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**QUALITY CONTROL IN THE CONSTRUCTION OF ENERGY-EFFICIENT
BUILDINGS**

LECTURE NOTES

*(for applicants of the second (Master's) level of higher education in all forms of study
in the specialty 192 – Construction and Civil Engineering
field of knowledge 19 – Architecture and Construction,
educational programs “Urban Construction and Economy,” “Industrial and Civil
Construction,” “Civil Engineering”)*

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The study addresses principles and methods of quality control in the construction of energy-efficient buildings. Emphasis is placed on ensuring compliance with modern standards, applying innovative technologies, and integrating sustainable practices to improve building performance and durability. The material is intended for Master's level students of Construction and Civil Engineering.

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INTRODUCTION

The construction of energy-efficient buildings has become one of the most important priorities in modern civil engineering and architecture. Growing global challenges, including climate change, depletion of natural resources, and the urgent need to reduce greenhouse gas emissions, require a rethinking of approaches to building design, construction, and operation. Energy-efficient construction is not only an environmental necessity but also an economic imperative, as it ensures the rational use of energy resources, lowers operating costs, and improves the comfort and safety of the indoor environment. In this context, quality control at every stage of construction plays a decisive role.

Quality control in the construction of energy-efficient buildings represents a comprehensive system that includes monitoring of design documentation, verification of building materials and engineering systems, supervision of construction processes, and assessment of completed structures. Unlike conventional construction projects, energy-efficient buildings demand a higher level of precision and adherence to technological requirements. This is due to the integration of advanced thermal insulation materials, innovative glazing systems, intelligent ventilation and heating technologies, as well as renewable energy installations. Any deviations from project requirements or technological standards can significantly reduce the energy efficiency of the building and compromise its overall performance.

At the international level, the implementation of energy-efficient construction is closely linked to the adoption of advanced standards such as LEED, BREEAM, and national certification systems. These frameworks emphasize not only the design of energy-efficient buildings but also the rigorous application of quality control procedures during construction and operation. For Ukraine, which is actively integrating European norms and developing its own regulatory base in the field of sustainable construction, the establishment of effective quality control systems is of strategic importance. Ensuring compliance with energy efficiency requirements directly contributes to achieving national energy independence and environmental

sustainability goals.

The introduction of quality control mechanisms in energy-efficient construction also reflects the growing demand for highly qualified specialists capable of integrating technical knowledge with practical skills in supervision, testing, and evaluation. For Master's level students in Construction and Civil Engineering, mastering this subject provides an essential foundation for professional competence and career development. Understanding modern principles of quality control equips future engineers and architects with the ability to critically evaluate building processes, detect potential risks, and implement corrective actions to ensure high-performance results.

Thus, the study of quality control in the construction of energy-efficient buildings combines theoretical foundations of construction science, practical aspects of engineering management, and strategic considerations of sustainable development. It is a key component of modern higher education in civil engineering, preparing specialists to meet the technological, environmental, and social challenges of the twenty-first century.

Lecture 1 Regulatory and Legal Framework in the Field of Energy-Efficient Construction

The European Union has established one of the most comprehensive and advanced regulatory and legal frameworks in the world to promote energy-efficient construction. This framework is the result of decades of policy development, integration of environmental concerns into economic and social strategies, and the recognition that the building sector is one of the largest energy consumers in Europe. Buildings account for a significant proportion of total energy demand, and therefore the improvement of their energy efficiency has become a strategic priority for the European Green Deal, which aims to achieve climate neutrality by 2050.

The central foundation of the European Union's regulatory framework in this field is the Energy Performance of Buildings Directive, often referred to as the EPBD. This directive requires Member States to establish minimum energy

performance standards for both new and existing buildings, to introduce systems for energy certification, and to provide reliable information to building owners and users regarding the efficiency of their properties. The directive also requires regular inspection of heating and cooling systems to ensure their compliance with the latest efficiency standards. Through the EPBD, the European Union has introduced the concept of nearly zero-energy buildings, which means that all new buildings constructed in Member States must demonstrate extremely high energy performance with the remaining low energy demand covered largely by renewable sources.

In addition to the EPBD, the Energy Efficiency Directive strengthens obligations for national governments to adopt measures aimed at reducing overall energy consumption, with direct implications for the construction sector. Member States are required to develop long-term renovation strategies for their national building stock, promoting deep renovation processes that go beyond simple repair and aim to bring old buildings in line with modern standards of energy performance. This legal obligation is closely tied to the Renovation Wave Strategy of the European Commission, which seeks to double the annual renovation rate of existing buildings across the European Union in order to meet climate targets and improve the quality of life for citizens. [1]

The European regulatory framework is not limited to directives but also includes technical standards, guidelines, and supporting financial instruments. Harmonized European standards developed by the European Committee for Standardization serve as technical references for calculating thermal performance, evaluating the quality of insulation materials, assessing ventilation systems, and verifying compliance with regulatory requirements. These standards ensure consistency across Member States while leaving room for national authorities to adapt regulations to local climatic conditions and construction traditions.

A significant legal component of the European framework is the system of energy performance certificates, which has become mandatory throughout the Union. These certificates provide transparent information on the energy consumption and environmental impact of buildings, empowering consumers, tenants, and investors to

make informed decisions. In practice, this instrument also functions as a regulatory lever, since poorly performing buildings lose market competitiveness and are gradually forced into renovation or modernization.

Financial and legal mechanisms also form an integral part of the European framework. Cohesion funds, the European Investment Bank, and various national incentive schemes provide support for projects that comply with energy-efficiency objectives. This financial dimension is legally embedded within broader EU climate and energy policy, ensuring that construction companies, local governments, and individual homeowners can access resources for renovation and modernization. In this way, the regulatory system is designed not only as a set of prohibitions or requirements but also as a supportive structure that fosters innovation and investment.

