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DESIGN OF HVAC SYSTEM FOR A COMMERCIAL BUILDING BY USING RADIANT COOLING

Mohammed Yaseen Ahmed[1] Asst Prof, Siripragada Bharghavi[2] Asst Prof, Md Javeed Ali Khan[3] Asst Prof & Shaik Azmath[4] Asst Prof, Mechanical Dept

ABSTRACT

The design of air conditioning (HVAC) systems for commercial building by using radiant cooling systems. Radiant cooling system is a promising technique, which is suitable for independent control processes of temperature and humidity. The two main benefits of radiant cooling systems include the potential to save energy and improvement of indoor thermal comfort. The Radiant Cooling with Ceiling system consolidate the pipe network in each panel and the piping are connected to the chiller through these pipes the chilled water will be circulated to the ceiling panels . ceiling panels are designed in such a way that there would be no condensation occur at ceiling panels as they are designed below dew point temperature . The radiant cooling panels can work more efficiently especially when proper control strategies are employed to avoid condensation.

The surveying data conducted during the design indicate how much of the tonnage required for the whole area with which we can distribute the temperature in the surface through radiant ceiling panels for the proper comfort of the occupants in the space.

our designing will make sure in this we are using a temperature controlled surface that cool cools indoor temperature by removing sensible heat and where the half of the heat transfer occur through thermal radiation i . e by lightning loads, equipment loads, and majorly the sensible heat generated by the occupants in the working space which will describe the total tonnage required for the space for proper comfort of the occupants . . Our calculations determine the coil size too for fixing it at the ceiling, the coil size will determine to fix it at ceiling for connecting it to the pipes which are travelling from the chiller unit by carrying the chilled water through out the ceiling panels. In our project there is a separate system to provide air for ventilation and for additional cooling for the occupants in the space . . These establishment will be really helpful in optimizing and controlling the strategies of HVAC system.

The project work includes heat load calculation of the building through hourly analysis program (HAP), duct designing through mc quay duct sizer, pipe sizing through mc quay pipe sizer, drafting of air distribution system.

Keywords: *hvac , radiant cooling , ceiling pannels.*

I. INTRODUCTION

The term HVAC which truncates to heating, ventilation, and air conditiong, as it has a huge scope. It managed the system utilized for application like heating, comfort cooling, and ventilation and cooling application in commercial areas. It incorporates study of extensive variety of equipments from little scale residential application to the huge industrial applications.

The standards or phrasing, terminology of HVAC are taken from the society called as ASHRAE which refers to American society of heating, refrigeration and air conditioning engineers.

Nowadays a innovative and better air conditioning system is majorly has the objective with the advancing, human comforts. In this incredible advancements can be made however the extent of further research still subsist.

Indoor air quality is a huge constraint in the outline of an aerating and cooling frameworks as it a note worthy concern worldwide since, it enormously influence the relieve in the work space or in industrial requirements. Majorly the study of indoor air quality and its effect are mostly concern in the field of an air conditioning.

The important consideration is conservation of energy resource in decreasing and optimizing the utilization of energy in recently constructed infrastructures and in existing spaces with wanted comfort conditions and indoor air superiority . As this requires a arrangements of certain disciplinary approach which are to be implemented while designing and an aerating system.

Heating:
Heating is defines as the procedure of increasing or expanding the warmth of the space where compared to surrounding heat of the space is gradually bringing down with standard temperature (25 ºc) respectively. The heating procedure is carried through by various methods such as equipments like boilers, heaters, etc…, heating methods or consideration are generally they are implemented in countries like USA, Australia , Canada etc..,

Cooling:
Cooling is defines as the way of lessening the temperature of the air where the surrounding temperature of that area is higher than the calm temperatureby implementing the various standards of refrigeration or heat exchanges to the lower body temperature is know as cooling.

Ventilation:
Ventilation has an imperative influence in parts of HVAC outline fill in as it is show as the procedure by which outside air is provided into the space being molded and it additionally expels the undesired air from the space and furthermore the contaminants which are available inside the space. The ventilation is done through constrained ventilation process or it should be possible by characteristic ventilation process for keeping up the great air quality with in the space.

Air conditioning:
Air conditioning describes as the procedure of regarding air in order to control simultaneously its temperature, humidity, cleanliness and distributing and meet the prerequisites of conditioned space.

importance of air conditioning:
As the principle of air conditioning is important on maintaining the good and flexible indoor air temperature of a space to be conditioned, which usually desired conditions and supply good indoor conditions. Primly the main goal of air conditioning is to provide good indoor surroundings for the occupants within the space with pleasant comfort condition in notwithstanding the outside conditions.
The enhancements of air an air conditioning system has a great significance for the arrangements of comfort surroundings to occupants inside the space during seasonal changes in seasonal situation. And also in giving preferred conditions of a industrial process to be successfully carried out.
As there is a availability of wide assortment of air conditioning equipments which are suitable for various applications and different seasonal changes.
The process of aerating and cooling imparts great benefit . A portion of the advantages are said underneath as they are:

- Air conditioning helps in extremely high temperature and humid surroundings which may be leads to discomforts for the occupants and the workers performing different activity inside the space and considering the tasks in that situations and resulting the good efficiency and superiority of work being performed reduced by changing the parameters of air with the desired limits.
- The air conditioning majorly gives health benefits to the occupants inside the conditioned space. Maintaining the temperature lower for the comfort surrounding in the room otherwise it may be result in sweating during high humid conditions it may be result

in dehydration for the occupants . as ventilating is improved the situation keeping up great inside surroundings with in the room.

- Air conditioning provides clean air to the room and there by leads to prompt keep the occupants from pollution and contaminants and maintaining cleanliness throughout the space to be conditioned.
- It is generally used in high temperature and damp conditions in industrial process by civilizing indoor air quality . where as in textiles processing where moistness is the key issue special air conditioning methods are executed in this process for breakdown the humidity with in the work place.

Applications:

To attain pleasant human comforts
Residential areas. Conditioning offices. Hotel and restaurants .
Super markets ,shopping malls , hospitals, etc,..
For process control:
Textiles processing industries Photographic applications
CNC (computer numerical control) machine process Clean air rooms
Medical laboratories , operation theatres, diagnostic rooms, etc,.. Food preservation, freezing drying, dairy processing, etc,..

Introduction on radiant cooling:

The radiant cooling system is a system using a temperature controlled surface that cools indoor temperature by evacuation of sensible heat where the half of the warmth happens through the thermal radiation. generally the radiant cooling system are concerned in chilled ceiling beams or panels.with the benefit of convection air cooling and additionally normal radiant temperature to be attain. Radiant system that utilizes water to cooled the desired surface are known as hydronic systems .the hrdronic radiant system flow the cooled water in pipes through an extraordinary mounted panels on a building floor or ceiling to supply comfortable temperature.

With this frameworks, individuals are cooled by brilliant warmth exchange from their bodies to nearby surfaces roofs, dividers, or floors—whose temperatures are held a couple of degrees cooler than surrounding. Space molding vitality is generally moved from chillers to panels boards or slabs utilizing 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 measure of cooling with under 5 percent of the energy required to covey cool air with fans. Generally , the Radiant cooling system are mixed up in chilled ceiling beams or panels, with the benefit of convection air cooling as well as average brillant temperature to be attain. As the cool wind stream downwards, it gets cooled while experiencing the chilled beam panel and the cooled air is provided to space.

In most commercial buildings, both cooling and ventilation are proficient by flowing huge volumes of air throughout the conditioned space. This requires generous fan power and substantial duct channels, and it’s a source of drafts and noise. With a radiant space conditioning frame work, the ventilating capacity is particular; the volume of air moved and the segments to move it can be approximately five times littler. Fan control is saved and ducts channels can be littler. In addition to substantially lowering energy and peak load costs for space conditioning and ventilation, radiant systems appreciate different focal points over VAV systems. in new buildings . Commercial buildings primarily chilled by radiant resources are additionally comfortable than buildings chilled by usual HVAC systems. The primary expenses for radiant systems are similar with those for conventional variable-air volume (VAV) systems, however their lifetime energy savings over VAV systems are usually 25 percent or even more.
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Statement of problem

The problem underlying of my project radiant cooling system to examine the indoor temperature and the thermal comfort in a surface where a cooling will be done by radiant cooling with the ceiling panel. An important study in my plan is to look into thermal comfort for people working in the office space, equipment to be cooled.

