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Coefficient of Performance Computation of a Lecture Hall

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***Abstract*: With improved living standards and rising ambient temperatures, human comfort is the most significant metric in the current environment. Electric air conditioning equipment is not recommended for large structures since it consumes a lot of electricity and has a short lifespan. Central air conditioning delivers greater dependability as well as fewer maintenance costs. Centralized air conditioning systems are installed in large buildings including commercial complexes, auditoriums, and office towers. With the increase in the students enrolled year after year, research and teaching institutions also demand comfort ability. The successful design of a refrigeration unit reduces electricity usage, lowers capital costs, and aids in the improvement the premises aesthetically. The research work illustrates about load of refrigeration evaluation in a climatic circumstance using the CLTD method. The MS-Excel tool can simply express the calculation of refrigeration load from things like occupancy gain of heat, illumination gain of heat, penetration and aeration gain of heat. The application is able to compute the refrigeration load from walls and roofs. The estimated figures were compared to the standard statistics compiled by the ASHRAE Fundamental Hand Books, and the findings were found to be validated.**

***Keywords*: cooling load, central air conditioning, ton of refrigeration, CLTD, human comfort, HVAC.**

1. Introduction

At the moment, there is an ecological equilibrium problem associated with energy use by enterprises and structures. Architecture, industry, commercial properties, residential dwellings, and marketplaces absorb 72 percent of global energy. In a big air - conditioned structure or complex, approximately energy of about 60 percent full amount needed for a structure assigned to the atmosphere habituation system install for cooling purposes. For reducing power consumption, we must supply a precise quantity of refrigeration and thermal load, suitable sized HVAC unit, also appropriate HVAC system monitor. External climatic parameters such as ambient temperature, sun radiation, and dampness are the primary elements that influence cooling demand. Native climate patterns are also significant variables for energy efficient buildings since energy usage in buildings is affected by climate patterns, plus effectiveness HVAC unit occurs like a result. Buildings would be more comfortable and energy efficient as a consequence.

Accurate cool and heat stack forecast, correct size for HVAC unit, plus optimized operation for unit are critical for minimizing power usage. Undeviating sun emission, transmitted stack, aeration/permeation stack plus interior stack are the constituents for premises refrigeration load. Computing and combining all of these loads yields an approximation of overall refrigeration stack. Computed load in this manner is the total sensible load. Based on building structure, a specific percentage from it will be usually added to account for dormant stack.

Principles for thermal transport and sun emissions are used to estimate load. CLTD, heat factors for the sun gain, and factors for refrigeration load computed for design circumstances and building materials utilized. Cosmic radiation computation principles used for estimating building's undeviating and deviating sun heat gain components. When mostly the constituents are put together, the overall load of chilling (or thermal) within the structure is calculated.

The potential loads are mentioned in the load sheet formats. Direct radiation from Sun, transmitting stack via exterior wall of varying degrees of lagging, enclosures, every conceivable wall type, ceiling, floor, plus outside atmosphere stack are among them. All transmission loads, along with ventilation/infiltration loads, are presented as a factor of the temperature differential between outside and interior air in this load calculation formulation.

The thermal load computation allows us to implement precise air conditioners equipment and air handling units. It also improves human comfort and air movement in the air-conditioned vicinity.

The CLTD approach is used in this research to estimate the cooling load of a Lecture Hall

2. Effective Temperature

Human beings' perception of hotness and coldness is mostly based upon below mentioned parameters:

- DBT (Temperature- Dry bulb)

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- RH (Humidity- Relative) and
- Velocity of Air

Cumulative sum involving three impacts is known as effective temperature, which also is described as the indicator that co-relates the cumulative effect on humans based on temperature of air, humidness plus velocity of air.

The chart of Human comfortability is a realistic implementation about notion for efficient temperature, which is shown in Fig 1.1. This figure is a study of ASHRAE research involving several types of persons treated to a wide variety of ambient temperature, relative humidity, and air velocity.

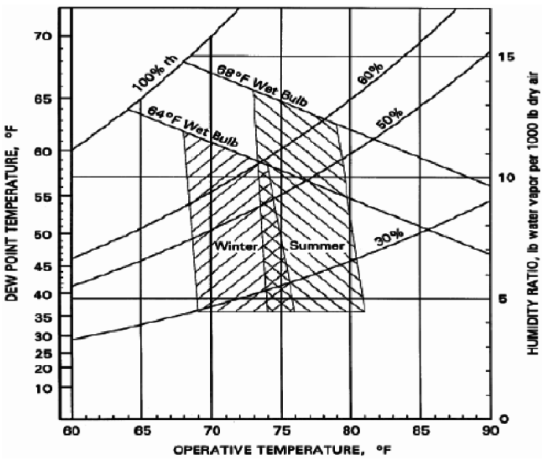

Fig. 1. Human comfort chart

3. Heat Transfer Scrutiny

Heat is transported through numerous mediums in any structure or area, including exterior walls, top roof, ground floor, windows, and doors. Heat transport occurs through three modes: radiation, convection, as well as conduction. The refrigeration load for a structure determined by various factors including local climate, material, thermal properties and building type. There is other software available for load of refrigeration estimations, like HAP 4.3, Elite, BLAST as well as DOE 2.1E. Such software employs TFA plus HBA. Because such approaches need sophisticated as well as extensive entry of data, the majority of consultants' don't apply such approaches.

