IJCRM
International Journal of Contemporary Research In Multidisciplinary

Review Article

The Role of Artificial Intelligence in Achieving Sustainable Development Goals in the Construction Industry

Devesh Ojha[1*]
[1]Assistant Professor, Civil Engineering Department, Amity University, Lucknow, Uttar Pradesh, India

Corresponding Author: *Devesh Ojha

DOI: https://doi.org/10.5281/zenodo.14918900

Abstract

Artificial intelligence (AI) has emerged as a transformative force in the construction industry, offering innovative solutions to enhance efficiency, sustainability, and decision-making. This paper explores how AI contributes to achieving the United Nations' Sustainable Development Goals (SDGs) by optimizing resource management, improving safety, and reducing environmental impact. Through a systematic literature review, the study examines AI applications across various construction phases, including planning, design, construction, and operation and maintenance. The findings highlight AI's significant role in SDGs 6 (Clean Water and Sanitation), 7 (Affordable and Clean Energy), 8 (Decent Work and Economic Growth), 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities), 12 (Responsible Consumption and Production), 13 (Climate Action), 15 (Life on Land), and 17 (Partnerships for the Goals). Challenges such as data privacy, ethical concerns, workforce adaptation, and high implementation costs are also discussed. The study underscores the need for structured AI adoption strategies to maximize its potential in fostering sustainable construction practices. Future research should focus on case studies, policy development, and interdisciplinary collaborations to drive AI-driven sustainability in the construction sector.

Manuscript Information

- **ISSN No:** 2583-7397
- **Received:** 09-01-2025
- **Accepted:** 27-01-2025
- **Published:** 23-02-2025
- **IJCRM:**4(S1); 2025: 12-24
- **©2025, All Rights Reserved**
- **Plagiarism Checked:** Yes
- **Peer Review Process:** Yes

How to Cite this Article

Ojha D. The Role of Artificial Intelligence in Achieving Sustainable Development Goals in the Construction Industry. Int J Contemp Res Multidiscip. 2025;4(S1):12–24.

Access this Article Online

www.multiarticlesjournal.com

KEYWORDS: Artificial Intelligence, Sustainable Development Goals, Construction Industry, Smart Cities, Machine Learning, Green Construction, Digital Transformation, AI in Construction

1. INTRODUCTION

The construction industry plays a crucial role in global economic growth and urbanization. However, it is also one of the largest contributors to environmental degradation, excessive resource consumption, and carbon emissions. The increasing demand for sustainable infrastructure and buildings has led to a growing focus on integrating Artificial Intelligence (AI) in construction practices to align with the United Nations' Sustainable Development Goals (SDGs). AI has the potential to enhance sustainability by optimizing energy use, reducing waste, and improving overall efficiency in project execution (Pan *et al.*, 2023; Regona *et al.*, 2022). The adoption of AI-driven technologies in the construction industry is gaining momentum due to its ability to automate complex tasks, analyze large datasets, and improve decision-making. Machine learning (ML), deep learning (DL), and predictive analytics are being used to streamline processes across different construction phases, from planning and design to operation and maintenance. AI-powered solutions, such as Building Information Modeling (BIM) and digital twins, enable real-time simulations, helping construction professionals predict project outcomes, optimize resource allocation, and mitigate risks (Yigitcanlar *et al.*, 2021). One of the key challenges in the construction industry is resource inefficiency, leading to excessive material waste and high carbon footprints. AI applications such as automated material tracking and AI-driven supply chain optimization help in reducing waste and ensuring responsible consumption and production (SDG 12). AI can also support climate action (SDG 13) by identifying patterns in energy usage and suggesting ways to improve energy efficiency in buildings. Smart grids and AI-based energy management systems further enable renewable energy integration and sustainable construction practices (Huang, 2023). Additionally, AI contributes to enhancing workplace safety and ensuring decent work conditions (SDG 8). AI-powered wearable devices and computer vision systems can monitor workers' movements, detect hazards in real-time, and provide alerts to prevent accidents. Furthermore, AI-driven automation and robotics are increasingly being utilized for repetitive and hazardous tasks, reducing human exposure to dangerous work environments and improving overall productivity (Akinosho *et al.*, 2020). Sustainable urban development (SDG 11) is another critical area where AI is making a significant impact. AI facilitates smart city planning by optimizing public transportation, reducing traffic congestion, and monitoring air quality. Advanced AI algorithms analyze urban growth patterns to recommend sustainable land-use strategies, thereby promoting resilient and inclusive cities (Gao *et al.*, 2020). Despite the numerous benefits of AI in achieving SDGs in the construction sector, several challenges remain. Ethical considerations, data privacy issues, and the digital divide hinder widespread AI adoption. Moreover, the lack of skilled workforce and high initial costs of AI implementation present barriers to its integration into construction practices. Addressing these challenges requires collaboration between governments, industries, and research institutions to develop AI policies, regulatory frameworks, and training programs (Saeed *et al.*, 2022).

This paper aims to explore the role of AI in achieving SDGs in the construction industry by examining its applications, challenges, and potential solutions. Through a comprehensive review of existing research, this study provides insights into how AI can drive sustainability and efficiency while addressing the pressing global challenges outlined in the SDGs.

