National Student Design Competition 2020-21

Design Theme: Design of Air Conditioning System for a IT COMPANY for Better Indoor Air Quality

TEAM DETAILS:

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INSTITUTE DETAILS:

S. No.	Particulars	Details
1	College Name with Address	Lokmanya Tilak College of Engineering, Navi Mumbai
2	Faculty Coordinator (Mobile No. & email ID)	Dr. Kavita Dhanawade Mobile No. - 9224410022 Email ID - kavitadhanawade2@gmail.com (ISHRAE membership ID – 56763, 59126)
3	Mentor for the Project (Mobile No. & email ID)	Mr. Dhaval Arvind Gajra Mobile No. - 9029191807 Email ID - dhavalgajra1997@gmail.com
4	ISHRAE Student Chapter in the Institution (Yes or No)?	Yes

Local ISHRAE Chapter:

S. No.	Particulars	Name of the Chapter / Sub Chapter
1	Local ISHRAE Chapter	Mumbai

OBJECTIVE

The purpose of HVAC system is to provide a healthy and comfortable environment by means of controlling

humidity and temperature. Also, HVAC systems are responsible for distributing this conditioned air to multiple locations at efficient rate.

The majority of this air-conditioned air can be re-circulated into the desired location, but a portion of the supply air

must be mixed with outside air to provide ample supply of oxygen in this indoor environment.

Due to the growing pandemic situation, the need for better Indoor Air Quality and need for prevention of Airborne disease spread is increasing rapidly.

Along with all these factors, the energy optimization and cost savings methods are needed to be implemented

ACKNOWLEDGEMENT

We would like to thank ISHRAE for providing us a platform to put our engineering skills to a test.We all had a great experience working as a team, helping each other at every step taken forward. We would like to thank all the faculty members and mentors who helped

us to hone our knowledge further and correct us at every lapse and error.

Special thanks to ISHRAE Mumbai Chapter for helping us in the time of need and also Mr. Dhaval Gajra for mentoring us to a right path.

Special thanks to Dr. Kavita Dhanavade madam for her motivation and guidance without which making this report was not possible.

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PROJECT DESCRIPTION

This report summarizes the building services and environmental design criteria developed during concept stage.

The Project is of IT Company Comprising of two floors (Ground and first floor) with a total capacity of 500PAX

- 15 Off-shore Development Centers
- Conference room
- 50pax Training room
- Meeting room – 12PAX x 4Nos; 2PAX x 2Nos
- General Manager room and Admin Manager room
- Server room
- 4 Male washroom, 4 Female washroom and 2 Washroom for differently abled person
- 15PAX Breakout area – 2Nos
- First-Aid room

ASSUMPTIONS

Standards

ISHRAE Handbook

ASHRAE UFAD Guide

CARRIER HANDBOOK FOR AIR CONDITIONING SYSTEMS

Basis of design

Site Location	Bengaluru
Orientation	Entrance side facing north
Latitude	12.9716° N
Altitude	921m at sea level

Outdoor Design Condition

	DBT (deg F)	**RH (%)**
Summer	93	35
Monsoon	82	77
Winter	79	73

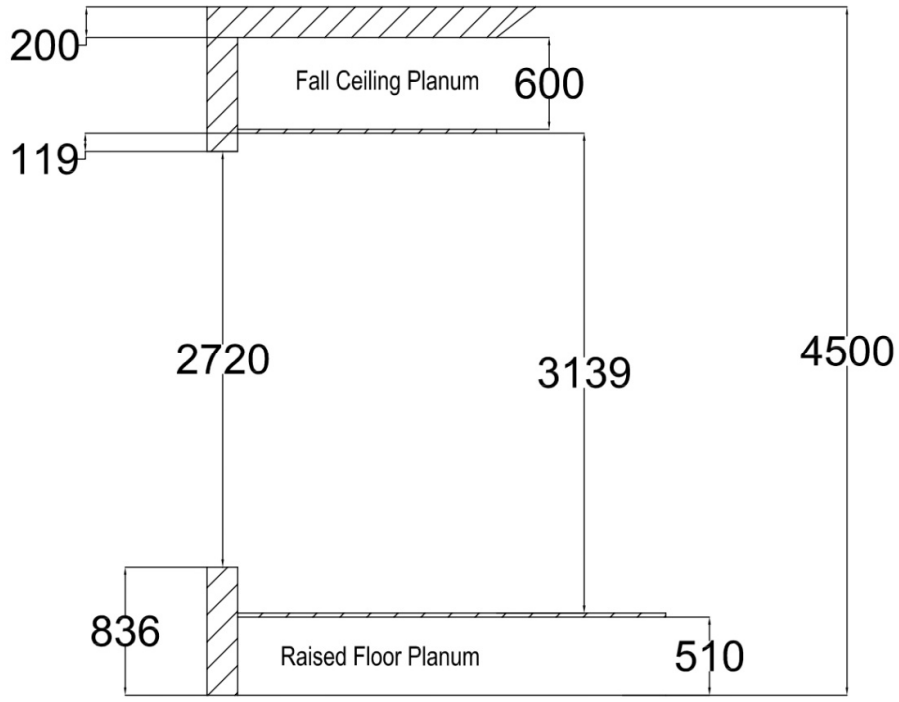
Indoor Design Condition

Temp (deg F)	**Relative Humidity %**
75	55

Assumptions for HVAC Loads

Sr. No.	**Building Envelope**	**Factors considered for this report**
1	Exterior Walls	U = 0.27 Btu/Hr Sqft °F
2	Glass Solar Factor (SHGC)	0.52
3	All Glass	U = 0.34 Btu/Hr Sqft °F
4	Partition 1	U = 0.252 Btu/Hr Sqft °F
5	Partition 2	U = 0.47 Btu/Hr Sqft °F
6	Floor	U = 0.48 Btu/Hr. Sqft °F
7	Roof (Exposed to sun)	U = 0.0865 Btu/Hr Sqft °F
8	Fresh air load	0.06 cfm/sqft + 5 cfm/person
9	Lighting load (Open Plan)	0.97 watt/Sq. ft.
10	Lighting load (Closed Plan)	1.11 watt/Sq. ft.
11	Occupancy	As per given input
12	Heat Gain from people	
a	Sensible load @ 75° F	245 Btu/h As per ISHRAE Standards
b	Latent load @ 75° F	205 Btu/h As per ISHRAE Standards

Assumed Cross Section:



Construction Material Details:

Construction	MATERIAL	Specifications	R(final)	U
External Wall	Cinder Block	Core	1.5	0.271327715
	Perlite aggregate	Plaster	1.25558	
	Air	Outside	0.25	
		Inside	0.68	
	Total		3.68558	
Roof	Lightweight Aggregate	Core	0.95	0.08665511265
	Lightweight Aggregate	Plaster	0.64	
	EPS	Insulation	8.87	
	Air	Outside	0.25	
		Inside	0.83	
	Total		11.54	
GLASS	Glass		2	0.3412969283
	Air	Outside	0.25	
		Inside	0.68	
	Total		2.93	

Equipment List

Equipment	Wattage
PC	135
Printer	320
FAX	30
Coffee maker	1050 (Latent : 540 Btu/hr)
Cold beverage	960
Water Cooler	350
Oven	400
Projector	400

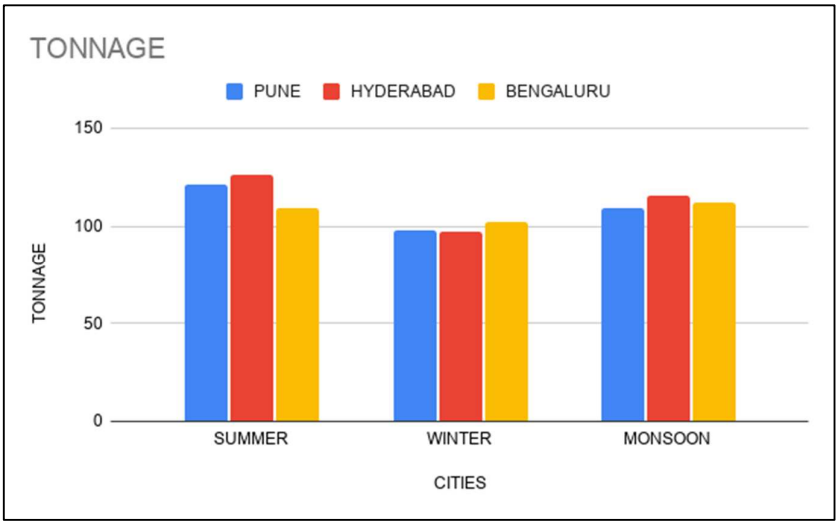
SELECTION OF LOCATION

c. Pune, Bengaluru and Hyderabad were shortlisted cities for the building as they are main IT hub of India

Outdoor Design Condition			
CITY	**SEASON**	**OUTDOOR DBT (°F)**	**OUTDOOR RH (%)**
Bengaluru	Sumner	93	35
	Winter	79	73
	Monsoon	82	77
Hyderabad	Sumner	100.6	35
	Winter	82	53
	Monsoon	84	74
Pune	Sumner	99	36
	Winter	86	40.5
	Monsoon	79	85