Environmental protection legislation within the European Union also interacts with the regulatory framework for energy-efficient construction. The Waste Framework Directive and related regulations on the circular economy encourage the use of sustainable building materials, recycling of construction waste, and minimization of environmental impact. Consequently, energy efficiency in construction is no longer considered in isolation but as part of a broader strategy that integrates climate policy, resource management, and public health.

The legal environment continues to evolve as the European Union adapts its rules to technological progress and political priorities. Recent revisions of the EPBD focus on digitalization, introducing smart readiness indicators for buildings that measure their ability to adapt energy consumption to the needs of occupants and the availability of renewable energy sources. This reflects the recognition that quality control and legal regulation of energy-efficient construction are inseparable from innovation and the transition toward smart cities.

Ultimately, the regulatory and legal framework of the European Union in the field of energy-efficient construction is characterized by its holistic and dynamic nature. It combines binding directives, technical standards, inspection systems, financial incentives, and environmental legislation in order to ensure that the building sector contributes to the Union's long-term goals of sustainability, competitiveness,

and climate neutrality. For students of civil engineering and architecture, studying this framework is essential not only to understand European practice but also to recognize the global significance of legal instruments in shaping the construction industry of the future.

Questions for self-control

1. What is the role of the Energy Performance of Buildings Directive (EPBD) in shaping energy-efficient construction across the European Union?
2. How does the Energy Efficiency Directive complement the EPBD, particularly in relation to building renovation strategies?
3. Why are energy performance certificates considered both an informational and regulatory tool in the EU construction sector?
4. In what ways do financial instruments and incentives support the implementation of energy-efficient construction policies within the EU?
5. How does the integration of circular economy principles and smart readiness indicators reflect the evolving nature of the EU regulatory framework for buildings?

Lecture 2 Author's Supervision and Technical Inspection

Author's supervision and technical inspection represent two essential mechanisms of quality assurance and compliance monitoring within the construction sector. Although they share a common goal of ensuring that construction works are executed in accordance with established standards, regulations, and project documentation, their scope, legal frameworks, and practical implementation differ across jurisdictions. A comparative view between the European Union and Ukraine highlights both common principles and significant divergences shaped by regulatory traditions and institutional development.

In the European Union, the practice of author's supervision is generally integrated into the broader framework of project management and architectural responsibility. The designer or architect who has prepared the project documentation

is typically expected to remain involved during the execution phase, providing professional oversight to ensure that the construction corresponds to the design intent, functional solutions, and aesthetic requirements. Author's supervision in this context is not only about preventing deviations from the drawings but also about adapting design solutions when unforeseen conditions arise on-site. The legal basis for this supervision is embedded in national building codes of Member States, harmonized under European directives such as the Construction Products Regulation and the Energy Performance of Buildings Directive, which emphasize accountability of designers for safety, energy efficiency, and sustainability outcomes. In many Member States, author's supervision is considered part of the ethical duty of the architect or engineer, formally tied to their professional license. [2]

Technical inspection within the European Union has a more formal and institutionalized character. It is usually performed by independent certified bodies or by public authorities responsible for building control. The main task of technical inspection is to verify compliance with safety standards, building codes, and technical specifications set out in law. Inspections cover structural integrity, fire safety, energy performance, environmental protection, and accessibility. These inspections are conducted at various stages of construction, from foundations to final commissioning. The European model emphasizes independence of technical inspectors to avoid conflicts of interest, ensuring that oversight is impartial and reliable. Furthermore, the European framework increasingly integrates digital tools, such as Building Information Modeling, into inspection practices, enhancing traceability and transparency.

In Ukraine, the legal and practical organization of author's supervision follows a similar conceptual line but with certain national specificities. According to Ukrainian construction legislation, author's supervision is the responsibility of the project organization or individual designer who developed the approved documentation. The primary role of this supervision is to ensure adherence to architectural and engineering solutions specified in the project, to confirm that technological requirements are met, and to make adjustments, when necessary, in

coordination with the client and contractor. Author's supervision is mandated by law for most categories of construction, especially in large-scale civil and industrial projects, and is documented through journals and official reports. This creates a system of accountability that directly connects the project author to the actual realization of the building.

Technical inspection in Ukraine is carried out within a regulatory system overseen by state institutions, particularly through mechanisms established by the State Architectural and Construction Inspectorate. Its main function is to control compliance of construction works with legislation, state building codes, and safety standards. Technical inspection in Ukraine includes monitoring the quality of construction materials, adherence to design and technological processes, and verification of the competence of contractors. Similar to the European Union, inspections are conducted at defined stages, but in Ukraine the process has often faced challenges related to bureaucratic complexity, administrative burdens, and the need for further digitalization and transparency. However, ongoing reforms are aimed at harmonizing Ukrainian technical inspection procedures with European practices, especially in the context of integration into the European Union.

A comparative analysis shows that in both the European Union and Ukraine, author's supervision maintains a focus on safeguarding the integrity of design solutions, while technical inspection ensures broader compliance with building codes and regulatory standards. The main difference lies in the degree of institutional development and the distribution of responsibilities. In the European Union, author's supervision is more closely connected with professional self-regulation and market accountability, while technical inspection operates within independent public or semi-public bodies with a high level of autonomy. In Ukraine, although the principles are similar, author's supervision remains more tightly bound to formal project documentation, and technical inspection is conducted under a more centralized state-controlled framework.

Both systems recognize that the effectiveness of construction oversight depends on the interaction between author's supervision and technical inspection.

