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INTEGRATION OF WALL AND ROOF IN A COMMERCIAL BUILDING FITTED WITH HVAC VIA LEED CERTIFICATION – A CASE STUDY

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ABSTRACT

The LEED idea is applied in this research to enhance ecological and energy conservation. For green buildings, LEED has established precise rules for construction, design, regular consumption, and operation. It is a method of assessment in which structures are evaluated and granted points in multiple domains based on their ability to meet standards. In this article, an investigation on the effectiveness and efficiency of constructed sidewalls in a building serves as the foundation for case studies. Its cooling and heating system uses a number of calculations to calculate the building's load. With the Green Building Certification method in place, computations for the fundamental situation have been accomplished. The choice of materials is carried out in compliance with ASHRAE norms.

Keywords: LEED Certificate, ASHRAE, HVAC, Selection of Material, Building Load.

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1. INTRODUCTION

Energy has become one of the many important aspects influencing the advancement and progress of any country's economy. While it pertains to rising economies, the power industry plays a critical role owing to the expanding demand for energy, necessitating large expenditures to meet the demand.

Before LEED was launched in India, there were numerous national and international construction norms and standards that satisfied some of the requirements for an environmentally friendly construction evaluation system. As previously stated, the CII Sohrabji Godrej Sustainable Enterprise Centre was India's first official LEED-certified building. The first edition of LEED India, edition 2.0, was issued in India in October 2006. The most recent edition, published at the beginning of 2007, is known as the LEED India NC (in the states of novel building) Technical Manual, edition 1.0.the one that is the primary focus of this study, applies to all newly constructed offices and residential complexes with no less than four operational levels. Another version, Green India for Central & Shell, is available; it certifies structures over which the proprietors or builders have little control, such as rentable sections in IT parks. The guide's core foundation is essentially comparable to the US translation in every way, with the exception of some alterations made to ensure that the Indian version fits into the IGBC programme. Applying American sustainability standards to new structures in India might be misleading due to differences in environmental circumstances, economy, and culture. As a result, you are under commitment to identify the issues and propose appropriate LEED adjustments.

India has announced a number of infrastructure-improvement initiatives as part of its continuous economic development. Residential or housing is one of India's fastest growing businesses. Raising earnings, a growing ageing population, and India's rapid urbanisation are driving this increase. India is scheduled to build 2.15 crore residences among 2015 and 2019. By 2022, PMAY, an Indian government initiative, seeks to build in excess of 2.5 crore dwellings across rural India. Furthermore, multiple additional developments would add to the already existing building stock. Once inhabited by citizens, each of these constructions consumes a large quantity of electricity.

The LEED 2011 environmentally friendly buildings Assessment Methodology is a driven by the market, voluntarily evaluation system based on proven technology and methods. It creates a precise concept of a "green building" by evaluating environmental evaluation from a comprehensive building structure perspective throughout the building's life span. This rating system strikes an equilibrium among established approaches and novel concepts by making decisions based on recognised ecological values and energy generating and conservation technologies. It is based on accomplishments with points awarded for achieving requirements addressing specific environmental challenges embedded in the layout and development. The proposed system is both comprehensive and user-friendly.

Jindal emphasises the significance of warmth requirements in enhancing building attributes in his case study. His studies emphasise the need to enhance the construction elements [1]. International Energy Efficiency Standards are comparable to IES Standard 90.1 [2]. Energy conservation regulations are a mandated collection of procedures that outline the efficacy needs or the maximum amount of energy use that is acceptable for a given building type or location [3]. According to Sansiwal, thermal research in the Indian construction industry are supposedly uncommon in the literature. The significance of constructing physiologically in attaining wellbeing in Indian dwellings is explored in his research work. Better thermal comfort can be achieved by enhancing a building's physical aspects, as per his research [4]. Many countries have the authority to set municipal or federal building energy efficiency rules.

