5.1.5 Intelligent to Smart Buildings

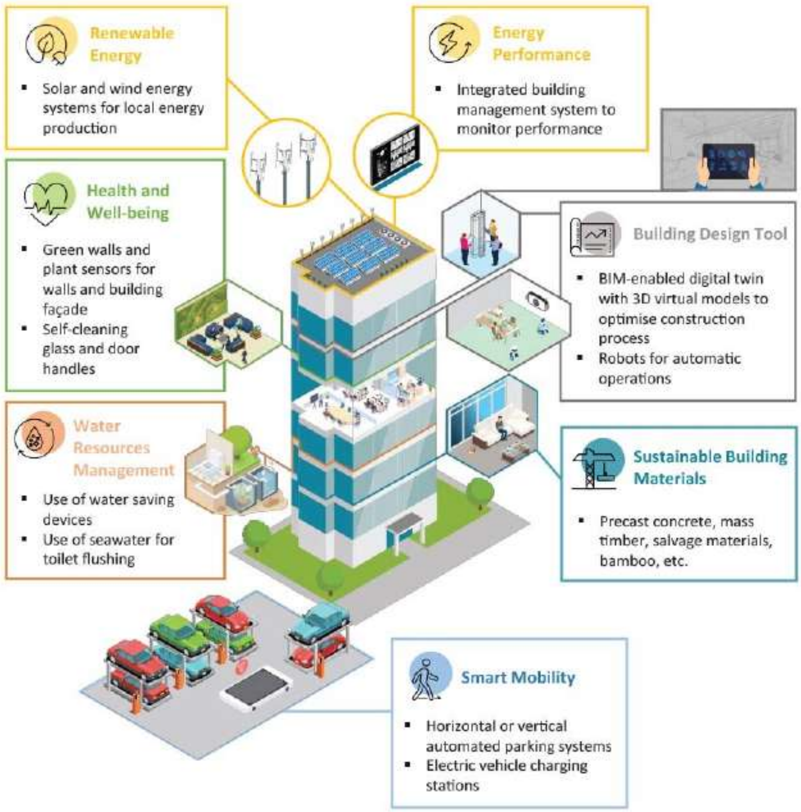

Fig. 5.8 : Smart Building technologies and features

The term, 'Intelligent building', is often used commonly to imply and 'Smart building', but their definitions have been evolving with time, since the 1980s when the term was first used to mean "*a building which totally controls its own environment*" (Stubbings, 1988). This equated the building to its BMS and other smart systems, with the intent to reduce human interaction. However, the two terms are complementary, as it may be argued that **Smart Buildings are Intelligent Buildings but with additional, integrated aspects** of '*adaptable control, enterprise and materials and construction'*, and addresses both 'intelligence and sustainability issues' to achieve the optimal energy consumption and overall comfort.

Smart Buildings are viewed as a 'subset of smart environments', where smart environments are "*able to acquire and apply knowledge about the environment and its inhabitants in order to improve their experience in that environment*". In a **smart environment**, such as 'Smart City', various elements, i.e., Smart Homes, Smart Buildings, Smart Grids, Smart Meters, Smart Transportation, etc. collaborate synergistically. Smart Buildings prioritize the occupants and encourage their active participation by incorporating feedback mechanisms, for both receiving and providing information about building usage. These buildings leverage integrated enterprise and intelligent systems to enable inherent control, by empowering occupants to make decisions regarding their comfort, while still maintaining regulated control. Smart buildings promote a personalized and interactive building experience.

Literature states that Smart Buildings have the **five fundamental** features;

- ***Automation***: the ability to accommodate automatic devices or perform automatic functions.
- ***Multi-functionality***: the ability to allow the performance of more than one function in a building.
- ***Adaptability***: the ability to learn, predict and satisfy the needs of users and the stress from the external environment.
- ***Interactivity***: the ability to allow the interaction among users.
- ***Efficiency***: the ability to provide energy efficiency and save time and costs.

