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Comparison of Cooling Load Calculation Using Manual Method and Hourly Analysis Program

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Abstract: Achieving an efficient system of air conditioning is required to both maximize the thermal comfort and the overall energy consumption and etermining the cooling load through calculation helps this. The primary objective of this research is determine and compare the cooling load using Hourly Analysis program to manual method such as CLTD method of FPTV (Block C&D), UTHM. Measurements from floor plan and prior study of CLTD cooling load calculation method were used to determine the cooling load in HAP software. The cooling load calculation by the HAP software is 3,275,100 BTU/hr (272.9 RT) is 77.9% efficient to chiller capacity and there is 5.79% difference compared to CLTD method. The research can be extended o non-air conditioned spaces in HAP software for future researches.

Keywords: Hourly Analysis Program, Cooling Load, CLTD

1. Introduction

The process of estimating the required air conditioning system is known as cooling load calculation. There are several method to calculate cooling loads such as CLTD, CLF, SCL, and HAP (TF). Each of these method employ different methodology and principles to calculate cooling load. Two commonly used methods are CLTD and HAP methods. The Cooling Load Temperature Difference (CLTD) methods estimate the cooling by estimating and compounding individual factors that may affect the cooling load by calculations. The Hourly Analysis Program (HAP) employs Transfer Function (TF) method to simulate the computer modelled space to calculate the cooling load. Both this methods are accurate enough for real life application.

However, manual method are tedious and can introduce human error into the calculation cooling load whereas the HAP software can reduce said disadvantages. Hence, identifying and comparing both methods are pertinent to obtain an optimised work flow for the engineer.

For this study, the two cooling calculations will conducted in a control space and controlled factors. The control space is FPTV (Block C & D), UTHM.

1.1 Problem statement

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The manual calculation method namely the Cooling Load Temperature Difference method is antiquated and requires significant amount of time to process. Thus, identifying the accuracy, efficacy and efficiency of alternative method in determining cooling load such as Hourly Analysis Program (Transfer Function method) is pertinent. Therefore, this study will compare two methods of calculating cooling load where one is by manual calculation whilst the other is by the use of software.

1.2 Objective of Study

The objective of this study is:

i. To compare the accuracy of cooling load calculation using manual method (by Cooling Load Temperature Difference Method) and hourly analysis program (by Transfer Function Method).

ii. To determine the cooling load of air conditioning system in FPTV (Block C & D), UTHM.

1.3 Scope of Study

The scope of study is:

i. The study is focused on a non-residential building.

ii. The study takes place in facilities of FPTV (Block C & D), UTHM.

iii. Cooling load estimation using CLTD and HAP software (Transfer Function) method.

iv. The study is carried out at peak time of the day where it is at its highest temperature to estimate peak cooling load for CLTD method.

2. Materials and Methods

This research focuses on the usage of Hourly Analysis program to obtain the cooling load of the FPTV (Block C&D), UTHM. Most of the data are retrieved form the software itself, however, some are required from floor plans of the studied facilities

2.1 Materials

Floor plans obtained for the University administrators were used to determine the floor area, the number of studied facilities and the the number of door and windows present in the studied building. These dimension were cross referenced to a prior study of the the cooling load of the same building to ensure correct dimensions. Figure 1, Figure2, Figure 3, Figure 4 and Figure 5 shows the floor plans of FPTV (Block C&D), UTHM. Other than that, the Hourly Analysis Program V5.11 by Carrier was used to determine the cooling load. Data collected from prior site visit such as the number of windows, doors and computers and the scheduling of students and lecturers.

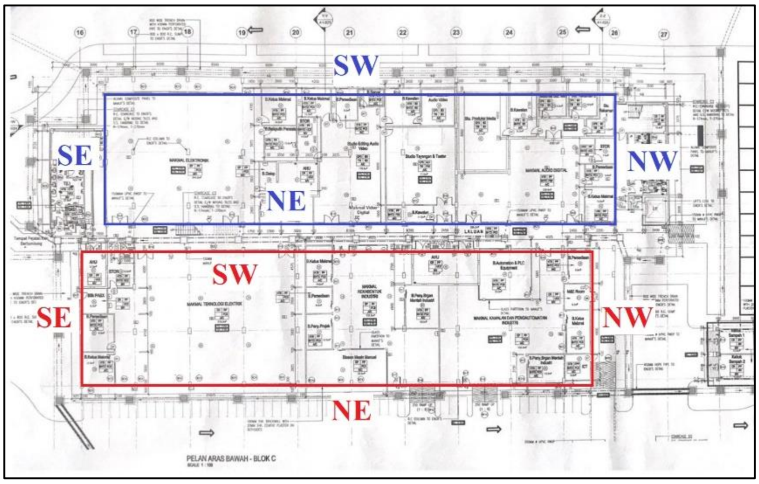

Figure 1: FPTV (Block C) - Floor Plan Drawing (Ground Floor)

