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Designing infrastructure facilities using modern building materials

Abstract. Infrastructure facilities play a key role in meeting the vital needs of society and economic development. Designing such facilities is becoming increasingly challenging, as it requires a combination of innovative technologies, environmental friendliness and consideration of potential risks. The purpose of the study was to investigate the impact of modern building materials on the quality, sustainability, and efficiency of infrastructure facilities. This study involved a thorough examination of different types of building materials, a literature review of scientific sources, an assessment of the strength and environmental friendliness of materials, testing of their durability, and an analysis of their aesthetic appeal. The analysis revealed that the process of selecting building materials had a significant impact on the efficiency, durability, and sustainability of the infrastructure facility. It was noted that the correct choice of materials helps to achieve an optimal balance of these characteristics, which is key to ensuring the durability and reliability of the structure. The study looked at the use of high-strength steel structures, energy-efficient insulation materials and innovative technologies to increase resistance to various hazards such as earthquakes and fires. The paper presented the methods and steps used in the design of infrastructure facilities with modern building materials in

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mind. The importance of sustainability in the construction of infrastructure facilities was also described, highlighting the need to use environmentally friendly materials and technologies with minimal environmental impact. Achieving sustainability, energy efficiency and environmental sustainability in construction were recognized as key challenges in the modern construction industry. The study concluded that a balanced approach to the selection of building materials and technologies is needed to create infrastructure facilities that meet the requirements of sustainable development and environmental protection. The practical significance of this study is that it provides specific recommendations for the selection of modern building materials and technologies for the optimal design and construction of infrastructure facilities that meet the requirements of efficiency, sustainability and environmental friendliness

Keywords: innovative structures; fire resistance; energy efficiency; strength; design; reinforced concrete

INTRODUCTION

Given the constant development of technology and growing demands on the efficiency and sustainability of structures, the design process is becoming increasingly complex and requires an integrated approach. The use of modern building materials plays a key role in the process of creating infrastructure facilities that meet modern standards of quality, efficiency and environmental friendliness. The latest construction materials help to achieve high quality and reliability of structures, ensure optimum efficiency in the use of resources and energy, and reduce the negative impact on the environment. Such materials allow for the design and construction of buildings that meet modern construction requirements, ensuring a high quality of life and comfort for users and maximum preservation of natural resources for future generations. In this context, it is important to consider the selection and use of materials that ensure structural reliability, operational efficiency and compliance with environmental criteria. The constant development of technology and the expanding range of building materials require research to determine the best solutions in the use of materials and technologies. These solutions must ensure the highest quality of structures, minimal environmental impact and compliance with modern sustainability standards. The purpose of such research is to provide better solutions to the problems associated with the design and construction of infrastructure facilities in the modern world.

The topic of research on the use of modern building materials in the design of infrastructure facilities attracts the attention of many scientists and practitioners in the construction industry. The study by T. Serdiuk *et al*. (2021) focuses on the use of energy-efficient materials in construction to ensure the sustainability and efficiency of facilities. O. Chapiuk *et al*. (2021) study the impact of steel structures on the stability and strength of infrastructure structures in earthquake zones. O. Fomin *et al*. (2022) investigate the use of composite materials to improve the efficiency and reduce the weight of structures. F. Jalaei *et al*. (2021) analyse the possibilities of using alternative building materials to reduce the environmental impact of construction. X. Wang *et al*. (2022) consider new methods and technologies to improve the energy efficiency of building materials. S. Shi *et al*. (2022) investigate the optimal combination of materials and structures to achieve maximum strength and efficiency. A. Ustaoglu *et al*. (2021) examine the impact of sustainability of building materials on the carbon footprint of construction and the ability to reduce greenhouse gas emissions. S.K. Baduge *et al*. (2022) analyse the use of intelligent control systems to optimize construction processes and material use. K.S. Pribadi *et al*. (2021) focus on the development of new methods and technologies to improve the safety and resilience of building structures in response to various hazards. However, there are gaps in understanding the optimal strategies for the selection and use of materials, as well as the need for further research on the impact of these materials on the resilience of infrastructure facilities in different operating conditions. That's why the purpose of the study was to assess the impact of modern building materials on the operational characteristics of infrastructure facilities.

MATERIALS AND METHODS

This study is based on an analysis of the construction materials and infrastructure used in Ukraine. Kharkiv Railway Station and Yevhen Paton Bridge (Kyiv) were chosen as the objects under study. The study has thoroughly examined various types of construction materials such as clay brick, wood, stone and high-strength steel. Each of these materials was examined in detail to determine their characteristics and possible applications in a particular project. A literature analysis of scientific sources on the chosen research topic was also conducted to obtain data on the actual behaviour and characteristics of various materials. This information helped to make an informed choice and identify the advantages and disadvantages of each of them for further use in the project. As part of the study, each building material was assessed for key characteristics such as naturalness, strength, aesthetic appearance, durability and environmental friendliness.