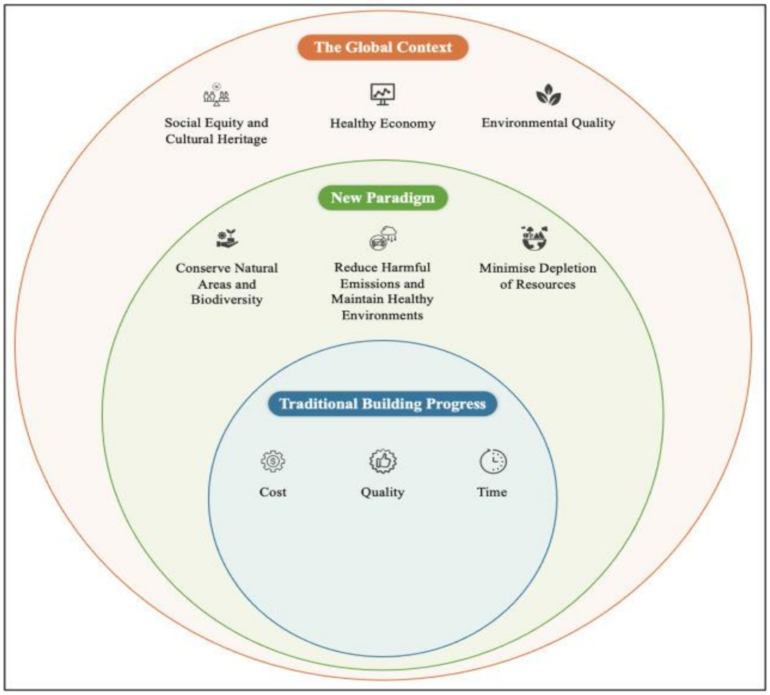

Fig. 1: Artificial intelligence and sustainable development goals

2. AI Applications in Construction and Sustainable Development Goals

2.1. SDG 6: Clean Water and Sanitation

The construction industry significantly impacts water management, from site preparation to infrastructure development. AI-driven solutions offer transformative capabilities in optimizing water usage, monitoring quality, and ensuring the sustainability of water resources. By leveraging machine learning algorithms, real-time data analysis, and automation, AI aids in the efficient planning and execution of water-related construction projects. One of the primary applications of AI in water management is its ability to monitor water quality and predict potential contamination. AI-powered sensors collect real-time data on water quality parameters such as pH levels, turbidity, and contaminant presence. Machine learning models analyze this data to identify anomalies and provide early warnings about potential pollution, allowing for immediate corrective actions. This is particularly beneficial in construction sites near water bodies, where runoff and waste can impact local ecosystems. AI also optimizes water distribution networks in urban construction projects. Advanced AI algorithms assess historical water consumption patterns and predict future demands, enabling more efficient allocation of water resources. Smart water grids use AI-driven leak detection systems that identify and address pipeline leaks in real-time, reducing water loss and improving overall infrastructure resilience. Predictive analytics further enhance the maintenance of water distribution systems by forecasting potential failures and scheduling timely interventions, thus preventing major disruptions. The construction industry increasingly integrates AI-driven Building Information Modeling (BIM) tools to design water-efficient buildings and infrastructure. These tools simulate water usage scenarios, optimize plumbing layouts, and recommend water-saving fixtures to minimize consumption. AI-assisted rainwater harvesting systems and greywater recycling solutions enhance sustainability by repurposing non-potable water for non-drinking applications such as irrigation and sanitation. Additionally, AI contributes to sustainable wastewater management. Smart AI-powered wastewater treatment plants optimize filtration processes, chemical usage, and energy consumption. AI models analyze historical treatment data to adjust operational parameters dynamically, ensuring compliance with environmental regulations while reducing operational costs. Furthermore, AI enhances desalination technologies by optimizing energy use and improving filtration efficiency, making clean water more accessible in regions facing water scarcity. In large-scale infrastructure projects, AI-driven geographic information systems (GIS) help construction planners assess the impact of development on local water bodies. By analyzing satellite imagery and hydrological data, AI tools identify areas at risk of flooding or water contamination, aiding in the design of flood-resistant structures and sustainable drainage systems. Moreover, AI applications in predictive climate modeling help assess the long-term impact of construction activities on water resources. By integrating weather pattern analysis with hydrological simulations, AI provides insights into future water availability, allowing for proactive planning and mitigation strategies.

In conclusion, AI plays a crucial role in advancing SDG 6 by ensuring sustainable water management practices in the construction industry. From real-time water quality monitoring and smart distribution networks to wastewater treatment and climate modeling, AI-driven solutions enhance efficiency, reduce waste, and contribute to the global effort to achieve clean water and sanitation for all.

- Machine learning algorithms predict pipeline failures and improve water resource management by analyzing consumption patterns and detecting leaks in real-time.
- Smart irrigation systems powered by AI help reduce water wastage in construction projects.

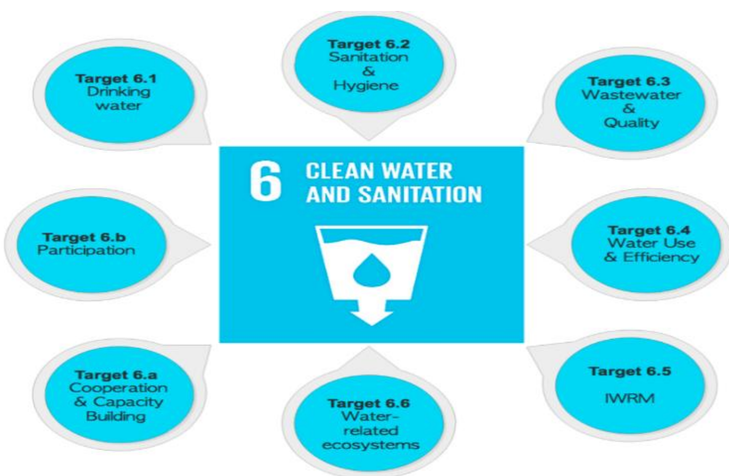

Fig. 2: SDG 6: Clean Water and Sanitation

2.2. SDG 7: Affordable and Clean Energy

The construction industry is a major consumer of energy, and integrating artificial intelligence (AI) can significantly enhance energy efficiency and sustainability. AI-driven solutions optimize energy usage, improve the integration of renewable energy sources, and reduce the environmental footprint of buildings and infrastructure. By leveraging machine learning, predictive analytics, and automation, AI contributes to achieving SDG 7 by making energy systems more affordable, efficient, and clean. One of the primary applications of AI in construction is energy management in buildings. AI-driven smart grids and building management systems (BMS) optimize energy consumption by analyzing real-time data on usage patterns. These systems adjust power distribution dynamically, ensuring optimal energy use and reducing waste. AI-powered sensors and Internet of Things (IoT) devices monitor heating, ventilation, and air conditioning (HVAC) systems, adjusting temperature settings in response to occupancy and external climate conditions. This reduces energy consumption while maintaining comfort levels, ultimately lowering operational costs and carbon emissions. AI also plays a crucial role in integrating renewable energy sources such as solar and wind power into construction projects. Machine learning algorithms predict energy demand and adjust the operation of renewable energy systems accordingly. AI-enhanced energy storage systems optimize battery charging and discharging cycles, ensuring maximum efficiency in using solar and wind energy. Additionally, AI-powered predictive maintenance systems enhance the performance and lifespan of renewable energy infrastructure by identifying potential failures before they occur, minimizing downtime and improving reliability. During the construction phase, AI helps optimize energy use by enhancing efficiency in material production and transportation. AI-driven simulations assess various construction methods and materials to determine the most energy-efficient options. AI-powered logistics and fleet management systems optimize transportation routes, reducing fuel consumption and emissions. Furthermore, AI is used in 3D printing and modular construction to minimize waste and energy consumption during the building process. Another critical application of AI in achieving SDG 7 is energy-efficient design. AI-driven generative design tools create optimized architectural models that maximize natural light and ventilation, reducing reliance on artificial lighting and HVAC systems. AI-based simulations analyze the thermal performance of buildings, recommending energy-efficient materials and structural modifications to enhance insulation and reduce heating and cooling requirements. AI also contributes to grid modernization and demand-side energy management. AI-powered demand response systems analyze energy consumption patterns and provide recommendations to shift usage to non-peak hours, reducing strain on the electrical grid. AI-driven blockchain technology facilitates peer-to-peer energy trading in smart grids, allowing buildings with excess renewable energy to sell electricity directly to consumers, making clean energy more accessible and cost-effective. Furthermore, AI enhances policy-making and regulatory compliance by analyzing vast amounts of data related to energy consumption, emissions, and building performance. Governments and policymakers use AI-driven insights to develop regulations and incentives that promote sustainable construction and energy efficiency.

In conclusion, AI is revolutionizing the construction industry's approach to energy efficiency and sustainability. By optimizing energy consumption, integrating renewable energy sources, enhancing grid management, and supporting energy-efficient design, AI is a crucial enabler of SDG 7. The adoption of AI-driven technologies in construction ensures that buildings and infrastructure are more energy-efficient, cost-effective, and environmentally sustainable, paving the way for a cleaner and more affordable energy future.

