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COB CONSTRUCTION: TECHNOLOGY FEATURES AND POSSIBILITIES OF ITS APPLICATION IN RUSSIA

Musostov Zelimkhan (a)*, Basnukaev Isa (b), Mairansaev Zurab (c)
*Corresponding author

(a) Chechen State University, Grozny, Russia, zmr@hotmail.co.uk
(b) Grozny State Oil Technical University, Grozny, Russia, ibasnukaev@mail.ru
(c) North Caucasus Mining and Metallurgical Institute, Vladikavkaz, Russia, sarmat007@inbox.ru

Abstract

In modern conditions, one of the key areas of social development is to improve the quality of life of the population. ATunlike most of the developed countries of the world, where individual housing construction is extremely common, in Russia a significant part of citizens live in apartment buildings with from two to twenty-five or more floors. The intensification of private housing construction in conditions of economic instability involves the search for optimal technologies that combine high quality products, low cost and minimal environmental impact. Among the current methods of construction of residential buildings is adobe construction: it combines traditionalism and innovation such as the latest building materials and additives allowing the construction of beautiful, durable and ergonomic houses in various climatic conditions. This paper discusses the features of adobe technology and comparing it to other methods of construction, the study aims to identify the benefits and drawbacks of using adobe in Russia. Moreover, the study will investigate the feasibility of implementing adobe technology in Russia's diverse climatic conditions and highlight the challenges and opportunities associated with its adoption. The findings of this study can inform policymakers, architects, and builders in making informed decisions about the use of adobe technology in their construction projects.

Keywords: Adobe construction, adobe house, construction industry, construction innovations, innovative building materials, sustainable materials

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1. Introduction

The term "saman" in translation from the Turkic language means "finely worn straw." Adobe is a composite material consisting of clay, sand, straw, water and various additives. Wet adobe is easily placed into formwork or used to form large bricks, which are then dried and used in construction (Trunkina et al., 2019).

Adobe construction is one of the most ancient building technologies: according to historians, such houses were built in ancient Egypt about 6000 years ago. Today, traditional adobe buildings are quite widespread in Asia and Africa. An analogue of adobe was also used by the indigenous inhabitants of the American continent: at present, in the state of New Mexico, several adobe houses have been preserved, whose age is almost a thousand years. The adobe came to Europe through Spain, where it was brought by the Moorish armies that captured the Iberian Peninsula in the 8th century (Goryachev & Solomentsev, 2013; Lityagina, 2022).

In the Russian Empire, adobe construction was mainly developed in the southern regions, where houses created in this way were called huts or huts (Korovkina, 2021). Huts can still be seen in the villages and villages of Ukraine, Belarus and Moldova, as well as in the Krasnodar and Stavropol Territories, Rostov and Astrakhan regions of Russia. However, the technology of adobe construction was also used in the northern territories: the Priory Palace in Gatchina, erected in 1799 according to the design of the architect N.A. Lvov, is an excellent example (Muratova, 2020).

The spread of adobe construction has historically been determined by climatic factors: this technology was used mainly in steppe and desert natural zones with a hot, dry climate, since high humidity led to rapid subsidence of structures. Meanwhile, modern building technologies make it possible to create adobe mixtures with increased plasticity, frost resistance and water resistance, which makes it possible to widely use this technology for individual housing construction (Figure 1).

The ancient fortress of Ouarzazate (Morocco)

Priory Palace in Gatchina 1799 (Russia)

Modern adobe house (Romania)

Figure 1. Adobe buildings in the modern world

Currently, two types of mixtures are used in adobe construction: light adobe and heavy adobe. Light adobe consists of 10% clay, the rest is straw or various additives. This is an environmentally friendly and inexpensive option, intended mainly for use as insulation in the construction of frame houses (Meteleva, 2019). Heavy adobe contains at least 40% clay and is almost as dense as burnt bricks and gas blocks. Heavy adobe bricks are used for the construction of load-bearing structures (Solonov et al., 2020).

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2. Problem Statement

Despite the prevalent use of individual housing construction in most developed countries, a significant portion of the Russian population still resides in apartment buildings. With the increasing economic instability, there is a need to identify optimal technologies that are cost-effective, high quality, and environmentally sustainable. One such technology currently gaining attention is adobe construction, which offers a blend of traditionalism and innovation to produce durable, ergonomic, and aesthetically pleasing houses. However, there is limited research on the potential application of this technology in Russia.