The stature of the floor influence the thermal comfort in the specified area. If the floor height modifies there will be a change in the ratio of convection and radiation. Mean radiant temperature (MRT) calculations are done very complicated because it requires the variation between the incoming air temperature and the incoming water temperature and also requires the leaving air temperature from the room and the leaving water temperature from the room.

For cooling, it is critical to maintain the temperature of the external surface of the tubing that carries cooling water lower than dew point temperature to avoid condensation.

In practice, the heat exchange through radiation did between the human body and the surroundings favored to convection heat exchange light of thermal comfort. When air based systems are coming into the picture the radiant system is a unique because when compare to the other HVAC frameworks in the building. Moreover, the Radiant system which is cooling the surface with the ceiling panels has lower consumption of energy when contrasted to the convective system.

With radiant systems occupants are cooled by radiant heat exchange from their bodies to neighboring surfaces ceiling, walls, or floors whose temperatures are check a couple of degrees cooler than surrounding.
Designers can incorporate the radiant system for any atmosphere in newly constructed structures because of numerous great reasons. Merchandising complexes for the most part cooled by radiant means are more convenient than the edifices cooled by conventional HVAC systems. The initial amount of radiant system is analysed through conventional VAV systems (variable air volume), where the long life investment funds by the energy can be spared by radiant air conditioning system is more than 25 percent than the VAV system.
People sense comfort as their heat will go to the nearest surfaces ceilings whose temperature is cooler as it is associated to the chilled system.

A radiant cooling air conditioner system is used for commercial application is designed under this project work.

The objective of the study:

At the first look of the possibility of my project, I have discussed the different challenges. However, examining of each challenge separately from each other it helps us to conclude the correct way of supplying the cooling to the surface. There are multiple objectives are to be completed for the radiant cooling system with ceiling panels. First is to examine the heat load, to find the heat load we are considering the different parameters, it's a first challenge total heat gain must be calculated, with this we can have the total tonnage required to be put.
The second goal is to get the cooling capacity estimations. These things must require heat load from all the possible angles of the complex, like the walls and glasses which are exposed to the solar rays evaluation of total tonnage for the area which is selected to execute the radiant cooling system.

The other sub objectives like with the help of heat load we will find the least amount air flow necessary to make the surface cooled and the people feel more comfortable as they attain excellent indoor air quality.

Another objective is to come across the coil sizing also a crucial part of these system using all associated methods we can find it. The temperature must be designed such that it be supposed to below the dew point temperature for condensation control. Thus, the sub-objectives are to get the volume and area of the surface.

Research methodology:

In research methodology, for computing the heat load there is a standard software HAP(hourly analysis program) which will give the complete report to find cooling conditions capacity to accomplish good indoor air quality as it is

a powerful tool.HAP give adaptable features for outlining hvac system for commercial buildings. As it also offer energy analysis and energy utilization .
Another tool used is duct sizer which is utilized for calculating duct sizes and the area and pipe sizer is utilized to cal calculate the pipe size for the flow of water through it.

ASHRAE standards are available to take the values and expressions to find the coil size which we utilized in ceiling panels.

8 scope and limitations:
As radiant cooling is a hyronic system as it uses water through water the hronic circulation is done which carries required cooled water by consuming very less amount of energy like 5% of energy needed.
In many commercial sectors mainly two methods are applied I. e cooling and fresh air is provided by diffusing huge amount of air in the required conditioned space. to achieve we require to keep significant inline and outline fans capacity and huge ducts are implemented,which tends for source of making noise .
Where as in this hrdronic system which we are using in this cooled water is directly supplied through chiller to the ceiling panels and for more comfort, provision of fresh air ducts are implemented for more cooling for the occupants. The ventilation is provided through the duct in which fresh air is blows down to the chilled surface of the panels. In this system fan energy is spared because the cooling concept is differ while compare other systems. This concept of a radiant cooling system is initially started and introduced in North America and has eventually accepted by the public and commissioned has greatly increased. Following are the main reasons that everyone accepting radiant air conditioning system and it is occupying everywhere:

- Energy Saver expertise
- High caliber comfort
- Outstanding architectural affability
- Operational and maintenance rates are cut down
- Control of ventilation Energy Efficiency is more adequate.

With the help of smaller transport energy consumption, more perfect operating ways, larger room set points, and very less number of losses in broadcast a radiant air conditioning system is greatly helping in decreasing the energy usage of complexes.
Perfect operating ways: by using pump power instead of using fan power we are able to lessened the energy consumption, our radiant cooling system allow the chillers to work in superlative modes with this the energy usage will overall low.

The common chilled water temperature lies between 12.7 C and 17.2 C for my radiant
cooling system.

Chillers can be operated in better efficient range due to bigger repossession water temperatures and these bigger repossession temperatures also maintain the greatest flexibility at chilled water origin. Possible other sources to have chilled water are fluid coolers, geothermal pumping system, and lake water temperature.

So that this method is integrated with the small force of fresh is drawn in the cabins through the ducts to the ceiling panels which helps for more comfort . as the fresh air is implemented throughout the conditioned surface due to we are saving energy consumption By circulation of fresh air in the space will diminishes and eliminates the growth of the bacteria.

Very less maintenance is required longer serviceable cooling coils are kept inside area and there is no separate equipment is needed for room conditioning and ducting is used for fresh air as well as the air which will blown on the ceiling panels .

Limitations:
Main limitation factor is the condensation forming in this hrdronic system as the chilled water passes all the way through the pipes by which the the surface of the pipes get cooled due to this issue condensation occur and which tends to reduce the cooling capacity. Mainly the condensation forms when the temperature is higher than the dew point temperature . it is the limiting factor in high humid areas .but in this system we are using DOAS (dedicated outdoor air system) which eliminates condensation and increase cooling capacity respectively.

The second limiting factor is ventilation in the space to maintain good indoor air temperature throughout the space. Air tight fall ceiling should be implemented throughout the space to eliminate the infiltration which mainly occurs in the commercial buildings.

The ventilation should be provided throughout the space by providing fresh air provision through which the fresh air is extracted into the space through a passages. The fresh air is delivered into the various spaces within a building for the better comfort for the occupants in the space.

II. RADIANT COOLING SYSTEM TYPES:

As currently there are two kinds of system are there:
integrated slabs:
Cooling originates from the structure of the building like slabs, in view of this it is named as thermally active building system(TABS). transfer of cooling in this kind of Radiant cooling system with integrated slabs to the area from the floor or ceiling. Europe since last couple of tens the heating is as same as floor cooling respectively.

ceiling panles:
As the ceiling panels are used to transport the cooling to the required areas of the given
As the ceiling panels are used to transport the cooling to the required areas of the given surface to be cooled .as these ceiling panels are mounted on the ceiling and have the coil embedded in it and those coil are used to deliver the cool air to the surface .
These coils are linked to the chillers from where the cooled water is carried through the ceiling panels.

The ceiling panels have less expenditure than that of integrated slabs ,ceiling panels are used to manage the temperature smoothly and faster and have more flexibility than salb integrated. Following table shows the comparison between radiant cooling using integrated slabs and the ceiling panel.

HVAC SYSTEM:

Radiant cooling from chilled slabs
Cooling originates from the structure of the building like slabs, in view of this it is named as thermally active building system (TABS). Transfer of cooling in this kind of Radiant cooling system with integrated slabs to the area as of the floor or ceiling. Europe since last couple of tens the heating is as same as floor cooling respectively.

The radiant air conditioning which are available in terms of chilled slabs or ceiling panels, to attain the benefit of convective conditioning and the mean radiant temperature .because of cool air sinks ,a chilled ceiling panel will cold the air that will make itself to spread into the space through specialized panels.

There are so many advantages to deliver the cooling with ceiling.

It is more agreeable to leave roofs presented to a room than floors, as it will increase the capability of thermal mass. Floors have furniture, covers, and decorations that decline the feasibility of the association.

Predominant convective warmth exchanges by a chilled ceiling as hot air help, in consequence of which more air will come and make contact with with the chilled surface.

