

MODULE -2

CURRENT TRENDS IN INFRASTRUCTURE ENGINEERING

Current Trends in Infrastructure Engineering

Concepts and Components; Smart City, Energy Efficient Building and Structural Health Monitoring

Building Information Modeling; Introduction, Components and Applications

SMART CITY:

A Smart City is a concept in civil engineering and urban planning that utilizes technology and data to enhance the quality of life for residents and improve the efficiency of city services. The aim of a Smart City is to create a sustainable and intelligent urban environment by integrating various systems and infrastructure components.

The primary goal of smart cities is to support information and communication technologies (ICT) to enhance urban services, infrastructure, and governance, ultimately creating more intelligent, connected, and responsive urban environments.

Components smart city include:

1. Infrastructure Development: Civil engineers play a crucial role in designing and constructing the infrastructure of a Smart City. This includes roads, bridges, transportation systems, water supply networks, sewage systems, waste management facilities, and more. Smart infrastructure is designed to be efficient, resilient, and adaptable to changing needs.
2. Sustainable Design: Civil engineers emphasize sustainable design principles in Smart City projects. This involves using environmentally friendly construction materials, incorporating energy-efficient technologies, and optimizing resource consumption to reduce the city's ecological footprint.
3. Transportation and Mobility: Smart Cities focus on improving transportation and mobility through innovative solutions. Civil engineers work on designing intelligent transportation systems, implementing traffic management solutions, integrating public transportation networks, and promoting alternative transportation methods such as bike lanes and pedestrian-friendly infrastructure.
4. Smart Utilities: Civil engineers are involved in developing smart utility systems, including advanced metering infrastructure for electricity, water, and gas. These systems enable better monitoring and management of resources, leading to optimized consumption and reduced wastage.

5. Data and Connectivity: Smart Cities thrive on data-driven decision-making. Civil engineers work on incorporating sensors and IoT (Internet of Things) devices into infrastructure to collect data on various parameters such as traffic flow, air quality, water usage, and more. This data is then analyzed to make informed decisions for city planning and management.
6. Resilience and Disaster Management: Civil engineers play a critical role in ensuring the resilience of Smart Cities against natural disasters and other emergencies. They design structures and infrastructure to withstand potential hazards, and they develop emergency response and evacuation plans to protect residents during crises.
7. Waste Management: Smart Cities implement efficient waste management systems to reduce the environmental impact and promote recycling and waste-to-energy solutions. Civil engineers design and optimize waste collection and disposal systems to keep the city clean and sustainable.
8. Public Safety and Security: Civil engineers work with other stakeholders to incorporate smart security and surveillance systems in public spaces. This includes the installation of CCTV cameras, emergency call stations, and other technologies to enhance public safety and deter criminal activities.
9. Urban Planning and Zoning: Smart Cities require thoughtful urban planning and zoning strategies. Civil engineers collaborate with urban planners to design spaces that promote mixed-use development, walkability, and connectivity to create vibrant and livable communities.
10. Citizen Engagement: Civil engineers may be involved in developing digital platforms and mobile applications to facilitate citizen engagement. These platforms allow residents to provide feedback, report issues, and participate in the decision-making process, fostering a sense of ownership and involvement in city development.

Overall, civil engineering plays a pivotal role in the realization of Smart Cities by providing the foundational infrastructure and systems that enable the integration of technology and data for the benefit of the urban population.

Importance of smart cities:

Efficient Resource Management: Smart cities use data and technology to optimize the use of resources such as energy, water, and transportation systems. This leads to reduced waste, lower energy consumption, and decreased environmental impact.

Improved Infrastructure: Smart cities invest in modern infrastructure, including smart grids, advanced public transportation systems, and intelligent waste management. This not only enhances the overall quality of life for residents but also attracts businesses and investors.

Enhanced Mobility: Smart cities prioritize efficient and sustainable transportation solutions, including real-time traffic management, intelligent parking systems, and seamless integration of public transportation. This reduces congestion, air pollution, and travel time.

