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THE STUDY OF THE COURTYARD EFFECTIVENESS AS SOLUTION FOR THE HOUSE DESIGN TRANSFORMATION PROBLEM ON NATURAL VENTILATION

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ABSTRACT

This article is based on a community service program. The program was planned to assist the public housing owner in developing their house to meet the spatial requirement. The assistance is started with interview with the occupant as preliminary spatial assessment. From the interview, it is found that after five years occupying, most of the program target have already transformed their unit and begun to deal with thermal comfort problem. The assistance recommends the courtyard as the solution to solve the problem. This paper is aimed to explain the courtyard efectiveness in solving design transformation problem on natural ventilation. The research was conducted with Ansys simulation. The simulation compares the initial desain and the proposed one with the courtyard as the additional room program. It focuses on temperature distribution, wind velocity and air circulation. Based on the simulation, the courtyard is proven to create better indoor air quality through lower temperature, faster wind velocity, and better air circulation. Therefore, courtyard can be recommended to add on house design transformation.

Keywords: Design assistance; Public Housing; Simulation research; Thermal comfort

1. INTRODUCTION

This article is based on a research integrated to a community service program. The program was in the form of assistance to the owners of the Rumah Inti Tumbuh (RIT) in transforming the design of their units. As preliminary step, the team conducted interviews to collect data for spatial need assessment. Most of the owners were aware of the limitation of the spatial requirement (Aryani, Mulyadi & Wahyuningsih, 2014).The team also observed the units to assess their quality on health, comfort, and safety aspects. Similar to the previous research (Sasongko et.al., 2015), it was found that most of the development had a tendency to optimize the back site of the house (Aryani, Mulyadi & Wahyuningsih, 2014); applying the method assumed to be practical, i.e. by constructing roofs to the entire un-built back site. This back yard exploitation then blocked the ventilation circulation that led to discomfort and humid indoor air quality as there was no exchange of air.

The interview has listed some complaints from the respondents related to their units;66,7% respondents complained about the mildewed wall, 83,3% respondents complained about the lack of fulfillment of spatial requirement, 16,7% respondents

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dissatisfied on the spatial width and 16,7% respondentfelt that the ventilation did not work properly that leads to hot indoor air temperature (Sasongko et.al, 2015). Those complaints support the statement of Kellet (1993) and Tipple (1992) on Sueca (2004) about the negative impacts of the house transformation. It is stated that the design transformation may cause bigger utility load, less natural lighting and ventilation, as well as inefficient usage of the natural resources. Based on the result, the proposed recommendation was to add a courtyard. The courtyard hopely can enhance air circulation and give access for the flow of rain water to the ground. This paper is aimed at explaining the effectiveness of a courtyard in solving those complaints.
The benefit of a courtyard in improving indoor air thermal has been stated by Dili, Naseer& Varghese (2010), Salama (2006), Myneni (2013), Zakaria& Ismail (nd), Asfour (2008), Binthabet (2007); Vakharia (2012), Masri (2010) and Sadafi et al (2011). Its effectiveness as micro climate regulator (Philokyprou& Michael, 2012; Heidari, 2010) is not very much influenced by wind direction (Yasa&Ik, 2014). However, the importance of the right dimension (the comparation between height and width) and its appropriate placement towards wind and sunlight composition has been discussed by Shi (2013); Zamani, Talegahni & Hoseini (2012); Xie, Zhang &Xu (2006); Tablada et al (nd); Das (2001) and Heidari (2010). Such consideration might come from the high land value (Ali, 2007) and the fact that wide courtyard does not guarantee the optimum result (Bensalem,1991). Therefore, it is necessary to find the smallest dimension of courtyard with the most optimum performance.

2. EXPERIMENTAL METHOD

2.1. Simulation Modelling

The indoor air temperature and wind velocity simulation was conducted with Ansyscfx 12.1 software. The chosen unit was simulated on the initial and re-designed condition. The purpose of the simulation was to predict the thermal distribution and the wind velocity inside the room which was theimportant factor for creating thermal comfort with variety cooling load in the afternoon. It also gave overview concerning air conditioning resulted in CFD (Computational Fluid Dynamics) simulation, such as the pattern of temperature distribution flow and air velocity, so that it could be used in design improvement consideration.
The numerical modelling took the mass balance equation, momentum (Navier – Stokes) and energy transfer into account. The air was presented in differential equation as Newtonian fluid on Cartesian coordinates and solved with Computational Fluid Dynamic (CFD) based software, i.e.three-dimensional Ansyscfx 12.1., which was based on numerical analysis using volume finite method. The CFD based analysis required basic knowledge and understanding about fluid mechanics to interpret the results of the simulation. There were three steps of simulation process, which were:
Pre-processing
In this stage, preliminary definition was conducted by computer. It consisted of geometrical specification, mesh optimization, the type of analysis, the fluid property that will be analysed, boundary condition, model turbulence selection and domain making.
Solver
In this step, the computer conducted some calculations to finish the defined project goals.
Post Processing

The post processing step resulted in some results from the solver process. The various visualization and treatment data were then re-selected as needed.

