Adaptable Housing – Analysis of Expandable Apartments in Reinforced Concrete Skeleton Construction

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Abstract

The issue of adaptable housing has been studied and verified in professional theory and practice for a long time. Currently, this topic is very relevant again, because its application in practice has been able to solve several problems related to social and ecological sustainability. The concept of adaptable housing uses several strategies, in particular flexibility, convertibility, expandability or downsizing. This article publishes partial results of research focused on the analysis of expandable apartments inserted into a reinforced concrete skeleton structure. Given the large number of old, unused buildings, the analysis of a reinforced concrete skeleton structure with a span of 7.8 m x 7.8 m, which was often used in Slovakia, especially in administrative buildings, was chosen for the purposes of publishing the results. Adaptable apartments with the potential for expansion or downsizing are inserted into open structures, which could provide more targeted support to various families who find themselves in need. During the concept design, the results of a survey focused on the requirements of various consumers were applied. The expandability of apartments will allow for higher efficiency of apartment occupancy with the same area and infrastructure. It is also believed that such modifications mean better use of space throughout the entire life cycle of buildings.

Keywords: *Architecture, adaptable housing, expandable apartments*

1. Introduction

Slovakia is one of the fastest ageing populations in Europe, and therefore it is very important to address issues related to sustainable housing that would be able to better respond to current market demands. The authors of the article are engaged in research on adaptable housing within the framework of a national project (hereafter referred to as the 'national project'), which is focused on the implementation of the national action plan. Transition from institutional care to community-based care in the social services system [1]. The research on adaptability and flexibility concerns various types of residential buildings, which should also be suitable for recipients of social services or for foster families with a larger number of children. Therefore, the apartments under study should also be able to function as supported housing, if necessary.

In designing and analysing adaptable, expandable apartments, the authors of the national project drew on the conclusions of previous research, in particular (1) Survey of the Client's Ability to Move and Navigate in the Built Environment, (2) Assessment of the Risks and Shortcomings of Existing Social Service Buildings, (3) Survey of the Desires and Wishes of Recipients of Year-round Residential Services about Their Own Housing, which have already been published [2]. Furthermore, research by other research teams was considered, in particular the Finnish study by Tarpia and Huuhku [3], which surveyed residents' opinions on adaptable housing in two virtually tested adaptable apartments. The participants assessed as particularly beneficial the provision of two different entrances to the apartment and the possibility of creating an independent unit from part of the apartment. Two entrances to the extended apartment could be particularly useful for separating the home space from the workspace, for providing their own entrances for young adults; to allow privacy for different parts of the family; and to allow for future changes, including the possibility of dividing the apartment into two parts for intergenerational living, or for small group living.

Another basis for research on adaptable housing was the analysis of architectural and construction documentation carried out in 59 housing investment projects in Slovakia, some of which met the requirements of adaptability, in particular the possibility of merging and dividing rooms within an apartment. These were mainly smaller apartment buildings or family houses in which social services were to be provided. The researchers of the national project analysed the fulfilment of functional and operational requirements, as well as the fulfilment of universal design requirements. For example, 32% of investment projects were found not to meet the requirements of universal design [4]. Research consistently shows that applying universal design principles benefits all users, not just those with disabilities. Steinfield and Maisel [5] describe universal design as - “a process that enables and empowers a diverse population by improving human performance, health and wellness, and social participation”.

This paper presents a selected part of the research focused on designing adaptable, expandable apartments in existing buildings with reinforced concrete skeleton construction. This type of building was chosen for research purposes because there is a surplus of older buildings in cities, especially administrative buildings, which can no longer meet current market requirements and have been assessed as suitable for a change of function using the Conversion meter method as described by Geraedts et al. [6]. The aim is to use existing non-functional buildings, in which a change of function could be created as social or rental apartments that would meet the required criteria. The advantage of these apartments could also be the proximity to various support services, resources and potential job or educational opportunities.

2. Methodology

Many articles [7,8] and literature reviews [9,10,11] have been published on adaptable housing. To achieve the defined objectives, the national research focuses mainly on the adaptability of apartment buildings over time, which means the ability of a building to physically change or expand during its lifetime as often as necessary. It is expected that adaptable, expandable apartments will be able to adapt to the current needs of their users, but also to the needs of service providers. Each apartment should meet the requirements of supported housing, if necessary. When designing apartments, it must be considered that potential users of these apartments may have high demands for the accessibility of the environment, i.e. they may have varying degrees of limitations in their motor, sensory and mental abilities. A very important criterion for assessing the quality of the design of a building or apartment is whether it meets the requirements of diverse users, who may have different and conflicting needs and preferences. The researchers defined the basic requirements for apartments that are related to national and European technical standards [12]:

- The hallway in the apartment must be at least 1.2 m wide.
- An apartment with more than 3 rooms must have an additional toilet or bathroom.
- The accessible bathroom must have dimensions of at least 1.7 m x 1.9 m, and the layout of the fixtures is also specified (minimum accessibility standard).
- Rooms should not face north, because of insufficient sunlight.
- Each apartment should have a connection to the exterior (via balcony, loggia, or terrace).

