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Resilient design and resilient city: toward a better living

THE EFFECT OF SPATIAL CONFIGURATION IN THE THERMAL AREA OF *FORT ORANJE* PUBLIC SPACE IN TERNATE CITY

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Abstract. Crowded city will be impact to the temperature of urban areas. This condition is commonly known as the urban heat island effect. It's impact to the activity that happened in the urban space. Recently, Fort Oranje (urban space/square) that has history value has been revitalized as an urban public space that is crowd visited by Ternate's people. Therefore, the thermal comfort becomes an important thing and that is available to the users. The research is aim to know the influence of space configuration change to the aspect of thermal comfort in the urban public space. The method that is used in this research is empirical measurement and simulation method using Envi-MET software. This method is used to simulate the condition of thermal area in Fort Oranje. The result of this research showed that space configuration that change before and after the development of Ternate waterfront city impact to the thermal conditions in Fort Oranje public space.

Keywords: thermal comfort, space configuration, urban public space, Envi-MET.

Introduction

Fort Oranje area is a trace of Dutch colonial legacy in Ternate. Now, Fort Oranje has been revitalized into an urban public space. Historically, Fort Oranje played an important role as the administrative capital of the Dutch during colonial times. The conservation of historical urban centres is an important resource for promoting the viability and sustainable development of the city in the context of global climate change (Algeciras *et al.* 2016).

Fort Oranje public space is located in Gamalama district which is the center of business district (CBD) in Ternate city and also belongs to Kota Tua (Old Town). Geographically, Fort Oranje area, initially and directly adjacent to the beach but the reclamation of the beach and the increase in density of buildings in the Gamalama district causing this area is no longer on the beach. These conditions affect the movement of the wind to the Fort Oranje, the movement of wind to the area is obstructed by the buildings that continue to grow around it. The development of space configuration in the area, the lack of vegetation and the wide pavement area also affect the thermal quality of the area. The thermal comfort of the outdoor area arises from the effect of building mass configuration on the temperature in an area (Lippsmeier 1994).

Urban micro climate undergoes specific changes such as wind speed that is getting slower or storage of solar radiation by the construction materials used (Sini *et al.* 1996). To control the rate of temperature increase, one should pay attention to the duration of daylight, the intensity of solar radiation, and the angle of solar rays (Satwiko 2004). In addition, air movement is also very helpful in controlling the existing temperature. This is a set of parameter, mainly due to the interaction of buildings and environment (Younsi, Kharrat 2016). By taking into account these parameters, thermal comfort condition in the urban public spaces can be created.

Today, urban innovations develop the concept of green architecture as a form of response to urban thermal comfort. Monitoring thermal comfort area is one of the indicators for the identification of environmental conditions in an area (Kusumawanto 2005). To create thermal comfort in an area, a specific engineering/treatment on the microclimate is required. There are three elements of the city that dominantly affect the micro thermal namely building, pavement area (conblock or asphalt) and green area (Wong 2009). This study aims to monitoring the thermal comfort of public space by analyzing changes in space configuration that affects it.

Methods

The research location was in Fort Oranje area in Gamalama District, Central Ternate Subdistrict with physical boundaries of the area, among others Jl. Kesatrian (North), Jl. Merdeka and Fort Oranje (West), Jl. Ketilang (South) and Jl. Pahlawan Revolusi (East).

The method used in this research was experimental method with simulation using computer application and field measurement. There are two simulation processes: *first*, empirical measurement to show thermal condition. The thermal analysis results conducted using data measured in locations by measuring instruments such as thermometer, hygrometer and anemometer; and *second*, a simulation using Envi-MET system software to determine the effects of the existing spatial structure on the thermal condition.

Discussion

Analysis process of Fort Oranje thermal comfort configuration had been conducted through four stages. *First,* dividing the Fort Oranje area into 9 (nine) blocks based on the spatial configuration (variable) (see Fig. 1); *Second,* analyzing the thermal comfort conditions in each part using a model of microclimate simulation with climate data measurement results. Measurement data from each part was taken at 3 different times i.e. morning, noon and afternoon; *Three,* determining the point that was considered as the most uncomfortable to be used as research model sample to get a spatial order affecting the thermal comfort variable; and *finally,* analyzing the existing model several years earlier in the Fort Oranje area before the development.

