

Danuta Konieczna

de.konieczna@gmail.com

Department of Architecture of Contemporary, Theory and Design Methodology, Faculty of Civil Engineering and Architecture, West Pomeranian University of Technology Szczecin

MODERN TRENDS IN THE FORMATION OF ADAPTIVE ARCHITECTURE

WSPÓŁCZESNE KIERUNKI W TWORZENIU ARCHITEKTURY ADAPTACYJNEJ

Abstract

Humans are flexible creatures that adapt their living environment for their own needs. A sedentary lifestyle forced humans to adapt the house building to changeable environmental conditions. Historical adaptable residential buildings were characterized by an increasing range of changes that occurred to the changing needs of occupants. Nowadays, evolving computer technology, intelligent systems and methods of the acquisition of renewable energy influence the growing expectations for residential buildings and their functions. The presented research describes selected contemporary adaptable houses, their features and range of adaptation. The aim is to formulate conclusions about the future of adaptable housing development and its potential. The reflection on this matter is the last part of the article.

Keywords: adaptive architecture, dynamic houses, contemporary residential architecture, flexible architecture

Streszczenie

Człowiek jest istotą od zawsze przystosowującą środowisko mieszkalne na własne potrzeby. Osiadły tryb życia wymusił na człowieku dostosowanie swoich domów do zmiennych warunków środowiskowych. Historyczne domy adaptowalne cechowały się coraz większym zakresem zmian, jakie można wprowadzać w stosunku do potrzeb. Współcześnie rozwijająca się technologia komputerowa, systemów inteligentnych oraz sposoby pozyskiwania energii ze źródeł odnawialnych wpływa na rosnące oczekiwania wobec funkcji budynku mieszkalnego i sposobu jego działania. Przedstawione badania opisują wybrane aktualne realizacje budynków adaptowalnych, ich cel oraz zakres zachodzącej adaptacji. Ma to na celu sformułowanie wniosków związanych z kierunkiem rozwoju architektury mieszkaniowej i potencjałem systemów adaptowalnych które stanowią ostatnią część wywodu.

Słowa kluczowe: architektura adaptacyjna, domy dynamiczne, współczesna architektura mieszkalna, architektura elastyczna

1. Introduction

Adaptable residential buildings and their historical forms were developed by humans in times before our era. According to Robert Kronenburg [9], the term “adaptable” means the built-in ability to adapt to changes in the function, ability of making spatial and functional changes and implementation of a new technology without disturbances within the environment and human life. The ability to adapt plays an important role in improving the comfort of living in the building. One of the first adaptable buildings were Japanese houses. Multifunctional space was achieved by sliding doors (shoji) and sliding panels (fusuma). The house plan consisted of interconnected rooms that could be divided by moving walls in a few seconds.

Adjusting the living space to human needs on the individual level improves the sense of security and well-being, quality of life and can help to maintain family relations on a high level. Adaptability could also bring benefits at the social level. Providing certain possibilities of a house and its configuration achieved without imposing noise and waste to the external environment allows for the proper maintenance of neighborly relations. Adaptable houses can, under certain conditions, benefit future generations – for example – regulations of space privacy between siblings or increasing the usable area for the larger family needs.

In an economic and ecological aspect, an adaptable house fulfills its function better than a traditional house. The possibility of adjusting the space to various stages of life of the residents may allow for a longer operation of the facility, reduce the consumption of materials and use the newest technologies to ensure the best home optimization in relation to environmental conditions. Adaptable processes in a house can provide minimal disturbances in the environment and do not require high financial resources.

The adaptation process can be both simple and complex. The study of a modern approach to the topic of adaptable houses is an essential element for further research of the presented issue. Today, several organizations are characterized by activities in the context of adaptable buildings. One of them is adaptable future¹. The organization focuses on changing the society’s approach to the issue of sustainable construction. Architecture according to Adaptable future should be susceptible to adaptation to the variable reality, becoming also variable. Currently, the group focuses on a research project at the University of Loughborough describing the adaptive abilities of historical buildings and tools that were used at that time. Based on the observations of the changes taking place, the group assumes working out a possible scenario of the future of adaptive construction.