3. Research Questions

This study aims to investigate the potential application of adobe technology in Russian residential construction. The research questions that guide this study are: what are the features of adobe technology for residential construction, how does adobe technology compare to other methods of construction in terms of cost, quality, and environmental impact, what is the potential for adobe construction to be applied in Russia's unique climatic conditions, and what are the challenges and opportunities associated with the implementation of adobe technology in Russia? By answering these research questions, the study seeks to identify the benefits and drawbacks of using adobe in Russia, examine the feasibility of implementing adobe technology in diverse climatic conditions, and highlight the challenges and opportunities associated with its adoption. The findings of this study can inform policymakers, architects, and builders in making informed decisions about the use of adobe technology in their construction projects.

4. Purpose of the Study

The purpose of this study is to explore the potential application of adobe technology in Russian residential construction. By examining the features of adobe technology and comparing it to other methods of construction, the study aims to identify the benefits and drawbacks of using adobe in Russia. Moreover, the study will investigate the feasibility of implementing adobe technology in Russia's diverse climatic conditions and highlight the challenges and opportunities associated with its adoption. The findings of this study can inform policymakers, architects, and builders in making informed decisions about the use of adobe technology in their construction projects.

5. Research Methods

The basis of adobe is clay soil, which is diluted with water and thoroughly mixed. Clay is harvested in autumn and laid in layers about 15 cm thick, watering each layer with water. The resulting mass is covered with straw and left for the winter in the open air. In the spring, the straw is removed and the clay is allowed to be saturated with rainwater, after which the necessary additives are added to it. The most important element of adobe is straw or flax fiber, cut into pieces 9-16 cm long and providing reinforcement of the material. The composition of adobe also includes sand, which allows to reduce the

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fat content of clay and avoid its cracking. In ancient times, horse manure was added to adobe, which acts as a natural plasticizer. Currently, to improve the characteristics of adobe, liquid glass, PVA glue, gravel, vegetable fibers, expanded clay, different kinds of antiseptics. Key types of additives and their technological purpose are systematized in Figure 2.

Increasing the tensile strength of cellulose fibers	Dry shrinkage reduction	Accelerated hardening and increased strength and water resistance	Stability improvement (plasticizers)
chopped straw campfire chaff wood chips manure	sand gravel rubble expanded clay	cement lime	liquid glass casein bone glue milk serum slurry syrup starch, etc.

Figure 2. Additives for making adobe

There are several technologies for building adobe houses (Figure 3).

Building from adobe blocks

Construction using Weisburd formwork

The construction of monolithic adobe walls without a frame

Figure 3. Technologies for the construction of adobe houses

The process of building with adobe blocks is similar to the process of building a traditional brick house.

6. Findings

The process of building an adobe house begins with studying the composition of clay soil, which can vary greatly in different areas (Ilaeva et al., 2021; Tsutsulaeva, 2019). To select a suitable material, test samples are made with various proportions of clay and sand, which start with a ratio of 1:1 and in increments of 0.5 and end with a ratio of 1:5. Clay evaluation is carried out after complete drying of the samples. There are from 8 to 18 kg of fillers per cubic meter of adobe mixture (Trofimov & Al Haddad, 2018).

The production of adobe blocks is carried out in the spring, followed by drying in the summer sun. The size of the elements is not standardized: depending on the conditions and tasks of construction, large

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blocks, bricks of medium or small sizes are used. For the manufacture of raw bricks, molds are used in the form of a box with a movable bottom, which can be either single or for several bricks. Large blocks of adobe allow you to get a wooden box without a bottom, knocked together from boards 30 mm thick (ConsultantPlus, 2004).

Adobe is prepared in the following sequence: clay is thoroughly mixed with sand, gradually adding water; wetted straw is added to the solution and mixed, bringing it to a homogeneous mass. Before immersing the clay mixture, the mold is moistened with water and sprinkled with agricultural waste - chaff, which helps prevent clay from sticking to the walls of the mold. After loading the clay together with the straw into the mold, it is compacted and smoothed, making sure that the clay evenly fills the entire space. Excess clay is removed, after which the form is removed and transferred to another place for the next filling.

Unlike ordinary bricks, adobe blocks are not fired, but dried in the sun under natural conditions. Drying is done in two stages. Freshly formed blocks are left in the open air for 4-6 days, placing them in direct sunlight or under a canopy. Then they are turned upside down and kept in this position for another 2-3 days, after which they are stacked in stacks for complete drying. The use of adobe building blocks for laying walls is allowed at a moisture content of not more than 5% by weight. The laying of adobe blocks is carried out using a clay-sand mortar, the thickness of the joints during laying should not exceed 12 mm. Adobe bricks are highly durable and do not crack even when dropped from a height of two meters.

