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STRENGTH AND DURABILITY OF CERAMIC MATERIALS FOR EXTERNAL APPLICATIONS.

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Анотація

У роботі розглянуто особливості та переваги керамічних матеріалів для зовнішнього застосування. Детально охарактеризовано клінкерну цеглу, фасадну керамічну плитку, керамограніт, різновиди черепиці (керамічну, цементно-піщану, полімерпіщану, бітумну, металочерепицю, композитну) та архітектурну теракоту. Проаналізовано їхні властивості, переваги та недоліки в контексті використання для зовнішнього оздоблення будівель. Окрема увага приділена фізико-механічним характеристикам матеріалів, що визначають їхню придатність для експлуатації в різних кліматичних умовах.

Ключові слова: керамічні матеріали, клінкерна цегла, фасадна керамічна плитка, керамограніт, черепиця, теракота, фізико-механічні характеристики матеріалів

Abstract

The work examines the features and advantages of ceramic materials for external application. It provides a detailed characterization of clinker bricks, facade ceramic tiles, porcelain stoneware, various types of roofing (ceramic, cement-sand, polymer-sand, bituminous, metal tiles, composite) and architectural terracotta. Their properties, advantages, and disadvantages are analyzed in the context of use for exterior finishing of buildings. Special attention is given to the physical and mechanical characteristics of the materials that determine their suitability for operation in various climatic conditions.

Keywords: ceramic materials, clinker brick, facade ceramic tiles, porcelain stoneware, tiles, terracotta, physical and mechanical characteristics of materials

Introduction

Ceramic materials are those obtained from clay-based masses through shaping, drying, and firing [1-3]. These ancient man-made construction materials are widely used in building due to their high durability, relatively simple manufacturing technology, and versatile properties [4-6].

The purpose of the research is to analyze the properties, advantages, and disadvantages of the main types of ceramic materials used for exterior building finishes, as well as to evaluate their effectiveness under various operating conditions [7-10].

In accordance with the purpose, the following tasks have been formulated:

1)To analyze the main physical and mechanical characteristics of modern ceramic materials;

2)To describe the advantages and disadvantages of clinker bricks, façade tiles, porcelain stoneware, various types of roof tiles, and terracotta;

3)To determine the feasibility of using specific types of ceramic materials depending on the conditions of use.

Research Results

Under conditions of high-quality manufacturing and proper building maintenance, ceramics is a durable material that can be used for decades or even centuries [11-14].

However, over time, due to exposure to atmospheric factors, aggressive environments, and mechanical stress, ceramic products may lose their properties and begin to deteriorate.

Clinker Brick.

Clinker brick is a very strong, well-fired type of brick designed for constructing foundations and vaults, paving roads or industrial facility floors, building factory chimneys, and lining sewer channels.

Advantages of Using Clinker Brick:

- High strength and durability: Clinker brick is made from high-quality clay that is fired at extremely high temperatures (over 1000°C). This makes it exceptionally strong and resistant to mechanical damage, allowing it to retain its structure and appearance for decades.
- Resistance to weather conditions: Clinker brick is not affected by rain, snow, or extreme temperatures. It does not absorb water, which reduces the risk of cracking during frost. It also retains its color under ultraviolet exposure.
- Fire resistance: Due to its high-temperature firing, clinker brick is non-combustible and resistant to high temperatures, making it a safe option in case of fire.
- Environmental friendliness: This material is made from natural clay without harmful chemical additives, making it eco-friendly and safe for human health and the environment.
- Aesthetic appearance and color variety: Clinker brick has a natural and attractive look. It is available in various shades, shapes, and textures.
- Low maintenance: Thanks to its properties, clinker brick requires almost no maintenance. It is not susceptible to mold, mildew, or corrosion, and can be easily cleaned from dirt.
- Energy efficiency: Clinker brick provides good thermal insulation, helping to retain heat in winter and coolness in summer. This can reduce heating and air conditioning costs.

