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GREEN CORE HOUSE

Abstract: *The Green Core House is a construction concept with low environmental impact, having as main central element a greenhouse. The greenhouse has the innovative role to use the biomass energy provided by plants to save energy. Although it is the central piece, the greenhouse is not the most innovative part of the Green Core House, but the whole building ensemble because it integrates many other sustainable systems as "waste purification systems", "transparent photovoltaic panels" or "double skin façades".*

Key words: *greenhouse, double skin façades, solar panels.*

1. INTRODUCTION

This concept was developed because the authors believe that the future begins at home. Therefore, the main idea was to rethink the entire home environment. The Green Core House concept is based on many new technologies focused on energy saving, self-sustainability, aesthetics and comfort.

The motivation for choosing this topic comes as a result of analyzing the current system of housing, which is mainly focused on massive buildings, without green spaces, that require a large amount of building materials and have a powerful negative impact on the environment. This trend is based on the human nature that is nowadays focused on excessive consumerism – a life style encouraged by society in the past decades.

The awareness on the importance of green buildings has increased in recent years, since humanity is becoming more and more aware of resource consumption and started a trend regarding eco-constructions and an eco-life in general.

The Green Core House concept unifies different technologies in an innovative way, with the main essential purpose to promote a healthy lifestyle and healthier homes.

2. GREEN CORE HOUSE CONCEPT

The Green Core House is a dome shaped building, depicted in figure 1.

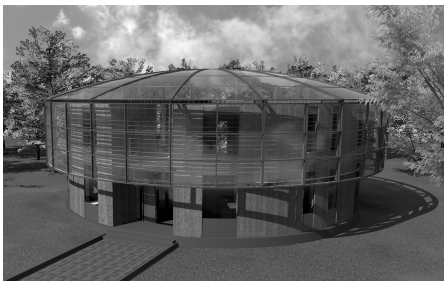

Fig. 1 External view of the Green Core House

This shape was chosen because it is ergonomic and it allows the use of the entire building area at full capacity and also eliminates thermal bridges that appear at corners. This shape is also favourable due to the need to use as many open spaces (spaces covered with transparent solar panels) allowing light to reach the centre of the house.

The main element of the Green Core House is the greenhouse, presented in figure 2, i.e. "the green core".

Fig. 2 External view of the Green Core House

The rooms are largely defined by functionality and only the rooms that require privacy are bounded by solid walls, as shown in figure 3.

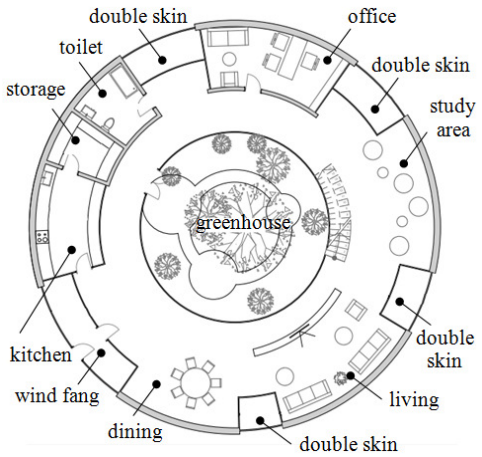

Fig. 3 Layout of ground-floor

One of the main purposes of this house is to bring man closer to nature and show that there are other ways to define the word ”home”. This is one reason why the greenhouse is centrally arranged. In addition, the thermal energy released by the plants passes through the glass

walls towards the rest of the building, and then to the external environment, using straw bale walls that allow the partial transfer of humidity and heat.

Straw bales was chosen as main filling material for the solid walls, due to several reasons: it is a natural material, it is easily produced, energy-efficient, available to anyone, and at the same time it is perfect for GF + 1F type buildings because of its properties.

Choosing straw bales as wall fillers comes as a consequence of the structure type - a frame structure that allows using a large variety of construction materials for the walls and floors. Another advantage in using this type of structure is the fact that it ensures functional flexibility, as the separation walls position can be changed anytime. A complete structure layout is depicted in figure 4.

