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Calculation of the Green Building Index (GBI) for commercial buildings during the design phase by taking advantage of quantitative factors

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Abstract

The evaluation of green building is very important to obtain a sustainable building that meets the requirements of agreed-upon evaluation systems and classification of building to accredited, silver, gold, or platinum. As we know, sustainable construction plays a major role in providing for current needs and securing the needs of future generations. This study aims to increase the number of evaluation points for the green building indicators during the design phase through some quantitative indicators to support the evaluation process and to increase the building evaluation points. In our results we have achieved about 13.552536 evaluation points out of a total of 15.17305 evaluation points, for five indicators, which are the cooling load index, the energy efficiency index, the water consumption index, the building transparency index, and the percentage of green coverage. These results will support the evaluation team in improving the classification of buildings, obtaining the approved building, and enhancing the accredited certificate according to the required specifications.

Keywords: ASHRAE, green building index, BIM vision, IFC, BIM

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1. Introduction

Currently, the world is experiencing a severe paucity of resources in different fields, including energy, materials, water, etc., in addition to widespread desertification, an increase in population, and a dearth of precipitation. This indicates that the challenges that must be overcome in order to meet the requirements of the current generation, also preserving the lives of next generations will be far more difficult.

EDSL Tas software[1] is one of the options for dynamic thermal simulation generation with ASHRAE [2] .that when utilizing the EDSL Tas software for a completely glazed facade in Santiago, the cooling and heating energy demand might approach 115 kWh/m^2 in the span of a single year [3]. In addition, the amount of energy required for heating and cooling the space will be 25 kWh/m^2 if the WWR is 20% and there is external sun protection and selective glazing. If night ventilation is used during cooling seasons, an additional 37% decrease will be achieved in cooling energy use. When temperatures are low, the use of artificial energy to maintain a suitable indoor climate is essential. In addition to this, the form and envelope of the building can have an effect on the climate inside [4].

Windows are one of the most vulnerable components of a building's exterior in warm regions of Europe, particularly when it comes to the process of cooling the interior of the building. If the thermal transmittance of the clear glass is between 2.00 W/m^{2}K and 3.00 W/m^{2}K, then the performance of the clear glass in terms of sustaining cooling loads is extremely good [5].

Controlling thermal comfort conditions and reducing cooling loads can be accomplished by opening windows and making use of natural ventilation. This can be accomplished by maintaining a physical link with the exterior and by operating windows. In addition, the use of natural ventilation will enhance the quality of the air inside[6],[7] The percentage of the window that is opened should be determined by the exterior air temperature, the time of year, the time of day, and the occupancy pattern [8],[9] By utilizing mixed-mode ventilation throughout the summer months in a variety of climates, it is possible to cut HVAC energy consumption by anywhere from 17–47 percent [10].

The indoor air quality can be managed by opening typologies and summer cooling depending on the natural ventilation strategy in countries with mild climates like Germany, Italy, and Turkey [11]. These countries have climates that are rather stable throughout the year. Utilizing envelope materials with a thermal resistance of RSI-0.5 or RSI-2.5 can cut annual cooling energy consumption in the United States by anywhere from 15% to 39%, depending on the environment. Depending on the size of the window and the amount of internal heat gained, annual heating energy savings of up to 10% are also possible [12]. Large windows in office buildings can let in more natural light and help strike a better balance between the amount of power needed for the building's lighting and its cooling systems [13].

The Ratio of Equivalent Transparency, also known as Req, is a fundamental index that can be used to determine whether or not a structure is energy-efficient. The ratio of the area of a building's complete envelope to the area of its envelope equivalent transparency is denoted by the symbol Req [1]. After conducting a small number of simulations in the region of Central Europe, researchers came to the conclusion that the best window-to-wall ratio would be 40 percent, with triple glazing and double low-emissivity coating [14] explained that the optimal ratio of window to exterior wall to maximize energy efficiency is 20% for south, east and west orientations; However, the optimal percentage for north direction is 20%–40% [1].

and as we know that the energy efficiency indicator is very important in giving a view of the energy consumption of buildings According to the figures on Malaysia's energy consumption in 2016, the construction industry consumed close to forty percent of the country's total energy [15] There is an immediate and pressing need to improve energy efficiency [16] given the prevalence of the usage of fossil fuels as primary sources of energy in emerging and poor countries as indicated by the aforementioned figures regarding energy consumption. Office buildings, shopping malls, governmental administration buildings, and other types of commercial constructions are all considered to be examples of commercial buildings [17] According to the findings of the building book compiled by the Council of Australian Governments, the types of structures that consume the most energy in many nations include retail complexes and office buildings. Offices and retail outlets in Australia are responsible for the consumption of sixty percent of all the energy that is used in commercial buildings [18].

Another important indicator is the water consumption indicator In recent years, Water conservation is one of the environmental concerns that is considered to be of the utmost importance on a global scale, and its significance is only going to expand in the coming years as a result of continuous population growth and the consequences of global warming [19]. Effective use of water (WE) According to a report on water that was completed in 2006, the available supply of water that can be consumed is insufficient; if the percentage of utilization of the water continues as it has been, there will be a suffering from the water trouble soon The Rainfall Harvesting System that the GBI has developed allows for the reusing of rainwater as well as grey water, which means that recycling of any and all waste created in the home is strongly encouraged for the purpose of consumption in buildings or irrigation [20].

The green building evaluation system that is used in Taiwan was initially implemented in 1999, and at the time, the water efficiency of a building was initially used as the threshold indicator for measuring the environmental impact of a structure. Since 1999, this method of assessment has been used to award the “Green Building Certification” to more than a thousand different structures [21].

A sort of positive feedback that should be communicated to policymakers is the quantitative results that have been achieved through water conservation programs. The implementation of water-saving facilities and the implementation of water-saving designs should, in theory, be beneficial to buildings in terms of the efficiency with which they use water [22],[23]. However, actual water usage in the real world is complicated since it is influenced by a wide variety of human behaviors in addition to other factors [24]. In order to validate the results of the estimation, an inquiry into the average water saving rate from 2000–2013 for 1,320 buildings that have been recognized as green buildings was carried out. In this study, there were a total of 568 case studies of environmentally friendly buildings, each of which included the design and operation of a rainwater collecting system as part of the validation. The results of the research show that these situations that incorporated a rainwater harvesting system saved an average of 48 percent of their water [25]. According to meteorological data between 1990 and 2013, the annual precipitation rate in Iran is about 320 mm, the average number of rainy days per year is 34 days, and the average minimum temperature during winter is –4 degrees Celsius, and during the summer there is nearly no There is precipitation, the average annual relative humidity is 46%, and the annual number of frozen days is 50. The maximum and maximum average daily precipitation are about 68 and 32.9 mm, respectively [26].

As for providing green areas, which are mandatory in any residential area and constitute between 30 and 50 percent of the total area inhabited by residents, in a quiet manner while ensuring their safety and not disturbing them. and a healthy environment. The environmental, social, and physical quality of human life in urban areas is directly dependent on the urban landscape and especially the quality and the quantity of urban green space within the built environment [23] According to the majority of individuals have a positive perception of a streetscape if more than thirty percent of the landscape consists of vegetation. UGSs have multiple benefits, including improving air quality, increasing urban biodiversity, and helping to regulate the microclimate, all of which are foundational components of the urban ecosystem. As a desirable environmental property [27], UGSs have a number of advantages. These advantages include the advantages offered by UGSs are reflected in property values; More specifically [28], there is an inverse relationship between a dwelling’s sale price and the distance from the green area in which it is located [27], [29]. It was discovered that undergraduate students who could see natural features from where they lived on campus performed significantly better on attentional activities than those who did not have a view of any green area nearby [30]. Urban planners apply green space ratios in green space distribution arrangements for residents, and urban officials take into account the green area index when evaluating the regional urban environment. This is done so that they can determine the extent to which the health of residents and the urban environment has improved as a result of the presence of green spaces. As a result, the accuracy with which UGS can quantify data plays an important role in the urban planning and administrative management process [31]. He explained that, with reference to the components of the GBI Green Structure Index, a GBI certification offers a measurable evaluation that demonstrates how "green" or sustainable a building is. Building in a sustainable manner offers a variety of advantages. Among them are the following: Green buildings are those that have been designed in such a way that they reduce the emission of harmful substances during their whole life cycle, save resources, energy, and materials, and recycle as much as possible [32]. Gains to Be Obtained Through Obtaining GBI Certification A building's operating costs can decrease by as much as 9 percent when green building principles are used, while building values can increase by 7.5% and a 6.6 percent increase in return on investment can be realized. Therefore, environmentally friendly buildings not only bode well, but they also bode well. In addition to that, the legislature has reported specific tax breaks for the development of environmentally friendly buildings [33].

Referring to the above, the specialists sought to pay attention to buildings and the need to pay attention to all stages of construction from design, construction, and operation to completion, and recycling and benefiting from materials that have positive effects on the environment. Among these buildings are green buildings, which face a great challenge, in whether to consider them as green buildings and how to classify them. International specifications such as LEED in America, BREEAM in Britain, and Green Star in Australia and other countries appeared, and evaluation teams of experts were formed to evaluate the building and issue a certificate regarding the description of the building, whether it is an approved building or a building with a silver certificate, gold certificate, or platinum certificate, and the evaluation is On the basis of qualitative indicators of standards such as energy, water, materials, and others, [34] indicated that they constitute 62% of the evaluation points, and many researches did not concern themselves with quantitative indicators, although their percentage is large, and their evaluation points constitute 38% of the evaluation points, as explained by [34]. It is divided into the three stages of construction (the planning and design stage, the construction stage, and the operation stage), and there are 17 quantitative indicators, as our research is concerned with this aspect and included An important phase of the construction phase, which is the planning and design phase of a commercial building. It aims to search for the largest number of indicators within this phase to obtain evaluation points for the project. We aim to increase the number of evaluation points along with qualitative indicators.

2. Methodology

In our Research methodology we have many steps as in Figure 1, started with studying the previous researchers related to green buildings standards, and the classification for these standards that mentioned by AZHAR [34] our research methodology has depended 17 quantitative standards that represented 38% from total evaluation points of green buildings.

In order to ensure the important of these standards that will be used in the calculation of green building indicator equations, Analytical Hierarchy Process AHP have used, the comparison between indicator have evaluated by specialists and experts, then we constructed a comparative matrix that helped to find the relative wight for each standard, and how much could be represented from the total evaluation points, as shown in Table 1.

The next step in our method is obtaining the necessary data that we need to perform calculations using Building Information Modeling (BIM) and Revit software, therefor we designed a 3D model of a commercial building with area of 6,664 m^2, consisting of 5 floors, and each floor contains 20 rooms.