- Smart grids and predictive maintenance enhance renewable energy integration by improving efficiency in energy storage and distribution.
- AI algorithms facilitate the design of energy-efficient buildings by recommending sustainable materials and green construction techniques.

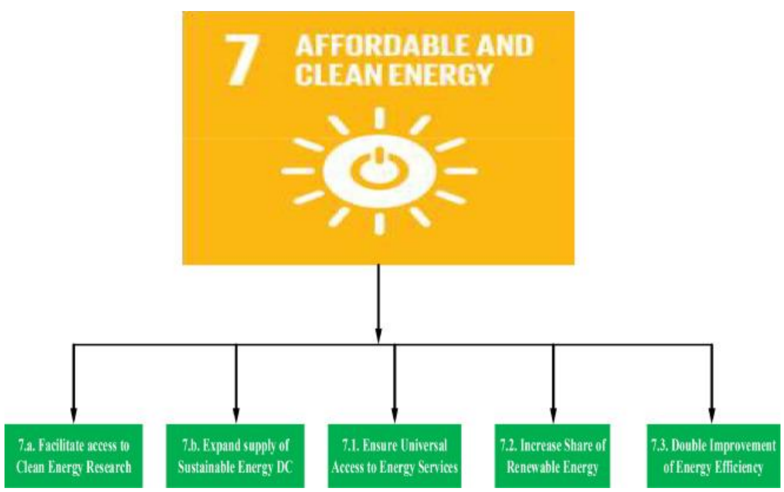

Fig. 3: SDG 7: Affordable and Clean Energy

2.3. SDG 8: Decent Work and Economic Growth

The construction industry is one of the largest employment sectors globally, but it faces numerous challenges, including labor shortages, workplace hazards, inefficiencies, and economic volatility. AI-driven technologies offer transformative solutions that enhance worker safety, boost productivity, and drive economic growth while maintaining sustainable and ethical employment practices. AI applications in construction support SDG 8 by fostering decent work environments, reducing risks, and improving workforce efficiency. One of the most impactful AI applications in construction is automating repetitive and labor-intensive tasks. AI-powered robotics and automated machinery assist in bricklaying, concrete pouring, welding, and material handling. These technologies not only improve efficiency but also minimize human exposure to hazardous environments, reducing workplace injuries and fatalities. Automation allows workers to focus on complex and value-added tasks, leading to higher job satisfaction and increased overall productivity. AI also enhances workplace safety through predictive analytics and real-time monitoring. AI-powered computer vision systems analyze live video feeds from construction sites to detect unsafe behaviors, such as workers not wearing protective gear or working near dangerous machinery. Wearable AI devices monitor workers' vital signs, fatigue levels, and environmental conditions to provide early warnings about potential health risks. By identifying hazards proactively, AI helps prevent accidents and ensures compliance with safety regulations. Moreover, AI-driven workforce management systems optimize labor allocation, ensuring that skilled workers are assigned to tasks that match their expertise. AI-powered scheduling tools analyze historical project data, weather patterns, and workforce availability to create efficient work schedules. This prevents overwork, reduces delays, and enhances overall project efficiency. By streamlining workflow management, AI contributes to higher job satisfaction and better working conditions. AI also plays a crucial role in addressing labor shortages by enabling remote construction monitoring and training. AI-powered virtual and augmented reality (VR/AR) platforms provide immersive training experiences for workers, helping them develop skills in a safe and controlled environment before entering the job site. AI chatbots and digital assistants provide real-time support to workers, offering guidance on tasks and troubleshooting common issues. These innovations ensure that construction workers are well-trained and equipped with the knowledge needed to perform their jobs efficiently and safely. From an economic perspective, AI contributes to sustainable growth by improving project management, reducing costs, and minimizing resource wastage. AI-driven cost estimation and procurement systems analyze market trends, material prices, and supplier performance to optimize budgets and reduce expenses. AI-powered predictive maintenance systems identify potential equipment failures before they occur, preventing costly downtime and enhancing the longevity of construction assets. By improving efficiency and reducing operational costs, AI ensures that construction companies remain competitive and financially stable, contributing to broader economic growth. Additionally, AI-driven data analytics provide valuable insights into industry trends, labor market fluctuations, and investment opportunities. Governments and policymakers leverage AI-generated reports to develop policies that promote fair wages, labor rights, and inclusive employment practices. By fostering a transparent and data-driven approach, AI helps create an equitable job market that benefits both workers and employers.

In conclusion, AI is revolutionizing the construction industry by enhancing worker safety, optimizing workforce management, improving training methods, and driving economic efficiency. By automating repetitive tasks, reducing risks, and enabling informed decision-making, AI contributes to achieving SDG 8 by fostering decent work conditions and promoting sustainable economic growth in the construction sector.

- Predictive analytics help in workforce planning, optimizing resource allocation, and reducing job site hazards.
- AI-driven robots and drones perform hazardous construction activities, minimizing risks and enhancing workplace safety.

2.4. SDG 9: Industry, Innovation, and Infrastructure

The construction industry is a key driver of economic growth and infrastructure development, but it faces challenges related to inefficiencies, high material consumption, and environmental impact. AI-powered innovations are transforming construction processes, improving efficiency, and enabling the development of smart, resilient, and sustainable infrastructure. By integrating AI into construction workflows, the industry can align with SDG 9, which focuses on fostering innovation, building resilient infrastructure, and promoting inclusive and sustainable industrialization. One of the most significant applications of AI in the construction industry is design optimization. AI-driven generative design tools analyze vast datasets to create efficient, sustainable, and structurally sound designs. These tools evaluate multiple design iterations, ensuring that materials and spatial arrangements are optimized for cost-effectiveness and performance. AI also enhances Building Information Modeling (BIM) systems by improving data analytics and predictive modeling, allowing architects and engineers to make informed decisions that enhance the sustainability and resilience of buildings and infrastructure. AI contributes to sustainable construction practices by reducing material waste and optimizing resource allocation. Predictive analytics assess supply chain logistics and demand forecasting, enabling companies to procure materials more efficiently and reduce excess inventory. AI-powered material tracking systems ensure that resources are used effectively, minimizing waste and reducing the environmental impact of construction projects. Furthermore, AI-based robotics automates tasks such as bricklaying, concrete pouring, and welding, increasing precision and reducing human errors that can lead to material wastage. Smart infrastructure development is another key area where AI is making an impact. AI-powered sensors embedded in bridges, roads, and buildings collect real-time data on structural integrity, enabling predictive maintenance and preventing costly failures. These sensors detect anomalies such as cracks, vibrations, and temperature fluctuations, allowing engineers to intervene before minor issues escalate into major problems. By facilitating proactive maintenance, AI helps extend the lifespan of critical infrastructure while enhancing safety and resilience. AI is also revolutionizing construction site management and project execution. AI-driven project management platforms analyze schedules, budgets, and labor productivity to optimize workflows and mitigate risks. AI-enhanced automation in construction equipment, such as autonomous excavators and cranes, improves efficiency and minimizes downtime. These innovations streamline operations, reduce project delays, and improve overall productivity, ultimately contributing to economic growth and sustainable industrialization. Moreover, AI plays a crucial role in advancing smart city initiatives. AI-driven urban planning tools analyze population growth, transportation networks, and environmental factors to design sustainable cities with efficient infrastructure. AI-powered traffic management systems optimize traffic flow and reduce congestion, enhancing mobility and accessibility in urban areas. These advancements contribute to the creation of smarter, more resilient, and technologically advanced cities. From a policy perspective, AI-driven data analytics help governments and organizations make informed decisions regarding infrastructure investments and regulatory frameworks. By analyzing large datasets on urban development, construction trends, and environmental impact, AI provides insights that guide sustainable development strategies and policy formulation.