Temperature and humadity analyze of the existing Fort Oranje area

Empirical measurment

Here are the results based on the measurement (at a predetermined point) of the heat distribution in the Fort Oranje area. In the morning (07.30–10.00) the lowest temperature is 30.4 °C (block 2) and the highest is 33.5 °C, at noon (11.00–14.00) the lowest temperature is 31.8 °C (block 3) and the highest is 36.4 °C (block 6), while in the afternoon the lowest temperature is 30.6 °C (block 3) and the highest is 33.8 °C (block 5). The data shows that in a condition of high

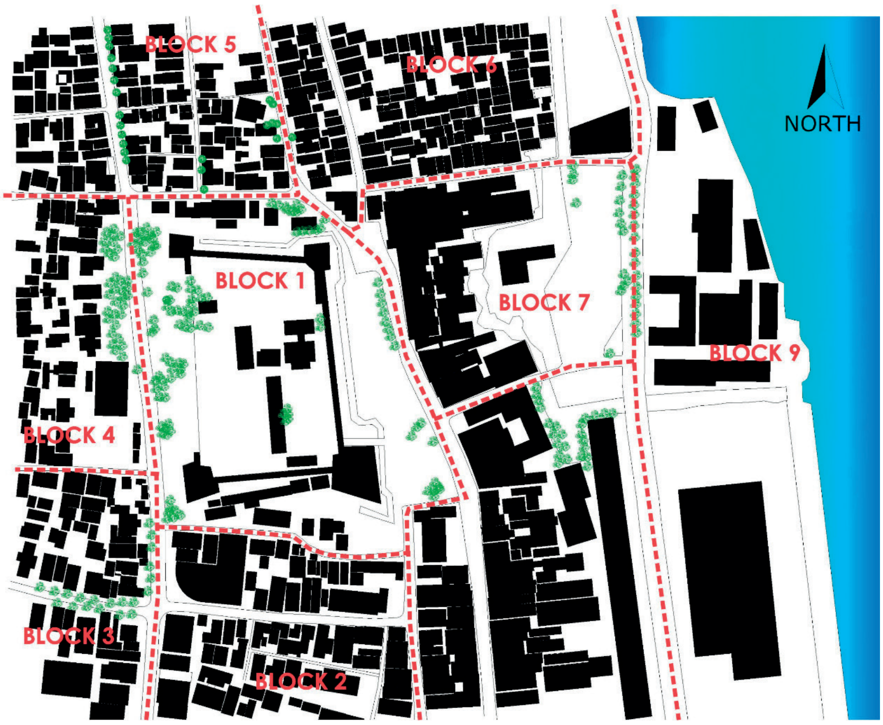

Fig. 1. Measurement Block in Fort Oranje Area

temperature, the humidity is low and during the low temperature, the humidity is high (see Figs 2–4). It is affected by the existing areas that are dominated by pavement material, building height and not vegetation. The pavement material is very good at increasing and reflecting the heat from direct sunlight, the building height blocks the movement of wind and not vegetation can block the direct rays from the sun to the surface of those materials. The presence of vegetations can also reduce heat and maintain moisture in the urban spaces.

