

Effect of Air Temperature and Air Velocity for Thermal Comfort within Study Club Room

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Abstract—In this research paper, we have thermal comfort as the main issue for this research. Jakarta as a capital city of Indonesia has many different types of building, ranging from low-rise with just few floors up to high-rise with hundreds of meters tall. Many of this buildings was designed and built with a main focus towards general aesthetic and appearance instead of good design that considered local climate. This design decision results in some kind situation where user's comfort are not considered as a priority and in the end to achieve thermal comfort the building needs much more energy than otherwise needed. This research is done to find out the effect of climate and air temperature towards high-rise thermal comfort in Jakarta. This research uses study club room at Tarumanagara University campus I as a sample. The room itself is located at Communication Faculty building, Tarumanagara University, Jakarta, which uses glass as the main material of building envelope. This research is done with quantitative approach and experimental methods.

Keywords: thermal comfort, wind seep, temperature, humidity, high rise building

I. INTRODUCTION

Indonesia is a developing nation with a relatively dense population, particularly around the nation's capital of Jakarta. Each year the city's growing in many aspects, including the amount of building that are being built each year. All those building have their own function and according to architectural rules, all of these buildings must be able to achieve many aspects of design, one of those aspect is thermal comfort. Thermal comfort is an important aspect to achieve particularly in a glass dominated building because of solar heat gain. As a result of this, most building decides to use air conditioning as a way to cool the room.

In practice, most glass building with air conditioned room tends to not achieve thermal comfort either, because what happens is the temperature becomes too low and a pretty high wind velocity which is then perceived by the users as too cold, therefore not comfortable, particularly over longer period of time. One of the example can be found at study club room at Campus I Main Building, Tarumanagara University. The purpose of this research is to figure out whether this room can achieve conditions within thermal comfort standard and

also the finding the correct value of air temperature and air velocity for this particular room (figure 1).

II. RESEARCH METHODS

This research uses quantitative approach and experimental methods. Instrument for this research are data collection with hot wire anemometer for collecting wind speed data and hygrometer for collecting air temperature and humidity data (figure 2), and list of multiple measurement points.

The room is divided into several measurement points, specifically 15 different locations each with four different height level. Measurement points are distributed evenly throughout the room with 200cm horizontal distance between each point (figure 3) and 50cm of vertical distance (figure 4). Each points are used to measure air temperature and air velocity.

After all measurements are collected, the data will be processed by using ADPI (Air Diffusion Performance Index) measurement standard, which it has an input EDT (Effective Draft Temperature) and an output of ADPI percentage.



Figure 1. Tarumanagara University's Study Club Room Condition (Survey, 2016)

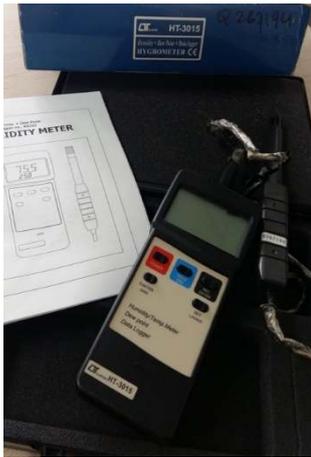


Figure 2. Hygrometer and Anemometer (Survey, 2016)

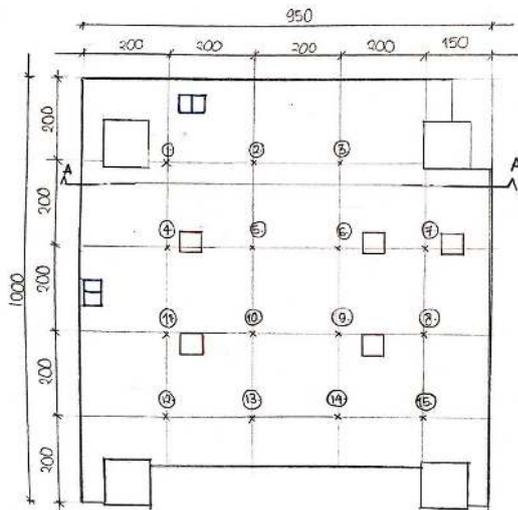


Figure 3. Plan Drawing of Measurement Points (Survey, 2016)

