Evaporative Cooling for Educational Institutions

External view of BITS, Pilani

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With its plurality and paradoxes, India never ceases to fascinate. And education in India is only one among various elements that have captured the attention of the world. While the United Nations is worried about the presence of a large number of illiterates, various other countries are amazed by the quality of some of the human resources that the Indian education system has produced.

About 50% of undergraduates are studying Humanities and Arts, while the industry needs a much higher number of Engineering, Medical, Finance and Service professionals.

Education presents a large opportunity to the private sector, especially corporate India, which needs to look at education not just as Corporate Social Responsibility (CSR), but as a business venture that will also create trained manpower for their other businesses.

Some of the initiatives taken by the private sector are:

- Dhirubhai Ambani International School, by Reliance Industries
- Stonehill International School, by Embassy Group
- Educomp Millennium Schools, by Knowledge Tree Infrastructure, a subsidiary of Ansal API and Educomp's subsidiary, Edu Infra Higher Education
- Proposed Vedanta University by Anil Agarwal, chairman of Vedanta Resources Plc, spread across 6,000 acres with estimated investment of more than US$ 3 billion in Orissa
- Proposed multi-disciplinary university by HCL's founder and chairman Shiv Nadar, spread across 300 acres in NOIDA
- Corporate India backed Indian School of Business (ISB) has announced plans for a second campus near Mohali

As the need for primary and higher education is felt all across the country, it is also felt that a comfortable indoor environment needs to be provided to the students with the objective of increasing focus, concentration and efficiency of the students within the campus environs.

To cater to the above, both central air-conditioning and natural adiabatic cooling systems are being installed in educational institutions in India.

As is well known, air conditioning provides precise control over the internal environmental conditions; however, the same is achieved at high capital and recurring costs. While air conditioning is seemingly a good alternative for comfort cooling in educational institutions, the very high capital costs and recurring costs impose heavy financial burden on the institutes. The financial implications are

About the Author

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borne by the students studying in these institutes, and eventually passed on to the parents.

India is still a developing nation and notwithstanding its giant strides towards becoming a prosperous nation, it has yet to provide inclusive growth to all its citizens. Hence, it inherently remains a poor nation. As the educational expenses of students are rising, albeit with better facilities, most Indian middle class families find the relatively high educational expenses beyond their meager financial resources.

Evaporative cooling of educational institutes entails lower deployment of capital and significantly lesser running costs. This makes it affordable to a larger section of the student community.

Another important reason for educational institutions to adopt evaporative cooling is due to its low energy requirements. As India is an energy-scarce country, the overall energy consumption of comfort cooling system being installed becomes an important criterion, making evaporative cooling preferable to conventional air conditioning.

The principles of central air conditioning are well known. However, the method of adiabatic or evaporative cooling is still relatively less understood in its application and the advantages it offers for comfort cooling purposes.

Basics of Evaporative Cooling

Evaporative cooling is responsible for the chill one feels when breeze strikes the skin – air evaporates the water on the skin, with body heat providing the energy for evaporation. The ancient Egyptians hung wet mats over their doors and windows, and wind blowing through the mats cooled the air – the first attempt at air conditioning. This basic idea was refined through the centuries: mechanical fans to provide air movement in the 16th century, cooling towers with fans that discharged water-cooled air inside factories in the early 19th century, spray and pad type cooling units in the 20th century.

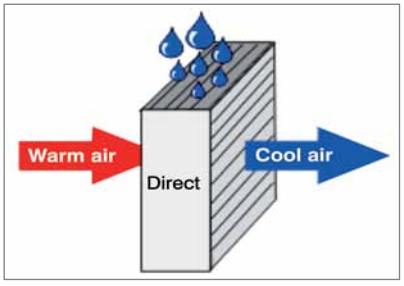
Modern technology has dramatically increased the efficiency and effectiveness of direct evaporative cooling and made possible other types of evaporative cooling such as indirect evaporative cooling and indirect/direct evaporative cooling.

The most common types of evaporative cooling prevalent nowadays are as follows:

Direct Evaporative Cooling

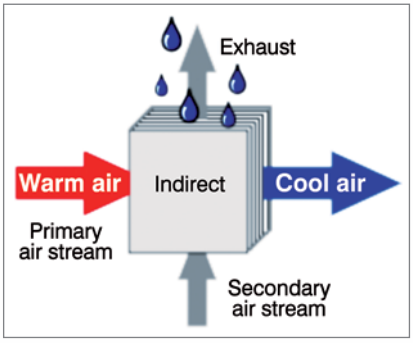
With direct evaporative cooling, outside air is blown through a water-saturated medium (usually cellulose pads) and cooled by evaporation. The cooled air is circulated by a blower.

