ACADEMICIA
An International Multidisciplinary Research Journal
(Double Blind Refereed & Peer Reviewed Journal)

DOI: 10.5958/2249-7137.2021.01602.5

ANALYSIS OF THE APPLICATION OF EXTERNAL WALLS WITH A SCREEN AND AN AIR GAP

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ABSTRACT

The article presents the results of the analysis of the investigated external walls of residential buildings with a screen and an air gap in a dry hot climate. The preferred distance between the wall and the screen was set equal to 30-40 cm. With these thicknesses of ventilated air layers, the air temperatures at the wall surfaces behind the screen did not differ from the outside air temperature. An air gap is formed in the process of forming by metal inserts by hollow formers, which are removed after the concrete has hardened. The production of such panels requires special molding equipment of the factory technological lines for the production of external wall panels.

KEYWORDS: *Outer Wall, Screen, Air Gap, Thermal Regime, Thermal Conductivity, Heat Resistance.*

INTRODUCTION

Currently, due to the rapid growth in energy consumption, the question of limiting and saving it by using local energy resources (electrical, solar and other types of energy) for heating and cooling premises, and using external fences with increased heat-shielding qualities has arisen.

The successful solution of the task largely depends on the choice of economically feasible, effective building systems, like the construction of a “Smart Home” - an intelligent control system that allows you to combine all communications in the house into one, controlled by artificial intelligence, programmable and customizable based on the needs and wishes of the owner houses and design of structures of residential buildings in specific construction conditions.

It is very important to effectively solve these problems for areas with extreme conditions, in particular, for areas with hot climates.

High requirements are imposed on construction in Central Asia, dictated, on the one hand, by the need to reduce summer overheating, and for certain areas of overcooling of buildings, on the other, by economic conditions: a decrease in labor intensity and an increase in the level of industrialization of construction, durability, and a decrease in capital and operating costs.

Achieving a high level of thermal comfort in buildings, reducing material consumption in walls and reducing energy consumption for cooling by air conditioning residential premises is facilitated by the transition to the use of external walls with screens and air gaps in buildings.

The purpose of this work is to analyze the use of lightweight concrete panel external walls with a screen for large-panel residential buildings in hot climates, which have improved performance and provide technical and economic efficiency.

In the CIS, hot climate regions include territories of climatic regions III and IV, including vast expanses of Central Asia, semi-deserts of the Caspian lowland, the Lower Volga region and the Transcaucasia.

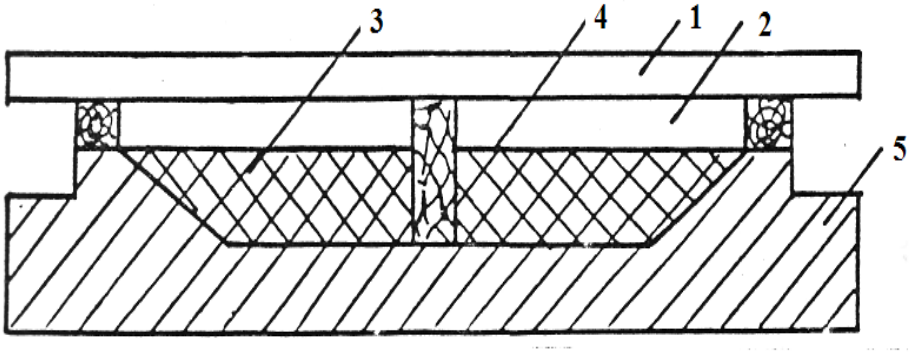
A common distinguishing feature of the climatic conditions of these southern regions is hot, and for the IV region and long summer, characterized by high levels of solar radiation and temperatures with large daily fluctuations, great dry air, strong winds, dust storms, little rain and poor vegetation.

The practice of constructing panel buildings with screened exterior walls has little experience so far. Shielding of external walls is used mainly in public buildings, such as the National, Russia and Belgrade hotels in Moscow, a shopping center building in Tashkent, an experimental 5-storey large-panel residential building in the years. Batumi, Vitebsk, Bukhara.

