

Typological analysis of mobile housing technology in the context of the problem of energy saving

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Abstract. The practice of using structural and functional features of mobile housing technologies is primarily related to migration processes: labour, tourist-recreational, educational, as well as forced ones (caused by military-political and natural-technogenic disasters). In many leading and economically developed countries there is considerable experience in the implementation of land- and water-based mobile housing technologies in the creation of socially affordable housing (including as part of an alternative approach to solving overpopulation problems). In modern conditions, new design methods based on the requirements of environmental friendliness and conservation of natural resources are introduced into architectural and construction activities all over the world. In the Ukrainian state, in connection with the existing political and economic situation, the practical development of mobile housing technologies is of particular social significance, taking into account the level of providing the population with housing of various types and quality. The application of mobile housing technologies can be, in particular, a temporary solution to the housing problem, thanks to certain advantages in terms of environmental friendliness and energy saving, in comparison with capital residential buildings. The use of mobile homes in Ukraine today is characterized by limited functional and typological composition. The development of the production of industrial mobile housing technologies has the prospect of their practical application in a wide operational spectrum.

1 Problem statement

The practice of using structural and functional features of mobile housing technologies is primarily related to migration processes: labour, tourist-recreational, educational, as well as forced ones (caused by military-political and natural-technogenic disasters).

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In many leading and economically developed countries, there is considerable experience in the implementation of land- and water-based mobile housing technologies in the creation of socially affordable housing (including as part of an alternative approach to solving overpopulation problems).

Many modern studies are devoted to the problems of kinematics and mobility of architecture and the application of innovative energy-saving technologies, among which certain issues related to regional and typological features were considered in their scientific works: P. Schumacher (characteristic features of parametricism, kinematic technologies in urban planning) [1, 2]; Y. Akgün, F. Maden, K. Korkmaz (fundamental principles of kinematic synthesis of mechanisms in architecture) [3]; N. Aalhashem, Z. Al-sharify, K Al-Kaissi's, T. Alsharify (digital architecture and urban space) [4]; R. Reffat (the role of digital architecture in reforming the urban environment) [5]; Y. Lin, W. Yang (energy-saving technologies used in building envelopes) [6]. It is considered appropriate to study the possibilities of using mobile housing technologies based on an ecological and energy-saving approach in the territory of the post-industrial Ukrainian state.

The purpose of the work is to carry out a typological study of modern mobile housing technologies, to identify optimal functional types, from the standpoint of using renewable energy sources and preserving the natural environment.

2 Main part

The history of the development of a residential building, the evolution of its formation in the environment is connected with the selection of two main forms - mobile housing and capital construction.

The mobile form of housing was characteristic of all ancient nomads living in the arid zone from the Danube to the Yellow River (Cimmerians, Xiongnu, Huns, Scythians, Sarmatians, Polovtsians, Turks, Mongols, etc.).

The principle of building a nomad's house has not undergone significant changes from ancient times to today: the main types of traditional housing are frame-tent constructions, which differ in the structure of the frame and covering (yurts, yarangs, chums, teepees, Berber and Bedouin tents, etc.).

In modern society, the classic housing of nomads is made, as before, from natural materials and is practically not affected by modern progress in terms of construction, technology and functionality (Fig. 1).

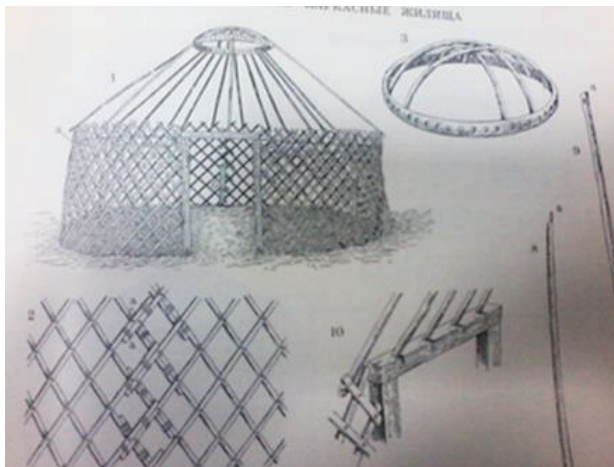


Fig. 1. The frame of the yurt

The structural and typological range of modern mobile housing (ground and water-based) is sufficiently developed:

- temporary housing for shift work, including in construction conditions, as well as in poorly developed and hard-to-reach regions, remote from anthropogenically developed centers, in areas with unfavorable natural and climatic conditions;
- in conditions of high population migration associated with employment problems;
- for accommodation of forced migrants as a result of extraordinary circumstances. caused by military and political instability and natural and man-made disasters;
- housing for the period of acquiring education;
- recreational and tourist housing, hotel;
- temporary garrison housing for military personnel.

Foreign experience in the use of mobile housing technologies shows that the most widespread are the designs of fully factory-ready residential modules in the form of container blocks [7].

The development of the market of mobile housing technologies and the use of certain typological types of mobile housing have significant regional differences.

The USA, Great Britain, Germany, Spain, etc. are the main producers of mobile homes, as well as those that use the advantages of mobile homes the most in the form of suburban residential units, summer cottages, tourist campsites, and hotels.

First of all, the use of former transport and cargo containers, primarily sea ones, is characteristic. A significant role in the development of container-type mobile housing was played by the emergence and wide spread of the new Cargotecture architectural style.

During the last two decades, many countries of the world with large port cities (especially Canada, the USA, the Netherlands, Germany, Denmark, Norway, Japan, and New Zealand) have accumulated a lot of experience in creating mobile and stationary modular-container residential and public architecture.

Initially, construction using shipping containers began as a creative experiment. One of the first to intensively popularize the idea of creating mobile homes using Cargotecture technologies was American architect Adam Calkin (in particular, the “12 Container House” is considered a symbol of the design of cargo and transport containers) [8] (Fig. 2).

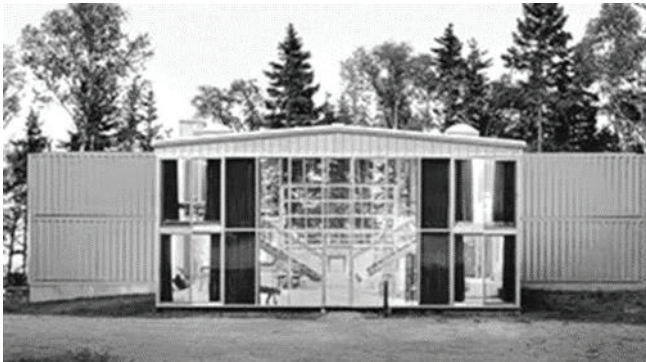


Fig. 2. “12 Container House” (Arch. Adam Calkin, USA, State of Maine, 2003)

Cargotecture-buildings gradually received a developed functional and typological assortment (container modules of various sizes are used to build objects: residential, recreational, commercial, administrative, economic and warehouse, industrial, also to create installations and art objects, use them as furniture and interior details, used in landscape design, turned into pools).

Cargotecture's modular container technologies have a steady tendency to increase construction volumes due to a number of reasons:

- the world resource of secondary material available for construction is virtually unlimited;
- buildings from containers demonstrate significant economic, time and energy-saving advantages associated with the specifics of the accelerated technological process of converting former containers into building modules (in world practice, transport and cargo containers with a length of 20 and 40 feet, a width of 2.4 m are mainly used, 2.6 m and 2.9 m high);
- buildings erected using Cargotecture technologies significantly reduce the harmful impact on the environment, especially mobile objects;
- the strength of transport-container modules is designed to withstand sea elements, which allows them to be used in regions with possible extreme wind loads (from hurricanes, tornadoes), as well as during construction in earthquake-prone areas;
- the possibility of quick dismantling of the container structure.

