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Proposal for Refugee Housing in Southeast Europe Utilizing Regionally Appropriate, Sustainable, and Affordable Construction Methods

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Abstract

This research focuses on the emergency-housing demand caused by the on-going refugee crisis in Southeastern Europe. The research and proposed solutions focus on Northern Serbia, as this region generally lacks permanent housing solutions for accommodating the increasing influx of immigrants. The outcome of this research is an architectural proposal for the refugee housing unit designed particularly for the situational factors of this focus region. The study identifies earth architecture as the primary building technique, due to its ability to satisfy a range of defined end-product goals. These goals include: the sustainability of the material, quality and durability of the final product, skill level required for non-professional construction, final cost of material and execution, historical regional precedent, and opportunity for communal engagement of the immigrant population. The proposed architectural design uses earth-bag construction as the sub-method most suitable for this location and in keeping with the goals outlined above. The proposed housing unit is a singular component that could be duplicated to create larger communal housing communities. A broad overview of possible solutions is included, followed by the development of the earth-bag construction option. The development of this proposal includes material studies, sketches, and an architectural model as representation tools. The outcomes of this research serve as a guideline, rather than a precise construction model, in creating much needed refugee housing communities in North Serbia.

Keywords: earthbag construction, crisis housing, architecture

Introduction

According to the UNHCR reports, in 2019 there were 70.8 million forcibly displaced people around the world (UNHCR Figures at Glance, 2019). Most of this increasing population was forced to leave their homes, because of their ethnicity, religion, social affiliation or race. European countries today are faced with the unprecedented refugee and migrant crisis which escalated in 2015, when 487,000 refugees arrived at Europe's Mediterranean shores, most of whom were fleeing violent armed conflicts in their homelands. This situation is leading to "the largest global humanitarian crisis of our time" (Holmes & Casteneda 2016).

European governments have responded to the growing numbers of migrant arrivals through the formation of refugee camps on the outskirts of large cities. The refugee camp is commonly defined as "temporary space[s] in which refugees may receive humanitarian protection until a durable solution can be found to their situation" (Ramadan, 2013, p. 65). These camps are typically composed of series of temporary tents in efforts to satisfy the base level of Toby Israel's adopted Maslow's hierarchy[1] (Figure 01) – "home as a structure that meets our basic physical needs including our need for safety and protection" (Israel, 2003, p. 56). However, such settlements fail to meet any of the higher criteria for healthy shelters ordered as following "home as satisfaction of a psychological need, home as satisfaction of a social need, home as satisfaction of aesthetic need and home as self-actualization" (Israel, 2003, p. 56).

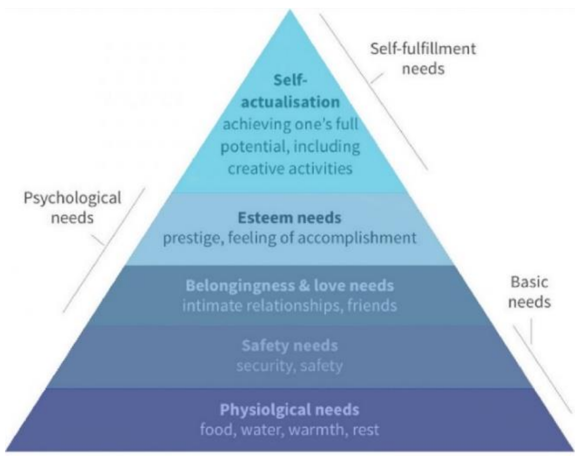

Figure 01. Maslow's Diagram

(2019). Retrieved from https://upload.wikimedia.org/wikipedia/commons/8/88/Maslow's_Hierarchy_of_Needs.jpg

In response to this refugee situation, this research study is based on a belief that architects have both a professional and moral obligation to use their expert knowledge and design skills to help the society in crisis situations. This research is guided by the following questions: How can governments, with the help of architects, design shelter housing that meets as many of the mentioned criteria from Israel-Maslow's hierarchy as possible? Should refugee settlements inherently be designed as temporary structures? What is the role of sustainable methods and materials in the creation of such settlements? Several innovative design solutions, which take many of these considerations into account, have already been proposed by architecture firms

[1] Maslow's hierarchy of needs, first proposed in the paper "A Theory of Human Motivation," is a psychology theory that classifies human motivation factors into a hierarchical pyramid.

such is Architects for Society (Hex House, 2016). This study proposes earthbag construction method as a sustainable technique for humanitarian crisis shelters, which requires low initial financial input.

