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Air Conditioning Using Radiant Cooling System

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Abstract: **A Radiant cooling system alludes to a temperature-controlled surface that cools indoor temperatures by evacuating sensible heat and where the greater part of heat exchange happens through thermal radiation. Heat will spill out of objects, occupants, equipment and lights in a space to a cooled surface the length of their temperatures are hotter than that of the cooled surface and they are inside the observable pathway of the cooled surface. The procedure of radiant exchange negligibly effects on air temperature, yet through the procedure of convection, the air temperature will be brought down when air interacts with the cooled surface. Radiant cooling system utilizes the inverse impact of Radiant cooling system, which depends on the procedure of heat spill out of a warmed surface to items and inhabitants.**

Keywords: air conditioner, radiant cooling, temperatures, AC

I. INTRODUCTION

Radiant cooling systems are generally chilled roof beams or panels, to exploit convective air cooling and in addition mean radiant temperature. Since cool air sinks, a chilled roof pillar will cool air that will sink and circulate itself through the space.

Convection is more imperative for radiant roof boards and beams in light of the fact that, dissimilar to radiant floors, nobody will touch these surfaces. Along these lines, they are some of the time basically called "chilled beams". Be that as it may, Radiant cooling systems can be situated in floors also. While there is an expansive scope of systems innovations, there are two essential sorts of Radiant cooling systems. The primary sort is systems that convey cooling through the building structure, typically chunks, these systems are likewise named thermally enacted assembling systems (TABS).The second sort is systems that convey cooling through particular boards. Systems utilizing solid sections are for the most part less expensive [illegible] while board systems offer quicker temperature control and adaptability radiant cooling cools a story or roof by retaining the warmth (heat) emanated from whatever remains of the room. At the point when the floor is cooled, it is regularly alluded to as Radiant floor

Cooling; cooling the roof is generally done in homes with Radiant boards. Albeit possibly appropriate for bone-dry atmospheres, radiant cooling is risky for homes in more sticky atmospheres.

Advantages of Radiant Cooling systems:

1. There are several good reasons designers should consider including radiant cooling systems in new buildings in any climate zones. Commercial buildings primarily cooled by radiant means are more comfortable than buildings cooled by traditional HVAC systems. The first costs for radiant systems are comparable with those for traditional variable-air-volume (VAV) systems, but their lifetime energy savings over VAV systems are routinely 25 percent or even more.
2. With radiant systems, people are cooled by radiant heat transfer from their bodies to adjacent surfaces ceilings, walls, or floors whose temperatures are held a few degrees cooler than ambient
3. Space conditioning energy is usually moved from chillers or boilers to radiant panels or concrete slab using water as a medium. This produces impressive savings, since water has roughly 3,500 times the energy transport capacity of air. Even accounting for the pressure drop involved in pumping water throughout a building, a hydronic system can transport a given amount of cooling with less than 5 percent of the energy required to deliver cool air with fans.
4. In most commercial buildings, both cooling and ventilation is expert by circling large volumes of air all through the conditioned space. This requires considerable fan power and vast ducts, and it's a wellspring of drafts and noise.

Types of Radiant Cooling Systems:

There are primarily two types of radiant cooling systems:

A. Chilled Slabs:

These convey cooling through the building structure, generally slab, and are otherwise called thermally actuated building frameworks (TABS). Radiant cooling from a section can be delivering to a space from the floor or roof. Floor cooling is like floor warming that has been [illegible]ce most recent couple of decades.

Modern Radiant Cooling takes after a similar guideline to cool a story or roof (or even dividers) by engrossing warmth transmitted by whatever remains of the room. As can be found in the diagram below, a Cooled Ceiling goes about as a warmth sink for all radiant warmth sources in the room (human inhabitant, sun oriented radiation (solar), gear, walls and so on.)

