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PASSIVE STRATEGIES OF VERNACULAR ARCHITECTURE FOR ENERGY EFFICIENCY

BY

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Abstract. Due to the need of sustainable development of the building sector, it is important to increase the energy efficiency in buildings and reduce the energy consumption for heating and cooling. In a changing world, full of innovative solutions and technologies, passive strategies of vernacular architecture are more used to achieve life quality and eliminate the negative impact on the environment and human health.
The vernacular architecture is based on the local construction materials and influenced by the traditions, culture and climate of the place. The “architecture without architect”, used mainly in housing, evolves over time and reflects the level of technology and historical context of the building. The core of this type of buildings was to use architecture to collect free energy from natural environment.
Demonstrated over time, the inherent and timeless knowledge of vernacular architecture offers the basic level of comfortable living without the active strategies that include technologies. Passive architecture strategies are defined by minimizing or avoiding the energy consumption, using architecture and the natural environment to produce heating, cooling, ventilation and light. The elements of the natural environment are the sources of the energy: the sun, the earth, the air – the wind, the water. By adding active technologies, the quality of living must increase, but without influencing the main resources gained through passive strategies.

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The present paper will provide the information needed to understand the importance of the vernacular architecture's passive strategies, as well as describe a few examples of those strategies in different parts of the world, examples that demonstrate the efficiency and the impact of these systems. The authors state that the use of those strategies in the first stage of architecture design helps to achieve easier the energy efficiency required nowadays and represents the fundamental base for passive houses and nearly zero energy buildings.

Keywords: sustainability, free energy, buildings, sustainable architecture, architectural identity

1. Introduction

Worldwide during the last years, the building sector usage of energy has been exponential increasing around 30% to 40% of all primary energy (UNEP, 2007). Due to the increasing pressure brought by global environmental problems, the architects and builders are embracing the knowledge gained in time about traditional structures, considered energy efficient and profound-sustainable. With the increasing focus on sustainable architecture practice, the smart use of the sun becomes a necessity.

The concept of Sustainable Development appeared first time in World Conservation Strategy (1981) and then in the Brundtland Report (1987), in which it was defined as "a new conception of development that meets the present generation without compromises the need of the next generation", and it became the core of the O.N.U. – Caring for the Earth.

Well-designed energy-efficient buildings are characterized by the best environment for human habitation while reducing the use of energy (electricity, natural gas) for heating, cooling and lighting. Improvement in energy efficiency is defined by Janssen (2004) as any action made to minimize the energy use without affecting the level of service provided.

The architect Ed Mazria in the "Architecture 2030 Challenge" urges to carbon-neutral design, which raises the bar for energy performance and significant changes in design thinking and practice.

The impact of the construction field generated the development of a series of regulations and recommendations regarding energy-efficient buildings in the European Union. The Directive regarding nearly Zero-Energy Building (nZEB) planned to be implemented in 2020, in which are the mandatory regulations in the EU countries, highlights the limitation of energy consumption and also the use of renewable sources (EU, 2016). Therefore, this paper aims to provide a multi-disciplinarity comprehension of the sustainable benefits of vernacular architecture's passive strategies.

2. Vernacular Architecture

Vernacular architecture evolved over time, reflecting environment, cultural, technological and historical context of a specific location (Nguyen and Reiter, 2017). Thereby, vernacular architecture is known to be well adapted to local climate and nature, exemplifying comprehensive wisdom, which was passed from our ancestors to present. This knowledge should be passed to the future generation as a sign of deep respect for nature, environment and traditional culture.

Today, in the era of fast technological development and massive and fast construction, the design of many modern buildings do not take local condition into account, the vernacular architecture seems to be almost forgotten. However, there is still much to learn from the traditional structures, well-suited to local climate and culture.

The link between vernacular buildings and climate has been examined much. Not to be forgotten that culture also has a significant influence on buildings: construction methods of countries in similar climates may be different considerably, and some methods are also used in totally different climates. Amos Rapoport, in his book "House Form and Culture" states that vernacular architecture aims for "a balance between Nature, means of livelihood, culture and security"(Rapoport, 1969).