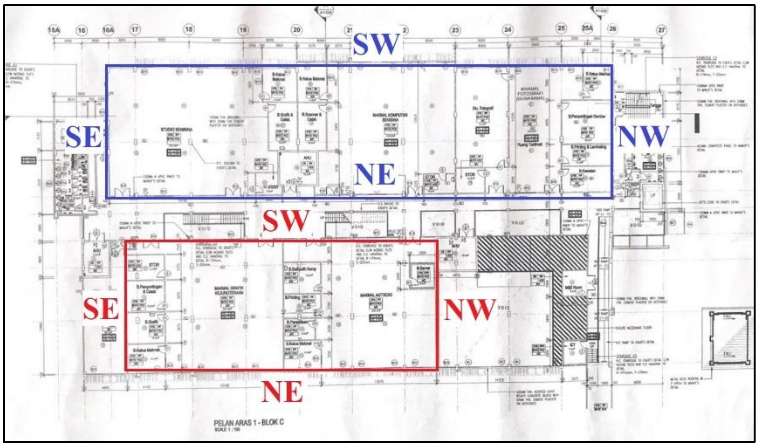

Figure 2: FPTV (Block C) - Floor Plan Drawing (First Floor)

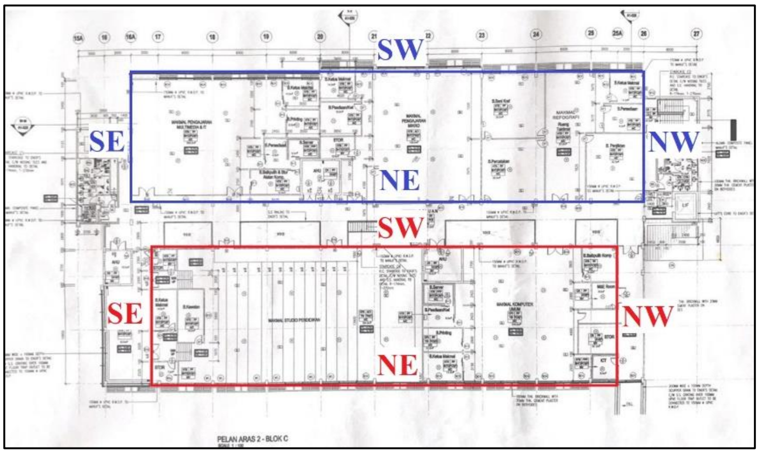

Figure 3: FPTV (Block C) - Floor Plan Drawing (Second Floor)

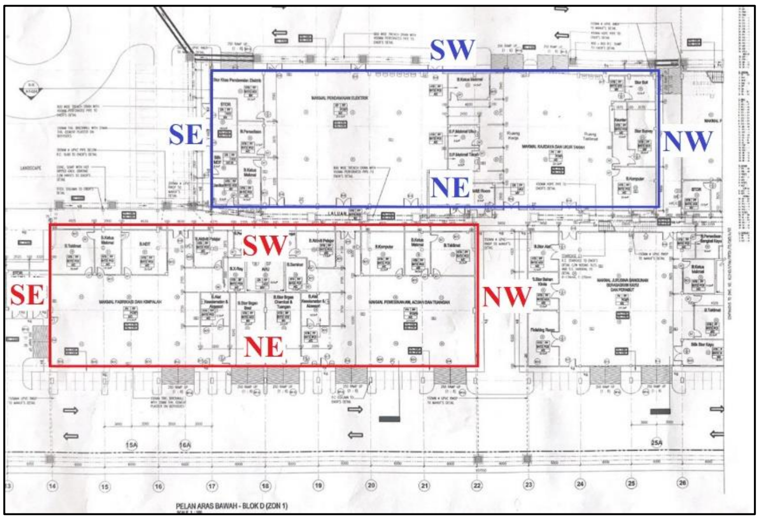

Figure 4: FPTV (Block D) - Left Side of Floor Plan Drawing (Ground Floor)

