INTERNATIONAL JOURNAL OF TECHNICAL AND NATURAL SCIENCES

DOI: https://doi.org//10.69648/AOAL9594

International Journal of Natural and Technical Sciences (IJTNS), 2024; 4(1): 39-53

ijtns.ibupress.com

Online ISSN: 2671-3519

Application : 10.04.2024

Revision : 01.06.2024

Acceptance : 16.06.2024

Publication : 25.06.2024

Konicanin, V. (2024). Entropy based network anomaly detection. International Journal of Natural and Technical Sciences, 4(1), 39-54.

https://doi.org//10.69648/KJDP2991

Marija Miloshevska Janakieska

International Balkan University, FENG, Department of Architecture

We declare no conflicts of interest.

Correspondence concerning this article should be addressed to .....

Email: ....

BALKAN JOURNALS

Structural Systems as Aesthetic Drivers: Unveiling the Influence of Structural Systems on Building Aesthetics

Marija Miloshevska Janakieska

Abstract

The primary purpose of the structural system is to support a building, to resist various forces, to transfer the loads safely to the ground, and to give stability. In addition to this primary function, the structural system can have secondary functions, such as influence on the functionality and impact on the overall aesthetics of the building presented in the interior and exterior design. The aesthetics of a building plays a vital role because it contributes to the character and identity of a place, creating a positive and welcoming environment for residents, visitors, and workers, and directly impacting the experience of people, helping in creation of a strong brand identity, establishing an image in the mind of the public. Therefore, in this study, analysis of the impact of the structural systems on the building's aesthetics has been made. Specific structural systems will be presented and explained. In addition, some case studies will be added to show the influence of the structural system on the building's aesthetics.

Keywords: structural systems, aesthetic, architecture.

Types of Structural Systems of Buildings

A structural system is a method of arranging and constructing different structural elements to support a building to receive and transfer loads safely to the ground without harming the other parts. These structural elements resist forces and loads such as gravity, wind, seismic activity, and dynamic loads (Günaydın, H. M., & Doğan, S. Z. 2004).

The structural system provides strength, rigidity, and durability to the building and ensures that it can safely withstand the forces and the loads during its lifespan. Usually, it is designed by structural engineers, who collaborate with architects so that the structure will be well-adjusted to the function of the building.

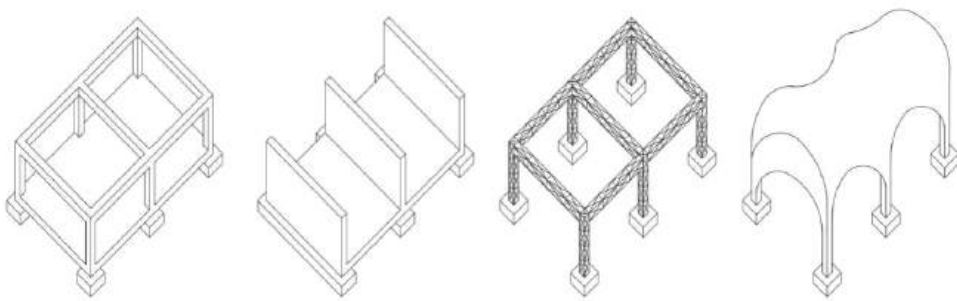
In addition, the structural system also influences functionality and impacts the overall aesthetics of a building, which will be elaborated further in this paper.

There are different types of structural systems of buildings:

- Massive Structural System or Structural System with LoadBearing Walls: In this system, the loadbearing walls carry the vertical loads of the building and are typically made of materials such as masonry (bricks or concrete blocks) or reinforced concrete. Furthermore, the walls have a structural and functional role, enclosing the building and dividing the space horizontally.
- Frame Structural System or System with Columns and Beams: The frame system consists of a framework of vertical columns and horizontal beams that form a skeletal structure, where the columns transfer the vertical loads to the foundation. In contrast, the beams distribute the loads horizontally. This system allows for large open spaces, as the walls are not loadbearing. Typical materials that can be used for this structural system are steel, reinforced concrete, or timber.
- Combination of Massive and Frame Structural System: A system with columns and beams, where loadbearing walls are added to ensure structural stability.
- System with trusses: Trusses are structural elements with interconnected members that are joined together to form a rigid framework. They are used for large spans in roofs and floors. Truss systems can be made of timber, steel, concrete, or other materials.
- Shell System: Shell structures are structural systems with loadbearing capacity derived from their curved or folded shape, which allows efficient load distribution. Different examples include domes, vaults, and thinshell concrete structures.

