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Ecological Technologies in Residential Construction

[*]Dr. Tamer Refaat[1], Eng. Marwa Hisham El-Zoklah[2]
[1]*Canadian International College (CIC), Land #6, Central services area, south of police academy, fifth settlement, New Cairo city, Cairo, Egypt*
[2]*Canadian International College (CIC), Land #6, Central services area, south of police academy, fifth settlement, New Cairo city, Cairo, Egypt*
Corresponding Author: [*]Dr. Tamer Refaat

ABSTRACT:- The The use of ecological technologies in residential construction cause permanent interest in the scientific community, among researchers and practitioners, construction companies and the local citizens. The main purpose of this paper is to overview the modern ideas and approaches in environmental technologies applied all over the world in residential construction. The main research method used is the analysis of the information on the topic received from various public sources. The paper considers the use of biodegradable and natural (organic) materials, alternative heating and lighting sources, various energy efficiency improvement schemes in residential construction while reducing energy consumption.

Keywords:- Environmental Technology, Housing, Biodegradable Materials, Natural Materials, Alternative Sources of Heating and Lighting, Energy Efficiency.

I. INTRODUCTION

In recent years, sustainable and energy efficient residential buildings have become a very popular trend in many countries. Homeowners continue looking for the ways to reduce energy consumption and lower construction costs by using sustainable or environmentally friendly construction techniques allowing the implementation of both of these needs.The residential construction is actively engaging new building materials, secondary materials, insulation, fencing, new types of glass paneling and translucent structures allowing to build houses with large glass areas. In addition, there is a large variety of individual sources of heat and energy now, more people tend to use alternative sources of energy: heat pumps, solar collectors, fuel cells, etc. The objective of sustainable or "green" construction is to reduce the building carbon dioxide emissions during construction and after its completion. This may include environmentally friendly or recycled building materials, reducing waste and using renewable energy sources. The modern conditions of preserving the natural environment make the issues of using environmental technologies in residential construction very urgent. In this paper we consider the modern approaches and innovations to using secondary, biodegradable and natural (organic) materials in residential construction, cyclic (closed) water technologies, increasing energy efficiency of residential buildings, as well as the use of alternative heating sources.

II. SECONDARY BIODEGRADABLE AND NATURAL (ORGANIC) MATERIALS IN RESIDENTIAL CONSTRUCTION

Modern houses can be constructed from a wide variety of secondary materials, including recycled wood, straw, plastics, shipping containers and various metal objects. Traditional secondary building materials include recycled wood, doors and frames from other houses or materials remaining from other building projects. By repeatedly using these materials in new construction, the construction company and the owner of the new house keep reducing landfill waste and eliminate the need to purchase new construction materials. Another method of using recycled materials is to convert them to new features. Such features include cabinets, doors, partitions, floors, and other construction materials. The recycled products themselves may contain 30 - 100% of recyclable materials. Unique construction materials include shipping containers, straw bales and other large objects. The world practice includes cases when residential houses were built using the old body panels of cars and decommissioned aircrafts.

Shipping containers are a great recycled building material, because they can be used to form the floor, walls and ceilings in the house, they are cheaper than traditional materials. They can even be laid side by side and on ttop of each other for large and high-rise buildings (Fig. 1)

Figure 1: An example of a two-storey building made of shipping containers [1]

In this case, two containers are placed on the sides for a higher common space in the building. The bedrooms are placed inside the containers, while the entrance, dining room, living room and attic are located in the center of the structure. The eco-house is not connected to the power line, using solar orientation, passive cooling, green roofs, furnace heating, and solar panels to create electricity. Fig. 2 shows an eco-house built from shipping containers in San Jose (Costa Rica). Such house construction was dedicated to provide spectacular views of the natural landscape (large transparent windows used for this purpose). The roof between the two containers is made of scrap metal.

Figure 2: Eco-house built from shipping containers in San Jose (Costa Rica) [2]

Environmentally friendly big green houses are made of straw. Straw bales can be used in conjunction with wooden frames or as bearing walls. The advantage of the straw is the quality of an excellent highly fire resistance insulator. The straw can reduce the need for heating and cooling residential building rooms up to 75%. Bales of straw are flame retardant being very tightly packed to reduce the inner oxygen level and make the active combustion process impossible.If the straw walls are designed as carrier walls, the upper surface of the straw can be covered with lime plaster and then painted or covered with decorative plaster. The remains of the straw on the construction project can be composted and used as fertilizer for grass, trees and shrubs. Straw-bale house shown in Fig. 3 was built by a married couple with 4 children. The couple with 4 children had the following main design criteria: compact layout, low power consumption, enough space to accommodate the children, the opportunity to give a part of the house for rent for additional income. This house has 4 bedrooms, an office and a separate one bedroom apartment with separate entrance (for rent), the house area is 760 m². Heating involves roof installed solar panels as well as good thermal insulation of the straw bales.