The second institution is the Open Building², representing the idea of being “open” to changes in the building. According to the institute, modern times, which are full of technical and social upheavals, require that buildings – by adaptation – remain safe, useful and attractive.

¹ More about organization “adaptable future” in [13].

² More about Open Building institution in [14].

2. Adaptable architecture levels

The typological demarcation of adaptable buildings was introduced by C.M.J.L. Lelieveld [8, pp. 245–252] in the conference article *Adaptable architecture*. As a general definition of adaptable architecture, Lelieveld adopted the architecture of which specific components can be changed in response to external stimuli (user and / or environment). “Based on the technological advancement levels of individual buildings, the grouping of buildings from the least technologically advanced to those with the most autonomous embedded systems.

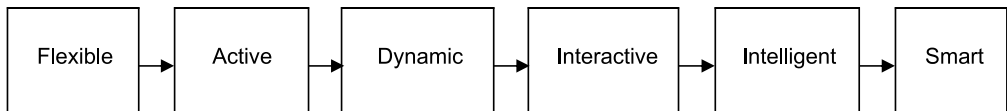


Fig. 1. Adaptation levels in architects adaptable according to C.M.J.L. Lelieveld

Flexible level – The first level in adaptable architecture. Adaptation activities are controlled directly by a human, which means no autonomous actions of the building. Flexible buildings are characterized by the use of common techniques of moving parts: bearings, rails, hinges.

Active level – Individual building components react to the activity of the user or the environment. The operation of the building is based on the action-reaction relationship. The most common example of an active reaction is a light switch. The active level requires the use of electricity in a building that was introduced from the beginning of the 20th century.

Dynamic level – Impacts from the user or the environment causes specific changes in the active components of the building. This is a more advanced level than the active level, because, in addition to action on the action – response relationship, there is a possibility to introduce more options and settings within each component. For dynamic adaptation, use of computer technology is essential. That technology is available for housing since around 1980.

Interactive level – This level is characterized by a bilateral relationship between the building and the user. This technology requires the user’s digital detection and undertaking programmed actions related to it. Most often, you can meet interactivity in experimental and demonstration installations placed in cities or tested in laboratories. Currently, intensive research on interactivity is conducted under the direction of Prof. Kas Oosterhuis at the University of Technology in Delft. The group’s name is Hyperbody³. The group focuses on improving the design techniques, construction and use of interactive architecture, and explores its applications. What is more, group works on interdisciplinary cooperation in digital projects, the implementation of electronic spatial environments and the creation of interactive architecture prototypes.

Intelligent level – The term “intelligent building appeared in the early 1980s. There is no one general definition of intelligent architecture, but the available bibliography offers many similar definitions. The definition of intelligent architecture can be taken from the colliery book by Collier and Thelen [2]. Users experience a system as intelligent not only if it accepts natural language input

³ More about projects and researches at Hyperbody in [15].

rather than just specific commands, but also if it allows the user to take initiative. If the system adapts itself to the users' interests and interaction preferences and works cooperatively with the user to accomplish specific goals with the use of additional sources of knowledge to meet the needs of the user, a system is considered intelligent." The system is capable of detecting, processing data, makes decisions as to whether to react. The system can take action without user intervention. Intelligent technologies support users in various aspects, such as security, energy saving, information, communication and ensuring comfort (ventilation, heating).

Smart level – Smart buildings have the ability to make changes on their own initiative. The systems of such buildings are integrated with both the life and behavior of users, receive and react to stimuli from the environment and are integrated with each other. In Richard Harper's book *Inside the smart home* [6], co-author Frances K. Aldrich defines the "smart home" as a "residence equipped with computing and information technology, which anticipated and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and the connections to the world beyond.