Dealing with the all information generated from Revit software are time consuming since they are not important to our aims, so we depended BIM vision software, as it has a great ability to open files in IFC format and easily help to select the characteristics of the building parts, according to our needs in to implement in equations to extract the value of quantitative standards such as walls,

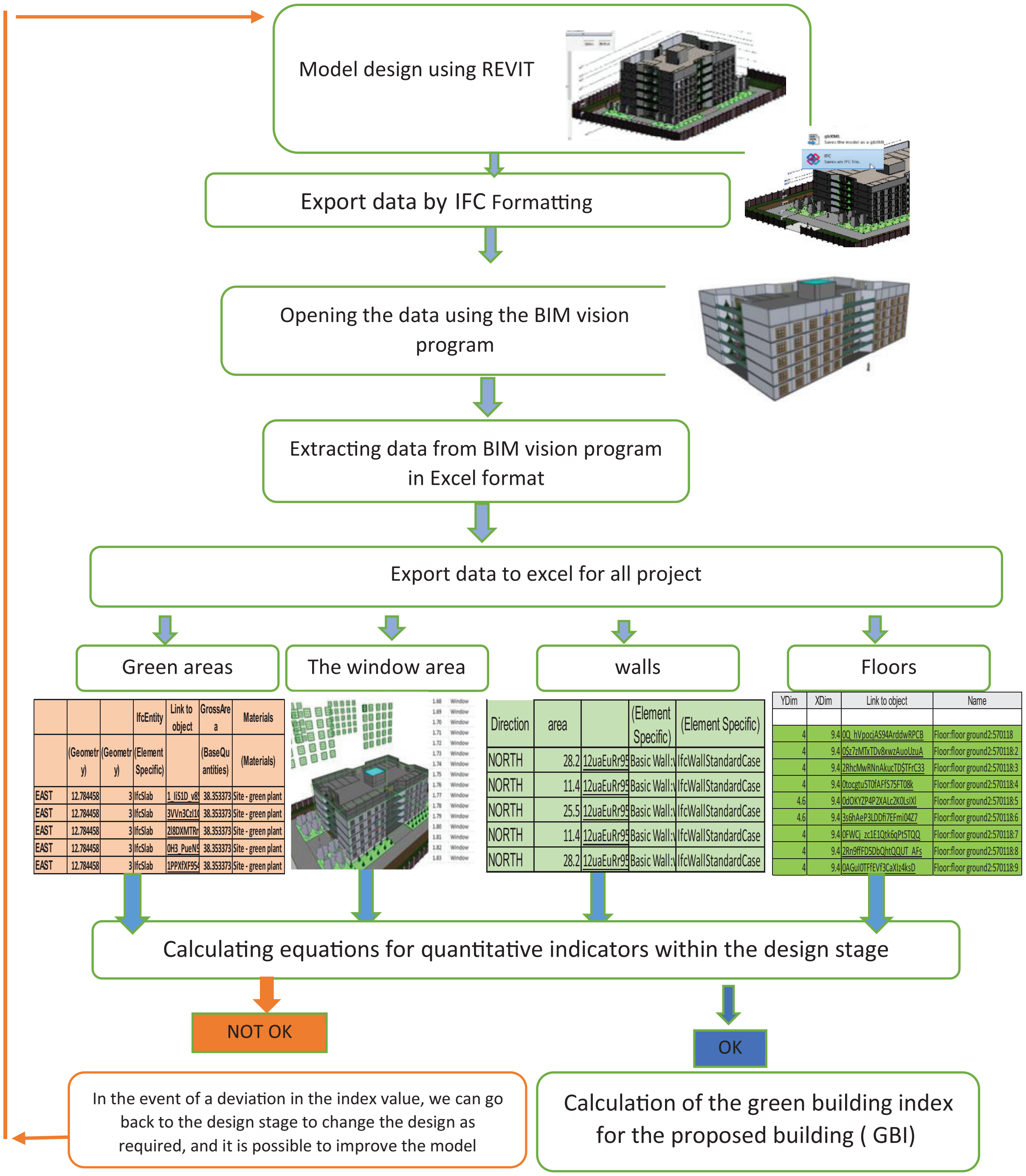


Figure 1: The Scheme shows the stages of obtaining the green building.

doors, windows according to preferred characteristics, thermal conductivity coefficient, the quality and dimensions of the materials used, and more details.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers specifications have depended in cooling load assessment for each room. The Microsoft Excel software have used to implement cooling equation and processing data as in equation 2.

Other standards have calculated using the resulted data of equations of each indicator.

The next step includes comparing the value of each standard with value of deviation, if any, and comparing it with the number of resulted points in order to calculate the Green Building Index (GBI) in addition to the number of evaluation points that collected by each indicator during the design stage.

Table 1: Quantitative indicators, their weight and the number of evaluation points for each indicator

(Indications)	Weight of Each Indicator	The product of the weight of each index is multiplied by 38
Environmental degradation index	0.115086998	4.373305924
Energy efficiency index	0.145274067	5.520414546
building transparency index	0.047383437	1.800570606
Water consumption index	0.09614089	3.65335382
Cooling load index	0.068312004	2.595856152
Green coverage ratio	0.042180343	1.602853034
Renewable energy consumption index	0.065740173	2.498126574
Indicator of comfort and health of residents and employees	0.04464055	1.6963409
index of residential buildings	0.044296293	1.683259134
Building life cycle cost index	0.050130376	1.904954288
Carbon consumption index	0.057123106	2.170678028
Low energy consumption index in the project life cycle	0.044761383	1.700932554
Index of reduction in the number of accidents and injuries	0.032444783	1.232901754
Capital return index	0.03714733	1.41159854
Sound insulation index	0.028522434	1.083852492
Economic carbon index	0.046613146	1.771299548
Air quality index AQI	0.034202687	1.299702106
		38 POINTS

3. Results & Discussion

Our results for the weights and points of qualitative standards as explained in Table 1 which resulted after applying the equations of 5 qualitative indicators

1. Cooling load indicator
2. Percentage of green coverage
3. Water consumption indicator
4. Energy efficiency index
5. Transparency index

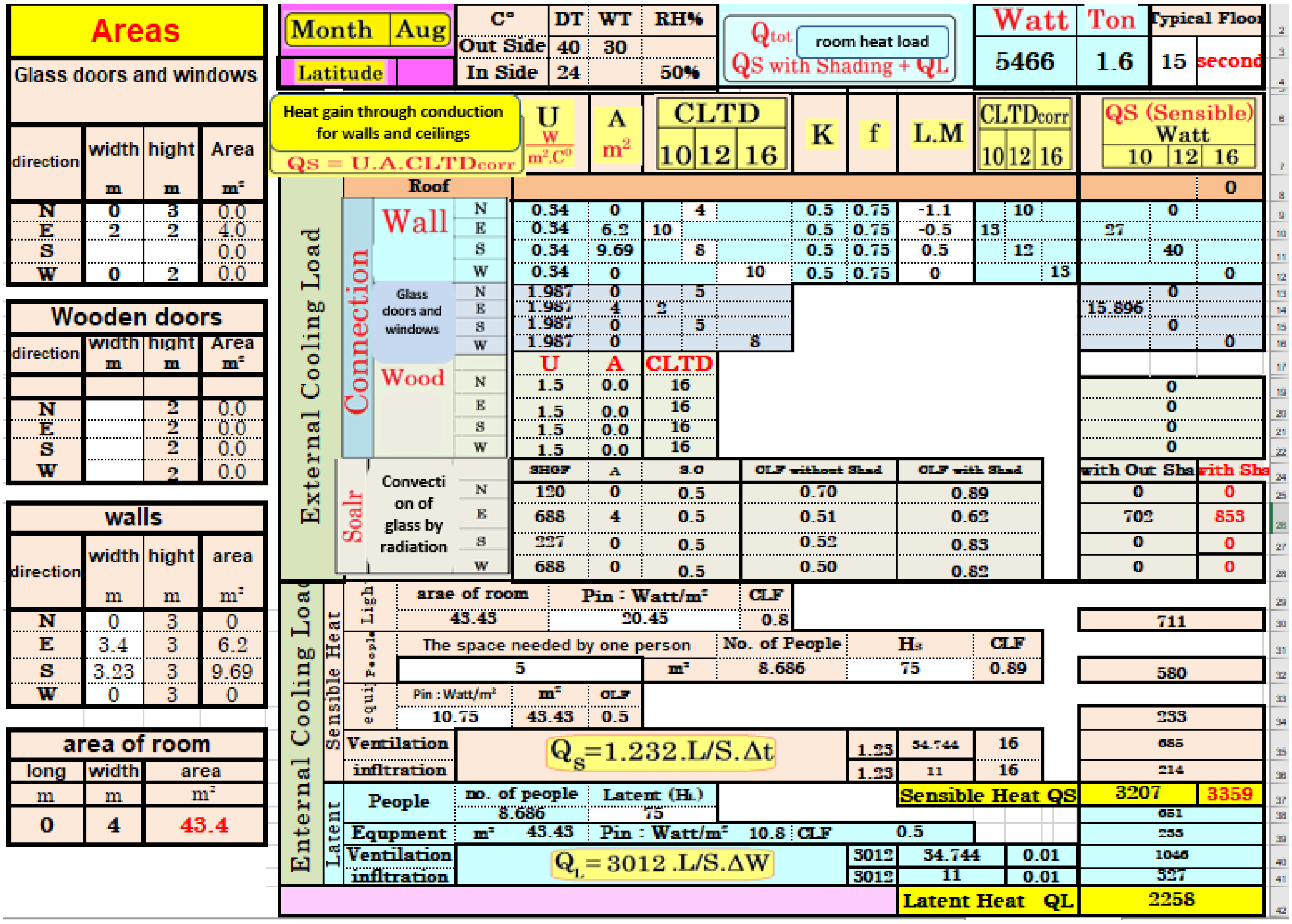
with the output data of the three-dimensional model (Tables and figures in Appendix A for calculating 5 indicators).

Below we will explain each indicator and the mechanism for calculating its value, the number of points obtained to get result of the GBI value within the design stage, in addition to explain the number of points collected out of 38 points.

3.1 Calculation of quantitative indicators based on the data extracted from the proposed 3D model

3.1.1 Calculation of Air-conditioning load indicator according to international standards (ASHRAE)

A) Internal cool load
B) External cool load



Areas

Glass doors and windows

direction	width m	hight m	Area m²
N	0	3	0.0
E	2	2	4.0
S			0.0
W	0	2	0.0

Wooden doors

direction	width m	hight m	Area m²
N		2	0.0
E		2	0.0
S		2	0.0
W		2	0.0

walls

direction	width m	hight m	area m²
N	0	3	0
E	3.4	3	6.2
S	3.23	3	9.69
W	0	3	0

area of room

long m	width m	area m²
0	4	43.4

Month	Aug	C°	DT	WT	RH%
Latitude		Out Side	40	30	
		In Side	24		50%

Q_{tot} room heat load
QS with Shading + QL

Watt	Ton	Typical Floor	
5466	1.6	15	second

Heat gain through conduction for walls and ceilings
$Qs = U.A.CLTDcorr$

		U $\frac{W}{m^2.C^0}$	A m²	CLTD 10	CLTD 12	CLTD 16	K	f	L.M	CLTDcorr 10	CLTDcorr 12	CLTDcorr 16	QS (Sensible) Watt 10	QS (Sensible) Watt 12	QS (Sensible) Watt 16
Roof															0
Wall	N	0.34	0		4		0.5	0.75	-1.1		10			0	
	E	0.34	6.2	10			0.5	0.75	-0.5	13			27		
	S	0.34	9.69		8		0.5	0.75	0.5		12			40	
	W	0.34	0			10	0.5	0.75	0			13			0
Glass doors and windows	N	1.987	0		5									0	
	E	1.987	4	2									15.896		
	S	1.987	0		5									0	
	W	1.987	0			8									0

Wood		U	A	CLTD	QS
	N	1.5	0.0	16	0
	E	1.5	0.0	16	0
	S	1.5	0.0	16	0
	W	1.5	0.0	16	0

Convection of glass by radiation		SHGF	A	S.C	CLF without Shad	CLF with Shad	with Out Sha	with Sha
	N	120	0	0.5	0.70	0.89	0	0
	E	688	4	0.5	0.51	0.62	702	853
	S	227	0	0.5	0.52	0.83	0	0
	W	688	0	0.5	0.50	0.82	0	0

Light	arae of room	Pin : Watt/m²	CLF	
	43.43	20.45	0.8	711

People	The space needed by one person		No. of People	Hs	CLF	
	5	m²	8.686	75	0.89	580

equip	Pin : Watt/m²	m²	CLF	
	10.75	43.43	0.5	233

Ventilation	$Q_S=1.232.L/S.\Delta t$	1.23	34.744	16	685
inftration		1.23	11	16	214

Sensible Heat QS 3207 3359

People	no. of people	Latent (HL)	
	8.686	75	651

Equpment	m²	43.43	Pin : Watt/m²	10.8	CLF	0.5	255

Ventilation	$Q_L = 3012 .L/S.\Delta W$	3012	34.744	0.01	1046
inftration		3012	11	0.01	327

Latent Heat QL 2258

Figure 2: Represents the image of the program for calculating loads of the building.

