Irina IGNĂTESCU-MANEA, Oana NECULAI, Ana-Maria TOMA

A STUDY ABOUT BUILDING A GARDEN INSIDE A KINDERGARTEN

Abstract: *Nowadays, the quality of human life in terms of the human-nature connection is greatly diminished because the activities take place mainly inside buildings. The authors aim to offer a solution for the kindergarten children from temperate climatic regions, especially for children from Romania, to spend more time in contact with nature. Thus, the designed kindergarten is aiming to meet the essential requirements in construction (mechanical resistance and stability; fire safety; hygiene, health and environment; safety and accessibility in operation; noise protection; energy saving and thermal insulation; sustainable use of natural resources) but also to offer beneficiaries direct contact with land and green plants, regardless of season or climatic conditions.*

Key words: *kindergarten, essential requirements in construction.*

1. INTRODUCTION

The idea started from observing the needs of today's world, especially thinking about the future that is built through children.

In the current context of life, when everything is fast-paced and people predominantly live in the virtual world, the human – nature connection is crucial for the global health and well-being. Nature provides vital resources such as water, food, and clean air, contributing to sustaining life on Earth. Moreover, connecting with nature can promote mental and emotional health, reducing stress and fostering feelings of happiness and connection. Protecting and respecting the environment is essential to ensure a healthy and prosperous planet for future generations.

From the perspective of vital resources, nature provides essential provisions for human survival, such as potable water, food, and clean air. Every aspect of people daily lives is contingent upon these natural resources.

Outdoor activities and exposure to nature have been associated with benefits for both emotional and physical health, including increased energy levels, enhanced immunity, and reduced risk of chronic illnesses.

Interaction with nature can lower stress levels, anxiety, and depression, leading to mental and emotional well-being. Natural landscapes and sounds have a calming and therapeutic effect on humans minds and emotions.

Connecting with nature can enhance ecological awareness and responsibility towards the environment. Individuals who spend time in nature are more likely to adopt sustainable lifestyle practices and support conservation efforts.

Activities conducted in nature, such as hiking or volunteering for environment conservation, can foster strong social bonds and communities that are more cohesive.

Nature provides an important source of recreation and rejuvenation. Activities such as forest walks, mountain hikes, or relaxing by a lake can ”recharge batteries” and revitalize the human spirit.

Overall, the human-nature connection is fundamental for the global health and well-being, and protecting and conserving the environment are crucial for ensuring a sustainable future for all beings on Earth.

Unfortunately, a significant portion of contemporary children allocate more time indoors, engaging with screens, rather than outdoors, thereby potentially increasing their distance from nature and self. It is imperative to foster children's connection with nature to develop their awareness and respect for the environment.

Despite the desire to spend more time outdoors, this is rarely possible, particularly among children. Therefore, as engineers, the authors feel compelled to come up with solutions to enhance quality of life. In this instance, the solution targets preschoolers, whose harmonious development lays the foundation for their adult lives and who spend the least amount of time in direct contact with nature.

2. ROMANIA SPECIFIC CONTEXT

In the current study, the researchers examine the specific context of Romania, its climatic conditions, and its citizens mentality. The observations reveal a notable trend over the past 10-15 years, wherein a significant percentage of Romanian children, especially those living in urban areas, are excessively shielded from cold, rain, sun, insects, and plants with allergenic potential, thus remaining confined to their homes, commuting in their parents' cars, and interacting with nature through screen devices.

According to the National Meteorological Administration [1], over the past 15 years in Romania, the number of sunny days with temperatures between 18 and 28 degrees Celsius has significantly decreased, accounting for less than 12% of the total of 365 days. Among these, over 65% fall within the summer school vacation.

Therefore, considering that an academic year comprises an average of 175 days, of which only 15 have sunny weather and temperatures between 18 and 28 degrees Celsius, we conclude that only 8.57% of the total school days allow children to enjoy contact with nature in the kindergarten playground.