Overview of the Refugee Housing Issues in Republic of Serbia

This research identifies Northern Serbia as the focus location for the proposed design strategies. Northern Serbia's Autonomous Province Vojvodina is situated on the vertex of borders between Croatia, Hungary, Romania, and Serbia. Out of all the mentioned states, the Republic of Serbia is the only country that is neither a member of the European Union nor the Schengen Zone. Consequently, migrants, mostly coming from Syria, Afghanistan, Pakistan, Iran, and Iraq (Asylum Information Database, 2020), use the so-called West-Balkan Route as a transit path to reach Schengen Zone territories. Due to the current socio-economic situation within the country, the government offers an insignificant amount of approvals to asylum seekers.

The West-Balkan Route was officially closed in March 2016 after Hungary tightened its anti-immigration policy by building a wire fence wall on the border with Serbia. Nevertheless, thousands of immigrants continue to enter Serbian territories, hoping to find alternative ways to reach Schengen Zone "despite the official impossibility to continue North via Hungary or Croatia" (Umek, Minca, & Šantić, 2019, p. 38). In May 2017, there were around 7000 immigrants in Serbia (Umek, Minca, & Šantić, 2019), who remained in the country for prolonged periods due to the legal inability to progress towards the Western European Countries.

Housing options for the immigrant population in Serbia are extremely limited. According to a UNICEF statement, "Refugee and migrant children, and women, are accommodated in collective centers that provide basic needs; however, they have limited access to safe places to rest and thrive, receiving only irregular specialized and community-based psychosocial support" (UNICEF The Refugee and Migrant Crisis, 2019). Those who can afford the rent commonly search for private apartments. Most reported immigrants are hosted in one of the state-run camps and asylum centers. However, according to the Belgrade Center for the Human Rights Report, these asylum centers are "overcrowded, with a lack of privacy and poor hygienic conditions" (Asylum Information Database, 2020).

In an attempt to create more space for crisis accommodation, the government has repurposed several buildings, such as roadside hotels and factories. However, a great number of immigrants are still forced to sleep outdoors, mainly settling in the areas around cities' parks and major bus and train terminals. According to Paradiso's writing in Mediterranean Mobilities, the number of makeshift camps, commonly called 'jungles', have been erected by the refugees in proximity to the border with Hungary and Croatia. Some improvised settlements made by immigrants are also located in the capital city, Belgrade (Paradiso, 2019). Given a current lack of adequate housing options, new shelter designs that satisfy many criteria of the Israel-Maslow hierarchy as possible are necessary in this region for sheltering the increasing numbers of incoming migrants.

Evaluation of Earth Construction Methods

An initial phase of the research focused on the evaluation of potential building materials and techniques for use in Northern Serbia. The following set of criteria was used to determine the most suitable construction materials and methods for the proposed housing design:

1. Sustainability of the material
2. Potential to use locally available materials
3. Quality and durability of the final product
4. Skill level required for construction
5. Final cost of material and execution
6. Historical and regional precedent
7. Opportunity of the communal engagement
8. Speed of construction

A review of potential building materials and techniques indicated architectural construction methods using earth as the primary material satisfies all of the above-stated criteria (Minke, 2005). As soil is a largely available material, many variations of earth-architecture methods have been used throughout the world since prehistoric times. These construction methods have been re-popularized in modern construction due to their inherent sustainability and low costs of production.

The most common building techniques with the earth include: adobe brick, earthbag, straw-bale, rammed earth, and cob (layered earth). Earth as a building material stores the heat because of its good thermal insulation properties. This quality is of a great importance in areas such as Serbia, where winters tend to be relatively cold with some snow. Building with earth is energy efficient and, in comparison with concrete construction, it is estimated that only around 1% of energy is used (Minke, 2005). It is comparably more sustainable than concrete construction, as its production, transportation, and installation is largely dependable on fossil fuel input and leads to high carbon dioxide emissions. Contrary to concrete, earth construction allows for materials to be harvested locally through manual labor, which is inherently more sustainable in terms of energy and emissions.

Moreover, earth as a construction material is cheap, sometimes even free, if there is a possibility to harvest it from the site itself. Harvesting the material from the site, or in proximity to the site, accounts for additional savings in transportation costs and lowers the fossil fuel consumption (Minke, 2005). The financial efficiency is of a great importance for shelter construction as humanitarian funds are typically very limited.

However, the disadvantage of this type of construction is the fact that earth is not a standardized material (Minke, 2005) and heavily depends on the site from which it is harvested. As ratios of soil components vary greatly, it is difficult to create a standardized formula for an optimal material mixture. In some instances, if the quality of soil itself is not adequate for construction, other materials, such as cement, need to be introduced to stabilize the mixture (Kariyawasam & Jayasinghe, 2016). Other disadvantages of this type of material are its propensity to small cracking and lower water resistance, which can typically be minimized with the addition of protection layers and extending overhangs (Minke, 2005). Table 01 summarizes the advantages and disadvantages of using earth as the primary building material.