3. Criteria and Methods

This study focuses on residential houses characterized by the adaptability of space at the flexible, active and dynamic level. All these three levels introduce physical changes to the object by changing the architectural features of the house, which is discussed in the article. According to Lelieveld's table, there are six adaptive levels. However, the interactive, intelligent and smart level introduce changes to the facility at the technological level, without affecting the building's architecture as the functional layout or extending the usability.

Buildings were searched by bibliography analysis (conference materials, articles, books) in the field of modern "mobile" architecture and the theory of architecture with ambitious computing⁴. Each house collected was analyzed, compared with other buildings, which allowed for a better understanding of the trends and design process of adaptive houses.

4. Residential architecture with a reconfigurable plan

The way of adapting to the needs by creating multifunctional rooms, the possibility of joining zones with each other or sharing them has been used for a long time, starting from Japanese homes and manifesting today in the form of modern homes with various functional configuration options. According to statistical surveys carried out by CENSUS in 2012–2013, the main reason for moving is the desire to change the house for the better and "other reasons related to the house"⁵ which suggests the inconvenience associated with the building

⁴ Phrase coined by Mark Weiser around 1988. Umbitious computing is a concept in software engineering and computer science where computing is made to appear anytime and everywhere.

⁵ CENSUS: *Reasons for Moving 2012 to 2013* [16].

itself. On this basis, it can be concluded that adaptable houses with the possibility of changing the layout of rooms or their size may be more convenient to use and over time become more appropriate by modern families. Below are selected examples of single-family residential architecture belonging to the group of adaptable buildings completed in the 21st century.

4.1. Naked House

The main idea of Naked House was to create a home that provided the maximum amount of common space, in which family members are not separated from each other by private spaces. The house provides everyone with the feeling of freedom so individual activities can be taken in a shared space. Semi-transparent facade of the house thanks to its construction allows a large amount of sunlight brightening the entire internal space. The external walls were made of two sheets of corrugated fiber-reinforced plastics with thermal insulation made of foamed polyethylene. The essence of adaptability in this house is the internal space, freely configurable through movable internal divisions of nylon fabric and wooden modules of bedroom rooms placed on wheels. The additional amount of equipment that can be used in several different ways adds extra freedom. Bedroom areas can be combined to form one large semi-private room, or – just like in Nyborg House – to extend outside the house. The upper cover of the bedroom is an additional space that is used, among other things, to play with children. The whole house is the quintessence of flexible living and is one of a few objects of this type in the world.



Fig. 2. Naked House, Shigeru Ban Architects (source: [25])

4.2. Nyborg Adaptable Houses⁶

The Danish design office Henning Larsen Architects and GXN designed the experimental housing estate in Nyborg with implementation in 2013. The estate includes six detached buildings, each of which was to reduce CO₂ emissions during construction and use. These

⁶ Full information about project in [17].

houses focus on the flexibility of the functional plan and material savings in the event of a reconstruction of the building. The house has an area of 146 m² and focuses on the changing needs of the family at various stages of life. A growing family, growing up children and changing privacy needs, leaving the house by children, divorce, partner's death. The houses have been designed to adapt functional plans to the needs of users at any stage of their life. In the buildings, load-bearing walls are only external walls. The kitchen can become a room open towards the dining room or living room thanks to the opaque walls. The modular design makes it easy to create an additional entrance to the building.

4.3. Raum transforming house⁷

Another way to transform the functional plan was found by architects from the French Raum studio. The building was designed and built in 2013 for a family with young children in the north-west of France. The building is divided into two parts. The first is a private part, while the second is a semi-private space, accessible from the outside through a large sliding balcony door. The ground floor of the building has an open plan and includes rooms in the living area: living room, kitchen and dining room. Next to the entrance to the house, there are mobile bedroom rooms, which if necessary or in the summer season are moved outside the building. This treatment allows



Fig. 3. Holiday home created by Raum architects. Pic. Audrey Cerdan
(source: www.tectonicablog.com, accessed 10.06.2018)

⁷ Plans and photos of project in [18].

the owners to increase the surface area of the living space without the need to rebuild or incur costs. The first floor of the building is intended for the main bedroom. Architects took the idea of mobile children's bedrooms from traditional stalls used in the early years in Brittany.

