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HEALTHY WORKSPACE: FIGHTING SICK BUILDING SYNDROME

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Abstract: Indoor as air quality (IAQ) plays a role in determining the comfort and work efficiency of individuals especially in Workspaces where people spend a significant amount of time working on their tasks. IAQ has an impact on the health and productivity of occupants as poor IAQ can worsen symptoms related to Sick Building Syndrome (SBS) like headaches, breathing problems and tiredness. Maintaining a temperature is essential for ensuring productivity levels, which is closely linked to IAQ conditions. When occupants feel uncomfortable due to temperatures, they are more likely to be distracted and experience reduced abilities underscoring the importance of architectural solutions. Installing HVAC systems with temperature controls, adequate insulation and smart shading devices is crucial for creating a pleasant indoor environment that promotes productivity. Additionally addressing IAQ issues is vital. High levels of pollutants such as organic compounds (VOCs) particulate matter and carbon dioxide not only worsen SBS symptoms but also hamper cognitive performance and increase absenteeism rates. Improving IAQ through ventilation systems, air purification methods and using friendly building materials are key architectural strategies for enhancing indoor spaces. This comprehensive approach, to designing office environments prioritizes the wellbeing of occupants by fostering healthiness, creativity, job satisfaction while mitigating the effects associated with SBS.

This research paper delves into the connection, between building design, comfortable temperatures, air quality indoors and Sick Building Syndrome (SBS) in office spaces. By reviewing existing research, case studies and design techniques it seeks to identify effective approaches for promoting healthy work environments and mitigating the prevalence of SBS.

Keywords: sick building syndrome, indoor air quality, healthy workspace, productivity

1. INTRODUCTION

Majority of people living in urban area work and spend majority of time indoors. The workplace is not only a space, for productivity but also plays a crucial role in the health and wellbeing of those who occupy it. Designing work environments that are sustainable, healthy and visually appealing can enhance productivity. However, amidst the pursuit of efficiency and functionality, a silent threat within many commercial buildings is Sick Building Syndrome (SBS). Sick Building Syndrome refers to a situation where people experience health issues and discomfort after spending time in a building. Symptoms may include headaches, fatigue, eye and throat irritation respiratory problems and overall uneasiness. The prevalence of SBS raises concerns not because of its impact on individual health but also due to its consequences for organizational performance. Employees affected by SBS are more likely to have decreased productivity levels, take sick leaves and Express lower job satisfaction leading to higher operational expenses and reduced efficiency for companies. Furthermore, in a time where employee well-being's crucial, for business success ignoring the issue of SBS can harm an organizations reputation. Make it challenging to attract and retain top talent. Though the symptoms are temporary as it disappears for hours or days when the occupant leaves the building. Therefore, the symptom is called building-related.

Various factors contribute to the onset of SBS, including issues, with air quality, ergonomic problems and stress factors. When ventilation systems don't bring in air it can cause a buildup of indoor pollutants like volatile organic compounds (VOCs) and airborne particles making it harder for people to breathe comfortably. Chemicals released by building materials, furniture and cleaning supplies also make the air quality worse. Mold spores and bacteria thrive in areas with ventilation leading to allergies and respiratory issues. Factors like lighting, uncomfortable temperatures and designed workstations add to physical discomfort and stress levels. Insufficient or poor lighting can strain the eyes. Cause headaches while environments disrupt focus and communication at work. By addressing these concerns like lighting, noise levels and other factors that contribute to SBS symptoms we can create workspaces that support well-being and productivity, for everyone.