To build a house with the help of Weisburd's fixed wooden formwork, light adobe is used, which is stuffed into the formwork and left to dry completely. After drying, the walls are plastered with clay mortar. When using this technology, the cost of fixed formwork increases, but these costs are offset by savings on the foundation. The advantages are the ability to build a two-story house or a house with an attic, as well as a short time frame: an adobe house can be built in just a few months.

When erecting monolithic walls without using a frame, a mixture of clay and straw is placed in portions on a pre-prepared foundation. Every day a small layer up to 150 mm high is laid, to prevent the composition from slipping, the wall is immediately plastered. Frameless technology is quite economical, but its main disadvantage is a long shrinkage period, which is 12 months.

Combined methods of adobe construction are also widespread. The outer walls of an adobe house are built from heavy adobe with a thickness of 500 to 600 mm, which corresponds to a brick wall with a thickness of about 1000 mm. Internal partitions should have a thickness of 300 mm, they are made of frame and filled with light adobe. Complex elements are made by hand, giving the mixture the desired shape by hand or using special tools.

When laying the foundation for an adobe house, concrete, stone and rubble bricks are usually used. The height of the plinth is about 500 mm, while the plinth must be securely insulated with roofing material, film or roofing felt. As a rule, a tape-type foundation is used; for the construction of a frame adobe house or in places with deep freezing of the soil, it is recommended to use a pile foundation.

Adobe is subject to adverse environmental effects, so the outer walls must be plastered, applying a layer of plaster with a thickness of 50 to 100 mm. You can use lime, silicate or acrylic mixtures with a high level of vapor permeability. Interior decoration involves leveling the walls with an adobe mixture

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and then painting the surface with lime with the addition of pigment. Also acceptable options are wallpapering with preliminary priming of the wall and the application of plaster, including gypsum.

The technology of building adobe houses has a number of features associated with the properties of clay, which is the main building material. One of the fundamental factors is the protection of the structure from the penetration of dampness, which has a destructive effect on the adobe mixture. Moisture can penetrate the walls from the soil, through slanting rains, or due to poorly installed roofing. To protect against excessive moisture, such techniques are used as the construction of foundations and a plinth from waterproof materials, a blind area to prevent water and snow from splashing onto the walls, the creation of a waterproofing layer under walls, window and door openings, and the arrangement of cornices with overhangs of at least 50 cm.

Cob houses most often have a gable roof with a slope of 30-45 °. For the rafter system, a mauerlat is required (a beam or a log laid on top along the perimeter of the outer wall), which allows you to save the adobe walls from uneven loads.

With the observance of construction technologies, an adobe house is a reliable and durable dwelling with many advantages. The main advantage of adobe housing construction is its low cost: the construction of an adobe house costs 1.5 - 2 times cheaper than a traditional timber or brick house (Chebodaev & Tulberov, 2021). This is primarily due to the very low cost of the main building materials: clay and straw. Also, when building a house from adobe, you do not need to rent construction equipment and seek the services of professional builders: minimal skills are required to build a house.

An important factor is the environmental friendliness of adobe construction, because natural raw materials are used in the construction of houses. At the same time, with proper operation, the life of an adobe house can reach a hundred years. Along with the cost-effectiveness of construction, the use of adobe will reduce energy costs for heating a home due to the ability of this material to retain heat for a long time.

Due to the high hygroscopicity of clay, the walls of an adobe house absorb moisture during rain and release it during hot weather. Thus, a comfortable temperature and humidity are almost always maintained in the house, which makes it possible not to install an air conditioner or humidifier in it. Another advantage of adobe is its high soundproofing properties, which far exceed those of wood, stone and fired brick. It is always quiet in an adobe house, even if it is located near a highway or railway tracks (Electronic fund of legal and regulatory and technical information, 1986; Electronic fund of legal and regulatory and technical information, 2011; Electronic fund of legal and regulatory and technical information, 2016).

The fire resistance of clay minimizes the risks of fires, and the increased vapor permeability does not allow mold to start. The high density of adobe gives the blocks the ability to hold weight. So, walls made of shell rock hold dowels rather poorly, while they are easily driven into adobe and perfectly hold hanging cabinets and shelves. The undoubted advantage of adobe building technology is the ease of restoration in case of damage or cracking - for this, an ordinary clay mortar is used, followed by grinding.

The main disadvantage of adobe houses can be called low moisture resistance, due to which this technology is not used in regions with high rainfall. Clay absorbs water well, and even one rainy season can be enough for a building to lose strength due to soaked blocks.

