Cooling Load Calculation for an Educational Building

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Abstract— Calculating cooling load of building is important to find exact A/C equipment and air handling unit, to achieve comfort operation and good air distribution in the air-conditioned zone. It should be taking into account the highest through the building and for the load are used to get the thermal load. Then, all equations can be inserted in a personal program like M.S. Excel, to get the results. An alternative way is to use available software, like HAP 4.5 results were compared by the outcomes from HAP 4.5 program. It is shown that there is large difference between the two results due to defining the thermal resistance for the used materials of the wall, roof, and windows.

Keywords: cooling load, air-conditioning, thermal resistance, HAP, thermal load, air distribution

I. INTRODUCTION

HVAC (heating, ventilating, and air conditioning; also heating, ventilation, and air conditioning) is that the technology of indoor and vehicular environmental comfort. Its goal is to supply thermal comfort and acceptable indoor air quality. HVAC system design may be a sub discipline of engineering, supported the principles of thermodynamics, hydraulics, and warmth transfer. Refrigeration is usually added to the field's abbreviation as HVAC&R or HVACR, (heating, ventilating and air-conditioning & Refrigeration) or ventilating is dropped as in HACR (such because the designation of HACR-rated circuit breakers). This system is used to design of medium to large industrial and office buildings such as skyscrapers, onboard vessels, and in marine environments like aquariums, where safe and healthy building conditions are regulated with regard to temperature and humidity, using fresh air from outdoors. Heaters are appliances whose purpose is to urge heat (i.e. warmth) for the building. This will be done via heating system. Such a system contains a boiler, furnace, or apparatus to heat water, steam, or air during a central location sort of a room during a home, or a mechanical room during a large building. the warmth are often transferred by convection, conduction, or radiation.

II. HVAC EQUIPMENTS

1) Evaporator
2) Condenser
3) Compressor
4) Reducing expenditure
5) Oil Circulating System

In the compressor, the refrigeration oil lubricates and cools the bearing and rotor via the differential pressure of the system and inner oil circuit. At the time of exhaust of the compressor, refrigeration oil will be discharged out of the compressor together with gassy refrigerant. If the refrigeration oil cannot return to the compressor, the compressor will lack oil, which will damage the compressor. With patent designed oil reclaim system, Screw water-cooled chiller ensures that the refrigeration oil discharged together with the gassy refrigerant return to the compressor and that the unit runs safely and reliably.

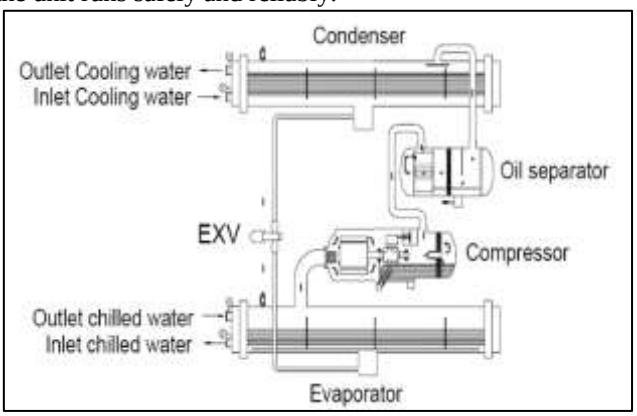
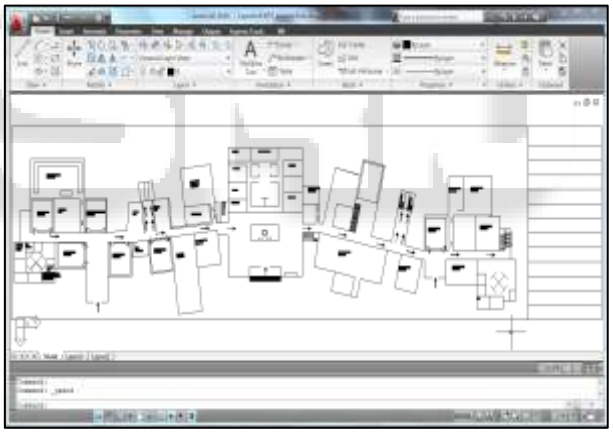


Fig. 1: Refrigeration circulating system for water-cooled screw chiller

III. BUILDING LAYOUT



IV. HOURLY ANALYSIS PROGRAM (HAP)

Carrier's (HAP) may be a computer tool which assists engineers in designing HVAC systems for commercial buildings. HAP is two tools in one. First it's a tool for estimating loads and designing systems. Second, it's a tool for simulating building energy use and calculating energy costs. In this capacity it's useful for LEED®, schematic design and detailed design energy cost evaluations. Hourly Analysis Program uses the ASHRAE-endorsed transfer function method for load calculations and detailed 8,760 hour- by-hour simulation techniques for the energy analysis. HAP is released as two separate, but similar products. The "HAP System Design Load" program provides system design and cargo estimating features. The full "HAP" program provides an equivalent system design capabilities plus energy analysis features. This Quick Reference Guide deals with both program.