Direct evaporative cooling adds moisture to the air stream until the air stream is close to saturation. The dry bulb temperature is reduced, while the wet bulb temperature stays the same.



Indirect Evaporative Cooling

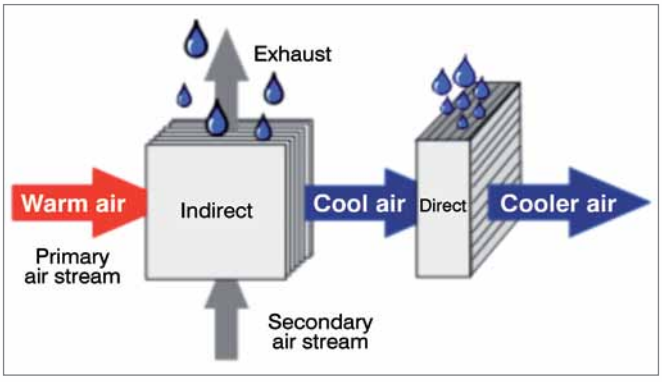
With indirect evaporative cooling, a secondary (scavenger) air stream is cooled by water. The cooled secondary air stream goes through a heat exchanger, where it cools the primary air stream. The cooled primary air stream is circulated by a blower.



Indirect evaporative cooling does not add moisture to the primary air stream. Both the dry bulb and wet bulb temperatures are reduced.

Indirect/Direct Evaporative Cooling

With indirect/direct evaporative cooling, the primary air stream is cooled first with indirect evaporative cooling and then cooled further with direct evaporative cooling.



Advantages of Evaporative Cooling

Evaporative cooling is economical, effective, environmentally friendly, and healthy.

Economical

Evaporative cooling is economical because it:

- Reduces DX/chilled water cooling requirements for fresh air
- Cuts mechanical cooling costs.
- Increases existing equipment cooling capacities.
- Is 50% cheaper to install and 3 times cheaper to run as compared to refrigerated cooling

Effective

- Evaporative cooling actually becomes more effective as the temperature increases – just when DX air conditioning becomes less effective.
- Evaporative cooling works in most areas of the country over 100 km inside the coastline; however, for process applications such as the textile industry, external environmental conditions are not a constraint for these systems.

ASHRAE Handbook 1995 HVAC Applications, Chapter 47, Evaporative Air Cooling notes **"...dry bulb temperature reduction due to the evaporation of water always results in a lower**

effective temperature, regardless of the relative humidity level... (evaporative cooling) can provide relief cooling almost regardless of geographical location."

However, evaporative cooling works best in hot and dry climates. Since the humidity, almost always, decreases proportionally as the temperature increases, the cooling power of evaporative systems increases as the temperature rises.

Our country has large expanses of land which are hot and dry. Some of the areas which are most suitable for the usage of evaporative cooling are listed in *Table 1*.

Table 1: Some cities with hot and dry climate suited for evaporative cooling

City	State	Temp. High In Month (°C)	Extreme High Temp. (°C)	Relative Humidity at 17:30 hrs (%)
Hyderabad	Andhra Pradesh	41.7	44.4	26
Patna	Bihar	43.7	45.6	32
Champa	Chattisgarh	45.9	48.0	20
Raigarh	Chattisgarh	45.9	48.3	21
Ahmedabad	Gujrat	44.7	47.8	22
Baroda	Gujrat	43.7	46.1	29
Bhavnagar	Gujrat	43.4	46.7	40
Bhuj	Gujrat	43.8	47.8	37
Gurgaon	Haryana	45.8	49.0	23
Ranchi	Jharkhand	41.7	43.3	38
Bokaro	Jharkhand	44.6	46.6	39
Bellary	Karnataka	41.4	43.9	30
Gulbarga	Karnataka	42.8	45.0	25
Bijapur	Karnataka	41.0	43.3	30
Bhopal	Madhya Pradesh	43.4	45.6	17
Gwalior	Madhya Pradesh	45.6	48.3	15
Indore	Madhya Pradesh	42.8	45.6	19
Jabalpur	Madhya Pradesh	44.7	46.7	19
Jhansi	Madhya Pradesh	45.4	47.8	18
Rewa	Madhya Pradesh	44.6	46.8	25
Aurangabad	Maharashtra	42.4	45.6	24
Nagpur	Maharashtra	45.5	47.8	19
Solapur	Maharashtra	43.0	45.6	28
Wardha	Maharashtra	45.5	47.2	19
Yeotmal	Maharashtra	44.6	46.3	20
Ambala	Punjab	44.0	47.8	26
Amritsar	Punjab	44.8	47.4	31
Ludhiana	Punjab	46.2	47.9	35
Ajmer	Rajasthan	43.0	47.4	20
Alwar	Rajasthan	44.8	50.6	32
Jaisalmer	Rajasthan	45.2	47.8	25
Mount Abu	Rajasthan	44.8	50.6	32
Udaipur	Rajasthan	41.8	44.6	28
Agra	Uttar Pradesh	45.5	47.5	26
Aligarh	Uttar Pradesh	44.1	46.1	24
Allahabad	Uttar Pradesh	45.9	47.3	20
Lucknow	Uttar Pradesh	44.1	47.2	29

Environmentally friendly

Because evaporative cooling does not use chlorofluorocarbons (CFCs), it does not contribute to ozone depletion.