The less positive features of container architecture include the low ergonomic indicators of residential premises, which are primarily related to the small size of the internal space (close to the type of residential capsules), as well as the constructive material of the container modules (as a rule, the cost of living in a container building is many times lower than in a house built from traditional materials) [9].

In particular, the metal base of the container block has high sound permeability (for example, during rain, the volume of the outer casing is especially felt) and high thermal conductivity (in hot climates, there are problems related to overheating of the premises, and operation in frosty periods is also problematic).

The technologies of using converted containers are used both in experimental design works, mainly for recreational use, and in the development of temporary mass housing for low-income groups of the population, refugees, emigrants.

Container-mobile architecture has become widespread in the hotel business, primarily of the hostel type (for example, mobile mini-hotels from recycled transport containers of the Snoozebox company) [10] (Fig. 3).



Fig. 3. Mini-hotel from containers “Snoozebox” based on a car chassis (Great Britain, 2013)

Thanks to the use of Cargotecture technologies, in some countries the problem of accommodation during the period of acquiring education is solved. An example of the largest mobile complex of student dormitories is “Keetwonen” in Amsterdam [11].

A special type of modern residential construction-container technologies is the so-called capsule dwellings (buildings with minimized functional and planning parameters, which have become the most widespread in megacities and industrial urban agglomerations of East and Southeast Asia) [12].

The promising design direction of modern mobile housing includes the development of mobile transformers (modular and prefabricated volume-planning solutions obtained as a result of the transformation of structural blanks).

A separate functional-typological variety is represented by mobile homes on the water (on the formation of which natural and hydrological prerequisites have a decisive influence, as well as the search for alternative places to live in conditions of land overpopulation).

Houses on a pontoon base have become widespread in European countries (the Netherlands, Denmark, etc.) and the South Asian region (China, Vietnam, Cambodia, etc.) [13] (Fig. 4).



Fig. 4. Floating houses on pontoons (Amsterdam, Netherlands)

Residential structures placed on the basis of a car chassis (campers and trailers) are widely used. Adaptation of vehicles for housing needs has also become a popular phenomenon: housing in buses, in truck bodies, in cargo containers.

The USA remains the country with the most significant experience of using serial automobile housing (at the beginning of the 21st century, more than 20 million US residents lived in mobile housing complexes – trailer parks, which is about 8% of the country's total population) [14] (Fig. 5).

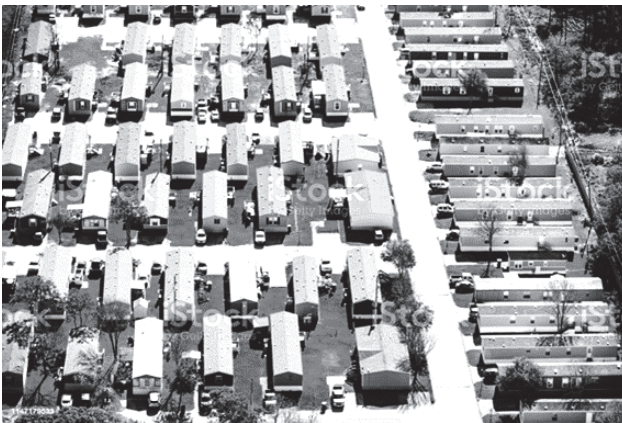


Fig. 5. Trailer Park (Texas, USA)

Mobile homes on wheels in the USA, which have become part of urban planning culture, have acquired, to a certain extent, the image of economy-class starter housing. But, in many cases, trailer parks have turned into depressed residential areas for low-skilled people; sometimes – in shelters for escapist and socially negative strata of society. Residential trailers used as the main year-round housing (in the USA, Canada and other countries) created a negative stereotype due to the low ergonomic qualities of the living environment [15].

