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FACULTY OF ARCHITECTURE, STRUCTURES AND AIRFIELDS
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Performed by: student of group ЦБ – 406 Ба, ДАМАТХ Баша Шаік

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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

ДОПУСТИТИ ДО ЗАХИСТУ
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ДИПЛОМНА РОБОТА
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ЗА СПЕЦІАЛЬНІСТЮ 192 «БУДІВНИЦТВО ТА ЦИВІЛЬНА ІНЖЕНЕРІЯ»
ОСВІТНЬО-ПРОФЕСІЙНА ПРОГРАМА
«ПРОМИСЛОВЕ І ЦИВІЛЬНЕ БУДІВНИЦТВО»

Тема: **«Виробнича будівля в м. Полтава»**

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Факультет наземних споруд і аеродромів

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ЗАВДАННЯ

на виконання кваліфікаційної роботи

ДАМАТХ Баша Шайк

(ПІБ випускника)

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Керівник кваліфікаційної роботи: ____________ Гасій Г.М.

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INTRODUCTION

Structural interpretations of roof systems in buildings are characterized by numerous junction points of components, resulting in the labor-intensive arrangement of individual roof elements, particularly their connection, and fixation. This intricate process requires careful attention to detail and precise execution to ensure the stability and durability of the roof structure.

Moreover, the process of assembling the roof element by element falls under the category of climbing, which poses significant risks to the workers involved. Climbing to different heights, carrying heavy materials, and navigating through complex junctions increase the chances of accidents and delays in the construction timeline.

To compound the challenges, the current trend of locating engineering infrastructures and equipment in the inter-farm space has further complicated the construction of roof structures. These additional elements necessitate careful integration into the overall design, requiring meticulous planning and coordination between different construction teams.

It is worth noting that more than 80% of industrial buildings adopt a single-story design. This design choice is not only influenced by functional requirements but also by the practicality and efficiency of construction. Metal structures are commonly employed for large spans in these buildings, especially in expansive structures where the need for structural integrity and load-bearing capacity is paramount.

The manufacturing complexity of building roofing constitutes approximately 75% of the total labor intensity in construction. This highlights the significant importance of the roof in the overall construction process. The time and effort dedicated to roofing directly impact the project's timeline and overall cost. Therefore, efficient and streamlined roofing solutions are crucial for successful project completion.

To illustrate the weight considerations in construction, let's take the example of a 12 by $24 -$ meter metal block. Such a block weighs around 40 tons, emphasizing the substantial load that needs to be supported by the roof structure. In contrast, prefabricated reinforced concrete structures for the same dimensions weigh up to three times more, further underscoring the advantage of utilizing steel blocks in terms of weight efficiency.

The structural design of steel blocks allows for the omission of heavily reinforced concrete trusses and floor slabs. This design approach not only reduces the weight burden on the roof structure but also simplifies the construction process. The use of steel blocks provides a more flexible and versatile approach to constructing roofs, offering increased possibilities for customization and adaptation to different building requirements.

By combining steel decking and insulation during unit assembly, it becomes possible to create roofing units that are highly construction-ready. These units can be manufactured off-site, ensuring better quality control and accelerated construction progress. Furthermore, the weight of these units can be optimized to be compatible with lifting cranes, facilitating efficient installation on-site.

The widespread adoption of large-scale structural roofs often eliminates the need for element-by-element assembly. This is because roofs are fully constructed on a leveled surface, where each component is meticulously integrated to form complete blocks. These finished blocks can then be elevated to their intended position, minimizing the complexity and time required for on-site assembly. This approach streamlines the construction process, enhances safety, and improves overall construction efficiency.

The advancements in construction technology and techniques have further revolutionized the process of roof structure assembly. Innovations such as modular roofing systems have emerged as a viable solution for streamlining the construction process and reducing labor-intensive tasks.

Modular roofing systems involve the prefabrication of complete roof units in controlled factory environments. These units are meticulously designed, engineered, and manufactured to precise specifications. By utilizing advanced machinery and automation, the production of these units is optimized for efficiency and accuracy.

The prefabricated roof units are then transported to the construction site, where they can be swiftly installed. This approach eliminates the need for on-site assembly of individual roof elements, minimizing the risks associated with working at heights and reducing construction time significantly.

The use of modular roofing systems offers several advantages. Firstly, it ensures consistent quality control as each unit undergoes rigorous inspection and testing before leaving the factory. This results in a higher level of structural integrity and durability compared to traditional construction methods.

Secondly, the modular nature of these systems allows for easy integration with other building components. The standardized dimensions and interfaces ensure seamless connections between the roof units and other structural elements, such as walls and columns. This promotes efficient coordination among different trades involved in the construction process.

Additionally, modular roofing systems can be customized to suit various architectural designs and functional requirements. With a wide range of materials, finishes, and configurations available, architects and builders have the flexibility to create visually appealing and functional roof structures that meet the specific needs of the project.

Furthermore, the off-site construction of roof units reduces the environmental impact of the construction process. By minimizing on-site waste generation and optimizing resource utilization in factory settings, modular roofing systems contribute to sustainable building practices.

It is important to note that while modular roofing systems offer significant advantages, proper planning, and coordination are crucial. Collaboration between architects, engineers, manufacturers, and contractors is essential to ensure seamless integration of the modular roof units into the overall building design and construction timeline.

In conclusion, the adoption of modular roofing systems represents a paradigm shift in the construction industry. By leveraging prefabrication and advanced manufacturing techniques, these systems offer improved safety, efficiency, quality, and sustainability. As the demand for faster and more cost-effective construction methods grows, modular roofing systems are poised to play a pivotal role in shaping the future of building design and construction practices.

CHAPTER 1. ANALYTICAL REVIEW

The primary methodologies for revitalization encompass various applications that manipulate the plasticity of existing industrial building facades, incorporating deceptive frontages as extensions or borders. Additionally, redesigning involves a fundamental overhaul of the building's external appearance, establishing a harmonious connection with the surrounding environment. Integration entails the insertion of elements and structures within standing edifices, resulting in the creation of a three-dimensional configuration.

The fundamental strategies for adapting industrial buildings and premises encompass diverse housing options, ranging from budget-class residences to high-end dwellings. Moreover, the incorporation of parking facilities, entertainment venues, supermarkets, and gaming halls is deemed essential. These transformative measures seek to address the challenges posed by the continuous development and increased density of urban areas, particularly in regions with a high demand for construction.

The revitalization of industrial structures has emerged as the optimal approach to tackle the issues associated with urban expansion and the repurposing of dormant industrial buildings. By converting workshop areas into modern residential complexes, commercial establishments, offices, and cultural hubs, these structures can regain their relevance and contribute to the growth of vibrant communities.

Several underlying factors highlight the imperative need for the rehabilitation of industrial buildings. These include the discrepancy between existing urban planning structures and evolving requirements, as well as the emergence of novel concepts and burdens on municipal areas. Furthermore, the outdated aesthetic and functional aspects of inner-city structures necessitate revitalization efforts. Ethical and physical evaluations of these buildings further emphasize the need for their renewal, along with the subpar performance observed in municipal settings.

The reinvigoration of industrial buildings serves as a strategic solution to foster sustainable urban development, capitalize on underutilized spaces, and meet the changing demands of a dynamic society. Through innovative architectural interventions, adaptive reuse, and the integration of modern amenities, these structures can regain their significance and contribute to the revitalization of urban landscapes.

In summary, the comprehensive rejuvenation of industrial buildings is a multifaceted endeavor that addresses various challenges inherent in urban development. By implementing strategic approaches and embracing transformative design principles, these structures can be transformed into thriving centers of residential, commercial, and cultural activities, aligning with the evolving needs of contemporary urban environments.

Let us explore diverse typologies of spatial planning designs for urban industrial buildings and their corresponding construction methodologies. The foremost approach involves strengthened concrete multi-story frames, where precast reinforced concrete components with specific dimensions and load-bearing capacities are utilized. These structures consist of multiple floors with varying spans, offering flexibility in design. Another common design is one-story industrial buildings, which make up a significant portion of urban industrial buildings. These structures feature a simplified layout with spacious single-level areas, although accommodating engineering systems can be challenging due to the span limitations.

Recent developments in space-planning techniques have introduced innovative approaches that optimize industrial building layouts. These methodologies leverage advanced computational algorithms, data analysis, and optimization models to achieve optimal space utilization and functionality. Modular construction techniques have also gained prominence, with the off-site fabrication of standardized modules that are assembled on-site, improving construction efficiency and reducing waste.

Sustainable design considerations are increasingly important in industrial building projects. Energy-efficient building envelopes, renewable energy systems, and water-saving technologies contribute to a more eco-friendly built environment. Building Information Modeling applications have revolutionized industrial building design and construction, allowing for enhanced coordination, visualization, and project management.

Advanced structural analysis methods ensure the safety and stability of industrial buildings, utilizing computational tools and simulation techniques to assess structural performance. The integration of smart technologies, such as IoT devices and automation systems, enhances energy management and operational efficiency. Consideration of occupant comfort and well-being involves proper ventilation, natural lighting, and ergonomic design to create a healthy and productive working environment.

The industrial building sector continues to witness future trends and emerging technologies, including robotics, additive manufacturing, sustainable materials, and energy storage systems. These advancements shape the future of industrial building design and construction, offering new possibilities and opportunities for improved efficiency and sustainability.

Overall, the planning and construction of urban industrial buildings involve a range of scientific and technical considerations, from structural analysis and sustainable design to the integration of smart technologies and emerging trends. These factors contribute to the development of functional, efficient, and environmentally conscious industrial spaces.

A multitude of structural components within industrial facilities can undergo renovation and repurposing within a reconstructed building. Ventilation systems in industrial settings are typically installed in a manner that facilitates easy disassembly, upgrade, or modification. Following reconstruction, these systems can be repurposed as specialized ventilation systems and enclosures for spaces with vastly different temperature and humidity requirements. Furthermore, the engineering systems for water supply, sewage, electricity, and heating can be converted and utilized in new environments.

The utilization of wide-span trusses, arches, and beams presents opportunities for incorporating auxiliary technical floors and additional equipment within the inter-beam, inter-arch, and inter-truss spaces. This allows for the integration of ventilation systems, power supply systems, and various other functionalities in these areas.

The concept of adaptive reuse entails the transformation of existing industrial structures to suit new objectives while maximizing the utilization of available resources. By implementing innovative engineering solutions, such as utilizing the inherent structural capabilities of the building, industrial conveniences can be repurposed to accommodate diverse functionalities and adapt to changing requirements.

Sustainable renovation practices play a significant role in the transformation of industrial facilities. Through the incorporation of energy-efficient technologies, such as intelligent control systems, renewable energy sources, and advanced insulation materials, the environmental performance of renovated buildings can be greatly enhanced.

To ensure successful adaptation, comprehensive analysis, and evaluation of existing structural elements and systems are imperative. This includes assessing load-bearing capacities, durability, and compatibility with the new purpose of the building. Additionally, the integration of advanced monitoring systems and sensors enables continuous performance evaluation and optimization of the renovated industrial structures.

The utilization of computer-aided design software and simulation tools aids in the visualization, analysis, and optimization of the renovation process. These technologies enable accurate modeling of structural elements and systems, allowing for informed decision-making and efficient utilization of resources.

The incorporation of sustainable water management strategies is an essential aspect of industrial building renovation. Rainwater harvesting systems, water-efficient fixtures, and wastewater treatment technologies contribute to the conservation and responsible use of water resources.

Integrating smart building technologies, such as Internet of Things devices and building automation systems, allows for enhanced control, monitoring, and optimization of various building systems. This includes HVAC systems, lighting, and energy management, resulting in improved operational efficiency and occupant comfort.

The adoption of circular economy principles in industrial building renovation promotes resource efficiency and waste reduction. By implementing strategies such as material recycling, repurposing, and eco-friendly construction practices, the environmental impact of renovation projects can be minimized.

Collaboration among multidisciplinary teams comprising architects, engineers, environmental experts, and stakeholders is crucial in achieving successful industrial building renovation. This collaborative approach ensures that the renovated structures meet the functional, aesthetic, and sustainable objectives outlined in the project.

