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Comparison of Cooling Load Calculations by using Theoretical Analysis and E-20 Software for Aesthetic Clinic with Time Series

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ABSTRACT

This paper provides the calculating of cooling load by using not only theoretical analysis and cooling load software (E-20) for aesthetic clinic. According to the surveys and measurement, the materials used for this clinic are roof with steel sheet without insulation but with finished ceiling, 10 cm thickness single clear glass with interior curtain shades and wall with 10 cm common brick with 2.5 cm insulation are used. According to the theoretical analysis, the clinic required 124.53 KW while required 131 KW based on E-20 software. The values difference between theoretical analysis and E-20 software for this clinic is 5%.

KEYWORDS: *air-conditioning, aesthetic clinic, cooling load, theoretical analysis, E-20 software*

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I. INTRODUCTION

Air conditioning is the process of altering the properties of air (humidity and temperature) to favourable conditions, typically with the aim of distributing the conditioned air to an occupied space is to improve human thermal comfort [1]. The use of air conditioning systems for residential and domestic buildings were very minimum in the earlier days of 1980's. Due to the technology advancement and industrial growth buildings were started construction in a closed area and construction of apartment also increased after 1980's with increased population. Hence air conditioning has become an essential commodity for residential and domestic building because of the climate changes [2,3].

The building choose for cooling load calculation was Marvel Aesthetic Clinic and this building is located at Hlaing township, Yangon. This study concentrates on calculating of cooling load by using not only theoretical analysis and also E-20 software for aesthetic clinic. The purpose of this paper is to know how much the values difference occur between these two methods for this clinic.

II. THEORY OF COOLING LOAD

The heat gains for cooling load calculation consist of the following for the building envelop.

Firstly, conduction through exterior walls, roof, glass and then conduction through interior partitions, ceilings, floors, solar radiation through glass, lighting, heat liberated from the occupants and equipment.

2.1. Total Cooling Load

The total building cooling load consists of heat transferred through the building envelope (walls, roof, floor, windows, doors etc.) and heat generated by occupants, equipment, and lights. The load due to heat transfer through the envelope is called as external load, while all other loads are called as internal loads. The grand total cooling load on any building consists of both sensible as well as latent load components. The sensible load affects dry bulb temperature, while the latent load affects the moisture content of the conditioned space.

Buildings may be classified as externally loaded and internally loaded. In externally loaded buildings the cooling load on the building is mainly due to heat transfer between the surroundings and the internal conditioned space. In internally loaded buildings the cooling load is mainly due to internal heat generating sources such as occupants or appliances or processes. In general, the heat generation due to internal heat sources may remain fairly constant, and since the heat transfer from the variable surroundings is much less compared to the internal heat sources, the cooling load of an internally loaded building remains fairly constant. Obviously from energy efficiency and economics points of view, the system design strategy for an externally loaded building should be different from an internally loaded building. Hence, prior knowledge of whether the building is externally loaded or internally loaded is essential for effective system design.

The external loads consist of heat transfer by conduction through the building walls, roof, floor, doors etc., heat transfer by radiation through fenestration such as windows and skylights. All these are sensible heat transfers. In addition to these the external load also consists of heat transfer due to infiltration, which consists of both sensible as well as latent components. The heat transfer due to ventilation is not a load on the building but a load on the system. The various internal loads consist of sensible and latent heat transfer due to occupants, products, processes and appliances, sensible heat transfer due to lighting and other equipment. In addition, heat gain from miscellaneous sources includes supply fan heat load, duct heat gain, duct leakage and diversity factors like usage and are applied to the refrigeration capacity of large air-conditioning systems. The grand total cooling load consists of heat transfer through building envelope (external heat gains), heat generated by occupants, equipment, lightning and ventilation (internal heat gains) as well as and miscellaneous heat gains. [7]

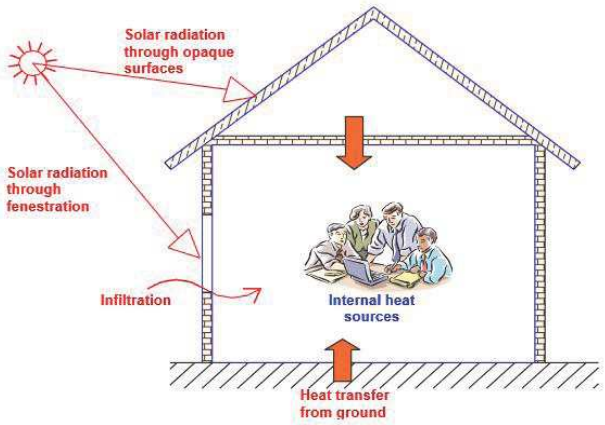

Figure 1 The heat gains for the buildings

2.2. The equations for cooling load calculation

The cooling load calculation with theoretical analysis may be obtained from the following equations,

Solar Radiation through Glass

Radiation energy from the sun passes through transparent materials such as glass which become a heat gain to the room. Its value varies with time, orientation, shading and storage effect. The net heat gain can be found from the following equation.