When assessing the naturalness of a material, its environmental impact was taken into account, as well as its origin and recyclability. The environmental sustainability of the material and its impact on the ecosystem were analysed. In addition, the authors of this study assessed production processes and selected raw materials with minimal negative impact on the environment. The possibility of using recycled materials or recycling the material was considered to minimize waste and conserve resources.

When assessing the strength of a material, the authors of this study evaluated its ability to withstand loads, which is a key factor in its performance. Various testing methods were used to determine the strength of the material in real-world conditions. Parameters such as tensile strength, degree of deformation, abrasion resistance and other characteristics that affect the material's ability to perform in conditions where high strength and reliability are required were analysed. The formula for calculating the load was as follows (1):

$$P_{max} = \frac{S_{max}}{SF}, \quad (1)$$

where P_{max} – the maximum load (kg/m^2); S_{max} – maximum material strength (MPa); SF – safety margin.

Calculating the wall thickness using the formula for material resistance (2):

$$R = \frac{\sigma \cdot t}{F}, \quad (2)$$

where R – material resistance (N); σ – material strength (MPa); t – material thickness (m); F – safety factor.

The dead weight of the carriageway (3):

$$GG = \text{width} \cdot \text{height} \cdot \text{tare weight}. \quad (3)$$

Payload (4):

$$Q = \text{width} \cdot \text{payload}. \quad (4)$$

Wind load (5):

$$W = \text{width} \cdot \text{wind load}. \quad (5)$$

Snow load (6):

$$S = \text{width} \cdot \text{snow load}. \quad (6)$$

Total load on the bridge (7):

$$P = G + Q + W + S. \quad (7)$$

Reaction in each column (8):

$$R = \frac{P}{\text{number of columns}}. \quad (8)$$

When assessing the aesthetic appearance of a material, the authors of this study evaluated its visual appeal and compliance with the architectural intent. The characteristics that affect the overall appearance of a structure or object, such as harmony with the environment, architectural style and design intent, were considered.

When assessing the durability of a material, the authors of this study analysed its resistance to wear, ageing and external factors. The assessment included an analysis of the material's response to various wear agents, such as friction, impact, corrosion, abrasion and other mechanical or chemical influences. The authors of this study also assessed the material's resistance to changes in climatic conditions, ultraviolet radiation, temperature, humidity, and other external factors that can affect its physical and chemical properties over a long period of operation. Then the possibility of maintaining or restoring the material's characteristics over time, which is important for predicting the service life of the structure or object in which it is used, was considered.

When assessing the environmental friendliness of a material, the level of damage it can cause to the environment during its life cycle was determined. All stages of the material's life cycle were analysed, from raw material extraction to production, transportation, use, and recovery or recycling. The energy and environmental efficiency of production processes, emissions, waste generation, and the impact on water resources, soil, and air were taken into account. The possibility of using recycled materials or recycling the material to reduce the environmental impact was also assessed. The analysis was carried out in the context of the material's compliance with the requirements of sustainable development and conservation of natural resources.

RESULTS

Construction, as an industry of material production, plays an important role in the development of infrastructure and shaping the face of cities and villages. It covers a wide range of activities, including new construction, reconstruction, repair, and restoration of buildings and structures. However, the economic reforms taking place in Ukraine have brought about significant changes in this sector. One of the key trends that defines the current state of construction in Ukraine is the rapid growth of new construction, especially in cities and their surroundings (Bannikov *et al.*, 2022). This growth is driven by the increasing demand for new residential and commercial space arising from population expansion and business development. In this regard, construction companies are actively expanding their operations and investing in new projects. However, this growth has also been accompanied by increased competition and higher demands on the quality and efficiency of construction projects. In 2024, the use of advanced technologies and materials will become increasingly important as they not only ensure the high quality of buildings, but also contribute to energy efficiency and environmental friendliness of construction. Thus, the construction industry in Ukraine is undergoing a period of intense change, driven by economic reforms and growing demand for housing and commercial space. To ensure the successful development of the industry, it is necessary to improve technologies, enhance the quality of construction projects and take into account the environmental aspects of construction (Table 1).

Table 1. Integrated materials for modern infrastructure

The design stage	Type of material	Purpose	Properties
Planning	Composite panels	Exterior of the facility	High strength, lightweight
	Steel structures	The basis of the building	High strength, corrosion resistance

Table 1. Continued

The design stage	Type of material	Purpose	Properties
Design	Double-glazed windows	Windows and facades	High thermal insulation, noise insulation
	Solar panels	Energy supply	Renewable energy, reducing energy costs
Construction	Concrete blocks	Walls and partitions	Durability, fire resistance
	Environmentally friendly insulation materials	Insulation	Environmental friendliness and energy efficiency
Completion	LED lighting	Interior lighting	Energy efficiency, service life
	Water treatment systems	Waste water treatment	Cleaning efficiency and environmental friendliness

Source: compiled by the authors

The Table 1 allows systematizing information about the use of different materials at different stages of the design and construction of an infrastructure facility. In construction, the choice of materials plays a crucial role in achieving a balance between various parameters such as quality, durability, environmental friendliness and cost-effectiveness. Thanks to advances in science and technology, modern building materials offer a wide range of options to achieve these goals (Lam *et al.*, 2023).

