any external shading; the 90% WWR have to face 10-12 hours transmitted heat from the sun every day. Regatta apartment was not designed with sun-shading devices, but have a balcony as another shading design elements which reducing heat from entering units. Thamrin Residence Executives apartment has ineffective 20cm depth horizontal overhang and good sizes of balconies which reduce the heat from entering units.

4. Conclusion
Based on the analysis, the study of the climate-responsive architecture of Jakarta’s apartments can be concluded as follow:

1. Architecture apartments in Jakarta were not designed to follow climate-responsive architecture-passive cooling design strategy, resulted in high usage on aircon to reduce and achieve desirable room temperature.

2. The climate-responsive architecture of Jakarta’s apartment is a passive cooling design strategy. Passive cooling design strategy basically is a design strategy to prevent/avoid transmitted heat from
sun to building and fast-release heat from building with design elements such as 1) building mass thickness, and orientation to the sun (source of heat and radiation); 2) roof design; 3) opening/ventilation-ratio between transparent wall and massif wall; 4) building materials; 5) green and vegetation; 6) building shade designs.

3. The case study on three apartments in Jakarta resulted in proofing were not designed with the climate-responsive architecture-passive cooling design strategy. Apartments in Jakarta still using active controlling approach to control room temperature and heat from the climate.

4. Suggestion and solution to the case study of three apartments in Jakarta are:
   a) Building mass thickness, and orientation to the sun (source of heat and radiation).
   b) Roof design. Using material heat insulation for the roof or designing a roof garden.
   c) Applying better calculation on creating opening/ventilation-ratio between the transparent wall and the massif wall.
   d) Building materials. To equip apartments with building materials functioned as climate filter.
   e) Green and Vegetation. To implement a significant measure of green and vegetation in apartments, creating cooling micro-climate.
   f) Building shade/External Shading Devices. The three apartments can adopt the use of sun-shading devices, especially the horizontal shading, to reduce the heat entering the building.

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