
Design Study Co-Working Space Building Based On Bioclimatic Architectural Principles

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Article info:

Received: 01-07-2022, Revised: 23-10-2022, Accepted: 05-12-2022

Abstract. Bioclimatic principles that provide solutions based on environmental conditions around the site can be applied in building design. This design study focuses on the suitability of bioclimatic principles applied to environmental conditions in providing thermal comfort. This research method uses a qualitative method with a descriptive approach. The analysis technique in data collection is visual assessment. The object of the building under study has building criteria with the Indonesian tropical concept. The results of the study concluded that the two objects had applied the principles of bioclimatic architecture, but the first object was still not maximized while the second object was quite optimal in responding to environmental conditions.

Keywords: design, co-working space, bioclimatic architecture

1. Introduction

The climate on the site must be considered before deciding on the overall design concept of a project (Yeang, 1991). Bioclimatic architecture is one approach that provides solutions based on architectural and environmental analysis, of the building's energy consumption (Dewangga & Purwanita, 2016). It has a goal of creating an environment that reduces energy requirements without causing harm (Cahyaningrum et al., 2016). It is an interaction between climate, occupants, and building design. It supports green principles which come with less environmental impact (Gaitani et al., 2007). It is a sustainable design where the building gets a certain comfort with minimum energy use and low carbon emissions. Implementation of a bioclimatic design is needed for thermal comfort needs that focus on wind direction, climate, solar radiation, and materials (Manzano-Agugliaro et al., 2015).

The principles of bioclimatic architecture according to (Yeang, 1991) are:

1. Orientation determination
2. Transitional space
3. Wall design
4. Relation to landscape
5. Use of passive shading tools.

Eco-friendly architecture must pay attention to the use of materials in buildings (Setiawan et al., 2019). The site analysis should determine the building design's wind direction and the openings' location. The key to the proper bioclimatic design is the maximum use of daylight to ensure good lighting in the space. Natural lighting must be well controlled to avoid the effects of reflections and overheating. Thermal comfort can be obtained from various, most efficient systems about floor and roof radiation (Widera, 1994).

In this study, the selected objects were in 2 different locations as a comparison of building designs according to their response to environmental conditions. The case studies of co-working spaces selected are Antologi Collaborative Space (Yogyakarta) and Sub-co (Surabaya). Both of these objects have a typical Indonesian tropical building style that can

be used as an assessment point based on bioclimatic principles. The problem limitations based on the bioclimatic principles are building orientation, transitional space, relation to landscape, wall design, and passive shading device. The goal of this research is to find out whether the application of bioclimatic architecture is to the environmental conditions, and whether the objects of the research have achieved thermal comfort in the application of bioclimatic architecture. The novelty of this research is that bioclimatic architecture can produce co-working space buildings that interact with the environment so as to produce thermal comfort for users who are working. The contribution of this research to the architecture field study is to help analyse architectural elements on thermal comfort in co-working space buildings in Indonesia through bioclimatic principles.

2. Methods

This study uses a qualitative method with a descriptive approach. The analytical technique used is visual assessment. This is used to obtain answers to the suitability of the application of bioclimatic principles to the research object. Data requirements include supporting photos obtained through observation and site visits. The object criteria in the research are a co-working space building with the Indonesian tropical concept.