All through architecture history, it has been utilized passive strategies in providing comfortable condition within local climates because the active technologies did not exist. For example, in hot regions are used air movement, evaporative cooling and a massive structure with big thermal capacity and in cold regions are used insulating materials, shield against cold winds and passive solar heating. The impact of climate adjustment on a conventional building method should be considered. Nowadays, the sum of know-how about a good plot, the shape of a building and other details can be valuable.

In the "Architecture without Architects", Rudofsky presents good examples of vernacular architecture adapted to the environment: Bad-gir wind scoops in Pakistan, architecture *à pilotis* in the South Sea region, planted windshields in Japan, *limonaie* shelter constructions against snow and cold in Italy, semi-covered streets in Africa, arcades in Europe, Sirocco room, loggia, the Japanese house with sliding doors, the wind towers of the Middle East, mushrabeyeh in the Arabic countries, brise-soleil (Rudofsky 1964, Chatelet 1998).

3. Passive Strategies

A literature review consisting of different journals, researches and related websites was made to establish the basic passive principles for designing energy-efficient buildings. Passive architecture strategies are systems that minimize or

avoid the consumption of energy and avoid the use of new active technologies. It represents the fundamental premise for near Zero-Energy Buildings (nZEB) and impacts the shape and details of the architecture. The main reason to use the passive strategies is the energy efficiency, but also highlights the aesthetical and functional relationship between the building field and the natural environment. The passive strategies use the architecture and natural environment to gain free energy for heating, cooling, ventilation and light, using the elements of nature: the sun, the wind, the earth and the water.

The passive strategies can be broadly classified as: passive cooling in hot climate and passive heating in cold climate. In both climates, there are available some strategies related to the geometry and aesthetic of the building.

3.1. Passive Design Process

All passive strategies work by imposing a particular condition of the space inside, and it is directly reflected in the planimetric configuration and volume of the building. The following elements are to be considered in the geometric definition of buildings: orientation of the building after the cardinal points, the position of the building according to the wind direction, the ratio between wall area and the interior volume, the shape of the building in plan and spatial configuration. Selecting a site is the first step in vernacular architecture, and it is also the most important in the passive design process. A right orientation, location and layout can help reduce heating requirements, energy costs and greenhouse gas emission.

The colour of the building plays an essential role in the aesthetics of the building, and it also helps the passive strategies. Albedo or the coefficient of reflection is the parameter equal to the ratio of the reflected radiation to the initial radiation incident on the same surface. For example, in a hot climate, it is used white as the colour of the buildings to help minimize the thermal gains.

David Orr stated in his book, The Nature of Design, that passive design is "the art of reconnecting with the beautiful world in which we evolved million years ago. That world should not be rebuild but rediscovered. For this, more than we should research, we must rediscover the old and forgotten things."

3.2. Passive Cooling Strategies

Passive cooling includes strategies as shading, ventilation systems, wing wall, thermal chimney, earth shelter, earth air tunnel, evaporative cooling and courtyard.

Shading is the primary method of preventing the thermal energy of the sun from entering into the construction. The essential source of warm buildup is daylight retained by the building through the roof, walls, and windows. Shading reduces the incident solar radiation and cools the building effectively,

with an energy-saving from 10%…40% (Maleki, 2011). Trees, roof overhangs and lightweight ventilated shading panels are the blocking techniques also used in the vernacular architecture (Kamal, 2012). Proper landscape and vegetation are one of the most useful elements of passive strategies. Used in the most different ways (high or low vegetation, façade and green roof) can provide increased comfort to users of buildings by shading, wind protection, noise protection and pollution. Shading from trees can reduce the surrounding air temperature as much as 5 degrees Celsius (Kamal, 2012) if there are used deciduous trees and shrubs on the Southside of the building. The evergreen trees placed on the West and East sides protect the building from the cold winter winds and sun at the low angles.

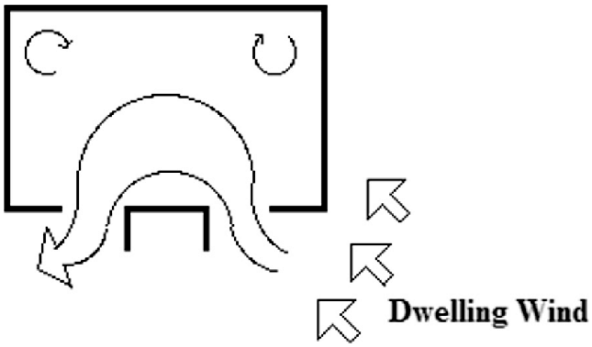


Fig. 1 –Top view of wing walls airflow pattern (Chel, 2017)

Wing walls, (Fig.1), are vertical solid panels placed alongside windows perpendicular to the wall on the windward side of the house. Wing walls accelerate the natural wind speed due to pressure differences created by the wing wall.