Cooling conveyed through the story achieves a large amount which sense there is a high amount of sunlight based additions from sun diffusion, each piece the cool floor would more be capable to effortlessly dispose of those loads than the roof.

Chilled slabs, contrasted with panels, offer more huge warm mass and thusly can take more full preferred standpoint of outside diurnal temperature swings. Chilled pieces cost a smaller amount per unit of surface zone, and are further coordinated with the construction.

At the point when guideline of a cooling talks in Radiant cooling system it utilizes the regular purpose of rule to convey the cooling to ceiling or through the floor or even with the walls since it ingests the warmth emanated through the rest of the way. The following diagram is clearly showing us the chilled ceiling

behaves as temperature go down for every origin throughout the space which includes likewise people present in the room, solar radiation, the equipment loads and the wall etc.

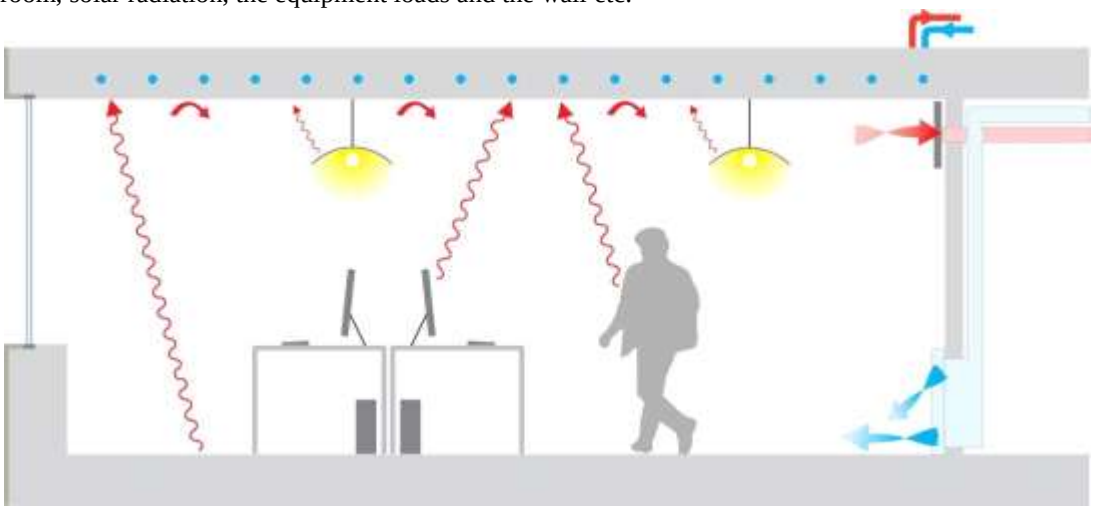

Figure 2.1- radiant cooling from ceiling

The radiant cooling system which normally utilizes chilled water ,as it is a hydronic system which uses water running in the pipes channel in thermal contact with the airfoil. The circling water just should be 2-4°C underneath the coveted indoor air temperature. The high temperature is expelled by the water falling in the pressure driven circuit once the heat from various starting points within the zone is engaged by the effectively cooled surface – ceiling which is on the roof ,base or walls.

The main part of the cooling procedure comes about because of expelling sensible heat through radiant replace with individuals in the zone and items which are reason for thermal radiation not the air, individual thermal comfort can be accomplished with warmer interior air temperature than with air-based cooling system.

Mixed with the higher cooling capability of water than air, and having a cooled surface near the coveted indoor air temperature, radiant cooling give generous diminishments in cooling energy utilization of goods and service.

Vitality compelling systems, for example, evening flushing, backhanded evaporative cooling, or ground source warm pumps.

Advantages of chilled slabs:
More noteworthy Architectural Flexibility With a brilliant cooling systems installed in the floor slab respectively, the visible component which are able to seen parts, such as for example, air handlers, ventilation work, grilles, diffusers,etc and so forth can be significantly small, permitting more prominent adaptability in the aesthetic

structural outline. The space necessities of the mechanical system (e.g., mechanical room, ceiling space, roof space for ventilation work) can be pressed together, conceivably diminishing building floor to floor stature or height.
Due to elimination of large ducts as compared other system eliminates the noise criterion throughout the space is been reduced because of air passing in the ducts for exposure to air is the major props in these system.
Major advantage in this system is that the large duct work is reduced in to small its benefits the good view of architectural flexibility as the provision for fresh air drawn through small ducts to the ceiling panels to attain greater comfort.

Lessened Operating and Maintenance Costs The inserted tubing inside the slabs requires no care.
In this system, letting in the chilled water source and dissemination, requires no more care than common fluid based plans. The littler constrained air framework made conceivable by this system by reducing and eliminating down the working and capital expenses (e.g; decreased fan power, less filtration is required, smaller dehumidification equipment ,etc)

More efficient Control of Ventilation In numerous warming, ventilation, and aerating and cooling (HVAC) system today, the air delivering system are measured to carry air stream are size up to send cooling and ventilation necessities of the spaces and occupants they are attending.

Managing of Thermo Active Building Systems (TABS) Thermo Active Building Systems (TABS) draws in the whole solid mass as a warm battery utilizing chilled or warmed water to stack the system.
Particularly for TABS, single room control utilizing the floor isn't even minded. Eventually, a zoning system, for example, North side/Southside or compass quadrants are proposed for situations where supply water temperature, normal water temperature or the flow rate may vary from zone to zone.

Generally little temperature contrasts between the warmed or cooled surface and space are run distinctive for TABS. This problem brings about a generous level of resolution.

In particular cases with low warming/cooling loads, a solid slab can be held at a steady center (water) temperature year-round. In the occasion that for example, the weight is kept at 72°F (22.2°C), at that point the slab will be space warming when room temperatures are under 22.2°C and space cooling when room temperatures are over 22.2°C.

Design of HVAC system:
Basic on radiant cooling system utilizing bore wells
To keep up slab temperature and soil temperature equal with an association comprises of two bore wells from which one is associated with radiant slab and water is pumped through it and another drag well is linked with the heated water that leaves the radiant slab. During the time the temperature of earth beneath 12ft is consistent which is a mean temperature of particular geographical limitation is. The underneath figure demonstrates recorded room temperature. Utilizing stack impact ventilation framework, the way is likewise ventilated.

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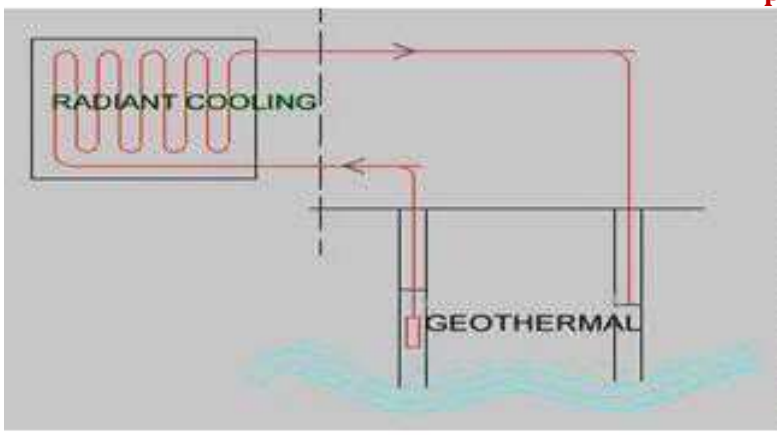

Figure 2.2-Radiant cooling system utilizing bore well

Firstly we should have to see the geological ground conditions at the site .from these survey we can get the ground parameters required by this we can send the water from the bottom to the ceiling panels by which a greater savings be able to be accomplished as the water is a natural resource.

radiant cooling systems utilizing cooled water

In this plan, the chiller creates the cool water by which the slab is chilled. The dew point temperature of breeze is progressively more when contrasted with the cool water temperature which was provided to a radiant slab. But the natural air climatically outline development can accomplish 24^0 C in space with no air dealing with unit by this systems. At the point when natural air is pumped it limits to 20% of power required for air taking care of units

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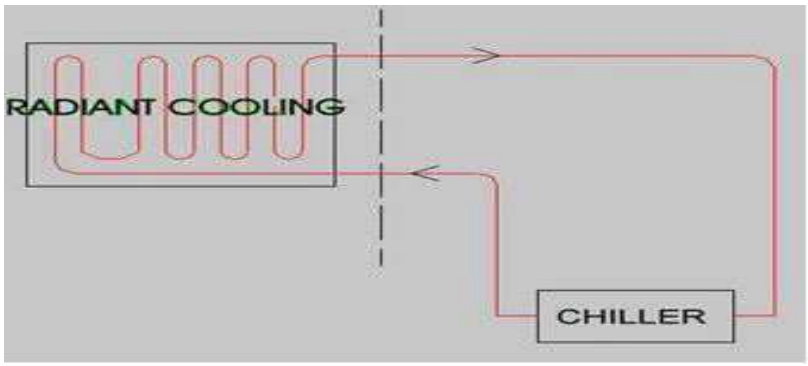


Figure 2.3- radiant cooling system utilizing cool water

In this type the cooled water is pumped into the ceiling panel through pipes, as radiant system which uses water are also known as hydronic system respectively. The cooled from chiller is drawn to the surface area of the ceiling panels and the ceiling panels get cooled by the chilled water supplied on it through chiller and extra amount of ventilation is done through fresh air conduit to attain more cooling in the required space.