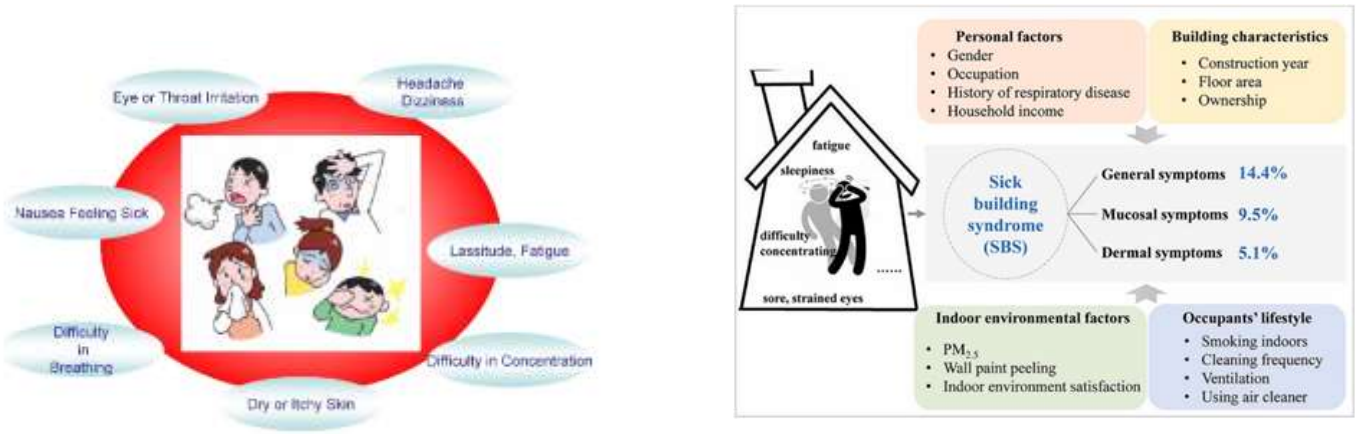


Figure 1 Sick building syndrome

2. FACTORS AFFECTING SICK BUILDING SYNDROME

The factors contributing to Sick Building Syndrome (SBS):

- Building material: microbes can be found growing on building materials
- Poor sanitation
- Volatile organic substances
- Poor ventilation, whether natural or artificial
- Poor maintenance and cleaning
- Poor IAQ and thermal comfort
- Environmental elements such as air temperature and humidity

3. INDOOR AIR QUALITY

Indoor Air Quality (IAQ) refers to the air quality, inside buildings considering elements like air pollutants, humidity levels, ventilation rates and thermal comfort. Poor IAQ can lead to the development and worsening of symptoms associated with Sick Building Syndrome (SBS) among those who occupy the building. Maintaining an IAQ is crucial for promoting the health and well-being of people in workspaces. Factors such as Volatile Organic Compounds (VOCs) and Carbon Dioxide (CO2) levels can significantly impact the occurrence and severity of SBS. Managing IAQ through ventilation systems, air filtration and pollutant control measures is essential for reducing the risk of SBS and enhancing health at work. Various approaches can be taken to enhance IAQ in work settings. Adequate ventilation plays a role by diluting pollutants and supplying fresh air to occupants. Designed ventilation systems that incorporate outdoor air intake rates and effective air distribution help eliminate contaminants and maintain optimal IAQ levels. Furthermore, employing air filtration systems like high efficiency particulate air (HEPA) filters can trap particles. Allergens, further enhancing indoor air quality. The ventilation rate within a building is influenced by factors such, as wind conditions, window types and window orientation.

Enhancing the airflow in a ventilated building can be achieved by incorporating openings of varying sizes. The ventilation efficiency of an office building is notably influenced by the proportion of window openings. The ASHRAE Standard 62.1-2013 (ASHRAE, 2013) recommends a minimum ventilation rate of 2.5 liters per second per person (5 cubic feet per minute per person) for office spaces. With a typical occupant density

of 5 per 100 square meters (1000 square feet) and a ceiling height of 3 meters (10 feet), adhering to the ASHRAE standard would necessitate an air exchange rate of approximately 3 air changes per hour (ACH) within an office space.