The current leading trend is the introduction of the concept of integrated ecological and energy-efficient assessment into architectural and construction activities (at the level of urban planning, landscape-spatial approach, building materials, projected operation of buildings, etc.) [16].

Despite the fact that modern mobile homes are mainly used for temporary stays, they must also meet the same environmental and energy-saving requirements as capital residential buildings, along with other building codes and requirements.

The analysis of the functional features of mobile residential technologies in the context of the energy saving problem shows certain advantages in comparison with capital residential buildings, in particular, the use of the possibilities of autonomous operation and rapid adaptability to changes in operating conditions.

In modern conditions, the energy efficiency of mobile homes (including in autonomous mode of operation) can be achieved due to a number of architectural, constructive and engineering measures:

- increasing the normative values of the thermal resistance indicators of the main enclosing structures;
- improvement of structures for filling light holes; at the same time, reducing heat loss should not be achieved by limiting the size of windows (in a temperate climate);
- a balanced and rational volume-planning solution that allows to combine the requirements of energy saving (in particular, the use of simple geometric shapes) and the possibility of creating an artistic expressiveness of the building, including through the use of transformation (in the presence of elements oriented to the external environment: terraces, verandas, sun visors and canopies, etc.);
- regulation of engineering equipment systems;
- the use of energy from renewable sources.

For mobile housing, power plants are the most technologically available based on solar radiation and wind power.

To increase the energy efficiency of a mobile home with the help of solar lighting, the following can be used:

1. Active systems containing solar equipment of two main types: solar cells and solar collectors. Solar cells (energy systems based on modules-panels of photovoltaic cells), as a rule, serve as a supplement to the main centralized source of electrical energy. Solar collectors for heating water are actively used for heat supply (in individual low-rise farms they allow to save an average of 60-70% of heat energy during the year, in summer – to provide 100% heat consumption) [17].
2. Passive systems based on the application of architectural and constructive solutions to increase the degree of use of solar radiation, without installing solar equipment [18].

In the conditions of modern Ukraine, which joined the strategic planetary program “Sustainable Development” in 2015, the principles of energy efficiency have become priority operating characteristics of construction at the legislative level; unfortunately, so far in our country, the efficiency of the use of energy resources, including in residential construction, is several times lower than the average indicators, compared to other regions of the world with similar climatic conditions [19].

On the territory of the Ukrainian state, in the existing socio-political circumstances, the problem of resettlement of people affected by military actions has gained considerable relevance.

It is considered expedient to use architectural and construction solutions capable of the fastest reaction to the effect of the time limitation factor, namely mobile temporary housing.

First of all, there are two main structural and planning types:

- a) Express housing during necessary emergency relocations. The use of various types of modular awning structures is typical for the initial residential shelter; also, the practice of applying various constructive transformations, including those created according to the principle of “self-packaging”, is introduced.
- b) Objects of rapid construction (all-season type, based on the use of technologies with a high degree of factory readiness). Structural and planning solutions provide for functional zoning of the interior space with the possibility of dividing it into separate rooms. Among the most common mobile technologies of rapid construction are modular-container and prefabricated houses.

The mobile home industry in Ukraine is currently in its infancy.

Mobile homes are traditionally used mainly as temporary working housing (mainly block-container type for domestic use). Light portable constructions for economic and commercial purposes (kiosks, booths, small hangars, etc.) and garages are in quite high demand. A small percentage is the use of motor home trailers by citizens.

Considering the perspective of political stabilization and recovery of economic development, mobile technologies can be used as: rental housing, which significantly contributes to the freedom of employment; temporary housing for the period of reconstruction works; hotel in the form of hostels; recreational and tourist, country.

3 Conclusions

The structural and functional capabilities of the mobile home allow to use its typological assortment with the use of energy-efficient technologies, the most affordable of which are energy systems based on solar and wind energy. Mobile housing can also play a significant role in the ecological optimization of the living conditions of the population.

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