In conclusion, AI is revolutionizing the construction industry by enhancing design processes, optimizing material use, improving infrastructure resilience, and streamlining project management. By leveraging AI-powered innovations, the industry can build smarter, more sustainable infrastructure, promote inclusive industrialization, and drive economic growth in alignment with SDG 9. The continued integration of AI in construction will play a critical role in shaping the future of industry, innovation, and infrastructure on a global scale.

- Digital twins and Building Information Modeling (BIM) improve construction efficiency by enabling real-time simulations and decision-making.
- AI-powered predictive maintenance systems reduce infrastructure downtime by identifying maintenance needs before failures occur.

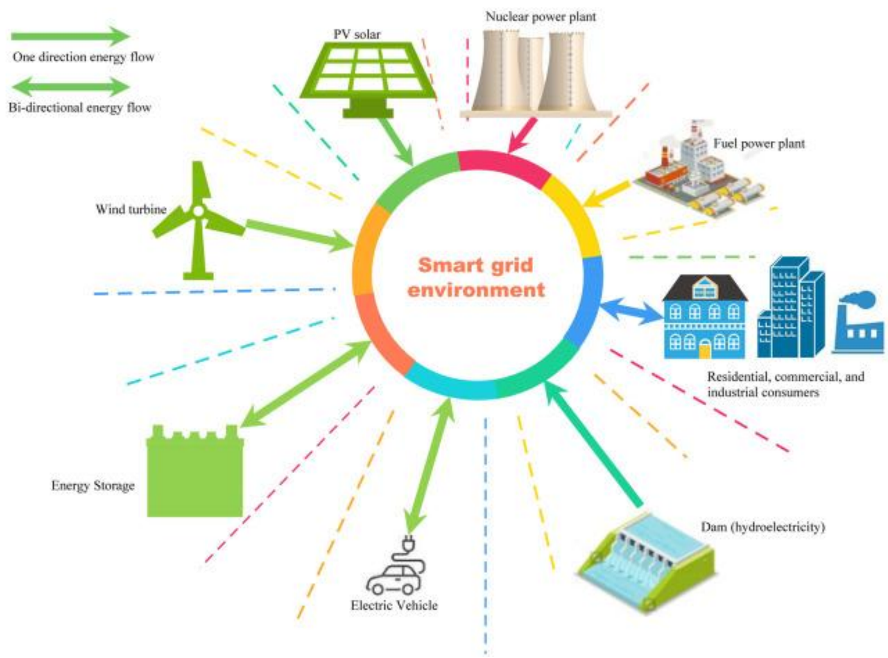

Fig. 4: SDG 9: Industry, Innovation, and Infrastructure

2.5. SDG 11: Sustainable Cities and Communities

The rapid pace of urbanization poses significant challenges for city planners and policymakers striving to create sustainable, resilient, and inclusive urban environments. AI-driven solutions are transforming urban development by optimizing resource use, enhancing infrastructure resilience, and improving the quality of life in cities. By integrating AI into urban planning, construction, and management, the construction industry plays a critical role in achieving SDG 11, which aims to make cities inclusive, safe, resilient, and sustainable. One of the most notable AI applications in sustainable cities is smart urban planning. AI-powered geographic information systems (GIS) analyze data from satellite imagery, sensors, and historical records to optimize city layouts, ensuring efficient land use and infrastructure development. Machine learning algorithms process data on population density, traffic flow, and environmental impact to help planners design cities that are both livable and sustainable. By simulating different urban development scenarios, AI enables decision-makers to evaluate the long-term consequences of their planning choices, minimizing the risk of overdevelopment and inefficient land use. AI also enhances the efficiency of public transportation systems, reducing congestion and promoting sustainable mobility. AI-powered predictive analytics analyze traffic patterns and commuter behaviors to optimize routes and schedules, improving public transportation accessibility and efficiency. AI-driven autonomous vehicles and smart traffic management systems help reduce carbon emissions by minimizing traffic congestion, reducing fuel consumption, and enhancing road safety. Moreover, AI-integrated ride-sharing platforms optimize vehicle allocation, reducing the overall number of cars on the road and promoting shared mobility. Another critical application of AI in sustainable urban development is energy-efficient building design. AI-driven generative design tools assist architects and engineers in optimizing building layouts for natural lighting, ventilation, and energy efficiency. AI-powered smart grids manage electricity distribution more effectively, integrating renewable energy sources and reducing energy waste. AI also facilitates real-time monitoring of energy consumption in buildings, automatically adjusting heating, cooling, and lighting systems to maximize efficiency. This not only reduces energy costs but also minimizes the environmental impact of urban buildings. Waste management and environmental monitoring are also greatly improved through AI applications. AI-powered waste sorting systems use computer vision and robotics to enhance recycling processes, reducing landfill waste and promoting a circular economy. Smart waste collection systems use AI to optimize collection routes and schedules, reducing fuel consumption and improving efficiency. Additionally, AI-driven air quality monitoring systems analyze pollution levels and identify sources of contamination, enabling city officials to implement targeted interventions to improve urban air quality. Resilient infrastructure development is another key area where AI is making an impact. AI-powered predictive maintenance systems monitor the structural health of bridges, roads, and buildings, detecting potential failures before they occur. By analyzing data from sensors embedded in infrastructure, AI helps extend the lifespan of critical urban assets and ensures the safety of residents. Furthermore, AI-driven flood prediction models and disaster response systems provide early warnings and optimize emergency response strategies, making cities more resilient to climate change and natural disasters. From a governance perspective, AI enables data-driven decision-making and citizen engagement. AI-powered chatbots and digital assistants facilitate communication between city officials and residents, providing real-time information on public services, transportation, and emergency alerts. AI-driven social analytics assess public sentiment and urban trends, helping policymakers understand community needs and prioritize sustainable development initiatives. In conclusion, AI plays a transformative role in shaping sustainable cities and communities by enhancing urban planning, optimizing transportation and energy efficiency, improving waste management, and ensuring infrastructure resilience. By leveraging AI technologies, city planners and construction professionals can create smart, inclusive, and environmentally sustainable urban environments in alignment with SDG 11. The continued integration of AI in urban development will be crucial in addressing the challenges of rapid urbanization and ensuring a sustainable future for growing cities worldwide.

- AI-powered generative design tools help in planning sustainable urban layouts that minimize environmental impact and improve resource allocation.
- AI-driven noise and air quality monitoring systems enhance urban livability by tracking pollution levels and suggesting mitigation strategies.

