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ENERGY-EFFICIENT EXTERNAL SOLAR CONTROL FOR PUBLIC BUILDINGS

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Abstract. The possibilities of energy saving and creating an optimal microclimate in public buildings through the implementation of energy-efficient external shading systems have been studied. The use of inorganic porous basalt material is recommended as a material for external shading. The data presented in the article confirm the expediency of using basalt material when combining different functional solutions (insulation, sun protection) in the development of modern external shading projects for civil buildings.
Key words*:* Energy efficiency, exterior sun control, advantages, basalt material, material qualities, thermal mass, types, modern sun protection systems

Introduction. The problems of energy conservation and creating an optimal microclimate in public buildings in the dry, hot climate of Uzbekistan can be solved by installing energy-efficient sun protection.

Currently, various sun protection devices are known in global and domestic practice, the purpose of which in building interiors is to reduce heat gain during the warm season (so-called passive cooling) and reduce heat loss during the cold season (passive solar heating) [1].

When designing sun protection devices, it is necessary to take into account the orientation of buildings and their purpose.

In ancient times, in Central Asia and the Middle East, buildings were oriented in relation to the prevailing winds in the area so that rooms were constantly ventilated. Windows were covered with special grilles to prevent direct, hot sunlight from entering the rooms, but to allow reflected light to pass through, which did not heat the room [2]. These grilles were called ‘panjara’ (grate) (Fig. 1).

Fig. 1. Fragment of an external sunshade grate (‘panjara’)

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Panjara was carved or cast from ganch. Ganch is obtained by burning stones containing gypsum and clay. Ganch is easy to work with and suitable for pouring into moulds of non-standard sizes and configurations.

Panjara was also made from wood. The lattice was assembled without nails or glue. All parts of the lattice are designed to fit into each other, forming a rigid patterned structure [2].

The practice of using modern sun protection in civil buildings recommends removable, adjustable devices for residential buildings and stationary devices for public buildings [3]. The most common modern sun protection in residential buildings and public office buildings are curtains and blinds, which limit the amount of sunlight entering the premises but do not prevent the rooms from heating up [4].

The advantages of fixed external sun protection are that it improves the indoor climate by effectively controlling the temperature. Fixed sun protection affects the energy balance of buildings, reducing the need for air conditioning in summer and heating in winter. According to statistics, fixed sun protection reduces the need for air conditioning by 60-80% compared to internal sun protection, which provides savings of 20-30% [3]. This ensures the energy efficiency of buildings.

The positive impact of fixed sun protection on the lighting environment in rooms with computers and other screen devices has been noted, due to the reduction of discomfort from brightness, contrast and glare. External sun protection has a significant impact on the exterior of buildings [5].

Despite the obvious advantages of fixed sun protection, it is important to note the existing disadvantages associated with its design solutions (covering part of the light opening with sun protection), disadvantages associated with the sun protection's resistance to external factors such as atmospheric precipitation, ultraviolet radiation, wind loads, and reduced lighting in cloudy weather.

Technologies. The following materials are used for external stationary sun protection: decorative concrete, glass, dense acrylic or glass fabrics, composite materials (high-strength acrylic fabrics, porous inorganic and organic materials). Materials with low heat capacity are selected for sun protection devices to prevent the heat trap effect [6].

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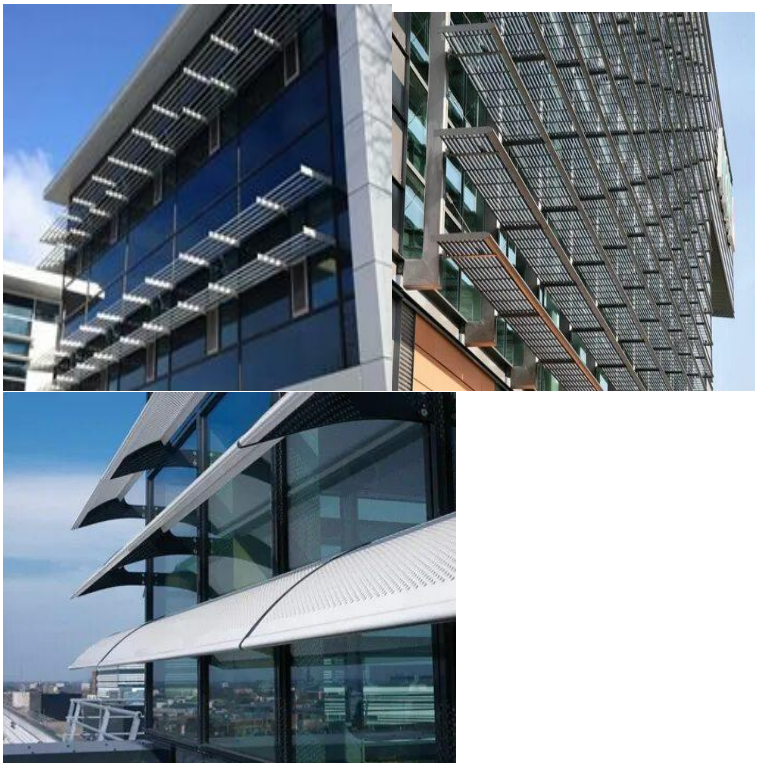

