The Study of Wind Behavior Around Building on Fishing Settlement

Krisna Dwi Handayani¹, I Gusti Ngurah Antaryama² and Happy Ratna Santosa³.

Abstract - This paper aims to analyse wind behavior around building on fishing settlement Cumpat and Greges Barat (West Greges) through the simulation program CFD (Computational Fluid Dynamics) version 6.2.16, in order to know the ventilation performance around the building on fishing settlement who have been determined as a fishing settlement which continue to be developed and built on its original position. By knowing the wind behavior on the settlement, expected to be known the quality of ventilation on settlements.

Using a simulation and evaluation research, with a climate data last 5 years, from BMKG Silver II Surabaya as an input data simulation and a settlement physical measurement data in the field. The simulation results ventilation performance due to the influence of the building arrangement and building density, in corridor (gang) at Cumpat building group indicate that the wind speed reaches a high value at a 2 storey building located on windward, when the venturi effect, and the geometry of buildings that create open space and located at windward. The existence of the geometry of buildings that create open spaces, but lack sufficient influence on ventilation performance, due to the open space has a distance less than 6H thus still affected wind shadow of the building. This condition also occurs in the corridor of each buildings group on Greges Barat.

Wind speed could come into the corridor when a group of buildings has a distance of 3 m and the distance is shrinking gradually. The condition occurs in the building group C (Kluster) at a location Greges Barat when it is influenced of wind coming from the East. This condition occurs in almost every corridor.

I. INTRODUCTION

Indonesia have small to large islands extending from east to west region of Indonesia. This conditions result in Indonesia has a long coastline. As the UN announced in 2008, that is now 95,181 km carrying a long coastline of Indonesia. That puts Indonesia in fourth in the world after the United States in the first, Canada second and Russia third longest coastline.

The position of Surabaya in Java, East Java, exactly. Surabaya has a coastal area that stretches from the East to the North. In the eastern part of Surabaya, most of these coastal areas directly adjacent to the beach, while on the West coast, the area is bordered by ponds (tambak). In the coastal area is mostly fishing settlements are located. These fishing settlement has high building density that most of the mass was followed by the arrangement that has its own specification. The condition was also found in the fishing settlement of on the East coast and the tambak area northern Surabaya. In the East coast fishing settlements, the position of a sea was directly adjacent in the East of settlements. While in the tambak area northern, the positions of a sea was in the North of settlements and separated by mangrove vegetation and the tambak area which is 300 m.

In the study conducted to identify the prospects for development of fishing settlements on the coastal areas of Surabaya known that there are 2 permanent settlements developed and built on its original position. Fishing settlements are Cumpat and West Greges (Sunarti, 1992).

II. WIND BEHAVIOR AROUND BUILDING

In principle, wind move from a place that has high pressure to the place that has low pressure, or from a positive pressure to the negative pressure, with the pattern of laminar flow, turbulent and separated (Boutet, 1987).

When the wind come in contact with the surface of the building on the windward side, the wind was divided into two parts. Two-thirds of the height of buildings, will move toward the side of the building, and the third part will move toward the top of the building (Boutet, 1987). Increasing wind velocity at the sides of buildings has a value of 137%, 128%, 120% and 110% of the free wind speed (Fig.1.).

![Fig. 1. Increased wind speeds at the sides of buildings. (Boutet, 1987).](image)

Wind direction turn because was blocked by vegetation and buildings, but will return and follow the wind direction. Wind flow can affect to venturi effect, due to the acceleration of wind flow over a confined laminar flow (Boutet, 1987).

Controlling the movement of wind can be affected by elements of the building in terms of layout, orientation, height, overhang, roof surfaces, and other architectural form without the influence of environmental factors (Boutet, 1987) (Fig.2.).
II. RESEARCH METHOD

A. Simulation

The aims of the simulation using CFD (Computational Fluid Dynamics) in this study is to see and obtain wind speed and aerodynamic behavior that occur around the building due to the influence of density and layout of the building mass. The program was also used by some preliminary researchers to study ventilation and thermal performance. For example the study by McAlpine, et al. (2004), to determine the airflow and pollutant distribution between urban and complex geometry and the research conducted by Hsieh, et al. (2007), to see an increase in thermal environment through the buildings arrangement in the settlement along the rivers.

The design of simulation based on the level of density and building arrangement in the group of buildings. The group of existing buildings, was drawn in the form of 3 dimensional solid. These 3 dimensional solid only equipped with a roof, but door opening and window are not made for reasons of simulations conducted to determine the aerodynamic behavior of wind around buildings so that simplified form of the openings of buildings that can slow the process of running was required.

Input simulation data was the climate data last 5 years, from BMKG Perak II Surabaya and physical measurement data in the field which made as a model of settlement and simulated with CFD software.

B. Research Object

The model simulated was a group of buildings which have the dimensions, layout and shape alike where the building is located. According to Satwiko (2000), simulations based on scenario building environment in the context properly, done to avoid the assessment of bias that can occur.