2.6. SDG 12: Responsible Consumption and Production

Artificial Intelligence (AI) is increasingly transforming industries across the globe, and the construction sector is no exception. As the world shifts toward more sustainable practices, AI applications in construction play a crucial role in advancing the United Nations Sustainable Development Goals (SDGs), particularly SDG 12: Responsible Consumption and Production. SDG 12 aims to promote sustainable consumption and production patterns by minimizing waste, optimizing resource use, and encouraging efficient processes. In this context, AI offers innovative solutions to improve efficiency, reduce waste, and foster sustainability in construction practices.

AI Applications in Construction:

1. **Efficient Resource Management:** AI can optimize the use of resources such as raw materials, energy, and water in construction projects. By utilizing machine learning algorithms and predictive analytics, AI can forecast the precise number of materials needed for construction, reducing excess consumption and preventing waste. For instance, AI can analyze historical data and current construction site conditions to predict the best materials and quantities required, ensuring the right resources are used at the right time. This helps minimize material waste and encourages responsible resource management, which directly supports SDG 12's objectives.
2. **Reducing Construction Waste:** Construction projects are notorious for generating significant amounts of waste, including unused materials, demolition debris, and packaging. AI-driven solutions, such as waste-sorting robots and automated inventory management systems, can reduce waste by identifying reusable materials and reducing inefficiencies. AI can also enable real-time monitoring of construction processes, ensuring that materials are used effectively and reducing the likelihood of overproduction or excessive stockpiling. This reduction in waste helps mitigate the environmental impact of construction activities and supports the goal of sustainable production and consumption.
3. **Energy-Efficient Building Design:** AI applications in construction are increasingly being used to create energy-efficient designs that minimize energy consumption and reduce the carbon footprint of buildings. By using AI to analyze factors like local climate, solar exposure, and building materials, architects and engineers can design structures that optimize energy use. For example, AI tools can help assess the thermal performance of materials, suggest better insulation options, and determine the most energy-efficient HVAC systems. These designs contribute to SDG 12 by reducing the need for excessive energy consumption during building operations and helping to create long-lasting, sustainable buildings.
4. **Predictive Maintenance:** In the construction industry, maintenance of machinery and equipment is critical to preventing downtime and maximizing operational efficiency. AI-powered predictive maintenance can analyze data from sensors embedded in construction machinery to predict when equipment will require maintenance or repair. By proactively addressing potential issues, AI helps avoid

costly and unnecessary equipment replacements, thus prolonging the lifecycle of construction machinery. This process helps reduce the consumption of new materials and energy, further contributing to responsible production and consumption.

Contribution to SDG 12:
AI's role in promoting sustainable practices aligns closely with SDG 12 by fostering responsible consumption and production in the construction industry. By leveraging AI, companies can reduce waste, improve resource efficiency, and minimize environmental impacts. AI's ability to optimize material usage, reduce energy consumption, and extend the life cycle of construction equipment ensures that the industry moves toward a more sustainable future. Moreover, AI can help transition the construction sector toward a circular economy model, where materials are reused, repurposed, or recycled. With AI-driven tools, construction projects can more effectively manage end-of-life materials, reducing the need for new resources and cutting down on waste. This not only helps in conserving raw materials but also minimizes the carbon footprint of construction projects. In conclusion, AI offers transformative solutions to address the challenges of sustainable consumption and production within the construction industry. By enhancing resource management, reducing waste, and fostering energy-efficient designs, AI helps meet the targets of SDG 12. As AI technologies continue to evolve, their potential to drive sustainability in construction will only grow, paving the way for a more responsible and environmentally conscious industry.

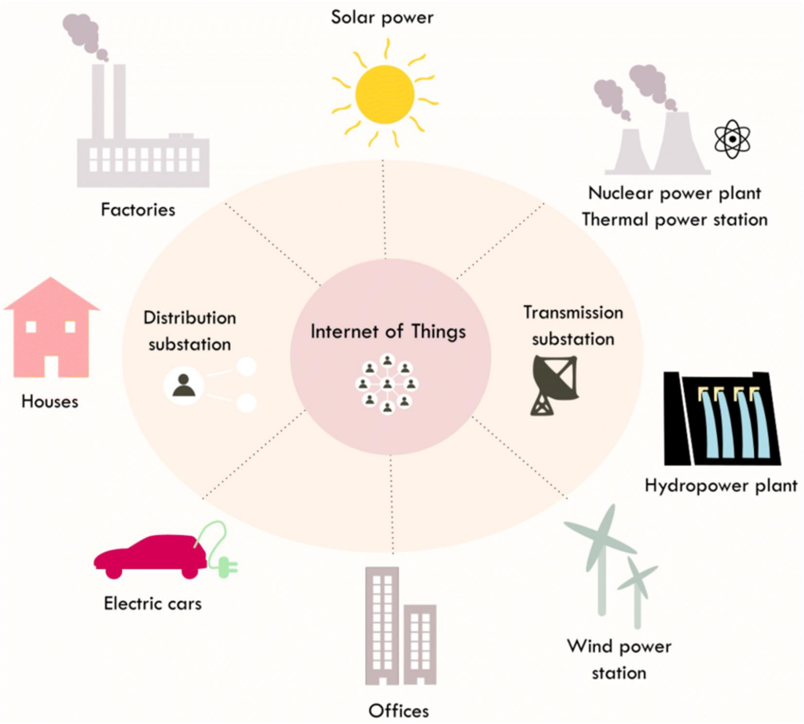

Fig. 5: SDG 12: Responsible Consumption and Production

2.7. SDG 13: Climate Action

Artificial Intelligence (AI) is playing an increasingly significant role in the construction industry, offering innovative solutions that contribute to the achievement of the United Nations Sustainable Development Goals (SDGs). One of the most critical goals in this context is SDG 13: Climate Action, which calls for urgent action to combat climate change and its impacts. AI applications in construction can directly influence climate action by improving sustainability, reducing carbon emissions, and enhancing resilience to climate-related challenges.

AI Applications in Construction:

1. **Energy-Efficient Building Design:** AI technologies are used extensively in the design phase of construction projects to create energy-efficient buildings. AI systems analyze large amounts of data, such as local climate conditions, building materials, and energy usage patterns, to design structures that optimize energy consumption. For example, AI tools can recommend the best insulation materials, window placements, and renewable energy sources (like solar panels) based on the building's geographic location and environmental factors. These energy-efficient designs reduce the need for heating, cooling, and lighting, ultimately lowering the carbon footprint of the building throughout its lifecycle. By improving energy efficiency, AI directly supports SDG 13's goal of reducing greenhouse gas emissions.

