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DESIGN OF AIR CONDITIONING SYSTEM FOR A MULTI -STOREYED BUILDING

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Abstract

The purpose of this work is to design an efficient air conditioning system for a multi-storeyed building. Students and staff spend long hours inside classrooms, laboratories, and offices, so maintaining comfortable indoor conditions is very important for better learning and working. In this project, the cooling load of the building is calculated by considering factors such as room size, number of people, lighting, equipment, and outside weather conditions. Based on these calculations, suitable air conditioning equipment is selected to provide good thermal comfort, proper ventilation, and energy efficiency. The final design aims to supply fresh, clean, and cool air to all floors of the college building while reducing power consumption and operating costs.

Keywords: Air Conditioning System, Cooling Load Calculation, Multi-Stored College building, Ventilation.

1. Introduction

Air conditioning has become an essential part of modern buildings like colleges, hospitals, offices, and shopping malls. In colleges, many people gather in classrooms and labs, which produce heat and make the environment uncomfortable. Also, heat from sunlight, electrical equipment, and computers increases the temperature inside the building. To maintain a healthy and pleasant environment, a proper air conditioning system is required. This project focuses on the design of an air conditioning system for a multi-stored college building. The design process includes calculating the cooling load, selecting suitable HVAC (Heating, Ventilation, and Air Conditioning) system components, and planning the distribution of air to each room. The goal is to ensure comfortable temperature, controlled humidity, and clean air throughout the building. A well-designed air conditioning system not only improves comfort but also supports better concentration, reduces fatigue, and enhances the overall performance of students and staff. Designing an HVAC (Heating, Ventilation, and Air Conditioning) system for a multi-storey building is a balancing act between energy efficiency, initial cost, and the specific needs of the tenants. Unlike a single-family home, high-rises deal with massive "stack effects" and varying cooling loads depending on which side of the building faces the sun. When designing an air conditioning system for a multi-storey building, the most common approach is the Variable Air Volume (VAV) system. This is a centralized "all-air" design where a massive Air Handling Unit (AHU), typically located on the roof or in a dedicated mechanical floor, cools a high volume of air and pushes it through large vertical ducts. As the air reaches different floors, VAV boxes—which act like smart dampers—modulate the amount of cold air allowed into specific zones based on local thermostat demands. This system is highly favored for large commercial office towers because it centralizes maintenance to a few locations and provides excellent ventilation, though it requires significant "plenum space" (the gap between the ceiling and the floor above) to house the bulky ductwork. Because they don't require large mechanical rooms or massive ducts, they are the go-to choice for retrofitting historical multi-storey buildings or for high-end residential towers where energy ratings (like LEED) are a primary goal.Finally, for buildings aiming for high-performance sustainability and quiet operation, Chilled Beam systems are becoming increasingly popular. These are "air-water" hybrids where chilled water pipes are integrated into ceiling-mounted fixtures.

FIG -1

For buildings where individual room control is the priority, such as hotels or luxury apartments, Fan Coil Unit (FCU) systems are often preferred. This "all-water" design uses a central chiller and boiler to circulate chilled or heated water through a network of pipes to small units installed in every room. Since pipes are much smaller than air ducts, this design saves a significant amount of vertical space, allowing architects to potentially add extra floors within the same building height. A "four-pipe" configuration is the gold standard here, as it allows one guest to cool their room while the person next door heats theirs, providing maximum comfort but requiring more complex plumbing and frequent filter changes in every unit. A more modern and highly efficient alternative is the Variable Refrigerant Flow (VRF) system. Instead of using air or water as the cooling medium, VRF systems circulate refrigerant directly between an outdoor condenser and multiple indoor units. These systems are incredibly sophisticated; they can perform heat recovery by capturing heat rejected from a cooling zone and transferring it to a zone that needs warmth, which drastically reduces energy bills. Alternatively, Variable Refrigerant Flow (VRF) systems have gained popularity because they allow for precise, individualized control—perfect for buildings with mixed-use spaces like offices and retail— without the massive ductwork required by traditional systems.A critical factor in the design is zoning. The "perimeter zone" of a building (the rooms with windows) faces constant fluctuations due to sunlight and outside temperatures, while the "interior core" usually requires cooling year-round because of heat generated by lights, computers, and people. A well-designed system uses Variable Air Volume (VAV) boxes to throttle the airflow to these different zones independently.

FIG -1.2

Facade Materials: Wood-finish ACP Panels: The brown section is likely made of Aluminium Composite Panels (ACP) with a timber texture. This gives a warm, organic look without the maintenance of real wood.

Grey Cladding: The right-hand section uses metallic or matte grey ACP panels, creating "modular" look.

Glass Curtain Wall: The dark, reflective glass section on the left is a structural glazing system. It’s designed to allow natural light while reflecting a portion of solar heat to keep the interiors cool.

Landscaping: The use of palm trees and manicured topiary bushes (conical trees) in the foreground suggests an eco-friendly "Green Building" approach, which helps in local temperature regulation.

Structure: It is a low-to-mid-rise structure (likely 4–5 floors) with high ceilings on the ground floor, typical for a grand lobby or reception area.

FIG -1.3

Air Conditioning (HVAC) System

Variable Refrigerant Flow systems are standard for this size. They allow individual temperature control for different rooms and are energy-efficient for buildings with glass facades that heat up unevenly.

Facade Materials: Wood-Finish ACP Panels: The central brown section consists of Aluminium Composite Panels (ACP) with a wooden texture. These provide the aesthetic warmth of wood but are weather-resistant and require much less maintenance.

Metallic Cladding: The grey section on the right also uses ACP sheets, providing a sleek, modular appearance typical of modern Indian corporate offices.

structural Glazing: The dark reflective section on the left is a glass curtain wall. This allows natural light to enter the workspace while reflecting solar heat to improve energy efficiency.

Structure & Landscaping: This is a mid-rise building (approx. 4–5 floors) with a grand, high-ceiling ground floor area. The presence of palm trees and conical topiary suggests an eco-friendly "Green Building" design, which helps mitigate local heat.

Likely Air Conditioning (HVAC) System

For a building of this scale and design (large glass facade and multiple floors), the following systems are standard in modern Indian commercial construction:

VRF/VRV System: Most Common. Variable Refrigerant Flow/Volume systems are highly efficient for buildings that have different cooling needs across various rooms or "zones".

Centralized Chiller: Possible if the building is part of a larger corporate campus. It uses chilled water to cool air via Air Handling Units (AHUs) hidden in the ceiling.

Ductable Splits: Often used for open-plan floors. The cooling units are placed above false ceilings, while compressors are typically hidden on the rooftop or in a service area.

FIG -1.4

APPLICATIONS

Classrooms and Lecture Halls: Provides comfortable conditions for teaching and learning.

Libraries and Study Areas: Maintains a quiet and comfortable environment for studying.

Laboratories and Research Facilities: Regulates temperature and humidity for sensitive equipment and experiments.

Administrative Offices: Provides a comfortable working environment for staff and faculty.

Common Areas and Cafeterias: Maintains a comfortable environment for students and faculty to socialize and relax.

BENEFITS

Improved Learning Environment: Enhances student learning and academic performance.

Increased Productivity: Boosts faculty productivity and efficiency.

Energy Savings: Reduces energy consumption and costs.

Reduced Maintenance: Minimizes maintenance and repair costs.