This System Design Features. HAP estimates design cooling and heating loads for commercial buildings in order to determine required sizes for HVAC system components. Finally, the program provides information needed for selecting and specifying equipment. Specifically, the program performs the following tasks:

- Calculates design cooling and heating loads for spaces, zones, and coils in the HVAC system.
- Determines required airflow rates for spaces, zones and the system.
- Sizes cooling and heating coils.
- Sizes air circulation fans.
- Sizes chillers and boilers.

This system's Energy Analysis Features. HAP estimates annual energy use and energy costs for HVAC and non-HVAC energy consuming systems in a building by simulating building operation for each of the 8,760 hours in a year. Outcomes of the energy analysis are used to compare the energy use and energy costs of alternate HVAC system designs so the best design can be chosen. HAP performs the following tasks during an energy analysis:

- Simulates hour-by-hour operation of all heating and air conditioning systems in the building.
- Simulates hour-by-hour operation of all plant equipment in the building.
- Simulates hour-by-hour operation of non-HVAC systems including lighting and appliances.
- Uses results of the hour-by-hour simulations to calculate total annual energy use and energy costs.
- Costs are calculated using actual utility rate features such as stepped, time-of-day and demand charges, if specified.
- Gather Data. Before design calculations can be performed, information about the building, its environment and its HVAC equipment must be gathered.

This process involves extracting data from building plans, evaluating building usage and studying HVAC system needs. Specific types of information needed include:

- Climate data for the building site.
- Construction material data for walls, roofs, windows, doors, exterior shading devices and floors, and for interior partitions between conditioned and non-conditioned regions.
- Building size and layout data including wall, roof, window, door and floor areas, exposure orientations and external shading features.
- Internal load characteristics determined by levels and schedules for occupancy, lighting systems, office equipment, appliances and machinery within the building.
- Data concerning HVAC equipment, controls and components to be used,

V. DATA SHEET OF AREA AND EQUIPMENTS

Table 1 shows the data sheet of area, equipments and number of people due to which heat transfer takes place.

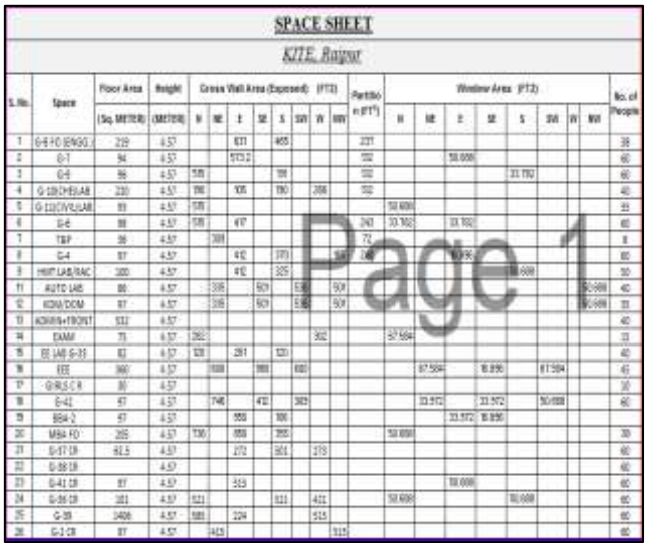


Table 1: Data sheet of area and equipments

VI. HAP ANALYSIS (ENTER DATA INTO HAP)

Use HAP to enter climate, building and HVAC equipment data. When using HAP, your base of operation is the main program window. From the main program window, first create a new project or open an existing project. Then define the following types of data which are needed for system design work:

A. Enter Weather Data

Weather data defines the temperature, humidity and solar radiation conditions the building encounters during the course of a year. These conditions play an important role in influencing loads and system operation. To define weather data, a city can be chosen from the program's weather database, or weather parameters can be directly entered. Weather data is entered using the weather input form.

