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"Low Energy Cooling Technique For Office Space In Mumbai"

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Abstract : The demand for effective cooling solutions in office buildings, particularly in regions like Mumbai with high temperatures and humidity levels, presents major challenges for centralised air conditioning systems. Although central air conditioning machines are commonly used, they have some drawbacks, such as high energy consumption and operational costs. To tackle these challenges, this paper presents an alternative technique employing existing HVAC technologies adapted. Variable Refrigerant Flow (VRF) systems, for example, increase energy efficiency by adjusting refrigerant flow rates in response to changing load demands. Energy recovery ventilation (ERV) systems can also be used to save energy by capturing heat and moisture from outgoing air streams. Using this new HVAC technology has several advantages over previous systems. They reduced power consumption significantly for the initial time, which reduced operational costs and their impact on the environment. Furthermore, they boost ventilation and cooling rates, giving workers a more comfortable working environment. Labour costs are reduced by these technologies since they require less workers to run. The abstract also emphasises the supplementary usage of passive cooling techniques to central air conditioning systems, such as roll-up curtains, reflective film, vegetation, thermal insulating walls, and building orientation optimisation. Without relying on mechanical cooling, passive cooling systems employ natural circulation and shade to lower heat buildup and enhance indoor comfort

***IndexTerms* - Component,formatting,style,styling,insert.**

I. INTRODUCTION

INTRODUCTION

Low-energy cooling methods for warm, humid environments In humid and hot cities like Mumbai, the ability to cool spaces effectively and continuously is essential. As the world's population grows and cities get more and more crowded, there is an increasing need for suitable workstations that don't use a lot of energy or hurt the environment. Hot and muggy places can be challenging due to traditional air conditioning systems' discomfort, health hazards, and high energy use. The overall objective of the project is to investigate potential low-energy cooling alternatives in order to address these issues. These suggestions could save costs, preserve the environment, and significantly reduce energy use. Thus, the project's goal is to update the old systems with economically cost, energy-efficient, and environmentally friendly cooling technologies. Mumbai is a humid and swampy city, so offices must have low-energy cooling equipment. They are good at keeping people comfortable while also having a low environmental impact. You can make a difference by using passive cooling methods that rely on natural indications such 2 as the sun and wind. Consider things like heat-regulating walls, plants, reflective film, and attractive roller curtains. Good windows, reflective roofs, and well-insulated buildings can all help to keep interior temperatures comfortable while using minimal energy.

1.1 Existing System

In the office space that we have considered the existing system used is the centralised air conditioning system. This system is one of the most commonly used in areas like Office Buildings, Hotels and Hospitality Industry, Shopping Malls and Retail Spaces, Healthcare Facilities, Educational Institutions, etc. Centralized air conditioning (AC) systems are widely used in office spaces for their efficiency, convenience, and cost-effectiveness. Centralized AC systems ensure uniform cooling throughout the office space, eliminating hotspots and ensuring a comfortable working environment for all employees, Centralised air conditioning systems guarantee consistent temperature throughout the organisation, removing discomfort and ensuring that every employee has a comfortable place to work. When it comes to energy efficiency, these systems are meant to be superior to decentralised ones. The need for separate cooling units in each office space is eliminated by centralised air conditioning systems, clearing up valuable floor space that can be used for more workplaces, meeting rooms, or common areas. This maximises the use of office space by reducing overall energy consumption and enhancing energy efficiency. This integration allows for centralised monitoring and control of all building functions while improving overall building efficiency. Office space requirements can be easily adjusted with centralised air conditioning systems. Additional cooling capacity can be added or changed as needed to meet the increasing demand.

In summary, the use of centralised air conditioning systems in office spaces has various advantages, including constant cooling, energy efficiency, space optimisation, centralised control, enhanced indoor air quality, scalability, interaction with building management systems. While meeting the functional requirements in modern office buildings, these systems help to provide a comfortable, effective, and sustainable work environment for employees.

Proposed System:-

The flow of refrigerant to indoor units is adjusted by variable refrigerant flow (VRF) systems according to demand. The VRF technology is the best choice for applications where zoning is necessary or when changing loads are present because it allows users to manage the quantity of refrigerant supplied to fan coil units spread throughout a building. In situations when simultaneous heating and cooling are necessary, VRF systems can be used as heat pump systems or heat recovery systems. VRF systems not only offer improved comfort but also design flexibility, energy savings, and affordable installation.

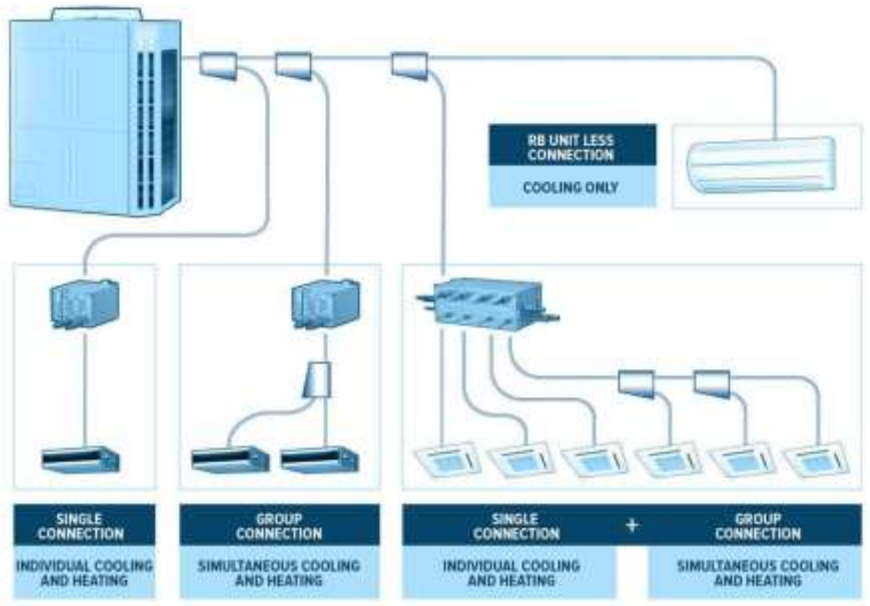


Fig 1.1 VRF System

One outdoor unit may be connected to several indoor fan coil units in a VRF system. The speed of the outdoor unit's one or more inverter-driven compressors can be changed by altering the frequency of the power supply to the compressor. The amount of refrigerant that will be delivered by the compressor changes along with the compressor speed. Each interior fan coil unit has its own metering device, which may be managed by the indoor unit or the outdoor unit. The outdoor unit distributes the amount of refrigerant required to satisfy each indoor unit's specific needs as soon as each indoor unit transmits a demand to it (Fig. 1.2). These features make the VRF system ideally suited for all applications that have part load requirements based on usage or building orientation, as well as applications that require zoning.

