SECTION 1. ARCHITECTURE AND URBAN PLANNING

DOI: 10.46299/ISG.2025.MONO.TECH.3.1.1

1.1 Changes in the planning and form-making structure of a university academic building

Introduction

The reconstruction of university buildings in Ukraine is one of the key directions of modernizing educational space, especially in the context of post-war recovery. A significant number of buildings constructed in the second half of the 20th century no longer meet modern requirements of safety, comfort, energy efficiency and organization of the educational process. These issues became particularly relevant after the extensive damage to the infrastructure of higher education institutions caused by the full-scale war, which made reconstruction not only an instrument of development, but also a necessary condition for the functioning of universities.

One example of such a case is an academic building that, before reconstruction, showed signs of physical and moral deterioration and had also suffered significant damage during hostilities. The original planning structure of the building was formed according to a typical scheme of the 1970–80s: a linear three-storey volume with a central corridor and classrooms around the perimeter. Such planning did not provide possibilities for interactive work, open spaces, flexible learning zones and modern interdisciplinary interaction.

In addition to building obsolescence, the building had a number of functional disadvantages that limited its efficient use.

A military strike led to a partial collapse of structures in the southern part of the building and the complete destruction of several rooms, which caused the loss of structural integrity in certain fragments of the building. The damage was critical and made it impossible to restore the building in its original geometry. Thus, reconstruction became not only a means of rebuilding, but also of modernization, which made it possible to rethink functional content, ensure compliance with current construction standards and create a new, high-quality educational environment.

The purpose of the study is to analyze the existing condition of the building before reconstruction and to identify key factors that formed the need to change the shape of the building.

Thus, consideration of the existing condition of the building before the start of design is an important prerequisite for further architectural decisions discussed in the following chapters of the study.

Analysis of the existing condition of the academic building before reconstruction

Before reconstruction, the building was characterized by an architectural and planning structure typical of its time and by a number of technical disadvantages that significantly limited its functionality. A detailed analysis of the actual condition of the building, carried out on the basis of measurement drawings and a site plan, makes it possible to identify a complex of problems that made further operation of the building in its original form impossible.

Planning features and disadvantages of the original scheme

The planning of the building was based on a two-storey corridor scheme with predominantly rectilinear geometry. (Fig. 1). Despite its simplicity, this model had a number of significant flaws:

• Irrational placement of rooms

• classrooms, laboratories, technical rooms and storage rooms were located without a clear logical structure;

• lack of zoning complicated internal logistics;

• some educational rooms adjoined auxiliary ones, which created acoustic and operational conflicts.

• Lack of necessary functional elements

• the building did not provide preparatory rooms — mandatory for laboratory activities;

• lack of recreational zones made the space monotonous and unsuitable for a modern educational process.

• Corridor scheme without possibilities for transformation

• narrow corridors had only a transit function;

• lack of spaces for group work, student hubs or open zones led to congestion of main passages.

Insufficient natural lighting

The building had a systemic problem with natural daylighting:

• significant depth of the building and its elongated shape limited the penetration of light;

• the central corridor had no access to daylight;

• internal rooms (for example, rooms without exterior walls) were not lit naturally at all;

• the sizes and configuration of window openings were insufficient to ensure the normative level of illumination.

This made the environment in the building energy-consuming and psychologically uncomfortable, which contradicts modern principles of organizing educational spaces.

Condition of engineering infrastructure and sanitary facilities

• Sanitary facilities were too small and did not meet regulatory requirements in terms of area;

• they had an insufficient number of cubicles;

• they did not ensure the required capacity.

• Lack of sanitary facilities for people with reduced mobility

• the dimensions of existing rooms did not allow organizing it by simple replanning.

• lack of elevators or other vertical communications suitable for PRM;

• insufficient ventilation in sanitary facilities and technical rooms.

Destroyed rooms as a key factor in the impossibility of repair

The building received a close strike that caused the complete destruction of several rooms.