- Composite System: A composite system combines different structural elements. For example, a composite system can be a combination of steel, concrete, and timber elements positioned together in such a way that their specific properties are used to the maximum.
- Suspended System: In this system, the building's floors or roof are suspended with a supporting structure, such as cables or hanging rods. This contributes to bigger open spaces and unique architectural designs.

Figure 1 *Different types of structural systems: a) frame structural system with load-bearing columns and beams; b) massive structural system with load-bearing walls; c) truss system; d) shell system*



Some of the main structural systems are presented in Figure 1. There are many different types of structural systems and combinations. The choice of the type of structural system depends on the project's specific requirements, architectural design, location, finances, and engineering considerations (Ali, M. M., & Moon, K. S. 2018).

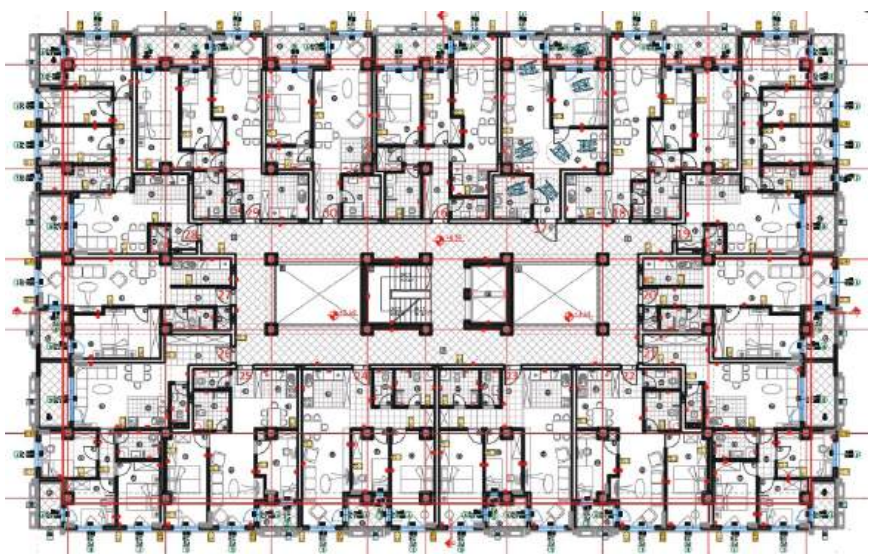
Structural Systems of Buildings in Macedonia

Even though there is an enormous variety of construction materials and types of structural systems, only a few construction systems are used in Macedonia with a limited number of materials, primarily due to financial reasons, ease of construction, and availability of materials.

In residential buildings, a combination of massive and frame structural systems is often used. The columns allow freedom in functional arrangement of the interior space, while the load-bearing walls provide additional structural stability, especial-

ly in horizontal direction. Macedonia is a seismically active region, and therefore, the horizontal stability of the buildings is of a great importance. The load-bearing walls are typically placed around the stairs and elevators, which are the most suitable places for such massive walls without openings or with tiny openings. Figure 2 presents a characteristic floor plan of a residential building in Prilep. The load-bearing walls are arranged around the stairs and elevators, while the other part of the building is solved with columns and beams, which allows an efficient functional arrangement of the apartments.

Figure 2 *Characteristic floor plan of a residential building in Prilep (Main Project on the Residential Building with technical number 03/23-1, responsible designer: Marija Miloshevska Janakieska)*

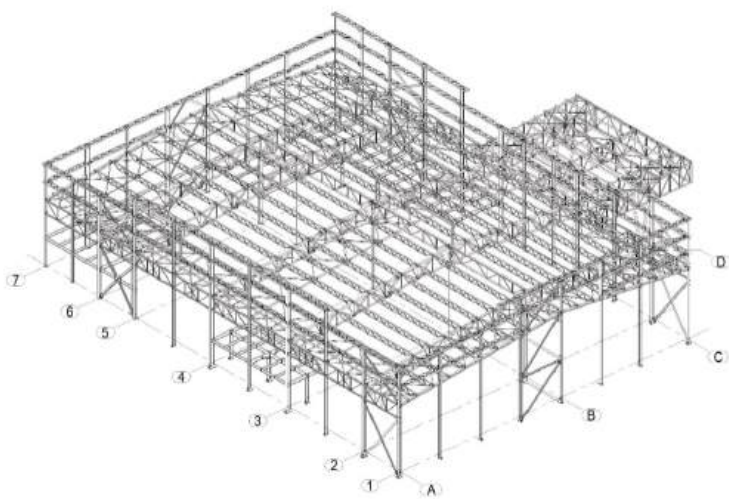


The most common material for this kind of structural system, which spans from 5-6 meters, is reinforced concrete for several reasons, such as strength, durability, versatility, cost-effectiveness, fire resistance, and sound insulation.

