The Use of Wind Rose to Improve the Quality of Site Analysis

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Abstract: Site analysis is the first step of building and environmental planning and design, which has to be done to get the aim of the design. There are many factors that should be analyzed in that step, and the wind, as one of the climate factors, is one of them. The importance of wind analysis is to formulate the concept of building façade and landscape, as well as building structure. This paper will concentrate on the first one. To formulate the concept of building and landscape, architects should know about wind, its types and categories. Designers commonly use wind data in a simple manner in their analysis. The need to enhance the quality analysis is urgent, which can be done by utilizing a wind rose diagram. Generating a wind rose diagram can be either manually or by using software. Several freeware can be obtained from the internet. The method used in this paper is the implementation of freeware called WRPLOT View Version 8.0.0., which depicts the wind direction and speed in a specific location and period of time. This paper will present how to produce a wind rose diagram by taking a sample wind data of Pekanbaru, Indonesia, which were obtained from Meteorology, Climate and Geophysics Board (BMKG) Riau Province. Analyzing the wind using wind rose diagram to produce the concept of building façade and landscape is a significant effort in improving the quality of analysis. Wind analysis using simple data, which usually contains incomplete information, gives less optimal results. It could be sufficient when it is applied in a small simple building plan, but neither in larger project nor in climate-related architectural project such as tropical and bio-climatic architecture. By using the wind data from wind rose graphic, in which the information is more complete, the quality of analysis will be improved. Finally, the author will show a simple example on how to implement wind rose in site analysis.

Keywords: Site analysis, wind rose, WRPLOT View Version 8.0.0., improved site analysis.

1. Introduction

Planning and design is the early process in architecture to create buildings and environment. According to Benjamin Handler, the aim of the architectural process is in the last subsystem, i.e. shaping human behavior by improving the building and environment [1]. Therefore architects have the responsibility to design good facilities which can be sustained and operated for a long time period and enhance good behavior of its user. A sustainable building and environment should become an important concept to architects.

Sustainable architecture which was promoted since 1991 by Earth Pledge Foundation is a part of sustainable lifestyle focused on the need to live and work in a prosperous and healthy environment [2]. Jason Frederick McLennan (2000) stated that one of the seven principles of living building is that it
has to be adapted specifically to site and climate. Furthermore, a living building should evolve as conditions change [2]. Further, Sustainable site analysis is applied to achieve sustainable buildings and environment, which will produce good behavior of the users. Many factors can be covered in site analysis, either physical or nonphysical. Joseph de Chiara and Lee E. Koppelman (1978) divided the factors into two general groups: natural and cultural resources, which were broken down into nine items, they are soil, vegetation, hydrology, climate, topography, aesthetics, historical significance, existing land use and physiographic obstruction. Moreover, the building’s orientation to the climate, such as sun, wind and vistas, is very important in a site analysis. Unfortunately the method used to analyze is generally insufficient, therefore the result is less optimal. Therefore, this condition needs to improve.

This paper contains three main subtopics which are related to each other to form the whole context, i.e. the understanding and using of wind rose in site analysis; they are as follows: Firstly, a review of the wind and how it needs to be analyzed to show the importance of wind analysis. Secondly, a brief method of generating a wind rose diagram will be presented by adopting a freeware, i.e. WRPLOT View Version 8.0.0. The wind data were taken from the Board of Meteorology, Climate and Geophysics (BMKG) Riau Province. Thirdly, an explanation on how to make the wind data with wind rose graphic and its use for site analysis.

2. Wind Factor in the Site Analysis

As De Chiara (1978) stated about the standard of site planning, wind is one of the factors influencing it. Edward T. White also said that one of the most important information in contextual analysis is wind direction. In terms of site analysis, it needs accurate data about the wind, its types and the way it works on a building and environment. Then the analysis will produce an excellent building and environment concept [5].

2.1 Categories of Wind

Phillip Tabb (1984) divided climate (including wind) into two categories: macro climate and micro climate. In terms of wind, the macro climate will cause prevailing wind, which refers to the wind in overall condition caused by general or global wind formed by the earth’s wind patterns. Whereas micro climate or local climate will cause a specific type of local wind that formed when the global wind meets a specific local condition, i.e. topography, natural and man-made physical feature. Indonesia, with its specific geographic character, has been influenced by the monsoon wind, which can be described as two different wind conditions of January and July. January’s wind tends to come from the North West and North East, whereas July’s wind comes from the South East and South West. Other types of wind such as hurricane, typhoon and tornados are chaotic. They are not considered to be prevailing wind, so this paper will not discuss about those. Sir Francis Beaufort (1808) has arranged the wind speed scale and detected some physical sign in nature. Dean Rudityo Ajie and M. Nur Cahyadi presented the table of Beaufort scale which was taken from Stewart (2008). Beaufort scale consists of information about wind speed level, description of each level, wind speed, and environment phenomena, such as the height of ocean waves that will make it easier to detect the wind without equipment [6]. Beaufort scale consists of 13 levels of wind speed including calm condition, while WRPLOT View has 6 levels of wind speed, calm condition is not be drawn in the graph.