Enhanced Reputation: Demonstrates commitment to providing a comfortable and healthy learning environment.

PROBLEM DEFINITION

Designing an air conditioning system for a multi-stored college building involves creating a system that provides a comfortable and healthy learning environment for students, faculty, and staff while minimizing energy consumption and environmental impact. The system must address varying cooling and heating loads, maintain good air quality, and ensure reliable operation with minimal maintenance. Key challenges include balancing energy efficiency with comfort, managing humidity and air distribution, and meeting the diverse needs of different building areas, such as classrooms, laboratories, and administrative offices, all within budgetary constraints.

2.LITERATURE REVIEW:

K.VenkataChary et,al., [1] the design of a centralized air-conditioning system for a multi-storeyed office building located in Hyderabad. The building consists of eight floors and two basements, with a total conditioned area of about 2,40,000 sq.ft. The main aim is to provide thermal comfort, good indoor air quality, and energy-efficient operation. The proposed system uses a combination of air cooled screw chillers and a water-cooled centrifugal chiller, installed on the terrace. A primary and secondary pumping system with VFDs is adopted to improve energy efficiency. AHUs are used for air distribution with proper zoning for different floors and functional areas such as offices, hub rooms, cafeterias, and data centers. For night operation and part-load conditions, VRF systems are recommended as standby units to reduce power consumption. The study concludes that the designed system is economical, energy-efficient, reliable, and easy to operate and maintain.

Chuneshwar Lal et,al., [2] the design of an air distribution (ducting) system for a multi-story office building using the Equal Friction Method. The objective is to ensure uniform air distribution, minimum pressure loss, reduced noise, and lower power consumption. The authors explain the importance of proper duct design, as poorly designed ducts lead to high friction losses, uneven cooling, increased fan power, and higher installation cost. Cooling load calculations are carried out first to determine the required air flow rate for different rooms. Based on the cooling load, FCUs are used for loads up to 5 TR, and AHUs are used for higher loads, where ducting is required. Duct sizes are calculated using standard hand calculations and then compared with ductulator software results. Further analysis using ANSYS CFD software shows that circular ducts have lower friction losses than rectangular ducts, making them more efficient. The study concludes that the equal friction method is simple, reliable, and suitable for practical duct design, and circular ducts are preferable for energy efficient air distribution.

Ruijun Chen et.al.,[3] study analyzes the energy performance of different air-conditioning (AC) technologies in a university building located in a tropical climate in Colombia. The existing system uses conventional split AC units, which consume a large amount of electricity. Using Energy Plus and Design Builder simulation tools, the authors evaluate four AC options: Split, VRF, VAV, and Chiller systems.

Actual energy consumption data are used to calibrate the model and ensure accuracy. The results show that replacing split AC units with more efficient technologies can reduce energy consumption by nearly 30% and life-cycle costs by about 15%, even though the building already meets national energy standards. The study highlights the importance of energy simulation, technology comparison, and life-cycle cost analysis in improving HVAC efficiency. It concludes that upgrading AC systems in educational buildings can significantly enhance energy performance and sustainability.

Juan Jose Cabello-Eras et.al.,[4] paper focuses on reducing energy consumption in university library buildings by improving real-time HVAC control strategies. HVAC systems account for a major share of energy use in libraries, and many older buildings still rely on manual or inefficient control methods. The authors propose an intelligent control strategy based on the Leven berg–Marquardt algorithm combined with a global optimization algorithm (LM-UGO). A university library is used as a case study, where real operational data are applied to optimize system parameters such as chilled water temperature, flow rate, and pressure. The results demonstrate that the proposed strategy achieves over 30% energy savings while maintaining or improving indoor thermal comfort. The study concludes that advanced optimization algorithms and real-time control can play a vital role in enhancing HVAC efficiency and sustainability in educational buildings**.**

Yiquan Zou et.al.,[5] focuses on improving the energy efficiency of HVAC systems in university library buildings, where HVAC accounts for 40–60% of total energy consumption. Many older libraries rely on manual or inefficient control methods, leading to excessive energy use and poor indoor comfort. The study proposes an intelligent real-time HVAC control strategy using a combination of the Levenberg–Marquardt (LM) algorithm and a Universal Global Optimization (UGO) algorithm. A university library building is selected as a case study, and real operational data are used to model and optimize HVAC system performance. The strategy dynamically adjusts parameters such as chilled water temperature, flow rate, and system pressure based on load demand and environmental conditions. Results show that the proposed control method achieves energy savings of over 30% while significantly improving thermal comfort for occupants. The study concludes that advanced algorithm-based real-time control is highly effective for enhancing HVAC energy efficiency and sustainability in educational buildings.

B. Yang et.al.,[6] journal presents a comprehensive review of advanced air distribution and ventilation methods used in HVAC systems, focusing on their impact on thermal comfort, indoor air quality, and energy efficiency. Ventilation strategies are classified into fully mixed ventilation and non-uniform ventilation, including displacement, stratum, piston, task, and personalized ventilation. The paper explains the theoretical principles, airflow characteristics, performance, and practical applications of each method. Limitations such as draft risk, buoyancy dependence, and heating-mode constraints are critically discussed, along with possible solutions. Special attention is given to stratified and displacement ventilation, which offer better air quality and energy savings compared to traditional mixing systems. The review also discusses evaluation indices, experimental measurement techniques, and recent research trends. The study concludes that selecting an appropriate air distribution method based on building type and climate can significantly enhance occupant comfort and HVAC energy performance.

Clito F. A. Afonso et.al.,[7] review paper discusses recent developments in building air-conditioning technologies aimed at reducing energy consumption, CO_2 emissions, and environmental impact. Traditional vapor compression systems are compared with advanced electrical, thermal, and hybrid cooling systems. The paper classifies cooling technologies based on the final energy source, including electrically driven systems, thermally driven systems (absorption, adsorption, ejector), and hybrid systems. Special emphasis is placed on solar cooling technologies, which utilize renewable energy and significantly reduce greenhouse gas emissions. The study explains the operating principles, coefficient of performance (COP), advantages, and applications of each system. It highlights that thermally driven systems produce lower CO_2 emissions than conventional electric systems and are attractive where waste heat or solar energy is available. The paper concludes that future HVAC development should focus on sustainable, energy-efficient, and environmentally friendly cooling technologies.

Abdel-Hamid Attia et.al.,[8] investigates the application of fuzzy logic control (FLC) to improve the energy efficiency and comfort performance of residential air-conditioning systems. A detailed mathematical model of a fan-coil unit (FCU) is developed to control both room temperature and relative humidity. The fuzzy controller adjusts chilled water, hot water, and steam flow rates based on thermal and humidity errors. Computer simulations are conducted for summer and winter conditions, and the performance of the fuzzy controller is compared with a conventional PID controller. Results show that the fuzzy logic controller maintains indoor conditions within the ASHRAE comfort zone and performs better during part-load operations, where PID control fails. The study demonstrates that fuzzy logic control achieves lower energy consumption, improved stability, and better comfort, making it a suitable intelligent control strategy for residential HVAC systems.