The consequences included:

• loss of external and internal walls;

• collapse of floor slabs;

• destruction of engineering networks in the damaged area;

• deformation of adjacent structures.

The existing condition of the building was characterized by a complex set of problems:

• outdated and irrational planning;

• critical deficit of natural lighting;

• small sanitary facilities and complete absence of sanitary facilities for PRM;

• lack of elevators and accessibility means;

• shortage of specialized auxiliary rooms;

• significant war damage to part of the building.

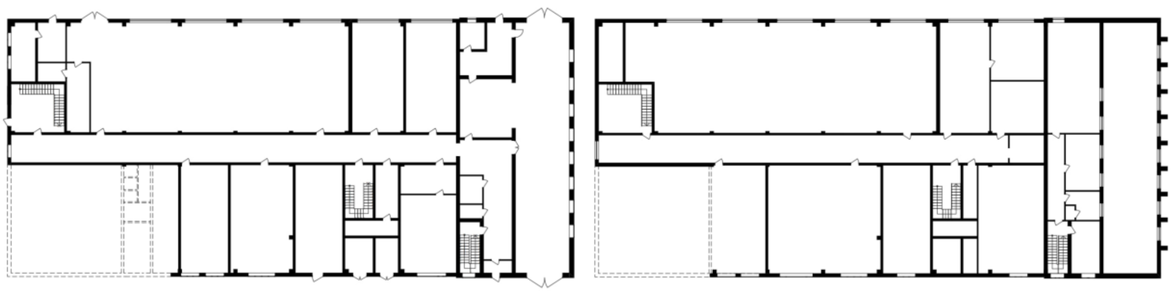


Fig. 1. Plans of the building before reconstruction [Author's development]

The combination of these factors created an objective impossibility of restoring the building in its original form and determined the need for reconstruction with a change of shape, which is discussed in the next chapters of the study.

Regulatory requirements for academic buildings and key criteria that influenced the necessity of reconstruction

During the assessment of the condition of the academic building, an important stage was the comparison of its actual characteristics with the requirements of current regulatory documents in Ukraine. Non-compliance with the main provisions of national construction standards regulating the design and operation of educational institutions became an objective reason for reconstruction with a significant revision of the functional and spatial structure of the building.

An analysis of current construction standards compared with the real condition of the building shows that the building:

• had systemic violations of daylighting standards;

• did not ensure inclusiveness;

• did not meet the requirements regarding sanitary facilities;

• had outdated logistics and non-functional planning;

• received critical structural damage during the war, which made repair impossible;

• did not meet fire safety standards in the damaged area.

Thus, in accordance with regulatory requirements, the building could not be restored in its original configuration.

Therefore, reconstruction with a change of shape was the only technically, functionally and normatively justified solution, which became the basis of further project development.

Analogues of academic building reconstruction

In contemporary practice of reconstruction of educational institutions, an important role is played by projects that combine technical renewal, transformation of spatial structure and formation of a new architectural image. To develop the concept of the reconstruction of the building, several international projects were analyzed, in which similar approaches were applied: working with the existing reinforced concrete frame, introducing new steel structures, creating internal atriums and changing the geometry of the façade.

The Diamond at the University of Sheffield (United Kingdom)

One of the most relevant examples of contemporary university reconstruction is The Diamond building at the University of Sheffield (United Kingdom). (Fig. 2). This 6-storey building for the Faculty of Engineering opened in 2015 and replaced an outdated facility, enclosing a new space with laboratories, lecture halls and open learning areas. Its façade is executed as a unique aluminum modular “shell” with a rhombic pattern over a concrete frame and glazing.

Fig. 2. Main façade of The Diamond [https://www.ngbailey.com/case-study/45/the-diamond,-university-of-sheffield]

The central atrium of the academic building (Fig. 3) serves as a distribution space: it unites lecture theatres, workshops, open-space areas, a café and places for independent study. Such a planning scheme ensures a high level of natural lighting, spatial flexibility and comfortable social interaction.