Basic section radiant cooling system utilizing cooling tower

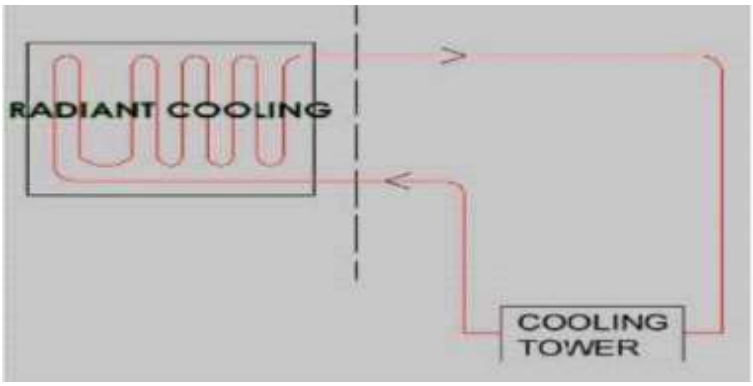


Figure 2.4 radiant cooling system utilizing cooling tower

To keep up the slab temperature close to wet globule temperature otherwise called wet knob approach, the slab of radiant cooling is connected to a cooling tower. The dry globule and wet knob temperature very change in hot and dry atmospheres so this plan cools the space well impressively. The high measure of warmth is emanated from sun to largest amount of structures to possess space is overwhelmed by utilizing this framework.

Radiant cooling through ceiling panels

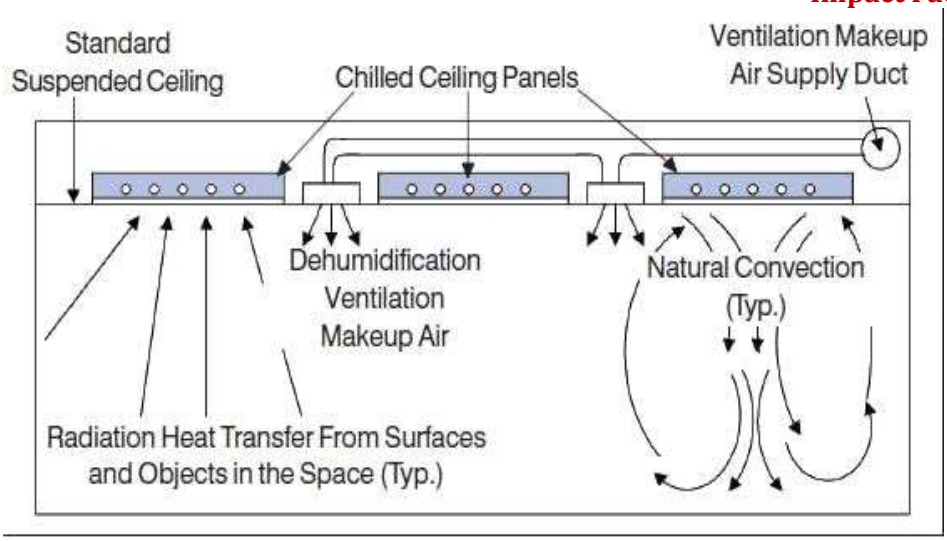
Radiant cooling boards are associated with ceiling and walls. They are generally ousted from the rooftop, yet can correspondingly be specifically integrated with constantly drop ceiling.

Secluded developments article most elevated adaptability in conditions like situating and coordination with electrical system or lighting. From warm capacity the advantage of placing passive cooling cannot be effortlessly taken by bring down warm mass when conrelated to chilled slabs, however constraint in panelscan quickly adjust to changes in outside temperature. Chilled panels are proper or space structures with spaces that includes a higher change in cooling loads.

Chilled ceiling panels or Chilled roof panles can be easily joined with ventilation given from the rooftop. Chilled sections cost less per unit than juries. Ceiling is cooled ordinarily in houses with radiant ceiling boards. In spite of possibly appropriable for broadcast atmosphere, families I high sultry atmospheres radiant cooling is questionable. In north America brilliant cooling home

apparatuses depend on ceiling boards suspended from the rooftop by which chilled water is dispressed.
Opening an entryway in moist atmosphere will permit adequate mugginess in the house with the goal that examination happens. As the board cover minimum of the roof capital costs of the framework are tremendous. An assistant ventilating framework is probable to control low stickiness in home aside from the aridest area builds the capital cost.

Condensation is a huge factor as the cooled water which has been drooped through the chiller to the ceiling panels which are placed on the ceiling then due to cooling it will gets condensate then form drops on the fall ceiling .thus, extra measure be supposed to be taken for the placement of the panles . depending upon the climatic condition should be measure a proper amount of humidty be supposed to be maintain to decrease the condensation factor .mainly the designed should be done by keep the surface warmth below the dew point temperature to avoid condensation issues.



2.5 – figure radiant cooling panels working

In spite of that constraint, a review performed by DOE's Oak Ridge National Laboratory found that some early morning cooling of a home' s solid chunk, joined with evening time breathing, could exchange the superior part of the cooling load for a house to off-crest hours, cutting the electrical request on electric utilities.

Advantages of ceiling panels:

- Advantages of radiant ceiling panels are mention below as they are
- Operational costs are conveyed down to the mechanical chilling system since cooled roof work at relativistic high temperatures (mean surface temperature of 16°C or 61°F).
- Radiant ceiling can be utilized for both warming and cooling , focusing the measure of tools and pipe channeling required contrasted with regular warming and cooling plan.
- Chillers can work at higher temperatures bringing about an expansion in proficiency and lessening in vitality costs.
- The ceiling gives excellent architectural view because of sleek design of panles.
- As the ceiling panels are easily to be installed, if any breakdown occurs then it be able to be easily solved.
- The ceiling panels eliminates the duct works with in the space, as they are easily to install and required less space while compare to the ducts.

The main advantage of ceiling panel is these can be retrofitted into the ceiling of the older buildings.

Essentials of Radiant cooling in HVAC

principle Of Radiant Cooling And Thermal Comfort

As the human body liberate heat as they are called as heat generators .The warmth emanation from the human body happens by means of four methods of exchange.

- Heat transfer by radiation.
- Heat transfer by convection.
- Heat transfer by evaporation.
- Heat transfer by conduction.

Whenever there is a temperature differs between two objects ,both objects will attempt to balance the temperature . The vitality exchange required to approach proportional temperature happens through radiation, conduction, and convection.

Our bodies transmit heat to any surface in viewable pathway which is cooler than our own particular surface temperature (85 - 90°F/29 - 32°C). People feel most great when they can balance in any event of their warmth outflow through radiation. Decreasing encompassing surface temperatures draws more warmth from our bodies by means of radiation. At the point when the breeze is warm, this is a genuine thing.

Mean Radiant Temperature (MRT)

As per ASHRAE (American Society of Heating, Refrigerating and Air - Conditioning Engineers) Standard 55-2010 characterizes six factors that influence warm human solace, They are (air temperature, radiant temperature, humidity, velocity of air, metabolism and clothing).

