ARCHITECTURE CIVIL ENGINEERING ENVIRONMENT
The Silesian University of Technology No. 3/2013

UNCONVENTIONAL BUILDING STRUCTURES IN SINGLE FAMILY SOCIAL HOUSING

Magdalena ZAŁĘCKA-MYSZKIEWICZ*

* MSc. Eng. Arch.; Faculty of Architecture, The Silesian University of Technology, Akademicka7, 44-100 Gliwice, Poland
E-mail address: *zalecka.magdalena@gmail.com*

Received: 9.09.2013; Revised: 17.09.2013 Accepted: 20.09.2013

Abstract
This paper is concerned with unconventional low-tech structures constructed from natural or/and recycled materials according to the concept of sustainable development of housing environment. Such ecological constructions may become an alternative to complex high-tech buildings in the future. The work presents main types of these structures. Moreover, it discusses possibilities and restrictions of their application as well as advantages and disadvantages of the implementation technology in the context of detached social housing issues.

Streszczenie
Opracowanie dotyczy niekonwencjonalnych konstrukcji low-tech, które zgodnie z ideą zrównoważonego rozwoju środowiska mieszkaniowego tworzone są z materiałów naturalnych lub/i recyklingowych. Te ekologiczne konstrukcje mogą w przyszłości stać się alternatywą dla skomplikowanych budowli high-tech. Przedstawiono główne rodzaje tych struktur, a ponadto możliwości i ograniczenia ich stosowania oraz wady i zalety technologii ich realizacji w kontekście problematyki socjalnej zabudowy jednorodzinnej.

Keywords: **Ecological building structures; Social architecture; Detached housing.**

1. INTRODUCTION

"Architecture plays a dominant role in the development of building technique. It is a field which most prominently tends to pursue new constructional solutions and new forms" [1]

Jerzy Hryniewiecki

The idea of the sustainable development of housing environment means using natural or recycled building materials in the housing construction as well as application of simple methods of execution of small residential buildings. An extreme example of such tendencies may be diverging from conventional building structures towards unconventional constructions and far-reaching simplification of building processes. This work attempts at defining possibilities and restrictions of the implementation of the above-mentioned structures in social housing. It also tries to answer the question if such implementation may considerably influence the development of social housing.

In order to introduce these issues, basic definitions of terms related to the subject have been provided below:

a. social housing: is addressed to the economically weakest groups of people and executed through social projects being the responsibility of communes,
b. single family housing: is a type of housing in which no stacking of flats occurs,
c. participatory social housing construction /PBS/: assumes participation of the future residents in the designing and building process of a residential unit [7].

2. CLASSIFICATION OF BUILDING STRUCTURES

There are many possibilities of types and division and thus classification of construction systems. According to *Władysław Borusiewicz* [1], one may distinguish certain categories taking into account:

a. geometrical characteristics which includes the following systems: massive (solid), bar, with flexible connectors, framing, panel, thin-walled surfaces as well as free or stretched membrane coverings;

b. static features which encompass beam and strut structures;

c. the kind of connection of elements in joints with division into systems with articulated joints, rigid joints or mixed ones;

d. mutual relations of elements in space; one distinguishes static planar and spatial systems;

e. methods and assumptions adopted in static calculations concerning statically determinate or indeterminate structures;

f. building material used in construction; one differentiates basic materials /construction materials/ and auxiliary materials, for instance different types of construction: wooden and wood-like, steel, concrete and reinforced concrete, natural stones /including ceramics/, plastics and glass products.

Some of the aforementioned structures may be subject to a prefabrication process, i.e. manufacturing of the entire elements or assembling, so-called modules, which in fact considerably increases the pace of the building process. At the moment, it is observed that there is a tendency to reuse shipping containers as spatial modules for constructional purposes. They are used to create structures having a new function, mainly residential or office one.

The above-listed construction types and their classification are well-known and commonly used, therefore, in this paper they will be called conventional building structures.