When both mechanisms function effectively, they complement each other: author's supervision preserves the design vision and technical consistency, while technical inspection guarantees compliance with public safety, environmental, and energy efficiency requirements. In the European Union, this balance has been strengthened by the integration of digital certification and international quality standards, while in Ukraine, reform efforts are moving toward the same direction, seeking to align oversight practices with European norms.

Ultimately, the comparison demonstrates that author's supervision and technical inspection are indispensable instruments of quality assurance in energy-efficient construction. Their harmonization and modernization, particularly in Ukraine, are central to ensuring that future construction projects meet both domestic needs and European integration requirements.

Questions for self-control

1. What is the primary role of author's supervision in both the European Union and Ukraine, and how does it differ in practice?
2. How is technical inspection organized in the European Union, and why is independence of inspectors emphasized?
3. In what ways does Ukrainian technical inspection reflect a more centralized system compared to European practices?
4. How do author's supervision and technical inspection complement each other in ensuring quality and compliance in construction projects?
5. What reforms are being implemented in Ukraine to harmonize its construction supervision system with European Union standards?

Lecture 3 Principles of Energy-Efficient Construction

Energy-efficient construction is based on a set of interconnected principles that aim to reduce energy consumption in buildings while ensuring high standards of comfort, durability, and environmental responsibility. These principles reflect the transformation of construction science from a resource-intensive industry into a

sector that actively contributes to sustainable development and climate change mitigation.

The first principle is the rational use of energy resources through the creation of buildings that minimize energy losses and maximize internal comfort conditions. This requires careful design of the building envelope to reduce heat transfer, air leakage, and uncontrolled moisture exchange. Modern materials such as high-performance insulation, energy-efficient windows, and advanced sealing systems allow engineers and architects to construct envelopes that preserve indoor thermal stability with minimal energy input.

Another fundamental principle is the integration of renewable energy sources into building systems. Energy-efficient construction increasingly relies on solar panels, geothermal heating and cooling, biomass systems, and wind energy where feasible. The aim is not only to reduce reliance on fossil fuels but also to achieve long-term energy independence for buildings. The combination of passive measures, such as natural lighting and ventilation, with active renewable technologies enhances the resilience and sustainability of the built environment.

Equally important is the principle of system efficiency, which focuses on the performance of heating, ventilation, air conditioning, and lighting systems. Modern energy-efficient buildings employ intelligent control technologies that optimize the use of these systems according to real-time needs. For example, smart thermostats, automated shading devices, and adaptive ventilation systems ensure that energy is consumed only, when necessary, without compromising comfort. In this way, energy efficiency becomes an integrated process rather than a series of isolated technical solutions. [3]

The principle of life-cycle thinking also plays a central role. Energy efficiency is not limited to the operational phase of a building but extends to the entire life cycle, from the production of construction materials to demolition and recycling. By selecting environmentally friendly materials, reducing embodied energy, and planning for reusability, the construction sector minimizes its long-term environmental footprint. This holistic approach ensures that energy efficiency aligns

with broader goals of sustainable development and circular economy.

Comfort and health of occupants are inseparable from energy efficiency. Buildings designed according to energy-efficient principles provide stable thermal conditions, sufficient natural lighting, and high indoor air quality. These characteristics reduce health risks, increase productivity, and improve quality of life. Thus, energy efficiency is not only a technical challenge but also a social responsibility that shapes living and working conditions.

Finally, the principle of compliance with regulations and certification standards ensures that energy-efficient construction is systematically applied and continuously improved. International frameworks such as LEED, BREEAM, and the European Union's nearly zero-energy building requirements set measurable benchmarks for performance. These standards drive innovation and guarantee that construction practices contribute to national and global objectives in energy conservation and climate protection.

In summary, the principles of energy-efficient construction combine technological innovation, environmental responsibility, and human-centered design. They represent a dynamic field where engineering, architecture, and policy converge to create buildings that respond to the challenges of the twenty-first century. For students of civil engineering and architecture, understanding these principles is essential for mastering the professional skills required to design, construct, and manage the buildings of the future.

Questions for self-control

1. How does the design of the building envelope influence energy efficiency and overall performance of a structure?
2. In what ways can renewable energy sources be integrated into modern energy-efficient buildings?
3. Why is system efficiency of heating, ventilation, and air conditioning considered a key principle in energy-efficient construction?
4. How does life-cycle thinking extend the concept of energy efficiency

beyond the operational phase of a building?

5. What is the role of international certification systems and regulatory frameworks in promoting energy-efficient construction practices?

Lecture 4 Organization of Quality Control of Works at All Stages of Construction

The organization of quality control in construction is a fundamental factor that determines the reliability, durability, and energy efficiency of buildings. Both the European Union and Ukraine have developed their own systems of regulatory oversight and professional responsibility, which share similar objectives but differ in terms of institutional maturity, legal traditions, and practical enforcement. A comparative analysis of these systems across all stages of construction highlights the convergence toward common standards while also revealing the specific challenges that remain for Ukraine in its path toward European integration.

In the European Union, quality control is organized as a continuous and integrated process that begins with project design and extends through construction, commissioning, and subsequent operation. The responsibility for quality is distributed across multiple actors: designers, contractors, independent supervisors, and regulatory authorities. At the design stage, quality control is embedded through rigorous application of European standards, harmonized technical norms, and building codes. Each project is expected to comply not only with national legislation but also with EU directives such as the Energy Performance of Buildings Directive and the Construction Products Regulation, which establish clear benchmarks for safety, energy efficiency, and sustainability.