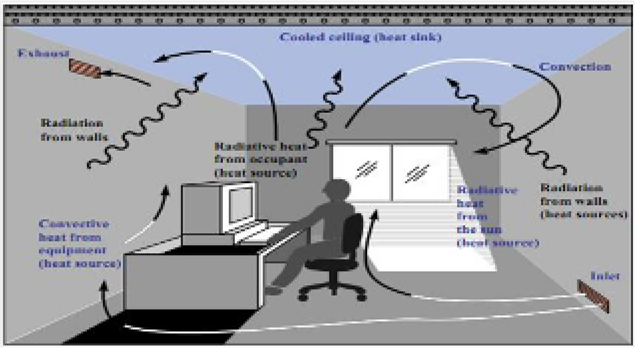

Fig. 1: Radiant Cooling from Ceiling

B) Ceiling Panels:

These deliver cooling through particular boards systems utilizing solid sections (concrete slabs) are by and large less expensive than board systems and offer the benefit of warm mass while board systems offer quicker temperature control and adaptability.

The following is the outline of comparison between Slab Integrated and Panel Systems:

Table 1: of comparison between Slab Integrated and Panel Systems

	Slab-Integrated Systems	**Panel Systems**
Method	Pipes are embedded on floors, walls or ceilings.	Mats of small, closely spaced tubes are embedded in plastic, gypsum or plaster on walls and ceilings.
Thermal Mass	High	Low
Thermal Inertia	High	Low
Typical Surface Area	Up to 100% of Ceiling/Floor Area.	50-70% of ceiling area.
Cooling Surface Temperature	18-24 deg C	13-15 deg C
Cooling Capacity	24 Btu/hr-ft2	30 Btu/hr-ft2
Best Application	1. Buildings with high-performance envelopes 2. Moderate Climates 3. Use with natural ventilation and/or low-energy cooling or heating sources.	1. Buildings with greater variation in skin loads 2. Buildings with spaces with highly variable internal loads 3. Mixed-mode buildings with zoned or seasonal operation.
Additional Opportunities	Use to remove solar loads from structural elements, or to create a "constant-temperature" slab or pre-cooled building. Lower cost per unit surface area.	Good for retrofit applications including supplementary space conditioning. Some designs integrate acoustical solutions.

Chilled ceiling panels can be all the more effortlessly coordinated with ventilation provided from the roof .panels tend to cost more for each unit of surface region than chilled slabs.

Cooling the roof is typically done in homes with radiant panels. Although potentially reasonable for bone-dry atmospheres, radiant cooling is dangerous for homes in more humid atmospheres.

Most radiant cooling home applications in North America have been founded on aluminum panels suspended from the roof, through which chilled water is coursed.

To be powerful, the boards (panels) must be kept up at a temperature exceptionally close to the dew point inside the house, and the house must be kept dehumidified.

Fig 2: Radiant cooling panel attached to ceiling

II. SYSTEM DESIGN AND CONSTRUCTION

A. Radiant Cooling System Components:

A radiant heating and cooling system is comprised of the following primary components;

***Cooling Water**:*

Unlike traditional HVAC, the water temperatures in radiant systems can often be within 20°F (11°C) of space temperature. In fact, it's not uncommon to see fluid temperatures for heating to be below core human body temperatures.

These low temperatures for heating and high temperatures for cooling enable higher efficiencies in traditional components such as chillers, boilers, solar and heat pumps, and enable the use of non- traditional sources such as ground water.

More commonly on high-performance buildings, ground source heat pumps can employ a bypass for the shoulder seasons. This flexibility adds another design dimension as systems can be integrated under a common plant and distribution piping with localized tempering; or parallel plants can be employed to optimize energy efficiency.

Circulators:

Standard circulators with or without speed control can be used for radiant systems. Certainly, due to the necessarily higher cooling fluid temperatures, there is less concern for condensation on circulator motors in comparison to traditional systems. Selection for circulators follows good engineering practice as with traditional systems.

Manifolds:

The central hub for distributing flow to a slab is the manifold and cabinet which can be furnished with a number of flow control and service options.

To account for system hydraulics and maintenance, manifold locations must be carefully coordinated with the architect.

