Architectural layout typologies for the sustainable reserve housing organization

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Abstract. The article is devoted to the problem of architectural and planning organization of sustainable reserve housing for refugees. The purpose of the article is to highlight typologies of reserve housing layout organization. As a result of a complex analysis of implemented and conceptual housing designs for migrants, existing and progressive approaches were systematized within the typological matrix. Contemporary feasible typologies include: free-space, pre-set, growing and transformable. The developed prognostic typologies include: augmented and integrated. The typologies were presented within the graphic matrix. The materials of the article will be useful for further practical modelling of modern prefabricated housing for refugees.

1 Introduction

With the increase in worldwide political tension, identifying approaches to the organization of reserve housing for migrants is becoming one of the most demanding issues. Modern technological approaches should be aimed at providing a comfortable and sustainable living environment in extreme conditions. According to UNHCR estimates, the average period displaced residents spend in refugee camps is 17 years, which makes temporary housing serve as permanent [1]. Currently, at the theoretical and practical level, the concept of refugee shelter as a long-term structure is being rethought [2].

This research makes an attempt to systematize modern architectural layout techniques for migrant housing organization based on the analysis of a wide range of dwellings and shelters. Architectural layout techniques include a set of stationary, replaceable and hybrid solutions relating to the functional program of the shelter. These solutions provide flexibility either rigidity of the layout structure, depending on the needs of the occupant and the influence of external natural, social, and temporary factors.

2 Materials and Methods

Attempts are currently being made to develop a universal layout scheme for refugee housing. The study by T. Scott-Smith examined the technological aspects of the “Better Shelter” by Ikea organization, which acted as a housing designer. The use of this universal scheme has

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caused criticism, since it did not appear suitable for all contexts and environments. Moreover, its assembly takes hours, in contrast to the standard 30 minutes for erecting a simple tent [3]. E. Pascucci analyses reserve housing for refugees in terms of flat-pack technology, which has shown its effectiveness in logistics. The ability to store and transport housing is an important quality in the process of providing humanitarian assistance to victims of social conflicts [4]. J. Hart et al. consider that the design of reserve housing should be coordinated with the user, as the quality of housing provided to refugees is often unsatisfactory [5]. The occupant also strives to give a temporary residence permanent features, bringing the objects of his own cultural life to the existing scheme [6]. R. Kiddey proves the effectiveness of DIY-houses, which refugees construct themselves as the direct participants of the construction process, adapting a particular dwelling to their needs [7]. In the study by S. Jaradat & N. Beunders, a positive experience of the collective design of architects and refugees within migrant camps in Greece is noted [8]. Attempts are being made to create a layout structure for refugee housing among practicing researchers. The study by N. Oliveira and I. Campos describe the design and layout of The Flex Refugee Shelter, which can be assembled into modules [9]. F. Moran et al. were involved in improving the thermal comfort of existing migrant shelters [10]. In the study by R. Ibrahim et al. typologies of layout schemes with plots were developed for implementation in the Middle Eastern climate using local materials [11]. The project of an ecological house for refugees in the northern climate of Sweden was developed by M. Dabaieh & J. Alwall using renewable energy sources [12]. A future-oriented macrotrend is the transference of virtual reality elements into the residential environment [13]. In the recent report, S.R. Rashnoodi & M.S. van Gisbergen noted the positive impact of the use of VR technologies in home design in relation to creating the spirit of place [14]. According to L. Rosenberg’s forecast, augmented reality will integrate into familiar spaces and will be widely used in everyday life by 2023 [15]. Nowadays, VR, AR, MR, XR technologies serve for visualization of housing during the design process [16]. This study is a continuation of previous research on the structure of reserve housing for refugees [17-18]. An attempt is made to systematize architectural layout typologies.

3 Reserve housing layout organization aspects

3.1 Free-space unit

The option of free-space organization is implemented in the form of a single empty unit, filled by the user at his own discretion. The free-space unit has no fixed walls, partitions or other stationary elements. A distinctive rigid feature is the assembled immutable shell. Within this approach, the “Dan Dan Dome” shelter, designed by architect Y. Murakami, develops the idea of an undivided geodesic dome for a reserve dwelling layout. The structure is made of high-strength waterproof cardboard and can be assembled without screws or nails, which is completely recyclable. The laminated coating prevents the shell from being damaged by precipitation. A prefabricated house made of waterproof cardboard weighing 13.7 kg was developed by Maawa architects. When folded, the shelter can fit into a suitcase, and when unpacked it can provide living space for 1-2 people. A portable solar panel can be installed on the roof of a temporary shelter. The house is planned to be located in a refugee camp in Jordan (fig.1).
3.2 Pre-set unit

The *pre-set* option for organizing a residential unit includes a fixed layout, enclosed in the shell of a building envelope. The walls and partitions of the *pre-set unit* are strictly predetermined. The user is provided with a ready-made layout option. In an extreme situation, there will be no need to invent a functional layout scenario.