During the construction stage, quality control is implemented through a system of author's supervision, technical inspection, and mandatory certification of materials and processes. Independent inspectors and supervisory bodies ensure compliance with legal requirements, verify the performance of materials in accordance with CE marking standards, and monitor adherence to health and safety regulations. The European model emphasizes transparency and accountability: all stages of control are

documented, and digital technologies such as Building Information Modeling increasingly serve as tools for ensuring traceability. Quality audits, risk management procedures, and continuous testing of construction elements form an inseparable part of the EU framework.

At the final stage of construction, commissioning procedures include thorough inspections of energy performance, fire safety, and structural stability. Buildings cannot be put into operation without official confirmation of compliance with regulatory requirements, and in many Member States, the issuance of energy performance certificates is obligatory. These certificates serve both as a control mechanism and as a market instrument, providing stakeholders with transparent information about the quality and efficiency of the completed structure. [4]

In Ukraine, the system of quality control has developed under different institutional and regulatory conditions but reflects similar conceptual principles. At the design stage, project documentation is subject to state expertise for complex or large-scale projects, ensuring compliance with national building codes and technical regulations. Quality assurance at this stage is heavily influenced by formal requirements and state supervision, although recent reforms aim to reduce bureaucratic barriers and align Ukrainian codes with European standards.

During construction, quality control in Ukraine relies on author's supervision by project designers and technical inspection by certified engineers or organizations. Author's supervision ensures fidelity to project documentation, while technical inspection focuses on compliance with safety norms, technological processes, and the use of approved construction materials. However, unlike in many EU countries, Ukrainian technical inspection has historically been centralized under state institutions, which has sometimes limited independence and flexibility. Nevertheless, reforms introduced in recent years aim to decentralize oversight, increase transparency, and incorporate private-sector supervisory organizations into the control system.

At the commissioning stage, Ukrainian practice requires comprehensive verification of construction works, including compliance with energy efficiency

requirements, fire safety standards, and environmental protection measures. The building can only be put into operation after obtaining official approval from relevant authorities. While this process is conceptually similar to EU practices, the level of digital integration and the degree of market-driven certification remain less developed. The introduction of energy performance certificates has begun in Ukraine, but their practical implementation is still in progress compared to the more advanced EU system.

The comparison between the European Union and Ukraine demonstrates that both systems aim to secure quality at all stages of construction, but the European model relies more on independent certification, professional self-regulation, and integration of market mechanisms, whereas Ukraine maintains a stronger emphasis on state-controlled supervision and formal regulatory compliance. At the same time, Ukraine is gradually reforming its system to align with European approaches, particularly in the areas of transparency, digitalization, and reliance on international standards.

The overall trend suggests that Ukraine is moving toward convergence with the European Union in quality control practices. As European experience shows, effective quality control requires a balance of responsibility between designers, contractors, inspectors, and public authorities, supported by clear legal frameworks and reliable technical standards. For Ukraine, further harmonization with European practices will strengthen its construction sector, enhance trust in building performance, and support integration into the European regulatory space.

Questions for self-control

1. How is quality control organized at the design stage in the European Union, and what role do EU directives play in this process?
2. What is the function of author's supervision and technical inspection during the construction stage in both the EU and Ukraine?
3. How do commissioning procedures in the EU ensure compliance with safety, energy efficiency, and sustainability standards?

4. In what ways does the Ukrainian system of quality control differ from the European model in terms of independence and institutional structure?
5. What reforms are being implemented in Ukraine to align its quality control practices with European Union standards?

Lecture 5 Application of Thermal Insulation to External and Internal Walls

Thermal insulation of building envelopes is one of the most critical components in achieving energy efficiency in modern construction. Proper insulation reduces heat loss, stabilizes indoor temperatures, minimizes energy consumption for heating and cooling, and enhances overall occupant comfort. Both the European Union and Ukraine recognize the importance of thermal insulation, but their approaches differ in regulatory requirements, material usage, and technological implementation, reflecting variations in legal frameworks, climatic conditions, and construction practices.

In the European Union, thermal insulation works are highly standardized and regulated through both national building codes and EU directives, particularly the Energy Performance of Buildings Directive. External walls are insulated using advanced materials such as mineral wool, expanded polystyrene, and high-performance insulation boards, often combined with external cladding systems that protect against weathering and moisture infiltration. Internal wall insulation is applied in cases where retrofitting is necessary or where external interventions are limited, but it is always designed to prevent thermal bridges and moisture accumulation. The installation process is strictly controlled, including verification of material conformity, thickness, density, and thermal conductivity. Independent inspectors or quality control authorities frequently monitor the application of insulation to ensure compliance with energy efficiency standards. Additionally, the EU emphasizes the integration of digital planning and monitoring tools, such as Building Information Modeling, to optimize insulation design, installation, and performance assessment.

In Ukraine, the practice of thermal insulation has historically been influenced by Soviet-era construction standards, which emphasized structural robustness over

energy efficiency. However, recent reforms and increasing alignment with European norms have brought significant changes. Modern Ukrainian construction increasingly employs mineral wool, polystyrene, and composite insulation systems for both external and internal walls. External wall insulation is typically prioritized in new constructions and major renovations to achieve compliance with nearly zero-energy building requirements. Internal insulation is used more selectively, especially in urban areas where façade modifications are restricted. Unlike in the EU, quality control procedures in Ukraine are still largely conducted by project authors and state technical inspection bodies, and while material standards exist, enforcement of installation quality may vary depending on local authorities and contractor practices. Efforts are underway to adopt certification systems and professional oversight similar to EU models to ensure uniformity and reliability in insulation works.

