Advances in Social Science, Education and Humanities Research, volume 671
International Webinar on Digital Architecture 2021 (IWEDA 2021)

Bioclimatic Architecture as a Design Approach for High School in Gedebage, Bandung City

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ABSTRACT
Gedebage Sub-district is targeted to become an area that synergizes in terms of education, creative economy, commercial, and government center with the concept of a technopolis city. To realize the target, schools need to be improved in terms of quantity and quality. High humidity level that cause thermal comfort in buildings cannot be achieved unless Bioclimatic Architectural approach is implemented. There are five design concepts based on Bioclimatic Architecture that can be implemented to reduce humidity in buildings: (1) building orientation, (2) openings, (3) light and thin wall material, (4) semi- outdoor space, and (5) maximizing vegetation. Application of these design parameters effectively in high school buildings will be able to reduce the high level of humidity.

Keywords: *Bioclimatic architecture, High school, Gedebage Sub-district, High humidity.*

1. INTRODUCTION

Located in Bandung City, Gedebage Sub-district is planned to be the second city center of Bandung City. Based on the Bandung City Detailed Spatial Planning and Zoning Regulations (Rencana Detail Tata Ruang dan Peraturan Zonasi Kota Bandung) 2015 – 2035 [1], Gedebage is targeted to become an area that synergizes in terms of education, creative economy, commercial, and government center with the concept of a technopolis city. Therefore, to realize the target, it is necessary to develop supporting facilities in Gedebage Sub-district. Among the supporting facilities that are important to note are educational facilities. Education is an important aspect that plays a role in improving quality of life for the people economically and socially [2].

Data from the Ministry of Education and Culture (Kementerian Pendidikan dan Kebudayaan) [3] shows that the number of schools in Gedebage is among the fewest compared to schools in other sub-districts within the city of Bandung. At the high school level, there is only one high school in Gedebage Sub-district, namely SMA Negeri 27 Bandung. Established in 2006, this school is the newest high school in Bandung City. Data from the Ministry of Education and Culture also shows that the population aged 15-19 years in Bandung City reached 3082 people in 2020. Certainly, this number is not proportional to the number of schools in Gedebage. So, in order to realize the urban planning in Gedebage, schools need to be improved in terms of quantity and quality.

Climate has always been a concern in tropical countries, including Indonesia. The effect of climate will have a bad impact on the comfort of building users. In context of educational facilities—where students as users are inside of it for more than 6 hours—the level of user comfort cannot be ignored. Several studies related to thermal comfort in schools in Indonesia stated that schools in Indonesia have not achieved thermal comfort effectively [4].

In the city of Bandung, a common climate-related problem is high humidity. Based on Bandung City EPW data released by Onebuilding in 2020 [5], the average humidity in Bandung City ranges from 75-85%, which could potentially causes several problems, both for the building users and for the building itself. This condition needs to be considered in the design to achieve a thermally comfortable educational facility building for users.

To overcome these problems, it is necessary to use the right design approach so that the negative impact could be minimized or even used as an advantage for the design. In the context of designing a building in Gedebage Sub-district, it is necessary to apply architectural design based on natural conditions and the surrounding climate and use them for the building's benefit. The right approach in this case is the

Bioclimatic Architecture approach. Bioclimatic architecture is a design approach that directs architects to get the design solutions based on both architectural forms and the local climate [6]. The Bioclimatic Architecture approach is carried out by responding to the local climate to support the design of the building [7]. So, this design is carried out with the aim of applying the Bioclimatic Architecture approach to the design of high school in Gedebage Sub-district.

2. BIOCLIMATIC ARCHITECTURAL APPROACH IN DESIGN BUILDING

2.1. Bioclimatic Architecture

Bioclimatic architecture is an architectural design approach that considers climate issues at the site. Bioclimatic architecture unites the disciplines of human physiology, climatology, and the integrated buildings on the site. The design minimizes the negative effects of the surrounding climate and takes advantage of its potential. Architecture must accommodate human activities so that humans can work optimally in comfortable and healthy conditions [8].

Bioclimatic architecture is a reflection of Frank Lloyd Wright's architectural approach, which is known for architecture related to nature and the environment. The main important principle of a building is not only talking about the efficiency but also the tranquility, harmony, wisdom, strength of the building, and activities in the building [9].

Bioclimatic design principles for sustainable architecture and energy efficiency present an evolutive integrated strategy for achieving efficiency, and healthier impact [10]. Also, the design takes into account the analysis of the climate and environmental characteristics of the site, provide comfort for building users and saving the energy consumption [11].

2.2. Design Parameter

Handoko and Ikaputra [6] in their research summarized the suitable design parameters for hot and humid climates in 7 points:

- Minimize the intensity of solar radiation
- Minimize solar heat gain
- Minimize conductive and convective heat gain
- Optimizing the potential of the building in obtaining natural ventilation
- The use of light and thin walls
- Protect the walls of the building from insects
- Provide a semi-outdoor space between indoor and outdoor spaces

Meanwhile, Kusuma [9] in his research includes the "integration of natural surroundings" variable as a characteristic of the Bioclimatic Architecture which includes 2 points:

- Design that supports a visual experience of the natural surroundings
- Prioritizing biodiversity

As previously explained, Gedebage Sub-district has a high level of humidity that could cause several negative impacts for building users and for the building itself. So, in this context, the design parameters taken are those who has the relation towards high humidity problems. Then, based on these parameters, the design concept for high school design is obtained as follow:

- Building orientation
- Openings
- Light and thin wall material
- Semi-outdoor space
- Maximizing vegetation

3. METHODS

The method used in this study is design simulation based on the design parameters related to bioclimatic architecture. The design parameters are based on the bioclimatic architecture applied to hot humid climate. Then, the parameters that correspond to the solution of the humidity problem are taken and synthesized into a design concept that will be implemented in buildings.

