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МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ НАЗЕМНИХ СПОРУД І АЕРОДРОМІВ
КАФЕДРА КОМП'ЮТЕРНИХ ТЕХНОЛОГІЙ БУДІВНИЦТВА ТА РЕКОНСТРУКЦІЇ АЕРОПОРТІВ

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КВАЛІФІКАЦІЙНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ БАКАЛАВР

ЗА СПЕЦІАЛЬНІСТЮ 192 «БУДІВНИЦТВО ТА ЦИВІЛЬНА ІНЖЕНЕРІЯ»
ОСВІТНЬО-ПРОФЕСІЙНА ПРОГРАМА
«ПРОМИСЛОВЕ І ЦИВІЛЬНЕ БУДІВНИЦТВО»

Тема: **«Виробнича будівля в м. Миргород Полтавської області »**

Виконавець: ЦБ – 406 Ба, НКУА Тхе Йохабелле
(студент, група, прізвище, ім'я, по батькові)

Керівник: **д.т.н., проф. Гасій Г.М.**
(науковий ступінь, вчене звання, прізвище, ім'я, по батькові)

Нормоконтролер: __________ (підпис) Родченко О.В. (ПІБ)

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НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

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ЗАВДАННЯ
на виконання кваліфікаційної роботи

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INTRODUCTION

Industrial buildings encompass extensive facilities that house production lines, providing an environment conducive to efficient workflow and equipment operation. These structures can be classified as either standard or unique, consisting of single or multiple units, and serve a wide range of functions including production shops, technical facilities, warehouses, logistics complexes, hangars, sheds, energy complexes, and administrative buildings. The construction of industrial buildings strictly adheres to regulated standards, encompassing compliance with fire safety regulations, structural integrity to withstand the loads encountered during production processes, and the incorporation of aesthetically pleasing facades.

To expedite the construction process, modern technology employs prefabricated metal structures that are manufactured off-site. These structures are then transported to the designated construction site, where a well-coordinated framework is meticulously assembled. Depending on the specific requirements of the facility, materials such as sandwich panels, corrugated sheets, or other suitable alternatives are affixed to the framework. This innovative approach offers several noteworthy advantages in the realm of industrial building construction:

Rapid Assembly: The utilization of prefabricated metal structures enables swift construction, surpassing the time constraints associated with traditional brick or concrete buildings.

Cost Efficiency: The implementation of this technology leads to significant reductions in construction expenses, demonstrating cost efficiency.

Aesthetic Appeal: The visually striking appearance of these structures assumes a pivotal role, leaving a lasting first impression and contributing to the overall image of the company or establishment.

Among industrial structures, one-story buildings account for the majority share, constituting approximately 64% of the total. This dominance can be attributed to the specific technological requirements, the direct transfer of heavy equipment loads to the ground, and the relative simplicity and cost-effectiveness inherent in their construction. In terms of both form and functional attributes, the structural characteristics of these one-story industrial buildings differ significantly from those observed in residential and public structures.

In the construction of industrial buildings, framed curtain wall panels composed of lightweight concrete or other suitable materials are commonly utilized. The structural design encompasses a diverse range of schemes, including single-span and multi-span frames that incorporate various types of coating systems such as flat and spatial structures, domes, and cable-stayed structures. Roofing options span from flat to pitched, with the possibility of incorporating skylights.

Single-story multi-span frame buildings offer versatility in spatial arrangements, with spans that can have equal or varying widths and heights. Conversely, single-span structures consist of a singular volume enclosed by two rows of columns and end walls. The availability of such diverse structural schemes allows for flexibility in meeting specific industrial requirements and spatial demands.

Framed curtain wall panels provide several distinct advantages in the construction of one-story industrial buildings:

Lightweight Construction: The utilization of lightweight concrete or other suitable materials reduces the overall weight of the structure, resulting in minimized foundation and construction costs.

Structural Efficiency: The framed curtain wall panels offer structural integrity and stability, enabling them to withstand the various loads imposed during industrial operations.

Thermal Insulation: The panels possess insulating properties that contribute to efficient energy management, ensuring desirable temperatures within the building and reducing the need for excessive heating or cooling.

Fire Resistance: The materials used in the panels exhibit fire-resistant characteristics, enhancing the safety and protection of the industrial facility.

Acoustic Performance: The curtain wall panels have the potential to contribute to sound insulation, reducing noise pollution and creating a more conducive working environment.

By carefully selecting appropriate structural schemes and employing framed curtain wall panels, durable, functional, and adaptable one-story industrial buildings can be created. Consideration of specific industrial needs and spatial requirements optimizes workflow efficiency, facilitates equipment integration, and promotes a safe and productive work environment. The continuous evolution and innovation in structural design contribute to the advancement of the industrial construction industry, enabling the realization of dynamic and sustainable industrial facilities.

CHAPTER 1. ANALYTICAL REVIEW

Within the realm of modern industrial construction practices, a significant focus is placed on the refurbishment and strengthening of pre-existing buildings and structures, as well as addressing specific concerns related to their individual elements. As a result, the assessment of the technical condition of such structures, particularly those posing operational challenges, has become of utmost importance. The evaluation of the technical condition of structural components in operational buildings is achieved through comprehensive surveys that aim to identify existing defects and damages. Verification calculations are then conducted to analyze the actual performance of these structures. These calculations involve a rigorous examination of various factors such as load-bearing capacities, material properties, and structural behavior in order to determine their adequacy and identify any potential weaknesses or areas requiring reinforcement. By performing these assessments and calculations, engineers and construction professionals can make informed decisions regarding the repair, strengthening, or modification of existing structures to ensure their long-term safety, reliability, and optimal performance. Notably, the assessment of the technical condition of structural components in operational buildings necessitates the consideration of specific factors outlined in prevailing standards [38, 56]. In the context of constructions built on subsiding soils, the irregular deformations of the underlying foundation can lead to the emergence of defects and damages. Departures from the intended position of building foundations result in distortions within the framework elements and alterations to their stress-strain state. Therefore, verification calculations for such constructions, in addition to considering designated loads and impacts, should incorporate assessments that account for the uneven deformations of the subsiding base.

Acknowledging the widespread adoption of information technologies in the field of architectural design and construction, this section emphasizes the paramount importance of integrating these advancements. It recognizes the invaluable experience gained from the application of building information modeling software and other cutting-edge technologies in the development of a steel frame for a one-story industrial building.

The contemporary approach to investigating the interaction between the "building foundation" system revolves around the utilization of spatial computational models that consider the soil foundation as a multilayered entity, thereby simulating the geological structure of the site's subsidence. By incorporating these models, engineers and researchers can analyze the complex behavior and response of the building foundation system to the varying deformations and stresses induced by the subsiding soil.

This approach enables a comprehensive understanding of the dynamic interaction between the building structure and the subsiding soil, facilitating informed decision-making in terms of design modifications, foundation reinforcement, and mitigation strategies. By employing advanced computational techniques, engineers can effectively assess the performance and structural integrity of constructions on subsiding soils, ensuring their long-term stability and resilience [27, 33, 56]. This approach enables the consideration of various factors, such as localized saturation leading to uneven ground deformations, heterogeneity in layer composition, and the presence of artificial deposits, among others. By employing such calculations, it becomes possible to anticipate uneven ground settlements and, consequently, changes in the stress-strain state of structures.

Nevertheless, when assessing the technical condition of operational facilities constructed on subsiding soils, a slightly different challenge frequently arises. In such cases, the initial data required to determine the stress-strain state of structures are obtained from their deformations and deviations from the intended position, which are measured through instrumental examinations.

Early investigations into the calculation of buildings and structures situated on subsiding soils employed simplified calculation schemes. For frameless structures, beam systems were employed as models [33, 39, 56]; Meanwhile, the analysis of frame buildings was limited to flat frame calculations [38, 39, 41]. These simplified approaches aimed to capture the essential behavior of the structures under the influence of soil subsidence, providing initial insights into their performance and response.

While these early studies laid the foundation for understanding the interaction between structures and subsiding soils, further advancements in computational techniques and analytical methods have since emerged. These developments have allowed for more sophisticated modeling approaches that capture the complex behavior and interactions occurring within the structural system and the subsiding soil.

By utilizing more refined computational models and analysis methods, researchers and engineers can accurately predict the stress-strain state of structures on subsiding soils. This includes considering factors such as soil properties, foundation characteristics, and the dynamic response of the structure to subsidence-induced deformations. These advanced calculation schemes provide valuable insights into the structural performance, allowing for informed decision-making regarding necessary modifications, reinforcements, or mitigation strategies.

Overall, the evolution of calculation methods for structures on subsiding soils has transitioned from simplified approaches to more advanced and comprehensive techniques. These advancements enable a deeper understanding of the behavior of such structures, leading to improved design practices and better management of the technical condition of operational facilities.

Steel structures find extensive application in the installation of expansive roofing systems in industrial buildings, as well as in public sports and entertainment facilities [27, 56]. They offer numerous advantages over reinforced concrete, such as reduced weight, shorter construction duration, decreased investment cycle, and energy savings during production, transportation, and assembly. Currently, industrial buildings and structures in Ukraine have an average lifespan ranging from 30 to 50 years, with some enduring for up to 80 years [38, 56]. Consequently, conducting scheduled inspections to assess the technical condition of these buildings and performing necessary repairs when required becomes imperative.

In Ukraine, snow load [39, 56] is one of the primary loads affecting the protective coatings of lightweight steel structures in buildings, accounting for approximately 50 – 70% of the total load, including the weight of the coating structures. Furthermore, wind load [27, 56], characterized by its fluctuating and variable nature based on the building's height, should be regarded as an unfavorable load combination [33–56]. In addition to atmospheric loads, the load-bearing steel frame of production buildings is significantly impacted by the load exerted by bridges or overhead cranes. This load is temporary, and variable, and necessitates the mandatory consideration of dynamic coefficients.

In spite of the numerous recommendations advocating for regular technical inspections of buildings and structures, the availability of comprehensive reports on these inspections, which encompass the identification of accident causes and the proposal of construction methods to prevent them, raises questions regarding the feasibility of modifying the design scheme to adjust the diameter of building elements' efforts.

While technical inspections play a crucial role in identifying potential risks and ensuring the safety and integrity of structures, the analysis of inspection reports can uncover opportunities for design modifications that address the identified concerns. One aspect to consider is the adjustment of the diameter of building elements' efforts. This entails assessing the load-bearing capacities of the structural components and analyzing their performance under different design scenarios.

By conducting feasibility studies and engineering analyses, it is possible to evaluate the practicality and effectiveness of modifying the design scheme to adjust the diameter of building elements' efforts. This may involve optimizing the dimensions of load-bearing elements such as columns, beams, or foundations to enhance their structural robustness and resilience.

Furthermore, the integration of advanced computational modeling techniques and simulation tools allows for the accurate prediction of the structural response to modified design parameters. These simulations enable engineers to assess the performance of the adjusted design scheme, considering factors such as stress distribution, load-bearing capacity, and overall structural stability.

It is important to note that any modifications to the design scheme should be carefully evaluated and implemented with a comprehensive understanding of the structural behavior and the specific requirements of the building or structure. Engineering expertise and thorough analysis are essential to ensure that the adjusted design effectively addresses the identified issues and contributes to the overall safety and longevity of the construction.

In conclusion, while technical inspections provide valuable insights into the condition of buildings and structures, considering the feasibility of modifying the design scheme to adjust the diameter of building elements' efforts can offer opportunities for enhancing structural performance and mitigating potential risks. Through rigorous feasibility studies and engineering analysis, informed decisions can be made regarding design modifications that align with the goal of ensuring the safety and durability of the construction..

The survey of existing buildings presented in [27–56] provides substantial evidence that primary structural defects arising from design, manufacturing, and installation errors [27–56]. Structural damage occurring during operation results from significant deviations from technical operation protocols and inaccuracies in considering the existing stress-strain state during reinforcement and reconstruction projects. [27–38] proposes a degradation model for elements, intending to establish a reliability law as a function of time to enable the prediction of their technical condition. The variation in internal forces within the structural elements of the spatial framework is primarily influenced by external loads and the chosen calculation scheme, including the degree of static uncertainty.

Despite the abundance of guidelines promoting regular technical inspections for buildings and structures, the presence of summarized reports detailing these inspections, along with the identification of accident causes and proposed preventive measures, prompts an inquiry into the feasibility of modifying the design scheme to adjust the diameter of building elements' efforts.

It is crucial to acknowledge that the reliability and performance of structures are influenced by a multitude of factors, including external loads, calculation schemes, and dynamic coefficients. Therefore, attaining a comprehensive understanding of these influences becomes imperative in ensuring the long-term integrity and safety of industrial buildings.

To effectively address structural defects and damages, rectifying errors in design, manufacturing, and installation processes is of utmost importance. Furthermore, meticulous consideration of the stress-strain state during reinforcement and reconstruction projects becomes vital to maintain the structural integrity of the building throughout its operational lifespan. By conducting thorough assessments and implementing appropriate measures, structural deficiencies can be remedied, and the overall stability and durability of the construction can be enhanced..

To achieve optimal structural performance and mitigate risks, it is essential to implement regular technical inspections, analyze inspection reports, and take proactive measures to address any identified issues. By doing so, the longevity and reliability of industrial buildings can be ensured, fostering a safe and efficient working environment for their occupants.

In addition to the aforementioned considerations, the ongoing advancements in construction technology and materials present new opportunities for improving the design, construction, and maintenance of industrial buildings and structures. Emerging technologies such as Building Information Modeling, robotics, and automation are revolutionizing the construction industry, enhancing efficiency, accuracy, and sustainability.

The adoption of software allows for comprehensive digital representations of the building process, enabling better collaboration among architects, engineers, and contractors. This integrated approach helps identify potential clashes or errors in the design phase, leading to cost savings and improved construction quality.

Furthermore, the integration of robotics and automation in construction processes optimizes repetitive tasks, minimizes manual labor, and enhances precision. Robotic systems can be effectively utilized for prefabrication, assembly, and even maintenance operations, leading to accelerated construction schedules and enhanced project delivery outcomes.

Considering the paramount importance of external loads, both the snow load and wind load exert substantial influence on the lightweight coatings of steel structures in Ukrainian regions. The snow load, which constitutes a significant proportion of the total load, coupled with the fluctuating characteristics of wind load, necessitates meticulous evaluation and incorporation into the design considerations [15, 18, 24].

Furthermore, the load-bearing steel framework of production buildings encounters additional stresses originating from bridges or overhead cranes. These transient and variable loads necessitate the incorporation of dynamic coefficients in the structural analysis to ensure the stability and safety of the building.

Sustainable building practices are gaining significant traction in the field of industrial construction. The integration of energy-efficient systems, utilization of renewable energy sources, and implementation of environmentally friendly materials can substantially mitigate the carbon footprint of industrial buildings. Simultaneously, these practices yield long-term cost savings through enhanced energy efficiency.

Moreover, the concept of adaptive reuse has become increasingly relevant. Rather than demolishing existing industrial structures, repurposing them for new functionalities not only preserves the architectural heritage but also minimizes waste generation and promotes sustainable development.

To maintain a prominent position in the realm of industrial construction, continuous research and development efforts are indispensable. Exploring innovative construction techniques, materials, and technologies will pave the way for safer, more efficient, and environmentally conscious industrial buildings in the future. These advancements will contribute to the evolution of the industry and foster sustainable growth.

CHAPTER 2. ARCHITECTURAL DESIGN

2.1. Master plan of the site

The undertaking entails the fabrication and construction of an industrial edifice located in Myrhorod, a region within the Poltava area renowned for its fertile arable land. The meticulousness of administrative considerations has been paramount throughout the preliminary phase of the project. Furthermore, the planning stage has encompassed a comprehensive evaluation of regulatory compliance, zoning restrictions, and permit requirements to ensure adherence to legal and governmental frameworks.

Moreover, the project team has diligently examined the logistical aspects concerning transportation routes, proximity to utility connections, and accessibility to facilitate seamless operations within the industrial building. In addition, a thorough assessment of environmental impact factors, such as potential soil erosion, drainage systems, and waste management protocols, has been conducted to mitigate any detrimental effects on the surrounding ecosystem.