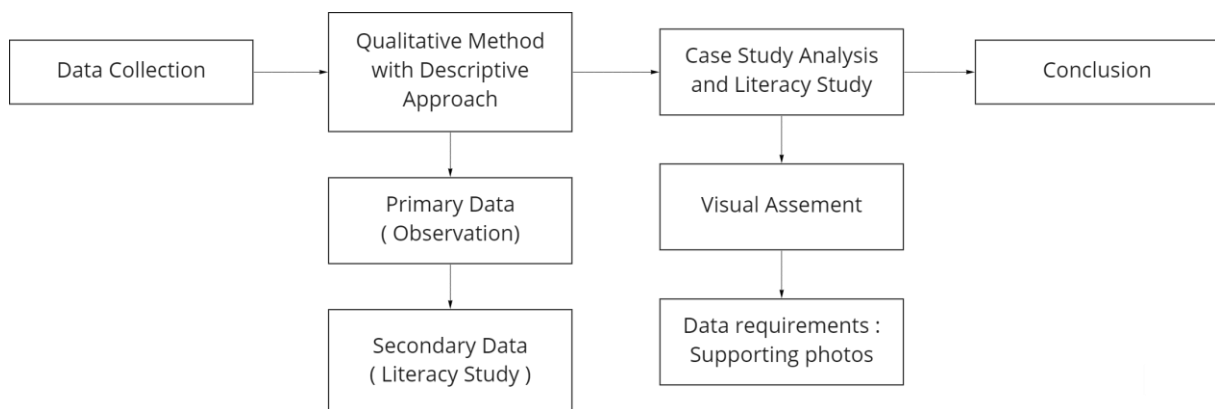


Figure 3.1. Research Method Diagram (writer, 2022)

3. Discussion

The activity pattern of co-working space users, in general, is working in the same room. Other activities that are usually carried out by users are training, sharing, charity events, book reviews, and others. Based on the activity pattern, space requirements as supporting facilities are needed such as a pantry, meeting room, and multipurpose rooms. To get a comfortable space quality for users, a flexible and interconnected space organization system in the interior must be fulfilled. The quality of comfortable space is also obtained from the thermal conditions of the room which are influenced by the materials used.

3.1. Antologi Collaborative Space



Figure 3.2. The front side of Antologi Collaborative Space (Author, 2022)

The building in Figure 3.2 is a co-working space located in Yogyakarta. This building applies the concept of a tropical Indonesian building seen from the use of a sloping roof, has a window that functions to enter maximum light, the use of a canopy, the use of lots of ventilation for air circulation, the direction of the smallest surface area facing east-west. From these several criteria, this object was chosen to be analyzed whether it is based on the principles of bioclimatic architecture.

A. Building Orientation

The main opening that minimizes the sun's insulation is the north and south direction (Yeang, 1991). In terms of solar radiation, the north-south direction is the best choice to reduce solar radiation (Hussein & Jamaludin, 2015). Based on observations on figure 3.3, this building has a west orientation. Another condition is the absence of sufficient vegetation or building to reduce radiant heat. This orientation causes the sun's heat to enter directly into the building. Direct solar radiation varies depending on the time and angle of incidence. The orientation of the openings in this building is facing the west, east, and north sides. Based on the on-site analysis, the wind direction is from southwest to northeast. Only in this orientation does the cross ventilation. Cross ventilation can be effective in a window that can be adjusted so that it can help circulate air (Yeang, 1991). Cross ventilation supplies air and is extracted through the grille. This system generally achieves good results with wind conditions (Ohba & Lun, 2010). This ventilation can help reduce the temperature due to solar radiation that directly leads into the building.

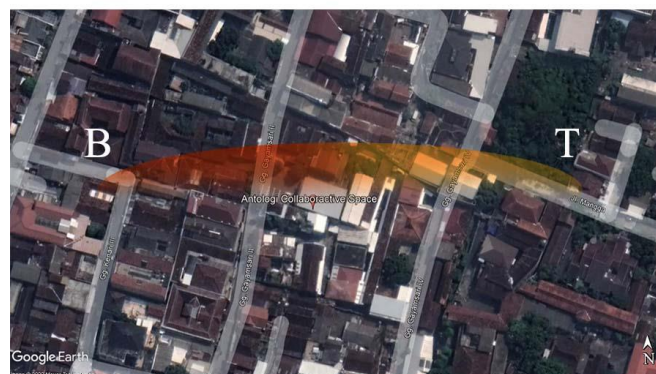


Figure 3.3. Site plan (google earth, 2022)