Table 1. Advantages and Disadvantages of Building with Earth

Advantages	Disadvantages
Balances air humidity	Not standardized
Stores heat	Shrinks when drying
Saves energy	Low water resistance
Affordable	
Low transportation costs	
Does not require silled labor	

Straw-Bale to Earthbag Construction Comparison

Straw-bale construction, which uses bales plastered with layers of clay earth, has deep, historical roots in the architecture of Northern Serbia. This construction method has the same general advantages and disadvantages as most of other forms of earth construction outlined in Table 1, yet several additional characteristics indicate the approach is not ideal for refugee housing. The additional benefit of this type of construction is the high durability of the final product as structures made using this technique can typically last for over 100 years. However, this construction method is labor-intensive, relatively slow to produce, and more expensive than other earth construction methods, as it is necessary to purchase large quantities of straw-bale and wood.

Figure 02. *Building a straw-bale house*. (n.d.). photograph. Retrieved from https://commons.wikimedia.org/wiki/File:Straw_bale_house.jpg

Unlike straw-bale construction, earthbag construction is an innovative technique. Building with earth-bags is significantly cheaper than building with straw-bale, because the only required materials are polypropylene bags, barbwire, and earth (Hunter & Kiffmeyer, 2004). The construction process is faster and does not require skilled labor. Therefore, this construction technique offers an opportunity for a community engagement from volunteers and refugee population themselves. Even though straw-bale has deep historic precedence in this region, earthbag construction has a stronger alignment with the end-product goals outlined previously, and thus, was selected for further investigation as part of this research.

Figure 03. Hart, K. (n.d.). photograph. Retrieved from shorturl.at/cewKV

The first recorded use of earthbag for construction dates to World War I when military bunkers and trenchers were constructed using this technique (Hunter & Kiffmeyer, 2004). This historic usage of earthbag demonstrates the flexibility of this construction method, as soldiers were able to construct bunkers within days. The wall building process for earthbag construction includes: harvesting the local soil; mixing it with water, and possible aggregates for increased stability[2] (such as gravel); inserting the mixture into the polypropylene bag; layering filled polypropylene bags with barbwire as a connection between layers; and letting the constructed walls dry for several days.

Even though other types of bags have been used for earthbag construction (e.g. burlap bags and hemp bags), polypropylene bags were proven to be the most water and insect resistant (Hunter & Kiffmeyer, 2004). These bags are also the most inexpensive solution, as large manufacturers who produce them for commercial food packaging typically sell the misprinted bags for a significantly lower price (Hunter & Kiffmeyer, 2004). These widely available bags can be purchased as long tubes, or fixed-size units, and can easily be transported to the site as they take minimum space in comparison to some other building materials.

Earthbag Housing Unit Proposal Shape

The architectural proposal for refugee housing draws inspiration from nature and the efficiencies of hexagonal geometries. Exemplifying the advantages of these geometries, the organization of honeycomb cells (Figure 04) and other examples found in nature create a tightly fitting geometry, minimizing space between neighboring cells. This efficiency is key to the

[2] Additional materials can be added to the mixture to increase its stability, structural and insulation performance, but are not essential for the basic earthbag construction

design of refugee housing, as housing units must be placed close together to take advantage of limited land available for housing camps.

A hexagonal plan for housing units offers more opportunities for closer placement of units than circular footprints that are typically used for earthbag construction. The comparison of utilized space in circular and hexagonal composition is shown in Figure 05 and Figure 06. This principle has been recognized and utilized by the firm Architects for Society who designed Hex Houses as a solution for refugee and crisis accommodation (Hex House, 2016). Similar to the Hex House, this architectural proposal put forth through this research is also proposing the utilization of this geometric form clusters, yet with alternative building materials that significantly lower the cost of construction. The shared walls of the clustered units also minimizes the cost of construction and retains heat better, significantly lowering the post-construction heating expenses.