The equations that were adopted in calculating the different types of air conditioning loads needed by the building whether external or internal, visible or invisible, based on international standards for air conditioning load, as shown in Table No. (2), The burden of air conditioning must be provided to cool the heat of the building inside the building or on the walls, whether from the building or from the equipment.

To determine the load of each room, our calculations are made using Microsoft Excel software as shown in Figure 2, the air condition load index for the building has been caculated. The result details in the tables, figures and graphs, are presentened in Appendix A.

All the important equations for calculating the air conditioning load were according to (ASHRAE) specifications. All important aspects of the building have been considered to calculate all building directions also if there are halls or glass in the walls. In addition to all other required data such as wall dimensions, types, and thermal conductivity coefficient. Tables that used to measure this data were according to on international standards, also special tables such as the person occupied space, person heat body, heat devices, and number of people required to occupy a specific area.

This results help can identify the type of air conditioning system according to building type and nature, due to the calculations details for the load of each floor, room, or the whole building, also the evaluation with respec to standards adopted in this field to ensure matching with required standards, and the amount of deviation, if any. These results are shown in the figures and tables in Appendix A.

Table 2: It explains the rules for calculating the adaptive load (ASHRAE). [35]

Cooling Load					
Enternal Cooling Load				External Cooling Load	
Latent		Sensible Heat		Connection	
		QS = A* Pin* CLF	Light	QS = U*A*CLTD corr	Wall
QS = No.of people *HL	People	QS = No.of people *A*HS*CLF	People	QS = U*A*CLTD	Windoww + door
QS = A* Pin * CLF	Equoment	QS = A* Pin * CLF	Equoment	QS = U*A*CLTD	Wood
QS = 1.232*US* DT	Ventilation	QS = 1.232*L/S* DT	Ventilation	QS = U*A*CLTD	Glass
QS = 1.232*US* OT	Infltration	QS = 1.232*L/S* DT	Infltration	QS = U*A*CLTD corr + SHGF*A* SC*CLF	Soalr

The resulted tabels and figures are presentend in In Appendix A, as follow:

Tables 3, 4, 5 and Figures 3, 4, 5 are a summary of the data representing the air conditioning load on the ground floor.

Tables 6, 7, 8 and Figures 6, 7, 8 are a summary of the data that represents the air conditioning load on the first floor.

Tables 9, 10, 11) and Figures 11, 12, 13 are a summary of the data that represents the air-conditioning load on the second floor.

Tables 12, 13, 14 and Figures 9, 10, 11) a summary of the data that represents the load of air conditioning on the third floor.

Tables 15, 16, 17 and Figures 15, 16, 17 summarize the data that represents the load of the fourth floor air-conditioning. In terms of the external load,

Our results demonstrated that most of the air-conditioning load comes from the glass. The other note is the largest energy for air conditioning belongs to the ventilation load in relation to the internal load (sensible and latent heat), because of the ventilation load is greater as the required people in the design are large, For example, the design consider 8 people, but the site is actually may occupied by half number or less, as we have some shops in this area that contain lees number of people, Moreover, there are certain times the place is empty. So, if we want to reduced load, can do that by considering the actual number required for the area. So, the burden of air conditioning is reduceded.

As far as the outdoor load is concerned, as explained earlier, most of the HVAC load comes from the glass through radiation due to the use of high transparency and uncolored glass or a great conductive factor, so, to obtain good insulation, the number of insulation layers is increased, For example, use two glass layers and use argon gas between layers. Also, we can say this problem is due to the type of used material; the lower the thermal conductivity factor, the lower the heat penetration into the building, and the higher the insulation.

Table 18 represents a summary of the internal and external cooling loads for all floors of the proposed building. These have obtained from the tables in Appendix A and also from Figure 18, and we note that the internal load is very large due to the ventilation resulting from the number of people, as we explained earlier.

Table 19 represents a summary of the monthly consumption of the cooling load for the entire building and for each floor as well. We note that the ceilings of the ground, first, third, third and fourth floors have almost equal loads due to the absence of heat exchange between the ceiling and the outer

Table 18: Summary of the all floor's internal and external air conditioning

Name of Floor	External Cooling Load	Internal Cooling Load
Ground	21899.27	154043
First	21899.27	154043
Second	21899.27	154043
Third	21899.27	154043
Fourth	22788.55	169720
Sum-watt	110385.63	785892
K. Watt	110.38563	785.892

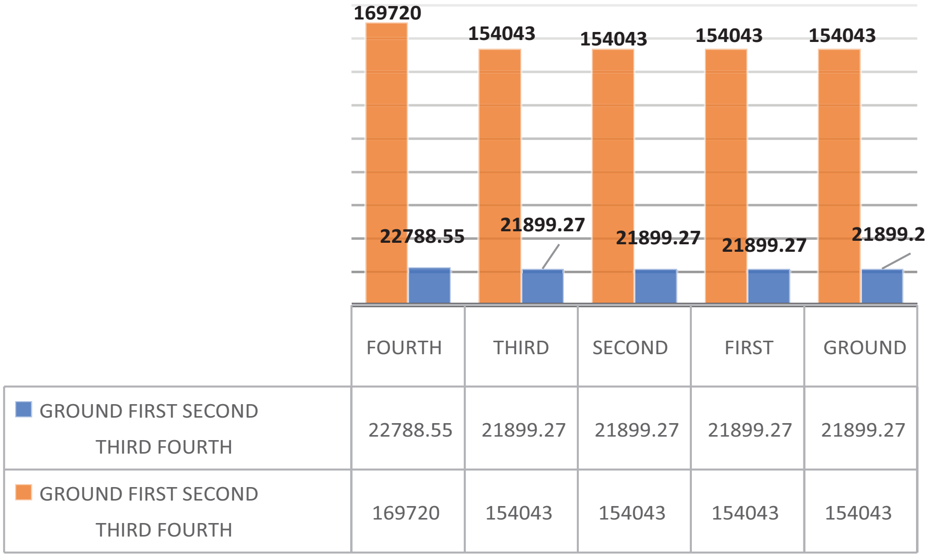


Figure 18: Shows a comparison between the internal and external air conditioning load for the all floors.

Table 19: Summary of the monthly consumption of the cooling load of the building

Floor name	Value (k.watt h/month)
Ground floor	246
First floor	246
Second floor	234
Third floor	246
Fourth floor	547
SUM	1519
The average	304

perimeter, but only heat exchange occurs in the walls. But for last floor we notice, the monthly consumption is very large because of the heat exchange between the in and outside, which means that the needs for more cooling devices than other floors, i.e. affects the energy consumption, and, the designer should takes into account this additional load in the future calculations, to either increase the insulation material in the ceiling or increase the number of devices, whichever is considered the least energy consuming.

But if we look to the average monthly consumption of the whole building, we find it within permissible limits. If we referred to the above tables of average amount of electrical energy consumption, and the adaptive load index of the proposed building is almost identical according to the Iranian Ministry of Electricity for the monthly consumption (The average monthly consumption of electric energy according to the instructions of the Iranian Ministry of Electricity = 300 kWh/month). Based on this fact, the air-conditioning load index obtained all evaluation points amounting to 2,595856147 points, as shown in Table 1.

3.1.2 The water consumption index

The water consumption indicator currently considered is one of the important indicators, as the whole world suffers from water shortage due to the lack of rain and the population increase, so we had to focus on this indicator importance in our research and find its most strength or positive points, that can be either recycle or take advantage of rainwater, to reuse it later. From other side the negative points, that represented the quantities of water that must be provided daily for the building, for daily life use, for drinking, regular washing, and water cycle. Therefore, for water indicator we consider three parts; one part is negative sign and two parts a positive sign, as shown below:

3.1.2.1 Gray water recycling (+)

Domestic wastewater produced in homes or office buildings from water streams that do not contain fecal contamination is referred to as gray water that includes all flows other than wastewater produced by toilets. Bathtubs, washing machines, and dishwashers contribute to the production of gray water. Because they contain less pathogens than black water, gray water is generally safer to handle than black water. It is also easier to treat and reuse locally for purposes such as flushing toilets, watering landscaping, or for agricultural and other non-potable applications.

According to our proposed design, the population of the building is 1410 people, and the daily consumption per person is 104 liters per day, so the total amount of water consumed by the building that must be provided is:

104 * 1410 = 146640 liters, which is approximately equivalent to 147 cubic liters

To calculate the gray water and its recycling based on the previous relationship from equation 1, and according to default percentage of gray water recycled is about 85–90%, and according to equation 1, the amount of recycled water can be obtained after calculating the amount of water that people consume daily.

$$\text{Gray water recycling} = \text{Daily consumption of individuals} * 0.9 \tag{1}$$

$$= 147000 * 0.9 = 180198 \text{ liter} = 132.3 \text{ m}^3$$

3.1.2.2 Monthly rain water (+)

Water scarcity is a big obstacle for developing urban landscapes in cities, Rainwater harvesting system, as an acceptable water resource management method, can be considered as an alternative method for landscape irrigation [26].

The collection of rain water is very important, especially in current time around the world due to this dangerous phenomenon that is starting to increase from the lack of rain, with respect to the increase of people that require to increase water consumption. Therefore, it is important to discover new methods can help to reducing the waste of fresh water and find new sources, even with small amount of rain water, but it is important to use good methods for collection, storage, and recycle according to equation (2).

$$\text{Monthly rain water} = \text{Surface area} * \text{Precipitation rate} *0.8 \tag{2}$$

- Climate data According to meteorological data the annual recipitation of the area is about 233 mm,
- Explain:
  Surface runoff factor = 0.8
  Surface area = 1528 m^2
  Precipitation rate = 0.233 m

$$1528*0.8*0.233 = 285 \text{ cubic meter}$$

3.1.2.3 People's daily water consumption (-)

It is known that commercial buildings differ from homes in terms of water consumption, not like home water consuming. Therefore the specified design standards are different. According to Iranian water transmission and distribution regulations in urban and rural areas in 2013, commercial buildings only need drinking water and sewage water, and it has been determined that one person needs between 130 and 150 liters per day. It is less than the residential buildings by about 30% of the total consumption per person, and according to that, as shown in Table 20, the commercial buildings consume only water only, paragraphs (1-6-7) of Table 20.

According to the above table, commercial buildings do not use everything mentioned in the above table, but rather their need as in sequence (1-7-6).