B. Transitional Space

Transitional spaces in this building are located on the front, middle, and north sides. The front side functions as a parking lot and terrace which can be seen in figure 3.4. Placing the terrace in sections of the building with high levels of heat can reduce the use of heat resistance panels (Diana et al., 2021). The terrace is quite instrumental in lowering the temperature from outside to inside, both front and back terraces (Caesariadi, 2019). The terrace is an area of high pressure and colder temperature so that the air from inside will be attracted to the outside and change (Sukawi, 2011). This helps the airflow from outside to inside. The north side area can help maximize natural lighting and as a view from outside the building because of its large size. In this area, the material used is paving. The use of this material can help dissipate heat quickly. Materials with hard materials with the majority of components cement and sand such as paving, and concrete can release heat the fastest. Paving can absorb and release heat, so paving has a high temperature during the day. While the concrete stores and reflects by releasing the temperature during the day can reach 53.8 °C (Faza et al., 2017). High environmental temperatures can be reduced using paving blocks, such as sand, water, cement, grass, palm fiber, sawdust, and Styrofoam. Developed shapes such as square and hexagonal effectively reduce heat (Imran et al., 2020).



Figure 3.4. Transitional space (google earth, 2022)

C. Relation to landscape

Landscapes or green areas can make buildings cooler and also for aesthetic purposes (Diana et al., 2021). Vegetation affects room temperature regulation because it has a cooling effect (Dekić et al., 2018). The shade from the tree helps lower temperatures and reduces energy use (Dekić et al., 2018). Based on figure 3.5, the landscape area of this building has less green area. It's only on the edge of the guardrail because the yard is used for parking. The function of the yard as a cooling effect is not optimal because most of the existing vegetation does not produce shadows and has little mass. There are several types of plants on the site for aesthetic function, shading, and barriers. The types of plants that exist are mostly small-mass plants that are less than optimal in providing shading. The landscape on this object still does not provide a maximum cooling effect on buildings that have large openings facing west.



Figure 3.5. Landscape (Author, 2022)

D. Wall Design

The outer walls must use a material with an insulating shield that can be adjusted during the hot season. Exterior walls must be adjustable and cross-ventilated to increase comfort in the building (Diana et al., 2021). The application of ventilation with a cross position results in lower air pressure inside the building and is able to supply a lot of air in one hour (Rizani, 2013). Ventilation works for air cooling and prevents air humidity increase (Talarosha, 2005). The openings in this building apply cross ventilation. Cross ventilation can help reduce heat in the room and the flow of the air. The wall material in this building uses exposed brick on all sides of the building. Brick walls can insulate temperatures up to 1.2 degrees Celsius. Another material on the walls is glass block. The material in the opening is glass with large size which can see on figure 3.6. The use of glass with a large size directly leads to the pattern of the sun's passage can increase the temperature in the room. This transparent material will enter most of the solar radiation which can increase the temperature inside the building. From the observations, placing large openings in the west-east orientation can make the room conditions uncomfortable, but with the help of cross ventilation, it can circulate air in the room.



Figure 3.6. Wall design (Author, 2022)

E. Passive Shading Device

Passive shading in this building is obtained from sun shading on the part of the building, trees around the building, and surrounding buildings. The orientation of the building that leads directly to the west-east is less profitable because the percentage of solar heat obtained is higher. Room temperature with the use of polycarbonate as the material is between 29,53 Celsius to 35,12 Celsius (Alahudin et al., 2013). Polycarbonate material is able to provide thermal comfort because it does not conduct heat and does not absorb heat (Kwa et al., 2022). On the west side of the building, the type of canopy uses polycarbonate blur only on the bottom while at the top, canopy is not wide enough which can see on figure 3.7. The average temperature inside the building during the day is 31°C. The trees in the western part are less than optimal in providing direct shadows on the building but serve as shade for the parking area. On the other side of the building, shadows are cast through the surrounding buildings. From the results of the analysis, the thermal room in the building is considered less comfortable because the shading is less than optimal in the use of sun shading, and lack of large trees as a solar heat filter.



Figure 3.7. Passive shading (writer, 2022)

3.2. Sub-co



Figure 3.8. The front side of Sub co (Author, 2022)

The building in Figure 3.8 is a co-working space located in Surabaya. This building is an Indonesian tropical-style building which was modified back in the appearance of the building to make it more modern. Architectural elements in this building such as the shape of the roof, eaves, windows, outdoor vegetation must be re-analysed whether it is in accordance with the surrounding environment through the principles of bioclimatic architecture.

