Design of Green Building Components

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ABSTRACT

A significant proportion of energy consumption in the Heat, Ventilation and Air Conditioning (HVAC) system can be attributed to the heat transportation with in the building. This can be addressed by reducing the volumetric flow rate of the heat transfer liquid

As density and specific heat capacity of air is very low, therefore a large volume of air needs to be circulated to effectively control the temperature in the building. Instead, as an alternate, water can be used as a heat transfer liquid. As water's density and specific heat capacity as compared to air are very large, this significantly reduces the volume of heat transfer liquid that is to be circulated to achieve the same degree of temperature changes as compared to using air.

In general, chillers and boilers are used as sources for heat generation and absorption. Additionally, as a supplement to chillers and boilers, low grade heating/cooling sources like night cooling with ventilation, solar heating, ground heat exchange etc can be used to further reduce effects on environment.

Design of radiant cooling system

Depending upon the positioning of cooling pipes of radiant cooling system, the following are the three different types of radiant cooling system

1. Suspended metal ceiling panels: With copper tubing attached to the top surface. Application both in retrofit and new construction
2. Pre-fabricated or installed in place systems: They consist of embedded tubing i.e small, closely spaced plastic tubing mats in thinner layers and insulated from the building structure. This design is also seen in both retrofit and new construction
3. Plastic tubing embedded in structural slabs: This type of construction is also referred to as Thermally active building system. This type of design is generally used in new construction

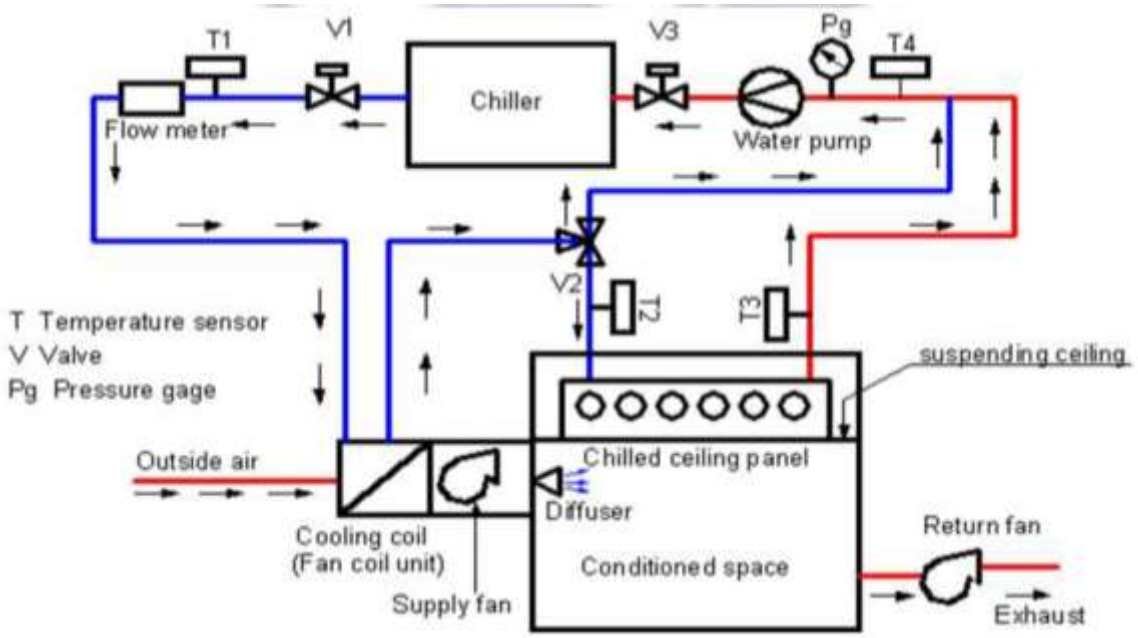
Steps in design of radiant cooling system:

1. Initial load calculations: Cooling load vs cooling capacity calculations are done in this step. Cooling load is the heat that is to be removed from space whereas cooling capacity is the ability of the conditioning equipment to remove this heat. This is done to understand whether the entire load demand can be handled by the radiant cooling system
2. Selection of type of radiant cooling system
3. Design of parameters of radiant cooling system like tube diameter, spacing, insulation, total tube length etc
4. Design of operation parameters: Surface temperature, supply temperature, flow rate etc
5. Simulation of whole building for annual energy and comfort assessment

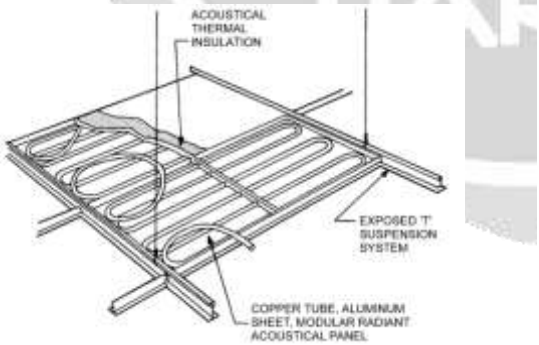
Components used:

- Copper tubes/polyethylene tubes
- Copper tube panels

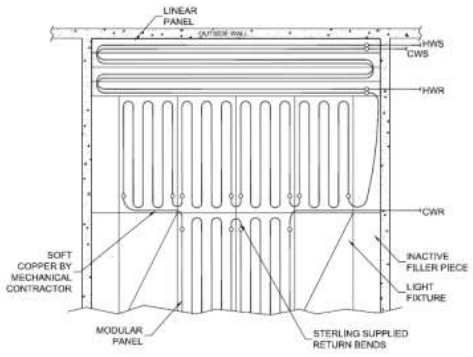
- Chilled water
- Ventilation System
- Motor
- Non-refrigerant cooling sources
- Fixtures
- Aluminium plate



