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HAND CALCULATION AND HAP SOFTWARE RESULT COMPARISON FOR ASSESSING TOTAL COOLING LOAD OF A BUILDING BEDROOM

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Abstract- *The motivation behind this paper is to analyze between (hand computation) and HAP programs to determine cooling load for thermal comfort, humidity comfort, ventilation, and air filtration. This task is created to locate the most ideal approach to apply the idea of (HVAC) system in a building situated in Sherpur, Bangladesh. HAP utilizes the ASHRAE transfer function method for load calculation. The main purpose of this study is to compute and compare between hand computations and HAP program. The structure is a one-storied building which bedroom is the main concern. The global standard is utilized in the displayed investigation. This paper estimates the cooling load for various outdoor conditions by utilizing CLTD strategy for the structure. Cooling load, for example, individuals, lighting, penetration and ventilation thermal addition can be effectively entered to the MS-Excel E20 form. Notwithstanding other information, for example, the cooling loads because of partitions and rooftops. The outcomes demonstrate that there are similar result between the two techniques. The difference between hand computation and HAP program result is not more than 1.2 %. So, the hourly analysis program can be used for any building configuration to figure out cooling load and select the unit.*

Keywords: HVAC, Heat load calculation, E20 form, HAP software.

1. INTRODUCTION

The principle purpose of an air conditioning system is to create a comfort zone for every individuals or machines inside a space. Thusly, cooling, heating, humidifying, dehumidifying and ventilation and cleaning is the main objectives of air conditioning system.

Human body temperature is typically assessed at 37 ℃. In the event that the body needs to dissipate a portion of its heat to the surroundings. Body feels good when the thermal level is moving to the surrounding air at a thermal comfort rate. The rate of heat transfer relies upon the properties of air surrounding temperature, humidity, and air speed [1].

HAP software is made by the ASHRAE's benchmarks. As HAP just gives differential incorporated dry-bulb temperature, differential enthalpy controls and differential non-integrated dry-bulb temperature control, the investigation is accordingly confined to those three kinds. Be that as it may, it would have been intriguing to understand the reenactment with a control considering integrated enthalpy and dry-bulb temperature [2]. Thermal load of structure is the main concern to set up definite cooling unit and air handling unit. Since it is critical to accomplish comfort operation and proper air circulation in the predetermined zone. It ought to consider the most maximum temperature of the summer and least in the winters that happen in the area of the building. Building materials and other inside load must be considered for estimation of precise thermal loads [3].The effective design of central air conditioning system can produce lower power consumption, lower capital cost. The result gained using CLTD method were examined with standard data by CARRIER Fundamental Hand Books and ASHRAE.

Transporter's Hourly Analysis Program HAP is intended for the rehearsing engineer, to encourage the effective everyday work of assessing loads, structuring frameworks and assessing vitality execution. Cautious consideration has been given to structure of the graphical UI and to announcing highlights. Unthinkable and graphical yield reports give both outline and nitty gritty data about structure, framework and gear execution.

Building area, development materials and other inside loads must be considered for estimation of precise thermal loads [3].The viable structure of focal cooling can give lower control utilization, capital expense and improve nature of a structure. The result of the figuring of distinction use of CLTD strategy were contrasted by ASHRAE and CARRIER Fundamental Hand Books [4].

Air conditioning has become an essential part of modern living like business, industry, schools, hospitals, hotels, theaters, restaurants and homes. There are some factors which affect human comfort like:

1. Temperature of the surrounding air.

2. The humidity of air.
3. Air purity.
4. Air moving.

Perfect air conditioning system must fulfill all listed factors for human health.

2. COOLING LOAD CALCULATION

Estimation of cooling load is commonly established on turbulent state heat flow. Transient examination must be used. The prompt thermal addition into a shaped space is the factor of time, in light of the strong transient effect made by the hourly assortment in sun based radiation. There may be an undeniable refinement between the thermal expansion of the structure and the thermal emptied by the cooling unit at a particular time. If this is overlooked, the cooling and dehumidifying equipment will generally be much bigger than normal.

Heat obtained for the most part in the accompanying structures:

- Solar radiation passes through straightforward region.
- Conduction of heat through surfaces and radiation comes from the inward surfaces into the space.
- Sensible heat convection and radiation from inner items.
- Ventilation and infiltration.
- Latent heat additions formed inside the space.

