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## The impact of construction technology on the sustainability of buildings

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## Abstract:

Numerous studies confirm that construction technology significantly contributes to enhancing the sustainability of buildings.

### The research focuses on several aspects:

- 1. Use of advanced and environmentally friendly building materials: New building materials have been developed to reduce resource consumption and environmental impact, such as green concrete and recyclable materials.
- 2. **Evolution of smart design:** Employing modern design techniques enables the construction of buildings that facilitate better airflow and natural light, thereby reducing energy consumption.
- 3. **Smart construction techniques**: Utilizing automation and robotics increases efficiency, decreases waste and errors, thus conserving materials and energy.
- 4. **Renewable energy:** Solar and wind energy technologies contribute to providing clean and renewable energy sources for buildings.
- 5. Smart management systems: Smart control technologies contribute to managing energy and water consumption in buildings, reducing wastage.

All these factors indicate that modern construction technology plays a significant role in enhancing the sustainability of buildings, leading to the development of more environmentally and economically sustainable communities.

Print ISSN 2735 - 539X

VOLUME 6, ISSUE 1, 2024, 31 – 50

Online ISSN 2735 - 5403

## **Introduction:**

The impact of construction technology on the sustainability of buildings has been a subject of significant interest and research in recent years. With the growing concern for environmental conservation and the need for more efficient use of resources, the role of technological advancements in the construction industry has gained prominence.

Numerous studies have delved into the multifaceted effects of integrating innovative technologies into the realm of construction. From the utilization of eco-friendly building materials to the implementation of smart design principles and the incorporation of renewable energy sources, these advancements have reshaped the landscape of sustainable building practices.

This research aims to explore and analyze the various facets through which construction technology contributes to the sustainability of buildings. By examining the utilization of advanced materials, smart design strategies, intelligent construction techniques, and the integration of renewable energy, this study seeks to elucidate the profound impact of technological innovation on fostering environmentally conscious and economically viable building solutions.

Through an in-depth analysis of these elements, this research endeavors to offer insights into how contemporary construction technology can play a pivotal role in creating more sustainable and environmentally friendly structures, ultimately contributing to the development of greener and more resilient communities.

## The research objectives regarding the impact of construction technology on building sustainability may include:

- 1. Environmental Impact Understanding: Analyzing how construction technology affects the environment and exploring methods to reduce negative effects while enhancing sustainability.
- 2. Energy Efficiency Evaluation: Studying how technology used in construction can improve energy consumption efficiency in buildings and decrease reliance on unsustainable energy sources.
- 3. **Development of Eco-Friendly Building Materials:** Researching technology allowing the use of sustainable and recyclable construction materials to reduce waste and enhance the environment.

 Print ISSN
 Online ISSN

 2735 - 539X
 VOLUME 6, ISSUE 1, 2024, 31 - 50
 2735 - 5403

- 4. **Management and Maintenance Improvement:** Using technology to enhance long-term building management and maintenance, reducing demolition and new construction.
- 5. **Innovation in Architectural Design:** Exploring how technology can contribute to designing more sustainable and space-efficient buildings with better air quality and natural light.
- 6. Enhancing Energy Sustainability: Studying how technology can facilitate the use of renewable energy sources in buildings and improve energy efficiency.
- 7. **Circular Economy Analysis:** Understanding how technology can improve recycling and waste management within the context of a circular economy.

These objectives shed light on different aspects that research on the impact of construction technology on building sustainability can cover.

Using advanced and environmentally friendly building materials refers to the utilization of technologically advanced materials that respect the environment and maintain ecological sustainability. These materials are often renewable, recyclable, or exhibit high efficiency in utilizing natural resources.

Examples of these materials include:

- Economical thermal insulations: These encompass insulating materials such as organic thermal insulators or those made from natural substances like wool or hemp. They reduce energy consumption for heating and cooling purposes.
- Recyclable materials: Examples include eco-friendly concrete that contains a higher proportion of recyclable materials, which can be easily reused or recycled.
- Renewable alternative materials: Such as sustainably sourced wood that relies on renewable natural resources.
- Organic materials: Like green cement that involves production processes with lower energy consumption, reducing carbon dioxide emissions.