Fig. 2. Fragments of modern external sun protection

In our opinion, the most significant is the modern external sun protection from the manufacturer ALUTECH, which is a fabric canvas fixed in a guide rail and installed outside the building [8].

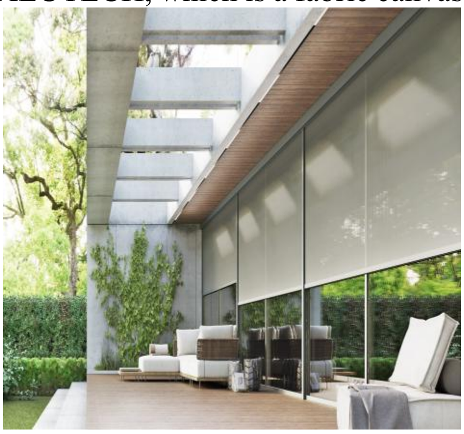

Fig. 3. Fragment of external sun protection manufactured by ALUTECH.

ALUTECH offers installation of its structures depending on their design on existing buildings (surface-mounted or built-in installation) or concealed installation during building renovation. To achieve various architectural solutions in the exterior, an external box with 450 and 900 angles is provided.

Discussion of results. When considering the choice of design and material for external sun protection, the choice of material with low heat capacity values is preferred in order to avoid the heat trap effect.

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In the Republic of Uzbekistan, such a material with low heat capacity is volcanic basalt, from the melt of which high-quality, technologically advanced insulation with a fibrous structure is obtained. The material is environmentally friendly, non-combustible, chemically stable, durable, non-hygroscopic, and does not release harmful substances into the environment [8]. The material guarantees twelve times the impact, vibration and noise insulation.

Basalt owes its durability to silicon oxide, which is contained in the fibres of volcanic basalt.

Inorganic porous materials containing silicon oxide have a unique porous network structure. They reflect and scatter UV rays, improving the photostability (light resistance) of the material, which ensures its durability.

The unique features of basalt include its high heat resistance, which makes it ideal for use in hot and extreme conditions, and the fact that it is non-combustible. Basalt also has excellent resistance to corrosion and chemical exposure, allowing it to be used in aggressive environments. **The heat capacity (thermal conductivity) of basalt material (insulation) is 0.032–0.048 W/m·K [9]. This provides high thermal insulation properties due to the porous structure with numerous air pockets between the fibres.**

Thermal conductivity depends on the type of product: mats — 0.046 W/m·K; lightweight slabs — 0.036 W/m·K; soft slabs — 0.036 W/m·K; semirigid slabs — 0.0326 W/m·K, rigid slabs — 0.043 W/m·K.

The heat capacity (thermal conductivity) of basalt is also influenced by: layer thickness (the thicker the layer, the higher the thermal conductivity); design features, manufacturing quality [10].

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The thermal conductivity of basalt material is regulated by standards, in particular GOST 9573-2012 (an interstate standard that establishes requirements for the thermal conductivity of mineral wool slabs with a synthetic binder).

Density and structure. The high density and fibrous structure of the material ensure strength and resistance to mechanical damage, such as compression or rupture.

The above-mentioned ability of basalt material to combine a variety of functional solutions (insulation, sun protection) is relevant for modern external sun protection projects.

The types of basalt materials produced by well-known manufacturers and most compatible with the selected basalt material for external sun protection structures have been studied [11--16].

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Fig. 4. General view of basalt materials produced

Below are galleries of basalt slabs of various thicknesses and colours, as well as basalt meshes (Figs. 2, 3).

