



First Radiant Cooled Commercial Building in India

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Abstract

Radiation has been an effective and proven way of heat transfer since ancient times; radiant heating, in particular, has been in existence in Europe for several centuries. But radiant cooling is a relatively new application of radiation heat transfer and is being used widely in Europe and to some extent in the US for the last 15-20 years. Radiant cooling is highly efficient compared to regular air conditioning due to the high water temperatures used, minimized air system and better quality of thermal comfort. Infosys, a premier IT company in India, in its quest towards energy efficiency and sustainability, constructed the first radiant cooled commercial building in India in its campus in Hyderabad. Having a total built up area of about 24000 sq m, the most significant feature of this building is that it is split into two identical halves – one with conventional air conditioning (high efficiency and surpassing ASHRAE standards [90.1 baseline] by about 30%), and the other with radiant cooling. Both halves of the building have separate sets of equipment and were extensively metered for accurate energy comparison. The building completed one year of operation and the results so far have been highly satisfactory. The radiant cooled half of the building has been consistently showing a significantly lower energy consumption compared to the conventional half. This article discusses in detail the systems in the two halves of the building, the energy and comfort comparisons, and also the costs, which make the radiant cooling system the most promising new technology for air conditioning in India. This building serves as a myth buster for a market where cost and risk have a high influence on any new technology implementation. The building has redefined the efficiency standards and will serve as a benchmark for the industry and be a global case study for radiant cooling technology with the most accurate comparisons of energy, comfort as well as cost!

The Idea

With a target of reducing the energy consumption by 50% in the new buildings of Infosys compared to 2007-08 levels, the approach to building and building systems design had to be radically different. Every aspect of building design right from the initial stages had to be perfect. Air conditioning, being the highest energy consuming system in a building, needed a new approach and therefore the idea of radiant cooling originated through discussions with global consultants. As with any new technology implementation, there was opposition from many stakeholders including consultants who were of the opinion that radiant cooling could never work in India. They were very skeptical of the new

technology, the associated costs and risks involved. But with the backing of the senior management and technical expertise of Rumsey Engineers, USA, Rohan Parikh – Head of Green Initiatives at Infosys – was able to drive in the idea of implementing the first radiant cooled commercial building in India. This resulted in one of the biggest experiments in air conditioning at the Hyderabad campus of Infosys. Since the technology had never been

About the Author

Guruprakash Sastry is a LEED AP, Certified Energy Auditor and Certified Measurement and Verification Professional (CMVP). He has an experience of over nine years in energy efficiency and green buildings. He is currently responsible for ensuring energy efficiency in new buildings of Infosys.