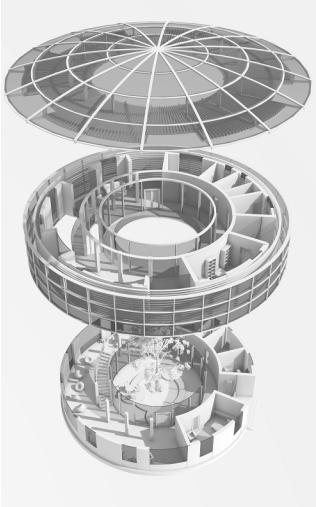

Fig. 4 Layout of the entire Green Code House

Daytime lighting is easily accomplished due to the large openings of the house which are covered with "brise-soleil" - elements introduced inside the double façade in order to increase the space inside the house, which make it easy to adjust the light intensity in the house and greenhouse.

3. GREEN CORE HOUSE COMPONENTS

3.1 Greenhouse

The innovative part of the whole ensemble is the greenhouse because it is now seen as a functional element.

Using a geothermal heat pump allows temperature control inside the greenhouse and, indirectly, elsewhere in the house.

Greenhouse plants are mostly plants that purify the air, such as: peace lilac (Spathiphyllum), Boston fern (Nephrolepis exalted), Alii ficus (Ficus Macleilandii), dwarf date palm (Phoenix roebelinii) etc., [1].

The greenhouse has multiple roles, from both physically and mentally points of view:

- Using a ventilation system, it helps adjusting the temperature inside the building due to the biomass from inside the greenhouse, where the temperature is higher due to natural processes of plants;
- It reduce stress, due to the natural green plants inside the house;
- It reduce noise and filters dust;
- It increases productivity due to the natural environment - scientific studies have shown a growth rate of 12% in work productivity, [2];
- It improves the welfare of the people living or working in the house due to better air quality and atmospheric humidity.

3.2 Straw bales

Since the 80s, there was an increased interest in building using natural environmentally friendly and sustainable materials. Increasingly more architects and civil engineers from all around the world come to work with straw bales, experimenting and developing new techniques while using this material.

Contrary to appearances, straw bale houses are durable. The first straw bale houses were built in the U.S.A. at the end of the 19th century, and a part of them are still operational today. Nowadays, the number of straw bale houses reaches thousands, especially met in countries like U.S.A, France, U.K., Netherlands, Norway and in Australia. With the increasing interest in straw bale houses, there is a growing number of companies specializing in their design and implementation, [3], [4].

In Romania, there is the advantage of a tradition in constructing using natural materials, straw and clay being among the favourite materials for homes in rural areas.

The construction techniques involving straw and clay have greatly varied over time. The Green Core House concept proposes an innovative technique of using these materials in order to achieve homes with higher levels of durability and comfort.

The straws are used in well-pressed bales which represent blocks for building up the walls, in a similar manner as masonry brick walls are built, figure 5.

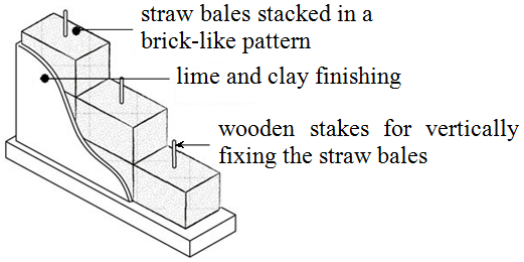

Fig. 5 Straw bale wall system, [5]

Wall plaster is made of clay and lime, to allow "breathing", to adjusts air humidity and to provide a pleasant and healthy living environment.

A straw bale is based on the same material as wood: cellulose. Because straws are hollow, they provide a better insulation than wood. Therefore, straw bale houses are energy efficient due to their insulating properties: a wall of straw bales plastered with clay and lime, with a total thickness of 50 cm, provides the same insulation as a wall of 20 cm by 20 cm polystyrene. Moreover, the

production of materials such as AAC, polystyrene, plaster and paint finishing require higher energy consumption than straw, wood, clay and lime, while generating a high level of CO_2 emissions.

