IARE
INSTITUTE OF
AERONAUTICAL ENGINEERING

HIGH IMPACT PRACTICES (HIPS)

ECO-CONSCIOUS CONCRETE

INFORMATION PACKET

2025 - 2026

INSTITUTE OF AERONAUTICAL ENGINEERING
25 YEARS 2000 2025

We appreciate IARE students who are showing interest in the Eco-Conscious Concrete (ECC) Project Program at the Institute of Aeronautical Engineering.

The ECC Project team members work as part of a research-driven group of students, research scholars, and faculty members to tackle novel design and research problems across domains like structural health monitoring, smart materials, sustainability, and urban systems.
Integrating Eco-Conscious Concrete (ECC) significantly improves project planning, resource optimization, safety, and predictive maintenance—empowering future-ready engineers.

The goals of ECC projects are,

1. **Undergraduate Research in AI & CE:** Student-led or supervised research initiatives exploring how AI can be used in domains like smart materials, structural analysis, geotechnical modeling, or construction automation to solve real-world civil engineering problems.
2. **Collaborative & Interdisciplinary Projects:** Projects combining knowledge from Civil Engineering, AI/ML, Architecture, and Environmental Science to design sustainable and data-driven infrastructure solutions.
3. **Capstone Design Projects:** Final-year design projects where students apply civil engineering knowledge, integrated with AI tools, to develop solutions like smart drainage systems, intelligent traffic control, or predictive maintenance of infrastructure.
4. **Internships & Industry Engagement:** Practical exposure through internships in civil engineering firms, government bodies, or research institutions focusing on smart city solutions, AI-based monitoring, or infrastructure planning.
5. **Service Learning / Community Projects:** Projects where students use geospatial mapping, AI-based flood prediction, or sustainable material usage to solve problems faced by rural or underserved communities.
6. **Global Learning & Exchange:** Programs and collaborative projects with international universities or global organizations focused on smart infrastructure, disaster-resilient design, and AI-driven urban planning.
7. **e-Portfolios:** A digital compilation of students' project reports, design work, field studies, AI models, and construction simulations, used to showcase learning, skills, and growth.
8. **Enhanced Problem-Solving and Innovation:** Encouraging students to apply AI tools, simulations, and modeling techniques to identify root causes and engineer optimized solutions for structural safety, materials efficiency, and sustainability.
9. **Improved Communication and Teamwork:** Building soft skills through team-based projects, collaborative site analysis, and interdisciplinary coordination, ensuring professional readiness.
10. **Real-World Readiness with Ethical and Societal Understanding:** Instilling an understanding of sustainable development goals, inclusive urban design, and ethical construction practices while preparing students for diverse work environments.
11. **Lifelong Learning Attitude:** Promoting the continuous pursuit of emerging technologies like BIM, AI in construction, digital twins, and environmental modeling tools to stay current and competent in the profession.

The research theme of this Eco-Conscious Concrete (ECC) projects also focuses on the challenges presented by the Sustainable Development Goals (SDGs).

Sustainability Development Goals (SDGs) for the Dept. of CE, IARE	
SDG 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
SDG 7	Ensure access to affordable, reliable, sustainable and modern energy for all
SDG 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
SDG 11	Make cities and human settlements inclusive, safe, resilient and sustainable
SDG 12	Ensure sustainable consumption and production patterns
SDG 13	Take urgent action to combat climate change and its impacts

Themes of Eco-Conscious Concrete (ECC) for the CE:

The following research domains are recommended for HIPs-ECC Projects, and selected students should find the research gap and frame the problem statements from any one of the themes below**.**

1. AI-Based Crack Detection and Health Monitoring in Concrete Structures Using Drones **(SDG #9, SDG #11)**
2. Development of Smart Concrete with Embedded Sensors for Structural Health Monitoring **(SDG #9, SDG #11)**
3. Energy-Efficient Curing Chambers for Sustainable Precast Concrete Production **(SDG #7, SDG #12, SDG #13)**
4. Real-Time Quality Control in Ready Mix Concrete Using IoT and Edge Analytics **(SDG #9, SDG #12)**
5. Augmented Reality (AR) for Virtual Visualization of Reinforcement Detailing in Concrete Structures **(SDG #4, SDG #9)**
6. Self-Healing Concrete with Bacterial Additives for Durability Enhancement **(SDG #9, SDG #11, SDG #13)**
7. Use of Recycled Aggregates and AI-Optimized Mix Design for Green Concrete **(SDG #9, SDG #12, SDG #13)**
8. Development of AI Models for Predicting Compressive Strength of Concrete with Industrial Waste Additives **(SDG #9, SDG #12, SDG #13)**
9. Digital Twin Technology for Monitoring and Maintenance of Concrete Bridges **(SDG #9, SDG #11)**
10. VR-Based Interactive Training Lab for Concrete Testing and Quality Assurance **(SDG #4, SDG #9)**

In order to participate in ECC Projects, you must formally apply and be accepted by the project coordinator. To proceed, please mail to the project coordinator, Dr. R Ramya swetha, Associate Professor and Head, Dept. of CE, Email Id: r.ramyaswetha@iare.ac.in. This will bring up all available open positions tagged as ECC projects. When submitting a project document and an updated résumé, include a statement regarding why you are interested in working with the team to which you are applying. Please note that participation by the ECC project team requires registration for the accompanying research statement from any of the specified domains. More information will be provided to all selected ECC project applicants who have been offered a position. If you have any questions about a particular team, please contact the team's faculty mentor(s). We encourage you to contemplate this fascinating new opportunity. We look forward to receiving your application submission.