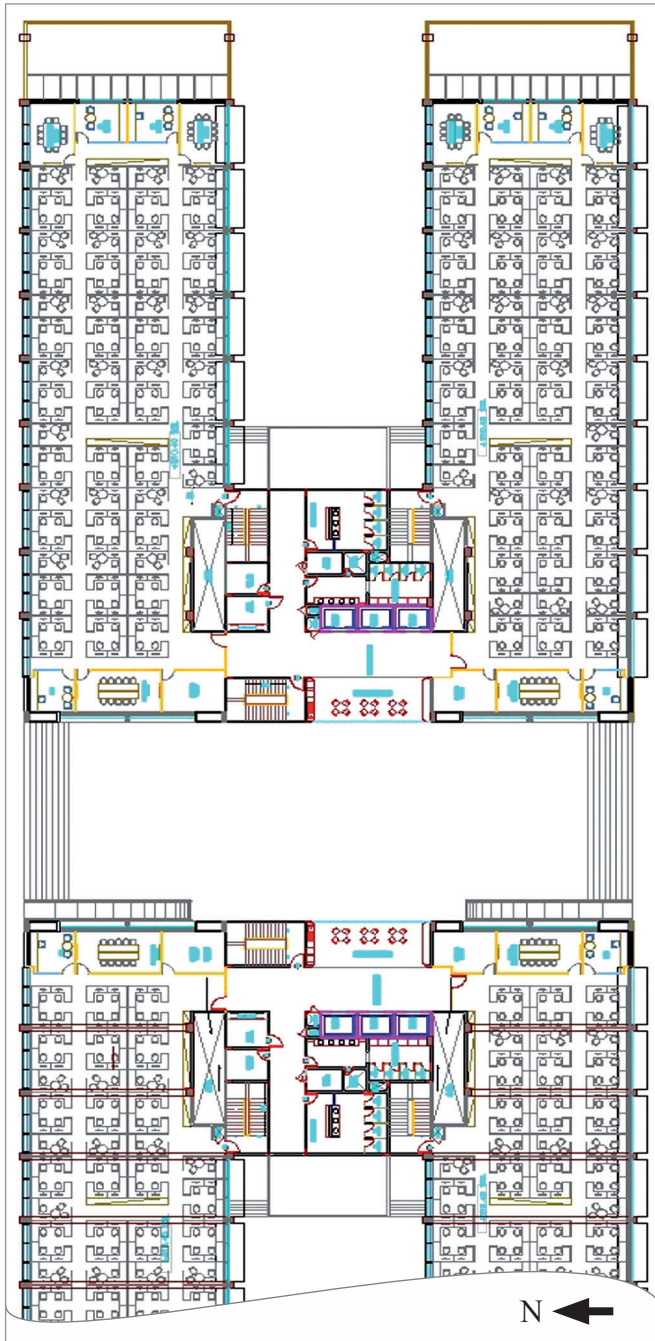


Figure 1: Typical floor plan of the building

implemented in India before, Infosys decided to make a clear comparison of radiant cooling with a conventional air conditioning system so as to pave the way for energy efficient technologies of the future. Thus, the building became a global case study for radiant cooling and a benchmark for comparing energy efficient technologies.

The Concept

The building (Software Development Block-1, Pocharam Campus, Hyderabad) has a total built-up area of about 24,000 sq m distributed into east and west wings of 11,600 sq m each and a

central wing of about 800 sq m. About 85% of the total building area is air conditioned office area, and the total occupancy of the building is about 2,500.

The most significant feature of the building is that it is split into two symmetric halves (see Figure 1). One half is cooled by conventional (but very efficient) air conditioning and the other half by radiant cooling. All parameters in the two halves – area, number of occupants, orientation, envelope and lighting – are similar and therefore the building is ideally suited for comparing two different technologies. To start with, the building has a highly efficient envelope with perfect orientation, double walls with insulation, insulated roof and efficient windows with appropriate shading to maximize natural light in the building and minimize heat ingress.

The hourly profile of ambient temperature and relative humidity for Hyderabad is given in Figure 2. The weather conditions show that there are different seasons in Hyderabad from hot dry in April-May to warm humid in July-August. This case study busts the myth that radiant cooling is not effective in tropical climates.

Radiant Cooling Process

Moving water is more efficient than moving air because of their physical and thermal properties. Water can carry 3,400 times the energy that air can carry for the same volume. This property of water is used to achieve maximum advantage in a radiant cooling system. Also, the natural manner in which the human body dissipates heat is mainly through radiation. This is the primary principle used in radiant cooling. Cold water flows through pipes embedded in a slab (see Figure 3) and cools the entire slab, resulting in the slab surface being maintained at about 20°C. Cooling inside the office space is achieved when the cold slab absorbs the heat (radiation) generated by people, computers, lighting and other equipment which are exposed to the slab. Fresh air is supplied through an air system to maintain a healthy indoor environment, and also to control the moisture inside the office space. In other words, the sensible heat load is addressed by the cooled slab and the latent heat load is addressed by the Dedicated Outdoor Air System (DOAS). See Figure 4.

System Configuration

A few salient features of the HVAC design of the building for both conventional and radiant systems are listed below.

Conventional air conditioning system

1. High efficiency chiller, pumps, AHUs and cooling tower, all with variable speed drives
2. Chilled water design temperatures: supply 7.8°C, return 15.6°C (high ΔT design)
3. Primary variable flow pumping system
4. Cooling tower approach: 2.2°C
5. AHUs with energy recovery wheel, evaporative cooling section and free cooling option for different ambient condition advantages
6. Low pressure piping and ducting design
7. VAVs for controlling air flow in office spaces

Radiant cooling system

1. The radiant slab was designed to give a cooling output of about 75 W/sq m, whereas the office loads were in the range

of 50 W/sq m due to highly efficient design of the building and efficient lighting and computers.