Figure 3: Straw-Bale House [3]

Deep overhangs and trellises provide shade in the summer to minimize cooling costs. The only place where the natural gas is used in the house is in the kitchen (for cooking). While straw walls are north and west oriented, the south wall of wooden frame has a lot of windows bringing natural light in the living quarters. Abundant natural light, LED lighting, and energy-efficient appliances let keep energy consumption to a minimum. Hot water is produced with a heat pump. Solar panels on the roof can compensate for power consumption.
Using rammed earth as a building material is one of the most ancient techniques (Fig. 4).

Figure 4: Earthen building blocks [3]

Today, the process of forming earthen foundations is not much different from the one a few centuries ago. A mixture of damp earth and clay-and-gravel debris combined with concrete, a stabilizing element, gives a very solid and reliable building material. The foundation of thick rammed earth is an ideal material for controlling the temperature of the building, which remain cool in summer and warm in winter. Construction of earth buildings is nowadays a rarity, but it still exists, and there are contractors who specialize in the earthen houses design. An excellent example of using natural materials in the residential construction apart from straw and earth is using clay, natural paints and plasters. Creating an organic paint mixture may involve milk protein, lime and mineral pigments.

In today's residential construction they actively use natural insulation, with natural origin and ecological security being its benefits. Examples are damask and reed insulation. Cellulose and cotton insulation made from recycled materials is actively used in the world. Cotton insulation is made of recycled jeans, whereas the cellulose insulation is mostly comprised with recycled newsprint. There is also fiberglass insulation from recycled glass, but it's production is more energy intensive than the paper cellulose insulation. Cellulose insulation is often composed of 75-85% recycled material, which is only 30-40% for glass fiber, with cellulose

holding heat better than the glass fiber. Painting roofs white is the easiest way of heat reflection and saving on costs in the summer. But an even better option is to plant greenery on rooftops. Roof gardens help insulate the building in winter and absorb rainwater in summer, reducing water pollution in urban runoff (Fig. 5).

Figure 5: Example of a green roof [4]

III. USE OF ALTERNATIVE HEATING AND LIGHTING SOURCES

The plants can be used to control the flow of rainwater, and the ground can be used to produce heat. As with wind and solar energy, geothermal energy is an efficient source of renewable energy, which is much more environmentally friendly than coal or gas. Pipes, buried several meters underground, avoiding the effects of temperature change. The temperature of the earth even in the winter period remains at 15oC, making it a warm source of energy in winter and a source of coolness in the summer. Water / antifreeze mixture is pumped through pipes under the ground to collect the thermal energy and is then directed to a heat pump and used for heating or cooling a residential building. reen building is primarily associated with the proper use of passive solar energy for heating and lighting of a house. Large windows may fill the house with heat and air vents can help spread the warm air throughout the room. An example of using passive solar energy for heating and lighting of an apartment house is shown in (Fig. 6).

Figure 6: An example of using passive solar energy for heating and lighting of an apartment house [5]

Active solar systems evidently provide more heat than the passive sun orientation. Solar panels absorb ultraviolet radiation and transmit heat to the water or air, reducing the consumption of gas or electricity.

Large glass area helps heat the house in cold weather, but it does not solve the problem of protection from the hot sun rays in summer. Awnings, canopies and overhangs of the roof can reduce the amount of incoming light, but there is a more modern solution as smart windows. Smart glass, or electrochromic glass, use a small electric charge for charging ions in the window layer and changing the amount of light to be reflected. Functional scheme of how smart windows work is shown in Fig. 7.