2.2. Boundary Condition

The room wall was assumed as adiabatic. The indoor fluid velocity was zero. The fluid temperature before air entering the room was 34°C (assumed to be taken in the afternoon).The observed indoor air system was the room volume of the chosen initial design.The observed parameter was the temperature and the wind velocity. The wind velocity entering the room through side opening was assumed to be equal to 0,9 m/s in 26^{o}C.The wind velocity entering the room through lower opening was assumed to be equal to 0,25 m/s with the temperature of 26^{o}C;circulate vertically.The wind velocity entering the room through rooster (higher opening) was assumed to be equal to 0,95 m/s with the temperature of 26^{o} C. The air moved out through back room rooster.

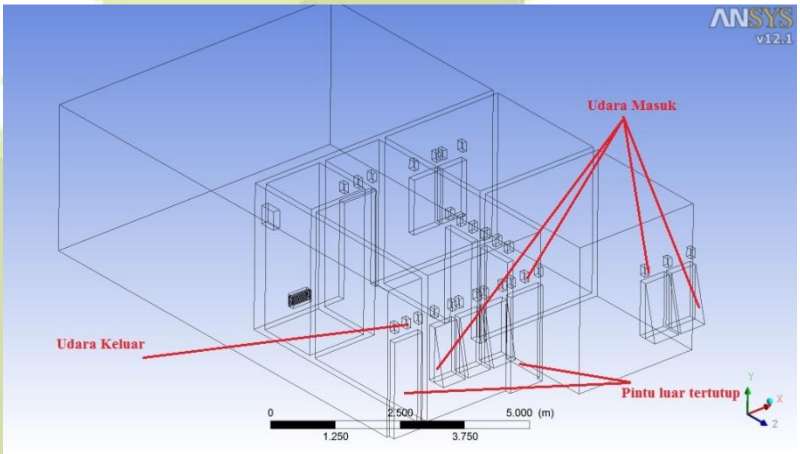

Figure 1 Boundary condition

There were four positions of diffuser that will be compared for the effectiveness of temperature distribution. The diffusers were the ventilation and the rooster for the air to enter and then exit the room through the back room rooster. In the simulation, the diffusers distribute the ambient air with the temperature of 26^{o}C to the room under the influence of speed and gravity.

The parameter of fluid properties influencing the room condition was generally applying the parameter default of CFD software, such as the density of 1,185 kg/m3 and the fluid viscosity of 0,831 kg/m.s, which is in this sense, is the air. For calculating the effectiveness, the contour area was chosen as the receiving subject for decreasing temperature which were represented as the vertical and horizontal parallel of two-dimensional shapes.

2.2. Purposed Condition

The initial temperature before the fluid entering the room was assumed to be 34 ^{o} C in the afternoon condition. The fluid velocity entering the room was assumed to be 0,9 m/passing every window with the temperature of 26^{0}C. The fluid velocity entering the guest room, through the front window from left and right opening, were 0.7m/s,0.8m/s and 0.9 m/s with the temperature of 26^{0}C. The fluid velocity entering the room was assumed to be 0,95 m/s through every rooster with the temperature of 26^{0}C. The different point of the purposed condition with the boundary one was the existence of courtyard that played the role as exhaust for ventilation.

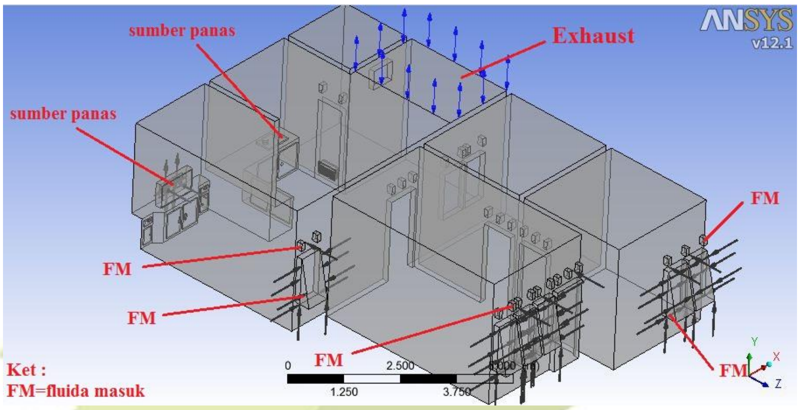

Figure 2 Proposed design condition

3. RESULTS

3.1. Temperature Distribution

The result of the simulation is reported as in the following description. Taken on the 60 second simulation and the height of 135 cm, the temperature distribution of the initial design is displayed in Figure 3. It shows that the indoor temperature is relatively hot, especially in the back part of the house. Only some areas near the windows have the same temperature with the entering wind.