As opposed to the types of constructions presented so-far, there is a current in building engineering which takes advantage of natural structures with the use of local materials available and accessible on the construction site or in its vicinity. Another example is systems built with the use of recycled materials. The key assumptions of buildings executed in such a way are their self-sufficiency as far as their operation is concerned and reduction of the construction costs to a minimum. These structures will be discussed in further chapters as unconventional ones due to their structural dissimilarity and different approach towards the building process than in the case of conventional structures.

3. ECO-STRUCTURES

"Nature, technology, humanity" is a motto of the Cohabitat Group which through education, development and popularization of natural technologies desires to provide people with possibility of dwelling in natural settlements, so-called "Habitats", constructed in compliance with the ecosystem. Eco-structures are created from materials such as: sand, earth, clay, grass, straw and wood, and are made of their combination, mixing, ramming or pressing (compacting). These are not, however, innovative solutions. The first earth houses or shelters woven from twigs or reeds (cane) were built in the Palaeolithic and Mesolithic Age. In our time, however, the construction of so-called "eko", that is structures erected using local resources, is a conscious decision of the community. It provides an alternative to contemporary architecture. Ekostructures like most of today's buildings, can be accompanied by media or arise as objects so-called off-grid buildings /not connected to the central grid, having their own power-generating system [3], [4], [5], [8].

3.1. Branche and earth House (Fig. 1)

This type of housing, most of all, refers to historical solutions which date back to prehistoric times. While locating a contemporary earth house one usually takes advantage of the existing considerable difference in ground levels or depression, or optimal arrangement of trees /in order to create a structure based on the existing vegetation/. Proper location of such a structure, partial sinking or/and covering it with earth, most often from the northern side, results in the reduction of heat loss and positively influences the microclimate. The walls are driven in the ground and finished with clay or erected with the use of adobes made of rammed or compacted earth or clay dried in the sun (Fig. 2). At present, the construction of such facilities is done for two principal reasons. Firstly, it is the minimization of costs and desire to commune with nature. This results in building modest buildings of small usable surface. Secondly, it is the desire to create an optimal microclimate in the object interior particularly in the countries having a hot and dry climate. This results in creating luxury suites or apartments [8].

Figure 1.
The skeleton of a branche house (photo [8])

Figure 2.
The wall of a building made in a rammed-earth technique (photo [5])

3.2. Straw Bale Homes (Fig. 3)

Straw bales, i.e. "clay and straw bales", are an experimental construction of objects in which a wooden skeleton (framework) is filled with straw blocks which function as thermal insulation. Today, the foundations of such a building are most often built with the use of tyres filled with earth while the interior and facade are finished with clay or clay mixed with lime. In spite of the fact that the first structures of this type were created in the 19th century, in our times this method is undergoing a revival. Originally, this system was used to build outbuildings (utility buildings). However, today this method is also applied to the housing construction, mainly in detached housing, due to its constructional possibilities. Several houses of this type have been built in Poland in the recent years and the interest in this technology has been on the increase [3], [5].

Figure 3.
The wall built in a straw-bale technique (photo [11])

3.3. Eco-dome (Fig. 4) and Igloo

The construction of a self-supporting monolithic eco-dome designed by Nader Khalili is a "dry" counterpart of an ice and snow structure called an igloo. Instead of snow blocks laid in the shape of a dome, the architect proposes to build a house with the use of long bag-like "sleeves" (so-called sandbags). They are filled with stabilized earth /mixed with cement or lime and water, creating thus a plastic mass/ compacted layer by layer, reinforced and interconnected by means of a barbed wire. The foundations are made with the use of the same construction as the walls. The function of the ice which appears on the outside of the snow structure and additionally stabilizes the whole construction is played here by the layer of clay on the eco-dome. The house is devised in such a way so as to survive extreme conditions, such as hurricanes, earthquakes or floods. The technique in which

this eco-house was built has been called "super-adobe". It is a combination of an ancient method using clay or mud bricks (blocks) with the technique of 'rammed earth'[8].