This is frequently achieved by the federal government creating a construction code that state or local governments subsequently implement [5]. An excellent example of the method used to uphold codes is the enforcement of the California IBC in the United States.

The energy-efficiency codes are established through the national consensus approach and are usually enforced by local governments to guarantee necessary compliance [6]. Carlo uses an approach based on the life cycle to identify aspects that promote building sustainability. His writings claim that the effects of buildings on the outer world are immediate and have an impact on the environment. Buildings that are sustainable are regenerative and have the potential to help rebuild community and ecosystems during their entire existence [7]. Buildings are being developed everywhere in metropolitan environments. This ever-increasing construction, if not environmentally friendly, may represent a threat to modern society. As a result, considerable effort has been directed towards determining the causes and drivers of building sustainability. Sharma's research identifies determinants of long-term viability in structures utilising MCDM methodologies [8]. Gupta's research has expanded the concept of sustainability to include corporate buildings. According to the research, the most important domains for achieving longevity in structures through organisational means are monetary client, and company procedures, as well as learning [9]. According to a Strike study, incorporating sustainability into buildings has the potential to benefit the physical, economic, and human-environmental aspects of urban civilization. His research identifies twenty elements in an Indian metropolis that can help improve building sustainability. The discipline of demography ecological issues, convenience, transportation infrastructure, congestion, as well as security are all extensively covered [10].

The goal of this investigation is to quantify the thermal load predictions in a structure using LEED standards in connection with the material selections for the project, as well as to optimise and increase the efficacy of the HVAC system of the exterior walls of the structure selected for the present case study.

2. ECOLOGICALLY SAFE BUILDING BY MEANS OF LEED ACCREDITATION

The market-driven, voluntary LEED 2011 environmentally friendly building rating system is founded on tried-and-true, in-use technologies and processes. It provides a precise definition of a "green building" by evaluating environmental evaluation throughout the life cycle of a construction from the perspective of the entire building structure. Not all criteria, however, may be considered equally relevant, therefore some aspects have a bigger effect than others. Each criterion will therefore be listed in order of significance. "Highly important," "Important," as well as "Lower importance." A table developed by the organisations "The concept of sustainability Quality Rating" and "Bench assessment of Structures" (2010) provided the framework for allocating the standards in each priority group.

3. PRACTICE FOR EMPLOYMENT OF DIVERSE DESIGNED SOFTWARE’S FOR A HVAC BUILDING

There is a presentation of the software used for the calculations and designing. The Hourly Analysis Programme (HAP), which is currently the most widely utilised in industry, is used to calculate load. Software such as DUCT SIZER and PIPE SIZER, which are utilised for duct and pipe design, are also covered.

Figure 1: Opening window screen of McQuay, DUCTSIZER Design tool [11]

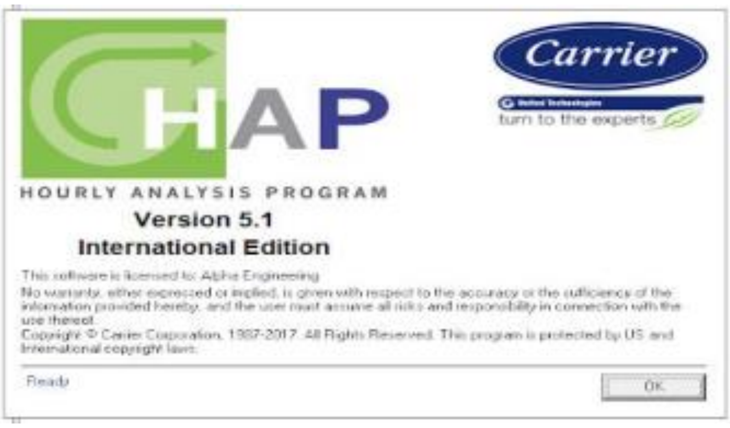


Figure 2: HAP software opening window from Carrier [11]