Similar pre-condition for simulation is applied to the design that was improved with a courtyard. With a courtyard, the temperature inside the house is relatively cooler than the one in the initial design. It can be seen from the absence of red color that represents hotter temperature. Similar degree of temperature with the entering wind occurs only around the windows. However, in this design, even if the temperature becomes warmer than the entering wind, the entire unit has relative steady temperature.

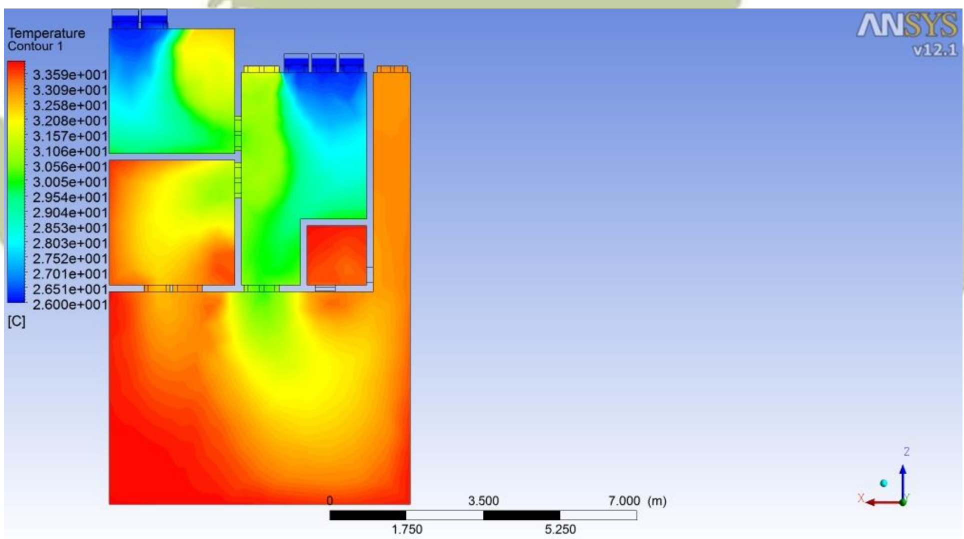

Figure 3 Temperature distribution of the initial design

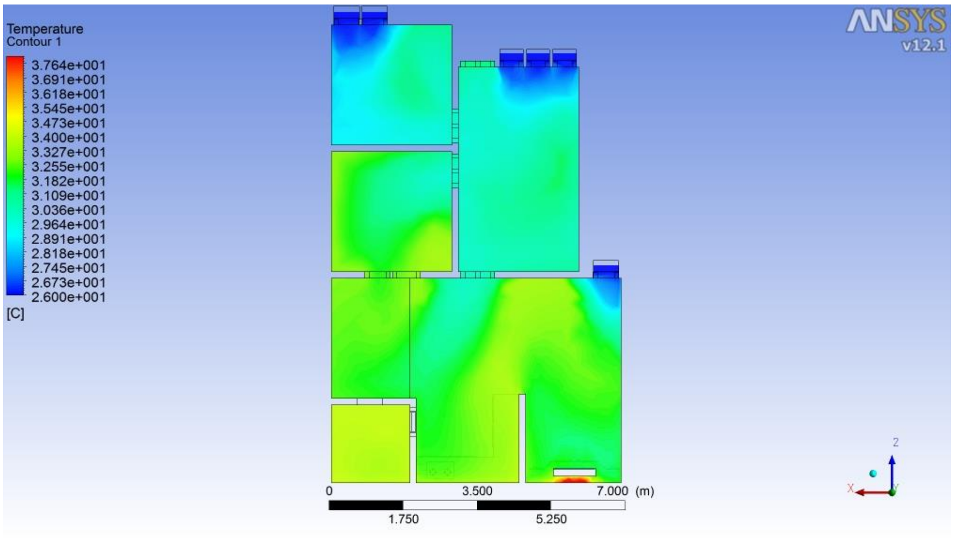

Figure 4Temperature distribution of the proposed design

3.2. Wind Velocity

The simulation result on wind velocity is reported as in the following description. In the initial design, there are spots where the wind has significant velocity around the window. The velocity decreases when reaching the back space. In the improved design with courtyard, it can be seen that it has an increase of the wind velocity. It is shown through the more area that have blue light, including the second bedroom. Moreover, the yellow color is shown on the middle area with bigger spot. Even on the back area, it has slight green color that represent faster wind velocity. However, the wind velocity of the bathroom area can be considered as the same as the initial design.