4.4. MJE House⁸

The idea of a multifunctional space and the transformation of a functional plan with sliding and rotating walls is increasingly used in small apartments. The demand for an additional bedroom for accommodating guests, a place in the living area has been implemented so far mainly using folding furniture, but in recent years the number of small apartments with a reconfigurable plan has been increasing. An example is MJE House in Madrid by PKMN architectures. The main assumption of the project was to divide the space of the flat to accommodate the whole family. The apartment uses rotatable – sliding furniture which also comprises partition walls. The space can have an open plan, or it can accommodate two bedrooms depending on the needs of the family.

4.5. The George House⁹

The house has a characteristic construction which is a separate element next to the external walls of the building. The idea of separating the walls from the structure was taken from traditional homes in Samoa. These houses were built using pillars supporting the roof, and the external walls did not have a supporting function. In addition, the walls consisted of blinds that could be raised or lowered as needed.

Architect Richard George assumes that the functional layout of the house should remain independent of the building's construction. The project questions the current traditional layout of residential houses and their permanent, permanent character. Architect's house allows you to change the size of rooms and even reduce their number thanks to the sliding inner walls. The construction of the building is simple and consists of steel poles and beams supporting the roof over the whole. Thanks to this, the outside walls remain non-bearing and consist mainly of glass. In addition, the glass external façade divided into parts can be quickly replaced with an opaque material to create privacy where it is needed. All changes taking place in the building are adjusted manually, quickly and do not require a construction permit.

5. Dynamic adaptable architecture

Dynamic houses are a group of more technologically advanced buildings from previously presented flexible and active buildings. These buildings may have both the ability to transform space and actively respond to changing environmental conditions without interference from human strength.

⁸ More information about project in [19].

⁹ More information about project in [20].

5.1. Sharifi-ha house¹⁰

A 3-story residential building located in Tehran by Next Office is another example of a dynamic home. The main idea of the building is based just like in the case of D*haus on adapting the building to a large amplitude of external temperatures. An additional factor imposing the nature of the project was the typical dimensions of the plot in Tehran imposing the design of a narrow front facade and a large depth of the building requiring appropriate lighting. The building has three rooms located above each other, which are installed on rotating platforms. Platforms enable the rotation of the room leading to the opening or closing of the building depending on the season, day or for functional reasons. In the summer, the building offers an open internal plan with a large terrace area. However, during the winter season, the building closes, reducing the number of window surfaces, and the terrace area is liquidated for the benefit of the enlarged interior space. The house also adapts to the functional needs of users. Both the guest room as well as the home office and dining room can change the purpose according to the requirements of the residents. The project assumed several scenarios for the functioning of buildings in specific seasons, both functional and in the lighting of rooms.

The house uses simple rotary mechanisms usually used in car showrooms or theaters. Taking into account the specificity of dynamic architecture, it was necessary to remember about dynamically variable ceiling loads and vibrations that could cause deformation of the structure. The construction of the building assumes resistance to the highest possible dynamic loads that may occur during the use of the building and the design process also included SAP2000 analyzes.



Fig. 4. Sharifi-ha house, NextOffice (source: [21])

¹⁰ More information about project in [21].