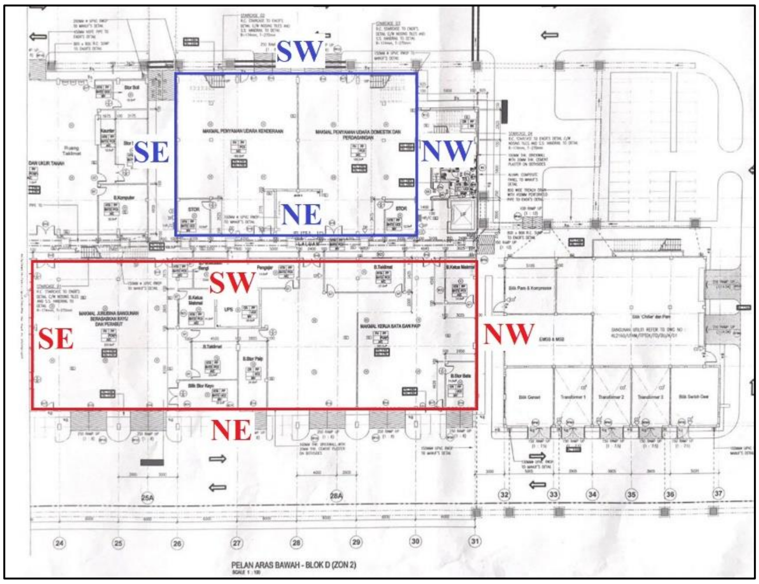

Figure 5: FPTV (Block D) - Right Side of Floor Plan Drawing (Ground Floor)

2.2 Methods

The methodology used in calculating the cooling load is by obtaining all the individual air conditioned facilities form the floor plan together with their physical dimensions such as floor area, number of windows and area, number of doors and area, and the ceiling height. Then the material of said structures were determined from site visit and the material database present in the Hourly Analysis Program was utilised to construct those spaces. Then the scheduling for the varying heat gaining properties was introduced in to the program. Figure 6 shows the scheduling determine for the usage of computers hour by hour. As an example, the number of computers at use is 100% which is 31 from 8am to 4pm. This was determined by the computer lab schedule of said facilities. Then, the weather properties was selected within the program as Johor Bahru, Malaysia. The studied building location is in Batu Pahat, Malaysia, however, Johor Bahru is the closest location that is catalogued in the Hourly Analysis Program. Then, a summary report for the cooling load was obtained and the cooling load was compared to the building chillers' cooling capacity at maximum load and 80% load and the CLTD method.