In conclusion, given the difficulty in shifting the adults mindset and ensuring children's exposure to nature

regardless of weather conditions, the initiative focuses on integrating natural elements within the indoor setting of the kindergarten. The objective is to introduce vegetation into the indoor environment, under controlled conditions, with moderate temperatures, natural lighting, artificial ventilation, and in compliance with the seven essential requirements in construction:

a) Mechanical strength and stability;
b) Fire safety;
c) Hygiene, health, and environmental considerations;
d) Safety and operational accessibility;
e) Noise protection;
f) Energy efficiency and thermal insulation;
g) Sustainable use of natural resources.

3. ARCHITECTURAL, STRUCTURAL AND TECHNICAL SOLUTIONS

3.1 Generating the structure and architecture

To maximize natural light intake, the choice was the dome as the architectural shape for the kindergarten building, having a diameter of 20 meters (a radius of 10 meters), as shown in Figure 1.

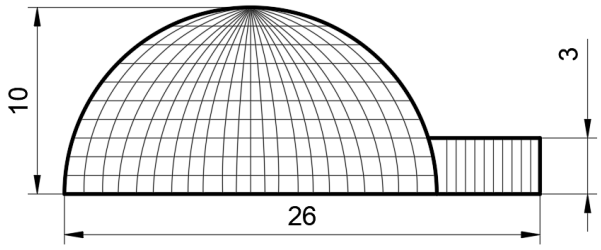

Figure 1 The shape of the structure - dome

This height allows to accommodate three indoor floors: a ground floor and two upper levels. The total built area is of 314 square meters.

The structure of the glass dome will be detailed more in a future article using descriptive geometry through plane tessellation or spatial tessellation.

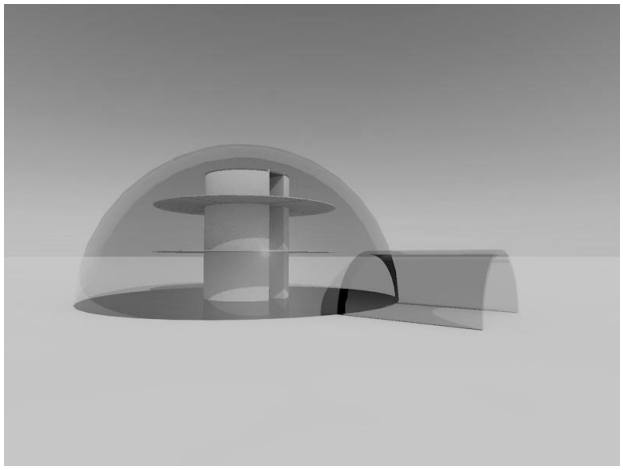

Figure 2.1 External view of the structure

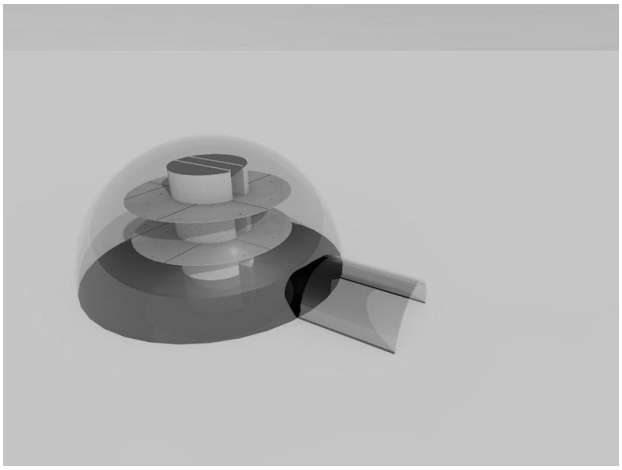

Figure 2.2 External view of the structure

For a better understanding of the concept Archicad software was used as one can see in Figures 2.1, 2.2, 2.3, which the researchers consider that can offer a better perspective on the building.