S. Prakash et.al.,[9] study analyzes the past, present, and future market trends of air-conditioning systems in European buildings. Using reformulated market diffusion models calibrated with sales data, the authors estimate sales growth, replacement rates, and installed stock levels of major air conditioning products across EU-27 countries. The research shows that although growth rates are slowing compared to earlier years, overall sales and installed capacity of air-conditioning systems will continue to increase. Split-system room air conditioners and chillers dominate the market in terms of cooling capacity, while variable refrigerant flow (VRF) systems are rapidly gaining popularity, particularly for new installations. The study highlights differences between residential and non residential markets and emphasizes the importance of understanding equipment lifetimes and replacement cycles. The findings provide a strong analytical foundation for developing future European energy and environmental policies related to air-conditioning systems.

P. Suresh et.al.,[10] paper compares centralized and decentralized air-conditioning systems used in residential buildings, focusing on their energy consumption and operational efficiency. Through three real residential case studies in China, the authors examine how system configuration, user control, and distribution methods influence overall energy performance. The results show that centralized air conditioning systems often consume significantly more energy than decentralized (split) systems, mainly due to continuous operation, low part-load efficiency, and high pumping and distribution energy. When users cannot control indoor terminals, cooling demand and electricity consumption increase drastically. Even when user control is available, centralized systems still suffer from inefficiencies under low load conditions. The study concludes that centralized systems in residential buildings may lead to high energy consumption unless carefully designed and operated. User adjustability, flexible operation, and proper system sizing are identified as key factors for improving energy efficiency.

Mehmet Azmi Aktacir et.al.,[11] study investigates how thermal insulation affects building cooling load and air-conditioning system performance in hot and humid regions of Turkey. A sample office building was analyzed using three different insulation levels based on national thermal insulation regulations. Cooling loads were calculated using the Radiant Time Series (RTS) method, and life-cycle cost analysis was performed to evaluate economic feasibility. The results demonstrate that effective thermal insulation significantly reduces both peak cooling demand and annual energy consumption of air-conditioning systems. Although increased insulation thickness slightly lowers cooling loads, the most economically optimal solution corresponds to a medium insulation level (C-type building). The study also shows that insulated buildings require smaller air-conditioning equipment, leading to reduced initial and operating costs. The authors conclude that thermal insulation is essential for energy savings and should be designed considering cooling requirements, especially in regions where cooling demand dominates.

Theo Elmer et.al.,[12] paper presents the experimental evaluation of a novel Integrated Desiccant Air Conditioning System (IDCS) developed for building applications. Conventional liquid desiccant systems face limitations such as large size, system complexity, desiccant leakage, and corrosion. To overcome these issues, the proposed system integrates the dehumidifier, regenerator, and evaporative intercooler into a single compact membrane-based heat and mass exchanger. Potassium formate, a non-corrosive and environmentally friendly desiccant, is used as the working fluid. Experimental tests were conducted to assess dehumidification performance, cooling output, and coefficient of performance. Results show cooling capacities between 570 W and 1362 W, dehumidifier effectiveness of 30–47%, and electrical COP values up to 3.67. Although moisture imbalance between regeneration and dehumidification was observed, adjusted thermal COP values up to 1.26 were achieved. The study confirms the technical feasibility of compact liquid desiccant air-conditioning systems for buildings.

F. W. H. Yik et.al.,[13] study investigates methods for predicting air-conditioning energy consumption in groups of buildings using different heat rejection systems, particularly in the context of Hong Kong.

The paper compares air-cooled air-conditioning systems (AACS) with water-cooled air conditioning systems (WACS), highlighting that WACS generally consume less electricity. Due to restrictions on freshwater use, Hong Kong mainly relies on air-cooled systems, prompting interest in centralized seawater cooling and district cooling systems. The authors analyze real energy consumption data from office buildings and hotels and develop a method to estimate cooling demand and electricity use on a district scale. Simulation tools are validated using survey and audit data. Results show significant energy savings when WACS or district cooling systems are adopted, especially in continuously operated buildings such as hotels. The study provides a practical framework for evaluating large-scale cooling infrastructure, supporting energy-efficient and environmentally sustainable urban planning.

Amreen Shajahan et.al.,[14] paper examines how indoor environmental parameters controlled by HVAC systems affect patient medical outcomes in mechanically ventilated hospital buildings. A systematic review of 176 research articles published after 1998 was conducted, focusing on temperature, relative humidity, ventilation rate, air filtration, and pressure control. The review highlights strong evidence linking indoor environmental quality to infection control, recovery time, length of hospital stay, and overall patient wellbeing. Improper temperature and humidity levels are shown to increase the risk of surgical site infections and airborne disease transmission. Adequate ventilation and filtration improve indoor air quality and reduce hospital-acquired infections. The study emphasizes that HVAC design plays a critical role in patient safety and healthcare performance. The authors conclude that existing standards should be refined based on medical outcomes and call for interdisciplinary research to establish optimal HVAC parameter ranges that enhance patient recovery and reduce healthcare costs.

Z. Ma et.al.,[15] study addresses the high energy consumption of HVAC systems in non-residential buildings by proposing a multizone predictive control strategy. Researchers modeled a real building in Perpignan, France, using EnergyPlus and developed low-order Artificial Neural Network (ANN) models to predict thermal conditions. A genetic algorithm was employed to optimize the on/off switching times for individual HVAC subsystems in both heating and cooling modes. Compared to basic scheduling techniques (like 24-hour operation or fixed timers), the predictive approach significantly reduced electrical power consumption while maintaining strict thermal comfort requirements, measured by the Predicted Mean Vote (PMV) index. Findings showed that optimized switching could save up to five hours of daily operation in winter and two hours in summer. The study concludes that predictive management is a highly effective alternative to conventional scheduling for improving building energy efficiency.

Chengliang Fan et.al.,[16] paper focuses on improving cooling load prediction to enhance the energy efficiency and operational stability of HVAC systems in office buildings. Since HVAC systems consume nearly 68% of total building energy, accurate cooling load forecasting is essential for optimal control strategies such as model predictive control. The authors propose an improved regression-based Autoregressive with Exogenous inputs (ARX) model. Unlike traditional regression methods, this model incorporates sensitivity analysis to select key influencing variables and includes quadratic terms to address system nonlinearity. A least squares method is used for training the model. Comparative studies show that the improved ARX model significantly enhances prediction accuracy and reduces the impact of outliers. The study concludes that this approach is practical, computationally efficient, and well suited for real-time HVAC control applications, contributing to reduced energy consumption and improved system reliability.

Moncef Krarti et.al.,[17] journal presents a comprehensive overview of energy-efficient HVAC systems and operational strategies for commercial buildings. It highlights that HVAC systems can account for nearly 50% of a building's total electrical energy consumption, emphasizing the need for efficient design and control. The paper explains the basic components of HVAC air distribution systems and outlines their primary objectives, including thermal comfort and indoor air quality. Special attention is given to demand-controlled ventilation (DCV), particularly CO_2-based control strategies, which adjust outdoor air intake based on occupancy levels. The study discusses suitable building conditions for effective DCV implementation and reports significant energy savings from field studies. The paper also addresses ventilation requirements for special spaces such as parking garages. Overall, the journal provides practical guidance for designers and engineers to reduce HVAC energy use while maintaining occupant comfort and compliance with standards.

