ARCHITECTURAL MORPHOLOGY STUDY TOWARDS SUSTAINABLE DESIGN SOLUTIONS (CASE STUDY OF HA NOI CHILDREN'S PALACE DESIGN)

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Abstract - Researching building architectural morphology is one of the important tasks of architectural design, not only referring to formal design but also related to factors affecting form such as function organization, technical structure, technology implementation. Sustainable design is not only a current trend but also a goal that designs should aim for in order to minimize environmental impacts, save energy as well as to preserve and promote cultural values. This article studies the dialectical relationship between architectural form and sustainable design solutions. The methods used in this paper include systematic and logical analysis methods, diagramming methods, and empirical research methods through the case study of the design of the Hanoi Children's Palace – a construction that was recently completed in July 2024.

Key words - Architectural form; Sustainable design; Hanoi Children's Palace.

1. Introduction

Although the definition of “Architecture” has been researched on for centuries, the term "Morphology" only started to emerge from the early 20th century. Morphology is the science that studies the nature of Form, the science that deals with consciousness itself, and the science of a possible form. Initially, the term "Morphology" was only used in the field of bioscience, but has now been increasingly used in fields such as geography, architecture, philosophy, and other disciplines [1].

The term "urban morphology" originated from the studies of S. Muratori, specifically his iconic morphological study on Venice [2]. This research introduced a new perspective on the architectural composition of historic cities, emphasizing structural analysis as the foundation for theories and practices of functionalist urban planning in the early 1970s.

Architectural morphology is the science that studies the form of architecture, a specialized field that examines the physical shape of architectural spaces in relation to the role of humans in shaping them [3]. Several ideologies that influence architectural morphology often have cultural or philosophical origins, including: Indigenous architecture, Classical architecture, Baroque architecture, Modernism, Postmodernism, Deconstructionism, Brutalism, and Futurism. Recent advances in analytical tools and multi-platform technologies such as 3D printing, virtual reality, and building information modeling have made contemporary architecture highly diverse and multifaceted. The creative research of "Architectural Morphology" (AM) is the focus of contemporary architecture [4].

Although there has been no definitive summary of new types of architectural morphology, contemporary architecture has presented a fresh, distinctive, and non-repetitive appearance compared to previous morphological styles. This is largely attributable to innovations in materials and construction techniques, but more importantly, to the creative design thinking of architects. This new mindset has made contemporary architecture consistently innovative while remaining feasible and adaptable in a society facing constant transformation challenges, from physical spaces to the natural environment. While the 20th-century modern architecture focused heavily on technical functionality, the 21st-century contemporary architecture has stripped away the complex requirements of modernist architecture and instead emphasizes environmentally friendly features, energy efficiency, and embraces all creative architectural forms to express these qualities. These new design approaches are part of sustainable design.

Recently, the term "sustainable design" (SD) has been frequently mentioned in contemporary architecture. SD focuses not only on greening the environment in terms of nature but also in terms of culture. Both of these aspects are critically important. A building that is a product of SD must play a dual role. On one hand, it must reduce greenhouse gas emissions, increase the absorption capacity of greenery, and at the same time, it needs to create a cultural and educational environment that fosters love for one's homeland and humanity. This means that SD is not only concerned with how it interacts with nature but also with human emotions [5].

In the relationship between architectural morphology (AM) and sustainable design (SD), it can be asserted that AM in contemporary architecture is designed not only to meet the functional and aesthetic aspects of 20th-century modern architecture but also to embody the two important aspects of SD as aforementioned. This research paper will delve into analyzing the components of AM and the criteria that form SD. From this, it will establish a bidirectional relationship between AM and SD, illustrated through the design solution of the "Hanoi Children's Palace" (HCP) project - a newly completed building in July 2024 in Hanoi. The aim of this research is to approach SD from the perspective of functional organization and the design of AM. The paper employs various research methods, including synthesizing sources, analyzing architectural morphology, comparative analysis, experimentation, and empirical research.

