5 Built Environment

UNIT SPECIFICS

Through this unit we have discussed the following aspects:

- ***The Built Environment and Its Impact***
  - *Facilities management & Sustainable Facility management strategies*
  - *Building Control systems - Climate control systems, Security systems*
  - *Energy efficient built environments & Recycling*
  - *LEED Rating & other Indian rating systems*
  - *Intelligent/ Smart Buildings*
- ***Aesthetics of built environment***
  - *Role of Urban Arts Commissions*
  - *Heritage Conservation, Structural Repair and Rehabilitation, Retrofitting*
- ***Innovations and methodologies for ensuring Sustainability***

Besides giving a large number of multiple choice questions as well as questions of short and long answer types marked in two categories following lower and higher order of Bloom's taxonomy, a list of references and suggested readings are given in the unit so that one can go through them for practice.

There is a "Know More" section, which has been carefully designed so that the supplementary information provided in this part becomes beneficial for the users of the book. It is important to note that for getting more information on various topics of interest some QR codes have been provided which can be scanned for relevant supportive knowledge This section mainly highlights applications of the subject matter for our day-to-day real life or/and industrial applications on variety of aspects, case study related to environmental, sustainability, social and ethical issues whichever applicable, and finally inquisitiveness and curiosity topics of the unit.

RATIONALE

This elementary unit on the built environment and its role to mitigate environmental impact, discusses the various practicalities, such as, Facility management, Building control systems, Building Rating, and Codes and Standards, to impart state-of-the-art knowledge to improve the civil engineers' technical know-how, and perhaps open up possibilities of pursuing future expertise in one of the several areas discussed.

UNIT OUTCOMES

List of outcomes of this unit is as follows:

U5-O1: Knowledge on the various aspects of Built Environment and its impact

U5-O2: Understanding of Aesthetics and its importance for cultural heritage

U5-O3: Knowledge on innovations and methodologies for ensuring environmental Sustainability (Codes and Standards)

Unit-5 Outcomes	EXPECTED MAPPING WITH COURSE OUTCOMES (1- Weak Correlation; 2- Medium correlation; 3- Strong Correlation)						
	CO-1	CO-2	CO-3	CO-4	CO-5	CO-6	CO-7
U5-O1	3	3	2	2	3	3	2
U5-O2	2	2	3	2	2	3	3
U5-O3	3	3	3	2	3	3	3

Our engineered, built-environment sits nestled in the natural environment, which is presently undergoing several climatic changes leading to rising concerns and potential risks to human life. The built-environment is defined by the U.S. Environmental Protection Agency (EPA, 2021) as *"human-made or modified surroundings in which people live, work, and recreate"*, to which the National Academies (2017) adds, *"surroundings that provide the setting for human activity, ranging in scale from buildings and parks or green space to neighbourhoods and cities that can often include their supporting infrastructure, such as water supply or energy networks"*.

5.1 THE BUILT ENVIRONMENT AND ITS IMPACT

The major burden of societal and global impact is created and experienced at the intersection of "*buildings, cities, and urban spaces, and the ways people use them*" (WHO, 2016), i.e., intersection of 'Spaces and Infrastructure', comprising of design, construction, occupancy management, building operations, maintenance, furniture and equipment, etc.; and 'People and Organisation', consisting of health services, catering, event management, hospitality, security, safety, human resources, logistics, document management, and accounting. The concept of "**sustainable construction**" integrates environmental criteria into the entire lifecycle of a project, including building, maintenance, and eventual demolition, suggests various factors to be emphasized during the construction phase, beyond material choices, such as techniques to minimize dust, noise, and soil and water contamination, waste management measures throughout the construction, use, and demolition phases, and efforts to enhance material reuse and recycling.

Buildings alone contribute to approximately 40% of energy and process-related CO2 emissions, 50% of all extracted materials, 33% of water consumption, and 35% of generated waste, and additionally, contribute towards resource depletion, pollution of air, water, and land, as well as loss of biodiversity. Of which, the use/operational phase leads to the highest environmental impact across the entire life of the building and is known to be caused by the users and the physical characteristics of the building, i.e., energy and water use and waste generation. Therefore, it is important to employ *systems thinking and the lifecycle view* to address impending issues of environmental impact mitigation through incorporating sustainability strategies, beyond design and construction, into facility management.

5.1.1 Facilities Management

Facilities management is a vital aspect of managing construction businesses, as it involves strategic planning and thoughtful consideration of daily operations. British architect and Editor of Architectural Association Journal (1965-67) and Facilities (1982-90), Francis Duffy explored the relationship between organisational structure and office layouts in his doctoral work during the 1960s, and later, pioneered 'Space Planning and Facility management' in Europe. At the

time, the term was propounded by Ross Perot, founder of Electronic Data Systems, USA, when the introduction of computers and IT infrastructure demanded design changes in the 1970s.

