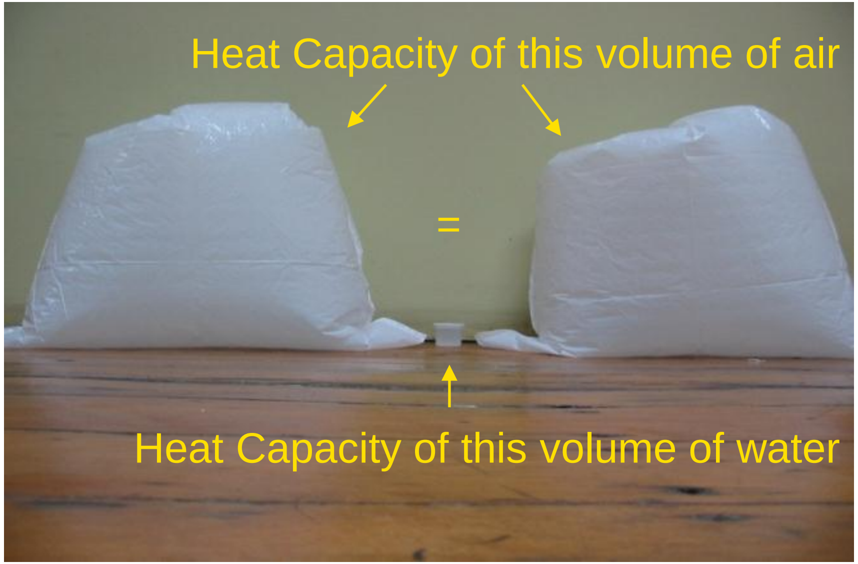
CASE STUDY - I

HYDERABAD SDB-1

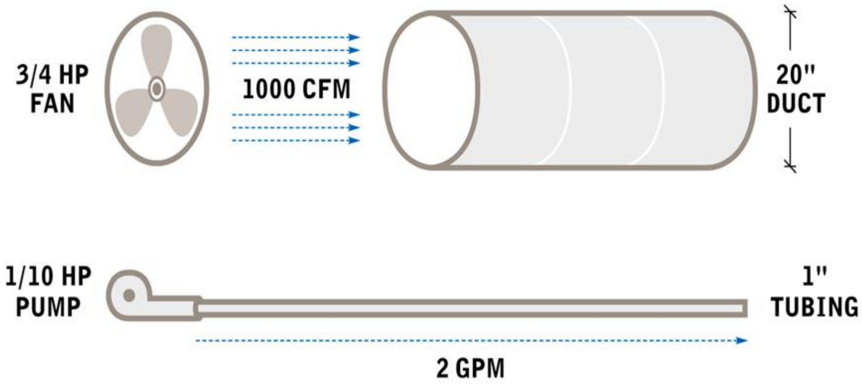
First radiant cooled commercial building in India

Efficient Heat transfer mode and medium



Water has 3400 times more heat carrying capacity than air for the same volume

Pumping Air Vs. Water for same cooling capacity



Pumping cost is 7.5 times lower

Efficient system - Radiant cooling

- Requires 75% less air compared to conventional systems
- 30% more efficient than conventional HVAC systems
- Higher thermal comfort on account of better mean radiant temperature
- Highest indoor air quality
- Radiant system equipment requires lesser space

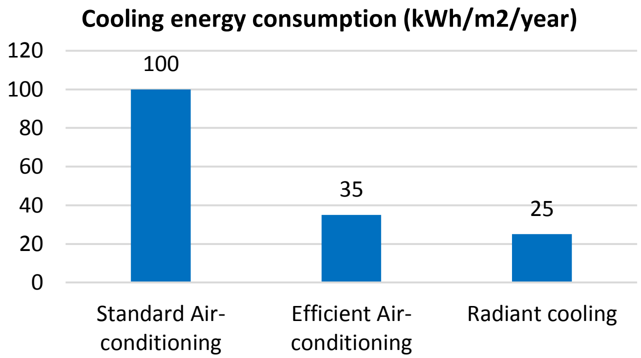
Radiant pipes

Radiant slab

Infosys case study - Radiant cooling

- Radiant cooling for the first time in India
- SDB-1 (Hyderabad SEZ) has 2 identical halves, one with radiant cooling and the other with conventional air conditioning
- This building is today the biggest demonstration of cooling technology comparison

Radiant slab



Live Energy Data

29.7°C 44.7% | Enthalpy 59.4kJ/kg | WB Temp 20.6°C | DP 16.3°C | OA CO_2 464.0ppm

Energy Reports

Date: 3/12/2015
Time:3:24:49 PM

Energy Consumption - Conventional Building					
SDB-1 Area	2011 (Jan- Dec)	2012 (Jan- Dec)	2013 (Jan-Dec)	2014 (Jan-Dec)	2015 (Jan-Till Date)
Lighting	83338	95351	108008	107696	120249
Raw Power	124702	224660	255642	106979	105188
UPS	361350	434098	428565	417589	400970
HVAC	408605	412164	345755	305399	290696
HVAC Equipment					
Chiller	242206	283211	228256	220931	217797
Conv Chiller For DOAS	-9803.6	-47067	-30922	-29846	-38205
AHU's	117492	115337	99242	66652	60880
------	------	------	------	------	------
Primary Pumps	12608	13221	8485	5838	6500
Condenser Pumps	15439	11587	14021	15278	14969
Cooling Tower Fan -1	5787	6578	5719	5605	4503
Cooling Tower Fan -2	5795	6590	5735	5267	4520
HRW & Exhaust Fans	19081	22707	15219	14772	19731
------	------	------	------	------	------
	408605	412164	345755	305399	290696

Energy Consumption - Radiant Building					
SDB-1 Area	2011 (Jan- Dec)	2012 (Jan- Dec)	2013 (Jan- Dec)	2014 (Jan- Dec)	2015 (Jan- Till Date)
Lighting	76065	98098	98091	101953	103268
Raw Power	151021	189694	203473	98783	95170
UPS	292640	369901	360798	305754	260797
HVAC	282293	299289	272572	197954	187312
HVAC Equipment					
Chiller	148241	153971	143482	111898	95839
Conv Chiller For DOAS	9803.6	47067	30922	29846	38205
DOAS - 1	16662	17452	18237	8426	9367
DOAS - 2	15610	16931	17637	6535	7087
Primary Pumps	14557	19320	22191	10231	10619.5
Condenser Pumps	19244	16730	18239	19359	16321
Cooling Tower Fan -1	4589	6254	5460	3360	2763
Cooling Tower Fan -2	4600	6270	5474	3412	2839
HRW & Exhaust Fans	12864	15294	10930	4885	4271
DX COIL	36123.2	0.0	0.0	0.0	0.0
	282293	299289	272572	197964	187312

CONV SYSTEMS
RAD SYSTEMS

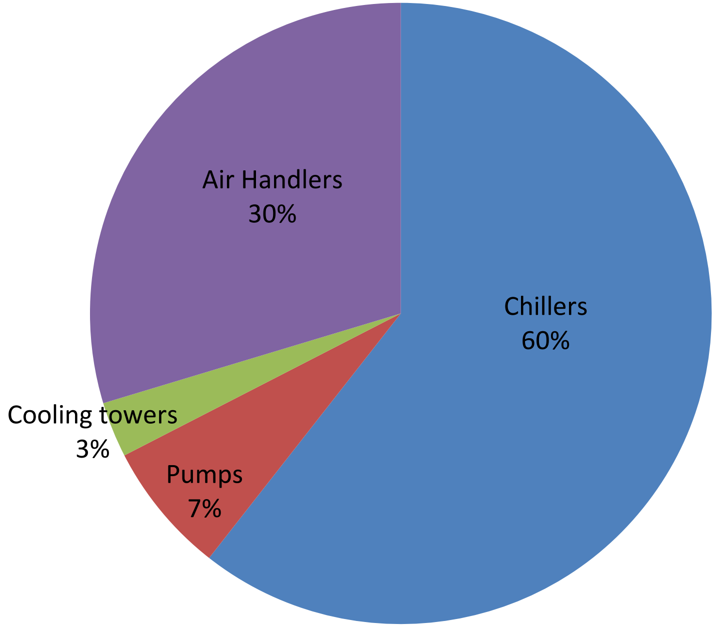
Savings - Radiant Cooling	
Radiant Bldg Savings in 2015 %	35.56
Radiant Bldg Savings in 2014 %	35.18
Radiant Bldg Savings in 2013 %	21.16
Radiant Bldg Savings in 2012 %	27.30
Radiant Bldg Savings in 2011 %	30.91

HVAC energy breakup

Conventional side

Total HVAC energy: 428,000 kWh

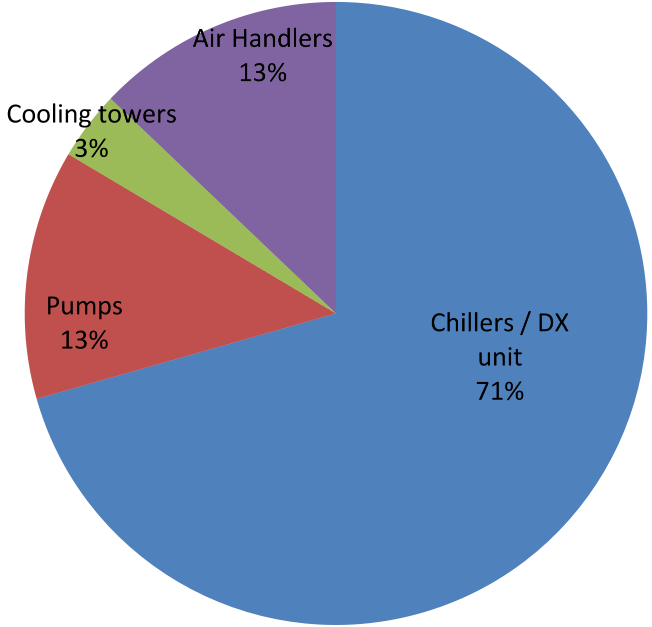
HVAC Energy index: 38.4 kWh/SQM



Radiant side

Total HVAC energy: 267,000 kWh

HVAC Energy index: 26.1 kWh/SQM



Cost comparison (Conventional Vs. Radiant)

	Conventional system	Radiant system
Chiller	3145200	3145200
Cooling tower	1306400	1306400
HVAC low side	22838756	15310396
AHUs, DOAS, HRW	5118200	2878900
Radiant piping, accessories, installation, etc.	0	9075760
BMS	6184000	6584000
Total cost (Rs.)	**38592556**	**38300656**
Area (sq.ft.)	120000	120000
Rs./sq.ft.	**322**	**319**