2. Related works

2.1. Architectural composition

In relation to architectural morphology of a construction work, it is essential to focus on the concept of architectural composition. The definition of "composition" has been researched many times over the past centuries. It appears in the context of various forms of art. Historically, Alberti defined, “composition is the procedure in painting whereby the parts are composed together in the picture” [6]. In music, "composition" refers to the process of creating or forming a musical work by combining various parts or elements of music. In architecture, Gaudet defines composition as "the combination of parts in a coherent whole” [7]. When discussing composition, experts often emphasize the syntax of arranging components. This not only pertains to the aesthetic requirements of composition but, more importantly, must express its content. From this perspective, a good layout should possess certain syntactic characteristics. The theoretical foundations of composition relate to “form” and “type,” the axes of the building, geometric unity, order, proportion, and the relationship between the composition and other architectural elements.

2.2. Figure, Form and Space in Architecture

Figure in architecture refers to the visual image, recognized through shape and type. Meanwhile, Form refers to the combination of the external outline, the internal structure, and the unity of design as a whole - a sense of order that architects create using space and mass [8].

Historically, the concept of Figure preceded those of form and architectural space. From the perspective of geometry, form connects all basic or composite entities through symbolic shapes. As a term with multiple meanings, form is related to the idea (the shaping) of fundamental forms. The synthesis of different ideas leads to an overall schema "of what can be conceived and what can be expressed". In architecture, form is seen as all the constituent elements that embody cultural values: "its specific or nonspecific efficiency in greening the environment lies in the synergy it creates." These elements accumulate and crystallize a range of diffuse, complex experiences that are not immediately perceptible. Thus, form is the integration of figure and structure, whose effects can generate far greater variety and complexity than in reality.

2.3. Form in Architectural language

Architectural language is expressed through symbolic architectural morphologies. The transmission of content in architectural language requires the arrangement of structural elements and the art of space planning. Each city has its own language, which is an intersection of architectural forms and the cultural values conveyed. Certain architectural forms can tell the story of the city’s history. Thus, through architectural language, one can decode architectural forms that are pragmatic or have their own syntax [10].

Morphology is the study that defines, analyzes, and describes the structure of forms. Semantics studies meaning within architectural language, relating to the signs that are interpreted and communicated to the community. Syntactics is the branch of science that examines the arrangement of composite elements to create a meaningful architectural whole. Unlike architectural grammar, which tends to focus on rules and structures, syntax refers more to the order and position of components within the whole. Pragmatics is the science that studies the relationship between architecture and the context that creates that architectural language. Glenn Gould argues that "architectural language does not only adhere to certain rules; it also contains a transcendent and non-displayed element that is difficult to explain explicitly” and “creative art is a close combination of rational and instinctive decisions" [10].

2.4. Architectural form and the elements of metaphor and symbolism

According to Marc Kushner, the architecture that humanity desires for the future needs to inspire people as well as be beneficial to the environment. Architecture provides mental comfort while ensuring functional and environmental needs, supported by technology and new materials [11].

Architecture is closely tied to culture. Culture is formed in each individual through a system of symbols, perceived visually. It represents the relationship between the symbolic world and the world of reality [12]. In architecture, the formation of architectural morphologies that are related to symbolic systems must harmoniously combine with functional use. Morphology is not solely dependent on pure functionality; rather, pure functionality must have the capacity to flexibly transform into creative forms. The relationship between form and function is a bidirectional one, interacting and supporting each other. This replaces the previous one-dimensional relationship of pure functionalism.

The use of space in architecture is not limited to the level of individual buildings; it is also recreated on a larger scale within the architectural landscape. At the same time, the façade of an independent building may not create an architectural space, but it can produce a sculpture-like effect, with shapes being arranged within a vast void [13].

2.5. Architectural form and the elements of functionality and technical aspect

Functionality in architecture meets human usage needs through principles of layout, circulation organization, and functional zoning of the construction work. Based on the intended use of the construction, one can create basic forms of architecture through the relationship: Usage - Structure - Expression - Information. In all cases, functionality remains the most sustainable factor over time and is the primary concern in the design process. However, over time, human needs may change, requiring functionality to be adaptable and flexible. This flexibility can alter the architectural appearance, while the elements of "Structure - Expression - Information" remain unchanged.