One of the key aspects of choosing materials is their properties. Steel, for example, is renowned for its high strength and long service life, making it a popular choice for structural applications. Concrete also plays a central role in construction due to its ability to be easily moulded and its high strength, which allows for stable and reliable structures. In addition, glass is widely used in construction as a material for windows, facades and interiors, due to its transparency and aesthetic appearance, which adds to the attractiveness and functionality of buildings. However, the choice of materials is not limited to their physical characteristics. It is also important to consider the environmental aspect. The use of environmentally friendly materials and technologies helps to reduce the environmental impact of construction and conserve natural resources. Clay brick, wood and stone are building materials that are natural, durable and aesthetically pleasing. Clay bricks are made by firing clay and have high strength, durability and fire resistance, making them a popular material for construction. Wood is known for its natural beauty, warm appearance and renewability as a resource, and is used to create a comfortable and cosy environment in buildings. Stone, on the other hand, has unsurpassed strength, fire resistance and a unique look that makes a building aesthetically pleasing and reliable. These materials also meet the requirements of environmental friendliness, as they are natural and do not harm the environment during production.

For example, in 2024, composite materials are of great interest, as they can be more resistant to corrosion and have a longer service life, while having less negative impact on the environment. At the same time, cost-effectiveness is also important when choosing materials. In addition to the cost of the material itself, it is worth considering its transportation, installation, and maintenance costs throughout its lifetime. This can include an analysis of the service life, maintenance requirements and recyclability of materials, which can reduce costs and increase economic benefits in the future. Thus, the choice of materials in construction is a complex task that requires careful analysis of various factors. Considering quality, durability, environmental friendliness and cost-effectiveness, it is possible to ensure the optimal choice of materials for construction projects that meet the needs of modern society and the requirements of sustainable development.

Built in the 20th century, Kharkiv Railway Station is known for its high modernity and popularity among other Ukrainian railway stations (Dreval *et al.*, 2024). It is fascinating not only for its enormous size and practicality, but also for its unique architectural style, which combines elements of classicism with modern trends. This building serves as an excellent example of the successful use of the latest building materials and advanced technologies in infrastructure construction (Fig. 1).

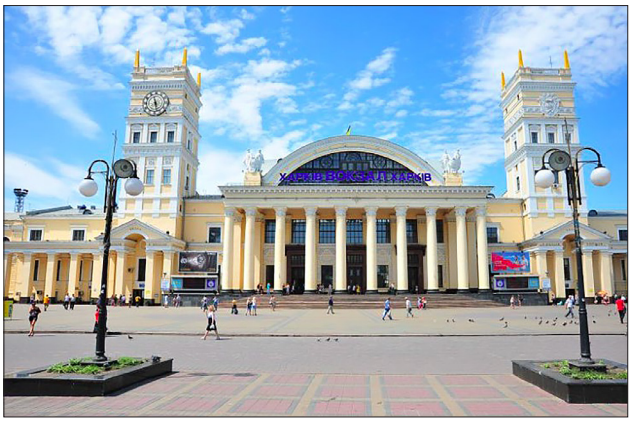

Figure 1. Kharkiv railway station
Source: Kharkiv Railway Station (n.d.)

The modern construction materials used in the construction of Kharkiv Railway Station are represented by a variety of high-quality components. High-strength steel is a material characterized by high strength, usually in the range of 500 to 700 megapascals (MPa). Its high strength allows it to withstand significant mechanical loads without serious deformation or fracture. In addition, high-strength steel is highly resistant to corrosion, making it an effective material for use in environments where there is interaction with moisture or chemically

aggressive environments. This ensures the durability of structures made of high-strength steel, which can exceed 100 years. This steel is perfect for building durable and reliable structures. High-strength steel was used for the load-bearing structures and the roof of the station, providing strength, corrosion resistance and durability. This material made it possible to create spacious waiting rooms, platforms and other premises, taking into account their resistance to loads. The maximum load on the roof of the station using high-strength steel was calculated using the formula for calculating the maximum permissible load on a structure (1). Substituting the permissible value: $P_{max} = \frac{500\ \text{MPa}}{2} = 250\ \text{MPa}$. Thus, the maximum load that high-strength steel can withstand with a given safety margin is 250 kg/m^2.

The facade of the station is made of stone and brick, which reflects its monumental appearance and provides high resistance to weathering. The material has a strength in the range of 10 to 20 MPa, which corresponds to the average values for stone and brick. The thickness of the facade walls ranges from 500 to 600 mm. These characteristics, together with the aesthetic appearance, create a reliable and attractive appearance of the station. To calculate the wall thickness using formula (2), the average material strength $\sigma = 15$ MPa and wall thickness $t = 550$ mm (average value) should be used for the material resistance. The safety factor $F = 2$. $R = \frac{15\ \text{MPa} \cdot 0.55\ \text{m}}{2} = \frac{825}{2}$. Therefore, the material resistance $R = 412.5$ N.