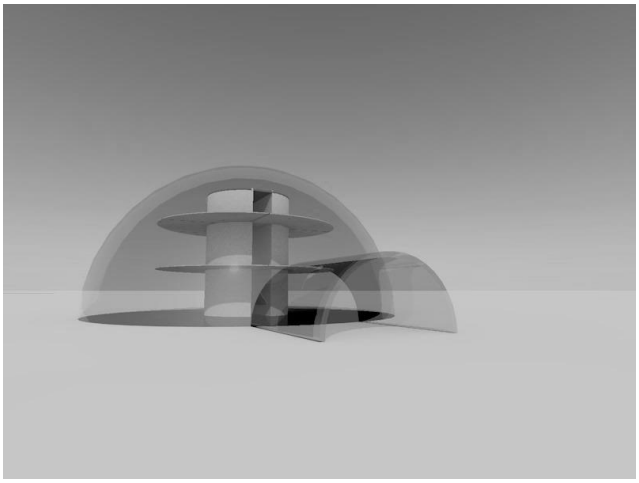

Figure 2.3 External view of the structure

The dome-shaped metallic structure will feature an additional metal framework inside to support the two levels housing the two groups of children with 25 people each.

This structure, supported by four metal pillars, accommodates three circular metal floors corresponding to levels 1 and 2 for classes and the technical space on the third floor Figure 3.

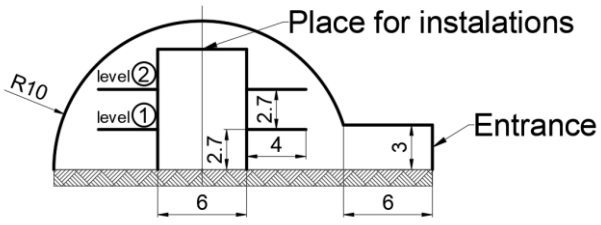

Figure 3 The vertical section of the structure

The ground floor boasts a vibrant natural setting, adorned with lush real plants, verdant grass, and colorful flowers, creating an inviting oasis. Additionally, it features playful zones equipped with kinetic sand for tactile exploration, as well as exciting slides and swings for endless fun and adventure.

In addition, elevated soil beds could be incorporated, providing an interactive opportunity for children to cultivate their vegetables through planting and nurturing seedlings, fostering a deeper connection with nature and instilling valuable lessons in gardening and responsibility as it is shown in Figure 4.

Nestled at the heart of the verdant expanse lie essential amenities, including fully equipped kitchen facilities, ample storage space, and conveniently located toilets featuring two separate children's sanitary groups and sinks. Adding to the accessibility, there is an elevator for effortless movement between floors, complemented by a charming spiral staircase, enhancing both functionality and aesthetic appeal.

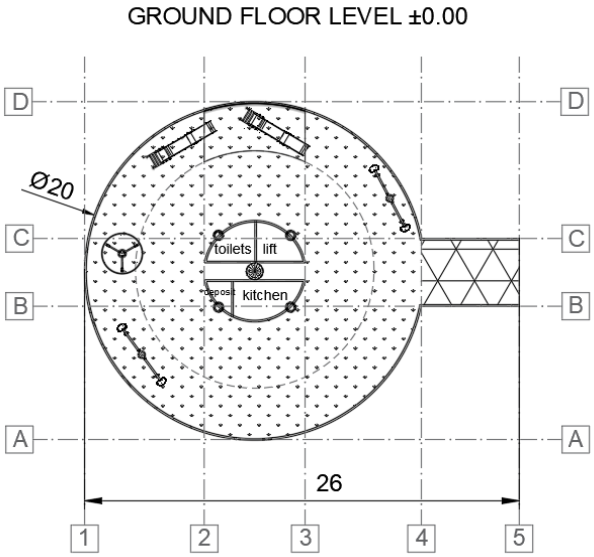

Figure 4 Horizontal cross-section of the structure, at ground-floor level

On levels 1 and 2, the spatial layout will be as shown in Figure 5 and Figure 6, accommodating play areas and classrooms, bedrooms, dining halls and centrally, located around the spiral staircase, children's toilets, teachers' restroom, lift and a storage space.

Inside the children's toilets it will be four sets of sanitary groups and four sinks that is enough for a class with 25 children.

For the teacher it will be a different space with a toilet, a sink and a shower in case they will need to wash a child that was too playful or had sick problems.