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Cob houses have a long period of shrinkage, while the height of the premises can be significantly reduced and this factor must be taken into account at the design stage. Due to the peculiarities of the material, adobe houses are not recommended to be built in seismically dangerous regions and in places where rivers of other water bodies can overflow. It is also necessary to take into account that an adobe house cannot be frozen: this will lead to the inevitable destruction of the blocks and the deformation of the entire building. Thus, in regions where frosts are possible, adobe houses can only be used for permanent residence.

Another problem is that a house built from natural raw materials attracts increased attention of animals and insects. Field mice and rats can settle inside the partitions; during prolonged wet weather, a fungus appears on the walls. To protect against these phenomena, the walls are treated with lime and antiseptics, and during construction, internal partitions are enclosed with a reinforcing mesh.

In the event of a violation of the technology, subsidence of the structure is possible - this is due to the significant mass of blocks and the lack of a high-quality foundation. It is quite difficult to build a second floor in an adobe house - this is possible only if an additional frame is used and the floors are strengthened.

7. Conclusion

According to the results of the study, the following advantages and disadvantages of adobe as a building material can be distinguished (Figure 4).

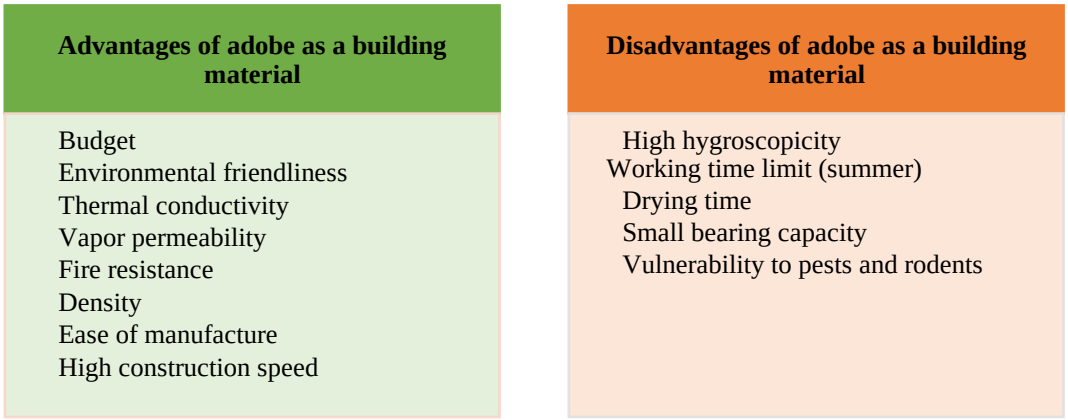

Figure 4. Advantages and disadvantages of adobe as a building material

The advantages and disadvantages of adobe buildings are systematized in Figure 5.

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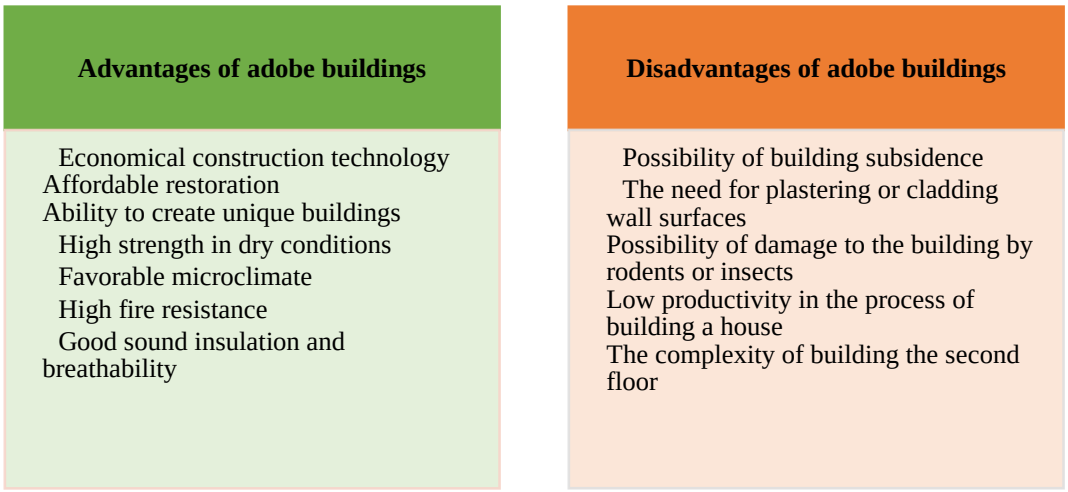

Figure 5. Advantages and disadvantages of adobe buildings

Thus, adobe housing construction is a traditional building technology that has been rethought taking into account the latest building materials and additives. Mass construction of adobe houses is possible in the southern regions of Russia, which will provide the population with inexpensive own housing, characterized by unique architecture and high performance.

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