4. IMPACT OF IAQ AND SBS ON HEALTH AND WELL-BEING

Poor indoor air quality (IAQ) has been identified as a factor contributing to Sick Building Syndrome (SBS) in buildings leading to a decrease, in the productivity of building occupants. Moreover, the presence of poor air quality indoors is linked to SBS, which can also trigger symptoms like stress, anxiety and aggression among those occupying the building. SBS refers to symptoms experienced by building occupants that are associated with the environment of the building. The effects of SBS on individuals vary since people respond differently to conditions and air pollutants. These effects can be classified into four categories; symptoms, psychological impacts, financial repercussions and work performance. Symptoms such as nasal congestion, eye irritation and itchiness fall under effects while stress levels, anxiety and overall satisfaction relate to impacts. Absences from work reduced efficiency at work and additional energy costs for maintaining comfort are some of the burdens linked with SBS occurrences. Furthermore, occupants can face consequences due, to building design and quality that may manifest as either physical or mental health issues.

Health issues, like headaches, itching, irritation, nausea and dizziness are considered concerns associated with Sick Building Syndrome (SBS). On the hand attention disorders, stress, frustration and anxiety experienced indoors are categorized as issues linked to SBS. Individuals with existing conditions may suffer more when exposed to SBS. Additionally certain medical conditions can be triggered in individuals due to their exposure, to elements found in environments of buildings.

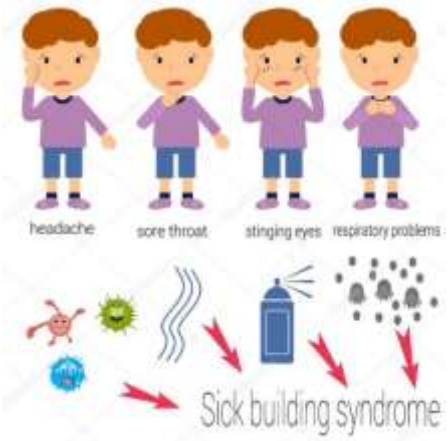


Figure 2 Signs of SBS

5. ARCHITECTURAL DESIGN APPROACHES

Architectural design plays a pivotal role in creating healthy workspaces that promote well-being and mitigate the risk of Sick Building Syndrome (SBS). Various design principles and strategies aimed at enhancing indoor environmental quality, optimizing occupant comfort, and fostering a positive workplace atmosphere.

1. Ventilation Systems and Air Quality:

Effective ventilation systems are essential for maintaining good indoor air quality and minimizing the risk of SBS. Proper ventilation ensures adequate dilution and removal of indoor pollutants, replenishment of oxygen, and control of humidity levels. Key considerations for ventilation design include:

- Mechanical Ventilation: Incorporation of mechanical ventilation systems with high-efficiency filters, such as HEPA (High-Efficiency Particulate Air) filters, to remove airborne contaminants and allergens.
- Demand-Controlled Ventilation: Implementation of demand-controlled ventilation systems that adjust ventilation rates based on occupancy levels, indoor air quality measurements, and other parameters to optimize energy efficiency while ensuring adequate ventilation.

- Natural Ventilation: Integration of natural ventilation strategies, such as operable windows, atria, and stack ventilation, to facilitate passive airflow and enhance occupant comfort.
- Air Filtration: Installation of air filtration systems, including particulate filters, activated carbon filters, and UV-C germicidal irradiation systems, to remove airborne particles, VOCs, and microbial contaminants.

By incorporating robust ventilation systems and air quality management strategies into architectural design, buildings can create healthier indoor environments that support occupant health and well-being.

2. Natural Light and Biophilic Design:

Access to natural light and connections to nature are essential elements of biophilic design that contribute to occupant well-being and productivity. Key strategies for integrating natural light and biophilic elements into architectural design include:

- Daylighting: Maximizing daylight penetration through the use of large windows, skylights, light shelves, and reflective surfaces to reduce reliance on artificial lighting, enhance visual comfort, and regulate circadian rhythms.
- Views to Nature: Providing occupants with views to outdoor green spaces, vegetation, water features, and natural landscapes to promote relaxation, reduce stress, and increase overall satisfaction.
- Indoor Greenery: Incorporating indoor plants, living walls, and greenery into interior spaces to improve air quality, regulate humidity levels, and enhance aesthetic appeal.