The VRF systems available on the market today differ according to the number and type of compressor. The 3 types of units that will be compared here are:

- Single Variable Speed Compressor
- Variable Speed Compressor Plus Fixed Speed Compressor
- Multiple Variable Speed Compressors

Single Variable Speed Compressor:

In this system with a single, large-capacity scroll compressor, the same compressor starts and runs when there is demand and no redundancy is available if the compressor fails.

Variable Speed Compressor Plus Fixed-Speed Compressor:

In this two-compressor system, the inverter-driven compressor always starts and ramps up until it reaches its maximum capacity at which time the fixed-speed compressor starts, and the inverter driven compressor ramps down. This system provides back-up capability.

Multiple Variable Speed Compressors:

Outdoor units with multiple inverter-driven twin rotary scroll compressors, offer the most complete set of advantages achievable with a VRF system. Multiple inverter-driven compressors allow the unit to provide better part load performance without the need to use hot gas bypass. Under low-load conditions, the system has the advantage of running only as many compressors at whatever speed is required to achieve the capacity necessary to satisfy the load and maintain comfort within the conditioned space.

NEED OF THE STUDY.

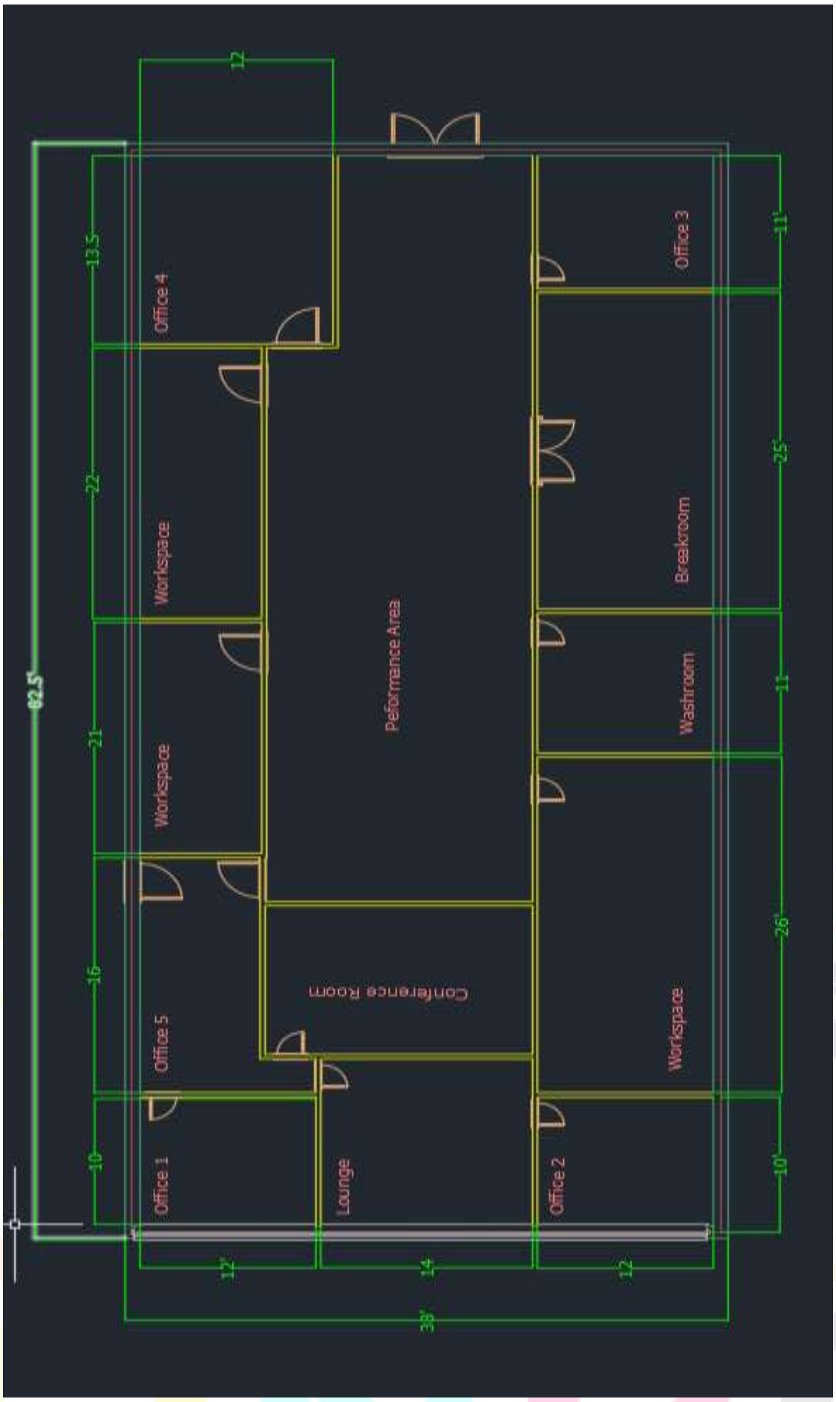
Having efficient cooling systems in place is crucial to ensuring that office workers can conduct business without discomfort in Mumbai, where heat and humidity are common. This supports the city's environmental goals by increasing output and helping to reduce energy use. This is the exact topic of the unique low-energy cooling experiment currently under way. Using innovative techniques that are especially suited to Mumbai's distinct surroundings, the project aims to leave a lasting impression. The objective is to significantly reduce the amount of energy needed for cooling by the use of a variety of passive cooling techniques, such as reflective film, energy-efficient HVAC systems, creative roller curtains, and thermal insulation. Automation of smart buildings is also used. As a result, this will support preserving each tenant's ideal degree of comfort in these office buildings. In addition, the project will look into the subject of sustainable energy sources, looking for ways to reduce dependency on conventional energy sources that harm the environment. Through the implementation of more sustainable and eco-friendly energy solutions, the initiative aims to lower global carbon emissions and open the door for additional environmental innovations. With the comprehensive low-energy cooling plan, Mumbai has a solid foundation for a more environmentally friendly and sustainable future. The goal of the project is to motivate other communities to work towards a greener, more energy-efficient future.

METHODOLOGY

The design procedure outlines the end-to-end solutions that are required to be taken to determine the appropriate heating, ventilation, and air conditioning (HVAC) system for a Office floor.

The first step involves visiting the location and analysing the site. This may involve assessing factors such as the orientation and position of the building, the climate and weather conditions in the area, and any potential sources of heat or humidity.

Once the architectural layout has been obtained, the next step is to calculate and measure the area that requires cooling. The heat load for each zone is then calculated based on factors such as the size and orientation of windows, the amount of insulation, and the heat generated by occupants and equipment. The cooling load calculation is an important step in the design process, as it provides the information necessary to properly size and select an air conditioning system that will meet the cooling needs of the building or space. The size of the air conditioning system will depend on the calculated cooling load and other factors such as the climate, budget, and energy efficiency requirements.