The cooling load is the rate at which vitality must be expelled from a space to keep up the temperature and humidity at the plan esteems. The cooling load will by and large vary from the thermal gain in light of the fact that the radiation from within surface of dividers and inside items just as the sunlight based radiation coming legitimately into the space through openings which does not heat the air inside the space straightforwardly. This extreme vitality is generally consumed by floors, inside dividers, and furniture, which are then cooled basically by convection as they achieve temperatures higher than that of the room air, only when the air receives the heat energy by convection, this energy becomes part of the cooling load.

3. The HAP software

Hourly Analysis Program (HAP) is a software for PC formed by Carrier, an organization which gives answers for cooling and refrigeration. This software helps specialists to planning HVAC frameworks for business structures. It combines two tools in one: calculation of the loads and designing system, and simulation of the energy use to estimate of energy costs. This program consists of two parts: HAP system design features and HAP Energy Analysis Features [5].

HAP can perform such programs:

- Configuring cooling and heating loads for spaces and curls.
- Estimating air flow rates for spaces, zones and framework.
- Sizing cooling and heating loops.
- Sizing air course fans.
- Measuring chillers and boilers. During the vitality investigation, HAP executes the accompanying assignments:
- Looking for hour-by-hour property of all heating and cooling unit.
- Simulating hour-by-hour estimation of non-HVAC frameworks.
- Ascertaining the all-out vitality use and vitality costs dependent on the past recreations.
- Producing tabular and graphical reports of hourly, daily, monthly and annual data.

4. MATHMETICAL MODEL

The structure as appeared in figure and for finding the overall heat transfer coefficient (U) we use below equation [17রব 32].

$$U=\frac{1}{\sum R} \quad (1)$$

R is the resistance to heat transfer for a particular material.

$$\sum R = R \text{ due to convection} + R \text{ due to conduction} + R \text{ due to radiation} \quad (2)$$

R for conduction $$R=\frac{\Delta x}{k} \quad (3)$$

4.1 Factors estimating cooling load

In cooling load temperature difference method (CLTD) for air conditioned space Factors are considered:- Indoor design temperature; Outdoor design temperature; Daily range; Latitude and the day of the year; Roof and external walls color; Building and walls orientation; Overall heat transfer coefficient for roof, walls, and floor; People inside the space and their activities; Number and type of lights and other electrical equipment. Average air temperature (outdoor):-

$$T=t - DR/2 \quad (4)$$

Roofs and walls (exposed to sun):

$$q \text{ (Wall / roof)} = U \times A \times CLTDc \quad (5)$$

Due to CLTD correction walls: -

$$CLTD_c = (CLTD+LM) \times K_w + (25.5-t_r) + (T-29.4) \quad (6)$$

Due to Correction CLTD roofs:

$$CLTD_c = [(CLTD+LM) \times K_w + (25.5-t_r) + (T-29.4)] \times f \quad (7)$$

Cooling load (windows):-

Due to Radiation $Q = (SHG) \text{ mix} \times CLF \times A \times S.C$ (8)

Due to Conduction $Q = A \times U \times CLTD$ (9)

Cooling load from people: Q = No. of people × sensible heat of people (10)

Q = No. of people × latent heat of people (11)

$$Q_{S.h} = m_{vent} \times (h_A - h_{in}) \quad (12)$$

$$Q_{L.h} = m_{vent} \times (h_{out} - h_A) \quad (13)$$

Thus, For Total Cooling Load = Q sensible heat + Q latent heat= **(**External wall + internal wall + Roof + Window +
S.H people++ S.H Infiltration+ S.H equipment + S.H ventilation) + (L.H people +L.H Infiltration+ L.H ventilation) (14)

5. RESULTS AND DISCUSSION

The structural design of the room and most of the property input in the HAP software are shown in the figures (3 to8) given below. The result gained from HAP software for cooling load calculation of the bedroom and the result gained by hand calculation in E20 form made in Microsoft excel are also shown below. The psychometric analysis if the room is also done and the graphical form of the psychometric analysis is given in figure 9.From psychometric analysis it is seen that the atmosphere inside the room is in comfort zone. All the dimensions are in fps (Foot, Pound, Second) system. From the results it is seen that all the results are almost same in both cases.