In summary, the renovation of industrial buildings offers ample opportunities to repurpose and maximize the use of existing structural elements and systems. By employing sustainable practices, advanced technologies, and interdisciplinary collaboration, these renovations can result in efficient, adaptive, and environmentally conscious industrial facilities.

CHAPTER 2. ARCHITECTURAL DESIGN

2.1. Site characteristics

The designated parcel of land allocated for the establishment of a maintenance and mechanical facility is situated at an adequate spatial separation from the residential edifices within the urban locale of Poltava. This strategic positioning adheres to the prescribed sanitary standards, thereby ensuring the mitigation of potential environmental and societal repercussions associated with the operational activities of the workshop. By adhering to the stipulated distance requirements, the construction of the repair and mechanical workshop maintains a harmonious coexistence with the surrounding residential infrastructure, thus fostering a balanced urban environment conducive to the well-being of the inhabitants.

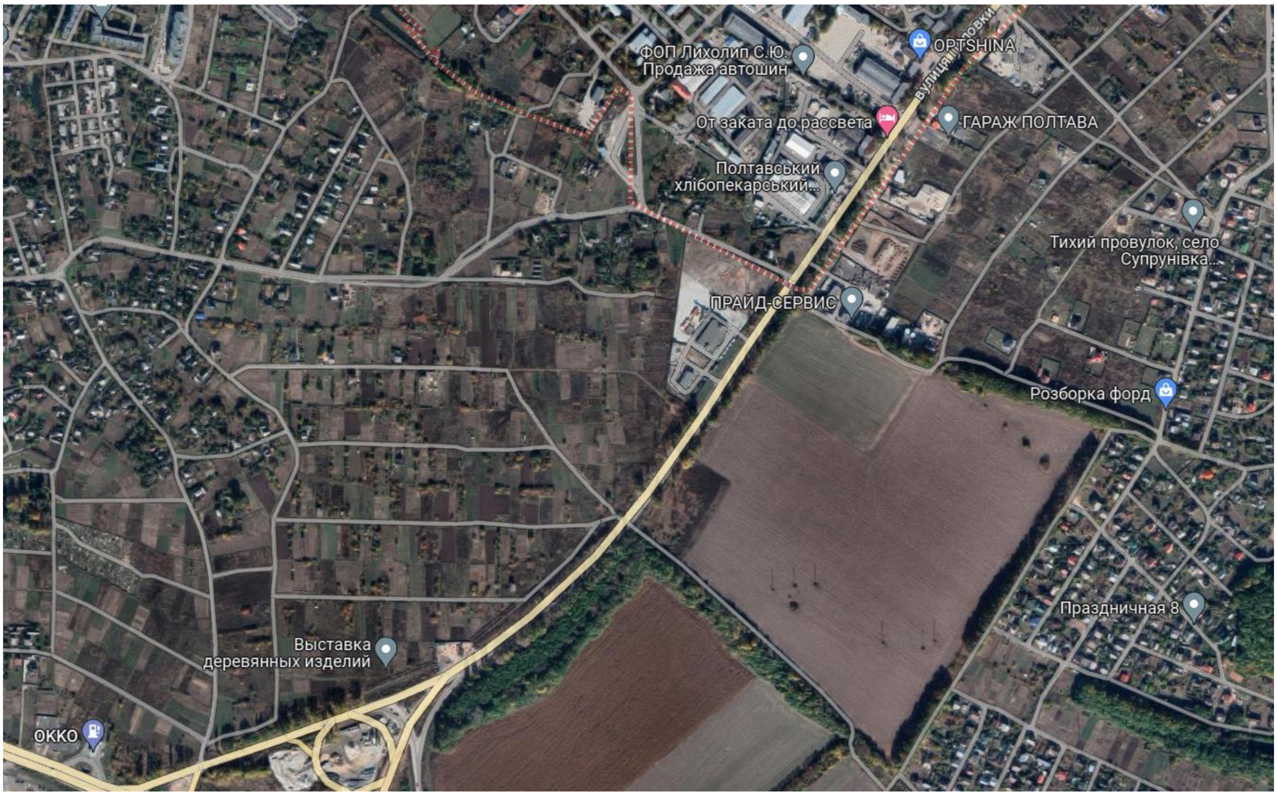


Fig. 2.1. Spatial Configuration and Layout

The construction site exhibits a rectangular configuration with a subsidiary branch, strategically situated within the expansive field area. An open-type surface water drainage system has been meticulously designed, employing planned planes and trays to effectively channel and manage water flow. Spanning across an extensive area of 11 hectares, the site features a consistent gradient that slopes uniformly from east to west.

The comprehensive master plan meticulously outlines the rational allocation of the repair and mechanical workshop, skillfully situating it within the designated section that remains unencumbered by intricate technological apparatus. The vertical planning project meticulously adheres to the principle of preserving the prevailing topography, duly considering hydrogeological landscapes, architectural and planning assessments of the proposed structure, as well as regulatory requisites stipulated in pertinent documents.

To meet the requirements of sanitary and hygienic standards, as well as ensure unimpeded vehicular and pedestrian movement, the surfacing of driveways and designated areas incorporate a judicious combination of gravel, crushed stone, and bitumen pavement. The design of the pavement is tailored to accommodate the projected intensity of traffic flow, optimizing durability and performance.

Careful consideration has been given to the positioning of the building within the site, meticulously accounting for the number of stories, to comply with the regulatory requirements governing the solar exposure of neighboring structures. This strategic placement ensures optimal solar access while preserving the overall architectural harmony and aesthetic integrity of the vicinity.

2.2. Vertical planning and landscaping

The primary layout has been meticulously devised, meticulously considering the existing structures, prevailing traffic conditions, and pedestrian movement patterns. The topographical arrangement plan for the construction site has been carefully developed, taking into account the contours and elevations of the adjacent terrains. The effective drainage of stream water and snowmelt from the site is achieved by following the natural gradient of the land.

Gravel driveways have been implemented throughout the remaining portion of the field, while pedestrian pathways are also surfaced with gravel material. Emphasis has been placed on the maximal preservation of the existing landscape features, ensuring their harmonious integration within the overall design. The transportation route leading to the repair workshop is furnished with asphalt pavement to facilitate smooth and efficient access.

The planning benchmarks have been established with due consideration given to the feasibility and safety of vehicular passage, accounting for the suitable gradients and inclinations necessary for unimpeded transport flow. In addition, careful attention has been directed toward ensuring optimal slopes across the site, contributing to a favorable and functional overall configuration.

2.3. Architectural and planning decisions

The architectural and spatial planning of the repair and mechanical workshop has been meticulously determined, taking into account the localized context, the dimensions of the plot, and the optimal proximity to existing structures.

To enhance the overall performance and aesthetics of the edifice, contemporary finishing materials have been carefully selected for the exterior embellishment. Furthermore, state-of-the-art metal-plastic windows with double-glazing have been installed.

The facade components of the workshop encompass a multitude of elements, incorporating cutting-edge design advancements. These elements contribute to creating a visually striking appearance, capturing attention and admiration.

The structural composition of the building is designed as a robust frame, characterized by a singular expanse of columns. Additionally, the roof system is constructed using steel trusses, ensuring optimal strength and load-bearing capacity.

In consideration of the convenience of the staff members, a designated area for temporary parking has been established close to the primary entrance of the edifice. This arrangement facilitates easy access and efficient transportation for employees.

Adjacent to the building, a well-planned recreational zone has been integrated, adorned with modest architectural features. This space offers a serene environment for individuals to unwind and relax during their breaks, promoting a sense of tranquility and rejuvenation.

By structuring the repair and mechanical workshop with meticulous attention to architectural and spatial planning, the aim is to create a functional and aesthetically pleasing space that harmonizes with the surrounding environment.

2.4. Structural Engineering Solutions

The construction of the repair and mechanical workshop is characterized by its utilization of a one-story frame structure with a single span and walls consisting of hinged three-layer panels. The design incorporates individual steel and tubular manufactured structures for columns and trusses, resulting in enhanced rigidity and load-bearing capacity.

To ensure optimal rigidity, a combination of tubular steel-concrete columns, steel trusses, and horizontal and vertical links is implemented. This structural system guarantees the stability and integrity of the building, allowing it to withstand various loads and external forces.

The foundations of the workshop play a crucial role in distributing the building loads to the underlying soil. Through a comprehensive analysis of soil characteristics and considering technical and economic factors, a shallow foundation of the monolithic glass type is selected. Reinforced concrete foundation beams are strategically placed beneath the outer walls to provide additional support and stability. The chosen foundation depth is determined to be 1.5 meters, ensuring a solid and reliable base for the structure.

The roof trusses of the workshop are carefully designed and constructed on individually engineered tubular steel-concrete columns. The selection of the column type is based on meticulous technical and economic analysis of various options, taking into account factors such as load-bearing capacity and cost-effectiveness. The roof itself has comprised of steel trapezoidal trusses with a height of 2.400 meters, featuring two equal-shelf corners manufactured with precision. To enhance its functionality and insulation properties, the roof is further improved by the installation of three-layer sandwich panels with a thickness of 0.300 meters. These panels are carefully placed on steel girders, specifically channel No. 8, which are positioned on the upper belt of the trusses with a spacing of 1.500 meters.

By incorporating advanced engineering principles and utilizing specialized structural components, the repair and mechanical workshop is designed to meet the highest standards of durability, stability, and efficient load distribution. The integration of individual steel and tubular manufactured structures, along with the implementation of three-layer sandwich panels, ensures optimal performance and functionality of the building. The meticulous selection of foundation type and the inclusion of reinforced concrete beams provide a solid and reliable foundation for the structure, ensuring its long-term stability and integrity.

The interior embellishment of the building entails a meticulous implementation of finishing works, paying close attention to intricate details. The external finishing of the structure adheres strictly to the specifications delineated in the finishing passport, ensuring conformity to established standards. Window and door openings are meticulously filled, seamlessly integrating them within the architectural design of the building. To optimize lighting conditions within the premises, strategically positioned window openings are employed, enabling the ingress of natural illumination.

Metallic components within the building undergo a dual application of black varnish, effectively fortifying them against wear and tear while enhancing their visual appeal. Door leaves, heaters, and tubes are meticulously coated with enamel paint on two occasions, augmenting their aesthetic quality and providing a protective barrier. The door leaves are securely affixed to two hinges, guaranteeing their smooth operation and stability. The building encompasses steel and plastic-wooden doors, all engineered to be acoustically insulated. To create a secure connection, door frames are firmly affixed to the scaffolding on the wall frame using self-tapping screws. Additionally, any gaps between the door frames and outer walls are carefully sealed with foam to ensure an airtight junction.

Given the non-corrosive nature of the atmospheric conditions, additional safeguards for reinforced concrete structures are deemed unnecessary. The project incorporates the installation of metal-plastic window blocks, incorporating double glazing for enhanced insulation and energy efficiency. These window blocks are securely fastened to the scaffolding on the steel-concrete columns using self-tapping screws, and any crevices between the window blocks and walls are meticulously sealed with spume. To protect the interior and exterior metal structures against corrosion, a double application of oil paint is administered, bestowing upon them long-lasting durability and shielding properties.

Embedded elements such as anchors and concealed metallic components within the structure are effectively safeguarded through the application of a cement-polymer layer. Walls positioned at the base of window openings are adorned with galvanized steel drains, providing robust protection against external influences. Defense against external atmospheric effects primarily entails shielding the structure from precipitation.

The ventilation system within the premises incorporates both mechanical and natural methods of supply and exhaust, ensuring optimal air circulation. The heating network relies on a heat generator housed in the existing operator building, with water serving as the heat carrier and operating within the temperature range of $95°C$ to $70°C$. Steel pipes are employed for the heat network, facilitating efficient heat transfer.

The water supply system for the repair shop is seamlessly integrated into the existing water supply system, utilizing pipes with a diameter of 50 mm.

The project encompasses the underground installation of thermal networks within reinforced concrete trays, exclusively designed to cater to heating and hot water supply needs. External networks are constructed using cast iron pressure tubes, while wells within the network are composed of reinforced concrete elements.

To establish the internal sewerage network, cast iron sewer pipes are employed, enabling effective waste management within the premises. In contrast, the external sewerage networks utilize ceramic sewer tubes with a diameter of 150 mm. These pipes lead to biological treatment plants, promoting environmental sustainability in the disposal and treatment of wastewater.

