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The Importance of the Thermal Aspects in Designing Public Buildings Along with Timber Structures

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Abstract

One of the most challenging aspects of buildings at present times is the process of merging thermal with environmental qualities in architecture. Therefore, to execute this process, it is necessary to have healthy and sustainable design strategies. One of the main problems in this joint strategy is providing efficiency, quality, and aesthetics within the buildings. Raising the question of this topic in the public buildings makes this issue even more complex and more emblematic. Before delivering a certain indoor quality of the structures, there is a tremendous necessity of proposing sustainable and efficient design approaches. Accordingly, in this text, wood buildings are taken into account. This research integrates sustainability and thermal aspects of public building design such as libraries. For that reason, the application of the results may find a place between various design methodologies to indicate thermal qualities.

Keywords: Public Buildings, Sustainability, Thermodynamics, Wood Architecture.

1. Introduction

The principle objective for this research is to provide quality results that find a proper application of the thermal features within the buildings. The proposed theme is related to the sustainability of architecture and its principal purpose is to express the sustainable aspects of the public buildings.

To provide thermal and acoustic comfort in public buildings means to take into consideration the values of the architecture. This brings to the question of solving technical and technological challenges in the design process of public buildings. The disciplines of this study find a relation within the building that has an engineering and scientific character. Besides its technical background, the research indicates the necessity to take into consideration of such features during the design process. In the following text, the authors are presenting results that have spatial character and descriptive characteristics. The beginning point of generic results is treating the buildings as closed systems. The consideration is that treating the places as closed systems would better control the climate conditions within architecture. That includes control of the air, relative humidity, smells, sounds, heat. These aspects are directly connected with the idea of establishing order in architecture. To make an order within the architecture, it is necessary to propose limits. In that direction, the reason for defining the borders is linked with sustaining the order itself, above all the inside order. This principle of establishing control on a broad term is presented from the beginning of human existence. Therefore, this principle can be directly and indirectly translated to the architecture context. The need for thermal comfort means providing the order, in other words, rules within the buildings. In the process of establishing the order, key responsibility plays the thermal qualities that are initials for comfortability in architecture. When this question is raised in public buildings, that becomes more asserted to solve spatial challenges. Besides the technical background of this topic, the beginning point of the evaluation is the spatial features in architecture. The space per se evolved a variety of values in architecture. For this research, the values are reflected throughout the results that have dual nature: graphic and numeric. Besides the rational background of the result, the authors express the importance and quality of the place in the process of evaluation of the thermal comfort within the buildings.

To provide a basis for thermal comfort, it will be explained upon a more theoretical and empirical approach. Besides its engineering background, this paper translates such discipline in architectural and spatial scale. The study will bring this field into the process of design. Therefore, providing such qualities would contribute towards the improvement of health and wellbeing performances. Thus, to say, providing indoor comfort in the buildings will result in work efficiency. In the following case of public buildings, it will improve the system of public services.

2. Material and Methods

The next section introduces the methodology of this investigation. Proposed topics of the research express the importance of the values in architecture. From one side it includes geometrical, design, and materiality characteristics of the public buildings. On the other side, that means structure properties such as components of the elements, layers, and finishes that define indoor climate properties of the buildings. In that direction, certain methods are applied for the

research purposes such as comparative method, method of analysis, method of rationalization, calculation model as a result of computer software for spatial and thermal simulation. Given the methods described above, their results find a place in the design process of the public buildings. The process itself can be understood with some general spatial challenges, such as wide spaces with wide spans. Those spatial dimensions provoke responsibilities that have architectural and engineering challenges. Therefore, the proposed topic is related to public buildings and their characteristics can be approached from the common grounds: wide spans, high ceilings, wide volumetric units. In the mentioned spatial context, the most challenging aspect is how to establish constant values in the temperature and indoor comfortability.

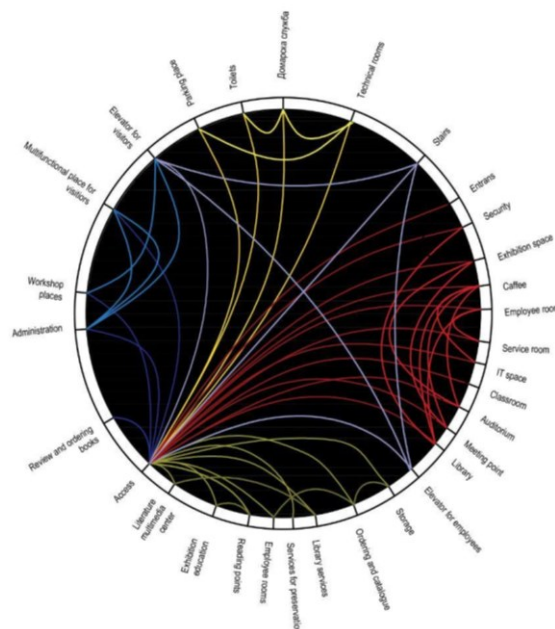


Figure 1. 3D and Diagram presentation.