Efforts have also been made to incorporate sustainable design principles and energy-efficient technologies, aiming to minimize the ecological footprint of the industrial facility. This involves the exploration of renewable energy sources, the implementation of efficient HVAC systems, and the integration of natural lighting strategies to optimize energy consumption and reduce greenhouse gas emissions.

Furthermore, the project's architectural layout has been meticulously crafted to meet the functional requirements of the industrial operations while considering ergonomic considerations, workflow efficiency, and safety standards. The integration of state-of-the-art building information modeling software has facilitated the visualization and simulation of various design scenarios, enabling informed decision-making and the identification of potential design enhancements.

Overall, the project's planning phase has encompassed a comprehensive and multidisciplinary approach, addressing various technical, logistical, environmental, and regulatory aspects to ensure the successful realization of the industrial building in the Myrhorod region of the Poltava area.

Fig. 2.1. Situational layout

Figure 2.1 presents an overview of the contextual arrangement, highlighting the undulating topography of the region characterized by a descending slope towards the northeast. The construction site encompasses pre-existing structures and subterranean utilities, which have been integrated into the development plans.

The master plan has undergone meticulous design to align with the technological scheme while adhering to prevailing regulations. The spatial arrangement of the building takes into account several crucial considerations, including the optimization of the technological workflow, efficient zoning for production and ancillary facilities, judicious land utilization, and the minimization of internal roadways and utility networks.

Vertical planning has been executed with careful consideration of specific work techniques, topographic conditions, and the projected highway for convenient accessibility. Elevation planning takes into account the natural landscape and involves local backfilling of driveways and areas to meet the prescribed building heights relative to the driveway axis.

To address surface water drainage on the site, an open system has been designed, incorporating artificial structures in low-lying areas to act as bypasses. The drainage system is integrated with the road's water management. Before commencing production activities, fertile soil at the embankment's base will be excavated and repurposed on unproductive lands. Imported soil will be utilized for embankment construction, ensuring layer-by-layer compaction to achieve a minimum density of 0.95 relatives to the soil's maximum density.

Passageways within the site are designed with single slopes. The carriageway width is set at 4.5 meters, while specific areas such as the technological pumping and diesel power plant employ a cross-section width of 3.5 meters. Pavements and driveways consist of 0.2 – meter thick concrete slabs laid on a leveling layer of sand (0.1 meters) and a rubble base (0.17 meters). Roadside reinforcement of 0.1 meters ensures stability. Pedestrian paths are primarily integrated with driveways, while separate sidewalks are constructed using medium-grained asphalt concrete with a thickness of 0.06 meters and a gravel base of 0.1 meters. A perimeter fence composed of a metal mesh supported by reinforced concrete pillars encloses the site. Lush lawns featuring perennial grasses contribute to the overall landscape design.

The industrial facility incorporates well-designed vehicular and pedestrian zones to ensure efficient movement and safety within the premises. The drivable areas feature wide lanes with smooth surfaces to accommodate various vehicles, including trucks, forklifts, and delivery vehicles. Roadways are designed with ample width to facilitate easy maneuverability and optimal traffic flow. Clear markings and signage are implemented to guide drivers and ensure proper routing throughout the site.

Considerable emphasis is placed on pedestrian zones within the industrial complex, encompassing meticulously planned pathways that prioritize the safety and convenience of workers and visitors. These dedicated walkways and sidewalks are engineered to create a secure and comfortable environment, facilitating the movement of pedestrians throughout the industrial facility. Illumination is strategically implemented to ensure proper visibility, while prominent markings delineate the pedestrian areas and minimize potential conflicts with vehicular traffic.

To enhance safety standards, various additional measures are implemented. These include the installation of speed limit indicators, designated pedestrian crossings, and appropriate signage at key locations. Traffic calming techniques, such as speed bumps or raised pedestrian crossings, may also be integrated to ensure reduced vehicle speeds within areas densely populated by pedestrians.

Furthermore, the integration of landscaping elements and green spaces within the pedestrian zones enhances the aesthetics of the surroundings and fosters a pleasant atmosphere for employees and visitors alike. Seating areas, shade structures, and designated rest zones may also be incorporated to provide additional comfort and opportunities for relaxation within the industrial premises.

In summary, the integration of well-designed drivable areas and pedestrian zones in industrial settings serves to prioritize safety, efficiency, and the creation of an environment conducive to both vehicular and pedestrian traffic.

2.2. Space planning

In pursuit of a grand project, the development of technical equipment sites and auxiliary buildings takes precedence. Simultaneously, existing structures are repurposed to accommodate the placement of equipment, optimizing resource utilization. The architects behind this venture exercise meticulous craftsmanship, weighing every detail against the backdrop of local construction techniques and prevailing climatic conditions. The geometric parameters of the buildings, including the modular dimensions of spans and floor heights, conform meticulously to the prescribed guidelines outlined in reference [86].

Such adherence ensures a harmonious integration of form and function within the architectural framework.

Safety, an indispensable consideration in any construction endeavor, takes center stage in the design process. Aiming to safeguard lives and assets, the buildings are endowed with a fire-resistance rating of II. This classification signifies a robust defense against fire-related incidents, bolstering the overall safety infrastructure. Further, the buildings assume classifications based on their significance within the site's context. Both the technological pump and the diesel power plant earn the distinction of Class I, affirming their criticality and underscoring the need for heightened attention to their design and operational integrity.

The design philosophy that underpins the buildings and structures finds its roots in the realm of technological layouts. Embracing the benefits of standardization, the architects skillfully incorporate proven solutions and maximize the utilization of readily available factory-produced equipment. The synergy between standardized components and structures promotes efficiency and ease of implementation, paving the way for enhanced productivity and streamlined construction processes. Typification, coupled with standardization, permeates the design ethos, resulting in a coherent system that harmonizes various elements into a cohesive whole.

When it comes to planning decisions, a twofold principle governs the approach. First and foremost, there is a concerted effort to maximize the clustering of interconnected technological areas. By strategically grouping related components, synergy is harnessed, facilitating seamless operations and reducing inefficiencies. However, mindful of the potential risks associated with concentrated technology, the architects prudently incorporate firebreaks into the spatial layout. These firebreaks serve as protective barriers, enabling swift containment of any fire outbreaks and safeguarding the integrity of the facilities.

Thus, the project unfolds as a testament to scientific ingenuity and meticulous planning. Technical equipment sites and auxiliary buildings come to life, their foundations firmly rooted in the principles of construction and design. With an unwavering commitment to safety, adherence to established standards, and an emphasis on optimizing resource utilization, this endeavor emerges as a beacon of progress. It is a testament to the union of scientific methodology and visionary aspirations, shaping a landscape where functionality and safety harmoniously coexist.

The building projects take into account the capabilities of the construction organization. Depending on the requirements of the technological processes, open technological sites may feature concrete or rubble coatings. The perimeter of the sites is outlined with side stones, providing delineation and demarcation.

Technological pipelines are supported by racks with traverses made of rolled profiles. Equipment foundations are constructed using monolithic concrete or reinforced concrete, with the installation of anchor bolts and embedded parts. Prefabricated metal platforms, ladders, and fences conforming to the applicable standards, are strategically positioned to facilitate the maintenance of technological equipment. The installation of communications and engineering networks is planned to be carried out using reinforced concrete racks.

Description of the pump's technological process:

– Pumping and injecting corrosion inhibitor and hydration solutions;

– Pumping hydrocarbon condensate into the condensate line.

The pumps are situated in the primary operational area of the pump. This area is designed to accommodate the largest volume and surface area necessary to ensure safety and prevent the accumulation of high gas concentrations mixed with air.

The additional area includes rooms for staff, a vent chamber, a compressed air compressor, and switchboards. The compressed air compressor is responsible for supplying clean compressed air and controlling and measuring devices using mechanisms in pneumatic control systems automation. The following technological equipment is present in this area:

– Two compressors with electric motors.
– An installation for air purification and dehumidification, equipped with an air trap for air accumulation.

The technological pump comprises various pumps for specific purposes, including:

– Pumps for injecting methanol into heat exchanger T-1.
– Pump for injecting methanol into the gas pipeline and condensate pipeline.
– Pumps for injecting corrosion inhibitors into gas wells and inlet threads.
– Pumps for pumping hydrocarbon condensate into the condensate pipeline.

The volume-planning solution for the technological pump involves a frame-type building composed of two sections:

– The main operational area measures 18×30 m, featuring a lantern design with a roof level of 7.95 m and a lantern design level of 9.75 m.
– The additional area measures 12×18 m, with a roof level of 6.3 m. This results in a height difference between the building sections.

The load-bearing structures consist of steel columns, trusses, and beams, providing structural support. The enclosing structures are composed of steel profile wall panels with "Sandwich" insulation.

Table 2.1 provides the technical and economic indicators of the building.

Table 2.1

Technical and economic indicators of the building

№	Name	Unit	Q-ty
1	Building area	$м^2$	220
2	Usable area	$м^2$	540
3	Total area	$м^2$	760
4	Primary purpose area	$м^2$	610
5	Auxiliary area	$м^2$	90
6	Construction volume	$м^2$	5710
7	Area of external fences	$м^2$	765
8	Planning ratio	–	1.4
9	Volume – to – area ratio	м	10.5
10	Compactness ratio	–	7.5

In the realm of construction site space planning, the calculation of technical and economic indicators is a crucial endeavor, aimed at optimizing resource utilization and ensuring efficient project execution. To achieve this, a series of sequential steps are followed, each contributing to the determination of these vital indicators.

The first step in this process involves defining the project requirements. This entails identifying and documenting the specific needs of the construction project, such as the building's purpose, the intended use of different areas, and any unique technical considerations. This comprehensive analysis lays the groundwork for subsequent calculations.

Moving forward, the focus shifts to determining the building area. This entails calculating the total area, encompassing both usable and non-usable spaces. By summing the areas of all floors and taking into account additional spaces like staircases, corridors, or mechanical rooms, an accurate representation of the building's overall area is obtained.

Next, attention is directed towards calculating the usable area, which represents the net floor area available for primary activities within the building. This excludes areas like walls, columns, and utility rooms. The determination of the usable area is crucial in assessing the efficiency and effectiveness of the building's functional layout.

Simultaneously, the assessment of the auxiliary area takes place. This involves evaluating the space required for auxiliary purposes, such as storage, maintenance, or utility rooms. Accurate estimation of these needs ensures the availability of supporting facilities, enabling the smooth operation and functionality of the building.

Furthermore, the evaluation of the construction volume becomes paramount. This entails determining the total volume of the building, considering factors such as the height of the structure and the presence of multiple floors. The construction volume provides valuable insights into the overall scale and magnitude of the project.

In addition, the analysis of the area encompassed by external perimeter fencing or boundary walls is conducted. By calculating this area, a better understanding of the spatial extent of the construction site is gained, contributing to effective planning and utilization of the site.

Once these foundational steps are completed, attention turns to determining planning factors. This involves evaluating ratios that represent the relationship between the main purpose premises area and the auxiliary area. Additionally, the volume-to-area ratio is assessed to gauge the efficient utilization of space, ensuring an optimal balance between different areas within the building.

Lastly, the compactness index is evaluated. This indicator compares the total building area to the area of the main purpose premises, providing insights into how efficiently the primary areas are organized within the overall building layout. A higher compactness index signifies a more efficient utilization of space and a well-optimized building design.

Through the meticulous execution of these sequential steps, construction professionals can accurately calculate and assess the technical and economic indicators essential for space planning. This scientific approach allows for the optimal utilization of resources, efficient project execution, and the creation of well-designed and functional built environments..

By considering these steps and calculating the relevant technical and economic indicators, project planners and stakeholders can optimize the use of space on a construction site, ensure efficient resource allocation, and make informed decisions regarding the project's design and layout.

2.3. Sanitation within the industrial sector

Industrial labor exposes individuals to various adverse elements known as industrial hazards, which can have detrimental effects on their well-being. These hazards are classified based on the specific impact they have on the human body. Within the context of the technological pumping environment, individuals are particularly affected by the following factors, which pose risks to their health and safety:

Physical Hazards: Improper installation of superchargers and pipelines can result in increased gas levels, exposing workers to potential respiratory risks. Additionally, concrete flooring can generate airborne dust particles, which can be inhaled and cause respiratory problems.

Noise and Vibration: The operation of pumps in the technological pumping environment generates high levels of noise and vibration. Prolonged exposure to these conditions can lead to hearing impairment and musculoskeletal disorders, impacting the overall well-being of workers.

Psychophysical Hazards: The constant exposure to the noise and vibration in the pumping environment can result in psychophysical hazards. These hazards manifest as physical and mental fatigue, affecting the cognitive and physical performance of workers.

It is essential to recognize and mitigate these detrimental factors to ensure the health and safety of individuals working in the technological pumping environment. Implementing appropriate control measures, such as proper installation and maintenance of equipment, effective ventilation systems, and the provision of personal protective equipment, can significantly reduce the risks associated with these industrial hazards. By prioritizing worker safety and well-being, organizations can create a healthier and more productive work environment..

The primary regulatory document governing sanitary and hygienic working conditions is the «State Sanitary Rules for Urban Planning and Construction» [84].

Elevated gas levels present a risk due to the influence of natural gas on the bloodstream and respiratory system. It is vital for the technological pumping procedure to consistently monitor the gas composition in the ambient air of the working area. This surveillance is periodically carried out by the station laboratory. Mitigation of gas-related poisoning involves minimizing workers' exposure to the air zone within the facility, primarily accomplished through mechanization and automation. Adequate ventilation of the facility also plays a significant role, aiming to disperse the gas concentration to a safe threshold. All personnel must be well-versed in safety protocols and capable of identifying early indications of gas exposure, while possessing first aid competencies.

Inorganic sources, particularly concrete flooring and dispersed dust particles, are the primary origins of dust hazards. While their level of harm is generally low, it is necessary to periodically monitor the concentration of airborne dust to prevent equipment malfunctions and ensure the well-being of workers. To address air pollution, it is vital to minimize the workforce within the facility and regularly perform thorough cleaning using either mobile or stationary vacuum units.

Vibrations are generated by pumps, although the levels of vibration within the pumping process are not excessively high due to the separate foundations on which the pumps are installed. Techniques for reducing vibrations involve minimizing the forces that cause vibrations within the pumps themselves. Additionally, measures such as vibration isolation and dynamic vibration dampers are employed to diminish the propagation of vibrations.

Pumps also contribute to noise pollution due to mechanical actions and the friction of gas against the inner surfaces of pipes. The sound pressure level should not surpass the values specified in [82]. To mitigate noise pressure, efforts should be focused on reducing noise levels at the source, such as by minimizing gaps in gears and bearings, ensuring timely lubrication of machine parts, and promptly repairing equipment. Noise protection covers and screens are utilized to attenuate gas-related noise.

2.4. Estimating Heat Transfer Resistance of Building and Structural Panels in a «Sandwich» Configuration

The parameters of the indoor air environment, including a temperature of $16°C$ and a relative humidity of 50%, contribute to a comfortable and balanced atmosphere within the room. Maintaining a normal humidity level is essential for the well-being of occupants and the preservation of materials in the space.

The wall panels, classified as "A" based on their operating conditions, demonstrate their suitability for the intended application. The wall construction features a layer of expanded polystyrene with a density of $40\,kg/m^3$. This lightweight yet durable material provides insulation properties that help regulate temperature and minimize energy loss. With a thermal conductivity of $0.041\,W/(m \times °C)$, the expanded polystyrene layer contributes to the overall energy efficiency of the building.

To ensure accuracy in calculations, it is important to exclude the steel sheets that encase the expanded polystyrene layer. Their contribution to structural integrity and safeguarding, however, can be deemed inconsequential within the scope of thermal property analysis.

By maintaining optimal indoor air parameters and employing efficient wall panel construction techniques, the space can offer a comfortable and energy-efficient environment for its inhabitants.

