Classroom Ventilation Design Strategy to Achieve Thermal Comfort
A Study on Student Access Center Building

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Abstract: Self Access Center (SAC) is one of the buildings that has several classrooms in State Islamic University of Sunan Ampel. Learning process needs comfortable classroom. Providing comfort indoor environment is one of the steps to reach it. From the existing classroom temperature (28.6°C-31°C), it cannot be classified as a comfortable indoor temperature. Therefore, to overcome this, providing a classroom ventilation design strategy is the solution. The strategy can be in the form of: 1) increasing the number of active ventilation; 2) providing inlets and outlets in each room; 3) reducing the effect of solar heat by giving secondary skin and shading device. By applying these three steps and analyzing through Ecotect program, the room temperature can be lowered by 2°C.

1 INTRODUCTION

Designing a building should be responsive to the climate because it will reduce adverse effects on the environment and increase user comfort. Nugroho (2007) has said that to create comfortable indoor environment, one must pay attention to the user needs. One of them is through the speed of natural air flow in the building that meets the required standards of thermal comfort. That is also what is needed in the classroom.

Kindangen (2005) also wrote that window with ventilation is only one part of an air control system that is used to flow to and cool the room; especially to achieve thermal comfort. To make natural air flow inside a room, it is needed to have inlet and outlet. Different dimensions of inlet and outlet will increase the air flow. According to Dora (2011), increasing the opening dimension will automatically enlarge the entry area of light and natural air exchange. The ventilation opening dimension ideally reaches 40-80% of the total wall area or 10-20% of the whole floor area.

Window type and position must be in consideration. According to Becket (1974), there are several ventilation window types that influence the natural air flow to the room. (Figure 1).

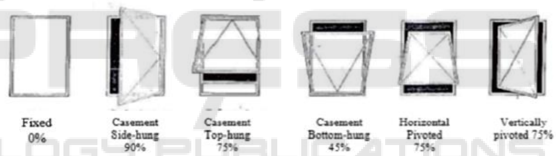

Figure 1: Ventilation type

Making a room modelling design with several window opening types needs to be done to optimize the thermal specific conditions of the environment, and to achieve thermal comfort.

2 METHOD

This research uses 2 (two) methods that are qualitative descriptive and simulation method. Qualitative descriptive method is used to find the right design recommendations, based on the description and theoretical studies that have been done previously. This method aims to find the best ventilation design strategy, based on existing conditions. Meanwhile, the simulation method serves to test the effectiveness and efficiency of the design results in the existing conditions. Simulation will be carried out with Ecotect program.

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3 DISCUSSION

3.1 General Description of Self Access Center (SAC)

Self Access Center (SAC) is one of the campus facilities in State Islamic University of Sunan Ampel Surabaya which serves the academic community in the field of language and culture. This SAC building is on the north side of the collage site and faces the south. This is shown in Figure 2 below. This building consists of 3 (three) floors. The first floor functions as a management office, while the second floor functions as classrooms, and the third floor functions as a multipurpose room.

The windows in the SAC's classrooms extend along the height of the floor, so the classrooms on the 2nd floor will tend to be hot. Moreover, there is not enough shade around it, especially in the south and west area. It is contrast with the east area, which is quite sheltered by the building next to it.

Figure 2: The position of SAC Building

SAC has 5 (five) classrooms namely SAC 201, 202, 203, 204 and 205. The illustration is in Figure 3.

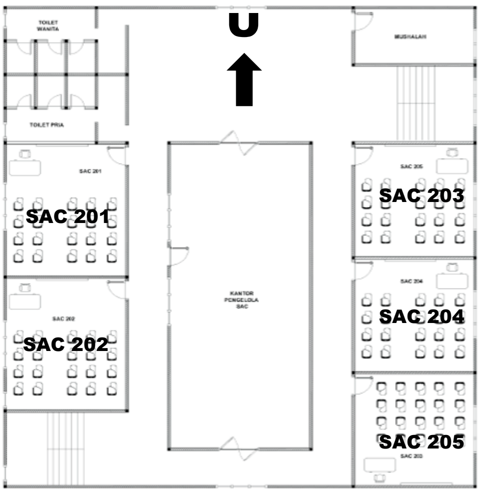


Figure 3: Five classroom in SAC Building

3.2 Existing Condition of Classroom at Self Access Center (SAC)

The five classes in SAC then were grouped into 2 (two) kinds of classes based on the size and position of the room. The groups were: 1) Group Class 1: SAC 201 and 202; and 2) Group Class 2: SAC 203, 204 and 205. However, the capacity is also the same, for 20 students.