Model of group building and parameter identification of field conditions at each location can be seen in the following description. The building of red color, showing 2 storey building, the building of green color is a typology of each group of buildings and the mass of the black color is the building 1 storey.

a. Group of Building on Cumpat

Model and parameter field conditions at Cumpat can be divided into groups of building A (Bercelah/Slotted), B (Menempel/Attached) and C (Kluster/Cluster) (Table I).

<table>
<thead>
<tr>
<th>Parameter Design of Building Group</th>
<th>Model Building Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. BERCELAH</strong></td>
<td></td>
</tr>
<tr>
<td>North-South Orientation</td>
<td></td>
</tr>
<tr>
<td>- North corridor: 1m</td>
<td></td>
</tr>
<tr>
<td>- South corridor: 1m</td>
<td></td>
</tr>
<tr>
<td>Building height: 1-2 storey</td>
<td></td>
</tr>
<tr>
<td>No vegetation</td>
<td></td>
</tr>
</tbody>
</table>

TABLE I
MODEL AND PARAMETERS OF BUILDING GROUP ON CUMPAT
b. Group of Building on Greges Barat

The model and the parameters field conditions in Greges Barat can be divided into groups A (Bercelah/Slotted), B (Menempel/Attached) and C (Kluster/Cluster) (Table II).

### TABLE II

**MODEL AND PARAMETERS BUILDING ON GREGES BARAT**

<table>
<thead>
<tr>
<th>Parameter Design of Building Group</th>
<th>Model Building Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. BERCELAH</strong></td>
<td></td>
</tr>
<tr>
<td>Orientation Northeast - Southwest</td>
<td></td>
</tr>
<tr>
<td>- Corridor A: 2m</td>
<td></td>
</tr>
<tr>
<td>- North corridor: 1m</td>
<td></td>
</tr>
<tr>
<td>- Building height 1 storey</td>
<td></td>
</tr>
<tr>
<td>- Mangrove vegetation along 0 - 300m from the sea</td>
<td></td>
</tr>
<tr>
<td><strong>B. MENEMPEL</strong></td>
<td></td>
</tr>
<tr>
<td>North-South Orientation</td>
<td></td>
</tr>
<tr>
<td>- North corridor: 1m</td>
<td></td>
</tr>
<tr>
<td>- South corridor: 1.5m</td>
<td></td>
</tr>
<tr>
<td>- Building height 1-2 storey</td>
<td></td>
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<tr>
<td>- Mangrove vegetation along 0 - 300m from the sea</td>
<td></td>
</tr>
<tr>
<td><strong>C. KLUSTER</strong></td>
<td></td>
</tr>
<tr>
<td>North-South Orientation</td>
<td></td>
</tr>
<tr>
<td>- North corridor: 1m</td>
<td></td>
</tr>
<tr>
<td>- South corridor: 3m</td>
<td></td>
</tr>
<tr>
<td>- Building height 1-2 storey</td>
<td></td>
</tr>
<tr>
<td>- Mangrove vegetation along 0 - 300m from the sea</td>
<td></td>
</tr>
</tbody>
</table>

IV. WIND BEHAVIOR AROUND BUILDING USING CFD

Wind behavior around building on fishing settlement for each location are described below. Settlement is influenced by the direction of the wind which come from the East and West, the hottest month (July) and coldest (November), with wind speed and temperature as the table below (Table III).

### TABLE III

**WIND SPEED ON THREE DIFFERENT TERRAIN**

<table>
<thead>
<tr>
<th>BMKG</th>
<th>V Terrain</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V open sea</td>
<td>V open country</td>
</tr>
<tr>
<td>Juli</td>
<td>5.15</td>
<td>4.10</td>
</tr>
<tr>
<td>November</td>
<td>6.07</td>
<td>4.92</td>
</tr>
</tbody>
</table>

The use of three types of terrain due to influence building density around settlements. When the wind comes from the same direction with the position of the sea and does not have the influence of obstruction, then we used the type of terrain open sea. When the wind come from the direction that is not much influenced by buildings and vegetation, then used the type of terrain open country. And when the wind came from the direction of dense settlement, then used the type of terrain suburban..

A. Fishing Settlement Cumpat

The result of CFD simulation analysis on each group of buildings at the site Cumpat, described below.

a. Building Group A (Bercelah/Slotted)

Venturi effect occurs when the wind comes from the east (parallel to the corridor). This venturi effect will increase the wind speed when it occur at the end of the corridor. This condition is due to the difference in Cp values in the leeward. Height 2 storey of buildings create the windward, so as to increase the wind speed (4.22 m / sec). Effect of windward result wind corridor along the corridor (Fig.5.).
Fig. 5. Wind behavior on building group A (Slotted), when the wind comes from the East and North.

Meanwhile, when the wind came from the North, the influence of the distance between buildings 1 m only able to create wind shadow, so there is no wind speed along the corridor. Wind speed on the corridor reach the highest value of 3.39 m/s, while there are 2-storey building located on the windward. Conditions resulted in Cp of 0.56 (on the windward), so create wind corridor in this area.

b. Building Group B (Menempel/Attached)

When the wind comes from the East, venturi effect occurs in both the corridor and increase in the end of the corridor because the influence of Cp on the Leeward area. Although there are open areas, but no increase in wind speed, due to the effect of building wind shadow (Fig. 6).