Steel can be used as a structural material for other types of buildings, especially if the spans between the columns are long. Steel is mainly used in industrial halls, warehouses, hotels, and administrative buildings. Steel as a structural material is used for the load-bearing elements in the frame system, such as columns and beams. If the spans exceed 10 meters, the steel beams can be replaced with steel trusses. Steel is used as a construction material only for structural elements above

the ground level. Due to moisture and water protection, all structural elements in contact with the soil, such as foundations, basement walls, slabs, etc., are made of reinforced concrete. Figure 3 shows a 3D model of a steel structure, with steel columns and trusses of a building that represents a hotel complex.

Figure 3 *3D Representation of a steel structure of a building (Main Project B5 - Hotel Complexes, with technical number 11/21-1, responsible designer: Marija Miloshevska Janakieska)*



Aesthetics of Buildings

Vitruvius believed that there were three central themes when preparing a design for a building, which are the most important: firmitas (strength), utilitas (functionality), and venustas (beauty) (Vitruvius 1999). All these three themes are equally important in a building design. The functionality is determined by the arrangement and position of the rooms, as well as the organization of the furniture. On the other hand, the strength is obtained by the structural system of the building, which ensures that the building is stable, safe, and resistant to different loads. The structural system should be in correlation with the functional arrangement of the building. The aesthetics of a building is an essential aspect because architecture is art and buildings, as creations, should be beautiful. The beauty of a building depends on several factors, such as cultural context, which covers the cultural back-

ground and the traditions of the society; historical period; function and purpose; environmental factors, because buildings are designed to respond to and interact with their environment; technological advancements, such as new construction materials, engineering techniques, and innovations in building systems; architectural movements and styles; economic factors; social and user preferences. The relative importance and influence of these factors can vary depending on the specific project, location, and the architect's design philosophy. Different buildings may prioritize different factors, resulting in various architectural styles and aesthetics.

The visual and sensory aspects of design determine the aesthetics in architecture. The objective of the architecture is to create buildings and spaces that are visually pleasing and harmonious, and evoke positive emotional responses. In buildings, aesthetics can include elements such as form and shape, materials and texture, colors, light and shadow, proportion and scale, contextual integration, and spatial experience (Ching, F. D. K. 2014), (Coburn, A., et al. 2020), (Simitch, A., & Warke, V. 2014).

Structural Systems and Aesthetics in Architecture

Despite its primary function to provide strength and stability to the building, the structural system also plays a significant role in its aesthetics. The design of the building's structure influences its visual appearance and contributes to its overall architectural impression [3, 5].

In some buildings, the structural system is left visible and emphasized as a part of the design aesthetics. This concept is not new. It was used in the past with traditional buildings but is also used in modern architecture (Figure 4).

Figure 4 *a) Milan Cathedral in Milan, Italy, where the vaults are displayed and are adding an aesthetic quality to the building (https://traveldigg.com/milan-cathedral-duomo-di-milano/); b) A truss house by ACDF* architecture in La Malbaie, Canada, with exposed steel truss (https://architizer.com/blog/inspiration/collections/truss-houses/)*

The choice of a structural system can shape the overall form and silhouette of a building. Structural systems have different capabilities in spanning large distances, supporting vertical loads, or accommodating unique shapes. Whether it is a skeletal frame, a cantilever, or an arch, the structural system influences the building's massing, proportions, and overall visual impact (Simitch, A., & Warke, V. 2014).

In addition, the structural system can influence the spatial experience inside a building. The arrangement of columns, beams, and other structural elements can define the organization of spaces and circulation patterns. As a part of the system, the structural elements can create open, flexible, vast spaces or more intimate, enclosed areas. The connection of the structure with light, shadows, and materials can contribute to a different atmosphere in the interior spaces, creating different user experiences (Figure 5).

Figure 5 *a) Visible reinforced concrete waffle structure in the interior of a building, creating an amazing experience of light and shadow (https://www.cedengineering.com/courses/structural-design-criteria-for-raised-floor-systems); b) Visible structure from EWPs which, due to the wood as a natural material, contributes to a beautiful and aesthetically pleasing design.*

The choice of structural materials used in the structural system has a significant influence on the visual and tactile qualities of a building. Different materials, such as exposed concrete, steel, timber, or a combination, can contribute to the overall aesthetic expression (Figure 6).