AI-Based Crack Detection and Health Monitoring in Concrete Structures Using Drones

Dr. R Ramya swetha, Associate Professor & Head, CE– Faculty Mentor

GOALS

The primary goal is to develop an intelligent drone-based system capable of autonomously detecting, classifying, and monitoring cracks in concrete structures such as bridges, buildings, and pavements using Artificial Intelligence (AI) and Computer Vision. This approach enhances the efficiency, safety, and reliability of structural health monitoring (SHM), especially in large-scale or inaccessible infrastructures.
Automated Crack Detection: Identify fine cracks, delaminations, and surface defects in concrete using high-resolution drone imagery.
Crack Classification and Severity Assessment: Use AI models to classify crack types (e.g., flexural, shear, surface) and estimate their severity levels.
Periodic Health Monitoring: Enable time-lapse imaging to monitor crack propagation and structural degradation over time.
Risk Prioritization: Generate maintenance alerts for critical defects to support decision-making in infrastructure management.
Minimize Human Risk: Eliminate the need for manual inspections in hazardous or hard-to-reach areas.
Smart Infrastructure Maintenance: Integrate health monitoring systems with Building Information Modeling (BIM) for predictive maintenance planning.

The integration of AI and drone technology provides a scalable, non-invasive, and real-time solution for ensuring the durability and safety of concrete structures, supporting modern smart infrastructure goals.

METHODS & TECHNOLOGIES

Methods

- **Data Acquisition:** High-resolution visual and thermal imagery using drones (UAVs).
- **Image Preprocessing:** Contrast enhancement, noise removal, and segmentation.
- **Model Training:** Deep learning using labeled image datasets of cracks and defects.
- **Crack Detection & Classification:** Using AI models like CNNs and object detection algorithms.
- **Damage Mapping:** Generating 2D/3D visualizations and defect heatmaps using geotagged data.
- **Integration:** Upload to cloud platforms or BIM systems for storage, analysis, and reporting.

Technologies & Tools

- **Deep Learning Models:** Convolutional Neural Networks (CNNs), YOLO, Faster R-CNN
- **AI Platforms:** TensorFlow, Keras, OpenCV, PyTorch
- **Drone Technology:** DJI Phantom, Mavic, Parrot Anafi with HD/IR cameras
- **Image Processing Tools:** MATLAB, ImageJ, OpenCV
- **GIS/BIM Integration:** ArcGIS, Autodesk Revit, Navisworks
- **IoT & Cloud:** AWS, Google Cloud for storage and remote monitoring dashboards

MAJORS & AREAS OF INTEREST

This project draws from a blend of academic programs and technical domains, reflecting the interdisciplinary nature of modern civil infrastructure inspection.
Civil Engineering: Foundational knowledge in structural mechanics, concrete behavior, and durability assessment is essential. Civil engineers interpret crack types, understand stress patterns, and apply SHM principles to assess risks and design interventions.
Artificial Intelligence and Computer Science: Supports the development of AI algorithms and real-time computer vision systems. Concepts like deep learning, image classification, and edge computing form the basis of smart inspection systems.
Aerospace and Mechatronics Engineering: Contributes through the design, navigation, and control of drone platforms used in automated site inspection and data collection in complex environments.

Electronics and Communication Engineering: Enables the use of embedded systems, sensor integration, and wireless communication for drone control, image capture, and real-time data transmission.
Data Science: Provides statistical methods, image analytics, and predictive modeling tools to evaluate crack progression, compare historical data, and forecast structural performance.
Remote Sensing and Geoinformatics: Supports the use of GPS-enabled drones and geospatial mapping tools to generate crack distribution maps and integrate findings with structural maps and BIM models.

The **AI-Drone crack detection system** exemplifies the **constructivist learning model**, where students actively engage in real-world problem-solving by applying and integrating knowledge from various fields. This high-impact practice fosters **experiential learning, interdisciplinary collaboration**, and innovation in sustainable infrastructure management.

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Development of Smart Concrete with Embedded Sensors for Structural Health Monitoring

Dr. M Venu, Professor & Deputy Head, CE– Faculty Mentor

GOALS

The primary goal of this project is to develop a next-generation concrete material integrated with embedded sensors that enable real-time monitoring of structural performance and deterioration. Smart concrete systems can detect strain, stress, cracks, corrosion, temperature, and moisture—providing actionable data that supports predictive maintenance, infrastructure safety, and lifecycle management.

Embedded Sensing Capability: Integrate sensors (e.g., strain gauges, piezoelectric sensors, fiber optics) directly into the concrete matrix.
Real-Time Data Acquisition: Enable live monitoring of mechanical and environmental parameters affecting concrete behavior.
Early Damage Detection: Detect microcracks, stress accumulation, and changes in load response before visible damage occurs.
Wireless and Autonomous Monitoring: Develop low-power, wireless data transmission modules for remote access to sensor data.
Predictive Maintenance: Use AI-based analysis of sensor data to forecast service life and schedule timely interventions.
Smart Infrastructure: Contribute to the development of intelligent buildings, bridges, and pavements capable of self-assessment and reporting.

Smart concrete is the foundation of intelligent infrastructure, enabling a shift from reactive repair to proactive management of civil structures, thus enhancing safety, durability, and cost-effectiveness.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

The development of this system involves several key methods:

- **Sensor Selection**: Choose appropriate embedded sensors (strain gauges, FBG sensors, piezoresistive sensors) based on application.
- **Mix Design Integration**: Develop concrete mix compatible with sensor embedding without compromising mechanical properties.
- **Data Acquisition Systems**: Design circuits for continuous monitoring and data logging.
- **Signal Processing**: Filter, calibrate, and interpret sensor signals to extract structural behavior metrics.
- **AI-Based Analysis**: Apply machine learning for anomaly detection, damage prediction, and pattern recognition.
- **Lifecycle Assessment**: Evaluate system performance over time under various loading and environmental conditions.