Fig. 6. Wind behavior on building group B (Attached), when the wind comes from the East and North.

The condition also occurs when the direction of the wind coming from the North. When the wind came from the North, an increase in wind speed due to the influence of buildings groups which overlooking the open area, resulting in windward at the end of the corridor.

c. Building Group C (Kluster/Cluster)

Venturi effect occurs only in the North corridor, when the wind comes parallel to the corridor. In South corridor, venturi effect does not occur because after 2-story building, the wind flow through the sharp corridor (less than 1 m and 90°). These conditions resulted in no difference in Cp values in the area (Fig. 7).

When the wind came perpendicular corridor, these corridor becomes the wind shadow, affected in wind flow stops in the area. An increase in wind speed occurs when there is geometry overlooking open space and a 2-storey building located in the windward.
B. Fishing Settlement Greges Barat
The results of CFD simulation analysis on each group of buildings in the West Greges locations, can be seen in the description below.

a. Building Group A (Bercelah/Slotted)
When the wind comes from the East, on the geometry extending from Northeast to Southwest and building orientation through Southeast and Northwest, this condition resulted in Cp values 1.42 and 1.7 at windward. Cp values are different due to the influence of geometry extending. Wind speed occurs in North and South corridor. In the North corridor, wind speed is also influenced by the venturi effect. A corridor A with distance of 2 m, still not able to increase wind speed. This condition was due to the influence windshadow previous the building. (Fig. 8.)

![Fig. 8. Wind behaviour on building group A (Slotted) when the wind comes from the East and North.](image)

When the wind comes from the North, the influence of buildings group overlooking the open area improve the wind speed which then distributes the air flow into the corridor. While in the corridor A, early wind speed 0.9 m/sec and the highest wind speed of 3.54 m/sec, due to the influence of windshadow of a North building geometry have a distance greater than 6H.

b. Building Group B (Menempel/Attached)
When the wind comes from the east, there was wind speed 0.74 m/sec at the end of the North corridor, but in the corridor does not occur variations in wind speed, because the influence of perpendicular geometry at the end of the corridor. In the South corridor, a venturi effect occurs due to the influence of Cp value of -0.2 on the leeward (Fig. 9.)

![Fig. 9. Wind behavior on building group B (Attached), when the wind comes from the East and North.](image)

Meanwhile, when the wind comes from the North, the variation of wind speed (2.77 m/sec) occurs, due to the effect of 2-storey building located in the windward, in the North, South and East corridor.

c. Building Group C (Kluster/Cluster)
In North and South corridor the highest wind speed of 3.77 m/sec was occurred, due to the venturi effect, while the wind comes from the East. High wind speeds was occurred in South corridor with the same magnitude, due to the influence of the corridor distance of 3 m and the gap gradually narrowed in a way (Fig. 10).
When the wind comes from the North, the highest wind speed of 1.35 m/sec also occurred in the corridor, when the winds meet 2-storey building, located in the windward area. The same wind speeds occur in North corridor, resulting distribution of the wind flow into the gap. The wind speed 0.5 m/sec occurs when there are groups of buildings overlooking open space and located in the windward.

V. CONCLUSION

Cumpat fishing settlements and Greges Barat have the same character building groups, namely A (Bercelah/Slotted), B (Menempel/Attached) and C (Kluster/Cluster). Although have the same the characters, but each building group has a different design parameters. This conditions affect in differences ventilation performance characteristics.

The simulation results of ventilation performance due to the influence of design parameters, on buildings group of Cumpat indicate that the wind speed has a high value at a height of 2-storey building located in the windward, during a venturi effect, and the geometry of buildings that create an open space and located on the windward. But there is also the geometry of buildings that create open spaces, but lack influence sufficient ventilation performance. This condition due to the existing open space has a distance less than 6H thus still affected by the wind shadow of the building. This is consistent with the theory presented by Boutet (1987), that required a minimum distance of six times the height of buildings, in order to achieve an appropriate distance so that a good natural ventilation achieved on a layout. This condition also occurs in the corridor of each group of buildings on Greges Barat.

Wind speed could come into the corridor when a group of buildings has a corridor distance of 3 m and the distance is shrinking gradually narrowed in a way. Condition occurs in the building group C (cluster) on Greges Barat when it was given the influence of wind coming from the East.

VI. REFERENCE

Books:

Papers Presented at Conferences (Unpublished):

Papers from Conference Proceedings (Published):
VII. BIOGRAPHIES

Krisna Dwi Handayani was born in Surabaya, on October 7, 1971. He graduated from the Institute Technologie of Adhi Tama Surabaya, and now studies at the Institute Technologie of Sepuluh Nopember Surabaya. Employment experience in the Design Consultant Engineering. And now as a lecturer at the University State of Surabaya.