Figure 6 *Comparison of structural systems made from different materials: reinforced concrete, steel, wood and glass with completely different visual and tactile qualities.*

The structural system must be integrated harmoniously with the building's architectural style and design intent, which means that the structural system should complement and reinforce the architectural concept. The choice of structural system can align with the desired aesthetic language, whether it is emphasizing simplicity, complexity, transparency, or ornamentation (Ambrose, J., & Harris, P. 2013).

The structural system can influence the visual hierarchy and composition of a building. The arrangement and repetition of structural elements can create patterns, rhythm, and visual interest. The proportions, spacing, and alignment of columns, beams, and other structural components can define the building's façade and relationship to the surrounding environment (Simitch, A., & Warke, V. 2014). Table 1 presents the impact of the structural system on the aesthetics of chosen buildings, whereas Figure 7 shows a Preliminary Project on a Botanical Garden in Skopje with a structural system from GLT–glued laminated timber.

Table 1 *The impact of the structural system on the aesthetics of chosen buildings*

Name and Architect	Place	Photo	Structure's impact on aesthetics
Scottish Parliament Building by Enric Miralles	Edinburgh, Scotland		The complex roof structure with trusses, made from laminated timber beams connected with stainless steel connectors, gives a magnificent look to the interior design. Wood is used as a structural material, but also as a non-structural material for decorative purposes and for furniture, which gives aesthetic value and emphasizes the biophilic design.

Leeza SOHO by Zaha Hadid Architects	Beijing, China	  	The two halves of the building are merged by the atrium from the base to the top, along with contorted structural skeleton and bridge rings, with a combination of concrete and wide-flange steel, which results in a spectacular exterior design.
Cruise Terminal by CCDI - JING Studio, CCDI - MOZHAO Studio	Qingdao, China		The folded steel roof structure continues in vertical direction, exposed on the exterior without curtain walls, so the structural form becomes the most powerful language of the façade. The interior sprung roof reveals the main structure so that passengers can still read the structural logic, which influences the aesthetics of the building.

1111 Lincoln Road by Herzog & de Meuron	Miami Beach, United States		Inspired by the brutalist style, the architects use visible main structural elements to provide shade, with smaller enclosing sub-elements. The slabs stand over irregular columns, giving a sense of a precarious equilibrium. These columns also cast different shadows, giving more character to the facade.

Figure 7 *Project proposal for a Botanical Garden in Skopje with a structural system from GLT, designed by Faton Kalisi, master student at the International Balkan University*


Conclusions

A structural system in building construction involves arrangement and construction of various structural elements to ensure safe support of the building and effective transfer of loads to the ground while avoiding damage to other building

components. In Macedonia, the utilization of construction materials and systems is limited and primarily driven by factors such as financial considerations, ease of construction, and material availability.

In addition to ensuring functionality and structural stability, architects seek to create aesthetically pleasing buildings. There are many elements that contribute to architectural aesthetics, including the shape of the building, the materials that are used in the design, the texture, the colors, the proportions, the correlation with the context, etc. The design of the building's structure plays a vital role in shaping the aesthetic appearance and gives a significant contribution to the overall impression.

References

Ali, M. M., & Moon, K. S. (2018). Advances in Structural Systems for Tall Buildings: Emerging Developments for Contemporary Urban Giants. Buildings, 8, 104.

Ambrose, J., & Harris, P. (2013). Building Structures Illustrated: Patterns, Systems, and Design. Wiley.

Charleson, A. (2015). Structure as Architecture. United Kingdom: Taylor & Francis.

Ching, F. D. K. (2014). Architecture: Form, Space, & Order. Germany: Wiley.

Coburn, A., et al. (2020). Psychological and Neural Responses to Architectural Interiors. Cortex, 126, 217-241.

Günaydın, H. M., & Doğan, S. Z. (2004). A Neural Network Approach for Early Cost Estimation of Structural Systems of Buildings. International Journal of Project Management, 22(7), 595-602.

Scaramozzino, D., Lacidogna, G., & Carpinteri, A. (2020). New Trends Towards Enhanced Structural Efficiency and Aesthetic Potential in Tall Buildings: The Case of Diagrids. Applied Sciences, 10, 3917.

Simitch, A., & Warke, V. (2014). The Language of Architecture: 26 Principles Every Architect Should Know. United Kingdom: Rockport Publishers.

Vitruvius. (1999). Vitruvius: Ten Books on Architecture (I. Rowland & T. Howe, Eds.). Cambridge: Cambridge University Press.