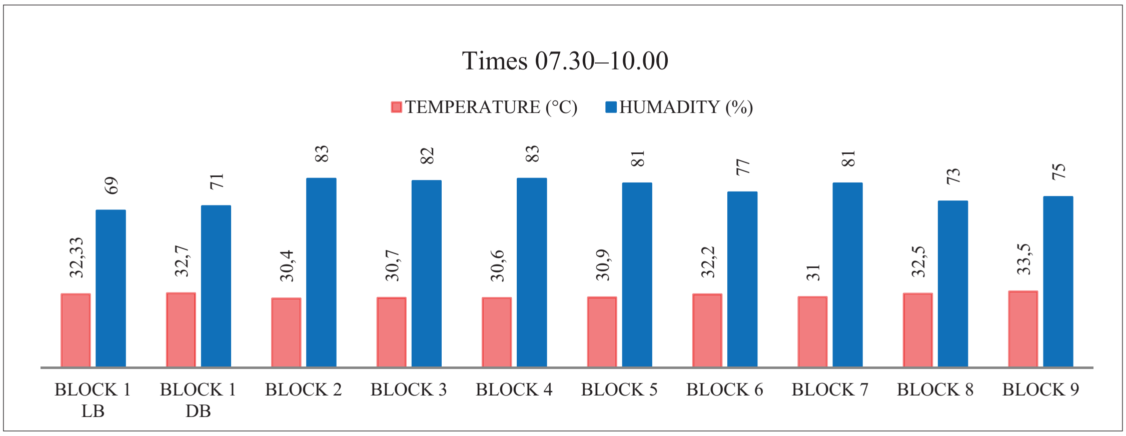

Fig. 2. Temperature and humidity graph at 7.30–10.00

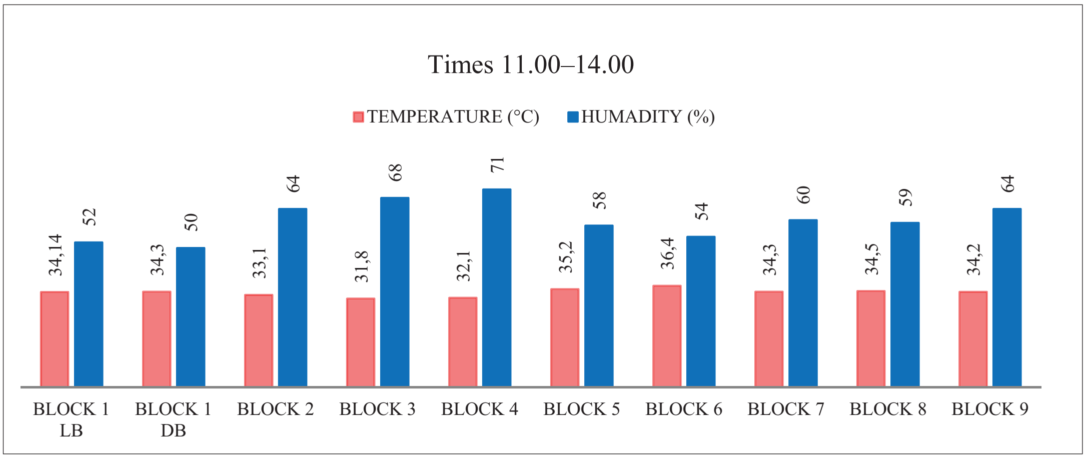

Fig. 3. Temperature and humidity graph at 11.00–14.00

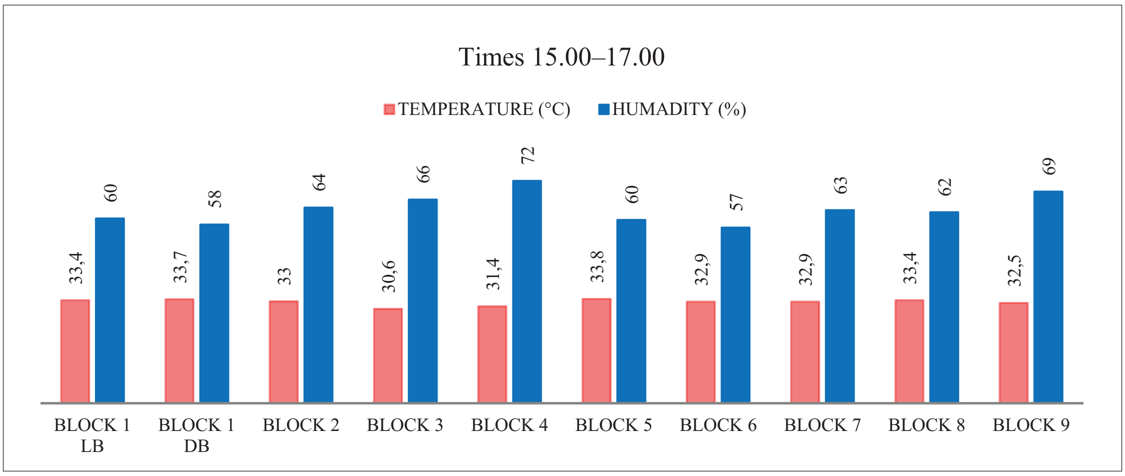

Fig. 4. Temperature and humidity graph at 15.00–17.00

Temperature and humadity simulation of the existing Fort Oranje area

To see the overall temperature and humidity condition of the area, a simulation using Envi-MET was performed (see Fig. 5).

Based on the simulation results above, blocks with low temperature have high air humidity at the same time. In blocks with solid building mass structures (blocks 2, 5 and 6), they show high temperature and low humidity. Conversely, in blocks with non-solid building mass structures (blocks 1 and 9), they show low temperature and high humidity. In addition, as well as the humidity, the air temperature increases during the day and drops in the afternoon.

Using the same treatment simulated by the existing condition, a simulation of Fort Oranje area was conducted in 2001 (see Fig. 6) when the coastal reclamation had not been conducted yet.

The simulation results above show the same condition as the existing condition. The blocks with high building density have high temperature and low humidity. If compared to the existing condition (Fig. 5) at the same time (at 13.00), it is seen that the area around Fort Oranje before the reclamation is hotter. This condition is affected by the existence of a fort that is closed to the sea so that the heat of the sea water surface is carried by the wind as seen in the field observation or measurement.