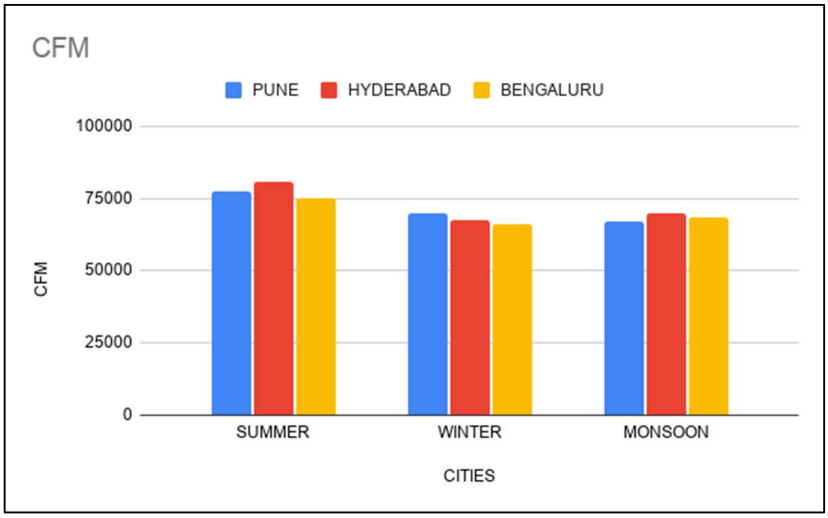
d. Comparison of Tonnage for different seasons at various location

TONNAGE				
	SUMMER	**WINTER**	**MONSOON**	**MAX TR**
Pune	121.1910	97.6137	109.3103	121.1910
Hyderabad	126.1612	97.0633	115.4356	126.1612
Bengaluru	109.1113	102.0059	111.7480	111.7480



a. Comparison of CFM for different seasons at various location

CFM				
	SUMMER	WINTER	MONSOON	MAX CFM
Pune	77389.9645	69819.6715	67253.3421	77389.9645
Hyderabad	80884.2352	67378.5574	69789.2309	80884.2352
Bengaluru	75275.6031	66246.0031	68388.5228	75275.6031



b. The peak Tonnage and peak CFM for Bengaluru is minimum, hence selecting Bengaluru as site location for the project

SAMPLE HEAT LOAD CALCULATION:

HEAT LOAD ESTIMATION							
Job Name	NSDC		Area (ft²)	802		Occupancy	24
Location	PUNE		Height (ft)	14.1		cfm/person	5
Space	ODC 2		Volume	11308.2		cfm/sq. ft.	0.06

SENSIBLE HEAT				
SOLAR GAIN GLASS				
Item	Area	Sun Gain/	U - Factor	Btu/hr.
N-Glass	0	16	0.52	0
NE- Wall	0		0.52	0
E-Glass	128.73344	11	0.52	736.3552768
SE-Glass	0		0.52	0
S-Glass	0	11	0.52	0
SW-Glass	0		0.52	0
W-Glass	0	163	0.52	0
NW-Glass	0		0.52	0
Skylight			0.52	0
Total	128.73344			736.3552768
SOLAR GAIN THROUGH WALLS AND ROOF				
N-Wall	0	14.11	0.271327715	0
NE- Wall	0	2.11	0.271327715	0
E-Wall	232.00096	15.11	0.271327715	951.1486673
SE-Wall	0	2.11	0.271327715	0
S-Wall	0	28.11	0.271327715	0
SW-Wall	0	2.11	0.271327715	0
W-Wall	0	35.11	0.271327715	0
NW-Wall	0	2.11	0.271327715	0
Roof Sun		37.11	0.08665511265	0
Roof		2.11	0.08665511265	0
SUB TOTAL				951.1486673
TRANSMISSION GAIN AND INTERNAL HEAT LOADS				
All Glass	128.73344	18	0.3412969283	790.8538975
Partition	218.75304	13	0.252	716.634959
Partition	0	13	0.47	0
Ceiling		13	0.08665511265	0
Floor		13	0.08665511265	0
Door		13	0.46	0
People		24	245	5880
Lighting	802	0.97	3.41	2652.7754
HP				0
Equipment	1	3560	3.41	12139.6
Outside Air	168.12	18	0.1296	392.190336
Infiltrated				0
SUB TOTAL				22572.05459
ROOM SENSIBLE HEAT (RSH)				24259.55854
Safety Factor			0.05	1212.977927
EFFECTIVE ROOM SENSIBLE HEAT (ERSH)				25472.53646

TEMPERATURE DIFFERENCE				
	DB (°F)	% RH	GR / LB	
Outside	93	35	81.2	
Room	75	55	71.4	
Difference	18		9.8	
OUTSIDE AIR (VENTILATION)				
Fresh Air	120	48.12	168.12	
Fresh Air (ACPH)				
			168.12	
CORECTION FACTOR			2.11	
BYPASS FACTOR			0.12	
LATENT HEAT				
People	24	205	4920	
Equipment		3.41	0	
Outside	168.12	9.8	0.0816	134.4422016
Infiltrated				0
ROOM LATENT HEAT (RLH)			5054.442202	
Safety Factor		0.05	252.7221101	
EFFECTIVE ROOM LATENT HEAT (ERLH)			5307.164312	
EFFECTIVE ROOM TOTAL HEAT (ERTH)			**30779.70078**	
OUTSIDE AIR LOAD				
	cfm	ΔT /	(1-	
Sensible	168.12	18	0.9504	2876.062464
Latent	168.12	9.8	0.5984	985.9094784
GRAND TOTAL HEAT (BTU/HR)			**34641.67272**	
EFFECTIVE SENSIBLE HEAT FACTOR (ESHF)			0.8275758315	
Indicated ADP		55	°F	
Selected ADP		61	°F	
Dehumidified ADP		12.32	°F	
Equipment	Watt/unit	Nos.	Watt	
PC	135	24	3240	
Printer	320	1	320	
			0	
			0	
			0	
Lighting Factor			0.97	
SQFT/TR			277.815684	
CFM/TR			663.1627457	
CFM/SQFT			2.387060141	
DEHUMIDIFIED CFM			**1914.422233**	
TONNAGE			**2.88680606**	

ESTIMATED HEAT LOAD

Bengaluru Summer (4.00 PM)

ROOM	AREA (SQFT.)	VOLUME (CUFT.)	OCCUPANCY	LIGHT (WATT)	EQUIPMENT (WATT)	TONNAGE	CFM	FRESH AIR
GROUND FLOOR								
ODC 1	1696.43	23919.66	50	1645.5371	7070	6.3079	4250.5888	351.7858
ODC 2	802	11308.2	24	777.94	3560	2.8868	1914.4222	168.12
ODC 3	1109	15636.9	24	1075.73	3560	2.7991	1802.3701	186.54
ODC 4	1681	23702.1	48	1630.57	6800	5.9407	3971.2960	340.86
ODC 5	1021	14396.1	26	990.37	3830	3.0430	1981.6087	191.26
ODC 6	999	14085.9	26	969.03	3830	2.9788	1926.0194	189.94
ODC 7	978	13789.8	26	948.66	3830	2.9677	1918.2733	188.68
ODC 8	1096	15453.6	26	1063.12	3830	3.0301	1961.8555	195.76
Meeting Room 1	743	10476.3	12	824.73	535	1.4943	966.4604	104.58
Meeting Room 2	686	9672.6	12	761.46	535	1.0807	599.5039	101.16
ADMIN MANAGER	335	4723.5	1	371.85	455	1.7341	1502.9113	25.1
BREAKOUT 1	919	12957.9	15	1020.09	2760	3.3958	2441.7841	130.14
BREAKOUT 2	998	14071.8	15	1107.78	2760	4.3141	3261.4531	134.88
TRAINING ROOM	1487	20966.7	50	1650.57	7470	6.1030	4088.2473	339.22
M 1	69.75	983.47	2	77.4225	135	0.2759	191.1644	14.185
M 2	69.75	983.47	2	77.4225	135	0.2010	123.5494	14.185
Corridor 1	4078.4457	57506.08	20	3956.0923	0	3.6713	2370.6886	344.706
FIRST FLOOR								
ODC 9	1792.966	25280.82	50	1739.1770	7070	6.7263	4617.5876	357.577
ODC 10	1931.26	27230.76	48	1873.3222	6800	6.0796	4069.7363	355.875
ODC 11	1681.527	23709.53	48	1631.0811	6800	6.4140	4398.1602	340.891
ODC 12	1021.075	14397.15	26	990.4427	3830	3.3304	2240.7471	191.264
ODC 13	999.095	14087.23	26	969.1221	3830	3.2600	2179.5854	189.945
ODC 14	978.1488	13791.89	26	948.8043	3830	3.2430	2166.5385	188.688
ODC 15	1096.417	15459.47	26	1063.5244	3830	3.3388	2240.2065	195.785
Meeting Room 3	743.409	10482.06	12	825.1839	535	1.7037	1155.2438	104.604
Meeting Room 4	686.748	9683.14	12	762.2902	535	1.2742	774.0116	101.204
GM Room	335.188	4726.15	1	372.0586	455	1.8285	1588.0301	25.111
BREAKOUT 3	914.642	12896.45	15	1015.2526	2760	3.6512	2672.5428	129.878
BREAKOUT 4	998.008	14071.91	15	1107.7888	2760	4.5949	3514.7198	134.880
Conference Room	1501.942	21177.38	20	1667.1556	535	2.7391	1806.5597	190.116
Server Room	978.1488	13791.89	1	1085.7451	5000	3.4409	2890.8449	63.688
M 3	69.75	983.47	2	77.4225	135	0.2214	141.9658	14.185
M 4	69.75	983.47	2	77.4225	135	0.2206	141.2499	14.185
Corridor 2	4078.4457	57506.08	20	3956.0923	0	4.8189	3405.6750	344.706
TOTAL	**38644.896**	**544893.03**		**39110.2611**	**99935**	**109.1112**	**75275.603**	**5963.693**