Key Points in Implementing Radiant Slab

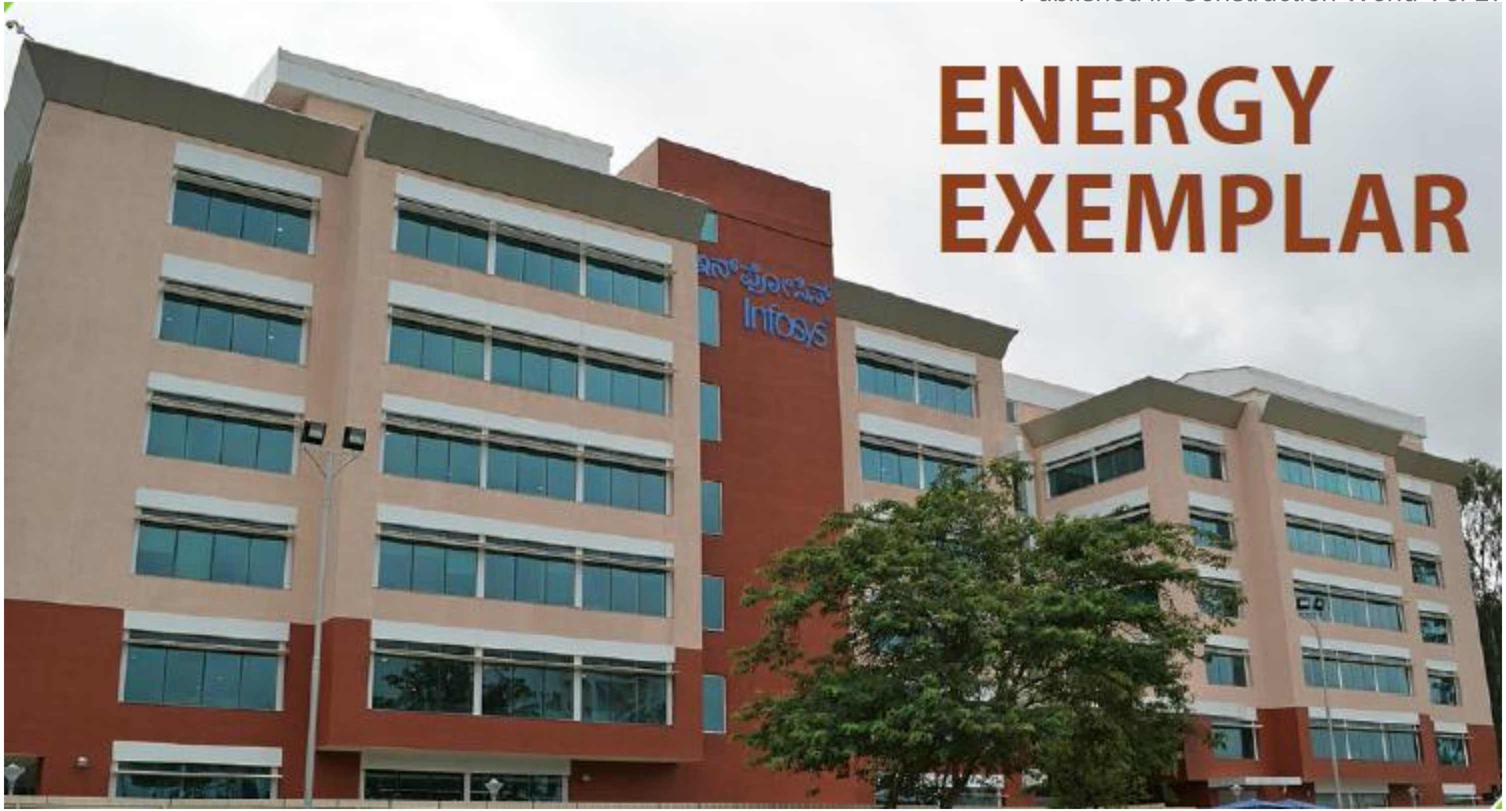
- No condensation has happened in last 5 years.
    a) Average water temp to control the manifolds
    b) Room dew point is over ride for manifold control
    c) Space temp to control PIBCV
    d) Condensation sensor installed in the shaft override
    e) Dehumidified air to control the dew point in space with VAV/thermafusers/slot diffusers
- Only 2 Punctures recorded in last 5 years. (Initial period)
- Capex and Opex is lower.

Learnings - Radiant Slab

- Radiant pipes to be kept under pressure of 3 – 4 kg/cm2 always during installation
- Manifolds to be preferably at the peripheral area
- Two separate controls for peripheral area near glass and work station area
- No radiant slab for meeting rooms/cabins – Design with air
- Not very Flexibile - All services to be planned during designed stage
- Additional drilling is difficult.
- Acoustics is a challenge - Infosys has no issues since there is no voice based operations

Radiant Panels cooling our Buildings

Published in Construction World Vol 17



Radiant Panel Based Cooling

- We are the first in India to implement the radiant panel based cooling system.
- Pipes are embedded in panels of modular sizes like ceiling tiles,
- These panels are interconnected to allow chilled water flow .
- Cooling is achieved when the Hot source radiate directly to the cold ceiling.
- Fresh air is supplied through an air system that maintains pleasant indoor air quality.

Learnings - Radiant Panels

- Flexible in design when compared to slab.
- Piping/ joints/ pressure drops are very high
- Acoustics is a challenge
- Expensive when compared with Slab

DIY Approach by Infosys

- Panels should be very flexible
- Piping and joints should be minimal
- Acoustics is addressed
- Should not be expensive than Slab.
- Ease of installation and maintenance

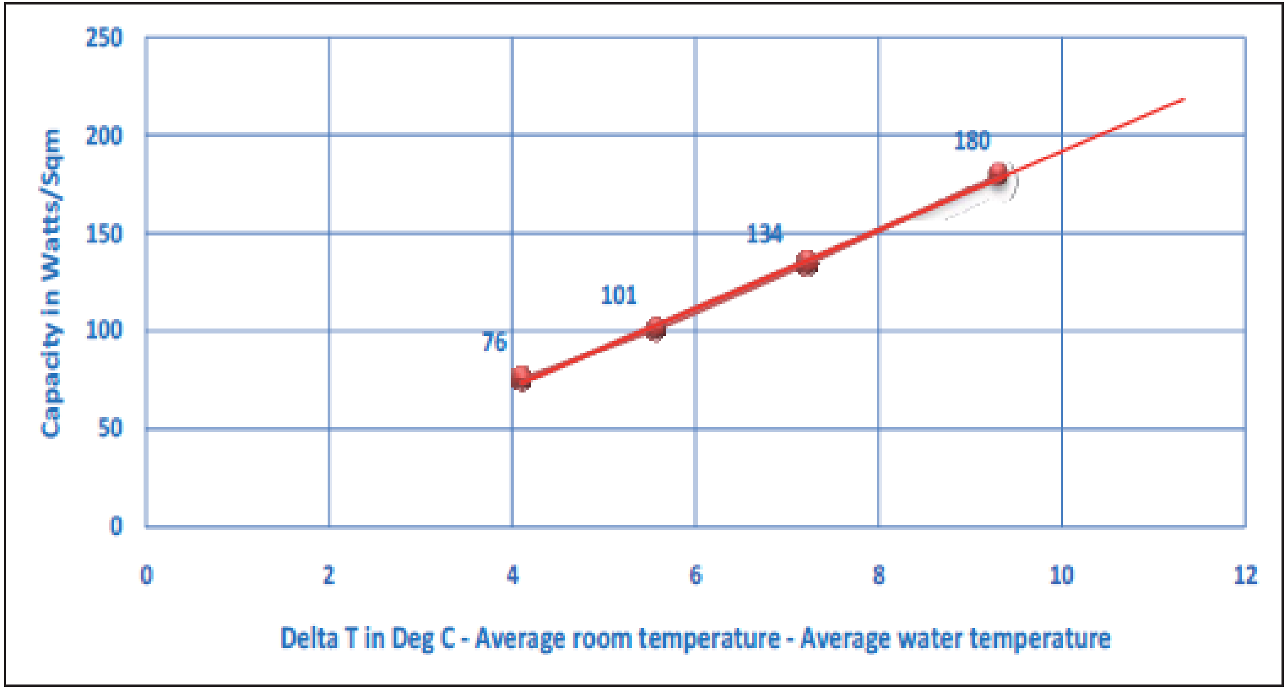
DIY Integrated Design Approach by Infosys

- Indoor air quality
- Thermal comfort
- Visual comfort
- Acoustic comfort
- Sustainable solution

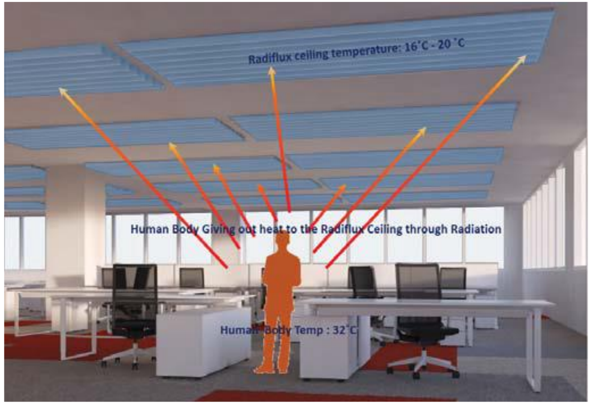
Infosys in-house radiant panels

- Developed by Infosys in-house team
- Tested and certified for its performance as per international standards in WSP lab Germany
- Produces twice the capacity and less cost , compared to current solutions in the market
- Produces 193 W/m2 at 10 K delta T as per EN14240 standards
- Radiant cooling is 30% more efficient than conventional system
- Patent filed in US, Europe and India

Capacity Graph – EN14240 standards



RADIFLUX


Radiflux ceiling temperature: 16˚C - 20 ˚C
Human Body Giving out heat to the Radiflux Ceiling through Radiation
Human Body Temp : 32˚C

KEY Features of RADIFLUX

- Monolithic and flexible in design
- Gives architects liberty in Ceiling designs – Ceilings can be designed with different shapes and colors
- Highest capacity in class
- Highest Air quality
- Lesser connections in the system
- Ease of Installation and maintenance

CASE STUDY - II

MC Building Infosys : Case Study

MC Building Infosys : Case Study

Outdoor design conditions:

ASHRAE climate design data 2013: For Bangalore

	Dry bulb(DB)	Wet Bulb (WB)
Summer (May)	96 ºF/ 35.55 ºC	78 ºF/ 25.55 ºC
Monsoon (September)	86.4 ºF/ 30.2 ºC	73.6 ºF/ 23.1 ºC

Inside design conditions:

Dry bulb(DB)	RH
75.2 ºF/ 24 +/- 1 ºC	Less than 55%

MC Building Infosys : Case Study

Building Envelope Details

Envelope type	Construction details	U factor (btu /hr.sq.ft.Deg.F)	SHGC
Wall Type	150mm Aerocon block + 50mm thick Foamlar insulation + 50mm air gap + 100mm Aerocon block	0.23	NA
Glass	Daylight and vision glazing. Vision glazing for North and south is of SHGC 0.2, East and west of SHGC 0.17. Daylight glazing of SHGC 0.36 on all sides. Frosted film is provided in east and west daylight glazing.(units in BTU)	0.187	0.2
Exposed roof	Normal concrete slab with underdeck insulation of 50mm thick (Btu/hr.ft2.ºF)	0.12	NA

MC Building Infosys : Case Study

Internal Load Details

Load Type	Input Data Considered
Lighting	0.7 W/Sq.Ft
Occupancy	100 Sq.Ft / Person
Equipment Load	1 computer per person – 70W per computer 1 PC / Cabin; 6 PCs or Laptop for Discussion Rooms