Fig. 3. Central atrium [https://www.ngbailey.com/case-study/45/the-diamond,-university-of-sheffield]

Daniels Building on the campus of the University of Toronto (Canada)

Daniels Building on the campus of the University of Toronto (Canada). (Fig. 4). The 2017 project combined the restoration of a historic 19th-century neo-Gothic building with a modern extension. The new part is created from steel, concrete and glass — it contrasts with the historic part, creating a modern educational and creative space. Inside the building, a spacious “interior main street” has been formed, which unites studios, workshops, exhibition halls, a library and gathering areas, accumulating educational, research and social functions.

Fig. 4. General view of the historic building with modern extension [https://www.archdaily.com/916301/daniels-building-at-university-of-toronto-nadaaa]

A hall with a 34-meter span and double height makes it possible to avoid columns, which gives great freedom in planning spaces for lectures, workshops or project activities. (Fig. 5).

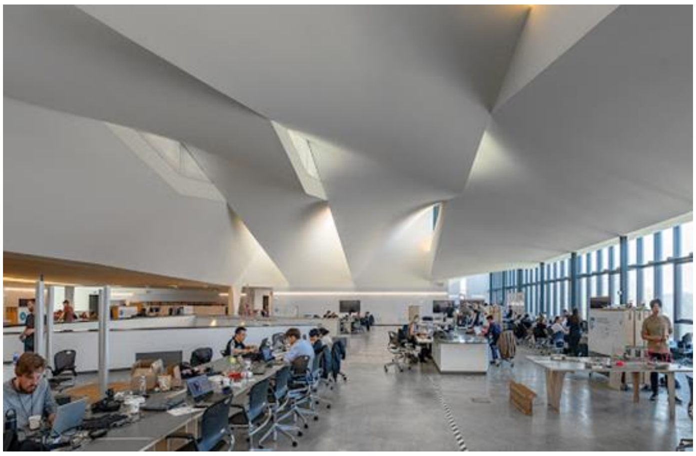


Fig. 5. Hall with a 34-meter span [https://www.archdaily.com/916301/daniels-building-at-university-of-toronto-nadaaa]

Both examples demonstrate important principles: preservation or adaptation of the existing structural frame, integration of new volumes, creation of a large central space inside the building, flexibility in planning. Such approaches make it possible to modernize outdated or damaged buildings, preserving the frame, but at the same time introducing modern standards of educational environment.

Concept of reconstruction with a change of building shape

It was decided not simply to restore the existing structure of the building, but to rethink it in a contemporary architectural context. The basis of the design solution is the aspiration to create a volumetric structure that provides a transition between the existing reinforced concrete frame and the new part of the building. The new volume is made of metal structures, which makes it possible to create complex geometric forms and ensures openness and flexibility of the internal space. Broken planes and a fragmented silhouette reflect the dynamics and directions of spatial transformation, emphasizing a distinctive architectural accent.

In the place of the destroyed part of the building, contrasting materials were installed — metal panels and glass, which differ from the main part of the building, making it possible to combine functionality and symbolic meaning. Such a solution forms a space that is a kind of marker of change and renewal, and also emphasizes the significance of the building within the structure of the campus. (Fig. 6).