Figure 4.
The structure of an eco-dome during construction (photo [8])

3.4. Other example technologies

Eco-building engineering uses also other technologies, such as:

a. "adobe" (Fig. 5): a block dried in the sun with no further firing; the material obtained in this way is cheap, however, it is characterized by very low resistance to humidity and precipitation;

b. "cob": a material obtained by mixing clay, sand, straw, water and earth; it is characterized by resistance to fire or earthquakes, however, similarly to "adobe" blocks, has low resistance to intense precipitation;

c. "cordwood" (Fig. 6): a wooden construction with an arrangement of wood pieces showing the intersection of the trunk; the wall includes 40-60% wooden trunks, the rest is glue and insulation mortar;

d. "straw-clay" (Fig. 7): light clay, the material used to fill in the spaces in the walls; it is obtained by mixing straw with clay; such a mixture is placed in temporary wooden moulds which are further used for the construction of the wall.

The eco-structures which have been discussed so far are often equipped with green roofs, often called

Figure 5.
Adobe blocks (photo [5])

Figure 6.
The wall built in a cordwood technique (photo [5])

"natural roofs", providing a partial or entire covering of the constructed objects. Such roofs aim at absorbing rainwater, reduction of temperature in the ecosystem and prevention against the greenhouse effect [5].

Figure 7.
The wall built in a straw-clay technique (photo [12])

Figure 8.
The interior of an earthship-type building (photo [9])

4. STRUCTURES MADE FROM RECYCLED MATERIALS

A forerunner of the trend to build housing structures, especially detached ones, with the use of recycled materials is an American architect Michael Reynolds. He designs and builds self-sufficient /off-grid/ houses making use of used tyres, aluminium tins, glass bottles or plastic containers. In spite of being original and functional, his concepts were acclaimed by the local authorities only after a re-building action following the flood in New Orleans and Hurricane Katrina. He came to the aid of the harmed then and assisted them in constructing houses made from materials left behind by the destructive elements [2], [6], [9].

4.1. Earthship (Fig. 8)

Earthship, that is "a ship made from earth" or "a ship on earth", is a passive, off-grid building constructed at a very low cost from materials available locally and recycled waste. The chief assumptions of this technology are: the possibility to build the house by its future residents and self-sufficiency of such a unit. The material base for such an investment is provided first of all by used car tyres. They are filled with earth and allow the structure to accumulate and maintain an optimal temperature using only solar energy in almost every type of climate. Moreover, by using local materials and all kinds of recycled materials in the construction one reduces considerably the cost of such a building. In addition to that, the maintenance of such a residential unit goes down to a minimum. The next step leading to self-sufficiency is having a home garden. Earthships use only natural sources of energy, such as wind and solar power, which are used for heating and ventilating the houses.

This technology was devised and implemented by the above-mentioned Michael Reynolds as early as in 1970. The first buildings were constructed in New Mexico. Until today about 2000 detached houses of this structure have been erected. The first building of this kind is going to be built in Poland within the next few years [2], [9].

5. UNCONVENTIONAL BUILDING STRUCTURES – POSSIBILITIES AND RESTRICTIONS

Ecological unconventional structures may considerably influence the development of social housing, in particular, detached housing. The methods of erecting eco-structures make it possible to create first of all simple and small residential buildings with a considerable cost reduction at the same time. Another advantage of such structures is the assumption of self-sufficiency and low costs of maintenance. Moreover, contrary to conventional developer's actions, where potential lodgers obtain ready-made flats hard to identify with, the natural building techniques enable activization of future residents already

in the designing and building process. It allows such people first of all to find their place in a new situation in an unknown location and secondly, to acquire new skills which might prove useful in the future.