5.2. Sliding House¹¹

London architects from the drMM office designed the world's first completed building in 2009 called the 'sliding house'. The building consists of three separate modules: a proper house, a guest house and a greenhouse. The object has a fourth element, movable in the form of an additional external façade located above the non-modular house modules. The façade moves along the longitudinal axis of the entire complex thanks to the railway rails placed in the concrete platform forming the basis of the entire building and the motors hidden in the thickness of the sliding walls. The mobility of the external façade enables year-round adjustment of the interior lighting and provides additional thermal insulation of selected parts of the building. The object has an internal courtyard and a terrace that can be protected from any precipitation at any time. The design assumption provides for the possibility of extending the ground with traffic lanes for the façade in the event of extending the house with additional functions.



Fig. 5. Sliding house, DRMM architects (source: [22])



Fig. 6. Sliding house, DRMM architects (source: [26])

5.3. A safe house¹²

The penultimate example of a dynamic home was designed by Robert Konieczny from the KWK Promes studio. The building is located near Warsaw, in Poland. The investor's wish was to design a building that would ensure a maximum sense of security, which influenced the use of dynamic systems in the home. The body of the building is perpendicular, combined with a partially movable façade. The house has the ability to "open" to the garden part while creating a closed pre-entering area. This prevents guests from getting into the garden part without going through the house, and children playing will not get out of the house or garden. At night, the mobile walls of the building return to the place, closing the house and providing security for the residents. According to the architect, a safe house is a new type of building with a functional context and is the first of its kind in the world.

In addition to the sliding walls, the building has shutters measuring 3.5 m x 2.8 m opening at a 180-degree angle and a drawbridge connecting the building with the pool pavilion. Another movable element is the rolling gate, which at the same time constitutes the south elevation measuring 14 x 6 meters. All movable elements except the aluminum, roller door

¹¹ Details about project and building in [22].

¹² Photos of the building and project description in [23].

have a steel truss structure and are finished with cement-bonded boards. The movement of components is possible due to the installation of electric motors placed in the wall thickness. In addition, the building has recuperation and a hybrid heating system that extracts some energy from the heat pump and solar panels, and some from gas heating. Like the previous examples, the architecture of this house is inspired by natural mechanisms observed in nature - the house operates in a daily cycle, opening during the day, and closing for the night.

5.4. D*Haus concept¹³

An interesting conceptual project awaiting implementation is the D * Haus house project. The idea of the project is based on the concept of the building adapting its form to changing environmental conditions both during the day, as well as during the season or weather conditions. The author of the project is David Ben Grunberg, who originally designed the house based on the atmospheric conditions prevailing in Lapland. The form and operation of the object are based on a mathematical formula that was written by Henry Dudeney. The formula assumes an appropriate division of the square that will enable the rotation of the resulting modules to form an equilateral triangle. The sliding parts of the building are to move on rails placed in the ground, opening the building with glass walls outside during the summer season, accumulating heat inside. In winter or at night, the house is formed to the base of the square, reducing the number of external glazing to a minimum and retaining heat in the interior.

Table 1. List of selected examples of adaptable buildings, its functions and typology

Architect	Name	Place	Year	Process of adaptation	Level
1	2	3	4	5	6
Ban Shigeru	Naked House	Tokyo, Japan	2000	Foldable walls and furniture, by a human	Flexible
Richard George	The George House	Auckland, New Zealand	2006	Foldable walls, change of room size, regulations of elevation's transparency by changing the panels	Flexible
KWK Promes	Dom bezpieczny	Near Warsaw, Poland	2005–2009	Partially mobile elevation that open and close the house	Dynamic
drMM	Sliding House	Suffolk, Great Britain	2009	Folding external elevation, movable on the rails	Active
Henning Larsen, DXN	Adaptable House	Nyborg, Denmark	2013	Dividing the rooms with sliding walls, a construction allows for quick expansion of the building	Flexible
Thomas Durant, Raum Studio	Transforming House	Brittany, France	2013	Pull-out box bedrooms outside the building	Flexible

¹³ Description of the idea in [24].