2. High efficiency chiller, pumps, AHUs and cooling tower, all with variable speed drives
3. Chilled water design temperatures: supply 14°C, return 17°C
4. DX unit was provided with a DOAS for achieving dehumidification, but this was replaced by chilled water coil in August 2011 as a retrofit to achieve higher efficiency in the system
5. Primary variable flow pumping system
6. Cooling tower approach: 2.2°C
7. DOAS with energy recovery wheel for supplying dehumidified fresh air into the office spaces
8. Low pressure piping and ducting design

Results
Energy

The design of the building and the building systems was such the building was estimated to be about 40% more efficient than an ASHRAE baseline building. The building was equipped with energy meters for each equipment of the air conditioning system as well as the radiant cooling system so that individual equipment level efficiencies could be compared accurately. Also, the building features a state of the art Building Automation System to monitor and control the operation of the building systems accurately. The building achieved full occupancy in February 2011. The comparative results from the energy meters in the building are given in Figure 5 and 6 for the whole building and load component-wise respectively; Figure 7 shows the monthly break-up of load component data.

In 2011-12, the total consumption in the conventional air conditioning system was about 4,40,000 units and in the radiant



Figure 3: Concreting of slab with radiant pipes

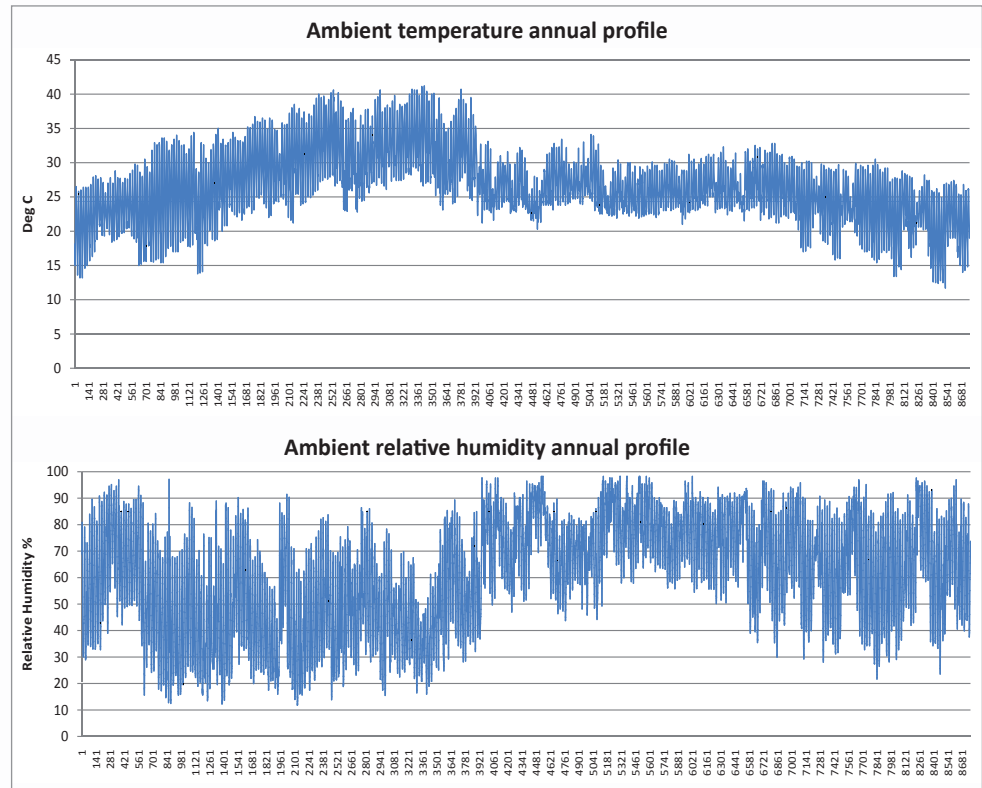


Figure 2: Annual ambient conditions for Hyderabad

cooling system was about 2,69,000 units. The conventional air conditioning energy index was recorded to be 38.7 kWh/sq m and the radiant cooling energy index was recorded as 25.7 kWh/sq m. So, the radiant cooling system was 33% lower in energy consumption compared to the conventional air conditioning system for the period April 2011 to March 2012.

The distribution of energy in the HVAC system is given in Figure 8.

The distribution of energy shows that the contribution of air handling system is very low in the radiant cooling system compared to conventional air conditioning system. The average chiller plant efficiency was observed in the range of 0.6 kW/TR for the conventional air conditioning system and 0.45 kW/TR for the radiant cooling system, though these vary through different seasons.