Dakheel, et al. (2020) analysed the above and extended it with four 'Smartness basic features', categorised with respect to four key functions - ***Climate response, Grid response***, ***User response*** and ***Monitoring and Supervision*** - to include;

- ***Nearly zero energy buildings target*** *(Climate response, Grid response*)
- ***Flexibility*** *(Climate response, Grid response*, *User response)*
- ***Real-time monitoring*** *(Monitoring and Supervision*)
- ***Real-time Interaction*** *(User response)*

However, every building has a capacity to adapt their operation to the needs of the grid and the occupants, and this is measured by **Smart-readiness indicator** (SRI), developed by EPBD. The SRI in buildings (Verbeke et al., 2017) are particularly important for India as we have stark socio-economic diversity, and introducing the right amount of '*smartness'* holds immense potential for transformative advancements in efficiency, sustainability, occupant comfort, and overall building performance.

5.2 AESTHETICS OF BUILT ENVIRONMENT

Aesthetics, a field within philosophy, is the study of the nature, expression and principles of beauty and artistic taste. The term originates from the Greek word "*aisthetikos*", which refers to sensory perception and understanding, or knowledge acquired through the senses, and hence, varies across people, places and time. There is no one style for aesthetics, but a constant evolution of elements as per the socio-cultural need of that time, or as discussed in earlier Units, as a response to an existing style. It is a deeper, more profound expression of human creativity, meant to be evocative, thought provoking or awe-striking. The **Vitruvian triad** – *firmitas* (durability), *utilitas* (usefulness), and *venustas* (beauty), deemed essential for a good building, captured the significance of aesthetics as visual appeal encompasses various design elements and principles, such as, its form, size, texture, colour, balance, unity, movement, emphasis, contrast, symmetry, proportion, space, alignment, pattern, as well as cultural relevance and contextual integration.

However, aesthetics must not always be understood as ornamentation or decoration, but can be grounded in structural integrity and material honesty, as seen in the works of architects like, Frank Lloyd Wright's integration of nature and the use of organic materials in design of Fallingwater, Pennsylvania; or Tadao Ando's Church of the Light in Osaka, Japan, a notable example of honest architecture, where he used concrete as the primary material.

The role of technology - new building materials and construction techniques, also plays an exciting role in developing new aesthetics as a synthesis of technology and art. Italian architect, Pier Luigi Nervi stated, "*the aesthetic sensibility of the designer, who understands their (technology and statistics') intrinsic beauty and validity, welcomes the suggestion and models it, emphasizes it, proportions it in a manner which constitutes the artistic element in architecture*". Parametricism or the parametric design paradigm leverages software like, Rhino with Grasshopper, Fusion 360, Solidworks, etc. to design built forms of unique visual appeal, as championed by architect Zaha Hadid. Therefore, it is crucial to consider not only functionality, safety, serviceability, and durability but also aesthetics, ensuring proper structural performance throughout the entire lifespan.

5.2.1 Role of Urban Arts Commissions

The Delhi Urban Art Commission (DUAC) was established through a parliamentary act in 1973 with the purpose of advising the Government of India on matters related to preserving, developing, and enhancing the aesthetic aspects of urban and environmental design in Delhi. The commission also provides guidance and recommendations to local bodies regarding construction projects, engineering operations, and development proposals that may impact the skyline, aesthetic quality of the surroundings, or public amenities.

The DUAC plays a crucial role in approving, supervising and recommending projects for development and beautification of urban spaces, conservation and beautification of monuments and green landscaped public areas, preservation and maintenance of heritage monuments and buildings, restoration and redevelopment.

It operates in three capacities: as a policy advisor to the government, a regulatory body, and a think tank. In addition, the following **duties** are assigned to the DUAC as per the Act, 1974;

a) Development of district centres, civic centres, areas earmarked for Government administrative buildings and for residential complexes, public parks and public gardens.
b) Re-development of the area within the jurisdiction of New Delhi Municipal Committee including Connaught Place Complex and its environs, Central Vista, the entire bungalow area of Lutyen's New Delhi, and such other areas as the Central Government may, by notification in the Official Gazette, specify.

c) Plans, architectural expressions, and visual appearance of new buildings in the centres, areas, parks and gardens specified in clauses (a) and (b) including selections of models or statues and fountains therein.
d) Re-development of areas in the vicinity of Jama Masjid, Red Fort, Qutab, Humayun's Tomb, Old Fort, Tuglakabad and of such other places of historical importance as the Central Government may, by notification in the Official Gazette, specify.
e) Conservation, preservation and beautification of monumental buildings, public parks and public gardens including location or installation of statues or fountains therein.
f) Under-passes, over-passes and regulations of street furniture and hoardings.
g) Location and plans of power houses, water towers, television and other communication towers and other allied structures.
h) any other project or lay-out which is calculated to beautify Delhi or to add to its cultural vitality or to enhance the quality of the surroundings thereof.
i) such other matters as may be prescribed by rules.