Wood is used for interior decoration and furniture making, adding cosiness and comfort to the room. Wood has a strength of 5 to 10 MPa, depending on its type and quality. This means that wood can withstand a certain load without breaking or deforming. Wood has a cosy and comfortable look that adds warmth and natural beauty to the room. Its natural texture and colour create an atmosphere of cosiness and luxury. Wood can last from 50 to 100 years, depending on the conditions of use, treatment, and care. Proper maintenance can significantly extend its service life, ensuring long-lasting comfort and aesthetic appearance of the interior. The innovative technologies used in the construction of Kharkiv Railway Station reflect the modernity and progress in the construction industry. Reinforced concrete structures formed the basis for creating spacious waiting rooms and platforms, providing the station with resistance to significant loads. The high-strength steel frame provides not only strength but also resistance to wind and snow. Modern heating, ventilation and air conditioning systems provide comfortable conditions for passengers at any time of the year, maintaining the optimum temperature and humidity. The station's electric lighting is based on energy-saving technologies, making it more environmentally friendly and efficient. The station is also equipped with modern information systems that provide passengers with access to train timetables, ticket availability information and other useful services, increasing the level of comfort and convenience for all users.

High-strength steel structures play a crucial role in construction, ensuring the stability, reliability, and efficiency of facilities. Their use has become an important step in the development of the construction industry, ensuring a high level of safety and durability of buildings. Steel is a material with high strength and durability, which allows for the creation of structures with high loads and at the same time ensures their stability even in the most difficult conditions. Steel structures are known for their quick installation and easy modification, which makes them efficiently used in any construction project and reduces the time required to complete the work. In addition, steel is highly resistant to various hazards, such as fire and earthquakes, making it an indispensable material for the construction of structures subject to safety and reliability requirements. It is also worth noting the environmental friendliness of high-strength steel structures. The use of steel in construction helps to reduce the environmental impact as it can be recycled and reused, reducing waste and contributing to sustainable development. This approach helps to conserve natural resources and reduce the negative impact of construction on the environment, in line with modern requirements for sustainable development and environmental protection. In light of the growing need for sustainable, safe and efficient building solutions, high-strength steel structures remain an integral part of modern construction. Their importance lies in ensuring the reliability and stability of buildings in all conditions, making them an indispensable element in the construction of the future (Tong *et al.*, 2021).

Yevhen Paton Bridge in Kyiv is one of the oldest and most famous bridges in Ukraine (Fig. 2). It was completed in 1953 and, at that time, was one of the longest welded bridges in the world. The Paton Bridge is an excellent example of how modern steel can be used to create strong, reliable and aesthetically pleasing infrastructure. About 28 thousand tonnes of St3SP steel were used in the construction of the bridge. This steel is known for its high strength and resistance to corrosion, making it an ideal material for structures that are subject to significant loads (Lobanov *et al.*, 2021). The use of modern steel has made it possible to create a strong and reliable bridge that can withstand significant loads. Thanks to this, the Paton Bridge has remained one of the most important transport arteries in Kyiv for many years. The use of modern steel in the construction of the Paton Bridge has brought a number of benefits, including increased strength and stability. The bridge can withstand significant loads and vibrations, making it safe to operate for many years. Reduced weight: due to its lightweight construction, the bridge required fewer materials and energy to build, making it more environmentally friendly. Increased durability: modern steel is resistant to corrosion and other types of damage, which significantly increases the service life of the bridge. Aesthetic appeal: the elegant design of the bridge makes it not only functional but also visually appealing. It is important to note that the Paton Bridge was built in 1953, when bridge construction technologies were significantly different

from todays. However, this bridge is an excellent example of how modern steel can be used to create a strong, reliable and aesthetically pleasing infrastructure.

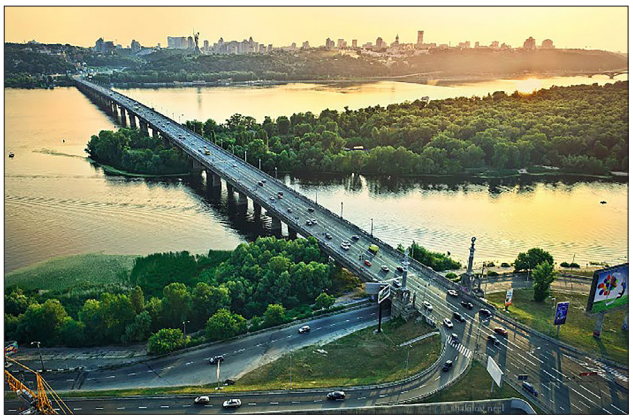

Figure 2. Yevhen Paton Bridge
Source: N. Shakilov (2013)

