RESEARCH FOR THERMAL MITIGATION OF THE SERVER ROOM WITH OLD BUILDING SPECIFICATION

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Abstract

In server room, air temperature of server neighborhood have a direct influence of the use of the server. Therefore in late years, many measures are carried out to efficiently dispose of released heat from server. For example server racks are aligned, supply air and exhaust air are separated two sides, and chill of cooling apparatus are efficiently use. In contrast, it is necessary to take measures in server room of old building specifications. Supply air and exhaust air of server are mixed because server racks don't align. Furthermore room temperature rise in summer, because of lack of thermal insulation and inappropriate air conditioner setting. Therefore, the thermal environmental measurement for the server room in the Computer and Network Center, the Saga University which is old building was carried out in summer 2012. Measurement items of indoor are room air temperature, temperature of cool supply air and hot exhaust air of server, surface temperatures of walls, a floor and ceiling. Furthermore the measurement items of outdoor are temperature and humidity of outdoor air, solar irradiance, roof surface temperature. The area of this room is about 87 m^2. There are five air conditioners for cooling, five electric fans which are to take away exhaust air of server, and 16 racks which are accommodated about 185 servers. North and west wall face outside, south wall face a passage, and east wall face another room. Thermal mitigation of the server rack neighborhood is examined based on the measurement results.

Keywords: Server, Old building Specification, Existing air conditioner, Hot spot, Thermal insulation

1. INTRODUCTION

Many researches concerning data center are carried out to efficiently dispose of released heat from server. In Addition, energy saving measures are also done because air conditioners always work and amount of energy consumption increase. Cho, J. and others researched on the cooling systems in various data centers. Suwa, Y. researched on the efficient-izing of air flow of air conditioners. Koganei, M. and others researched on energy saving and cost-saving by using outdoor air cooling system. However these are aimed at new building specifications.

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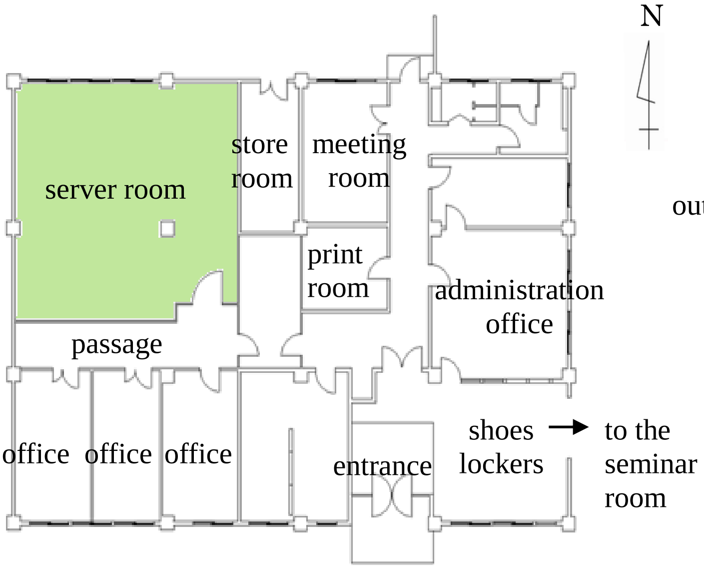


Figure 1: Ground plan of the Computer and Network Center at Saga University

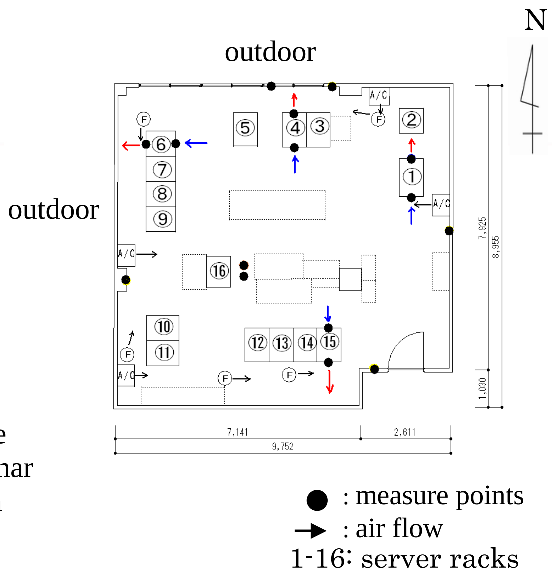


Figure 2: Server rack layout in the server room (Unit: mm)

In contrast, Okamoto, M. and others researched on energy saving by using outdoor air cooling system at data center of old building specification. However they didn't discuss about the influence on data center due to the old building specification. Therefore the aim of this research is to grasp influence on server room due to the old building specification and to consider taking steps to improve thermal environment of server room.