2.2 Local Wind Data Retrieval

It is not a simple work to get the local wind data, because it needs several scientific equipment or wind speed instrument to quantify the wind speed, blowing hits, etc. The data retrieval will also need a time period that is statistically reasonable. A decent data should at least 5 years’ worth of wind data. This means that the local wind measurement work will be very expensive to do by individual projects. Thus, it is a common practice to buy wind data from the nearest local meteorological station. It saves time and money, but they will not get data of the precise project’s location. Advanced wind data of specific location may be provided to a mega project. This is not included in this paper.

In the subtopic about generating wind rose below, this paper will use a sample of the wind data, taken from Meteorology Station Class 1 of The Board of Meteorology, Climatology and Geophysics (Henceforth: BMKG) Riau Province, of Sultan Syarif Qasim II Airport Station, Pekanbaru.
3. Generating the Wind Rose

A wind rose is actually a diagram in concentric circle form. This diagram can be applied to produce not only wind data, but also other data such as its direction and quantity. Wind rose diagram is mostly used in designing airport and seaport. Generating a wind rose diagram can be done by drawing with CAD software such as AutoCAD. The data which has to be prepared in a table form by using a software such as Microsoft Excel, can be transformed manually into a graph by using AutoCAD. Another method is by using a different software program called the WRPLOT View, and in this paper it will be used to give a sample on how to generate a wind rose. WRPLOT View is a freeware which can be obtained from the internet by registering one’s self in the system and the software can be downloaded freely. After inputting the registration code, the WRPLOT window will appear and a wind rose diagram can be generated using several main steps as follows:

Step 1. Prepare the climate data in Excel table format before starting. Import the data to WRPLOT program to create a data file in SAMSON format, which is the standard format of this software. In doing data import, one should follow all the steps and adjust several information settings correctly, such as “hour” which has alternatives that can be chosen depending on the Excel data format. After finishing setting the import surface data information, push the “import” button.

Step 2. Create a backup file of the SAMSON data format outside of the WRPLOT software. Once the software has finished inputting the data, it will automatically produce several forms of data, such as meteorology data information, frequency count, frequency distribution, graph and wind rose. Click the wind rose button to see the wind rose diagram. This paper used BMKG’s wind data 2017, and the result of the generating process is the wind rose diagram below (Figure 1).

Figure 1. Wind rose year 2017 “blow to” direction.
Figure 2. Wind rose year 2017 “blow from” direction.

**Figure 1** is wind rose in “blow to” direction showing that the winds blow to leave the location for the North (N), South (S), South East (SE) and West (W). That means that these winds are suction winds, which work to pull off the leeward of the building. On the other hand as present in the **Figure 2**, the winds came from the South (S), North West (NW), and North (N). These winds act as pushing winds that blow and give compression to the building.

The two figures above explain that the wind condition in Pekanbaru 2017 was dominated mostly with red color and then yellow color. The red color represents wind speed of 5-7 Knot or 2.57-3.60 m/s or 5.75 – 8.05 Mph; while the yellow color represents 4.08 – 7 Knots or 2.1 -3.6 m/s or 4.69 – 8.055. Furthermore, In Beaufort scale it means these wind range from the light air to gentle breeze, which are not hazardous. In terms of wind load to the building structure, this wind speed is considered light, but still has to be counted in the structure calculation, especially when the project has the possibility to meet the gust wind. That’s another type of wind, but this paper doesn’t discuss about building structure.

### 4. Improving the Quality of Analysis

In order to improve site analysis, there should be an understanding about the limitation of the improvement. Ideally, the analysis will be more quantitative and give a precise result. But it is difficult to get, because site analysis also depends on the analyzer’s style, science background, experiences and other resources. It also depends on the morality of the designer, whether he or she has awareness on implementing a sustainable concept of architecture. Wind, which is only small part among many factors of site analysis, might determine the future world. Therefore, This paper will demonstrate how to analyze with the author’s version, which might be a different style when done by someone else. Before analyzing, several limitations have to be dealt with as follows:

Firstly, limitations of wind data. The wind rose created above only covers one year (2017), which is insufficient. A reasonable data ideally has a range of minimum 5 years. Climate, including wind, is very unstable and even sometimes difficult to predict. In one location the wind data on several years in a row (2014-2017) vary in its conditions while in Pekanbaru, year 2014-2017, South wind is stable with speed of 6-7 Knot (May-August). This behavior formed a stable pattern, but in other months there are many changes in their directions, therefore the pattern is unpredictable. These wind behaviors should be considered in the site analysis, at least by using a 5 years wind data which
represents the wind’s behaviors during that range of time. This paper will give an example on how to improve the analysis with assumption data, not necessarily a real data. Secondly, limitations of the site. A very simple form of site will be applied in the analysis example. The samples used in this paper are basic, so that the environment’s components, thus the analysis, does not vary and make it too complicated. Thirdly, limitations of the scope of analysis. The analysis example will consist of 2 steps which should be done in order: the wind analysis to the environment and the wind analysis to the building. Both analyses are drawn in Figures 3 to 6 in simple, rough sketches.