Thermal chimneys, (Fig.2), draw the hot air out of the building, and it can be made in a narrow configuration (like a chimney) with an easily heated black metal absorber. The high of the chimney must be bigger than the roof, and a rotating metal scoop at the top allow heated air to exhaust.

In ancient times, the houses were made under the earth. This technique was used both for passive cooling as well as heating of buildings. The temperature at a depth of about 4 m below ground is nearly constant round the year and in nearly equal to the annual average temperature of the climate. Additional to the earth berming/shelter, tunnels made underground with circulating air help cooling or heating the air for the inside spaces.

In hot-dry climate, houses were built near ponds or fountain to use evaporating cooling to lower indoor air temperature by evaporating water. In this strategy, the sensitive heat of air is used to evaporate water, thereby cooling the air of the living space of the building.

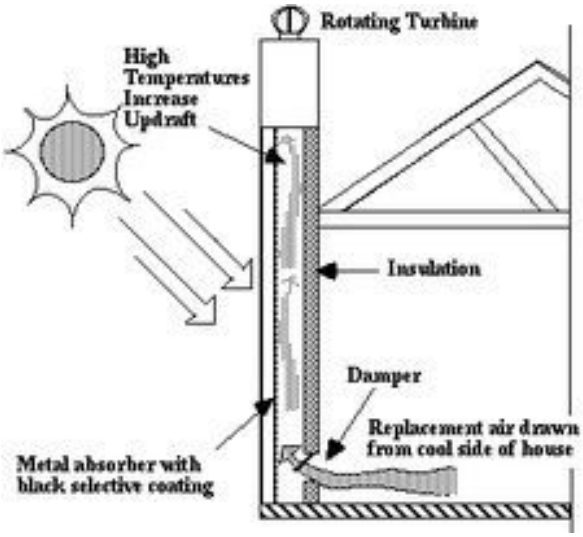


Fig. 2 –Thermal chimney (Chel, 2017)

Also, the vernacular architecture of the hot-dry climate zones is characterized by the presence of the courtyard. Due to the incident solar radiation in the courtyard, the air becomes warmer, and in contrast with the cool air from ground levels, it produces airflow, ventilating the building. The courtyard must be shaded and only partially open to the sky.

3.3. Passive heating

Passive solar heating strategies are classified in direct gain systems and indirect gain systems. The direct gain is the most used passive solar system as heating from direct solar radiation (through windows). The glazing system is generally located on the southern side of the building to receive maximum sunlight during winter (in the northern hemisphere) and uses 60-75% of the sun's energy.

The indirect gain systems use convection and thermal mass between the sun and the living spaces, which absorbs the sunlight and transfers it to the living spaces, using just 30-45% of the solar energy. The effect of thermal mass is based on the potential heat absorbed by the building elements.

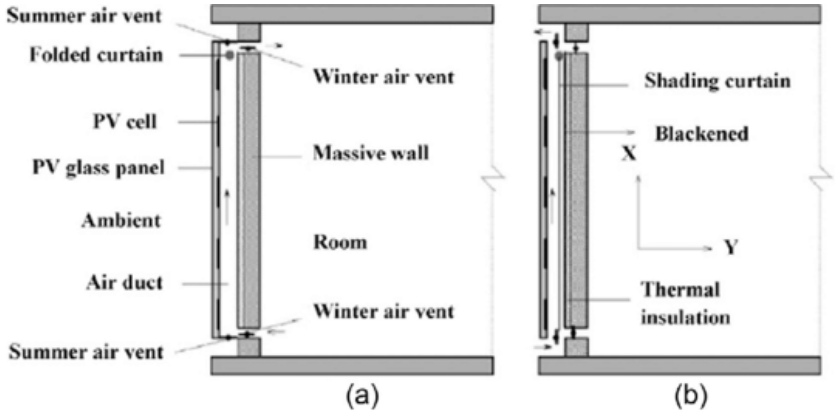


Fig. 3 – Trombe wall for (a) winter heating and (b) summer cooling (Chel, 2017)

