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To Identify the HVAC Energy Savings through Chilled Beam Cooling Technique

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***Abstract:** The movement toward sustainable building designs is being driven largely by environmentally-sensitive building owners and/or their prospective tenants. There are also heightened concerns about assuring a proper indoor environment at all times and conditions for the building occupants. In addition to providing temperature control, a fully effective HVAC system must also address many other indoor environmental issues that affect occupant comfort, productivity and health such as ventilation air, air distribution, humidity control, noise levels, etc.*

As these owners and their consultants weigh their HVAC system alternatives, they often find that chilled beam systems are the ideal "green" solution for many buildings. There is also a persuasive overall comfort and economic argument for the use of active chilled beam systems over other of the more conventional systems choices. While relatively new in India, chilled beam systems are proven and are successfully being used in Europe since a decade.

The chilled beam system promotes excellent thermal comfort, energy conservation and efficient use of space due to the high heat capacity of water used as heat transfer medium. It is an energy efficient HVAC technology which works on dry cooling principle. Chilled beams system would be examined which would show energy conservation and has potential to save 30-40% HVAC energy consumption to a conventional Air conditioned Building case. The simulation results would be encouraging, and they would confirm the advantage of the application of these Chilled beams system cooling strategies.

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***Keywords:** sustainable, chilled beam, simulation, chilled beam*

I. INTRODUCTION

Chilled beam systems are used mostly in the nonresidential buildings. These are commercial buildings, offices, hotels, banks, universities, schools and hospitals. Typical applications are cellular and open plans offices, hotel rooms, hospital wards, and retail shops, bank halls etc Chilled beam systems are primarily used for cooling, heating and ventilating spaces, where good indoor environmental quality and individual space control are appreciated. These systems are dedicated outdoor air systems meant to be applied primarily in spaces where internal humidity loads are moderate.

II. OVERVIEW OF CHILLED BEAMS

“A cooled element or cooling coil situated in, above or under a ceiling which cools convectively using natural or induced air flows. the cooling medium is usually water.” there are two basic types of chilled beams: active and passive.

A. Active chilled beams (acb)

Uses a pre-cooled (and dehumidified) primary air using chilled water in a quantity needed to meet the room latent load and ensure good air quality for the occupied area. the cooled and dehumidified primary air absorbs the space latent load; ensuring the chilled beam coil operating without condensation. the chilled beam then cools or heats the induced air to meet the room sensible load and react to the room thermostat requirements.

Active chilled beams operate using the induction process. during induction, the primary air discharges under pressure through nozzles located within the device. this high velocity incoming primary air creates a negative pressure in the inlet portion of the beam thereby inducing room air through the beam coil where it mixes with the cold primary air. This mixed air is then discharged through the outlet slot of the beam into the room, resulting in a total airflow quantity 3 to 4 times greater than the primary airflow.

we refer to this ratio of total air to primary air as the induction ratio. “a convector with integrated air supply where primary air, induced air or primary air plus induced air passing through the cooling coils. the cooling medium in the coil is water.”

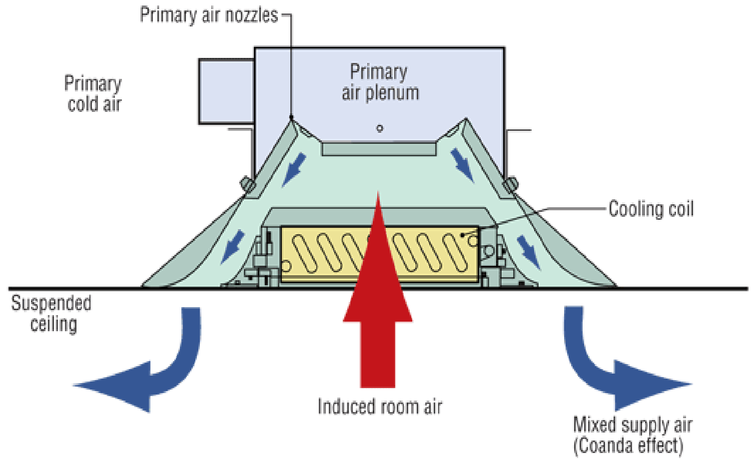

FIGURE 4. Active chilled beam—forced convection.