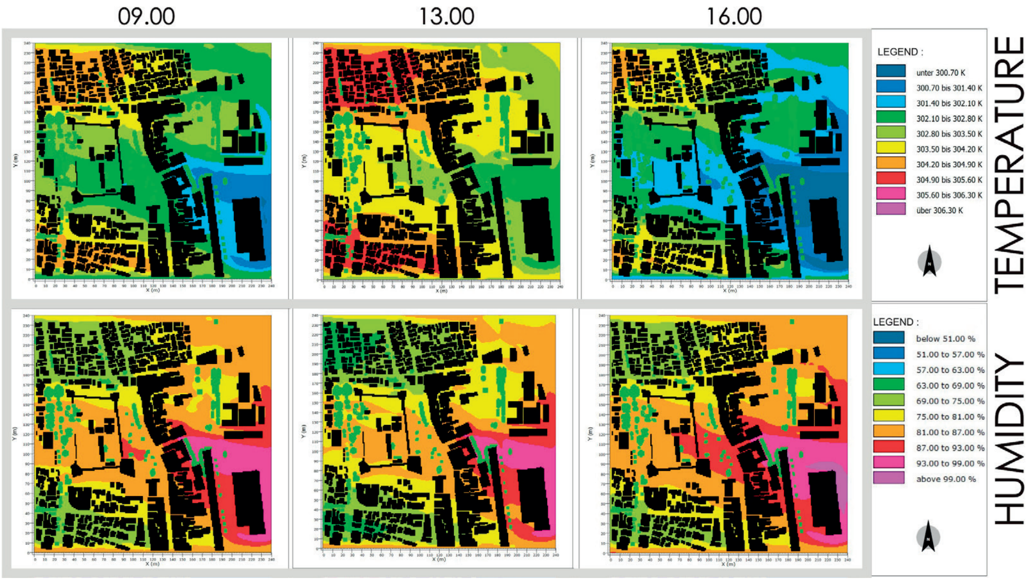

Fig. 5. Temperature and Humidity Simulation Result of the Fort Oranje Area

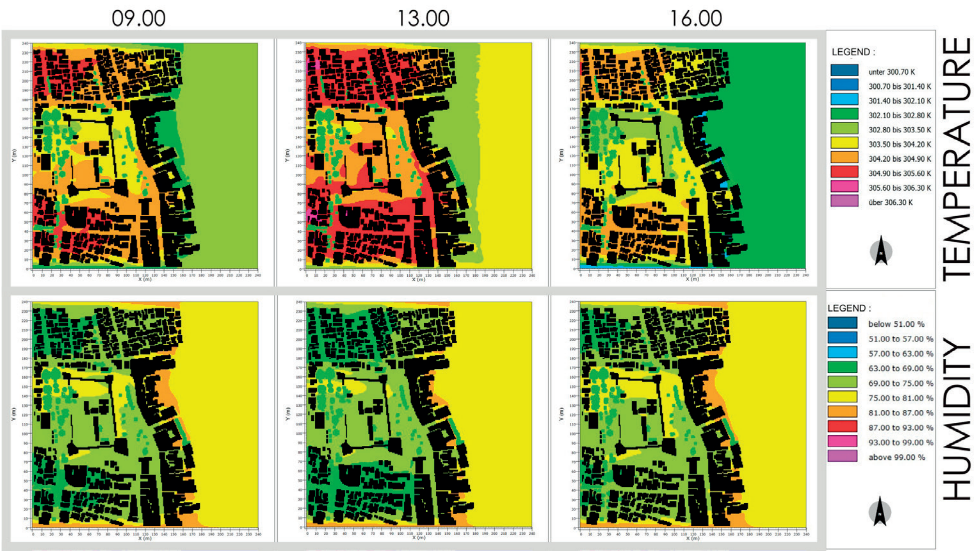

Fig. 6. Simulation Result of the Fort Oranje Area in 2001

Air movement analysis of the Fort Oranje area

Empirical measurement

The wind movement on the blocks increased in the afternoon. Considering to the above data, at 15.00–17.00, the average wind speed is quite high. It is in line with the decrease in room temperature and air humidity that rises. Based on the observations at the field during the day, wind speed does not significantly affect the temperature drops. Otherwise, there is an increase in temperature as wind speed increases. It occurs due to the wind blows bringing the heat from the places they passed through (Fig. 7).

Air movement simulation of existing Fort Oranje area

Based on the simulation results, the condition of the air movement at all three times did not have many differences. However, if we observed, it appeared that the wind that hits the building, the speed and pattern of the movement might decrease. Then, on the other part, it was precisely accelerated, blocked, diverted and reduced. This condition can be seen in the picture below (see Fig. 8).