3.2.1 Group Class 1 : SAC 201 and 202

This group of classrooms has 42m² area (6mx7m). These rooms are on the west side of the building. Figure 4 describes the SAC 201 classroom existing condition.

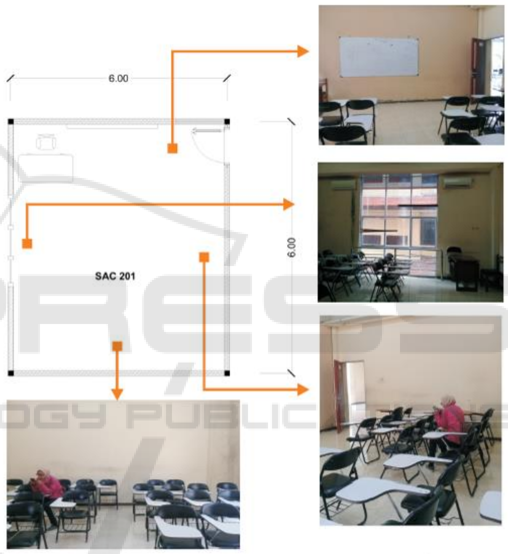
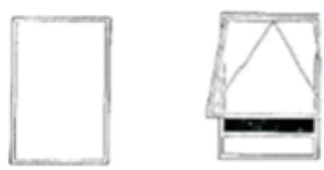


Figure 4: SAC 201 Classroom

The SAC 201 class only has 1 (one) compact ventilation on the west side, with 2 (two) types of ventilation at once, that are the fixed type (Figure 5a) and top hung casement type (Figure 5b). Beckett (1974) has said that fixed type ventilation cannot flow air while top hung casement type is active ventilation that can create air flow until 75%.



(a) (b)

Figure 5: (a) Fixed type and (b) Top hung casement type

The SAC 201 ventilation is shown in Figure 6 below. It can be seen that active ventilation in top hung casement type is very small because it is only 1.7m² (19%) of total ventilation of 8.925m².

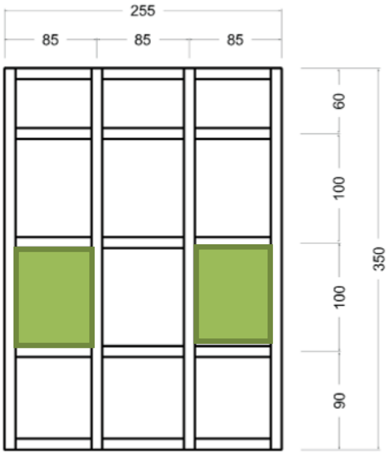


Figure 6: SAC 201 Ventilation

: Ventilation with top hung casement type

Whereas, according to Lechner (2014), ideally a room at least has 10% of the floor area.

Ideal Ventilation Size = 10% x 42 = 4.2m².
Ideal Number of Ventilation = 4,2 / (0.85x1) = 5

So, ideally SAC 201 classroom should have at least 5 (five) active ventilations with top hung casement type. Meanwhile, now there are only 2 ventilations of that kind. Now, the SAC 202 classroom existing condition is the described in Figure 7.

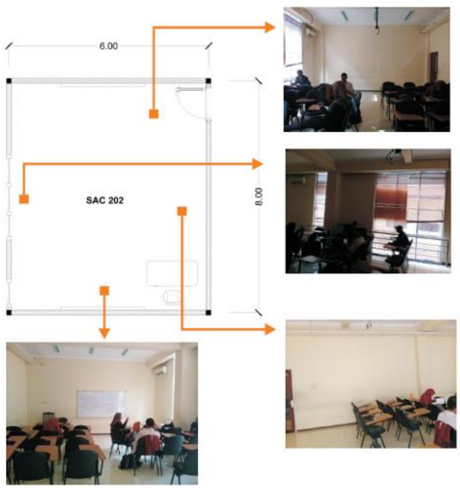
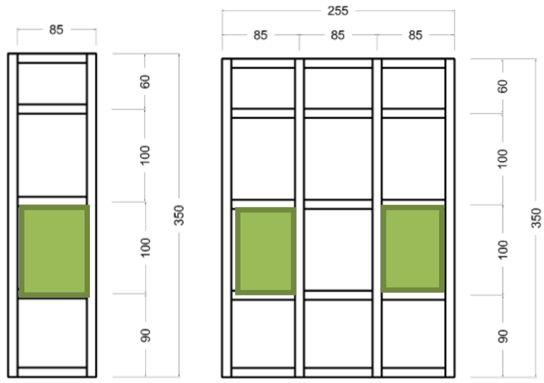