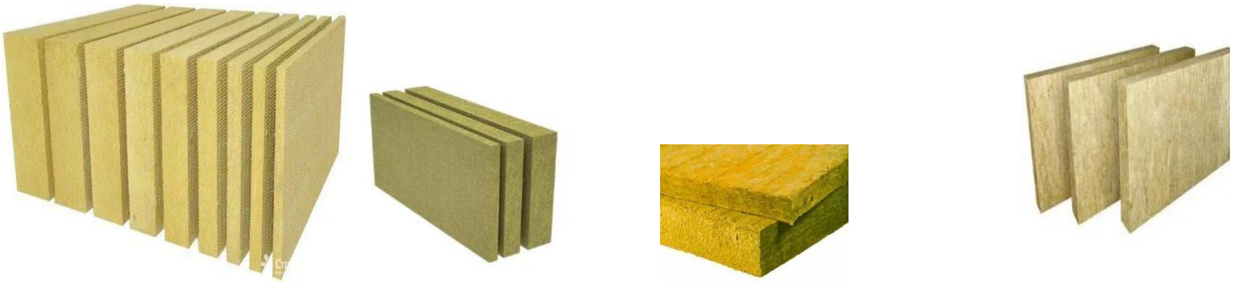

Fig. 5. Gallery of basalt slabs of various thicknesses and colours

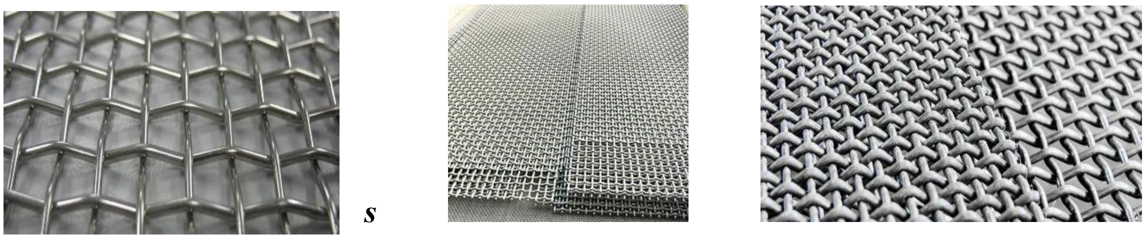

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Fig. 6. Gallery of basalt meshes

Modern types of external sun protection for public buildings have also been studied [11-16]. A combined structure consisting of two or more systems of shading elements in different positions and dynamically adapted to changing conditions (Fig. 7) has been adopted as the basic (supporting) structure made of basalt material.

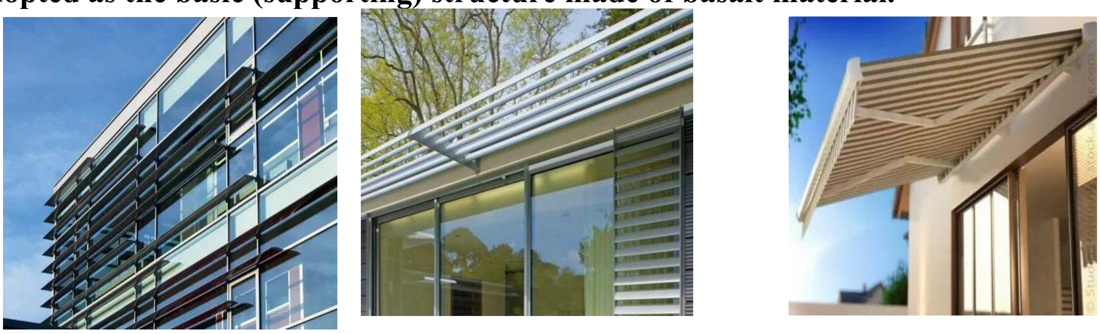

Fig. 7. Basic designs for external sun protection made from basalt fibre

The type of sun protection installation is determined by the functional purpose of the public building, allowing adjustments to be made to the sun protection design and influencing the exterior of the building.

Conclusion.

The advantages described above of modern environmentally friendly volcanic basalt material, which has low heat capacity (thermal conductivity), high density and a fibrous structure, ensuring strength and resistance to mechanical damage.

The ability of basalt material to combine a variety of functional solutions (insulation, sun protection) confirms its applicability in modern energy-efficient outdoor sun protection

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projects with sun protection structures that are dynamically adapted to changing conditions.

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