Print ISSN 2735 - 539X

VOLUME 6, ISSUE 1, 2024, 31 – 50

Online ISSN 2735 - 5403

The use of these materials contributes to reducing the environmental impact of construction processes and demonstrates a commitment to sustainability and environmental protection. It also fosters innovation in the construction industry by developing and employing new materials that respect the environment while preserving building quality and occupants' health. Using advanced and environmentally friendly building materials refers to the utilization of technologically advanced materials that respect the environment and maintain ecological sustainability. These materials are often renewable, recyclable, or exhibit high efficiency in utilizing natural resources.

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The sustainability of using basalt fibers in construction materials.

## The Environmental Benefits of Using Basalt Fibers:

- 1. Conservation of Natural Resources: Basalt is extracted from volcanic rocks, serving as a plentiful and sustainable alternative to other materials used in construction and insulation.
- 2. Environmental Sustainability: Basalt fibers are easily recyclable, reducing solid waste and enhancing the sustainable lifecycle of these materials.
- 3. Carbon Emission Reduction: The use of basalt contributes to lowering carbon emissions due to lower energy-intensive processes compared to some alternative materials.
- 4. Environmental and Health Safety: Basalt fibers are non-toxic, noncombustible, and free from harmful chemicals, ensuring their safe use in living environments without impacting human health.
- 5. Positive Impact on Energy Efficiency: Basalt is employed in thermal and acoustic insulation, technologies that aid in reducing energy consumption in buildings and improving energy efficiency.

Print ISSN 2735 - 539X

VOLUME 6, ISSUE 1, 2024, 31 – 50 2735

Online ISSN 2735 - 5403

The utilization of basalt fibers is considered an excellent environmentally friendly choice in construction and insulation sectors, as it combines high performance with a positive impact on the environment and human health. **Developing Smart Design means using innovation and technology to create innovative and efficient solutions that meet people's needs and improve the quality of life. This approach encompasses several aspects:** 

- 1. **Sustainability:** Smart designs ensure efficient resource use and environmental preservation, whether in buildings, technology, or daily operations.
- 2. **Comfort and Efficiency:** Smart design aims to provide comfortable and efficient living and working environments through the use of technology and creative thinking.
- 3. **Communication and Interaction:** It encourages the development of products and services that interact with users and provide exceptional user experiences.
- 4. Advanced Technology: Smart design relies on technological innovation and modern technologies such as artificial intelligence, the Internet of Things, and cloud computing.
- 5. Environmental and Social Suitability: It aims to meet the needs of society by providing solutions that address environmental and social needs.

Developing smart design contributes to creating more sustainable and efficient products and services, fostering interaction between technology and the needs of communities and individuals. A smart building is equipped with advanced technologies that enable data connectivity, control, and analysis to enhance resource efficiency and improve user experience. Several elements distinguish smart buildings:

- 1. **Centralized Control:** Smart systems allow centralized control of various building systems such as lighting, HVAC, security, and energy from a single location.
- 2. Sensors and Data Collection: Smart buildings utilize sensors to collect data on energy consumption, air quality, and space utilization, aiding data-driven decision-making.

 Print ISSN
 Online ISSN

 2735 - 539X
 VOLUME 6, ISSUE 1, 2024, 31 - 50
 2735 - 5403

- 3. **Interaction and Integration:** Smart systems interact with users and integrate different building systems to improve user comfort and operational efficiency.
- 4. **Seamless Communication:** Smart buildings interact with connected devices like smartphones and tablets to provide sophisticated and convenient user experiences.
- 5. Automatic Responsiveness: Smart technologies enable buildings to automatically respond to user requirements or environmental changes intelligently.

Smart buildings leverage technology to enhance efficiency, comfort, security, and resource sustainability, making them ideal for urban environments, commercial enterprises, and communities aiming for innovation and sustainability.

The evolution of smart design reflects the continuous advancement in technology application and innovations to enhance solutions and products. The focus on intelligent design initially aimed to meet user needs and improve efficiency and comfort. Over time, smart design has witnessed notable evolution:

1. **Technology Integration:** Advancing smart design is intricately linked to the development and implementation of technologies like smart sensors, remote control, and artificial intelligence.

**Smart Sensors Technology:** refers to the use of advanced sensors connected to smart systems for collecting and intelligently analyzing data. This technology allows systems to leverage environmental or monitored event information to make decisions or trigger changes.

In the context of recent technological advancements, smart sensors technology is used in a wide range of applications, from smart home systems and smart buildings to industries and healthcare. This includes the use of motion sensors, light sensors, temperature sensors, and even more complex sensors such as label sensors and gas sensors.