Technologies Used

- **Sensors:** Fiber Bragg Grating (FBG), piezoelectric transducers, carbon nanotube-based sensors, corrosion sensors.
- **Microcontrollers/Hardware**: Arduino, Raspberry Pi, NI DAQ, STM32
- **Data Communication**: Zigbee, LoRa, Wi-Fi, Bluetooth, RFID
- **Analysis Tools**: MATLAB, LabVIEW, Python, TensorFlow
- **Software for SHM**: ANSYS, ABAQUS (for structural simulation and validation)
- **Energy Systems**: Embedded energy harvesting systems or battery-powered modules

MAJORS & AREAS OF INTEREST

The project embodies **cross-disciplinary convergence**, combining material science, electronics, AI, and structural engineering.
Civil Engineering: Provides core understanding of concrete behavior under load, stress-strain relationships, cracking mechanisms, and durability. Civil engineers design sensor placement strategies and interpret data in the context of structural performance and codes.
Electronics and Communication Engineering: Supports sensor design, signal conditioning, data acquisition systems, and wireless communication, ensuring accurate and real-time sensing within the concrete structure.
A**rtificial Intelligence and Computer Science**: Enables the analysis of complex data streams from embedded sensors using AI algorithms like anomaly detection, trend analysis, and fault forecasting.
Materials Science: Helps in tailoring concrete mixes to accommodate sensors without affecting workability or strength. Explores use of self-sensing materials like CNT-infused concrete.
Mechanical Engineering: Assists in stress-strain analysis, calibration of embedded systems, and modeling mechanical responses under different load conditions.
Instrumentation and Control Engineering: Focuses on automation, feedback loops, and integration of sensor systems into structural monitoring platforms, enabling real-time alert systems and dashboards.

The smart concrete platform aligns with constructivist and experiential learning models, enabling students to build solutions that mimic real-world civil infrastructure challenges. Through interdisciplinary collaboration and hands-on prototyping, students gain deeper insights into intelligent materials, embedded systems, and AI-powered decision making in the built environment.

MENTOR CONTACT INFORMATION

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Energy-Efficient Curing Chambers for Sustainable Precast Concrete Production

Dr. U Vamsi Mohan, Professor, CE– Faculty Mentor

GOALS

The main goal is to design and implement energy-efficient curing chambers that optimize the hydration process of precast concrete, while reducing energy consumption, minimizing emissions, and enhancing sustainability in industrial-scale concrete production. The system should maintain ideal temperature and humidity for strength gain while integrating smart monitoring and control systems for maximum efficiency.

Optimize Curing Conditions: Maintain optimal humidity and temperature ranges to accelerate hydration and improve early strength gain.

Reduce Energy Consumption: Utilize insulation, heat recovery systems, and alternative energy sources to lower thermal and electrical demands.

Integrate Intelligent Control Systems: Implement sensors and automated controllers (AI or PLC-based) to maintain precise curing conditions and reduce energy waste.

Enable Uniform and High-Quality Production: Ensure consistency in curing across all concrete elements, improving durability and surface finish.

Utilize Renewable Energy: Integrate solar heating, biomass, or waste heat recovery to power the chamber, reducing reliance on fossil fuels.

Promote Sustainability and Cost Reduction: Achieve environmental compliance, reduce curing time, and lower production costs through efficient thermal management.

Scalable for Industrial Use: Design systems suitable for various precast units like beams, columns, panels, and blocks.

With precast concrete becoming a pillar of modern infrastructure, sustainable curing systems can significantly enhance eco-efficiency and competitiveness in construction manufacturing.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

- **Thermal Simulation & Design**: Use thermal modeling (CFD/FEM) to simulate heat distribution, optimize insulation, and avoid energy loss.
- **Sensor-Based Monitoring**: Install temperature, humidity, and CO_2 sensors inside the chamber for real-time monitoring.
- **Automated Control Systems**: Use PLCs or AI algorithms to regulate heating, misting, and ventilation based on sensor inputs.
- **Moisture Retention Systems**: Incorporate sealed environments, foggers, and water recycling to reduce water and heat loss.
- **Heat Recovery & Recycling**: Capture and reuse waste heat from other production units or internal recirculation systems.

Technologies Used

- **Smart Sensors**: DHT22, PT100, thermocouples, and humidity transducers.
- **Control Systems**: PLC (Siemens, Allen-Bradley), microcontrollers (Arduino, ESP32), AI-based controllers (Raspberry Pi + Python)
- **Insulating Materials**: Aerogels, vacuum-insulated panels (VIPs), eco-friendly foams
- **Energy Systems**: Solar thermal panels, infrared heaters, phase change materials (PCMs) for thermal storage
- **Simulation Tools**: ANSYS Fluent, COMSOL Multiphysics, MATLAB Simulink for thermal behavior
- **Data Logging**: Cloud-based dashboards, IoT platforms for energy and curing cycle analytics

MAJORS & AREAS OF INTEREST

Core knowledge of concrete technology, hydration chemistry, and precast production techniques. Civil engineers determine curing parameters that affect strength, durability, and microstructure development.
Mechanical Engineering Supports thermal system design, HVAC integration, fluid mechanics (for fogging/misting), and energy modeling. Also helps in designing compact, insulated chamber structures.
Electrical and Electronics Engineering (EEE) Provides expertise in control system design, sensor interfacing, power distribution, and integration of automated logic for efficient chamber regulation.
Renewable Energy Engineering Focuses on integration of solar, geothermal, or waste-heat systems for curing chamber operation. Evaluates sustainability metrics and energy performance indicators.
Computer Science and AI Enables smart control algorithms, predictive analytics for curing cycle optimization, and cloud-based dashboards for remote monitoring.
Environmental Engineering Assesses emission reduction, energy conservation, and water reuse strategies. Contributes to life-cycle analysis and green certification.
Instrumentation and Control Engineering Ensures accurate data acquisition, feedback loop control, and integration of PID or AI-based regulation systems for chamber conditions.