In addition to functionality, the material and construction techniques have a significant relationship with architectural morphology. Materials are objective

elements found in nature but are perceived subjectively by humans. They only gain meaning through human scientific knowledge and artistic emotion. The properties of materials are reflected in the architectural form through the expressive qualities of surfaces and volumes. Materials not only serve technical functions such as waterproofing, thermal insulation, fire resistance, and impact resistance, but they also play a role in creating aesthetic emotions. They are closely linked to architectural language and symbolic systems.

3. Sustainable architecture design

3.1. Definition

In recent decades, sustainable design has been recognized globally as a contemporary trend. Sustainable architecture design tends to conserve natural resources while promoting cultural and historical values. Architecture acts as a second skin for humans in relation to nature, aiming to minimize solar radiation, respond to climate change, and mitigate other impacts. Additionally, architecture positively reflects various socio-cultural contexts. To achieve these two objectives, sustainable architectural design requires sustainable planning and architectural solutions [14]. From an ecological perspective, sustainable design aims for a balance between natural and human ecosystems. The concept of "ecosystem" originates from biological research, a field within sociology from the 1920s and 1930s. The human ecological model has general principles that allow organisms to interact within their environment. Interactions among elements form an ecosystem of varying scales. The human ecosystem is considered a unified system of physiological and social elements that interact with each other. Sustainable design must ensure a balance among these elements, enabling them to be adaptable and sustainable over time, which can be perceived and expressed at different levels [15].

3.2. The principles of sustainable architecture design

Regarding planning, the orientation of buildings within the overall layout should utilize the south and southeast directions at its predominant one. The landscape and infrastructure need to be emphasized in the design of outdoor spaces, as urban design and landscape design, whether for individual products or systems, are all part of sustainable architecture.

The arrangement of buildings in the overall layout should adhere to the principle of maximizing the capture of cooling breezes and avoiding obstruction of those breezes for the buildings located behind. Therefore, the blocks should be positioned to minimize exposure to the east and west while maximizing exposure to the north and south [16]. The most crucial aspect of the overall architectural space organization is defining the structure of various architectural spatial forms, including: a centralized axis, one-dimensional linear forms, two-dimensional linear forms, radial linear forms, network forms, super composition forms and labyrinth forms [17].

In terms of architecture, it is essential to emphasize the relationship between interior and exterior spaces to maximize positive natural impacts while minimizing negative ones. Modern construction technology and methods serve as supportive factors for energy efficiency. At the same time, architecture plays a crucial role in creating opportunities for flexibility and long-term adaptability of functional components. These designs allow for changes and the maintenance of those changes based on the immediate and long-term needs of users.