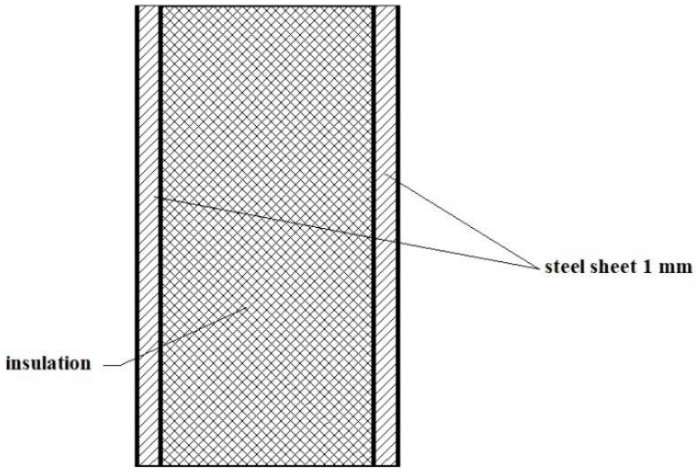

Fig. 2.2. Structural Cross – Section of the Wall Panel

Let's determine the calculated heat transfer resistance of our wall:

$$R_0 = \frac{n(t_e - t_i)}{\Delta t^e \alpha} = \frac{1(16 + 23)}{5 \times 8.7} = 0{,}89 м^2 \times {}^0C/W \quad (2.1)$$

The calculated heat transfer resistance of our wall can be determined using the following parameters. The indoor air is designed to maintain a temperature of $t_e = 16$ °C. For the winter season, we estimate the outdoor air temperature to be $t_i = -23$ °C, representing the average temperature during the coldest period with a five-day security level of 0.92. There is a normative temperature difference of $\Delta t^e = 5$ °C between the indoor air temperature and the inner surface temperature of the enclosing structure.

To evaluate the heat transfer characteristics, we consider the heat transfer coefficient (α) of the inner surface of the enclosing structure, which is measured at $\alpha = 8.7\, W/(m \times °C)$. This coefficient helps determine the efficiency of heat transfer from the enclosed space.

By understanding these parameters and coefficients, we can accurately assess the thermal behavior and design considerations of the indoor environment and the enclosing structure.

To calculate the heat transfer resistance, we need to consider the coefficient n, which varies depending on the position of the outer surface of the wall to the outside air (where $n = 1$ in this case). By incorporating these parameters, we can accurately determine the heat transfer characteristics of our wall.

Economically feasible wall resistance:

$$R_0^{ek} = kR_0 = 2 \times 0.89 = 1.78\, m^2 \times ℃/W, \tag{2.2}$$

The obtained panel exhibits a thermal resistance that can be calculated based on the following parameters and specifications:

The required insulation thickness is $\delta = 0.066\, m$. Considering the structural thickness of the "Sandwich" panel, we adopt a $10\, cm$ insulation thickness. This choice ensures sufficient thermal insulation properties to meet the desired performance standards.

To determine the thermal resistance, we consider the minimum increasing ratio, where $k = 2$. This ratio indicates the rate at which the thermal resistance increases within the panel.

By incorporating these parameters and specifications, we can accurately calculate the thermal resistance of the panel. This information is crucial in evaluating the panel's effectiveness in minimizing heat transfer and maintaining optimal thermal conditions within the enclosed space.

The thermal resistance of the obtained panel refers to its ability to impede heat transfer through its structure, which is a critical parameter in assessing the panel's insulation performance. It serves as an indicator of the panel's effectiveness in minimizing heat flow, leading to enhanced energy efficiency and superior temperature control within the enclosed space. Key factors influencing the thermal resistance include the choice of insulation material, panel thickness, and construction techniques. By conscientiously optimizing the thermal resistance of the obtained panel, we can establish a thermally efficient and comfortable environment while concurrently minimizing energy consumption.

$$R = \frac{\delta}{\lambda} = \frac{0.1}{0.041} = 2.43\ m^2 \times {}^\circ\mathrm{C}/W. \tag{2.3}$$

The thermal inertia of the enclosing structure, defined as its capacity to withstand temperature variations over time, is a crucial parameter in evaluating its thermal behavior. It quantifies the structure's ability to absorb and release heat, thereby influencing its thermal stability. A higher thermal inertia value implies that the structure can maintain a more consistent indoor temperature, minimizing the necessity for frequent heating or cooling interventions. Elements such as the material composition, thickness, and insulation characteristics of the enclosing structure significantly impact its thermal inertia. Through meticulous optimization of the enclosing structure's thermal inertia, we can enhance energy efficiency and establish an indoor environment that is both comfortable and sustainable.

$$D = Rs = 2.43 \times 0.41 = 0.99, \tag{2.4}$$

where $S = 0.41\ W/(m^2 \times {}^\circ C)$ – heat transfer coefficient.

In order to achieve optimal thermal performance in the "Sandwich" panel, a meticulous assessment of insulation thickness is imperative. Our calculations have led us to determine that a 10 cm insulation thickness is the most suitable choice, taking into account critical factors such as heat transfer mitigation, energy efficiency optimization, and adherence to performance standards.

By specifically selecting this insulation thickness, our objective is to bolster the panel's resistance to heat flow and enhance its overall thermal efficiency. A well-insulated panel plays a pivotal role in maintaining a comfortable and stable indoor temperature, thus mitigating the need for excessive heating and cooling systems.

The consideration of insulation thickness as an integral part of the panel's design and construction is paramount in the creation of a thermally efficient and sustainable environment. It contributes significantly to the reduction of energy consumption while augmenting the overall thermal insulation performance of the "Sandwich" panel.

CHAPTER 3. STRUCTURAL DESIGN

3.1. Load accumulation

In engineering calculations for buildings and structures, the process of load collection encompasses several pivotal aspects, demanding a meticulous approach. It requires the identification, analysis, and comprehension of various loads exerted upon the structure, including dead loads (the permanent weight of the structure), live loads (transient and variable loads such as occupants, furniture, and environmental factors), and other imposed loads (such as wind loads, snow loads, or seismic forces).

The accurate collection of loads necessitates a comprehensive understanding of region-specific design codes and standards that govern load determination and distribution. These codes provide guidelines for assessing load magnitudes and their spatial allocation, ensuring the structural safety and stability of the system.

In addition, the evaluation of load distribution plays a crucial role in the load collection process. Depending on the structural system and its components, loads may concentrate at specific locations or distribute uniformly across the entire structure. A thorough analysis of load distribution is vital for determining the structural response and verifying that the design meets the required safety margins.

Furthermore, meticulous attention must be given to load combinations during the load collection process. Different types of loads often act concurrently on a structure, and engineering codes specify precise combinations to consider in such cases. By combining diverse loads with appropriate safety factors, engineers can determine the maximum load effects that the structure needs to withstand, ensuring its structural integrity and resilience.

The design load is concentrated at the node of the upper belt of the truss due to the constant load

$$FP = \sum_i \gamma f_i g_i^H \frac{d_1 + d_2}{2} \cdot B = 1{,}7 \cdot 3 \cdot 6 \approx 30\ kN \tag{3.1}$$

Where $g_i^H -$ The load imposed by roofs and structures as dictated by regulations;

B – step truss;

$d_1, d_2 -$ length of panels;

$\gamma f_i -$ reliability factor.

Table 3.1

Load collection

№	*Roofing system*	g_H	γf	g
1	A layer of gravel is applied on top of bituminous mastic	0.4	1.3	0.52
2	three layers of roofing material on mastic	0.15	1.3	0.194
3	Plates mineral wool	0.241	1.2	0.29
4	Ball of roofing material	0.049	1.2	0.059
5	Metal profiled flooring	0.156	1.05	0.163
6	Runs span	0.079	1.05	0.084
7	Construction farm coating	0.258	1.05	0.273
8	Lantern	0.077	1.05	0.084

In engineering calculations for buildings and structures, the process of snow load collection involves specific considerations to ensure structural safety and integrity. The collection of snow load requires a comprehensive understanding of the climatic conditions, as well as the characteristics of snow in the region. Factors such as snow density, accumulation rates, and thermal effects significantly influence the determination of snow load on a structure.

Accurate data on snowfall patterns, historical records, and statistical analysis are essential for estimating the maximum expected snow load. Snow load calculations take into account various factors, including roof shape, slope, and surface roughness, which directly impact snow accumulation and distribution.

Snow load collection also encompasses the effects of snow sliding and drifting. Structures with sloping roofs or complex geometries are susceptible to snow sliding or wind-induced drifting, resulting in localized and uneven snow loading. Thorough analysis of these factors is crucial for ensuring the safety and structural integrity of the building.

Furthermore, snow load combinations are considered in conjunction with other design loads, such as dead loads and live loads. Engineering codes provide specific load combinations to account for simultaneous effects and safety margins. By combining various loads and considering their timing and duration, engineers can accurately determine the snow load effects on a structure.

In summary, the process of snow load collection in engineering calculations involves a comprehensive understanding of climatic conditions, snow characteristics, and their effects on different types of structures. Accurate data collection, thorough analysis, and consideration of load combinations are vital for designing structures capable of withstanding the snow loads they may encounter.

The snow load results in a concentrated design load at the node of the upper belt of the truss, measured in kilonewtons (kN):

$$FC = \gamma f S_o \mu \frac{d_1 + d_2}{2} B \qquad (3.2)$$

Where $S_o -$ the normative value of snow mass per 1 m2 of the horizontal surface of the earth;

μ – ratio;

γf – coefficient of reliability of snow load.

$$QA = \gamma f \omega_o K C_e^a B \tag{3.3}$$

Where $\omega_o -$ the normative value of wind load;

$C_e^a -$ aerodynamic coefficient;

К – The coefficient considers the variation in wind load caused by changes in height.

$$QA = 0.42 \cdot 0.79 \cdot 0.8 \cdot 6 = 1.579\ {}^{kN}/_{m}$$

Accurate wind load collection involves the application of relevant design codes and standards specific to the region and type of structure being analyzed. These codes provide guidelines for determining wind load magnitudes, considering factors such as the importance of the structure, its exposure category, and the terrain category.

The spatial distribution of wind loads is a crucial factor in load collection. Wind loads can vary across the structure's surface due to factors such as shape, orientation, and surface roughness. Proper analysis and consideration of these factors are essential to ensure the structure's safety and integrity.

Wind load collection also includes the assessment of dynamic effects, such as vortex shedding and wind-induced vibrations. These phenomena can have significant implications for the structural response and must be carefully accounted for during the load collection process.

Furthermore, load combinations are considered to account for the simultaneous effects of wind load along with other design loads, such as dead loads, live loads, and snow loads. Engineering codes provide specific combinations to ensure the structure is designed to withstand the maximum expected loads.

The collection of wind load in engineering calculations for buildings and structures involves specific considerations unique to this type of load. Wind load collection requires a comprehensive understanding of the local wind climate, including wind speed, directionality, and turbulence characteristics. Additionally, the effects of terrain, nearby structures, and topography must be taken into account.

In summary, wind load collection in engineering calculations requires a comprehensive understanding of the local wind climate, adherence to design codes, consideration of the structure's characteristics, and accounting for dynamic effects. By accurately collecting and analyzing wind loads, engineers can ensure the structural safety and performance of buildings and structures in varying wind conditions.

The anticipated concentrated wind load acting on the frame riser, kN:

$$W = \gamma f \omega_o \phi_{ek} (C_e^a - C_e^н) \cdot B \qquad (3.4)$$

$\phi_{ek} -$ The average coefficient of wind pressure variation concerning height is multiplied by the height of the cargo area.

$$W = 1.4 \cdot 0.3 \cdot 1.5 \times 1{,}4 \cdot 6 = 5.1 \quad kN$$

Crane load. The collection of crane load in engineering calculations for industrial buildings and structures involves specific considerations tailored to this type of load. Crane load collection requires a thorough understanding of the intended use of the crane, the type of loads it will handle, and the structural requirements to support those loads.

Accurate crane load collection necessitates analyzing factors such as the crane's capacity, lifting radius, and the characteristics of the loads being lifted. This includes considerations of static loads (the weight of the lifted object) and dynamic loads (caused by crane movement, acceleration, or deceleration).

The collection of crane load also involves assessing the impact of the crane's movements on the structure, such as the resulting vibrations and induced forces. Proper analysis of these dynamic effects is crucial to ensure the structural integrity and safety of the building.

Furthermore, load combinations are considered during the crane load collection process. Different types of loads, including dead loads, live loads, and crane loads, may act simultaneously on the structure. Engineering codes provide specific load combinations to account for these scenarios and ensure that the design meets the necessary safety standards.

Additionally, the collection of crane load may involve considering special factors, such as wind effects on the crane or the potential for side loading during crane operations.

In summary, crane load collection in engineering calculations for industrial buildings and structures requires a comprehensive understanding of crane specifications, load characteristics, dynamic effects, and load combinations. By accurately collecting and analyzing crane loads, engineers can ensure the safe and efficient operation of cranes within the structural framework of industrial buildings and facilities.

The anticipated peak pressure exerted on the truss due to the impact of two taps, kN:

$$D_{MAX} = \psi\gamma f F^{H} \sum y + \gamma f_u \sigma_{nr} \tag{3.5}$$

P^{H} – The maximum pressure exerted by the crane on a single cart as stipulated by the regulations;

σ_{nr} – the weight of the suspension beam;

$\sum y$ – The total sum of the ordinates along the pressure line of influence on the truss.

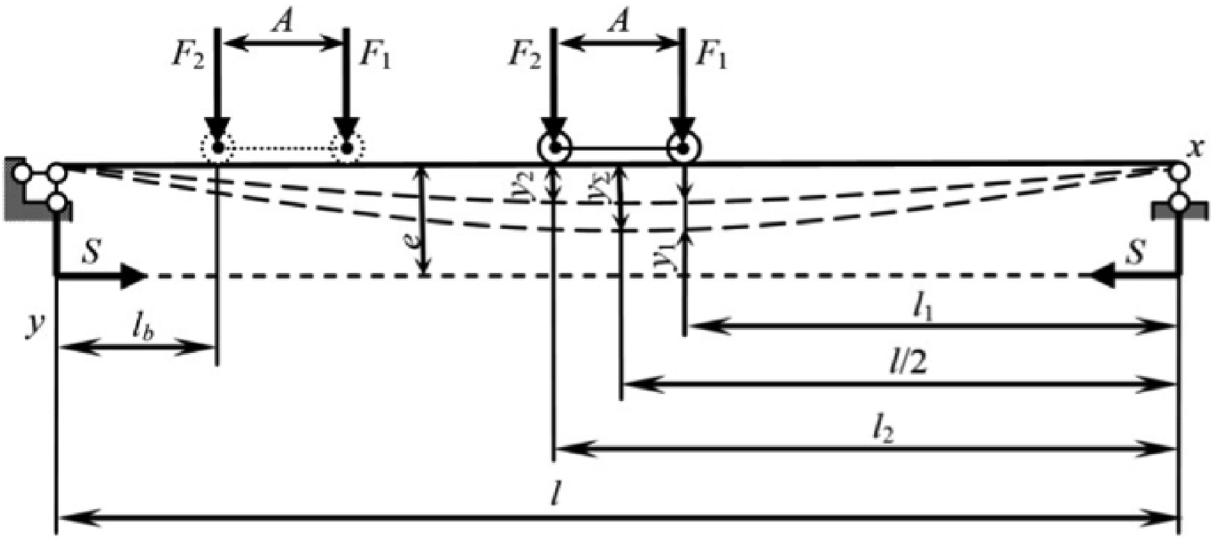

Fig. 3.1. The diagram illustrating the load distribution of the crane on the beam

$\psi = 0.85$

$\gamma f = 1.1 \; F^{H} = 26.31$ кН

$\frac{y_1}{6} = \frac{y_2}{6-0.211}; \quad y_2 = 0.97;$

$\frac{y_1}{6} = \frac{y_3}{3.54}; \quad y_3 = 0.59;$

$\frac{y_1}{6} = \frac{y_4}{3,91}; \quad y_4 = 0.651;$

$\sum y = 1 + 0.97 + 0.59 + 0.651 = 3.21$

Suspension track weight: $G_{п.к.} = 50 \cdot 6 = 300\ N$,

Then $D_{MAX} = 0.85 \cdot 1.1 \cdot 26.31 \cdot 3.21 + 1.05 \cdot 3 = 82.1\ kN$

The anticipated minimum pressure exerted on the truss by two overhead cranes on the track, kN:

$$D_{MIN} = \psi \gamma f F_{min}^{H \sum y_{n_{п.к.}}} \qquad (3.6)$$

F_{min}^{H} – the minimum pressure of the overhead crane on one cart.