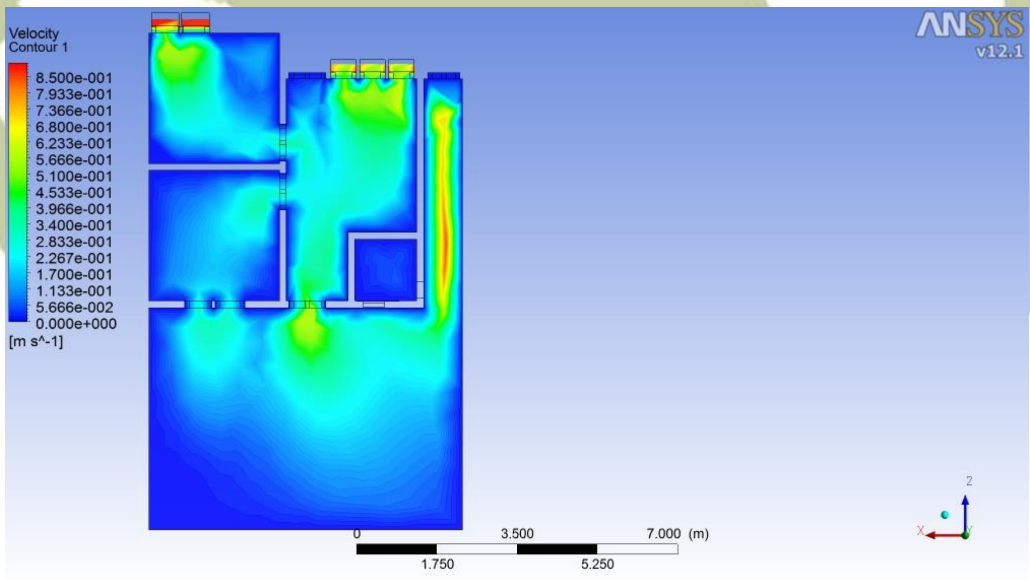

Figure 5 Wind velocity of the initial design

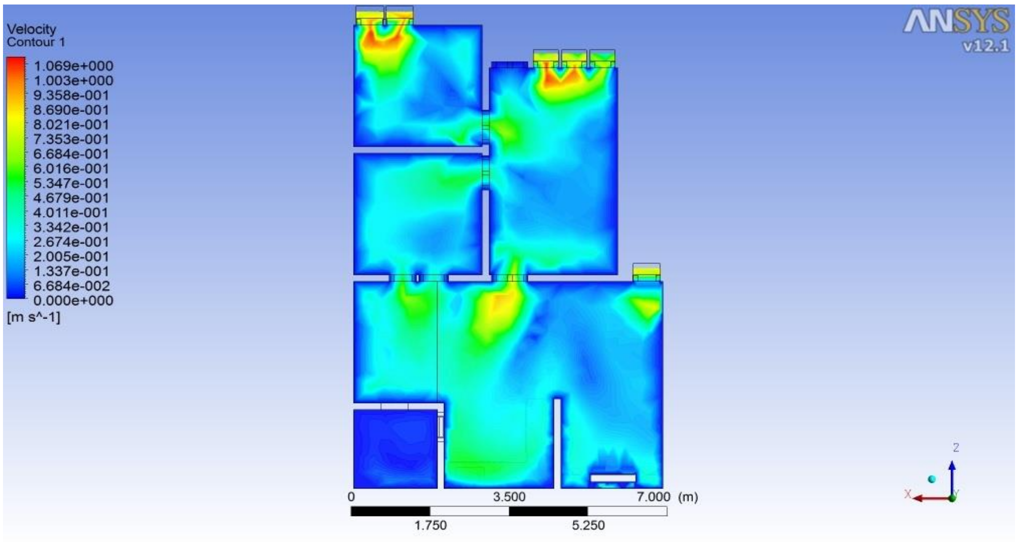

Figure 6 Wind velocity of the proposed design

3.3. Wind Movement

The simulation result of wind movement inside the house is explained in the following description. In the initial design, the wind moves in slower velocity that is shown by more blue lines colour that represent lower speed. In the improved design, the simulation result shows relatively faster and more flowing wind movement as there is an exit access for warmer wind.