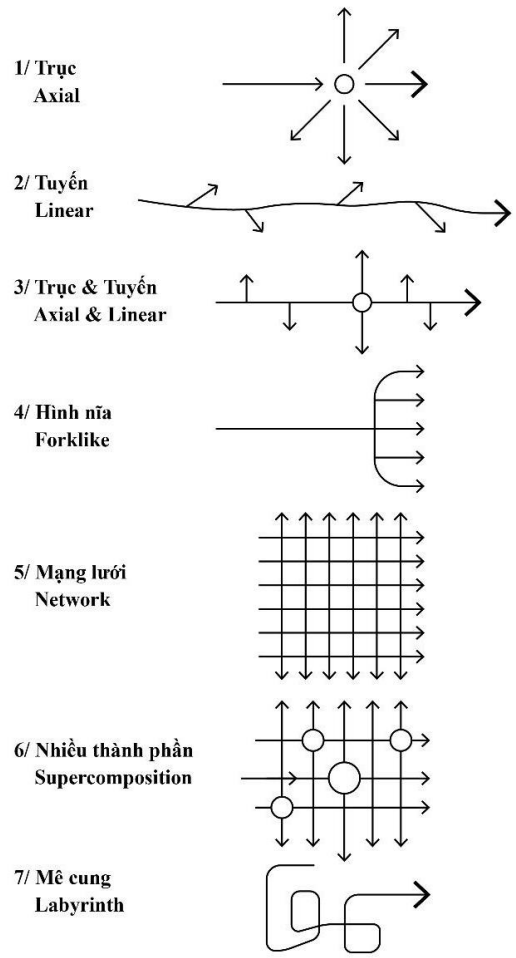


Figure 1. *Types of compositional axis in architectural space organization [17]*

Additionally, the building envelope system is significant for the architectural form - it serves three basic functions. The first is the function of enclosure between interior and exterior spaces, regulating the natural elements that affect the building. Secondly, it is the load-bearing function. The third function is the aesthetic function. Sustainable architecture focuses on the two functions: enclosure and aesthetics, as modern structural systems have liberated the load-bearing function of the envelope [18].

4. Result analysis - case study of Hanoi Children's Palace

4.1. Project information

This is a cultural building dedicated specifically to the children of the Hanoi capital, with an unprecedented scale in Vietnam. The site, resembling a peninsula along a lakeshore, spans nearly 4 hectares, with a construction density of 26%. It offers a world designed for children,

including an 800-seat multifunctional auditorium, three 3D and 4D movie theaters, an indoor all-season swimming pool with 10 lanes, an indoor sports hall, a system of club activity rooms, specialized classrooms, and study rooms. One particular highlight is the 68-meter-high Astronomical Tower, serving as a focal point in the overall design. The project, funded by the city with a total investment of nearly VND 1,400 billion, took nearly three years to complete and was inaugurated on September 21, 2024.

Figure 2. *Hanoi's Children Palace from the West-facing main entrance*

4.2. The functional zoning solution

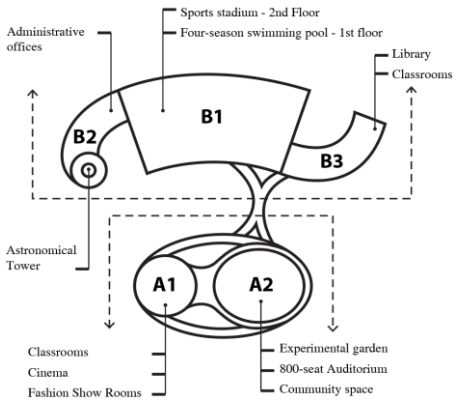


Figure 3. *The functional zoning map in Hanoi's Children Palace master plan*

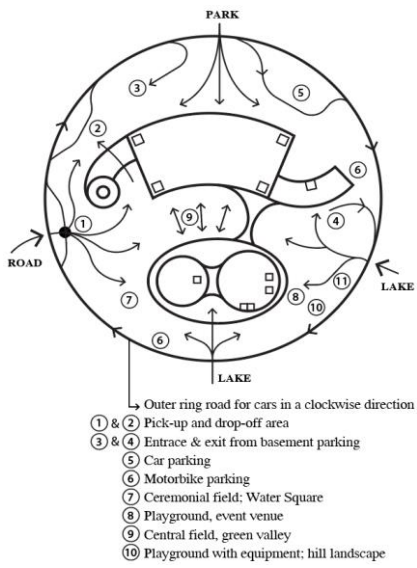


Figure 4. *The circulation organization map in Hanoi's Children Palace master plan*

According to the design, the Hanoi Children's Palace project consists of two main buildings, A and B, and five functional areas (A1+A2+B1+B2+B3). The highlight of Building A is the cultural and artistic block, which includes an 800-seat auditorium (A2) and a block with 3D and 4D cinemas, as well as club activity rooms (A1). Building B is the sports block (B1), featuring two large overlapping spaces: a multipurpose sports hall above and an all-season swimming pool below. Two additional areas, the study block (B3) and the administrative block (B2), are positioned on either side of B1.

4.3. The design of architectural blocks

4.3.1. Towards maximizing the positive impacts of nature

The project is composed of two main buildings, A and B, arranged parallel to each other. Building A has a circular and elliptical floor plan, with a curved, vaulted roof forming two "cupolas" with a gap between their interfaces. Southern winds blow from the lake, passing through Building A to Building B via a gap between the two buildings, where a grass courtyard and trees are planted. The overall site plan positions the two buildings' end walls along the East-West axis, while the lateral sides face North-South.