2. PURPOSE

The measuring object is the server room of the Computer and Network Center at Saga University. The measurement purpose is to grasp influence on the server room, supply and exhaust air by existing cooling air conditioners and outdoor temperature. Also it is purpose to grasp existence of hot spot. Heat flow analysis is instituted to grasp influence of outdoor temperature on the server room.

3. OBJECT

Figure 1 shows the ground plan of the Computer and Network Center and figure 2 shows the server rack layout in the server room. Dots mean measurement points and arrows mean t he direction of the air flow in fig.2. North and west walls are close to the outdoor, south wall i s close to the passage, and east wall adjacents to the next room. There are 16 server racks (Fig .2 rack number1-16) and those contain about 185 servers. There are four package air conditio ners to cool the room and five fans to push out exhaust air from servers. All servers, package a ir conditioners and fans always work. Nearby server rack 7 and 8, there is a ceiling mounted a ir conditioner. It works from the end of July to the first of October. Setting temperature of eac h air conditioner is 22°C.

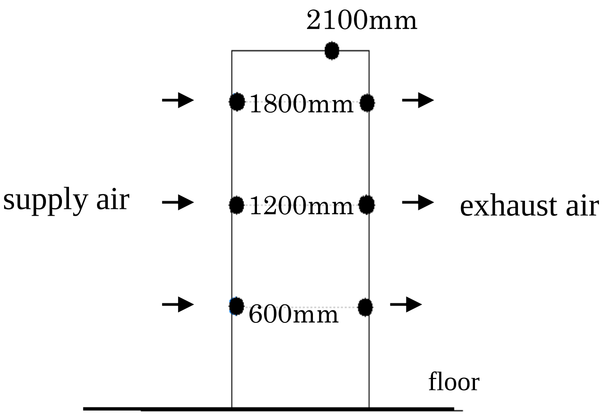


Figure 3: Temperature measuring points of supply and exhaust air of server

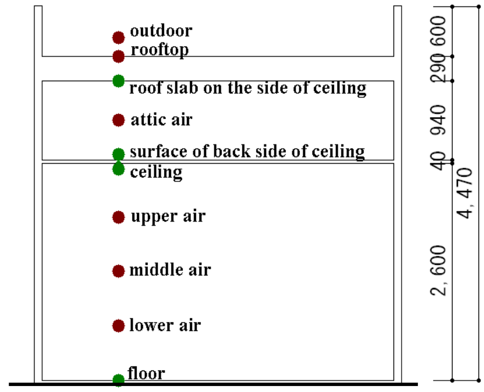


Figure 4: Temperature measuring points of vertical direction of the server room (Unit: mm)

4. MEASUREMENT METHOD

The measurement was conducted about two months from July 24th to September 27th in 2012. In this measurement, four server racks were selected from all and the rack number is 1, 4, 6, and15. Figure 3 shows the measurement position of supply and exhaust air temperatures, which was a height of 600 mm, 1200 mm, 1800 mm, and 2100mm. There were small fans at height of 2100 mm to exhaust hot air. Surface temperatures of the east, south, west, and north wall of the server room were measured, at 1800 mm height. On the rooftop of the server room, surface temperature, outdoor air temperature, relative humidity and solar radiation were measured. Temperature measuring points of vertical direction of the server room were rooftop, roof slab on the side of ceiling, attic air, surface of back side of ceiling, ceiling surface, floor surface, and the upper, middle and lower air, as shown in Figure 4.

To measure temperature of vicinity of servers and building surface, thermocouples (ϕ0.32 mm), two data loggers (GL820, GL200, GRAPHTEC), and data loggers with thermometer (Ondotori Jr. TR-52S, T AND D) was used. To measure outdoor air temperature and humidity, a data logger with thermometer and hygrometer (Ondotori TR-72Ui, T AND D) was used, and to measure solar radiation on rooftop, a pyranometer (ML-020VM, EKO INSTRUMENTS) was used. All equipments were set every ten minutes to measure those points.