5.2.2 Heritage Conservation and Structural Repair and Rehabilitation

Structures, be it built recently or of heritage value, deteriorate due to natural weathering or get damaged due to calamities, historic events, etc. and require design and construction interventions. There are various **types of interventions**, such as, *historic preservation, heritage conservation, restoration, rebuilding, rehabilitation, retro-fitting* etc. and each in turn employs different methods to achieve the desired outcome of reviving the original or intended look and feel of the structure.

Heritage Conservation, objectives and guidelines

Architectural conservation, as a discipline is concerned with the "*integrated informed understanding, sustainable care and appropriate renewal and development of the historic environment*". The aim is to examine the connections between the indoor environment, which is shaped by the interactions among building architecture, materials, structures, services, contents, decorations, and occupants, and the surrounding external environments. It is also the "*process through which the material, historical, and design integrity of any built heritage are prolonged through carefully planned interventions*" (American Conservation Experience). The primary goal is to preserve the original material in its most unchanged state possible, which implies that any repairs or additions made to the built object should not remove, alter, or permanently attach to the original material. It is crucial that all interventions are reversible and removable without causing any damage to the original material, both presently and in the future, and does not involve making artistic choices or experimenting with different materials, i.e., the process of conservation strictly adheres to the object's requirements and specifications, with the sole focus on safeguarding and maintaining the object's authenticity and condition. MoHUA, GoI states that "*Conservation of heritage sites shall include buildings, artifacts, structures, areas and precincts of historic, aesthetic, architectural, cultural or environmentally significant nature (heritage buildings and heritage precincts), natural feature areas of environmental significance or sites of scenic beauty*".