Bengaluru Monson (4.00 PM)

ROOM	AREA (SQFT.)	VOLUME (CUFT.)	OCCUPANCY	LIGHT (WATT)	EQUIPMENT (WATT)	TONNAGE	CFM	FRESH AIR
GROUND FLOOR								
ODC 1	1696.43	23919.663	50	1645.5371	7070	6.3834	3772.1673	351.785
ODC 2	802	11308.2	24	777.94	3560	3.0128	1766.884	168.12
ODC 3	1109	15636.9	24	1075.73	3560	3.0441	1733.5321	186.54
ODC 4	1681	23702.1	48	1630.57	6800	6.4969	3943.3624	340.86
ODC 5	1021	14396.1	26	990.37	3830	3.2497	1870.8652	191.26
ODC 6	999	14085.9	26	969.03	3830	3.1913	1822.6043	189.94
ODC 7	978	13789.8	26	948.66	3830	3.1801	1816.7198	188.68
ODC 8	1096	15453.6	26	1063.12	3830	3.2430	1849.7934	195.76
Meeting Room 1	743	10476.3	12	824.73	535	1.7713	1053.8162	104.58
Meeting Room 2	686	9672.6	12	761.46	535	1.2423	588.1234	101.16
ADMIN MANAGER	335	4723.5	1	371.85	455	1.6613	1398.2451	25.1
BREAKOUT 1	919	12957.9	15	1020.09	2760	3.4576	2295.3342	130.14
BREAKOUT 2	998	14071.8	15	1107.78	2760	4.1879	2938.0730	134.88
TRAINING ROOM	1487	20966.7	50	1650.57	7470	6.2368	3681.8935	339.22
M 1	69.75	983.475	2	77.4225	135	0.2116	111.1108	14.185
M 2	69.75	983.475	2	77.4225	135	0.2001	100.7085	14.185
Corridor 1	4078.4457	57506.08437	20	3956.09	0	3.5327	1710.1693	344.706
FIRST FLOOR								
ODC 9	1792.966	25280.8206	50	1739.1770	7070	6.7913	4120.6760	357.577
ODC 10	1931.26	27230.766	48	1873.3222	6800	6.3955	3801.7754	355.875
ODC 11	1681.527	23709.5307	48	1631.0811	6800	6.8744	4283.7635	340.891
ODC 12	1021.075	14397.1575	26	990.4427	3830	3.4789	2077.5023	191.264
ODC 13	999.095	14087.2395	26	969.1221	3830	3.4155	2024.7989	189.945
ODC 14	978.1488	13791.89808	26	948.8043	3830	3.3997	2014.6902	188.688
ODC 15	1096.417	15459.4797	26	1063.5244	3830	3.4892	2071.7668	195.785
Meeting Room 3	743.409	10482.0669	12	825.1839	535	1.9384	1204.3711	104.604
Meeting Room 4	686.748	9683.1468	12	762.2902	535	1.3968	727.3153	101.204
GM Room	335.188	4726.1508	1	372.0586	455	1.7366	1466.1282	25.111
BREAKOUT 3	914.642	12896.4522	15	1015.2526	2760	3.6604	2479.0939	129.878
BREAKOUT 4	998.008	14071.9128	15	1107.7888	2760	4.4118	3140.0249	134.880
Conference Room	1501.942	21177.3822	20	1667.1556	535	2.6553	1435.6820	190.116
Server Room	978.1488	13791.8980	1	1085.7451	5000	2.9202	2322.3216	63.688
M 3	69.75	983.475	2	77.4225	135	0.2158	114.9327	14.185
M 4	69.75	983.475	2	77.4225	135	0.2157	114.8226	14.185
Corridor 2	4078.4457	57506.0843	20	3956.0923	0	4.4478/	2535.4531	344.706
TOTAL	**38644.896**	**544893.0336**		**39110.2611**	**99935**	**111.7479**	**68388.522**	**5963.693**

Bengaluru Winter (4.00 PM)

ROOM	AREA (SQFT.)	VOLUME (CUFT.)	OCCUPANCY	LIGHT (WATT)	EQUIPMENT (WATT)	TONNAGE	CFM	FRESH AIR
GROUND FLOOR								
ODC 1	1696.43	23919.6	50	1645.5371	7070	5.7673	3608.3201	351.785
ODC 2	802	11308.2	24	777.94	3560	2.7428	1710.6819	168.120
ODC 3	1109	15636.9	24	1075.73	3560	2.7929	1714.7582	186.540
ODC 4	1681	23702.1	48	1630.57	6800	6.3161	4160.0220	340.860
ODC 5	1021	14396.1	26	990.37	3830	2.9742	1835.4428	191.260
ODC 6	999	14085.9	26	969.03	3830	2.9255	1794.4002	189.940
ODC 7	978	13789.8	26	948.66	3830	2.9164	1789.0235	188.680
ODC 8	1096	15453.6	26	1063.12	3830	2.9674	1819.2311	195.760
Meeting Room 1	743	10476.3	12	824.73	535	1.8606	1250.7767	104.580
Meeting Room 2	686	9672.6	12	761.46	535	1.1140	585.0197	101.160
ADMIN MANAGER	335	4723.5	1	371.85	455	1.5610	1335.6605	25.100
BREAKOUT 1	919	12957.9	15	1020.09	2760	3.1469	2160.0719	130.140
BREAKOUT 2	998	14071.8	15	1107.78	2760	3.7558	2698.6467	134.880
TRAINING ROOM	1487	20966.7	50	1650.57	7470	5.6721	3550.5396	339.220
M 1	69.75	983.47	2	77.4225	135	0.1699	89.2780	14.185
M 2	69.75	983.47	2	77.4225	135	0.1757	94.4791	14.185
Corridor 1	4078.4457	57506.08	**20**	3956.09232	0	2.8880	1512.6817	344.706
FIRST FLOOR								
ODC 9	1792.966	25280.82	50	1739.1770	7070	6.1505	3941.0378	357.5780
ODC 10	1931.26	27230.76	48	1873.3222	6800	5.8215	3680.5019	355.875
ODC 11	1681.527	23709.53	48	1631.0812	6800	6.6364	4448.7810	340.891
ODC 12	1021.075	14397.15	26	990.4428	3830	3.1686	2010.7216	191.264
ODC 13	999.095	14087.23	26	969.1222	3830	3.1157	1965.9116	189.945
ODC 14	978.1488	13791.89	26	948.8043	3830	3.1026	1956.9538	188.688
ODC 15	1096.417	15459.47	26	1063.5245	3830	3.1762	2007.5318	195.785
Meeting Room 3	743.409	10482.06	12	825.1840	535	2.0023	1378.4997	104.604
Meeting Room 4	686.748	9683.14	12	762.2903	535	1.2450	703.1196	101.204
GM Room	335.188	4726.15	1	372.0587	455	1.6248	1393.2493	25.111
BREAKOUT 3	914.642	12896.45	15	1015.2526	2760	3.3189	2315.7501	129.878
BREAKOUT 4	998.008	14071.91	15	1107.7889	2760	3.9458	2869.9489	134.880
Conference Room	1501.942	21177.38	20	1667.1556	535	2.2676	1297.7433	190.116
Server Room	978.1488	13791.89	1	1085.7452	5000	2.6412	2141.6588	63.688
M 3	69.75	983.47	2	77.4225	135	0.1889	106.3961	14.185
M 4	69.75	983.47	2	77.4225	135	0.1890	106.4512	14.185
Corridor 2	4078.4457	57506.08	20	3956.0923	0	3.6642	2212.7129	344.706
TOTAL	**38644.896**	**544893.03**		**39110.261**	**99935**	**102.0059**	**66246.003**	**5963.693**

SYSTEM DESCRIPTION

Since monsoon season has peak tonnage and summer season has peak cfm, selecting 111.7TR and 75275 cfm as system requirements.