Better choose simpler and extra packed in technique to this application. The one-step process provided in the 2019 ASHRAE Handbook of Fundamentals is a more simple technique for determining load of refrigeration via approach of transfer function. This approach also known as cooling load temperature differences (CLTD) technique and it uses hands-on calculations for computation of refrigeration load.

Manual measurements are performed within enclosed premises (Lecture Hall) utilizing all of the equations, calculation processes, and material described. In order to determine thermal load, all of the equations above must be used about movement of heat in the course of the premises plus the interior stack. The computations then entered into a specific application called MS Excel to achieve the study objectives.

The following are the typical bit by bit processes in estimation of overall load of heat:

- Determine the interior premises situation (Temp., RH).
- Choose exterior premises conditions (Temp., RH).
- Calculate overall coefficient of heat transfer (U_o) of each parameters of premises.
- Determine the square units for each window, door, rooftop &floor.
- Determine transmitted gain of heat.
- Determine the gain of heat from sun.
- Determine rational as well as dormant gain of heat due to aeration, permeation, plus occupant.
- Determine the illumination gain of heat.
- Determine overall gain of heat, at last
- Determine Tonnes of Refrigeration.

4. Design Condition

The quantity of refrigeration needed to make location pleasant in the summer and winter is determined by the intended inside conditions as well as the external temperatures on any particular day.

Such circumstances are considered as "Design of Indoor Environment" and the "Design of Outdoor Environment" respectively.

The following are the recommended interior temperatures and relative humidity levels for human comfort.

Table 1
Recommended interior temperatures and relative humidity levels for human comfort

Temperature-Dry Bulb (DBT)		**Humidity-Relative (RH)**	
Summer	22.7ºC - 26.1ºC	Summer	50 %
Winter	22.1⁰C - 22.2 ⁰C	Winter	20-30%

The refrigeration load of Lecture Hall is based on a dry bulb temperature (DBT) of 23 degrees Celsius and a relative humidity (RH) of 50 percent, this combination of Temperature & relative humidity depicting the scenario of indoor design.

The outside design circumstances are based on public data for the given area, which is based on weather bureau or aviation statistics. Kanpur City's suitable climatic circumstances are 41.2 ºC DBT and 45 percent relative humidity (month of May).

The refrigeration load computation for the Lecture hall is given in an MS EXCEL worksheet.

The cumulative statistical worksheet represents heat acquisition from a various parameters of heat transmission and the required load of refrigeration for cooling purpose.

WORKSHEET OF COP ESTIMATION						
PROJECT NAME	COEEFICIENT OF PERFORMANCE COMPUTATION OF A LECTURE HALL	Climatic Condition	DBT	WBT	RH (%)	
ADDRESS OF LOCATION	Naraina College Of Engineering & Technology (NCET)	Outside	41.2	21.5	45	
CITY	KANPUR/ UTTAR PRADESH (26.475 N & 80.225 E)	Inside	24		50	
MONTH UNDER STUDY	MAY (2021-22)	Diff.	17.2			
SEASON	SUMMER	No. of Air Change per Hour = 1				