So, the total amount we need to provide for daily water use is 27.5 gallons.

and since each gallon equals 3.78 liters:

the total amount that we need is equal to (3.78 * 27.5) liters = 104 liters, as shown in equation 3.

$$\text{People's daily water consumption } 104*1410 = 147 \text{ m}^3 \tag{3}$$

Through equations (1-2-3) and settling accounts, we get the amount of 270 cubic meter of surplus and a positive sign, and this means that if we take into account during the design these considerations by taking care of making a good storage for rainwater, as well as gray water other than healthy polluted water, then we can get advantage from this pointer well, we save water and reduce the consumption of clean water, and we can once again use the water for various purposes such as watering, washing, and others.

Result

$$\text{Water consumption index} = (-147) + (+285) + (132.3) = 270 \text{ m}^3 \ (+)$$

From this Index and to find out the amount of evaluation points obtained, we note the required amount of water for the daily consumption of people and compare it with recycled water and water collected from rainwater. We note that the collected and recycled water is greater than the consumed water, and this is a positive matter, so, it can be given all evaluation points, amounting to 3.6533533827 according to the evaluation points in Table 1.

Table 20: The average person uses 101.5 gallons of water Per day

Sequence	Activates	Gallon
1	Flush	18–24
2	Full Tub	36
3	Showers	20
4	A Washing Machine	15
5	Dishwasher	4–10
6	Hygin (washing face – brushing teeth … etc)	2.5
7	Drinking	1

3.1.3 Energy efficiency index (EEI)

Energy efficiency index “EEI” is an important indicator used for evaluating buildings, especially for green buildings to estimate on the suitable energy for according to building needs based on area. [36] have studied the classrooms needs, they have pointed out that the number of people who occupied a building had a significant impact on energy consumption. For example, the area that should be occupied by 50 people depends on the specification, which states that a certain area must be occupied by a specific number of people depending on the area occupied by one person divided by the total area. But some places and classrooms are not occupied by the exact number of people, and this results in energy consumption because the building design takes the exact number stipulated in the specification into account. Therefore, the study states that the energy equation must take into account. The actual number that the area occupies, by multiplying the energy efficiency equation with the total number divided by the exact number that occupies the area, and here half of the required number has been taken.

If the real number is taken into account, the energy efficiency will be accurate. In our study, the number of people in the sample was 1410. But in reality, this number does not occupy all the space, so if we take half of the required number according to the design, then this means (1410)/2 = (705)

According to this hypothesis, this indicator is calculated according to equation (3).

$$EEI = \frac{EC}{A}\frac{O_{base}}{o_{actule}} \tag{4}$$

EEI = Energy efficiency index
EC = The average energy consumption of the building
A = The total area of the building
O_{base}= The basic number of occupants of the building
o_{actule} = Actual number of building occupants

The results we obtained from the 3D model, and the details of the data are shown in Tables (3-6-9-12, and 15) in Appendix A. As a result, we made the calculations related to the energy calculation for each room on each floor, and the EEI value was obtained from The output of dividing the energy per room by the area of each room on the same floor, then taking the average of the entire floor to obtain the EEI value of the floor, as shown in the summary of all floors in Table 21.

- According to equation (4), after obtaining the energy value of the entire building, we will take half of the expected number of people occupying the building.

$$EEI = 0.1263711 * \frac{1410}{705}$$
$$EEI = 0.2527422$$

Table 21: Summary of energy efficiency for each floor

Name of floor	EC (k watt.h/m^2)
Ground floor	0.125654
First floor	0.1257
Second floor	0.125654
Third floor	0.115
Fourth floor	0.1398
Ave.	0.1263711

Table 22: Spanish international specifications for energy efficiency [37]

Class (EEI)	Permissible Limits
A	0.4 >
B	$0.40 \le \text{EEIB} < 0.65$
C	$0.65 \le \text{EEIB} < 1.00$
D	$1.00 \le \text{EEIB} < 1.30$
E	$1.30 \le \text{EEIB} < 1.60$
F	$1.60 \le \text{EEIB} < 2.00$
G	$2.00 \le \text{EEIB}$

- And from the result that we obtained from equation (4), and after comparing the results with the international Spanish specifications for energy efficiency of the proposed building in Table 22, we note that the building got good value, within rating A (less than 0.4), So, building obtained all evaluation points related to this indicator is equal to (5.520414545).

3.1.4 Green Coverage Area

- Green area indicators are more important to evaluate green buildings. They have a major role in reducing the rate of pollution, increasing the proportion of oxygen and carbon dioxide withdrawal, as well as creating shade. In order to reduce the heat of the building that can help to reduce energy consumption, and to give a good feeling and comfort to the residents of the building, and increase the productivity of workers in the buildings, [38] indicated that the percentage of green area in crowded places is equal to 30% of the building area, so this indicator was of important in our research.
- From the proposed three-dimensional model, we calculated the percentage of green areas as in equation (5).

$$\text{Green coverage area} = \frac{\text{The green area of construction site}}{\text{The area of the construction site}} \tag{5}$$

Table 23 represents a summary of the green area occupied by the building, which were obtained through the proposed three-dimensional model.

Based on the data taken from the proposed design and the tables above, the following is how to figure out this indicator using equation (5)

$$\text{The green area of construction site} = 4262.127\ \text{m}^2$$

$$\text{The area of the construction site} = 7590\ \text{m}^2$$

$$\text{Green coverage area} = \frac{4272.127}{7590} = 0.5615$$

$$= \mathbf{56}\%$$

The percentage of green area in our proposed building was very good, that mean we have reached the required percentage value of green area in our proposed model, which ranges between 30 and 50 percent of the building area. As a result, this indicator received an evaluation score of 100%, i.e. a number of points equal to 1.602853033.

Table 23: Represents the green areas extracted from BIM vision

Direction	Width	Length	Link to object	Area	Materials	Name	IfcEntity
East	12.784458	3	1_liS1D_v85Rlzs4sokuN_B	38.35337302	Site - green plant	Floor:balcon:487575:3	IfcSlab
East	12.784458	3	3VVn3Czl_1CBRgfd_AfsYOYp	38.35337302	Site - green plant	Floor:balcon:575240:3	IfcSlab
East	12.784458	3	2I8DXMTRrOMPf8DglaHI85	38.35337302	Site - green plant	Floor:balcon:579741:3	IfcSlab
East	12.784458	3	0H3_PueN_94ARpY$D8KVmkt	38.35337302	Site - green plant	Floor:balcon:579795:3	IfcSlab
East	12.784458	3	lPPXfXF954gvBDqKwbE_pH	38.35337302	Site - green plant	Floor:balcon:584498:3	IfcSlab
Direction	Width	Length	Link to object	Area	Materials	Name	IfcEntity
North	12.784458	3	3G$GW2Zu5ElRq59i0BNDWO	38.353374	Site - green plant	Floor:balcon:487575:4	IfcSlab
North	12.784458	3	2Pm4XsNwnCl9TBh_co8v1N	38.353374	Site - green plant	Floor:balcon:575240:4	IfcSlab
North	12.784458	3	ls9uTu3Xj0EfKg28c0The0	38.353374	Site - green plant	Floor:balcon:579741:4	IfcSlab
North	12.784458	3	0KRE6gSKXlP8v8kOt3U 5kr	38.353374	Site - green plant	Floor:balcon:579795:4	IfcSlab
North	12.784458	3	0ew7JzPDHFzPY9vwCcpV5e	38.353374	Site - green plant	Floor:balcon:584498:4	IfcSlab
Direction	Width	Length	Link to object	Area	Materials	Name	IfcEntity
West	12.784458	3	0Nt95QlnPBUwY7vgMrf2Jj	38.353374	Site - green plant	Floor:balcon:487575:2	IfcSlab
West	12.784458	3	ORY lrlMv4uw5UhWFSAcj4	38.353374	Site - green plant	Floor:balcon:575240:2	IfcSlab
West	12.784458	3	0V7PmBlyLCkByEwRQRZSmf	38.353374	Site - green plant	Floor:balcon:579741:2	IfcSlab
West	12.784458	3	3xl2n3NQlDjfkYHHcDVBqR	38.353374	Site - green plant	Floor:balcon:579795:2	IfcSlab
West	12.784458	3	0QvOMxVYj8lB2IVlej5Dd3	38.353374	Site - green plant	Floor:balcon:584498:2	IfcSlab
Direction	Length	Height	Link to object	GrossArea	Materials	Name	IfcEntity
South	12.784458	3	2lqSlmjUrAn92oZa0Lv8Nc	38.353374	Site - green plant	Floor:balcon:487575	IfcSlab
South	12.784458	3	0uiwZEwL900g6nzYA8DjYO	38.353374	Site - green plant	Floor:balcon:575240	IfcSlab
South	12.784458	3	33gHlHbj5AhQvqMRlt57nA	38.353374	Site - green plant	Floor:balcon:579741	IfcSlab
South	12.784458	3	33gHlHbj5AhQvqMRlt57m4	38.353374	Site - green plant	Floor:balcon:579795	IfcSlab
South	12.784458	3	33gHlHbj5AhQvqMRlt54$b	38.353374	Site - green plant	Floor:balcon:584498	IfcSlab
Direction	Width	Length	Link to object	Area	Materials	Name	IfcEntity
Site	98.46	68.34	0vu93gnFPCZR2weumHgDoa	672a 7564	Site - green plant	Surface: 609497	IfcSite

3.1.5 Transparency Index (req)

Transparency Index defined the ratio of building areas represented by windows (as stated in equation 6), and the ratio of the total opened area to the building cover compared to the total building area. This index has a major role in the interior lighting of the building without the need to use additional source, which reduces energy consumption, energy expenditures, and increases people's desire to live in, due to the decrease in energy costs and the increase in the well-being of people inside the building. It is also related to the issue of interior lighting and natural ventilation, that help to increase the fresh air. By the way this results will help to reduce the amount of energy used and costs associated with lighting and air conditioning.

$$\text{(req)} = \frac{\text{Aeq}}{\text{Aen}} \tag{6}$$

Req = Equivalent transparency ratio
Aen = The total area of the building envelope
Aeq = Total equivalent transparency area

$$\text{Aen} = \sum Awi + \sum Ari \tag{7}$$

Ari = Surface area
Awi = External wall area

$$\text{Aeq} = \sum Agi * fk * ki\, fvi + \sum Agsi * fk * ki * fvi \tag{8}$$

Agi = External wall openings
Agsi = Roof hataches
fk = The sun-effect factor = 0.5 (ASHREA)
ki = Shading factor = 0.5 (ASHREA)
fvi = Ventilation factor 0.75 (ASHREA)

From the extracted data of proposed three-dimensional model, as in Table (24), part of this data indicate to obtain the required areas for roof and wall halls such as windows and doors, as well as the ceilings and walls areas for the building cover.

From equation (6) result we obtained the percentage of transparency according to the international standards of ASHREA, as: shade coefficient, the ventilation coefficient, and the sun effect coefficient were obtained [1].

$$\text{Aen} = \sum 2688 + \sum 1518.56 = 4206.56\, m^2$$

$$\text{Aeq} = (Agi * fk * ki\, fvi) + (Agsi * fk * ki * fvi) = 225.1875$$

$$\text{Transparency Index (req)} = \frac{225.1875}{4206.56} = 0.054$$

Table 24: Represents a summary of some of the data extracted from the proposed three-dimensional building for the openings in the building envelope

Area	Height	Width	IfcEntity	Materials	Link to Object
4	2	2	IfcWindow	Trim; Glass; Sash	33xRR5JeH9h9AGdve90xUC
4	2	2	IfcWindow	Trim; Glass; Sash	33xRR5JeH9h9AGdve90xT4
4	2	2	IfcWindow	Trim; Glass; Sash	33xRR5JeH9h9AGdve90xSW
4	2	2	IfcWindow	Trim; Glass; Sash	33xRR5JeH9h9AGdve90xSO
4	2	2	IfcWindow	Trim; Glass; Sash	33xRR5JeH9h9AGdve90xR3
4	2	2	IfcWindow	Trim; Glass; Sash	33xRR5JeH9h9AGdve90xQz

According to the obtained percentage results, is not good, and there is a large deviation that affects the results of green building evaluation. Moreover, the optimal percentage of this indicator should be between 30–50% of the building outside wall area. However, our percentage result is 10% of the total percentage. Therefore, we recommend paying attention to this indicator in order to increase the required halls in the building. The number of points for this indicator was (0.1800571) out of (1.800570596).