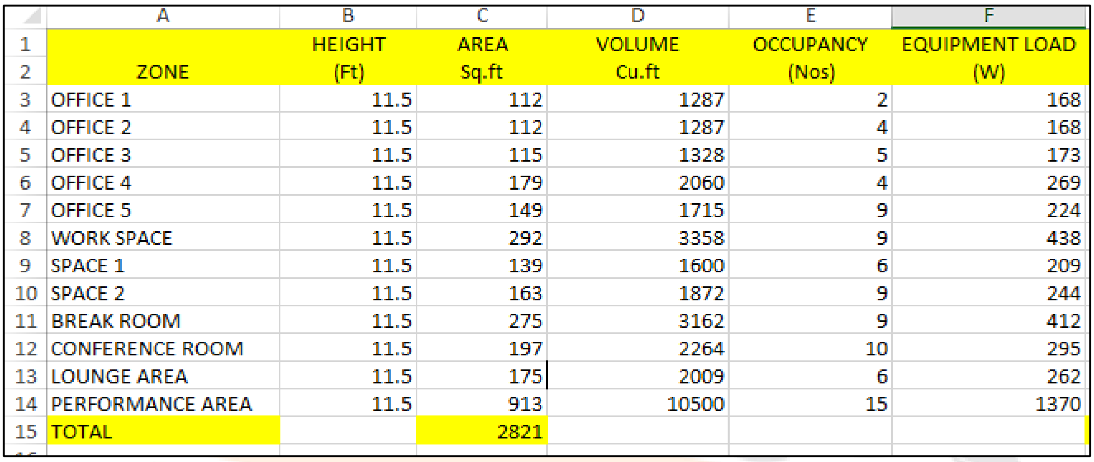
The heat load gives details such as the refrigeration capacity, CFM requirement, and fresh air requirement for each room. Refrigeration capacity refers to the amount of cooling required to maintain a comfortable temperature in the room, while CFM requirement is the volume of air that needs to be circulated to maintain a healthy and comfortable indoor environment. Fresh air requirement refers to the amount of outside air that needs to be brought into the room to maintain good indoor air quality.

Once the refrigeration capacity, CFM requirement, and fresh air requirement for each room have been determined, specific IDUs and ODUs can be selected from manufacturer catalogues. These components must meet technical specifications such as the required cooling capacity, airflow rate, and noise level, as well as cost requirements for the project budget.

In addition to the HVAC system, ventilation systems must also be selected for supply and exhaust ventilation to maintain the required amount of pressure in the room and meet the CFM requirement. Ventilation systems are needed to be designed particularly in places like Toilets.

Floor Plan:-

Area calculation sheet



	A	B	C	D	E	F
1		HEIGHT	AREA	VOLUME	OCCUPANCY	EQUIPMENT LOAD
2	ZONE	(Ft)	Sq.ft	Cu.ft	(Nos)	(W)
3	OFFICE 1	11.5	112	1287	2	168
4	OFFICE 2	11.5	112	1287	4	168
5	OFFICE 3	11.5	115	1328	5	173
6	OFFICE 4	11.5	179	2060	4	269
7	OFFICE 5	11.5	149	1715	9	224
8	WORK SPACE	11.5	292	3358	9	438
9	SPACE 1	11.5	139	1600	6	209
10	SPACE 2	11.5	163	1872	9	244
11	BREAK ROOM	11.5	275	3162	9	412
12	CONFERENCE ROOM	11.5	197	2264	10	295
13	LOUNGE AREA	11.5	175	2009	6	262
14	PERFORMANCE AREA	11.5	913	10500	15	1370
15	TOTAL		2821			

Method 1- Without Any Modification:-

Without Any modification that is without passive cooling technique. Initially to begin with we start the simulation on revit considering the major parameters like singe pane glass, centralised AC system, no insulation and brick wall which did not include and of the passive cooling technique.

Project Summary

Location and Weather	
Project	Project Name
Address	
Calculation Time	12 April 2024 13:17
Report Type	Standard
Latitude	19.14°
Longitude	72.88°
Summer Dry Bulb	32 °C
Summer Wet Bulb	25 °C
Winter Dry Bulb	17 °C
Mean Daily Range	6 °C

Building Summary

Inputs	
Building Type	Office
Area (ft^2)	2,943
Volume (CF)	33,842.95
Calculated Results	
Peak Cooling Total Load (ton)	**16.221**
Peak Cooling Month and Hour	July 16:00
Peak Cooling Sensible Load (ton)	12.435
Peak Cooling Latent Load (ton)	3.785
Maximum Cooling Capacity (ton)	16.295
Peak Cooling Airflow (CFM)	6,927.9
Peak Heating Load (W)	**-14,253**
Peak Heating Airflow (CFM)	626.6
Checksums	
Cooling Load Density (W/m^2)	208.65
Cooling Flow Density ($L/(s\cdot m^2)$)	11.96
Cooling Flow / Load ($L/(s\cdot kW)$)	57.32
Cooling Area / Load (m^2/kW)	4.79
Heating Load Density (W/m^2)	-52.13
Heating Flow Density ($L/(s\cdot m^2)$)	1.08

Fig 3.5 Without modification Result

To conclude with, we could find out the total tonnage require for centralised ac without any of Low Energy Cooling Technique & passive cooling techniques is 16.22ton

3.10 Method -2 With Modification:-

In order to verify the reduction in heat load require we consider the passive cooling techniques modification & low energy colloing technique

Reflective film :

Reflective films is a passive cooling technique commonly used in architecture and automotive industries to reduce heat gain from sunlight. It involves applying a thin film or coating to windows or other surfaces that reflects a portion of the incoming solar radiation, thus reducing the amount of heat that enters a building or vehicle.

Roller blinds:

Roller blinds are a simple and effective passive cooling solution that is widely used in buildings to reduce solar heat gain and improve thermal comfort Roller blinds can be mounted on windows to prevent or limit direct sunlight from entering a building's interior. The use of roller blinds serve to reduce solar heat gain by limiting the amount of sunlight that enters the space, keeping the indoor temperature lower. Roller blinds come in a variety of materials, including reflecting coatings and opaque textiles. These materials can reflect some of the sunlight away from the window or completely block it, lowering the amount of heat that enters the structure. Some roller blind materials offer additional insulation, which can help reduce heat transfer through windows in both hot and cold weather.