However, despite many advantages one should take into consideration also limitations connected with unconventional structures and the technology of their implementation. Due to the application of natural and recycled materials, an issue arises how to determine their construction parameters and obtain approvals allowing the use of such materials in the building process. This refers also to the quality control of the construction of such a building. There is also a noticeable lack of adequate quantity and quality of materials as well as supplementary products for such constructions, which would meet insulation, installation and finishing requirements. The discussed-above structures are characterized by rather small resistance to excessive dampness and intense rainfall, which may have a negative or even disastrous effect in the countries having a cold and humid climate. Problems may arise with adjusting the buildings to the existing technical conditions and administrative procedures as well as with obtaining a bank loan or insurance for such investments. Also, some doubts may be caused by a possibility of occurring social stigmatizing of the dwellers as well as their territorial isolation because of the untypical appearance of the buildings and often associated with low technical and functional standard of such building structures.

Bearing in mind Frederick Douglas's words: "there is no progress without struggle", the precursors of structures made from ecological and recycled materials should keep improving green technologies. In a persistent way and in compliance with their ideology, they should adapt the proposed solutions to various conditions connected either with certain policies, functions or types of climate. These technologies may turn out to play a significant role in the future in the sector of social detached housing due to the idea of participation, simplicity and availability.

6. CONCLUSIONS

Ecological structures taking advantage of natural and recycled materials provide an alternative to complex high-tech buildings. They require, however, the specification of details within the scope of adaptation to other functional needs and climatic conditions, different from the ones implemented today.

Unconventional building structures may positively influence social housing. They are appropriate for small objects of a moderate technical and functional standard. They use available materials and do not require either high building skills or specialist equipment. They enable activization and participation of the future residents in the designing and building process. The natural environment is not burdened, as such structures are a part of a sustainable development current. However, some doubts may be raised in the scope of technical, legal and administrative issues related to the implementation of such unconventional structures. Another issue is a social one referring to the risk of ghettoization and stigmatization. Such new ideas should never be bracketed as utopian and thus characterized by social isolation and testing them on the poorest social classes.

As Alvar Aalto said: "The essential cost-effectiveness of building engineering shows how many good solutions can be provided at the lowest cost. However, we must never forget that we build for people." [1]

REFERENCES

[1] *Borusiewicz W.*; Konstrukcje budowlane dla architektów (Building structures for architects), Arkady, Warszawa; 1978

[2] *Kossak-Jagodzińska A.*: Archetyp funkcji domu jednorodzinnego – jego ewolucja i współczesny obraz (The functional archetype of the single family house - its evolution and contemporary vision), [w:] Inicjacje w architekturze, W poszukiwaniu funkcji, Postmodernizm (Initiations in the architecture, In the search for functions, Postmodernism), Gliwice, 2012, ISBN 978-83-934068-4-5.

[3] *Jagielak M., Kołakowski M.M.*; Słoma? Słoma.. słoma! (Straw? Straw.. straw!), [w:] Architektura&Biznes (Architecture&Business) 11/2010, wydawnictwo RAM, ISSN 1230-1817

[4] *Kołakowski M.M.*; Wszystko, co chcielibyście wiedzieć o glinie, ale boicie się zapytać (Everything you always wanted to know about clay, but you were afraid to ask), [accessible on the internet: www.zb.eco.pl, 21.12.2012, at 15.34

[5] www.cohabitat.net, acccess: 21.12.2012, at 14.30

[6] www.bryla.gazetadom.pl, acccess: 20.12.2012, at 21.37

[7] www.freelab.bzzz.net/cholernylewak/files/2012/09/Partycypacyjne-budownictwo-socjalne.pdf, acccess: 20.12.2012, at 20.32

[8] www.kodczasu.pl, acccess: 5.07.2013, at 15.12

[9] www.purpose.com.pl, acccess: 10.07.2012, at 17.35

[10] www.bkhousing.pl, acccess: 20.12.2012, at 21.08

[11] www.inhabitat.com, acccess: 6.07.2013, at 14.58

[12] www.naturalcottageproject.com, acccess: 7.07.2013, at 10.58