Ventilation in air conditioned areas: As per ASHRAE STD 62.1

Area	Fresh Air Considered
Office Space	(5 cfm/person+ 0.06CFM/Sqft) + 30% extra

MC Building Infosys : Case Study

Heat Load Details

Floor Level	Conditioned Area	Peak occupancy considered in all areas	Fresh air CFM	Total cooling load
	Sqft	Nos		TR
Ground floor	15877	289	4027	18 (S) + 5 (L)
Level 1	25184	480	6615	24 (S) + 8.5 (L)
Level 2	25184	480	6615	24 (S) + 8.5 (L)
Level 3	25184	464	6390	23 (S) + 8 (L)
Level 4	25184	480	6615	24 (S) + 8.5 (L)
Level 5	25184	480	6610	29 (S) + 8.5 (L)
Total	141797	2673	36872	142 (S) + 47 (L) = 189

MC Building Infosys : Case Study

Chiller Configuration

	Water Temperature	Total Chiller Capacity (TR)	Chiller Capacity for pre-cooling of air (TR)	Chiller capacity used for radiant system (TR)	IkW / TR @ 100% load
High Temp. Chiller	16 - 20	100	55	45	0.5
Low Temp. Chiller	8 - 15	90	NA	NA	0.6

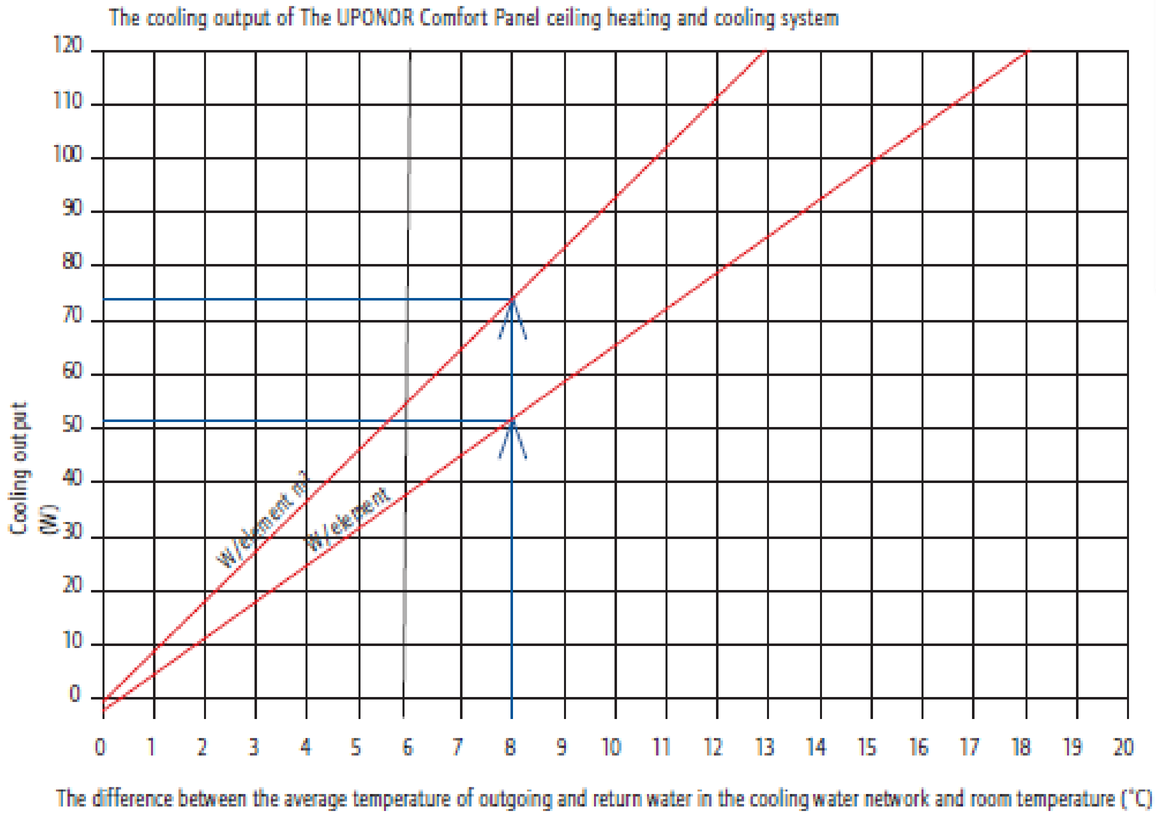
MC Building Infosys : Case Study

Energy Saving with VAV Based Conventional AC System

Overall Energy Saving (%)	30
Reduction in air movement (CFM) (%)	55
Volume of FA from total air movement (%)	100

MC Building Infosys : Case Study

Panels Cooling Output

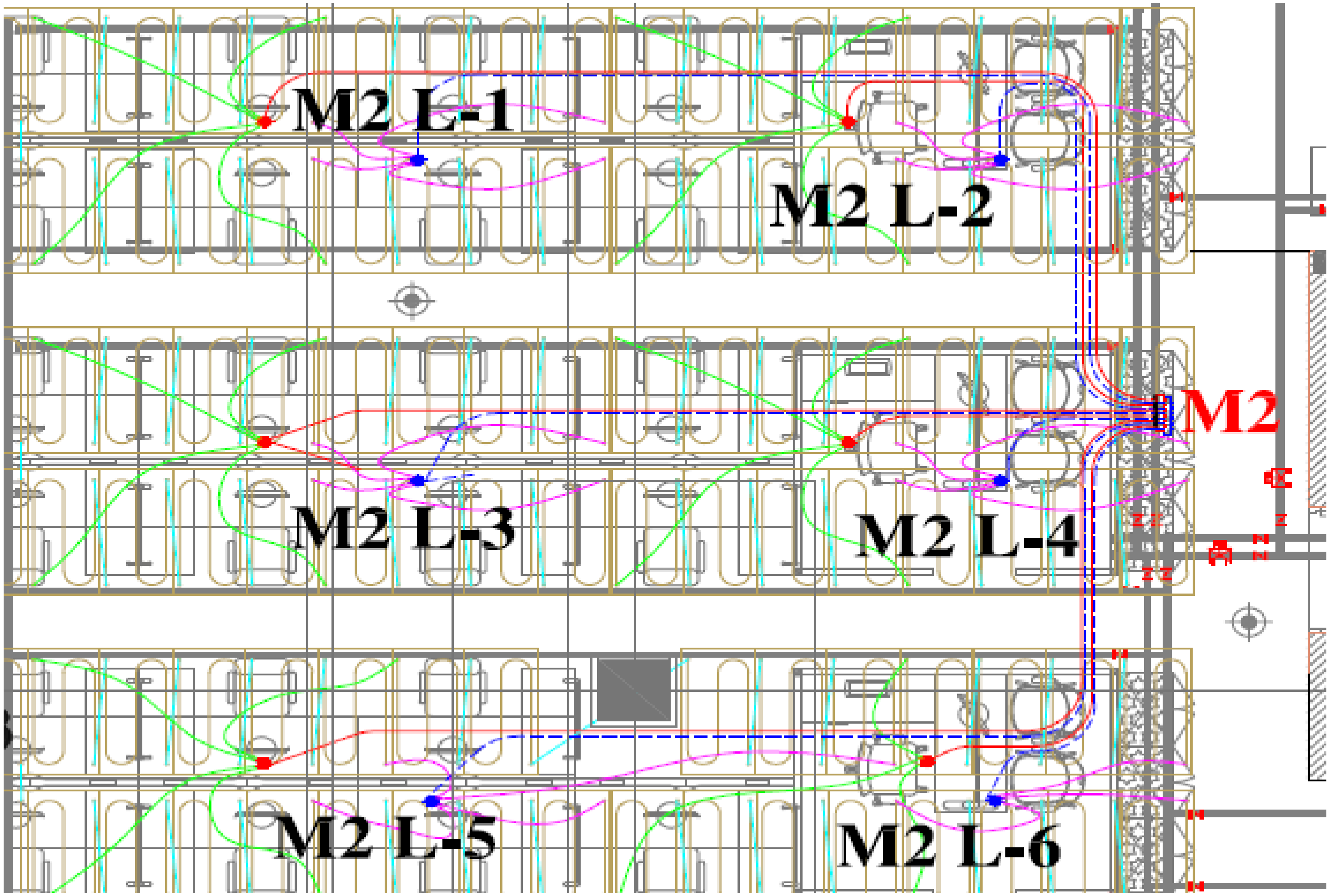


Room Temperature : 24°C			
Supply Water Temp. (°C)	Return Water Temp. (°C)	Average Temp Difference with Room Temp (K)	Cooling Output (W/m2)
16	20	6	55

Room Temperature : 26°C			
Supply Water Temp. (°C)	Return Water Temp. (°C)	Average Temp Difference with Room Temp (K)	Cooling Output (W/m2)
16	20	8	74
16	19	8.5	78.8
16	18	9	83.8

MC Building Infosys : Case Study

Typical Panel Layout



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Panel Installation

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Uponor in India, References

IT Buildings

MC Building, Infosys, Bangalore
Ceiling Comfort Panel System
Area : 141,800 sq.ft

UST Global, Trivandrum
Under Floor Cooling
Area : 60,000 sq.ft

Uponor in India, References

Educational Institutions

K L University,
Vijayawada,
TABS,
Area : 175,000 sq.ft

St. Marks School,
New Delhi
Under Floor Cooling,
Area : 3,000 sq.ft

Paul George School,
New Delhi
Under Floor Cooling,
Area : 70,000 sq.ft

Uponor in India, References

Villas

Malhotra Villa,
Gurgaon, Haryana
Underfloor Cooling,
Heating
Area : 3,500 sq.ft

Garg Villa,
Kandla, Gujarat
Under Floor Cooling
Area : 4,500 sq.ft

Rajendra Villa, (Under
Construction)
Bangalore
TABS,
Area : 4,000 sq.ft

Uponor in India, References

Hotel, Hospital

Soaltee Group Hotel, (Under Construction)
Nepalganj, Nepal
TABS
Area : 65,000 sq.ft

Garg Nursing Home,
Moga Punjab
Under Floor Cooling
Area : 8,000 sq.ft

CASE STUDY - III

RAAS KANGRA

A Resort in Dharamshala With Radiant Floor for Cooling and Heating

Presented by: Gian Modgil gcm@sterlingindia.in

What is radiant floor heating?

Invented by the innovative ancient Romans, who had slaves fanning wood-burning fires under elevated marble floors, radiant floor heating is an under-the-floor heating system that conducts heat through the floor surface rather than through the air (as in conventional forced-air heating systems).

How does radiant floor cooling/heating work?