$D_{MIN} = (0.85 \cdot 1.1 \cdot 4.7 \cdot 3.21) + 1.05 \cdot 3 = 17200\ N$

The force applied to a crossbar of a frame due to the braking of electric melts, kN:

$$\mathrm{T} = \frac{Q + g_T}{20n} \psi \gamma f \sum y = \frac{7.91}{20 \cdot 2} 0.85 \cdot 1.1 \cdot 3.2 = 1.8\ kN \qquad (3.7)$$

3.2. Calculation of cross-sections of truss elements

In engineering calculations for industrial buildings and structures, the calculation of cross-sections of truss elements is a critical aspect. It involves determining the appropriate dimensions and properties of the truss members to ensure they can withstand the anticipated loads and provide the necessary structural stability.

The calculation of truss cross-sections considers factors such as the material properties, including the yield strength and modulus of elasticity, to determine the capacity of the members to resist bending, compression, and tension forces. The load-bearing capacity of the truss is assessed by analyzing the internal forces and stresses that occur within the members due to the applied loads.

Additionally, considerations are made for various factors that can affect the truss elements, such as the connections between the members, the presence of joints or nodes, and the overall geometry of the truss structure. These factors influence the distribution of forces and the choice of appropriate cross-sectional shapes and sizes for the truss members.

Engineering codes and standards provide guidelines and equations for the calculation of truss cross-sections based on the specific design requirements and load conditions. By accurately calculating the cross-sections of truss elements, engineers can ensure the structural integrity, safety, and efficiency of industrial buildings and structures.

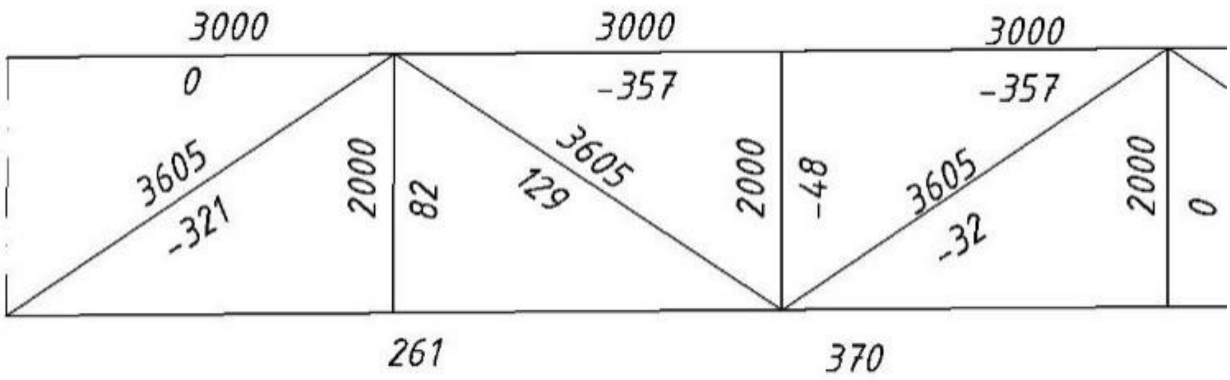

Fig. 3.2. Geometric scheme of trusses (1/2 from length)

The trusses are constructed using steel grade ВСт3пс6 (class C245) with an estimated yield strength $R_y = 240\,MPa$ [80]. The design resistance is accepted as $24\,kN/cm$ for sheet thicknesses ranging from $4\,to\,20\,mm$. Calculated lengths are determined for the belts and the support bevel in the plane of the truss, with l_x set as equal to l_0, the distance of the truss, and l_y set as equal to l_1, the distance between the points of attachment from the plane of the truss. The estimated length of the lattice element is $l_x = 0{,}8 \cdot l_0$ and $l_y = l_0$. The selection of sections and testing of the strength and stability of the truss elements are conducted according to the provided formulas:

for stretched elements:

$$A = \frac{N}{\phi \cdot R_y \cdot \frac{\gamma c}{\gamma n}} \text{ and } \sigma = \frac{N}{\phi \cdot A \cdot \frac{\gamma c}{\gamma n}} \tag{3.8}$$

for compressed elements:

$$A = \frac{N}{R_y \cdot \frac{\gamma c}{\gamma n}} \text{ and } \sigma = \frac{N}{A \cdot \frac{\gamma c}{\gamma n}} \tag{3.9}$$

The selected cross-sections are placed on the sheet.

CHAPTER 4. TECHNOLOGY OF CONSTRUCTION

4.1. Scope and design characteristics

The scope and design characteristics of a technological map are essential aspects of various industrial processes. A technological map outlines the sequential steps, procedures, and parameters required to achieve specific objectives efficiently. It provides a comprehensive overview of the entire process, including the necessary resources, equipment, tools, and materials involved.

The scope of a technological map varies depending on the context and industry. It can range from manufacturing and production processes to construction, assembly, or maintenance activities. The map aims to optimize workflow, minimize errors, reduce costs, and ensure the overall quality of the final product or outcome.

Design characteristics play a vital role in the effectiveness of a technological map. These characteristics include clear and concise instructions, accurate specifications, and precise measurements. The map should provide detailed information about each step, such as the order of operations, safety precautions, and any required quality checks. Additionally, it may incorporate diagrams, illustrations, or visual aids to enhance understanding and facilitate implementation.

The design of a technological map also takes into account flexibility and adaptability. As processes evolve or new technologies emerge, the map should be able to accommodate changes and updates without compromising efficiency or safety.

In summary, the scope and design characteristics of a technological map are crucial elements in ensuring the smooth and efficient execution of industrial processes. By providing a structured and comprehensive approach, a well-designed map contributes to improved productivity, quality, and overall success in various industries and applications.

A valid technological map has been created for the installation of solid section folded I-beam steel columns in a one-story production building. The weight of the columns, for which the technological map has been developed, is provided in Table 4.1.

Table 4.1.

Specification of elements

№	Name of the brand	Quantity	Unit weight, t	The mass of all, t
1	$K1$	14	0,43	6.07
Together				6.07

The installation technology of steel columns in an industrial single-story building involves a series of steps and processes to ensure proper structural integration. The process begins with a careful analysis of the building design and engineering drawings to determine the precise location and orientation of each column. The design characteristics, such as the column section type and dimensions, are taken into account to ensure compatibility with the overall structural system.

Before the installation begins, the site is prepared by clearing the area, leveling the ground, and setting up temporary supports or scaffolding if necessary. The foundation is inspected to ensure it meets the required specifications and can adequately support the weight and load-bearing capacity of the steel columns.

The installation itself typically starts with the positioning and alignment of the baseplates or anchor bolts on the foundation. These baseplates serve as the connection points for securing the columns. Accurate measurement and leveling are crucial at this stage to ensure proper alignment and verticality of the columns.

Once the baseplates are in place, the columns are lifted and maneuvered into position using cranes or other lifting equipment. The columns are carefully aligned and connected to the baseplates, ensuring proper fit and tightness of the connections. Bolts, welds, or other fastening methods are employed to secure the columns firmly in place.

Throughout the installation process, strict adherence to safety protocols and engineering standards is essential. Regular inspections are conducted to verify the integrity of the connections, alignment, and overall stability of the steel columns. Any necessary adjustments or corrective measures are taken to ensure the columns are properly installed and meet the required specifications.

In conclusion, the technology for installing steel columns in an industrial single-story building involves meticulous planning, precise positioning, and meticulous execution to ensure the structural integrity and safety of the overall construction. The use of engineering terminology and adherence to industry standards is vital to achieving a successful and reliable installation process.

4.2. Structure of the complex process and scope of work

The complex process of assembling a steel frame for a single-story industrial building involves multiple interconnected stages. It begins with a detailed analysis of engineering drawings and structural design specifications. The structural design determines the type and arrangement of steel members, such as columns, beams, and braces. The first step in the assembly process is the preparation of the construction site. This includes clearing the area, leveling the ground, and establishing temporary supports or scaffolding.

The next stage is the installation of the foundation, which provides the base for the steel frame. This typically involves excavating the soil, pouring concrete footings, and placing anchor bolts or embedment plates. The anchor bolts are strategically positioned to align with the column locations specified in the design.

Once the foundation is ready, the columns are erected. This process entails lifting each column into position and aligning it with the anchor bolts. Temporary braces are used to secure the columns during assembly. The column connections are made by bolting or welding them to the anchor bolts or embedment plates.

With the columns in place, the next step is the installation of the beams. The beams are positioned and connected to the columns using appropriate connection details, such as moment connections or shear connections. Welding or bolting methods are employed to ensure a strong and rigid connection.

After the beams are installed, the purlins or girts are added. These secondary steel members are attached to the beams and provide support for the roof and wall panels. The purlins and girts are secured using clips, brackets, or other appropriate fastening methods.

Following the installation of the purlins and girts, the roof and wall panels are attached to the steel frame. These panels can be made of various materials, such as metal sheets or insulated panels. The panels are secured to the frame using screws, clips, or other approved fasteners.

Once the structural framework and panels are in place, attention turns to the installation of doors, windows, and other building components. This includes the placement of frames, hardware, and weatherproofing elements.

Throughout the assembly process, quality control measures are implemented to ensure compliance with engineering standards and specifications. Inspections are conducted at various stages to verify the accuracy of the assembly, the proper alignment of components, and the overall structural integrity.

Table 4.2.

The structure of the complex process and the scope of work

№	Name of process	Unit of measurement	Count record	Amount of work
1	2	3	4	5
1	Unloading columns with a crane	100 t	$14 * 0.43/100$	0,1
4	Installation of steel resistance plates	1	14	14
5	Grasping steel support plates	1	14	14
6	Gravy concrete mixture under the slabs	1 cubic meter	$14 * 0.8 * 0.8 * 0.05$	0,5
7	Installation of columns	Piece	$according\ to\ the\ drawing$	14
8	Installation of columns	1 t	$0{,}06 * 100$	6
9	Installation and fastening of bolts	100 pcs	$14 * 4/100$	0,6

The final stage of the assembly process involves finishing touches and adjustments. This includes the installation of trim, flashings, and any additional architectural features specified in the design.

In summary, the complex process of assembling a steel frame for a single-story industrial building involves several stages, including site preparation, foundation installation, column erection, beam installation, purlin, and girt attachment, panel installation, component installation, quality control, and finishing touches. Each stage requires careful planning, precise execution, and adherence to engineering standards to ensure the successful construction of a structurally sound and functional industrial building.

4.3. Selection of mounting cranes and load-lifting devices

The selection of mounting cranes and load-lifting devices is a critical aspect of the assembly process for a steel frame in a single-story industrial building. It involves careful consideration of various factors to ensure the safe and efficient lifting and placement of structural elements.

One of the primary considerations in selecting mounting cranes is their lifting capacity. The cranes must be able to handle the weight of the heaviest components, such as steel beams and columns, with an appropriate safety margin. The lifting capacity of the cranes is determined based on the maximum anticipated loads during the assembly process.

Another important factor is the reach of the cranes. The reach should be sufficient to position the components accurately and safely. It is crucial to consider the dimensions and layout of the construction site, including any obstacles or restrictions that may affect crane movement and reach.

The type of crane is also a key consideration. Different types of cranes, such as tower cranes, mobile cranes, or crawler cranes, may be suitable depending on the specific requirements of the project. Factors such as site conditions, available space, and the height of the structure influence the choice of crane type.

In addition to cranes, load-lifting devices such as slings, chains, or hooks are used during the assembly process. These devices should be selected based on their load capacity, material strength, and compatibility with the components being lifted. Safety factors, such as load stability and secure attachment, must be taken into account when choosing load-lifting devices.

The selection of mounting cranes and load-lifting devices also involves compliance with relevant regulations and standards. Engineering codes specify the minimum requirements for equipment selection, load capacity calculations, and safety measures. Adherence to these regulations is crucial to ensure the safe execution of the assembly process.

Furthermore, considerations related to crane operation and maneuverability should be taken into account. Factors such as operator experience and training, equipment maintenance, and site logistics play a significant role in the overall efficiency and safety of the assembly process.

A comprehensive risk assessment should be conducted during the selection process to identify potential hazards and develop appropriate mitigation strategies. This includes evaluating factors such as weather conditions, ground stability, and nearby structures or utilities that may affect crane operations.

Regular inspections and maintenance of the selected cranes and load-lifting devices are essential to ensure their continued reliability and safety throughout the assembly process. Any signs of wear, damage, or malfunction should be promptly addressed to prevent accidents or delays.

In conclusion, the selection of mounting cranes and load-lifting devices is a critical aspect of the assembly process for a steel frame in a single-story industrial building. It requires careful consideration of factors such as lifting capacity, reach, crane type, load-lifting devices, compliance with regulations, operator expertise, and risk assessment. By making informed decisions and prioritizing safety, engineers can ensure the successful and efficient assembly of the steel frame.

When selecting a mounting crane, one of the crucial factors to consider is the lifting capacity. The lifting capacity refers to the maximum weight that the crane can safely lift and transport. It is determined by various factors, including the size and weight of the structural components that need to be lifted during the construction process.

To determine the required lifting capacity, engineers calculate the total weight of the heaviest components and add an appropriate safety margin. This ensures that the crane can handle the anticipated loads without exceeding its rated capacity. Additionally, factors such as the reach and height of the crane, as well as any additional attachments or equipment, should be taken into account.

It is important to note that the lifting capacity of a crane is specified by the manufacturer and can vary depending on the crane's configuration, boom length, and other factors. The selection process involves identifying cranes with sufficient lifting capacity to meet the specific requirements of the construction project.

Careful consideration is given to the weight distribution and balance of the loads being lifted to ensure stability and prevent any tipping or overloading situations. The selected crane should have the necessary capacity to handle the heaviest loads expected during the construction process, while also considering any potential future modifications or additions to the structure.

By accurately assessing the lifting capacity requirements and selecting a crane that meets those requirements, engineers can ensure the safe and efficient execution of the construction project. Regular inspections and maintenance of the crane are also essential to verify that its lifting capacity remains within acceptable limits throughout the duration of the project.

The selection of mounting cranes is based on the alternative design. In the initial phase, we consider the technical specifications and consult reference materials to identify two potential options for cranes with identical carrying capacities.

The formula is used to determine the necessary lifting capacity of the crane:$Q_{г}$

$$Q_{г} = m_{е} + m_{ст} + m_{г}, \tag{4.1}$$

$$Q_{г} = 0{,}43 + 0{,}12 = 0{,}55\ t$$

Where $m_{ст}$– strop mass (traverse);

m– the mass of the element, t (task);$m_{е}$

$m_{г}$ – the mass of arrangement and reinforcement of the element.

When selecting a mounting crane, another important consideration is the height of the hook. The height of the hook refers to the distance between the ground or the crane's base and the lowest point of the hook when it is in its fully extended position. This measurement is crucial as it determines the maximum vertical reach of the crane and affects its ability to lift and place components at different elevations.

The height of the hook is influenced by several factors, including the height of the building or structure constructed, the desired clearance between the ground and the lifted objects, and any overhead obstructions that may restrict the vertical movement of the crane. It is essential to ensure that the selected crane has a hook height that allows for the safe and efficient lifting and placement of the required components within the desired construction height.

Engineers consider the design specifications and construction plans to determine the appropriate hook height for the mounting crane. They assess the vertical space available at the construction site, taking into account any potential obstacles such as power lines, trees, or nearby structures. Additionally, factors such as the height of the load, the reach of the crane, and the desired maneuverability of the crane's boom should also be considered during the selection process.

By carefully evaluating the height of the hook and ensuring it aligns with the specific requirements of the construction project, engineers can choose a mounting crane that can effectively handle the lifting tasks while maintaining a safe and efficient workflow. Regular monitoring and adjustments to the hook height may be necessary throughout the construction process to accommodate changes in elevation or any modifications to the project's design.