By embracing biophilic design principles and maximizing access to natural light and greenery, architects can create workspaces that foster a deep connection to nature and promote occupant health, well-being, and productivity.

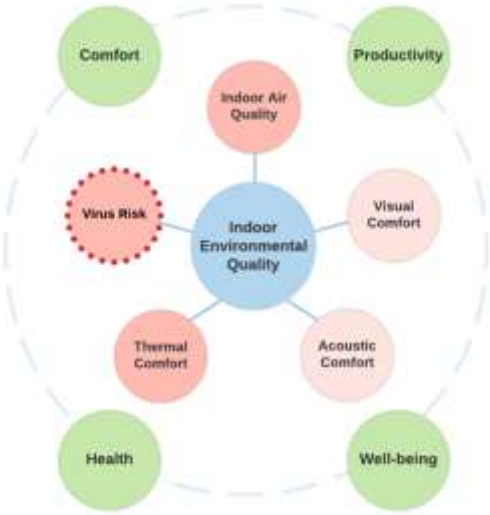


Figure 3 Relation between IEQ, IAQ, Health, Productivity

3. Thermal Comfort and Its Effect on Users:

Thermal comfort refers to the subjective satisfaction with the thermal environment, influenced by factors such as air temperature, humidity, air movement, and clothing insulation. Maintaining optimal thermal comfort is crucial for occupant well-being and productivity in the workplace. Key considerations for achieving thermal comfort include:

- Temperature Control: Providing flexible temperature control systems, such as thermostats and zoning, to accommodate individual preferences and seasonal variations.
- Humidity Regulation: Controlling indoor humidity levels to prevent condensation, mold growth, and discomfort, typically within the range of 30% to 60% relative humidity.

- Air Movement: Ensuring adequate air circulation and ventilation to prevent stagnant air pockets and maintain a comfortable environment.

Effective management of thermal comfort not only enhances occupant satisfaction and well-being but also contributes to improved productivity, concentration, and cognitive performance in the workplace.

6. INTERNAL LAYOUT AND DESIGN FOR ENHANCED INDOOR AIR QUALITY(IAQ) AND SBS MITIGATION:

The layout and design of interior spaces play a pivotal role in influencing indoor environmental quality (IEQ) and mitigating the risk of Sick Building Syndrome (SBS). Research has highlighted various design elements that impact well-being and satisfaction, including the integration of natural elements, selection of materials, color schemes, and workspace layout.

1. Plants: Studies have demonstrated that incorporating biophilic elements such as plants and green walls into interior spaces can promote well-being by reducing negative emotions, state anxiety, and enhancing cognitive function. Greenery not only improves air quality but also contributes to a sense of connection with nature, fostering a healthier and more vibrant indoor environment.

2. Materials: The choice of materials used in interior design profoundly influences physiological responses, emotional states, and cognitive functions of occupants. Natural materials, particularly wood, have been shown to reduce stress responses and enhance well-being compared to artificial materials. Selecting low-emission and non-toxic materials further contributes to improving indoor air quality and creating a healthier workspace.

3. Colors: The color scheme employed in interior design can impact occupant productivity and cognitive performance. Research suggests that warm and cool colors can influence perceptions of temperature, with warm colors imparting a sense of warmth and cool colors evoking a feeling of coolness. Additionally, recent studies have explored the potential of color schemes to improve occupant perception of heat, thereby potentially reducing energy consumption.

4. Layout: The physical arrangement and layout of workspace significantly influence occupant well-being and productivity. Activity-based working (ABW) setups, which provide flexibility and designated spaces for different work activities, have been associated with higher levels of satisfaction compared to traditional open-plan or enclosed offices. Factors such as desk location, privacy, and access to natural light impact the creation of healthy workspaces.

5. Illumination: Lighting design plays a crucial role in creating comfortable and productive indoor environments. Adequate levels and quality of light can improve mood and physical health, while exposure to natural sunlight has been linked to better sleep quality and reduced absenteeism. Incorporating more natural light into workspaces can enhance health outcomes and promote well-being among occupants.