Energy-efficient curing chambers provide a real-world, high-impact platform for students to explore applied sustainability in construction, combining experiential learning with multidisciplinary collaboration. These systems align with global trends in green construction, smart manufacturing, and resource optimization, and serve as a practical gateway into industry 4.0 for civil infrastructure.

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Real-Time Quality Control in Ready Mix Concrete Using IoT and Edge Analytics

Dr. Praveena Rao, Assistant Professor, CE – Faculty Mentor

GOALS

The primary goal is to **implement an intelligent, real-time quality control system** for Ready Mix Concrete (RMC) plants by integrating **IoT-based sensors** and **edge analytics**. This system continuously monitors and analyzes critical parameters—such as temperature, slump, moisture content, mixing time, and delivery conditions—ensuring consistency, traceability, and compliance with standards at every stage of concrete production and delivery.

Real-Time Monitoring: Capture live data on concrete mix parameters (e.g., water-cement ratio, aggregate moisture, mixing speed) during batching and transit.

Edge-Based Processing: Use edge devices to locally analyze sensor data and detect anomalies without requiring constant cloud connectivity.

Minimize Human Error: Reduce manual testing dependency and ensure automated alerts for deviations from design mix specifications.

Improved Traceability and Reporting: Log and store data for each batch, enabling traceability and quality audits.

In-Transit Quality Tracking: Monitor slump retention and temperature changes during transport to construction sites.

Predictive Adjustments: Implement real-time feedback loops to auto-adjust water or admixture dosage when necessary.

Reduce Wastage and Rejections: Detect faults before concrete placement to minimize site-level rejection and material loss.

The system enhances operational efficiency, compliance, and customer satisfaction, aligning RMC production with smart manufacturing and data-driven construction practices.

METHODS & TECHNOLOGIES

Methods

- **Sensor Integration**: Use embedded sensors in mixers, bins, and trucks to capture parameters like temperature, humidity, load weight, rotation speed, and slump.
- **Edge Analytics**: Analyze data at the plant or vehicle level using edge computing devices to detect anomalies, trigger alarms, and ensure real-time decision-making.
- **Cloud Sync and Reporting**: Store processed data on cloud dashboards for historical analysis, remote quality verification, and compliance tracking.
- **Automated Feedback Control**: Integrate closed-loop control systems that adjust mixing parameters in real time based on sensor feedback.
- **Predictive Quality Control**: Apply machine learning algorithms to historical data for predicting quality outcomes and optimizing mix design.

Technologies & Tools:

- **IoT Sensors**: Temperature sensors, moisture sensors, slump meters, rotational sensors, GPS trackers, load cells.
- **Edge Devices**: Raspberry Pi, NVIDIA Jetson, Arduino with IoT shields for local data processing.
- **Communication Protocols**: MQTT, Zigbee, Modbus, LTE/5G for transmitting real-time data.
- **Edge Analytics Platforms**: Azure IoT Edge, AWS Greengrass, Google Edge TPU.
- **Cloud Tools**: AWS IoT Core, Firebase, ThingsBoard, Grafana for data visualization and control.
- **AI & Data Analytics**: Python, TensorFlow Lite, OpenCV for edge-level inference and anomaly detection.
- **Integration with ERP/SCADA**: Sync real-time data with batching software, SCADA, or ERP systems for centralized control.

MAJORS & AREAS OF INTEREST

This project bridges **civil engineering material science** with **smart manufacturing**, **IoT**, and **AI-based decision systems**, representing an interdisciplinary application of emerging technologies in construction.
Civil Engineering: Fundamental knowledge of concrete mix design, quality control protocols, material behavior, and standards like IS 4926. Civil engineers guide sensor placement, interpret test parameters, and ensure specification adherence.
Electronics and Communication Engineering (ECE): Supports sensor design, wireless communication, signal conditioning, and real-time data transmission from batching plants and transit mixers.
Computer Science and AI: Develops algorithms for edge analytics, machine learning models for quality prediction, and mobile/cloud-based dashboards for live monitoring and alerts.
Instrumentation and Control Engineering: Ensures accurate sensing, control loop development, and integration of automation hardware for real-time adjustments in batching equipment.
Mechanical Engineering: Involved in the mechanical design and integration of sensors into mixers, bins, and vehicles. Supports diagnostics related to equipment condition and mixing dynamics.
Construction Management: Focuses on logistics optimization, digital documentation, compliance tracking, and performance auditing using the quality data generated.
Smart Manufacturing / Industry 4.0: Aligns with cyber-physical systems, predictive maintenance, and data-driven process control in concrete production, supporting the goals of lean construction.

Real-time IoT-based concrete quality control is a game-changing innovation for modern RMC operations. It enables experiential and simulation-based learning for students and engineers, supporting constructivist educational models while preparing them for the data-centric future of construction under Industry 4.0.