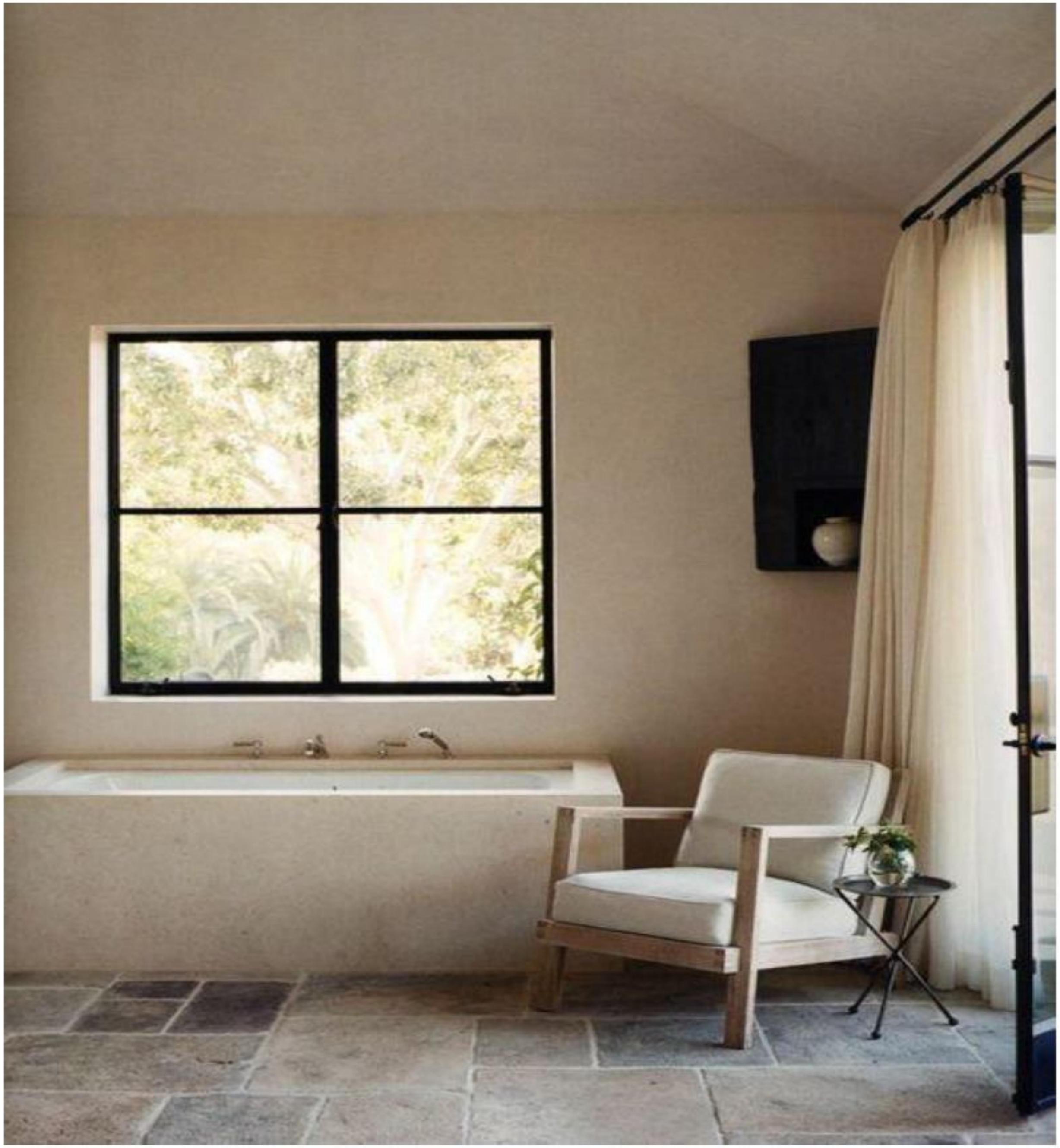
- Hydronic (heat or cool with water tubes) – High capital cost; complicated to install; low operating cost.
- Electric (heat via electric wires) – Easy to install; Low capital cost; High operating cost

What are the cons of radiant floor cooling/heating?

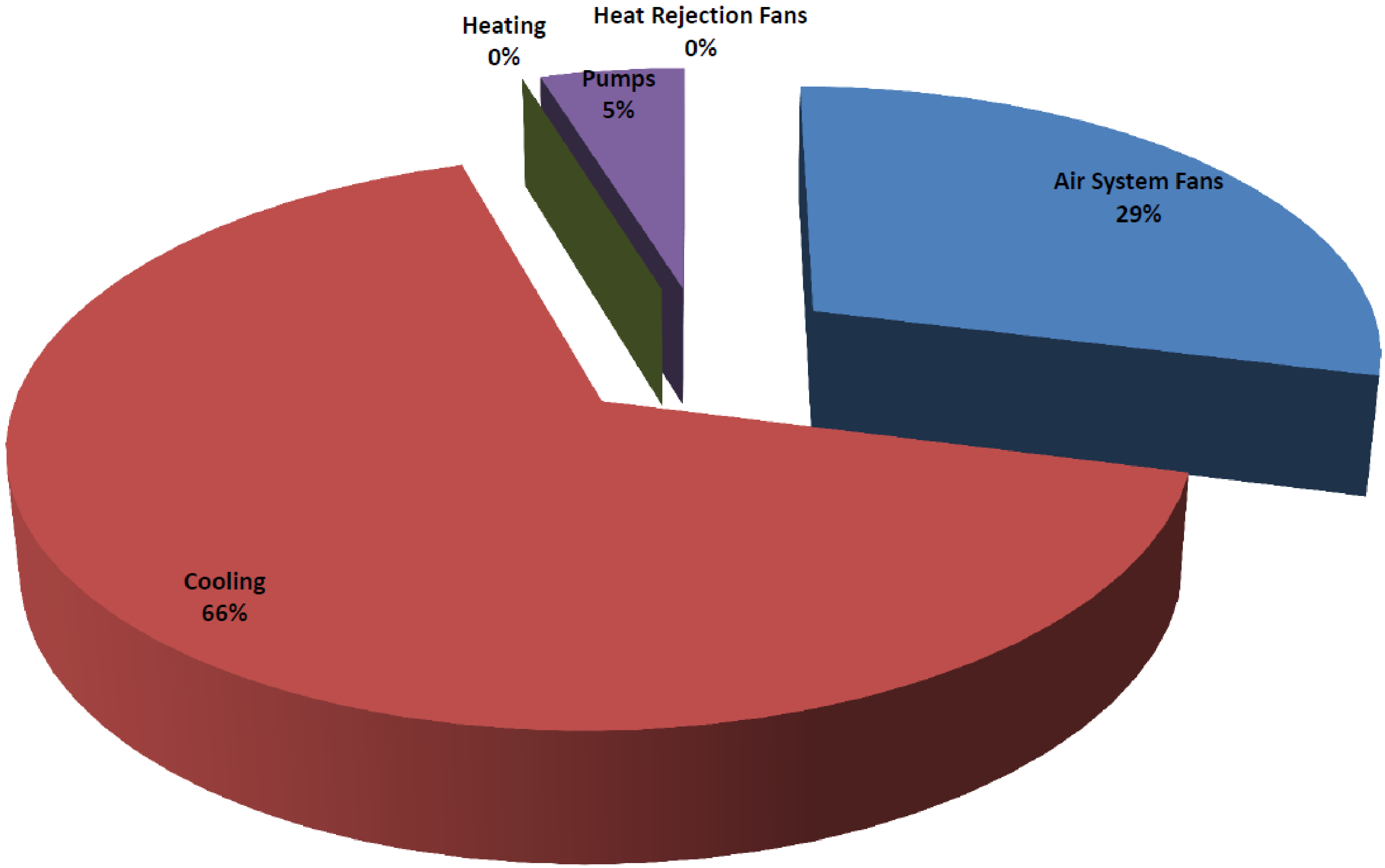
- Difficult to install after a floor is already in place
- More Flooring margin

Flooring materials

- Conducting materials - Stone; Concrete; Ceramic tile; Slate – YES
- Wood, Carpet, Vinyl, Plastic laminates – NO