Yufeng Zhang et.al.,[18] study investigates thermal comfort, occupant behavior, and adaptive responses in buildings equipped with split air-conditioners in the hot-humid climate of South China. A year-long field study was conducted with 30 college students, combining questionnaire surveys with environmental measurements. The results show that thermal sensation is linearly related to effective temperature indices (ET* and SET), with thermal neutrality around 25–26 °C. The acceptable thermal comfort range was wider than conventional standards, indicating strong occupant adaptation. Adaptive behaviors such as clothing adjustment, window operation, and fan use were closely linked to indoor temperature. Compared to naturally ventilated buildings, occupants in split air-conditioned buildings preferred cooler indoor environments and showed more sensitive thermal perception. The study provides valuable insights for designing energy-efficient buildings and setting realistic comfort standards in hot-humid regions.

Xudong Zhao et.al.,[19] study evaluates the viability of a novel dew point evaporative cooling system across various climatic regions in China. Unlike traditional methods, this system uses a polygonal sheets-stacked heat exchanger to cool air below its wet bulb temperature without adding moisture. Researchers analyzed weather data from seven locations to assess cooling capacity and water consumption. The findings indicate the system is highly effective in hot, dry climates like northern and western China, achieving a dew point effectiveness of up to 85%. In humid regions like Shanghai, efficiency is lower, though pre-treating air with a silica-gel dehumidifier can make the technology feasible. The system uses standard tap water at a rate of 2.6–3 liters per kWh of cooling. Ultimately, the paper highlights this technology as a sustainable, energy-efficient alternative to conventional mechanical compression systems.

A. Coronas et.al.,[20] research focuses on the thermal behavior and energy efficiency of an absorption-based air-conditioning system at a university building in Spain. While many HVAC studies rely on simulations, the authors argue these often fail to reflect real-world transient conditions. To address this, they enhanced an existing monitoring system with additional sensors and flow meters to track a double-effect water-lithium bromide absorption chiller throughout the summer of 2002. Data was recorded every minute and stored in a remote MySQL database for real-time analysis. The study evaluates the actual Coefficient of Performance (COP) and the impact of frequent on/off cycles on energy consumption. By establishing a comprehensive energy balance for the integrated system— including distribution circuits and terminal units—the work provides essential experimental data to validate and improve existing HVAC simulation models.

3.METHODOLOGY

The process typically starts with a thorough analysis of the building's layout, orientation, and usage patterns, followed by the calculation of building loads using software or manual calculations. The next step involves selecting suitable components, such as chillers, air handling units, and pumps, and designing an efficient air distribution system. The design should also incorporate energy-efficient strategies, such as variable air volume systems, energy recovery ventilation, and building management systems, to minimize energy consumption and environmental impact. Designing an HVAC (Heating, Ventilation, and Air Conditioning) system for a multi-storey building is a complex process that balances thermal comfort, energy efficiency, and structural constraints. The methodology begins with a rigorous Cooling Load Calculation. Using industry-standard software and ASHRAE guidelines, engineers analyze the building's "skin" (walls, windows, and roof), internal heat gains from occupants and equipment, and geographical orientation. This step ensures the system is neither undersized— leaving occupants sweltering—nor oversized, which leads to inefficient "short-cycling" and poor humidity control.By considering different types of air conditioning systems so based on the architecture of our college building has modern commercial structure featuring a large glass curtain wall and integrated composite paneling—the air conditioning system is a Centralized VRF (Variable Refrigerant Flow) or a Chilled Water System. These systems are designed to handle the specific thermal challenges of modern buildings.

Phases

System Selection and Zoning

Once the total load is established, the designer must select the Air Conditioning Topology. For multi-storey structures, the choice usually falls between centralized systems (like Chilled Water Systems) or decentralized systems (like Variable Refrigerant Flow/Volume, VRF/VRV). Centralized systems typically utilize a rooftop chiller and a basement boiler, circulating fluids to Air Handling Units (AHUs) on each floor.Effective Zoning is critical here; the perimeter of the building (affected by the sun) and the interior core (affected by lights and computers) have vastly different thermal needs and must be controlled independently to prevent some rooms from being ice boxes while others stay warm.

Ventilation and Control Logic

Modern methodology places a high premium on Indoor Air Quality (IAQ) and Energy Recovery. Designers integrate Dedicated Outdoor Air Systems (DOAS) to bring in fresh air, often using heat exchangers to "pre-cool" incoming hot outside air using the exhausted cool building air. Finally, a Building Management System (BMS) is programmed. This is the "brain" of the building, using sensors to monitor CO2 levels, occupancy, and temperature in real-time. It adjusts variable speed drives (VSDs) on pumps and fans to ensure the system only works as hard as it needs to, significantly cutting down on utility bills.Building on the initial design phases, the methodology transitions into the technical specifics of fluid dynamics and long-term sustainability.

Hydronic Piping and Pumping Design

For chilled water systems, the Hydronic Design is as vital as the air distribution. Engineers must calculate the "Pressure Drop" across the entire circuit to size the primary and secondary pumps. A common methodology uses a Primary-Secondary Pumping Loop, where the primary pumps maintain a constant flow through the chiller to prevent freezing, while secondary pumps use variable frequency drives (VFDs) to deliver only the amount of water needed by the various floors. This stage requires careful selection of pipe materials—often black steel or copper—and insulation thickness to prevent condensation from dripping onto ceiling tiles.

Acoustic Engineering and Vibration Isolation

In a multi-storey environment, the HVAC system is often the primary source of noise. The methodology must include Acoustic Mitigation. This involves placing "Sound Attenuators" (silencers) within the ductwork near the Air Handling Units and using flexible connections to join ducts to fans. For the heavy machinery, Vibration Isolation is used; chillers and pumps are mounted on inertia bases with spring isolators. Without this, the mechanical vibrations would travel through the building's steel or concrete frame, turning the entire structure into a giant tuning fork.

Life Cycle Cost Analysis (LCCA)

Beyond the physical installation, a professional methodology includes a Life Cycle Cost Analysis. This goes beyond the initial "sticker price" of the equipment. Designers simulate the building’s energy consumption over 15 to 20 years, factoring in: Maintenance accessibility: Ensuring filters and motors can be reached without tearing down walls. Energy tariffs: Optimizing the system to run heavy loads (like ice storage) during off-peak night hours. Water treatment: Planning for the chemical upkeep of cooling towers to prevent scaling and Legionella growth.

BENEFITS

Benefits for Occupants: Improved Comfort: Maintains a comfortable temperature and humidity level, enhancing learning and productivity.

Better Air Quality: Removes pollutants and allergens, creating a healthier environment.

Reduced Noise Pollution: Minimizes noise levels, reducing distractions and improving focus. Benefits for Building Management:

Energy Efficiency: Optimizes energy consumption, reducing energy costs and environmental impact.

Reliability and Maintenance: Ensures reliable operation and easy maintenance, minimizing downtime and disruptions.

Increased Productivity: Creates a comfortable and healthy environment, boosting occupant productivity and satisfaction.