5. MEASUREMENT RESULT

Three days of measurement terms which satisfy conditions were selected to analyze measured data. The selected days are July 27th, August 16th, and September 20th. Table 1 shows the conditions of selected three days.

Table 1: Conditions of selected three days

Measuring day	Outdoor	In server room	
	Temperature	Package air conditioners	Ceiling mounted air conditioner
July 27th	high	working	not working
August 16th	high	working	working
September 20th	low	working	working

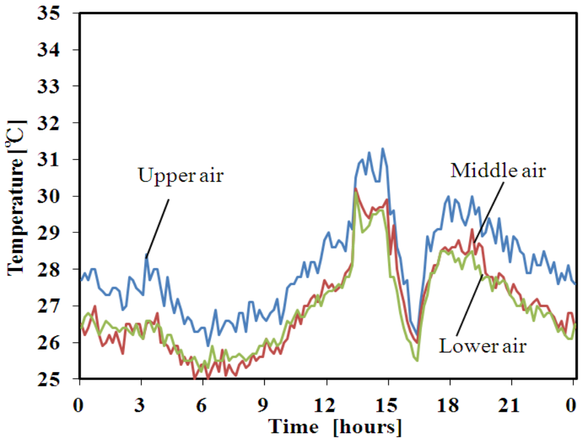


Figure 5: Temperature change of the server room on July 27th

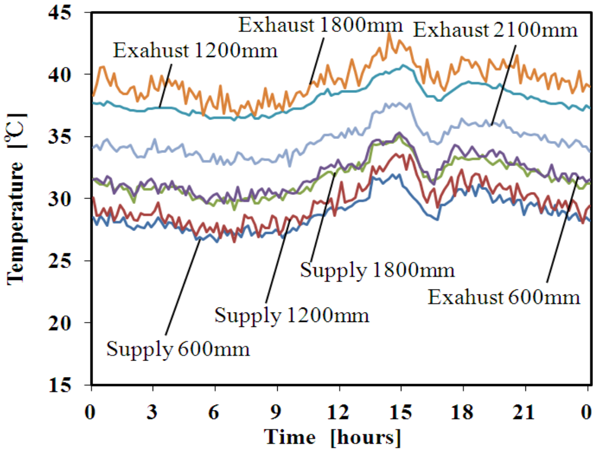


Figure 6: Temperature change of supply and exhaust air of rack number 15 on July 27th

Figure 5, 7 and 9 show temperature transition over time of the server room and that of supply and exhaust air in selected days. Figure 6, 8 and 10 show temperature change of the rack number 15 which is the most rating heat value of servers. On July 27th, supply air temperature nearly equaled with server room temperature, which changed highly in the range of 25 to 30 °C. Being put servers which were a large amount of heat value, exhaust air temperature of this server rack highly changed. On August 16th, exhaust air temperature fell with falling of supply air temperature by working the ceiling mounted air conditioner. On September 20th, according to outdoor air temperature drop, supply air temperature nearly equaled with server room temperature, however exhaust air temperature still changed highly because of plenty of heat value from the server. The temperature differences between supply and exhaust air in height 1800mm were about 7.8 °C on July 27th, 5.3 °C on August 16th, and about 2.3 °C on September 20th. If the temperature difference between supply and exhaust air was stable in September 20th, and the other temperature differences were larger. It caused that there was always exhaust air with high temperature in height 1200mm and that air rose to the height of 1800mm. Therefore it is estimated that there was a hot spot from height 1200mm to 1800mm. Each fan set exhaust side of server could not blow out hot exhaust air.