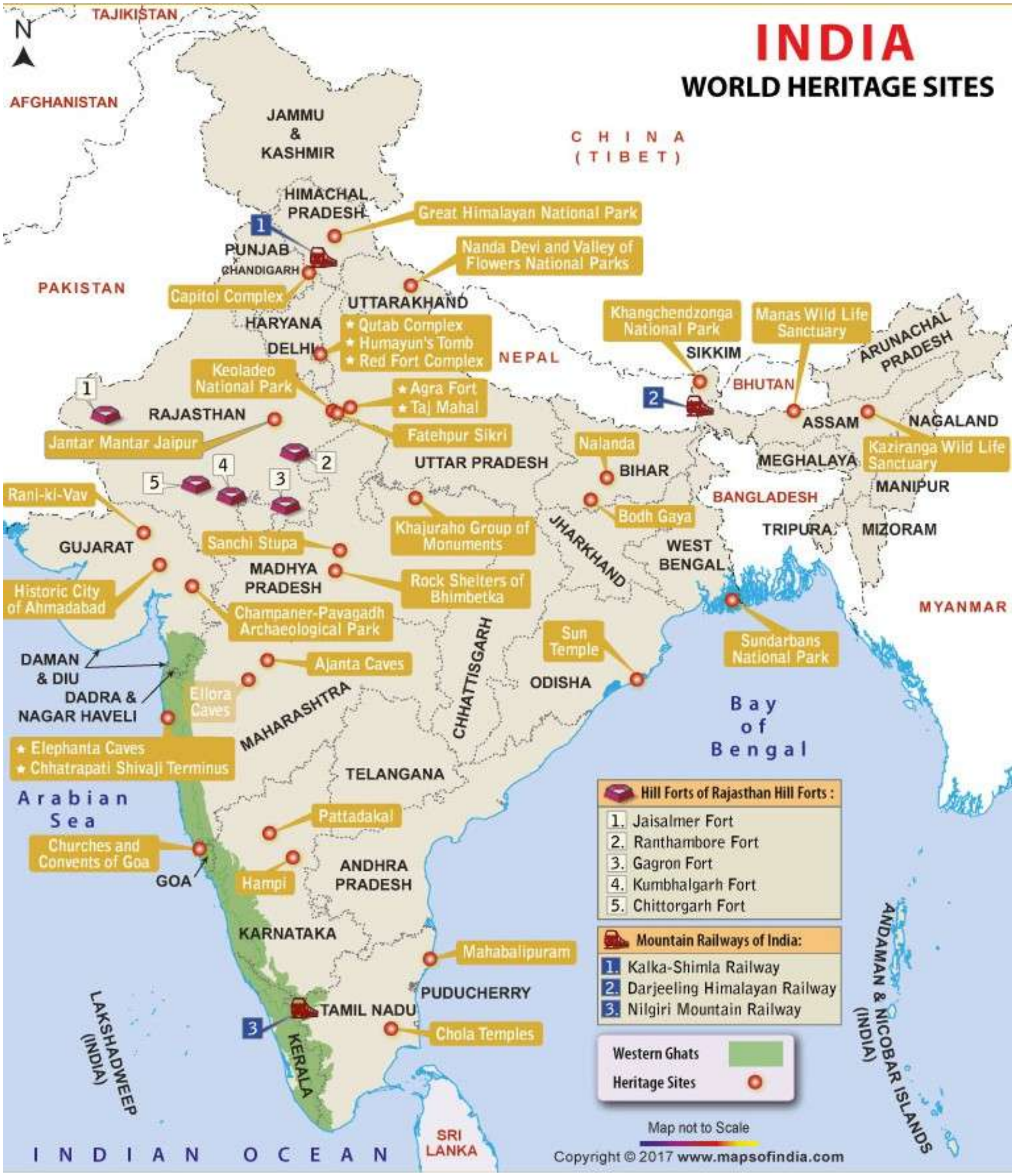

Fig. 5.9 : UNESCO World Heritage Sites in India (2017)

INTACH (Indian National Trust for Art and Cultural Heritage) further states, "*Conservation of architectural heritage and sites must retain meaning for the society in which it exists. This meaning may change over time, but taking it into consideration ensures that conservation will, at all times, have a contemporary logic underpinning its practice. This necessitates viewing conservation as a multi-disciplinary activity*".

The **conservation objectives** relevant for India, compiled by INTACH, are as below;

- ***Retain Visual Identity***: Preserving the distinct visual identity of a place, created by its architectural heritage and sites, is crucial amidst global homogenization. This preservation should not mimic legally protected monuments but rather adapt to contemporary society while maintaining heritage relevance. Balancing the needs of heritage and societal changes ensures integration into daily life, while controlling visual clutter like advertisements, cables, and antennas enhances the architectural heritage. Additions, such as, street furniture and signage contribute to appreciating the heritage.

- ***Adaptive Reuse***: Reusing historic buildings and neighbourhoods is economically viable and conserving architectural heritage by involving traditional craftspeople is effective. Prioritizing continuity of original functions, any new use should consider its impact on the local context, adhering to the capacity and vulnerability of the heritage. Comprehensive documentation should accompany any changes to the original fabric, ensuring coherence and engagement with traditional materials and skills. When altering internal functions, the external Fig. should be retained, involving the local community and communicating the benefits of the changes.

- ***Restoration/ Replication/ Rebuilding***: Restoration reinstates the integrity or completeness of architectural heritage/site, aiming to effectively convey its meaning, and may involve reassembly or replacement of missing or deteriorated parts, preceded and followed by documentation. Replication can be appropriate to conserve historic buildings and encourage traditional building methods. Rebuilding at the urban level enhances the visual and experiential quality of the built environment, countering global homogeneity. Reconstruction should be based on minimal physical evidence supported by local crafts people's knowledge and folklore, reinforcing the heritage's bond with society.
  Other sources (URA, Singapore) state that the core principle of conservation that applies to all preserved buildings, regardless of their size or complexity, is based on the ***concept of maximum retention, sensitive restoration, and careful repair,*** often referred to as the "3R"s. Replacement of original elements should only be considered when absolutely necessary, while complete reconstruction contradicts established international conservation practices. When upgrading and adapting a building for new purposes, the existing structure should be preserved by strengthening and repairing its structural elements. Any alterations or reinforcements to these elements should be carried out in a manner that is sympathetic and unobtrusive, utilizing original methods and materials whenever feasible.