The maximum lifting height of the hook is calculated using a specific formula:$H_г$

$$H_г = h_0 + h_з + h_е + h_{ст}, \tag{4.2}$$

$$H_г = 0 + 1 + 6{,}0 + 1 = 8{,}0 \text{ м}$$

where – the distance from the level of parking of the crane to the height of the support of the mounting element, m; h_0

$h_е$ – height or thickness of the element, m;

$h_з$ – height reserve for the safety of installation;$h_з = 1\ m$

$h_{ст}$ – the height of slinging, m.

The horizontal displacement of the crane hook is denoted as $L_г$, is determined based on the organizational and technological plan for the installation of structures.

$$L_г = \sqrt{6^2 + 3{,}5^2} = 7 \text{ м}$$

We accept an arrow length of $12.5\ m$.

4.4. Selection of mounting cranes

The selection of mounting cranes involves careful consideration of various factors to ensure the successful execution of a construction project. One of the key considerations is the specific requirements of the project, such as the size, weight, and configuration of the structural components that need to be lifted and placed.

Engineers evaluate the lifting capacity, reach, and height of the cranes to determine their suitability for the project. The lifting capacity should be sufficient to handle the heaviest loads expected during the construction process, with an added safety margin to account for unforeseen circumstances. The reach of the crane should allow for efficient movement and placement of the components, considering the layout and constraints of the construction site.

Additionally, the terrain, accessibility, and logistical constraints of the project site are taken into account. The selection process may involve analyzing the ground conditions, available space for maneuvering the crane, and any potential obstacles or obstructions that could impact the crane's operations.

The availability and reliability of the cranes are also important factors to consider. The selected cranes should be from reputable manufacturers and well-maintained to ensure their performance and safety during the construction process.

Furthermore, cost-effectiveness and budget considerations play a role in the selection of mounting cranes. Engineers assess the financial implications of renting or purchasing the cranes and compare them to the project budget.

By carefully evaluating these factors and conducting a thorough analysis, engineers can select the most suitable mounting cranes for the specific requirements and constraints of the construction project. This ensures efficient and safe lifting operations, contributing to the successful completion of the project.

Based on the calculated installation parameters found in the reference literature, we choose two cranes for column installation and record the selection outcomes in Table 4.3.

Table 4.3.

The process of crane selection based on mounting parameters

Name and brand of elements	Calculation parameters				Crane Options				
	Mounting mass	Required hook lifting height	Required hook departure	Required arrow length	Type and brand of crane	Payload	Crane hook lifting height	Fly out the hook	Arrow length
Installation of columns	0.6	8.0	7	12.5	Tracked crane $MCG-25$	2	10	7	17.5
					Kwound $KS-59712$	2,5	11	7	18

To identify the cost-effective option for the mounting crane, it is essential to evaluate the technical and economic indicators for each alternative. The key factor in determining efficiency and optimality is the associated costs.

4.5. Selection of vehicles

When it comes to transporting building structures to the construction site, the process of selecting suitable vehicles plays a crucial role. The selection of vehicles involves assessing various factors such as the size and weight of the construction elements, the distance to be covered, the type of terrain, and any logistical constraints.

It is important to choose vehicles that can safely and efficiently transport the construction components, ensuring that they arrive at the construction site in optimal condition. Factors like load capacity, stability, maneuverability, and compatibility with the construction materials are taken into consideration during the selection process.

By carefully evaluating these factors, the appropriate vehicles can be chosen to facilitate the transportation of building structures to the construction site, ensuring a smooth and efficient construction process.

Based on the weight and dimensions of the columns and steel crane beams, we carefully select the suitable type and brand of vehicles for transportation, taking guidance from relevant reference materials. Considering the distance of transportation, we opt for the pendulum method of delivery. Specifically, we choose the Semi-trailer $PL\,2212\,D1$ in combination with the Tractor $MAZ-6422$ for this purpose.

4.6. Work organization and technology

To ensure the proper execution of bolt connections with controlled tension, it is essential to have trained workers who possess the appropriate certification. The alignment of parts with a surface difference (explanation) ranging from 0.5 to 3 mm should be achieved by machining, creating a smooth bevel with a slope not steeper than $1:10$. If the difference exceeds 3 mm, gaskets of the required thickness should be installed, following the same machining process as the connection details.

During assembly, the holes in the parts should be aligned and secured using traffic jams to prevent any shifting. The number of traffic jams should be determined based on calculations considering the mounting loads, with a minimum of 10% for connections with 20 or more holes and at least two for connections with a smaller number of holes. In the assembled package, a slight divergence of holes (blackness) is allowed as long as it does not hinder the free and distortion-free placement of the bolts. A caliber with a diameter $0.5\,mm$ larger than the nominal diameter of the bolt should pass through 100% of the holes in each connection.

In cases where tightly pulled bags obstruct the holes, it is permissible to clean them using a drill with a diameter equal to the nominal diameter of the hole. However, the blackness should not exceed the difference between the nominal diameters of the hole and the bolt. The use of water, emulsions, and oil for cleaning holes is strictly prohibited.

For tightening bolt connections, Dynamometric Dremometer keys of the $E\,750 - 2000\,N \times m$ type and Torcofic keys of UP to $10 - 750\,N \times m$ are recommended. Dynamometric keys used for tension control of high-strength bolts should be inspected at least once per shift to ensure their proper functioning, provided there are no signs of mechanical damage. Additionally, an inspection should be conducted after each replacement of the control device or repair of the key

When installing high-strength bolts and nuts, it is necessary to place one washer under the head of the bolt and one washer under the nut. If there is a difference in the diameter of the hole and the bolt not exceeding $4\,mm$, it is acceptable to install only one washer under the element (nut or bolt head) responsible for tensioning the bolt.

Once all the bolts in a compound are tightened, the senior worker-gatherer (brigadier) is responsible for marking the assigned number or sign in the designated area. The tension of bolts should be monitored based on the number of bolts in the connection: for up to 4 bolts, all of them should be checked; for 5 to 9 bolts, at least three should be checked; and for 10 or more bolts, a minimum of 10% should be checked, but not less than three in each connection. If any bolt fails to meet the required torque value during re-inspection, all bolts should be rechecked and tightened to the specified value.

All activities related to tension and tension control should be documented in the connection log specifically designed for bolts with controlled tension. Flange joints should have bolts stretched according to the forces specified in the working drawings, with the nut being rotated until the estimated tightening time. The actual moment of twisting should not be less than the calculated value determined by the relevant formula, but should not exceed it by more than 10%.

Welding operations must adhere to the prescribed requirements. The supervision of welding work should be carried out by an individual holding a document certifying their professional education or training in the field of welding. Welding work should be performed based on an approved project for the production of welding works. Only certified electric welders, following the approved Rules of certification of welders, should carry out welding and tacking.

Furthermore, the welded surfaces, constructions, and the welder's workplace should be adequately protected from adverse weather conditions such as rain, snow, and wind. In environments where the ambient air temperature falls below $-10°C$, a heated inventory room near the welder's workplace should be provided, while temperatures below $-40°C$ require the provision of a greenhouse.

To ensure the desired quality of welds, attention should be given to the addition of a concave profile to the corner seams, creating a smooth transition to the base metal. Additionally, the execution of butt joints without reinforcement (if specified in the drawings) should be achieved through the selection of welding modes that align with the spatial arrangement of the welded elements and structures, or by mechanized cleaning using an abrasive tool.

After welding, the welded surfaces and seams must be meticulously cleaned of any toxins, breezes, or influxes of molten metal. Welded assembly and mounting devices should be removed without causing damage to the base metal, and the areas where they were welded should be cleaned to match the level of the base metal, ensuring the absence of any unacceptable defects.

The decision to remove assembly bolts in mounting welded joints after welding should be determined by the organization responsible for the installation. It is crucial to ensure that the quality of tacks and welded connections of fasteners for assembly and mounting devices is not inferior to the quality of the main welded joints, as determined through external inspection.

By following these guidelines and procedures, the overall quality and integrity of bolt connections and welded joints can be maintained, contributing to the structural stability and safety of the construction project.

4.7. The quality standards and criteria for accepting the completed works

The successful execution of any project requires adherence to specific requirements for quality and the subsequent acceptance of the completed works. These requirements ensure that the project meets the necessary standards and specifications. Quality requirements encompass various aspects, such as materials, workmanship, and compliance with design specifications. The acceptance of works involves a thorough inspection and evaluation process to ensure that all the predetermined criteria have been met. This includes assessing the functionality, durability, and safety of the completed works. Adhering to these requirements and achieving acceptance is crucial to ensure the overall success and reliability of the project.

To ensure the integrity and quality of the assembled package, it is necessary to verify the density of the screed using a specialized probe with a thickness of 0.3 mm. This probe should be carefully inserted within the region bounded by the washer, ensuring that it does not pass between the assembled parts at a depth exceeding $20\,mm$. Furthermore, it is crucial to assess the tightening quality of permanent bolts by subjecting them to restocking with a hammer weighing $0.4\,kg$. During this process, it is essential to ensure that the bolts remain securely in place without any shifting. Lastly, when accepting the mounted structures, it is important to closely monitor and control the actual position of these structures, ensuring that the observed limit deviations do not exceed the specified values provided in the accompanying table. By adhering to these measures, the overall quality and stability of the construction can be guaranteed.

Table 4.5.

The acceptable tolerances for the actual position of the installed structures

Setting	Limit deviations, mm	Control (method, volume, type of registration)
1. Variation in the elevation of the column and support base surfaces compared to the intended design levels	5	The geodetic surveying procedure is carried out to measure and establish the accurate positions of each column and support, following the prescribed executive scheme
2. Discrepancy in the elevation of the adjacent column and support base surfaces within the row and across the span	3	Same
3. Offsetting of the column and support axes from the reference axes within the support section	5	Same
4. Deviation of column axes from the vertical position at the upper section, measured in millimeters along the column length, mm:		
from 4000 to 8000	10	Same
from 8000 to 16000	12	Same
from 16000 to 25000	15	Same

5. The deflection (curvature) of the column, support, and beam connections is measured to determine any arrow deflection present	The allowable distance between anchor points should not exceed 0.0013, with a maximum limit of 15 units	Accurate measurements are taken for each element during the process of conducting the journal of works.
6. The presence of a one-sided gap between milled surfaces in column joints is assessed to ensure proper alignment and fit	0The transverse crossing size of the column should not exceed 0.0007, ensuring that the contact area does not exceed 65% of the cross-sectional area.	Same

4.8. Calculation of labor costs, machine time, and wages

The calculation of labor costs, machine time, and wages play a crucial role in project management and cost estimation. It involves assessing the amount of time and effort required to complete specific tasks and assigning corresponding monetary values. Labor costs are determined by considering the number of workers involved, their skill levels, and the duration of their work. Machine time calculations factor in the utilization of equipment and machinery, considering factors such as setup time, operation time, and maintenance intervals. Wages are calculated based on the agreed-upon rates for different job positions and may include additional allowances or overtime considerations. Accurate calculations of labor costs, machine time, and wages contribute to effective budgeting and resource allocation, ensuring the project remains on track financially and meets the desired productivity targets.

In addition to the calculation of labor costs, machine time, and wages, it is essential to consider various factors that can influence these parameters. These factors include the complexity of tasks, the efficiency of workers and machinery, any potential downtime or delays, and the availability of skilled personnel.

Table 4. 6.

Calculation of labor costs, machine time, and wages

№	Name of process	Unit of measurement	Amount of work	Norm of time		Labor costs	
				man-hour	machine-hour	man-hour	machine-hour
1	2	3	5	6	7	10	11
1	Lifting and transferring columns using a crane	100 t	0.1	12	4.4	0.7	0.3
2	Placing steel reinforcement plates	1 cooker	14	1.6	0.5	22.4	7.4
3	Handling steel support plates	1 cooker	14	0.2		3.4	
4	Pouring concrete mixture beneath the slabs	1 cubic meter	0.5	0.6		0.3	
5	Column installation	Piece	14	3	0.6	42	8.4
		1 t	6	0.6	0.13	3.7	0.8
6	Mounting and securing bolts	100 pcs	0.6	11.5	4.5	6.4	2.5
							79

It is also important to account for any additional costs such as materials, transportation, and overhead expenses. Moreover, industry standards, regulations, and contractual obligations need to be taken into consideration during the calculation process. By conducting thorough calculations and considering these factors, project managers can make informed decisions, allocate resources efficiently, and ensure that the project remains within budget while maintaining high-quality standards and meeting project timelines.

4.9. Schedule of installation and welding works

The work schedule is prepared by considering the estimation of labor requirements and machine utilization time, and it is presented in the graphical section. Additionally, the schedule serves as a comprehensive plan for coordinating the activities and resources involved in the project.

Table 4. 8.

Source data for constructing a linear graph

№	Name of process	Unit of measurement	Amount of work	Labor costs. man-shift	Duration. days	Number of changes in days	The number of links. people
1	Lifting and transferring columns using a crane	100 t	0.1	0.1	0.5	1	2
2	Placing steel reinforcement plates	1 cooker	14	2.8	1	2	3
3	Handling steel support plates	1 cooker	14	0.4			
4	Pouring concrete mixture beneath the slabs	1 cubic meter	0.5	0.03			
5		Piece	14	5.3	1	2	4

	Column installation	1 t	6	0.5			
6	Mounting and securing bolts	100 pcs	0.6	0.8	0.5	1	2

4.10. Material and technical resources

Table 4. 9.

Statement of the need for devices, devices, and tools

No p/p	Tools and equipment	The normative document, working drawing	Quantity	Appointment
Resistance plates				
1	Hook	Custom fabrication	2	Lifting and positioning of resistance plates
2	Installation bolts	Custom fabrication	3	Provisional securing and verification of elements and structures
3	Spacer tubes	Custom fabrication	2	Temporary fastening of resistance plates
4	Four-digital sling Q=3 t; m=88 kg; h_{st}= 4,24 m. Q=5 t; m=215 kg; h_{st}=9,3 m.	Custom fabrication	1	Rigging and hoisting of goods and structures
5	Multi-coal sling	DSTU B B.2.8-10-98	1	Rigging and hoisting of goods and structures
6	Mounting scrap LM-24	DSTU B B.2.8-16: 2009	4	Adjusting, shifting, and installing structural elements
7	Wrench drawer	Custom fabrication	4	Fastening and tightening of bolts
8	Scraper	Custom fabrication	2	Cleaning surfaces of parts to remove dirt
9	Rectangular steel brush	Custom fabrication	2	Cleaning surfaces to eliminate dirt and rust
10	Construction level US1-300	DSTU B B.2.8-19: 2009	1	Verification of horizontality and verticality

11	Folding metal meter	Custom fabrication	1	Taking linear measurements
12	Leveler NV-1	Custom fabrication	1	Determination of excesses or deviations
13	Leveling rail	Custom fabrication	2	Identification of any excesses or deviations
14	Welding machine	Custom fabrication	1	Welding steel elements and structures
15	Universal sling	DSTU B B.2.8-10-98	1	Rigging and hoisting of goods and structures
16	Stretching from the stump rope	GOST 30055-93	1	Applying tension to elements during installation
17	Steel rope shrugging	Custom fabrication	1	Provisional fastening
18	Ladder set	Custom fabrication	1	Installation of a work platform for elevated installation and welding operations
19	Metal roulette RS-20	DSTU 4179-2003	2	Taking linear measurements
20	Rectangular steel brush	Custom fabrication	2	Cleaning surfaces to remove dirt and rust
21	Scarpe	Custom fabrication	2	Cleaning surfaces to remove solution and dirt residues
22	High steel construction OT-400	DSTU B B.2.8-18: 2009	2	Verification of verticality for structural elements
23	Folding metal meter	Custom fabrication	3	Taking linear measurements
24	Mounting scrap LM-24	DSTU B B.2.8-16: 2009	2	Adjusting, shifting, and installing structural elements
25	Wrench double-sided	DSTU B B.2.8-18: 2009	2	Fastening and tightening of bolts

4.11. Safety

During construction and installation works, it is crucial to adhere to the guidelines specified in [82]. To ensure safety on the construction site, it is necessary to assign individuals responsible for various tasks in each shift, including:

– A designated person responsible for the safe operation of the crane
– Individuals responsible for the safe operation of removable devices and containers
– Slingers

All work should be conducted under the supervision and guidance of the person responsible for ensuring safety. It is strictly prohibited to use lifting machines, removable load-lifting devices, and containers that have not undergone proper technical inspection. Slinging cargo in precarious positions, adjusting the position of slinging equipment while lifting, and pulling cargo with obliquely placed ropes are strictly forbidden.