A key difference between the EU and Ukraine lies in the integration of energy-efficient principles at the design stage. In the EU, thermal insulation planning is closely linked to energy modeling, climate-adapted design, and consideration of the entire building envelope as a holistic system. This includes attention to airtightness, prevention of thermal bridging, and interaction with ventilation and heating systems. In Ukraine, while modern projects increasingly adopt these principles, many constructions still rely on prescriptive insulation thicknesses and conventional installation methods without detailed energy simulation, although this is changing rapidly under EU-influenced reforms.

Another important aspect is the post-installation assessment. In the EU, performance verification often includes thermographic inspections, blower-door tests, and continuous monitoring in high-performance buildings to ensure that thermal insulation functions as designed. In Ukraine, such verification methods are less commonly applied, though there is growing interest in using these techniques in public and commercial buildings. The gap between practice and regulation is narrowing as Ukrainian legislation incorporates stricter energy efficiency norms and encourages international best practices.

In conclusion, thermal insulation of external and internal walls is a cornerstone

of energy-efficient construction. While both the European Union and Ukraine recognize its significance, the EU demonstrates a more integrated and standardized approach, combining strict regulation, advanced materials, independent inspection, and digital tools. Ukraine, while historically less advanced in this domain, is rapidly adopting EU-inspired methodologies, improving regulatory frameworks, and implementing modern construction technologies to enhance the performance and sustainability of its building stock. Effective insulation works in both regions not only reduce energy consumption but also improve occupant comfort, building durability, and environmental sustainability.

Questions for self-control

1. How does the European Union regulate the application of thermal insulation to external and internal walls in energy-efficient buildings?
2. What are the main materials and technologies used for wall insulation in the EU, and how do they ensure thermal efficiency and moisture control?
3. How does the Ukrainian approach to thermal insulation differ from EU practices in terms of quality control and regulatory enforcement?
4. Why is integration of thermal insulation with energy modeling and building envelope design emphasized in EU construction, and how does this compare to Ukraine?
5. What modern verification methods are used in the EU to assess the performance of installed insulation, and how is Ukraine adapting similar practices?

Lecture 6 Application of Insulation to Roofs, Attic Floors, Ground Floors, and Plinths

Insulation of building elements such as roofs, attic floors, ground floors, and plinths is a critical aspect of energy-efficient construction. Proper insulation of these structural components significantly reduces heat losses, stabilizes indoor temperatures, and prevents moisture accumulation, which can lead to structural degradation. Both the European Union and Ukraine recognize the importance of

thermal insulation in these areas, but the approaches differ due to regulatory frameworks, technological standards, and institutional practices.

In the European Union, roof insulation is designed to maximize thermal performance while maintaining structural integrity and moisture protection. Materials such as mineral wool, rigid foam boards, and high-performance reflective membranes are commonly used. Attic floors are insulated not only to reduce heat transfer between living spaces and unheated attic zones but also to prevent condensation and mold growth. Ground floors and plinths are insulated with a focus on preventing heat loss to the ground and mitigating the effects of moisture ingress. EU regulations emphasize integration of insulation with overall building energy modeling, ensuring that each element contributes to achieving nearly zero-energy standards. Defect detection is an integral part of quality control, including visual inspections, thermographic imaging, and moisture measurements, all documented by independent inspectors or quality control authorities.

In Ukraine, the insulation of roofs, attic floors, ground floors, and plinths has historically been influenced by prescriptive standards, which focused on material thickness rather than holistic thermal performance. Roof and attic floor insulation is commonly implemented using mineral wool or polystyrene boards, while ground floors and plinths employ bituminous or polymer-based insulation layers. Quality control is primarily carried out by author's supervision and state technical inspection. Defect detection, although mandatory, has often been less systematic and relies on visual checks rather than advanced diagnostic tools. However, reforms are promoting the use of thermography, moisture sensors, and standardized testing to bring Ukrainian practices closer to EU methodologies.

A key distinction between the EU and Ukraine is the emphasis on integrated design. In the European Union, insulation planning considers interactions between roofs, floors, walls, and plinths to prevent thermal bridges and moisture accumulation. Attention is paid to continuous insulation layers, airtightness, and ventilation coordination. In Ukraine, while modern projects increasingly follow these principles, many constructions still use traditional insulation methods with less

comprehensive integration. The enforcement of standards is gradually improving with the introduction of stricter building codes and alignment with European energy performance requirements.

Defect detection also highlights differences in practice. In the EU, it is conducted through rigorous methods such as blower-door tests, thermographic surveys, and moisture content analysis, allowing early identification of gaps, compression, or misalignment in insulation layers. Ukrainian procedures are evolving, with increasing use of similar methods, particularly in large-scale and public buildings. Early detection and correction of defects are essential to ensuring long-term energy efficiency, structural durability, and occupant comfort.

Overall, proper insulation of roofs, attic floors, ground floors, and plinths is essential for achieving energy-efficient construction. While the European Union demonstrates a highly integrated, regulated, and technologically advanced approach, Ukraine is in a transitional phase, progressively adopting EU-inspired standards and methods. Harmonizing insulation practices and defect detection procedures will ensure that Ukrainian buildings meet modern energy efficiency requirements, reduce operational costs, and provide sustainable, comfortable environments for occupants.

Questions for self-control

1. How are insulation works for roofs and attic floors organized in the European Union, and what materials and methods are commonly used?
2. In what ways does the insulation of ground floors and plinths differ between EU and Ukrainian construction practices?
3. How is defect detection conducted in the EU during insulation works, and what advanced methods are employed?
4. What are the main differences in quality control and regulatory oversight of insulation works between Ukraine and the European Union?
5. How do integrated design principles influence insulation effectiveness and defect prevention in EU construction, and how is Ukraine adapting similar practices?