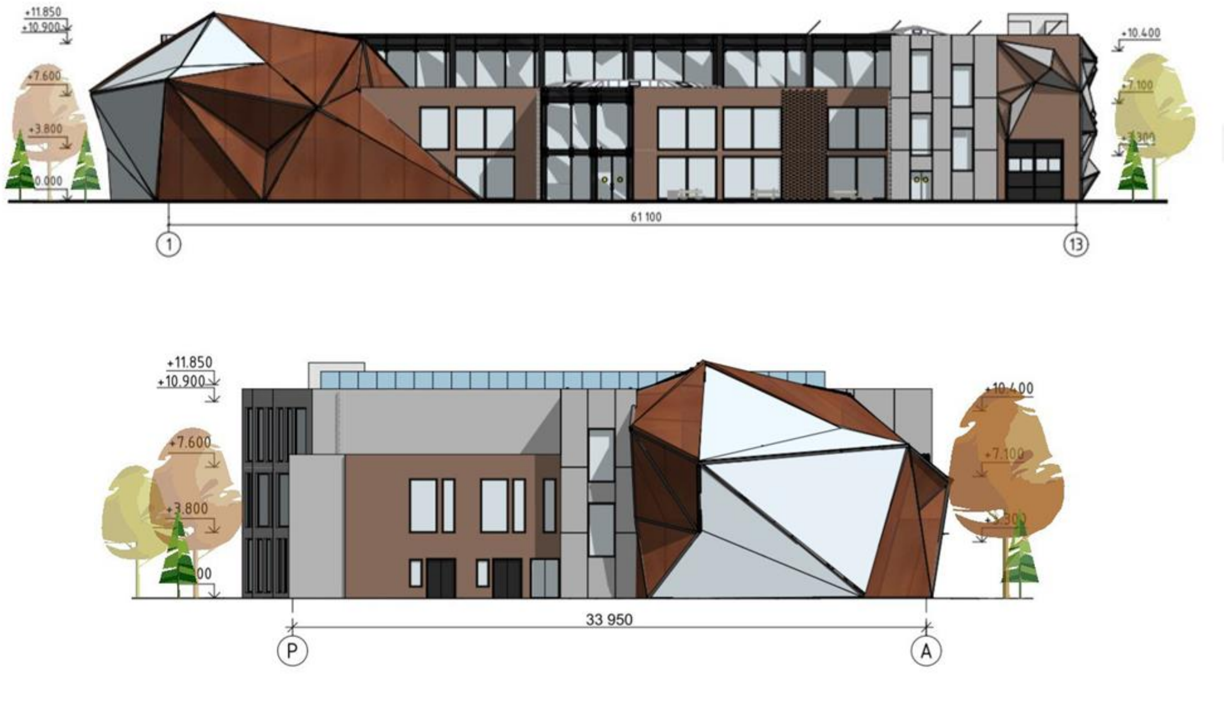


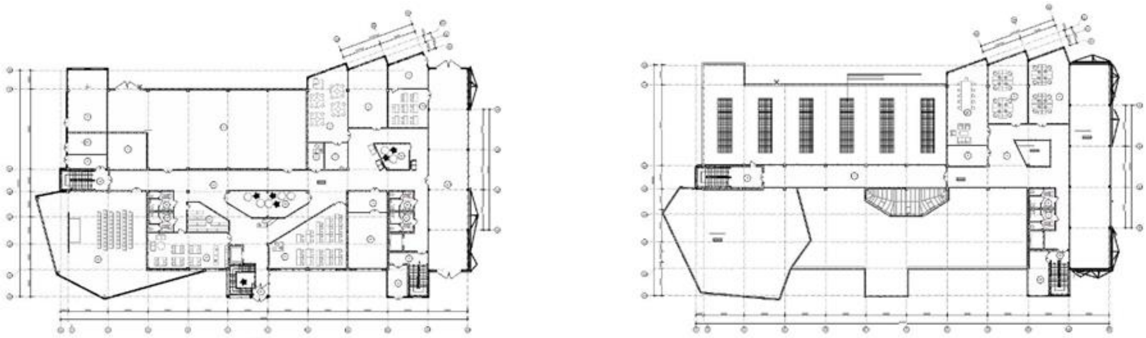
Fig. 6. Facades of building [Author's development]

Thus, reconstruction of the building with a change of shape ensures a complex combination of contemporary architectural approaches, optimization of flows, natural lighting and functional transformation of interior spaces, giving the building a unique contemporary image while integrating it into the overall structure of the university campus.