Additionally, on each level, there will be the elevator shaft. The lift was calculated to be enough for ten children and an adult in a shift.

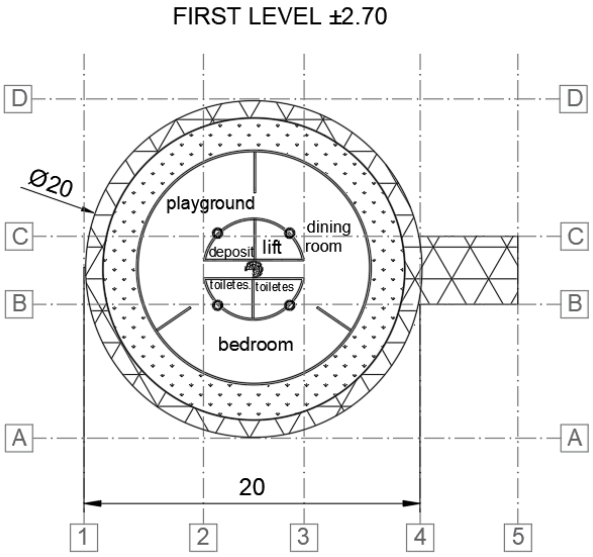

Figure 5 Horizontal cross-section of the structure, at first floor level

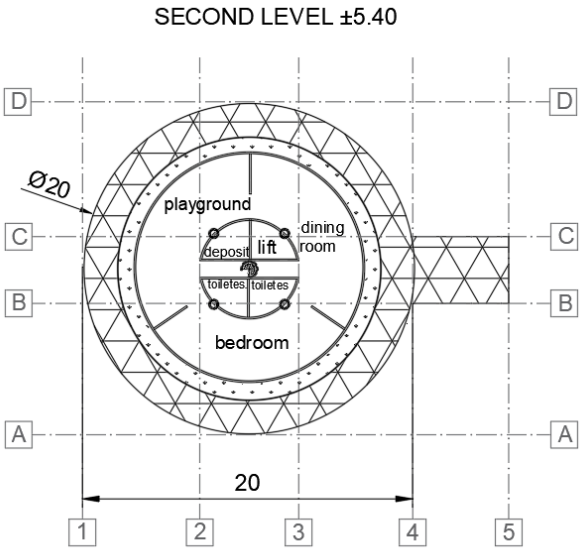

Figure 6 Horizontal cross-section of the structure at the second floor level

On the third level, meticulous attention has been given to designating a specialized area exclusively for ventilation systems, electrical infrastructure, and other essential installations. This deliberate allocation not only guarantees optimal functionality and efficiency but also upholds a streamlined and organized environment, ensuring seamless operations within the facility.

The spiral staircase, showcasing its elegant design and central role in the overall architectural composition at the core of the structure is depicted in Figure 7.

Serving as both a functional element and a striking visual feature, it seamlessly integrates with the overall composition.

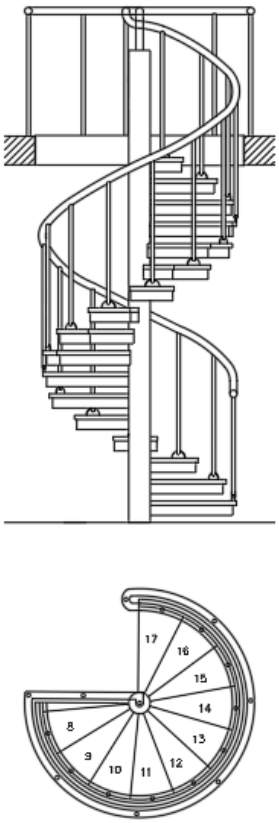

Figure 7 Central staircase

3.2 Covering the metallic structure

When considering the optimal covering for the metallic structure, two primary options stand out: glass and membrane. Each option offers unique advantages and considerations, presenting architects and designers with a choice that balances aesthetics, functionality, and practicality.