Lecture 7 Types of Thermal Bridges

Thermal bridges are localized areas in a building envelope where heat transfer occurs at a higher rate than through the surrounding materials. They are critical to consider in energy-efficient construction because they can significantly reduce the overall thermal performance of a building, lead to increased energy consumption, and cause moisture accumulation that may result in mold growth and structural damage. Both the European Union and Ukraine emphasize the identification and mitigation of thermal bridges, but practices differ in terms of regulatory frameworks, technical standards, and implementation methods.

Thermal bridges can be classified according to their location and geometry within the building envelope. Linear thermal bridges typically occur at junctions between walls, floors, and roofs, where construction materials of differing thermal conductivity meet. Examples include the connection between external walls and balconies or the intersection of floor slabs with external walls. Point thermal bridges, on the other hand, arise from localized elements such as window frames, steel fasteners, or penetrations for utilities. These points create concentrated paths for heat transfer, which may not be apparent in simple thermal calculations but have a measurable impact on energy performance.

In the European Union, understanding and mitigating thermal bridges is integrated into energy-efficient building design. EU standards, such as those harmonized under the Construction Products Regulation and relevant EN standards, require calculation of thermal bridge effects in both new constructions and renovations. Advanced design software allows engineers to model linear and point thermal bridges, enabling accurate estimation of energy losses and optimization of insulation placement. Continuous insulation, thermal breaks, and careful detailing at junctions are essential strategies to minimize the negative effects of thermal bridges. Furthermore, thermographic inspection and infrared imaging are commonly used during construction to detect unexpected thermal bridges, ensuring that the building envelope performs as designed.

In Ukraine, thermal bridges have historically been less systematically addressed, especially in Soviet-era constructions, where attention was focused primarily on overall wall thickness and material properties rather than junction detailing. However, modern Ukrainian building codes and reforms increasingly align with EU practices. Designers and engineers are now encouraged to identify linear and point thermal bridges during the planning stage, apply thermal breaks, and optimize insulation placement at vulnerable junctions. Construction quality control, including thermographic inspection, is gradually becoming more common in larger projects to detect and correct thermal bridges before they compromise energy efficiency.

A particular focus in both the European Union and Ukraine is the mitigation of thermal bridges at high-risk points, such as balcony connections, roof-wall intersections, and around window and door frames. Proper detailing, continuous insulation, and material selection are essential in preventing heat loss and avoiding condensation problems. In the EU, nearly zero-energy buildings require comprehensive treatment of thermal bridges, and failure to do so can significantly reduce the building's compliance with energy performance standards. In Ukraine, awareness of these issues is increasing, and adherence to detailed construction practices is promoted as part of the national push toward energy efficiency and alignment with European norms.

Overall, thermal bridges are a critical factor in the design and construction of energy-efficient buildings. Identifying their types—linear, point, or complex—and implementing appropriate mitigation strategies is essential for minimizing energy losses, improving occupant comfort, and ensuring the durability of building structures. Comparing the EU and Ukraine demonstrates that while European practices are highly standardized and technologically integrated, Ukraine is progressively adopting similar approaches, ensuring that modern buildings meet contemporary energy performance requirements.

Questions for self-control

1. What are the main categories of thermal bridges, and how do linear and

point thermal bridges differ?

2. How do thermal bridges affect energy efficiency, indoor comfort, and building durability?

3. What strategies are used in the European Union to mitigate thermal bridges in energy-efficient buildings?

4. How has Ukraine's approach to identifying and addressing thermal bridges evolved compared to EU practices?

5. Why is thermographic inspection important in detecting and correcting thermal bridges during construction?

Lecture 8 Fundamental Principles of Energy-Efficient Design of Engineering Systems

Energy-efficient design of engineering systems is a critical aspect of sustainable construction, aiming to minimize energy consumption while maintaining optimal comfort, safety, and functionality in buildings. Engineering systems, including heating, ventilation, air conditioning, lighting, and water supply, constitute the backbone of building performance. Applying energy-efficient principles in their design is essential for reducing operational costs, lowering environmental impact, and complying with modern energy standards. Both the European Union and Ukraine emphasize the importance of these principles, though practices and regulatory frameworks differ.

The first principle is the integration of system design with the building's overall energy performance. In the European Union, engineering systems are planned considering the building envelope, passive design features, and anticipated occupancy patterns. Heating and cooling loads are calculated with precise energy modeling, which allows designers to select equipment that operates efficiently under real conditions. Ventilation systems are designed to balance indoor air quality with energy conservation, often employing heat recovery units and demand-controlled operation to minimize unnecessary energy expenditure. Lighting systems are optimized using natural daylight, high-efficiency lamps, and automated control to reduce electrical

consumption while maintaining comfort.

The second principle involves the selection of high-efficiency equipment and renewable energy sources. In EU buildings, boilers, heat pumps, chillers, and fans are chosen for their energy efficiency ratings, and renewable sources such as solar thermal, photovoltaic panels, and geothermal systems are integrated whenever feasible. The combination of active systems with passive energy-saving measures ensures that engineering systems contribute to the building's overall energy efficiency without excessive reliance on fossil fuels.

The third principle is the implementation of intelligent control and automation. Energy-efficient engineering systems employ smart thermostats, automated shading, adaptive ventilation, and lighting controls that respond to real-time conditions. These technologies optimize energy consumption, reduce operational waste, and maintain comfort for occupants. In addition, monitoring and diagnostic tools are used to detect inefficiencies or malfunctions, enabling proactive maintenance and continuous improvement of system performance.