Smart sensors technology relies on integration with the Internet of Things (IoT) and intelligent data analytics, enabling it to enhance understanding and response to the monitored environment or conditions effectively.

Print ISSN 2735 - 539X VOLUME 6, ISSUE 1, 2024, 31 – 50

Online ISSN 2735 - 5403

**Remote control technology** pertains to devices that allow users to control other devices from a distance. This technology is sometimes referred to as "remote control" or "smart remote control." It can include remote control systems for televisions, air conditioning units, audio systems, lighting, and various other devices.

This technology often involves the use of smart remote control devices equipped with technologies such as infrared or radiofrequency that enable the transmission of signals from a distance. Sometimes, internet communication technologies are used for remote control, allowing users to control devices through smartphone or tablet applications.

Advancements in this field have also included the integration of artificial intelligence and the Internet of Things, providing users with more intelligent and integrated remote control capabilities in their home or work environments.

Artificial Intelligence (AI) technology refers to the use of computation and programming to grant computer systems the ability to perform tasks considered intelligent, akin to human intelligence. This technology involves employing algorithms and mathematical models to represent and simulate human-like cognitive functions, enabling systems to understand data, make decisions, and even learn from experience.

AI technology is utilized in a wide range of applications, including big data analysis, speech and image recognition, and enhancing the performance of automated systems in executing complex tasks. Notable categories of artificial intelligence include deep neural networks, machine learning, and cognitive enhancement.

By advancing artificial intelligence techniques, systems can adapt and improve their performance over time based on new experiences and data.

- 2. User Experience Focus: Smart design evolution goes beyond technical performance, emphasizing user experience, comfort, and ease of use.
- 3. **Sustainability and Environment:** Smart design has increasingly aligned with sustainability, with a growing emphasis on reducing environmental footprints and using resources more efficiently.

Print ISSN		Online ISSN
2735 - 539X	VOLUME 6, ISSUE 1, 2024, 31 – 50	2735 - 5403

- 4. **Continuous Progression:** The evolution of smart design continues with increased adoption and utilization of new technologies in building and product design.
- 5. **Future-Oriented Approach:** Future advancements in smart design are expected to focus on enhanced device communication, artificial intelligence, and sustainability.

This evolution represents an ongoing shift towards utilizing technology and innovation to achieve smarter and more effective solutions across various domains, making smart design a pivotal focus in future developments.



تصميم المباني الذكية -Smart Building Design

# The use of automation in smart construction technologies refers to applying technology to enhance and streamline construction processes, making them more efficient and intelligent. This encompasses several aspects:

1. Lighting, Heating, and Ventilation Systems: Automation enables automated control of lighting, heating, and ventilation based on needs, contributing to energy conservation.

 Print ISSN
 Online ISSN

 2735 - 539X
 VOLUME 6, ISSUE 1, 2024, 31 - 50
 2735 - 5403

- 2. Smart Infrastructure: Smart infrastructure involves automated control of mechanical and electrical systems, intelligent allocation of streams, and networks.
- 3. Safety and Surveillance Systems: Automation can enhance safety and surveillance systems, allowing remote monitoring and automated actions during emergencies.
- 4. Smart Technology in Design and Construction: Smart technology can be utilized in design and construction processes, such as using 3D printing and Building Information Modeling (BIM).
- 5. Intelligent Building Management: Automation can efficiently manage and maintain buildings, including energy systems and waste management.

The use of automation in smart construction technologies enhances efficiency, comfort, and safety, contributing to improved sustainability and streamlined construction processes, making it a crucial part of the construction industry's advancement."

"Utilizing robotics in smart construction technologies refers to employing automation and technology to enable robots to perform a variety of tasks within construction processes. These robots are used to enhance efficiency, accuracy, reduce time, and effort required in numerous construction tasks. Some common applications of robotics in smart construction technologies include:

- 1. **3D Printing Construction:** Robots are utilized in printing building structures using 3D printing techniques, allowing for the rapid and efficient creation of complex architectural structures.
- 2. Automated Demolition and Dismantling: Robots are employed in demolition and dismantling operations of old buildings in an organized and safe manner, reducing environmental risks and saving time.
- 3. **Construction Robotics:** Robots are used to place and install construction materials such as bricks or cement in a precise and rapid manner.