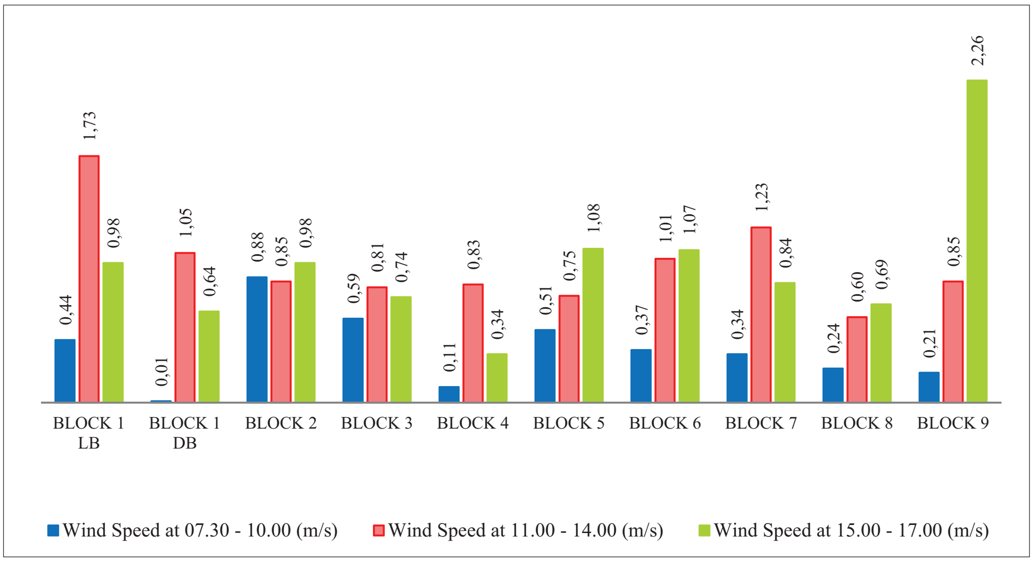

Fig. 7. Wind speed graph of The Fort Oranje area at 07.30–17.00

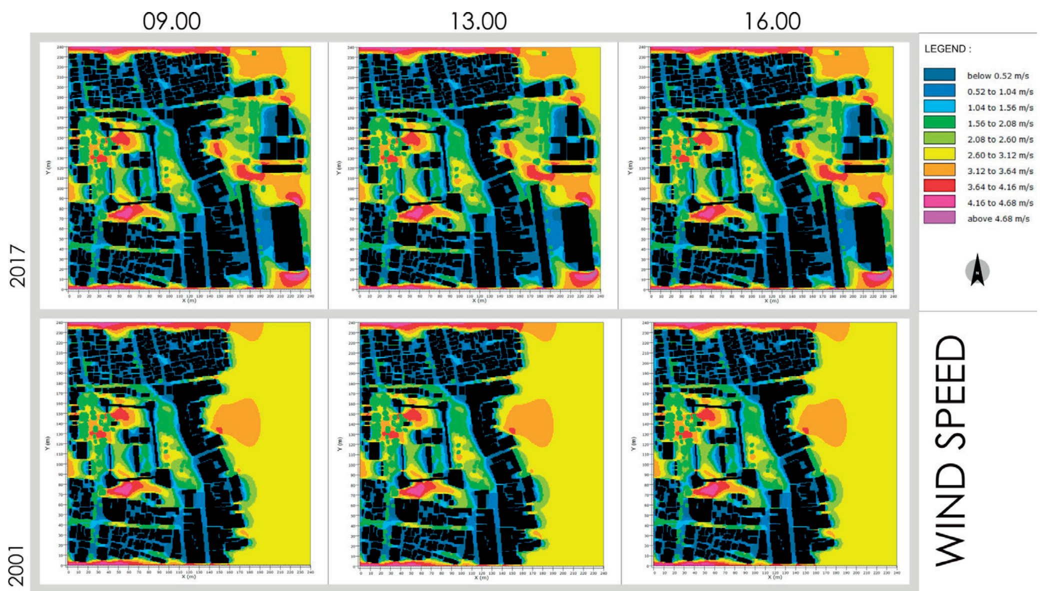

Fig. 8. Simulation result of The Fort Oranje Areain 2001 and existing area in 2017

In addition, the existence of buildings that blocks the wind movement also affects its next movement because the speed is reduced.

Such wind patterns that blow to the Fort Oranje area become lower, because they are diverted before it reaches the public space. In the morning to late afternoon, the maximum temperature in the Fort Oranje area ranges between 33.5–36.8 °C, and the minimum humidity that up to 50% creates an uncomfortable public space. Therefore, the thermal condition of the public space needs to be re-arranged so the comfortable thermal condition can be fulfilled (Figs 9–10).