A. Building Orientation

The orientation of the building to the sun pattern affects the temperature so it needs to be considered (Kuruseng et al., 2017). The best building orientation is to place the smaller surface on the east-west side (Diana et al., 2021). Based on observations on figure 3.9, this

building has a southeast orientation. This will help reduce solar radiation entering the building. This condition will be beneficial because it can affect the thermal conditions to be cooled in the building. The orientation of the openings in this building is northwest-southeast according to the direction of the wind on site. Bad air quality can reduce the quality of work, there is a way to improve air quality by designing air vents (Ayu, 2013). Utilization of ventilation to enter sunlight and change air can prevent health problems for users (Candrasari & Mukono, 2013). They still have not implemented cross ventilation which can cause less than maximum airflow from inside to outside. The orientation of the building is appropriate and does not include a lot of solar heat, without the use of cross ventilation, the airflow will not be optimal and will affect thermal comfort.



Figure 3.9. Site plan (google earth, 2022)

B. Transitional Space

The transitional space is in front of the building. Its function is as a green open space and a terrace. This area will maximize the airflow into the building, optimizing the natural lighting in the building, and a view from outside. Optimizing vegetation will help cool and reduce energy use (Prihatmanti & Taib, 2017). The grass is a good ground cover for protecting solar radiation and also has the lowest temperature compared to other materials (Faza et al., 2017). Vegetation in the form of trees can reduce temperature, increase air humidity, and reduce wind speed during the day (Erdianto et al., 2019). The existence of a green area on figure 3.10 as a transitional space can help reduce the hot temperature in the building and the environment.



Figure 3.10. Transitional space (Author, 2022)

C. Relation to Landscape

Based on the observation, the relation to the landscape of this building connection between the building and the landscape through the windows. View from the window is the garden on the west and south sides of the building. Protective vegetation can provide shade and help improve home comfort (Latif et al., 2017). The types of vegetation that exist on-site function as aesthetic and shadowing. The location of the vegetation in the landscape is on the south and west sides. In the western area on figure 3.11, the plant is mostly large and has a dense leaf mass. It benefits the west side of the building because it provides shade and filters direct solar radiation from the west side. On the south side which can see on figure 3.12, the type of plant that exists on the landscape mostly functions as aesthetics like frangipani and shrubs. This vegetations help reduce the hot temperature. The regulation of vegetation on site can still circulate the air well.



Figure 3.11. Landscape space (google earth, 2022)



Figure 3.12. Landscape area (Author, 2022)

D. Wall Design

The wall material used in this building is brick with a white paint finish. Brick material is included in the large specific gravity, so the thermal insulation power is small (Pandu & Purwanto, 2021). The white paint finish has the smallest absorption capacity compared to the old colour (Talarosha, 2005). Thermal comfort is done by providing good ventilation that has been adapted to wind and environmental conditions (Prakash & Ravikumar, 2015). The openings in the walls use transparent glass material of a fairly large size. The use of a glass of a large size can increase the temperature of the room. The existence of this transparent material can enter most solar radiation into buildings which increases the temperature. The use of this type of dead glass on figure 3.13 in this building has an impact on the less than

optimal airflow from inside out of the building so that the thermal conditions become less comfortable.

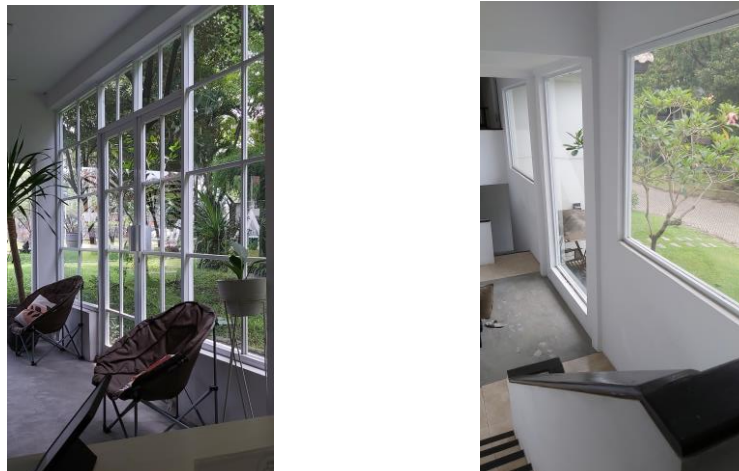


Figure 3.13. Wall design (Author, 2022)