Workers of all specialties must be provided with appropriate protective helmets and overalls. Those working at heights should be equipped with tested and reliable safety belts with insurance and carbines, secured to a robust structure as indicated by the supervisor or foreman. Workers need to possess the necessary certificates for their specific type of work and undergo regular safety briefings as required.

When unloading long-sized structures with a crane, it is recommended to use flexible grinding methods to prevent structural reversal during lifting. It is strictly prohibited to use unmarked, defective, or unrelated removable load-lifting devices. Any defective devices must be promptly removed from the work site.

When slinging structures with sharp ribs, it is essential to place protective gaskets to prevent rope grinding between the edges of the elements and the rope. The dangerous area around the crane should be fenced off with visible protective barriers, clearly illuminated for visibility in the dark. Signs warning about crane operations should be installed on the boundary of the danger zone. Safety signs should also be placed along the temporary road, suspended on a taut rope. The space between the suspended signs and the road should have a safe clearance of 4.5 meters.

Installation work should not be performed at open sites when wind speeds exceed 15 m/s or under adverse weather conditions such as ice, thunderstorms, or fog that impairs visibility. For the movement and installation of vertical panels and similar structures with significant wind resistance, work should be halted when wind speeds reach 10 m/s or more.

Materials and structures should be placed on level surfaces following the specified requirements, taking necessary measures to prevent involuntary displacement, subsidence, and falling. Crane operators, slingers, and individuals responsible for crane operations should be briefed on safety procedures.

During the installation of a house or structural elements, installers must stand on previously installed and securely fixed structures or use suitable platforms. It is strictly forbidden to remain on elements of structures and equipment during lifting and movement. Stairs, transitional bridges, and protective canopies should be used for the safe transition of installers from one structure to another.

Grinding operations should be conducted away from traffic areas and construction machinery. Grinding should not be performed against sharp corners of other structures. If necessary, the bending of structures should only be carried out after verifying the strength and stability of the elements involved.

Before commencing installation work, it is important to establish a clear procedure for communication and signaling between the machine operator and the installation personnel. When raising structures, it is recommended to do so in two stages: first lifting the structure to a height of 20-30 cm, and then, after ensuring the reliability of the slinging, proceeding with further lifting.

When moving structures or equipment, a minimum horizontal distance of 1 meter and a vertical distance of at least 0.5 meters should be maintained between them and any protruding parts of mounted equipment or other structures.

During work breaks, it is strictly prohibited to leave suspended elements of structures and equipment in a hanging position. Once elements of structures or equipment are installed in their designated positions, they should be securely fixed to ensure their stability and geometric precision.

To summarize, adherence to the specified guidelines, including safety measures, proper equipment usage, and effective communication, is essential during construction and installation works. Ensuring the safety of workers, preventing accidents, and maintaining the integrity of structures are paramount considerations.

During the unloading process using a crane, it is crucial to employ flexible slings to prevent any unexpected movement or tipping of the lifted structures. Unmarked, defective, or unrelated load-lifting devices must never be utilized, and any defective equipment should be promptly removed from the work area. When slinging structures with sharp ribs, it is necessary to install protective gaskets to prevent the ropes from getting damaged between the edges of the elements and the sling.

To ensure the safety of personnel and prevent unauthorized access, the dangerous area around the crane should be fenced with visible protective barriers. Illuminated signs should be placed to indicate the presence of the crane and warn individuals about its operation. Additionally, safety signs should be positioned along temporary roadways and hung on ropes to ensure visibility. A sufficient road dimension of 4.5 meters should be maintained between the suspended signs and the roadway to ensure safe passage.

Work at heights in open areas should not be carried out when wind speeds exceed 15 m/s or in adverse weather conditions such as ice, thunderstorms, or fog that impede visibility. Similarly, the movement and installation of vertical panels and structures susceptible to strong winds should be halted when wind speeds reach 10 m/s or higher. These precautions are necessary to safeguard the workers and prevent accidents caused by unpredictable weather conditions.

Proper storage and placement of materials and structures are crucial to prevent displacement, subsidence, and fall accidents. Materials should be placed on leveled surfaces, and measures should be taken to prevent involuntary movement or rolling. Installers must be acquainted with safety procedures and receive training on crane operation, slinging techniques, and the safe use of equipment.

Lastly, it is vital to establish clear communication protocols between the crane operator and the person overseeing the installation. Signals for lifting and moving structures should be agreed upon and followed to ensure a smooth and coordinated workflow. Structures should be raised in two stages, first lifting them to a height of 20-30 cm and then conducting a thorough sling check before proceeding with further lifting.

By adhering to these guidelines and implementing safety measures at every stage, construction, and installation works can be carried out efficiently while prioritizing the well-being and safety of the workers involved.

4.12. Technical and economic indicators

The technical and economic parameters include the normative labor costs for workers, measured at 79 people-hours per hour, as well as the normative costs for machinists, estimated at 19.4 people-hours per hour. The work duration is set at 2 shifts, and the expected production per worker per shift is projected to be 1.5 units.

4.13. Selection of methods of production of works, machines, and mechanisms

The selection of work production methods is based on the utilization of advanced machinery and complex mechanization, taking into account typical technological maps, labor process diagrams, and relevant literature. The findings and outcomes of this process are consolidated and presented in Table 4.10.

Table 4.10

Selection of mechanisms and methods of work

№	Name of works	Method of work	Maximum parameters during installation work			The mechanism and its brand
			departure hook. m	hook lifting height. m	mounting weight of the element. t	
1	Utilizing a bulldozer to remove the top layer of vegetation from the soil	Removing the vegetative layer of soil				Bulldozer D3-8
2	Establishing the layout and design of the construction site	Using a bulldozer to level the surface of the soil	-	-	-	Bulldozer D3-8

3	Excavating and relocating soil using an excavator	Excavating the soil using an excavator	-	-	-	Excavator E-5015
4	Ensuring caution to prevent backfilling beneath the foundation beams using a bulldozer	Filling voids using a bulldozer	-	-	-	Bulldozer D3-8
5	Placing and securing foundation beams in position	Installing through crane operation	5	3.5	3.2	MCG-25 tracked crane equipped with a 12.5 m long boom
6	Installing metal columns for structural support	Assembling using a crane	7	8.0	0.6	MKG-25 caterpillar crane featuring a 12.5 m long boom
7	Erecting truss systems for the building envelope	Mounting with the assistance of a crane	6	16	4	A tracked crane, specifically the MCG-25 model, with an 18 m long boom
8	Filling gaps around window frames with metal strips	Mounting with the assistance of a crane	6	13	1	A tracked crane, known as the MCG-25, with a boom length of 18 m
9	Mounting wall sandwich panels for construction	Mounting with the assistance of a crane	6	13	1.1	A tracked crane, designated as the MCG-25, equipped with an 18 m long boom

10	Installing the framework for the entrance gate	Mounting with the assistance of a crane	4.5	10	1	An automobile crane, specifically the KS-4561A model, with a boom length of 18 m
11	Compacting soil with gravel beneath the base layer	Sealing with the use of pneumatic motorized tools	-	-	-	Pneumothrambovka D-220

CONCLUSIONS

The industrial building in Myrhorod, Poltava region, was successfully designed for this project. The thesis is divided into two parts, starting with an analytical review. The second part focuses on the architectural solution of the industrial building, specifically designed for the location in Myrhorod, Poltava region.

The site where the construction took place has a hilly terrain with a slope towards the northeast. Some sections of the construction site were already occupied by existing buildings and underground utilities. The development of the master plan took into consideration the technological requirements and adhered to current norms and regulations.

Vertical planning was carefully addressed, considering the work technology, topographic conditions, and the projected highway, which required appropriate access points. The elevation planning accounted for the natural terrain and involved local backfilling to achieve the desired height of the building above the driveway axis.

To manage surface water drainage on the site, an open drainage system was designed, which included artificial structures in low-lying areas. The drainage system was also coordinated with the road's water drainage. Before commencing construction, fertile soil was carefully removed from the embankment area and repurposed for unproductive lands. The embankment planning involved importing soil and filling it in layers with proper compaction to achieve a minimum density of 0.95 relatives to the maximum achievable density for the soil type used.

The site passages are designed with a single-slope configuration. In one area, the carriageway is 4.5 m wide and paved with side stones. These passages are strategically placed near the technological pumping and diesel power plant. In another area, the cross-section is narrower, measuring 3.5 m in width and 1 m in width.

The pavement and driveways consist of concrete slabs, with a thickness of 0.18 m. These slabs rest on a leveling layer of sand, which is further supported by a rubble base. To reinforce the edges, a roadside reinforcement of 0.08 m is applied. Pedestrian paths are often combined with driveways. Additionally, separate sidewalks are constructed using medium-grained asphalt concrete, measuring 0.04 m in thickness, with a gravel base of 0.08 m.

For security and boundary purposes, a metal mesh fence is installed along the perimeter of the site, supported by reinforced concrete pillars. To enhance the aesthetic appeal, perennial grasses are sown in designated lawn areas.

The project incorporates the construction of sites dedicated to technical equipment and ancillary buildings. Existing structures are also repurposed to accommodate equipment. Architectural decisions consider the specific construction and climatic conditions of the area.

The design of buildings and structures is based on technological layouts, prioritizing standard solutions and maximizing factory readiness of equipment. Emphasis is placed on typification and unification of components and structures.

Planning decisions are guided by the principle of effectively blocking interconnected sites while maintaining adequate fire breaks.

Construction organization capabilities are taken into account during the development of building projects. Open technological areas will have either concrete or rubble coatings, depending on the requirements of the processes. Side stones are installed along the perimeter of these areas.

Technological pipelines are supported by racks with traverses made of rolled profiles. Foundations for equipment incorporate either monolithic concrete or reinforced concrete, with the inclusion of anchor bolts and embedded parts. Prefabricated metal platforms, ladders, and fences adhering to industry standards, are included to facilitate maintenance of the technological equipment. The laying of communication and engineering networks is planned to be performed using reinforced concrete racks.

The pumps are strategically positioned within the primary working area, which has been allocated the largest volume and area to ensure safety and minimize the risk of high gas concentrations when mixed with air.

Adjacent to this area, there are additional rooms dedicated to staff, a vent chamber, a compressed air compressor, and switchboards.

The technological map outlines the installation process for solid-section steel columns composed of folded I-beams in a single-story production building.

The selection of mounting cranes is carried out based on the design options. Initially, two identical cranes with equal carrying capacity are chosen by considering technical parameters and referring to relevant literature.

To transport the columns and steel beams, suitable types and brands of vehicles are selected based on their weight and dimensions, following guidance provided in the appropriate reference literature.

Considering the distance of transportation, the pendulum delivery method is adopted.

In this case, the selected combination includes a Semi-trailer PL 2212 D1 and a Tractor MAZ-6422.

To perform bolt connections with controlled tension, only workers who have undergone specialized training and possess the necessary certification are permitted.

Any surface irregularities exceeding 0.5 mm and up to 3 mm should be rectified by machining, ensuring the formation of a smooth bevel with a slope not steeper than 1:10.

When there is a difference of more than 3 mm, it is necessary to incorporate gaskets of appropriate thickness, treated in the same manner as the connecting components.

During assembly, the holes in the parts should be aligned and secured using plugs to prevent any shifting. The number of plugs required is determined through calculations based on the mounting loads. For assemblies with 20 or more holes, a minimum of 10% of the holes should have plugs, and for assemblies with fewer holes, at least two plugs are necessary.

In the assembled package, which is secured by plugs, slight misalignment of the holes (known as blackness) is allowed as long as it does not hinder the free insertion of bolts without distortion. A gauge with a diameter 0.5 mm larger than the nominal bolt diameter should fit through 100% of the holes in each connection.

If tightly fitted plugs obstruct the holes, they can be cleaned using a drill with a diameter equal to the nominal hole diameter. However, the blackness should not exceed the difference between the nominal hole and bolt diameters.

The use of water, emulsions, and oil for hole cleaning is prohibited.

For tightening bolt connections, Dynamometric Dremometer keys of type E 750-2000 N×m and Torcofic keys of type UP up to 10-750 N×m are used.

Dynamometric keys used for tensioning and controlling high-strength bolts should be checked for calibration at least once per shift, provided there is no mechanical damage. Additionally, they should be checked after replacing the control device or repairing the key.

A single washer should be placed beneath the head of a high-strength bolt and high-strength nut. If the difference in diameter between the hole and bolt is no more than 4 mm, it is permissible to install only one washer beneath the element (nut or bolt head) responsible for tensioning the bolt.

Upon completion of bolt tightening in the assembly, the senior worker-gatherer (brigadier) is responsible for placing their assigned stigma (a unique number or sign) in the designated location.

The tension of bolts must be closely monitored based on the number of bolts in each connection. For connections with up to 4 bolts, all bolts should be checked. For connections with 5 to 9 bolts, a minimum of three bolts should be inspected. For connections with 10 or more bolts, 10% of the bolts should be checked, but not less than three bolts in each connection.

If any bolt is found to not meet these requirements, double the number of bolts in that connection must be checked. If, during re-inspection, a bolt is found with a lower torque value, all bolts should be checked again, ensuring that they are tightened to the required value.

All work related to bolt tensioning and tension control must be recorded in the connection log specifically designated for bolts with controlled tension.

In flange joints, bolts should be tightened according to the forces specified in the working drawings, gradually rotating the nut until the estimated tightening time is reached.

The actual torque applied during tightening should be no less than the calculated value determined by the appropriate formula, and it should not exceed the calculated value by more than 10%.

During welding operations, strict adherence to the specified requirements is necessary.

The supervision of welding work should be entrusted to an individual who possesses proper professional education or training in the field of welding.

Welding operations must be carried out based on the approved project for the production of welding works.

Welding and tacking operations should only be carried out by electric welders who hold a valid certificate for performing welding works. These certificates are issued in compliance with the approved Rules of certification for welders.

To ensure the integrity of the welded surfaces, structures, and the welder's workplace, adequate protection must be provided against adverse weather conditions such as rain, snow, and wind. In environments with temperatures below minus 10 °C, an inventory room equipped with heating should be made available near the welder's workstation. In extremely low temperatures below minus 40 °C, the provision of a greenhouse is necessary.

To achieve the desired quality of welds, specific welding modes should be selected to incorporate a concave profile into corner seams and ensure a smooth transition to the base metal. Additionally, butt joints should be executed without reinforcement, if specified by the KSCA drawings. Mechanized cleaning using an abrasive tool may be employed to achieve the required weld characteristics following the spatial arrangement of welded elements and structures during consolidation.

Following welding, the welded surfaces of the structure and the weld seams must be thoroughly cleaned to remove any contaminants, oxides, or excessive molten metal. It is essential to achieve a clean surface.

Assembly and mounting devices that were used for welding should be carefully removed without causing any damage to the base metal, and without resorting to excessive force or impacts. The areas where these devices were welded must be cleaned to ensure they are level with the base metal. Any defects found should be rectified appropriately.

The decision to remove assembly bolts from welded joints after welding is at the discretion of the installation organization, based on their assessment of the specific situation.

During external inspections, the quality of tacks, as well as welded connections of fasteners in assembly and mounting devices, should meet or exceed the quality standards of the main welded joints.