6. Thermal Comfort: Achieving thermal comfort is essential for occupant satisfaction and well-being. Proper temperature and humidity levels, along with adequate ventilation, contribute to creating a comfortable indoor environment. Activity-based work setups offer advantages in engagement and job satisfaction but may pose challenges in privacy and focus, highlighting the importance of addressing individual preferences and needs.

7. TECHNOLOGY INTEGRATION

In practices incorporating technology into building design is crucial, for creating healthy work environments and addressing Sick Building Syndrome (SBS).

7.1 Air Quality Monitoring Systems;

Air quality monitoring systems use sensors and data analysis to track indoor air quality factors like volatile organic compounds (VOCs) particulate matter, carbon dioxide (CO2) temperature and humidity. These systems provide real time insights into conditions allowing proactive management of air quality. Key features include sensor networks, real time monitoring, data analysis, alert mechanisms and integration with Building Management Systems (BMS). By utilizing air quality monitoring systems building operators can promptly. Resolve indoor air quality issues reducing the chances of SBS occurrences and promoting indoor spaces for occupants.

7.2 HVAC Automation for Optimal Ventilation;

Air quality monitoring systems employ sensors and data analysis to consistently monitor indoor air quality parameters such as organic compounds (VOCs) particulate matter, carbon dioxide (CO2) temperature and humidity. These systems offer real time insights into conditions to facilitate proactive management of air quality. Key elements include sensor networks, real time monitoring capabilities, data analysis functionalities, alert mechanisms and integration, with Building Management Systems (BMS). By using air quality monitoring systems facility managers can quickly. Resolve indoor air quality concerns reducing the chances of Sick Building Syndrome (SBS) and promoting indoor spaces, for occupants. The main objective of HVAC systems is to keep factors within levels, such as

Temperature: Around 75 degrees Fahrenheit.

Relative Humidity: Ideally between 40% to 60%.

Ventilation: Following ASHRAE 62.0 standards or keeping CO2 levels below 1000 parts per million (PPM).

In buildings HVAC systems are responsible for 40% of energy consumption. The efficiency of an HVAC system significantly influences the comfort levels within a building. However, they require space for installation. Contribute substantially to operational costs. Different types of HVAC systems, such as centralized units, packaged systems or individual units are commonly utilized in buildings. Proper planning, installation, regular maintenance and other practices can result in improved energy efficiency and cost savings for facilities.

Figure 4 Strategies to improve indoor air quality

7.3 Smart Lighting Solutions:

Smart lighting solutions incorporate lighting controls, sensors and automation technologies to optimize lighting levels reduce energy usage and enhance occupant comfort. These solutions include features like daylight harvesting, occupancy-based lighting controls, tunable white lighting options and task lighting choices. Implementing lighting solutions enables building operators to establish energy efficient lighting environments that promote occupant comfort, productivity, wellbeing while minimizing the likelihood of SBS related symptoms.

8. BUILDING BYELAWS AND NATIIONAL BUILDING CODES

The National Building Code (NBC) of India acts as a guide to ensure indoor environmental quality by addressing ventilation standards proper lighting design with attention to orientation considerations and acoustic design elements crucial, for occupant health and well-being. Following NBCs guidelines is crucial when planning and building structures focusing on aspects such, as ensuring the comfort of occupants promoting energy efficiency and enhancing safety.

1. Taller openings give greater penetrations; broader openings give better distribution of light. It is preferable that some area of the sky at an altitude of 20° to 25° should light up the working plane.

2. Openings on two opposite sides will give greater uniformity of internal daylight illumination, especially when the room is 7m or more across.

3. Openings shall be provided with chajjas, louvers, baffles or other shading devices to exclude direct sunlight entering the room.

4. In office building windows of height 1.2m or more in the center of bay with sill level at 1.0 m to 1.2 m above floor level are recommended for good distribution of daylight indoors.