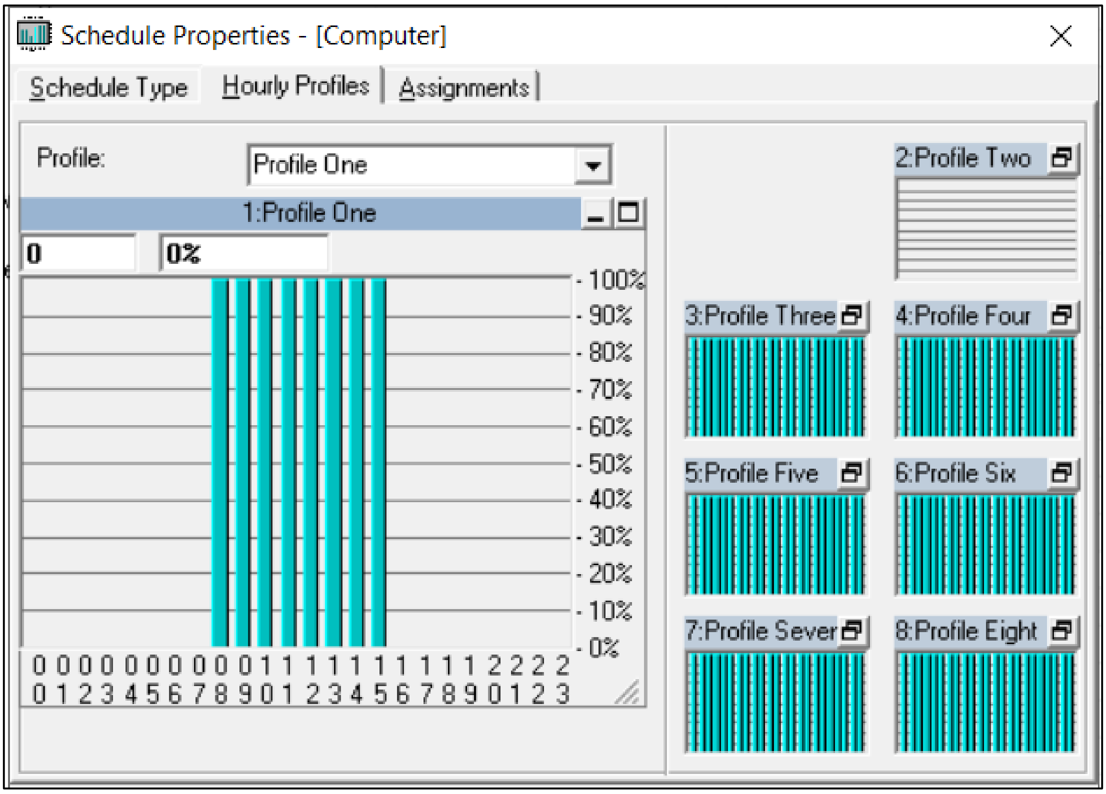

Figure 6: Computer schedule profile panel in Hourly Analysis Program

3. Results and Discussion

This study investigates the cooling load of the air conditioning system in FPTV (Block C & D), UTHM. The cooling load estimation was carried out using Transfer Function method using the Hourly Analysis Program. A comparison was drawn between the buildings' chiller cooling capacity and the cooling load estimation using CLTD/CLF/SCL method to the Transfer Function method using Hourly Analysis Program. This determines the efficiency of the air conditioning system in use in FPTV (Block C &D), UTHM. The studied building of Block C and Block D shares the same chiller.

3.1 Results

The Hourly Analysis program provides a summary report based on the the wall, roof, floor, window and door dimensions input into the program. The figure 7 below shows the summary report produced by the Hourly Analysis Program based on the FPTV (Block C&D), UTHM. The 23 air conditioned facilities requires a cooling load of 272.9 RT or 3275.1 MBH (3,275,100 BTU/hr).

Air System Sizing Summary for Default System

Project Name: FPTV
Prepared by: HVAC SIMPLIFIED AMK

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Air System Information

Air System Name	Default System		Number of zones	1	
Equipment Class	CW AHU		Floor Area	51986.9	ft²
Air System Type	SZCAV		Location	Johor Baharu, Malaysia	

Sizing Calculation Information

Calculation Months	Jan to Dec		Zone CFM Sizing	Sum of space airflow rates	
Sizing Data	Calculated		Space CFM Sizing	Individual peak space loads	

Central Cooling Coil Sizing Data

Total coil load	272.9	Tons	Load occurs at	Aug 1400	
Total coil load	3275.1	MBH	OA DB / WB	91.4 / 80.7	°F
Sensible coil load	2398.3	MBH	Entering DB / WB	78.0 / 66.1	°F
Coil CFM at Aug 1400	105738	CFM	Leaving DB / WB	56.9 / 55.8	°F
Max block CFM	105738	CFM	Coil ADP	54.6	°F
Sum of peak zone CFM	105738	CFM	Bypass Factor	0.100	
Sensible heat ratio	0.732		Resulting RH	50	%
CFM/Ton	387.4		Design supply temp.	55.0	°F
ft²/Ton	190.5		Zone T-stat Check	1 of 1	OK
BTU/(hr-ft²)	63.0		Max zone temperature deviation	0.0	°F
Water flow @ 10.0 °F rise	655.38	gpm			

Supply Fan Sizing Data

Actual max CFM	105738	CFM	Fan motor BHP	0.00	BHP
Standard CFM	105265	CFM	Fan motor kW	0.00	kW
Actual max CFM/ft²	2.03	CFM/ft²	Fan static	0.00	in wg

Outdoor Ventilation Air Data

Design airflow CFM	13368	CFM	CFM/person	18.75	CFM/person
CFM/ft²	0.26	CFM/ft²			

Figure 7: Example of presenting data using a figure

The figure 8 below shows the individual facilities cooling load requirement. The facility MSP, MAC and MPE are the three highest cooling load requiring spaces respectively. While, the facility STT and MR are the two least cooling load requiring spaces respectively. Other facilities are close in cooling load requirement to each other. The primary reason for the three highest cooling load requiring facilities is the large floor area, usage of electrical equipments such as computers and the amount of windows and door present. This let to higher heat gaining properties present in the room, therefore, higher cooling load requirement. Conversely, the STT and MR facilities are comparatively smaller spaces with less electrical equipment and windows and doors, therefore, the low cooling load requirement.