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Augmented Reality (AR) for Virtual Visualization of Reinforcement Detailing in Concrete Structures

Dr. R Ramya swetha, Associate Professor & Head, CE– Faculty Mentor

GOALS

To design and implement an Augmented Reality (AR)-based system that enables immersive and interactive 3D visualization of reinforcement detailing in concrete structures, thereby enhancing accuracy, reducing rework, and improving comprehension for design, construction, and educational purposes.
Virtual Visualization of Reinforcement Layouts: Develop 3D models of reinforcement detailing from CAD/BIM drawings and render them using AR for on-site and classroom visualization.
Real-Time Overlay on Physical Structures: Enable on-site AR overlay of virtual rebar detailing on actual formwork or construction elements to validate accuracy before concrete placement.
Interactive and Scalable Interface: Implement scalable AR interfaces allowing users to zoom, rotate, and interact with reinforcement models for better understanding and verification.
Integration with BIM and CAD Tools: Facilitate seamless integration of AR platforms with standard BIM software (e.g., Revit, Tekla) for dynamic data import and synchronization.
Enhance Error Detection and Design Validation: Provide a visual feedback loop for identifying clashes, misalignments, and deviations in reinforcement placement, reducing manual errors.

METHODS & TECHNOLOGIES

AR-Based Visualization Tools Leverage AR SDKs (e.g., Unity + Vuforia, ARCore, ARKit) to create cross-platform applications that project 3D reinforcement detailing on physical environments using tablets, smartphones, or AR headsets (e.g., HoloLens).
BIM and Revit Model Integration Integrate detailed BIM models exported from tools like AutoCAD/Revit into the AR environment to ensure accuracy and compatibility with industry standards.
Cloud-Based Model Management Use cloud storage and version control to manage and retrieve reinforcement models in real-time from site or design office, ensuring data consistency and access.
Gesture and Voice-Based Navigation Incorporate intuitive gesture control and voice commands to navigate complex reinforcement models without interrupting site workflows.
QR Code/Marker-Based Anchoring Enable precise spatial alignment of virtual reinforcement over real-world elements using markers (e.g., QR codes) on formwork or structural elements.

MAJORS & AREAS OF INTEREST

Civil and Structural Engineering Core knowledge in reinforced concrete design, detailing practices, and construction codes (e.g., IS 456, ACI, Eurocode). In-depth understanding of bar bending schedules, rebar placement strategies, and structural safety considerations is crucial for AR model accuracy.
Computer Engineering Focus on developing efficient AR rendering engines, 3D visualization frameworks, and mobile-based deployment using platforms like Unity and Unreal Engine. Expertise in edge computing and GPU optimization ensures real-time model interaction and scalability on site.
Electrical and Electronics Engineering (EEE) Design of embedded sensor systems, QR code/RFID tag interfacing, and hardware-software integration for on-site AR deployment. Circuit design for AR headset interfaces and real-time communication with structural monitoring devices.
Construction Management and Building Information Modeling (BIM) Knowledge of digital construction workflows, BIM-to-AR data conversion, and integration of 3D reinforcement models with construction schedules (4D BIM). AR visualization supports clash detection, rework reduction, and quality control in reinforcement placement.
Artificial Intelligence and Computer Vision Application of object recognition, marker tracking, and SLAM (Simultaneous Localization and Mapping) for accurate alignment of virtual rebar models on real-world structures. AI-based suggestions for rebar correction and construction error detection.
Materials Science and Engineering Support in visualizing material behavior and degradation patterns. Helps simulate long-term performance of reinforcements and concrete under various environmental conditions using AR overlays, aiding in durability-based design.

Architecture and Design Facilitates seamless collaboration between architects and structural engineers by visually resolving reinforcement-to-formwork conflicts and ensuring constructability without compromising aesthetics.

Education Technology and Training Use of AR for training civil engineering students and construction workers in reinforcement detailing, interpretation of bar bending schedules, and safe construction practices through interactive, immersive modules.

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Smart Bio-Concrete: AI-Driven Monitoring and Prediction of Self-Healing Performance

Ms. B Bhavani, Assistant Professor, CE– Faculty Mentor

GOALS

The goal of this research is to develop the Smart Bio-Concrete by integrating bacterial self-healing agents with artificial intelligence (AI) for real-time monitoring and predictive analysis of crack healing in concrete structures. The core innovation lies in combining biogenic crack repair mechanisms—typically using Bacillus subtilis or Bacillus pasteurii—with AI algorithms that analyze sensor and image data to evaluate healing efficiency, durability, and structural integrity over time. This hybrid approach not only enhances the lifespan of infrastructure but also enables automated assessment, reduced maintenance costs, and data-driven durability forecasting.

METHODS & TECHNOLOGIES

Multimodal Sensing & Data Fusion
Prefers integration of strain gauges, acoustic emission sensors, ultrasonic pulse velocity, thermal imaging, and visual data to capture early crack initiation and healing activity.
Computer Vision & Deep Learning
Prefers convolutional neural networks (CNNs) for detecting and classifying micro-cracks and their healing progress using image datasets.
Hybrid AI-Mechanistic Models
Prefers combining AI algorithms with hydration and calcium carbonate precipitation models to simulate bacterial healing behavior under various environmental conditions.
Digital Twin Technology
Prefers real-time synchronization of physical concrete behavior with a virtual twin to simulate crack development and healing timelines under stress loading.
Explainable AI (XAI)
Prefers interpretable AI models that provide insight into healing success rates, anomalies, and environmental dependencies.
Reinforcement Learning (RL)
Prefers optimizing the timing and intensity of bacterial activation and nutrient supply via RL for maximum healing efficiency.
Edge AI & Embedded Systems
Prefers deploying low-power AI chips integrated within concrete infrastructure for on-site computation and sensor data processing.