The roof of Building B is made of curved 3D aluminum, which forms an exterior shell with thermal insulation, waterproofing, and aesthetic metaphorical value. For Building A, the hemispherical roof covers both the roof and walls, creating an outer shell over the inner glass wall. Between these two layers is a gap that acts as a ventilated corridor around the building.

Table 1. *The measurement results of the internal & external surface of Building B's aluminum roof*

Measurement point	Internal / External surface	1st reading	2nd reading	3rd reading	Avg temperature	Amplitude °C
1	Internal surface	34.1	32.5	33.2	33.3	7.5
	External surface	45.3	42.1	35	40.8	
2	Internal roof surface	36.5	34.2	33.6	34.8	6.4
	External roof surface	46.8	41.1	35.6	41.2	
3	Internal roof surface	33.6	33.5	33.6	33.6	6.0
	External roof surface	43.5	40.3	34.8	39.5	
4	Internal roof surface	33.6	33.2	33.8	33.5	6.0
	External roof surface	43.5	40.8	34.2	39.5	
5	Internal roof surface	32.5	31.7	32.8	32.3	6.5
	External roof surface	41.2	40.6	34.6	38.8	
6	Internal roof surface	35.5	34.9	34.9	35.1	4.7
	External roof surface	39.9	44.2	35.4	39.8	
7	Internal roof surface	36	33.7	34.2	34.6	4.9

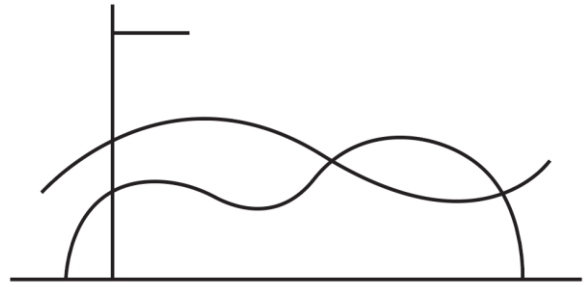
	External roof surface	46	38.7	34	39.6	
8	Internal roof surface	35.5	34.9	34.5	35.0	2.1
	External roof surface	38.5	39.4	33.4	37.1	
9	Internal roof surface	34	35.2	34.2	34.5	3.2
	External roof surface	35.3	43.9	33.7	37.6	
10	Internal roof surface	34.2	34.7	34.8	34.6	4.6
	External roof surface	35.9	47.2	34.4	39.2	
11	Internal roof surface	34.2	34.6	34.7	34.5	5.2
	External roof surface	37.8	46.9	34.3	39.7	
12	Internal roof surface	34.8	35	34.6	34.8	5.5
	External roof surface	42.7	44.6	33.6	40.3	
13	Internal roof surface	34.7	36.9	34.5	35.4	5.2
	External roof surface	46.4	42.3	33.1	40.6	
14	Internal roof surface	32.7	33.8	33.6	33.4	8.7
	External roof surface	37.8	53.4	35	42.1	
15	Internal roof surface	-	32.1	32.4	32.3	8.5
	External roof surface	-	46	35.5	40.8	

Evaluation of the temperature results for the inner and outer surfaces of the aluminum roof:

The measurement results in Table 1 indicate that the average temperature of the internal surface of the aluminum roof ranges from 32.3 to 35.4°C, while the temperature of the external surface ranges from 37.1 to 42.1°C. The temperature amplitude between the external and internal surfaces of the roof ranges from 2.1 to 8.5°C. Thus, the aluminum roof demonstrates relatively good thermal insulation properties.

4.3.2. Towards enhancing cultural and educational values for the community

The architectural form is designed according to the principle of conveying geographical and historical space as a **semantic factor** in organizing the natural landscape between the two buildings. The blocks on both sides have soft forms that blend harmoniously with nature (considering the topography and hills), while the open space between the two buildings is shaped like a green valley that connects the East-West axis running along the building. The indoor and outdoor spaces, as well as the above and below areas, are organically and harmoniously connected, allowing for the revival of traditional folk games that have faded away (such as "Rồng rắn lên mây" and "Trồng nụ, trồng hoa", etc.). The forms of the buildings aim towards a system of cultural and educational symbols: Building A symbolizes nurture, Building B represents development, and the Astronomical Tower symbolizes the traditional torch.