The principle of life-cycle efficiency is equally important. Design decisions are made not only to minimize operational energy but also to reduce embodied energy in materials, maintenance requirements, and eventual replacement costs. EU standards, including nearly zero-energy building requirements, emphasize life-cycle thinking to ensure that engineering systems remain sustainable throughout the building's lifespan.

In Ukraine, energy-efficient design of engineering systems is gradually aligning with European approaches. Historically, designs focused primarily on functional performance and compliance with prescriptive norms. Modern Ukrainian projects increasingly employ energy modeling, high-efficiency equipment, and system integration to achieve greater sustainability. Attention is given to ventilation efficiency, proper insulation of ducts and pipes, and the use of automated control systems to reduce unnecessary energy consumption. Reforms in building codes and national energy regulations are promoting the adoption of nearly zero-energy building standards and the integration of renewable energy sources in engineering

systems.

Finally, both the European Union and Ukraine recognize that energy-efficient design must also prioritize occupant comfort and indoor environmental quality. Properly designed heating, ventilation, and air conditioning systems maintain stable temperatures, humidity, and air quality while minimizing energy use. The balance between energy conservation, functional performance, and occupant well-being is central to effective engineering system design.

In conclusion, the fundamental principles of energy-efficient design for engineering systems combine integrated planning, high-performance equipment, intelligent control, life-cycle thinking, and occupant-centered approaches. European practices demonstrate a highly standardized, technologically advanced framework, while Ukraine is progressively implementing similar methods, aligning its building sector with modern energy efficiency requirements and sustainable development goals.

Questions for self-control

1. How is integration of engineering systems with the building's overall energy performance applied in the European Union, and how does it affect efficiency?
2. What role do high-efficiency equipment and renewable energy sources play in energy-efficient engineering system design?
3. How does intelligent control and automation contribute to energy savings and occupant comfort in modern buildings?
4. What is the importance of life-cycle efficiency in the design of engineering systems, and how is it reflected in EU standards?
5. How are Ukraine's practices in energy-efficient design of engineering systems evolving to align with European approaches?

Lecture 9 Quality Control in Energy-Efficient Construction of Ventilation and Cooling Systems

Quality control in the construction of ventilation and cooling systems is essential for ensuring energy efficiency, indoor air quality, and the durability of building systems. Properly designed and installed systems maintain thermal comfort while minimizing energy consumption, which is critical in modern construction standards both in the European Union and Ukraine. Despite similar objectives, the approaches in quality control differ due to regulatory frameworks, technological adoption, and institutional practices.

In the European Union, quality control is implemented throughout the entire lifecycle of ventilation and cooling systems. During the design stage, energy modeling and simulation are employed to calculate airflow, temperature distribution, and cooling loads. Compliance with EU directives and harmonized technical standards ensures that systems are sized appropriately, materials meet efficiency requirements, and installations are feasible for maintenance. During construction, independent inspections and author's supervision verify that installation procedures conform to design specifications. Testing includes airflow measurements, temperature balancing, leak detection in ductwork, and verification of cooling capacity. These procedures are often documented digitally, allowing for traceable records and facilitating performance audits. Post-installation, commissioning procedures involve performance verification, energy consumption monitoring, and optimization of control systems, ensuring the building achieves nearly zero-energy performance where applicable.

In Ukraine, quality control in ventilation and cooling systems traditionally relied on state technical inspections and author's supervision, with an emphasis on compliance with national building codes and prescriptive norms. Design calculations were often based on standard tables rather than detailed energy modeling, and installation inspections primarily focused on adherence to drawings and safety standards. However, modern Ukrainian practices are evolving, increasingly incorporating energy-efficient principles inspired by EU standards. This includes

detailed system calculations, selection of high-efficiency fans, chillers, and heat recovery units, as well as commissioning tests to verify actual performance. Independent verification is gradually being introduced to enhance reliability and reduce energy waste.

A major difference between EU and Ukrainian practices lies in the systematic approach to defect detection and system optimization. In the EU, advanced diagnostic tools such as airflow meters, thermographic imaging, and digital monitoring of control systems allow for early detection of inefficiencies or malfunctions. In Ukraine, such methods are emerging, particularly in large public and commercial buildings, but are not yet widespread in residential construction. Corrective measures are applied based on observed deviations from design parameters, ensuring long-term system performance and occupant comfort.

Overall, quality control in energy-efficient ventilation and cooling systems combines rigorous design verification, standardized installation practices, and systematic commissioning and monitoring. While the European Union demonstrates a highly integrated and technologically advanced approach, Ukraine is progressively adopting similar methods, enhancing system reliability, reducing energy consumption, and improving indoor environmental quality. Effective quality control not only ensures compliance with energy efficiency standards but also contributes to occupant well-being, sustainability, and the durability of building systems.

Questions for self-control

1. How is quality control applied during the design stage of ventilation and cooling systems in the European Union?
2. What methods are used in the EU to verify installation quality and performance of ventilation and cooling systems?
3. How does quality control in Ukraine differ from EU practices in terms of inspection, testing, and system optimization?
4. Why is commissioning and post-installation monitoring important for energy-efficient ventilation and cooling systems?

5. How are advanced diagnostic tools, such as airflow meters and thermographic imaging, used to detect defects and inefficiencies in these systems?

Lecture 10 Quality Control in Energy-Efficient Construction of Heating Systems

Quality control in the construction of heating systems is a critical aspect of energy-efficient building design. Properly designed and installed heating systems reduce energy consumption, maintain thermal comfort, and ensure long-term operational reliability. Both the European Union and Ukraine emphasize the importance of quality control in this domain, although approaches differ in terms of regulatory frameworks, technical standards, and monitoring practices.