Facility management entails the effective management of physical workspaces - buildings, infrastructure, and other physical assets, to support the delivery of services and achieve organizational objectives. Civil engineers are ideal for this role due to their technical skills and good communication, and develop leadership in the upcoming area of facility management. Facility Management integrates the principles of business administration, architecture, and the behavioural and engineering sciences; and involves a wide range of activities, including maintenance and operations, space planning, asset management, health and safety, energy management, and sustainability.

The **key activities** involved are:

- Asset Management
- Master Planning
- Space Management
- Estates Strategies
- Maintenance, cleaning, testing, and inspection
- Refurbishment, retrofitting, and renovation
- Acquisitions and sales
- Procurement and project management
- MEP (Mechanical, Electrical and Plumbing) and Technical services
- Contract Management
- Sustainability
- Budget Management
- Brand Management
- Quality Assessment
- Regulatory Compliance
- Asset exploitation and income generation
- Ensuring the continuity of the business
- Delivery of new technologies
- Bringing change and efficiency in work practices
- Safety and security
- Traffic, transport, and parking

Role of Facility manager responsibility towards sustainability

In the field of facilities management, the focus has shifted to the impacts of climate change, encompassing not only the environmental effects of buildings but also their resilience and capacity to address associated issues. The primary challenge lies in the increasingly severe weather conditions and unpredictable shifts in weather patterns, such as tides, cold spells, floods, storms and droughts, and prolonged seasons, making it necessary for facilities managers to transition from preventive measures to predictive strategies, like enhanced service level

requirements and disaster recovery plans for ensuring business continuity. Facility managers have **three significant responsibilities** in addressing climate change:

- ***Conduct assessments to evaluate the vulnerability of current facilities*** and their ability to adapt to climate change. This involves creating plans and procedures to address climate-related challenges and ensure effective responses.
- ***Assist in the development of new structures and buildings*** that align with the changing environmental landscape. This includes reviewing designs and incorporating sustainable building materials to promote environmentally friendly practices.
- ***Develop a forward-looking strategy to manage the evolving dynamics of the built environment*** due to shifts in climate change regulations and compliance requirements. This involves anticipating future changes and implementing measures to ensure ongoing environmental sustainability.

Fig. 5.1 : 11 Core competencies of Facility Management (source : www.ifma.org)

Sustainability Facility management strategies

Sustainable facility management (SFM) is "*a unique process that offers a facility manager the authority to make structural, architectural, and operational changes to reduce the negative impact of buildings on their occupants and the environment*" (Fennimore, 2014). Implementing sustainable practices in facility management to mitigate climate change risks requires a comprehensive approach that considers various aspects of operations. Adopting a lifecycle approach in decision-making processes, taking into account the environmental impacts of products and systems from extraction to disposal, and considering factors such as, durability, recyclability, and end-of-life management are essential towards enabling sustainable facility management.

The following are some **practical strategies** for implementing sustainable practices in facility management:

1. ***Energy Efficiency***: Implement energy-saving measures, such as, installing energy-efficient lighting, utilizing programmable thermostats, optimizing HVAC systems, and conducting energy audits to identify areas for improvement.
2. ***Renewable Energy Integration***: Explore opportunities to incorporate renewable energy sources, such as solar panels or wind turbines to reduce reliance on fossil fuels and decrease carbon emissions.
3. ***Waste Management***: Develop a waste management plan that includes recycling programs, waste reduction initiatives, proper disposal methods, and encourage all stakeholders to reduce, reuse, and recycle materials.
4. ***Water Conservation***: Implement water-saving measures, such as, installing low-flow fixtures, conducting regular maintenance to prevent leaks, and promoting water-efficient practices among all stakeholders.
5. ***Indoor Air Quality*** (IAQ): Implement measures to improve indoor air quality, such as, regular maintenance of HVAC systems, proper ventilation, and use of low VOC (volatile organic compound) materials in building interiors.
6. ***Green Building Certification***: Consider pursuing green building certifications, like LEED (Leadership in Energy and Environmental Design), to guide sustainable building practices and ensure compliance with established standards.
7. ***Performance Monitoring***: Establish performance metrics, and regularly monitor and track energy consumption, water usage, waste generation, and other sustainability indicators, and in turn, use this data to identify areas for improvement and set targets for continuous enhancement.
8. ***Sustainable Procurement***: Source environmentally friendly products and materials that are made from recycled content, are energy-efficient, and have a reduced environmental impact. Consider the lifecycle of products and choose those with minimal environmental footprints.
9. ***Stakeholder Engagement***: Engage employees, tenants, and other stakeholders in sustainability initiatives by promoting awareness, providing training on sustainable practices, and encouraging their active participation.