Healthy

Evaporative cooling is healthy and comfortable because it:

- Brings in outside air and exhausts stale air, smoke, odors, and germs.
- Helps maintain natural humidity levels and cuts static electricity.

Evaporative cooling does not need air-tight structures as the exhaust of incoming fresh and cooled air is critical for achieving maximum efficiency. The exhaust can be through mechanical or natural means depending on the site conditions.

Case Study: Birla Institute of Technology and Science, Pilani

Premises	:	Class rooms
Area	:	18,500 sqft
Height	:	12 ft
Outside Conditions		
Dry Bulb Temp	:	45°C
Wet Bulb Temp	:	24°C
Inside Conditions	:	31 + 1°C
Design Criterion	:	30 air changes per hour
Design Air Qty	:	188,000 Cmh
Selected Equipment	:	2 x 68,000 Cmh + 2 x 25,500 Cmh units
Description of Equipment		
1. 68,000 Cmh	:	consisting of two centrifugal fans, two motors 10 HP each, 1 HP pump, 90% efficient humidification media, FRP water sump, inlet filters, etc.
2. 25,500 Cmh	:	consisting of one centrifugal fan, one motor of 7.5 HP, 1 HP pump, 90% efficient humidification media, FRP water sump, inlet filters, etc.
Exhaust Arrangement	:	Exhaust louvers at the entrance-doors.
Energy Consumption	:	44 kwh for the entire system i.e. Rs 225 per hour @ Rs 5 per kwh

Selecting Capacity of Evaporative Cooling Plant

In the case of evaporative cooling, capacity is rated in terms of cubic feet per minute (CFM). The capacity of evaporative cooling units is decided considering the room heat load, ambient and room conditions, field experience of similar operating installations such as CFM per square feet of floor area or number of air changes needed to provide desired comfort conditions.

BITS Pilani - an interior view

The areas in such institutes which are generally conditioned are class rooms, lecture halls, auditoriums, sports arenas such as indoor badminton and table tennis courts, etc.

continued on page 68

continued from page 66

The design for these areas is normally based on the air-change method, as generally the internal heat loads are negligible.

Design Basis

- Ambient summer temperature 45°C DBT and 24°C WBT.
- 200 mm thick cellulose cooling media providing 90% saturation efficiency at 500 fpm velocity.
- Between 25 and 30 air changes per hour.
- Uniform air distribution.

Temperature at Outlet of Cooling Pad

Tpad = dbt – Sat. η (dbt – wbt)
= 45-0.90 (45-24)
= 26.1°C

Temperature at Grill Outlet

27-28°C

Temperature at Study / Work Level

30-31°C

Energy Consumption

Typically, the power consumption in evaporative cooling for institutes is approximately 12-14 paisa/sqm/hr, while the power consumption of a conventional air conditioning system for institutes is 40-42 paisa/sqm/hr, assuming the energy cost as Rs 5 per kwh.

Some Educational Institutes that are Evaporatively Cooled

Some of the leading educational institutions that have been comfortably cooled using evaporative cooling are:

1. Birla Institute of Technology and Science, Pilani
2. Dhirubhai Ambani Institute of Information and Communication Technology, Gandhinagar.
3. Delhi University, Delhi.
4. Jaypee Institute of Information and Technology, Noida and Guna.
5. Amity International, Noida.
7. The Delhi Public School, New Delhi.
8. L.N. Mittal Institute of Information and Technology, Jaipur.
9. The Seedling Public School, Jaipur.
10. Indian Agricultural Research Institute, Delhi.
11. Jodhpur Institute of Information and Technology.

Air Conditioning as an Alternative

In the event that the customer had decided to install a conventional air conditioning system, to maintain inside condition of 24+/-1°C a total of 100 TR nominal capacity air-cooled system would have been required to be installed.

The energy consumption for 100 TR air conditioning system would be Rs 750 per hour(1.5kwh/TR) @ Rs 5 per kwh.

Conclusion

Evaporative cooling is a viable alternative to air conditioning in many parts of the country with a low capital cost and low operating expenses. ❖