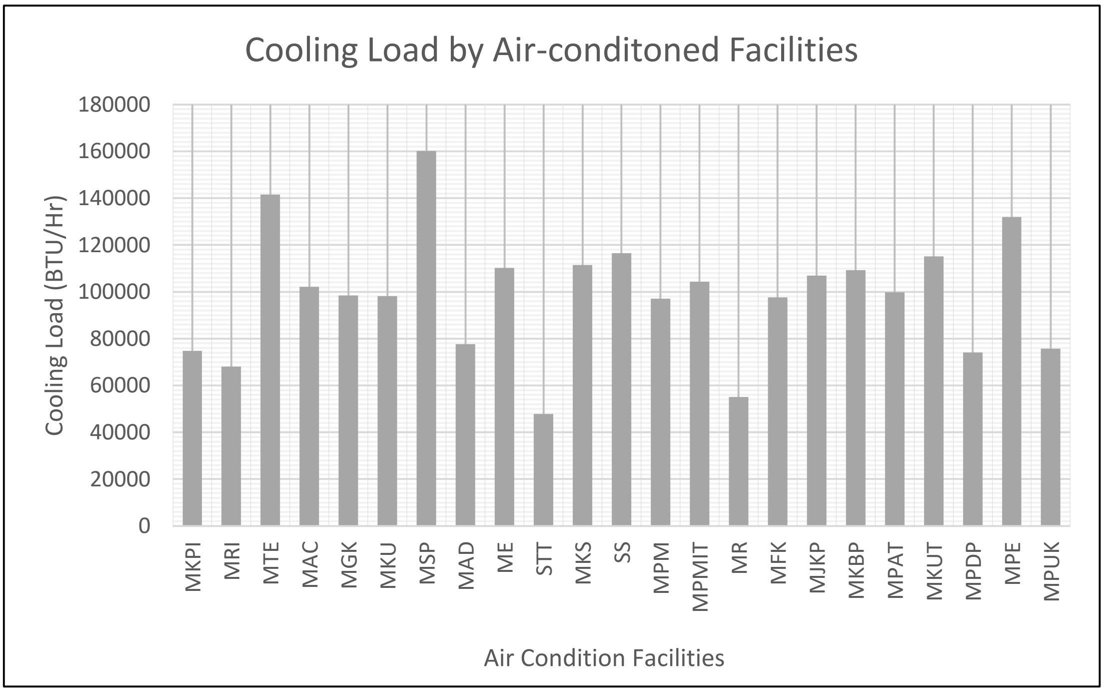

Figure 8: Calculated cooling load by air-conditioned spaces of FPTV (Block C &D), UTHM

3.2 Comparison of Cooling Load

A comparison was done based on the calculated cooling load by Hourly Analysis Program, the chillers' cooling capacity at maximum, the chillers' cooling capacity at 80% and the CLTD method. Chillers generally operate at 80% of their maximum capacity due to energy loss in its system through the motor. The table 1 below shows the comparison between these cooling load to the hourly analysis program.

The Hourly Analysis Program produced a reading of 3,275,100.00 BTU/hr compared to the 4,200,000.00 BTU/hr by the chiller. The HAP method predicts an 77.9% efficiency comparatively, therefore, the chiller is apt for the purpose it is being used for.

The comparison between CLTD and HAP method produced a difference of 5.79% with the CLTD estimating a higher cooling load requirement than the HAP method. The CLTD method estimates a cooling load higher than the 80% chiller's cooling capacity.

Table 1: The chiller's cooling capacity at maximum/full load and 80 % load, calculated total cooling load, and calculated total cooling load by HAP of FPTV of FPTV (Block C & D), UTHM.