Disadvantages of Using Clinker Brick:

- High cost: Clinker brick is more expensive than regular ceramic brick due to its more complex manufacturing process (firing at very high temperatures) and the use of high-quality raw materials.
- Weight: Because of its high density, clinker brick is quite heavy, which can complicate transportation, installation, and increase the load on a building's foundation.
- Difficulty in processing: Due to its exceptional strength, clinker brick is hard to cut or drill without special equipment, which complicates construction work.
- Poor vapor permeability: Because of its low water absorption and dense structure, clinker brick tends not to "breathe," which can sometimes lead to moisture issues within walls if proper ventilation is not provided.

Exterior Ceramic Cladding Tile.

Advantages of Using Façade Ceramic Tile:

- Strength and durability: Façade tile can withstand significant mechanical loads and weather exposure while maintaining its properties for many years.
- Resistance to atmospheric conditions: It is resistant to UV radiation, frost, moisture, and other environmental factors, making it suitable for use in all climate zones.
- Aesthetic appeal: A wide variety of colors, textures, and shapes is available, allowing for versatile design options.
- Ease of maintenance: Façade tile requires no special care, is easy to wash and clean, making it a practical choice for exterior decoration.

Disadvantages of Using Façade Ceramic Tile:

- Brittleness: Although the tile is quite strong, it remains a brittle material, especially under impact. Dropping heavy objects or strong mechanical shocks can cause cracks or chips.
- Limited vapor permeability: Ceramic tile has low vapor permeability. If sufficient ventilation of the façade is not ensured or the structure of a "ventilated façade" is not properly designed, moisture can accumulate inside the walls.

Porcelain Stoneware (Gres).

Porcelain stoneware is an artificial material produced through high-temperature sintering of a mixture of clay, feldspar, quartz, and natural pigments. This process gives the material properties similar to natural stone, but with certain advantages[15-17].

The production of porcelain stoneware involves several stages: raw material preparation, tile forming under high pressure, drying, and firing at temperatures up to 1300°C. This technology ensures high strength and density of the material, as well as minimal water absorption.

Advantages of Using Porcelain Stoneware:

- Strength: Porcelain stoneware has high mechanical strength, allowing it to be used in areas with heavy foot traffic.
- Wear resistance: The material is resistant to scratches and other mechanical damage.
- Water absorption: Due to its low water absorption, porcelain stoneware is suitable for use in humid environments and outdoor spaces.
- Frost resistance: It withstands extreme temperatures, making it ideal for exterior use.
- Chemical resistance: The material is resistant to the effects of chemicals, which makes it suitable for use in industrial facilities.

Disadvantages of Using Porcelain Stoneware:

- High cost of material and installation.
- Difficult to process: Due to its hardness, the material is difficult to cut, drill, or work with. It requires the use of professional tools (diamond blades, milling cutters), which increases the time and cost of installation.
- Requires a well-prepared base: Porcelain stoneware is very dense and heavy, so it needs a perfectly level, strong, and stable surface. Any defects or movement in the base can lead to damage of the cladding.

Roof Tiles.

There are six different types of roof tiles: ceramic, cement-sand, polymer-sand, bitumen, metal tiles, and composite tiles.

1)Ceramic Roof Tiles

This is the most classic option for roofing.

Advantages:

- Firstly, ceramic tiles are considered the most environmentally friendly roofing option. Essentially, ceramic roof tiles are just clay that has undergone thermal processing.
- Secondly, this type of roofing has stood the test of time. Manufacturers guarantee a minimum service life of 100 years.
- Thirdly, ceramic roofing is repairable — individual tiles can be replaced without having to redo the entire roof or large sections of it.
- The material is resistant to temperature fluctuations, provides good sound insulation, and has excellent waterproofing properties.

Disadvantages:

- The main drawbacks of ceramic tiles are their cost and weight. This type of material is more expensive than the others listed below due to its high production cost and material fragility, which makes transportation and installation more expensive.
- Significant weight of the tiles, which requires the construction of reinforced rafter systems to support the load.

2)Cement-Sand Roof Tiles

In terms of properties, cement-sand tiles are nearly identical to ceramic roof tiles described above. The main difference lies in the composition: sand, pigments, and cement are used in the manufacturing process.