The Level Properties in HAP 6.0 provide for a wall's height of eleven feets and a level-to-level height of twelve feet (as presented in Figure 1&2). The disparity in heights suggests that the user wants to depict a raised floor or a wall space. The user checked the boxes for the wall height, floors height and ceiling space. This states that neither a raised floor, nor a ceiling space exist. The heights imply that there should be a raised floor, wall and ceiling space, but neither was stated, which leads to contradictory inputs. It deserves to be stated that a significant amount of running expenses is attributed to the energy used by fans, as well as that the network of ducts required for the correct transmission of climate control accounts for approximately 30% of overall price of every piece of equipment needed. Therefore, it's crucial to design a ventilation conduit network with a minimum of feasible fan maintenance and conduit expenditures.

4. HVAC DESIGN OF A BUILDING WITH CONVENTIONAL METHOD AND WITH LEED CERTIFICATION

The main function of air conditioning is to maintain conditions within an area that are either (1) beneficial to people being comfortable or (2) required for an operation or product. To do this, equipment with the right capacity needs to be installed and kept up year-round.

The machinery's breakdown load specifications and kind of regulation are determined by the conditions that must be sustained at maximum and reduced load. Generally, it is difficult to figure out the highest and breakdown loads on any given space, thus one must assume them. This objective has guided the collection of the data. prior to the amount of load can be calculated, a comprehensive survey must be carried out to guarantee a reliable assessment of the load elements. If the structure's utilities and the genuine simultaneous demand for a particular building's mass are carefully assessed, as indicated in figure 3-4, then smooth, issue-free functioning is then attainable.

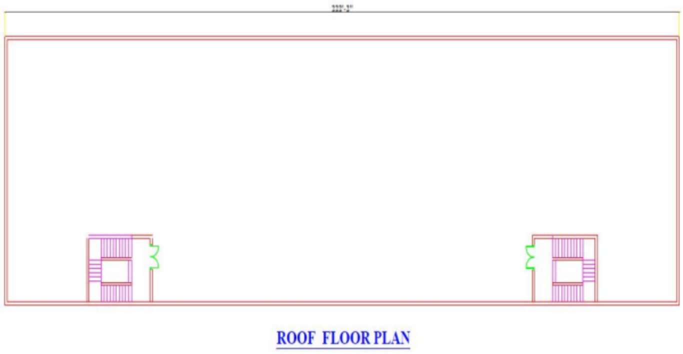


Figure 3: Roof Floor Plan

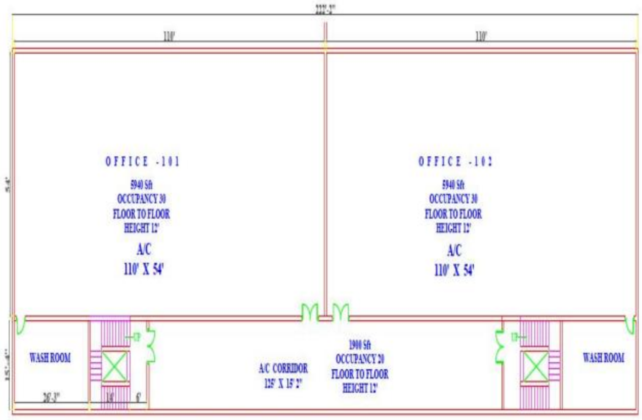


Figure 4: Typical floor Plan of a Building

5. RESULTS AND DISCUSSION

Primarily case construction and conventional method analysis are conducted utilising low-conductive value materials and sustainable ways. Using the aforementioned programme, the calculations are performed according to the design parameters and meteorological circumstances. With dimensions as indicated in civil drawings, it is regarded as a base case building. ASHRAE STANDARD 90.1-2019 was used in the design of its HVAC system (using HAP software).

The U-Values Referred Below Are As Per ASHRAE 90.1.