Therefore, the chosen construction materials allow building a wall with a power consumption sixteen times lower than a wall of concrete, polystyrene and industrial finishing (a value of 30 MJ opposed to 490 MJ).

In addition, the costs for one square meter of straw bales wall plastered with clay and lime is three times cheaper than one square meter wall of concrete, polystyrene and plaster, [3], [4].

It should also be noted that the pressed straw bales are resistant to compression, which makes them suitable for solid walls construction.

Among the advantages of using straw bales, the following ones were considered as reasons for choosing them as part of the Green Core House:

- The reduced costs – 1 square meter of straw bales wall costs are half than materials such as brick or brick blocks, insulated with expanded polystyrene;
- Ecological – straw bales are biodegradable and will not contribute to an increased waste;
- Time efficient – they are lightweight, therefore easy to handle, and they have large sizes, so that construction is progressing rapidly;
- Good thermal insulation – the temperature is kept constant for a longer time period, which means energy savings up to 75% of the costs for heating/cooling the house. In other words, straw bales walls keep the house warm in winter and cool in summer;
- A pleasant and healthy living environment – straw bale walls plastered with clay ensure a healthy and pleasant microclimate. Clay plaster absorbs water vapours and reduces moisture content from inside the house. When the atmosphere becomes too dry, the walls release moisture and act as a humidifier. In addition, because the walls "breathe", there are fewer problems regarding mould and dampness, which reduce the risk of allergies. Lime finishing also creates a healthier atmosphere, by avoiding exposure to chemicals present in most commercial paints;
- Soundproofing – ensured by the wall thickness;
- Fire safety – straw bales houses present high fire resistance. Laboratory tests have shown that a straw bale wall plastered with clay withstands exposure to direct fire for longer than 2 hours. This happens due to the highly compressed bales, there is not a lot of air inside the straws to facilitate burning. In addition, clay plaster exposed to fire turns into a ceramic mass that flames can hardly penetrate;
- Earthquake resistance – the straw bale walls are flexible, allowing structure movement without risk of collapse.

3.3 Double skin ventilated façades

Closing the openings with double skin (glass) façades is an effective solution to reduce energy consumption.

Because the concept of double skin façades is complex and the use and operation of such a system affects the internal parameters of the building, which often interact with each other – such as natural ventilation, energy consumption, indoor air quality, acoustics, visual and thermal comfort etc.), [6].

Double skin façades represent an European architectural trend boosted mostly by the need to:

- Reduce energy consumption during life service;
- Improve indoor environmental conditions;
- Use aesthetic façades with high transparency;
- Soundproof buildings placed in noisy areas.

Double skin façades have been developed as an alternative technology to improve the thermal performance of buildings with glass enveloping. A crucial element to achieve low power consumption, therefore an energy efficient building, is limiting strong solar gains in summer. This can be achieved by using external vertical shading on south, east and west sides of the house.

In Romania, during the summer the solar gains through a window having 3 glass rows is of approximately 6.5 [MJ/m^2] per day on the south facade and of approximately 5.5 [MJ/m^2] per day on the east and west facades. An adjustable external shading system can reduce solar gains by 90- 95%, or less than 0.5 [MJ/m^2] per day, [6].

Double skin façades have important functions, they:

- Facilitate natural ventilation of the building;
- Contribute to the growing contribution of solar gain during the cold season;
- Increase the input of natural light;
- Improve the soundproof properties of the envelope.

A double skin façade consists of two transparent surfaces separated by a gap, which is used as air channel. Its components are depicted in figure 6 and listed below.