Figure 7: SAC 202 Classroom

Unlike SAC 201, SAC 202 classroom has 2 (two) separate ventilations on the west side. The shape and size detail of ventilation in the SAC 202 classroom are in Figure 8.



(Left) (Right)

Figure 8: SAC 202 Ventilation

: Ventilation with top hung casement type

The size and type of ventilation in the SAC 202 classroom are on the right side, the same as the one in the SAC 201 classromm. Meanwhile, the size and type of ventilation on the left side are 1/3 the size modulation of the large model ventilation, like in Figure 6.

So, if the number of ventilations in SAC 202 classroom is calculated according to the Lechner formula, while the size of SAC 201 classroom and SAC 202 classroom is the same, then ideally the SAC 202 classroom should have 5 (five) active ventilations too, with the same size as the existing active ventilation.

3.2.2 Group Class 2 : SAC 203, 204 and 205

SAC 203, 204 and 205 classrooms have a typical form, both in the room size, and the ventilation position and size. So, the explanation of this group class 2 will be represented by only one room, that is SAC 203 classroom.

This type of classrooms has 36m² area (6mx6m). These rooms are on the west side of the building, and there are 1 (one) compact ventilation on the west side, with 2 (two) types of ventilation at once, that are fixed type and top hung casement type, like shown in Figure 6. Figure 9 describes SAC 203 classroom existing condition.

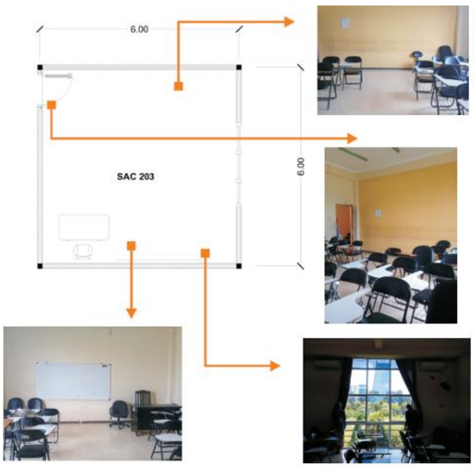


Figure 9: SAC 203 Classroom

3.2.3 Existing Classroom Temperature

Temperature of the five classrooms was measured regularly, as listed in Table 1 below:

Table 1: Temperature of Existing Classroom in SAC

Measurement time	Class	Temperature (°C)			
		M	N	AN	A
April 13th 2018	**201**	28,5	29,4	28,4	**28,7**
	202	28,5	29,4	29,4	**28,7**
	203	28,4	30,5	34,2	**31,0**
	204	28,4	30,5	34,2	**31,0**
	205	28,4	30,5	34,2	**31,0**
April 27th 2018	**201**	28,2	29,7	27,8	**28,6**
	202	28,2	29,7	27,8	**28,6**
	203	27,6	29,8	30,5	**29,0**
	204	27,6	29,8	30,5	**29,0**
	205	27,6	29,8	30,5	**29,0**

remarks:
M : Morning Temperature
N : Noon Temperature
AN : Afternoon Temperature
A : Average Temperature

From the table 1, it can be concluded that group class 1 has cooler temperature with 28.6°C-28.7°C than group class 2 with 29°C-31°C. This can happen because the group class 2 is on the east side of the building. Moreover, there is no building or vegetation that becomes shelter from the sun heat, so sunlight with high heat intensity directly penetrates classrooms. Based on SNI 03-6572-2001, the existing classroom temperature is not classified as comfortable indoor temperature, because maximum temperature for comfortable indoor is 27.1°C.