The project incorporates various communication and signaling systems, including an automatic fire alarm system, district telephone communication, and radio broadcasting, thus facilitating effective communication and ensuring the safety of occupants within the facility.

By meticulously incorporating these design considerations and harnessing advanced technical solutions, the repair and mechanical workshop is equipped with a comprehensive range of functional and efficient communication, heating, ventilation, and plumbing systems, thereby guaranteeing optimal performance and functionality. The careful selection of materials and construction techniques ensures the durability and longevity of the building, meeting the most stringent standards of quality and safety.

2.6. Specialized Considerations and Technical Solutions

Measures related to construction in special conditions should be implemented due to the specific nature of the project. Special events and works are accounted for, ensuring the smooth execution of the construction process.

In particular, the manufacture of the monolithic foundation and concrete floor screed must incorporate the use of antifreeze additives to mitigate the effects of low temperatures during winter construction. To ensure the quality of materials used for concrete work in winter, systematic control through laboratory tests is conducted, guaranteeing the integrity and strength of the structures.

The projected building is categorized as belonging to the II degrees of fire resistance and is situated within an explosion and fire zone. Accordingly, a range of explosion and fire safety measures are implemented to ensure the safety of the occupants and protect the property. These measures include the provision of fire engines within a distance of not less than 5 m and not more than 8 m from the building. Furthermore, the building is equipped with two evacuation exits to facilitate swift emptying during emergencies. Access to the roof is facilitated through the installation of an external metal ladder. Additionally, the building incorporates roofs with a II degree of fire resistance, which are constructed using non-combustible materials.

Environmental protection measures are also incorporated into the project design. The building is equipped with a centralized water supply, heat supply, and sewerage systems, promoting sustainable resource management. The construction site is subjected to landscape gardening efforts, preserving existing green areas to the fullest extent possible while introducing new ornamental shrubs and sowing perennial grasses. To minimize dust and sound pollution, gravel roads and sidewalks near the workshop building are designed. The project includes the excavation of a 0.50 m thick fertile layer, ensuring proper vertical planning for effective drainage of stormwater runoff.

To mitigate household noise and vibration stemming from the operation of electric motors and equipment within the engineering systems, the project emphasizes the careful implementation of sound and vibration insulation requirements outlined in the design. This ensures a conducive working environment and minimizes disturbances. Furthermore, the watering of green plantings is facilitated through the utilization of existing watering cranes, which are strategically installed within the niches of the adjacent operator's building. This approach promotes efficient water distribution and maintains the vitality of the greenery surrounding the workshop.

By incorporating these specialized measures, the construction project addresses the unique challenges posed by special conditions. From ensuring structural integrity in winter to guaranteeing the safety and environmental sustainability of the building, every aspect is meticulously considered. The implementation of explosion and fire safety measures, adherence to environmental protection protocols, and the integration of sound and vibration insulation measures demonstrate the commitment to safety, efficiency, and sustainability in the construction of the workshop facility.

The following measures have been implemented to safeguard the environment during the construction period:

- Strict prohibition on the contamination of the fertile layer with paints and solvents, ensuring the preservation of soil quality and preventing pollution.
- Stringent protocols are in place to prevent air pollution, including the verification of all construction machinery for exhaust toxicity before operation.
- Proper disposal of construction waste, ensuring that it is transported to designated landfills and strictly prohibiting its burial on the construction site.

- Prohibition of the use of mechanisms that may contribute to environmental degradation or pollution.
- Adherence to dust and air pollution prevention requirements during construction and installation activities to minimize environmental impact.

To ensure interior fire safety, two fire hydrants with a production capacity of 5 liters per second have been installed. Exterior fire protection is facilitated by strategically positioned fire hydrants connected to the fire water supply network. In the event of a fire, with an estimated extinguishing time of 3 hours, the water consumption is projected to be 173 cubic meters. A dedicated firefighting pumping station, located within the fire station building, ensures a reliable water supply to the network for firefighting purposes.

By implementing these comprehensive environmental defense measures and adopting rigorous fire safety protocols, the construction project demonstrates a commitment to sustainability, environmental responsibility, and the safety of personnel and surrounding areas.

2.7. Thermal Analysis and Evaluation of the Enclosure System

The thermal performance of the enclosing structure is a critical aspect that needs careful consideration. Steel, being a material with high thermal conductivity, can act as a thermal bridge, causing heat loss through the outer walls. To address this issue, the thermal calculation for the outer wall adopts a single-layer insulation structure.

The construction of the wall incorporates a steel profile sheet, 20 mm thick, on both sides of the insulation material. This design helps to enhance the thermal resistance and minimize heat transfer. The project specifies the use of three-layer industrial-hinged sandwich panels for the exterior wall. These panels consist of an inner and outer profile sheet with insulation provided by expanded polystyrene extrusion plates, which have a density of 80 kg/m³.

To ensure optimal thermal insulation, the insulation material consists of extended polystyrene extrusion plates with a thickness of 260 mm. These plates are carefully positioned between the inner and outer profile sheets, creating a continuous layer of insulation. This arrangement effectively reduces heat transfer and maintains a comfortable indoor temperature.

Figure 2.2 illustrates the specific configuration of the outer wall, depicting the placement of the insulation material and the steel profile sheets. This diagram serves as a visual representation of the thermal calculation and highlights the importance of the insulation layer in preventing thermal bridging and heat loss.

Through the implementation of these advanced construction techniques and utilization of cutting-edge materials, the outer walls of the building can attain exceptional thermal performance, thereby significantly contributing to enhanced energy efficiency. The incorporation of top-tier insulation materials, coupled with meticulous wall structure design, synergistically establishes a well-insulated and thermally optimized building envelope.

Moreover, this innovative design approach ensures strict compliance with energy efficiency regulations while actively promoting sustainable building practices. By minimizing heat dissipation across the outer walls, the building can effectively curtail its energy consumption for both heating and cooling purposes, consequently yielding a diminished environmental footprint and reduced operational expenditures.

Undoubtedly, the thermal calculation of the enclosing structure assumes utmost significance within the design process, as it empowers engineers and architects to meticulously optimize energy performance while simultaneously prioritizing occupant comfort. It serves as a cornerstone, enabling informed decision-making pertaining to the selection of appropriate materials, insulation thickness, and wall construction methodologies.

To summarize, the thermal calculation of the outer wall meticulously integrates steel profile sheets, state-of-the-art insulation materials, and a methodical design framework aimed at mitigating thermal bridging and maximizing energy efficiency. This comprehensive approach ensures the establishment of a meticulously insulated building envelope, facilitating a congenial indoor environment while concurrently minimizing energy consumption and environmental repercussions.

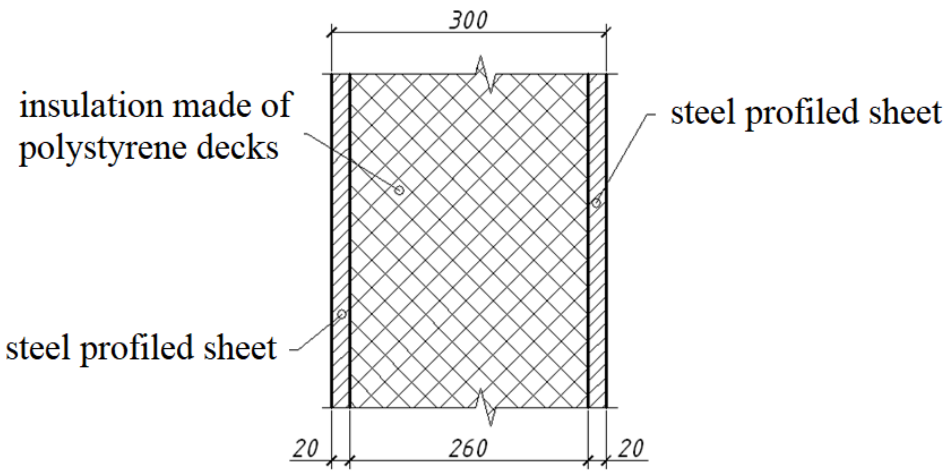


Fig. 2.2. Technological Considerations in Exterior Wall Construction for Enhanced Performance

In the design and construction of industrial buildings, it is crucial to ensure that the enclosing structures meet the minimum allowable heat transfer resistance, denoted as R_qmin. For an industrial building, the specific value of R_{qmin} is determined based on various factors such as the desired energy efficiency and the local climate conditions.

In this particular case, the minimum allowable value for R_qmin is established as R_{qmin} =2.0 m^2K/W. This value serves as a benchmark to assess the thermal performance of the enclosing structures and their ability to resist heat transfer.

To determine the thermal resistance of homogeneous fencing structures or individual layers within multilayer fences, a formula is employed. This formula takes into account the material properties, thickness, and conductivity of the different layers.

It is important to note that the thermal resistance of each layer contributes to the overall heat transfer resistance of the enclosing structure. By calculating the individual thermal resistances and summing them, the total heat transfer resistance can be determined.

By applying this formula to each layer within the enclosing structures, the total thermal resistance can be calculated and compared against the minimum allowable value to ensure compliance with energy efficiency standards.

In addition to the thermal resistance, other factors such as air infiltration, thermal bridging, and insulation placement should also be considered when evaluating the overall thermal performance of the enclosing structures.

It is essential to conduct thorough analysis and simulations to assess the heat transfer characteristics of the enclosing structures and identify any areas that may require improvements or modifications to meet the required thermal resistance values.

Furthermore, the selection of appropriate insulation materials with suitable thermal properties plays a vital role in achieving the desired heat transfer resistance and ensuring optimal energy efficiency.

Regular inspections and quality control measures should be implemented during the construction process to verify that the installed enclosing structures meet the specified thermal resistance requirements.

By adhering to the minimum allowable heat transfer resistance values and employing effective design strategies, industrial buildings can achieve improved energy efficiency, reduced heat loss, and enhanced occupant comfort.

In summary, the determination and analysis of the minimum allowable heat transfer resistance for the enclosing structures of industrial buildings are crucial for ensuring energy efficiency and thermal performance. By using appropriate formulas and considering factors such as material properties and thickness, the thermal resistance of each layer can be calculated and evaluated. Compliance with the specified minimum value is essential to meet energy efficiency standards and create a thermally efficient building envelope.

$$R = \frac{\delta}{\lambda} \tag{2.1}$$

where δ – the thickness of the layer, m,

λ – the coefficient of thermal conductivity of the material, W/(m^{2}K).

The calculation of heat transfer resistance in thermally homogeneous, multilayer, opaque enclosing structures involves considering various estimated characteristics of the wall structure. These characteristics include density (ρ), thickness (δ), and thermal conductivity (λ).

For the specific wall structure being analyzed, the estimated density is $\rho = 80\ \mathrm{kg/m^3}$, the thickness is $\delta = 0.26\ \mathrm{m}$, and the thermal conductivity is $\lambda = 0.041\ \mathrm{W/(m^2K)}$.

The estimation of characteristics such as density, thickness, and thermal conductivity is essential for accurate heat transfer resistance calculations. These characteristics directly influence the overall thermal performance and energy efficiency of the wall structure.

Thermal conductivity represents the ability of a material to conduct heat, while density and thickness affect the amount of heat that can be transferred through the wall.

In analyzing the heat transfer resistance, it is important to consider the combined effect of multiple layers within the multilayer structure. Each layer contributes to the overall resistance, and their individual thermal conductivities and thicknesses must be taken into account.

By accurately calculating the heat transfer resistance, engineers and architects can assess the thermal performance of the wall structure and make informed decisions regarding insulation materials, thicknesses, and design strategies.

Understanding the heat transfer characteristics of the wall structure is crucial for optimizing energy efficiency, reducing heat loss, and ensuring occupant comfort.