The proposed system configurations are:

VRF/VRV	AIR-COOLED CHILLERS	PACKAGED ROOFTOP UNITS
VRF/VRV Unit and AHU	Air-Cooled chiller unit and AHU	Only packaged rooftop unit

Comparison of technical specifications:

PARAMETERS	VRF/VRV	AIR COOLED CHILLER	PACKAGED ROOFTOP UNITS
Accessories	Moderate	More	Less
Partial load response	High	Low	Moderate
Type of Piping	Refrigerant	Water	No piping
Acoustic / Noise Treatment	-	Needed	-
Designing	Moderate	Complicated	Easy
Initial Cost	Moderate	Less	More
Refrigerant leakage	Yes	-	Yes
Water Leakage	-	Yes	-
Metering	Only power	Power + Water	Only power
Water treatment	-	Needed	-
Cooling done by	Refrigerant	Water	Refrigerant
Spare Parts	Moderate	More	Less
Energy efficiency	More	Moderate	Less

- **VRV/VRF System to be used**

AIR DISTRIBUTION SYSTEM

Under floor Air Distribution is selected for the building.
The air will be distributed through the plenum created by the raised (access) floor. This plenum will have a small positive pressure as compared to the conditioned spaces. The raised floor has 2x2 ft. panels, supported by adjustable pedestals. This raised floor can work in integration with other systems. The floor panel thickness will be 24 mm. User control swirl diffuser and perimeter diffuser system to be used.

Properties of floor panel used:

1. Wear resistance
2. Dimensional stability
3. Antistatic characteristic
4. Fire rated

Plenum Configuration:

	Raised floor	Ceiling plenum
Purpose	Supply air to conditioned spaces	Return air from conditioned spaces
Plenum height	510 mm	600 mm

Air Diffusion comparison at various positions:

POSITION	FLOOR	BASEBOARD	LOW SIDEWALL	HIGH SIDEWALL	CEILING
COOLING PERFORMANCE	Excellent	Excellent if used with perimeter systems	Excellent if used with perimeter systems	Good	Good

RAISED FLOOR OF 2 PAX MEETING ROOM:

UNDER FLOOR AIR DISTRIBUTION *vs.* OVERHEAD AIR DISTRIBUTION

PARAMTERS	UNDERFLOOR AIR DISTRIBUTION	OVERHEAD
Room Air Distribution	Thermal Displacement	Mixed Air
Ventilation effectiveness	1.2	0.8
Amount of ducting	Less	More
Duct Velocity	High	Low
Duct Cross-section	Smaller	Larger
Fan Static Pressure	Less	More
Flexibility	More	Less
Supply Temperature	61°F - 64°F	54°F-56°F
Energy consumption	Less	More
Pollutants concentration in occupied zone	Less	More
Short-circuit of air	Very less probability	High probability
Indoor Air Quality	More	Less
Occupant Productivity	More	Less
Maintenance	Easy	Complicated

For proper Air Distribution, the conditioned space is to be divided into zones

Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
ODC 1	12PAX Meeting Room 1	ODC 9	12PAX Meeting Room 3	Server Room
ODC 2	12PAX Meeting Room 2	ODC 10	12PAX Meeting Room 4	
ODC 3	ADMIN MANAGER	ODC 11	GM Room	
ODC 4	BREAKOUT 1	ODC 12	BREAKOUT 3	
ODC 5	BREAKOUT 2	ODC 13	BREAKOUT 4	
ODC 6	50PAX TRAINING ROOM	ODC 14	Conference Room	
ODC 7	CORRIDOR 1 B	ODC 15	CORRIDOR 2 B	
ODC 8		M 3	CORRIDOR 2 C	
M 1		M 4		
M 2		CORRIDOR 2 A		
CORRIDOR 1 A				

- The Ventilation Effectiveness of Under floor Air Distribution system is 1.2. Hence, only about 83% of calculated cfm is sufficient for thermal comfort.

ZONE NUMBER	CALCULATED CFM	DESIGNED CFM
1	21676.9235	18064.10292
2	13595.27388	11329.3949
3	24545.69344	20454.74454
4	11738.93128	10103.44135
5	2890.844935	2409.037446

AHU's and their zones:

	ZONES ASSIGNED	RATED CAPACITY	DUCTED CAPACITY
AHU-1	Zone 1 & Zone 3	18000 cfm	18000 cfm
AHU-2	Zone 1 & Zone 3	10000 cfm	9000 cfm
AHU-3	Zone 1 & Zone 3	14000 cfm	12000 cfm
AHU-4	Zone 2 & Zone 4	10000 cfm	8000 cfm
AHU-5	Zone 2 & Zone 4	14000 cfm	13000 cfm
AHU-6	Zone 5	3000 cfm	3000 cfm

Zone 5 will have 100% redundancy with (1+1) configuration. Hence AHU-9 will be connected to zone 5.

VENTILATION:

ACTIVITY	AREA (ft^2)	height (ft)	VOLUME (ft^3)	ACPH	REQ CFM
GENTS TOILET 1	517.78	14.10	7304.73	10	1217.4561
GENTS TOILET 2	578.16	14.10	8156.51	10	1359.4196
LADIES TOILET 1	595.91	14.10	8406.91	10	1401.1526
LADIES TOILET 2	513.70	14.10	7247.21	10	1207.8683
DIFFERENTLY ABLED TOILET 1	122.39	14.10	1726.70	10	287.7834
Entrance Lobby 1	2254.32	14.10	31803.17	12	6360.6358
GENTS TOILET 3	517.78	14.10	7304.73	10	1217.4561
GENTS TOILET 4	578.16	14.10	8156.51	10	1359.4196
LADIES TOILET 3	595.91	14.10	8406.91	10	1401.1526
LADIES TOILET 4	513.70	14.10	7247.21	10	1207.8683
DIFFERENTLY ABLED TOILET 2	122.39	14.10	1726.70	10	287.7834
Entrance Lobby 2	2254.32	14.10	31803.17	12	6360.6358
TOTAL					**23668.6322**

AHU's for Ventilation

	ROOMS ASSIGNED	RATED CAPACITY	DUCTED CAPACITY
AHU-7	Entrance Lobby	14000 cfm	13000 cfm
AHU-8	Toilets	12000 cfm	11000 cfm

The stairs at either ends will have operable windows for Ventilation

DUCT DESIGN

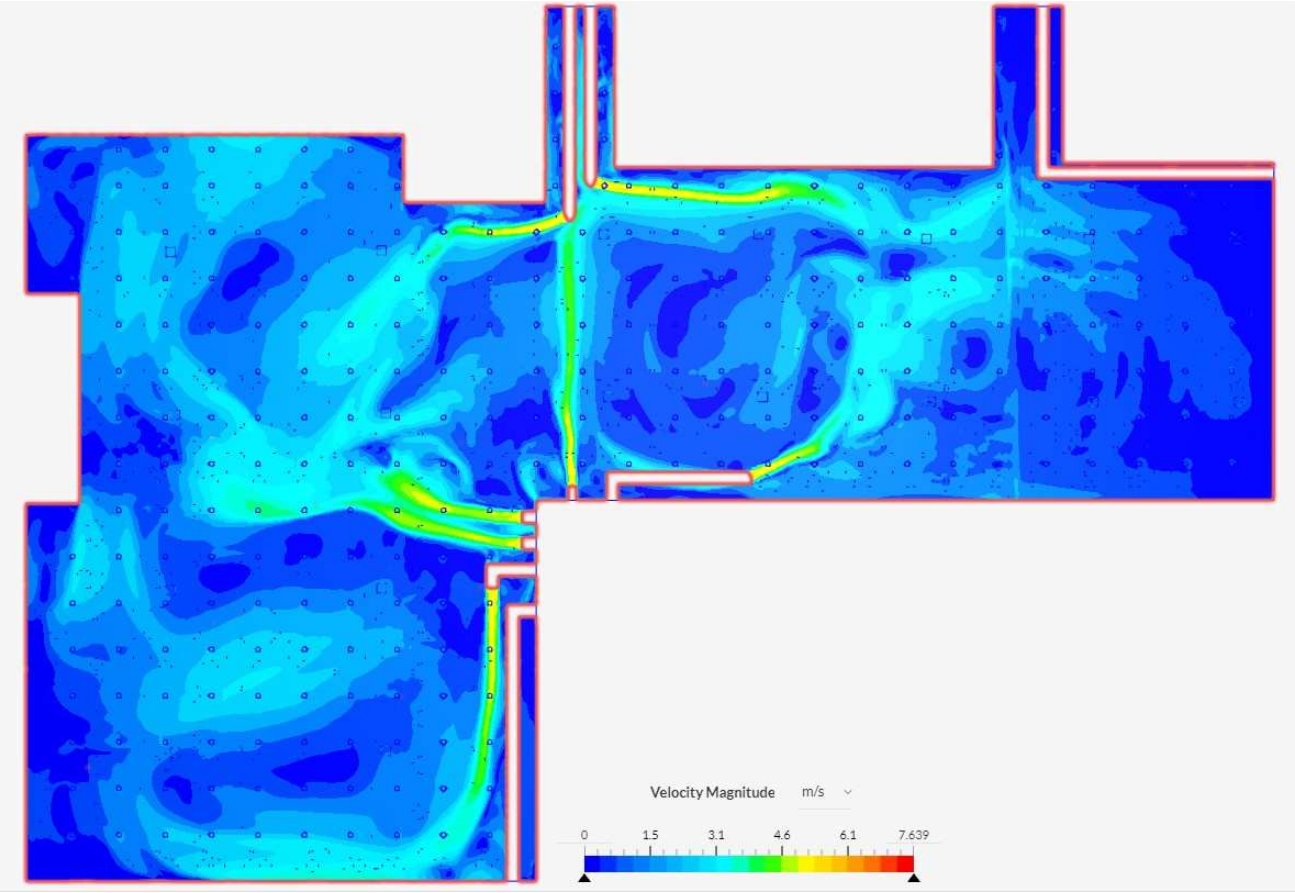
Since, raised floor plenum is used for air distribution in conditioned spaces, higher velocities can be used for duct design.