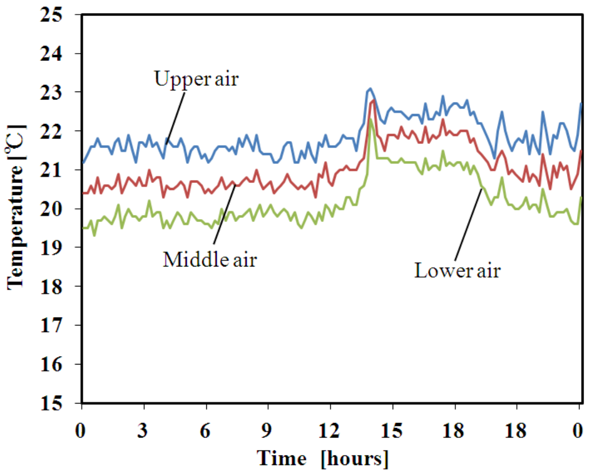


Figure 7: Temperature change of the server room on August 16th

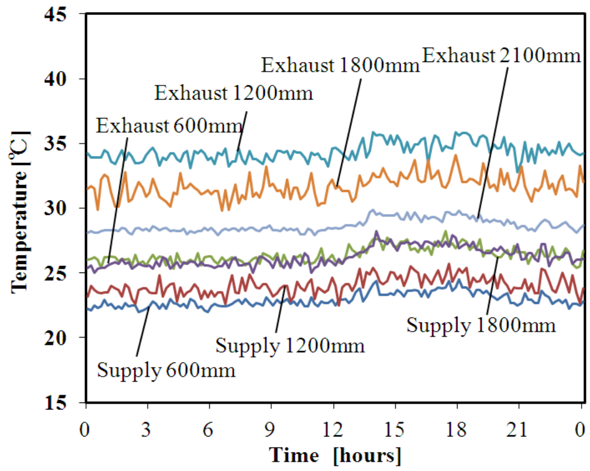


Figure 8: Temperature change of supply and exhaust air of rack number 15 on August 16th

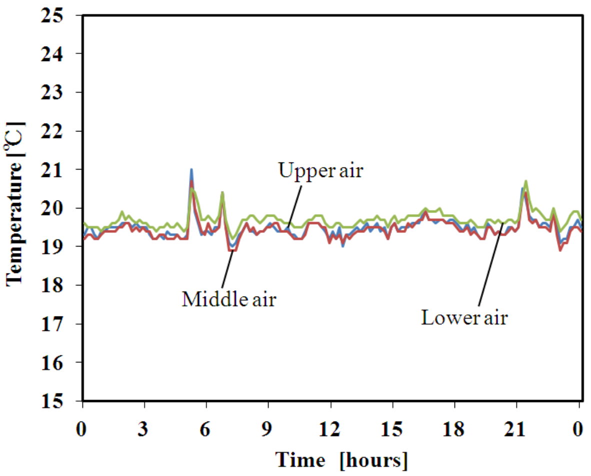


Figure 9: Temperature change of the server room on September 20th

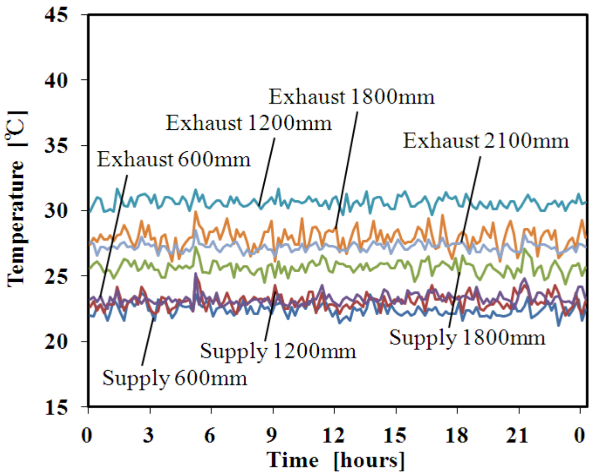
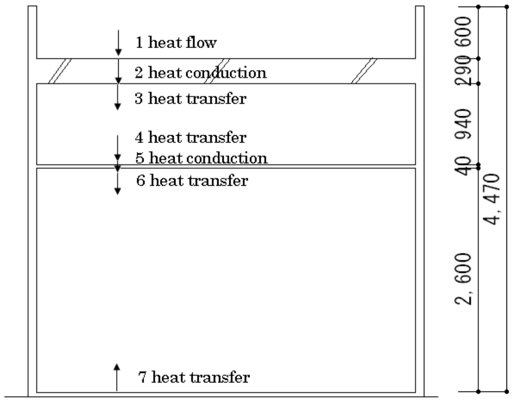


Figure 10: Temperature change of supply and exhaust air of rack number 15 on September 20th

6. HEAT FLOW RATE ANALYSIS METHOD

Heat flow rate in the server room and amount of heat flow rates per day were calculated to select parts of building frame which is effective improvement of thermal environment. The heat flow rate in the server room was calculated to multiply difference between surface temperature and air temperature of the server room by heat transfer coefficient.