Print ISSN 2735 - 539X

VOLUME 6, ISSUE 1, 2024, 31 – 50

Online ISSN 2735 - 5403



- 4. **Inspection and Site Management:** Robots are utilized for monitoring and inspecting construction sites, providing accurate data on progress and quality.
- 5. **Smart Delivery and Transportation:** Robots can be employed in internal transportation and delivery operations of materials and equipment within construction sites.

The use of robots in smart construction technologies contributes to enhancing efficiency, safety, and precision in construction processes, representing a significant advancement in the development of the construction industry. The use of renewable energy in construction technology significantly impacts the sustainability of buildings in several ways:

- 1. Environmental Sustainability: Renewable energy sources like solar and wind power help reduce harmful environmental emissions, lessening the building's impact on climate change and air pollution.
- 2. **Operational Costs:** Utilizing renewable energy can lower operational costs through reduced or even zero-energy bills, enhancing cost-effectiveness and decreasing maintenance expenses.

 Print ISSN
 Online ISSN

 2735 - 539X
 VOLUME 6, ISSUE 1, 2024, 31 - 50
 2735 - 5403

- 3. Energy Independence: Incorporating renewable energy increases buildings' independence from traditional energy sources, reducing reliance on fossil fuels and promoting long-term sustainability.
- 4. **Sustainable Design:** Renewable energy technologies can be integrated into smart and sustainable building designs, contributing to constructing structures that utilize natural resources more efficiently.
- 5. **Increased Property Value:** Adopting renewable energy technologies is a tangible factor in boosting property values, aligning with the growing demand for sustainable and environmentally friendly buildings.

By employing renewable energy in construction technology, it's possible to enhance the sustainability of buildings, reduce the environmental footprint of construction and building operations, thus fostering sustainable communities and a better living. Using solar and wind energy as renewable sources in construction technology encompasses several positive aspects:

- 1. Solar Energy:
  - Solar panels are used to convert sunlight into electrical energy:

These panels consist of photovoltaic cells, usually made of silicon. When exposed to sunlight, these cells interact with photons (particles of light), generating an electric current. These cells are assembled into a single solar panel to produce a certain level of electrical power, and they are typically grouped together to generate larger amounts of electrical energy.

• Typically installed on building rooftops to maximize sunlight exposure: Installing solar panels on building rooftops serves to optimize the capture of sunlight for energy production. Here are the specifics:

**Placement:** Solar panels are strategically positioned on rooftops to receive maximum sunlight throughout the day. South-facing rooftops in the northern hemisphere (and vice versa in the southern hemisphere) tend to receive the most sunlight.

Print ISSN 2735 - 539X

VOLUME 6, ISSUE 1, 2024, 31 – 50

**Online ISSN** 2735 - 5403

**Panel Orientation:** The panels are tilted or angled to optimize their exposure to the sun's rays. This positioning helps enhance energy absorption and efficiency.

Mounting Systems: Various mounting systems are used to secure the panels to rooftops, ensuring stability and durability while allowing for proper orientation toward the sun.

Connection to Electrical Systems: Once installed, the panels are connected to the building's electrical systems. The electricity generated by these panels can power the building's electrical components or be fed into the local grid.

Energy Generation: When sunlight strikes the photovoltaic cells within the solar panels, it triggers a reaction that generates direct current (DC) electricity. This electricity is then converted into alternating current (AC) through an inverter, making it compatible with the building's electrical systems.

Environmental Impact: Utilizing solar panels on rooftops promotes clean energy production, significantly reducing reliance on fossil fuels and mitigating greenhouse gas emissions.

Cost Efficiency: While the initial installation cost may vary, over time, solar panels can contribute to cost savings on energy bills, depending on the system's size and the amount of sunlight available.

Installing solar panels on building rooftops offers an eco-friendly and sustainable approach to generating electricity for both residential and commercial purposes.

#### Used to power electrical systems, illuminate buildings, and heat • water:

**Operating Electrical Systems:** Solar panels are used to generate electrical energy that can be employed to operate a wide range of electrical systems in homes, businesses, and institutions.

Print ISSN 2735 - 539X 
 Online ISSN

 VOLUME 6, ISSUE 1, 2024, 31 – 50
 2735 - 5403

**Building Illumination**: The electrical energy generated from solar panels can be used to illuminate various types of buildings, whether for indoor or outdoor lighting purposes.

**Water Heating**: The thermal energy generated from solar panels can be utilized for heating water, whether for daily household purposes like bathing or for industrial applications.