- Total cooling load in tons = 1.0 tons in HAP and 0.99 tons in E20 Form
- Total cooling load in MBH = 11.8 MBH in HAP and 11.85 MBH in E20 form
- Total sensible Coil load in MBH = 10.2 MBH in HAP and 10.755 MBH in E20 form

All the other results are very close to each other. So, it can be said that the result is very satisfying and the HAP software agrees with the hand calculation for cooling load calculation and thus it is understood that this software can be used for HVAC engineering. Percentage of error is not more than 1% in all cages. All the property and parameters like internal load (lights, human, and equipment), U value of walls, roofs, Floor, dimensions of building and all other necessary inputs are shown below. For Bangladesh U value for roof and walls is commonly 1.7W/m2. (0.29 BTU/hr/ft2) [6]

Air System Information

Air System Name	bedroom
Equipment Class	SPLT AHU
Air System Type	SZCAV

Sizing Calculation Information

Calculation Months	Jan to Dec
Sizing Data	Calculated

Central Cooling Coil Sizing Data

Total coil load	1.0	Tons
Total coil load	11.8	MBH
Sensible coil load	10.2	MBH
Coil CFM at Jun 1700	484	CFM
Max block CFM	484	CFM
Sum of peak zone CFM	484	CFM
Sensible heat ratio	0.862	
ft²/Ton	228.1	
BTU/(hr-ft²)	52.6	
Water flow @ 10.0 °F rise	N/A	

Fig .1: Cooling load Calculation by HAP

OUTSIDE AIR TOTAL HEAT		994.29
GRAND SUB-TOTAL HEAT		11,505.87
Fac	1-3%	345.18
GRAND TOTAL HEAT		11,851.05
	TMBH	11.85
	TKW	3.44
	TSMBH	10,755.52
	TSKW	3,119.10
TONS=GRAND TOTAL HEAT/12000		0.99