In summary, the estimation of characteristics such as density, thickness, and thermal conductivity is integral to calculating the heat transfer resistance of thermally homogeneous, multilayer, opaque enclosing structures. By applying the appropriate formula, the heat transfer resistance can be determined, enabling informed decisions to be made regarding insulation and design strategies to achieve optimal energy efficiency and thermal performance.

$$R_{\Sigma} = \frac{1}{\alpha_B} + \sum_{i=1}^{n} \frac{\delta_i}{\lambda_{ip}} + \frac{1}{\alpha_3} \tag{2.2}$$

Formula contains The thermal conductivity (λ_{ip}) refers to the ability of the material in the i-th layer of the structure to conduct heat, taking into account the specific operating conditions that have been calculated; α_B, α_3 – The heat transfer coefficients of the interior and exterior surfaces of the enclosing structure are expressed in units of W/(m²K). Respectively α_B=8,7 W/(m²K), α_3=23 W/(m²K).

Following the design solution of the enclosing structure, we can express the formula for calculating the heat transfer resistance. By substituting the values of the estimated characteristics into the formula, we can obtain the specific heat transfer resistance value for the given wall structure. For the wall structure under consideration, with estimated characteristics including density ($\rho = 80\ \mathrm{kg/m^3}$), thickness ($\delta = 0.26\ \mathrm{m}$), and thermal conductivity ($\lambda = 0.041\ \mathrm{W/(m^2K)}$), the heat transfer resistance can be calculated as:

$$R\ =\ 6.5\ m^2K/W. \tag{2.3}$$

This calculated heat transfer resistance value provides crucial information about the thermal performance and energy efficiency of the enclosing structure, aiding in the selection of suitable insulation materials and design optimizations.

Therefore, by utilizing the appropriate formula and plugging in the specific values of the estimated characteristics, we can determine the heat transfer resistance, allowing for informed decisions and improvements in the design of the enclosing structure to enhance its thermal efficiency.

This wall structure fully satisfies the requirements of thermal insulation, as evidenced by the calculated value of the heat transfer resistance exceeding the normative value. To elaborate on the technical aspects, the heat transfer resistance of a wall structure can be determined by considering its thermal conductivity, thickness, and surface area. By analyzing these parameters, one can calculate the amount of heat transferred through the structure per unit time.

In the present case, the calculated value of the heat transfer resistance for the accepted wall structure surpasses the normative value. This outcome indicates that the structure efficiently inhibits heat transfer, thus fulfilling the thermal insulation requirements. By exceeding the normative value, the wall structure demonstrates enhanced thermal resistance, minimizing heat flow and maintaining optimal thermal conditions within the enclosed space.

CHAPTER 3. STRUCTURAL DESIGN

3.1. Load calculation

During the engineering calculation of the building, much attention is paid to the load collection on the structures. It is a process that includes the analysis and consideration of various factors affecting the safety and stability of the building.

One of the main features of load collection is the distinction between static and dynamic loads. Static loads include permanent forces, building weight, loads from equipment and materials placed inside the building. Dynamic loads arise as a result of movement, vibrations, wind, seismic shocks and other dynamic factors.

Another important feature is the distribution of the load on different structures of the building. Depending on the functional purpose of the building, different structural elements can bear different loads. For example, walls can bear vertical load, roof - horizontal, foundation - vertical and horizontal load.

Additional factors such as temperature fluctuations, soil shifts, expansion and contraction of materials, corrosion and other external influences are also taken into account during load collection. These factors have a significant impact on the durability and stability of the building, so they must be taken into account during load collection.

The compilation of load calculations for every 1 m^2 of the floor is presented in table 3.1.

The placement of the projected slab span is determined when it is supported by the walls of the floor. The estimated span is considered in this scenario:

$$l = 6.3 - 0.12 - 0.17 = 6.01\ m.$$

Table 3.1

The load characteristics and design load for each square meter of floor area

Load	Characteristic load N/m²	Load reliability factor γ_{fm}	Estimated load, N/m²
Constant: Own weight of a multi-hollow slab with round cavities	3000	1.1	3300
Also, a layer of cement mortar δ = 30mm, ($\rho = 2200\ kg/m^3$)	660	1.3	858
Also, ceramic tiles, $\delta = 13\ mm$, ($\rho = 1800\ kg/m^3$)	240	1.1	264
Total	3900	—	4422
Variable load	2000	1.2	2400
Full load	5900	—	6822

The projected load for a 1-meter span with a slab width of 1.5 meters, considering the building's reliability factor $\gamma n=1$:

– constant load:

$$g = 4.422 \cdot 1.5 \cdot 1 = 6{,}633\,\frac{kN}{m};$$

– characteristic load:

$$g + v = 6.822 \cdot 1.5 \cdot 1 = 10{,}233\,\frac{kN}{m};$$

$$v = 6.0 \cdot 1.5 \cdot 1 = 9.0\,\frac{kN}{m}.$$

Characteristic load per 1 m:

– constant load:

$$g = 3.9 \cdot 1.5 \cdot 1 = 5.85\ kN/m;$$

– full load:

$$g + v = 5.9 \cdot 1.5 \cdot 1 = 8.85\ kN/m;$$

Forces resulting from design loads and characteristic loads.

Derived from the design load.

$$M = (g + v)\,\frac{l_0^2}{8}, \qquad (3.1)$$

where $(g + v)$ – full load, kN/m;

l_0 – estimated span, m

$$M = 6.822\,\frac{6.01^2}{8} = 30.8\ kNm;$$

$$V = (g + v)\,\frac{l_0}{2}, \qquad (3.2)$$

$$V = 6.822\frac{6.01}{2} = 20.5\ kN$$

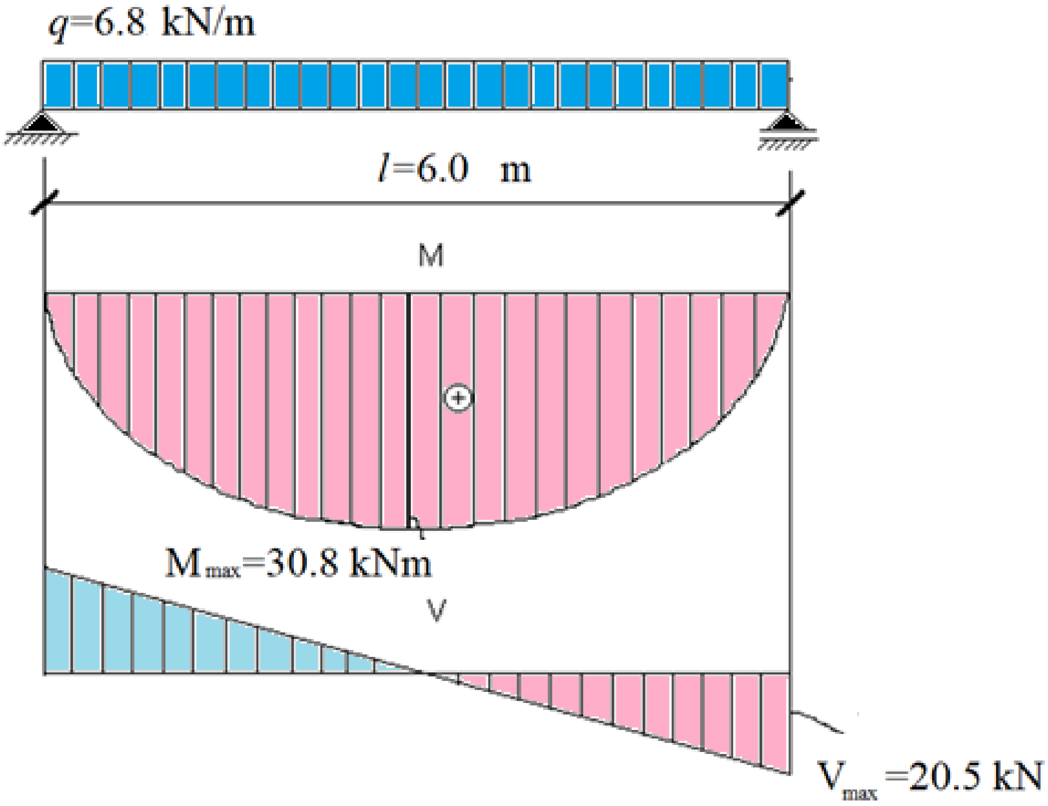


Fig. 3.1. Calculation of design forces M and V.

From the characteristic full load:

$$M = 5.9\frac{6.01^2}{8} = 24.05\ kNm;$$

$$V = 5.9\frac{6.01}{2} = 16.84\ kN$$

From characteristic constant and long loadings:

$$M = 15.0\frac{6.01^2}{8} = 76.3\ kNm$$

3.2. Performing calculations for the column

When it comes to industrial buildings, performing accurate calculations for the steel columns is of utmost importance. These calculations are crucial in ensuring the structural integrity, stability, and safety of the entire building.

The process of performing calculations for steel columns involves a comprehensive analysis of various factors. Firstly, the load-bearing capacity of the column is assessed by considering the anticipated loads that the column will be subjected to during its operational lifespan. These loads may include static loads, such as the weight of the building itself, as well as dynamic loads caused by machinery, equipment, and other moving components within the industrial facility.

In addition to load considerations, other factors that are taken into account during the calculation process include the column's dimensions, material properties, and the specific requirements and standards outlined by engineering codes and regulations. The dimensions of the column, such as its cross-sectional area, height, and moment of inertia, directly affect its load-carrying capacity and overall structural behavior.

The material properties of the steel column, including its yield strength, modulus of elasticity, and other mechanical properties, are carefully evaluated. These properties determine the column's ability to resist loads, deformations, and other stresses that may occur during its service life.

Moreover, the calculations for steel columns in industrial buildings also consider various design constraints, such as allowable deflections, stability requirements, and factors of safety. The goal is to ensure that the column can withstand the applied loads without experiencing excessive deflections or buckling under compression forces.

To perform these calculations, engineers utilize advanced mathematical models, structural analysis software, and industry-specific formulas. The calculations are typically performed in accordance with established engineering principles and guidelines to ensure accuracy and reliability.

Once the calculations are complete, engineers can determine the required size, shape, and reinforcement details for the steel column to meet the structural design criteria. These specifications are then used during the fabrication and construction processes to ensure that the column is built according to the calculated requirements.

In conclusion, performing calculations for steel columns in industrial buildings is a complex and critical task. By considering loads, dimensions, material properties, design constraints, and utilizing advanced engineering tools, engineers can accurately determine the optimal design of the steel column, ensuring the overall safety and performance of the industrial structure.

The design incorporates the following data:

Pipe parameters:

– The thickness of the pipe wall

$tp = 0.8\,cm = 0.8 / 100 = 0.008\,m$;

– The external diameter of the tube

$Dp = 32.5\,cm = 32.5 / 100 = 0.325\,m$;

Effort:

– axial force

$N = 34.97626 / 101.97162123 = 0.343\ MN$;

– bending

$M = 5.20055 / 101.97162123 = 0.051\ MN\,m;$

Characteristics of the steel tube include:

Temporary rupture resistance of the steel tube: 370 MPa

Estimated shear resistance of the steel tube: 124 MPa

Calculated tensile, compressive, and bending resistance based on the temporary resistance of the steel tube: 350 MPa

Flow limit of the steel tube: 225 MPa

Estimated tensile, compressive, and bending resistance of the steel tube beyond the flow limit: 215 MPa

Reliability ratio and working conditions:

Reliability ratio for calculations based on temporary resistance: 1.3

Coefficient for concrete working conditions, considering the influence of additional factors: 1

Characteristics of the concrete:

Concrete class: C20/25

Heavy concrete

Normative value of concrete resistance to axial compression: 18.5 MPa

Estimated resistance of concrete to axial tension: 1.05 MPa

Estimated concrete resistance to axial compression: 14.5 MPa

Normative value of concrete resistance to axial tension: 1.55 MPa

The radius of the concrete core. The radius of the concrete core refers to the distance from the center of the cross-section of a concrete element, such as a column or a beam, to the outer edge of the concrete. It represents the distance from the centerline of the reinforcing steel bars or any other structural elements within the concrete to the outer surface of the concrete element. The radius of the concrete core is an essential parameter used in structural analysis and design calculations to determine the behavior and capacity of the concrete element under different loading conditions.

$$r_b = (D_p - 2\,t_p)/2 = (0.325 - 2 \cdot 0.008)/2 = 0.1545\ m = 15.4\ \ cm.$$

Concrete core diameter:

$$D_b = 2\,r_b = 2 \cdot 0.1545 = 0.309\ m = 30.9\ cm. \quad (3.3)$$

The area of the cross-section of the metal pipe:

$$A_p = p/4\,(D_p{}^2 - D_b{}^2) = 3{,}14159/4 \cdot (0{,}325^2 - 0{,}309^2) = = 79.7\ cm^2. \quad (3.4)$$

The approximate strength of the metal pipe under a uniaxial stress condition is 215 MPa.