5. In the case of large and multistoried buildings, independent air handling unit should be provided for each floor

6. When large windows/curtain walls are used, it may be necessary to provide shading/north orientation to protect the occupants from solar radiation and to reduce the cooling load on the system

7. If rooms have large glazed panels or ventilation openings facing directly on the circulation areas, human traffic passing by the rooms should be controlled.

8. Air flow within a building should be controlled to minimize transfer of fumes and smells

9. Air movement is desirable, as it contributes a feeling of freshness, although excessive movement should be avoided as this leads to complaints of draughts. The speed of an air current becomes more noticeable as the air temperature falls, owing to its increased cooling effect

10. A high humidity reduces evaporative cooling from the body and hence creates the sensation of a higher temperature. Beyond certain limits, however, humidity produces disagreeable sensations. For normal comfort conditions, relative humidity (RH) values between 40 percent and 70 percent are acceptable.

9. LITERATURE SURVEY ANALYSIS

The research conducted compared two office buildings in Jaipur, India: Genpact, a non-green-rated building, and Infosys, a LEED Platinum-certified green building. Both buildings are air-conditioned, lack natural ventilation, and accommodate over 30 occupants per floor.

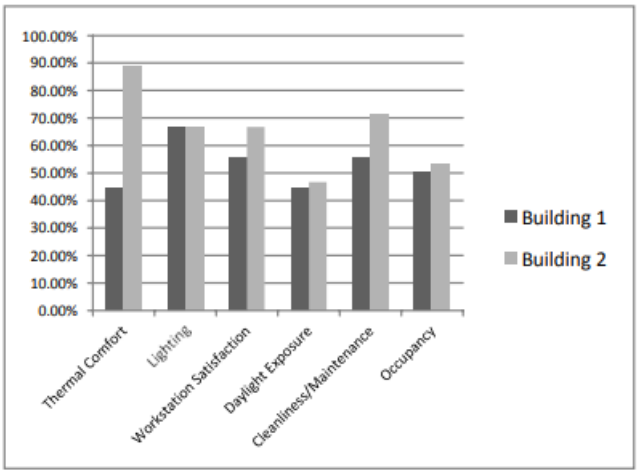
1. Infosys: Situated on the outskirts, G+8 floors, LEED Platinum-certified, radiant refrigeration, energy-efficient design with features like high-performance glazing and efficient HVAC systems. The Infosys Campus demonstrates a strong commitment to environmental sustainability through various green features. These include high-albedo roof paint, high-performance glazing, efficient HVAC systems, and integration of renewable energy sources like solar panels. These initiatives not only reduce energy consumption and greenhouse gas emissions but also enhance indoor comfort.

2. Genpact: Located in the main city, with G+6 floors, open-plan workspace, centrally air-conditioned, with operable windows rarely used. The temperature fluctuates during the whole day and split ac are there for separate rooms. Glare issues are there in some parts

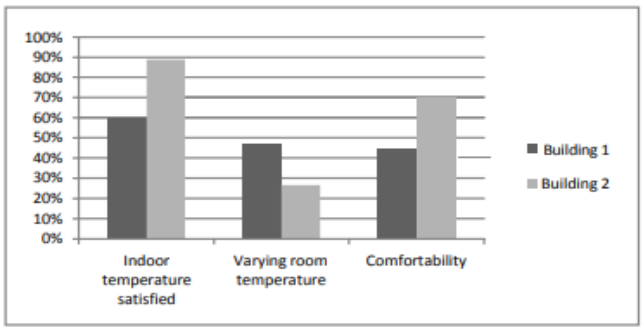
A survey was carried out through google forms and consisted of questions listed below:

Question 1	Floor number, gender, age, working hours
Question 2	Satisfaction with temperature
Question 3	Satisfaction with air quality
Question 4	Requirement of artificial light, daylight exposure, glare issues
Question 5	Clean or comfortable spaces
Question 6	Number of occupants on single floor
Question 7	Health related problem like headache, nausea

table 1 Questainnare



Graph 1 Occupant's satisfaction with the categories



Graph 2 Occupant's satisfaction with room temperature

Graph 3 Occupant's satisfaction with air quality

9.1 RESULTS AND ANALYSIS

The survey conducted on two office buildings, one green-rated (Infosys) and one non-green-rated (Genpact), provides valuable insights into the health and comfort of occupants and sheds light on the merits and demerits of each building.