Fig 3: Manifold in Flush-mounted Wall Cabinet

Conditioned Slab:

The slab is warmed or cooled by water flowing through tubing embedded in the slab, either the structural slab or a topping slab. The tubing material of choice for radiant heating and cooling applications is Wirsbo hepex, which is a PEX-a material that has an oxygen-diffusion barrier to protect the system's ferrous components

Control System:

The HVAC control system is a critical component of any building system; and will manage indoor temperature, fluid and surface temperatures and relative humidity.

In addition to being a key component in facilitating plant efficiency, it will also provide safety dew point monitoring in case of failure in the latent control systems.

B. Selecting the Construction Method

There are a variety of options for installing a radiant heating and cooling system, depending on the building construction. It is important to discuss these installation methods with the architect and structural engineer early during the design process.

The most common configurations for commercial construction are:

- Floor slab on grade
- Floor slab over steel deck
- Topping slab on slab
- Floor slab on wood subfloor

Installing Tubing in a Structural Slab:

In most radiant system installations, PEX-a tubing is embedded directly in the structural slab. This method transforms the building structure into a controllable thermal mass.

Depending on the design and construction of the slab, coordination between the mechanical engineer and structural engineer is required during the design phase.

Some jurisdictions will require structural calculations to show the strength of the slab with the proposed tubing in place.

During the construction phase, the mechanical contractor should coordinate with the general contractor to ensure that the manifold locations are properly prepared and that there are no interferences between the PEX-a tubing and any reinforcing steel, post-tension tendons, electrical conduits, etc. In many cases, the PEX-a tubing can be secured with wire ties directly to the rebar.

***Chilled slab on grade*:**

The most common installation method for commercial construction is slab on grade, where the PEX-a tubing is embedded directly in the structural slab.

A vapour barrier, such as high- density polyethylene sheeting, is recommended between the radiant slab and supporting layers.

Insulation:

Insulation is crucial for proper and efficient operation of the radiant floor system. Heat energy flows in the line of least resistance.

Proper use of insulation facilitates the flow of heat toward the intended space, which is especially important in areas with high water tables and/or moist soil conditions.

Good insulation practices also increase the response time of the system. In the absence of local codes, the insulation should have a minimum R-value on the order of five times the R-value of the proposed floor covering to minimize downward heat loss.

Typical extruded polystyrene foam (XPS) has an R-value of 4.5 to 5.0 per inch, so 1-inch insulation is adequate for most tile, stone or wood flooring applications in mild climates. However 2-inch insulation is recomm ended, especially in more severe climates. Under-slab insulation must be rated for use in slab applications.

Insulation below concrete slabs must be able to withstand the weight of the slab along with any additional dead or live loads. When concrete is applied over the insulation, the weight may slightly compress some types.

Although this compression reduces the insulating effect of the foam, it presents little concern if the foam is properly selected and installed. Consult your local Upon or representative for additional insulation design assistance.

Securing the Tubing:

The PEX-a tubing is looped at the prescribed spacing and secured in place using one of the following methods:

- Plastic staples: Staples can be used to secure the tubing directly to the foam insulation board. Staples should be placed a maximum of 3 feet along straight runs, at the top of each 180-degree arc and once on each side 12 inches from the top of the arc.

- Fixing wire: Wire ties can be used to secure the tubing onto a non-structural wire mesh or rebar. Wire ties should be placed a maximum of 3 feet along straight runs, at the top of each 180-degree arc and once on each side 12 inches from the top of the arc.

- PEX rails: Tubing can be secured using plastic PEX rails. PEX rails should be fastened to the subfloor perpendicular to the loop direction 12 inches from the edge of the wall and every 36 inches thereafter. Once the tubing is in place and connected to the manifold, the system should be pressure tested at 50 psi for 24 hours. The system should be kept under pressure until after the concrete is poured. There should be a minimum of 3 concrete on top of the tubing. Slab thickness should be determined by the structural engineer.