1	2	3	4	5	6
Nextoffice – Alireza Taghaboni	Sharifi – ha house	Tehran, Iran	2013	Rotating three rooms that regulates the terrace area, lighting and internal temperature	Dynamic
PKMN architectures	MJE House	Salinas, Spain	2014	Folding wall units are dividing the open space	Flexible
David Grunberg	D*Haus	Conception stage	–	The building's form is based on the Haberdasher's formula. Each of the four building's components is rotary and settled on rails	Dynamic

Source: author's study

Table 2. The main goals of the buildings

Naked House in Saitama, Japan	Shigeru Ban Architects	<ul style="list-style-type: none"> ► Providing shelter for a 5–person family ► The house is to provide the maximum amount of common space and a private minimum „to give everyone the opportunity to take individual actions in a shared atmosphere” ► Mobility of small room boxes
The George House, New Zealand	Richard George, Stephenson&Turner architects	<ul style="list-style-type: none"> ► Development of an open plan to the building using sliding walls and non–load bearing external walls ► Regulation of privacy level
Dom bezpieczny, Warszawa	KWK Promes	<ul style="list-style-type: none"> ► The basic assumption was to ensure maximum sense of security for residents
Sliding House, Suffolk, England	DRMM architects	<ul style="list-style-type: none"> ► The division of the house zones from semi–private to private ► Building a comfortable home for people of retirement age ► Diversification of the character of the building depending on the season, weather or preferences of residents using the button
Adaptable House, Nyborg, Denmark	Henning Larsen architects, DXN	<ul style="list-style-type: none"> ► Flexibility of the functional plan adapting to the needs of families at every stage of life ► Reduction of CO2 emissions
Transforming House, Brittany, France	Thomas Durant, Raum Studio	<ul style="list-style-type: none"> ► Possibility to enlarge the living space in a small building
Sharifi-ha House, Tehran, Iran	Nextoffice	<ul style="list-style-type: none"> ► Active regulation of the lighting of the building with narrow elevations ► Active temperature control due to the high temperature amplitude in Iran
MJE House, Salinas, Spain	PKMN architectures	<ul style="list-style-type: none"> ► The apartment was to be a residence for both a couple of people and for the whole family at the same time
D*Haus	The D*Haus company	<ul style="list-style-type: none"> ► The purpose of the building is to adapt the body to extreme outdoor temperatures

Source: author's study

6. Desire to create an ideal home: conclusions

There is no doubt that the development of materials and technology has a significant impact on the increasingly frequent implementation of intelligent components for the building. The presented table indicates the presence of adaptable houses around the world, but also shows a wide variety of ways of adapting each object. It should be emphasized here that each building is unique, has diverse functional properties, structure and a different home – user relationship. There is no recipe and it should not be for one, ideal, universal house model. Based on the above analyzes of adaptable houses, the following conclusions were deduced:

- ▶ To ensure the best functioning of an adaptable house project, it is necessary to maintain and develop cooperation between the construction industry and specialists in the automation and robotics as well as IT industries. Knowledge and cooperation of individual industries is essential for the proper adaptation of adaptable tools that are to be used in the building as well as for creating possible building configurations.
- ▶ When designing a building, the architect should pay attention primarily to the occupants' comfort of using the building. The success of adaptive buildings depends primarily on their adaptation to the user. A building that does not provide comfort of use, created mainly for the idea, may not be implemented or not be met with public interest – just like the D * Haus house.
- ▶ The building should have adaptive abilities that are applicable at several stages of use over a longer period of time. For example, the variable size of rooms within a building should be available at all times, but also the possibility of expanding the usable floor space should be taken into account. The elevation should be constructed in such a way that creating an additional external entrance to the building would not be a problem.
- ▶ Adaptation should be easy to achieve. It should take place in a short period of time and does not constitute complicated activities, if they are to be performed by the user. Adaptation requiring a complicated series of commands should be adjusted by a computer to a single user command.
- ▶ Adaptation process requiring the operation of automatic components should absolutely be able to switch to manual mode. Changes occurring in buildings often raise doubts both in terms of human security and the preference for independent decision-making about changes. This applies mainly to cyclical changes such as: changing the interior lighting, or automatically adjusting the temperature inside the building.
- ▶ For economic reasons, we should look for adaptable solutions that will be the simplest in both design and replacement or maintenance. The largest group of adaptable buildings being constructed are flexible houses. The solutions used in them are not expensive to build and are characterized by the least costly operation and low failure rate. As a result, adaptable buildings will be available to the majority of society with an average material status.