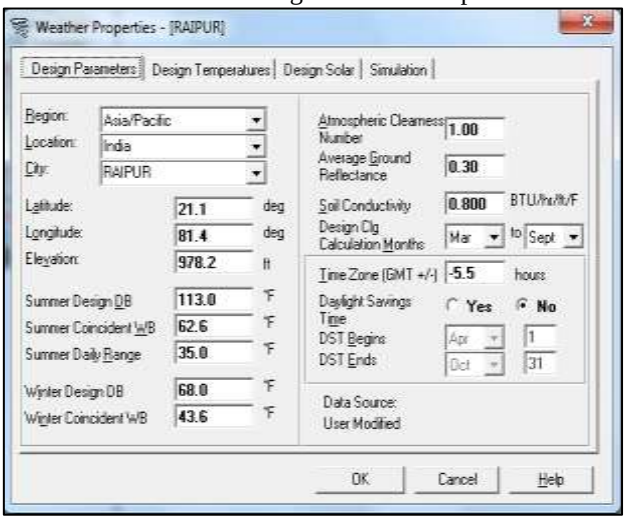


Table 2: Weather properties design parameters

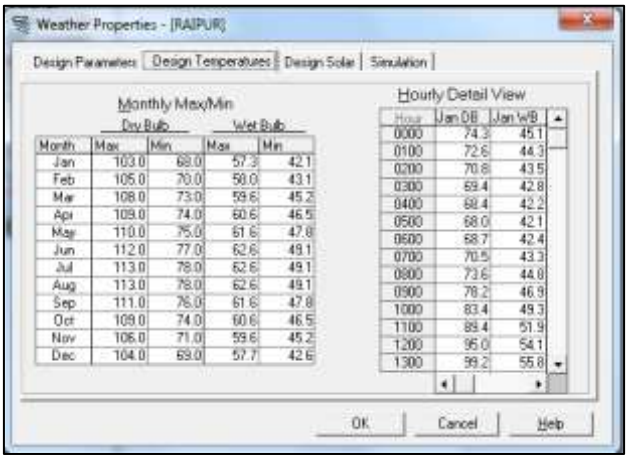


Table 3: Weather properties design temp.

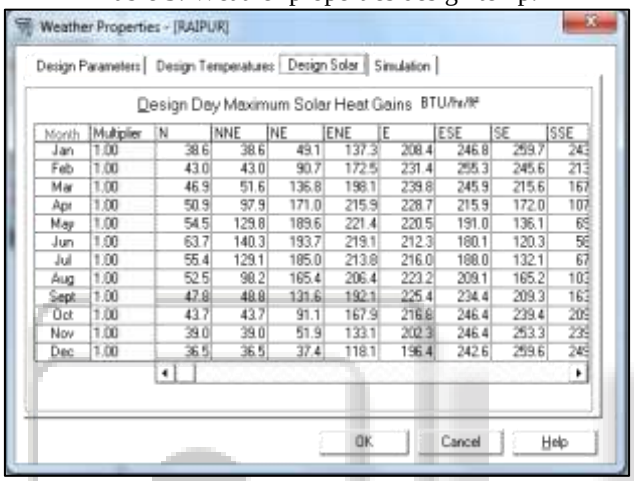


Table 4: Weather properties design solar.

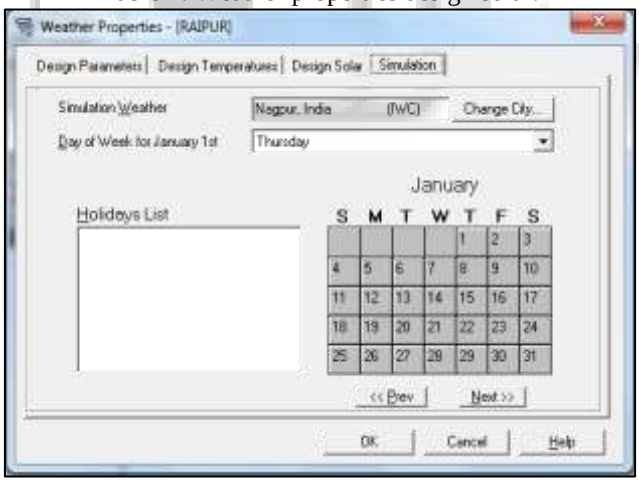


Table 5: Weather properties simulation.

B. Enter Space Data:

The space is a region of the building comprised of one or more heat flow elements and served by one or more air distribution terminals. Usually a space represents a single room. The explanation of a space is flexible. For more applications, it is more efficient for a space to represent a group of rooms or even an entire building.