The computed value for the concrete's resistance to axial stretching for the boundary states of the second group is 1.55 MPa.

The strain modulus of the concrete, which is determined based on the load duration and the presence of cracks, is Eb1 = 0.85 Eb = 25500 MPa.

The moment of inertia of the concrete section refers to a property that quantifies how the mass of the concrete is distributed around a specific axis. It is a measure of the resistance of the concrete section to bending and torsional forces. The moment of inertia depends on the shape and dimensions of the concrete section and is commonly used in structural engineering calculations to determine the structural response and behavior of concrete elements under loading conditions. It plays a critical role in analyzing and designing beams, columns, and other structural components made of concrete. The moment of inertia of the concrete section with respect to the centroid of the given cross-section is calculated as follows:

$$I = p\ (D_p - 2\ t_p)^{\ 4}/64 =$$
$$= 3{,}14159 \cdot (0{,}325 - 2 \cdot 0{,}008)^{\ 4}/64 = 44751 \quad cm^{\ 4} \tag{3.5}$$

The moment of inertia of the pipe section refers to a property that characterizes the distribution of mass around a specific axis of a pipe. It quantifies the resistance of the pipe section to bending and torsional forces. The moment of inertia depends on the dimensions and shape of the pipe, such as its outer diameter and wall thickness. It is an important parameter used in structural analysis and design calculations to assess the structural behavior and strength of pipes under different loading conditions. The moment of inertia is particularly relevant for analyzing the deflection, stress distribution, and stability of pipe structures in various engineering applications. Moment of inertia of the pipe section:

$$I_p = p\ (D_p^{\ 4} - (D_p - 2\ t_p)^{\ 4})/64 =$$
$$= 3{,}14159 \cdot (0{,}325^{\ 4} - (0.325 - 2 \cdot 0.008)^{\ 4})/64 = 10014 \quad cm^4 \tag{3.6}$$

The moment of inertia of the specific section of the element with respect to its centroid:

$$I_{red} = I + I_p\ a_p =$$
$$= 0.000447511 + 0.000100139 \cdot 8.07843 = 126{,}000\ cm^{\ 4} \tag{3.7}$$

The coefficient for connecting the steel pipe to the concrete:

$$a_p = E_p\ /\ E_{b1} = 206000/25500 = 8{,}07843 \tag{3.8}$$

The surface area of the provided cross-section:

$A_{red} = A_b + A_p\, a_p$ = 0.07499+0.00797 · 8.07843 = 0.13938 m^2 = 1393.8 cm^2

The highest tensile stresses experienced by the concrete due to stretching:

$$s_{bt}, \max = -N/A_{red} + M/I_{red}\,(D_p - 2\,t_p)/2 =$$

$$= -0{,}343/0{,}13938 + 0{,}05162/0{,}00126 \cdot (0.325 - 2 \cdot 0.008)/2 = 3.87\ MPa \qquad (3.9)$$

The radius of energy of the given cross-section:

$$i_{red} = \sqrt{I_{red} / A_{red}} = \sqrt{0{,}00126 / 0{,}13938} = 9{,}51\ см. \qquad (3.10)$$

As sbt, max (3.8687 MPa) is greater than Rbt, ser (1.55 MPa), cracks will form.

The moment of inertia of the concrete section with respect to the centroid of the given section is calculated as follows:

$I = p\,(D_p - 2\,t_p)^4/64$ = 3.14159 · (0,325–2 · 0,008)^4/64 = 44751.1 cm^4

The moment of inertia of the specified section of the element in relation to its centroid:

$I_{red}[p] = a_b[p]\, I + I_p$ = 10013.9 cm^4

The area of casting the cross-section of the element:

$A_{red}[p] = a_b[p]\, A_b + A_p$ = 79.7 cm^2

The radius of energy given to the metal pipe section:

$$i_{red}[p] = \sqrt{I_{red}[p] / A_{red}[p]} = \sqrt{0{,}000100139 / 0{,}00797} = 11{,}21\ см. \qquad (3.11)$$

The longitudinal displacement from the center of gravity of the given section $e_o = M/N = 0.051/0.343 = 0.14869\ m = 14.87\ cm.$

Random eccentricity:

$$e_a = \max(l/600; D_p/30; 0.01) = \max(4/600; 0.325/30; 0.01) = 0.01083\ m = 1.08\ cm.$$

For elements within statically indeterminate structures, the eccentricity of the longitudinal force is determined relative to the center of gravity of the given cross-section. This eccentricity value is derived from the static calculation and is set to be equal to or greater than the minimum eccentricity value, denoted as "e a."

Subsequently, the length of the non-center-compressed element is estimated. It is assumed that one end of the element has a flexible hinge connection, while the other end has a rigid connection.

Continuing the calculation, since the ratio lo/ired is determined to be 6/0.11, which equals 53.53, and is greater than 12, further analysis can be conducted.

The estimated length of the element, lo, is calculated as 1.5 times the standard length, l, resulting in lo = 1.5 * 4 = 6 meters, or 600 centimeters.

Finally, the moment relative to the center is evaluated for the most stretched or least compressed rod under the influence of constant and prolonged loads:

$$M_{l1} = abs\ (M_l) + N_l\, r_s = abs\ (0.05162) + 0.343 \cdot 0.2 = \\ = 0.12\ MN\ m \quad (3.12)$$

The moment with respect to the center of the most elongated or least compressed rod due to the complete load:

$$M_1 = abs(M) + N\, r_s = abs\,(0.051) + 0.343 \cdot 0.2 = 0.12 \;\; MN\, m \qquad (3.13)$$

The coefficient that considers the influence of the load duration:

$$f_l = 1 + M_{l1}/M_1 = 1 + 0{,}12022/0{,}1196 = 2 \qquad (3.14)$$

Factor:

$d_e = e_o/D_p = 0{,}14869/0{,}325 = 0{,}45751.$

$k_b = 0{,}15/\,(f_l\,(0{,}3 + d_e)) = 0{,}15/(2 \cdot (0{,}3 + 0{,}45751)) = 0{,}09901.$

$k_s = 0{,}7.$

Eccentricity:

$e = e_o = 0.14869\, m = 14.87\, cm.$

Since

$(1-7.5\, e/\,(D_p - 2\, t_p)) = (1-7.5 \cdot 0.14869/\,(0.325-2 \cdot 0.008)) = -2.60898 < 0,$

Subsequently, the determined compressive resistance of the concrete in the pipe-concrete element is 215 MPa.

Bending stiffness:

$$D_1 = k_b\, E_{b1}\, I + k_s\, E_p\, I_p =$$

$$= 0{,}09901 \cdot 0 \cdot 0{,}000447511 + 0{,}7 \cdot 206000 \cdot 0{,}000100139 = \qquad (3.15)$$

$$= 14.44 \;\; MN\, m^2$$

$$D_2 = k_b\, E_{b1}\, I + l_o^{\,2}/p^{\,2}\, R_{pc}\, A_p =$$

$$= 0{,}09901 \cdot 0 \cdot 0{,}000447511 + 6^{\,2}/3{,}14159^{\,2} \cdot 215 \cdot 0{,}00797 = \qquad (3.16)$$

$$= 6.25\, MN\, m^2$$

$D = \min\,(D_1; D_2) = \min\,(14.44004; 6.25028) = 6.25\, MN\, m^2.$

Critical force:

$$N_{cr} = p^2 D/l_o^2 = \\ =3.14159^2 \cdot 6.25028/6^2 = 1.7\ MN \tag{3.17}$$

Then

N = 0.34 MN, which is less than $N_{cr} = 1.7\ MN$ (20% of the limit value), the condition is satisfied.

Calculation of the concrete's calculated resistance is determined based on the following considerations:

Since

$t_p/D_p = 0.008/0.325 = 0.02462.$

Factor:

$c = 25.$

Limit bending moment:

$M_{ult} = 2/3 \cdot 0{,}1545^3 \cdot 14{,}5 \cdot \sin(1{,}2621)^3 + 1/3{,}1 \cdot 0{,}008 \cdot 0{,}16 \cdot \sin(1{,}2621) \cdot (215+215) = 0.196\ MN\ m$

$M = 0.051\ MN\ m < M_{ult} = 0.196\ MN\ m$ (26.1% of the threshold) —

the condition is met.

CHAPTER 4. TECHNOLOGY OF CONSTRUCTION

4.1. Field of application

The advanced technology used for the construction of the final product - a single building - includes the installation of steel columns with weights of 314.9 kg, 316.2 kg, 316.2 kg, and 285.5 kg.

Additionally, the technology involves the installation of steel support plates.

4.2. Characteristics of structures to be installed

During the installation of the framework for a single-story industrial building, there are several specific aspects that need to be considered. One of the main aspects is the choice of installation technology, which ensures the efficiency and reliability of the process.

First and foremost, it is necessary to consider the characteristics of the framework itself. It may consist of steel columns, beams, and trusses that provide the necessary strength and stability to the building. The framework can be preassembled off-site or assembled on-site. In either case, adherence to the specified technical requirements and standards is crucial to ensure the quality of the installation.

The second important aspect is proper planning and organization of the installation work. This includes the layout of materials and equipment at the construction site, the installation of the framework according to the design drawings and sequence of operations. Additionally, ensuring the safety of workers during the installation by complying with workplace safety requirements and using appropriate protective equipment is essential.

The third aspect is the use of specialized equipment for framework installation. This can include crane mechanisms for lifting heavy framework components, fastening devices for connecting framework elements, and other technical means that facilitate and expedite the installation process.

Furthermore, specific requirements for foundation installation and connecting the framework to it should be taken into account. The foundation needs to be sufficiently strong and stable to withstand the loads from the building's framework. Various types of foundations, such as pad foundations, monolithic strip foundations, or pile foundations, can be used depending on the soil conditions and project requirements.

Moreover, the installation of the framework requires coordination and collaboration among different subcontracting organizations, such as installation teams, material suppliers, and engineers. This ensures a smooth and efficient installation process while adhering to the schedule and quality standards.

One of the key features of installing the framework for an industrial building is the need for precise alignment and positioning of the framework elements. This requires high accuracy and attention to detail, as incorrect alignment can affect the strength and stability of the building.

Additionally, it is important to consider fire safety requirements and overall safety during the framework installation. This may include the use of fire-resistant materials, installation of fire suppression systems, and adherence to relevant safety regulations and standards.

In conclusion, the installation of the framework for a single-story industrial building is a complex technological process that requires attention to detail, coordination of work, and adherence to safety and quality requirements.

The table shows the specification of structures for the setting up in which this technology is developed.

Table 4. 1

Installation element specification

Item Name	Mark	Quantity, pcs.	Mass of elements, t	
			One	All
Support plate	–	16	0.64	10.3
Together				10.3
Column	K – 1 K – 2 K – 3 K – 4	8 2 2 4	0.32 0.316 0.316 0.286	2.52 0.63 0.63 1.14

4.3. The configuration of the elaborate procedure and the extent of tasks

The installation of a steel framework for a single-story industrial building involves a complex process and a wide scope of work. This undertaking encompasses various stages and activities that contribute to the successful assembly of the structure.

The first step in the installation process is the preparation of the construction site. This includes clearing the area, leveling the ground, and ensuring proper access for equipment and materials. Site preparation is crucial as it sets the foundation for the subsequent construction activities.

Once the site is ready, the next phase involves the assembly of the steel framework. This typically begins with the erection of steel columns, which provide the vertical support for the structure. The columns are positioned according to the engineering drawings and securely anchored to the foundation. Precision and accuracy are essential during this stage to ensure the proper alignment and stability of the columns.

After the columns are in place, horizontal beams and trusses are installed to create the skeletal framework of the building. These components are connected to the columns using appropriate fastening techniques, such as welding or bolting. Careful attention is given to ensure the structural integrity and load-bearing capacity of the framework.