The smooth curves and the ever-changing shapes can create a natural space of our Vietname country with mountains, paddy fields, green valleys, the water surface and more. They can also ignite the children's imagination of a world full of flowers, fruits, birds and animals

Figure 5. *The illustration of Hanoi's Children Palace's South-facing front elevation. The front layer (A) transform its form from low to high. The back layer (B) transform its form from high to low*

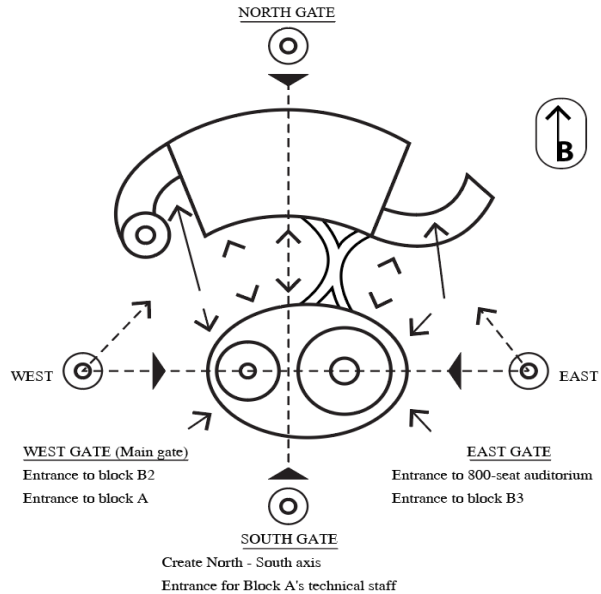


Figure 6. *The illustration of the interaction relationship between two buildings (A&B) of Hanoi's Children Palace according to the East-West and North-South axis*

The circular shape is characterized by a focus on the center, differing from linear and dispersed forms. Towards flexibility and multifunctionality

The building utilizes the surrounding nature: the regulating lake is located to the South and Southeast, the park to the North, and the main entrance is from the West. The opening of gates on all four sides allows for multifunctional use, enabling the integration or separation of different functional areas: performing arts, movie viewing, indoor sports, learning, club activities, and administrative management. Each functional unit can also flexibly accommodate other functions through smart equipment: the multifunctional auditorium features movable seating solution; the multipurpose sports hall incorporates sound absorption design; the all-season swimming pool includes lighting poles that integrate four functions (lighting, speakers, Wi-Fi, and cameras), among others.

Figure 7. *Hanoi's Children Palace from above*

5. Conclusion

Sustainable architecture design is a priority in the current phase of development. Sustainable design focuses on the relationship with the natural environment, the efficient and economical use of natural energy, and ensuring an ecological architectural environment. From another perspective, sustainable design emphasizes the enrichment of human values, culture, and identity. Additionally, the functional aspect remains crucial throughout the lifecycle of a building in use. There are numerous interdisciplinary studies that can positively impact SD. However, the study of architectural morphology plays a vital role in meeting SD criteria, making it one of the key issues in today's contemporary architecture. Especially for cultural buildings for children, the study of architectural morphology adds value by enhancing creative spaces for young people, guiding them towards a vibrant world and creating engaging architectural spaces and blocks.

Designing architectural morphology in the direction of sustainable design involves the organization of functions, space, and blocks across different levels. In the case of the Hanoi Children's Palace: At the master planning level, it addresses the contextual relationship between the form of the site and the shape of the lake and the park. At the general site planning level, it concerns the relationship between functional zones and the axes of spatial architectural landscape organization based on spatial syntax. At the building level, it involves the use of materials and technology in shaping the exterior through façade structures, and the flexibility of multifunctional interior spaces.

Many software tools support the design of architectural forms using parametric and fractal design methods. These are modern approaches that can help architects get closer to achieving sustainable design.

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