APPLICATIONS

Classrooms and Lecture Halls: Provides comfortable conditions for teaching and learning**.**

Libraries and Study Areas: Maintains a quiet and comfortable environment for studying**.**

INFRASTRUCTURE DETAILS:

INFRASTRUCTURE OF THE COLLEGE BUILDING:

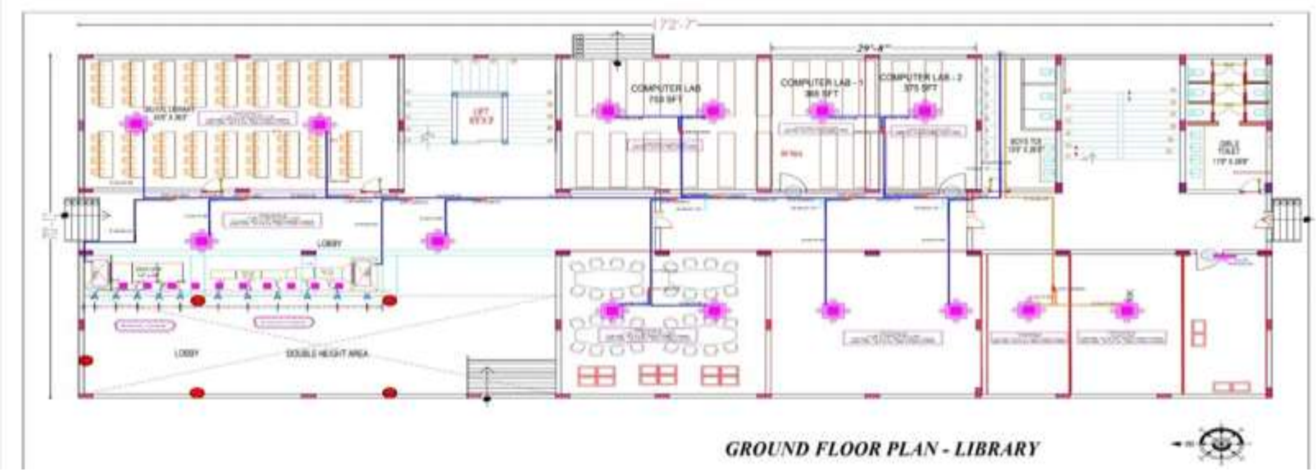


FIG-3.1

Infrastructure Overview:

Building Layout: The ground floor plan includes various spaces like a digital library, computer labs, toilets, lobby, and meeting areas.

Spaces and Dimensions: Specific areas are labeled with dimensions, such as the digital library (60' x 80'), computer labs (758 sq ft, 365 sq ft, 375 sq ft), and toilets (109' x 26', 119' x 26').

Air Conditioning Considerations: The design likely requires zoning for air conditioning to cater to different areas like labs, library, and common spaces, ensuring proper temperature and air quality.

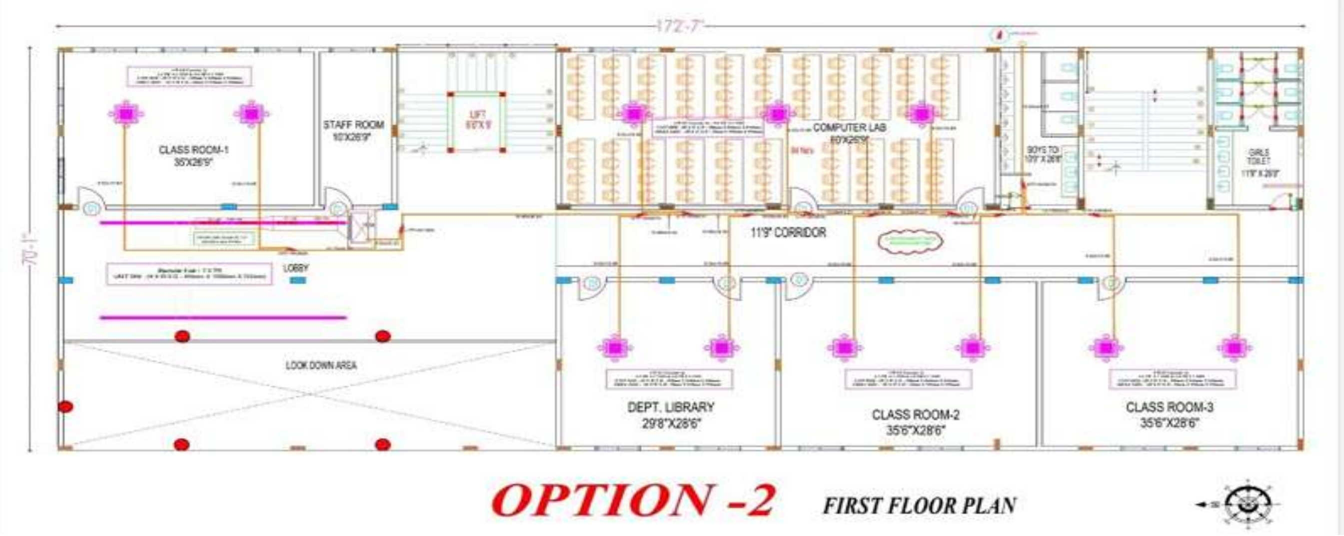


FIG -3.2

- Overall size: The floor plan spans approximately 172'-7" in length and 70'-1" in width.
- Rooms & dimensions:
- Class Room-1: 35' × 26'9".
- Staff Room: 10' × 26'9".
- Lift: 6'5" × 9'.
- Computer Lab: 40' × 26'9" with 84 computer stations.
- Boys Toilet: 19'9" × 28'9".
- Girls Toilet: 11'9" × 28'9".
- Lobby with a unit air- conditioner (7.5 TR).
- Dept. Library: 29'8" × 28'6".

- Class Room-2 & 3: both 35'6" × 28'6".

- Corridor: 11'9" wide connecting all major spaces.

The infrastructure for second & third floor is same as infrastructure for first floor

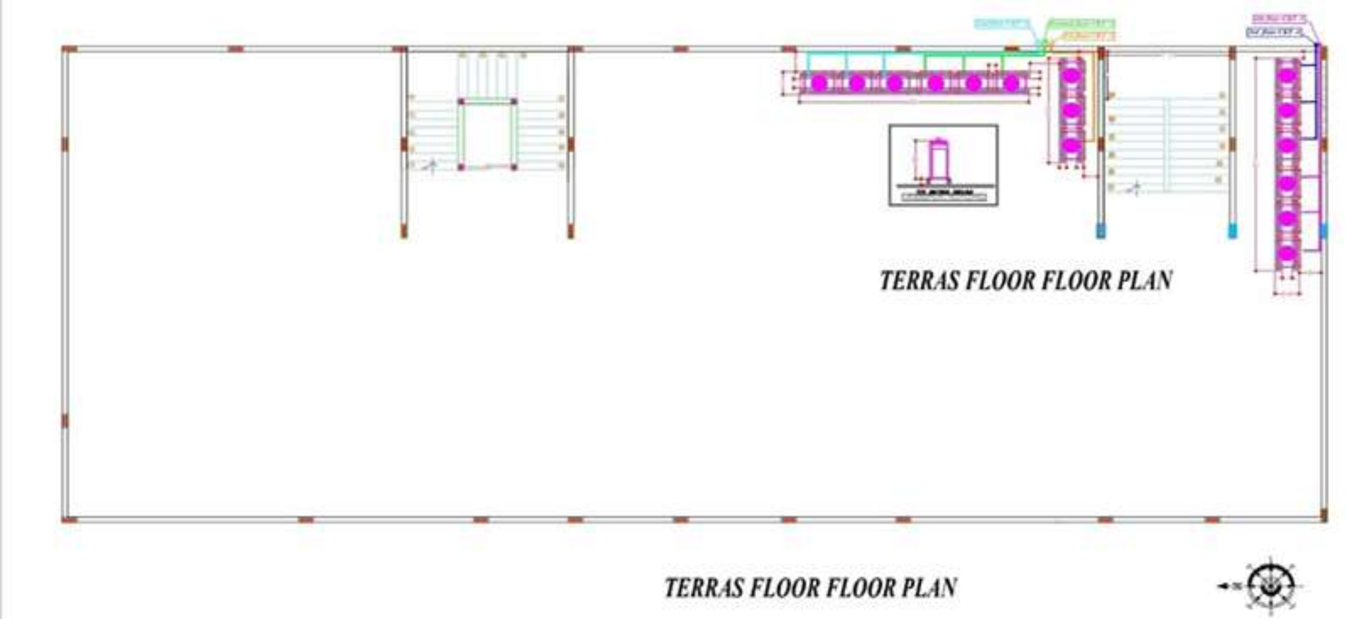


FIG -3.4

Left side: A larger, simplified outline of the terrace floor layout showing the building envelope and column positions (red dashes indicate structural elements).