3.3 Classroom Ventilation Design Strategy

Because the ventilation in every SAC classroom has the same shape and size, as it is shown by Figure 6, so discussion about ventilation design strategies will be based on that one prototype only. Based on Lechner theory (2014) about the calculation of the ideal number of ventilation in one room, it is clear that the number of active ventilation that is available in SAC classrooms is less and needs to be added without changing the existing structure. Therefore, the number of active ventilation that is only two from the existing ventilations (Figure 5) will be added by four more sections with top hung casement type, as illustrated in Figure 10.

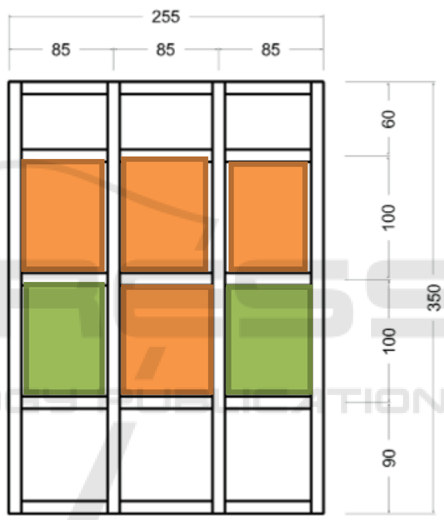


Figure 10: Addition of active ventilation in existing window

: Existing Ventilation
: Planned Ventilation

According to Mediastika (2004), creating natural air conditioning systems in tropical buildings is very dependent on ventilation as the air flow medium. Ventilation needs inlet and outlet to make air flow process. Whereas in the SAC classroom existing condition, there is only one ventilation hole at one side, so the concept of cross ventilation cannot run yet. Therefore, the second strategy that can be done to maximize air flow is by adding ventilation holes on the other side, in which one becomes inlet and the other becomes outlet. The illustration is in Figure 11 and 12.

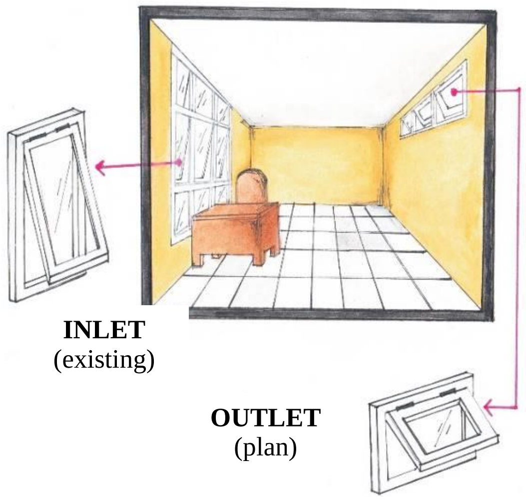


Figure 11: Adding ventilation on other side

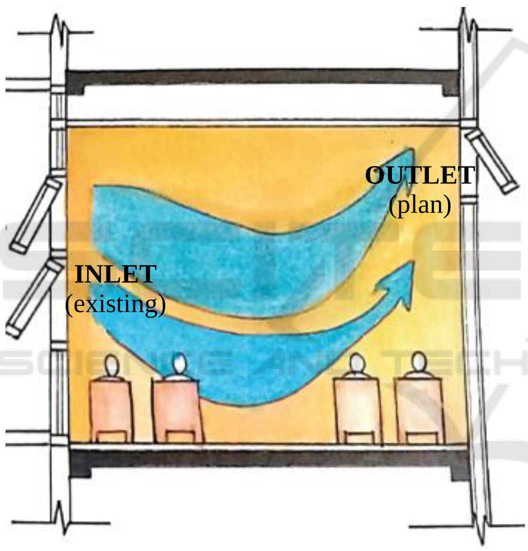


Figure 12: Natural air flow illustration in SAC classroom, after using cross ventilation

Seputra (2017) has said that to maximize cross ventilation, the placement of ventilation must be in consideration. Inlet must be placed at human height in sitting or standing positions which is 60cm-150cm, so the natural air flow can be felt. Besides that, outlet is placed in higher position, so hot air can be easily removed. Mediastika (2004) also said that the different dimension of inlet and outlet will increase the air speed. Based on this theory, the inlet and outlet should be placed like in Figure 12.

The third way of classroom ventilation design strategy to maximize natural air flow can be done by giving *jettying* and secondary skin around the inlet to avoid direct sun heat and to become a wind direction tool to the room. Vegetation is also added to make the room cooler. It is very suggested for group class 1 (SAC 201 and 202) to use shading device and secondary skin. The illustration is in Figure 13.