2. **Sustainable Construction Practices:** AI can help optimize the construction process itself by ensuring that materials and resources are used more efficiently. Machine learning algorithms can predict the precise number of materials required for a project, thus minimizing waste and reducing the energy and resources needed to produce new materials. Moreover, AI-driven solutions can track the carbon footprint of construction materials, helping companies select more sustainable alternatives that produce fewer emissions during their lifecycle. The optimization of construction practices contributes to mitigating climate change by reducing the environmental impact of the building process.
3. **Real-Time Monitoring and Climate Risk Assessment:** AI technologies, such as sensors and drones, are increasingly used on construction sites to monitor environmental conditions in real time. These AI-driven systems can detect issues like poor air quality, water usage inefficiencies, and energy consumption patterns, helping construction managers adjust reduce environmental harm. Additionally, AI models can assess climate risks such as flooding, extreme heat, or other natural disasters, enabling builders to design structures that are resilient to climate change. For example, AI tools can simulate how a building would react to extreme weather conditions and suggest modifications to improve its ability to withstand such events. This enhances the resilience of infrastructure, a key component of SDG 13's focus on adaptation to climate change.
4. **Carbon Emission Tracking and Reduction:** AI can also be employed to track and reduce carbon emissions across the entire construction process. By integrating AI into project management systems, companies can monitor emissions from construction equipment, transportation, and energy usage. AI models can identify areas where emissions can be reduced, such as by recommending the use of electric vehicles instead of diesel-powered ones or optimizing transportation routes to reduce fuel consumption. Moreover, AI can be used to design carbon capture and storage solutions for construction sites, helping to offset some of the emissions produced during construction activities.

Contribution to SDG 13: Climate Action:

AI's ability to optimize energy consumption, reduce waste, and mitigate carbon emissions aligns directly with the objectives of SDG 13: Climate Action. The construction industry is one of the largest contributors to global carbon emissions, so integrating AI can play a pivotal role in reducing the sector's impact on climate change. AI helps construction companies make data-driven decisions that minimize environmental harm and promote sustainable practices. AI's potential to enhance resilience to climate impacts is another important contribution. As extreme weather events become more frequent due to climate change, the construction industry must adapt to these new challenges. AI allows for better climate risk assessments and designs that can withstand extreme conditions, contributing to more climate-resilient infrastructure. In conclusion, AI applications in construction are essential to addressing the urgent need for climate action. By improving energy efficiency, reducing waste, tracking carbon emissions, and enhancing climate resilience, AI supports the goals of SDG 13. As AI technologies continue to evolve, their role in mitigating climate change and fostering sustainable practices in construction will become even more significant, driving the industry toward a low-carbon, climate-resilient future.

2.8. SDG 15: Life on Land

Artificial Intelligence (AI) is making a substantial impact across a variety of industries, and the construction sector is no exception. One of the United Nations' Sustainable Development Goals (SDGs) that benefits from AI advancements is SDG 15: Life on Land, which focuses on protecting, restoring, and promoting the sustainable use of terrestrial ecosystems. The construction industry, due to its high resource consumption and land use, can significantly contribute to environmental degradation if not managed properly. AI applications in construction can help minimize negative impacts on land ecosystems, promote biodiversity, and ensure that land is used responsibly and sustainably.

AI Applications in Construction:

1. **Minimizing Habitat Destruction:** Construction projects often involve land clearing, which can lead to the destruction of habitats for local wildlife. AI-driven tools, such as drones and satellite imagery analysis, can be used to conduct environmental impact assessments before starting construction. These AI systems can analyze the biodiversity of the land and detect areas where construction might pose a threat to ecosystems or endangered species. By identifying critical habitats, AI can help developers make informed decisions about where and how to build, minimizing disruption to wildlife and preserving natural areas. This supports SDG 15's aim to protect and restore terrestrial ecosystems.
2. **Smart Land Use Planning:** AI plays a pivotal role in optimizing land use to balance construction needs with environmental preservation. Machine learning algorithms can analyze geographic data to identify suitable areas for development while avoiding sensitive ecosystems such as forests, wetlands, and wildlife corridors. AI can also assess land degradation and suggest sites where construction could contribute to land restoration, such as areas that are currently underutilized or degraded but can be rehabilitated. This helps to ensure that land is used in a way that respects both human needs and biodiversity, thus promoting sustainable development in line with SDG 15.
3. **Promoting Sustainable Building Materials:** The selection of building materials can have a significant impact on land ecosystems. AI is helping the construction industry shift toward sustainable, eco-friendly materials that have minimal environmental impact. Machine learning algorithms can evaluate the environmental footprint of various materials, factoring in resource extraction

processes, energy consumption, and the potential for recycling. By recommending low-impact materials and encouraging the use of renewable resources, AI can reduce the depletion of natural resources and minimize harm to land ecosystems. This contributes to SDG 15 by promoting more responsible land management and reducing the extraction of non-renewable resources.

4. **Biodiversity Monitoring and Preservation:** During and after construction, it is crucial to monitor the impact on local biodiversity. AI tools can be used for continuous monitoring of ecosystems around construction sites. AI-powered sensors and drones can track changes in vegetation, wildlife activity, and other ecological factors, ensuring that biodiversity is maintained. If AI detects any disruptions, it can trigger alerts to adjust construction practices or initiate remediation actions. This ongoing monitoring helps protect local ecosystems and supports the restoration of habitats that may have been affected by construction, aligning with SDG 15's goals of preserving and restoring biodiversity and halting the loss of species.

Contribution to SDG 15: Life on Land:
AI technologies directly contribute to SDG 15 by promoting sustainable land management and reducing the negative impact of construction on terrestrial ecosystems. By enabling better planning, reducing habitat destruction, optimizing the use of resources, and supporting biodiversity preservation, AI helps ensure that construction projects are more environmentally responsible. Furthermore, AI’s ability to recommend sustainable building materials and monitor biodiversity during construction ensures that human development can proceed without sacrificing the health of the planet’s ecosystems. AI applications in construction also play a critical role in promoting land restoration, a key component of SDG 15. Through data analysis and predictive models, AI can identify degraded lands that could be revitalized through construction activities such as reforestation, soil rehabilitation, or the creation of green spaces. These efforts not only improve the environmental quality of the land but also foster long-term ecological balance. In conclusion, AI has the potential to transform the construction industry by supporting more sustainable practices that protect life on land. By minimizing habitat destruction, promoting smart land use, facilitating sustainable material choices, and enabling ongoing biodiversity monitoring, AI aligns construction activities with the goals of SDG 15. As the construction industry embraces AI technologies, it can help create a future where development and nature coexist harmoniously, ensuring a healthy planet for future generations.

2.9. SDG 17: Partnerships for the Goals
Artificial Intelligence (AI) is rapidly transforming the construction industry, offering a variety of applications that can contribute to achieving the United Nations Sustainable Development Goals (SDGs). One of the most critical goals in fostering global collaboration is SDG 17: Partnerships for the Goals, which emphasizes the need for partnerships between governments, the private sector, civil society, and other stakeholders to support sustainable development. AI applications in construction can play a pivotal role in facilitating these partnerships, creating synergies between different sectors, and enabling more effective collaborations to achieve the SDGs.