Q = SHGF x A x SC x CLF

Conduction through Exterior Structure

The conduction heat gains through exterior roof, wall and glass are each found from the following equation.

Q = U x A x CLTD

Conduction through Interior Structure

The heat that flows from interior unconditioned spaces to the conditioned spaced through partitions, floor and ceiling can be found with the following equation.

Q = U x A x TD

Corrected cooling load Temperature difference

The corrected cooling load temperature equation is

CLTD c = [(CLTD + LM) + (25 – TR) + (TA– 29)]

Lighting

The equation for determining heat gain from lighting is

Q = W x BF x CLF

People

The heat gain from people is composed of two parts, sensible heat and latent heat resulting from perspiration. Some of the sensible and heat may be absorbed by the heat storage effect, but not the latent heat. The equation for sensible and latent heat gains from people are:

Q S = q s x n x CLF

Q L = q l x n

2.3. Design Assumptions

The amount of cooling load for the building are mostly depends on the usage of building construction materials, shading, orientation. Therefore, building materials is important for cooling load calculation. When calculating the cooling load, the outside temperature is based on the hourly change of temperatures throughout the day. Desired inside temperature (TR) is taken as 23 °C. The maximum people capacity of this clinic is assumed as 10. The design materials for the existing building is shown in Table 1.

Table 1 Design Specification for Marvel Aesthetic Clinic

Project Name	MarvelAesthetic Clinic
Building Location	Shwe Myanmar Mya Condo,Panita Road, Hlaing Township.
	16.8508 North Latitude, 96.1156 East Longitude.
Elevation	Hlaing Township, Yangon, Myanmar.
	1.83 meter over the sea level.
Roof	Steel Sheet without Insulation but with Finished Ceiling
Glass	10 cm thickness single clear glass with curtain
Wall	15cm commonbrick and 2.5 cm insulation.

III. METHODOLOGY

The methodology used in this study was calculating the cooling load by using not only theoretical analysis and also cooling load software (E-20) from carrier.

In first step, calculate the area of the aesthetic clinic by using auto-cad drawing software. In the next step, choose the design month for the building from SHGF table based on the latitude of Yangon (16.8508N) and facing direction of glass and the correction of latitude and month applied to wall and roof table. According to the latitude of Yangon, commonly the maximum temperature occurring in Yangon is in afternoon at April. And then, choose the desired inside temperature (TR) is obtained from the ASHRAE standard is taken as 23 °C for theoretical analysis and also outside temperature of Yangon (TA) is derived on the hourly change of temperatures throughout the day. According to the building specifications, read the factors from tabulated data table like Shading Coefficient (SC), Cooling load factor (CLF), Solar heat gain factor (SHGF), Cooling load temperature different (CLTD), Thermal transmittance (U), etc. For the cooling load stimulation with hourly analysis program, the overall heat transfer coefficient for building construction materials are taken from ASHRAE fundamental handbooks. The outside temperature for E-20 software is also taken hourly changes temperature provided by the software.

3.1. Area of the Clinic

By using Auto-CAD drawing software, the area of the clinic is shown in Table 2.

Table 2 Area of the Clinic

Area/Facing	East (m2)	West (m2)	South (m2)	North (m2)
Glass Area	-	8.046	2.56	4.019
Wall Area	28.747	33.203	27.472	19.033
Total Area	28.747	41.249	30.032	23.052

IV. Cooling Load Calculation by Using Theoretical Analysis

The building choose for cooling load calculation is Marvel Aesthetic Clinic and it is located Shwe Myanmar Mya Condo, Panita Road, Hlaing Township., Yangon. The area of the whole clinic is 123.08 square meter and has large facing glass surface area in west direction.

