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Calculation for Design Peak Time of Commercial Building using Theoretical Analysis in Tropical Climate Country

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ABSTRACT

This paper provides the calculating of peak time on various possible hours during operating time. According to the surveys and measurement, the peak time will occur at March (due to the facing of glass) and April (due to the wall and roof). In addition, the value of solar heat gain factor (SHGF) in March for this building is greater than the April on the direction of East, South and West and the SHGF for April is greater than the March on North based on the latitude of Yangon (16.7875N). According to the theoretical analysis, the peak load occurs at 16hour (4PM) in March with the amount of 40.459 KW for 4th floor of building envelope.

KEYWORDS: *air-conditioning, design month peak time, cooling load, peak load*

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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 peak time calculation was 5 story RC building and this building is located at Mingalar Taung Nyunt Township, Yangon and the name of the building is Myanmar Medical Association (Central). This study concentrates on calculating the peak time on various possible hours during operating time for commercial building. The purpose of the peak time calculation is to know the design month and design time for the specified building. In this paper, the calculation of the area of the building by using the Auto-Cad drawing software and the peak time calculation for different hours (15hr, 16hr, 17hr) by using numerical analysis.

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 after finally solar radiation through glass.

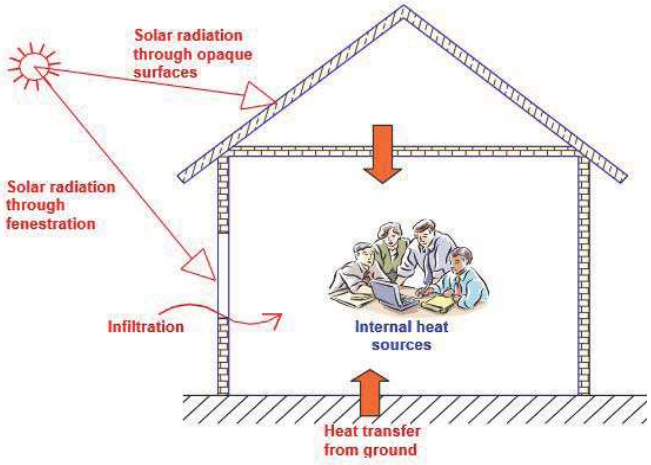

Figure 1 The heat gains for the buildings

2.1. Determination for the peak time

For west facing glass maximum total heat gains occur in mid-summer in the afternoon. For east facing glass maximum total heat gains occur in early or mid-summer in the morning. For south facing glass maximum total heat gains occur in the fall or winter in early afternoon. For south-west facing glass maximum total heat gains occur in the fall in the

afternoon. For roofs and the walls maximum heat gain occur in the summer in the afternoon or evening.

2.2. The equations for calculating the peak time

The peak time calculating for different hours 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)]

2.3. Design Parameter

The amount of cooling load in the building envelope depend on the roof, wall, glass, building materials, shading and orientation. Therefore, building materials is important when calculating the cooling load. This is the design materials for the existing building. Roof is 10.16-cm light-weight concrete with suspended ceiling. Single clear glass with 15.24cm thickness and there is no colour coating and glass with interior shading (grey curtain) for north and east and without shading for south and west. Wall with 10.16cm face brick and 2.54cm aluminium composite panel insulation so type of wall is group C. Outside temperature (TA) of Yangon is derived from weather focus data collected for the last 8 years. Desired inside temperature (TR) is obtained from the ASHRAE standard.

2.4. Design Consideration

For the estimation of peak time, choose the 4th floor which belongs to the most glass and wall area and also it directly exposed with the flat roof. Cooling load temperature difference for flat roof and wall occur at 15hr, 16hr and 17hr. The maximum CLTD for glass occur at 15hr and 16 hr. So, the possible hours for peak time calculation are 15hr, 16hr and 17 hr. According to the tabulated data tables, the peak time will occur at March (due to the facing of glass) and April (due to the correction of latitude and month applied to wall and roof).

III. METHODOLOGY

The methodology used in this study was calculating the peak load by using the auto-cad drawing software and numerical analysis and choose the peak time base on the peak load.

In first step, calculate the area of the entire building and area of each floor by using auto-cad drawing software. After that compare the area of glass and wall of each floor and select the 4th floor which belong not only glass and wall area also direct expose with the flat roof area. In the next step, choose the design month for the building from SHGF table based on the latitude of Yangon (16.7875N) and facing direction of glass and the correction of latitude and month applied to wall and roof table. And then, choose the desired inside temperature (TR) is obtained from the ASHRAE standard and also outside temperature of Yangon (TA) is derived from the weather focus data collected for the last 8 years. 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. After that, calculate the peak time for different solar times and finally choose the peak time based on the peak load.