Better Governance and Services: Digital technologies allow for improved governance through data-driven decision-making. Services such as e-governance, online public services, and smart healthcare systems can make urban administration more efficient and responsive to citizens' needs.

Environmental Sustainability: Smart cities emphasize sustainability by implementing green building practices, renewable energy solutions, and waste reduction strategies. This contributes to the reduction of carbon emissions and promotes a healthier environment.

Economic Growth: The integration of technology and innovation in a city's infrastructure can attract tech companies, startups, and entrepreneurs. This fosters economic growth, creates job opportunities, and positions the city as a hub for innovation.

Quality of Life: By focusing on smart solutions for public safety, healthcare, education, and public spaces, smart cities enhance residents' overall quality of life. Smart lighting, security systems, and access to digital education resources are just a few examples.

Data-Driven Decision-Making: Smart cities collect and analyze vast amounts of data from various sources. This data can be used to make informed decisions, identify trends, and address challenges proactively, leading to better urban planning and policy implementation.

Community Engagement: Smart cities often involve citizens in the planning and decision-making processes. Digital platforms and apps can be used to gather feedback, facilitate communication between citizens and local authorities, and promote a sense of community.

Resilience and Disaster Management: Smart cities can implement systems to monitor and respond to emergencies and natural disasters more effectively. This improves the city's resilience and minimizes the impact of such events on residents and infrastructure.

Tourism and Livability: A city that embraces smart technologies and offers a high quality of life becomes an attractive destination for tourists and potential residents. Livability factors, such as clean environments and efficient transportation, contribute to the city's overall appeal.

Inclusivity and Accessibility: Smart city initiatives can work towards making urban spaces more accessible to people with disabilities and elderly individuals. Digital solutions can enhance mobility, communication, and engagement for all members of the community.

Smart city concept in India: India has been actively pursuing the smart city concept to address the challenges posed by rapid urbanization and improve the quality of life for its citizens. In 2015, the Indian government launched the "Smart Cities Mission," an ambitious program aimed at developing 100 smart cities across the country. The mission focuses on using technology and data-driven solutions to enhance urban infrastructure, services, and governance.

There are 98 nominated by states national level smart cities challenge, based on state level competition. In Karnataka state Bengaluru, Mangaluru, Belagavi, Shivamogga, Hubballi-Dharwad, Tumakuru, Davanagere are the selected cities for the project.

STRUCTURAL HEALTH MONITORING (SHM)

- ❖ Structural health monitoring (SHM) is the process of using damage detection and characterization techniques for critical structures like bridges, wind turbines, and tunnels.
- ❖ It is a non-destructive in-situ structural evaluation method that employs several types of sensors embedded or attached to the structure.
- ❖ The structural health monitoring process includes installing sensors, data acquisition, data transfer, and diagnostics through which the structure's safety, strength, integrity, and performance are monitored. If overloading or any other defects are observed, proper correction measures are suggested.

❖ Purpose of SHM in Civil Engineering

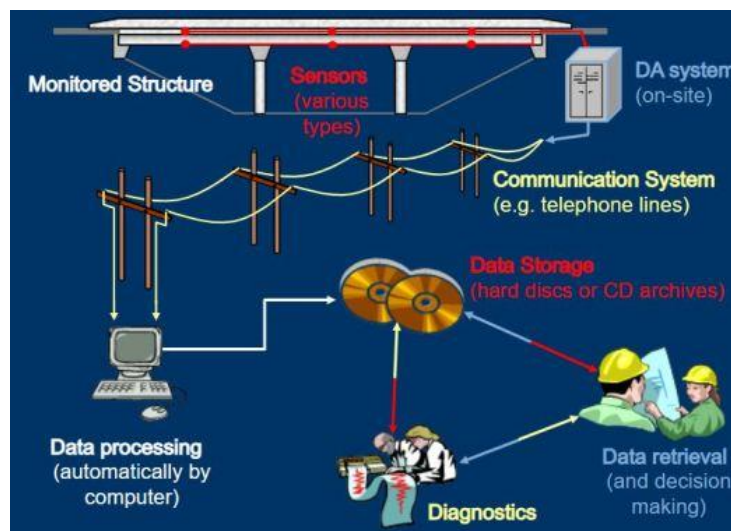
1. SHM helps ensure the safety of structures and the people who use them. By monitoring structural conditions, potential risks can be identified and addressed before they lead to catastrophic failures
2. SHM systems are equipped with sensors that can detect even minor changes in structural behavior. This enables early detection of damage, deterioration, or anomalies that might not be visible to the naked eye.