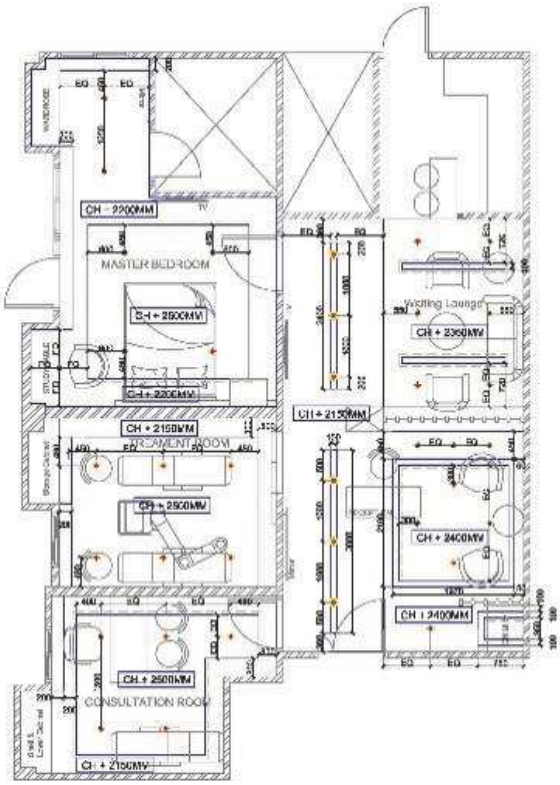

Figure 2 Aesthetic Clinic Plan Drawing

4.1. Cooling Load Calculation for Clinic by Using Theoretical Analysis

By using the above mention equations, the cooling load calculation for this clinic are as follow:

Table 3 Total Cooling Load with Time Series Method Between 10 Hr. – 17 Hr. for clinic by Using Theoretical Analysis

Operating Hours	Outside Design Temperature TA(°C)	Q Total (KW)
10 Hr.	27.9 °C	10.14
11 Hr.	29.2 °C	11.97
12 Hr.	30.4 °C	13.57
13 Hr.	31.4 °C	15.68
14 Hr.	32 °C	16.05
15 Hr.	32.2 °C	19.13
16 Hr.	32 °C	19.41
17 Hr.	31.4 °C	18.58
10 Hr. –17 Hr.	-	124.53

V. Cooling Load Calculation by Using E-20 Software

(E-20) software is a computer tool which assist engineers in designing HVAC systems for commercial buildings. E20 software is also known as the Hourly Analysis Program (HAP), manufacture from the Carrier. In this paper version 4.9 of North American Edition is used.

The procedure of the hourly analysis program (E-20) software is to set the weather conditions of the respective regions. And then enter construction materials specification like wall, window, roof and partition, overall heat transfer coefficients. After that go to the enter space data like floor area, ceiling height, building weight and space usage etc. And set the building materials usage in detail like wall, window, doors orientation, area, numbers of window and door, type of roof, slope of roof, roof area and type of floor. And then, enter system data like type of system, system components, zone components, sizing data etc. and also define the thermostat running hours. And finally go to the generate simulation reports and then evaluate the result.

The input data of HAP program are the area of the wall, floor, window, roof, partition and the overall heat transfer coefficient for construction materials, weather, space usage, ceiling height, building weight, fixture types, lightening and electrical equipment's watt, number of people, location, shading and orientation.

The output result are total coil load (sensible and latent coil load), air system design load, generate peak cooling load in tabular and graphical energy and loads reports of hourly, daily, monthly and annual data, building energy modeling, refrigerant piping design and schematic design.