AI Applications in Construction and SDG 17:

1. **Collaborative Data Sharing and Integration:** AI technologies can enable seamless data sharing and integration across various stakeholders in the construction process. By collecting and analyzing data from multiple sources—such as construction managers, contractors, local governments, and environmental experts, AI can create centralized platforms for collaboration. These platforms allow all partners to access real-time data, such as construction progress, environmental impact, material usage, and safety protocols. This shared data can foster better decision-making and ensure that all partners work towards common goals. For example, AI systems can help ensure that contractors align with local government regulations on environmental protection or that sustainable construction practices are adopted across multiple construction sites. This collaboration through AI-driven data platforms helps foster partnerships between public and private sectors, enhancing the efficiency and transparency of construction projects.
2. **Global Collaboration for Sustainable Construction Practices:** AI’s ability to aggregate vast amounts of information allows stakeholders from various parts of the world to collaborate on global challenges such as climate change, resource depletion, and urbanization. For example, AI-based systems can facilitate the sharing of best practices for energy-efficient buildings, sustainable materials, and low-carbon construction methods across international construction networks. Companies and governments can leverage AI to identify and adopt innovations that can be scaled globally, leading to shared knowledge and tools for implementing sustainable development. This international collaboration not only promotes SDG 17’s goal of building partnerships but also supports the global effort to achieve SDGs related to climate action, sustainable cities, and responsible consumption.
3. **Optimizing Supply Chain and Resource Management:** The construction supply chain is often complex, involving multiple players such as material suppliers, logistics providers, contractors, and regulatory bodies. AI can optimize supply chains by predicting demand, tracking inventory, and enhancing communication between stakeholders. Machine learning algorithms can analyze data to forecast material needs and help manage resources more effectively, ensuring that construction projects stay on schedule and within budget. AI’s ability to enhance collaboration within the supply chain is crucial in building long-term partnerships between companies and external stakeholders. For example, AI systems can help construction firms work with suppliers to source sustainable

materials that align with environmental goals, further supporting SDG 17's focus on partnerships.

4. **Enhanced Project Management and Stakeholder Coordination:** AI-powered tools like Building Information Modeling (BIM) and project management software can help coordinate tasks and monitor progress across construction projects. These tools facilitate collaboration among contractors, architects, engineers, and other stakeholders by providing real-time updates on project milestones and timelines. With AI's predictive capabilities, project delays or cost overruns can be mitigated, and teams can work together more efficiently. Moreover, AI-powered platforms can integrate feedback from local communities, environmental groups, and regulatory authorities to ensure that construction projects align with broader sustainability goals. By improving communication and alignment among stakeholders, AI supports the creation of partnerships that work toward common objectives and long-term success.
5. **Public-Private Partnerships for Sustainable Infrastructure:** AI plays a key role in the development of sustainable infrastructure through public-private partnerships (PPPs). Governments, businesses, and nonprofit organizations can use AI to optimize urban planning, enhance infrastructure resilience, and address issues such as traffic congestion and energy consumption. For example, AI can help design smart cities that use renewable energy, reduce carbon emissions, and promote waste reduction. By leveraging AI technologies, public-private partnerships can collaborate on projects that are not only economically viable but also environmentally sustainable. These partnerships foster innovation and provide the necessary resources to tackle complex challenges, promoting SDG 17's vision of building cross-sectoral collaborations.

Contribution to SDG 17: Partnerships for the Goals:

AI's transformative impact on the construction industry underscores its potential to support SDG 17 by facilitating effective partnerships. Whether through improved data sharing, optimized supply chains, or enhanced coordination of projects, AI encourages collaboration between different sectors, governments, businesses, and communities—to create more sustainable outcomes. Furthermore, AI enables the construction industry to align with other SDGs, such as SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action), all of which require robust partnerships to achieve their goals. In conclusion, AI applications in construction are not only improving project efficiency and sustainability but also promoting global cooperation to achieve the SDGs. By facilitating data sharing, optimizing resource management, and fostering collaboration among various stakeholders, AI plays a crucial role in supporting SDG 17: Partnerships for the Goals. As AI technology continues to evolve, its ability to create more effective partnerships will be instrumental in ensuring that sustainable development becomes a collective effort across all sectors of society.

3. Challenges in AI Adoption for Sustainable Construction

Data Privacy and Security: AI systems require access to vast amounts of data, raising concerns about confidentiality and cybersecurity threats.

Ethical Considerations: The use of AI should align with ethical guidelines to prevent biases in decision-making and ensure fairness in workforce management.

Workforce Readiness: AI adoption necessitates comprehensive training programs to equip workers with relevant digital and technical skills.

High Initial Investment: The deployment of AI solutions involves significant upfront costs, which may pose barriers for smaller firms and developing economies.

4. CONCLUSION & FUTURE RESEARCH DIRECTIONS

AI presents a transformative opportunity for the construction industry to align with SDGs and foster sustainable development. While AI-driven solutions enhance efficiency and sustainability, challenges such as ethical concerns, data security, and workforce adaptation need to be addressed. Future research should explore case studies of AI implementation in construction projects, develop standardized AI frameworks for sustainability, and investigate policy measures that support AI adoption in the industry. Cross-disciplinary collaboration between technology developers, policymakers, and industry stakeholders is crucial in maximizing AI's potential for sustainability.

REFERENCES

1. Kia A, Sensoy S. Classification of earthquake-induced damage for R/C slab column frames using multiclass SVM and its combination with MLP neural network. Math Probl Eng. 2014;2014:1–14.
2. Hirokane M, Nomura Y, Kusunose Y. Damage detection using support vector machine for integrity assessment of concrete structure. Archit Civil Eng. 2008;64(4):739–49.
3. Cheng C, Jun L. Study on the damage identification of long-span cable-stayed bridge based on support vector machine. In: Proceedings of the International Conference on Information Engineering and Computer Science. Wuhan: IEEE; 2009. p. 1–4.
4. Akande K, Owolabi T, Twaha S, Olatunji S. Performance comparison of SVM and ANN in predicting compressive strength of concrete. IOSR J Comput Eng. 2014;16(5):88–94.
5. Oh C. Bayesian learning for earthquake engineering applications and structure health monitoring [dissertation]. California: California Institute of Technology; 2007.
6. Chen B, Chang T, Shih J, Wang J. Estimation of exposed temperature for fire-damaged concrete using support vector. Comput Mater Sci. 2009;44(3):913–20.
7. Dai H, Zhao W, Wang W, Cao Z. An improved radial basis function network for structural reliability analysis. J Mech Sci Technol. 2011;25(9):2151–9.
8. Gonzalez M, Zapico J. Seismic damage identification in building using neural network and modal data. Comput Struct. 2008;8(5):416–26.