- ***Employment Generation***: Conservation strategies should focus on employing local craftsmen, labour, and materials to sustain traditional building practices economically. Utilizing architectural heritage as an alternate strategy meets contemporary needs and supports traditional ways of building.

- ***Local Material and Traditional Technology***: Preference should be given to local materials and traditional technologies, based on available traditional knowledge systems. Modern substitutes should be considered only if proven efficient and judicious, without compromising the integrity of local building traditions. However, caution must be exercised in using certain materials that may damage ecological systems, such as shell lime in coastal areas or wood in general, which may require appropriate substitutions.

- ***Integrated Conservation***: Architectural heritage conservation should be integrated with social and economic aspirations of the community. Conservation-oriented development should be prioritized, necessitating multi-disciplinary teams that include social workers to facilitate dialogue and decision-making, considering diverse social aspirations.

- ***Sustainability***: Conservation should aim to sustain the buildings and/or the traditional skills and knowledge systems for building, positively contributing to the quality of life for the local community over time.

Several Conservation guidelines are available from INTACH, ICOMOS (international council on monuments and sites), and International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), UNESCO.

Repair and Rehabilitation of Structure

Rehabilitation is the process of restoring the structure to service level, once it had and now lost, strengthening consists in endowing the structure with a service level, higher than that initially planned by modifying the structure not necessarily damaged structure. **Repair** is the process of restoring something that is damaged or deteriorated or broken, to good condition, and is a means to perform rehabilitation through the improvement or modification of a structure, partly or wholly, which is damaged in appearance or serviceability. The primary objective of Repair and Rehabilitation is to *restore the structure, maximizing its functional usefulness*. It also serves the purpose of adapting the structure to fulfil new functional and other requirements. Repair and Rehabilitation techniques are employed for various reasons in structures, including but not limited to the following: damage due to accidents, deterioration due to Environment effects (Fire, Natural calamities like earthquake, Flood, Tsunami, cyclones, Soil and structure interaction, such as, settlement of soil or soil failure), and new functional or loading requirements requiring modifications to structure.

The general approach followed in the **Repair and Rehabilitation** process involves;

- ***Identifying the building*** in need of rehabilitation by performing a Structural Audit of the building.
- ***Gathering information*** about its history, conducting a preliminary survey that includes necessary tests to evaluate various retrofitting options, materials, feasibility and economy.
- ***Identifying the problems*** by performing structural calculations and capacity demand ratio for structural members.
- ***Conceptualising appropriate and feasible solutions***, such as, retrofitting/construction, that aligns with the building's topographical conditions.
- ***Execution of the solution*** by getting the rehabilitation of the building done.
- ***Post repair/retrofitting tests***.

Retrofitting

Retrofitting refers to the engineering process of modifying existing buildings to improve their structural behaviour while preserving their fundamental intended use. It is important to consider the following aspects for retrofitting, as recommended by (Chandar, 2014);

- ***Functionality aspect***: The basic function/ operation of the structure should not be hampered.
- ***Structural safety Aspect***: The susceptibility of the structure to an earthquake event has to be within acceptable standards.
- ***Importance Level Aspect***: Historic buildings with immense archaeological importance are sometimes beyond the cost factor for retrofitting. Such structures have to be rehabilitated without changing its elegance.
- ***Construction Methodology Aspect***: The retrofitting has to be performed using latest construction techniques that have the minimal impact on usual functioning of the buildings.
- ***Economy Aspect***: The entire cost of construction has to be practical and logical towards extended life of the structure.
- ***Skilled labour availability***: The retrofitting practices need unusual construction method and is highly technical job and calls for utmost care to implement it. A very skilled workmanship must be provided to instrument the suggested measures.