In the European Union, quality control begins at the design stage, where engineers perform detailed calculations of heat loads, flow rates, and energy consumption for the building. The selection of boilers, heat pumps, radiators, piping, and control equipment is based on energy efficiency ratings and compliance with EU standards. During construction, installations are subject to rigorous inspections, ensuring correct assembly, proper insulation of pipes, and adherence to design specifications. Commissioning procedures include flow balancing, verification of temperature distribution, and testing of control systems. Documentation of all procedures is mandatory, enabling traceable performance verification and facilitating long-term energy monitoring. Advanced monitoring systems are often integrated to track operational efficiency, detect anomalies, and optimize performance over time.

In Ukraine, traditional quality control has relied heavily on author's supervision and state technical inspection, with a focus on compliance with national building codes and prescriptive norms. Historically, designs often used standard calculation tables rather than detailed energy modeling, and inspections focused on visual confirmation of installations. However, modern Ukrainian practices are increasingly adopting EU-inspired methodologies, including detailed system calculations, selection of high-efficiency boilers and pumps, and implementation of automated control systems. Commissioning procedures are gradually being enhanced with performance verification techniques similar to those used in the EU, although

the widespread adoption of continuous monitoring and digital record-keeping is still developing.

A major difference between the EU and Ukraine lies in systematic defect detection and optimization. In the EU, advanced diagnostic tools such as flow meters, thermal imaging, and automated monitoring allow early identification of inefficiencies, leaks, or installation errors. Corrective measures are promptly applied to ensure that heating systems operate at maximum energy efficiency and maintain occupant comfort. In Ukraine, defect detection is improving, particularly in large-scale projects, but remains less standardized across smaller residential construction.

Overall, quality control in energy-efficient heating systems involves coordinated efforts at every stage—from design and material selection to installation, commissioning, and long-term monitoring. The European Union demonstrates a highly structured, technology-driven approach, whereas Ukraine is progressively integrating similar practices. Effective quality control ensures that heating systems achieve energy efficiency targets, reduce operational costs, enhance occupant comfort, and contribute to the overall sustainability and durability of buildings.

Questions for self-control

1. How is quality control implemented during the design stage of heating systems in the European Union, and what role do detailed energy calculations play?
2. What inspection and verification methods are used during the installation of heating systems in EU energy-efficient buildings?
3. How does the Ukrainian approach to quality control in heating systems differ from European practices in terms of oversight and methodology?
4. Why is commissioning and performance testing critical for ensuring energy efficiency in heating systems?
5. How are advanced diagnostic tools, such as flow meters and thermal imaging, used to detect defects and optimize the operation of heating systems?

Lecture 11 Quality Control in Energy-Efficient Construction of Electrical Supply Systems

Quality control in the construction of electrical supply systems is a crucial component of energy-efficient building design. Proper planning, installation, and verification of electrical systems ensure reliable power delivery, optimize energy consumption, and support the integration of energy-saving technologies. Both the European Union and Ukraine recognize the importance of controlling the quality of electrical installations, although their approaches reflect differences in regulatory frameworks, technological standards, and monitoring practices.

In the European Union, quality control begins at the design stage, where engineers analyze electrical loads, distribution networks, and energy demand patterns. The design process incorporates energy-efficient principles, such as low-loss transformers, high-efficiency wiring, LED lighting systems, and intelligent energy management systems. During construction, installations are carefully inspected to verify adherence to design specifications, correct connections, grounding and bonding, as well as proper routing of cables to minimize energy losses. Independent inspections and certifications ensure compliance with EU directives and standards, including EN and IEC norms, which emphasize safety, reliability, and energy efficiency. Post-installation, commissioning includes testing of circuits, verification of protective devices, functional testing of energy-saving controls, and integration with building automation systems to monitor energy usage.

In Ukraine, quality control has traditionally focused on compliance with national electrical codes and prescriptive norms, with inspections largely carried out by state technical authorities and author's supervision. Design calculations were often simplified, focusing on ensuring safety rather than optimizing energy efficiency. However, modern Ukrainian practices increasingly align with European standards. High-efficiency equipment, intelligent metering, and energy management systems are gradually being incorporated into new buildings. Commissioning procedures are becoming more thorough, including functional testing, load balancing, and verification of energy-saving systems. Defect detection is also improving, with

greater attention to wiring errors, insufficient grounding, and potential energy losses.

A key distinction between the EU and Ukraine lies in the integration of energy-efficient strategies with building automation and monitoring. In the EU, electrical systems are increasingly connected to smart building management platforms, enabling real-time energy monitoring, automated load management, and predictive maintenance. In Ukraine, the adoption of such digital systems is growing, particularly in commercial and public buildings, but is still less widespread in residential construction. Both regions, however, recognize that early detection and correction of defects are essential to maintaining system reliability and achieving energy efficiency goals.

Overall, quality control in energy-efficient electrical supply systems involves a comprehensive approach encompassing design verification, installation inspection, commissioning, and ongoing monitoring. The European Union demonstrates a highly integrated, technology-driven system, whereas Ukraine is progressively adopting similar practices. Effective quality control ensures safe, reliable, and energy-efficient electrical systems that support sustainable building operation, reduce energy consumption, and enhance occupant comfort.

Questions for self-control

1. How is quality control applied during the design stage of electrical supply systems in the European Union, and how does it ensure energy efficiency?
2. What inspection and verification procedures are used during the installation of electrical supply systems in EU energy-efficient buildings?
3. How does Ukraine's approach to quality control in electrical supply systems differ from European practices in terms of oversight and methodology?
4. Why is commissioning and functional testing critical for energy efficiency and system reliability in electrical installations?
5. How are intelligent monitoring and building automation systems used to detect defects and optimize energy consumption in modern electrical supply systems?

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