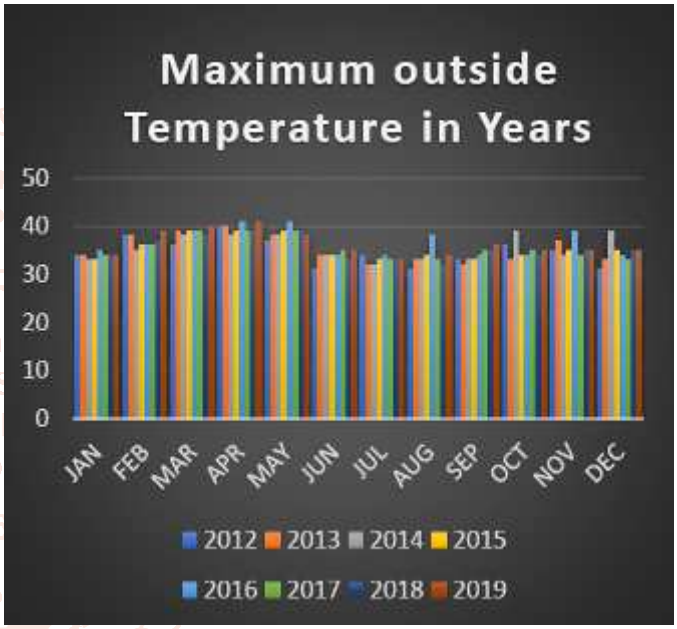

Figure 2 Maximum outside Temperature of Yangon between (2012-2019)

IV. PEAK TIME CALCULATION

The building choose for peak time calculation is located at Thein Phyu road, Mingalar Taung Nyunt Township, Yangon and the name of the building is Myanmar Medical Association (Central). The glass area of the whole building is 293.93 square meter and has large facing glass surface area in south direction.

4.1. Area of the whole building and 4th floor

By using Auto-CAD drawing software, the area of the whole building [Table 1] and 4th floor area [Table 2] are as follows:

Table 1 Area of the whole building

Area/Facing	East (m2)	West (m2)	South (m2)	North (m2)
Glass Area	72.46	39.52	113.92	68.03
Wall Area	243.41	276.35	274.36	320.25
Total Area	315.87	315.87	388.28	388.28

Table 2 Area of the 4th Floor

Area/Facing	East (m2)	West (m2)	South (m2)	North (m2)
Glass Area	14.49	7.90	25.90	13.37
Wall Area	62.62	69.21	66.63	79.16
Total Area	77.11	77.11	92.53	92.53

The 4th floor has more glass and wall area, more directly exposed with the roof. So, the 4th floor is used for peak time estimation.

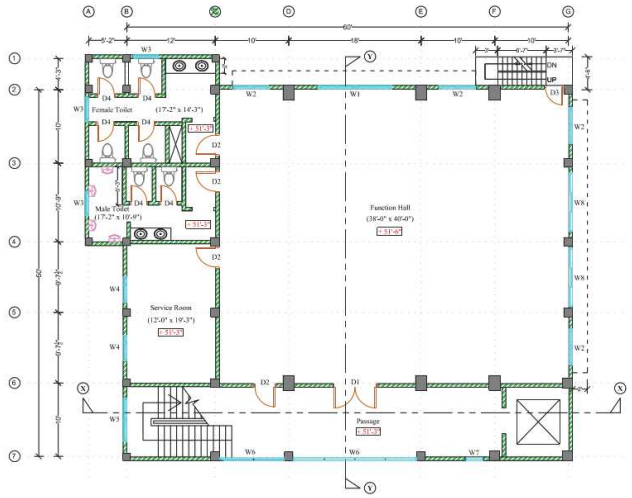

Figure 3 Fourth Floor Plan Drawing

4.2. Peak time calculation for March and April

By using the above mention equations, the peak time calculation for March and April are as follow:

Table 3 Peak load calculation on various times (15hr, 16hr, 17hr) during operating hours for March

Solar time (hour)	Q (glass)	Q (roof)	Q (wall)	Total load (Watts)
15hr	21733.29	5557.72	12904.56	40195.57
16hr	21558.85	5996.48	12904.56	40459.89
17hr	20757.99	6289.00	13031.85	40078.84

Table 4 Peak load calculation on various times (15hr, 16hr, 17hr) during operating hours for April

Solar time (hour)	Q (glass)	Q (roof)	Q (wall)	Total load (Watts)
15hr	18044.97	5703.97	12904.56	36653.50
16hr	18222.08	6142.74	12904.56	37269.38
17hr	17808.57	6435.25	13031.85	37275.66

According to table 03 and table 04, the peak load occurs at 16hr (4PM) in March.

V. CONCLUSION AND DISSCUSSION

Cooling load temperature difference for flat roof and wall occur at 15hr, 16hr and 17hr. The maximum CLTD for glass occur at 15hr and 16 hr. So, the possible hours for peak time calculation are 15hr, 16hr and 17 hr. According to the surveys and measurement, the peak time will occur at March (due to the facing of glass) and April (due to the wall and roof). Based on peak load calculation, the peak time for March is at 16hour (4PM) and April also at 16hour (4PM). So, the design time is 16hour (4PM). Comparison of the design time 16hour (4PM) between March and April, the peak load for March is higher than the April. Therefore, the design month is March with the amount of 40.459 KW. So, the design month and hour is the March at 16hour (4PM) for the specified building.

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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

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