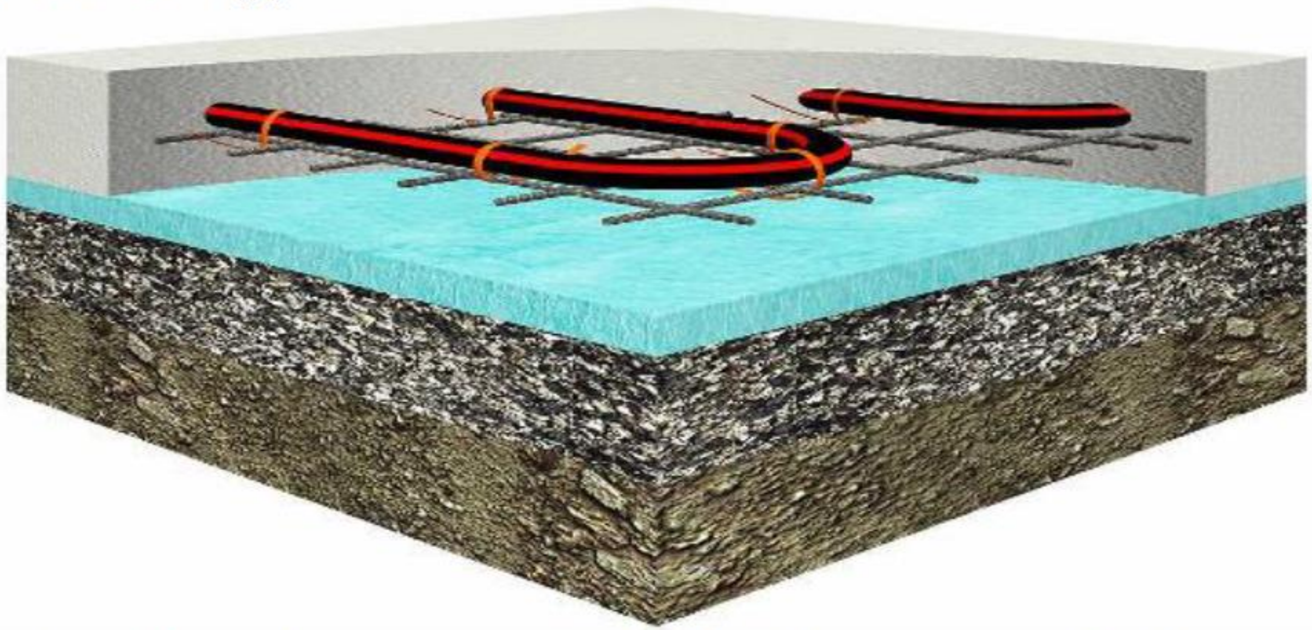


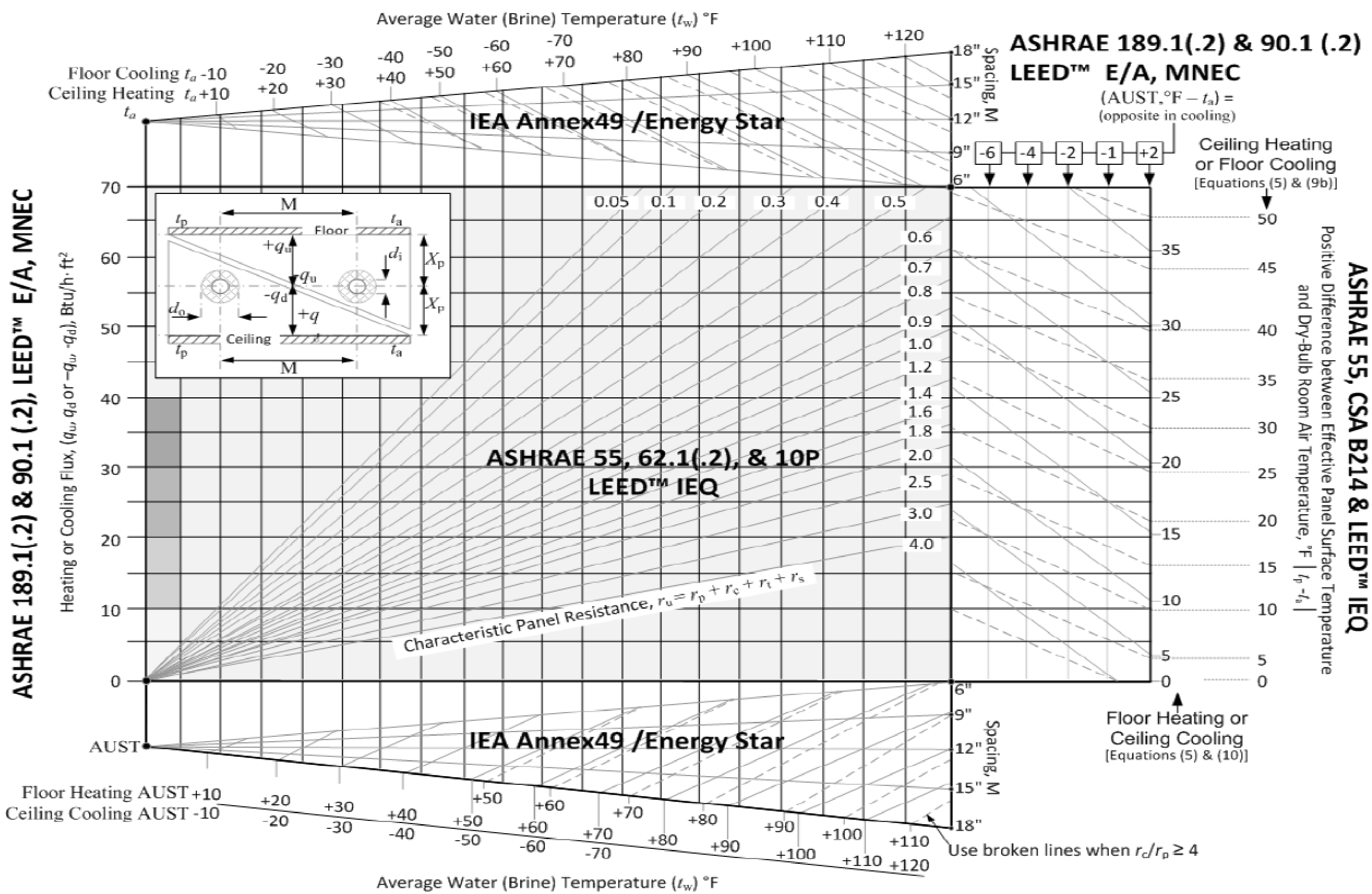
TERI NBC 2#100 TR Screw



Radiant Floor Benefit

- Hydronic radiant cooling systems significantly reduce energy consumption in the built environment
- It achieve energy performance targets by coupling radiant and forced air systems
- Carrying Water requires appx 1/25 of space than to carry air
- Benefit of Thermal Storage
- Low Fan Energy
- Low Chiller energy





ASHRAE Design Graph for Sensible Heating and Cooling with Floor and Ceiling Panels
shown with relevant codes, standards and guidelines

Fig. 1

- **Heating or Cooling Flux (*q*), Btuh•ft^2(W/m^2)**

Table 1. Enclosures level performance: based on combined convective and radiative flux per unit of floor area (sensible loads only in the long wave range).	
Enclosure performance level	Thermal flux, Btu/ft^2·hr, (W/m^2)
Terrific (high)	< 10 (31)
Transitional (good)	10 to 20 (31 to 63)
Traditional (moderate)	20 to 30 (31 to 94)
Terrible (poor)	> 30 (94)

- **Average Unconditioned Surface Temperatures**
- **Positive Difference Between Effective Panel Surface Temperature and Dry-Bulb Room Air Temperature**
- **Characteristic Panel Resistance**
- **Spacing**
- **Average Fluid Temperature**

- **Ensure efficient envelope with low heat ingress avoiding direct solar gains**
- **Ensuring 1.6 C (3 F) difference between CHWT and dewpoint avoids condensation**
- **Ensure positive pressure within the conditioned space**

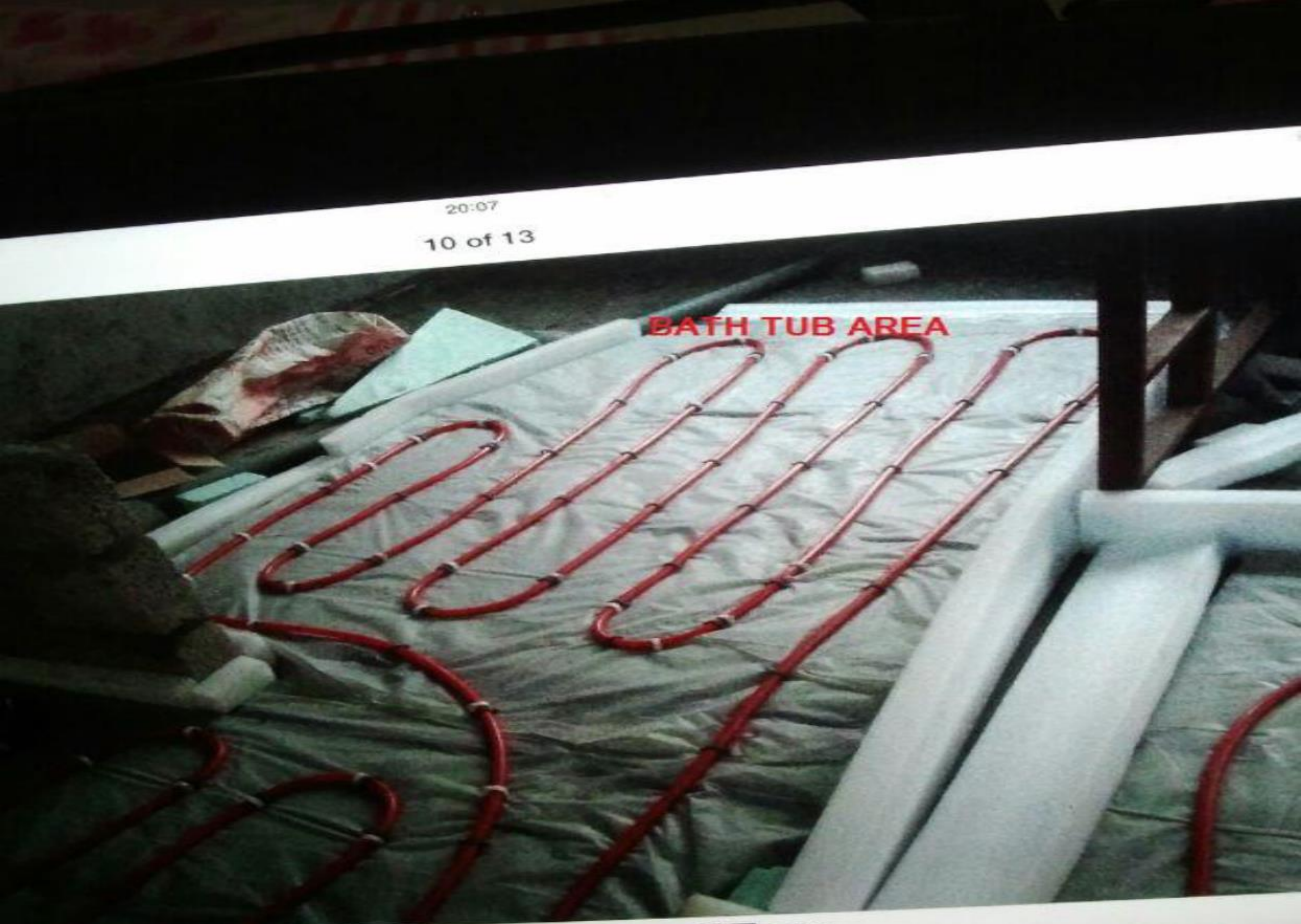
Radiant Floor Laying Procedure

- The concrete floor shall be properly leveled and then surface cleaned. 50mm thick slabs of Extruded Polystyrene insulation with reflective aluminum foil coated surface shall be installed above the floor with tung & groove joints. PEX tubes shall be installed above the water proofing. The tubing shall be secured between furring strips (sleepers) to carry the weight of the new subfloor and finished floor surface.
- The tube shall be provided with tracks/retainers so as to hold the tube in fixed position. The supports/trackers should preferably be in aluminum or conducting material so as to improve the heat transfer efficiency as well as provide even surface temperature.

Radiant Floor Laying Procedure

- Screed shall be laid above the pipes and slate floor covering shall be provided as finish.
- Cross-linked polyethylene (PEX) tubing with an oxygen diffusion barrier shall be provided for carrying the water through the tubes in the floor. Proper care shall be taken at joints so as to avoid any chance of leakage.
- The System shall be provided with a supply and return manifold. The Manifold should have multiple circuit valves for isolation of circuits from supply and return. Main manifold isolation valves shall also be provided. The floor system shall be provided by two way modulating valve with actuator controlled by a floor/RWT thermostat.


20:07
9 of 13
BED ROOM AREA


20:07
10 of 13
BATH TUB AREA


Required support for edge insulation to stay back its position along with floor insulation. So that ensure no gap between floor & edge insultation.


Put screed in
between these
gaps first so that
it will give support
to edge insulation
& there is no gap
between egde &
floor insulation.