4. Results Summary

Our results for quantitative indicators that affecting the green building, have collected a good number of points that will help to support the evaluation team and adding the number of quantitative indicators points in addition to the qualitative indicators that depend on the experience of the evaluation team.

The method used in our research is the mathematical equations to calculate five indicators out of 17 quantitative indicators of design stage, that represent all three stages of construction (design, construction and operation).

By adding the values of the indicators that we obtained, we get a number of points are equal to 13.552536 out of 15.17305, as shown below:

$$\text{GBI} = (\text{Cooling Load Index}) + (\text{Energy Efficiency Index}) + (\text{Water Consumption Index}) + (\text{Building Transparency Index}) + (\text{Green Coverage Percentage})$$

$$(\text{Green Building Index})\ \text{GBI TOTAL} = 5.520414545 + 2.595856147 + 1.602853033 + 3.653353827 + 0.180057 = 13.552536$$

From the results we obtained, the value of the green building index for five quantitative indicators equals 13.552536, which constitutes a good percentage of the total evaluation points when added to other evaluation points in order to obtain a sustainable building. So, Our research method will help to get higher rating for green buildings.

5. Conclusion

In this research we have used the method of evaluating a commercial building of five floors to evaluate quantitative indicators that have a significant impact to increase the evaluation points. The green building index for commercial buildings in Tehran (the capital of Iran) has calculated in the design phase. While some indicators did not get good evaluation points, but it is important to reconsider the reasons and fix them. One of these indicators is the Transparency Index, that was less than required percentage is between 30 and 50% [1] of the building cover which needs to improve as it is important to increase the illumination and temperature of the building through the penetration of sunlight i.e. reducing energy consumption. To find a solution for this problem, the building cover halls must as windows or increase halls in the roof. Another option is to modify the structure of the building to incorporate more windows and vents that increase sunlight and fresh inside.

The green building index helps in evaluating of green buildings, and we have obtained about 13.552536 out of the total evaluation points for five quantitative indicators out of 15.17305 evaluation points, which is a good percentage that can help to add new evaluation points.

The cooling load index, the energy efficiency index, the water consumption index, and the green coverage ratio all these have got full evaluation points, but the building transparency index did not get full points and its deviation was clear by 30%.

6. Future Works

The study can be extended to extract the green building index for the construction and operation stages or by completing the green building index for other indicators and other types of buildings, for example residential, administrative or educational buildings. This will support the process of evaluating green buildings to obtain the highest points.

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Appendix A

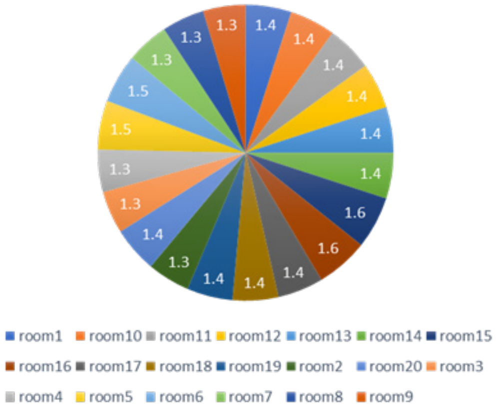


Figure 3: The cooling load is in tons for each room.

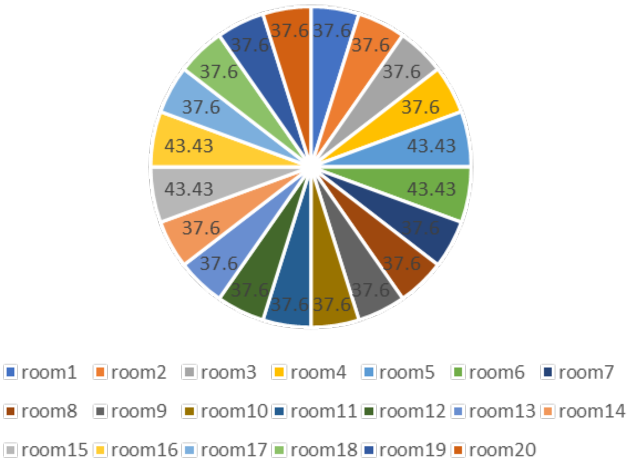


Figure 4: Area in square meters for each room.

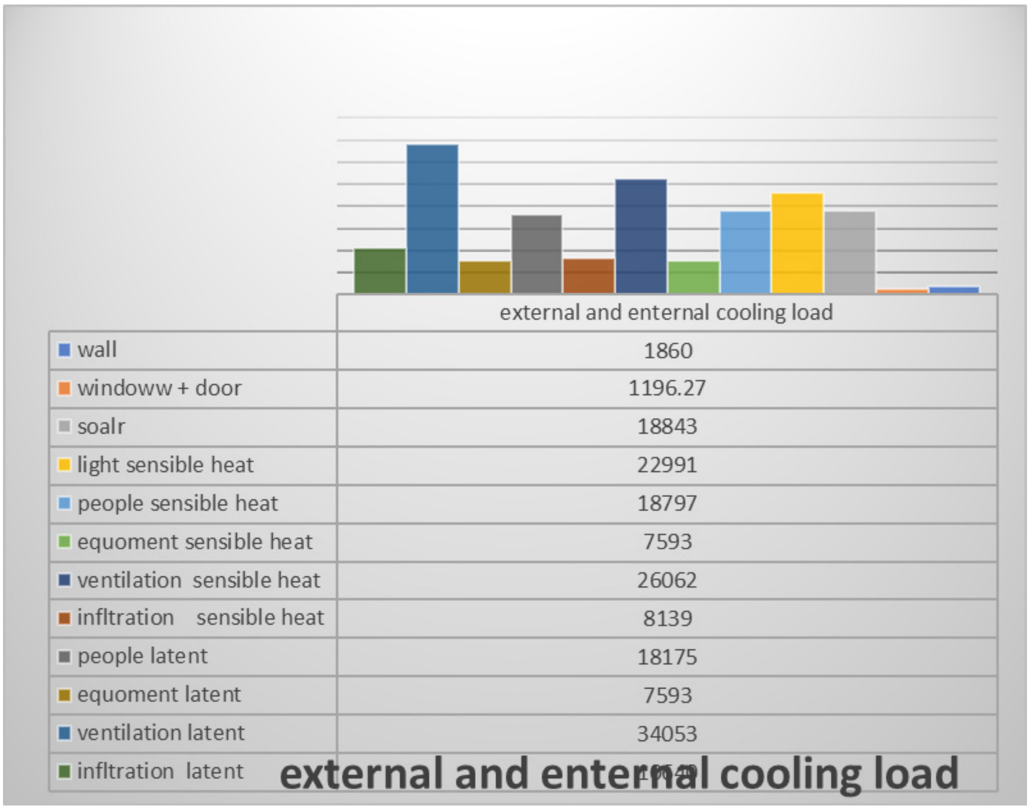
Table 3: Air conditioning load calculation for the ground floor

	Cooling Load		Area		Ground Floor
Room No.	Watt	Ton	m^2	k watt	k watt.h/m^2
Room1	4783	1.4	37.6	4.783	0.127207
Room2	4667	1.3	37.6	4.667	0.124122
Room3	4667	1.3	37.6	4.667	0.124122
Room4	4667	1.3	37.6	4.667	0.124122
Room5	5294	1.5	43.43	5.294	0.121897
Room6	5301	1.5	43.43	5.301	0.122058
Room7	4667	1.3	37.6	4.667	0.124122
Room8	4667	1.3	37.6	4.667	0.124122
Room9	4667	1.3	37.6	4.667	0.124122

(*Continued*)

Table 3: (*Continued*)

	Cooling Load		Area		Ground Floor
Room No.	Watt	Ton	m^2	k watt	k watt.h/m^2
Room10	4763	1.4	37.6	4.763	0.126676
Room11	4902	1.4	37.6	4.902	0.130372
Room12	4806	1.4	37.6	4.806	0.127819
Room13	4806	1.4	37.6	4.806	0.127819
Room14	4806	1.4	37.6	4.806	0.127819
Room15	5466	1.6	43.43	5.466	0.125858
Room16	5459	1.6	43.43	5.459	0.125697
Room17	4806	1.4	37.6	4.806	0.127819
Room18	4806	1.4	37.6	4.806	0.127819
Room19	4806	1.4	37.6	4.806	0.127819
Room20	4921	1.4	37.6	4.921	0.130878
Room21	74288	21.2	638	74.288	0.116439
SUM	172015	49.2	1413.32	172.015	2.638731
The average				8.191190476	0.125654
	Monthly	Energy	Consumption	245.7357143	



	external and enternal cooling load
■ wall	1860
■ windoww + door	1196.27
■ soalr	18843
■ light sensible heat	22991
■ people sensible heat	18797
■ equoment sensible heat	7593
■ ventilation sensible heat	26062
■ infltration sensible heat	8139
■ people latent	18175
■ equoment latent	7593
■ ventilation latent	34053
■ infltration latent	[illegible]

Figure 5: Internal and external cooling load

Table 4: Summary of the ground floor’s internal and external air conditioning

SUM	R21	R20	R19	R18	R17	R16	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	ROOM1			GROUND
1860	624	150	35	35	35	60	67	35	35	35	131	131	35	35	35	67	60	35	35	35	150	wall		external cooling load
1196.27	396.74	15.89	15.98	15.98	15.98	15.89	15.89	15.98	15.98	15.98	15.98	64	64	64	64	64	64	64	64	64	64	windoww + door		
																						wood		
18843	4943	702	702	702	702	702	702	702	702	702	702	688	688	688	688	688	688	688	688	688	688	soalr		
22991	10438	615	615	615	615	580	711	615	615	615	615	615	615	615	615	711	711	615	615	615	615	light	sensible heat	enternal cooling load
18797	8517	502	502	502	502	580	580	502	502	502	502	495	495	495	495	572	572	495	495	495	495	people		
7593	3429	202	202	202	202	233	233	202	202	202	202	202	202	202	202	233	233	202	202	202	202	equoment		
26062	13834	593	593	593	593	685	685	593	593	593	593	593	593	593	593	685	685	593	593	593	593	ventilation		
8139	4323	185	185	185	185	214	214	185	185	185	185	185	185	185	185	214	214	185	185	185	185	infltration		
18176	9570	399	399	399	399	651	651	399	399	399	399	399	399	399	399	460	460	399	399	399	399	people	latent	
7593	3429	202	202	202	202	233	233	202	202	202	202	202	202	202	202	233	233	202	202	202	202	equoment		
34053	15373	906	906	906	906	1046	1046	906	906	906	906	906	906	906	906	1046	1046	906	906	906	906	ventilation		
10640	4804	283	283	283	283	327	327	283	283	283	283	283	283	283	283	327	327	283	283	283	283	infltration		