In addition to the primary framework elements, secondary elements are also incorporated into the structure. These may include purlins, girts, and bracing systems, which provide additional support and stability to the framework. The installation of these elements requires meticulous alignment and proper attachment to ensure the overall strength and rigidity of the building.

Once the framework is complete, the next phase involves the installation of roofing and wall cladding systems. This includes the placement of roof panels, insulation materials, and exterior cladding. Proper installation techniques are employed to achieve weather-tightness, thermal insulation, and aesthetic appeal.

Electrical and mechanical systems are integrated into the framework during the subsequent stage of the installation process. This includes the routing of electrical wiring, installation of lighting fixtures, and incorporation of HVAC (Heating, Ventilation, and Air Conditioning) systems. Careful coordination and adherence to safety standards are necessary to ensure the proper functioning and efficiency of these systems.

Furthermore, the installation of doors, windows, and other architectural features is carried out to complete the building envelope. Attention is given to the proper sealing and alignment of these components to maintain the desired level of thermal insulation, security, and aesthetic appeal.

Throughout the entire installation process, quality control measures are implemented to verify compliance with design specifications and industry standards. This includes inspections, testing, and documentation of various aspects such as material quality, welding integrity, and structural stability. Any necessary adjustments or corrections are made to ensure the overall quality and safety of the completed structure.

It is important to note that the complexity and scope of work involved in installing a steel framework for a single-story industrial building may vary depending on the specific project requirements, design complexity, and site conditions. Close collaboration among architects, engineers, contractors, and other stakeholders is crucial to ensure effective project management, efficient workflow, and successful completion of the structure.

In summary, the installation of a steel framework for a single-story industrial building is a comprehensive process that encompasses various stages and activities. From site preparation to the assembly of primary and secondary framework elements, the installation process requires meticulous attention to detail, adherence to engineering standards, and close coordination among multiple disciplines. The successful execution of these tasks results in a robust and functional structure that meets the specific needs of the industrial facility.

The arrangement of the intricate procedure involved in installing steel columns is defined by the individual operational processes.

Table 4. 2

The organization of the intricate procedure for installing steel columns

№	Name of process	Unit of measurement	Count record	Quantity
1	Unloading components using a crane	100 t	$(0.32 \times 8 + 0.32 \times 2 +$ $+0.32 \times 2 + 0.2$ $86 \times 4 + 10.3)/100$	0.15
2	Mounting steel anchor plates	1 cooker	16	16
3	Securing steel support plates in position	1 cooker	16	16
4	Pouring concrete mixture beneath the slabs	1 m^3	0.03×16	0.45
5	Assembling and erecting columns	Piece.	16	16
		1 t	15.2	15.2
6	Installing and securing bolts	100 pcs.	$4 \times 16/100$	0.64

4.4. Choosing appropriate crane and lifting equipment for installation

Choosing the right crane and lifting equipment is a crucial aspect when it comes to the installation process of a single-story industrial building with a steel frame. The successful and efficient completion of the construction project greatly depends on the selection of appropriate machinery that can handle the required tasks safely and effectively.

First and foremost, it is important to consider the specific requirements of the construction site and the characteristics of the steel frame. Factors such as the weight and dimensions of the steel components, as well as the height and reach needed for installation, play a significant role in determining the type of crane and lifting equipment that should be used.

The selection process involves evaluating various aspects, including the load capacity and lifting capabilities of the equipment. The crane must have the necessary lifting capacity to handle the heaviest steel components, such as columns, beams, and trusses. Additionally, the crane's boom length and reach should be sufficient to safely maneuver and position the loads at the desired locations within the construction site.

Another important consideration is the mobility and maneuverability of the crane. The layout and terrain of the construction site need to be taken into account to ensure that the crane can access all required areas without any restrictions or obstacles. This may involve considering factors such as the presence of nearby structures, overhead power lines, or uneven ground conditions.

In addition to the crane, other lifting equipment may be required for specific tasks during the installation process. This could include hoists, slings, chains, or rigging equipment, depending on the nature of the components and the installation method. The equipment must be selected based on their compatibility with the crane and their ability to securely lift and position the steel elements.

Safety is of paramount importance in any construction project, and the selection of appropriate lifting equipment is no exception. It is essential to choose equipment that complies with relevant safety standards and regulations. Additionally, the operators of the machinery should be properly trained and certified to ensure safe operation and minimize the risk of accidents or damage to the structure.

Furthermore, it is advisable to involve experienced professionals, such as structural engineers or crane specialists, in the selection process. Their expertise can provide valuable insights and guidance in choosing the most suitable crane and lifting equipment based on the specific requirements of the project.

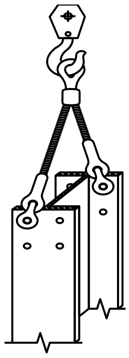
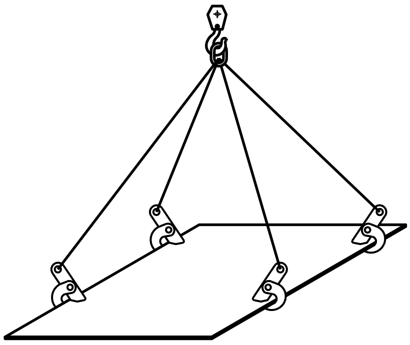
In conclusion, selecting the appropriate crane and lifting equipment is a critical decision in the installation of a single-story industrial building with a steel frame. Factors such as load capacity, mobility, safety, and compatibility with other equipment should be carefully considered to ensure the smooth and successful execution of the construction project. By making informed choices, construction teams can optimize efficiency, productivity, and safety during the installation process

4.4.1. Choosing suitable lifting equipment for handling loads.

When it comes to erecting structures as outlined in the specifications, it is important to carefully select appropriate load-lifting devices that consider the specific characteristics of the project.

Table 4. 3

Cargo-lifting devices

Appointment	*Name*	*Schematic diagram*	*Carrying capacity, t*	*Own mass, t*	*Estimated height, m*
1	2	3	4	5	6
Slinging steel columns	Universal sling		4	0.1	1
Slinging of supporting plates	Sling 4-branch		3	0,1	2,4

4.4.2. Specify mounting parameters.

When choosing the appropriate mounting cranes and load-lifting devices for the assembly of a steel frame in a single-story industrial building, several factors must be carefully considered. This process is crucial to ensure the safe and efficient lifting and placement of structural elements.

One of the primary considerations is the lifting capacity of the cranes. They need to be capable of handling the weight of the heaviest components, such as steel beams and columns, with an appropriate safety margin. The lifting capacity is determined based on the maximum anticipated loads during the assembly process.

The reach of the cranes is another important factor to consider. It should be sufficient to accurately and safely position the components. The dimensions and layout of the construction site, as well as any obstacles or restrictions that may affect crane movement and reach, must be taken into account.

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

In addition to cranes, load-lifting devices like 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 considered when choosing load-lifting devices.

Compliance with relevant regulations and standards is also a crucial part of the selection process. Engineering codes specify minimum requirements for equipment selection, load capacity calculations, and safety measures. Adhering to these regulations ensures the safe execution of the assembly process.

Considerations related to crane operation and maneuverability should not be overlooked. Operator experience and training, equipment maintenance, and site logistics play significant roles 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. Factors like weather conditions, ground stability, and nearby structures or utilities that may affect crane operations should be evaluated.

Regular inspections and maintenance of the chosen cranes and load-lifting devices are essential to ensure their ongoing 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.

In order to choose crawler cranes, the load characteristics were calculated based on the heaviest component, which is the column.

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

$$Q_{г} = m_{е} + m_{ст} = 0.32 + 0.08 = 0.4 \text{ т}, \quad (4.1)$$

where – $m_{е}$ the mass of the element, t;

$m_{ст}$ – strop mass (traverse), t;

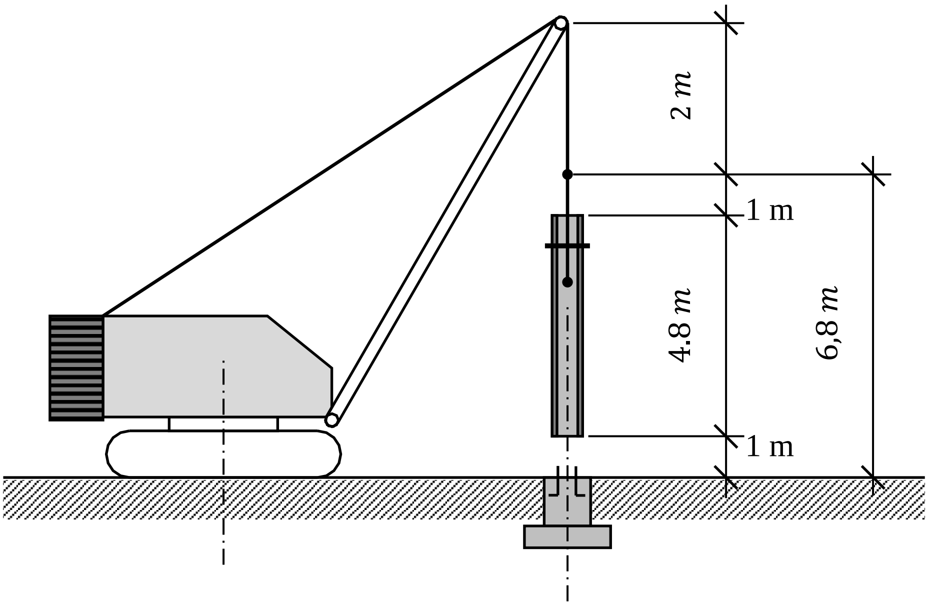


Fig. 3.1. Calculate the necessary technical specifications for the boom crawler crane

When choosing a mounting crane, an important factor to consider is the elevation of the hook. The hook elevation refers to the distance between the crane's base or the ground and the lowest point of the hook when it is fully extended. This measurement is critical as it determines the crane's maximum vertical reach and its ability to lift and position components at different heights.

Several factors influence the hook elevation, including the height of the building or structure being constructed, the desired clearance between the ground and lifted objects, and any overhead obstructions that may restrict the crane's vertical movement. It is essential to ensure that the selected crane has a suitable hook elevation to facilitate the safe and efficient lifting and placement of the required components within the desired construction height.

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

By carefully evaluating the hook elevation and ensuring it meets 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 elevation may be necessary throughout the construction process to accommodate changes in elevation or modifications to the project's design.

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

$$H_{\text{г}} = h_0 + h_{\text{з}} + h_{\text{е}} + h_{\text{ст}} = 0 + 1 + 4.8 + 1 = 6.8\,m, \quad (4.2)$$

Where, The vertical distance between the crane's parking level and the height of the mounting element's support is measured, m;h_0

$h_{\text{з}}$ – height reserve for the safety of installation;$h_{\text{з}} = 1$ м

$h_{\text{ст}}$ – the height of slinging, m;

$h_{\text{е}}$ – height or thickness of the element, m.

The crane hook radius, denoted as Lг, is determined to be 5.8 meters based on the arrangement of the columns.

When determining the appropriate length of the boom for a self-propelled crane employed in the installation of a single-story industrial building frame, several key factors must be considered to optimize performance and ensure operational safety.

Firstly, the height of the structure being erected is a primary consideration. The boom length should be selected to facilitate the elevation necessary for lifting and placing the building's structural components. Careful attention must be given to the dimensions of columns, beams, and other elements, ensuring that the boom possesses sufficient reach and maneuverability to navigate around them effectively.

Another significant factor is the crane's reach capability. The boom's length should enable precise positioning of components at various locations within the construction site. This necessitates a thorough evaluation of the building's layout, considering potential obstructions or obstacles that may restrict the crane's movement.

The weight and size of the components being lifted are crucial considerations when determining the appropriate boom length. Longer booms generally offer increased lifting capacities, facilitating the handling of heavier loads. However, engineers must strike a balance between boom length, crane stability, and maneuverability to optimize performance.

Site conditions also influence the selection process. Factors such as uneven terrain, confined spaces, or restricted access areas may necessitate specific boom lengths to ensure safe and efficient operations. A comprehensive site assessment should be conducted, accounting for potential challenges that may impact crane performance.

Lastly, strict adherence to safety regulations and standards is of paramount importance. The chosen boom length must align with manufacturer guidelines and industry regulations to guarantee safe crane operations and mitigate the risk of accidents.