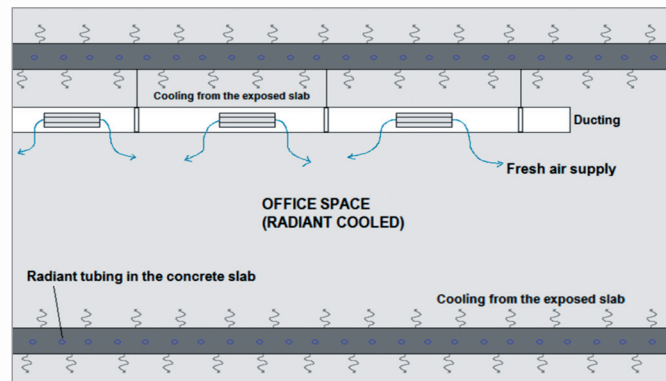


Figure 4: Cross section of a radiant cooled space

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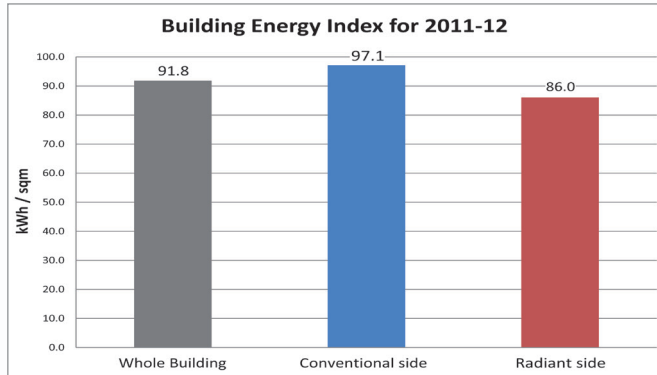


Figure 5: Annual Energy Index of the whole building including lighting, computers, HVAC and miscellaneous loads

Comfort

The radiant cooling system inherently provides a healthier indoor air quality as there is no recirculation of air in the system. Treated fresh air is provided to the occupants for maintaining healthy conditions as well as to remove moisture from the space. In principle, the radiant cooling system reduces the Mean Radiant Temperature (MRT) of the space since the slab is cooled. Therefore the perception of thermal comfort is expected to be higher for a radiant cooling system.

The building automation system ensures accurate monitoring and control of comfort parameters in the building such as temperature, RH and CO₂ levels. A detailed measurement and study by a team of researchers from the Technical University of Braunschweig, Germany highlighted that the perceived thermal comfort in the radiant side of the building was better than the

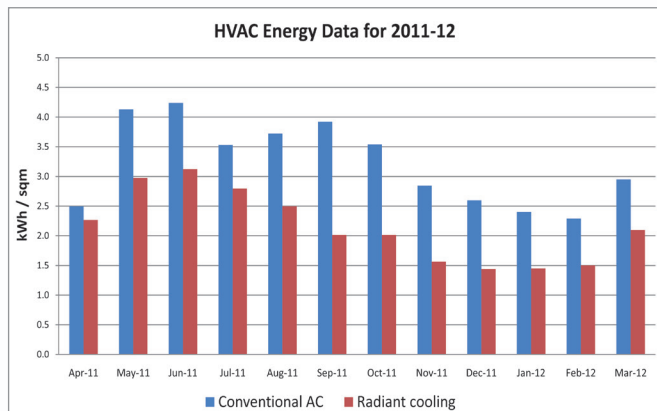


Figure 7: Month-wise Energy Index of conventional air-conditioning and radiant cooling systems

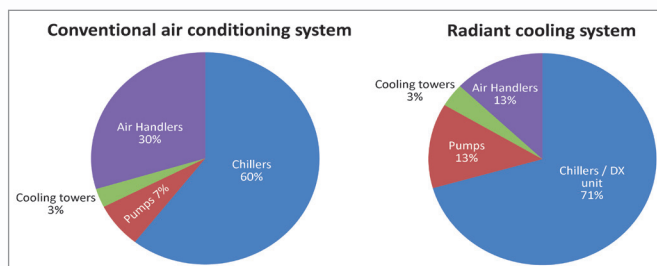


Figure 8: Component-wise distribution of HVAC energy in conventional and radiant systems