The unladen weight of the carriageway (denoted as G) is calculated using formula (3), which takes into account the width, height, and density of the material. In this case, $G=10\ m \cdot 0.4\ m \cdot 28\ t/m^3 = 112\ t$. The payload (denoted as Q) is calculated using formula (4), which considers only the width of the carriageway and the value of the payload. As a result of the calculations, $Q = 10\ m \cdot 20\ t/m = 200\ t/m$. The wind load (denoted as W) is calculated using formula (5), which considers the width of the carriageway and the value of the wind load. As a result, $W = 10\ m \cdot 2\ t/m = 20\ t/m$. The snow load (denoted as S) is calculated using formula (6), which also considers only the width of the carriageway and the value of the snow load. The result of the calculation is $S = 10\ m \cdot 1.5\ t/m = 15\ t/m$. The total load on the bridge is calculated using formula (7), which sums the dead weight, payload, wind, and snow loads. As a result of the calculations, $P = 112\ t/m + 200\ t/m + 20\ t/m + 15\ t/m = 347\ t/m$. The reaction in each column (denoted as R) is calculated using formula (8), which divides the total load by the number of columns. After performing the calculations, $R = \frac{347\ t/m}{4} = 86.75\ t/m$.

In construction, where the demand for materials with high strength and lightness is constantly growing, steel composites are becoming an interesting solution for many projects. These materials combine the advantages of steel with the properties of other composite materials, which opens up great opportunities for creating the most durable and lightweight building structures. One of the main advantages of steel composites is their high strength (Sajan & Selvaraj, 2021). Due to the unique combination of steel with other lightweight and strong materials, such as glass fibre or carbon fibre, composite materials provide high stability and durability of structures with minimal weight. This reduces the weight of building elements, which is particularly important in the case of large structures or in environments with limited ground loads. The use of steel composites helps to improve the efficiency of the construction process, reduce transportation and installation costs, and ensure that structures are more resistant to various environmental influences. In addition, steel composite materials are highly flexible and have a high degree of corrosion resistance. This makes them an ideal choice for construction in aggressive environments or in areas with high levels of humidity. Such materials ensure the durability and reliability of structures even in the most difficult operating conditions. They can successfully withstand extreme conditions and ensure the stability of building structures over time, making them an attractive choice for a wide range of projects and applications. The use of steel composites in construction opens up wide prospects for creating innovative and sustainable structures. They allow for the realization of even the most complex design ideas and ensure a high level of safety and reliability of structures. Therefore, the use of steel composite materials in construction is a reasonable step towards achieving sustainable, innovative and efficient construction projects.

In light of the growing awareness of environmental issues and the need for sustainable development, the issue of sustainability is becoming increasingly relevant in construction. Taking environmental aspects into account when choosing materials and technologies is becoming a prerequisite for reducing the negative impact of construction on the environment and creating sustainable and environmentally friendly construction projects. One of the key components of green construction is the selection of environmentally friendly building materials. The use of materials such as recycled steel, wood from regenerated forests, or biodegradable polymers helps to reduce emissions and environmental pollution. In addition, it is important to consider not only the sustainability of individual materials, but also their interaction with nature during production, use, and disposal. For instance, the use of materials that can be easily recovered or recycled without great environmental damage contributes to a more sustainable construction that conserves natural resources and minimizes its impact on the ecosystem. In addition, an important aspect of green building is the use of energy-efficient technologies and the development of green infrastructure solutions. This includes the installation of solar panels to generate the own electricity, which reduces dependence on traditional energy sources and helps to save energy. In addition, the use of water drainage and treatment systems reduces water consumption and minimizes the discharge of polluted water into the environment. Green roofs and walls are also an important element of green infrastructure, as they contribute to improving air quality by absorbing carbon dioxide and other harmful substances, as well as reducing heat emissions and retaining moisture, which helps to maintain a comfortable microclimate in the building. All these measures are aimed at creating environmentally friendly and sustainable construction projects that meet the requirements of modern society for sustainable development and environmental

protection. Environmental friendliness in construction is not only important for reducing the negative impact on nature, but also helps to create healthy and comfortable conditions for residents and users of construction projects.

Careful consideration of architectural and aesthetic aspects is a key element in the creation of infrastructure facilities that exist in the visual context of their surroundings. When designing any infrastructure facility, it is necessary to take into account not only its technical characteristics and functional purpose, but also its visual interaction with the environment (Ghomejshi, 2021). Ensuring the harmonious integration of an object into the visual context of the surrounding space requires a thorough study of the local architecture and landscape. This allows integrating a new facility into the existing aesthetics of the environment, creating a single, harmonious environment. It is important not only to comply with architectural design standards, but also to consider the unique features and cultural aspects of the local heritage. This approach to designing infrastructure facilities contributes not only to their aesthetic appeal, but also to a positive impact on the psychological and emotional state of people who use them. A sense of harmony and harmony with the environment creates a favourable atmosphere for living, working and recreation, which is an important factor in improving the quality of life of the population and creating sustainable and aesthetically pleasing communities.