Simulations are carried out using Sketchup software to simulate the buildings in 3D. The simulation is carried out in several steps by implementing the design concepts to get the final design. The design process can be seen in Figure 1.

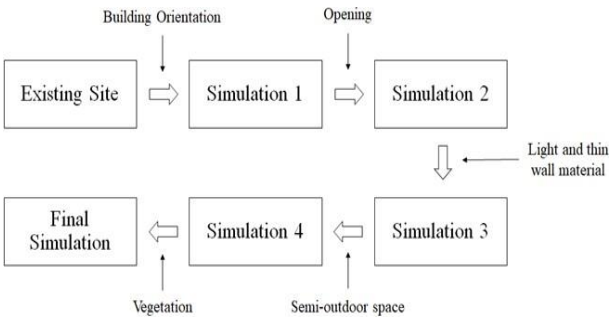

Figure 1 Design process.

4. RESULTS AND DISCUSSION

4.1. Site Location

The location of the site design is at Jalan Edelweiss in the Summarecon Area in Gedebage Sub-district of Bandung City. The site is functioned as a commercial area and supporting facilities for Summarecon. The slope of the land is relatively small and tends to be flat.

The site location is easily accessible by cars or motorbikes. It is located close to the main road, which makes it easy for vehicle to access. The road is large enough to minimize the occurrence of traffic jams. Around the site area, there are cluster housing as the target reach of prospective students. The site, which is part of the Summarecon area, makes the function of the site and other facilities at Summarecon mutually supportive. The establishment of a high school in the Summarecon area contributes to the needs of schools in the Gedebage Sub-district.

4.2. Site Analysis

4.2.1. Sunlight

In the morning, the site receives sunlight from the east. There is a public facility building located right to the east of the site so that it slightly blocks sunlight from entering the site, but such conditions can still be tolerated. When the sun is at a sufficient altitude, sunlight can enter the site. In the west, there are no massive buildings so that even when the sun goes down, sunlight can still enter the site. In general, the site is exposed to sunlight for almost a full day.

Sunlight that enters directly into the building will cause glare and heat so that thermal comfort is not achieved. So, the design solution is to minimize the use of openings in the west and east areas of the site. Besides, the use of eaves and double skin facades can be done to reduce the entry of excess light intensity into the site. Furthermore, openings in the north and south areas of the site need to be maximized to get natural lighting in the site.

4.2.2. Wind Speed

The average wind speed in a year based on Bandung City EPW data is in the green color range, which indicates normal wind speed, ranging around 1-2 m/s. The highest wind speed occurs in January, reaching 2.7 m/s in the afternoon and evening. Wind movement towards the site comes from the south of the site.

4.2.3. Best View

The best views are to the north and southwest of the site. There is Mount Manglayang in the north which is the right view from the building, while in the southwest, there are lakes and parks as a place of recreation.

4.3. Design Evaluation Based on Bioclimatic Principle

4.3.1. Building Orientation

The building orientation is based on the wind direction and the natural view of the site. Buildings that are perpendicular to the wind direction will maximize cross ventilation in the building so that the air in the building can circulate properly. The view of Mount Manglayang displayed on the site to integrate the site with the surrounding nature.

4.3.2. Openings

Openings are maximized in the north and south areas to provide cross ventilation. The use of large windows could be used in the northern area to show the view of Manglayang Mountain. However, openings in the north need to be added to overcome the entry of excess sunlight. While in the southern area, windows, ventilation, and roster can be used as openings.

4.3.3. Light and Thin Wall Material

Light and thin walls are used to protect the building from heavy rainfall, which can increase humidity. Furthermore, the walls must be strong and efficient. So, based on these two factors, the material for the walls that can be used is Hebel.

4.3.4. Semi-outdoor Space

The transition space between indoor and outdoor spaces is applied to the circulation of the building. At the corner of the building, the walls are not designed to be massive so that a semi-outdoor area is formed. This area will provide good air circulation in the building.

4.3.5. Vegetation

The trees are effective for wind circulation in the building and to give the impression of coolness to its users. Trees are placed along pedestrian on the site where activity in the area is quite intense.

5. CONCLUSION

In Gedebage Sub-district, which has a high level of humidity, a bioclimatic architectural approach can be used to overcome these problems. Based on the bioclimatic design parameters according to Handoko and Ikaputra [6] and Kusuma [9], there are 5 design concepts that could be implemented to reduce humidity in buildings: (1) building orientation, (2) openings, (3)

light and thin wall material, (4) semi-outdoor space, and (5) maximizing vegetation. These parameters aim to maximize the potential of wind and sunlight as a solution to high humidity in the building. Application of these design parameters effectively in high school buildings will be able to reduce the high level of humidity.

ACKNOWLEDGMENT

This article was supported by the Ministry of Education, Culture, Research, and Technology of Republic Indonesia. Grant numbers 317/UN40.LP/PT.01.03/2021 under LPPM- Universitas Pendidikan Indonesia.

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