Length(mtrs)	Widths(mtrs)	Elevation (mtrs)	Total Region(sq.mtrs)	Total Cubic Region (mtrs cube)
9.43	5.67	4.36	53	233
BPF = 0.12				
SOLAR HEAT GAIN THROUGH GLASS				
Entities	**Area (mtr sq.)**	**Factor**	**W/m2**	**W**
Glass(N)		0.49	43.24	0
Glass(NE)	2.4	0.14	96.14	**32.30304**
Glass (E)		0.12	144.58	0
Glass(SE)		0.15	131.5	0
Glass(S)		0.23	79.38	0
Glass(SW)		0.53	131.57	0
Glass(W)		0.53	144.58	0
Glass(NW)		0.48	96.14	0
WALLS & ROOF - SOLAR & TRANSMISSION HEAT GAIN				
Entities	**Area (mtr sq.)**	**Factor (W/m^2-^0C)**	**Temp. Diff. (^0C)**	**W**
Wall (N)		1.07	17.4	
Wall (NE)	8.93	1.07	23.7	**226.45587**
Wall (E)		1.07	25.7	
Wall (SE)		1.07	25.7	
Wall (S)		1.07	20.7	
Wall (SW)		1.07	25.7	
Wall (W)		1.07	25.7	
Wall (NW)		1.07	23.7	
SOLAR & TRANSMISSION HEAT GAIN EXCLUDING WALLS & ROOF				
Entities	**Area (mtr sq.)**	**Factor (W/m^2-^0C)**	**Temp. Diff. (^0C)**	**W**
All Glass	2.4	6.16	21.7	**320.8128**
Ceilings	53	2.48	18.4	**2439.856339**
Floor	53	4.51	2.5	**602.8528275**
HEAT GAIN THROUGH INFILTERATION				
Infiltrated Air	**Bypass**	**Factor**	**Temp. Diff. (^0C)**	**W**
3.88	1	20.44	17.2	**1364.08384**
INTERNAL SENSIBLE HEAT GAIN				
Entities		Factor		W
Attendance	60	70		**4200**
Illumination (W)	15	15		**225**
Equipments(KW)				
SUB-TOTAL OF ROOM SENSIBLE HEAT GAIN			**9411.364717**	
Heat Gain, Leak Loss & Safety Factor (5%)			**470.5682358**	
TOTAL SENSIBLE HEAT OF A ROOM (RSH)			**9881.932953**	
CALCULATION - LATENT HEAT GAIN IN A ROOM				
Infiltrated Air	Bypass	Factor	Diff. (kg/kg)	W
2.6	1	50000	0.0144	**1877.2**
Entities		Factor		W
Attendance (No.)	60	45		**2700**
Steam				
Appliances				
Vapour Transmission				
SUB-TOTAL OF ROOM LATENT HEAT GAIN			**4577.2**	
Heat Gain, Leak Loss & Safety Factor (5%)			**228.86**	
TOTAL LATENT HEAT OF A ROOM (RLH)			**4806.06**	
TOTAL HEAT GAIN IN A ROOM (RTH) = RSH+RLH			**14687.99295**	
CALCULATION - OUTSIDE AIR HEAT GAIN				
Sensible Heat Gain By Outside Air **(OASH)**				
Outside Air	**BPF**	**Factor**	**Temp. Diff. (^0C)**	**W**
2.5	0.88	20.44	17.2	**773.4496**
Latent Heat Gain By Outside Air **(OALH)**				
Outside Air	**BPF**	**Factor**	Diff. (kg/kg)	**W**
2.5	0.88	50000	0.0144	**1584**
SUB TOTAL :			**17045.44255**	
Heat Gain, Leak Loss & Safety Factor (5%)			**852.2721276**	
GRAND TOTAL :			**17897.71468**	
TONNES OF REFRIGERATION (TR) = {(W/3500)} :			**5.113632766**	

Fig. 2. Load estimation worksheet

5. Result and Outcome

This section gives the conversation of the after effects of created worksheet for refrigeration load computation of a Lecture Hall for solace cooling in a structure of Research and Training Institute. The refrigeration load computation worksheet has been independently evolved dependent on measurements readings observed and required standard values sourced from ASHRAE Fundamental Data Book for Kanpur (UP, India) 26°N latitude. A portion of the analysts and HVAC specialists compute the refrigeration load by thumb rule. In the current investigation, refrigeration load estimation worksheet has been created from ASHRAE standard and followed CLTD strategy and refrigeration load can be obtained precisely.

The optimum refrigeration loads, sensible heat proportions, latent heat proportions of the Lecture Hall with a seating of 60 all at once of Institutional structure has been determined utilizing cooling load temperature contrast (CLTD) strategy.

The detailed result including assessment of maximum Refrigeration Load required for Air conditioning of Lecture Hall, also mention as COP estimation of the Lecture Hall was carried out, and the below mentioned following statistical results have been obtained:

HEAT TRANSMISSION (W)	HEAT GAINS IN A ROOM (W)	HEAT GAIN FROM OUTSIDE	V infiltration (m3/min)
Through Glass	Sensible Heat Gain	Sensible Heat Gain	3.88
320.8128	9866.18	773.44	
Through Ceiling	Latent Heat Gain	Latent Heat Gain	
2439.85	4806.06	1584	
Through Floor	Total Heat Gain	Total Heat Gain	
602.85	14672.24	2357.44	
Maximum Total Heat Gain (W) =	**17881.17**		
Tonnes Of Refrigeration (TR) =	**5.11 (TONS)**		

Fig. 3. Result and Outcome

6. Conclusion

In this research paper, the investigation of a lecture hall, which is part of a research and training institute located in Kanpur, was taken under consideration for computation of refrigeration loads. The sensible refrigeration difference of temperature (CLTD) technique applied for obtaining overall load of refrigeration i.e. the COP of a system during the month of May in summer.

From the calculations, investigation and after effects of this exploration work, the following inferences have been made:

- Software (MS-Excel) base Refrigeration load computation can be achieved efficiently, speedily plus with extra precision.
- In the current exploration, observed about refrigeration load depends on the ambient degrees. Like the surrounding degree lowers, chilling request lowers furthermore, vice-versa.
- The developed worksheet incorporated by some stage like:
    1. Immediate sunlight based radiation heat acquire for glass windows
    2. Transmission heat acquires

3. Inward warmth acquires
4. Ventilation and invasion
5. Absolute outcome and show person

Watt (W), Kilowatt (kW), BTU/h also Ton of refrigeration (TR) can be the units of refrigeration required for the system.

People, light, infiltration, and ventilation are parameters of cooling load items that may be simply inserted into the MS-Excel software.

All the parameters involved in the process of computation of refrigeration load are of utmost importance and put in correct order definitely gives the desired outcomes for any system of air conditioning.

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