- Exterior Wall Construction (U-Value)-0.124 Btu /hr.ft^2 ^{o}F (0.357W/M^2 ^{o}K)
- Roof Construction(U- Value)- 0.063 Btu /hr.ft^2 ^{o}F (0.704W/M^2 ^{o}K)
- Floor Slab/Construction(U-Value)- 0..35 Btu /hr.ft^2 ^{o}F (1.987W/M^2 ^{o}K)
- Fenestation-Glass (U-Value)- 1.25 Btu /hr.ft^2 ^{o}F and 0.25 SHGC(7.097 W/M^2 ^{o}K and 0.28 Shading Coefficient)

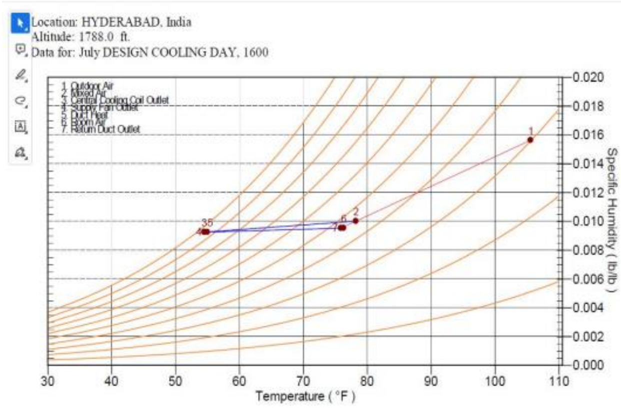


Figure 5: Psychometric chart for base case [11]

According to ASHRAE 90.1, the base case report shown in Figure 5 above indicates that the building under examination at the Hyderabad location has a total tonnage of 126.3 TR. With the exception of the wall's U value (U_{wall} = 0.0060Btu/hr.ft^2 ^{o}F (0.704W/m^{2o}K), Case 1 considers values consistent with the base case. It is noted that the building under examination at the Hyderabad location yielded a total tonnage of 124.5 TR. Comparatively speaking, there is a 1.8TR difference at 1.42% fluctuation [11].

Case-2 of the HAP system design report, U_{wall} 0.060 U_r 0.021. The values taken into account in example 2 are as per case 1 anticipate the roof's U value, as indicated in fig. 6-8. The U value of a roof is taken into account while utilising commercially feasible standard materials to raise efficiency and lower TR in order to satisfy LEED requirements and earn points towards certification. U_{roof} is defined as U_{roof} = 0.119W/m^{2o}K or 0.021 Btu/hr ft^2 ^{o}F.

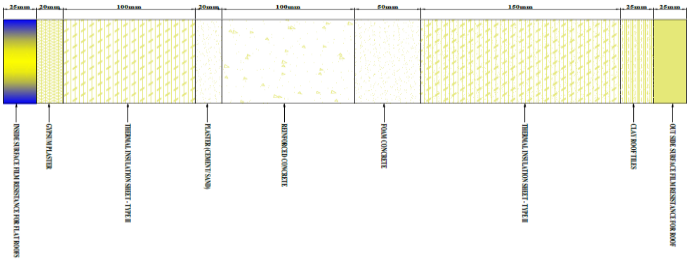
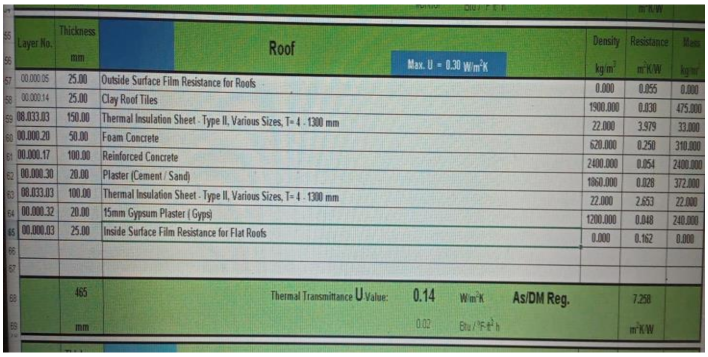