Slab on Steel Deck:

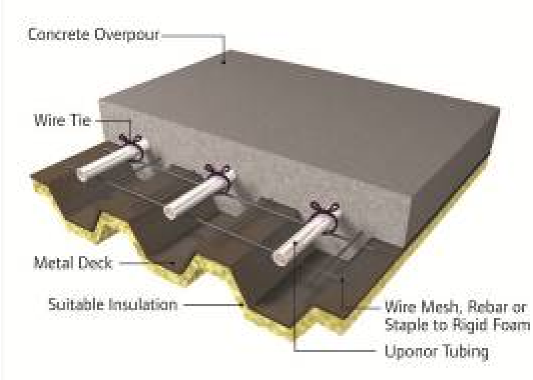

Fig 4 Slab on Steel deck

Structural slab on metal deck installations are common for the upper levels of multi-story buildings. The installation of radiant tubing is very similar to slab-on-grade installation.

The main difference is the insulation, which is typically polyurethane spray foam applied to the underside of the deck. In some cases, the contractor may wish to lay rigid foam board insulation on top of the metal deck under the structural slab.

Topping Slab on Slab:

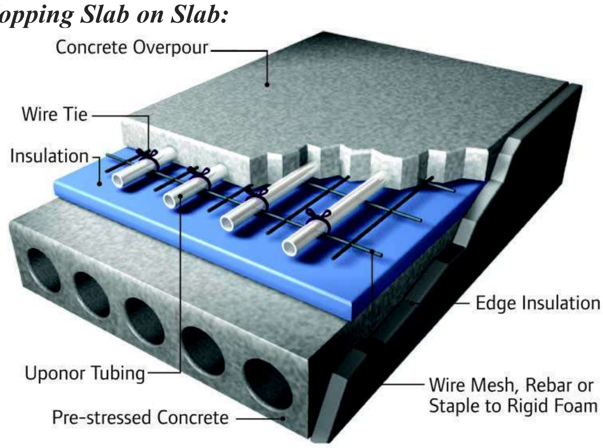

Fig 5 - Topping slab on slab

For installations on existing slabs, or where the structural engineer or local jurisdiction prohibits the installation of tubing within the structural slab, the tubing can be installed in a non-structural topping slab.

This installation method is very similar to a slab- on-grade installation. Since the topping slab does not provide any structural support, it is typically thinner (approximately 2 to 3 inches) and is therefore considered a low-mass system.

A topping slab has shorter response times, but it also has less thermal mass due to the thermal break of the insulation layer. Design of an unbonded topping slab should be done by the project structural engineer.

III. Securing the Tubing

The PEX-a tubing is looped at the prescribed spacing and secured in place using one of the following methods:

- Plastic staples: Staples can be used to secure the tubing directly to the foam insulation board. Staples should be placed a maximum of 3 feet along straight runs, at the top of each 180-degree arc and once on each side 12 inches from the top of the arc.
- Fixing wire: Wire ties can be used to secure the tubing onto a non-structural wire mesh or rebar. Wire ties should be placed a maximum of 3 feet along straight runs, at the top of each 180-degree arc and once on each side 12 inches from the top of the arc.
- PEX Rails: Tubing can be secured using plastic PEX rails. PEX rails should be fastened to the insulation perpendicular to the loop direction 12 inches from the edge of the wall and every 36 inches thereafter.

*A. **Determining System Parameters and Operating Conditions**:*

Once the construction method is established, the following system parameters can be determined:

- Active area
- Tubing diameter

Active Area:

The active area is defined as the actual area where tubing can be installed. When calculating system capacity, it is important to consider the active area, not the gross area.

For example, if 10% of a cooled floor is covered by cabinets, equipment or furniture, or is void of tubing, then only 90% of the floor should be considered for the total cooling capacity.

Tubing Diameter:

The most common tubing sizes for commercial heating and cooling applications are 1 Tubing diameters are selected on the same engineering principals for other piping systems — maintaining head losses between 1 and 4 feet of head per 100 feet of tubing, which typically occurs in velocities between 2 and 5 fps. ⁄2", 5 ⁄8" and 3 ⁄4"

In general, larger diameter tubing means lower head losses, fewer loops and fewer connections. However, larger diameter tubing and associated fittings are more costly and more difficult to work with, particularly at colder temperatures.