MERITS:

1. INFOSYS, JAIPUR (GREEN RATED BUILDING)
   - Majority of occupants reported high satisfaction levels, particularly in thermal comfort, lighting, and cleanliness.
   - Green features such as efficient HVAC systems and proper air circulation contribute to improved indoor air quality and overall comfort.
   - Reduced instances of Sick Building Syndrome (SBS) symptoms among occupants compared to non-green buildings.
   - Proper maintenance procedures ensure a conducive working environment, minimizing health risks associated with poor indoor environmental quality.

2. GENPACT, JAIPUR (NON-GREEN RATED BUILDING)
   - Operable windows provide some degree of air movement, albeit not utilized effectively.
   - Some occupants reported satisfaction with air quality, indicating potential for improvement.

DEMERITS:

1. INFOSYS, JAIPUR (GREEN RATED BUILDING)
   - Noise levels are a concern due to open-plan workspaces, impacting concentration levels and potentially causing discomfort.
   - Despite high satisfaction levels overall, daylight exposure remains a low-ranking category, suggesting room for improvement in design aspects.

2. GENPACT, JAIPUR (NON-GREEN RATED BUILDING)
   - Thermal discomfort due to ineffective ventilation and fluctuating temperatures, leading to dissatisfaction among occupants.
   - Higher prevalence of SBS symptoms reported by occupants, indicating potential health risks associated with poor indoor environmental quality.
   - Limited ability to control indoor temperature and ventilation exacerbates comfort issues for occupants.

In summary although both buildings have their pros and cons the survey emphasizes the significance of putting health and comfort in building design and upkeep. Buildings, with ratings such as Infosys showcase indoor environmental conditions and occupant happiness showcasing the advantages of sustainable building approaches. On the hand non rated buildings like Genpact encounter issues with indoor comfort and air quality requiring enhancements, in ventilation and maintenance procedures to reduce health hazards and improve occupant welfare.

10. LITERATURE CASE STUDY- THE CAIRO PETROLEUM COMPLEX

Figure 5 Cairo petroleum complex

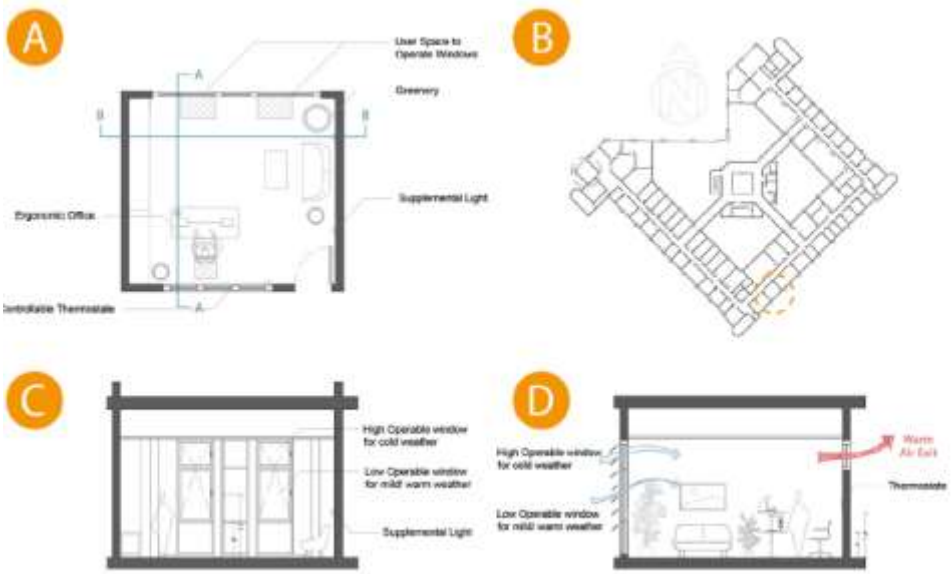
Location- Alexandria, Egypt
Climate- Mediterranean climate. Winter- 9° to 19°C. Summer- 30°-31°C
Area- 3370 m2 and has a rectangular shape measuring 60 m x 67 m, with a height of 20 m.
Year of construction- 2002