Below are the commonly used **techniques for retrofitting** a building:

1. Installation of additional ***Shear Walls*** is usually in the exterior of non-ductile reinforced concrete buildings. The wall maybe cast-in-place or pre-cast.
2. Addition of ***Steel Bracing*** is done for higher strength and stiffness when large openings are required, usually for natural lighting.
3. Application of ***Wall Thickening Technique*** to existing walls of a building is done by adding bricks, concrete and steel reinforcement, and is designed special conditions.
4. Implementation of ***Base Isolation Technique*** of the superstructure from the foundation is done as a passive structural vibration control technique. It buffers seismic loads and protect the building from damage, however, it is inefficient in high-rises.
5. Adoption of ***Mass Reduction Technique,*** such as removal of a storey, is done to decrease the loading.
6. Utilization of ***Jacketing Method*** to strengthen columns and beams by adding a jacket of longitudinal and traverse reinforcement, along with cement, around the structural element.
7. Incorporation of ***Fibre Reinforced Polymer (FRP)*** to axially strengthen columns and enhance its ductility, and in turn, increase load carrying capacity and improve shear capacity of the member.

8. Application of ***Epoxy Injection Method*** to non-moving cracks in concrete walls, slabs, columns, and piers, thereby restoring the strength of the concrete.
9. Implementation of ***External Plate Bonding*** for increasing the shear strength of reinforced concrete beams by completely or partially wrapping steel plates at the joint of a column and beam with external plates or strips, improves the shear strength.
10. ***Section-enlarging Reinforcing Method*** is used to increase the bearing capacity and cross-section stiffness, widely used for RCC beam, slabs, columns.

Fig. 10: Retrofitting Solutions (*Top Left to Right*) Shear Wall, Steel Bracing, Section Enlarging reinforcement, (*Middle Left to Right*) FRP Reinforced, (*Bottom Left to Right)* Epoxy Injection Method, External plate Bonding

5.3 INNOVATIONS AND METHODOLOGIES FOR SUSTAINABILITY

Various national and international codes and standards are being developed and updated, grounded on methodologies for optimisation, efficiency and further, integrated with sustainability considerations. These entail for specific civil engineering tasks, design requirements and specifications, construction techniques, environmental management and overall, sustainable infrastructure development.

5.3.1 Building Codes

The International Building Code (IBC), developed by the International Code Council (ICC), is widely used and adopted across the United States and the continent of North America. It also serves as the basis for the legislative building codes for several countries, like Mexico and Abu Dhabi. It focuses on adequate light and ventilation, energy conservation, means of egress facilities, and safety to life and property from fire, explosion, and other hazards; etc. India's indigenous building code, the **National Building Code** is developed by BIS.

The **NBC 2016**, has incorporated a lot of new and salient features (Annexure 2) in keeping with the current automation trends and sustainability goals, a few of which are as follows ;

- Detailed provisions relating to requirements for **accessibility in buildings and built environment** for persons with disabilities and the elderly.
- Norms for **solar energy** utilization.
- **Fire and life safety in modern complex buildings** including the high rises, glazed buildings, atria, commercial kitchen and car parking facilities.
- Updated **structural design provisions for wind and seismic loads**, imposed load due to helipad, and blast loads, for safe design and construction of buildings with due focus on ductile detailing.
- Latest research and development inputs and provisions on concrete, steel and masonry buildings with a view to ensuring **disaster resilient buildings**.
- Updated provisions on engineered use of **bamboo in housing** and other building construction.
- Promotion of use of **agricultural and industrial wastes** including **construction and demolition wastes** in building construction without compromising the quality and safety.
- **New and alternative building materials, and technologies** for building construction such as, reinforced masonry, confined masonry building construction and masonry wall construction using rat-trap bond.
- Inclusion of modern lighting techniques such as **LED and induction light** and their energy consumption.
- Provisions on aviation obstacle lights; **electric vehicle charging** and car park management.
- Use of **refrigerants** for air conditioning addressing zero ozone depletion potential **(ODP)** and ultra-low global warming potential **(GWP)**.
- Inclusion of new and **energy efficient options of air conditioning**, heating and mechanical ventilation, such as variable refrigerant flow system, inverter technology, district cooling

system, hybrid central plant using chilled beams, radiant floor components, and geo-thermal cooling and heating.