The rapid development of technologies in the field of kinetic systems and the use of energy from renewable sources has opened up possibilities leading to the partial autonomy

of buildings and related experiments. In spite of the really small number of adapted adaptable houses, it can be concluded that the most objects are located in the group of flexible objects. Regulating the functional plan is the simplest to achieve without the involvement of advanced technologies and large financial outlays. Houses reacting actively to changing external conditions are treated separately. The interest in ecology and the change of building regulations in the field of zero energy construction can contribute to the increase in the use of intelligent systems in homes, which, in combination with a flexible functional plan, can in practice mean the development of dynamic construction. An increase in the tendency to create semi-autonomous buildings should be expected, aimed at the best possible adaptation to the user with simultaneous broadly understood building optimization.

References

- [1] Brand S., *How Buildings Learn: What Happens after They're Built*, Penguin, New York 1995.
- [2] Collier R., and Thelen E., *User-System Interaction Based on Spoken Dialogue. The New Everyday*, 010 Publishers, Rotterdam 2003.
- [3] Estaji H., *Flexible Spatial Configuration in Traditional Houses, the Case of Sabzevar*. International Journal of Contemporary Architecture "The New ARCH", 2014.
- [4] Friedman A., *The Adaptable House: Designing Homes for Change*, McGraw-Hill, 2002.
- [5] Graham P., *Design for adaptability – an introduction to the principles and basic strategies*, The Royal Australian Institute of Architects, 2005. GEN66.
- [6] Habraken N.J., Teicher J., *Supports: an alternative to mass housing*, Architectural Press London, 1972.
- [7] Harper R., *Inside the smart home*, Springer Science & Business Media, 2006.
- [8] Kronenburg R., *Flexible: architecture that responds to change*, Laurence King, 2007.
- [9] Lelieveld C.M.J.L., Voorbij A.I.M., Poelman W.A., *Adaptable architecture*, Building Stock Activation, 2007.
- [10] Nathan V., *Residents' satisfaction with the sites and services approach in affordable housing*, Housing and society, 1995.
- [11] Kronenburg D., *Flexible: Architecture that Responds to Change*, Laurence King Publishers, 2007.
- [12] Schneider T., Till J., *Flexible housing*, Taylor & Francis, 2007.
- [13] <http://adaptablefutures.com> (access: 02.12.2017).
- [14] <http://www.open-building.org> (access: 02.12.2017).
- [15] <http://www.hyperbody.nl> (access: 02.12.2017).
- [16] <https://www.census.gov/prod/2014pubs/p20-574.pdf> (access: 02.12.2017).
- [17] <https://henninglarsen.com> (access: 06.01.2018).
- [18] <http://www.raum.fr/Maison-Sarzeau-S6-France-2013> (access: 06.01.2018).
- [19] <http://enormestudio.es/east-1> (access: 06.01.2018).
- [20] <http://www.designguide.co.nz/adaptable-house-design> (access: 06.01.2018).



- [21] <http://nextoffice.ir> (access: 07.01.2018).
- [22] <http://www.therussellhouse.org> (access: 06.01.2018).
- [23] <http://www.kwkpromes.pl> (access: 08.01.2018).
- [24] <http://thedhaus.com> (access: 08.01.2018).
- [25] www.eltrazoinvisible.wordpress.com (access: 03.12.2017).
- [26] arch5541.wordpress.com (access: 02.12.2017).