A passive strategy also used in vernacular architecture is the Trombe Wall, (Fig.3), a thermally massive wall located in the southern side (in the northern hemisphere) of the building with vents placed at the top and the bottom. Solar radiation is absorbed by the wall during the day and stored as sensible heat. The vents are closed during the night, and heat stored in the wall during the day heats up the living space by conduction and radiation. The indoor temperature of the buildings with thermal storage walls is maintained at about 15 degrees Celsius when the outside temperature is at -10 degrees Celsius.

The greenhouse is also a passive strategy used in vernacular architecture, a combination of direct and indirect gain systems. The solar radiation heats up, directly and indirectly, the living space by convection and conduction through the mass wall.

In history, people also used the thermal energy of the earth to obtain comfort in the interior living spaces. This procedure implicates zones or buried equipment of a building benefits from the thermal mass of the land that has a constant temperature from a certain depth.

4. Examples Of Passive Strategies In Vernacular Architecture

In different parts of the world are a lot of examples of vernacular architecture with passive strategies that can be used nowadays also.



Fig. 4 – Underground villages in China (Rudofsky, 1964)

One of the most radical examples is the underground villages in Chinese, (Fig. 4), where the houses, but also other types of buildings, where hollowed into loess. Because loess, as a material, is soft and porous (45%), it was carved to 40 feet deep, leaving just square pits that are behaving as courtyards. The vertical sides of the pits are around 30 feet deep, and the access to the internal spaces is made through an L-shaped stair, (Rudofsky, 1964). The houses are made into the ground, and it also uses the courtyard, both known as passive strategies.

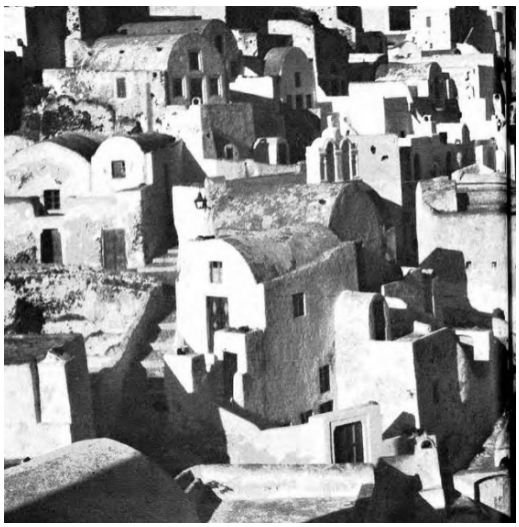


Fig. 5 – White buildings in Apanomeria (Rudofsky, 1964)

In Greek climate, in Apanomeria for example, (Fig.5), the traditional buildings are single dwelling type, the vaulted cell and the exterior aesthetics are characterized by small windows on white walls and ceilings that reflect the light (Rudofsky, 1964).

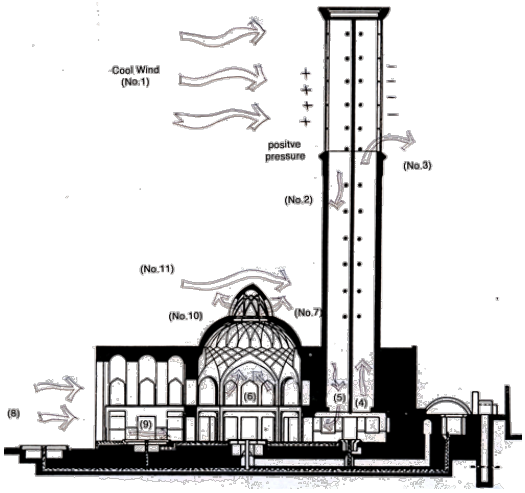


Fig. 6 – Bad-gir in Iran and the air flows (picture taken from new-learn.info)

In hot-arid climates, in West Pakistan and Iran, where the temperature in summer hits 50 degrees Celsius, is used “bad-gir”, (Fig. 6), on the roofs for each room, a traditional architectural element to create natural ventilation. At the afternoon, when the breeze blows, the wind scoops installed on the roofs direct the wind into the building (Rudofsky, 1964). Those wind towers remain present in Iran and are made in various design depending on the number of the direction of the wind or mechanism: the airflow can be directed using direct wind entry, a wind-assisted temperature gradient or a solar-assisted temperature gradient. In Iran, the walls are made of thick ceramic that has a high insulation value, the windows are small, and the buildings are made near other buildings to maximize the shade.