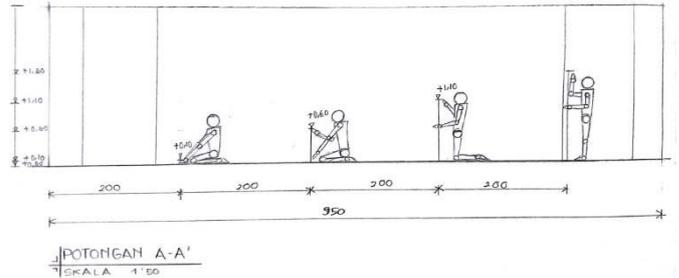


Figure 4. Section of Measurement Height (Survey, 2016)

Steps for processing the data are as follows:

- Input measurement results of air temperature and air velocity at each measurement point into a table at Microsoft Excel;
- Input the following EDT equation into the table:

$$EDT = (T_x - T_r) - 8(V_x - 0.15)$$

Keterangan:

- $T_{x_{\text{loang}}}$: Local Air Temperature (°C)
- $T_{x_{\text{rata}}}$: Average test zone temperature (°C)
- V_x : Local Air Speed (m/s)

- Results from EDT equation will show differences at each measurement point, thermal comfort standards dictate the value should be around -1,7°C and 1,1°C with air velocity equal or less of 0,35 m/s (ASHRAE, 2005);
- Input the number of test point that are within standard into the ADPI equation, if the results are equal or more than 80%, then the room is within thermal comfort standards:

$$ADPI = \frac{\text{Number of test point } -1.7^{\circ}\text{C} < EDT_x < 1.1^{\circ}\text{C} \text{ and } V_x \leq 0.35 \text{ m/s}}{\text{Total number of Atest point}} \times 100\%$$

Keterangan:

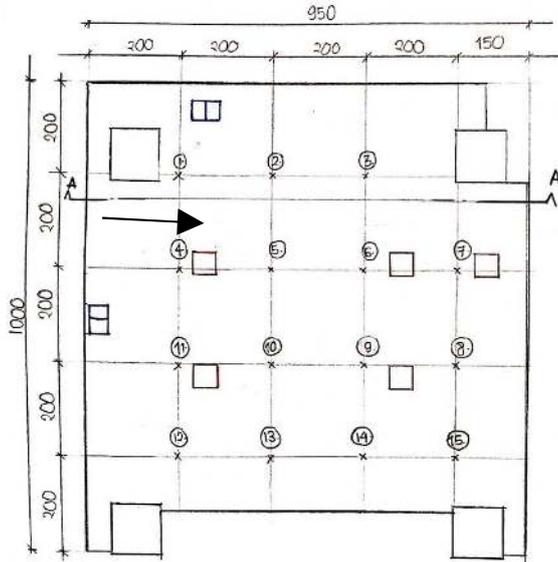
- $ADPI$: Air Diffusion Performance Index (%)
- EDT : Effective Draft Temperature (°C)
- V_x : Local Air Speed (m/s)

(2)

- If the room are not within standards, writers would do three experiments with altering the measurement results. Here are the three experiments that needs to be done:
 - First experiment: alter air temperature measurement data;
 - Second experiment: alter air velocity measurement data;
 - Third experiment: alter air temperature and velocity measurement data;
- Analyze and create a conclusion from this research and experiment

III. RESULTS AND DISCUSSION

Results from measurement that have been done at Tarumanagara University’s study club includes plan drawing (figure 5), air temperature and air velocity including EDT calculations (table 1).



Note :



Casette AC, dimension 40x60 cm.



Central Casette AC, dimension 50x50 cm

Figure 5. Plan Drawing of Measurement Points and AC Location (Survey, 2016)