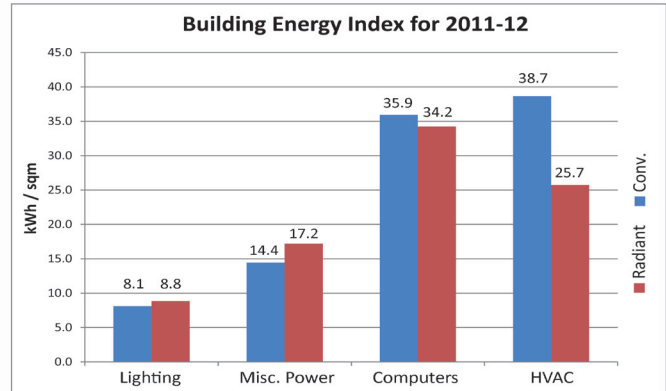


Figure 6: Annual Energy Index of different load components in the building

conventional side. Another detailed monitoring of IAQ carried out by SGS India Pvt. Ltd. reported that the comfort parameters were within the permissible limits of ASHRAE 55-2004 and ASHRAE 62.1-2007 for most of the building. Also, the building has been operational with full occupancy for about 1.5 years and no major complaints have been recorded for radiant cooling.

Cost

One of the most important aspects while implementing any new technology is the capital cost involved. Higher capital cost usually means higher risk and therefore slow adoption by the society. In the case of radiant cooling, it was a completely different case where the capital cost of the system was slightly lower than the conventional air conditioning system. A detailed breakup of the HVAC costs incurred for the building is given in Table 1 (all costs are in Indian Rupees - INR).

Table 1: Cost comparison of conventional and radiant cooling system

	Conventional system	Radiant system
Chiller	31,45,200	31,45,200
Cooling tower	13,06,400	13,06,400
HVAC low side works	2,28,39,000	1,53,10,000
AHUs, DOAS, HRW	51,18,200	28,78,900
Radiant piping, accessories, installation, etc.	0	90,75,800
Building Automation System	61,84,000	65,84,000
Total cost (INR)	3,85,92,600	3,83,00,300
Area (sq m)	11,600	11,600
INR/sq m	3,327	3,302

The attractive costing is expected to be a major factor in driving the radiant cooling technology mainstream in India. One of the main objectives that Infosys set out to achieve through this building was to show that new and efficient technologies need not necessarily be expensive.

Conclusion

Radiant cooling technology is an emerging efficient technology in HVAC industry. It may be the technology of the future and may redefine the way cooling is done in India. The following conclusions may be drawn from the Infosys case study:

- Radiant cooling system is easier to build since it requires fewer equipment and the overall cost of the system is slightly lower than the conventional air conditioning system.

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- Radiant cooling system occupies just one-third of the space compared to the conventional air conditioning system.
- The efficiency of the radiant cooling system is about 33% better than a highly efficient conventional air conditioning system.
- Radiant cooling system provides a better indoor air quality and thermal comfort compared to conventional air conditioning.

The radiant building in Hyderabad is considered among the most efficient buildings in the world for such climatic conditions. Comparison of the two cooling technologies at such scale has provided us an opportunity to make a clear conclusion about the advantages of radiant cooling. This building serves as a global case study for radiant cooling technology by providing accurate energy, comfort and cost data. The building has been awarded LEED India Platinum rating and redefines the benchmark for energy efficiency in India. The building was also featured in the *Best Practices Guide for High Performance Office Buildings* published by the Lawrence Berkeley National Lab, USA. The data from this building paved the way for several buildings being currently designed with radiant cooling at Infosys as well as other corporates in India. Infosys hopes to lead by example and bring new efficient technologies mainstream, thereby starting an energy efficiency revolution.

References

1. *Infosys – Advanced Efficiency Building Hyderabad, India Schematic Design Narrative*, Rumsey Engineers, Inc., Oakland, California, USA, 2009

2. *Underfloor Heating/Cooling System Part 1: System Components*, Technical Information 864.600E, REHAU AG, Germany
3. *Infosys SDB-1 Hyderabad, Evaluation of Efficiency and User Comfort*, Technische Universitat Braunschweig, Braunschweig, 2011
4. *Modelling and Simulation of a Room with a Radiant Cooling Ceiling*, Vladimír Zmrhal, Jan Hensen and František Drkal, IBPSA, Netherlands, 2003
5. *Radiant Heating and Cooling by Embedded Water Based Systems*, Bjarne W. Olesen, Technical University of Denmark, Denmark, 2008
6. *Radiant Cooling Research*, Center for the Built Environment, University of California, Berkeley, USA, 2010
7. *SDB-1 Hyderabad Final Energy Simulation Report, Environmental Design Solutions*, New Delhi, 2011
8. <http://www.radiantcooling.org/> as accessed on 25th April 2012

Acknowledgements

1. Rohan M. Parikh, Head of Green Initiatives, Infosys Ltd, Bangalore
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