DISCUSSION

When designing an infrastructure facility using modern construction materials, a thorough analysis of various aspects was carried out. Starting with the choice of materials, the authors of this study took into account their technical characteristics, resistance to loads, environmental friendliness and efficiency of use. Kharkiv Railway Station was a unique architectural structure that combined the best traditions of classicism and modern architectural solutions. The use of various types of building materials, such as clay brick, wood, stone and high-strength steel, allowed for the creation of a unique architectural structure that reflected both historical traditions and modern needs and standards. The Yevhen Paton Bridge in Kyiv is one of the oldest and most famous bridges in Ukraine, built in 1953. The use of St3SP steel made it possible to create a strong and reliable bridge that can withstand heavy loads and remains an important transport artery in Kyiv. The advantages of using this steel include increased strength and stability, reduced structural weight, increased durability and aesthetic design.

Researchers J. Zhao & S. Li (2022) found that life cycle assessment of building materials is an important step in choosing the best material for construction. A comparative analysis of energy and environmental impacts allows to assess the environmental impact of each material, from raw material extraction to disposal. Improving environmental efficiency can be achieved through the use of environmentally friendly materials and optimization of production processes. The use of standards and certifications helps to ensure the objectivity of comparative analysis and contributes to the creation of more environmentally sustainable construction projects.

According to the results of recent studies by B. Bickel *et al*. (2010), the design and manufacture of materials with the desired deformation properties is an important step in engineering and industrial activities. This process involves not only the selection of a suitable material, but also the development of its structure and processing to achieve certain mechanical characteristics. It is important to consider various factors, such as strength, elasticity, ductility and other properties, depending on the specific application of the material. To achieve the desired deformation properties, various material processing methods are often used, such as casting, rolling, moulding, and others. In addition, composite materials and nanomaterials technologies allow for the creation of materials with unique properties that can be precisely tailored to meet specific needs (Zakharova, 2024). These data are consistent with the points made in the previous section. Another important aspect of material design is the consideration of economic and environmental factors. Efficient use of resources and minimization of waste are key challenges in developing materials with the desired deformation properties. In addition, it is important to ensure that materials are safe and sustainable in service, so that they not only have the required mechanical properties but are also durable and safe for the environment and humans (Ratushnyak *et al*., 2023).

Modern construction technologies were also studied to ensure efficient use of the selected materials and maximum quality and durability of the facility. Referring to the definition of X. Chen *et al*. (2022), the introduction of technology in the construction industry is an integral part of the modern construction process. Construction companies are constantly introducing new technologies to improve efficiency, reduce costs and shorten construction time. One of the key areas of technology adoption is the use of information systems and software for project management, resource planning and automation of construction processes. This helps to optimize project management, improve coordination between construction stakeholders and reduce the time required to complete the work.

As noted by B.J. Meacham (2022), fire performance and regulatory requirements in modern construction play a key role in ensuring the safety of buildings and their occupants. Modern construction methods require careful selection of fire protection materials and technologies, as well as careful design of fire safety systems. Regulatory requirements apply not only to materials but also to evacuation, fire alarm and extinguishing systems. The use of modern technologies, such as automated fire detection and extinguishing systems, helps to improve the effectiveness of fire protection measures. However, it is important not only to install, but also to properly design and maintain these systems to ensure their reliability and efficiency. It is worth noting that the introduction of technology plays a key role in the development of the construction

industry, contributing to its competitiveness, improving the quality of construction and reducing the negative impact on the environment. However, it is also important to take into account the need to train specialists in new technologies and adapt legislation to the changing realities of the construction industry.

During the design process, it was important to consider not only technical aspects but also architectural and aesthetic requirements. It was necessary to ensure that the choice of materials matched the appearance and functionality of the facility, in accordance with its purpose and the nature of the area. P.V. Ghom & A. George (2021) state that aesthetics in architecture determines the appearance and interior design of buildings, influencing the perception and emotions of observers. It manifests itself through architectural styles, shapes, colours and textures, creating a variety of visual experiences. Aesthetics is also related to the functionality and usability of space, and the efficiency of materials and technologies. A successful balance between these aspects allows to create not only attractive, but also functional and efficient buildings that meet the needs of modern society.

Researchers Y. Yuan *et al*. (2021) identified that architectural design plays a key role in shaping the consumer experience, especially for buildings and structures used in public or commercial settings. Efficient use of space, original design and convenient arrangement of elements inside the premises can significantly increase user satisfaction and comfort. In doing so, architects take into account not only aesthetic aspects but also functional requirements, as well as the needs and preferences of end users. An important factor in architectural design is the creation of spaces that stimulate positive impressions and emotions in users. This may include considering natural light, creating pleasant views from windows, using environmentally friendly and healthy materials, and organizing functional areas to meet the needs of users. Thus, architectural design is closely related to consumer experience, as it has a direct impact on the comfort, convenience, and aesthetic perception of buildings and structures. Understanding the needs and preferences of users is an important aspect in the development of architectural solutions aimed at creating a positive and satisfactory user experience (Kuznetsov, 2024). These results confirm the above study, as careful consideration of architectural and aesthetic aspects allowed to create an infrastructure facility that not only meets the technical requirements and functional purpose, but also harmoniously fits into the visual context of the environment, perceiving feedback from the architecture and aesthetics of the surrounding space.