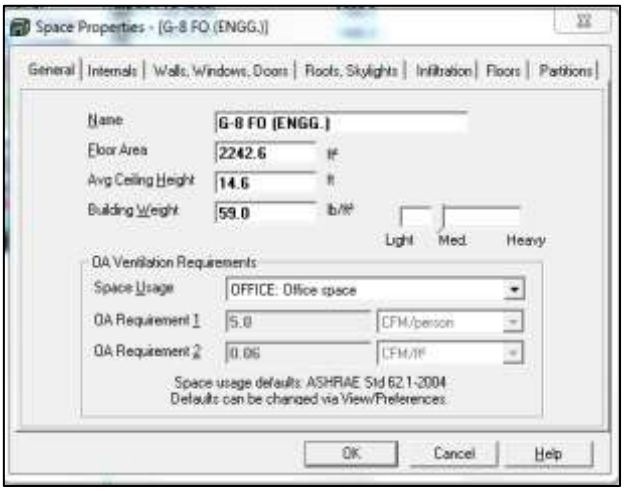


Table 6: Space properties general

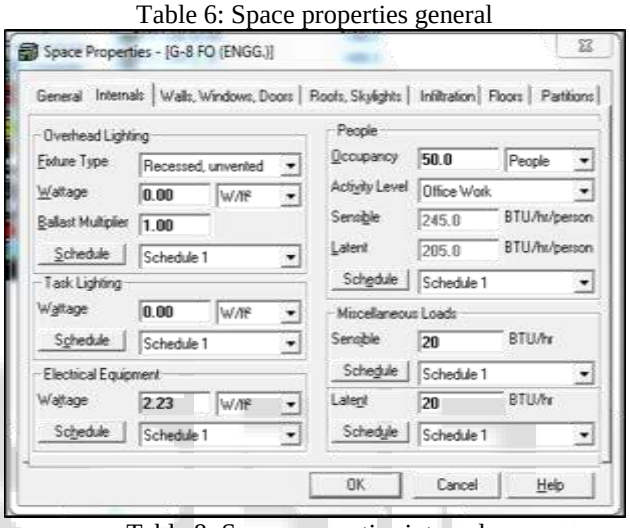


Table 8: Space properties internals.

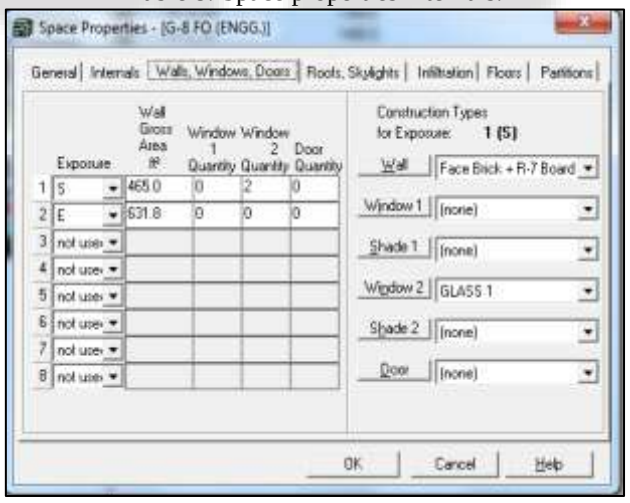


Table 9: Space properties walls, windows, doors.

C. Enter Air System Data.

Air System is the equipment and controls used to provide cooling and heating to a region of a building. An air system serves one or more zones. Zones are group of spaces having a single thermostatic control. This system includes central station air handlers, packaged rooftop units, packaged vertical units, split systems, packaged DX fan coils hydraulic fan coils and water source heat pumps. In all cases, the air system also includes associated ductwork, supply terminals and controls.