Cutwork Studio has developed the “Cortex Shelter”, a unit that can be built in a day. The building shell is made of textile concrete, which hardens within 24 hours when water hits its surface. The 1.25 cm thick concrete structure can last up to 30 years and requires minimal maintenance. The construction of such a shelter does not require skilled labour and can be carried out by two residents. At the beginning of construction, the shell is fixed to a frame made of metal tubes. Once water is added to concrete textiles, the water-soluble fabric holding it in place disintegrates, leaving solid concrete. The shelter has a determined layout: a joint kitchen and living space, divided from the sanitary unit with a fixed partition.

As part of the “Micro-Housing competition 2022”, architect F. Campolina developed a design for a collapsible modular housing that can be placed in parking lots in case of crisis situations. Each dwelling has an area of 32.4 m² and is designed to accommodate up to 4 people. The frame of the residential module is based on scaffolding covered with polycarbonate tiles. The interior decoration is made of particle boards. The fixed interior space is divided into two levels: the ground floor contains a living room with a kitchen, bathroom and sleeping areas. On the second floor there is a work place, accessed via a ladder that takes up minimal space (fig.2).
3.3 Growing unit

Within a growing unit, it is possible to expand the dwelling structure to accommodate more functions or occupants. The growing option involves a modular complementary structure that can be expanded.

The custom “Wikkelhouse” shelter was designed by Dutch architects Fiction Factory. The house structures are made of durable cardboard, which is wrapped on a steel frame in several layers. The layers of cardboard are glued together with environmentally friendly glue, and the structure is lined with a layer of waterproof film and wooden panels on top. All materials in the house can be recycled. The housing layout is assembled from individual segments measuring 1.2 x 4.6 m and can be expanded and supplemented to suit the needs of the residents.

The construction set for assembling the temporary residential module “Y-BIO” was developed by Archinoma. The elements of the design are combined by hand and form durable tetrahedral modules that can be hung and turned over depending on the functional purpose of the structure. The module can be used to form a two-level shelter, serve as an individual tent or a fireplace. The triangular components are filled with wood either with clear plastic panels.

The project of a multifunctional modular house that can be moved to remote regions and assembled on site was proposed by Equals Architecture. The basic element of the home consists of 5 sheets of plywood and can be expanded by adding more modules. The exterior of the module is made of rubber, recycled waterproof canvas and corrugated steel. The module design allows to add an insulating layer for exploitation in regions with cold climates. The unit can be built on any terrain with a system of anchors (fig. 3).
3.4 Transformable unit

The transformable unit has the ability to change the internal structure. The structural elements of the dwelling can change the location and configuration depending on the requests of the occupants.

The project of portable folding housing on the basis of a cart, which can be moved by bicycle, motorcycle, as well as manually or by a pack animal, was presented as part of the competition for the development of multifunctional shelters in 2016. Bolivian architect J. Balderrama developed a complex tent structure mounted on a mobile wheeled platform. The rectangular form of the foundation allows the transformation of connected mobile units for the construction of larger stationary residential or public spaces.

The multifunctional structure “Superforma” can be used as a tent, a sleeping place or a backpack. The structure consists of a single canvas made of recycled polyester, which can be folded in 3 different ways, depending on specific needs. Instructions and guides are printed on the fabric in red, which makes it easier for users to erect the tent. The shelter comes with a portable metal frame that can be combined with other modules and form a larger protected area.

3.5 Augmented unit

Within the augmented unit, it is possible to integrate tools from virtual reality or the metaverse. In 2021, M. Zuckerberg, the creator of the global social network Facebook, announced the “Metaverse” virtual universe project, which caused a wide public response. It is assumed that with the help of three-dimensional virtual doubles, familiar social interactions will be transferred to the context of a fictional reality. At the World Economic Forum in Davos on January 18, 2023, Chris Cox (Meta Platforms CPO) announced that, along with virtual reality (VR), the company is actively working on augmented reality (AR) technologies, which make it possible to bring holograms of material objects into the environment of reality.

“The Row” project brought together a group of artists to create 30 3D models for life in a metaverse, unconstrained by the laws of physics and the natural environment. Each object can be purchased as an NFT (non-fungible token), confirming the right to own virtual real estate. The “Mirage House” by architect A. Christodoulou is a structure floating on a circular support, placed in a deserted landscape. The “Make room for us” home by Six N. Five is located in an imaginary ecosystem of rocks and imitates the shape of simple cellular organisms that adapt to the environment. A. Reisinger’s transparent house, surrounded by the
mirror surface of a swimming pool, rethinks the image of a home in the virtual world and is depicted as “intangible”.