Coordination Issues

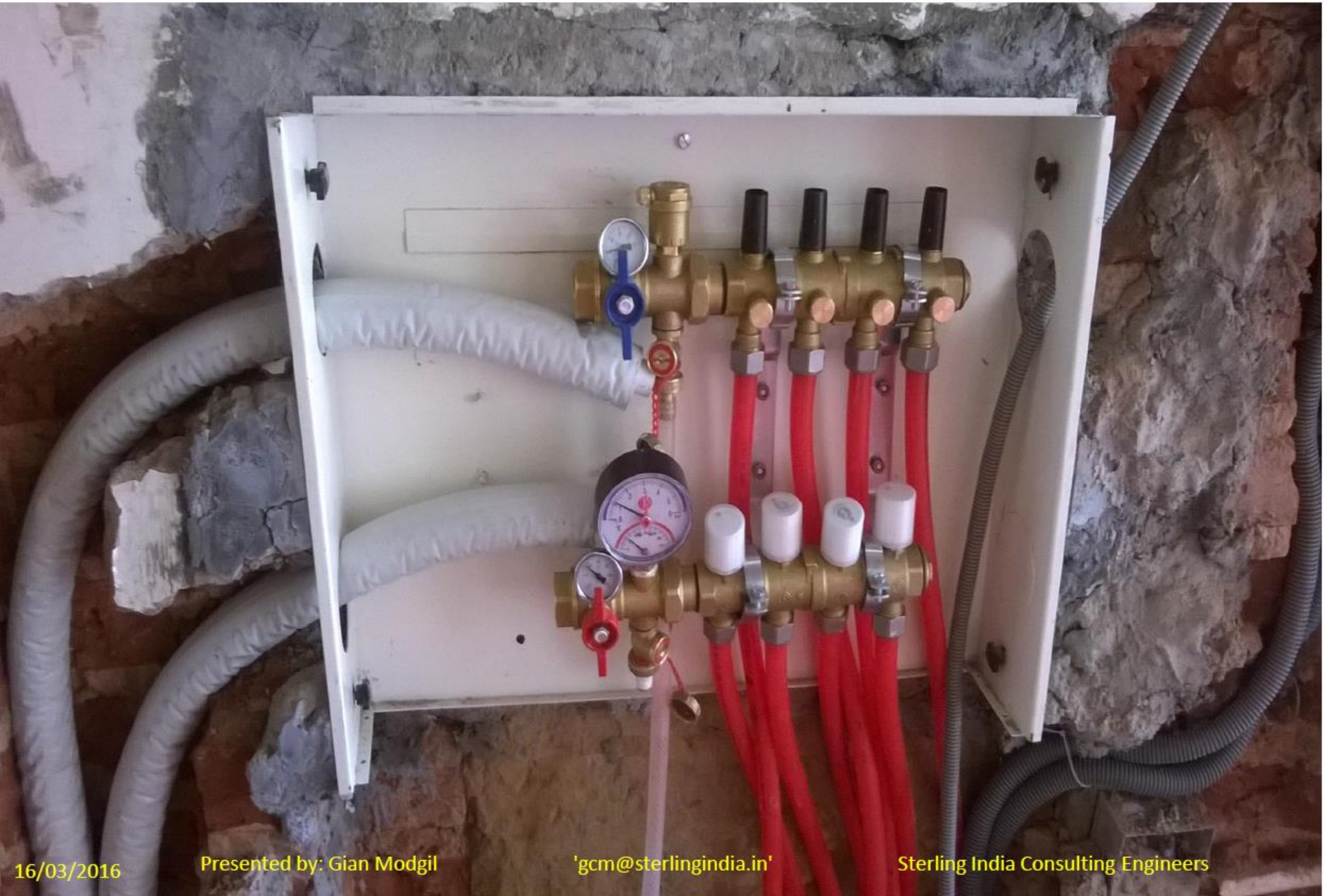
- HVAC designers cannot operate in isolation from Architects/ interior design
- Avoid gap between floor and side/edge insulation
- Avoid displacement of PEX Pipes during PCC pouring.
- Provide waterproofing membrane between insulation and PCC.
- Provide multiple circuits for slab cooling
- The pipes for various circuits from manifold shall be laid in orderly manner.
- Location of Manifold need to be planned
- DOAS for fresh air and latent loads need to be accommodated with air distribution

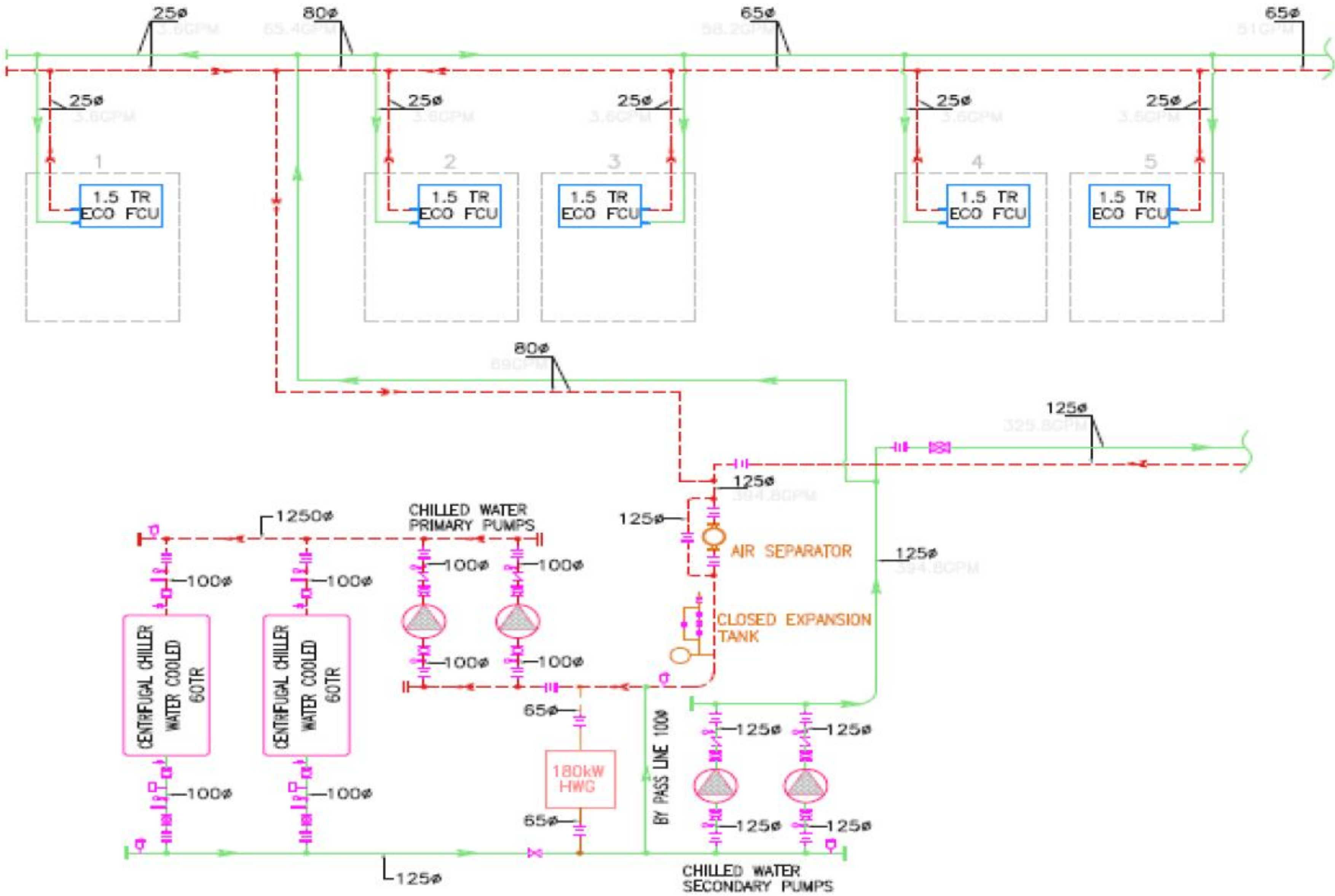

Please put some
back support for
edge insulation.
As this will help us
edge insulation to
stick with floor
insulation.


The circuit pipes shall be multiple and laid in orderly manner so as to have neat finish