Figure 11 shows the analysis points of heat flow rate from the roof to the floor. In this analysis, calculations were performed by assuming one dimensional steady state heat conduction. The number 1 to 6 in Figure 11 show the analysis points of heat flow rate and these numbers are assigned to the other from the roof to air in the server room. The number 7 shows the analysis points of the floor and the heat flow direction of this point is assumed from the floor to air. These arrows of heat flow direction express positive value. In this analysis, the



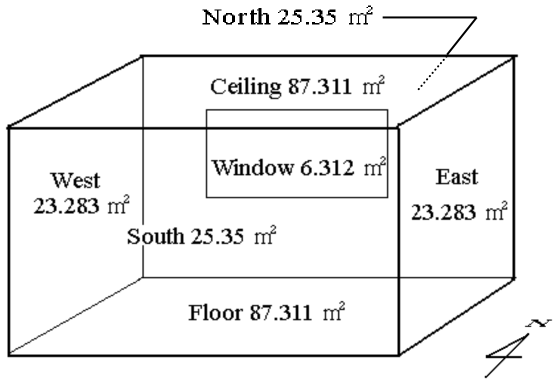


Figure 11: The analysis points of heat flow rate **Figure 12**: The surface area

Table 2 : Materials, Composition and Thickness of each part

Parts	Slab	Ceiling Board	Walls (East, North, West)			Wall (South)	Floor
Materials	Plain Concrete	Plaster Board	Calcium Silicate Board	Fiber-glass	Plain Concrete	Steel Partition	Plain Concrete
Composition							
Thickness	290	40	8	25	150	60	12

Unit: mm

surface area of each part of the server room is assumed as shown in Figure 12. Table 2 shows Materials, Composition and Thickness of each part.

7. RESULTS OF HEAT FLOW RATE ANALYSIS OF SERVER ROOM

7.1 HEAT FLOW RATE ON HIGHER OUTDOOR TEMPERATURE DAY

Figure 13 shows temperature and amount of solar radiation on July 27th. Figure 14 and 15 show the wall heat flow rate of the server room and the amount of heat flow rate per day on July 27th, respectively. The heat flow rate of the ceiling was most and that of north window was lowest due to small window area. The heat flow rate of south wall was most among all walls due to two reasons. One reason is that the material of south wall has lower thermal insulation performance than other walls. The other reason is that the south wall was close to hot air in the passage. The reason of hot air in the passage is that the entrance lead to