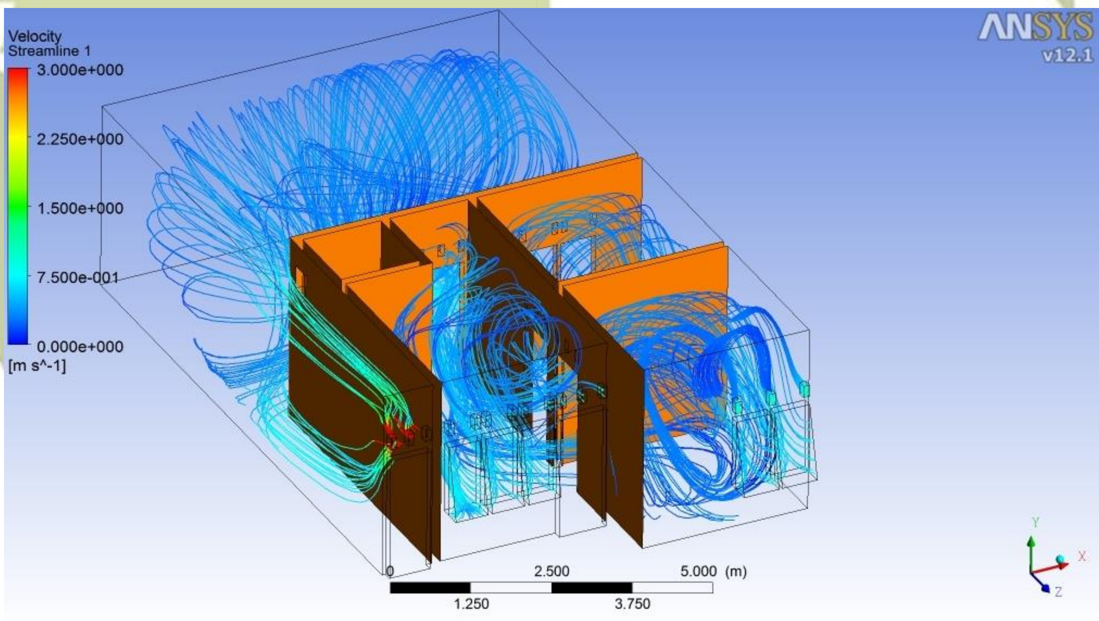

Figure 7 The simulation result of wind movement of the initial design

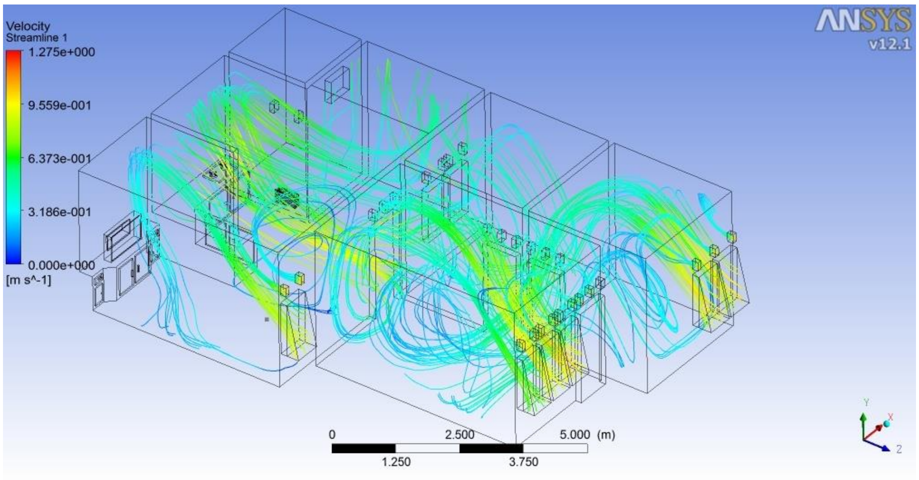

Figure 8 The simulation result of the wind movement of the proposed design

4. CONCLUSION

Based on the result and discussion, it can be concluded that in this simulation, the courtyard is proven to be giving contribution in creating required thermal comfort. It is presented through lower indoor temperature, faster wind velocity and relatively good air circulation. Therefore, it can be proposed as room program addition in every design transformation. However, for providing detail about the most efficient courtyard, further researches are required to figure out the appropriate size and its relation to wind direction.

5. ACKNOWLEDGEMENT

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