MAJORS & AREAS OF INTEREST

Advanced Civil and Structural Engineering Domains

- **Smart Infrastructure Materials**
  Prefers research in materials that self-heal, self-sense, and communicate performance metrics to central systems.
- **Structural Health Monitoring (SHM)**
  Prefers sensor-based SHM integrated with AI-driven anomaly detection and damage classification.

Artificial Intelligence & Computational Mechanics

- **Neural Networks & Spatiotemporal Analysis**
  Prefers deep learning models (CNNs, LSTMs) trained on long-term concrete behavior datasets for predictive analysis.
- **Physics-Informed Neural Networks (PINNs)**
  Prefers combining physics laws (e.g., diffusion, crystallization) with neural networks to improve healing behavior prediction.

Bioengineering and Sustainable Technologies

- **Biogenic Material Engineering**
  Prefers designing bio-concrete matrices with optimal bacterial strains, growth media, and encapsulation methods.
- **Green Construction and Lifecycle Assessment**
  Prefers quantifying carbon savings and reduced environmental impact due to longer service life and reduced maintenance.

Emerging Interdisciplinary Areas

- **Human-AI Interaction in Construction Monitoring**
  Prefers involving civil engineers in AI model feedback loops to improve prediction reliability and usability.
- **Synthetic Data Generation & AR for Construction Training**
  Prefers creating synthetic crack patterns for training AI models and using AR to visualize healing progression for field engineers.

Industry-Focused Applications

- **Smart Cities and Intelligent Infrastructure**
  Prefers deployment in bridges, tunnels, and highways requiring automated maintenance with real-time diagnostics.
- **Predictive Maintenance Platforms**
  Prefers integrating AI-driven concrete diagnostics into asset management systems for cost-effective scheduling.

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Use of Recycled Aggregates and AI-Optimized Mix Design for Green Concrete

Dr. M Venu, Professor & Deputy Head, CE– Faculty Mentor

GOAL

This research aims to promote sustainable construction by integrating recycled aggregates with AI-optimized mix designs to produce green concrete with superior mechanical and environmental performance. It employs advanced machine learning models and multi-objective optimization algorithms to predict and enhance the strength, durability, and workability of concrete while minimizing carbon footprint. The approach leverages material informatics, life-cycle assessment (LCA), and digital twin simulations to facilitate data-driven decision-making. AI techniques such as genetic algorithms, artificial neural networks (ANNs), and Bayesian optimization are applied to balance trade-offs between cost, sustainability, and performance. Sensor-based real-time quality monitoring and feedback loops are integrated for continuous process improvement, enabling closed-loop green concrete production.

METHODS & TECHNOLOGIES

AI-Based Mix Design Optimization:
Uses genetic algorithms, neural networks, and support vector regression to optimize mix proportions with recycled aggregates for target properties such as strength, slump, and durability.
Life Cycle Assessment (LCA) Integration:
Incorporates environmental impact data (CO_2 emissions, energy use, and water consumption) into AI models to optimize eco-performance alongside mechanical properties.
Digital Twin for Concrete Manufacturing:
Develops virtual models of batching plants to simulate, monitor, and predict concrete behavior in real time, improving operational efficiency and minimizing waste.
Material Informatics Platforms:
Uses large datasets of aggregate properties (shape, gradation, texture, absorption) and mix outcomes to train predictive models for performance estimation.
Multi-Objective Optimization Algorithms:
Applies Pareto-based approaches to simultaneously optimize cost, strength, setting time, and carbon footprint.
Non-Destructive Testing (NDT) with AI Interpretation:
Integrates ultrasonic pulse velocity, rebound hammer, and thermal imaging with AI to assess in-situ concrete quality and forecast long-term performance.
Real-Time Quality Monitoring:
Embeds sensors in mixers or batching units to track consistency, temperature, and moisture, feeding data into AI systems for immediate adjustment of mix parameters.

MAJORS & AREAS OF INTEREST

Civil and Environmental Engineering with Focus on Sustainable Materials:
Prefers researchers skilled in concrete technology, recycling of construction waste, and eco-construction practices.
Construction Materials Engineering and Testing:
Prefers expertise in testing recycled aggregates, pozzolanic materials, and cementitious composites.
Artificial Intelligence in Civil Engineering:
Prefers knowledge of applying machine learning and optimization models in materials science and mix design.
Materials Science with Emphasis on Recycled and Alternative Binders:
Prefers understanding of microstructural behavior, compatibility, and durability of mixed recycled and conventional components.
Smart Manufacturing and Industrial Automation:
Prefers proficiency in real-time process monitoring, control, and digital twin technologies for material production.

Big Data Analytics in Construction:
Prefers experience in handling experimental and field data to train and validate predictive material models.
Sustainable Design and Circular Economy:
Prefers familiarity with green building standards, life cycle thinking, and upcycling of industrial by-products.
Sensor Technology and IoT in Construction Materials:
Prefers ability to integrate smart sensors into mixing and curing processes for automated quality control.
Data-Driven Life Cycle Assessment:
Prefers application of AI for rapid, continuous environmental impact evaluation of concrete mix alternatives.
Optimization and Decision Science:
Prefers skills in solving constrained, multi-objective problems using evolutionary and metaheuristic algorithms.
Smart Cities and Infrastructure Resilience:
Prefers interest in green material deployment at urban scale, considering sustainability, durability, and climate adaptation.
Computer Science with Machine Learning Applications in Engineering:
Prefers developers of intelligent algorithms for mix proportioning, strength prediction, and sustainability modeling.