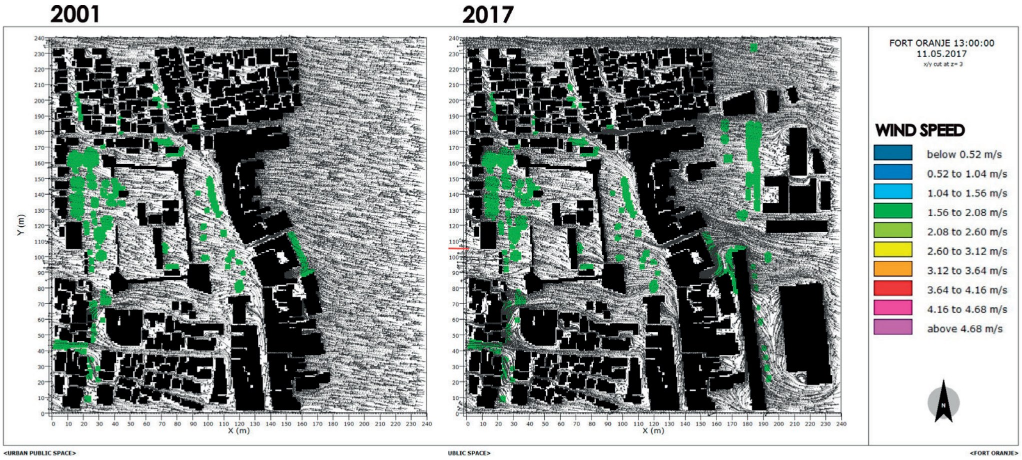

Fig. 9. Air movement of the Fort Oranje area

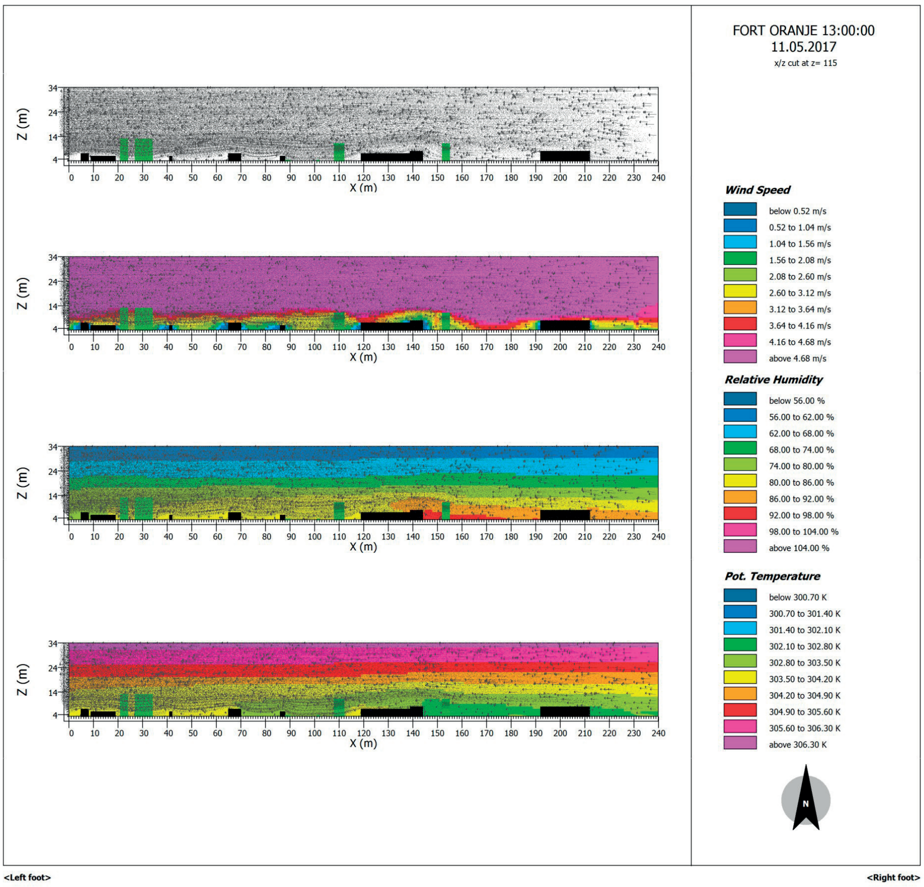

Fig. 10. Cut of existing the Fort Oranje area

Conclusions

The spatial configuration affects the comfortable thermal condition of the Fort Oranje area where the distance among buildings reduces the wind speed, increases the temperature and causes low humidity. Excellent materials in increasing and reflecting heat from direct sunlight and the high buildings that block the wind movement dominate the condition of the surface area. The presence of vegetation can block direct light from the sun to the surface of these materials. It can also reduce the heat and maintain the moisture of the urban spaces.

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