Gypsum wall partition:

Gypsum partition walls can contribute to maintaining a comfortable indoor temperature by providing thermal mass, insulation, and aiding in the distribution of cool air throughout the building. Thickness of the gypsum is 6 inch

3D Floor Design

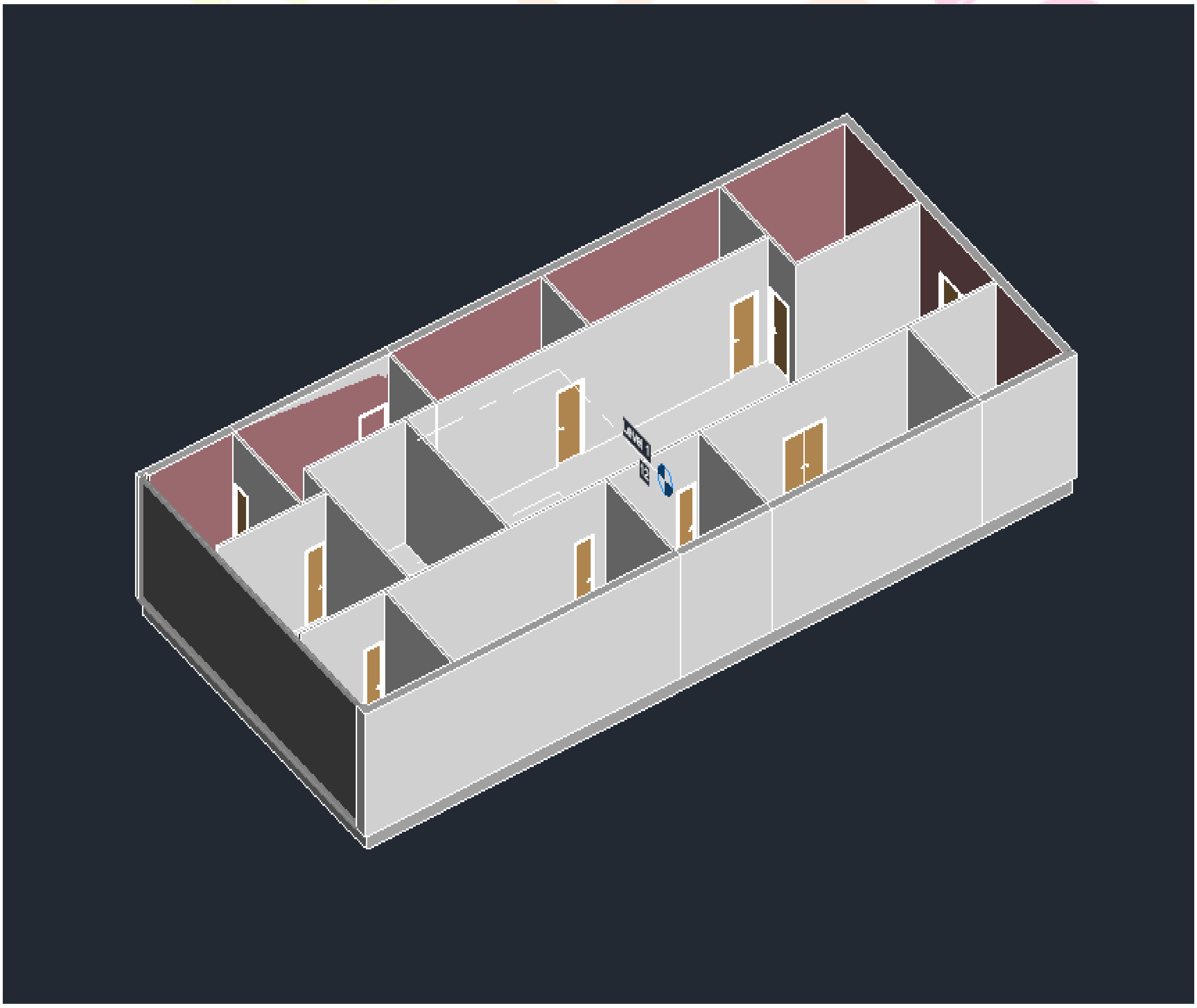
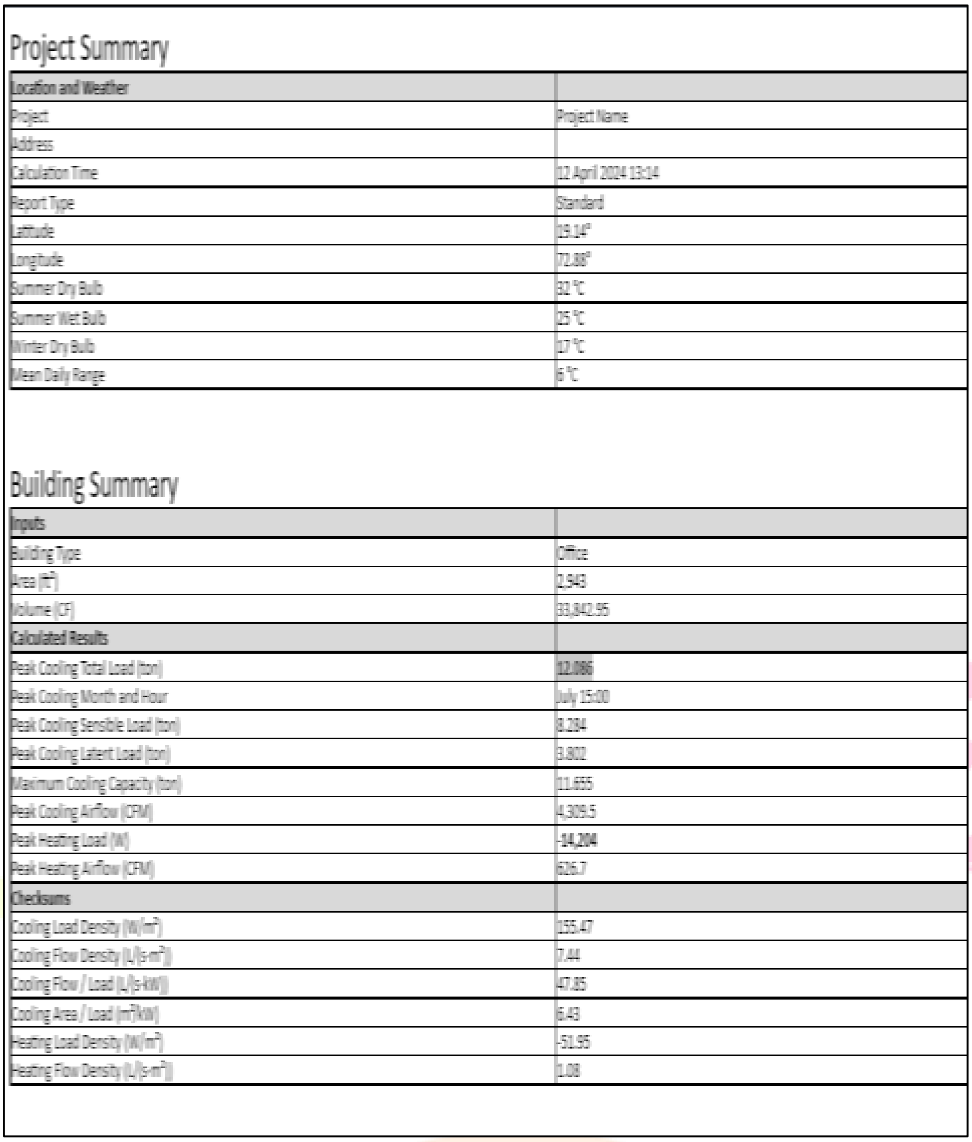