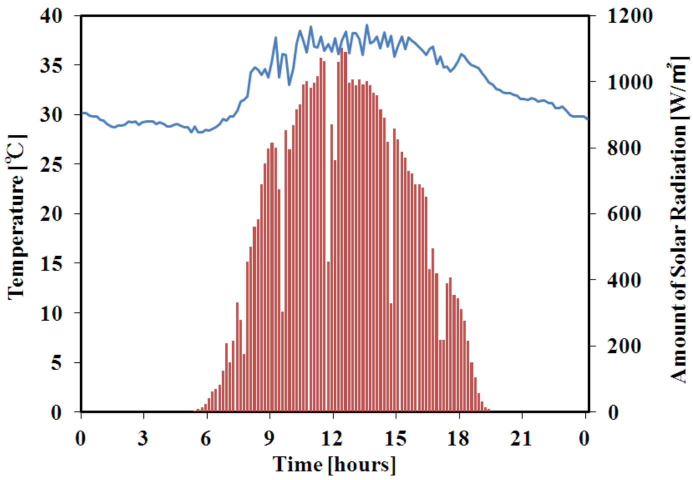


Figure 13: Temperature and amount of solar radiation on July 27th

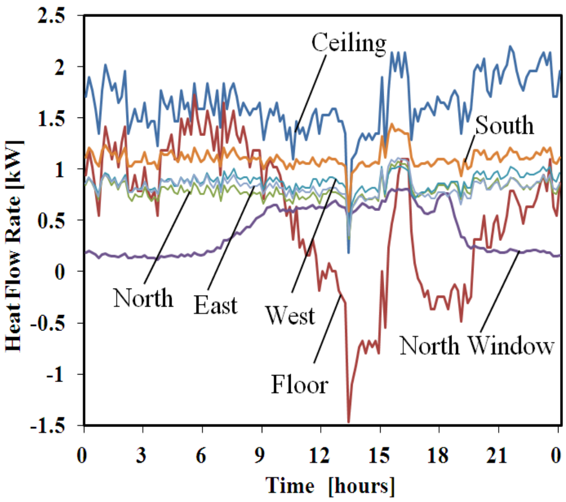


Figure 14: Wall heat flow rate of the server room on July 27th

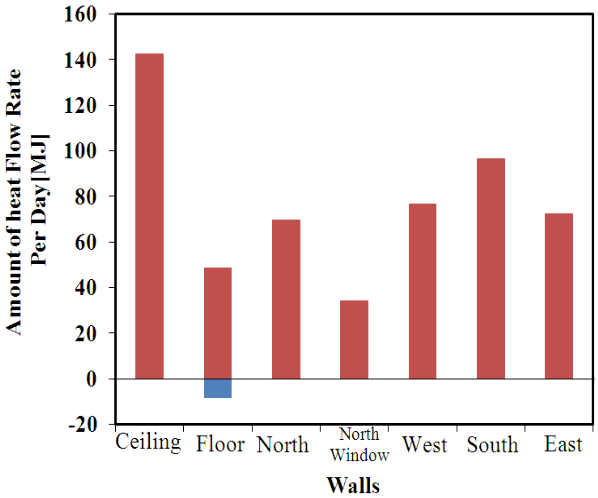


Figure 15: The amount of heat flow rate per day on July 27th

the passage was always opened and outdoor hot air flew into the passage. The heat flow rate of the ceiling and that of the floor were kept at night because the stored heat in them flew into air of the server room when the outside temperature fell. temperature difference between the s erver room and outdoor increased.

7.2 HEAT FLOW RATE ON ALL AIR CONDITIONERS WORKING DAY

Figure 16 shows temperature and amount of solar radiation on August 16th. Figure 17 and 18 show that wall heat flow rate of the server room and amount of heat flow rate per day on August 16th, respectively. In comparison with result of July 27th, the heat flow rate into the server room increased because the ceiling mounted air conditioner worked and