4.1 Wind analysis to the environment

There is an obvious influence of wind blow to the environment, as mentioned in De Chiara’s Site Planning Standard. The scope of environment and wind speed mean velocity should be controlled through its speed, direction and stability. To do a complete analysis the gust wind should also be included. In this analysis sample only the wind speed mean velocity will be reviewed. Mangun Wijaya divided the prevailing wind in Indonesia into 2 periods, they are January period, which is dominated by West wet wind, and July period, which is dominated by South dry wind. Both winds’ speed is dominated by red color (7.00-11.08 Knots) and yellow color (4.08-7.00 Knots) respectively.

In Figure 3, the wind analysis to the environment, January period is explained. The assumed wind on January period blows from (+) NW, wet, red, 17%; NW, wet, yellow, 25%; and N, wet, yellow, 8.55%. The most stable wind is NW, yellow. The concept to control these winds, not every wind speed, is by putting the porous hard scape, because wet wind may cause humidity, so that the receiving area should easily catch the sunbeam. That’s why this area doesn’t need a dense tree shade. But spruce and lawn trees need to absorb the rainwater, so they are combined with absorbent hardscape such as charcoal and pumice stone to absorb the humidity of air. The important factor in controlling humidity is the smooth flow of wind circulation, for the arrangement of hardscapes should be porous.

![Figure 3: Wind analysis to the environment, January period.](image-url)
In Figure 4, the assumed July period winds comes from (+) S, dry, red, 25%; S, dry, yellow, 16.4%; and W, red, dry, 8.6%. In this period, the dry wind coming from the South dominantly blows to the site. Although the speed of these wind are not quite strong, but sometimes small wind acceleration can occur and it may bring dust to the site. To control this wind are: (1) filter the dusty wind through the combination of plants, i.e. fir, shade trees, shrub and lawn in combination, and (2) increase the wind humidity by providing a pond to give water vapor, thus avoiding too much hard scape on this side.

![Wind Analysis to the Environment, July Period](image)

**Figure 4.** Wind analysis to the environment, July period.

### 4.2 Wind Analysis to the Building

The wind analysis to the building is limited to the building façade. The intention is to show how the façade respond to the incoming wind. As mentioned before, the wind speed is not so strong, so there is no need to hide or turning the façade away from the wind exposure. This is the reason of why the long side of the building faced the North and the North West.

The façade concepts are to catch the conditioned wind, after blowing through the porous hard scape, in order to supply the building through vertical louvers which can be adjusted. Vertical louvers give an optimal opening vertically. These are suitable to catch clean wind. Whereas the opposite façade building uses horizontal louvers that can be adjusted to prevent lower dusty wind from entering the building. The concept of terrace is to give space where the blowing wind can be conditioned before entering the building. A wide opening of terrace faced the incoming clean wind (NW & N), while a narrow opening faced the incoming conditioned dusty dry wind (SE).

The below Figures 5 and 6 will show how the wet wind and the dry one will be given different treatments to achieve suitably conditioned wind which are needed by the persons in the building. All the treatments are natural, with the assumption that mechanical treatments are not applied in this step of design.
The South and West wind in July period are coming from Australia and Siberia which are dry wind, which needed to be conditioned before reaching the building. Figure 6 shows an effort of conditioning by planting shady dense trees, shrubs and pond. The conditioned wind reaches and enters the building through horizontal louvers and narrow opening terrace. Patios will help to refresh the air entering the inner space of building.

Figure 5. Wind analysis to the building, July period.

Figure 6. Wind analysis to the building, January period.
In January period, the wind coming from North and North West are stable wet wind. The speed is suitable to the building, but sometimes acceleration may occur, especially when it rains. Applying porous hard scape will reduce the humidity of the air and act as a wind breaker of the accelerated wind blow when it rains. In the leeward of hard scape, conditioned winds are conveniently enters the building through the vertical louvers with maximum opening. Wide opening of terrace lets the fresh clean wind enter the building via patios.

The example above is a very basic analysis. It will be more complicated as variables of its factors increase such as the size of site, specific topography condition, extreme climate etc. What the author’s aim for is to bring awareness to young designers on the wind factor in site analysis, so that designers can be efficient in his or her design, which are part of the sustainable design. A building and its environment, which is designed with awareness to the nature, wind included, will influence the user’s morality and hopefully improve their behavior.

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