Duct		Velocity
For Conditioned spaces		2000 fpm
For Ventilated spaces	(a) Main (Controlling factor- Duct friction)	2000 fpm
	(b) Branch (Controlling factor- Duct friction)	1600 fpm

Duct Specification:

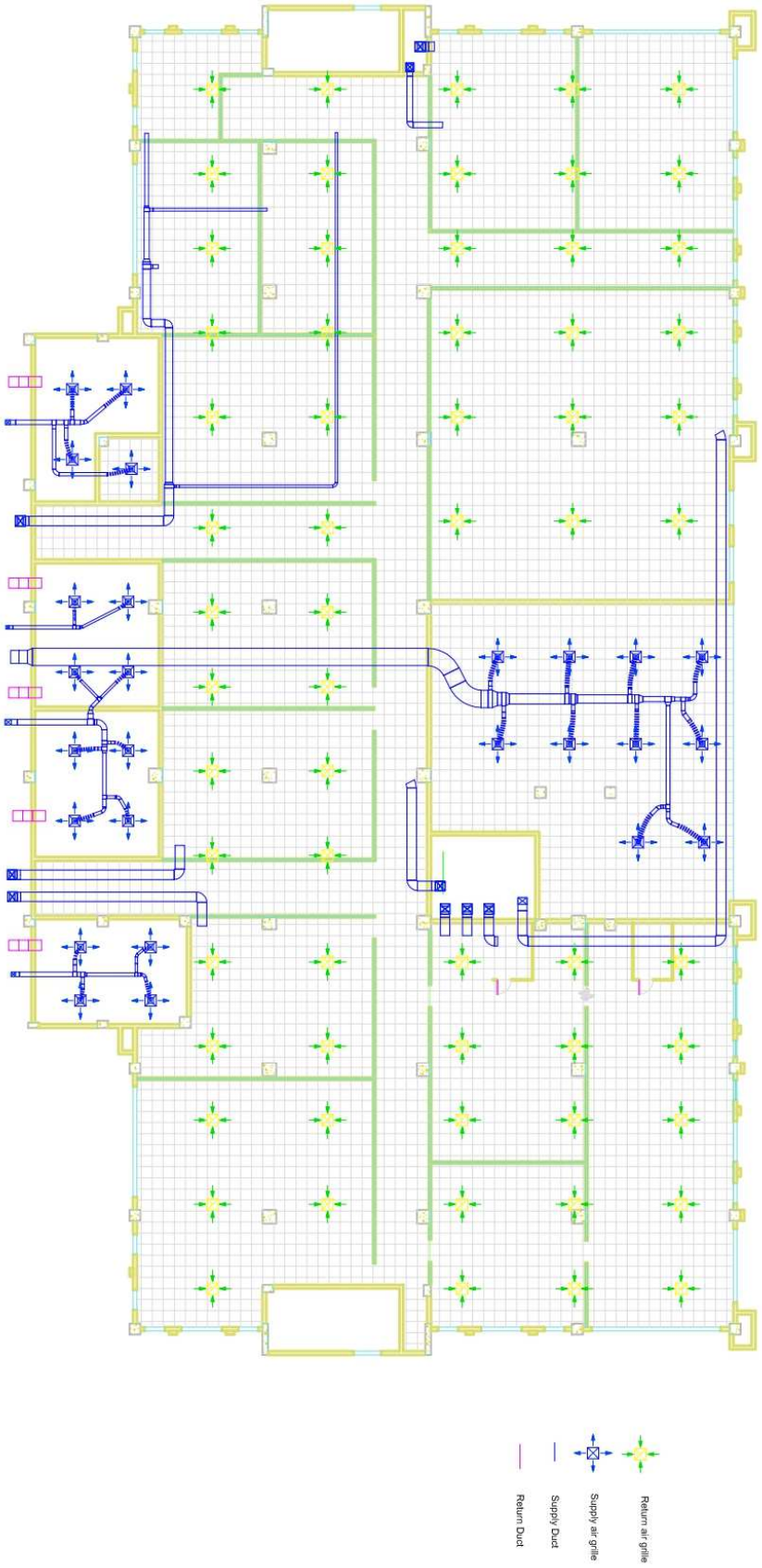
- Duct Cross-section
    1. Rectangular
    2. Round (Flexible ducts)
- Duct Material

UNDERFLOOR AIR DISTRIBUTION SIMULATION OF ZONE 3 (FIRST FLOOR):

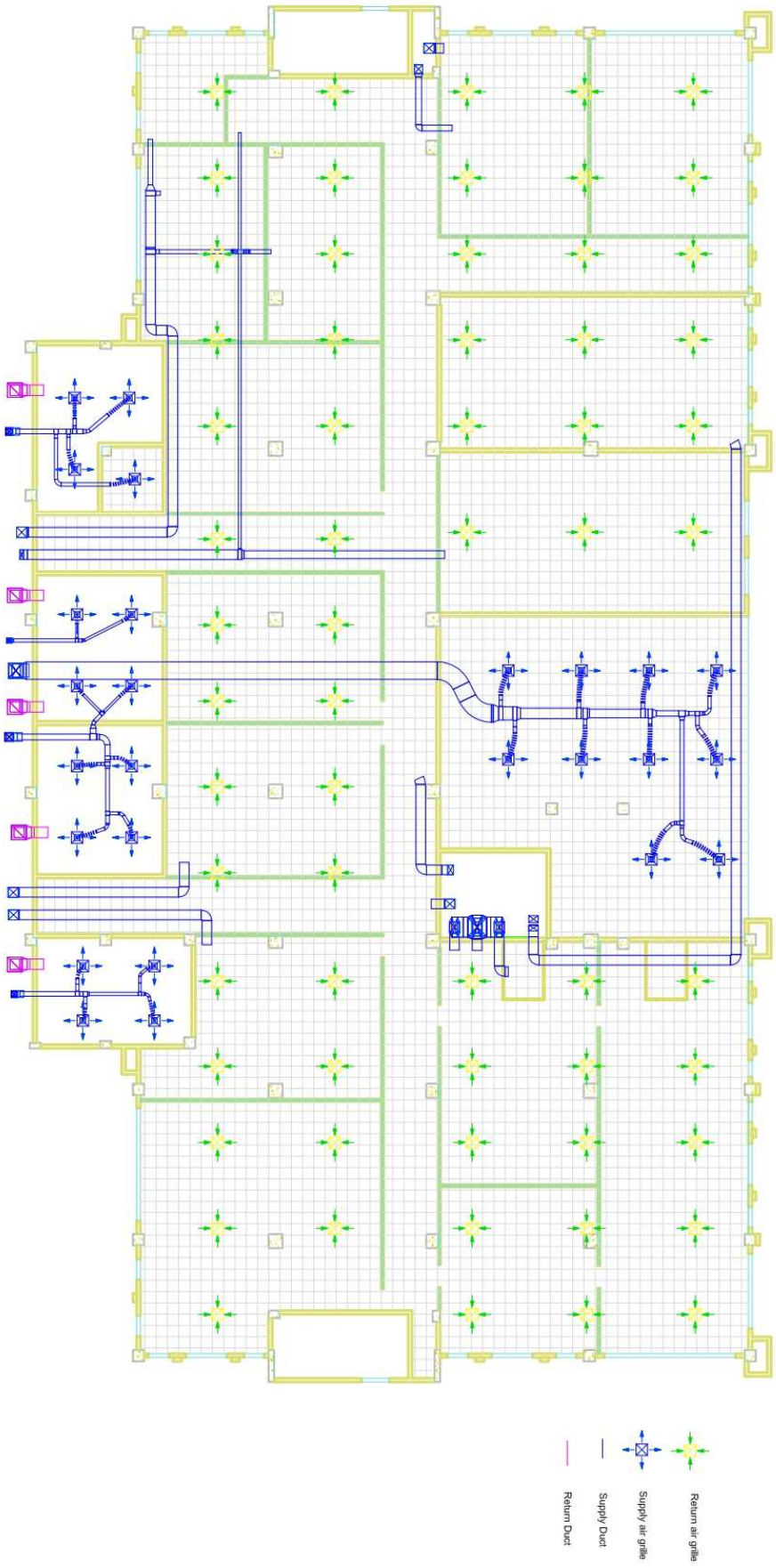


- From above CFD analysis it is observed that the proposed ducting for underfloor air distribution is suitable for uniform air distribution.