Figure 04. Labelle, S. (2019). Retrieved from https://unsplash.com/photos/dWSygTBemRo/info

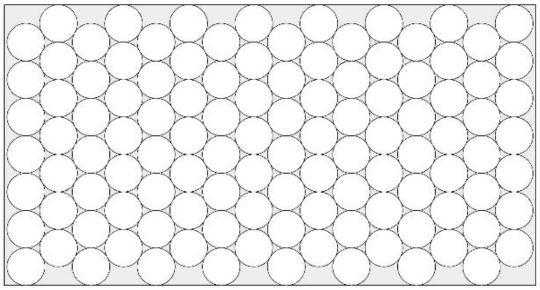

Figure 05. Circular Multiple Assembly

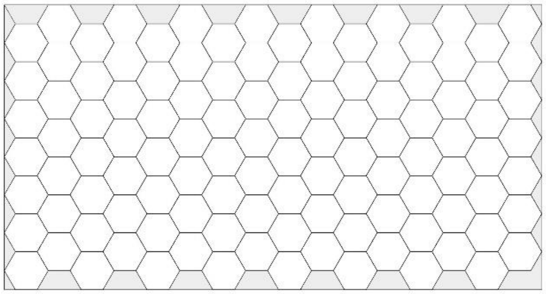

Figure 06. Hexagonal Multiple Assembly

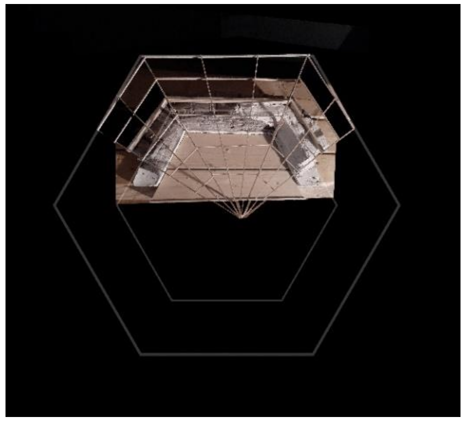

Figure 07. Sectional Model – Plan View

The most challenging facets of hexagonal assembly of a single housing unit are the corners, because they fold at a 120° angle rather than the more conventional 90° angle. This study proposes to solve this issue with a modified corner joint earthbag that fills in the specifically designed shape. This modification does not require the production of a special type of a bag, but rather involves a special procedure of filling the bag volume and sewing the folds to create the needed geometry. All earthbags, other than corners, are typical cuboid volumes that construct flat layers within the walls. The modified joints can be seen in Figure 08.

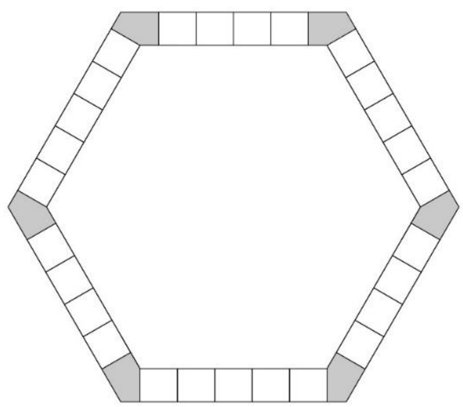

Figure 08. Corner Joints

Material Studies

To increase the stability and strength of earthbag construction, earth is mixed with additional materials. Small-scale material studies were undertaken to test the efficiency of several mixtures with a variety of material ratios. Materials used for tests are 2x2.7-inch organza bags, sand, soil, plaster, and water. In these studies, plaster is used to simulate the performance of cement, a binder that would typically be used in full-scale earth bag construction. The organza bags similate the polypropylene bags at the architectural scale of ½” equals one foot. After filling the bags with a different mixture, each bag was let to dry on the sun for 3 days. When the drying period finished, the differences between the various mixtures were recorded. The material tests with the corresponding ratios can be seen in Figure 09.

Figure 09. Material Studies

Tests containing only soil and water proved to be least solid when dried. Tests with soil and some addition of aggregate sand were sturdier in the dried condition. However, when too much sand was added into the mixture, the final product lost its strength. The optimum mixture was achieved when a small quantity of plaster was introduced as the second aggregate into the mixture of soil, sand, and water. The mixture with a ratio Soil : Sand : Plaster : Water = 3 : 2 : 1 : 2.5 was chosen for the rest of the research as it proved to be the sturdiest and had the least amount of cracking after the drying process.

However, binders, like plaster and cement, are not necessary for the fully scale on-site production, because typical local soils contain a larger percentage of natural clay that gives additional strength to the final product. Cement can be used in place of plaster if the soil found on site does not contain enough binding elements. Plaster was used only as an additive for this study, as the commercial soil purchased for the research did not contain an adequate amount of natural clay. According to Minke, soils with a high clay content, or even the addition of pure clay, enhances the binding force of earth axes during the process of drying (Minke, 2005).

Figure 10 shows the exterior of the model[3] made using 2”x2.7”-inch organza bags filled with soil, sand, plaster, and water. The model is a section of the proposed architectural proposal and

[3] The model is made in ½” = 1’ 0” scale

shows the connection between three exterior walls. Each wall meets the neighboring wall on an angle of 120°, which allows 6 exterior walls to create a hexagonal shape. After the assembly, the sectional model was left to dry in sun for 3 days.