Glass Covering:

1. *Advantages*

- Transparency and Elegance: Glass provides a sleek and modern aesthetic, offering transparency that allows natural light to illuminate the interior space, creating a bright and inviting atmosphere.
- Durability and Weather Resistance: Tempered or laminated glass options offer durability and resilience against harsh weather conditions, ensuring long-term structural integrity.
- Design Flexibility: With glass, architects have the freedom to create striking visual designs and panoramic views, making it ideal for iconic architectural structures.
- Types: Various types of glass can be used, including tempered, laminated, or insulated glass, each offering different properties in terms of strength, safety, and insulation.

2. *Considerations:*

- Weight: Glass is much more heavy than membrane which may require additional structural support.
- Costs: Glass can also be more expensive than membrane materials. In addition, to transport and manipulate this material is more expensive than membrane materials.
- Energy Efficiency: While glass allows ample natural light, it may require additional measures for thermal insulation to minimize heat loss or gain, depending on the climate.
- Maintenance: Glass requires regular cleaning to maintain its transparency and aesthetic appeal, especially in outdoor environments where it can accumulate dirt and debris.

Membrane Covering:

1. *Advantages:*

- Lightweight and Versatile: Membrane materials such as ETFE (ethylene tetrafluoroethylene) or PVC offer lightweight and flexible options for covering metallic structures, reducing the load on supporting frameworks and foundations.
- Customization and Creativity: Membranes can be tailored and customized to specific project requirements in terms of color, translucency, and shape, offering designers greater creative freedom.
- Cost-Effectiveness: Membrane structures are often more cost-effective than glass, both in terms of materials and installation, making them an attractive option for projects with budget constraints.
- Durability: High-quality membrane materials are resistant to weathering, UV radiation and chemical exposure, requiring minimal maintenance over their lifespan.

2. *Considerations:*

- Maintenance: While membranes offer flexibility, they may require more maintenance than glass over time, including cleaning and occasional repairs. Depending on the material and design, membranes may have a shorter lifespan compared to glass.
- Transparency and Elegance: While the membranes provides some level of transparency, it may not be as clear or crisp as glass.

In summary, while glass provides clarity, durability, and aesthetic appeal, membrane coverings offer lightweight flexibility, customization, and cost-effectiveness.

Ultimately, the choice between glass and membrane covering for the metallic structure depends on the project's specific requirements, including aesthetic preferences, functional needs, budget considerations, and environmental factors. By carefully evaluating the advantages and considerations of each option, architects can determine the most suitable covering solution that enhances the overall design while meeting the project's objectives.

3.3 Waterproofing solutions for the ground floor slab

Since the ground floor will constantly have soil that must be irrigated, thus continuously being moist, the intent is to treat it as a swimming pool. The proposal is to use the waterproofing solutions for swimming pools from Alchimica, as indicated in Figure 8 [2], [3].

When selecting the indoors vegetation, meticulous attention must be given to ensure that the roots are fibrous or ramified so as not to affect the waterproofing.

Additionally, the depth of the container in which the soil will be placed must be adjusted to the depth at which the roots penetrate.

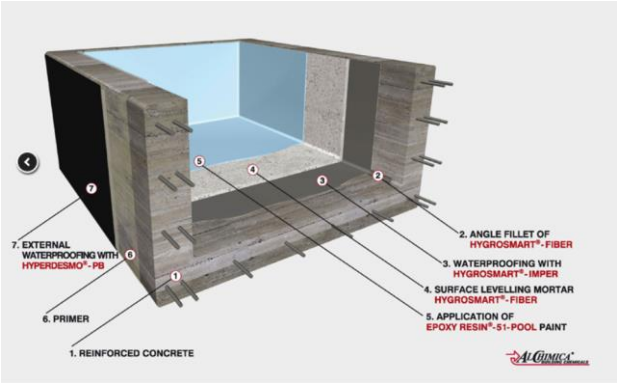

Figure 8 Waterproofing solutions for the concrete slab on the ground floor

4. PROPOSED SOLUTIONS FOR INSTALLATIONS

4.1 Ventilation solutions

Ventilation is the process of exchanging or replacing air within a space to maintain a high level of indoor air quality. There are two types of ventilation: natural and mechanical.