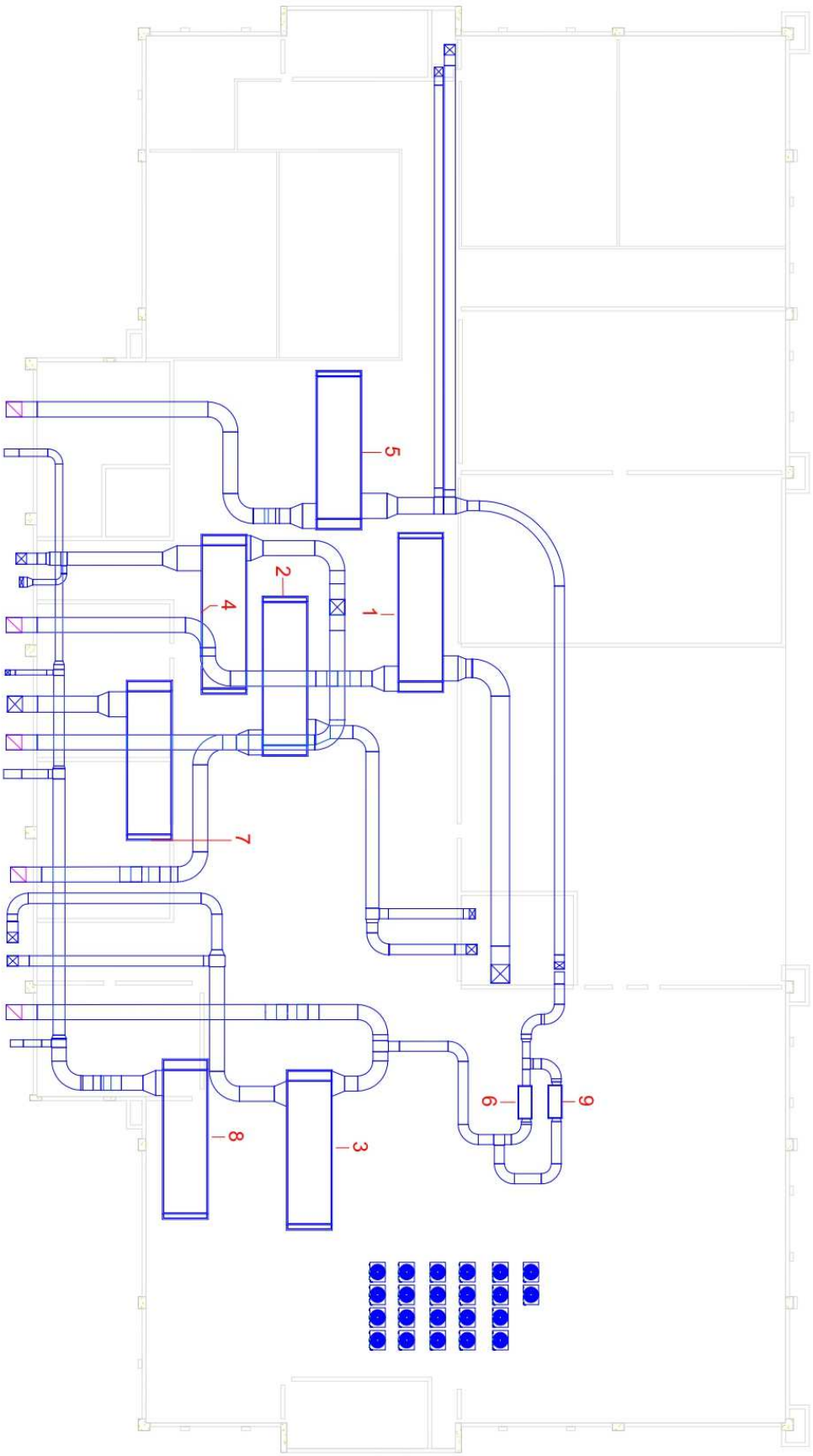
Duct Layout:



Ground Floor

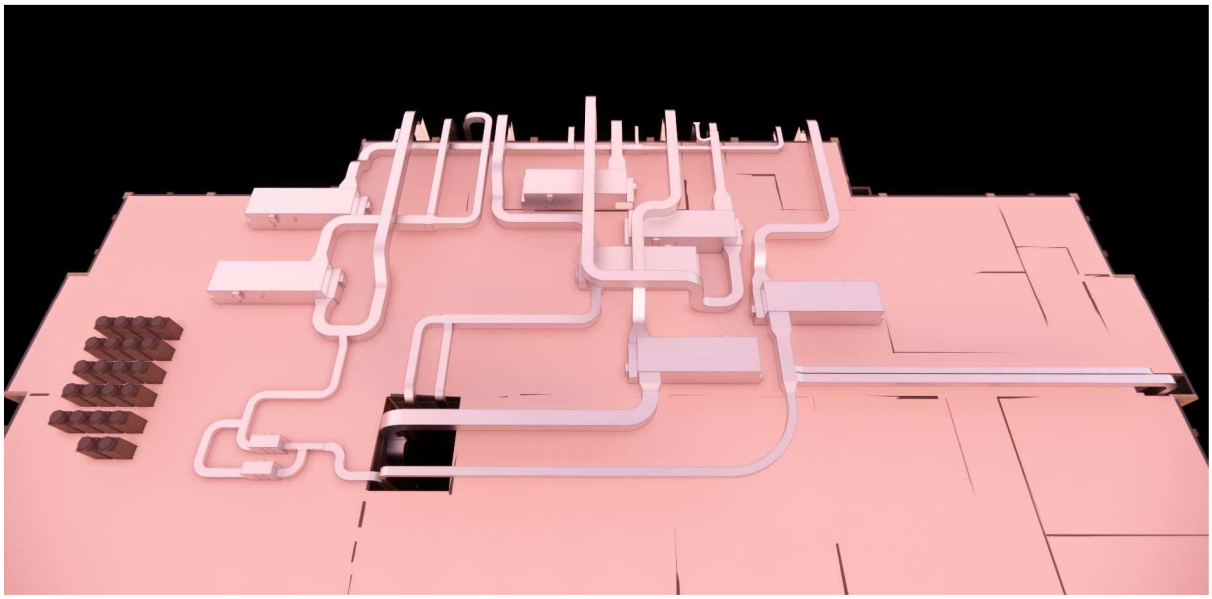

Return Duct
Supply Duct
Supply air grille
Return air grille

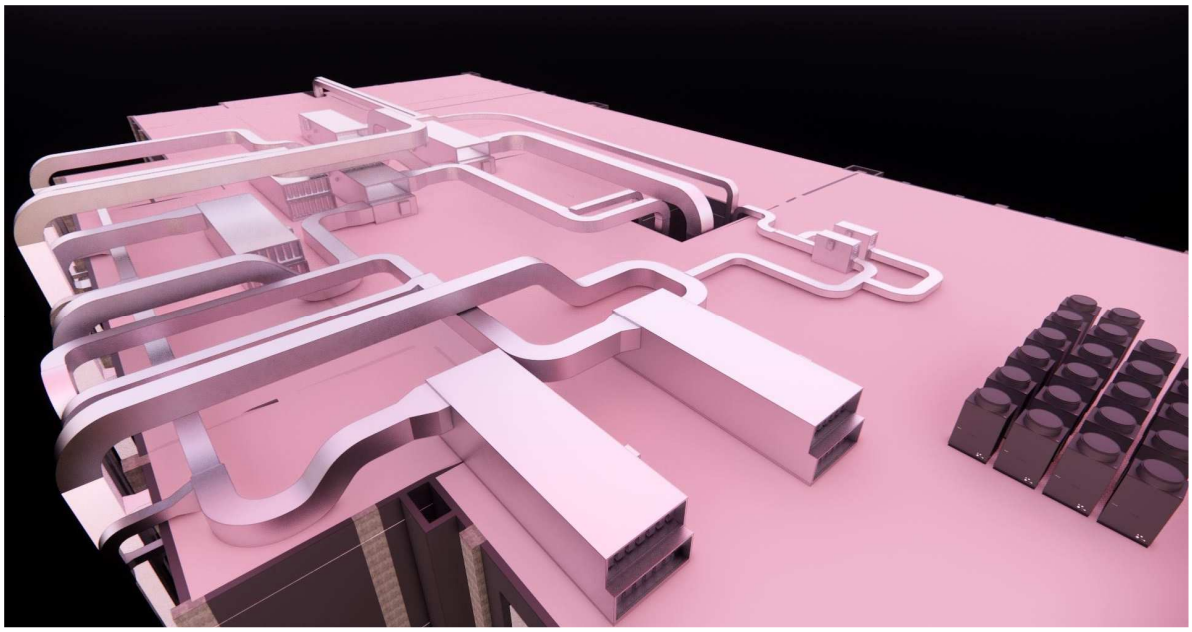
First Floor

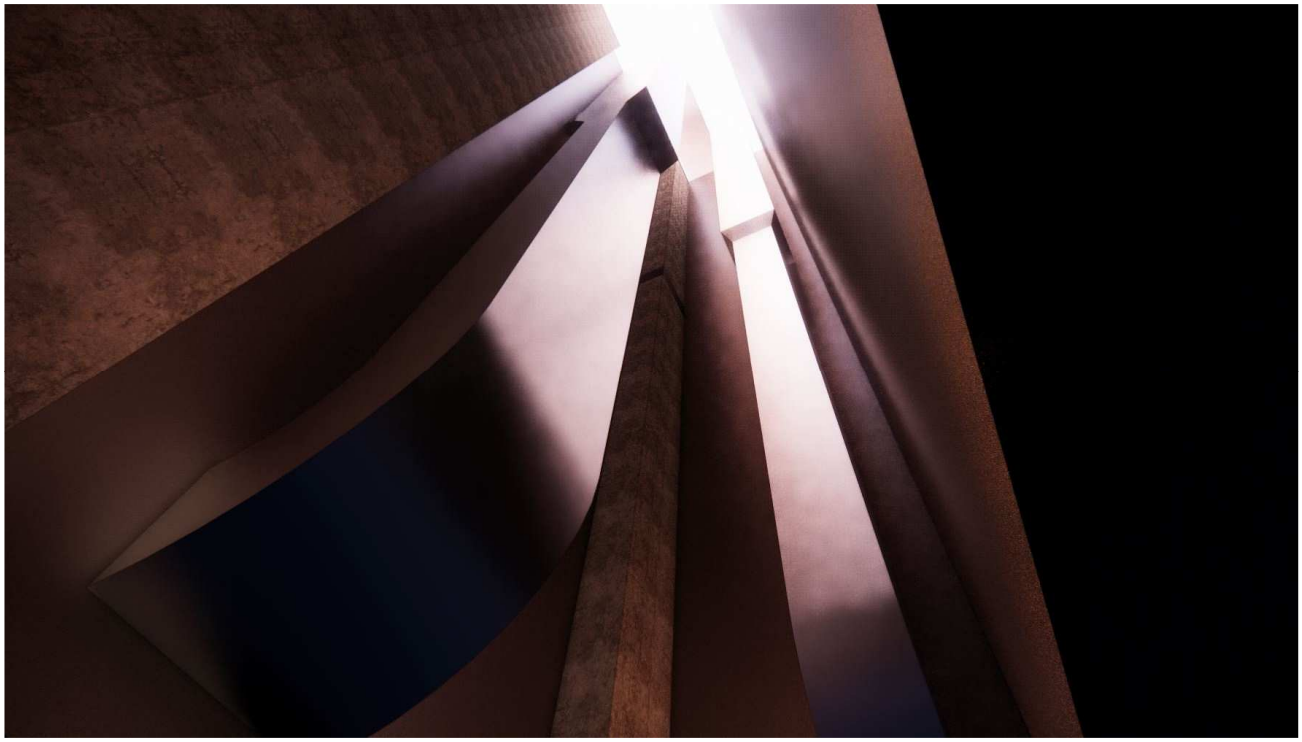


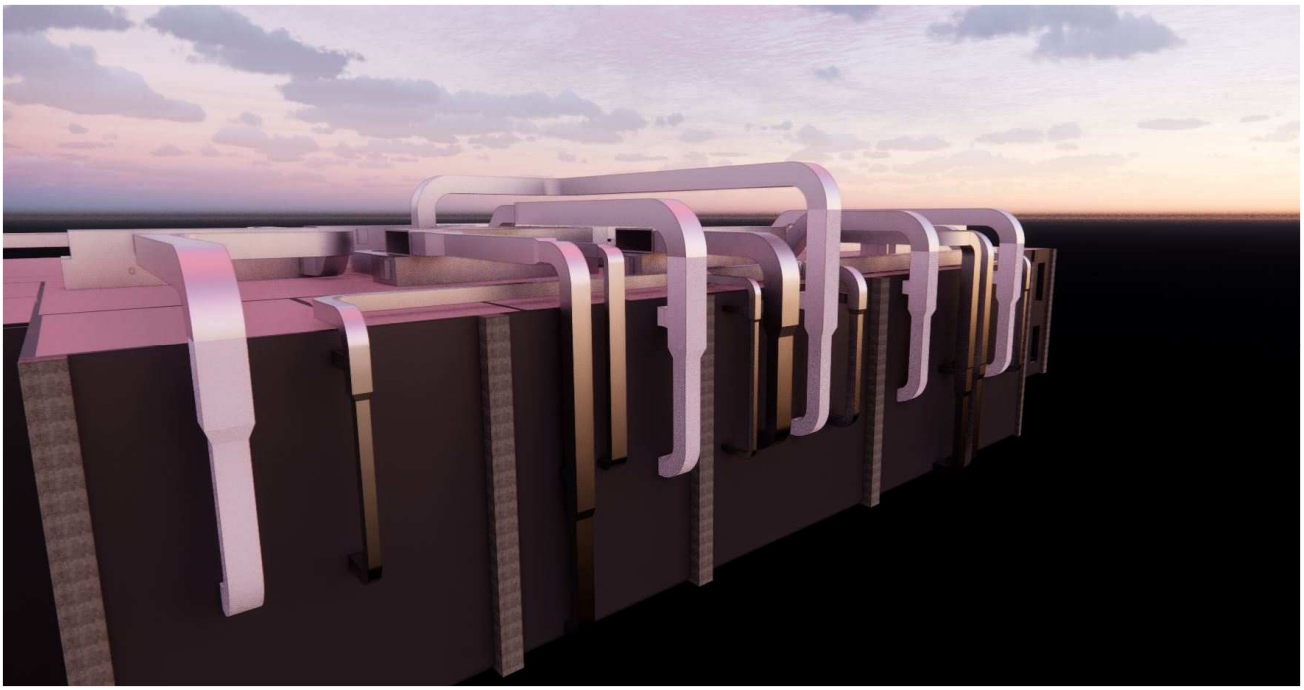
Terrace Floor

SYSTEM PLACEMENT FROM DIFFERENT VIEWS:









IAQ:

Issues due to poor IAQ:

- Acute discomfort – headache
- Eye, nose, or throat irritation, dry cough, dry or itchy skin, dizziness, nausea, difficulty in concentrating.
- Shortness of breath.
- Reduction in productivity due to discomfort.

Causes:

- Limited supply of fresh air into Conditioned spaces to conserve energy
- Emission of harmful VOC's by cleaning agents, paints, varnish, etc.
- Off-gassing from cabling, dust shed from slab, debris and spills sifted down

Filtration types

1. Mechanical – dust filtered by Impingement, interception, straining, diffusion.
2. Electronic – particulate matter is attracted and captured on charged plates-plates need to be cleaned regularly
3. Chemical

MERV efficiency Rating of filter for commercial building

Sr. No.	MERV Rating	Particle Size (in micrometer)	Pollutants	Filters type
1.	5-8	3-10	dust, mold, spores	Pleated Panel filter
2.	9-12	1-3	Auto fumes, welding dust	Bag, cartridge, mini- pleat
3.	13-16	0.1-0.3	Tobacco smoke, bacteria	Bag, cartridge

Solutions for better IAQ:

1. AHU

- Decontamination of the surface of cooling coil, by combination of Ultra Violet Germicidal Irradiation (UVGI) and Photocatalytic Oxidation.

2. UNDERFLOOR AIR DISTRIBUTION

- The rise of thermal plumes carries the pollutants along with the air flow. The concentration of pollutants increase in upper stratified zone leaving the occupied zone with less concentration.
- The contaminants of air borne diseases suspended in air moves up to return air rather than mixing with supply.

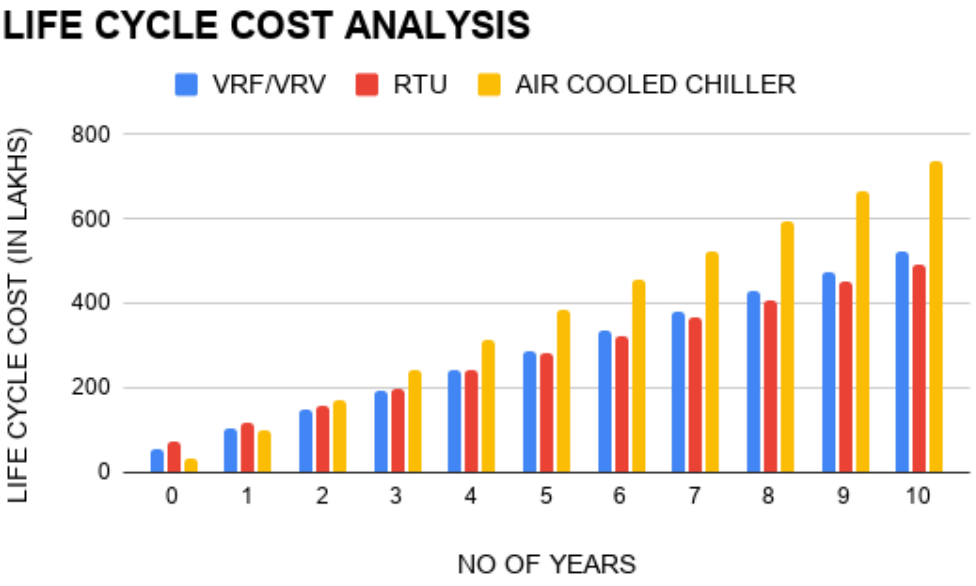
LIFE CYCLE COST ANALYSIS

CONSIDERATIONS FOR ANALYSIS:

1. 7440 Hrs operation
2. Energy Rate= 8.75 Rs/kWhr

LOAD	OPERATING TIME
100%	1%
75%	42%
50%	45%
25%	12%

SYSTEM	VRV/VRF		Packaged Rooftop Unit	Air cooled chiller	
Particular	VRV/VRF unit	AHU	RTU	CHILLER	AHU
Capital Cost	40000 Rs/Tr	80000 Rs/Unit	60000 Rs/Tr	17000 Rs/Tr	80000 Rs/Unit
Energy Consumption	0.7033 kW/Tr	0.4 kW/Tr	0.99 kW/Tr	1.25 kW/Tr	0.4 kW/Tr
Maintenance	3000 Rs/Unit	3000 Rs/Unit	15000 Rs/Unit	1200 Rs/Tr	3000 Rs/Unit

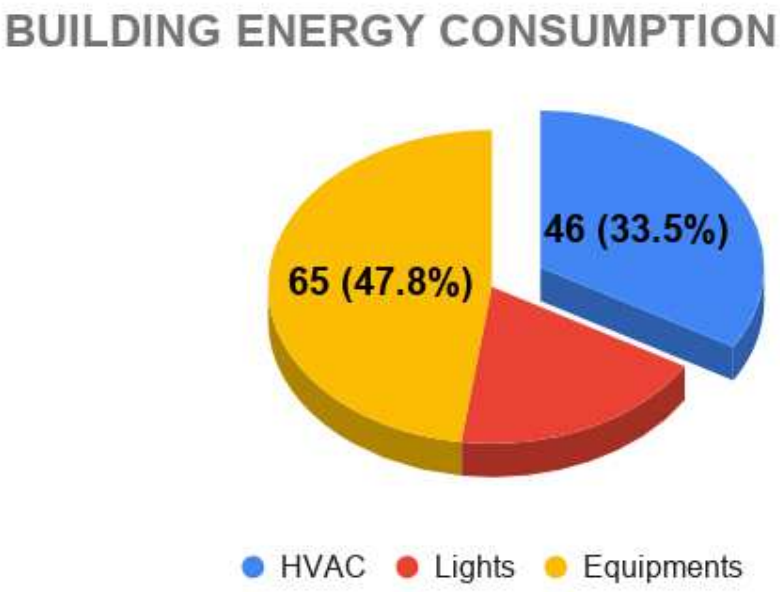


- The capital cost of air-cooled chiller is least but over the years it remains the most expensive configuration.
- VRF has the lowest initial cost and overall cost for 4 years.
- Packaged rooftop units have higher capital as well as overall costs for 4 years and its return on investment is about 8-9 years.

BUILDING ENERGY CONSUMPTION:

CONSIDERATIONS FOR ANALYSIS:

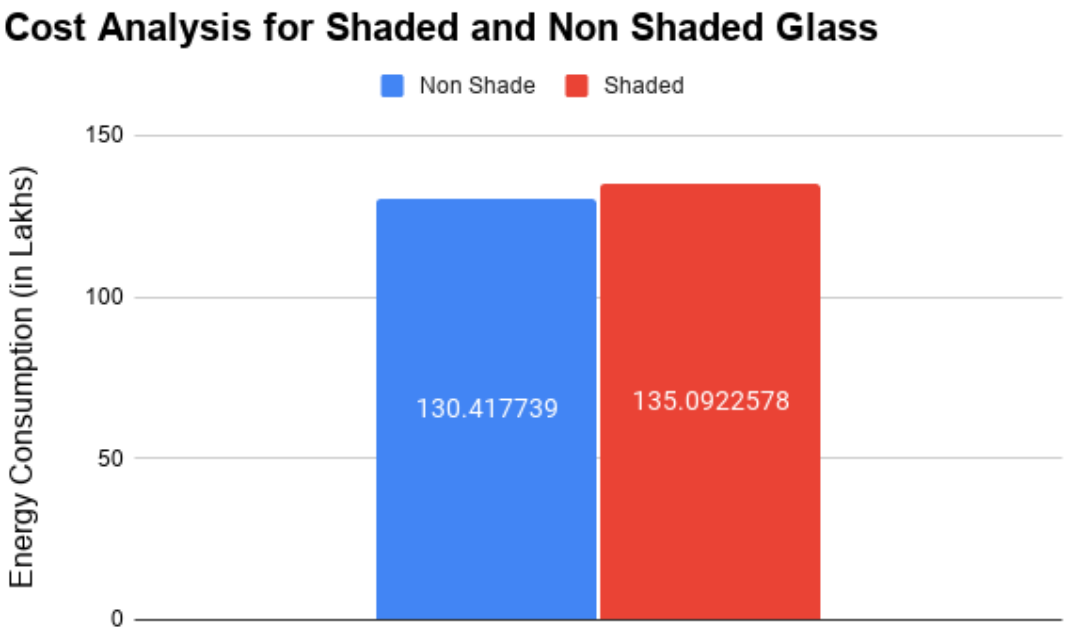
1. Energy Rate= 8.75 Rs/kWhr
2. Equipment wattage = 99.935 kWhr
3. Lighting wattage = 39.11 kWhr



PROPOSED COST SAVING METHODS FOR BUILDING ENERGY OPTIMIZATION:

1. COST ANALYSIS FOR SHADED AND NON-SHADED GLASS:

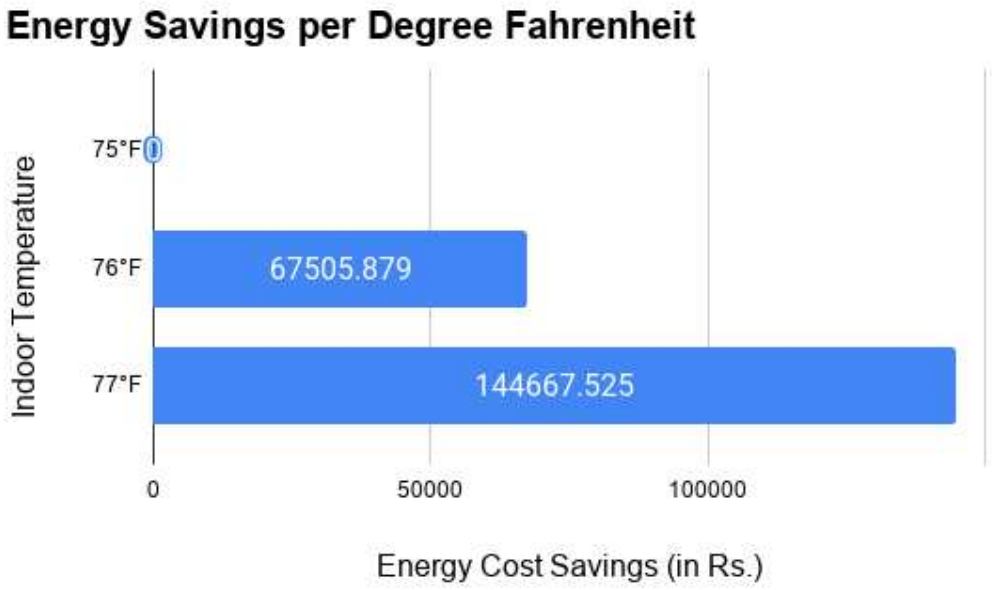
- SHGC (without shade) =0.52
- SHGC (with roller blinds) =0.36
- In no shade condition energy cost is calculated considering 25% reduction in artificial lighting.



- Rs. 4.67 Lakhs saving can be achieved by allowing daylight to enter into the building.

2. ENERGY SAVING PER DEGREE FAHRENHIET:

- The system is designed and will be operating at 75°F
- However, thermal comfort can also be achieved at 76° F and 77°F for office spaces.
- Energy Rate= 8.75 Rs/kWhr



- The above energy costs were calculated under the assumption that the occupants does not feel discomfort till 77°F. Thus, by increasing the required cooling temperature cost savings can be achieved.

LEED POINTS ESTIMATION:

SECTION	PARTICULARS		ESTIMAED LEED POINTS
SUSTAINABLE SITES	Site Selection		1
	Development density and community connectivity		5
ENERGY AND ATMOSPHERE	Optimize energy performance		10
	Enhanced refrigerant management		2
INDOOR ENVIRONMENTAL QUALITY	Low emitting materials	Floor systems	1
	CONTROLLABILITY of system	Lighting	1
		Thermal Comfort	1
	Thermal Comfort	Design	1
		Ventilation	1
	Daylight		1
	Views		1
TOTAL ESTIMATED LEED POINTS			25

Link for Drawings

https://drive.google.com/drive/folders/1sefCitjxIWkxYT8lFQry-m_qPdy6MSng?usp=sharing