The hypothesis could be made that improvement of spatial performances is a result of improved qualities within the buildings. The question asked here is how to make a good and quality approach in the process of providing thermal comfort. Another question is how to provide a constant temperature in a volumetric unit with expressed heights and open floors. Also, how to minimize and accumulate warm air of the higher points of the multi-height volume unit. In a general direction, answers to these questions can be provided while applying various methods. For that instance, there is a need for a rational, analytical and comparative approach in solving such thermal challenges. On the other hand, indoor qualities in architecture are conceived as qualities that have certain responsibilities. While spreading in the space, the temperature gets in contact with the surfaces. In that case, it reflects or absorbs depending on the material properties of the finishes. That process of spreading the air temperature in a certain direction is blocked by the solid materials that are defined by the structural properties of the buildings. Moreover, it is of great importance to apply materials and finishes that contribute towards constant indoor temperature. The view of the authors is the need for rationalization of the geometric and tectonic features. That is the main methodology applied for this research proposal. In that process, a distinction must be made between geometry and materiality. This paper shows the importance of the materiality that is directly related to the thermodynamics within the buildings. In that direction, this paper expresses the necessity to connect the structure of the elements with the materiality of the surfaces and finishes. In this text, structures and materials place direct relation with the thermal properties of the buildings. In addition to that, special attention is addressed to the public buildings that include timber materiality. Therefore, the principal thesis can be related to the improvement of the thermal and visual qualities of the public buildings in timber structures.

In this study, the aspects of architecture physics are in direct relation to climate characteristics and the internal fabric of the building. That includes considering the following: location conditions, human process, treatment of the environment, and the impact of the built environment. It is self-evident that the following aspects need to be taken into consideration during the design process in order creative treatment of sustainability. The understanding of this topic has been limited to the relation between the built environment and climate conditions. Some of their characteristics are referred to these values in the central part of Macedonia as follows:

- Average annual air temperature 12°C - 15°C
- Average summer air temperature 24.7 °C

- Average winter air temperature 3.1 °C
- Number of the days with temperature below zero: 58
- Temperature amplitude 58.6
- Average hours per year with sun rays 2148
- Average precipitation 477mm/m²
- Dominant winds: from north and west-north direction
- Insolation condition: axial orientation

While considering the climate context, the understanding has been limited to applying the method of rationalization and optimization in the design process. One of the possible explanations of applied methodology is that sound and temperature are directly related to the architecture. This would explain why we need to consider building physics in the process of architecture design. This diversity of approaches reflect the importance of geometry and materialization in public buildings. In other words, why is it necessary to consider building physics in the process of the design. Broadly speaking that covers placing thermal and acoustic insulation of the envelope and solid materials of the entire buildings.

3. Results

In this text, the authors are describing the importance of thermal conditions in architecture. From the previously applied methods, there are results that have dual nature: spatial and performative. These results show that geometry and materialization are directly connected with the scope of this study. Both of these terms have a very important part in determining the following aspects: absorption, reflection, aesthetics, environmental and spatial characteristics.



Figure 2. 3D and Site plan presentation.

To ensure that the methodology is directly applied, we designed a new public building. It is a result of a design process for the purpose of the public architecture competition in Macedonia. For that instance, this study elaborates a place for comfortable and performative function as a library. The principal objective of this building is to make a place based on rational approaches to function as a new public building. In that process, the main requirement is including local, national regulations and the relevant parameters for the design of a public building. The authors are also relying on the aspects of sustainability and efficiency within the buildings. As a result of the design process, the following aspects are provided:

- Access for everyone
- Daylight distributed to every volume unit
- Application of sustainable methods of the design
- Compatibility of materials with different physical properties
- Providing visual, thermal, and acoustic comfort.

The concept of the solution presents a multi-height place that is atrium oriented and that includes vertical and horizontal communications. The central place of the building is directly lighted from the roof windows. This strategy enables direct import of the sunlight within the central place of the building. The entire program units are oriented towards this central volumetric unit. At this point, the authors would like to outline the importance of materialization of the building and the alternation between timber, concrete, and lime mortar. In this direction, the proposed solution is based on a skeleton construction system with flexible units that can be adjusted to the variety of tectonic concepts. Following the contemporary ideas of functioning a public library, the intention is to make a flexible and multifunctional place. Architecture is based on ideas of rationality and reductions. The entrance of the building is distinguished between the employees and visitors. Therefore, it creates a differentiation between the following units: administrative work, access for visitors, group events, exhibitions, lectures, readings, etc. Besides the access, the solution provides communication between units on a horizontal and vertical level. There are many responses on how to solve a variety of architecture challenges. The response of the authors is based on programmatic and performability in architecture with multifunctional

character. Concerning the hypothesis of this text, there are favoring rationality and orthogonality in architecture. It should be emphasized that the internal covered atrium is a direct result of the applied methodology. That is a very important spatial element that covers the gap between strategies and hypotheses. Observations of this study suggest that the hypothesis is connected to the spatial and energy performance of the building. In other words, the relation between thermal conditions with the properties of the internal fabric of the solution.