9. Yang Y, Nagarajaiah S. Harnessing data structure for recovery of randomly missing structural vibration responses time history: Sparse representation versus low-rank structure. Mech Syst Signal Process. 2016;74:165–82.
10. Yuan X, Anumba C, Parfitt M. Cyber-physical systems for temporary structure monitoring. Autom Constr. 2016;66:1–14.
11. Cho C, Kim K, Park J, Cho Y. Data-driven monitoring system for preventing the collapse of scaffolding structures. J Constr Eng Manag. 2018;144(8):1–12.
12. Levitt R, Kartam N, Kunz J. Artificial intelligence technique for generating construction project plans. J Constr Eng Manag. 1992;114(3):329–43.
13. Tommelein I, Levitt R, Roth B. Site-layout modeling: How can artificial intelligence help. J Constr Eng Manag. 1992;118(3):594–611.
14. Fayek A, Oduba A. Predicting industrial construction labour productivity using fuzzy expert systems. J Constr Eng Manag. 2005;131(8):938–41.
15. Hu C, Lie D. Improved critical path method with trapezoidal fuzzy activity durations. J Constr Eng Manag. 2018;144(9):1–12.
16. Lam K, Tang C, Lee W. Application of the entropy technique and genetic algorithms to construction site layout planning of medium-size projects. Constr Manag Econ. 2005;23:127–45.
17. Rafiei M, Adeli H. Novel machine learning model for estimating construction costs considering economic variables and indexes. J Constr Eng Manag. 2018;144(12):1–9.
18. Pesko I, Mucenski V, Seslija M, Radovic N, Vujkov N, Bibic D, et al. Estimation of costs and durations of construction of urban roads using ANN and SVM. Complexity. 2017;2017:1–13.
19. Green Building [Internet]. Available from: https://archive.epa.gov/greenbuilding/web/html/. [Accessed 2019 Sept 10].
20. Zhang C, Cui C, Zhang Y, Yuan J, Luo Y, Gang W. A review of renewable energy assessment methods in green building and green neighborhood rating systems. Energy Build. 2019;195:68–81.
21. Tushar W, Wijerathe N, Li W, Yuen C, Poor H, Saha T, et al. Internet of things for green building management. Signal Process Internet Things. 2018;35(5):100–10.
22. Chou J, Pham A. Enhanced artificial intelligence for ensemble approach to predicting high-performance concrete compressive strength. Constr Build Mater. 2013;49:543–63.
23. Zhou Q, Wang F, Zhu F. Estimation of compressive strength of hollow concrete masonry prisms using artificial neural networks and adaptive neuro-fuzzy interference. Constr Build Mater. 2016;125:417–26.
24. Dantas A, Leite M, Nagahama K. Prediction of compressive strength of concrete containing construction and demolition waste using artificial neural networks. Constr Build Mater. 2013;38:717–22.
25. Deng F, He Y, Zhou S, Yu Y, Cheng H, Wu X. Compressive strength prediction of recycled concrete based on deep learning. Constr Build Mater. 2018;175:62–569.
26. Aggarwal V, Sharma A. Prediction of slump in concrete using artificial neural networks. Int J Civil Environ Eng. 2010;4(9):279–86.
27. Liu S, Huang J, Sung J, Lee C. Detection of cracks using neural networks and computational mechanics. Comput Methods Appl Mech Eng. 2002;191(26):2831–45.
28. Kang F, Li J, Dai J. Prediction of long-term temperature effect in structural health monitoring of concrete dams using support vector machines with Jaya optimizer and salp swarm algorithms. Adv Eng Softw. 2016;131:60–76.
29. Allam Z, Dhunny Z. On big data, artificial intelligence, and smart cities. Cities. 2019;89:80–91.
30. Hasancebi O, Dumlupinar T. Linear and nonlinear model updating of reinforced concrete T-beam bridges using artificial neural networks. Comput Struct. 2013;119:1–11.
31. Campa J, Pezeshk S. On the application of machine learning technique to derive seismic fragility curves. Comput Struct. 2019;218:108–22.
32. Al-Shmairi A, Kim J, Yuan T, Yoon Y. Modeling the compressive strength of high-strength concrete: an extreme learning approach. Constr Build Mater. 2019;208:204–19.
33. Ding Z, Li J, Hao H, Lu Z. Structural damage identification with uncertain modeling error and measurement noise by clustering-based tree seed algorithm. Eng Struct. 2019;185:301–14.
34. Yang L, Qi C, Lin X, Li J, Dong X. Prediction of dynamic increase factor for steel fibre reinforced concrete using a hybrid artificial intelligence model. Eng Struct. 2019;189:309–18.
35. Yan W, Deng L, Zhang F, Li T, Li S. Probabilistic machine learning approach to bridge fatigue failure analysis due to vehicular overloading. Eng Struct. 2019;193:91–9.
36. Liu H, Fu Z, Yang K, Xu X, Bauchy M. Machine learning for glass science and engineering: a review. J Non-Cryst Solids. 2019;Article in Press.
37. Gulgec N, Takac M, Pakzad S. Convolutional neural network approach for robust structural damage detection and localization. J Comput Civil Eng. 2019;33(3):1–11.
38. Dede T, Kankal M, Vosoughi A, Grzywinski M, Kripka M. Artificial intelligence application in civil engineering. Adv Civil Eng. 2019;2019:1–4.
39. Machine Learning [Internet]. Available from: https://in.mathworks.com/solutions/machine-learning.html. [Accessed 2019 Aug 15].
40. AI with MATLAB [Internet]. Available from: https://in.mathworks.com/campaigns/offers/ai-with-matlab.html. [Accessed 2019 Aug 3].
41. Deep Learning [Internet]. Available from: https://in.mathworks.com/solutions/deep-learning.html. [Accessed 2019 Aug 12].
42. Neural Network [Internet]. Available from: https://in.mathworks.com/discovery/neural-network.html. [Accessed 2019 Aug 17].

43. Krishnamoorthy C, Rajeev S. Artificial Intelligence and Expert Systems for Engineers. 1st ed. New York: Taylor and Francis Group; 1996.
44. Russell S, Norvig P. Artificial Intelligence: A Modern Approach. 3rd ed. USA: Pearson; 2010.
45. Sharma S. Application of support vector machines for damage detection in structure [master's thesis]. Massachusetts: Worcester Polytechnic Institute; 2008.
46. Nehdi M, Soliman A. Artificial intelligence model for early-age autogenous shrinkage of concrete. ACI Mater J. 2010;109(3):353–62.
47. Arslan M. An evaluation of effective design parameters on earthquake performance of RC building using neural networks. Eng Struct. 2010;32:888–98.
48. Lu P, Chen S, Zheng Y. Artificial intelligence in civil engineering. Math Probl Eng. 2012;2012:1–22.
49. Yuen K. Bayesian Methods for Structural Dynamics and Civil Engineering. Singapore: John Wiley and Sons; 2010.
50. Salehi H, Burgueno R. Emerging artificial intelligence methods in structural engineering. Eng Struct. 2018;171:170–89.
51. Efstatiades C, Baniotopoulos C, Nazarko P, Ziemianski L, Stavroulakis G. Application of neural network for the structural health monitoring in curtain-wall systems. Eng Struct. 2007;29:3475–84.
52. Flood I. Towards the next generation of artificial neural networks for civil engineering. Adv Eng Inform. 2008;22:4–14.
53. Ngo L, Wang T, Chen Y. Applying adaptive neural fuzzy inference system to improve concrete strength estimation in ultrasonic pulse velocity tests. Adv Civil Eng. 2018;2018:1–12.
54. Deakin M, Waer H. From intelligent to smart cities. Intell Build Int. 2011;3:140–52.
55. Smarsly K, Lehner K, Hartmann D. Structural health monitoring based on artificial intelligence techniques. In: International Workshop on Computing in Civil Engineering; 2007. p. 111–8.