Augmented reality components that are mainly used in gaming and cultural exhibitions contexts, are becoming the distinctive part of urban environments. In 2020 giant KAWS sculptures were exhibited in 12 cities around the world, blending into urban surroundings and visible only on smartphones. Massive monuments and art objects were included in the LACMA exhibition landscape in 2021 (fig. 4).

![Augmented reality art installations](https://www.designboom.com/art/kaws-acute-art-augmented-reality-sculptures-03-12-2020/)

**Fig. 4.** Augmented reality art installations, Source: https://www.designboom.com/art/kaws-acute-art-augmented-reality-sculptures-03-12-2020/; https://www.designboom.com/art/lacma-snapchat-interview-augmented-reality-monumental-perspectives-04-13-2021/

### 3.6 Integrated unit

An *integrated unit* is a module placed inside a rigid frame according to the principle of “supports” and “infill” by H. Hertzberger, used within the framework of a rational industrial approach [19]. This type of organization is also related to the approaches developed in the predictive architecture of metabolism [20].

The skyscraper “Horizontal City of No Nation” is located in the desert and serves as a border structure between the two states. A system of cylindrical rail elevators is integrated into the fabric of the skyscraper, capable of moving between residential blocks horizontally and vertically, maintaining a fixed position of the cabin. The structure of a horizontal skyscraper includes public spaces and industrial facilities that ensure the functioning of all building systems (fig. 5).

![“Horizontal City of No Nation” project](https://www.evolo.us/horizontal-city-of-no-nation/)

**Fig. 5.** “Horizontal City of No Nation” project by Zhichen Gong, Yong Chen, Tianrong Wu, Yingzhi He, Congying He, Source: https://www.evolo.us/horizontal-city-of-no-nation/

The “Helix” skyscraper project offers an alternative settlement system in the form of modules arranged in a spiral vertical complex. The shape of the high-rise building provides effective natural ventilation and lighting of residential premises. Each module of the spiral skyscraper has operable roof platforms on which high-rise gardens and farms are located.
The cylindrical skyscraper consists of trapezoidal modules grouped around a central rigid core with a staircase & elevator unit. Integrated residential modules of four sizes (S, M, L, XL) can be assembled on a static floor platform and covered with sheets of aluminum, plywood or fabric. The smallest module accommodates 4 people. The cafeteria, grocery store and playground are located on the ground floor level of the high-rise.

4 Discussion

All identified approaches to the architectural layout organization of housing for refugees were systematized in the form of a graphic matrix. The data reflected in the matrix can be used for interdisciplinary research devoted to the formation of a comfortable living environment for prefabricated facilities, involved in related fields of knowledge: engineering, construction, design of alternative energy facilities. This matrix can serve as a starting point for future practical and theoretical modelling of concepts associated with reserve shelter (fig. 6).

<table>
<thead>
<tr>
<th>Illustration</th>
<th>Operating principle</th>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1. Free-space unit</td>
<td></td>
<td>spatial flexibility; ability to fill out the structure at the user’s discretion</td>
<td>lack of delimiters within the layout</td>
</tr>
<tr>
<td>1.2. Pre-set unit</td>
<td></td>
<td>availability of a ready-made solution for functional zoning</td>
<td>rigidity; no layout adaptation</td>
</tr>
<tr>
<td>1.3. Growing unit</td>
<td></td>
<td>possibility of area extension</td>
<td>module configuration limits</td>
</tr>
<tr>
<td>1.4. Transformable unit</td>
<td></td>
<td>ability to change configuration upon request</td>
<td>lack of a ready-made solution</td>
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<tr>
<td>1.5. Augmented unit</td>
<td></td>
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possibility of introducing additional digital objects; diversity of living environment; interactivity

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<th>1.6. Integrated unit</th>
<th>increase in construction costs</th>
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<td>adaptation to different terrains</td>
<td>growth is limited by the boundaries of the structure</td>
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Fig. 6. Matrix of architectural layout solutions for reserve housing in conditions of social conflict

5 Conclusion

The identified architectural layout approaches made it possible to systematize the existing concepts of housing for refugees and predict the development of the new ones. Subsequent research will be devoted to aspects of the form-finding and constructive organization of reserve housing in conditions of social conflict.

Form-finding techniques will accumulate the variety of shapes and models accumulated in recent years with the development of the latest constructive and digital design technologies. Form-finding techniques will structure the palette of available forms of shelters, produced by designers, generated by artificial intelligence, and hybrid-created forms.

Constructive techniques will contain a complex of structural and construction systems used in the development of reserve housing in conditions of social conflict. The nature of the systems used ensures the need for change, sustainability, expansion and adaptation.

Acknowledgements

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