When designing apartments, it is continuously verified whether the adaptability system is capable of operating in existing buildings with reinforced concrete skeleton construction using the most used column spacing of 7.8 m x 7.8 m or 8.1 m x 8.1 m. The expected benefit of adaptable apartments is their ability to support constant changes in the requirements of apartment users in a short time and at lower costs.

The research is divided into two phases:

1. Analysis of case studies of the conversion of 12 office buildings into apartment buildings, comparison of individual solutions, analysis of risks and shortcomings.
2. Analysis of the adaptability of apartments, using various adaptability strategies, in particular flexibility, convertibility, expandability or downsizing within the research by design method.

The second phase of the research aims to analyse the advantages and disadvantages of creating adaptable apartments in existing buildings with reinforced concrete skeleton construction. Each alternative design analyses the potential for downsizing and upsizing apartments and their impact on the level of functionality and occupancy within the entire building.

3. Research Findings

3.1. Case Study Analysis

In general, there are four possible ways to deal with buildings that are either long-term vacant or at the end of their useful life: consolidation, renovation or modernisation, demolition and new construction and transformation. Conversion, as a type of transformation, is becoming an increasingly common architectural practice. When it comes to office buildings, in most cases, various aspects of converting office buildings into permanent or temporary housing are considered. Several studies focus on the characteristics of office buildings and their locations that contribute to successful conversion [13].

In the first phase of the investigation, 12 administrative buildings in Bratislava with potential for functional change were analysed. The results of the partial research of this part are published as Verification of the Adaptability Level of Administrative Buildings in Bratislava. The objective of case studies was to place units of different sizes (single room, double room, and larger) in different structural modules (which were used in the selected buildings). The tested layouts reflect the demand in the local market and are also in line with local requirements for residential buildings.

The result of this phase was the finding that in the analysed buildings with reinforced concrete skeleton construction, it is possible to create apartments of various sizes, and the proposed layout of the apartments could meet the requirements for adaptable housing according to the set criteria. However, the potential transformation of each of the examined buildings will have to face specific obstacles in the subsequent phases of project preparation. New designs will have to address the impact of noise pollution on the facade from adjacent traffic, which will require the implementation of appropriate acoustic solutions. Likewise, each design will have to meet the natural lighting requirements for sunlight and light in the apartments, which will need to be considered for each design separately. One of the common obstacles of a technical nature is the inappropriate facade design in nine of the twelve analysed buildings, where the perimeter beams are hidden in the windowsill. This facade solution does not allow for balconies to be installed at the floor level of the apartment during the conversion, therefore, only loggias can be created, which however reduce the floor area of the apartments.

3.2. Analysis of the Adaptability of Apartments

In this phase of the research, using the research by design method, possible layout solutions of test-fit floor plans were analysed. The aim was to adapt units of different sizes (one-room, two-room and larger) to the different structural modules that were used in the selected buildings. For the purposes of publication, the analysis of the Twin Tower building, which has a structural module of 7.8 m x 7.8 m (Fig. 1), was selected.

The diagrams of functional zones in apartments in Fig. 2. consider the requirements for adaptable housing with the potential for increasing and decreasing the size of apartments. Here, the emphasis is placed on the functionality of the interior spaces of the apartments so that the above-mentioned technical standards are met. When designing apartments, the biggest problem seems to be the placement of wet areas such as the kitchen and bathroom, because vertical water and sewage pipes must be placed close to the supporting columns. Most designs for expanding apartments therefore focus on meeting the requirement for a second bathroom or at least a toilet with a sink, while maintaining the functionality of the enlarged apartment.

Figure 3 shows two variants of the layout of adaptable apartments in the existing Twin City building. The apartments can be enlarged or reduced according to the current needs of users or service providers as shown in Fig.1. The left side of Figure 3. presents a layout variant with larger apartments, in which the occupancy of 102 users on one floor is achieved. The right side of Figure 3. By contrast, shows a variant with small apartments, when the occupancy is 88 users of the apartments on one floor. This comparison demonstrates that the expandability of apartments allows for greater efficiency in apartment occupancy while using the same floor area and infrastructure.