5.1.2 Building Control system

A building control system is a centralized system that monitors and controls various building systems and equipment to ensure efficient operation, occupant comfort, and safety. These systems are commonly referred as; Energy Management Systems (EMS), which is responsible for managing environmental functions within a building; Building Automation Systems (BAS), which focuses on controlling technical automation processes; and Building Management Systems (BMS), which encompasses a broader range of functions, including providing status reports on environmental

conditions, monitoring elevator operations, and tracking the location of individuals for security purposes.

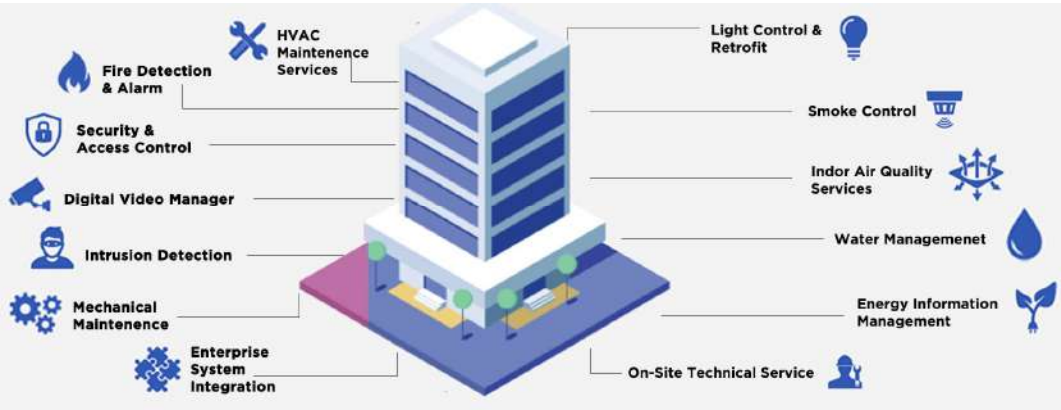

Fig. 5.2: Elements of a Building Control System (source : www.truviconline.com)

The major functions are, as follows;

- ***Data Analysis and Reporting:*** Building control systems provide data analysis and reporting capabilities, enabling facility managers to assess building performance, identify trends, and make informed decisions for improving energy efficiency and operational effectiveness.
- ***Monitoring and Control:*** Monitoring systems collect data on various parameters such as temperature, humidity, occupancy, and energy consumption to monitor the building's performance and ensure it operates within predefined limits. Based on the collected data, the system can automatically adjust and control the building systems to maintain optimal conditions. For example, it can regulate HVAC systems to provide comfortable temperatures or adjust lighting levels based on occupancy.
- ***Management and Decision-aid:*** Building control systems help optimize energy usage by tracking energy consumption, identifying inefficiencies, and implementing strategies for energy conservation, such as scheduling equipment operation and implementing demand response programs. The system also generates alerts and notifications in case of equipment malfunctions, abnormal conditions, or security breaches, allowing facility managers to take prompt action.

EMS, BAS, and BMS consists of a network of sensors, controllers, and software that communicate and coordinate the functioning of different building systems. EMS collects data from sensors throughout the building and uses the information to make adjustments and optimize the performance of these systems. While **BMS/BAS typically integrates and controls systems** such as heating, ventilation, and air conditioning (HVAC), lighting, access control, fire alarms, security systems, and energy management. The key difference is, while an **EMS is primarily a monitoring tool** at a micro-level, gathering detailed device-level telemetry data from the deployed sensors and analysing it, the BMS/BAS, often used synonymously, works at a macro-

level by providing high-level, real-time control, such as, regulate the temperature, humidity or pressure, or prevent smoke from spreading throughout a building.

Building Climate Control System

A building and its indoor spaces are constantly influenced by both internal and external factors that can disrupt the indoor climate, such as heat, air emissions, and changes in humidity levels. Climate control in buildings refers to the adjustment of indoor climate conditions according to the preferences of the occupants, while ensuring that external weather conditions, such as extreme heat or harsh environmental factors, do not impact the indoor environment. **Indoor Environment Quality** (IEQ) refers to "*the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it*", as per the National Institute of Occupational Safety and Health (NIOSH). IEQ is of great importance, as the four primary parameters - thermal, visual, and acoustic comfort, indoor air quality (IAQ), have *direct impact on various aspects of human well- being, such as, occupant comfort, productivity, mental health, satisfaction, as well as study and work performance* (Ali and Acharya, 2023) and hence, there is a need for climate control considering the drastic change in temperatures, high levels of noise and particulate pollutants in the surrounding and excess use of artificial lighting that may cause visual discomfort.