Right side: A detailed section of the terrace floor with: -

Four labeled “2nd Floor CFT” ducts or shafts (green text). –

Pink-highlighted areas representing structural or utility elements (possibly columns or service cores). –

An inset detail showing a column section with dimensions.

4.CALCULATIONS

This chapter describes about designing an air conditioning system for a multi-storey college building involves calculating the cooling load using factors like building area, occupancy, and external climate. The building is divided into zones based on usage and exposure, and each zone's load is calculated to tailor airflow and capacity. A centralized or decentralized system is chosen, and air handling units (AHUs) are sized based on required airflow. Duct design, chiller and pump sizing, and energy efficiency measures like variable speed drives are also considered. The system is designed to meet local building codes and ASHRAE standards for indoor comfort and energy performance, ensuring a comfortable and healthy learning environment while minimizing energy consumption and environmental impact. The step by step calculations were calculated below.

LOAD CALCULATIONS FOR THE GROUND FLOOR

Load calculations for digital lab:

Assumptions-

- Specific heat of air Cp = 1005J/KG°C.
- Inside temp = 24°C.
- Outside temp = 35°C.
- Air density = 1.2 kg/m³.
- ACH (infiltration) = 1.0
- Sensible heat = 100 W/person
- Appliances (lights, TV, computers, fan)
- Window solar / glazing assumptions: single-pane / clear glass approximations:
- Conductive U-value ≈ 5.7 W/m²·°C (single pane).
- Solar heat gain coefficient (SHGC) ≈ 0.70 and a full-sun incident radiation of ~600 W/m² for an exposed sunlit wall/window
- Brick wall U ≈ 1.5 W/m²·°C.
- Latent heat of condensation ≈ 2,450 kJ/kg (2,450,000 J/kg).
- Atmospheric pressure = 101.325 kPa.
- Outside RH = 60% • Inside RH = 40%
- Dimensions of digital lab = 45'6" X 26'8"(13.87m*8.13m)
- Height = 14 feet (4.267m) • Wall area = (L + B) * H Formulas
- Volumetric flow = V *1ACH/3600S

- V=LBH • Mass flow = v.f * air density
- Qs vent = m.cp * ΔT
- Q walls = U × A × ΔT
- Q conductive = U-Glass * A-Glass * ΔT
- Solar through glass (rough) = solar incident × SHGC × A
- Latent power = ṁ × Δw × h_fg

Recalculation (sensible + latent breakdown)

Sensible heat

1) Occupants = 20 * 100 (people) = 200W

2) Appliances – Lights = 6 * 40W = 240W

Fans = 4 * 100W = 400W

Computers = 20 * 300W = 6000W

Total = 6640W

3) Ventilation sensible(1ACH)

Volumetric flow = V *1ACH/3600S V=LBH =13.87*8.13*4.267 =481.16*1/3600 =0.1336 m³/s

4) Mass flow = v.f * air density = 0.1336 * 1.2 = 0.160 kg/s

5) Qs vent = m.cp * ΔT = 0.160 * 1005 * (35 – 24) = 1768.8W

6) Walls (conductive, estimate)

Qwalls = U × A × ΔT = 1.7 * 93.874 * 11 = 1755.443W

7) Conductive glass Q cond = U-Glass * A-Glass *

ΔT = 5.7 * 9.786 * 11 = 290.4644W

8) Solar through glass (rough) = solar incident × SHGC × A = 600 W/m² * 0.70 * 9.786 = 4110.12W

9) Total window sensible = 290.4644 + 4110.12 = 4400.584W

10) Total sensible = 2000 + 6640 + 1768.8 + 1755.44 + 4400.584 = 16.56KW

Latent heat

- Two main latent sources considered:
- Latent from ventilation (outside air moisture to be removed to inside condition).
- Latent from occupants (people produce moisture)
- Ventilation latent (calculation)
- Using psychrometric approximation:

At 35°C, 60% RH → humid ratio ≈ 0.015 kg water / kg dry air At 24°C, 40% RH → humid ratio ≈ 0.0074 kg water / kg dry air

1) Δw = 0.015 - 0.0074 = 0.0141 kg water / kg dry air

2) ṁ-dry air = 0.183 kg/s (from ventilation) Latent power = ṁ × Δw × h_fg = 0.183 * 0.0141 * 2,450,000 = 6321.73W

3) Latent from people = 20 * 45W = 900W

4) Total latent = 6321.73 + 900 = 7221.73W

TOTAL (LATENT + SESNIBLE) = 7.22 + 16.56 = 23KW

That is roughly ~6.54 refrigeration tons (1 TR ≈ 3.517 kW) = 6.54TR

Load calculations for computer lab:

Sensible heat Dimensions = 29'-8" = 9.04m

Wall area = (9.04 + 9.04)*4.267 = 77.14m2

Glass area = 1.5 * 1.5 = 2.25*5 = 11.25m2

1) Occupants = 30 * 100 (people) = 300W

2) Appliances – Lights = 4 * 40 = 1600W Fans = 2 * 100 = 200W

Computers = 30 * 300 = 9000 Total = 10800

3) Ventilation sensible(1ACH)

Volumetric flow = V *1ACH/3600S

V=LBH =9.04*9.04*4.267 =348.70*1/3600 =0.0968m³/s

4) Mass flow = v.f * air density = 0.0968 * 1.2 = 0.11616kg/s

5) Qs vent = m.cp * ΔT = 0.11616 * 1005 * (35 – 24) = 1282.38W

6) Walls (conductive, estimate)

Qwalls = U × A × ΔT = 1.7 * 77.14 * 11 = 1442.51W

7) Conductive glass Q cond = U-Glass * A-Glass * ΔT = 5.7 * 11.25 * 11 = 705.37W

8) Solar through glass (rough) = solar incident × SHGC × A = 600 W/m² * 0.70 * 11.25 = 4425W

9) Total window sensible = 705.37 + 4725 = 5430.37W

10) Total sensible = 3000 + 10800 + 1282.38 + 1442.5 + 5430.37 = 21.95KW

Latent heat

- Two main latent sources considered:
- Latent from ventilation (outside air moisture to be removed to inside condition).
- Latent from occupants (people produce moisture)
- Ventilation latent (calculation)
- Using psychrometric approximation:

At 35°C, 60% RH → humid ratio ≈ 0.015 kg water / kg dry air At 24°C, 40% RH → humid ratio ≈ 0.0074 kg water / kg dry air