10.1 BUILDING CHALLENGES

- Despite its modern design and advanced mechanical ventilation system, the building faces challenges related to thermal gain and glare due to inadequate shading devices.
- Offices located on the West and South facades experience discomfort from excessive heat gain and glare, affecting occupants' productivity and well-being.
- Inadequate natural ventilation further compounds the problem, with some facades having only 25% operable windows or none at all, hindering airflow and indoor air quality.
- Together these difficulties form a complex challenge requiring detailed consideration to ensure comfortable conditions with minimal energy consumption

10.2 PROPOSED SOLUTIONS

- Curtain wall: Designing different height operable windows in the façade to allow natural ventilation, higher
  operable windows for winter, and lower operable windows for summer.
- Operable windows must be opened at least halfway, with the maximum height from the finished floor not exceeding 1.8mand a minimum dimension of 0.3 m for the smallest opening. Window operation control is a minimum of 1.7 m above the finished floor.
- Shading: Application of automatic shading devices of curtain wall facades (louvres) to decrease direct sunlight entering the offices and eliminate glare.
- Cross Ventilation: Applying a high operable window opposite the curtain wall creates cross-ventilation.
- Circadian Lighting Design: The necessary light levels should be achieved from a height of 45 cm above the
- work plane.
- Location of Furniture: The distance between envelope glazing and seating area is within 5 m.



10.3 EXPECTED BENEFITS

- Implementation of these solutions will enhance indoor comfort, reduce reliance on mechanical cooling systems, and result in energy savings.
- Improved natural ventilation and daylighting will create a healthier and more pleasant work environment, boosting occupant satisfaction and productivity.
- Installation of shading devices will mitigate solar heat gain and glare, minimizing discomfort and enhancing visual comfort.
- Cross ventilation will promote air circulation, reducing the risk of indoor air pollutants and creating a more refreshing atmosphere for occupants.

11. CONCLUSION

The crucial aspect of designing indoor environments for human habitation cannot be overstated, considering the significant portion of time individuals spend indoors. The quality of these environments profoundly impacts human health and well-being. Hence, when planning a building it's crucial to think about how people will interact with their surroundings. This interaction plays a role in shaping the layout, features and elements of the building. Understanding the connection between design, building quality and sick building syndrome (SBS) is essential for creating work environments that support health and productivity. This research sheds light on workspace building design principles that aim to improve spaces and occupants' well-being. It also delves into the design considerations for indoor air quality (IAQ) and SBS in workspace settings.

Integrating natural ventilation methods, like windows, skylights and cross ventilation systems can boost air circulation and freshness indoors. Allowing air to flow in helps clear out pollutants and maintain good air quality levels lowering the risk of SBS symptoms. Introducing fragrances using aromatherapy diffusers or pure essential oils can enhance the air quality indoors. Establish a cozy and welcoming ambiance. Some scents, like lavender or eucalyptus are known for their calming effects and ability to enhance moods, which can help reduce stress and discomfort related to SBS. Using colors in design can impact emotions and behaviors potentially easing SBS symptoms. For instance, soothing shades like blue and green may induce relaxation and lower stress levels while vibrant colors such as yellow and orange could boost energy levels and creativity. Moreover, incorporating plants has been proven to lower stress levels and foster a feeling of well-being among occupants ultimately improving productivity.

Moving forward, there is a need to revolutionize architectural design by embracing passive and innovative technologies. By integrating these approaches, buildings can be developed to be not only environmentally friendly but also conducive to the health and productivity of their users. This shift towards sustainable and health-conscious design practices will pave the way for the creation of workspace that prioritize occupant health, well-being, and overall satisfaction.

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