Since the velocity of air , and metabolism and clothing are inhabitant reliant ,initially just the air temperature ,humidity factor, velocity of air, metabolism and clothing these can be observed and controlled by the HVAC system . conventional aerating and cooling system normally screen and control air temperature, humidity, velocity of air of these space condition, over looking radiant temperature.

As the key consideration in thermal comfort respectively the radiant heating, and the cooling system marks only mean radiant temperature (MRT)

MRT is characterized as the hypothetical uniform surface Temperature of a fenced in area in which a individual would trade an indistinguishable amount of radiant warmth from in the real non-uniform closed area. Not at all like in an avionics just system, the MRT in a radiant molded space perceives the comfortable relationship inhabitants have with The surroundings by means of radiant warmth exchange.
This family relationship is a focal factor in thermal solace when coordinated with air temperature to working temperature lists as referenced in warm solace criteria.

The working temperature is numerically the normal of the air temperature to and implies radiant temperature there one-sided by their separate warmth exchange coefficients. the majority fundamentals for comfort are grounded along the working temperature in a place.

The temperature is calculated as :

$$\theta_{f,i} = \frac{(hc \bullet ta) + (hr \bullet tr)}{HC + hr}$$

Where
Ta =temperature of air . Tr =radiant temperature.
Hc =heat transfer coefficient . = convective heat transfer coefficient for the human body,
Btu/h • ft² •°F (W/m²k)
Hr =radiant heat transfer coefficient. brilliant warmth exchange coefficient for the human body, Btu/h • ft² •°F (W/m² K) In most reasonable illustrations where the relative velocity is little at <40 fpm (0.2 m/s) or where the distinction between mean radiation and air temperature is little at <4°C, the agent temperature Can be assessed with adequate estimation as the normal air and mean brilliant temperature.

$$\theta = \frac{\text{Air Temperature} + \text{MRT}}{2}$$

In any case, if the mean radiant temperature is altogether lower or higher than the air temperature, the convective and long-wave brilliant warmth motion ought to be ascertained independently.

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Basics of heat transfer

Mainly heat transfer occurs when there is exchange happens at whatever point there is a temperature distinction between two substance and it proceeds until the point that the two items are in heat balance.

As such, warmth will dependably normally spill out of hot to sub zero. The high temperature is transmitted in three different ways: conduction, convection, and light. A brilliant cooling framework uses each of the three styles of heat transfer.

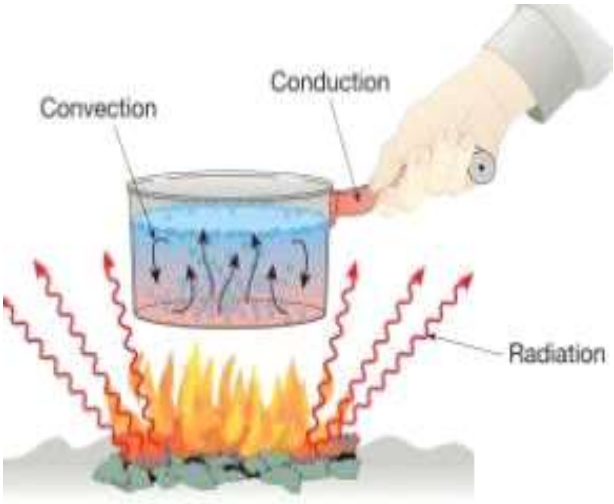


Figure - 2.6 showing the heat transfer

III. RADIANT COOLING CONTROL SYSTEMS:

As in this system panels are for the most part linked to the ceiling, but can be joined to wall as well. They are typically suspended from the roof ,but it can be directly integrates with continuously dropped ceilings . Secluded development offers expanded adaptability in states of situating and mix with lighting or other electrical frameworks. It mainly Lower heat mass contrasted with chilled slabs implies they can't undoubtedly exploit latent cooling from heat capacity, however controls in panels would more be capable to quickly adjust to changes in outside temperature. Chilled panels are likewise more qualified to structures with spaces that experience a bigger fluctuation in cooling loads.

Perforated panels like wise give preferred acoustical dampening over chilled slabs. Roof panels are also suited for retrofits as they can coordinated to any roof.
Chilled ceiling panels can be more easily coordinates with ventilation provided from the roof. As
Panels are cost more per unit area than chilled slabs .

Manifolds :

Manifolds is defines as a pipe through which the branching of pipes can be easily done. These are connected with motor for the supply of water throughout out the panels. generally For zoning manifolds are implemented as it have many openings through which the pipes are connected to run throughout the space.

Manifolds are used for water flow through them and it has pressure gauges for sensing the water pressure running in PEX pipes .

If the water pressure decreases the pressure gauges indicates and it has to b recharged again by means of pump.

Manifolds are generally used in making zoning each zoning requires an individual manifolds for the water to carry to their respective zones.

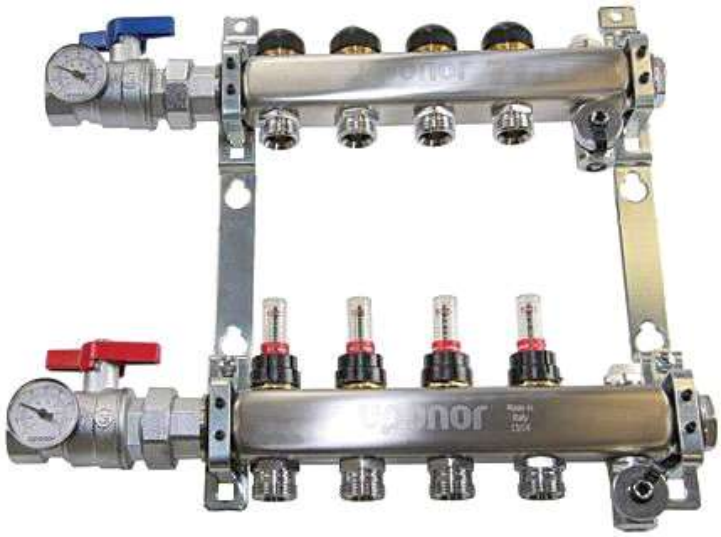


Figure 2.5.1 manifold

IV. BUILDING DETAILS

BUILDING DESCRIPTION:

In this project work the type of building for which a radiant cooling system with ceiling panels is designed and implemented, is a commercial type of application that is the buil
-ding which is chosen is intended as to be used as a commercial building i.e. office buil
-ding. The orientation of the building is such that as it is facing towards north direction Building is provided with complete glass portion or it may be called as envelope.

FLOORS AND AREAS:

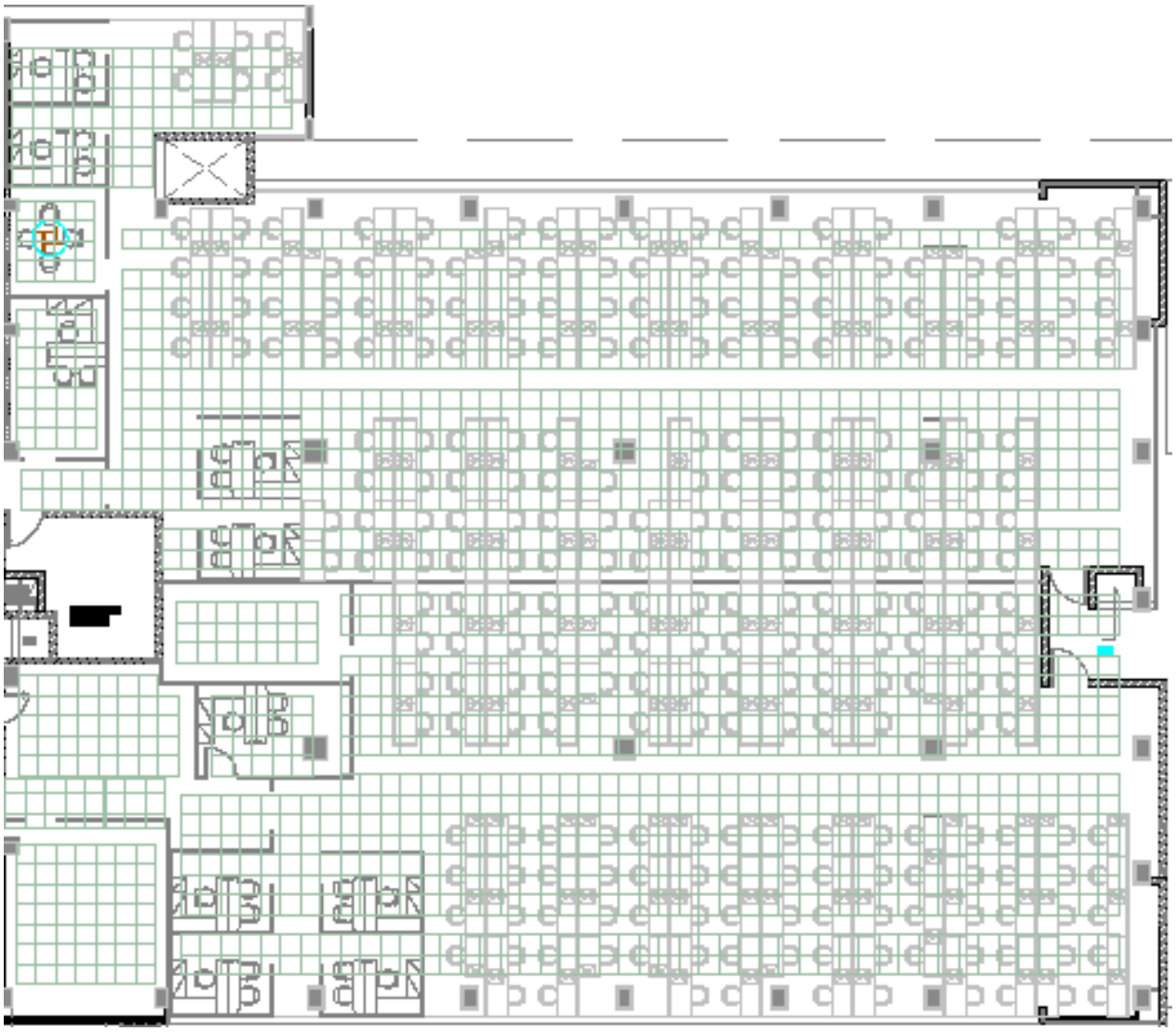
The building comprises of four floors i.e. a ground floor, first floor, second and third floors respectively. As my project designed for a commercial space the whole amount of area where my radiant cooling system has been planned is about 84218sqft. And the TR 440 tonnage .The following are the areas block wise as my commercial building is divided into two sub portions at each floor.
Ground floor partition 1 : 8000sqft Ground floor partition 2 : 9340sqft First floor partition 1 : 10895sqft First floor partition 2 : 10313sqft Second floor partition 1 : 10525sqft Second floor partition 2 : 10341sqft Third floor partition 1 : 12152sqft Third floor partition 2 : 12152sqft
There is different kind of spaces in this building as it is a commercial building such as lobby, lift section, corridor, spaces for outlets.

OCCUPANCY :

The maximum occupancy of this building ranges up to 1500 for all four floors and the number of occupants that can be accommodated with each floor is estimated from the ASHRAE standard that specifies about 30 square feet per person . An important consideration in this aspect is, the number of occupants is selected based on the area to be air conditioned and not the total building area ,hence the above stated range of occupancy is selected for the air conditioned area only.

As in my project the type of building is commercial building used by software company the equipment also be present as per the number of occupants as many number of occupants are present those many equipments are taken .

Special consideration are implemented I am considering more 10% of maximum capacity as the whole occupancy for all the floors, by doing this it will help us to control the humdif-cation.



PLANS PICTURE :

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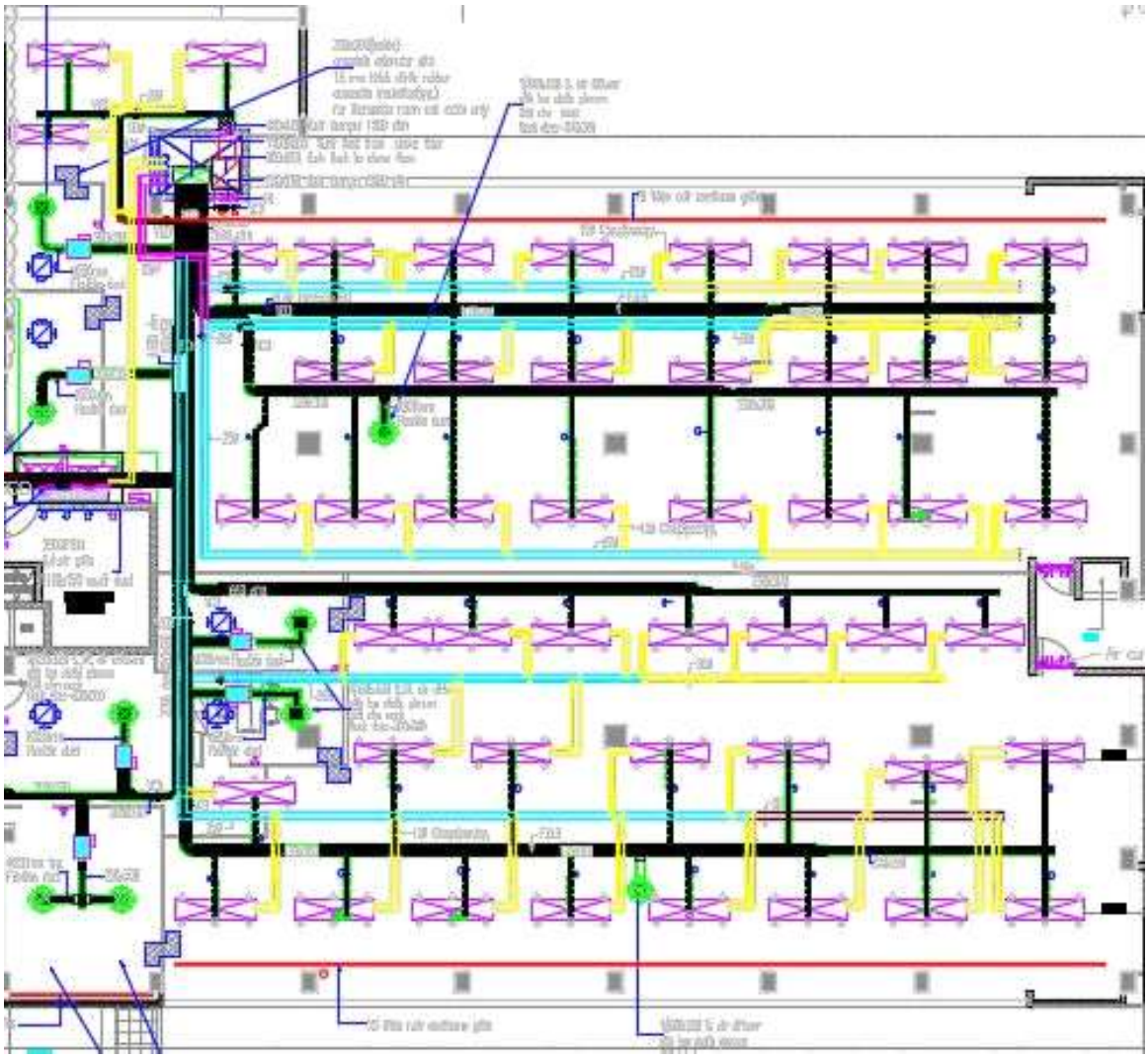
DESIGNED PLANNED



- **CALCULATIONS**

HEAT LOAD CALCULATIONS

To find the heat load of a office space we will need to know the following things:

- Area of the space
- The number walls facing to the solar
- The number of occupants
- The lighting load
- The equipment load
- Area of the unconditioned partition

4.1.1 HEAT LOAD OF GROUND FLOOR PARTITION 1 :

Area =757621200 mm 757621200/10^6 sq meters

= 757.62x10.76 (convert in to sq feet)
= 8152 sq feet

Height of thebuilding Volume of thesurface	= =	10feet 8152x10	
	=81520		
Occupancy of the area	=310 (People)		
Lighting load	=1.5 wt/ft^2		
Equipment load	=310x0.2kw		
	=62kw		
CFM per person	=310x10		
	=3100		
CFM per sqfeet	=8152x0.01		
	=82		
	=82+3100	= 3182	