REFERENCES

1. Gasii G. Constructive concept of composite structures for construction including geological specifics / G. Gasii, O. Zabolotskyi // Budownictwo o zoptymalizowanym potencjale energetycznym. – Częstochowa: Wydawnictwo Politechniki Częstochowskiej, 2017. – vol. 20. – № 2. – P. 37–42.
2. Gasii G. Estimate of technical and economic benefits of a new space composite structure / G. Gasii, O. Hasii, O. Zabolotskyi // MATEC Web of Conferences. – 2017. – № 116.
3. Gasii G. Experimental investigation of displacement of the support nodes of the steel and concrete composite cable space frames / Grygorii Gasii // Proceedings XVII International scientific conference VSU'2017, Sofia, Bulgaria, 8–9 June, 2017. – Sofia: VSU, 2017. – vol. 1. – p. 197–201.
4. Gasii G. Full changing of the load-bearing wall of the bunker's building of the coal mine / G. Gasii, V. Shushkevych, O. Hasii, O. Telichenko // E3S Web Conf. – 2020. – vol. 201. –01031.
5. Gasii G. M. A solution of construction problem of long-span civil structure by introduction steel and concrete composite cable space frames / G. M. Gasii // Zbiór artykułów naukowych. Konferencji Miedzynarodowej Naukowo-Praktycznej "Badania podstawowe i stosowane: wyzwania i wyniki" (May 30-31, 2017, Gdańsk, Polska). – Gdańsk: Diamond trading tour. – p. 6–7.
6. Gasii G. M. Comparative characteristics of the spatial grid-cable steel-concrete composite slab / G. M. Gasii / Вісник Національного університету "Львівська політехніка". Теорія і практика будівництва. – 2016. – № 844. – С. 260–265.
7. Gasii G. M. Connections systems of the composite cable space frame / G. M. Gasii // Сучасні технології, матеріали і конструкції в будівництві. – Вінниця: ВНТУ, 2017. – Т. 22. – № 1. – С. 5– 10.

8. Gasii G. M. Form-building units of the steel and concrete composite cable space frames / G. M. Gasii // Ресурсоекономні матеріали, конструкції, будівлі та споруди. – Рівне, 2017. – № 34. – С. 184–190.
9. Gasii G. M. Laboratory testing the combined elongate structural elements of support of a mine opening / G. M. Gasii, O. V. Hasii // Modern Technology, Materials and Design in Construction. - 2021. - 1 (30). - P. 20-27.
10. Gasii G. M. Production of full-scale experimental modular specimens of the steel and concrete composite cable space frame / G. M. Gasii // Inżynieria Bezpieczeństwa Obiektów Antropogenicznych. – Warszawa, 2017. – № 3–4. – P. 13–17.
11. Gasii G. M. Small mobile fortification system for quick installation / G. M. Gasii, O. V. Hasii, V. I. Shushkevych, N. N. Sribniak // IOP Conference Series: Materials Science and Engineering. — 2019. — № 708 (1). — 012049.
12. Gasii G. M. Study of behavior of flexible rods as a part of the steel and concrete composite cable space frame / G. M. Gasii // Construction, materials science, mechanical engineering. Series: Innovative lifecycle technology of housing and civil, industrial and transportation purposes. – Dnipro, 2017. – № 100. – P. 64–69.
13. Gasii G. M. The flat double-layer grid-cable steel-concrete composite / G. M. Gasii // Proceedings of the METNET Seminar 2016 in Castellon. – Hämeenlinna, Finland: HAMK University of Applied Sciences, 2016. – P. 56 – 62.
14. Gasii G. M. The methodology and results of experimental investigations of steel and concrete composite cable space frame on effect short-term loading / G. M. Gasii / Вісник Національного університету "Львівська політехніка". Теорія і практика будівництва. – 2017. – № 877. – С. 241–246.
15. Gasii G. M. The Steel and Concrete Composite Cable Space Frames / G. M. Gasii // Annual of The University of Architecture, Civil Engineering and Geodesy. – Sofia: UACEG, 2018. – Vol. 51. – iss. 4. – P. 67-75.

16. Gasii G. M. Types of steel and concrete composite cable space frames / G. M. Gasii // Science and Transport Progress. Bulletin of Dnipropetrovsk National University of Railway Transport. – 2016. – №6 (66). – P. 158 – 165.
17. Gasii G. Testing of the combined structural elements of support of a mine opening / G. Gasii O. Hasii V. Klimenko // E3S Web Conf. — 2020. — Volume 168. — 00028.
18. Gasii G. The structural and design specifics of space grid systems / G. Gasii, O. Zabolotskyi // Proceedings XVII International scientific conference VSU'2017, Sofia, Bulgaria, 8–9 June, 2017. – Sofia: VSU, 2017. – vol. 1. – p. 202–206.
19. Gasii G. M. Structural and design specifics of space grid systems / G. M. Gasii // Science and Technique. – 2017. – № 16 (6). – P. 475–484.
20. Gasii G.M. Installation technology of composite steel and concrete grid-cable coverings / G.M. Gasii // Вісник Сумського національного аграрного університету. Серія: Будівництво. – Суми; СНАУ, 2014. – № 10(18). – С. 204–207
21. Gasii G.M. Technological and design features of flat-rod elements with usage of composite reinforced concrete [Electronic resource] / G.M. Gasii // Metallurgical and Mining Industry. – 2014. – №4. – P. 23 – 25.
22. Gasii, G., & Hasii, O. (2023). Stress-Strain State Analyses of the Composite Steel and Concrete Grid Structure. International Journal of Sustainable Construction Engineering and Technology, 14(1), 296-305.
23. Gasii, G., & Hasii, O. (2023). Stress-Strain State Analyses of the Composite Steel and Concrete Grid Structure. International Journal of Sustainable Construction Engineering and Technology, 14(1), 296-305.
24. Gasii, G., Hasii, O., Hohol, M., & Obbad, J. (2023, March). The New Approach and Requests in Designing the Composite Steel and Concrete Grid Structures. In Proceedings of the 4th International Conference on Building Innovations: ICBI 2022 (pp. 135-141). Cham: Springer International Publishing.

25. Gasii, G., Hasii, O., Hohol, M., & Obbad, J. (2023, March). The New Approach and Requests in Designing the Composite Steel and Concrete Grid Structures. In Proceedings of the 4th International Conference on Building Innovations: ICBI 2022 (pp. 135-141). Cham: Springer International Publishing.
26. Hohol, M., Gasii, G., Pents, V., & Sydorak, D. (2021, September). Structural—Parametric Synthesis of Steel Combined Trusses. In Proceedings of the 3rd International Conference on Building Innovations: ICBI 2020 (pp. 163-171). Cham: Springer International Publishing.
27. Hradil P. Reusability of components from single-storey steel-framed buildings / P. Hradil, L. Fülöp, V. Ungureanu // Steel Construction. – 2019. – Vol. 12(2). – pp. 91-97.
28. Hudz S. Plastic bearing capacity of the steel element cross-section by internal forces combination and restraint / S. Hudz, G. Gasii, A. Hasenko, V. Dariienko // Academic journal. Series: Industrial Machine Building, Civil Engineering. – Полтава: ПНТУ, 2019. – № 2(53). – P. 73-78. – doi: https://doi.org/10.26906/znp.2019.53.1893.
29. Hudz S. Features of operation and design of steel sloping roof purlins / S. Hudz, L. Storozhenko, G. Gasii, O. Hasii // Lecture Notes in Civil Engineering. – 2020. – vol. 73. – P. 65–73.
30. Hudz S. The Problem of Consideration Torsion Emergence in Beams / S. Hudz, G. Gasii, V. Pents // International Journal of Engineering & Technology. – 2018. – Vol. 7. – № 3.2. – P. 141–148.
31. Hudz S. A. Increasing the accuracy of definition torsional geometric properties for rolled and welded beams / S. A. Hudz, G. M. Gasii, O. V. Hasii // IOP Conference Series: Materials Science and Engineering. — 2019. — № 708 (1). — 012051.
32. Hwang, B. G., Ngo, J., & Teo, J. Z. K. (2022). Challenges and strategies for the adoption of smart technologies in the construction industry: The case of Singapore. Journal of Management in Engineering, 38(1), 05021014.

33. Junior V. S. Numerical Modelling Of A Single Storey Industrial Building At Elevated Temperature-Comparison Between The 2d And 3d Analyses / V. S. Junior, G. J. Creus, J. M. Franssen // Mecanica Computacional. – 2020. – Vol. 1. – pp. 1986-1997.

34. Kolokhov V. Structure material physic-mechanical characteristics accuracy determination while changing the level of stresses in the structure / V. Kolokhov, A. Sopilniak, G. Gasii, A. Kolokhov // International Journal of Engineering & Technology. – 2018. – Vol. 7. – № 4.8. – P. 74–78.

35. Kolokhov V. Time measurement of ultrasonic vibrations extension in concrete of different compositions / V. Kolokhov, M. Savytskyi, A. Sopilniak, G. Gasii // Lecture Notes in Civil Engineering. – 2020. – vol. 73. – P. 95–102.

36. Navaratnam, S., Satheeskumar, A., Zhang, G., Nguyen, K., Venkatesan, S., & Poologanathan, K. (2022). The challenges confronting the growth of sustainable prefabricated building construction in Australia: Construction industry views. Journal of Building Engineering, 48, 103935.

37. Regona, M., Yigitcanlar, T., Xia, B., & Li, R. Y. M. (2022). Opportunities and adoption challenges of AI in the construction industry: a PRISMA review. Journal of open innovation: technology, market, and complexity, 8(1), 45.

38. Roy K. (2019). Collapse behaviour of a fire engineering designed single-storey steel building in severe fires / K. Roy, J. B. Lim, H. H. Lau, P. M. Yong, G. C. Clifton, R. P. Johnston, C. C. Mei // Thin-Walled Structures. – 2019. – Vol. 142. – pp. 340-357.

39. Scozzese F. Analysis of non-structural damage in single-storey industrial steel buildings / F. Scozzese, G. Terracciano, A. Zona, G. Della Corte, A. Dall’Asta, R. Landolfo // Soil Dynamics and Earthquake Engineering. – 2018. – Vol. 114. Pp. 505-519.

40. Semko, P., & Gasii, G. (2021). Determination of the Bearing Capacity of Concrete-Filled Steel Tubular Structures Coupled with Dismountable Joints / P. Semko, G. Gasii //International Journal of Sustainable Construction

Engineering and Technology. – 2021. – 11(4). P. 8–17. – https://doi.org/10.30880/ijscet.2021.11.04.002

41. Song Y. (2019). The behaviour of single-storey industrial steel frames / Y. Song, Z. Huang, I. W. Burgess, R. J. Plank // International Journal of Advanced Steel Construction. – 2009. – Vol. 5(3). – pp. 289-302.

42. Stororezhenko L.I. Steel-reinforced concrete structural guy-rope cladding / L.I. Storozhenko, G.M. Gasii, S.A. Gapchenko // Proceedings of the METNET Seminar 2014 in Moscow. – Hämeenlinna, Finland: HAMK University of Applied Sciences, 2014. – P. 79 – 85.

43. Storozhenko L. I. Combined cable space frames for agricultural buildings / L. I. Storozhenko, G. M. Gasii // Actual problems of modern technologies : book of abstracts of the IV International scientific and technical conference of young researchers and students, (Ternopil, 16th-17th of November 2017.). – Ternopil : TNTU, 2017. – 226.

44. Storozhenko L. I. Composite steel and concrete large-span constructions for airport structures / L. I. Storozhenko, G. M. Gasii // Proceeding the Seventh World Congress «Aviation in the XXI-st century» – «Safety in Aviation and Space Technologies», Kyiv, Ukraine, September 19–21, 2016. – Kyiv: NAU, 2016. – P. 10.1.22–10.1.26.

45. Storozhenko L. I. Development methodology of the new space combined designs for building construction / L. I. Storozhenko, G. M. Gasii, D. M. Gasii // Bulletin of the Kazakh Head Architectural and Construction Academy. – Almaty: KazGASA, 2017. – № 4 (66). – C. 46–51.

46. Storozhenko L. I. Numerical studies of behavior of a curved steel and concrete composite cable space frame / L. I. Storozhenko, G. M. Gasii // Proceedings of the METNET Seminar 2017 in Cottbus. – Hämeenlinna, Finland: HAMK University of Applied Sciences, 2017. – P. 105–111.

47. Storozhenko L. I. The composite steel and concrete grid structures: issues and perspectives / L. I. Storozhenko, G. M. Gasii, J. M Obbad // Збірник наукових

праць IV Міжнародної азербайджансько-української конференції «Building Innovations – 2021», 20–21 травня 2021 року. – Баку, Полтава: ПолтНТУ, 2021. – С. 169–171.

48. Storozhenko L. Preparation Technique of Experimental Specimens of Steel and Concrete Composite Slabs / L. Storozhenko, G. Gasii, M. Hohol, O. Hasii // Lecture Notes in Civil Engineering. – 2022. – vol. 181. – P. 147–154. Springer, Cham. https://doi.org/10.1007/978-3-030-85043-2_14
49. Storozhenko L. The modern steel and concrete composite cable space frames / L. Storozhenko, G. Gasii // Sustainable housing and human settlement: Monograph. – Dnipro – Bratislava: SHEE «Prydniprovska State Academy of Civil Engineering and Architecture» – Slovak University of Technology in Bratislava, 2018. – P. 116–119.
50. Storozhenko L.I. Analysis of stress-strain state of the steel-concrete composite ribbed slab as a part of the spatial grid-cable suspended structure / L. I. Storozhenko, G. M. Gasii // Academic journal. Industrial Machine Building, Civil Engineering. – Poltava: PoltNTU, 2016. – iss. 2 (47). – P. 81–86
51. Storozhenko L.I. Experience and current issues of designing of steel and concrete composite structures of roof and floor systems / L.I. Storozhenko, G.M. Gasii // ACADEMIC JOURNAL Industrial Machine Building, Civil Engineering. – Poltava: PNTU, 2020. – VOL. 2 (55). – P. 15–25. – https://doi.org/10.26906/znp.2020.55.2337
52. Storozhenko L.I. Experimental research of strain-stress state of ferrocement slabs of composite reinforced concrete structure elements [Electronic resource] / L.I. Storozhenko, G.M. Gasii // Metallurgical and Mining Industry. – 2014. – №6. – P. 40 – 42.
53. Storozhenko L. Investigation of the Deformation State of a Composite Cable Space Frame Structures with a Photogrammetric Method / L. Storozhenko, D. Yermolenko, G. Gasii // International Journal of Engineering & Technology. – 2018. – Vol. 7. – № 3.2. – P. 442–446.

54. Storozhenko, L., & Gasii, G. (2020). Experience and current issues of designing of steel and concrete composite structures of roof and floor systems. ACADEMIC JOURNAL Industrial Machine Building, Civil Engineering, 2(55), 15-25.

55. Storozhenko, L., Gasii, G., Hohol, M., & Hasii, O. (2021, September). Preparation Technique of Experimental Specimens of Steel and Concrete Composite Slabs. In Proceedings of the 3rd International Conference on Building Innovations: ICBI 2020 (pp. 147-154). Cham: Springer International Publishing.

56. Van Thuat D. (2019). Effects of vertical actions on the responses of single-storey industrial steel building frames / D. Van Thuat, N. D. Hoa, H. V. Chuong, T. V. Hung // Journal of Science and Technology in Civil Engineering. – 2019. Vol. 13(3). – pp. 73-84.

57. Гасій Г. М. Можливості використання структурно-вантових систем в будівництві / Г. М. Гасій // Сталезалізобетонні конструкції: дослідження, проектування, будівництво, експлуатація. Зб. наук. статей. – Вип. 12. – Полтава: ПолтНТУ, 2016. – С. 71–75.

58. Гасій Г. М. Напружено-деформований стан структурно-вантової сталезалізобетонної конструкції / Г. М. Гасій // Сучасні будівельні конструкції з металу, деревини та пластмас. – Одеса, 2017. – № 21. – С. 33–39.

59. Гасій Г. М. Основи формотворення і проектування просторових покриттів із структурно-вантових сталезалізобетонних конструкцій / Г. М. Гасій // Строительство, материаловедение, машиностроение: сб. научных трудов. – Дн-ск: ГВУЗ «ПГАСА», 2016. – Вип. 87. – С. 48–53.

60. Гасій Г. М. Аналіз напружено-деформованого стану трапецієподібної сталевої пластини вузла з’єднання елементів нижнього пояса експериментальної структурно-вантової сталезалізобетонної

циліндричної оболонки / Г. М. Гасій // Збірник наукових праць УкрДУЗТ. – Харків: УкрДУЗТ, 2016. – №162. – С.41–47.