B. *Passive chilled beams (pcb)*

Passive chilled beams work using natural convection. Warm air rising up in the space passes over the top and into the passive chilled beam. As the air between the aluminium thermal conducting fins is cooled, it becomes denser and returns, due to negative buoyancy, downwards to the space below. Good circulation of air is essential for the operation of passive chilled beams. Sufficiently large openings above the passive beam casing or ceiling system must be provided to allow air to circulate properly.

“The cooled element or cooling coil fixed in, above or under a ceiling fitted with a cooling coil mainly convectively using natural airflows. the cooling medium is usually water” chilled beams offer a quiet indoor air free from draught. in a typical chilled beam, the air is cooled by means of supplying chilled water and the supply of air flow rate is dimensioned to meet the indoor air quality requirements.

III. ADVANTAGES OF CHILLED BEAM SYSTEMS OVER CONVENTIONAL DESIGNS

Chilled beam systems are suitable for use in high sensible cooling load applications or where individual temperature control is required. compared with a system where the cooling duty is supplied entirely by air (all-air systems), a chilled beam system reduces the fan power requirements and space needed for air- handling plant equipment and ducting.

TABLE - 1

S.No	SYSTEM	Energy	Noise	Output (w/m²)
1	FCU (Fan Coil Unit)	Medium / High	Medium	100-200
2	VAV (Variable Air Volume)	Low/Medium	Low/Medium	100-200
3	VRF (Variable Refrigerant Volume)	Medium / High	Medium	150-200
4	Chilled Beam	Low	Low	100-300

IV. BUILDING DETAILS

The building chosen is intended to be used as school . The building is proposed to be located in Hyderabad, India. s provided.The building comprises of two floors i.e. a ground floor and the first floor. The total area of the building is about 70000 square feet and it comprises of different sections including the areas with and without air condition system. There are different kinds of spaces in this building as it is a commercial building such as classrooms, teacher rooms, principal room, library, computer labs, cafeteria, lobby, corridor, and many other spaces. Hence, a total area of about 55000 square feet out of the overall building area is supplied with the conditioned air and about 72 spaces are considered while designing an air conditioning system.The number of occupants that can be accommodated within each floor is estimated from the ASHRAE standard. 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.