- Thrust on **envelope optimization** using energy modelling, day lighting simulation, solar shade analysis and wind modelling software to optimize the air conditioning load.
- Air conditioning, heating, and ventilation (HVAC) provisions considering **adaptive thermal comfort conditions** for energy efficiency.
- Updated provisions on **building automation system** to include the latest practices for web-based monitoring and control of performance parameters.
- New chapter on **information and communication enabled installations** in buildings.
- Updated provisions on **rainwater harvesting**.
- New chapter on **solid waste management** covering various solid waste management systems within the building and building complexes.
- Promoting quality of outdoor built environment through updated provisions on **landscape planning**, design and development.
- Promoting **sustainability** in buildings and built environment in tandem with relevant sustainable development goals.
- New chapter on **asset and facility management** to cover provisions relating to management of building assets and associated services, also covering responsibilities of occupants for maintenance of facilities, such as structures, equipment and exterior property.

Another complimentary body is the Indian Society of Heating, Refrigerating and Air-Conditioning Engineers (ISHRAE), which is the only national body in India which has developed **code for IEQ of buildings**, as stated in their 2015 position paper, and has further emphasized on the need for an integrated design approach that blends IEQ and Energy efficiency.

5.3.2 Building Information Modeling Standards

ISO 19650 standard is an internationally recognized guideline for effectively managing information throughout the entire lifecycle of a built asset using building information modeling (BIM). It encompasses the same principles and high-level requirements as the UK BIM Framework and aligns closely with the existing UK 1192 standards.

It is a series of international standards that provide guidelines and requirements for the organization and management of information within the construction industry, including civil engineering projects, by promoting the use of Building Information Modeling (BIM) and standardized processes for information management. It covers various aspects of information management, such as the creation, exchange, and management of digital information throughout the lifecycle of a construction project, with the aim to improve collaboration, efficiency, and interoperability among project stakeholders via BIM. ISO 19650 also addresses topics such as data classification, information security, and documentation requirements. The ISO 19650 standard series includes ;

- **BS EN ISO 19650-1**: This part focuses on the organization and digitalization of information related to buildings and civil engineering works, including building information modelling. It outlines the concepts and principles of information management using BIM.
- **BS EN ISO 19650-2**: This part deals with the organization and digitalization of information during the delivery phase of assets in buildings and civil engineering works. It provides guidance on information management using BIM during this stage.
- **BS EN ISO 19650-3:2020:** This part addresses the organization and digitalization of information in the operational phase of assets in buildings and civil engineering works. It covers information management using BIM during this period.
- **BS EN ISO 19650-5:2020**: This part focuses on the organization and digitalization of information, including building information modelling, with a security-minded approach to information management.

These standards are founded on the UK's standards for information management using building information modelling, namely BS 1192:2007 + A2:2016 and PAS 1192-2:2013. PD 19650-0 - UK Transition Guidance, which will along with the UK National Forewords and National Annex aid implementation of the ISO standards in the UK

5.3.3 Environment Management System Standards

An **Environmental Management System** is "*a framework that helps an organization achieve its environmental goals through consistent review, evaluation, and improvement of its environmental performance*" (EPA). It enables organizations to address their regulatory obligations in a systematic and cost-effective manner, proactively reduces environmental risks and enhances health and safety practices for both, occupants, and the public. Additionally, an EMS can tackle non-regulated concerns like, energy conservation, while promoting better operational control and encouraging stakeholder stewardship.

The **fundamental components of an Environmental Management System** encompass;

1. Assessing the organization's environmental objectives.
2. Analysing environmental impacts and compliance obligations, including legal and other requirements.
3. Establishing environmental objectives and targets aimed at reducing environmental impacts and meeting compliance obligations.
4. Implementing programs to achieve these objectives and targets.
5. Monitoring and measuring progress towards the established objectives.
6. Ensuring employees are well-informed and possess the necessary environmental awareness and competence.

7. Conducting regular reviews to track progress and identify opportunities for improvement.

The **ISO 14001:2015** is a standard that establishes the requirements for an Environment Management System to enable organizations to improve their environmental performance, fulfilment of compliance obligations and achievement of environmental objectives. ISO 14001:2015 is applicable to organizations of all sizes, types, and industries, and covers the environmental aspects of an organization's activities, products, and services that the organization can control or influence taking a life cycle perspective into account. It can be utilised either in its entirety or partially, to systematically enhance their environmental management practices, however, it does not establish specific environmental performance criteria.