Fig 3.16 With modification 3D Design



Project Summary

Location and Weather	
Project	Project Name
Address	
Calculation Time	12 April 2024 13:14
Report Type	Standard
Latitude	19.14°
Longitude	72.88°
Summer Dry Bulb	32 °C
Summer Wet Bulb	25 °C
Winter Dry Bulb	17 °C
Mean Daily Range	6 °C

Building Summary

Inputs	
Building Type	Office
Area (ft²)	2,943
Volume (CF)	33,842.95
Calculated Results	
Peak Cooling Total Load (ton)	12.086
Peak Cooling Month and Hour	July 15:00
Peak Cooling Sensible Load (ton)	8.284
Peak Cooling Latent Load (ton)	3.802
Maximum Cooling Capacity (ton)	11.655
Peak Cooling Airflow (CFM)	4,309.5
Peak Heating Load (W)	-14,204
Peak Heating Airflow (CFM)	626.7
Checksums	
Cooling Load Density (W/m²)	155.47
Cooling Flow Density (L/(s-m²))	7.44
Cooling Flow / Load (L/(s-kW))	47.85
Cooling Area / Load (m²/kW)	6.43
Heating Load Density (W/m²)	-51.95
Heating Flow Density (L/(s-m²))	1.08

Fig 3.7 With modification Result

Considering Modification , we could find out the total tonnage required for VRF AC system by using Low Energy Cooling Technique & passive cooling techniques is 12.08 ton.

Percentage reduce in heat load due to modification

=[(16.22-12.08)/16.22]x100

=25.52%

Tonnage Comparison

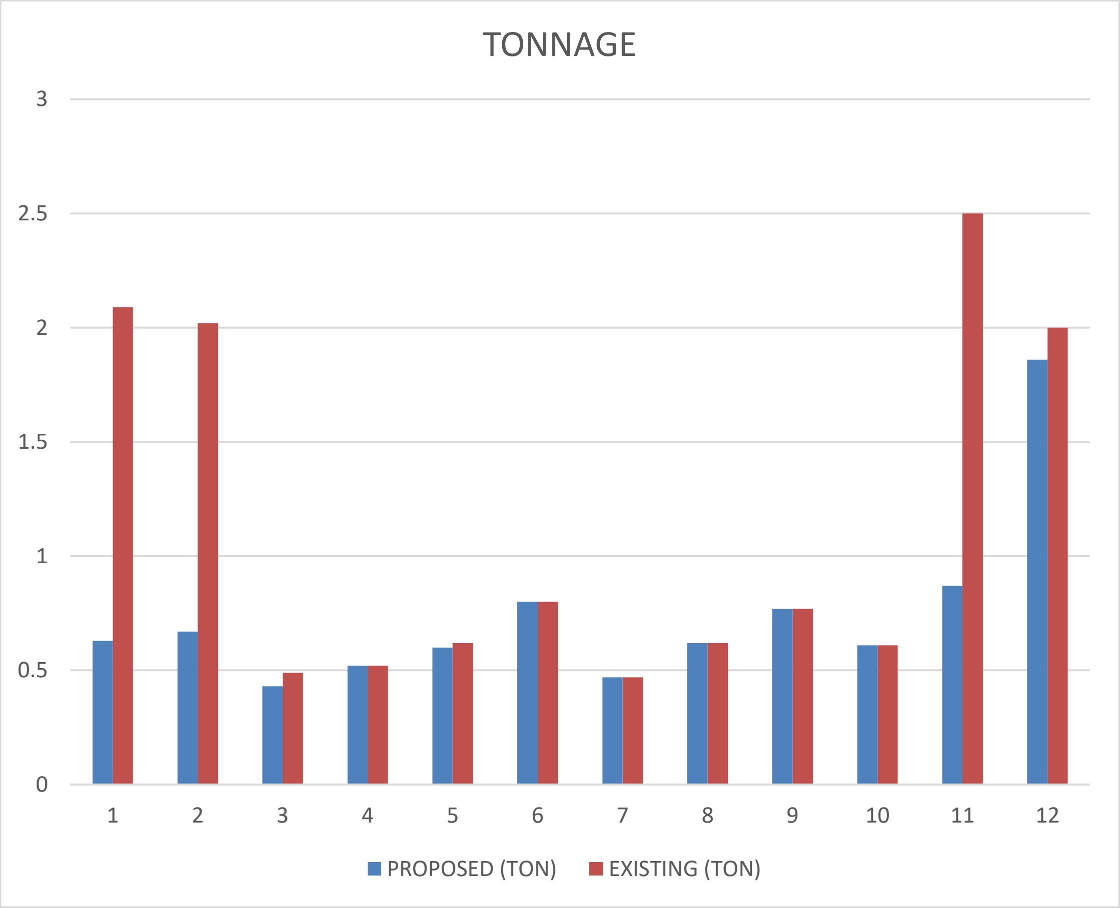
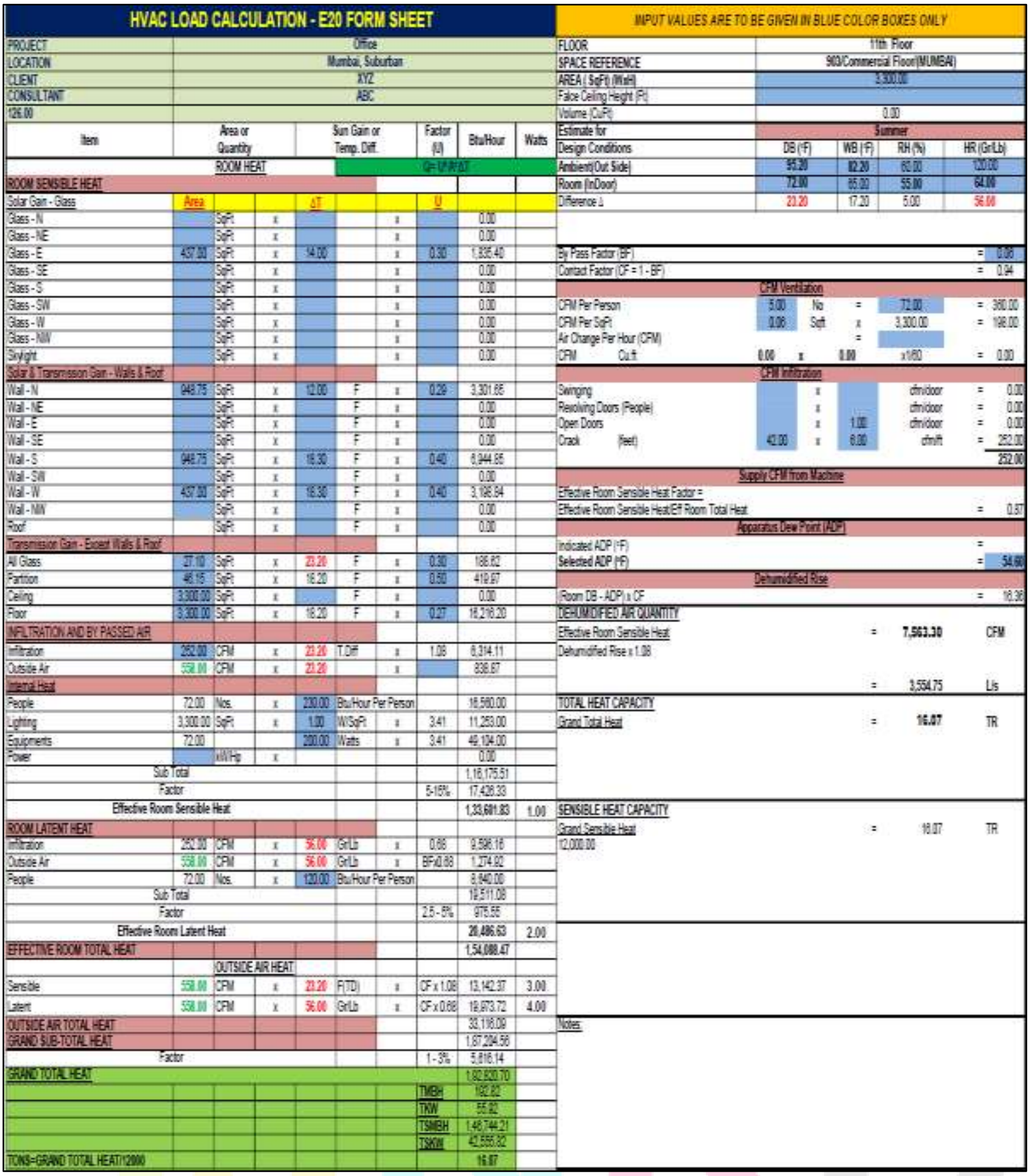