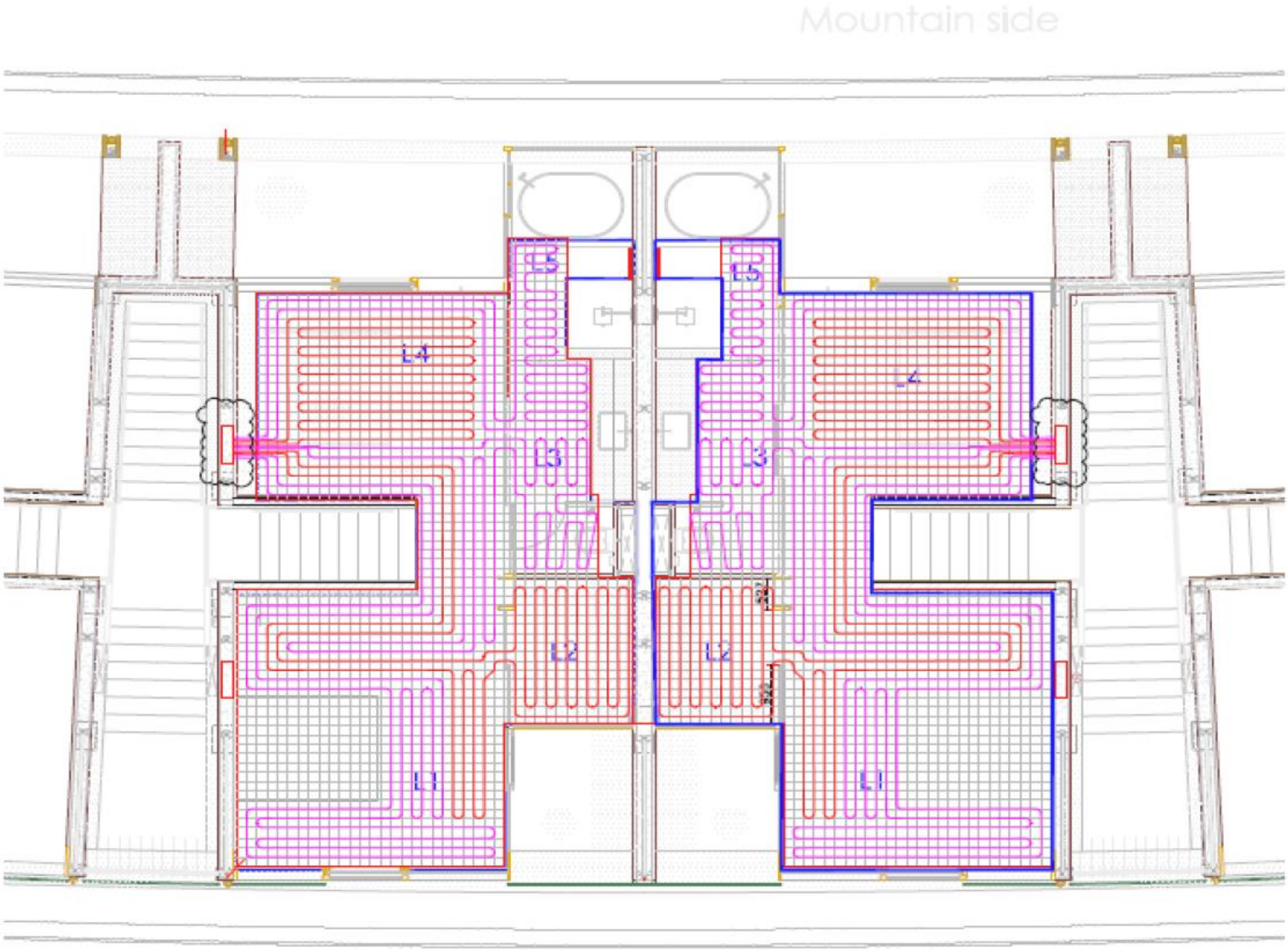

GIACOMINI

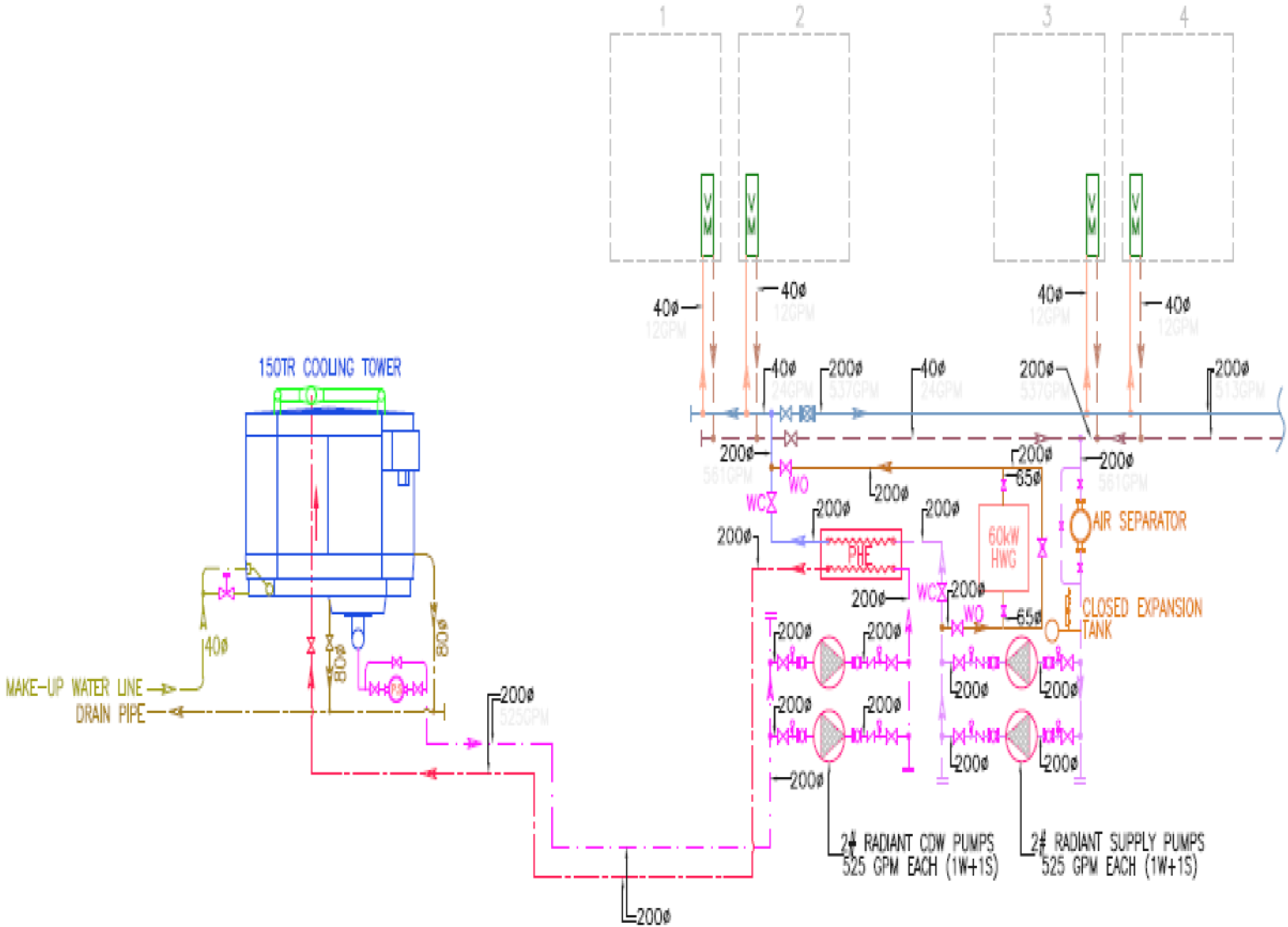
Radiant Floor Manifold





HVAC PLANT ROOM


Mountain side
L5
L4
L3
L2
L1
L5
L4
L3
L2
L1
Tea side

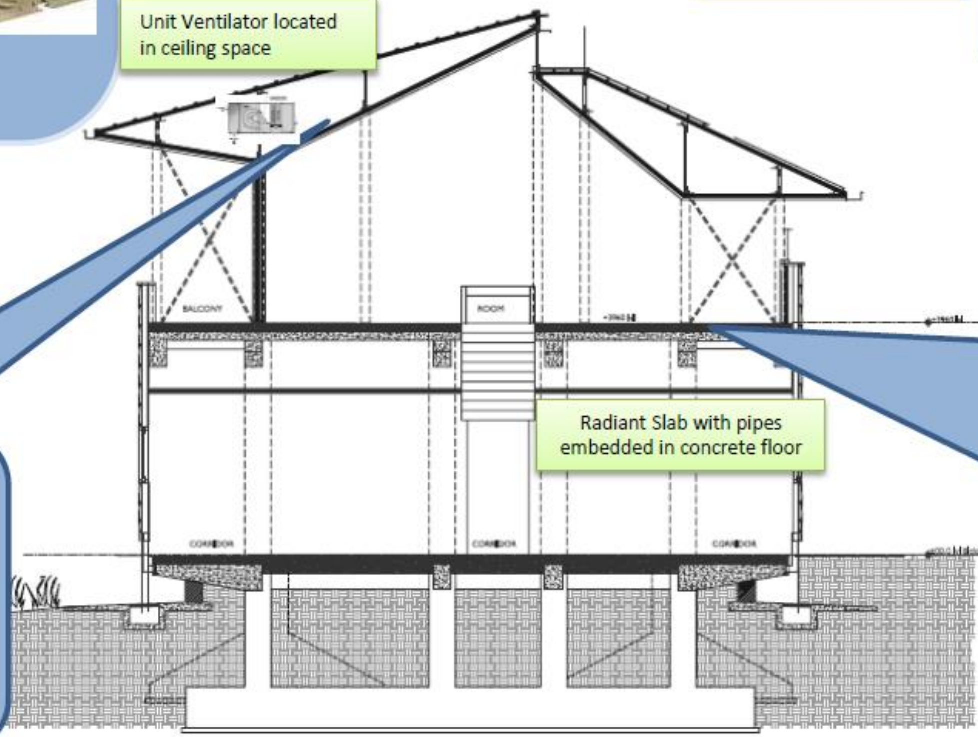

1
2
3
4
VM
40ø
12GPM
200ø
537GPM
513GPM
24GPM
561GPM
65ø
WO
WC
PHE
60kW HWG
AIR SEPARATOR
CLOSED EXPANSION TANK
150TR COOLING TOWER
MAKE-UP WATER LINE
DRAIN PIPE
80ø
525GPM
2# RADIANT CDW PUMPS
525 GPM EACH (1W+1S)
2# RADIANT SUPPLY PUMPS
525 GPM EACH (1W+1S)