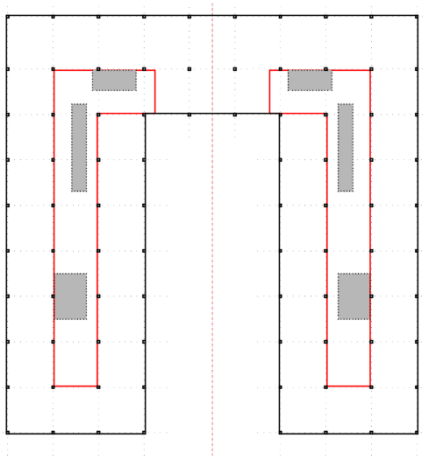

Fig. 1. Twin Tower floor plan with the 7.8 x 7.8 module marked

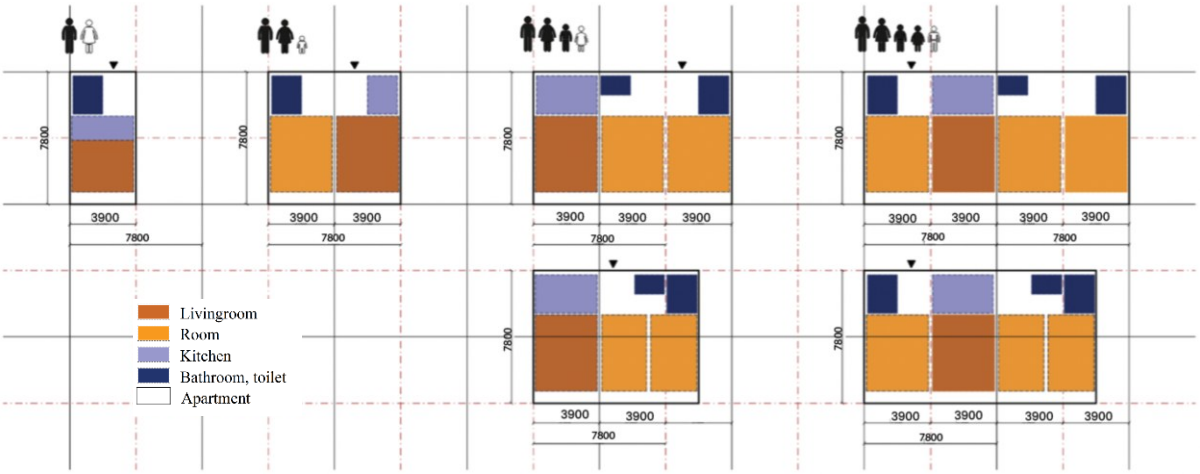

Fig. 2. Diagrams of functional zones in apartments of different sizes

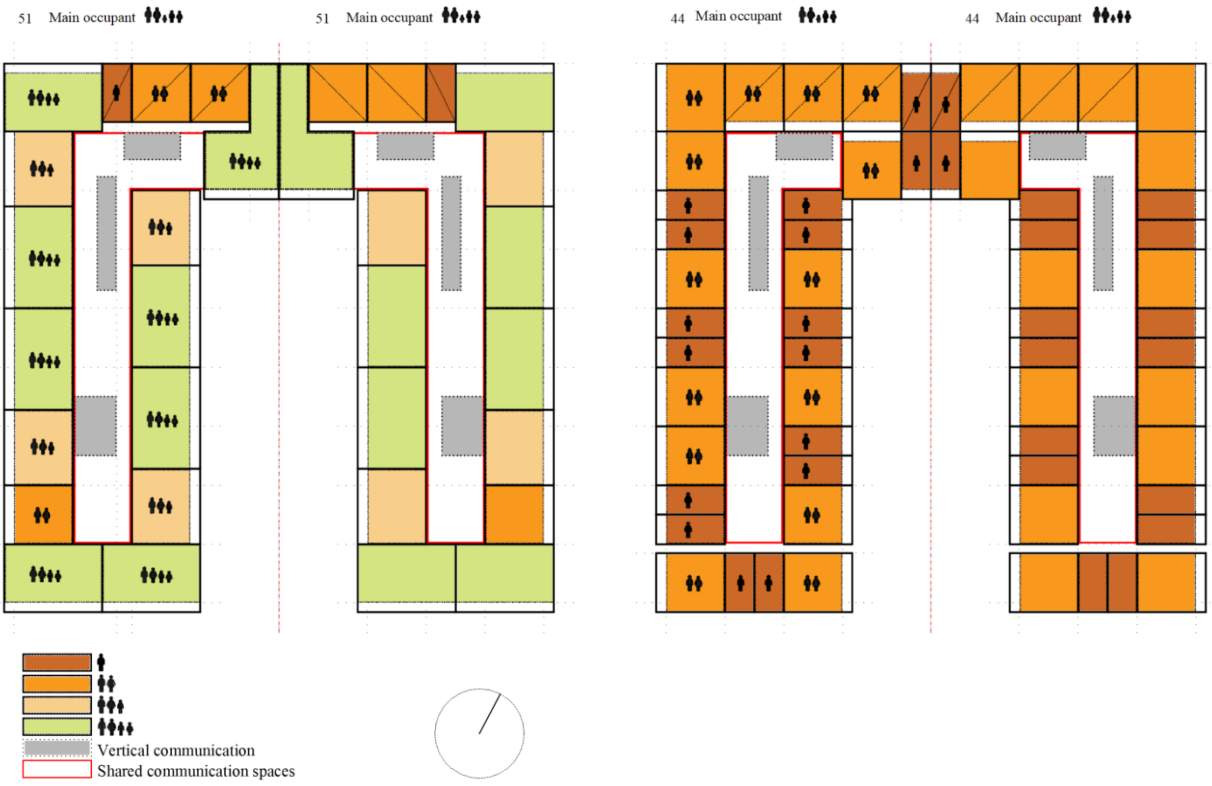

Fig. 3. Apartment layout diagrams with the possibility of enlarging and reducing

4. Discussion

Currently, there are only a few buildings that have been deliberately designed with adaptability in mind and have stood the test of time. Therefore, it is not easy to evaluate the real benefits of adaptability in practice in terms of improving sustainability, especially environmental performance or social responsibility. Relevant actors in the construction sector admit the necessity of change but are nevertheless not very willing to experiment. The team of researchers of the national project is trying to implement adaptable housing in Slovakia in the context of the sustainability of the social system, with the aim of enabling older adults or people with disabilities to continue living independently at home with the support of professional personnel, even in adverse life situations. The positive development is that this concept is also supported by public institutions, and new construction legislation is currently being promoted, where the obligation to build adaptable apartments in apartment buildings that are built with public funds should be introduced. However, from the perspective of the growing need to provide social services in the home environment, it would be beneficial if all newly built apartments were adaptable, including commercial apartments, so that they could be converted into barrier-free apartments with a minimum standard.

Long-term research on adaptable housing in Slovakia has resulted in the construction of new family houses or small apartment buildings that were built specifically for the purpose of providing social services in the community. As mentioned in the introduction, the researchers of the national project analysed the architectural and construction documentation carried out in 59 housing investment projects. All proposed buildings addressed the issue of accessibility in the sense of universal design, although in 32% of the proposals, it was applied incorrectly. Adaptable housing was applied only in those investment projects that were designed according to the catalogue of published exemplary architectural studies on the website of the Ministry of Labour, Social Affairs and Family of the Slovak Republic. This also proves that the benefits of adaptable housing are not sufficiently known to investors and designers, or they do not consider them important.