Schematic diagram of tested chilled ceiling panel with DOAS



Metal ceiling panels bonded to Copper bonding



Linear and modular 4pipes arrangement

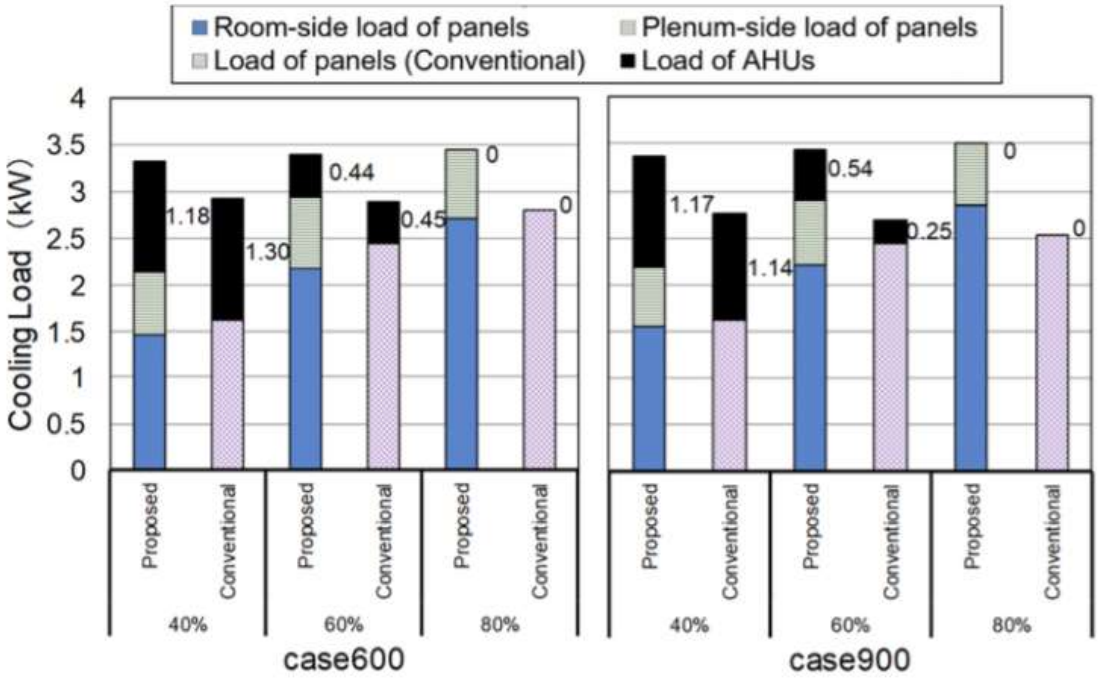
DISCUSSION

One challenging question in design of radiant cooling system is the effect of surroundings on the performance of the radiant cooling system. As the radiant system is exposed to dynamic and constantly

changing loads, there is a chance this could affect the performance of the system. Studies suggest that cooling capacity can be improved by 30% with the help of an air diffuser.

When water is used as a heat transfer liquid in the radiant cooling system, it is to be noted that the heating/cooling effect would take time due to the large thermal inertia of water. This response time depends on various factors like depth of the tube, heat capacity of the radiant slab etc.

Figure below shows that the thermal load was larger in the proposed flow than in the conventional flow regardless of the laying rate of panels. This is thought to be due to differences of thermal environment conditions depending on whether θrs is controlled or not, and the thermal load of the plenum. As the laying rate increased, the entire thermal load in the conventional flow decreased, but that in the proposed flow increased. Looking at the breakdown of the thermal load, the panel was able to remove the entire thermal load with laying rate of 80%. The numerical values of the load of AHUs in the conventional flow shows that the thermal load to be removed by AHUs is underestimated when the laying rate is 60% in Case 900. Although the setting of θra and θrs in Cases 600 and 900 was equal for both the laying rates of 60% and 80%, θw,0 can be slightly raised when the heat capacity is larger. Thus, the proposed flow makes it possible to design an appropriate equipment capacity.



The breakdown of the thermal loads to decide equipment specification
(Numerical values are the loads of AHU's)

Each temperature in the proposed flow and water temperature in the conventional flow

	Case	*Case600*			*Case900*		
	Heat Capacity	*Small*			*Large*		
	Laying rate of panels	*40%*	*60%*	*80%*	*40%*	*60%*	*80%*
	θ_{ra} [°C]	26.5	27	28	26.5	27	28
Proposed	θ_{rs} [°C]	22	21.5	21.5	21.5	21.5	21.5
	OT [°C]	26.99	26.90	26.66	26.94	26.97	26.93
	$\theta_{w,0}$ [°C]	18.18	17.11	16.65	17.32	17.17	16.75
Conventional	*OT* [°C]	29.29	29.72	30.62	29.08	29.48	30.33
	$\theta_{w,0}$ [°C]	16	16	17.40	16	16	18.25

CONCLUSION

Generally, in calculating the load requirements for radiant cooling system, tools which employed ASHRAE load calculation methods are used. However, these tools have been perceived to be complex to use as well as time consuming, hence making it difficult to use in most projects. Radiant cooling

system design incorporation in India is still is in nascent stages. There is a lot of potential for scope and scale improvement in implementing the radiant cooling systems in building construction. Studies indicate that radiant cooling systems using water are 18-21% have higher instantaneous cooling rates compared to air systems.

To encourage the design and implementation, awareness among contractors and manufacturers is to be created regarding the cost vs benefits of incorporating this system in the design and also it is opined that there is still a long way to bring in improvement in the easiness in usage of tools for designing the radiant cooling system.

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