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Development of AI Models for Predicting Compressive Strength of Concrete with Industrial Waste Additives

Mr. K Anand Goud, Assistant Professor, CE– Faculty Mentor

GOALS

The primary aim of this research is to develop robust Artificial Intelligence (AI)-based predictive models capable of estimating the compressive strength of concrete containing various industrial waste additives such as fly ash, GGBS, silica fume, metakaolin, red mud, and steel slag. This study focuses on improving the accuracy and reliability of strength prediction by incorporating material composition, curing conditions, and environmental parameters into machine learning (ML) and deep learning frameworks. The objectives also include identifying the optimal dosage of industrial waste for sustainability, reducing experimental costs and time, and building explainable AI models that assist civil engineers in mixture design and quality control. The research further seeks to establish a user-friendly interface for practitioners and integrate the models into Building Information Modeling (BIM) environments for smart construction workflows.

METHODS & TECHNOLOGIES

Data Collection and Preprocessing
Collect experimental datasets from published literature, lab tests, and industrial reports. Perform data cleaning, normalization, outlier handling, and feature engineering (e.g., water-cement ratio, additive percentage, age of curing).

AI/ML Modeling Techniques
Employ supervised machine learning algorithms including Random Forest (RF), Support Vector Machines (SVM), Gradient Boosting (XGBoost), and Artificial Neural Networks (ANN). Deep learning methods such as Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) may be used to capture non-linearities and time-dependent behavior in strength development.

Hyperparameter Optimization
Use grid search, random search, or Bayesian optimization (e.g., Hyperopt or Optuna) to tune model parameters for improved performance.

Model Validation and Performance Metrics
Apply k-fold cross-validation and use RMSE, MAE, R^2, and MAPE as evaluation metrics to ensure generalizability and accuracy of predictions.

Explainable AI (XAI)
Integrate SHAP (SHapley Additive exPlanations) and LIME (Local Interpretable Model-Agnostic Explanations) tools to interpret AI model outputs, providing transparency in how each input affects strength outcomes.

Software Tools and Platforms
Use Python with libraries such as Scikit-learn, TensorFlow, Keras, PyTorch, Pandas, NumPy, and Matplotlib. Data visualization through Tableau or Power BI. Jupyter for collaborative development.

Deployment and Integration
Develop web-based or mobile apps using Flask/Django for end-user interaction. Optionally, integrate models into BIM platforms like Autodesk Revit for smart design validation.

MAJORS & AREAS OF INTEREST

Civil and Structural Engineering
Fundamental understanding of concrete technology, behavior of admixtures, material characterization, and mix design for sustainable construction.

Artificial Intelligence and Data Science
Proficiency in machine learning algorithms, neural networks, data mining, and model interpretability for real-world application in material science.

Materials Science and Engineering
Knowledge of physical and chemical properties of industrial waste additives and their impact on hydration, microstructure, and strength development of concrete.

Construction Technology
Integration of smart tools for predictive maintenance, quality control, and design automation using AI-driven approaches.

Computer Science and Software Engineering
Experience in algorithm development, backend deployment, API design, and interfacing with civil engineering tools and simulation software.

Environmental Engineering
Focus on circular economy, waste valorization, and carbon footprint analysis in concrete production using industrial by-products.

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Digital Twin Technology for Monitoring and Maintenance of Concrete Bridges

Dr. Praveena Rao, Assistant Professor, CE – Faculty Mentor

GOALS

The primary aim of this research is to develop and implement a comprehensive digital twin (DT) framework for real-time monitoring, performance prediction, and maintenance planning of concrete bridge structures. The goal is to integrate structural health monitoring (SHM) systems, finite element modeling (FEM), AI-based predictive analytics, and Internet of Things (IoT) technologies to enable continuous data acquisition and intelligent decision-making. The digital twin will mirror the physical bridge in real-time and forecast structural deterioration due to load, fatigue, and environmental stressors. The research also aims to reduce lifecycle costs, improve safety, optimize inspection schedules, and enable proactive maintenance strategies.

METHODS & TECHNOLOGIES

Digital Twin Framework Development

- Develop a multi-scale digital twin using 3D BIM (Building Information Modeling) and FEM for geometry, materials, and behavior representation.
- Synchronize virtual models with live sensor data using bidirectional data flow architecture.

Structural Health Monitoring (SHM)

- Deploy sensors (e.g., strain gauges, accelerometers, corrosion sensors, temperature & humidity sensors) across critical bridge sections.
- Stream real-time data through LoRaWAN, NB-IoT, or 5G-based edge networks into the digital twin.

IoT and Cloud Integration

- Use IoT platforms like AWS IoT, Azure Digital Twins, or ThingWorx for device management, data ingestion, and cloud analytics.
- Implement edge computing for local preprocessing of high-frequency data (e.g., vibration, crack propagation).

AI & Machine Learning Algorithms

- Develop AI models using time-series forecasting (LSTM, ARIMA) and anomaly detection (Autoencoders, Isolation Forest) for damage prediction.
- Use classification models (Random Forest, XGBoost) for predicting defect types and severity.

Finite Element Analysis (FEA)

- Perform real-time structural simulations in ANSYS, Abaqus, or COMSOL using updated sensor inputs (e.g., traffic loads, thermal effects).
- Integrate results into the digital twin for dynamic stress-strain and fatigue analysis.