5.3.4 ISO TC268 'Sustainable Cities and Communities'

TC 268 in the area of **Sustainable Cities and Communities** focuses on standardization efforts that involve developing requirements, frameworks, guidance, and tools to promote sustainable development, with considerations for smartness and resilience. The aim is to support all cities, communities, and stakeholders in rural and urban areas in their journey towards increased sustainability, in line with the SDGs. It has several working groups in the areas of infrastructure metrics, Integration and interaction framework for smart community infrastructures, Data exchange and sharing for smart community infrastructures, Power plant, Disaster risk reduction and Utility tunnel.

ISO/TC268, is responsible for the ISO 37100: 2016 series of standards that assists cities in defining their sustainability objectives and implementing strategies to achieve them. ISO/TR 37150 introduced indicators like Global City Indicators, Green City Index, and Smart City concepts driven by ICT. Efforts are underway to enhance existing indicators, such as, ISO/NP 37122, which focuses on "Sustainable Development in Communities - Indicators for Smart Cities" through legislations (currently in the proposal phase, and soon to be replaced by the ISO/AWI 37100)

The world is constantly developing new knowledge, methodologies, and innovative tools to strategically address improvements in the built environment and strive towards sustainability, due to its profound impact – at the societal and global level. It is imperative that the civil engineer of the future is much more than a master builder, but must gain competence in several other areas of leadership to ensure that the aim of sustainable development is achieved.

UNIT SUMMARY

This elementary unit presents the three pronged story of a good built-environment, as described by Vitruvius – utility, durability and beauty (aesthetics), from the lens of sustainable development. The unit elaborates the various sustainability practices and applications within the domain, such as, Facility management and sustainability strategies, Building control systems, Building certification and rating, and Smartness readiness Index, to enable the civil engineer for sound environmental decision-making. Additionally, the unit further introduces the importance and relevance of 'aesthetics' and its need to preserve the culture inherent in built-environment through practices of heritage conservation, and repair and rehabilitation. Lastly, the knowledge of the various national and international codes and standards for ensuring prioritisation and incorporation of environmental sustainability in practice is propounded.

EXERCISES

I. Multiple Choice Questions

Q. 5.1 Which of the following are not key activities of Facility Management?
- (a) Maintenance, cleaning, testing, and inspection
- (b) Regulatory Compliance
- (c) Heritage Conservation
- (d) Safety and Security

Q. 5.2 What are practical strategies of sustainable facility management?
- (a) Waste management
- (b) Green Building Certification
- (c) Performance Monitoring
- (d) all of the above

Q. 5.3 Which is not a design strategy for reduction of embodied energy?
- (a) Use of recyclable materials
- (b) Parametricism
- (c) Design for deconstruction
- (d) Low maintenance design

Q. 5.4 Which LEED category has the highest associated credit points (33 credits)?
(a) Location and Transportation
(b) Materials and Resources
(c) Energy and Atmosphere
(d) Water efficiency

Q. 5.5 Name India's national body responsible for developing contextually appropriate Heritage Conservation guidelines and objectives?
(a) INTACH
(b) ICOMOS
(c) ICCROM
(d) UNESCO

Answers of Multiple Choice Questions: 5.1 (c) , 5.2 (d) , 5.3 (b), 5.4 (c), 5.5 (a)

II. Short and Long Answer Type Questions

Q. 5.6 What is Aesthetics? Why is it an important consideration in built-environment.

Q. 5.7 What is a Building Control System? Illustrate the different types of sub-systems that it may have and their functionalities.

Q. 5.8 Discuss the various Green Building Certification/Rating systems used in India. Discuss one in detail.

Q. 5.9 What is embodied energy and embodied carbon? What are some of the design strategies for reduction of embodied energy and embodied carbon, elucidate with examples.

Q. 5.10 What are some of the new and innovative additions to the NBC 2016? Explain any two that will have profound impact on environmental sustainability.