Solar facing sides = NE (Glass)= 29725mm
= 29725/1000 meters
= 30x3.28 feets
= 98.4x10
= 984 volume of a glass
= SW(Window)= 8410mm
= 8410/1000meters
= 8.41x3.28feets
= 27.58x4
= 110.33 window
= 165 is the remaing volume of wall from the window. =SW(Wall) =1260+3450+3500
= 19590/1000meters
= 19.59x3.28feets

= 64.25x10
= 642.55 volume of a wall
= SE(Glass)= 26157mm+8828mm
= 34985/1000meters
= 35x3.28feets
= 115x10
= 1147.5 volume of a glass in SE
= partition heat = 5375mm+2423mm+2349mm
= 10147/1000meters
= 10.14x3.28feet
= 33.28x10
= 333volume of a partition

SHEET FOR THE HEAT LOAD CALCULATION:

Job Name	Radiant Cooling				Space Used For	Office PARTITION 1			
Address	HYD				Area (SqFt)	8161			
Room sizes	Length (Ft)	Width (Ft)	Height (Ft)		Height (Ft)	10			
	80	75	10		Volume (CuFt)	81610			
Item	Area or Quantity	Sun Gain or Temp. Diff.	Factor	Btu/Hour	Date	12-08-17			
					CONDITION	DB (F)	WB (F)	RH (%)	Gr/Lb
ROOM SENSIBLE HEAT					Outside	110	77	30	86
Solar Gain - Glass					Room	72	61	66	66
Glass - N	0	SqFt x	23	x 0.56	0	Difference	41	XXX	XXX	20.4
Glass - NE	984	SqFt x	12	x 0.56	6612	Daily Range (F)			=	26
Glass - E	0	SqFt x	12	x 0.56	0	Correction for Temp. Diff. (F)			=	27
Glass - SE	1147	SqFt x	12	x 0.56	7708	By Pass Factor (BF)			=	0.1
Glass - S	0	SqFt x	6	x 0.56	0	Contact Factor (CF = 1 - BF)			=	0.90
Glass - SW	110	SqFt x	42.5	x 0.56	2618	Occupancy (Nos)			=	310
Glass - W	0	SqFt x	163	x 0.56	0	Lighting Load (W/SqFt)			=	1.6
Glass - NW	0	SqFt x	69	x 0.56	0	Equipment Load (kW)			=	62.0
Skylight	0	SqFt x		x 0.56	0		OUTSIDE AIR			
Solar & Trans. Gain - Walls & Roof						Cfm Per Person	310	10	=	3100
Wall - N	0	SqFt x	30	F x 0.34	0	Cfm Per Sq.ft.	8152	0.01	=	82
Wall - NE	0	SqFt x	36	F x 0.34	0					3182
Wall - E	0	SqFt x	44	F x 0.34	0					
Wall - SE	0	SqFt x	44	F x 0.34	0	Air Change Per Hour :		1	=	1359
Wall - S	0	SqFt x	42	F x 0.34	0	Ventilation (Cfm)			=	3182
Wall - SW	642	SqFt x	40	F x 0.34	8731	EFF. ROOM SENS. HEAT FACTOR				
Wall - W	0	SqFt x	38	F x 0.34	0	Eff. Room Sens. Heat	523871		=	0.88
Wall - NW	0	SqFt x	32	F x 0.34	0	Eff. Room Total Heat	595233			
Roof	0	SqFt x	61	F x 0.1	0	APPARATUS DEW POINT (ADP)				
Trans. Gain - Except Walls & Roof						Indicated ADP (F)			=	54.0
All Glass	2241	SqFt x	41	F x 1.13	103826	Selected ADP (F)			=	52.0
Partition	333	SqFt x	36	F x 0.3	3596	DEHUMIDIFIED RISE				
Ceiling	0	SqFt x	36	F x 0.4	0	(Room Temp. - ADP) x CF		18	=	18
Floor	0	SqFt x	31	F x 0.5	0	DEHUMIDIFIED Cfm				
Outside Air						Room Sens. Heat	523871		=	3844
Ventilation	3182	Cfm x	41	F x 0.11	14088	Delivery Rise x 1.08	19			
Internal Heat						OUTLET TEMP DIFF				
People	310	Nos. x	245		75950	Room Sens. Heat	523871		=	18
Light	8152	SqFt x	1.5	W/SqFt x 3.41	41697	Delivery CFM x 1.08	29104			
Equipment	62	kW x	3410		211420	SUPPLY AIR CFM				
Effective Room Sensible Heat Sub Total					476247	Room Sens. Heat	523871		=	18866
Factor				10.0%	47625	Desired temp diff x 1.08	44	1.08		
EFFECTIVE ROOM SENSIBLE HEAT					523871					
ROOM LATENT HEAT						ACTUAL T R			=	66.7
Ventilation	3182	Cfm x	20.4	GrLb x 0.068	4413	DEHUMIDIFIED CFM/SFT			=	0.8
People	310	Nos. x	205		63550	SFT/ TR OF REFRIGN.			=	122.3
Effective Room Latent Heat Sub Total					67963					
Factor				5.0%	3398	RECOMMENDED				
EFFECTIVE ROOM LATENT HEAT					71362	AS 10% SAFETY FACTOR	=	74.1		
EFFECTIVE ROOM TOTAL HEAT					595233	AS PER CFM	=	67.4		
OUTSIDE AIR HEAT										
Sensible	3182	Cfm x	41	F x 0.97	126790					
Latent	3182	Cfm x	20.4	GrLb x 0.61	39721					
Grand Total Heat Sub Total					761744	SUGGESTED TR	=	74.1		
Factor				5.0%	38087	SUGGESTED CFM	=	3844		
GRAND TOTAL HEAT					799831					

DUCT DESIGNING:

The duct element is an important part of an air conditioning system and is categorized under the air distribution system. The ducts are the enclosed passage way that are meant to carry the conditioned air to the space from the system outlet and also to carry away the exhaust or return air from the spaces back to the system for conditioning.

It is important that the design of duct system must be carefully done as it greatly affects the design of air conditioning system. Also, the execution of the duct work must be done under close supervision as any errors in the duct installation may lead to inefficiency of the plant.

The main factor to be designed in terms of duct designing is the size of the duct that is suitable to convey the desired amount of air at proper flow rate and pressure. The size should be optimum corresponding to the air flow.

Any disparity in the design of duct may lead to drawback like surplus cost expenditure, noisy operation, and excess energy usage. The air flow rate should be maintained throughout the space as per the cfm provided, also the pressure and the velocity which ensure the effective air distribution in a room and enhance the comfort.

CLASSIFICATION OF DUCTS:
Based on the shape of duct, the duct are classified as

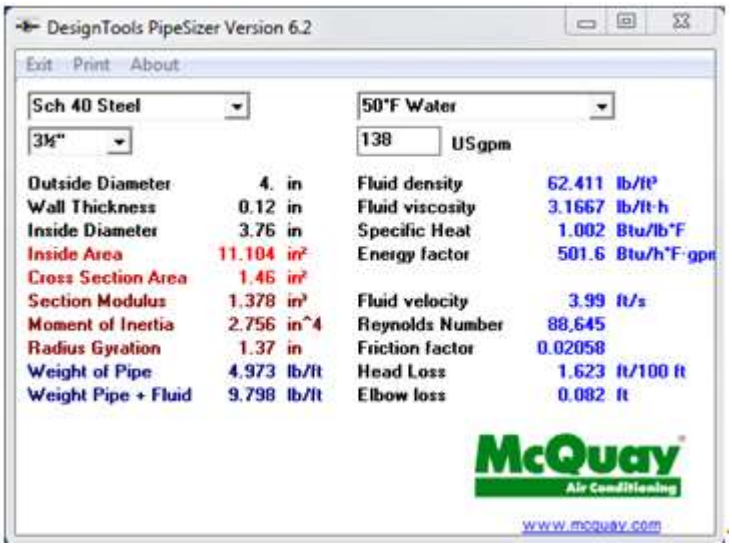
- Circular or round ducts
- Rectangle or square ducts
- Oval ducts

METHODS OF DUCTING DESIGNING:
There are mainly three methods of duct designing they are;