This paper presents a part of the research that deals with the creation of adaptable housing in existing non-functional administrative buildings, where there is a potential for changing the function to a residential building. The advantage is that administrative buildings have a higher clear height of the premises, which provides more options for alternative use of space and for convenient routing of new engineering networks through lowered ceilings or raised floors. There is a great demand for rental and social apartments in cities, and in the conversion of existing buildings, we see the greatest potential for creating adaptable apartments, also from public sources. Possible solutions for the layout of test floor plans of adaptable apartments in predetermined modules of 7.8 m x 7.8 m were analysed. Furthermore, the possibility of enlarging and shrinking apartments according to current needs was verified. The designed apartments could be beneficial for future operators or users, especially because they allow for simple modifications to be made in a short time and at low cost. Balconies or loggias for each apartment add an exterior space, which can also be used as a winter garden if necessary. In terms of spatial relationships between interior and exterior, public and private environments, this concept may also have the potential to change the design of adaptable office buildings. When designing each building, the architect must consider the possibility of additional balcony connections, and the solution to the building's facade must also correspond to this. The expandability of apartments can allow the building to adapt to a much higher occupancy with the same floor area and infrastructure. Larger apartments are created by connecting two to three apartments, and there is the possibility of maintaining multiple entrances to the apartment, if necessary. This benefit could be used, for example, by shared households with multiple social service recipients. The recognised expert in social work K. Grunewald, dealt with "The principle of the small group" and states that the optimal group is composed of 4 recipients and two caregivers in one household [14].

5. Conclusion

The key role in creating an adaptable building is played by the designer, who must design the building so that all elements of the building are as independent as possible from each other, so that they can be adjusted separately. The facade of the building must be transformable, as well as the possibility of easy replacement of new engineering services within the lowered ceilings or raised floors. In terms of accessibility for all, height differences between floors or between transitions from interior to exterior should not be unnecessarily created. If these efforts could be applied to a greater extent, buildings would be easier to transform in the future.

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