Figure 10. Sectional Model Exterior

Foundation System and Moisture Control Strategies

Figure 11 shows an interior view of the wall assembly. Plaster was poured into the ground as a simulation of a shallow foundation system. The foundation acts as a protection from both seismic forces and possible moisture damage. Both protections are necessary in this part of the world where earthquakes are not uncommon and yearly rainfall amounts are significant.

A typical concrete foundation/stem wall system is commonly used to support the earthbag structures. In order to simplify the construction and procurement of the foundation materials, while maintaining its sustainability levels, this study proposes the usage of packed gravel trench foundation and cement stabilized earth stem walls. This type of stem wall uses larger bags that create more stable volumes for additional support. The weight of the bags holds them in place, while every upper earthbag layer is connected to the below one with barbwire. The soil for the stabilized foundation earthbags is chosen carefully and includes less clay, and more sand than the soil used for upper earthbags (Hunter & Kiffmeyer, 2004). This type of soil allows for the addition of cement, which acts as a binding agent and makes the mixture stronger and more capable of withstanding loading forces.

Figure 12. Sectional Model Interior

Other moisture control strategies include a steep roof and plaster layers. Supported by the earthbag walls, a wood roof structure creates an extended overhang to protect the walls from weather. Despite the increase in total construction cost caused by the wood structure, the roof is necessary in Southeastern Europe due to the high yearly rainfall and snowfall. Therefore, dome-like roofs, which are more typical for earthbag construction, are not suitable for construction in this part of the world.

A plaster layer (Figure 13) is applied to both the interior and exterior side of the wall to seal any holes and unevenness resulting from the earth-bags' imperfections, but also as an additional moisture control system. Additionally, the plaster finish protects the polypropylene bags[4] from sun UV damage.

Figure 13. Wall and Plaster Detail

[4] Polypropylene is a type of plastic typically used for many household items and to produce thicker plastic containers and bags.

Future Work

Future steps in this research begin with the design of the refugee community or neighborhood, which would test a range of configurations of single housing units presented in this research. The feedback from this community design would indicate needed to be adjustments. Through this testing, a higher level of detailing and development, including the material and structural connections between several housing units, could be developed. The design of the simple roof structure would be a focus of these revisions when two or more housing units are to be connected. This community design, including the development of clusters, would open possibilities to design exterior spaces for recreating and communal gatherings, addressing additional needs highlighted in Maslow's hierarchy and creating a more satisfying living experience for future residents.

Set Criteria Overview

The following outline highlights the key advantages and capabilities of using regionally appropriate, sustainable and affordable earthbag construction method to address the refugee housing crisis.

Sustainability of the material – Earth is regarded as a highly sustainable building material because it requires very little mechanization and uses minimum amounts of fossil fuels for production, transportation, and installation.

Potential to use locally available materials – Building soil can be harvested almost anywhere in the world and on-site harvesting significantly alleviates material transportation and handling.

Quality and durability of the final product – If built properly, buildings produced with the earth can endure for several decades, and with regular maintenance potentially even centuries.

Skill level required for non-professional construction – Earthbag construction can easily be though to non-professionals.

The final cost of material and execution – If harvested from the site, the earth is a free material that significantly lowers the overall cost of construction. Other materials involved in earthbag construction are comparatively low and no high mechanization is needed.

Historical and regional precedent – Even though earthbag was not commonly used in Northern Serbia before, other earth architecture methods, such is straw-bale have a strong historic presence.

The opportunity of the communal engagement – As this technique does not require skilled labor, both volunteers and the immigrant population can engage in the construction, which would decrease the costs of construction while making a positive social impact.

Speed of construction – Building with earth is faster than most of the other common building techniques. Even though earthbag construction is less time-efficient than building temporary tent structures, it leaves permanent structures that can later be reused for other purposes.

Conclusion

This study proposes the implementation of the earthbag building technique for the design of refugee housing in Southeastern Europe, a region that faces an immigrant crisis and needs immediate housing solutions. Looking specifically at Northern Serbia, the model proposes a foundation, wall, and roof system with appropriate moisture control strategies for this climate. The geometry of the housing unit utilizes the efficiencies of the hexagonal form, allowing for several units to connect tightly and create housing clusters that would increase the communal character of the design.

In summary, this research on earthbag construction and this model unit show strong potential to create spaces that satisfy criteria higher than simple 'home as a shelter' base of the Israel-Maslow's hierarchy.

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