New functional and spatial scheme of the building

It was decided to change the internal planning structure of the building in order to ensure compliance with modern educational and communication needs. The key task was to form learning spaces that combine flexibility, openness and functionality, as well as to create areas for collaborative work, rest and cultural interaction.

In the area where the organization of large open spaces was previously impossible, a multifunctional hall and exhibition space were designed. The hall is designed for lectures, presentations, conferences and student events. The exhibition part functions as a gallery where student works can be displayed, scientific and cultural events can be held, as well as temporary exhibitions organized. Thus, the new space combines the educational and public functions of the building, creating a contemporary environment for learning and communication. (Fig. 7).



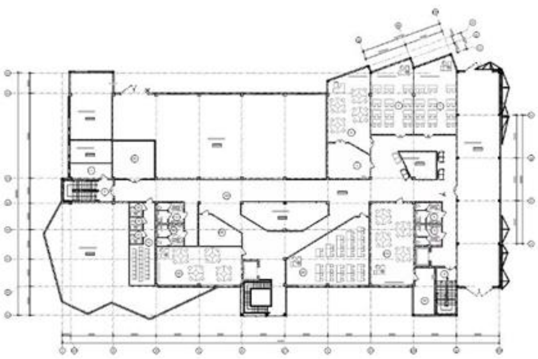


Fig. 7. Planes of building [Author's development]

Old long dark corridors were replaced with shorter and more logical routes, which facilitate the movement of students and staff. Improved daylighting of internal rooms was also ensured thanks to transparent façade planes and two atriums, which fill the space with natural light. New spaces make it possible to create open learning zones for collaborative work and rest, improving the quality of staying in the building.

The updated planning scheme ensures efficient use of every square meter, while forming an environment that stimulates educational, social and cultural activity. Learning zones cease to be isolated, and corridors become integrated elements of space, ensuring interaction between students and staff. This approach makes it possible to transform the building from a classical educational facility into a modern university centre, where education, culture and social interaction are combined.

Master Plan and Landscape Design

The master plan of the reconstruction acts as a basic structural model that transforms a previously inefficiently organized site into an orderly, functionally coordinated, and modern educational space. It forms a new zoning system in which the territory is divided into a group of clearly defined functional sectors that increase the rationality of land use and ensure safe movement of users.

The recreational green zone, which occupies the largest part of the site, is formed as a complex landscape space with terrace benches with greenery at different levels, pathways, and expressive terrain geometry. It functions as an informal communication environment, a place for rest and social interaction.

The transport zone (entrances, parking, and technical access) is assigned to the periphery of the site. This localization minimizes the intersection of pedestrian routes with transport routes, reduces the risk of conflict situations, and ensures safe movement of students within the building area. Pedestrian connections with the possibility of fire truck access in case of emergencies are provided.

The geometry of the landscape repeats the stylized broken lines of the architectural facades, creating visual integrity between the outdoor environment and the reconstructed building. Particular attention is paid to lighting and navigation, ensuring convenient and safe use of the area in the evening. The combination of natural materials with modern surface finishes creates a diverse tactile and visual structure.

Inclusiveness is a fundamental principle of the master plan. All main routes have minimal height differences or are equipped with ramps in accordance with state standards. Tactile elements and visual markers are placed in key movement areas, and site furnishings are arranged so as not to create obstacles. A high level of landscaping emphasizes the priority of forming an environmentally sustainable and comfortable public space in accordance with modern educational environment standards. (Fig. 8).

Fig. 8. Master plan [Author's development]

Structural Solutions for Changing the Building Shape

The use of complex geometry determined the need to form a spatial metal frame, executed as a polyhedral structure similar to a geodesic dome. Such a frame functions as a spatial truss that provides high rigidity with minimal weight and allows large spans to be covered without internal supports. The spatial system is the main load-bearing element, later filled with glass units and corten steel panels.