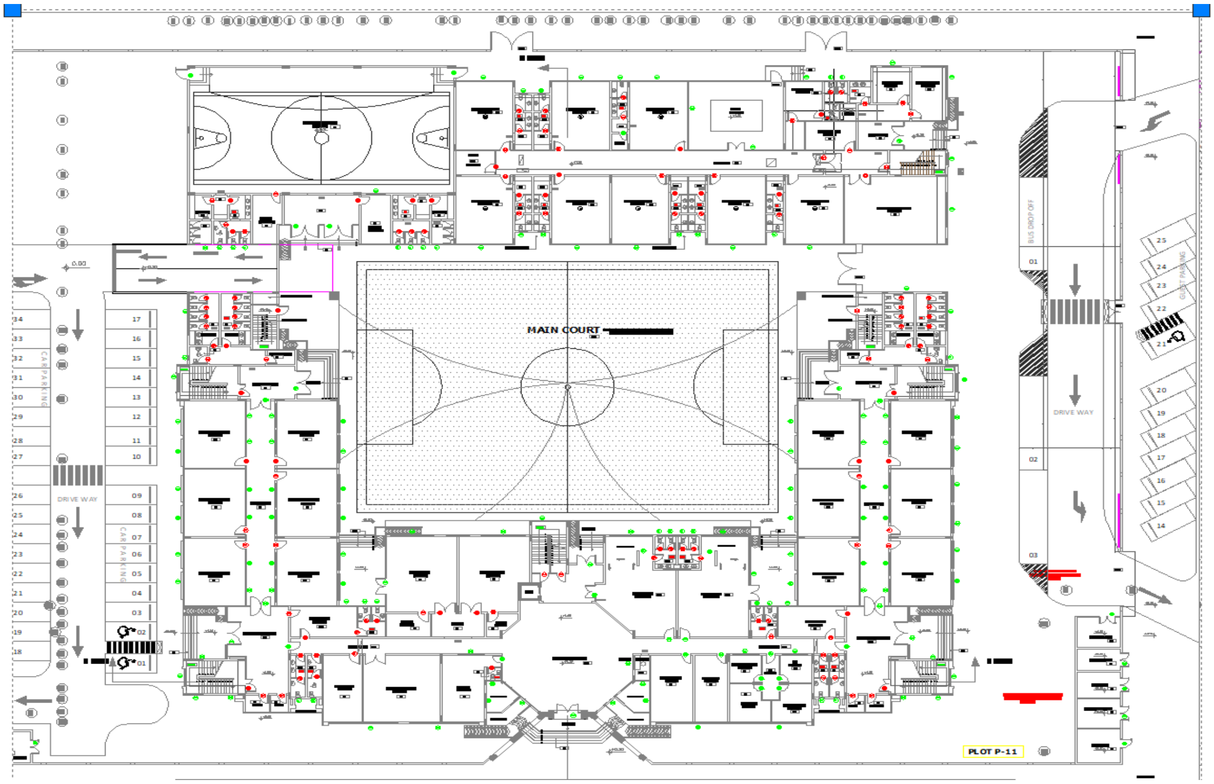

Fig. 2 Building Plan

V. CALCULATIONS

A. Heat Load Calculation

The heat load calculation is done using hourly analysis program (HAP) software. The net heat load estimated for the specified building is 242.25 T.R .The maximum air flow rate obtained in terms of cubic feet per minute for first floor is 145009 CFM.

B. Pipe Sizing

The cooling water pipe sizing is done using the software named pipe sizer developed by Mc Quay. The main consideration or the input parameter in the design of cooling water pipe size is the water consumption rating.

1) Water consumption rating – 2.4 gpm per TR for closed cycle
2) Total gpm required = 275.2 × 2.4 = 660.48 gpm
3) Pipe size obtained from calculation = Ø 6”

C. Sizing of chilled beam

Chilled beam sizing and the percentile reduction in primary air is calculated for
FCU-01

Total tonnage by Hap-3.2 TR CFM-1927

Total Fresh Air CFM-219.6

Sensible load =1.08*cfm*(OAT-RT)

= 1.08*219.6*30=7115.04 btu/hr

Latent load = 0.68*cfm*ΔW

= 0.68*219.6*33 =4897.5 btu/hr

Total load = SL+LL = 12012.54 btu/hr

= 12012.54/12000 =1.001 TR

Latent load for people = 200*no.of persons
= 200*15=3000 btu/hr =0.25 TR
DOAS load = 1.001 + 0.25 =1.25 TR
Load on Chilled Beam = Total load-DOAS load
= 3.2 – 1.25 = 1.95 TR
= 23400 btu/hr

On average chilled beam can produce 1500 Btu/Hr/LF of sensible cooling capacity

Chilled beam size in Linear Foot = 23400/1500 = 15.6 LF = 4.75 mt

Assuming LF/ACB = 3 Mt

No. of Chilled Beams =4.75/3 = 1.58 ACB'S = 2 ACB's

Fresh Air for Each ACB = 219.6/2 = 109.6 cfm

Total ton for each ACB = 1.95/2 = 0.975 TR

Primary Air Reduction = 1-(primary air cfm / Total current supply cfm)
= 1-(219.6/1866) = 0.88 = 88%

Primary air reduction of the total building

Total Supply air of the building = 145009 CFM

Total Ventilation air of the building = 20203 CFM

Total primary air reduction = 1-(primary air cfm / Total current supply cfm)
= 1-(20203 ÷ 145009)
= 0.85

D. Chilled beam initial cost analysis

1) *Duct work:* The sizing of chilled beams and primary air calculations yielded an 85% reduction in air. s. Ductwork cost is based on the weight of the duct installed. A 85% reduction in air will not reduce the weight of the ductwork by 85%. A reasonably accurate method to determine reduction in ductwork weight is to reduce the cross-sectional area of a square duct and calculate the reduction in surface area of the reduced duct.

Assume a 10"x10" duct

Surface Area = 10+10+10+10=40"

Reduced Cross sectional area = 100in² x 0.15 = 15 in²

Reduced size = 15 in² = 3.9"x3.9"

Reduced Surface Area = 3.9"+3.9"+3.9"+3.9"=15.6in

From this calculation, we can conclude that there will be a 60% savings in ductwork material cost. However this does not tell us anything about the labor savings. The labor costs to hang a duct that is 60% lighter and 85% smaller in cross section is not reduced by 60% because the craft still has to follow the same procedure .There will be savings with handling and lifting the duct.

E. AHU's and Fans

The AHU's and fans can be downsized by 85% because they only provide 15-20% of their design CFM's.The savings were estimated as 60% for material and 40% for labour for the AHU's and Fans.