Fig.2: Hand calculation result

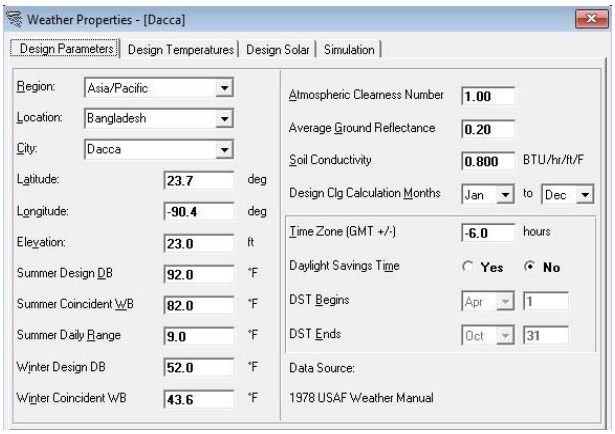

Fig.3: Input of weather property

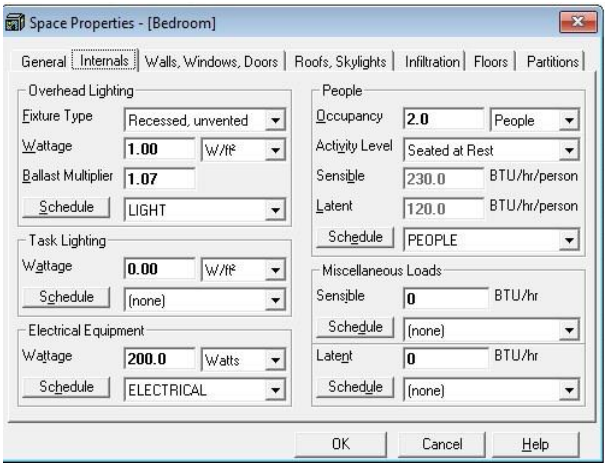

Fig.4: Property input of internal loads

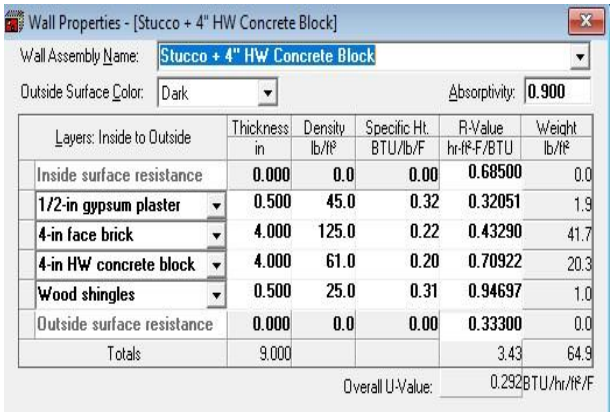

Fig.5: Input of wall property

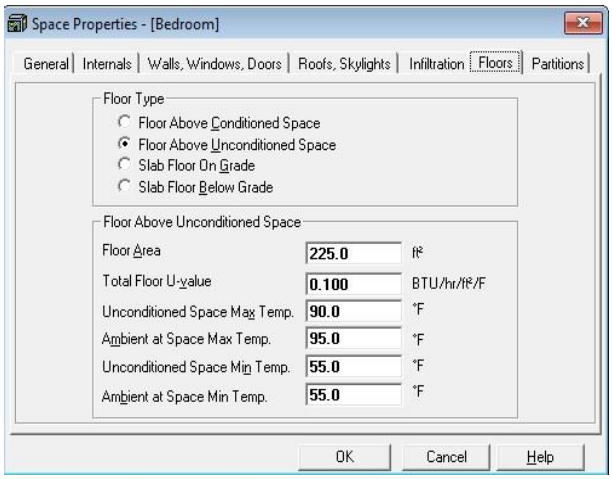

Fig.6: Input of space property (bedroom)

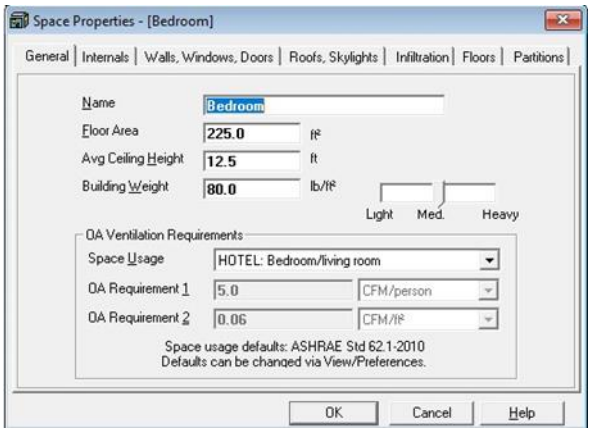

Fig.7: Input of floor area property

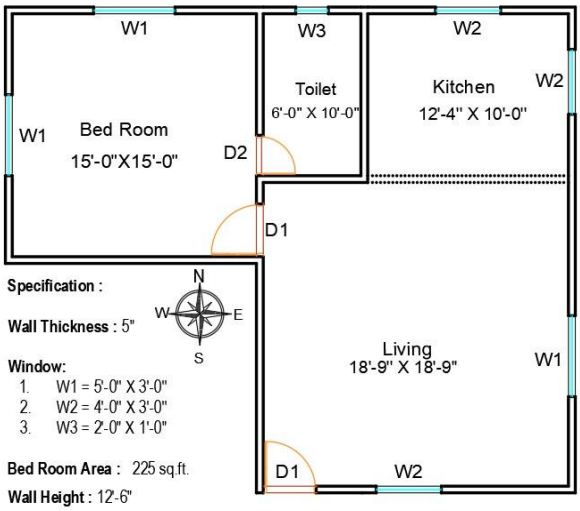

Fig.8: Building architecture Drawing

6. CONCLUSION

In this study, the building situated in Sherpur, Bangladesh was inspected to calculate the cooling load. Matching of both of the result makes the HAP software suitable for HVAC engineering and which was the main objective of the study.

The main conclusions which can be drawn from the results of the present work are:-

The total cooling load calculated for the Air conditioning system of by hand calculation shows 0.99TR and total cooling load gained from HAP programs is 1 TR and both of them satisfy the result.

8. REFERENCES

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7. NOMENCLATURE

Symbol	Meaning	Unit
A	Area	m^2
ACH	Air change per hours	m^3 /h
CLTDc	Cooling load temperature difference correct	ºC
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers	
HVAC	Heating, ventilating, and air conditioning	
CLF	Cooling load factor	
DR	Daily range	ºC
F	Factor for attic fan or duct above ceiling	
HAP	Hourly Analysis Program	
kW	Kilo wattage wall color correction	kW
Kw	Latitude & month	
LM	applied to wall & roof roof color correction	ºC
KR	Mass of ventilation	
M vent	Sensible heat factor	kg/s
Q s.h	Latent heat Factor	W/m^2
Q l.h	Solar heat gain	W/m^2
SHG	Shading coefficient	W/m^2

S.C	Overall heat transfer coefficient	W/m^2.ºC
U		
T	Average outside temperature	ºC
t	Maximum outdoor temperature	ºC
tr	Temperature room	ºC
TR	Tons of refrigeration	
V	Volume	m^3