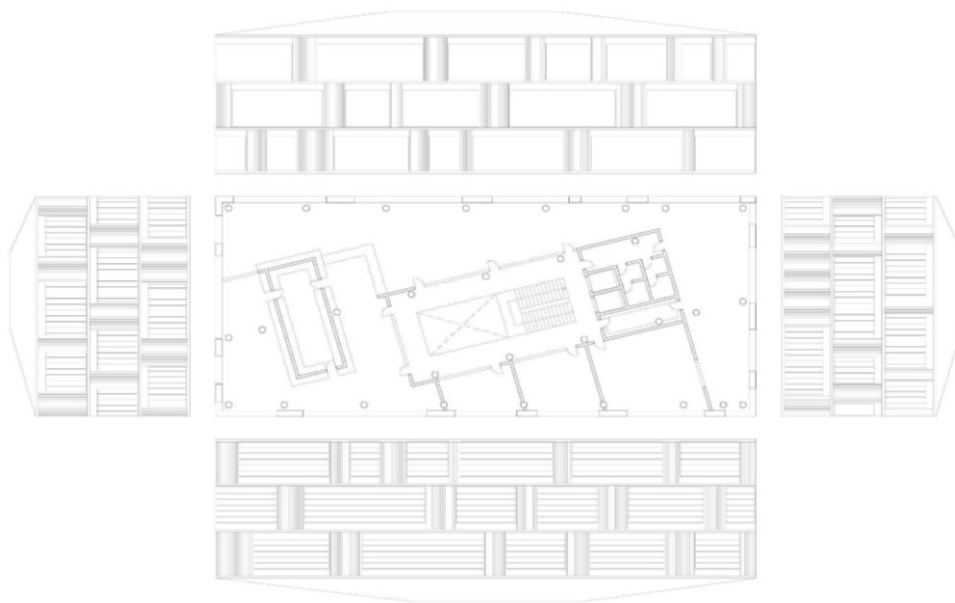


Figure 3. Plan and elevations.

The structure of the building presents an orthogonally rotated matrix of reinforced concrete columns and beams. Broadly speaking, the structure is skeleton type with various material alterations: timber, reinforced concrete, and lime mortar. This approach is followed by the idea of compatibility and sculpturally. On the other side, making timber slab and timber roof makes the entire building more vital. It divides the structure between primary and secondary ones. This combination of materiality and structural degrees stimulates the strength of the structure and makes the building more resistant to outside influences. Most of the elements are conducted as dry construction. In such cases, we should emphasize the windows and openings. The suggestion is that the window detail is executed with good sealing. This evolves the necessity of a combination between finishes and solid elements with openings. The finishes themselves present alternation of burnt timber and corrugated metal sheets on the outside of the building. The inside of the finishes is materialized with timber and lime mortar. Besides the combination of the solid elements and openings, we are placing attention on the isolation layers. One of the most important layers of the structural elements is thermal and water isolations. Their application is under various spatial and structural contexts. Above all, our strategy is placing the isolation materials from the outside of the composition elements. The reason behind this is creating a strong difference between the inside and outside of the building. Such placing of the layers contributes towards better control of the internal climate condition of the building. This would explain why the buildings are treated as closed systems. In other words, this contributes towards better control of the thermal performances of the building.

Table 1. Diagrams and numeric results.

	Wall	Slab	Roof
Diagram 1- Temperature			

Diagram 2- Thermal diffusion			
Components	2.5 cm Timber finish 1.8 cm Timber board 20 cm Thermal insulation 0.1 cm Waterproof 3.5 cm Air 1.8 cm Timber board 2.5 cm Timber finish	2.5 cm Timber floor 1.8 cm Timber board 20 cm Thermal insulation 1.8 cm Timber board 40cm Air 1.8 cm Timber board 2.5 cm Timber ceiling	0.2 cm Corrugated sheet 0.1 cm Waterproof 10 cm Air 10 cm Thermal insulation 20 cm Thermal insulation 1.8 cm Timber board 2.5 cm Plaster finish
Area	674 m ²	2168 m ²	740 m ²
U value	0.158 W/m ² K	0.150 W/m ² K	0.112 W/m ² K