Architectural design, engineering and construction is of utmost importance to ensure climate control and comfortable IEQ as several factors such as, temperature, humidity, rainfall, direction of wind and sunlight, etc. plays a crucial role in material selection, orientation and structural design. Air temperature affects the exterior of the building while the soil temperature affects the foundation. Humidity is a very important consideration for the structural integrity of the materials, and anti-corrosive and water-resistant materials are preferred in areas with higher levels of humidity. In areas with heavy rainfall, sloping roofs are preferred as opposed to flat roofs, so that the integrity of the structure is not compromised. Sunlight is also an important consideration, as the wall to window ratio increases or decreases according to need of the climate. Wind load is also considered while designing, since it has the capability to damage the building structurally. **Active and Passive design strategies** are employed to improve IEQ and liveability of a building. '*Active'* implies the use of mechanical and electrical systems, such as, air-conditioning, heat pumps, radiant heating, heat recovery ventilators, and electric lighting which uses purchased energy, while '*Passive'* refers to harnessing available ambient energy through techniques such as, maximizing natural light (daylighting), utilizing natural airflow for ventilation, and garnering solar energy. Some **passive design strategies** are;

- ***Seeking inspiration from Vernacular architecture***. It is the ancient traditional architectural design and construction method of a civilisation, and usually it is incorporated with unique elements and techniques that controls the natural climate of that region and suitable of the life of the indigenous people. Introduction of verandahs and courtyards are one such design element borrowed from vernacular architecture that has the ability to reduce heat and allow cross-ventilation.

- ***Incorporating Bioclimatic design***, which aims to maximize the utilization of local climate data and leverages local environmental resources like sunlight, wind, air, vegetation, soil, and sky to minimize energy consumption. Proper thermal insulation of the external envelope of the building and air-tight structures; use of solar energy for heating in winter time, achieved by a proper passive solar heating system; removal of the heat from the building by passive cooling systems and natural ventilation; Protection of the building from overheating by proper shading solutions and vegetation in summer time; and the use of solar energy for day-lighting all year round, are some of the recommendations by EU. It may be argued that this is also seen in vernacular architecture.
- ***Employing shading devices***, such as, fin walls, vertical or horizontal shading overhang devices, and extended roof overhangs, which are integrated into the building structure, and external shading devices, such as, eaves, awnings, screens and shutters, louvres, verandahs, pergolas, and shading with foliage, trees, and shrubs.
- ***Introducing rigid air barrier, thermal insulation and sound attenuating interior lining*** to brick or concrete masonry or to high-density sheet cladding for exterior walls and building envelope, using concrete or tiled roofing, and affixing sound-attenuating external windows and doors, to reduce external noise and overall, acoustic discomfort.

'*Active*' control systems leverage technologies, such as, ICT, cloud computing, wireless sensors, and tools, such as, BMS and BAS to help improve climate control efficiency.

Building Security System

The **building security system** is specifically developed to oversee and regulate mechanical and electrical installations, fire protection and escape mechanisms, as well as address issues related to burglary, assault, and emergency communication.

Fig. 5.3 : Features of a Building Security System (source:www.truviconline.com)

In high-rise buildings and large complexes which are densely occupied, ensuring effective fire safety measures is of utmost importance. To ensure **fire safety** as it is necessary to monitor and manage the following:

- Detection and suppression of fires,
- Ensuring the movement and safety of individuals,
- Controlling smoke through pressurization and barriers,
- Establishing safe places of refuge, and
- Facilitating emergency arrangements and communication.

An **effective security system** has the following components:

Video surveillance systems comprises of the placement of multiple cameras in strategic locations both inside and outside a building, to serve as a deterrent to potential criminals, and to provide valuable evidence for police investigations and insurance claims. Furthermore, modern video surveillance systems can be integrated with other security technologies. For instance, you can have a surveillance camera positioned to monitor a keypad entry system at the front door, which can enable detection of any tampering or misuse of the entry device.

Access control encompasses the procedures and mechanisms that regulate entry and restrict unauthorized access to buildings, rooms, or specific areas, and is a fundamental aspect of maintaining security in any location. To ensure optimal security, it is essential to have a cohesive access control system in place, as it is inconvenient for occupants to use different Access control technologies, such as, separate key fobs, PIN codes, or key cards, to access different areas within the building. Therefore, it is recommended to synchronize the access control system throughout the building, preferably by using a unified system provided by the same security system company.

Alarm systems are installed at doors and windows, including emergency-only exits, and are designed to emit a loud noise when triggered, alerting building staff to the specific location. If empowered with smart technology it can notify occupants about the occurrence and precise location of the triggered alarm, enhancing response effectiveness.

Intercom systems provide a means for visitors to request entry into the building, while allowing tenants to remotely grant access, and facilitates verification of the identity of individuals seeking entry.

Computer systems are essential to cohesively tie up the surveillance, access control, alarm and intercom systems in the backend and enable the user to control, communicate and interact remotely with assets and people. Currently, smartphones are integrated to allow the same, on the move.