Natural ventilation occurs when air circulates through various "openings" in buildings naturally, driven by wind or stack effect.

The authors achieved mechanical ventilation by using a mechanical device (such as a fan) that circulates outdoor air or a mixture of indoor and outdoor air within the space. This involves a system through which the indoor environment is continuously ventilated, in a controlled manner (introducing fresh air into the building and removing stale air).

Mechanical ventilation systems are an essential component of modern buildings, especially those with high energy efficiency - buildings characterized by high levels of thermal insulation and, consequently, superior airtightness.

The system operates as follows: centralized ventilation units with heat recovery can continuously transfer thermal energy and humidity from the extracted (stale) air from areas with higher humidity levels to the fresh air introduced into the building [4].

During winter, the cold air introduced into the building passes through the heat exchanger integrated into the ventilation unit, absorbing the temperature of the warm expelled air, thereby reducing the energy requirement for heating the building.

During summer, the warm air introduced into the building passes through the heat exchanger integrated into the ventilation unit, absorbing the temperature of the cool expelled air, thereby reducing the energy requirement for cooling the building.

Centralized units also integrate the "Free cooling" function - at night, when the outdoor air is cooler than the indoor air, filtered air is introduced directly (without passing through the heat exchanger).

Energy savings are achieved by comparing the heat recovery ventilation solution with conventional ventilation/ airing without heat recovery, like, for example, opened windows.

To ensure optimal humidity levels between 60-65%, an automated system shall be used.

4.2 Heating solutions

The proposed solution for heating the first and second level is underfloor heating together with the ventilation system.

Heat pumps serve as a heat source for space heating and domestic hot water preparation. Due to their high technological level, they are considered equivalent heat sources to traditional ones, but with significantly higher operating efficiency.

Heat pumps represent a preferred heat source as their environmental impact is significantly lower compared to other heating systems. They help reduce greenhouse gas emissions into the atmosphere, decrease the consumption of non-renewable resources (gas, coal, wood etc.), and their high-quality products do not acoustically pollute the surrounding environment [5].

4.3 Irrigation systems

To meet hygiene standards within the kindergarten, the proposal is to irrigate the green spaces using a subsurface irrigation system, supplying water directly to the plants roots.

This system is highly suitable, as it has low water and energy consumption, requires minimal maintenance, and eliminates the risk of children getting injured.

Subsurface irrigation systems, also known as sub-surface drip irrigation (SDI) or subsurface drip irrigation (SSDI), are innovative methods of delivering water directly to the root zone of plants, typically below the soil surface [6].

How Subsurface Irrigation Systems Work:

1. Placement of Emitters: Small emitters, often made of durable materials like plastic or silicone, are buried beneath the soil surface at specific intervals. These emitters release water directly into the root zone of plants.
2. Precise Water Distribution: The emitters release water slowly and evenly, ensuring precise distribution directly to the root zone where it is needed most by the plants. This reduces water loss due to evaporation and runoff, maximizing water use efficiency.
3. Controlled by a Central System: Subsurface irrigation systems are typically controlled by a central control unit or timer, allowing users to regulate the frequency and duration of watering based on plant needs and environmental conditions.

Benefits of Subsurface Irrigation Systems:

1. Water Efficiency: By delivering water directly to the root zone, subsurface irrigation systems minimize water waste associated with surface evaporation and runoff. This results in higher water use efficiency and reduced

water consumption compared to traditional surface irrigation methods.
2. Improved Plant Health: Subsurface irrigation promotes healthier plant growth by providing consistent moisture levels directly to the roots. This helps prevent water stress and encourages deeper root development, leading to stronger and more resilient plants.
3. Weed and Disease Control: Since water is delivered directly to the root zone, subsurface irrigation systems help reduce weed growth by minimizing moisture on the soil surface where weed seeds typically germinate. Additionally, keeping foliage dry can reduce the spread of certain plant diseases.
4. Soil Conservation: Subsurface irrigation minimizes soil erosion and compaction associated with traditional surface irrigation methods, preserving soil structure and promoting soil health over time.
5. Flexibility and Aesthetics: Subsurface irrigation systems are discreet and hidden beneath the soil surface, allowing for more flexibility in landscaping design and preserving the visual appeal of gardens and landscapes.