3. Instead of relying on fixed maintenance schedules, SHM allows for maintenance to be performed when needed. This prevents over-maintenance and extends the service life of structures, saving time and resources.
4. By addressing problems early, SHM can help prevent costly repairs or replacements that might be necessary if damage is left untreated. It can also minimize downtime and associated losses in revenue.
5. SHM helps allocate resources more effectively by focusing maintenance efforts on areas that require attention, rather than treating the entire structure uniformly.
6. By extending the lifespan of structures and reducing the need for frequent repairs or replacements, SHM can contribute to sustainability and reduce the environmental impact associated with construction and demolition.

Application of SHM in Civil Engineering

1. Improve performance (safety and functionality) of existing structures.
2. The placement of sensors during construction works enables observers to assess the structure's condition and specify its remaining life span.
3. Evaluate the integrity of a structure after earthquakes.
4. Structural monitoring and assessment are essential for on-time and cost-effective maintenance. So, it reduces construction work and increases maintenance activities.
5. The SHM process collects data on the realistic performance of structures. This data can help design better structures in the future.
6. Shift towards a performance-based design philosophy

Components of Structural Health Monitoring System



1. Structure

The critical structures like bridges, tunnels, dams, and wind turbines are mostly monitored as they are a vital part of the national infrastructure.

2. Data Acquisition System

Data acquisition addresses the number and type of sensors, how to activate sensors, and techniques to save data. The placement of sensors should not alter the behavior of the structure. This can be achieved by considering the placement of wiring, boxing, etc., at the design stage.

3. Data Transfer

The transfer of data can be done through a wire communication or wireless communication.

4. Digital Processing

After the data is transferred, digital processing is carried out. Unwanted effects such as noises are eliminated. And only necessary data is retained

5. Storage of Data

The processed data can be stored for a long time and retrieved in the future for analysis and interpretation

6. Data Diagnostics

Diagnostic processes involve the conversion of abstract data to useful information about the structure's condition and its responses to loads. So, the final data obtained from structural health monitoring should be detailed and physical, based on which rational and knowledge-based engineering decisions can be made.

ENERGY EFFICIENT BUILDING:

Energy-efficient buildings are structures designed and constructed to minimize their energy consumption while maximizing comfort, functionality, and sustainability. The primary goal of energy-efficient buildings is to reduce the amount of energy required for heating, cooling, lighting, and other purposes, which in turn lowers energy costs and decreases their environmental impact.

Components /Strategies commonly employed in energy-efficient buildings:

1. Insulation: Proper insulation is essential for reducing heat transfer between the interior and exterior of a building. Insulated walls, roofs, and windows help maintain a consistent indoor temperature, reducing the need for excessive heating or cooling.
2. High-performance windows: Energy-efficient windows, such as double or triple-glazed windows, can minimize heat loss and gain while allowing natural light to enter the building.