TABLE 1. MEASUREMENT DATA AND EDT, ADPI CALCULATION RESULT

Ketinggian	Temperatur pada Posisi Pengukuran (Tx) (°C)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.1	24.280	24.290	23.910	22.250	22.750	22.800	23.110	22.160	22.820	23.270	23.380	23.140	23.370	22.380	22.180
0.6	24.190	24.280	23.900	22.940	22.800	23.090	22.870	22.070	22.560	23.050	23.440	23.180	23.540	22.500	22.290
1.1	24.230	24.250	24.360	23.120	22.590	23.500	23.050	22.000	22.540	22.920	23.530	23.220	23.720	22.460	22.250
1.7	24.220	24.360	24.380	23.350	21.990	22.740	23.020	22.200	22.500	23.040	23.460	23.290	23.300	22.460	22.320
Tr	23.119														
Ketinggian	Kecepatan angin (Vx) (m/s)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.1	0.020	0.000	0.000	0.000	0.010	0.010	0.010	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000
0.6	0.000	0.000	0.010	0.000	0.010	0.010	0.010	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000
1.1	0.000	0.000	0.000	0.000	0.010	0.010	0.010	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000
1.7	0.000	0.010	0.010	0.000	0.010	0.020	0.020	0.010	0.010	0.000	0.000	0.000	0.010	0.000	0.010
Vr	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Ketinggian	Effective Draft Temperature (Tx-Tr)-8(Vx-0.15)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.1	2.201	2.371	1.991	0.331	0.751	0.801	1.111	0.241	0.821	1.351	1.461	1.221	1.451	0.461	0.261
0.6	2.271	2.361	1.901	1.021	0.801	1.091	0.871	0.151	0.561	1.131	1.521	1.261	1.621	0.581	0.371
1.1	2.311	2.331	2.441	1.201	0.591	1.501	1.051	0.081	0.541	1.001	1.611	1.301	1.801	0.541	0.331
1.7	2.301	2.361	2.381	1.431	-0.009	0.661	0.941	0.201	0.501	1.121	1.541	1.371	1.301	0.541	0.321
ADPI = 29/60x100% =48.33%															

Note:

- Red colored value: EDT standards are not achieved at that measurement point
- Black colored value: EDT standards are achieved at that measurement point

From the table we can infer that based on EDT calculation, there are 29 out of 60 measurement points that meet EDT standard, while the rest 31 points can be considered do not meet EDT standard. If this value is plugged

into ADPI formula the results would be ADPI of 48,33%. This calculation proves that Tarumanagara University’s study club room is not meeting thermal comfort standard ADPI of $\geq 80\%$ (ASHRAE, 2005).

Because the room are not meeting thermal comfort standard, the next step to do is experiment with altering measurement data to figure out the steps that can be done so the room can achieve thermal comfort standard ADPI of $\geq 80\%$. These are the three different experiment:

- First experiment: alter air temperature measurement data by 1°C;

- Second experiment: alter air velocity measurement data by 0,1 m/s;
- Third experiment alter air temperature by 2°C and air velocity by 0,15m/s;

Here are the results from those three experiment:

TABLE 2. ADPI CALCULATION RESULTS FROM MEASUREMENT AND EXPERIMENT

Note	ADPI (%)
Measurement Data	48.33%
First Experiment	48.33%
Second Experiment	78.33%
Third Experiment	95%

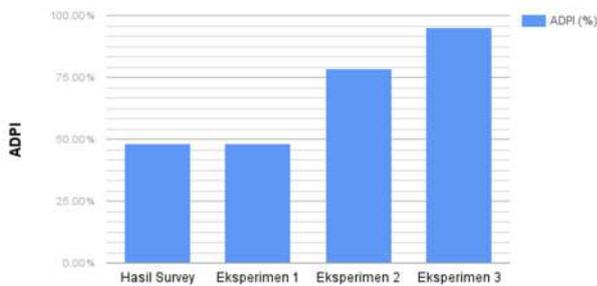


Figure 6. ADPI Calculation Result Diagram from Measurement and Experiment

From first experiment we can see that a shift of +1°C doesn't give a significant difference in ADPI percentage. This proves that if the actual measurement data are like this, then the room would still not meet the standard.

Second experiment does bring much closer to the minimum ADPI percentage, but still not meet the minimum requirement with a value of only 78,33%, which is actually a significant difference from the actual room measurement.

The third experiment does combine both first and second experiment. The result is an even bigger increase of ADPI percentage with a value of 95%. This means that if the room can have a measurement similar to this experiment, the room would be meeting thermal comfort standard.

IV. CONCLUSION

Based on this research, a conclusion can be made that Tarumanagara University's study club room is not meeting thermal comfort standard. The use of air conditioning (AC) which should help to provide comfort for users instead have the opposite effect of making the room uncomfortable. Based on the experiment results, the third experiment is able to achieve standard, with an average air temperature of 25,186°C and an average air velocity of 0,15 – 0,17 m/s. If the room can be modified so it is possible to achieve those measurement, the result would be a room that's meeting thermal comfort standard. One of the way to achieve that could be with a use of fan. Fan could have the effect of increasing air velocity by 0,15 m/s.

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