VI. CONCLUSIONS

Chilled beams were shown to have many advantages over other systems in this analysis. Chilled beams save a great deal of energy in terms of transferring cooling, ventilating of airflow, using higher chilled water temperature and eliminating the need for reheating the cooled air. Even though the chilled beam system was more expensive initially, the operating costs are much lower and then revenues are higher whenever the chilled beam system is used. Most of the savings are from the downsizing of air handling unit due to reduction in primary air ,with significant savings in ductwork and labour.

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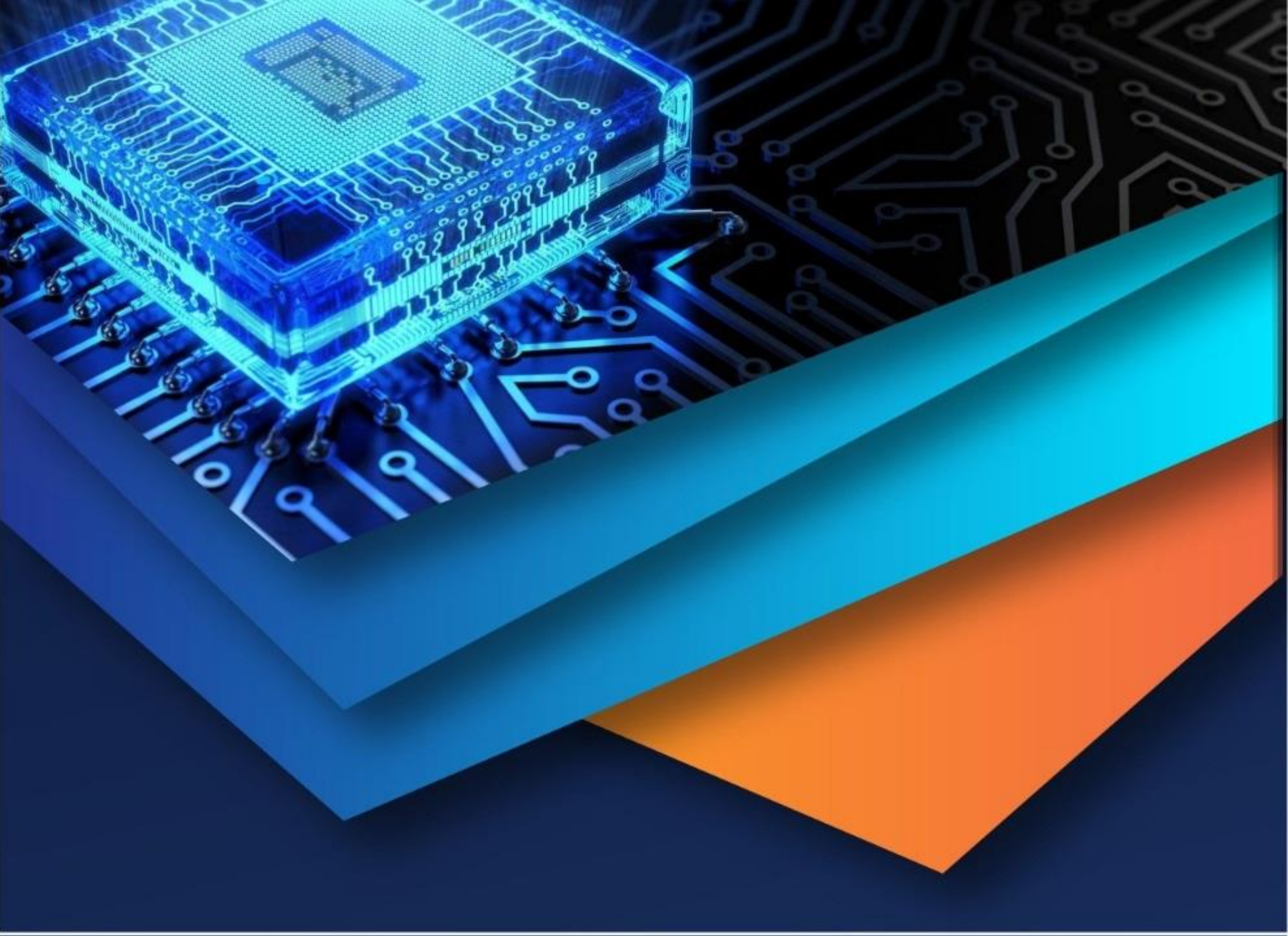

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