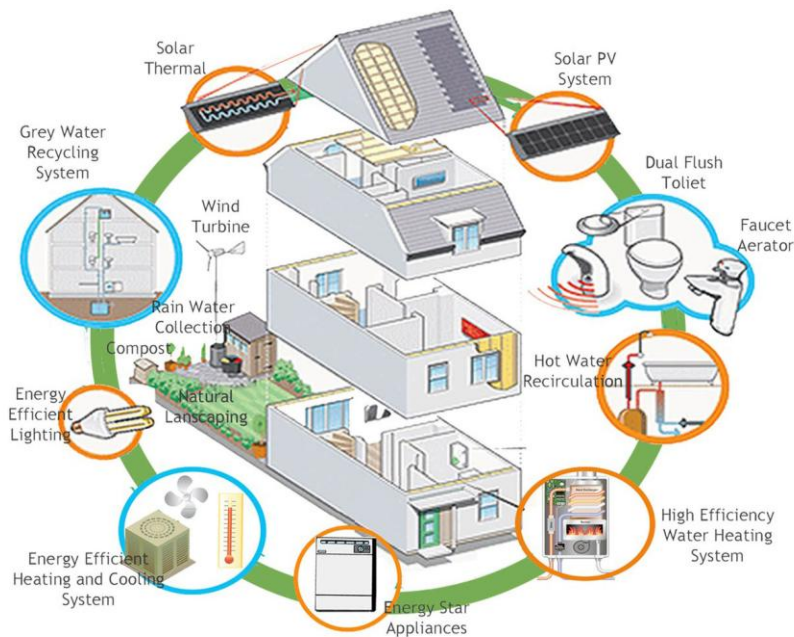
3. Sealing and weatherization: Air leaks around doors, windows, and other openings are responsible for significant energy losses. Sealing these gaps and weatherizing the building helps maintain indoor comfort and saves energy.
4. Energy-efficient HVAC systems: Heating, ventilation, and air conditioning (HVAC) systems that are designed to be energy-efficient can significantly reduce energy consumption. This can involve using heat pumps, energy recovery ventilation, and smart thermostat controls.
5. Efficient lighting: LED (Light Emitting Diode) and CFL (Compact Fluorescent Lamp) lighting are more energy-efficient than traditional incandescent bulbs and can significantly reduce lighting-related energy consumption.
6. Renewable energy integration: Some energy-efficient buildings incorporate renewable energy sources, such as solar panels, wind turbines, or geothermal systems, to generate their electricity or heat.
7. Passive design: Passive design techniques utilize the building's orientation, layout, and materials to naturally regulate indoor temperatures, reducing the need for mechanical heating or cooling.
8. Energy-efficient appliances and equipment: Using energy-efficient appliances and equipment throughout the building helps minimize energy consumption and lowers utility bills.
9. Energy management systems: Installing smart energy management systems can optimize energy usage by monitoring and controlling various building systems based on occupancy, weather conditions, and other factors.
10. Water conservation: Implementing water-saving fixtures and technologies, such as low-flow toilets and rainwater harvesting systems, can contribute to overall energy efficiency by reducing water heating and pumping requirements.
11. Green building materials: Using sustainable and eco-friendly construction materials can reduce the environmental impact of the building and improve indoor air quality.

Applications of energy-efficient buildings:

1. Energy-efficient buildings are designed to minimize energy waste. They often incorporate better insulation, advanced windows, and tightly sealed building envelopes to reduce the need for excessive heating or cooling. This leads to lower energy bills for occupants.
2. Energy-efficient buildings can incorporate renewable energy sources such as solar panels, wind turbines, and geothermal systems. These sources generate clean energy on-site, reducing the reliance on fossil fuels and lowering greenhouse gas emissions.

3. Energy-efficient buildings use smart lighting systems that adjust brightness based on natural light levels and occupancy. LED lights are often used due to their efficiency and longer lifespan. Motion sensors and timers help prevent unnecessary energy consumption.
4. Architectural design that maximizes natural light and facilitates natural ventilation reduces the need for artificial lighting and mechanical cooling. This improves indoor air quality and reduces energy demand.
5. While the upfront costs of designing and constructing energy-efficient buildings might be higher, the long-term cost savings from reduced energy bills, maintenance, and operational expenses can be substantial.
6. Energy-efficient buildings often have higher market value due to their reduced operational costs and sustainability features, making them attractive to investors and tenants.
7. By reducing energy consumption and reliance on fossil fuels, energy-efficient buildings contribute to lower carbon emissions and help combat climate change.