In conclusion, the selection of the boom length for a self-propelled crane during the installation of a single-story industrial building frame entails a meticulous evaluation of factors including structure height, reach requirements, component weight, site conditions, and safety considerations. By carefully considering these aspects, engineers can determine the optimal boom length that ensures the efficient and secure assembly of the building frame.

The length of the boom is determined by the formula, m:

$$L_с = \frac{H_г + h_п + h_с}{\sin \alpha} = \frac{6.8 + 2 - 1.5}{0,81} = 9\ m, \tag{4.3}$$

where the measurement from the axis of the boom mounting to the height of the crane's parking level is a crucial parameter to consider;$h_с = 1,5 \div 2$ м

$h_п = 2 \div 5$ м – The length of the cargo tackle system of the crane should be taken into account;

α – The ideal angle of inclination of the crane boom relative to the horizon should be considered.

Based on the calculation results, two crane options were initially chosen for the alternative design.

Table 4. 4

The cranes were initially selected based on their calculated parameters

Name of cargo	Calculation parameters				Crane Options				
	The required load capa	Required crane hook li	The required radius of	Boom length required	Type, brand	Payload Q, т	Hook lifting height H, м	Crane hook radiusL, м	Arrow length L_c, м
1	2	3	4	5	6	7	8	9	10
Column	0,4	6,8	5,8	9,1	MCG-25.01	15	13	5,8	14,4
					RDK-250	11,7	11	5,8	12,5

The crane's cargo characteristics are presented in the graphical section of the technical documentation. When considering two cranes with identical load capacities, the selection is made based on economic factors, aiming for minimal costs. Following the necessary calculations, a comparative analysis is conducted.

4.4.3. Choice of vehicles.

The transportation of building structures to construction sites is a complex undertaking that requires meticulous planning and consideration of various factors. One crucial aspect of this process is the selection of appropriate vehicles to facilitate the transportation of construction components. This selection process plays a pivotal role in ensuring the safe and efficient delivery of the materials, as well as preserving their integrity throughout the journey.

When choosing vehicles for the transportation of building structures, several key factors come into play. Firstly, the dimensions and weight of the construction elements must be carefully assessed. This information helps determine the type and size of vehicles that can accommodate and safely transport the materials. Oversized or overweight components may require specialized transport solutions, such as flatbed trucks or heavy-duty trailers, to ensure their secure and stable transportation.

Another vital consideration is the distance that needs to be covered during transportation. Long-distance hauls may necessitate vehicles with enhanced fuel efficiency or larger storage capacities to minimize the number of trips required. Additionally, the nature of the terrain should be taken into account. Construction sites located in remote or challenging areas, such as mountainous regions or rough terrains, may require vehicles with robust off-road capabilities to navigate through difficult conditions.

Logistical constraints, such as road regulations, access limitations, or time constraints, also play a significant role in vehicle selection. For instance, certain areas may have restrictions on the weight or size of vehicles allowed on specific roads or bridges. Additionally, tight deadlines may require the use of vehicles with faster transportation speeds or the availability of multiple vehicles to expedite the delivery process.

Load capacity is a critical factor when selecting vehicles. It determines the maximum weight that can be safely carried by a vehicle without compromising its stability or structural integrity. The vehicles must be capable of handling the weight of the construction components and distributing the load evenly to prevent any damage or accidents during transportation. Moreover, the compatibility of the vehicles with the construction materials is crucial. Specialized materials, such as fragile or sensitive components, may require vehicles equipped with features like cushioning or climate control to protect them from vibrations, impacts, or adverse weather conditions.

To ensure an optimal vehicle selection process, thorough research and reference literature examination are essential. Industry standards, guidelines, and best practices can provide valuable insights into the appropriate types and brands of vehicles suitable for specific transportation requirements. By leveraging this knowledge, construction professionals can make informed decisions that align with the unique needs of each project.

Furthermore, the determination of the number of vehicles and the laying method of the elements depends on the parameters outlined in the vehicle's passport. This document contains vital information about the vehicle's technical specifications, including load capacity, dimensions, and weight restrictions. By closely adhering to these parameters, construction teams can effectively plan the logistics of transporting the building structures and optimize the utilization of resources.

In conclusion, the selection of suitable vehicles for the transportation of building structures is a critical aspect of construction logistics. By carefully considering factors such as dimensions, weight, distance, terrain, and logistical constraints, construction professionals can identify the most appropriate vehicles to ensure the safe and efficient delivery of materials to the construction site. Thorough research, adherence to industry standards, and the utilization of vehicle passports are instrumental in making informed decisions and optimizing the transportation process.

Table 4. 5

Choice of vehicles

Name of the transported structure	Mass of construction. t	Dimensions of the structure. m $H \times b \times h$	Vehicle brand	Carrying capacity q . t	Cargo transported		Factor $K_т$
					N, pcs.	Q, t	
$К-1$; $К-2$; $К-3$; $К-4$	0.315; 0.316; 0.316; 0.286	$4.8 \times 0.28 \times 0.28$; $10.105 \times 0.28 \times 0.28$; $11.2 \times 0.28 \times 0.28$; $6.7 \times 0.28 \times 0.28$	Semi-trailer UPR-1212M and tractor MAZ-6422	12	8; 2; 2; 4	2.52; 0.63; 0.63; 1.14	0.2; 0.05; 0.05; 0.09

The selection of vehicles was conducted by considering the utilization ratio of each vehicle $K_т$:

$$K_т = \frac{Q}{q} \leq 1, \quad (4.4)$$

where Q – the cargo being transported, t;

q – load capacity of the vehicle, t.

4.5. Organization and technology of work

During the installation of steel structures, strict adherence to the regulations outlined in the DBN A.3.2-2-2009 "System of labor safety standards. Industrial safety in construction. the main provisions" is of utmost importance. These regulations provide essential guidance to ensure the safety and quality of the installation process.

The installation procedure for resistance slabs involves securing them to the foundation using three connection bolts, which are threaded into nuts welded to the stove. Once positioned, the slabs undergo calibration and are secured against upward movement by employing spacer tubes. These tubes are placed over anchor bolts, with their lower ends resting on strips equipped with welded holes, affixed to the bottom of the resistance plate. The upper ends of the tubes are then firmly clamped using nuts fastened onto the anchor bolts.

To form the resistance plates, a solution is poured and allowed to solidify. After the solution has fully cured, the spacer tubes are detached from the anchor bolts, and the strips are welded to the anchor bolts to provide additional reinforcement.

Before commencing the lifting process, meticulous preparations are made for the columns. This includes the installation of ladders with stands to facilitate access and maneuverability. The column setup procedure encompasses several sequential operations, namely slinging, transitioning from a horizontal to a vertical position, elevation to the designated height on the foundation, and subsequent lowering onto the foundation.

Once the columns are correctly positioned, they are secured by fixing them in place using anchor bolts. The nuts on the anchor bolts are then tightened to the specified design value. To enhance stability during the installation of ancillary components such as spacers and crane beams, additional measures such as bracing are implemented. The bracing elements are temporarily attached to the columns on the ground prior to lifting. Moreover, the lower ends of the spacers are also affixed to the foundation, necessitating prior planning and arrangement for their proper integration.

By meticulously adhering to these procedures and complying with the specified regulations, the installation of steel structures can be executed with the utmost safety and efficiency, meeting the required quality standards. Emphasizing safety and accuracy throughout the entirety of the process is paramount to ensure the structural integrity and long-lasting performance of the installed steel components.

4.6. Quality standards and acceptance criteria for completed works: an examination of scientific approaches and methodologies

The successful execution of any project hinges upon strict adherence to precise quality requirements and subsequent acceptance of the completed works. These requirements serve as pivotal benchmarks, ensuring that the project aligns with requisite standards, specifications, and regulations. The pursuit of quality encompasses multifaceted critical aspects, encompassing judicious selection and utilization of fitting materials, adherence to meticulous workmanship techniques, and unwavering adherence to the project's design specifications. Subsequently, the acceptance of works entails an exhaustive inspection and evaluation process wherein the completed works undergo rigorous scrutiny to guarantee satisfaction of predetermined criteria and achievement of the project's objectives.

The acceptance process entails meticulous examination of various factors that collectively contribute to the overarching quality and reliability of the completed works. Functionality occupies a prominent place, ensuring that the constructed elements fulfill their intended purpose and operate as envisaged. Durability assumes paramount importance, necessitating scrutiny of materials, structures, and components to ascertain their longevity and resilience in the face of environmental stresses. Moreover, the safety of the completed works becomes a prime concern, necessitating thorough evaluation of all safety-related aspects to identify and address potential hazards with utmost efficacy.

To ensure integrity and quality of the assembled package, a repertoire of specific measures and procedures are judiciously employed. For instance, verification of the screed density is achieved through utilization of a specialized probe with a predetermined thickness of 0.3 mm. With precision, this probe is methodically inserted within the region demarcated by the washer, being cautious not to trespass the depth of 20 mm between assembled parts. By conducting this meticulous test, assessment of screed density and uniformity is accomplished, ultimately contributing to the overall quality and performance of the structure.

Another pivotal facet of the acceptance process involves assessment of the tightening quality of permanent bolts. This evaluation entails subjecting bolts to restocking, applying a hammer weighing 0.4 kg. Throughout this process, utmost care is exercised to ensure bolts remain steadfast, devoid of any indications of shifting. By conducting this rigorous examination, the integrity and stability of assembled components are rigorously verified, ultimately contributing to the overall strength and safety of the structure.

Furthermore, acceptance of mounted structures necessitates rigorous monitoring and control of their actual positioning. Precise measurements are conducted, meticulously comparing the observed position against specified values meticulously delineated in the accompanying table. This meticulous process guarantees that any deviations from the intended position remain within permissible limits, thereby safeguarding structural integrity and functional efficacy of the construction.

Table 4. 6

Requirements for the quality of acceptance of works

Setting	Limit deviations, mm	Control (methods, volume, type of registration)
1. Deviation of the marks of the supporting surfaces of the column and supports from the design	5	Measuring, each column, and supporting, the geodetic executive scheme
2. The difference in the marks of the supporting surfaces of neighboring columns and supports in a row and the span	3	Likewise
3. Displacement of the axes of columns and supports relative to the axes of the breakdown in the supporting section	5	Likewise
4. Deviation of columns axes from the vertical at the upper section at the length of the columns, mm: more than 4000 to 8000 "8000" 16 000 "16 000" 25 000	 10 12 15	Likewise
5. Arrow deflection (curvature) of the column, support, and ligaments on the columns	0.0013 distances between anchor points, but not more than 15	Measuring, each element, work history
6. The one-sided gap between milled surfaces in the joints of columns	in this case, the contact area should be at least 65% cross-sectional area	Likewise

4.7. Quantification of labor expenditure and machine utilization through calculation methods

The computation of labor expenses, machine duration, and remuneration is presented in tabular format.

Table 4. 7

Quantification of Labor Expenditure, Machinery Duration, and Remuneration Calculation

№	Name of process	Unit of measurement	Amount of work	Norm of time		Labor costs	
				man.-h.	mash.-h.	man.-h.	mash.-h.
1	Unloading components using a crane	100 t	0.15	22	11	3.3	1.7
2	Mounting steel anchor plates	1 cooker	16	5.8	1.9	92.8	30.4
3	Securing steel support plates in position	1 cooker	16	1.2	–	19.2	–
4	Pouring concrete mixture beneath the slabs	1 m^3	0.45	2.2	–	1	–
5	Assembling and erecting columns	Piece.	16	3	0.6	48	9.6
		1 t	15.2	0.54	0.1	8.2	1.7
6	Installing and securing bolts	100 pcs.	0.64	11.5	–	7.4	–

4.8. Timetable for work execution

The construction of a work schedule relies on accurate and detailed data analysis of labor costs and machine time. This involves collecting and examining information related to the required tasks, estimating the time and resources needed to complete each task, and assessing the associated costs. By analyzing labor costs, which include wages and other related expenses, and machine time, which refers to the utilization and productivity of machinery and equipment, a comprehensive understanding of the project's resource requirements is obtained.

The work schedule is meticulously crafted to ensure the smooth and efficient execution of the project. It takes into account the interdependencies and mutual coordination of various processes involved in the construction activities. This includes considering the sequential order of tasks, their durations, and any dependencies or constraints that may exist between them. Technical factors, such as the availability and compatibility of equipment, materials, and tools, are carefully considered during the scheduling process.

