Taking into Account the Requirements of Ergonomics as an Important Factor in Creating a Comfortable Environment in an Educational Institution

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Abstract. The research aim was to suggest a project version for a comfortable stay to people, including handicapped population groups in an educational institution, taking into account current ergonomics requirements. It is the principle of ergonomics that determines the concept of design, architectural and equipment capability of a building. The objective of the present research is to find the right combination of ergonomic principles suggested by the authors for the most comfortable stay of various groups of people, including those with limited mobility while studying in a university building. The university building was modeled in the Revit Structure 2020 Computer-aided design (CAD) system to solve this problem taking into account actual building regulations including the ergonomics requirements. The scientific merit of the study consists of the suggestion and validation of the available ergonomic requirements applied in a definite project. The object is a university building with an inner courtyard and an adjacent entrance hall, a gym and four academic buildings. The structure of the main building of the university is an elliptic paraboloid. The safety provisions and ergonomics for people with reduced mobility are focused on according to the present performance requirements. The paper also describes the original construction of the building. In addition to the convenient location of objects, it lets the wind flows level down.

1. Introduction
Ergonomics is an index of technological and cultural development. Ergonomics can be defined as the study of various relationships between a man and a building, as well as the applied knowledge obtained to solve problems that might occur with those relationships. This dual definition comprises both science and technology. Science is supposed to be the study of a man in his interaction with the living environment. And technology deals with the application of scientific knowledge. Ergonomics aims at studying and realizing a man-building interaction, in-building environment and infrastructure of it to make a person’s being more comfortable while in it. This means providing the efficiency and safety of man – building system, while coincidently ensuring safety, well-being and accomplishment in the field of human activities within this system. The ergonomic methods and techniques that are used to develop the concept include modeling and methods for analyzing tasks, scaled models and full-size models, and group (panel) discussions.
The functional way of dealing with 3D compositions is also taken into account since the ambient conditions for creating an object are outlined by the construction site in advance where the designed construction objects are going to be allocated.

1.1. Relevance, scientific relevance and literature review
The ergonomic requirements while designing different rooms of educational buildings differ greatly. The review and study of certain types of work activities are crucial in space design. The interior design of classrooms and offices with architectural elements and tools, decor and ergonomics is aimed at providing the best workplace and short breaks, promoting a sense of work satisfaction and, thus, improving the efficiency and performance quality [1, 2, 3]. Furthermore, a key component is to ensure a comfortable stay and working conditions for all people, including those with limited mobility and with disabilities. Moreover, when designing higher education institutions, much attention needs to be focused on the object-spatial environment modeling of studying.

The scientific relevance of the research consists of the suggestion and validation of applying the present ergonomic requirements in a certain project. The object is a university building with a courtyard and an adjacent entrance hall, a gym and four academic buildings. The construction of the main university building is an elliptical paraboloid. This structure was chosen regarding the tectonics of form, flexible planning concepts (design decisions) and ergonomics. In the project, the ergonomics of the building is one of the key aspects to choose 3D forms.

The interconnection of 3D-forms with ergonomics is observed in the papers [4 - 10]. The main properties of shapes include geometric pattern, position in space, size, and weight. Texture, light, and color are considered to be additional properties.

The relation of ergonomics to the conditions for people with reduced mobility was reviewed in the papers [11-13]. The authors in the paper [14] also suggest a range of decisions for adapting the territory to the needs of low-mobility people, using transformable structures.

To clear up the situation when designing and an opportunity of careful consideration of the object ergonomics, including that for low-mobility groups, as well as BIM-technologies software solutions, are used [15-22].

1.2. Formulation of the problem
The aim of the study is to think of an effective combination of ergonomic principles offered by the authors for the most comfortable stay of various groups of people, including those with limited mobility, when studying in the university building. To solve this problem, the university building was modeled in Revit Structure 2020 CAD system, taking into account the current building specifications, as well as ergonomics decisions.

2. Features of space-planning solutions taking into account ergonomics

2.1. Volumetric composition
The designed university building is a building with a courtyard and an adjacent entrance hall (lobby), a gym and four academic buildings.

The central building (Fig. 1) has the form of a four-storeyed rectangular edifice according to the building plan, flexed from its all four sides as a concave lens. The building planning pattern is complicated and designed individually, based on the requirements applied to higher education institutions. Architectonically, the building is divided into four modules. They are placed according to the current land layout.