E. Passive Shading Device

Passive shading in this building is obtained from roof overhangs, shading fins from walls, and vegetation. The wide eaves and the roof jutting out of the building can dissipate the heat and just receive the light (Latif et al., 2017). Almost all openings are shaded by the overhang. On the west side of the building, many large trees shade the west side of the building. This condition is very beneficial because it can reduce the radiation of heat directly entering the building. Shadows are obtained from the roof, vegetation, and the wall of the building. The length of the roof on figure 3.14 produces a shadow that can help decrease the temperature. The location of the windows and walls is deeper so that there is a wall area that produces shadow when exposed to the sun. The vegetation that produced large shadows is located on the west side building.

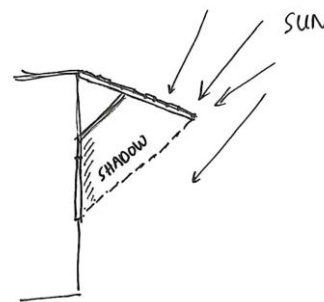


Figure 3.14. Passive shading (Author, 2022)

Based on the analysis of the 2 case studies above, here are the results of the comparison of the bioclimatic principles in the two buildings.

Table 3.1. Comparison of bioclimatic principles (Author, 2022)

Bioclimatic Principles	Case Study 1	Case Study 2
Building Orientation	The building orientation causes the sun's heat to enter directly into the building. The orientation of the	The building orientation help reduce solar radiation entering the building. The orientation of the

	openings in this building is facing the west, east, and north sides.	openings in this building is northwest, southeast side.
Transitional space	Transitional spaces in this building are located on the front, middle, and north sides. They function as parking lot, terrace.	The transitional space is in front of the building. Its function is as a green open space and a terrace.
Relation to landscape	Landscape area of this building has less green area. It's only on the edge of guardrail because the yard is used for parking. The landscape on this object still does not provide a maximum cooling effect on buildings that have large openings facing west.	The relation to the landscape of this building connection between the building and the landscape through the windows. The regulation of vegetation on site can still circulate the air well.
Wall design	The wall material in this building uses exposed brick on all sides of the building. The material in the opening is glass with large size directly leads to the pattern of the sun's passage.	The wall material used in this building is brick with a white paint finish. The openings in the walls use transparent dead glass material of a fairly large size.
Use of passive shading tools	Passive shading in this building is obtained from sun shading on the part of the building, trees around the building, and surrounding buildings but still not optimal to reduce heat.	Passive shading in this building is obtained from the roof and vegetation which help reduce heat.

4. Conclusion

The bioclimatic principle on the first object has been applied to the building, but some points are still not optimal and are not suitable in helping to maintain thermal conditions such as the orientation of the building that does not respond to environmental conditions, the use of large glass materials but does not pay attention to the direction of openings and passive shading that is less maximum in providing shadows into the building. Thermal comfort in this building is still not optimal because the condition of the building directly leads to solar radiation but is not responded well. In the second object, almost all the bioclimatic principles applied are by environmental conditions. The drawback is that it has not implemented cross ventilation or open windows so the airflow in the room is not optimal. This condition can cause the thermal conditions in the room to be less comfortable. The principles of bioclimatic architecture under environmental conditions can help improve thermal comfort both outside and inside the building. Appropriate bioclimatic strategies can reduce energy use in solving the climatic conditions of buildings located (Manzano-Agugliaro et al., 2015). Suggestions for further research are an analysis of the application of appropriate design principles for various types of buildings in Indonesia with minimal energy use and the application of zero waste to reduce negative impacts on the environment.

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