Fig. 7 – Thatch roof in Japan (Rudofsky, 1964)

The roofs in the vernacular architecture of Japan, (Fig. 7), are protecting the interior spaces but also provide shade using the earflaps reaching the ground. The roof material, the thatch, in everlasting and provides excellent insulation against heat or cold. Rudofsky mentions in his book "Architecture without Architects" that "many old Japanese farmsteads which formerly blended into their natural surroundings today advertise their presence by shiny new tin roofs" (Rudofsky, 1964).

5. Conclusions

The passive strategies can be useful even today, the lessons learned from vernacular architecture and old buildings should be the base of the architecture nowadays. The needed functions, the lifestyle of people, the technology and equipment have changed over time, and the old constructions do not offer the comfort required today. The climate-conscious architecture today gain a lot of information adjusting to the new circumstances the archetypal buildings types and details. For example, the white buildings in the Latin cultures are sources of inspirations for the modern sustainable architecture in the warm-dry climate zones. The lessons from vernacular architecture highlight the importance of a climate-conscious approach to building design to accomplish human comfort without destroying the harmony with nature. The contemporary architects should balance the use of traditional vernacular elements and the use of innovative passive techniques to obtain a perfect mediation between the exterior (local climate) and the comfortable interior of buildings.

A genuine architecture of the sun and wind, an efficient energy architecture is more than the sum of the passive strategies, technological systems and ecological engineering. It is as Sim Van der Ryn stated in his book "Design

For Life": "Architecture is "re-membering" - putting back together our collective dreams…The building should tell a story about place and people and be a pathway to understanding ourselves within nature", designing should be about the ecological relationship with the world. (Sim Van der Ryn, 2005)

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STRATEGII PASIVE ALE ARHITECTURII VERNACULARE PENTRU EFICIENŢĂ ENERGETICĂ

(Rezumat)

Dezvoltarea durabilă a sectorului construcțiilor este necesară și se poate realiza prin creșterea eficienței energetice a clădirilor și reducerea consumului de energie pentru încălzire și răcire. Într-o lume în schimbare, plină de soluții și tehnologii inovatoare, strategiile pasive ale arhitecturii vernaculare sunt utilizate pentru a creşte calitatea vieții și a elimina impactul negativ asupra mediului și sănătății umane.

Arhitectura vernaculară se bazează pe materialele de construcție locale și este influențată de tradițiile, cultura și clima locului. „Arhitectura fără arhitect", folosită mai

ales în locuințe, evoluează în timp și reflectă nivelul de tehnică utilizate în construcţii. Principiul de bază al clădirilor vernaculare a fost utilizarea arhitecturii pentru a colecta energie gratuită din mediul natural.

Demonstrate de-a lungul timpului, cunoștințele inerente și atemporale ale arhitecturii vernaculare oferă nivelul de bază al traiului confortabil fără tehnologia strategiilor active. Strategiile de arhitectură pasivă sunt definite prin minimizarea sau evitarea consumului de energie, folosind arhitectura și mediul natural pentru a beneficia de încălzire, răcire, ventilație și lumină. Elementele mediului natural sunt sursele de energie: soarele, pământul, aerul – vântul, apa. Strategiile active aduc un plus calităţii vieţii, însă nu trebuie să interfereze cu principalele resurse câștigate prin strategii pasive.

Lucrarea de față oferă informațiile de bază pentru a înțelege importanța strategiilor pasive ale arhitecturii vernacular şi descrie câteva exemple ale acestor strategii în diferite părți ale lumii. Aceste exemple demonstrează eficiența și impactul acestor sisteme în balanţa energetică. Autorii afirmă că utilizarea acestor strategii în prima etapă a proiectării de arhitectură ajută la obținerea facilă a eficienței energetice și reprezintă baza fundamentală de proiectare pentru casele pasive și clădirile cu energie aproape zero.