Figure 6: Cross Section of Slab / Roof and material used



Layer No.	Thickness mm	Roof (Max. U = 0.30 W/m²K)	Density kg/m³	Resistance m²K/W	Mass kg/m²
00.000.05	25.00	Outside Surface Film Resistance for Roofs	0.000	0.055	0.000
00.000.14	25.00	Clay Roof Tiles	1900.000	0.030	475.000
08.033.03	150.00	Thermal Insulation Sheet - Type II, Various Sizes, T= 4 - 1300 mm	22.000	3.979	33.000
00.000.20	50.00	Foam Concrete	620.000	0.250	310.000
00.000.17	100.00	Reinforced Concrete	2400.000	0.054	2400.000
00.000.30	20.00	Plaster (Cement / Sand)	1860.000	0.028	372.000
08.033.03	100.00	Thermal Insulation Sheet - Type II, Various Sizes, T= 4 - 1300 mm	22.000	2.653	22.000
00.000.32	20.00	15mm Gypsum Plaster (Gyps)	1200.000	0.048	240.000
00.000.03	25.00	Inside Surface Film Resistance for Flat Roofs	0.000	0.162	0.000
	465 mm	Thermal Transmittance U Value: 0.14 W/m²K (0.02 Btu/°F ft² h) As/DM Reg.		7.258 m²K/W	

Figure 7: Results of U value of roof along with materials

Air System Sizing Summary for Chiller AHU + FA load

Project Name: KAS LEED HVAC Project case2 W0.60 +Uroof 0.021 — 09/04/2023

Prepared by: ecopact constructions — 07:36PM

Air System Information

Air System Name	Chiller AHU + FA load		Number of zones	1	
Equipment Class	CW AHU		Floor Area	55120.0	ft²
Air System Type	VAV		Location	HYDERABAD, India	

Sizing Calculation Information

Calculation Months	Jan to Dec	Zone CFM Sizing	Peak zone sensible load
Sizing Data	Calculated	Space CFM Sizing	Individual peak space loads

Central Cooling Coil Sizing Data

Total coil load	119.5	Tons	Load occurs at	Jul 1600	
Total coil load	1433.7	MBH	OA DB / WB	105.6 / 77.9	°F
Sensible coil load	1247.4	MBH	Entering DB / WB	78.4 / 63.7	°F
Coil CFM at Jul 1600	51589	CFM	Leaving DB / WB	54.5 / 53.8	°F
Max block CFM at Jul 1600	57368	CFM	Coil ADP	53.3	°F
Sum of peak zone CFM	57368	CFM	Bypass Factor	0.050	
Sensible heat ratio	0.870		Resulting RH	46	%
ft²/Ton	461.4		Design supply temp.	55.0	°F
BTU/(hr-ft²)	26.0		Zone T-stat Check	1 of 1	OK
Water flow @ 10.0 °F rise	286.88	gpm	Max zone temperature deviation	0.0	°F

Figure 8: HAP software calculated coil load

Based on the case-2 report Figure 8 (U Wall = 0.060 Btu /hr.ft^2 ^{o}F (0.338W/m^2 ^{o}K) & U Roof = 0.021 Btu /hr.ft^2 ^{o}F (0.119W/m^2 ^{o}K)), it can be noticed that the total tonnage obtained for the building under consideration at the Hyderabad site is 119.5 TR.

6. CONCLUSIONS

The Principal conclusions are as follows:

1. The total tonnage acquired for the structure under examination at the Hyderabad location is 124.5 to 119.5 TR, with a difference value of 5 TR, based on comparison between case 1 and case 2 (as per ASHRAE 90.1). Case 2 (U Wall and Uroof taken into consideration) shows that the building under examination at the Hyderabad location has a total tonnage of 119.5 TR, with a difference of 4.01% among the two cases.
2. It is noted how much energy is saved by the different systems by utilising the LEED technique. It is discovered that there is a 33% difference in percentage between the VRF and DX systems. This means that by using the VRF system, we can save up to 42% of the energy used by the DX system.

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