Fig 3.8 Tonnage Comparison with modification & without modification for different rooms

Heat Load Sheet (E20)



HVAC LOAD CALCULATION - E20 FORM SHEET

PROJECT	Office
LOCATION	Mumbai, Suburban
CLIENT	XYZ
CONSULTANT	ABC
126.00	

Item	Area or Quantity			Sun Gain or Temp. Diff.			Factor (U)	Btu/Hour	Watts
	ROOM HEAT				Q= U*A*ΔT				
ROOM SENSIBLE HEAT									
Solar Gain - Glass	Area			ΔT			U		
Glass - N		SqFt	x			x		0.00	
Glass - NE		SqFt	x			x		0.00	
Glass - E	437.00	SqFt	x	14.00		x	0.30	1,835.40	
Glass - SE		SqFt	x			x		0.00	
Glass - S		SqFt	x			x		0.00	
Glass - SW		SqFt	x			x		0.00	
Glass - W		SqFt	x			x		0.00	
Glass - NW		SqFt	x			x		0.00	
Skylight		SqFt	x			x		0.00	
Solar & Transmission Gain - Walls & Roof									
Wall - N	948.75	SqFt	x	12.00	F	x	0.29	3,301.65	
Wall - NE		SqFt	x		F	x		0.00	
Wall - E		SqFt	x		F	x		0.00	
Wall - SE		SqFt	x		F	x		0.00	
Wall - S	948.75	SqFt	x	18.30	F	x	0.40	6,944.85	
Wall - SW		SqFt	x		F	x		0.00	
Wall - W	437.00	SqFt	x	18.30	F	x	0.40	3,198.84	
Wall - NW		SqFt	x		F	x		0.00	
Roof		SqFt	x		F	x		0.00	
Transmission Gain - Except Walls & Roof									
All Glass	27.10	SqFt	x	23.20	F	x	0.30	188.62	
Partition	46.15	SqFt	x	18.20	F	x	0.50	419.97	
Ceiling	3,300.00	SqFt	x		F	x		0.00	
Floor	3,300.00	SqFt	x	18.20	F	x	0.27	16,216.20	
INFILTRATION AND BY PASSED AIR									
Infiltration	252.00	CFM	x	23.20	T.Diff	x	1.08	6,314.11	
Outside Air	558.00	CFM	x	23.20		x		838.67	
Internal Heat									
People	72.00	Nos.	x	230.00	Btu/Hour Per Person			16,560.00	
Lighting	3,300.00	SqFt	x	1.00	W/SqFt	x	3.41	11,253.00	
Equipments	72.00			200.00	Watts	x	3.41	49,104.00	
Power		kW/Hp	x					0.00	
Sub Total								1,16,175.51	
Factor							5-15%	17,426.33	
Effective Room Sensible Heat								1,33,601.83	1.00
ROOM LATENT HEAT									
Infiltration	252.00	CFM	x	56.00	Gr/Lb	x	0.68	9,596.16	
Outside Air	558.00	CFM	x	56.00	Gr/Lb	x	BFx0.68	1,274.92	
People	72.00	Nos.	x	120.00	Btu/Hour Per Person			8,640.00	
Sub Total								19,511.08	
Factor							2.5 - 5%	975.55	
Effective Room Latent Heat								20,486.63	2.00
EFFECTIVE ROOM TOTAL HEAT								1,54,088.47	
		OUTSIDE AIR HEAT							
Sensible	558.00	CFM	x	23.20	F(TD)	x	CF x 1.08	13,142.37	3.00
Latent	558.00	CFM	x	56.00	Gr/Lb	x	CF x 0.68	19,973.72	4.00
OUTSIDE AIR TOTAL HEAT								33,116.09	
GRAND SUB-TOTAL HEAT								1,87,204.56	
Factor							1 - 3%	5,616.14	
GRAND TOTAL HEAT								1,92,820.70	
							TMBH	192.82	
							TKW	55.82	
							TSMBH	1,46,744.21	
							TSKW	42,555.82	
TONS=GRAND TOTAL HEAT/12000								16.07	

INPUT VALUES ARE TO BE GIVEN IN BLUE COLOR BOXES ONLY

FLOOR	11th Floor
SPACE REFERENCE	903/Commercial Floor(MUMBAI)
AREA (SqFt) (WxH)	3,300.00
Falce Ceiling Height (Ft)	
Volume (CuFt)	0.00
Estimate for	Summer

Design Conditions	DB (°F)	WB (°F)	RH (%)	HR (Gr/Lb)
Ambient(Out Side)	95.20	82.20	60.00	120.00
Room (InDoor)	72.00	65.00	55.00	64.00
Difference Δ	23.20	17.20	5.00	56.00

By Pass Factor (BF) = 0.06

Contact Factor (CF = 1 - BF) = 0.94

CFM Ventilation

CFM Per Person	5.00	No	=	72.00		= 360.00
CFM Per SqFt	0.06	Sqft	x	3,300.00		= 198.00
Air Change Per Hour (CFM)			=			
CFM Cu.ft	0.00	x	0.00		x1/60	= 0.00

CFM Infiltration

Swinging		x		cfm/door	= 0.00
Revolving Doors (People)		x		cfm/door	= 0.00
Open Doors		x	1.00	cfm/door	= 0.00
Crack (feet)	40.00	x	6.00	cfm/ft	= 252.00
					252.00