61. Гасій Г. М. Динаміка розвитку, сутність та галузь застосування просторових структурно-вантових сталезалізобетонних конструкцій / Г. М. Гасій // Наука та прогрес транспорту. Вісник Дніпропетровського національного університету залізничного транспорту імені академіка В. Лазаряна. – Дніпро, 2017. – № 5 (71). – С. 107–114. DOI: https://doi.org/10.15802/stp2017/107449

62. Гасій Г. М. Експериментально-теоретичні дослідження напружено-деформованого стану плити структурно-вантової сталезалізобетонної конструкції / Г. М. Гасій // Збірник наукових праць Українського державного університету залізничного транспорту. – Харків: УкрДУЗТ, 2017. – Вип. 170. – С. 72–78.

63. Гасій Г. М. Напружено-деформований стан сталевої пластини прямокутної форми вузла з'єднання стрижневих елементів структурно-вантової сталезалізобетонної циліндричної оболонки / Г. М. Гасій // Вісник Одеської державної академії будівництва та архітектури. – Одеса: Зовнішрекламсервіс, 2016. – №62. – С. 215–219

64. Гасій Г. М. Проектування опорного вузла структурно-вантової сталезалізобетонної вигнутої плити / Г. М. Гасій // Ресурсоекономні матеріали, конструкції, будівлі та споруди. – Рівне:НУВГП 2016. – №32. – С. 129–136.

65. Гасій Г. М. Проектування опорного вузла структурно-вантової сталезалізобетонної вигнутої плити / Г. М. Гасій // Ресурсоекономні матеріали, конструкції, будівлі та споруди. – Рівне:НУВГП 2016. – Вип. 32. – С. 129–136.

66. Гасій Г. М. Скінченно-елементний аналіз НДС вузла з'єднання елементів верхнього пояса структурно-вантової сталезалізобетонної конструкції / Г. М. Гасій // Збірник наукових праць Українського державного

університету залізничного транспорту. – Харків: УкрДУЗТ, 2017. – Вип. 171. – С. 69–76.

67. Гасій Г.М. The researches of composite and spatial grid cable-stayed constructions for civil engineering / Г.М. Гасій // «Актуальні питання сучасної науки» (м. Київ, 24-25 жовтня 2014 р.). — Херсон : Видавничий дім "Гельветика", 2014. – С. 56 – 59.

68. Гасій Г.М. Техніко-економічне обґрунтування ефективності потокового методу зведення сталезалізобетонного структурно-вантового покриття / Г.М. Гасій // Збірник наукових праць Харківського університету Повітряних сил. – 2014. – №2(39). – С. 176–177.

69. Гасій Г. М. Вузлове з'єднання елементів просторового сталезалізобетонного покриття / Г. М. Гасій // Молодий вчений. – 2014. – № 9. – С. 10–12.

70. Гасій Г. М. Напружено-деформований стан структурно-вантових сталезалізобетонних конструкцій покриття / Г. М. Гасій // Проблеми сучасного будівництва: матер. Всеукр. інтернет-конф. мол. уч. і студ., 21–22 листопада 2012 р., Полтава / ПолтНТУ, Полт. держ. центр науки, інновацій та інформатизації. – Полтава, 2012. – С. 121–122.

71. Гасій Г. М. Просторові структурно-вантові сталезалізобетонні конструкції: монографія / Г. М. Гасій – Полтава: ТОВ «АСМІ», 2018. – 347 с.

72. Гасій Г. М. Результати експериментальних досліджень макету структурно-вантової циліндричної оболонки / Г. М. Гасій, С. А. Гапченко, Л. І. Стороженко // Перспективи розвитку будівельної галузі: матер. Всеукр. конф. мол. уч. і студ. – Полтава: ПолтНТУ, 2013. – С. 80–85.

73. Гасій Г.М. Експериментальні дослідження структурно-вантових покриттів / Г.М. Гасій // Збірник наукових праць. Серія: галузеве машинобудування, будівництво. – 2014. – №3(42). – С. 47–51.

74. Гасій, Г. М., & Гасій, О. В. (2021). Laboratory testing the combined elongate structural elements of support of a mine opening. Сучасні технології, матеріали і конструкції в будівництві, 30(1), 20-27.

75. Гудзь С. А. Аналіз і моделювання великопролітних будівель із портальними рамами і хрестовими в'язями/ С. А. Гудзь, Г. М. Гасій, О. В. Гасій, В. В. Дарієнко // Збірник наукових праць ІІІ Міжнародної азербайджансько-української конференції «Building Innovations – 2020», 1–2 червня 2020 року. – Баку, Полтава: ПолтНТУ, 2020. – С. 85–87.

76. Гудзь С. А. До проблеми виникнення та врахування кручення в балках / С. А. Гудзь, Г. М. Гасій, В. Ф. Пенц // Збірник наукових праць І Міжнародної азербайджансько-української конференції "Building Innovations - 2018", 24-25 травня 2018 року. - Баку: ПолтНТУ, 2018. - С. 116-118.

77. Гудзь С. А. Заходи щодо зменшення металоємності прогонів покриття / С. А. Гудзь, Г. М. Гасій, О. В. Гасій, В. В. Дарієнко // Збірник наукових праць IV Міжнародної азербайджансько-української конференції «Building Innovations – 2021», 20–21 травня 2021 року. – Баку, Полтава: ПолтНТУ, 2021. – С. 119–121.

78. Гудзь С. А. Розвинена модель розрахунку сталевих розкріплених елементів на стійкість при сумісній дії поперечного згину та кручення / С. А. Гудзь, Г. М. Гасій, В. В. Дарієнко // Сучасні будівельні конструкції з металу та деревини. – Одеса: ОДАБА, 2020. – № 24. – С. 43-52. – doi:10.31650/2707-3068-2020-24-43-52

79. Гудзь С. А. Уточнення положень нормативного розрахунку гнучких сталезалізобетонних колон за умов дії стиску зі згином / С. А. Гудзь, Г. М. Гасій // Engineering science: development prospects in countries of Europe at the beginning of the third millennium: collective monograph. – Riga: Izdevnieciba "Baltija Publishing", 2018. – Vol. 1. – P. 130–154.

80. ДБН В.2.6-198:2014 Сталеві конструкції. Норми проектування – [Чинний від 2015-10-01]. – К.: Мінрегіонбуд України, 2015.

81. ДБН А.3.1-5:2016 Організація будівельного виробництва – [Чинний від 2017-01-01]. – К.: Мінрегіон України, 2016. – 52 с.

82. ДБН А.3.2-2-2009 Система стандартів безпеки праці. Охорона праці і промислова безпека у будівництві. Основні положення (НПАОП 45.2-7.02-12) – [Чинний від 2012-04-01]. – К.: Мінрегіонбуд України, 2012. – 116 с.

83. ДБН Б.2.2-12:2019 Планування та забудова територій – [Чинний від 2019-10-01]. – К.: Мінрегіонбуд України, 2019. – 177 с.

84. ДСП 173-96 Державні санітарні правила планування та забудови населених пунктів. Зі змінами – [Чинний від 2019-03-07]. – К.: Міністерство охорони здоров'я (МОЗ), 2019. – (Національні стандарти України).

85. ДСТУ Б А.3.1-22:2013 Визначення тривалості будівництва об'єктів – [Чинний від 2014-01-01]. – К.: Мінрегіон України, 2014. – 30 с. – (Національні стандарти України).

86. ДСТУ Б В.2.2-29:2011 Будинки і споруди. Будівлі підприємств. Параметри – [Чинний від 2012-12-01]. – К.: Мінрегіонбуд України, 2012. – (Національні стандарти України).

87. Стороженко Л. І. Дослідження структурно-вантових сталезалізобетонних конструкцій / Л. І. Стороженко. Г. М. Гасій // Сталезалізобетонні конструкції: дослідження, проектування, будівництво, експлуатація. Зб. наук. статей. – Вип. 12. – Полтава: ПолтНТУ, 2016. – С. 228–234.

88. Стороженко Л. І. Методика експериментального дослідження великогабаритного зразка просторової структурно-вантової сталезалізобетонної конструкції / Л. І. Стороженко, Г. М. Гасій // Збірник наукових праць [Полтавського національного технічного університету ім. Ю. Кондратюка]. Серія: Галузеве машинобудування, будівництво. – Полтава, 2017. – № 2 (49). – С. 270–276.

89. Стороженко Л. І. Великопролітні структурно-вантові сталезалізобетонні покриття для будівель і споруд аеропортів / Л. І. Стороженко, Г. М. Гасій // Проблеми розвитку міського середовища. – К.: НАУ, 2016. – Вип. 2(16). – С. 72–79.
90. Стороженко Л. І. Визначення переміщень вузлів просторової структурно-вантової сталезалізобетонної конструкції експериментальним шляхом / Л. І. Стороженко, Г. М. Гасій // Збірник наукових праць Українського державного університету залізничного транспорту. – Харків: УкрДУЗТ, 2017. – Вип. 169. – С.118–128.
91. Стороженко Л. І. Випробування експериментальних зразків пологої структурно-вантової оболонки з суцільним нижнім поясом / Л. І. Стороженко, Г. М. Гасій // Вісник Львівського національного аграрного університету: архітектура і сільськогосподарське будівництво. – Львів: ЛНАУ, 2017. – № 18. – С. 109–115.
92. Стороженко Л. І. Дослідження напруженого стану елементів вузлових з’єднань структурно-вантових сталезалізобетонних покриттів на основі результатів моделювання умов їх роботи / Л. І. Стороженко, Г. М. Гасій // Містобудування та територіальне планування. – К.: КНУБА, 2016. – №№61. – С. 343–347
93. Стороженко Л. І. Розрахунок напружено-деформованого стану структурно-вантової конструкції / Л. І. Стороженко, Д. А. Єрмоленко, Г. М. Гасій // Збірник наукових праць Українського державного університету залізничного транспорту. – Харків: УкрДУЗТ, 2017. – Вип. 174. – С. 33–42.
94. Стороженко Л. І. Проектування сталезалізобетонних структурно-вантових покриттів / Л. І. Стороженко, Г. М. Гасій, С. А. Гапченко // Молодий вчений. – 2014. – № 8. – С. 30–32.
95. Стороженко Л.І. Визначення геометричних параметрів сталезалізобетонних структурно-вантових елементів циліндричних покриттів / Л.І. Стороженко, Г.М. Гасій // Ресурсоекономні матеріали,

конструкції, будівлі та споруди. – Рівне: НУВГП, 2015. – Вип. 31. – С. 511–516.

96. Стороженко Л.І. Дослідження просторової роботи та напружено-деформованого стану нової структурно-вантової сталезалізобетонної конструкції / Л.І. Стороженко, Г.М. Гасій // Промислове будівництво та інженерні споруди. – 2018. – № 1. – С. 19–22.
97. Стороженко Л.І. Експериментальне дослідження деформативності макету сталезалізобетонного структурно-вантового покриття / Л.І. Стороженко, Г.М. Гасій // Вісник Одеської державної академії будівництва та архітектури. – Одеса: ОДАБА, 2016. – №61. – С. 371–378.
98. Стороженко Л.І. Нові композитні матеріали кріплення гірничої виробки / Л.І. Стороженко, Г.М. Гасій// Науковий вісник Національного гірничого університету. – 2015. – № 4. – С. 28–34
99. Стороженко Л.І. Організація й технологія зведення каркасів будівель із струкурно-вантовим сталезалізобетонним покриттям / Л.І. Стороженко, Г.М. Гасій, М.О. Коршунов, Є.В. Дяченко // Збірник наукових праць Харківського університету Повітряних сил. – 2014. – №1(38). – С. 210–212.
100. Стороженко Л.І. Особливості будови та базові положення щодо проектування й виробництва просторової структурно-вантової сталезалізобетонної конструкції // Л.І. Стороженко, Г.М. Гасій // Промислове будівництво та інженерні споруди. – 2017. – № 2. – С. 29–33.
101. Стороженко Л.І. Технологія та організація монтажних робіт зі зведення покриттів із сталезалізобетонних структурно-вантових конструкцій / Л.І. Стороженко, Г.М. Гасій, Є.В. Дяченко, С.А. Гапченко // Молодий вчений. – 2014. – №7. – С. 17–20.
102. Стороженко Л. І. Експериментальне дослідження деформативності окремих несучих елементів сталезалізобетонного структурно-вантового покриття / Л. І. Стороженко, Г. М. Гасій // Строительство,

материаловедение, машиностроение: сб. научных трудов. – Дн-ск: ГВУЗ «ПГАСА», 2015. – Вип. 82. – С. 219–225.

103. Стороженко Л. І. Експериментальне дослідження моделей структурно-вантової сталезалізобетонної конструкції / Л. І. Стороженко, Д. А. Єрмоленко, Г. М. Гасій, Ю.Л. Гладченко // Збірник наукових праць. Серія: галузеве машинобудування, будівництво. – Полтава: ПолтНТУ, 2012. – №3(33). – С. 243–249.

104. Стороженко Л. І. Експериментальні дослідження огороджувальних плит структурно-вантового покриття / Л. І. Стороженко, Г. М. Гасій, С. А. Гапченко, Н. Л. Голенко, В. О. Логвіненко // Тези 66-ої наукової конференції професорів, викладачів, наукових працівників, аспірантів та студентів університету. – Полтава: ПолтНТУ, 2014. – Т. 2. – С. 202–204.

105. Стороженко Л. І. Нові сталезалізобетонні структурно-вантові конструкції / Л. І. Стороженко, Г. М. Гасій, С. А. Гапченко // Збірник наукових праць. Серія: галузеве машинобудування, будівництво. – Полтава: ПолтНТУ, 2014. – №1(40). – С. 91–96.

106. Стороженко Л. І. Особливості конструктивного рішення та проектування повнорозмірного експериментального зразка структурно-вантового сталезалізобетонного покриття / Л. І. Стороженко, Г. М. Гасій // Збірник наукових праць. Серія: галузеве машинобудування, будівництво. – Полтава: ПолтНТУ, 2016. – №1. – С. 51–59.

107. Стороженко Л. І. Просторове сталезалізобетонне структурно-вантове покриття / Л. І. Стороженко, Г. М. Гасій // Строительство, материаловедение, машиностроение: сб. научных трудов. – Дн-ск: ГВУЗ «ПГАСА», 2015. – Вип. 82. – С. 226–230.

108. Стороженко Л. І. Просторові сталезалізобетонні структурно-вантові покриття: Монографія /Л. І. Стороженко, Г. М. Гасій, С. А. Гапченко – Полтава: ТОВ «АСМІ», 2015. – 218 с.

109. Стороженко Л. І. Статичний розрахунок просторових конструкцій, складених з жорстких дисків / Л. І. Стороженко, Д. А. Єрмоленко, Г. М.

Гасій // Сучасні технології, матеріали і конструкції в будівництві. – Вінниця: ВНТУ, 2017. – Т. 23. – № 2. – С. 6– 12.

110. Стороженко Л. І. Структурно-вантова положиста оболонка / Л. І. Стороженко, Г. М. Гасій, С. А. Гапченко, В. В. Волошин // Збірник наукових праць. Серія: галузеве машинобудування, будівництво. – Полтава: ПолтНТУ, 2014. – №3(42). – С. 178–182.
111. Стороженко Л. І. Структурно-вантові сталезалізобетонні конструкції покриттів / Л. І. Стороженко, Г. М. Гасій // Збірник наукових праць. Серія: галузеве машинобудування, будівництво. – Полтава: ПолтНТУ, 2012. – №3(33). – С. 230–234.
112. Стороженко Л.І. Виготовлення та зведення просторового сталезалізобетонного структурно-вантового покриття одноповерхової промислової будівлі / Л.І. Стороженко, Г.М. Гасій, М.О. КоршуновС.А. Гапченко, // Збірник наукових праць. Серія: галузеве машинобудування, будівництво. – 2014. – №3. – С. 192–197.
113. Стороженко Л.І. Ресурсозберігаючі технології монтажу просторового сталезалізобетонного структурно-вантового покриття / Л.І. Стороженко, Г.М. Гасій, С.А. Гапченко, М.О. Коршунов // Тези 66-ої наукової конференції професорів, викладачів, наукових працівників, аспірантів та студентів університету. – Полтава: ПолтНТУ, 2014. – Т.3. – С. 31–32.