Item	Item	Cooling Load	Unit or Dimension
1	Chiller's Cooling Capacity (Maximum/Full Load)	4,200,000.00	(BTU/hr)
2	Chiller's Cooling Capacity (80% Load)	3,360,000.00	(BTU/hr)
3	Calculated Total Cooling Load	3,464,094.26	(BTU/hr)
4	Hourly Analysis Program Estimation	3,275,100.00	(BTU/hr)

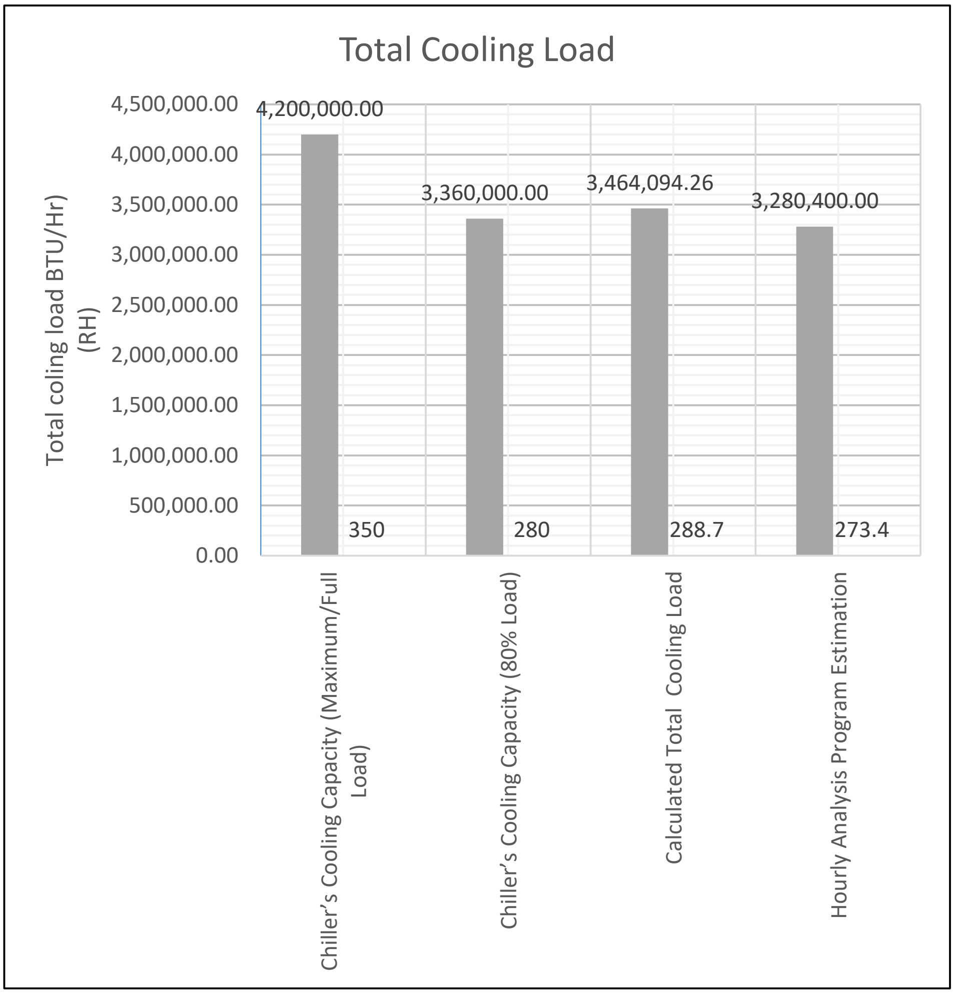

Figure 9: Example of presenting data using a figure

The primary difference between the CLTD and HAP method can be attributed to the scheduling of computer usage, people and lighting. The Hourly Analysis method is able to take into account the changes in the usage of said heat gaining properties hourly and therefore can be adjusted precisely to actual usage situation. Beyond that, the HAP analysis program utilises its own material and weather database compared to the CLTD method. Therefore, there is a degree of consistency between each calculation in the Hourly Analysis Program that is not present in the CLTD method.

4. Conclusion

In conclusion, it is found that he total cooling load of the studied buildings is 3,275,100 BTU/hr (272.9 RT). Compared to the FPTV (Block C&D), UTHM's chillers capacity of 4,200,000 BTU/hr (350 RT), the cooling load is 77.9% efficient and is under the 80% chillers capacity. Therefore, the chiller does not have to be replaced. The cooling load calculation as compared to the CLTD method and HAP method, there is a difference of 5.79% with HAP software producing a lower cooling load. There difference are minuscule but are statistically significant for the the operational, maintenance and installation cost for an air conditioning system. Some suggestions to improve the research further on in the future, is to include all the non-air conditioned spaces such as the toilets, closet and technicians' room. Other than that, more electrical equipment that are present in the FPTV (Block C&D), UTHM should be studied.

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