Supply CFM from Machine

Effective Room Sensible Heat Factor =

Effective Room Sensible Heat/Eff Room Total Heat = 0.87

Apparatus Dew Point (ADP)

Indicated ADP (°F) =

Selected ADP (°F) = 54.60

Dehumidified Rise

(Room DB - ADP) x CF = 16.36

DEHUMIDIFIED AIR QUANTITY

Effective Room Sensible Heat = **7,563.30** CFM

Dehumidified Rise x 1.08

= 3,554.75 L/s

TOTAL HEAT CAPACITY

Grand Total Heat = **16.07** TR

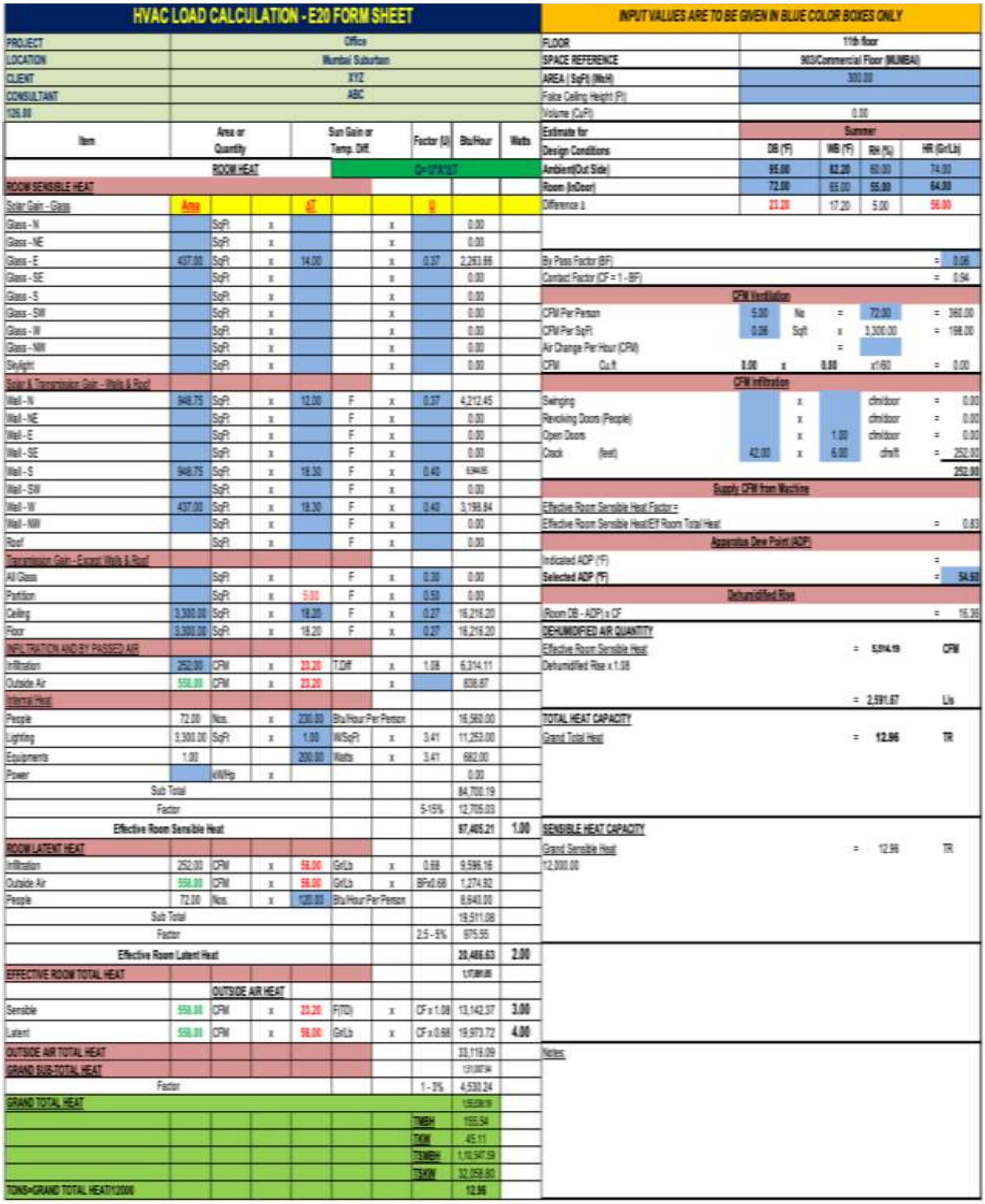
SENSIBLE HEAT CAPACITY

Grand Sensible Heat = 16.07 TR

12,000.00

Notes:

Fig Heat load calculations for existing system



HVAC LOAD CALCULATION - E20 FORM SHEET

PROJECT	Office
LOCATION	Mumbai Suburban
CLIENT	XYZ
CONSULTANT	ABC
126.00	

Item	Area or Quantity			Sun Gain or Temp. Diff			Factor (U)	Btu/Hour	Watts
		ROOM HEAT			Q=U*A*ΔT				
ROOM SENSIBLE HEAT									
Solar Gain - Glass	Area			ΔT			U		
Glass - N		SqFt	x			x		0.00	
Glass - NE		SqFt	x			x		0.00	
Glass - E	437.00	SqFt	x	14.00		x	0.37	2,263.66	
Glass - SE		SqFt	x			x		0.00	
Glass - S		SqFt	x			x		0.00	
Glass - SW		SqFt	x			x		0.00	
Glass - W		SqFt	x			x		0.00	
Glass - NW		SqFt	x			x		0.00	
Skylight		SqFt	x			x		0.00	
Solar & Transmission Gain - Walls & Roof									
Wall - N	948.75	SqFt	x	12.00	F	x	0.37	4,212.45	
Wall - NE		SqFt	x		F	x		0.00	
Wall - E		SqFt	x		F	x		0.00	
Wall - SE		SqFt	x		F	x		0.00	
Wall - S	948.75	SqFt	x	18.30	F	x	0.40	[illegible]	
Wall - SW		SqFt	x		F	x		0.00	
Wall - W	437.00	SqFt	x	18.30	F	x	0.40	3,198.84	
Wall - NW		SqFt	x		F	x		0.00	
Roof		SqFt	x		F	x		0.00	
Transmission Gain - Except Walls & Roof									
All Glass		SqFt	x		F	x	0.30	0.00	
Partition		SqFt	x	5.00	F	x	0.58	0.00	
Ceiling	3,300.00	SqFt	x	18.20	F	x	0.27	16,216.20	
Floor	3,300.00	SqFt	x	18.20	F	x	0.27	16,216.20	
INFILTRATION AND BY PASSED AIR									
Infiltration	252.00	CFM	x	23.20	T.Diff	x	1.08	6,314.11	
Outside Air	558.00	CFM	x	23.20		x		838.87	
Internal Heat									
People	72.00	Nos.	x	230.00	Btu/Hour Per Person			16,560.00	
Lighting	3,300.00	SqFt	x	1.00	W/SqFt	x	3.41	11,253.00	
Equipments	1.00			200.00	Watts	x	3.41	682.00	
Power		kW/Hp	x					0.00	
Sub Total								84,700.19	
Factor							5-15%	12,705.03	
Effective Room Sensible Heat								97,405.21	1.00
ROOM LATENT HEAT									
Infiltration	252.00	CFM	x	56.00	Gr/Lb	x	0.68	9,596.16	
Outside Air	558.00	CFM	x	56.00	Gr/Lb	x	BFx0.68	1,274.92	
People	72.00	Nos.	x	120.00	Btu/Hour Per Person			8,640.00	
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Factor							2.5 - 5%	975.55	
Effective Room Latent Heat								20,486.63	2.00
EFFECTIVE ROOM TOTAL HEAT								[illegible]	
		OUTSIDE AIR HEAT							
Sensible	558.00	CFM	x	23.20	F(TD)	x	CF x 1.08	13,142.37	3.00
Latent	558.00	CFM	x	56.00	Gr/Lb	x	CF x 0.68	19,973.72	4.00
OUTSIDE AIR TOTAL HEAT								33,116.09	
GRAND SUB-TOTAL HEAT								[illegible]	
Factor							1 - 3%	4,530.24	
GRAND TOTAL HEAT								[illegible]	
							TMBH	155.54	
							TKW	45.11	
							TSMBH	1,10,547.59	
							TSKW	32,058.80	
TONS=GRAND TOTAL HEAT/12000								12.96	