Advantages: They share all the benefits of ceramic roof tiles. In addition, they have increased strength, which reduces transportation and installation costs. The production cost of cement-sand tiles is also lower.

Disadvantages: The main relative drawback is the considerable weight of this roofing option, which places greater demands on the structural strength of the roof.

3)Polymer-Sand Roof Tiles

These tiles are produced by pressing a mixture of polymer materials, sand, and pigments at high temperatures.

Advantages: The production and transportation costs are relatively low. The tiles possess nearly all the advantages of ceramic roof tiles.

Disadvantages: Manufacturers typically guarantee a minimum service life of 50 years, compared to 100 years for the two previously mentioned types. Additionally, the use of polymers makes this material less environmentally friendly.

4)Bitumen Roof Tiles.

This type of roofing is made from a combination of bitumen, fiberglass, and polymers.

Advantages: Lightweight and adequately strong. Good sound insulation and low thermal conductivity.

Easy to install, especially on complex-shaped roofs. Low cost of the material itself and low transportation expenses. Good repairability — damaged sections can be replaced individually.

Disadvantages: Due to its composition, bitumen roofing cannot be considered an environmentally friendly building material. It is also relatively short-lived, with a service life of up to 20 years.

5)Metal Tiles (Metal Roofing).

Metal tiles are made from steel sheets bent into a specific shape, with zinc and polymer coatings applied to protect the metal from corrosion.

Advantages: Low production and transportation costs. Lightweight and easy to install. Durability of approximately 50 years.

Disadvantages: Virtually no sound or thermal insulation. Therefore, to address these issues, a metal roof on a residential building requires additional sound and thermal insulation work on the inner surface of the roof.

6) Composite Tiles

Unlike metal tiles, the outer surface of composite tiles is additionally treated with a protective coating of natural stone. This coating provides extra protection from external influences.

Advantages: Better sound insulation compared to regular metal tiles. The additional protection for the metal extends the potential service life.

Disadvantages: The main drawback of this type of tile is the high cost of the material.

Terracotta (Architectural)

Terracotta, a ceramic tile, offers several benefits when used in architecture:

Advantages of Terracotta:

- Strength: Terracotta ceramic tiles are strong, with a flexural strength of 16 MPa.
- Frost Resistance: The material boasts a frost resistance rating of up to 100 cycles.
- UV Resistance and Insulation: Terracotta is resistant to UV radiation. Its fine-pored structure helps retain heat and provides sound insulation. It also doesn't accumulate static electricity, so dust doesn't cling to its surface.
- Lightweight: The material is relatively light.

Disadvantages of Terracotta:

- Low Moisture Resistance: Terracotta has low moisture resistance, requiring the use of a special hydrophobic mastic during installation.
- Brittleness: Due to its porous structure, the material is quite brittle and not very resistant to impacts.

Comparison of Ceramic Materials for External Application by Main Physical and Mechanical Characteristics is presented in Table 1.

Table 1. Comparison of Characteristics of Clinker Bricks, Porcelain Stoneware, Facade Ceramic Tiles,

Material	**Strength**	**Water Absorption**	**Frost Resistance**	**Application**
Clinker Brick	35–60 MPa	<6%	F100 – F300	Facades, plinths, paving
Porcelain Stoneware	45–60 MPa	<0,5%	F150 – F300	Facades, flooring, stairs
Facade Ceramic Tile	близько 15–25 MPa	6-10%	F25 – F75	Facade cladding
Roof Tile	20–35 MPa	<10%	F100 – F150	Roof
Terracotta	10–20 MPa	10-15%	F15 – F50	Decoration, architectural elements

Висновки

Ceramic materials remain a reliable and time-tested choice for construction, especially for exterior applications. Their durability, resistance to weather conditions, and visual appeal make them suitable for a wide range of uses—from facades and roofs to paving and cladding. While each type—clinker brick, façade tile, porcelain stoneware, or roofing tile—has its own strengths and drawbacks, proper selection based on technical properties, climate, and project requirements ensures long-term performance and cost-efficiency.

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