In this study, the thermal characteristics of the buildings are considered from the aspect of architectural physics. For the research, the authors are applying a calculation model of the structural elements such as slab, wall, and roof. The team conducts the research separately for every element and wholly for the entire building. As a starting point, every layer is defined separately. Also, the authors are considering the temperature differences, openings, areas, and materialization. Outdoor temperature differs between -20°C and +5°C during the heating days (158 per year). It is important to consider that the results of this study are a combination of the consideration of geometry and materialization of the building. These two aspects are key terms in defining thermal and acoustic properties in architecture. The results presented in the table are related to the elements separately and the entire building. The results present the entire heating consumption that is 40013.07 kWh or 18.72 kW/m² on an annual basis. These outcomes evaluate the building in A category according to the European energy scale. The authors are emphasizing that those numbers are a consequence of the thermal gains and loss of the building. The solar gains are 519.8 kWh that is an indication of the orientation of the building and the material treatment.

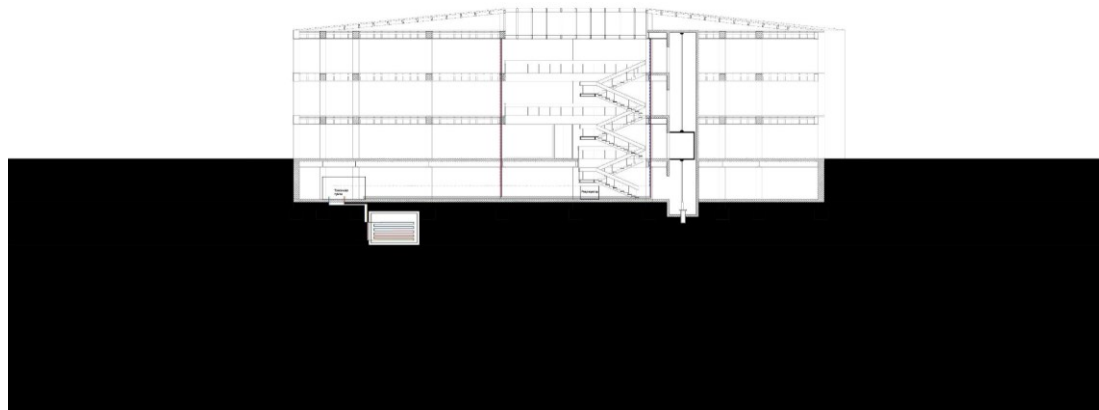


Figure 3. Section

4. Discussion

The results presented in this text may have important implications in the process of architecture design. Thermal conditions may find their application in disciplinary contexts that become interdisciplinary. There are obvious limitations of the results that can find a fit in the spatial aspect of public buildings. For that purpose, the end up a result of the process is architecture from public character, materialized in timber. Following the methods and outcomes of the research, the principal ground of this discipline is the geometric and material aspects of the results. That shows the numbers of the alternation of various layers of the structural elements such as wall, slab, roof. All of these features are in direct relation to the entire performance of the building. Translated in numbers, total heat energy consumption is 18.72 kWh/m² on an annual basis. This place the building in the A category. The energy consumption is a result of the spatial values of the solution followed by the technical and technological characteristics. Therefore, the results are a consequence of the applied methodology related to optimization and rationalization. To conclude, this process of design

is directly linked to the material and structural features within an architectural context. For that instance, the authors believe that the results are directly related to the following conclusions:

- Dense trees planted on the south and east side of the location
- Application of systems that stimulates energy efficiency in heating, ventilation, and air cooling process
- Application of materials with low emission of carbon dioxide in the atmosphere
- Placing vertical shadings on the west and east side of the building
- Placing horizontal shadings on the south side of the building
- The size of the windows provides thermal gains during the wintertime. The shadings block the direct sun heating during the summertime.

Another note to take into consideration is related to placing the shadings on the external side of the openings. The authors find in the results that the following strategy contributes towards reduced energy consumption for heating and cooling. In addition to that, the temperature is related to HVAC systems that follow the optimal standards and contributes towards energy efficiency in the buildings. The findings presented here define the building as NZEB (Near Zero Energy Building). Further investigations need to focus on the updates of regulatory standards and directives of the energy community in order to contribute towards sustainable development of the public buildings.

5. Conclusion

The general conclusion can be related to the thermal performability within the buildings that are directly connected with elements of the fabric within architecture. We can conclude that the aspects of indoor air conditions can be taken into consideration during architecture design and the entire spatial thinking. This contributes towards the evaluation of architecture with other engineering and scientific disciplines. Even these conclusions may find their application in various stages of architecture projects. The belief of the authors means to consider the outcomes during the architecture design process. Following these sustainable design strategies, there might be an improvement in the following fields: health, comfort, functionality, property value, and spatial performability. This discussion leads towards the quality treatment of the built environment and brings us a step closer to a more quality natural environment.

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Conflict of Interests

The Authors declare no conflict of interest.

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