The frame structure is built from rectangular steel tubes. The main elements have differentiated cross-sections according to loads:

• vertical posts are made of 120×80×4 mm tube;

• chords and main structural elements are made of 200×150×6 mm tube, capable of carrying primary vertical and horizontal forces.

The system of joints provides a combination of welded and bolted elements, allowing reliable load transfer in areas of complex geometry and ensuring the possibility of installation onto existing columns. Steel plates in the joints reinforce the structure and stabilize force flows.

A key stage was the connection of the new steel frame with the existing reinforced concrete frame of the building. The metal structure rests on reinforced concrete columns, which take part of the vertical and horizontal loads, including the weight of enclosing structures and snow and wind pressure. Such interaction ensures structural integrity of the new building shape and achieves a harmonious combination of old and new parts of the building.

Interior Solutions and Educational Environment

The internal environment of the building, before reconstruction, was dark and poorly adapted to inclusive needs, however, in the developed project it underwent fundamental changes aimed at improving comfort, functionality, and efficiency of the educational process. The implementation of two large atriums made it possible to radically transform the nature of the internal space. Vertical light wells became the main source of natural light in the central zones of the building. Thanks to this, corridors ceased to be only transit areas and gained the functions of recreational and working zones. Natural light stabilized students' daily perception rhythms, created an emotionally comfortable environment, and reduced the need for active artificial lighting during daytime.

A significant element of the new space was live greenery in the atriums. The inclusion of plants in the interior of university buildings is a common practice in European educational complexes, since it has been proven that green zones act as natural air filters, reduce CO_2 concentration, and regulate humidity. In the case of the reconstructed building, the green corner plays an additional psycho-emotional role: plants are integrated into rest zones where students spend time between classes, as well as into group work areas, where greenery promotes concentration and reduces stress.

The main hall space became a logical point of intersection between student and staff flows. Its composition — open stairs, a lightweight metal elevator core, and semi-transparent railings — enhances the sense of vertical unity of the building. Thus, the hall performs not only a communication function, but also becomes a place for meetings and informal interaction. The integrated coffee-break area has become a social hub that influences the organization of student life. Furniture with soft forms has been installed here, adapting to different usage scenarios: short rest, laptop work, group discussions. Warm local lighting creates an intimate atmosphere, compensating for the visual openness of the space.

A particularly important element of the reconstruction is the assembly hall in the new annex to the building. It is a space where symbolic memory of wartime events is combined with modern requirements for conference halls. Its interior is formed on the principle of transformation, allowing changes in configuration depending on needs: scientific conference, concert performance, plenary lecture, or exhibition. Mobile chairs with 360° rotation and folding capability, acoustic panels with micro-perforation, and window systems with multi-layer glass units create a space with high acoustic qualities.

The laboratory suite also underwent significant changes. Trapezoidal tables were designed for group work: the shape allows circular, wave-like, and linear configurations that correspond to modern team-based learning methods. Materials for laboratory furniture were selected considering chemical resistance and ease of cleaning. Lecture classrooms are equipped with mobile modular desks and interactive display panels that promote the integration of digital technologies into the learning process.

Teachers’ offices were also rethought. Ergonomic desks with height adjustment, local dimmed lighting, acoustic wall panels, and a small meeting area ensure a productive working atmosphere. Offices are organized into blocks, where storage places and lounge zones are provided.

On the building roof, a passage between the blocks was created, significantly shortening internal routes. This element increases logistical efficiency and makes movement between academic departments more convenient, especially in winter.

10. Innovative Glazing Units, Artificial Lighting, and Energy Efficiency

One of the key technological solutions of the reconstruction was the use of innovative glazing units with variable light transmittance. The window systems of the building are equipped with multilayer glazing units with a special selective coating capable of regulating the transmission of visible and infrared spectrum depending on the angle of light incidence. In case of intense solar radiation, the coating reduces the passage of infrared heat, which helps prevent overheating of the rooms in the summer period. At the same time, in winter these glazing units are able to reflect thermal radiation from internal sources back into the premises, increasing the building's energy efficiency by 25–30%.