Visualization & Interaction

- Employ web-based dashboards (Grafana, Power BI) and 3D visualization tools (Unity3D, Unreal Engine) to provide interactive and immersive interfaces for engineers.
- Use AR/VR overlays for on-site inspections and maintenance guidance.

Lifecycle Cost Analysis & Maintenance Planning

- Embed decision-support systems for maintenance prioritization, risk assessment, and cost-benefit analysis.
- Apply Markov Chain models and Bayesian Networks for reliability-based maintenance optimization.

Cybersecurity & Data Integrity

- Ensure secure data transmission and system integrity using blockchain, TLS encryption, and access control protocols.
- Comply with standards like ISO/IEC 27001 and IEC 62443 for industrial control systems.

MAJORS & AREAS OF INTEREST

Civil and Structural Engineering

Expertise in bridge design, structural analysis, fatigue behavior, and deterioration modeling of concrete elements under traffic and environmental loads. Proficient in finite element modeling, structural health monitoring (SHM), and damage detection strategies.

Artificial Intelligence and Data Science

Proficiency in time-series forecasting, anomaly detection, supervised learning, and deep learning (e.g., LSTM, CNN) for predictive maintenance and structural condition assessment using sensor-generated data streams.

Materials Science and Engineering

Understanding of long-term behavior of concrete materials, crack propagation, and the influence of material degradation on performance indicators. Familiarity with microstructure evolution due to environmental and mechanical stressors.

Construction Technology

Application of digital twins for smart infrastructure management, real-time monitoring, and lifecycle maintenance planning. Integration of SHM data with BIM and cloud platforms for digital construction workflows.

Computer Science and Software Engineering

Competency in developing cloud-based applications, real-time data pipelines, digital twin platforms, and APIs. Skilled in integrating IoT systems, backend processing, and deploying simulation models with visual dashboards.

Electronics and Communication Engineering

Knowledge of embedded systems, sensor network design, wireless data transmission protocols (e.g., LoRa, NB-IoT), and signal conditioning techniques for acquiring accurate SHM data.

Environmental and Infrastructure Sustainability

Focus on optimizing bridge maintenance for sustainability through reduced resource usage, carbon footprint minimization, and lifecycle extension of infrastructure using predictive, AI-enabled decision-making.

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VR-Based Interactive Training Lab for Concrete Testing and Quality Assurance

Dr. U Vamsi Mohan, Professor, CE– Faculty Mentor

GOAL

The primary aim of this research is to develop an immersive Virtual Reality (VR)-based training environment that simulates concrete testing procedures for enhancing quality assurance and hands-on learning. This interactive lab will replicate standard laboratory setups, equipment handling, and testing protocols such as slump test, compressive strength test, and non-destructive testing. The study seeks to bridge the gap between theoretical knowledge and practical execution by providing a safe, repeatable, and cost-effective platform for students, technicians, and site engineers. It also aims to standardize training, reduce human error in quality assessment, and integrate the VR system with learning analytics for performance evaluation.

METHODS & TECHNOLOGIES

Content Design and Scenario Modeling

- Develop 3D models of concrete lab equipment and testing environments using Unity3D or Unreal Engine.
- Script procedural steps of each test based on IS/ASTM standards.
- Include environmental realism, haptic feedback, and voice/narrative guidance.

VR Development Platforms

- Use Unity or Unreal Engine for building immersive modules.
- Deploy on VR devices like Oculus Quest, HTC Vive, or Windows Mixed Reality headsets.
- Include gesture recognition and object manipulation using XR toolkits.

Instructional Design and Pedagogy

- Follow the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) for instructional content.
- Integrate formative and summative assessments into the simulation.
- Include interactive quizzes and performance feedback.

User Testing and Evaluation

- Conduct usability testing with students, lab instructors, and site engineers.
- Use System Usability Scale (SUS), NASA-TLX for workload, and learning gain metrics.
- Iterate based on feedback to improve user experience and pedagogical effectiveness.

Integration with Learning Management Systems (LMS)

- Capture user performance data and push to LMS platforms like Moodle or Canvas.
- Enable instructor dashboards for tracking learning progress and competency mapping.

Software and Tools

- Unity3D, Blender, Visual Studio, C# scripting
- XR Toolkit, OpenXR, SteamVR
- Oculus SDK / HTC Vive SDK
- Adobe Illustrator for UI/UX and lab manuals
- Learning Analytics with Python (Pandas, Matplotlib)

MAJORS & AREAS OF INTEREST

Civil and Structural Engineering
Strong foundation in concrete testing procedures, laboratory standards (e.g., IS/ASTM), and quality control measures essential for construction material certification and compliance.

Virtual Reality and Simulation Engineering
Expertise in 3D modeling, immersive simulation design, and haptic feedback integration to replicate real-life lab environments for concrete testing in virtual platforms.

Construction Technology
Application of digital tools for workforce training, safety protocol education, and real-time skill assessment using interactive virtual environments for on-site and off-site learners.

Computer Science and Software Engineering
Proficiency in VR software development (e.g., Unity, Unreal Engine), backend programming, database integration, and user interface design for creating scalable VR lab systems.
Educational Technology and Learning Sciences
Understanding of learning behavior, cognitive load theory, and gamification techniques for enhancing skill retention and engagement in virtual concrete labs.
Materials Science and Engineering
Insight into behavior of concrete materials under different test conditions, enabling realistic simulation of slump test, compressive strength, flexural strength, and non-destructive tests.

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