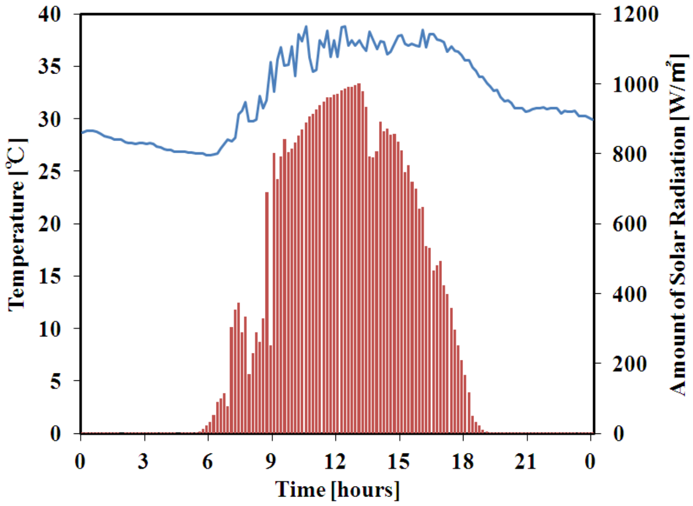


Figure 16: Temperature and amount of solar radiation on August 16th

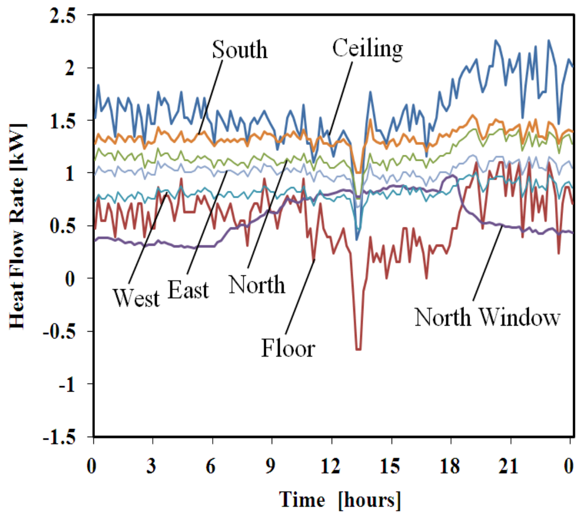


Figure 17: Wall heat flow rate of the server room on August 16th

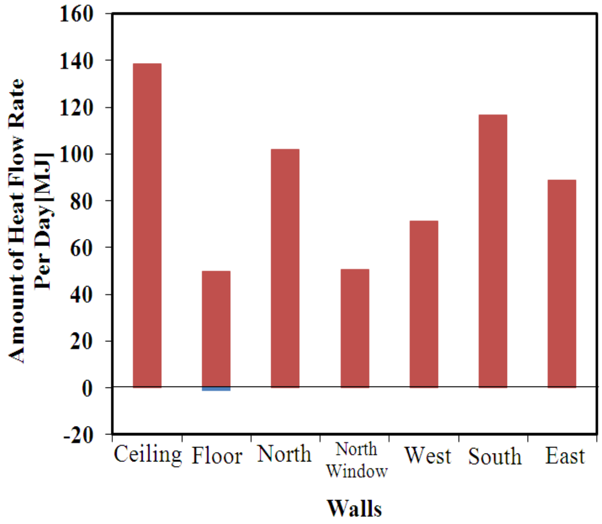


Figure 18: The amount of heat flow rate per day on August 16th

7.3 HEAT FLOW RATE ON LOWER OUTDOOR TEMPERATURE DAY

Figure 19 shows temperature and amount of solar radiation on September 20th. Figure 20 and 21 show that wall heat flow rate of the server room and amount of heat flow rate per day on September 20th, respectively. The heat flow rate of the south wall was most as well as the results of July 27th and August 16th. The heat flow rate of the ceiling was low because that decreased by falling of the outside temperature. In contrast, the heat flow rate of floor was high. The floor temperature was steady because under-floor was foundation which doesn’t contact cooler outdoor air. Therefore temperature difference between server room and floor becomes large, and the heat flow rate was high.