Overall, subsurface irrigation systems offer numerous benefits in terms of water efficiency, plant health, and soil conservation, making them a sustainable and effective option for watering gardens, agricultural crops, and landscapes.

4.4 Solutions for maintaining cleanliness

Nowadays, maintaining cleanliness is no longer a challenge. Now that people can control outlets, light intensity, access and surveillance cameras via their phones, it is only natural that they also use technology for cleaning.

Robot vacuum cleaners are intelligent electronic devices designed to automatically clean floors without constant human intervention. They are equipped with sensors and navigation algorithms that allow them to identify obstacles and navigate around them. Many models also have mapping functions, allowing them to learn and memorize cleaning routes for increased efficiency. Robot vacuum cleaners are popular for the convenience they provide, allowing humans to save time and effort in maintaining cleanliness in their living or working spaces.

Similarly, for lawn maintenance, robots will be used, that relieve human labor and keep the play areas clean.

4.5 Solutions for smoke vent in case of fire

In the event of a fire inside the dome, air intake systems ensure the necessary "ventilation efficiency", the smoke generated by the fire being evacuated through them. In this regard, the coordinated interaction of fresh air intake and exhaust air evacuation solutions is crucial. Air is circulated through special openings, equipped with mechanisms for air intake activation, located at the bottom of the building. These enhance the thermal updraft force, allowing combustion gases to be evacuated through ventilation openings at the top of the building.

5. CONCLUSIONS

In conclusion, the proposal largely addresses the 7 essential requirements in construction: mechanical strength and stability, fire safety, hygiene, health, and the environment, safety and accessibility in operation, noise protection, energy efficiency and thermal insulation, and sustainable use of natural resources, while also adding an extra layer of comfort and beauty.

This engineering-focused study introduces an innovative kindergarten design that integrates natural elements, addressing climatic and environmental considerations specific to Romania. By leveraging architectural ingenuity, such as dome-shaped structures for optimal light distribution and material selection focused on functional and aesthetic value, the research pioneers a new standard in educational facility engineering. The authors' methodology emphasizes sustainable design principles, energy efficiency, and the psychological benefits of nature integration. Their findings underscore the critical role of engineering in developing educational spaces that enhance children's interaction with their environment, promoting a balanced development. This work sets a precedent in the engineering community for incorporating biophilic design into educational infrastructure, highlighting the intersection of engineering excellence, sustainability, and user well-being.

REFERENCES

[1]https://www.mmediu.ro/articol/2022-a-fost-al-treilea-cel-mai-calduros-an-din-istoria-masuratorilor-meteorologice-din-romania/5909
[2] https://alchimica.ro/piscine/
[3] hidroizolatii.ro/wp-content/uploads/2014/04/2.png
[4]https://deretica.ro/ventilatie-rezidential/?gad_source=1&gclid=CjwKCAjw7-SvBhB6EiwAwYdCAarJhqALYXvPcItwSysOXykUs7QXVk1OhdaNVZZfqm52udKtNbMd4BoC3Z4QAvD_BwE
[5] https://www.regulusromtherm.ro/ro/why-heat-pumps
[6] https://edis.ifas.ufl.edu/publication/hs388

Author(s):

Ph. D. Assistant professor Irina IGNĂTESCU-MANEA, Gheorghe Asachi Technical University of Iasi, Department of Engineering Graphics, E-mail.: irina.ignatescu-manea@academic.tuiasi.ro
Ph. D. Senior Lecturer Oana NECULAI, Gheorghe Asachi Technical University of Iasi, Department of Civil and Industrial Engineering, E-mail.: oana.neculai@academic.tuiasi.ro
Ph. D. Senior Lecturer Ana – Maria TOMA, Gheorghe Asachi Technical University of Iasi, Department of Engineering Graphics, E-mail.: ana-maria.toma@academic.tuiasi.ro