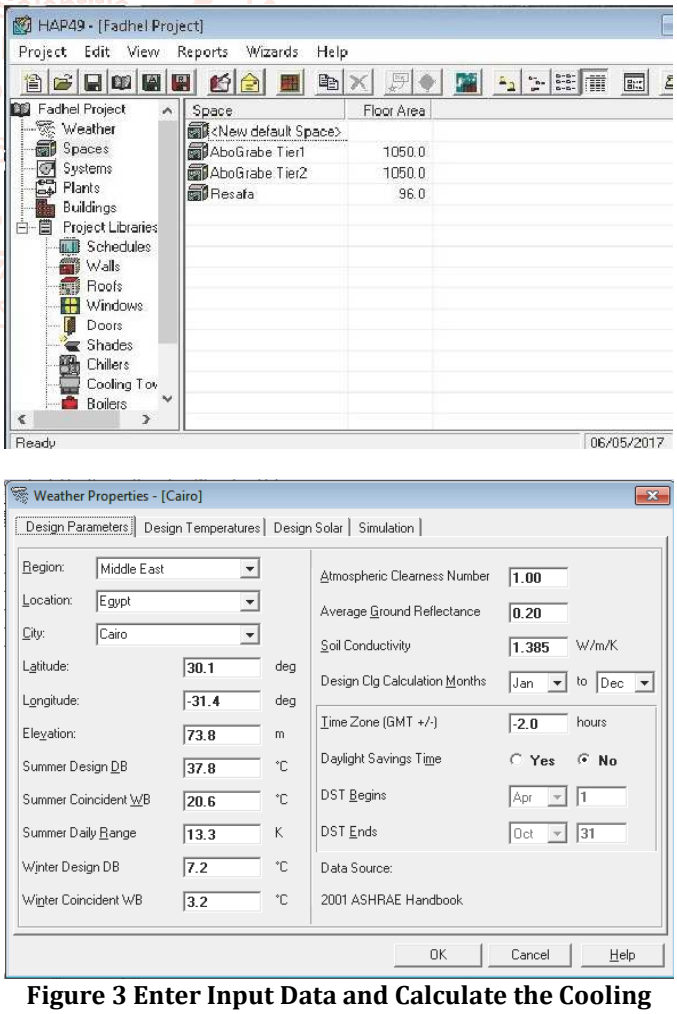

Figure 3 Enter Input Data and Calculate the Cooling Load by Using E-20 Software

Table 4 show the stimulation of cooling load for aesthetic clinic

Table 4 E-20 Print out Sheet for Clinic

DESIGN MONTH: APRIL				
Hour	OA TEMP (°C)	SUPPLY AIRFLOW (L/s)	CENTRAL COOLING SENSIBLE (kW)	CENTRAL COOLING TOTAL (kW)
0	25.8	394	5.5	8.3
100	25.5	382	5.3	8
200	25.1	370	5.1	7.8
300	24.8	359	4.9	7.5
400	24.5	349	4.8	7.3
500	24.4	341	4.7	7.1
600	24.6	345	4.7	7.2
700	25	383	5.3	8
800	25.7	458	6.4	9.6
900	26.7	542	7.8	11.5
1000	27.9	621	9.2	13.4
1100	29.2	686	10.4	15.1
1200	30.4	735	11.4	16.4
1300	31.4	771	12.1	17.4
1400	32	785	12.5	18.9
1500	32.2	772	12.3	18.0
1600	32	730	11.6	17.0
1700	31.4	653	10.2	14.8
1800	30.6	552	8.4	12.4
1900	29.6	494	7.4	10.9
2000	28.6	463	6.8	10.1
2100	27.7	442	6.4	9.6
2200	26.9	424	6.1	9.1
2300	26.3	408	5.8	8.7

Table 5 Total Cooling Load for clinic by Using E-20 Software

Operating Hours	Outside Design Temperature TA(°C)	Q Total (KW)
10 Hr.	27.9 °C	13.4
11 Hr.	29.2 °C	15.1
12 Hr.	30.4 °C	16.4
13 Hr.	31.4 °C	17.4
14 Hr.	32 °C	18.9
15 Hr.	32.2 °C	18.0
16 Hr.	32 °C	17.0
17 Hr.	31.4 °C	14.8
10 Hr. –17 Hr.	-	131.00

VI. CONCLUSION AND DISSCUSSION

According to the theoretical analysis, the clinic required 124.53 KW while required 131 KW based on E-20 software. The values difference between theoretical analysis and E-20 software is 5%. The centralized air conditioning system is selected for the aesthetic clinic. It has the advantage of more efficient cooling, noiseless and comfort for the people.

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NOMENCLATURE

SHGF - maximum solar heat gain factor. W/(m²K)
A - Area of the glass, wall, roof. m².
Q - Heat Conduction through interior structure (or) exterior structure (or) net solar radiation through glass. W
SC - Shading Coefficient
CLF - Cooling load factor
U - Thermal transmittance (or) Heat transfer coefficient. W/(m²K)
TD - Temperature difference between unconditioned and conditioned space. C
CLTD - Corrected Cooling load temperature difference. C
CLTD - Cooling load temperature difference. C
TR - Room temperature (or) Desired inside temperature. C
TA - Outdoor design temperature. C
LM - Correction for Latitude and month
Q S - Sensible Heat Gain. W
Q L - Latent Heat Gain. W
q S - Sensible Heat Gain Per Person. W
q L - Latent Heat Gain Per Person. W
BF - Ballast Factor.
CLF - Cooling Load Factor.

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