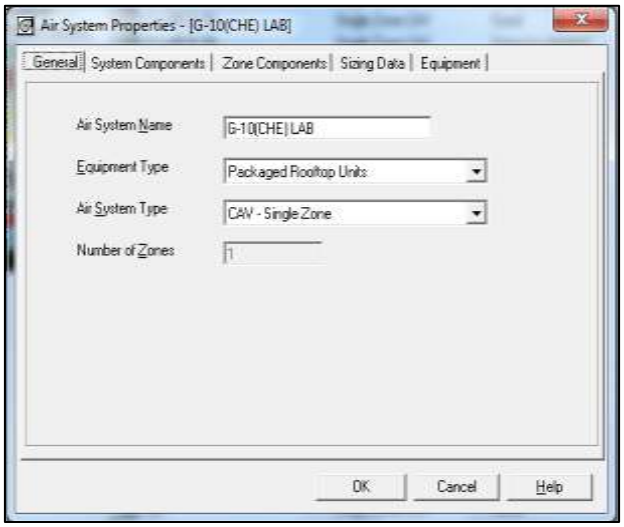


Fig. 2: Air system properties general

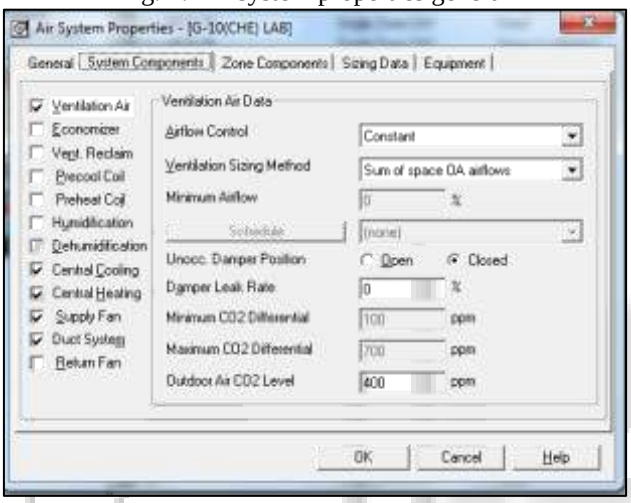


Fig. 3: Air system properties system components.

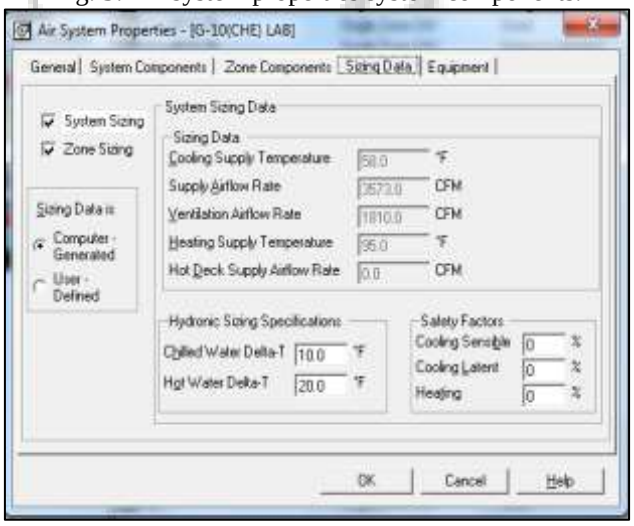


Fig. 4: Air system properties sizing data.

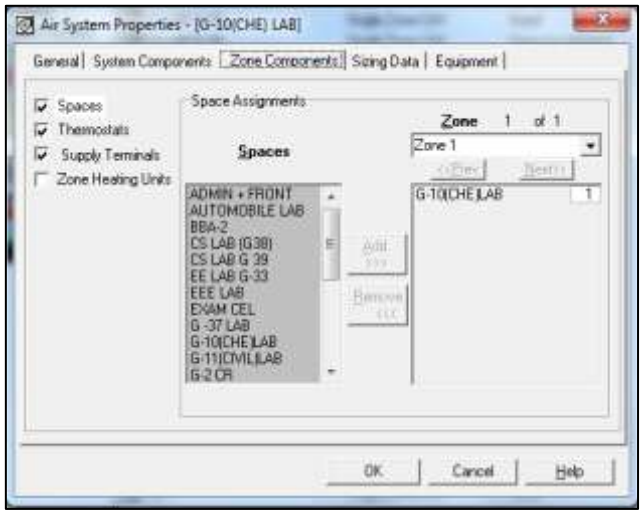


Fig. 5: Air system properties zone components.

VII. COOLING LOAD CALCULATION

When we start cooling load calculation, it is required to know how much area to be maintain for human comfort, what are the sources of heat emission (like peoples, electrical equipment etc.) location of area. First start with measure dimensions of classrooms, labs, cabins, and whole building area and also measure exposed parts. Then conceder how many things are there which is emitting heat like peoples, equipments, lights etc. and make a tabulated form that attached below, called Data sheet, and make a Layout of the building, only ground floor. This layout is made in Auto Cad software version 2010. Then all data put in HAP 4.5 version to calculating optimum cooling load in Tons. Table 10 shows he load calculation sheet for different areas and Table 11 shows cooling load cost estimation.