These examples illustrate the diverse applications of the energy generated by solar panels and how this technology can offer multiple benefits across various fields.



Solar PS10 is the first tower based solar thermal power plant in the world that generates electricity commercially

## 2. Wind Energy:

## • Wind turbines are used to convert wind movement into electrical energy

Wind turbines are used to convert the movement of wind into electrical energy. This process relies on a fan with blades that respond to the wind's movement, rotating at high speeds, thereby generating mechanical energy. This mechanical motion is then converted into electrical energy through an electric generator connected to the fan. Typically, several wind turbines are assembled

**Print ISSN** 2735 - 539X VOLUME 6, ISSUE 1, 2024, 31 – 50

**Online ISSN** 2735 - 5403

together in wind farms to generate large quantities of electrical power.

Wind turbines can be installed in areas with strong winds to • generate power: When wind turbines are installed in regions with strong and consistent winds, they harness the kinetic energy from the wind and convert it into electrical power. Here are further details:

Location Selection: Wind turbines are strategically placed in areas known for their consistent and strong winds. Coastal areas, mountain passes, and open plains are often preferred due to their reliable wind patterns.

**Turbine Structure:** These turbines consist of tall towers with large blades attached to a rotor at the top. The blades rotate as the wind blows, turning the rotor connected to a generator, which then produces electricity.

Wind Speed Requirements: For optimal energy production, a certain minimum wind speed is required. Typically, turbines need wind speeds of about 7-10 miles per hour (3-4.5 meters per second) to start generating electricity efficiently.

Electricity Generation: As the wind turns the blades, the kinetic energy is converted into mechanical energy. This mechanical energy is then transformed into electrical power by the generator within the turbine.

Grid Integration: The electricity generated by wind turbines is often integrated into the power grid, providing sustainable and renewable energy for communities, industries, or sometimes even individual homes.

Environmental Impact: Wind power is considered a clean and renewable energy source, as it doesn't produce greenhouse gas emissions or pollutants during electricity generation, contributing to a reduction in carbon footprint.

Print ISSN		Online ISSN
2735 - 539X	VOLUME 6, ISSUE 1, 2024, 31 – 50	2735 - 5403

These turbines play a significant role in harnessing wind energy and contributing to the global shift towards sustainable and eco-friendly energy sources.

## • Used to feed electrical grids or generate power for direct use in buildings:

Wind energy can be used to efficiently generate electrical power. This is accomplished through devices known as "wind turbines," which convert the movement of air into electrical energy. Typically, these turbines are installed on tall towers called wind towers.

Each wind turbine generally consists of a fan called the rotor, which rotates due to the force of the wind. This rotational motion is then converted into electrical energy through an electric generator. The generated electrical power can be used to supply large electrical grids, or it can be directed directly for use in buildings or remote locations.

Wind energy is considered one of the renewable energy sources, and wind farms are an essential part of a diverse array of clean energy sources aimed at reducing our reliance on fossil fuels and minimizing harmful environmental emissions.



Wind Energy

 Print ISSN
 Online ISSN

 2735 - 539X
 VOLUME 6, ISSUE 1, 2024, 31 - 50
 2735 - 5403

### 3. Benefits:

- Solar and wind energy sources are clean, renewable, and environmentally friendly.
- They reduce environmental emissions compared to fossil fuels.
- They contribute to reducing energy costs and promote environmental sustainability.

Utilizing these energy sources in construction technology demonstrates a commitment to sustainability and contributes to creating more efficient and environmentally friendly buildings, reducing the negative impact of non-renewable resource use.

Smart management systems play a vital role in the evolution of construction technology and its impact on construction operations and projects. These systems significantly contribute to enhancing performance, efficiency, and sustainability in construction by:

- 1. **Improving Management Processes:** Smart systems offer solutions to organize management operations such as project management, resource scheduling, cost monitoring, and timetables.
- 2. Enhancing Coordination and Communication: These systems bolster communication and coordination among diverse teams involved in the project, reducing errors and improving collaboration.
- 3. **Increasing Efficiency:** Automation, data analytics, and predictions contribute to increased resource efficiency, improved work quality, and cost-effectiveness.
- 4. Enhancing Safety and Security: These systems provide continuous monitoring of safety and security, facilitating immediate action in emergency situations.
- 5. Smart Technology in Design and Construction: Smart technology is utilized in design and construction processes, including 3D printing, virtual reality, and augmented reality.