Energy-efficient buildings not only benefit the environment by reducing greenhouse gas emissions and conserving natural resources but also offer long-term cost savings to occupants and owners. Many countries have established building codes and standards that encourage or mandate energy-efficient practices in construction to promote sustainable development and combat climate change.



BUILDING INFORMATION MODELING; INTRODUCTION, APPLICATION AND SOFTWARE'S

Introduction:

Building information modeling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of places. In simple terms BIM is basically a technology or process of creating 3D models using various other software BIM is supported by various tools, technologies and contracts. Building information models (BIMs) are computer files which can be extracted, exchanged or networked to support decision-making regarding a structure.

BIM software is used by individuals, businesses and government agencies that plan, design, construct, operate and maintain buildings and diverse physical infrastructures, such as water, refuse, electricity, gas, communication utilities, roads, railways, bridges, ports and tunnels.

It allows multiple stakeholders, including architects, engineers, contractors, and facility managers, to work together efficiently and effectively throughout the entire project lifecycle.

Objectives:

1. To carry out cost estimation and budgeting
2. To share accurate information among different parties involved in the project
3. To analyze energy performance, daylighting, and other sustainable design factors.
4. To carry out sequence of activities, resource allocation, and construction phasing.
5. To effectively collaborate with various stakeholders of the project

Applications

1. Visualization and Design: BIM enables 3D modeling of buildings and infrastructure, providing a visual representation of the project's design. This helps stakeholders better understand the proposed construction and identify potential design conflicts and issues early in the process.
2. Data Integration: BIM goes beyond 3D geometry and incorporates a wide range of data, including structural details, material specifications, cost information, construction schedules, and sustainability features. This data integration streamlines decision-making and improves project coordination.
3. Collaboration and Communication: BIM fosters collaboration among various disciplines, allowing architects, civil engineers, structural engineers, MEP (mechanical, electrical, plumbing) engineers, and other specialists to work together on a shared platform. Effective communication between team members reduces errors and improves project outcomes.

4. Clash Detection: BIM software can identify clashes and conflicts between different building systems, such as structural elements interfering with HVAC ducts or plumbing pipes. Detecting clashes early helps prevent costly rework during construction.
5. Quantification and Cost Estimation: BIM models can be used to generate accurate quantity takeoffs and cost estimates, aiding in project budgeting and cost management.
6. Construction Planning and Sequencing: BIM allows construction professionals to create detailed construction schedules and sequences based on the 3D model, enhancing project planning and coordination on the construction site.
7. Facility Management and Operations: After construction is completed, BIM models can be handed over to facility managers for ongoing maintenance and operations. BIM's data-rich models assist in facility management tasks such as asset tracking, maintenance planning, and energy analysis.
8. Sustainability Analysis: BIM facilitates sustainability analysis, allowing designers to assess the environmental impact of design choices and optimize energy efficiency and resource usage.
9. Modular Construction: BIM supports the concept of modular construction by enabling prefabrication and assembly of components with high precision, reducing on-site labor and construction time.
10. Regulatory Compliance: BIM aids in compliance with building codes and regulations by providing a comprehensive digital record of the design and construction process.

Overall, BIM enhances efficiency, reduces errors, improves collaboration, and optimizes decision-making in civil engineering projects.

Softwares:

1. Autodesk Revit
2. Autodesk BIM 360
3. Tekla Structures
4. ArchiCAD
5. Autodesk Civil 3D
6. Vectorworks Architect
7. Graphisoft ARCHICAD
8. Microstation
9. Procore BIM Software
10. Autodesk Navisworks