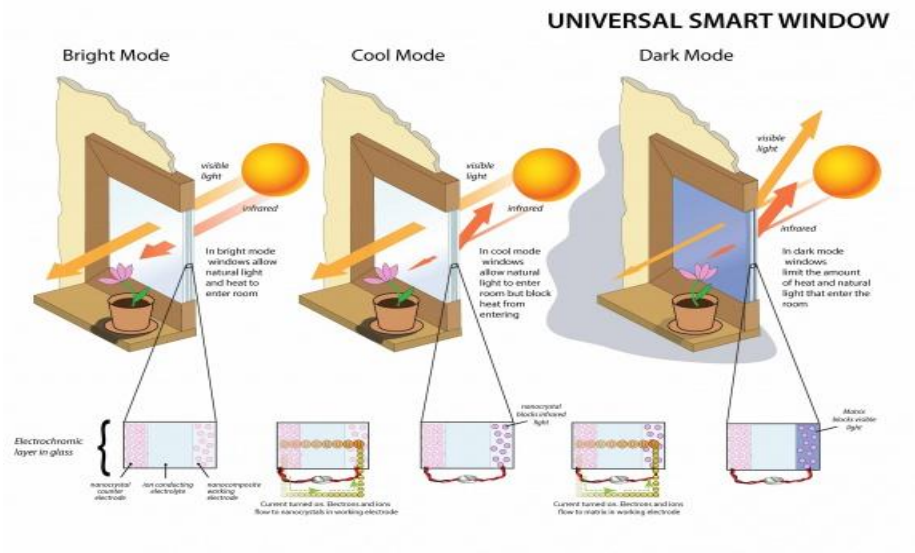

Figure 7: Functional scheme of how smart windows work [6]

Figure 7: Functional scheme of how smart windows work [6] These windows are often used in skyscrapers, so the control system let you alter the flow of light penetrating the building. At the same time, smart windows are increasingly used in residential construction. Developers of smart windows reduce their costs to make them available for a wide range of consumers. Therefore, it is expected that in the near future, the smart windows will be widely used in residential construction.

IV. IMPROVING THE ENERGY EFFICIENCY OF RESIDENTIAL BUILDINGS, REDUCING ENERGY CONSUMPTION

The opportunities to reduce energy consumption are largely related to the use of modern household appliances with a greater degree of energy efficiency.Modern refrigerators, washing machines and dishwashers include smart meters collecting data in real time and able to share it with different devices for a more efficient use of energy. For example, LG's smart appliances can determine current energy rate and start automatically when it is cheaper. Modern refrigerator can keep track of the product expiry and notify you by smartphone which of the products you lack by constantly updating your list of products in a mobile application (Fig. 8).

Figure 8: LG Smart refrigerator [7]

All these technologies are designed to reduce energy consumption and to bring a house to the ideal state, which is usually called "zero consumption".Buildings with zero consumption are those constructed with a

view to successfully operate independently of the usual power line. In other words, they provide consumers with their own energy through renewable energy sources. The value of "zero" threshold applies to both energy consumption and carbon dioxide emissions: such buildings consume a small amount of energy during the year and do not produce emissions of carbon dioxide, as they use renewable energy sources such as solar or wind energy.Houses with zero energy consumption (also called passive houses) are specially constructed so as to be extremely energy efficient, from a variety of insulation materials and using modern methods of construction, such as passive solar design. These projects use complete solutions: wind and solar collectors are sometimes combined with heating with biofuels. The construction of buildings with zero energy consumption is most effective in small towns where a few houses can benefit from a common renewable source, for example, like in the Dyssekilde eco-settlement in Denmark. This eco-village consists of 74 unique blocks of flats, which vary according to the type from the hobbit style thatched houses to the most modern buildings (Fig. 9).

Figure 9: Dyssekilde eco-village [8]

In 2007, the village obtained a geothermal heating system, and the result was so successful that most houses currently use this system for heating and hot water. 7 windmills provide more electricity than Dyssekilde can consume, a 450 kW enough to cover the needs of a 2,5 times bigger house community. The surplus electricity is sold. The village is a home to 118 people, 60 of them are children. The construction of houses with zero energy consumption obviously does not appear very easy or cheap. But with the rising cost of utility fares, these houses are becoming more and more attractive in different regions of the world. The construction of such houses most importantly must combine modern technology and natural materials to reduce anthropogenic and human impacts of such construction on the environment.

V. CONCLUSION AND RECOMMENDATIONS

The review shows that today the construction of residential houses widely involve the technology of using secondary, biodegradable and natural (organic) materials together with alternative sources of heating and lighting, energy efficiency improving design and reducing energy consumption. Using such approaches has significant environmental benefits, as well as reduces electric energy consumption down to the level of zero consumption. There is no doubt that the further development of residential construction technologies is related to the widespread use of natural ecological friendly materials, and innovative technologies in the field of energy supply, heating, ventilation, water supply and others. Today, many developers in various countries all over the world as well as citizens passed from the bold design solutions to the mass construction of houses built with the principles of environmental safety and energy efficiency. It must be assumed that the environmentally friendly individual solutions, energy self-sufficient small private houses will soon stop being an exception in the overall number of construction projects, and will become a standard solution.

In this scenario it is of particular interest the question of how to most effectively and economically combine different housing technologies based on the use of natural eco-friendly materials and modern high-tech products. The issue of economic costs in the construction of such houses is fundamentally important, whereas its

successful completion will make the construction of small eco-friendly and energy-efficient private houses a public demand and a truly mass phenomenon. The search for economic efficiency and reducing the construction cost of private houses are the main directions for the further research in the practical application of environmental technologies in residential construction.

VI. LIST OF FIGURES

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