Moreover, organizational aspects play a crucial role in the construction of the work schedule. This involves considering factors such as the availability of skilled labor, the allocation of resources, and the project's overall timeline. Effective coordination and communication among different teams and stakeholders are essential for the successful implementation of the schedule.

By incorporating all these elements, the work schedule serves as a roadmap for the project, guiding the timely execution of tasks, resource allocation, and overall project management. It helps in optimizing productivity, minimizing delays, and ensuring the efficient utilization of resources, ultimately contributing to the successful completion of the project within the defined parameters.

Table 4. 8

Chronological Plan for Column Installation Activities

№	Name of process	Unit of measurement	Amount of work	Labor costs		Duration of the process
				man.-sh.	mash.-sh.	
1	Unloading components using a crane	100 t	0.15	0.4	0.2	1
2	Mounting steel anchor plates	1 cooker	16	11.6	3.8	5
3	Securing steel support plates in position	1 cooker	16	2.4	–	2
4	Pouring concrete mixture beneath the slabs	1 m^3	0.45	0.12	–	1
5	Assembling and erecting columns	Piece.	16	6	1.2	2
		1 t	15.2	1.03	0.2	
6	Installing and securing bolts	100 pcs.	0.64	0.9	–	1

4.9. Determining the requirements for material and technical resources

These calculations consider various factors such as the quantity and specifications of materials needed, as well as the types and quantities of tools, equipment, and devices required. The analysis of labor processes and operations helps in identifying the specific tasks and activities where these resources are necessary. The use of standards, typical technological maps, and reference literature provides valuable guidance and benchmarks for making precise assessments. By conducting these calculations, project managers can effectively plan and allocate resources, ensuring that the necessary materials and technical tools are available at the right time and in the right quantities. This meticulous approach minimizes the risk of resource shortages, delays, and disruptions, ultimately contributing to the successful execution of the project.

Table 4. 9

Material and Semi-Finished Product Requirement Statement for Work Implementation

Identification of Materials and Semi-Finished Products	Unit of measurement	Quantification of Work in Normative Units	Rate of Approved Material Consumption	The need for materials
Electrodes, ø4 mm, brand E46	t	10.3	0.0004	0.004
Electrodes, ø2 mm, brand E42	t	15.2	0.0004	0.006
Channel N40 made of ordinary carbon steel	t	25.5	0.002	0.05
Various other materials, individual structures, and fastening parts will be utilized in the construction process	t	15.2	0.0003	0.005

4.10. Safety and occupational health: ensuring a secure work environment

To establish a secure and conducive working environment, it is imperative to adhere to the guidelines outlined in DBN A.3.2-2-2009 "Labor Safety Standards System: Industrial Safety in Construction" and the "Instruction on Labor Protection during the Installation of Metal and Reinforced Concrete Structures."

At the construction site, specific roles must be assigned during each shift to ensure safety:

– Workers responsible for the safe operation of removable cargo-lifting devices and containers
– The designated worker responsible for the safe operation of the crane
– Slingers

Operating thrilling machines, removable load-lifting devices, and containers that have not undergone technical review is strictly prohibited. All work activities require approval and supervision by an assigned individual responsible for ensuring safety.

Workers performing tasks at elevated heights must be equipped with tested and approved safety belts secured by reliable safety carbines, following the instructions provided by the master or foreman. These belts should be registered and subjected to regular testing. Furthermore, workers of all specialties must be provided with appropriate protective helmets and clothing.

Workers must possess valid certificates authorizing them to perform specific types of work and receive comprehensive safety training in accordance with the specified requirements.

The use of unmarked or defective removable load-lifting devices is strictly prohibited. Cargo should not be slung in an unstable position, and adjustments must be made to the position of slinging equipment elements during cargo lifting to prevent oblique positioning of cargo ropes.

During the unloading of long-sized structures using a crane, flexible grinding techniques should be employed to prevent structure reversal.

To ensure safety within the crane operation area, it must be enclosed by a visible defensive fence equipped with illuminated signs for visibility in low-light conditions. Warning signs indicating crane operations should be mounted at the hazardous sector's edge. Safety signs along temporary roadways should be suspended from taut cables.

Installation work at elevated heights in open spaces should not be performed under adverse weather conditions such as wind speeds of 15 m/s or higher, the presence of ice, thunderstorms, or fog.

Detailed information regarding crane operators, slingers, and individuals responsible for crane operations should be communicated and documented.

When slinging structures with sharp ribs, it is essential to use gaskets between the edges of the elements and the rope to protect against abrasion. These gaskets should be specifically designed for the load or permanently fixed to the sling.

Materials and products must not be stored on non-compacted soils. They should be placed on leveled surfaces in accordance with the prescribed guidelines, ensuring storage areas are protected from surface water.

For safe transitioning between structures, the use of stairs, transitional bridges, and fencing canopies is recommended.

During structure installation, installers must stand on previously installed and securely fixed structures or employ means of reinforcement.

Staying on elements of structures and equipment during lifting and movement is strictly prohibited.

Prior to commencing installation work, a well-defined procedure for exchanging signals between the driver and the individual directing the installation must be established.

Elements of structures or equipment mounted in their designated locations should be securely fixed to ensure stability and geometric precision.

Grinding activities should be conducted away from areas with traffic and construction machinery. Contact between grinding equipment and sharp corners of other structures must be avoided. Bending of elements at the connection points with other structures is only permitted following an assessment of the strength and stability of these elements.

When lifting structures, it is advisable to perform the lifting process in two stages: initially lifting to a height of 20-30 cm and subsequently conducting supplementary lifting after verifying the reliability of the slinging.

During the movement of structures or equipment, a minimum horizontal distance of 1 m and a vertical distance of 0.5 m should be maintained between them and any protruding parts of mounted equipment or other structures.

During work breaks, it is strictly prohibited to leave raised elements of structures and equipment in a suspended position.

4.11. Technical and economic indicators

1. Normative labor costs of workers: 22.5 man.-sh;

2. Normative labor costs of machine time: 5,4 mash.-sh;

3. Duration of work according to the schedule: 8 sh;

4. Planned production of one worker per shift calculated by the formula:

$$\text{В} = \frac{V}{\sum m_\text{р}} = \frac{15{,}2}{22{,}5} = 0{,}7\ \frac{\text{т}}{\text{люд.} - \text{зм.}}$$

where – the volume of final products, that is;V

$\sum m_\text{р}$ – labor costs for the amount of work in this region, man.-sh

CONCLUSIONS

This work involves the design of an industrial building in Poltava. The first part of the thesis provides an analytical review of the project. The second part focuses on the architectural solution for the industrial building, which is specifically designed for the Poltava location.

The design incorporates an open-type surface water drainage system, consisting of planned planes and trays. Situated in a field area, the construction site takes on a rectangular shape with a branch extending from it. Encompassing an expansive 11 hectares, the site boasts a gentle slope that gradually descends from the east to the west. The chosen land plot for the construction of the repair and mechanical workshop is situated at a sanitary distance from residential buildings in Poltava. The master plan aims to strategically position the workshop in an area that is free from technological equipment, allowing for efficient metering and parting operations.

The placement of the building on the site, considering its number of stories, adheres to the necessary regulations for ensuring proper sunlight exposure for neighboring buildings. The vertical planning of the site takes into account the preservation of the existing terrain, considering hydrogeological landscapes, architectural and planning considerations of the proposed building, and compliance with regulatory requirements.

To meet sanitary and hygienic requirements and facilitate smooth vehicular and pedestrian movement, driveways and areas are covered with a combination of gravel, crushed stone, and bitumen pavement. The design of the pavement takes into consideration the expected intensity of traffic.

The overall plan incorporates existing buildings, traffic conditions, and pedestrian accessibility. Planning levels are determined to ensure suitable and safe transportation routes, as well as gradual slopes. The site organization plan for the construction project takes into consideration the existing topography of adjacent areas. Surface drainage of streams and meltwater is designed to follow the natural slope of the terrain.

Efforts are made to preserve the existing landscape as much as possible. The access road to the repair shop is paved with asphalt, while the remaining areas within the field utilize gravel driveways and pedestrian paths.

Modern finishing materials are employed for the exterior decoration, and the building features contemporary metal-plastic windows with double-glazing.

The architectural and three-dimensional design of the repair and mechanical workshop is based on the local conditions, the size of the land, and the proximity to existing buildings.

The building structure is designed as a frame with single-span columns and a roof supported by steel trusses. The facade incorporates various elements that showcase modern design advancements.

To facilitate convenience for staff, a temporary parking area is provided near the main entrance of the building. Additionally, a recreational space with minor architectural features is situated adjacent to the building to enhance the quality of breaks.

The construction of the building involves the utilization of individual steel and tubular components for columns and trusses. Structural rigidity is ensured through the combined behavior of tubular steel-concrete columns, steel trusses, and horizontal and vertical connections.

The structural design consists of a single-span framework with a span of 18 m, featuring two rows of tubular steel-concrete columns supporting steel trusses for the roof. These trusses are positioned at intervals of 6 m.

The repair and mechanical workshop is designed as a one-story frame structure with walls composed of hinged three-layer panels.

The primary objective of the foundations is to distribute the building loads to the foundation. Considering the soil characteristics of the construction site, a shallow monolithic glass-type foundation is adopted, along with manufactured reinforced concrete foundation beams under the outer walls. The foundation depth is set at 1.5 m.

The roof is constructed using three-layer sandwich panels, 0.300 m thick, supported by steel girders of channel №8 placed on the upper portion of the trusses with a spacing of 1.500 m.

For thermal insulation purposes, the external walls are made of three-layer sandwich panels, with a thickness of 300 mm.

Partitions between different sections consist of 100 mm thick steel-framed walls lined with steel sheets.

The roof incorporates steel trapezoidal trusses with a height of 2.400 m, consisting of two equal-shelf angles manufactured individually. These roof trusses are supported by individually manufactured tubular steel-concrete columns. The selection of column type is based on technical and economic analysis of various options.

Interior decoration of the rooms involves the completion of finishing works, including painting door leaves, heaters, and pipes with two coats of enamel paint. The exterior finishing of the building follows the specifications provided in the external finishing passport. Metal elements undergo two coats of black varnish.

Window and door openings are filled accordingly, providing natural lighting within the building.

As part of the project, metal-plastic window blocks with double glazing will be installed. These window blocks will be firmly attached to the scaffolding on the steel-concrete columns using self-tapping screws. To ensure a proper fit, any gaps between the window blocks and the walls will be filled with foam.

Doors are mounted on two hinges, and the building incorporates steel and plastic-wooden doors, all of which are solid. The door frames are affixed to the scaffolding on the wall frame using self-tapping screws. To ensure a tight seal, any gaps between the door frames and the exterior walls are filled with foam.

Due to the non-corrosive nature of the air environment, reinforced concrete structures do not require additional protection.

To prevent corrosion, interior and exterior metal structures are treated with two coats of oil-based paint.

Galvanized steel gutters are installed on the bottom of window openings to ensure proper drainage. Protection against external air effects is primarily focused on safeguarding against precipitation.

Embedded elements, such as anchors and other unseen metal components within the construction, are protected by applying a cement-polymer layer.

The heating system is supplied by a heat generator located in the existing operator building. Water is used as the heat carrier, with temperature parameters ranging from 95° to 70°. Steel pipes are employed for the heat network.

The project incorporates underground ducts for laying thermal networks within reinforced concrete trays, separately dedicated to heating and hot water supply. The ventilation system incorporates both mechanical and natural supply and exhaust methods.

The water supply for the repair shop is sourced from the existing water supply system, utilizing pipes with a diameter of 50 mm.

The internal sewerage network is comprised of cast iron sewer pipes, providing effective waste management within the premises. In contrast, the external sewerage networks are constructed using ceramic sewer tubes with a diameter of 150 mm. These tubes lead to biological treatment plants, promoting environmentally-friendly wastewater treatment.

For the construction of the external networks, cast iron pressure pipes are utilized, providing durability and strength. In addition, wells within the network are constructed using reinforced concrete elements, ensuring their stability and longevity.

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