1) Δw = 0.015 - 0.0074 = 0.0141 kg water / kg dry air

2) ṁ-dry air = 0.183 kg/s (from ventilation)

Latent power = ṁ × Δw × h_fg = 0.183 * 0.0141 * 2,450,000 = 6321.73W

3) Latent from people = 30 * 45W = 1350W

4) Total latent = 6321.73 + 1350 = 7671.73W TOTAL (LATENT + SESNIBLE) = 7.22 + 16.56 = 23KW

That is roughly ~6.54 refrigeration tons (1 TR ≈ 3.517 kW) = 6.54TR

- The ton of refrigeration for the another computer lab = 6.54TR

Load calculations for another room in ground floor:

Sensible heat Dimensions– l = 8.83m, b = 8.83m, h = 4.267m Wall area = (8.83)*4.267 = 30.92m

Glass area = 1.5 * 1.5 = 2.25*3 = 6.75m2

1) Occupants = 10 * 100 (people) = 1000W

2) Appliances –

Lights = 2 * 40 = 80W

Fans = 2 * 100 = 200W

Computers = 4 * 300 = 1200W

Total = 2480W

3) Ventilation sensible(1ACH) Volumetric flow = V *1ACH/3600S

V=LBH =8.83*8.83*4.267

=327.46*1/3600 =0.09m³/s

4) Mass flow = v.f * air density = 0.09 * 1.2 = 0.108kg/s

5) Qs vent = m.cp * ΔT = 0.108 * 1005 * (35 – 24) = 1193.94W

6) Walls (conductive, estimate) Qwalls = U × A × ΔT = 1.7 * 30.92 * 11 = 578.204W

7) Conductive glass Q cond = U-Glass * A-Glass * ΔT = 5.7 * 6.75 * 11 = 423.22W

8) Solar through glass (rough) = solar incident × SHGC × A = 600 W/m² * 0.70 * 6.75 = 2835W

9) Total window sensible = 2835 + 423.22 = 3258.22W

10) Total sensible = 2480 + 1193.94 + 578.204 + 3258.22= 7.5KW

Latent heat

- Two main latent sources considered:

- Latent from ventilation (outside air moisture to be removed to inside condition).

- Latent from occupants (people produce moisture)

- Ventilation latent (calculation)

- Using psychrometric approximation:

At 35°C, 60% RH → humid ratio ≈ 0.015 kg water / kg dry air At 24°C, 40% RH → humid ratio ≈ 0.0074 kg water / kg dry air

1) $\Delta w = 0.015 - 0.0074 = 0.0141$ kg water / kg dry air

2) $\dot{m}$-dry air = 0.183 kg/s (from ventilation)

Latent power = $\dot{m} \times \Delta w \times h_{fg} = 0.183 * 0.0141 * 2{,}450{,}000 = 6321.73$W

3) Latent from people = 10 * 45W = 450W

4) Total latent = 6321.73 + 450 = 6.77W

TOTAL (LATENT + SESNIBLE) = 6.77+ 7.5 = 14KW

That is roughly ~3.9 refrigeration tons (1 TR ≈ 3.517 kW) = 3.9TR

- The ton of refrigeration for another 2 rooms = 3.9 TR & 3.9 TR

The total ton of refrigeration required for the ground floor = 6.54 + 6.54 + 6.54 +3.9 +3.9 +3.9 = 31.32 TR

LOAD CALCULATIONS FOR FIRST FLOOR

Load calculations for the department room:

Required TR = 4 TR

Load calculations for the computer lab:

Required TR = 11.94 TR

Load calculations for the classrooms 2 & 3:

Required TR = 6.03 TR

Load calculations for the classroom

1: Required TR = 6 TR

The total ton of refrigeration required for the first floor = 4 + 11.94 + 6.03 + 6 = 27.97 TR

LOAD CALCULATIONS FOR SECOND FLOOR

Required TR ≈ 27.97 TR (because of having same infrastructure & same number of rooms)

LOAD CALCULATIONS FOR THIRD FLOOR & FOURTH FLOOR

Required TR ≈ 27.97 TR (because of having same infrastructure & same number of rooms)

THE TOTAL TON OF REFRIGERATION FOR BUILDING

= Required TR for ground floor + Required TR for first floor + Required TR for second floor + Required TR for third floor = 31.32 + 27.97 + 27.97 + 27.97 +27.97= 143.2 TR

5.RESULTS & DISCUSSION:

INTRODUCTION:

The results of the air conditioning system design for the multi-storeyed college building show that the calculated cooling load adequately meets the thermal comfort requirements of classrooms, laboratories, offices, and common areas. By considering heat gains due to occupants, lighting, equipment, solar radiation, and ventilation air, the total cooling capacity was determined in accordance with ASHRAE (American Society of Heating Refrigerating and Air-Conditiong Engineers) comfort standards. The selected centralized air conditioning system ensures uniform temperature distribution, proper humidity control, and sufficient fresh air supply across all floors. The design also demonstrates energy efficiency by using appropriate zoning, optimized airflow rates, and suitable equipment sizing, which helps reduce unnecessary power consumption. Overall, the proposed system provides a comfortable indoor environment for students and staff while maintaining reliable operation and economical performance, making it suitable for a large educational building.

RESULTS:

Ground Floor Cooling Load

- Detailed sensible and latent heat calculations were carried out for digital labs, computer labs, and other rooms considering occupants, equipment, lighting, ventilation, wall conduction, and solar heat gain.

- The digital lab cooling load was found to be 23 kW (≈ 6.54 TR).

- Each computer lab required approximately 6.54 TR, mainly due to high internal heat gains from computers and occupants.

- Smaller rooms on the ground floor required 3.9 TR each.

- The total cooling load for the ground floor was calculated as 31.32 TR.

First Floor Cooling Load

- Load calculations for department rooms, computer labs, and classrooms were performed using similar assumptions and design conditions.

- The department room required 4 TR, while the computer lab required 11.94 TR.

- Classrooms required between 6 TR and 6.03 TR.

- The total cooling load for the first floor was 27.97 TR.

Second and Third & Fourth Floor Cooling Loads

- Since room usage, occupancy, and construction were similar to the first floor, the cooling load for both floors was taken as 27.97 TR each.

- Total Building Cooling Load

- The overall cooling capacity required for the entire multi-storeyed college building was calculated as: 31.32 + 27.97 + 27.97 + 27.97 = 143.2 TR

DISCUSSION ¬

Effect of Internal Heat Gains

- Internal loads from computers, lighting, and occupants contributed the largest portion of the sensible heat, especially in digital and computer labs.

- This highlights the importance of accurate equipment load estimation in educational buildings with high technology usage. ¬ Ventilation and Latent Load Impact

- Ventilation at 1 ACH significantly increased both sensible and latent loads.

- Latent heat due to moisture removal from outside air (35°C, 60% RH) to indoor conditions (24°C, 40% RH) formed a major part of the total load, emphasizing the need for proper humidity control.

Building Envelope Contribution

- Heat gain through walls and glazing, especially solar radiation through glass, had a noticeable impact on cooling load

- Single-pane glass with high SHGC increased solar heat gain, suggesting that better glazing could reduce overall cooling demand.

- **Floor-wise Load Distribution**

- The ground floor showed a slightly higher load due to a greater number of labs and equipment intensive spaces.