Table 5: Summary of the ground floor's internal and external air conditioning

	GROUND					
		SUM				
	21899.27	21899.27	1860	wall	CONNECTION	external cooling load
			1196.27	windoww + door		
				wood		
			18843	soalr		
WATT						
175942.27						
		83582	22991	light	sensible heat	enternal cooling load
	154043		18797	people		
			7593	equoment		
			26062	ventilation		
			8139	infltration		
		70461	18175	people	latent	
			7593	equoment		
			34053	ventilation		
			10640	infltration		

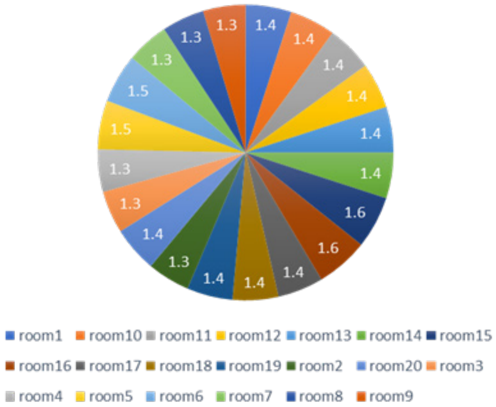


Figure 6: The cooling load is in tons for each room

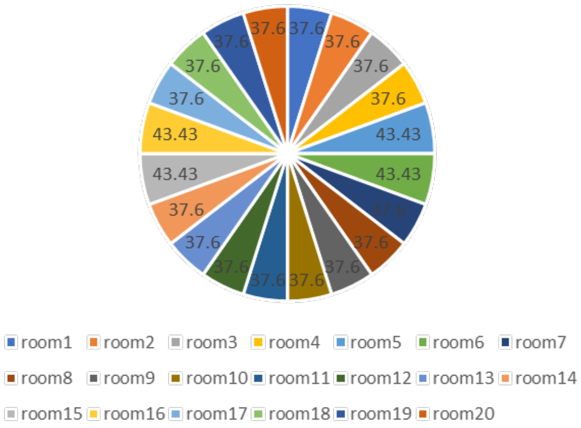


Figure 7: The cooling load is in tons for each room

Table 6: Air conditioning load calculation for the first floor

First Floor					
			Cooling Load		
k watt.h/m²	k watt	Area (m²)	Ton	Watt	Room No.
0.1272074	4.783	37.6	1.4	4783	Room1
0.1241223	4.667	37.6	1.3	4667	Room2
0.1241223	4.667	37.6	1.3	4667	Room3
0.1241223	4.667	37.6	1.3	4667	Room4
0.1218973	5.294	43.43	1.5	5294	Room5
0.1220585	5.301	43.43	1.5	5301	Room6
0.1241223	4.667	37.6	1.3	4667	Room7
0.1241223	4.667	37.6	1.3	4667	Room8
0.1241223	4.667	37.6	1.3	4667	Room9
0.1266755	4.763	37.6	1.4	4763	Room10
0.1303723	4.902	37.6	1.4	4902	Room11
0.1278191	4.806	37.6	1.4	4806	Room12
0.1278191	4.806	37.6	1.4	4806	Room13
0.1278191	4.806	37.6	1.4	4806	Room14
0.1258577	5.466	43.43	1.6	5466	Room15
0.1258577	5.466	43.43	1.6	5466	Room16
0.1278191	4.806	37.6	1.4	4806	Room17
0.1278191	4.806	37.6	1.4	4806	Room18
0.1278191	4.806	37.6	1.4	4806	Room19
0.1308777	4.921	37.6	1.4	4921	Room20
0.1171646	74.751	638	21.4	74751	Room21
2.6396177	172.485	1413.32	49.4	172485	SUM
0.1256961	8.213571				The average
	246.4071	Monthly energy consumption			

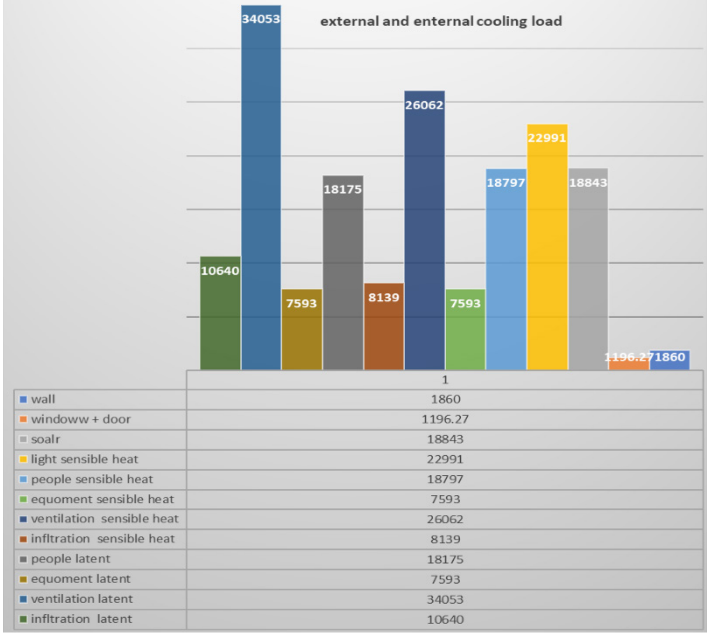


Figure 8: Internal and external cooling load

Table 7: Summary of the first floor’s internal and external air conditioning

SUM	R21	R20	R19	R18	R17	R16	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	ROOM1			FIRST
1860	624	150	35	35	35	60	67	35	35	35	131	131	35	35	35	67	60	35	35	35	150	wall		
1196.27	396.74	15.89	15.98	15.98	15.98	15.89	15.89	15.98	15.98	15.98	15.98	64	64	64	64	64	64	64	64	64	64	windoww + door		external cooling load
																						wood		
18843	4943	702	702	702	702	702	702	702	702	702	702	688	688	688	688	688	688	688	688	688	688	soalr		
22991	10438	615	615	615	615	580	711	615	615	615	615	615	615	615	615	711	711	615	615	615	615	light	sensible heat	enternal cooling load
18797	8517	502	502	502	502	580	580	502	502	502	502	495	495	495	495	572	572	495	495	495	495	people		
7593	3429	202	202	202	202	233	233	202	202	202	202	202	202	202	202	233	233	202	202	202	202	equoment		
26062	13834	593	593	593	593	685	685	593	593	593	593	593	593	593	593	685	685	593	593	593	593	ventilation		
8139	4323	185	185	185	185	214	214	185	185	185	185	185	185	185	185	214	214	185	185	185	185	infltration		
18176	9570	399	399	399	399	651	651	399	399	399	399	399	399	399	399	460	460	399	399	399	399	people	latent	
7593	3429	202	202	202	202	233	233	202	202	202	202	202	202	202	202	233	233	202	202	202	202	equoment		
34053	15373	906	906	906	906	1046	1046	906	906	906	906	906	906	906	906	1046	1046	906	906	906	906	ventilation		
10640	4804	283	283	283	283	327	327	283	283	283	283	283	283	283	283	327	327	283	283	283	283	infltration		

Table 8: Summary of the first floor's internal and external air conditioning

	FIRST					
		SUM				
	21899.27	21899.27	1860	wall	CONNECTION	external cooling load
			1196.27	windoww + door		
				wood		
			18843	soalr		
WATT						
175942.27						
		83582	22991	light	sensible heat	enternal cooling load
	154043		18797	people		
			7593	equoment		
			26062	ventilation		
			8139	infltration		
		70461	18175	people	latent	
			7593	equoment		
			34053	ventilation		
			10640	infltration		

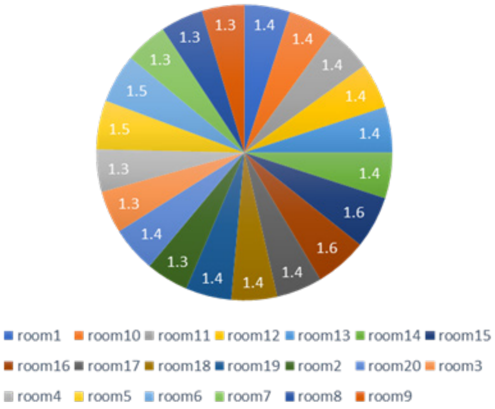


Figure 9: The cooling load is in tons for each room

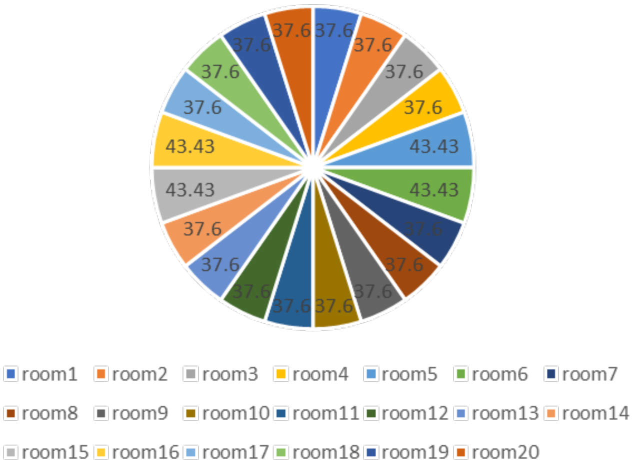


Figure 10: The cooling load is in tons for each room

Table 9: Air conditioning load calculation for the second Floor floor

		Second Floor			
k watt.h/m^2	K Watt	Area (m^2)	Ton	Watt	Room No.
0.1272074	4.783	37.6	1.4	4783	Room1
0.1241223	4.667	37.6	1.3	4667	Room2
0.1241223	4.667	37.6	1.3	4667	Room3
0.1241223	4.667	37.6	1.3	4667	Room4
0.1218973	5.294	43.43	1.5	5294	Room5
0.1220585	5.301	43.43	1.5	5301	Room6
0.1241223	4.667	37.6	1.3	4667	Room7
0.1241223	4.667	37.6	1.3	4667	Room8
0.1241223	4.667	37.6	1.3	4667	Room9
0.1266755	4.763	37.6	1.4	4763	Room10
0.1303723	4.902	37.6	1.4	4902	Room11
0.1278191	4.806	37.6	1.4	4806	Room12
0.1278191	4.806	37.6	1.4	4806	Room13
0.1278191	4.806	37.6	1.4	4806	Room14
0.1258577	5.466	43.43	1.6	5466	Room15
0.1256965	5.459	43.43	1.6	5459	Room16
0.1278191	4.806	37.6	1.4	4806	Room17
0.1278191	4.806	37.6	1.4	4806	Room18
0.1278191	4.806	37.6	1.4	4806	Room19
0.1308777	4.921	37.6	1.4	4921	Room20
0.1164389	74.288	638	21.2	74288	Room21
2.6387308	172.015	1413.32	49.2	172015	SUM
0.1256538	8.19119				The average
	245.7357	Monthly energy consumption			