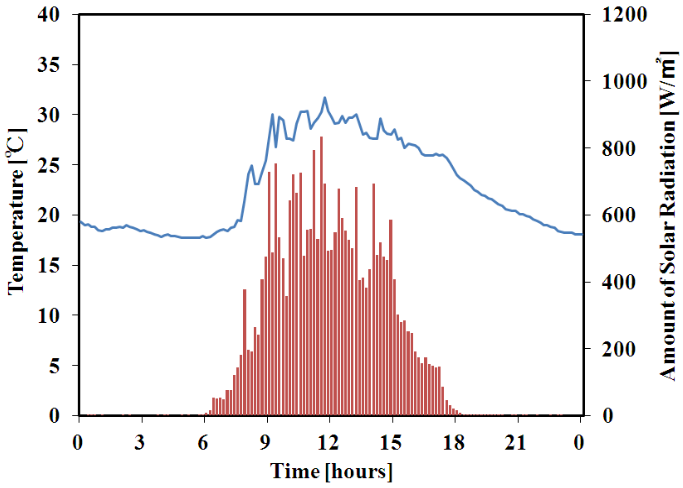


Figure 19: Temperature and amount of solar radiation on September 20th

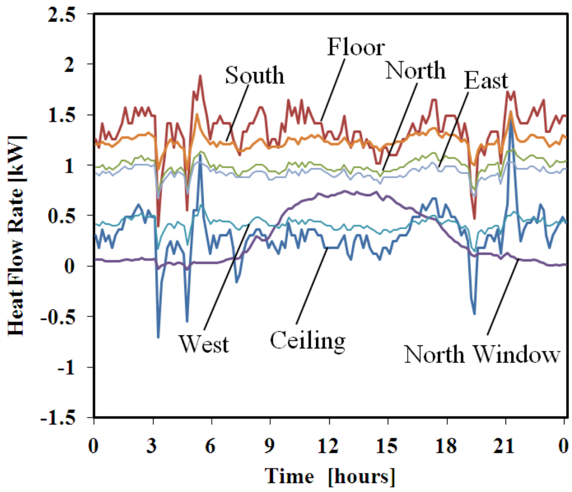


Figure 20: Wall heat flow rate of the server room on September 20th

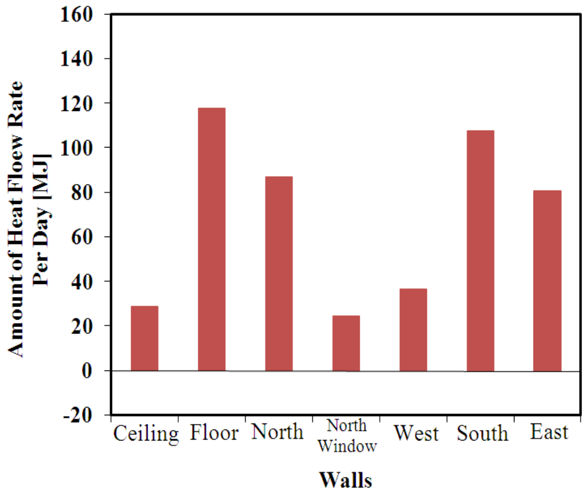


Figure 21: The amount of heat flow rate per day on September 20th

8. HEAT FLOW RATE ANALYSIS OF VERTICAL SECTION

Figure 22 and 23 show that the amount of heat flow rate per day, high outdoor temperature on July 27th, and the amount of heat flow rate per day, low outdoor temperature on September 20th, respectively. The analysis points in the both figures are shown before in Figure 12.The heat flow rate of roof was most on July 27th which high outdoor temperature and many amounts of solar radiation. In contrast, that was less on September 20th which low outdoor temperature and few amounts of solar radiation. Especially on July 27th, the heat flow rate gradually reduced the direction was 1 to 6. Because heat capacity of the roof slab concrete was large and attic air and ceiling board reduced the heat flow rate.

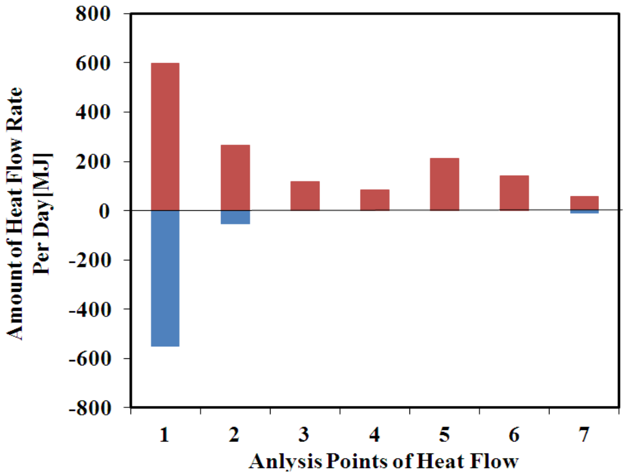


Figure 22: The amount of heat flow rate per day on July 27th

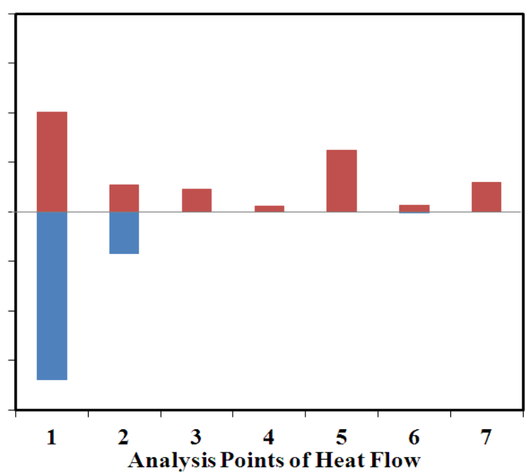


Figure 23: The amount of heat flow rate per day on September 20th

9. CONCLUSION

It is difficult to flow the hot spot by exhaust air of servers because the fans set exhaust side of servers do not have good enough air volume. Cooling effects of the ceiling mounted air conditioner is greater. However the thermal insulation performance of walls of server room is insufficient, the room is susceptible to the influence of outdoor condition on the heat flow rate because the heat flow rate is abundance. Therefore it is effective to take measures as heat shield on the roof surface and heat insulator on the south surface of wall because both are much heat flow rate. To give heat shield on the roof and heat insulator on south wall, the heat flow rate into the server room was reduced. Therefore temperature rising of server room and supply and exhaust air of server could be controlled.

10. REFERENCES

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