 Print ISSN
 Online ISSN

 2735 - 539X
 VOLUME 6, ISSUE 1, 2024, 31 - 50
 2735 - 5403

Adopting smart management systems in construction technology enhances efficiency, quality, and safety, contributing to the development of an industry that delivers more organized, effective, and appealing construction projects.

- 1. **Integrated Design and Smart Urban Planning:** Consider how technology can be used to better design buildings for more sustainable urban planning and efficient space utilization.
- 2. Smart Insulation and Ventilation Techniques: Research technology that improves thermal insulation and ventilation efficiency in buildings, reducing energy consumption and improving air quality.
- 3. **Innovations in Maintenance and Renewal:** Explore technology that facilitates regular maintenance and renewal operations to improve building lifespan and minimize unsustainable demolition.

Selecting one of these directions or combining several can provide ample space for a comprehensive study of technology's impact on building sustainability.

## Recommendations

- 1. Analysis of New Building Materials' Impact: Explore technologies enabling the use of sustainable and eco-friendly construction materials, such as sustainability-certified concrete or recyclable materials.
- 2. Study of Innovative Construction Methods: Investigate innovative construction technologies like 3D printing, IoT-connected smart structures, and their impact on construction sustainability.
- 3. **Technology and Renewable Energy:** Utilize technology to integrate renewable energy systems like solar or wind power into buildings, improving energy efficiency and reducing environmental footprints.
- 4. Artificial Intelligence and Smart Management Systems: Study how AI and smart control systems can enhance energy and resource management in buildings, increasing environmental efficiency.
- 5. Technology Analysis for Waste Management: Understand how technology can better manage construction waste, enhance recycling processes, or reduce waste.

Print ISSN		Online ISSN
2735 - 539X	VOLUME 6, ISSUE 1, 2024, 31 – 50	2735 - 5403

- 6. **Smart Climate Control Technologies:** Investigate technology's impact on smart heating, cooling, ventilation systems, and how it can improve indoor air quality in buildings.
- 7. **Infrastructure Maintenance Innovations:** Examine how technology can improve long-term maintenance and management of buildings, reducing the need for reconstruction.

## **Results:**

The research outcomes regarding the impact of construction technology on building sustainability may include:

- 1. **Improved Construction Efficiency:** Utilizing technology can lead to more efficient and precise construction processes, reducing waste and excessive material consumption.
- 2. **Reduced Environmental Footprint:** Embracing technology in using ecofriendly building materials and renewable energy systems can decrease the environmental impact of buildings.
- 3. Enhanced Construction Quality: Relying on technology can result in better construction quality and increased durability of buildings.
- 4. **Increased Energy Efficiency:** Employing technology to integrate renewable energy systems can reduce energy consumption and enhance its efficiency.
- 5. Waste Management and Environmental Sustainability: Using technology in managing construction waste and improving recycling processes can bolster the environmental sustainability of buildings.
- 6. **Cost and Resource Savings:** Some technologies may cut costs and required resources for construction, promoting financial sustainability.
- 7. Enhanced Livability and Comfort: Advanced construction technology may improve the work environment and daily life within buildings by enhancing comfort, ventilation, and lighting.

These outcomes highlight the potential benefits of adopting construction technology in achieving better sustainability for buildings and the surrounding environment.

Print ISSN		Online ISSN
2735 - 539X	VOLUME 6, ISSUE 1, 2024, 31 – 50	2735 - 5403

## **Conclusion:**

## The conclusion of the research on the impact of construction technology on building sustainability might include:

"The utilization of technology in construction enables significant advancements in the industry and enhances the sustainability of buildings. Through the use of sustainable building materials, smart technology, and renewable energy systems, environmental impact can be reduced, energy efficiency increased, and construction quality improved.

Understanding the impact of construction technology on building sustainability is crucial for achieving a more environmentally sustainable future. However, further research and innovation are needed to develop construction techniques that offer better performance and higher sustainability.

It's evident that technology will remain a key driver in improving building sustainability, and focusing on its innovative and sustainable applications presents a promising challenge worthy of ongoing exploration.

Studying the impact of technology in this context will continue to be pivotal in achieving sustainable communities and buildings that reflect our commitment to the environment, economy, and society.

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2735 - 539X	VOLUME 6, ISSUE 1, 2024, 31 – 50	2735 - 5403

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