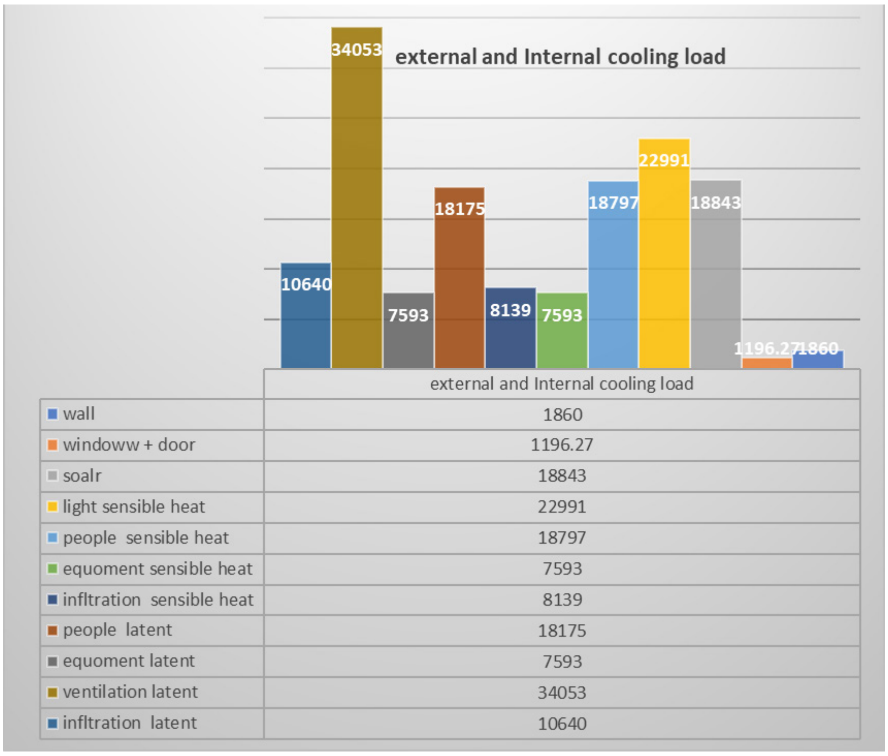


Figure 11: Internal and external cooling load

Table 10: Summary of the second floor’s internal and external air conditioning

SUM	R21	R20	R19	R18	R17	R16	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	ROOM1			SECOND
1860	624	150	35	35	35	60	67	35	35	35	131	131	35	35	35	67	60	35	35	35	150	wall		
1196.27	396.74	15.89	15.98	15.98	15.98	15.89	15.89	15.98	15.98	15.98	15.98	64	64	64	64	64	64	64	64	64	64	windoww + door		external cooling load
																						wood		
18843	4943	702	702	702	702	702	702	702	702	702	702	688	688	688	688	688	688	688	688	688	688	soalr		
22991	10438	615	615	615	615	580	711	615	615	615	615	615	615	615	615	711	711	615	615	615	615	light	sensible heat	enternal cooling load
18797	8517	502	502	502	502	580	580	502	502	502	502	495	495	495	495	572	572	495	495	495	495	people		
7593	3429	202	202	202	202	233	233	202	202	202	202	202	202	202	202	233	233	202	202	202	202	equoment		
26062	13834	593	593	593	593	685	685	593	593	593	593	593	593	593	593	685	685	593	593	593	593	ventilation		
8139	4323	185	185	185	185	214	214	185	185	185	185	185	185	185	185	214	214	185	185	185	185	infltration		
18176	9570	399	399	399	399	651	651	399	399	399	399	399	399	399	399	460	460	399	399	399	399	people	latent	
7593	3429	202	202	202	202	233	233	202	202	202	202	202	202	202	202	233	233	202	202	202	202	equoment		
34053	15373	906	906	906	906	1046	1046	906	906	906	906	906	906	906	906	1046	1046	906	906	906	906	ventilation		
10640	4804	283	283	283	283	327	327	283	283	283	283	283	283	283	283	327	327	283	283	283	283	infltration		

Table 11: Summary of the second floor's internal and external air conditioning

	SECOND					
		SUM				**external cooling load**
	21899.27	**21899.27**	**1860**	**wall**	**CONNECTION**	
			1196.27	**window + door**		
				wood		
			18843	**solar**		
WATT						
175942.27						
		83582	**22991**	**light**	**sensible heat**	**enternal cooling load**
	154043		**18797**	**people**		
			7593	**equipment**		
			26062	**ventilation**		
			8139	**infiltration**		
		70461	**18175**	**people**	**latent**	
			7593	**equipment**		
			34053	**ventilation**		
			10640	**infiltration**		

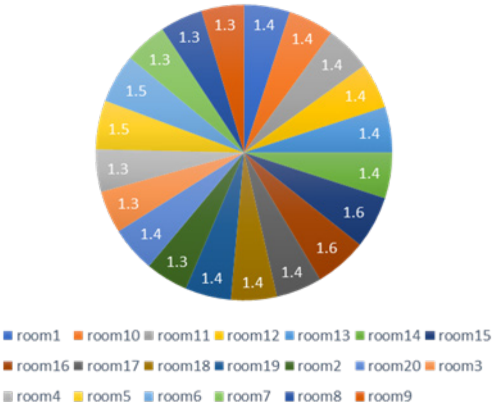


Figure 12: The cooling load is in tons for each room

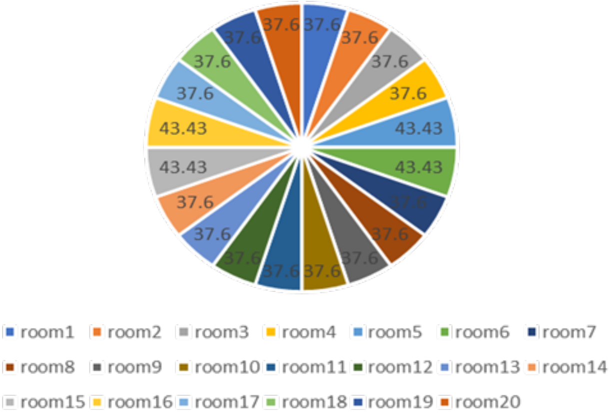


Figure 13: The cooling load is in tons for each room

Table 9: Air conditioning load calculation for the third floor

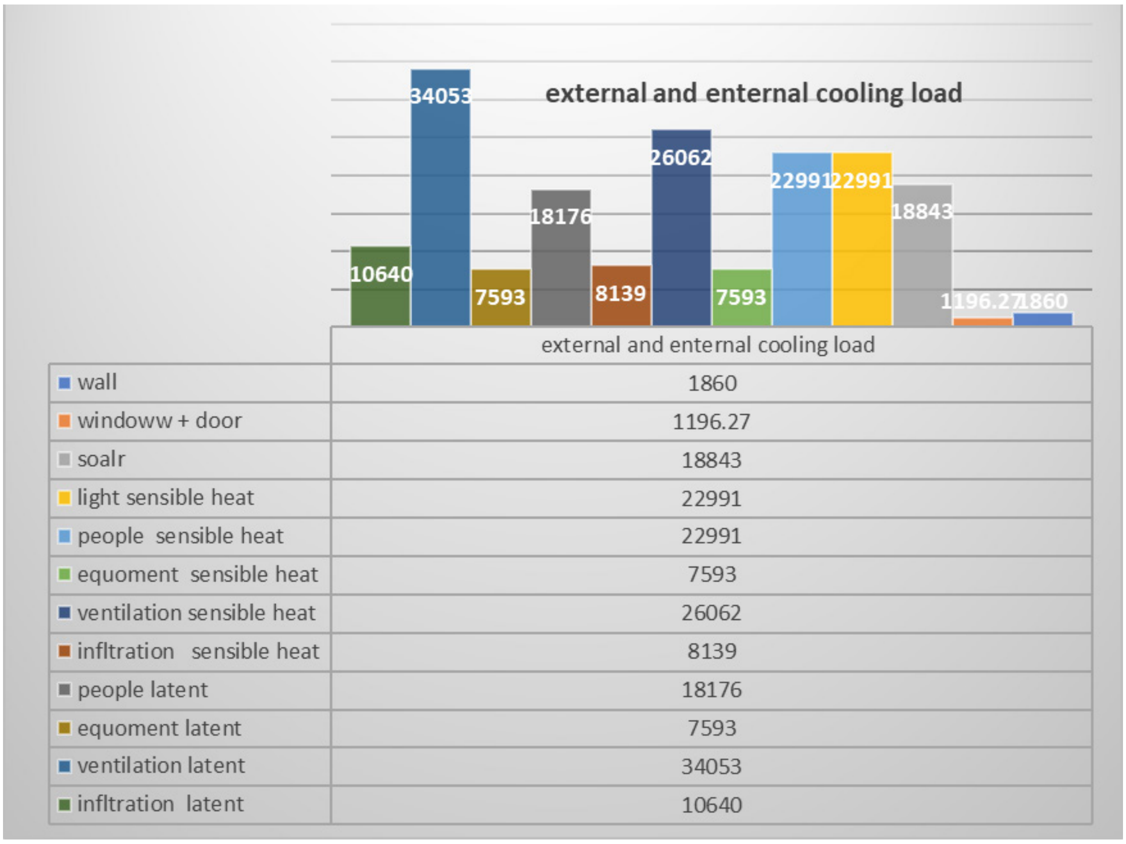
Third Floor					
k watt.h/m^2	K Watt	Area (m^2)	Ton	Watt	Room No.
0.1272074	4.783	37.6	1.4	4783	Room1
0.1241223	4.667	37.6	1.3	4667	Room2
0.1241223	4.667	37.6	1.3	4667	Room3
0.1241223	4.667	37.6	1.3	4667	Room4
0.1218973	5.294	43.43	1.5	5294	Room5
0.1220585	5.301	43.43	1.5	5301	Room6
0.1241223	4.667	37.6	1.3	4667	Room7
0.0124202	0.467	37.6	1.3	467	Room8
0.0124202	0.467	37.6	1.3	467	Room9
0.1266755	4.763	37.6	1.4	4763	Room10
0.1303723	4.902	37.6	1.4	4902	Room11
0.1278191	4.806	37.6	1.4	4806	Room12
0.1278191	4.806	37.6	1.4	4806	Room13
0.1278191	4.806	37.6	1.4	4806	Room14
0.1258577	5.466	43.43	1.6	5466	Room15
0.1256965	5.459	43.43	1.6	5459	Room16
0.1278191	4.806	37.6	1.4	4806	Room17
0.1278191	4.806	37.6	1.4	4806	Room18
0.1278191	4.806	37.6	1.4	4806	Room19
0.1308777	4.921	37.6	1.4	4921	Room20
0.1164389	74.288	638	21.2	74288	Room21
2.4153265	163.615	1413.32	49.2	163615	SUM
0.1150155	7.79119			The average	
	233.7357		Monthly energy consumption		

Table 13: Summary of the third floor's internal and external air conditioning

SUM	R21	R20	R19	R18	R17	R16	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	ROOM1			THIRD
1860	624	150	35	35	35	60	67	35	35	35	131	131	35	35	35	67	60	35	35	35	150	wall		external cooling load
1196.27	396.74	15.89	15.98	15.98	15.98	15.89	15.89	15.98	15.98	15.98	15.98	64	64	64	64	64	64	64	64	64	64	windoww + door		
																						wood		
18843	4943	702	702	702	702	702	702	702	702	702	702	688	688	688	688	688	688	688	688	688	688	soalr		
22991	10438	615	615	615	615	580	711	615	615	615	615	615	615	615	615	711	711	615	615	615	615	light	sensible heat	enternal cooling load
18797	8517	502	502	502	502	580	580	502	502	502	502	495	495	495	495	572	572	495	495	495	495	people		
7593	3429	202	202	202	202	233	233	202	202	202	202	202	202	202	202	233	233	202	202	202	202	equoment		
26062	13834	593	593	593	593	685	685	593	593	593	593	593	593	593	593	685	685	593	593	593	593	ventilation		
8139	4323	185	185	185	185	214	214	185	185	185	185	185	185	185	185	214	214	185	185	185	185	infltration		
18176	9570	399	399	399	399	651	651	399	399	399	399	399	399	399	399	460	460	399	399	399	399	people	latent	
7593	3429	202	202	202	202	233	233	202	202	202	202	202	202	202	202	233	233	202	202	202	202	equoment		
34053	15373	906	906	906	906	1046	1046	906	906	906	906	906	906	906	906	1046	1046	906	906	906	906	ventilation		
10640	4804	283	283	283	283	327	327	283	283	283	283	283	283	283	283	327	327	283	283	283	283	infltration		