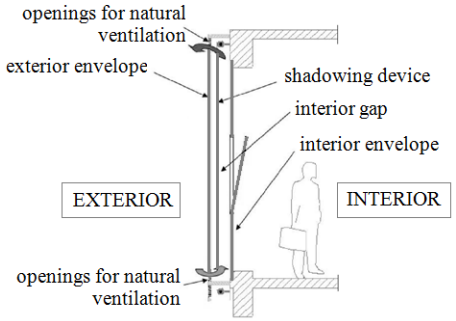

Fig. 6 Components of a double skin façade, [6]

- External (outer) envelope is made of high strength glass with a thickness between 8-12 mm. Its main role is to protect the construction to outdoor climate conditions and to ensure soundproofing;
- The gap is an intermediate air layer with a width between 250 mm - 2m, depending on its purpose. Its role is to increase the thermal insulation of the whole façade, while providing the possibility, under certain conditions, to have pre-heated air for natural ventilation;
- Shading systems can be mounted inside for a sunscreen effect;
- Internal (inner) envelope is composed of fixed glass panels or mobile windows with steel, aluminium, PVC or wood frameworks, with two or three layers of glass.

3.4 Transparent solar panels

By their nature, transparent materials allow the passage of light. Therefore, transparent photovoltaic panels are unachievable because they generate energy by converting absorbed photons into electrons, and in the case of transparent materials, photons would pass completely through the material without being absorbed.

Nevertheless, the University of Michigan [7] created a transparent luminescent solar, which uses organic salts to absorb light on the wavelengths of infrared and ultraviolet, visible by human eye. The rate of absorption and conversion of light energy of these panels is 5%, but experts claim that if such panels would fully replace the glass mounted on office buildings, they could meet the entire needs for heat and electricity of that space.

3.5 Evacuation of waste

The solutions most commonly used nowadays for waste evacuation are:

a) Septic tank, which costs less than a treatment plant but creates discomfort by odors;

b) Absorbent pit, which are declared illegal, as it infests underground water, thus causing illness;

c) Individual treatment sewage station, that takes over all waste water (shower, bathroom, toilet, kitchen) from all residents and inside which biodegradation processes take place. The bacteria consume organic residues, thus cleaning the water, and the resulting water has the necessary quality for discharging. The treated water is colorless, odorless and can be discharge into natural receivers (lakes, rivers, sewers, drainage) in accordance with environmental legislation and local authority requirements.

For the Green Core House, solution c) was chosen. The individual station sewage treatment is the ideal solution for all houses that are not connected to the city sewerage system, where running water is used.

The internal structure of the individual treatment sewage station has five steps: two steps for sedimentation and anaerobic digestion, a step for aerobic digestion, a step for final sedimentation and one step for chlorination. Water passes from one compartment to another by gravity, and the aeration, sludge recirculation, cleaning and maintenance are provided by an external blower, [8].

The advantages of a treatment sewage plant are presented below, applied to an example for a home with 5 members, producing 1 cubic meter of water/day, [8]:

- It has a small volume, of approximately 4.5 m^3;
- Reduced frequency and costs for waste discharge, of about 2-3 m^3 annually;
- Reduced and controlled odours;
- Water can be discharged into natural receivers, drained or daily used for irrigating 100 m^2 of lawn;
- Durable materials, the glass fibres or concrete provide good insulation and are durable in time.

4. CONCLUSIONS

At this moment, there are not enough studies pointing out to clear conclusions on all presented technologies but there is an obvious need for detailed analyses on new technologies emerging in the construction domain.

The presence of the greenhouse inside the Green Core House brings physical and mental balance to its inhabitants by getting them closer to nature and by all the benefits that plants offer, like air purification, energy consumption reduction, noise and stress reduction.

The uniqueness of the Green Core House consists in the fact that, for the first time, a greenhouse is looked at as an important living space, placed in the middle of the building. Therefore, the novelty of this concept lies on the combination of several technologies and systems, on rethinking the home functionality and utility of greenhouses in an efficient and economical manner, in terms of energy savings and environmental friendly approaches.

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