Smaller diameter tubing and fittings cost less and are more easily handled, but require more connections and are restricted by loop distances.

B. Average Loop Lengths

The maximum tubing length is normally between 250 and 450 feet per loop to limit pressure drop.

This length includes the active length serving the space and the distance between the manifold and the space being served.

The combined total length of tubing (sum of all loops) needed for a space is a function of the area (in square feet) and the on-center spacing.

To approximate the active length, simply multiply the active area by the following multiplier:

Table 2 - Approximate active length

Tubing Calculation 1

Estimate the length of tubing and number of loops needed, given the following parameters.

Room Area: 2,000 ft² Active area 6 inches on-center

6 inches on center	Area served x 2.0
7inches on center	Area served x 1.7
8 inches on center	Area served x 1.5
9 inches on center	Area served x 1.33

spacing

Average Active Loop Length: 300 ft.

Assume an average leader length of 10 ft. per loop.

Active Length Required: Area x 2.0 ft / area = Length of tubing required

2,000 ft² x 2.0 ft / s*f* = 4,000 feet of active tubing

Loop Calculation

Number of loops = Total active length / average loop length

Number of loops = 4,000 ft./300 ft. = 13.333 or 14 loops

Assuming 14 loops, the active length per loop would be: 4,000 ft. / 14 loops = 286 ft. / loop

Total length per loop = active length + leader length

Total length per loop = 286 ft. + 10 ft. = 296 ft. / loop

Therefore: Total length: 296 / loop x 14 loops = 4,144 ft.

Total number of loops: 14

IV. LOOP LAYOUT

Serpentine Layout:

One strategy is to locate the coldest supply water as close as possible to the highest heat gains. Because internal heat gains are often difficult to predict and are subject to change over the life of the building, this strategy is normally executed by locating the colder supply water close to the perimeter of the building, where envelope loads are more concentrated.

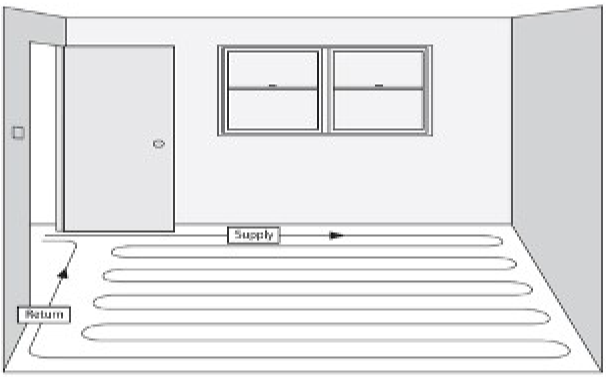

Fig 6: Serpentine Layout

Table 3: Project Estimate: INR

Compressor	**2500**
Condensor	260
Copper Pipes	1200
Wood And Thermocool	850
Wiring And Motor	220
Welding Gas And R-134a (Refrigerent)	750

Fig 7: Fabricated model of cooling system

Fig 8: radiant cooling coil arrangement

Fig 9: Model of hall with cooling coil

Fig 10: final fabricated model

V. CONCLUSION

Based on the inputs & room data sheets and data Summary sheet the projected TONS will be calculated. To offset this load we propose to provide Air cooled Chillers with a standby option. Three will be as duty chiller while other one will be as standby.

The Air cooled Chillers and the pumps will be located in the Chiller plant room assigned for the purpose on the Roof Deck floor. The plant room will be duly ventilated. The FAN COIL UNITS' will also be located on the Roof Deck Floor.

It is proposed to incorporate a primary water distribution system in the AC system design. The Primary system will comprise of a set of Primary pumps which will circulate the water to the chillers and they will circulate the water from the chillers to the Various Zone AIR HANDLING UNITS are constant speed type. This way the pumps need not run at constant speed always and hence energy is savedThe desired working model of Radiant cooling through chilled slabs is successfully fabricated.

It is also successfully tested for working. The model gives the best results.

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