ROOM AIR CONDITIONING SUMMERS

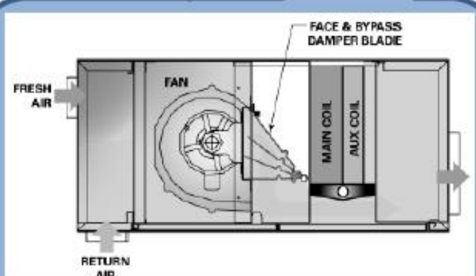
CENTRAL CHILLED WATER PLANT ROOM

COOLING TOWER

Unit Ventilator located in ceiling space

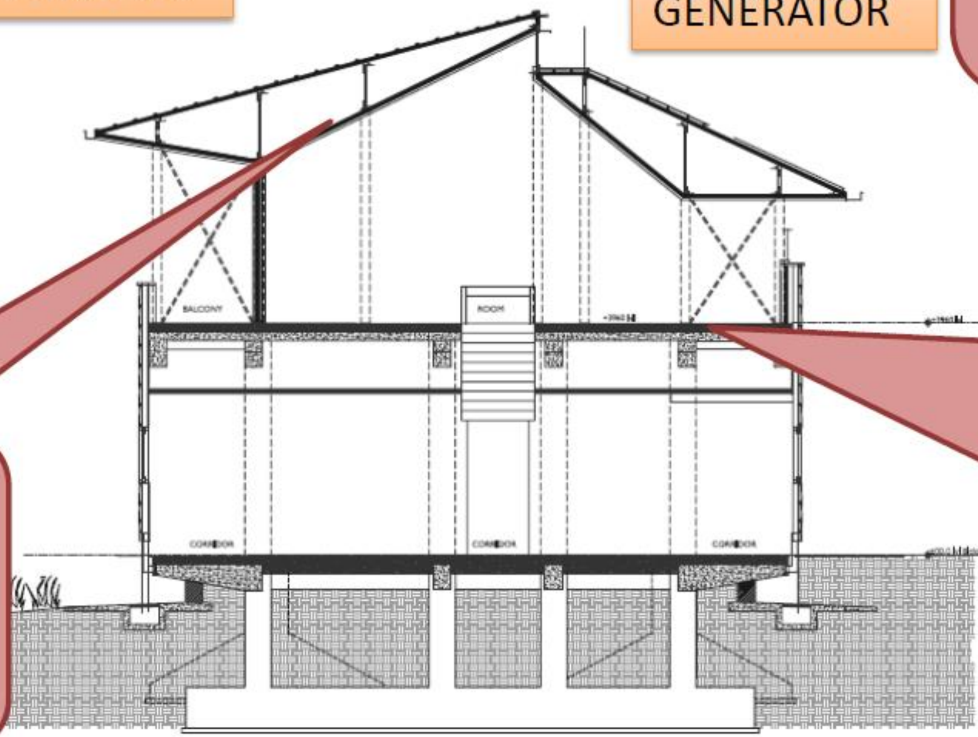


Radiant Slab with pipes embedded in concrete floor

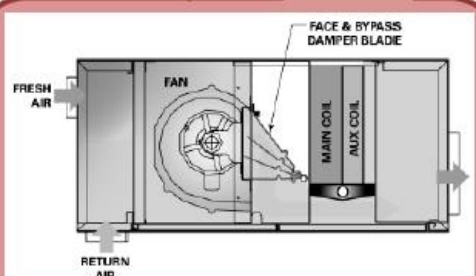


ROOM AIR CONDITIONING WINTERS

CENTRAL HOT WATER GENERATOR



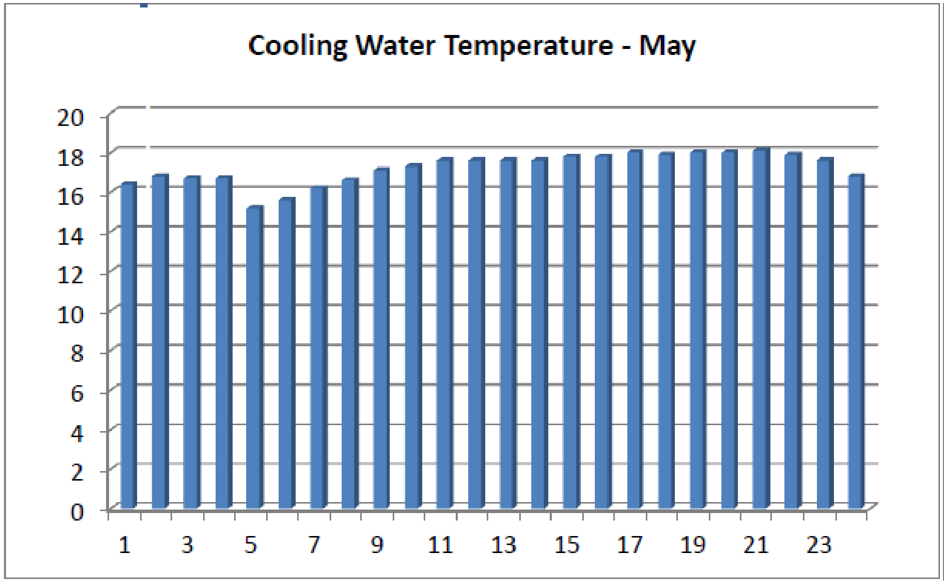
CENTRAL HOT WATER GENERATOR

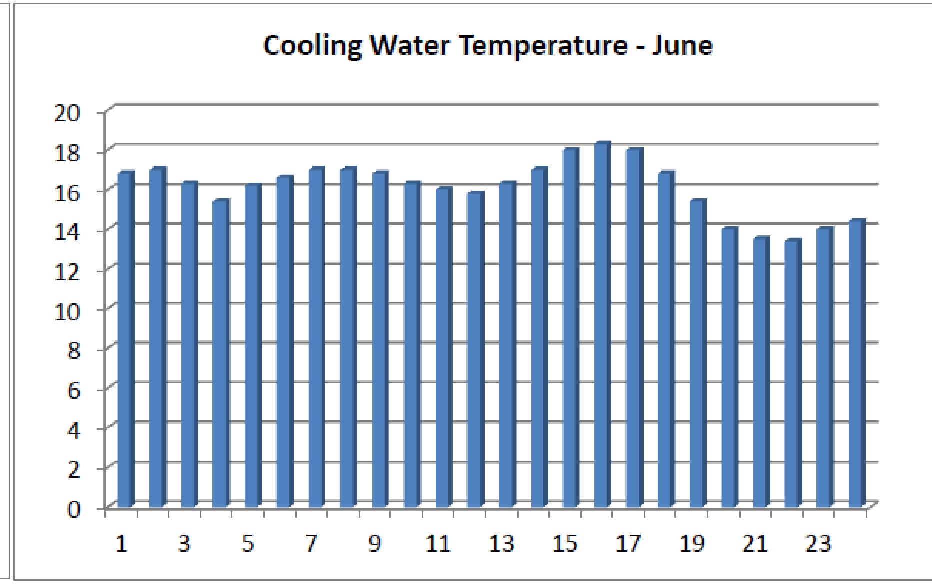


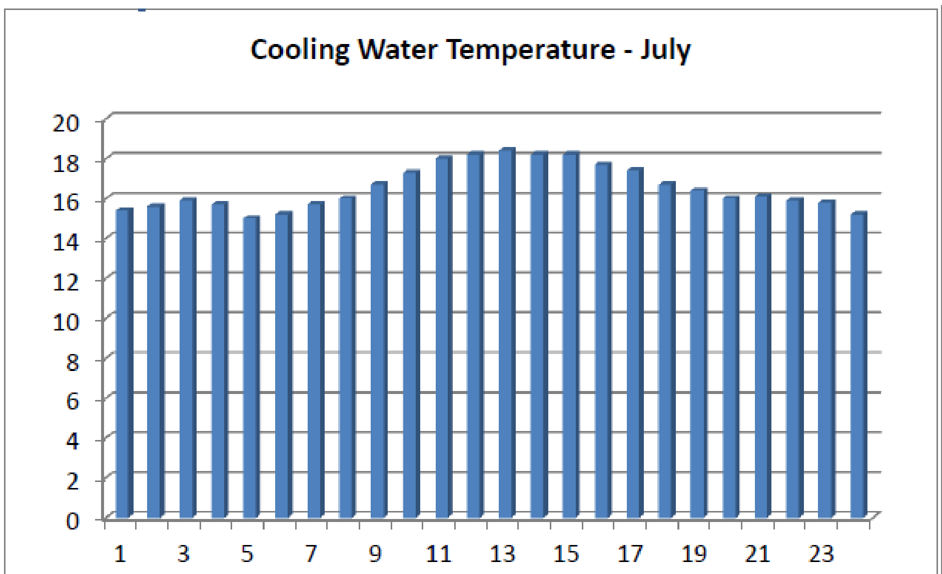
UNIT VENTILATOR

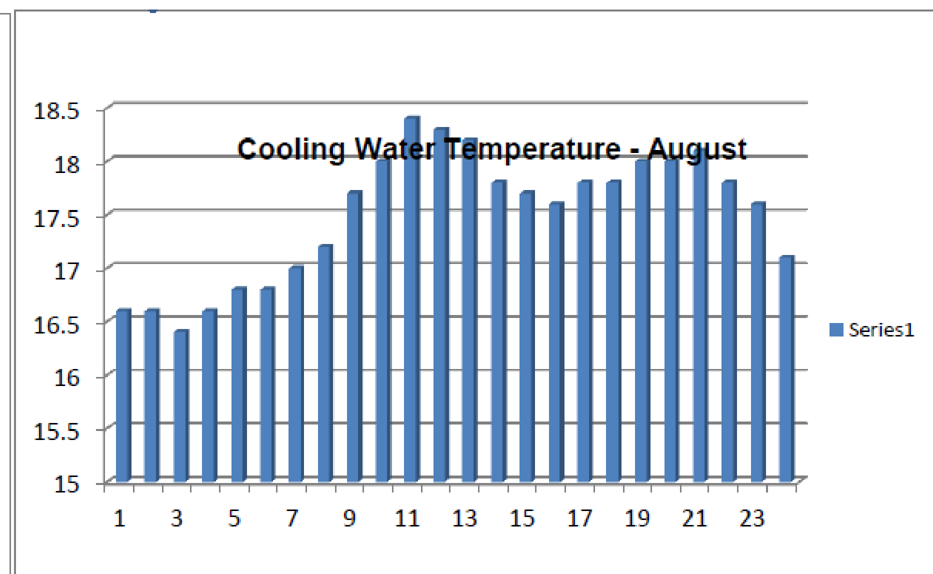
RADIANT SLAB

Radiant Floor Cooling Water Temperature





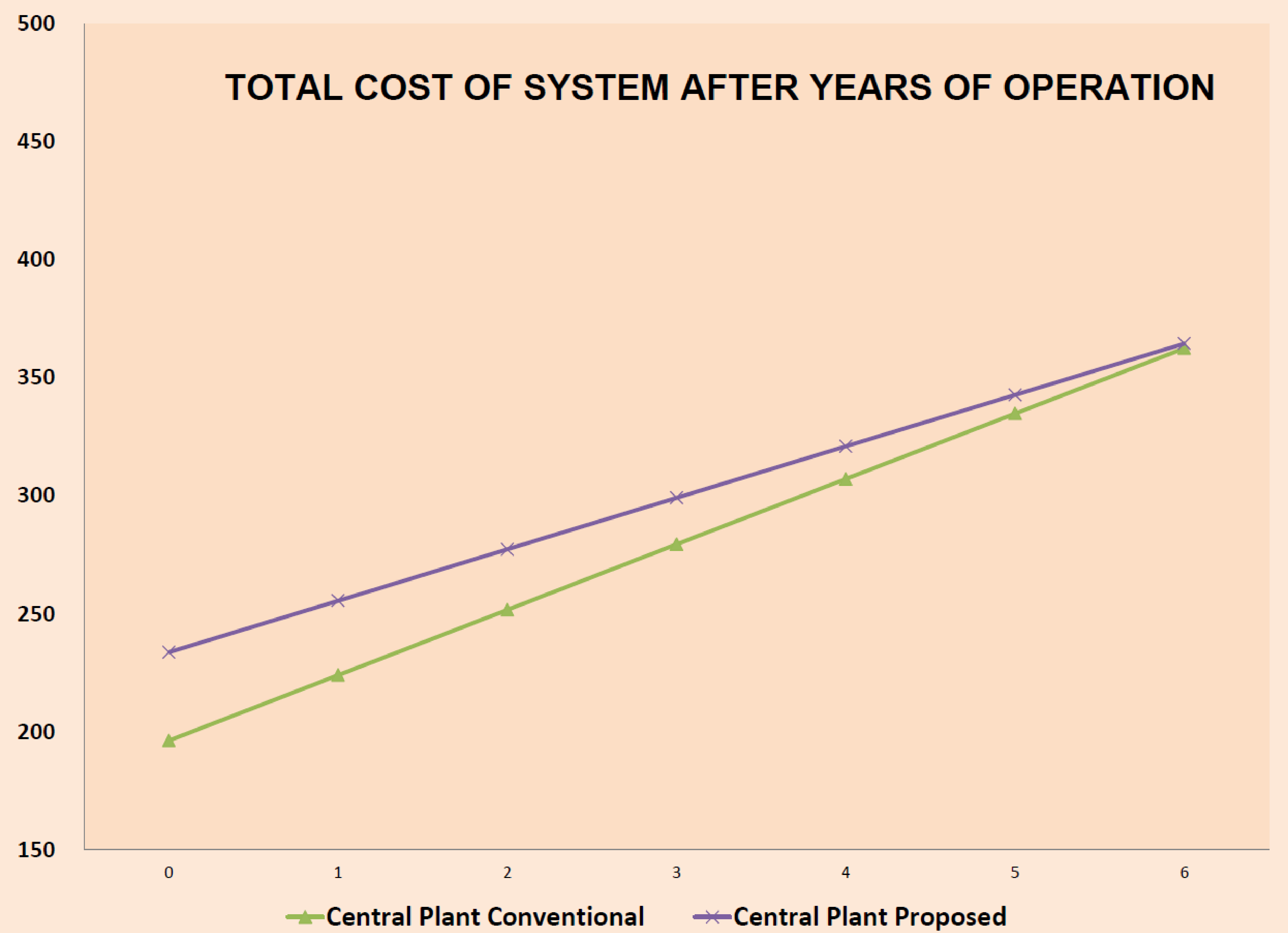




COMPARISON OF AC SYSTEMS for CBR Dharamsala

Description	Units	Scenario A	Scenario B
Heating Type		Electric/HWG/ FCU	Electric/ Radiant Floor/FCU
Area of one GR Unit	Sft.	560	560
Cooling load each GR Unit	TR	2.0	1.5
Total No. of GR units	Nos.	45	45
Total AC TR of Rooms	TR	92	67
Public Areas	Sft.	-	-
Total AC TR of Public Areas	TR	-	-
Total HVAC Plant Capacity	TR	92	67
Cooling Plant Capacity Installed	TR	82	60
Total Power Required	kW	91	67
Energy tariff (avg of 25% DG and 75% grid)	Rs/kWh	7.50	7.50
Capital costs:			
AC Cost Cooling Plant	Rs L	59.00	48.75
Hot Water Generator	Rs L	1.30	1.30
Low Side	Rs L	95.50	95.50
Radiant Floor Cooling/Heating Cost	Rs L	-	55.95
Transformer, DG and electrical cost	Rs L	22.68	16.63
Total capital costs	Rs L	178.48	218.13
Life span of a/c equipment in years		25	25
Depreciation/year		4.0%	4.0%
Energy consumed	kWh/yr	1,08,864	63,867
Operating and maintenance costs:			
Energy cost	Rs L/yr	8	5
Maintenance costs	Rs L/yr	1	1
Operation Cost	Rs L/yr	3	3
Water cost (@ Rs 100/kl)	Rs L/yr	0.99	1.33
Total O & M costs	Rs L/yr	13.39	10.02
Depreciation for HVAC system cost only	Rs L/yr	6.23	5.82
Total O & M costs with depreciation	Rs L/yr	19.62	15.84

		Central Plant Conventional	Central Plant Proposed
Total cost at end of year (Rs L)	0	178	218
Total cost at end of year (Rs L)	1	198	234
Total cost at end of year (Rs L)	2	218	250
Total cost at end of year (Rs L)	3	237	266
Total cost at end of year (Rs L)	4	257	282
Total cost at end of year (Rs L)	5	277	297
Total cost at end of year (Rs L)	6	296	313


TOTAL COST OF SYSTEM AFTER YEARS OF OPERATION
500
450
400
350
300
250
200
150
0
1
2
3
4
5
6
Central Plant Conventional
Central Plant Proposed