LOAD CALCULATION BY RULE OF THUMB

KITE, Raipur

S. No.	Space	Area (Sq. METER)	MULTIPLYING FACTOR	LOAD (TONNS)	PRESENT TONNS	HAP TONNS
1	G-8 FO (ENGG.)	219	0.07	15.33	25.5	12.5
2	G-7	94	0.07	6.58	6	5
3	G-9	96	0.07	6.72	6	4.6
4	G-10(CHE)LAB	220	0.07	15.4	16	10.9
5	G-11(CIVIL)LAB	93	0.07	6.51	6	4.8
6	G-6	98	0.07	6.86	6	5
7	T&P	36	0.07	2.52	2	1.1
8	G-4	97	0.07	6.79	6	4.7
9	HMT LAB/RAC	100	0.07	7	8	5.2
10	G-2	97	0.07	6.79	6	5.2
11	AUTO LAB	86	0.07	6.02	6	5.2
12	KOM/DOM	97	0.07	6.79	6	4.7
13	ADMIN+FRONT	532	0.07	37.24	36	24.9
14	EXAM	75	0.07	5.25	6	1.9
15	EE LAB G-33	82	0.07	5.74	8	4.7
16	EEE	360	0.07	25.2	24	19
17	GIRLS C R	30	0.07	2.1	2	1.9
18	G-42	97	0.07	6.79	6	4.3
19	BBA-2	97	0.07	6.79	6	4.5
20	MBA FO	205	0.07	14.35	12	11.4
21	G-37 CR	63	0.07	4.41	6	3.5
22	G-38 CR	132	0.07	9.24	12	5.3
23	G-41 CR	90	0.07	6.3	6	4
24	G-36 CR	97	0.07	6.79	6	5.3
25	G-39	100	0.07	7	6	4.6
	TOTAL			**230.51**	**235.5**	**164.2**

Table 10: Load calculation by rule of thumb (data sheet in excel)

Cost Estimation Table						
S. No.	Space	HAP (TONNS	Company of AC	No. of AC	Total Cost of purchesing in	Rating in Star
1	G-8 FO (ENGG.)	12.5	Blue Star	7	324000	*****
2	G-7	5	Blue Star	3	144000	*****
3	G-9	4.6	Blue Star	2	96000	*****
4	G-10(CHE)LAB	10.9	Blue Star	6	288000	*****
5	G-11(CIVIL)LAB	4.8	Blue Star	3	144000	*****
6	G-6	5	Blue Star	3	132000	*****
7	T&P	1.1	Blue Star	1	36000	*****
8	G-4	4.7	Blue Star	3	132000	*****
9	HMT LAB/RAC	5.2	Blue Star	3	132000	*****
10	G-2	5.2	Blue Star	3	132000	*****
11	AUTO LAB	5.2	Blue Star	3	132000	*****
12	KOM/DOM	4.7	Blue Star	3	132000	*****
13	ADMIN+FRONT	24.9	Blue Star	13	624000	*****
14	EXAM	1.9	Blue Star	1	48000	*****
15	EE LAB G-33	4.7	Blue Star	3	132000	*****
16	EEE	19	Blue Star	10	480000	*****
17	GIRLS C R	1.9	Blue Star	1	48000	*****
18	G-42	4.3	Blue Star	3	132000	*****
19	BBA-2	4.5	Blue Star	3	132000	*****
20	MBA FO	11.4	Blue Star	6	288000	*****
21	G-37 CR	3.5	Blue Star	2	84000	*****
22	G-38 CR	5.3	Blue Star	3	132000	*****
23	G-41 CR	4	Blue Star	2	96000	*****
24	G-36 CR	5.3	Blue Star	3	132000	*****
25	G-39	4.6	Blue Star	3	132000	*****
Total		164.2		93	4284000	

Table 11: Cooling load cost estimation table

VIII. Results and Discussion

By creating the space sheet of the considered building which is meant for education purpose and considering all the constructional, location and climatic details of the building, cooling load calculation in been performed very effectively which shows the optimum result of (164.2 ton). We also calculated the load by thumb rule for the same building which results around (230.51 ton). The precise calculation carried out in this project shows very much accurate results in the form of tonnage to design the HVAC system for educational building which finally will result in the savings both in energy terms and monetary terms and also the space will be cooled very effectively.

IX. Conclusion

Cooling load analysis has been conducted for educational building exists in hot and humid area in Raipur. HAP program produced by carrier was used for cooling load estimation. Hand calculation was used to verify the results. According to the load analysis, suitable air-conditioning systems were selected for the building. Energy analysis was done to calculate the effective of the system which shows good performance.

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