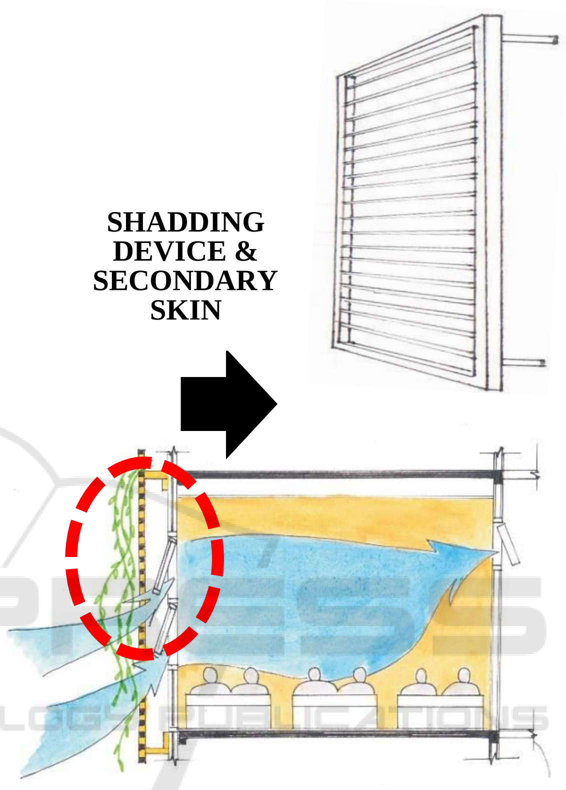


Figure 13: Shadding device and secondary skin in front of the inlet ventilation

According to Mediastika (2004), secondary skin with jalousie model can increase natural air flow by 75%.

3.4 Ecotect Simulation Analysis

The effect of ventilation design to temperature is very difficult to determine with a simple analysis approach. It is then necessary to conduct an investigation using computer simulations, by entering climate data and building elements into the program. Ecotect is a tool used to model the temperature of the room and the surrounding environment. The Ecotect validity is obtained from the comparison between the results of the field study and the results of the Ecotect simulation itself.

After cross ventilation system created by adding several active ventilations in inlet and outlet, and by adding secondary skin too, there are significant effect on the classroom temperature. The temperature decreased 2°C. The visualization is shown in Figure 14 and 15. A lot of blue colour interpreted that the room is in cool temperature. Otherwise, yellow colour means the hottest temperature.

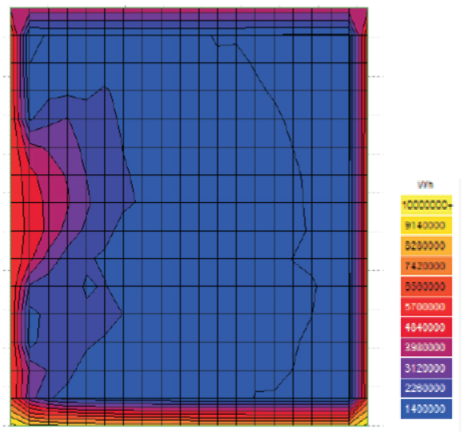


Figure 14: Simulation in group class 1

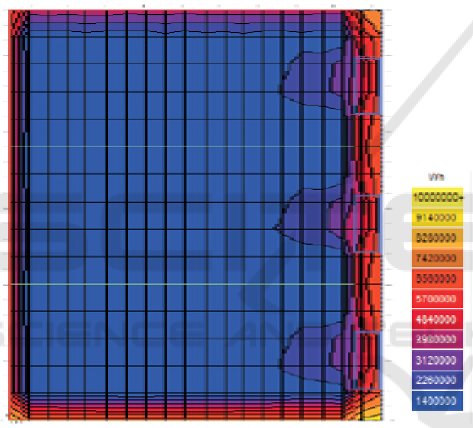


Figure 15: Simulation in group class 2

4 CONCLUSIONS

Comfortable indoor environment is one thing that supports human activity, which can be pursued through ventilation design. To make a good natural airflow in the room, cross ventilation is a must. It needs inlet and outlet. The choice of ventilation type will also determine the speed of airflow in the room. Ecotect program will help us to check the indoor temperature distribution, which is influenced by ventilation design and wind flow strength.

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