In addition, it was important to consider the environmental aspect during the design process. The selected building materials had to meet modern environmental standards, so they had to be selected with due regard to their environmental friendliness and safety for the environment. It was important to ensure that the building materials not only met the requirements of technical and aesthetic quality, but also had a minimal negative impact on nature, helping to maintain ecological balance and ensure the health of residents and the environment for the long term. Referring to the work of P. Lamba *et al*. (2022), plastic waste recycling in the construction sector can contribute to sustainable development by reducing the use of natural resources and the amount of plastic waste in the environment. However, innovative recycling technologies and waste management strategies are needed to successfully implement this idea. It is necessary to improve the quality and sustainability of the materials obtained, ensure energy efficiency of recycling processes and take into account the environmental aspects of these activities. It is also important to encourage the use of recycled materials in construction by creating incentives for manufacturers and construction companies. To achieve the goals of sustainable construction, cooperation between various industry players and government agencies is needed to develop new recycling methods and implement effective waste management strategies.

Researchers T.-T. Liu *et al*. (2022) have shown that interest in green building materials has increased significantly in recent decades due to the awareness of environmental issues and the need for sustainable development. Green building materials are materials that are produced with minimal impact on the environment and have high energy efficiency during their production, use, and disposal. These materials can be either naturally occurring or synthetic, but they are usually characterized by lower energy consumption and less environmental impact than traditional building materials. Examples of green building materials include wood from sustainably managed forests, clay, hemp, cellulose insulation materials, and concrete using admixtures from recycled waste. These materials have several advantages, including good thermal insulation properties, environmental friendliness, renewable resources and reduced harm to human health and the environment. There is no doubt that green building materials play an important role in creating healthy and sustainable buildings, contributing to the reduction of greenhouse gas emissions, energy savings and construction waste (Stepanov *et al*., 2023). In addition, their use contributes to a more conscious and responsible approach to construction and sustainable development in general.

Another important stage of the process was to determine the architectural solution for the facility. The use of modern construction materials allowed to implement the best architectural ideas, ensuring not only practicality but also the aesthetics of the building. Referring to the definition of M. Condotta & E. Zatta (2021), the use of recycled building materials in architectural practice and European standards faces a number of challenges. The uncertainty of standards and classification of materials makes it difficult to verify their compliance with building codes. The quality and safety of such materials are also important, as they can be defective or worn out. To address these issues, standardized quality and safety testing procedures need to be

developed and certification systems introduced. The use of recycled materials should be actively promoted through financial and tax instruments. This could help develop a market for used construction products and reduce the negative environmental impact of construction.

Researchers A. Almssad *et al*. (2022) found that masonry, especially brickwork, plays an important role in creating sustainable buildings. Bricks are one of the oldest and most traditional building materials, but their importance in modern architecture is maintained and expanding. This overview of the role of bricks in architecture examines their contribution to the creation of buildings that meet the principles of sustainable development and environmental safety. One of the key aspects of using bricks is their energy efficiency. Bricks have good thermal insulation, which reduces energy consumption for heating and air conditioning in a building. This helps to reduce carbon dioxide emissions and reduce the negative impact on the environment. Thus, the use of bricks in construction contributes to the creation of buildings with low energy consumption and contributes to the sustainable development of urban infrastructure (Mysak *et al*., 2016).

The process of designing an infrastructure facility using modern building materials required a comprehensive approach and consideration of various factors. This approach allowed to create a high-quality, efficient and aesthetic facility that meets modern requirements and satisfies the needs of consumers. The result of this process was the creation of an infrastructure facility that not only meets technical standards, but also harmoniously fits into the visual and functional environment, contributing to comfortable and safe use by consumers. As noted by K. Herman & Ł. Drozda (2021) in times of social distancing caused by the COVID-19 pandemic, green infrastructure is becoming especially important for the urban environment and living space. City authorities are forced to revise their urban policies and tactics, paying more attention to the creation of green areas, parks, squares and public spaces that contribute to the physical and psychological well-being of citizens. Green infrastructure is not only a means of beautifying the urban environment, but also a powerful tool for mitigating the negative effects of social exclusion and improving the quality of life. The development of green infrastructure in urban environments during the pandemic poses several tasks and challenges for city authorities. It is important not only to create new green spaces, but also to ensure their accessibility and affordability for all groups of the population, including people with disabilities and low-income groups. In addition, strategies for the sustainable use of green spaces need to be developed, providing for their maintenance and care to preserve their value and attractiveness in the long term.