- Similarity in loads of the first, second, and third floors indicates uniform building usage and construction.

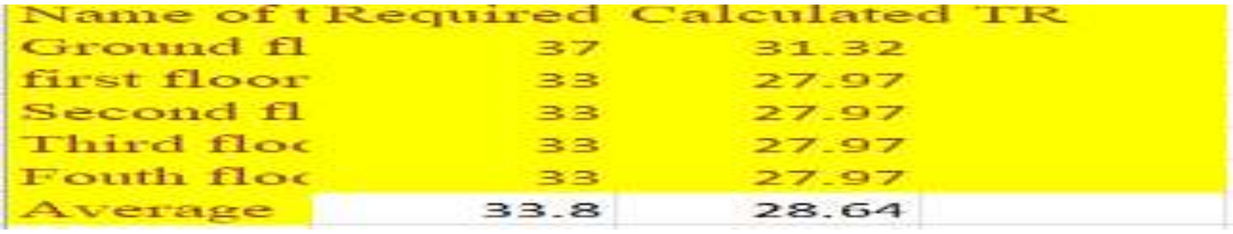
System Design Implication

- The total load of 115.23 TR supports the selection of a centralized air conditioning system with proper zoning for different floors and spaces.

- The calculated loads ensure thermal comfort as per standard indoor design conditions while avoiding over- or under-sizing of equipment. ¬

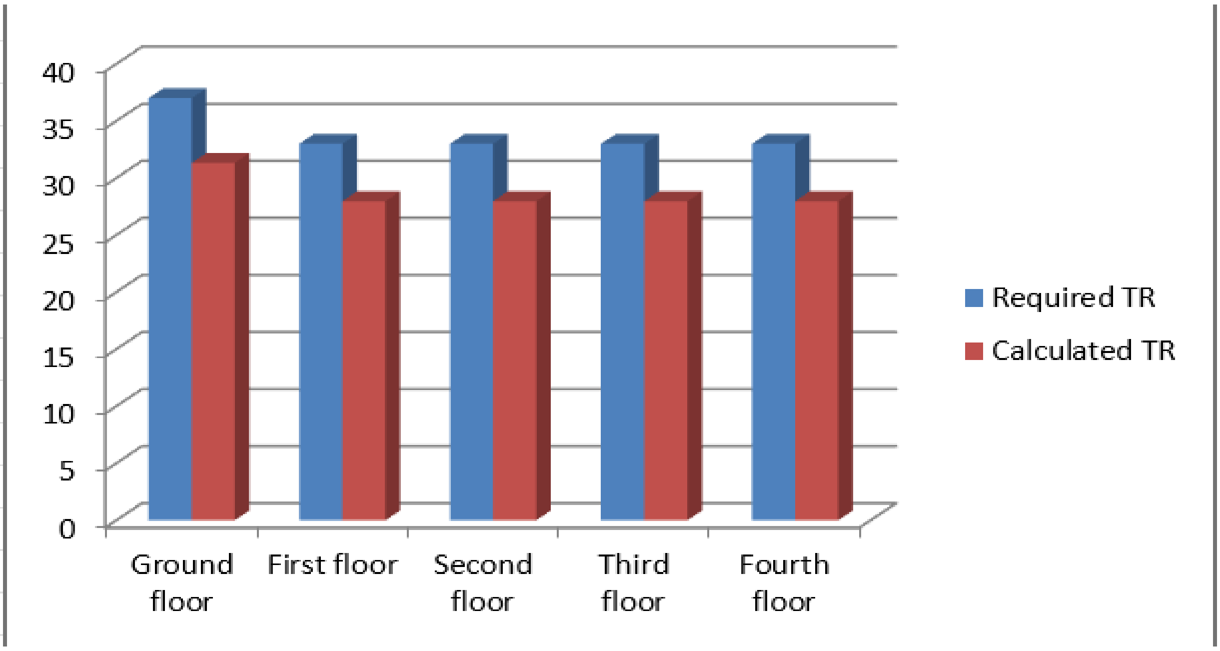
Overall Performance

- The designed air conditioning system is capable of maintaining comfortable temperature and humidity levels for students and staff.



Name of t	Required	Calculated TR
Ground fl	37	31.32
first floor	33	27.97
Second fl	33	27.97
Third floo	33	27.97
Fouth floo	33	27.97
Average	33.8	28.64

TABLE -5.1



Graph – 5.2

S.NO	Name of the floor	Required TR	Calculated TR
1	Ground floor • Digital lab • Computer labs • Classes Total	37 TR	6.54 TR 2 × 6.54 = 13.08 TR 3 × 3.9 = 11.7 TR = 31.37TR
2	First floor	33 TR	27.97
3	Second floor	33 TR	27.97
4	Third floor	33 TR	27.97
5	Fourth floor	33 Total = 169 TR Avg = 33.8 TR	27.97 Total = 143.2 TR Avg = 28.64 TR

Table -5.3

CONCLUSION:

This chapter describes about the conclusion of the air conditioning system for the multi-storeyed college building was successfully designed by carrying out detailed sensible and latent heat load calculations for each room and floor under standard indoor and outdoor design conditions. All major heat gain sources such as occupants, lighting, equipment, ventilation, wall conduction, and solar radiation through glazing were carefully considered. The results showed that computer labs and digital labs contribute the highest cooling load due to dense occupancy and extensive use of electronic equipment, while classrooms and department rooms have comparatively lower loads. The total cooling load for the entire building was estimated to be 143.2 TR, which provides a reliable basis for selecting and sizing the HVAC (Heating, Ventilation, and Air Conditioning) equipment. The proposed design ensures adequate thermal comfort, effective humidity control, and proper ventilation for students and staff. Overall, the system is suitable for educational buildings and can be further optimized for energy efficiency by using improved insulation, better glazing, and high-efficiency HVAC components. The load calculation methodology adopted in this project follows standard HVAC design practices and ensures realistic estimation of cooling requirements for an educational building. Proper separation of sensible and latent heat loads helped in understanding the impact of temperature control and humidity removal, which is essential for maintaining indoor air quality. The calculated total capacity of 143.2TR allows flexibility in selecting chillers or packaged units with standby margins for future expansion. The proposed air conditioning design not only satisfies thermal comfort requirements but also enhances productivity, concentration, and overall comfort of students and staff. This project demonstrates the practical application of thermodynamics, heat transfer, and psychrometric principles in real-world HVAC system design.

REASON TO REQUIRE HIGH TR (31.32) FOR GROUND FLOOR

The ground floor requires higher TR compared to the other floors mainly because of higher heat gain sources acting together:

More internal heat load

The ground floor contains digital labs and multiple computer labs, which have a large number of computers, servers, and occupants. These equipment continuously release heat, increasing the cooling requirement.

Heat gain from ground and walls The ground floor receives additional heat through floor contact with the ground, along with wall conduction from surrounding outdoor areas, which upper floors do not experience to the same extent.

Higher infiltration and ventilation load

Being closer to entrances and frequently used doors, the ground floor experiences more outside air infiltration, bringing hot air into the building and increasing the cooling load.

Direct solar heat gain

Ground floor rooms often have larger exposed wall areas and windows, leading to higher solar heat gain, especially during daytime.

The combination of high equipment density, more occupants, extra heat from the ground, higher air infiltration, and solar heat gain makes the ground floor cooling load higher, resulting in a greater TR compared to the upper floors.

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