The main entrance is highlighted in 3D composition of the building. It is emphasized by an ellipsoid (oval) volume with a full facade glazing, which is centrally located from the main bulk of the building. Against the background of the active complicated volume of the main facade, four-storeyed volumes of 4 long units with a curved geometry are placed. They are to balance the superior height of the complicated shape of the facades of the central part.
2.2. Features of facades
The overall architectural and artistic concept of the building is presented in a contemporary style. It combines the decisions made in 3D composition of the building facades, as well as uses technological innovations in decoration and energy saving facade systems. This solution fits into the general developed urban built-up area best of all.

The overall architectural view of the building facades is set by the horizontal division of the facade by color on each floor. The horizontal division of the facade into dark blue stained-glass windows also has a functional value (Fig. 2). In particular, the utility systems located between monolithic floors and suspended ceilings are to be hidden. The basement part of the building is marked and designed in the project with the revetment with ceramic veneers which match the facade system. A curtain wall system based on aluminium galvanized sidings with underlining made of heat-insulated semi-stiffened plates, with a furring and facade cassette facing covered with an outer dark blue polymer coating is
used for facing the exterior walls of the courtyard of the university office building. A proper architecture design of the facades is pointed out due to the similar colors used. The project provides for a curtain wall system based on aluminium extruded sections for full façade glazing. The system is completed with joint filling material and fasteners (fittings) for multiple glass units. The cladding of the translucent structure of the facades is made up of triple-pane glass: the outer glass is sandwich-type, shock-proof resistant glass, body-tinted glass (turquoise blue color), antisun glass, sized (joint) with a semi-translucent plastic sheeting, the overall thickness of the triplex glass is 2-1-3 mm.

The major coloring of the facades is calm arctic blue added to a darker shade to bring out a contrast between the floor flights of stairs. This solution provides the appropriate sober characteristic of administration buildings. The colouristics of the facades is emphasized by various materials used in decoration - ceramics, glass, metal.

3. Results and discussion

The basic principle of choosing three-dimensional forms taken into account when designing the university campus is to make it possible to separate streams of people with and without disabilities. As a result of this, the interior space of the main building is designed so that to give independent access to wheelchair users and other visitors to the main building of the university.

![Figure 3](image3.png)

**Figure 3.** The shape of the ground floor of the university building.

This principle is implemented mainly by designing a separate entrance in the academic buildings with an outside lift for wheelchair users to get access to other floors of the building (Fig. 4). The circulation inside the central building is ring with a branch towards the academic buildings. This scheme can be vividly traced illustrated by an example of the plan of the ground floor of the building. (Fig. 3, 4).

This circulation pattern allows avoiding scores of people during class breaks in the corridors of the main building as it is supposed to be the link between the academic buildings. This scheme can also be traced to the gardening and landscaping plan of the land (Fig. 1.)

In addition to the outside lifts, all buildings and outdoor lawns are equipped with tactile paths for the blind or weak sighted people (Fig. 4.).
Figure 4. The shape of the first floor of the university building.

Besides the events mentioned above, there are seats given for wheelchair users in the assembly hall of the central building. Similar events have also been implemented at the central car parking in front of the university park (Fig. 1.). To arrange a technologically advanced learning environment, two computer classrooms with wider door openings and spacious aisles between desks for wheelchair users were equipped with headphones and keyboards with Braille alphabet for the blind on the first floor of the main building of the university.

Another important design feature is that all the buildings are on the same level as each other, while there are no thresholds between the buildings. It makes a comfortable barrier-free environment. The facade appearance of the building does not have squint quoins. So all the buildings of the university look unified and monolithic, breaking and smoothing wind flows (Fig. 2). The external color scheme of the stained glass windows allows one to concentrate visually and adjust to the appropriate learning while letting enough light in the indoor premises. It is important to note that the taken three-dimensional form made it possible to compose the interior spaces appropriately considering the architecture, the boundaries of the site of land and construction regulations.

4. Conclusions
Thus, while designing, the effective movement of people streams was taken into account both inside the building and between the buildings. The building provides offices, classrooms, technical rooms. These rooms are connected by a system of corridors, stairs and a lift for people with disabilities. The layout allows easy access to all buildings.

The application of the color of the wall covering was also focused on, considering the influence on the psychoemotional state of employees and students. The interior decoration of the premises is designed for premises following health and fire requirements, as well as aesthetically more desirable. The decorative and art design of the interior is made by traditional techniques.

In the course of construction, useful light of the interior was provided due to the storey full-height stained glazing. This design allows sunlight distribution inside the room. Thereby, the insolation is rising, electricity is being saved, and a stay there is getting more comfortable. And that is especially important for students and staff with disabilities. Such an educational institution is going to become a comfortable learning environment, accessible for movement, promoting activity and successful socialization of people with disabilities.
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