Following the results of F. Dadakhanov *et al*. (2022), the prospects for the production of innovative building materials are reduced to the development of environmentally friendly composites, the use of advanced technologies such as 3D printing and nanomaterials, and the creation of smart materials adaptive to environmental changes. Successful realization of these prospects requires a combination of research, creativity, investment, and compliance with quality and safety standards. It is important to ensure that new materials are available on the market to support the sustainable development of the construction industry. Analysing the results and conclusions, green infrastructure plays a key role in adapting cities to new living conditions during the pandemic and social distancing. It not only helps to improve the physical and psychological health of citizens, but also contributes to the formation of more sustainable, healthy and harmonious urban environments.

CONCLUSIONS

The design of an infrastructure facility using modern building materials is an important component of the construction industry, as it determines the quality and functionality of the future structure. The use of modern materials in the design process allows to achieve a high level of efficiency and environmental friendliness of the facility. Kharkiv Railway Station is an excellent example of the use of modern building materials and innovative technologies in infrastructure construction. The Paton Bridge is a great example of how steel can be used to create efficient and sustainable infrastructure. The use of this steel has created a bridge that is not only safe and reliable, but also aesthetically pleasing.

The study confirmed that the use of modern building materials is a key factor in ensuring maximum strength and durability of structures. The use of the latest production and material processing technologies makes it possible to create structures that are resistant to weather, mechanical damage and other negative influences, thereby ensuring their durability and reliability over a long period of operation. The table of integrated materials for modern infrastructure provided valuable information on various building materials. This information helped to select the best materials based on quality, efficiency and environmental performance. In addition, the use of modern materials has helped to reduce energy consumption and improve the energy efficiency of buildings. Innovative materials and advanced thermal insulation technologies allow for efficient heat retention in the premises, reducing heating and air conditioning costs, resulting in lower energy consumption and resource savings.

The study confirmed the importance of environmental friendliness of building materials and their impact on the environment. The choice of environmentally friendly materials has a double effect: it helps to reduce emissions of toxic substances into the atmosphere and protects the ecosystem from negative environmental impact. This approach was an important step towards sustainable development of construction, helping to preserve natural resources and ensure a healthy environment for future generations. Designing an infrastructure facility using modern building materials is a complex and responsible process that requires a

comprehensive approach and careful consideration of various aspects. Taking all these factors into account allows creating a building that will meet the requirements of modernity, ensuring comfort and safety for its users.

The limitation of this study is the limited amount of available information on the impact of the use of specific modern building materials on the environmental footprint of construction. The impact of the use of modern building materials on the cost and technical complexity of infrastructure construction needs to be investigated.

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CONFLICT OF INTEREST

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Проєктування інфраструктурних об’єктів з використанням сучасних будівельних матеріалів

Анотація. Інфраструктурні об’єкти відіграють ключову роль у забезпеченні життєвих потреб суспільства та розвитку економіки. Проєктування таких об’єктів стає все більш складним завданням, оскільки вимагає поєднання інноваційних технологій, екологічності та врахування потенційних ризиків. Мета дослідження полягала у вивченні впливу сучасних будівельних матеріалів на якість, стійкість та ефективність інфраструктурних об’єктів. У цьому дослідженні використовувалися ретельне вивчення різних типів будівельних матеріалів, літературний аналіз наукових джерел, оцінка міцності та екологічності матеріалів, тестування їхньої довговічності, а також аналіз їхньої естетичної привабливості. У результаті аналізу було виявлено, що процес вибору будівельних матеріалів мав значний вплив на ефективність, міцність та стійкість інфраструктурного об’єкту. Було зазначено, що правильний вибір матеріалів сприяє досягненню оптимального балансу цих характеристик, що є ключовим для забезпечення довговічності та надійності споруди. Дослідження розглянуло використання високоміцних сталевих конструкцій, енергоефективних ізоляційних матеріалів та інноваційних технологій для підвищення стійкості до різних небезпек, таких як землетруси та пожежі. У роботі було представлено методи та кроки, які використовувалися при проєктуванні інфраструктурних об’єктів з урахуванням сучасних будівельних матеріалів. Також було описано значення екологічності в будівництві інфраструктурних об’єктів, що підкреслило необхідність використання екологічно чистих матеріалів та технологій з мінімальним впливом на довкілля. Досягнення стабільності, енергоефективності та екологічної стійкості у будівництві були визнані ключовими завданнями в сучасній галузі будівництва. Висновок дослідження полягав у необхідності збалансованого підходу до вибору будівельних матеріалів та технологій для створення інфраструктурних об’єктів, що відповідають вимогам сталого розвитку та збереження навколишнього середовища. Практичне значення цього дослідження полягає в тому, що воно надає конкретні рекомендації щодо вибору сучасних будівельних матеріалів та технологій для оптимального проєктування та будівництва інфраструктурних об’єктів, що відповідають вимогам ефективності, стійкості та екологічності

Ключові слова: інноваційні конструкції; пожежостійкість; енергоефективність; міцність; дизайн; залізобетон