INPUT VALUES ARE TO BE GIVEN IN BLUE COLOR BOXES ONLY

FLOOR	11th floor			
SPACE REFERENCE	903/Commercial Floor (MUMBAI)			
AREA | SqFt (MxH)	300.00			
False Ceiling Height (Ft)				
Volume (CuFt)	0.00			
Estimate for	Summer			
Design Conditions	DB (°F)	WB (°F)	RH (%)	HR (Gr/Lb)
Ambient(Out Side)	95.00	82.20	60.00	74.00
Room (InDoor)	72.00	65.00	55.00	64.00
Difference Δ	23.20	17.20	5.00	56.00

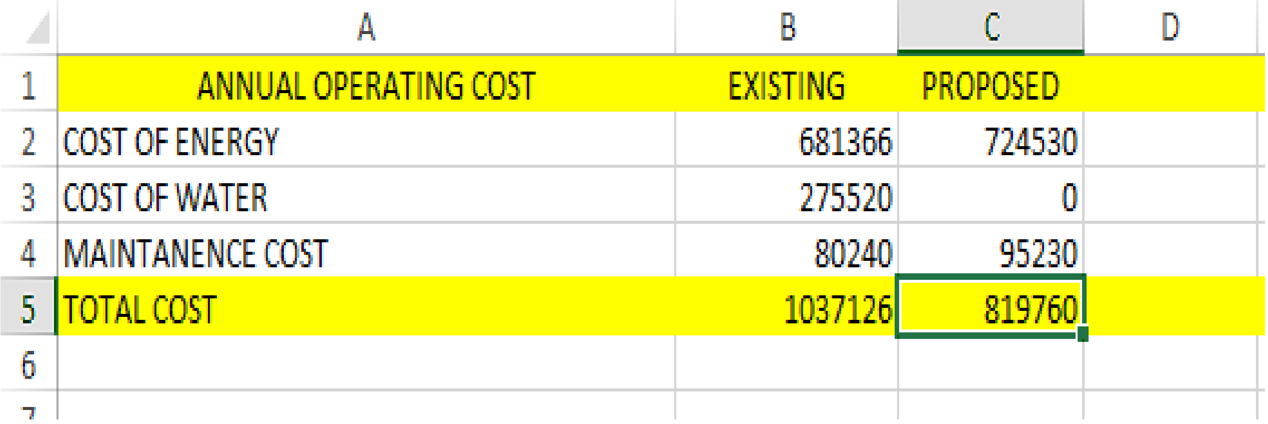
By Pass Factor (BF)						=	0.06
Contact Factor (CF = 1 - BF)						=	0.94
CFM Ventilation							
CFM Per Person	5.00	No	=	72.00		=	360.00
CFM Per SqFt	0.06	Sqft	x	3,300.00		=	198.00
Air Change Per Hour (CFM)			=				
CFM Cu.ft	0.00	x		0.00	x1/60	=	0.00
CFM Infiltration							
Swinging		x			cfm/door	=	0.00
Revolving Doors (People)		x			cfm/door	=	0.00
Open Doors		x		1.00	cfm/door	=	0.00
Crack (feet)	42.00	x		6.00	cfm/ft	=	252.00
							252.00
Supply CFM from Machine							
Effective Room Sensible Heat Factor =							
Effective Room Sensible Heat/Eff Room Total Heat						=	0.83
Apparatus Dew Point (ADP)							
Indicated ADP (°F)						=	
Selected ADP (°F)						=	54.60
Dehumidified Rise							
(Room DB - ADP) x CF						=	16.36
DEHUMIDIFIED AIR QUANTITY							
Effective Room Sensible Heat Dehumidified Rise x 1.08				=	5,514.19		CFM
				=	2,591.67		L/s
TOTAL HEAT CAPACITY							
Grand Total Heat				=	12.96		TR
SENSIBLE HEAT CAPACITY							
Grand Sensible Heat 12,000.00				=	12.96		TR
Notes:							

Fig Heat load calculations for Proposed system

IV. RESULTS AND DISCUSSION

Sr. No.	Name	Number of Quantity	Single quantity cost	Total quantity cost	Installation cost	Total cost
1	Outdoor unit [35 HP]	2	100000	200000	20000	220000
2	Casssette 1.5TR	11	48000	528000	52800	580800
3	Casssette 2.0TR	2	65000	130000	13000	143000
4	Copper pipe	30m	650 per meter	20000	2000	22000
5	Gypsum Standard Board	3000 sq ft	85 per sq ft	255000	25000	280000
6	Dehumidifier [40 pints]	2	22000	44000	4000	48000
7	Passive Technique	440 sq ft	75 per sq ft	54136	5400	59536
				1210000	122200	1332200

Fig Proposed System



	A	B	C	D
1	ANNUAL OPERATING COST	EXISTING	PROPOSED	
2	COST OF ENERGY	681366	724530	
3	COST OF WATER	275520	0	
4	MAINTANENCE COST	80240	95230	
5	TOTAL COST	1037126	819760	
6				

Fig Annual Running Cost

Conclusion:-

A sustainable HVAC system's major purpose is to provide thermal comfort while using the least amount of energy possible, as well as suitable interior air conditioning and high-quality ventilation . Using theoretical and analytical methods, the energy consumed is 9100kw , and the running cost / life analysis cost is 7.2 LPA. The Proposed system will take a total of six years to return its costs. By using analytical methods The energy Consumed is reduced by 25.52% and the running life cost is lowered by 20.95%. The modified system will take a total of six years to return its cost.

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