Table 14: Summary of the third floor’s internal and external air conditioning

	THIRD					
		SUM				external cooling load
	21899.27	21899.27	1860	wall	CONNECTION	
			1196.27	windoww + door		
				wood		
			18843	soalr		
WATT						
175942.27						
		83582	22991	light	sensible heat	enternal cooling load
	154043		18797	people		
			7593	equoment		
			26062	ventilation		
			8139	infltration		
		70461	18175	people	latent	
			7593	equoment		
			34053	ventilation		
			10640	infltration		



	external and enternal cooling load
■ wall	1860
■ windoww + door	1196.27
■ soalr	18843
■ light sensible heat	22991
■ people sensible heat	22991
■ equoment sensible heat	7593
■ ventilation sensible heat	26062
■ infltration sensible heat	8139
■ people latent	18176
■ equoment latent	7593
■ ventilation latent	34053
■ infltration latent	10640

Figure 14: Internal and external cooling load

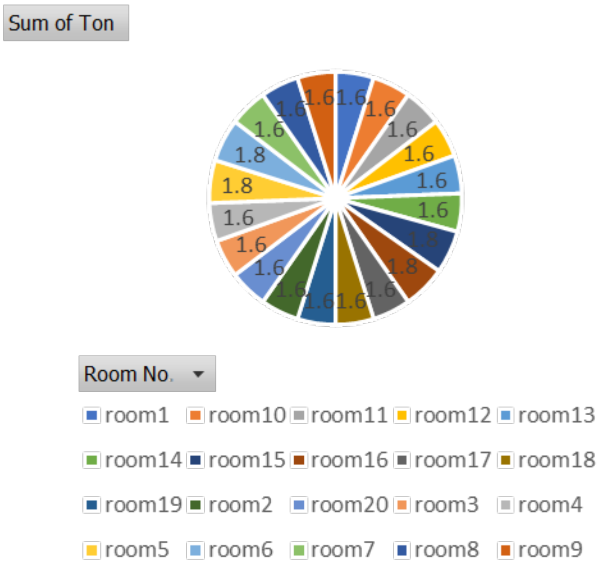


Figure 15: The cooling load is in tons for each room

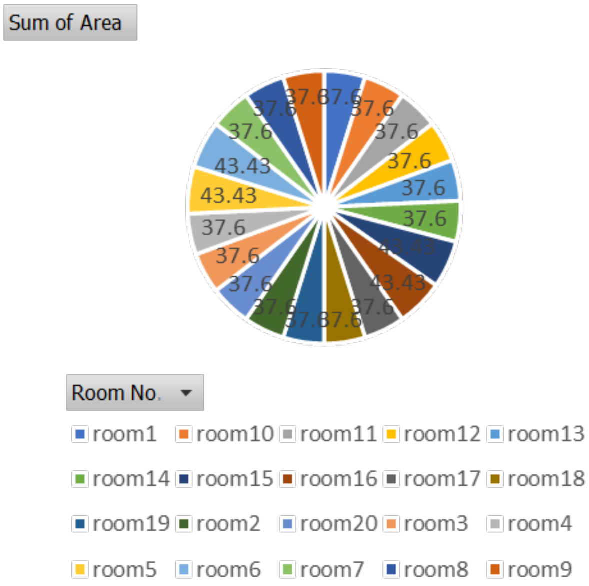


Figure 16: The cooling load is in tons for each room

Table 15: Air conditioning load calculation for the forth

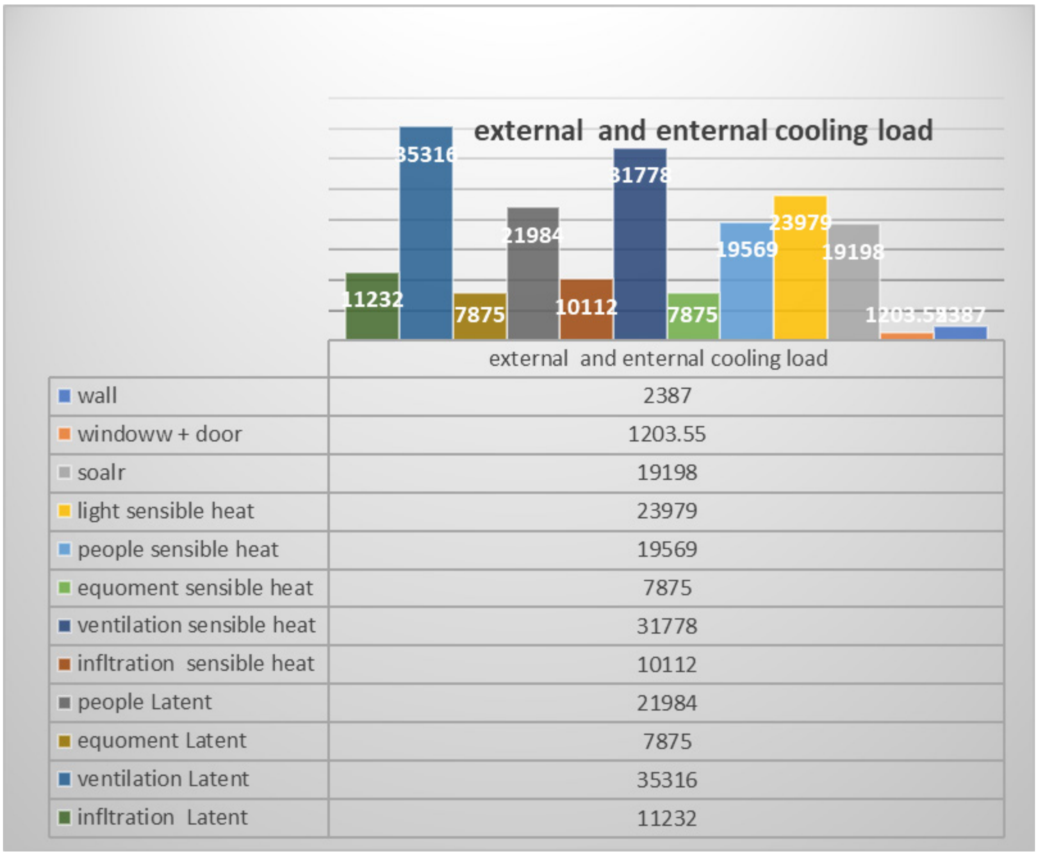
Fouth floor					
			Cooling Load		
k watt.h/m^2	K Watt	Area (m^2)	Ton	Watt	Room No.
0.1503989	5.655	37.6	1.6	5655	Room1
0.1473404	5.54	37.6	1.6	5540	Room2
0.1473404	5.54	37.6	1.6	5540	Room3
0.1473404	5.54	37.6	1.6	5540	Room4
0.1451071	6.302	43.43	1.8	6302	Room5
0.1452682	6.309	43.43	1.8	6309	Room6
0.1473404	5.54	37.6	1.6	5540	Room7
0.1473404	5.54	37.6	1.6	5540	Room8
0.1473404	5.54	37.6	1.6	5540	Room9
0.1498936	5.636	37.6	1.6	5636	Room10
0.1489894	5.602	37.6	1.6	5602	Room11
0.1464362	5.506	37.6	1.6	5506	Room12
0.1464362	5.506	37.6	1.6	5506	Room13
0.1464362	5.506	37.6	1.6	5506	Room14
0.1443242	6.268	43.43	1.8	6268	Room15
0.1444854	6.275	43.43	1.8	6275	Room16
0.1464362	5.506	37.6	1.6	5506	Room17
0.1464362	5.506	37.6	1.6	5506	Room18
0.1464362	5.506	37.6	1.6	5506	Room19
0.1494947	5.621	37.6	1.6	5621	Room20
0.1357743	86.624	638	24.7	86624	Room21
3.0763954	200.568	52.4	2.3	7915	Room22
0.1398362	401.136	1465.72	59.8	208483	SUM
6.1527907	18.23345			The average	
	547.0036	Monthly energy consumption			

Table 16: Summary of the forth floor’s internal and external air conditioning

FOURTH	external cooling load					enternal cooling load												
						sensible heat							latent					
	wall	windoww + door	wood	soalr		light	people	equoment	ventilation	infltration			people	equoment	ventilation	infltration		
ROOM1	150	64		688		615	502	202	815	255			564	202	906	283		
R2	35	64		688		615	502	202	815	255			564	202	906	283		
R3	35	64		688		615	502	202	815	255			564	202	906	283		
R4	35	64		688		615	502	202	815	255			564	202	906	283		
R5	60	64		688		711	580	233	942	294			651	233	1046	327		
R6	67	64		688		711	580	233	942	294			651	233	1046	327		
R7	35	64		688		615	502	202	815	255			564	202	906	283		
R8	35	64		688		615	502	202	815	255			564	202	906	283		
R9	35	64		688		615	502	202	815	255			564	202	906	283		
R10	131	64		688		615	502	202	815	255			564	202	906	283		
R11	131	15.89		702		615	502	202	815	255			564	202	906	283		
R12	35	15.89		702		615	502	202	815	255			564	202	906	283		
R13	35	15.89		702		615	502	202	815	255			564	202	906	283		
R14	35	15.89		702		615	502	202	815	255			564	202	906	283		
R15	60	15.89		702		711	580	233	942	294			651	233	1046	327		
R16	67	15.89		702		711	580	233	942	294			651	233	1046	327		
R17	35	15.89		702		615	502	202	815	255			564	202	906	283		
R18	35	15.89		702		615	502	202	815	255			564	202	906	283		
R19	35	15.89		702		615	502	202	815	255			564	202	906	283		
R20	120	15.89		702		615	502	202	815	255			564	202	906	283		
R21	624	396.7		4947		10438	8517	3429	13834	4323			9570	3429	15373	4804		
R22	557	7.948		351		857	700	282	1136	533			786	282	1263	592		
SUM	2387	1203.548		19198		23979	19569	7875	31778	10112			21984	7875	35316	11232		

Table 17: Summary of the forth floor's internal and external air conditioning

FOURTH						
		SUM				
	22788.55	21899.27	2387	wall	CONNECTION	external cooling load
			1203.55	windoww + door		
				wood		
			19198	soalr		
WATT						
192508.55						
		93313	23979	light	sensible heat	enternal cooling load
	169720		19569	people		
			7875	equoment		
			31778	ventilation		
			10112	infltration		
		76407	21984	people	latent	
			7875	equoment		
			35316	ventilation		
			11232	infltration		



	external and enternal cooling load
🟦 wall	2387
🟧 windoww + door	1203.55
⬜ soalr	19198
🟨 light sensible heat	23979
🟦 people sensible heat	19569
🟩 equoment sensible heat	7875
🟦 ventilation sensible heat	31778
🟫 infltration sensible heat	10112
⬛ people Latent	21984
🟫 equoment Latent	7875
🟦 ventilation Latent	35316
🟩 infltration Latent	11232

Figure 17: Internal and external cooling load