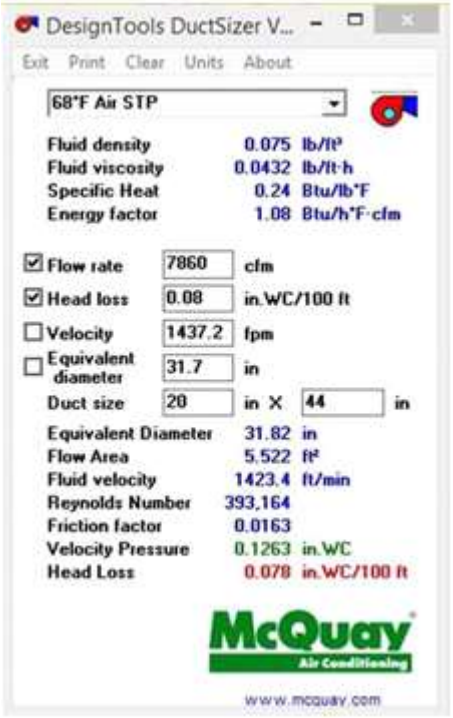
- Constant friction loss or equal friction method
- Velocity reduction method
- Static regain method

EQUAL FRICTION METHOD:
It is a straightforward strategy for estimating the conduit and the essential standard of this technique is to plan a pipe with square with grating misfortune all through the ducting i.e. the weight drop in a conduit will be kept consistent all through its length. To process the conduit measure, a product named pipe sizer created by Mc Quay is utilized as a part of which the information for measure estimation is characterized regarding the required wind stream rate and the consistent erosion misfortune rate. In this manner, for numerous spaces just the wind current rate is differed and the erosion rate is kept steady. The grating misfortune is for the most part characterized regarding creeps of water segment per 100 feet (in W. C. per 100 ft) and the standard average plan rate of grinding misfortune to be kept up ranges up to 0.1 in W.C per 100 ft for business applications.

4.3. floor partition 1 ducting: Ground floor partition 1 flow rate is 7



4.4. 500 cfm. Q = A x V
7860 = A x 1200
A = 7860 / 1200 A = 6.55 x144
A = 943.2sqinch



943.2 sqin W = 943 / 20 W = 47.16

PUMP HEAD CALCULATION AS PER TONNAGE

Total tonnage = 440 TR

Total water flow for 440 TR = 440 x 3 Total water flow = 1320 gpm

GPM x TOTAL HEAD = HP
3960

Where gpm is the total water flow in gpm.

total head = static head + velocity head loss + pressure head + friction head loss

Static head = □ *B*

(A is the horizontal length and B is the vertical Pressure height of building) Static head = $\frac{100'}{2}$ + 35'

Static head = 50’ + 35’ Static head = 85’

Velocity head loss = $\frac{v1^2}{2g} + \frac{v2^2}{2g}$

Velocity head loss = $\frac{6^2 + 8^2}{2 \times 9.8}$ (where v_1 = 5 to 7 and v_2 = 6 to 10)

Velocity head loss = 5.10’

(where g is gravitational constant 9.8 m/s^2)

Pressure head = 10% of vertical height Pressure head = 35' = 3.5'
Friction head = 20'
Total head = 85 + 5.10 + 3.5 + 20 Total head = 113.6

Pump HP =1320 x 113.6 /3960 Pump HP = 37.8 HP(±15%)

COIL CALCULATION:
Cooling coil calculation will determine the rows deep and coil sizes to be kept in each radiant ceiling panel in the space. In each panel we are supplying 2 TR of cooling

Total BTU/hr = 500 x gpm x liv. Water temp-ent water temp Where 500 = lbs / gal x min/hr x sp heat water
Lbs/gal = 8.33
Min/hr = 60
Sp. Heat water = 1
Total BTU/hr = 500 x 4.8 x (22-
12) Total BTU/hr = 24000 BTU/hr
(each panel of ground floor partition 1 is having 1.96tr to convert that in BTU multiplied with 12000 i.e, 2x12000 = 24000 BTU/hr)
Water velocity:

3.

Water velocity fps =1.144 x gpm / 1.144x 4.8 Water velocity fps =1
Water velocity = 5.49 FPS
Rows deep:

Rows deep = total btu/hr /face area x wsf x Med x U x FR

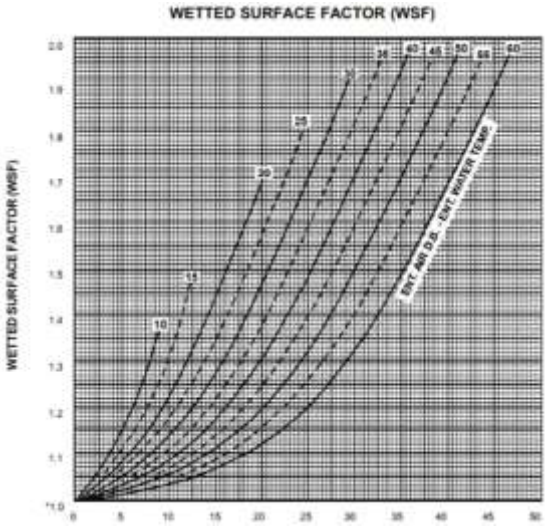


Figure 4.1 wetted surface factor

Where WSF = wetted surface factor.
MED = log mean temperature difference.
Face area = $\frac{860}{400}$
face area = 2.15sqft WSF = 1.2
$_{MED}$ =18-16
$\log_e$ 18-16
MED = 17

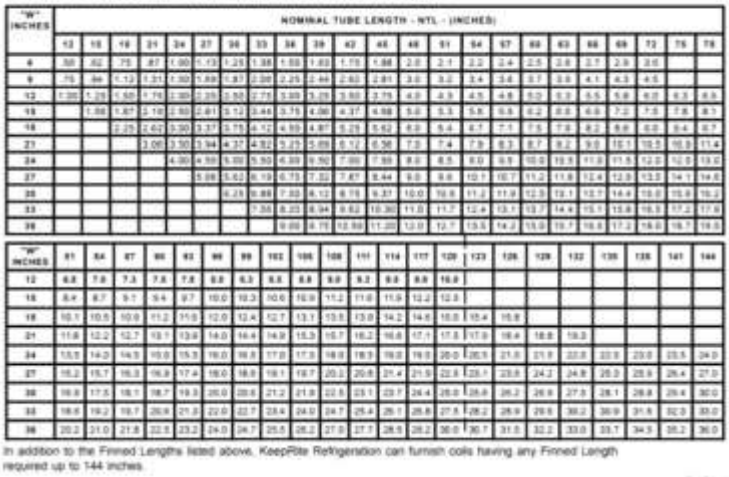
U =155
^{F}FR
= 1

Rows deep =
24000
2.15 x 1.2 x 17 x 155 x 1
Rows deep = 3.6

- A four row KWD84-6x51 will m,eet the required load for each panel in the space .
- The tube length of the coil is 51'' respectively and the dimension is 6''
- As KWD84-6x51 where KW is the coil type and D is the double serpentine tube within the panel which have 4 rows of tube, where as in 84 (80 is the fin series and 4 is the rows deep.

SIZES

TABLE 1 - COIL SIZES - NOMINAL FACE AREA IN SQ. FT.



In addition to the Finned Lengths listed above, KeepRite Refrigeration can furnish coils having any Finned Length required up to 144 inches.

Figure 4.2 coil selection

V. CONCLUSION

A complete design of a radiant cooling air conditioning system is presented under this project work and the following results are obtained during the course of this project.

The net heat load estimated for the commercial building is 440 TR throughout the floors.

The purpose of the project was to cool the spaces through radiant cooling frameworks using the ceiling panels, as this system is also called as hydronic system due to utilization of water.

The cooling water pipe size is obtained as 4 inches in diameter corresponding to the total water consumption rating of 138 gpm.

For the interior region with internal load , the cooling rate difference ranged from 7%-26% at surface level as its mainly depends on fraction of internal laods.

The pump capacity determined is 38 H. P

This will results in the higher radiant fraction in the process of heat gain generates bigger difference in peak cooling rates.

As in this we are using ceiling panel 4.5% amount of cash been saved through ceiling panel when compared to other systems.

Material cost is 40% less .
The consumption of electricity usage is 30% when compared to the other traditional HVAC systems
The result has shown 50% more efficiency.
The project is productively consummate and given reasonable results

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