A separate innovative solution was the use of dynamic glazing units installed in the assembly hall. They contain photochromic layers that react to the intensity of ultraviolet light: in strong sunny weather, the glass automatically darkens, reducing glare and heat load, while on a cloudy day — on the contrary, it remains transparent. This helps reduce the use of air conditioners in summer and decrease artificial lighting costs in winter months.

Artificial lighting of the building is based on the principles of multi-level adaptability. The main level consists of linear LED luminaires integrated into the ceilings of corridors and laboratories. Their color temperature automatically adjusts depending on the time of day: neutral daylight (4000–4500 K) ensures maximum concentration, while warm evening light (2800–3200 K) helps reduce fatigue. Local lighting is built into laboratory furniture, creating focal zones of maximum visibility for working with equipment. Touch panels allow adjusting lighting intensity, and presence sensors automatically reduce power in empty rooms.

A specific feature of the lighting system is that a significant part of its power supply comes from solar panels installed on the roof. The panels made of monocrystalline silicon have a high energy conversion efficiency — from 19% to 22%, which ensures stable electricity production throughout the year. The inverter system allows accumulating excess electricity and directing it to power lighting in the evening. Thus, a closed energy consumption cycle has been implemented, significantly reducing the load on the central power grid.

Thanks to the combination of innovative light technologies, deep consideration of natural insolation, and integration of solar panels, the building forms a balanced energy regime. This not only reduces university expenses but also demonstrates environmental responsibility and a focus on sustainable development.

Conclusion

The reconstruction of the academic building has become an example of how a deep rethinking of an outdated structure can create a fundamentally new quality of educational environment. Analysis of the initial conditions showed that the building, erected in previous decades and additionally damaged by combat actions, had lost its ability to perform its intended functions. Planning issues, imperfections of engineering systems, lack of inclusivity, and significant structural damage indicated that simple restoration could no longer ensure compliance with modern standards. Therefore, the reconstruction became not so much a repair as the creation of a new architectural and functional environment using the remains of the existing structure as a basis for further transformation.

The proposed design solution demonstrates that the combination of the old frame with new spatial forms can open opportunities that were impossible within the original configuration. The use of a metal spatial structure made it possible to form a complex geometry and give the building a new character, while stabilizing its structural scheme. This transforms the damaged part of the building into an architecturally defining element that not only covers the loss but creates a new identity. This approach demonstrates the transition from an old model of educational space to a modern one.

An important result is the formation of a new internal environment that responds to the current requirements of the educational process. Thanks to the creation of atriums, transparent enclosure structures, and open spaces, the interior gained light, airiness, and flexibility. Premises that were previously dark and closed have been transformed into adaptive universal zones suitable for both work and rest. The interior was enriched with natural greenery, ergonomic furniture, and modern elements of information infrastructure, which made it possible to create a psychologically comfortable and productive environment.

A significant role in the renewal of the building was played by the implementation of high-tech engineering solutions. Systems of controllable natural and artificial lighting, dynamic glazing units, and the use of renewable energy made it possible to raise the level of energy efficiency and comfort to standards necessary for intensive use of educational infrastructure. The organized area around the building complemented this transformation: the landscape became an extension of the architecture, reinforcing its dynamics and at the same time ensuring barrier-free access and functionality of the external space.

In summary, the reconstruction of the academic building was a process in which technical, architectural, ecological, and educational factors were combined into a holistic concept. The result is a building that not only restores its function but also embodies a new model of university environment — open, bright, inclusive, and flexible. The building is no longer just an infrastructure object; it has become a space that supports modern formats of learning, promotes social interaction, and demonstrates the ability of architecture to meet the challenges of time. In this project, reconstruction became a tool not for reproducing the past, but for creating the future, where space forms a new quality of educational experience.