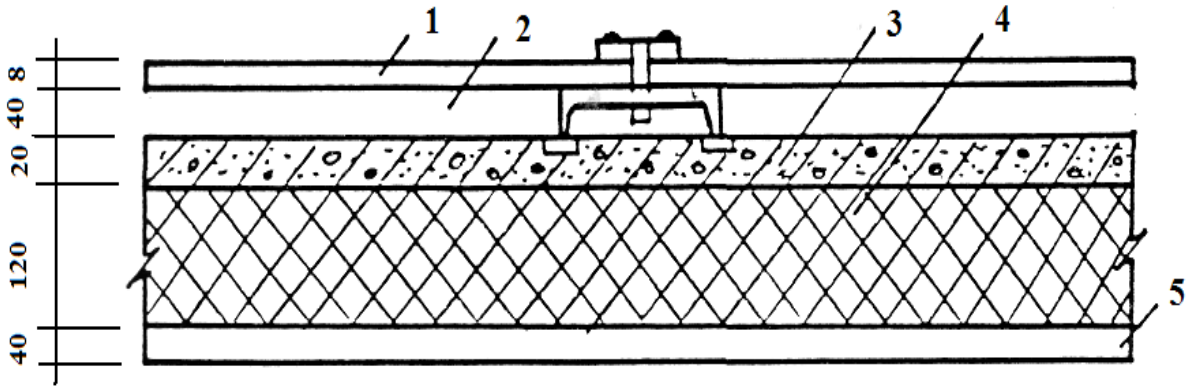
Wall constructions with a screen were developed by TbilZNIIEP [2], "Kievorgstroy" trust [3], Tash ZNIIEP [10], as well as some individual authors. [6,8]

The design of the outer walls with a ventilated air gap and thin mineral wool insulation turned out to be unsatisfactory due to the violation of a number of design requirements

In fig. 1.shows the design of the external wall panel used in the construction of a residential building on Sayat-Nova street in Yerevan, proposed by GS Dzhanyan [5].



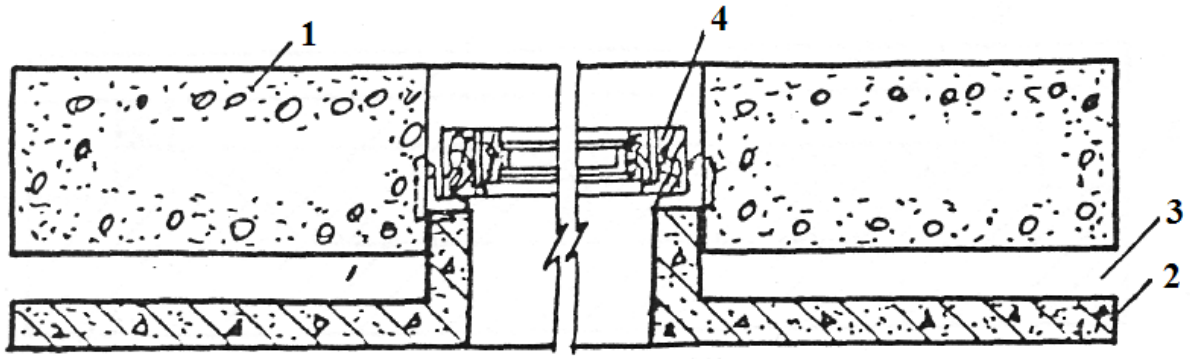
Picture.1.Solution of a ventilated panel for a residential building on the street.Sayat-Nova in Yerevan: 1-plaster on shingles; 2-air gap; 3-mineral wool slabs; 4-coating with bitumen; 5-reinforced concrete panel. In Picture 2.shows the outer wall with screens made of sheet materials, proposed by G.N. Bazylenko [1] 1970



Picture 2. The design of the wall proposed by G.I. Bazylenko:

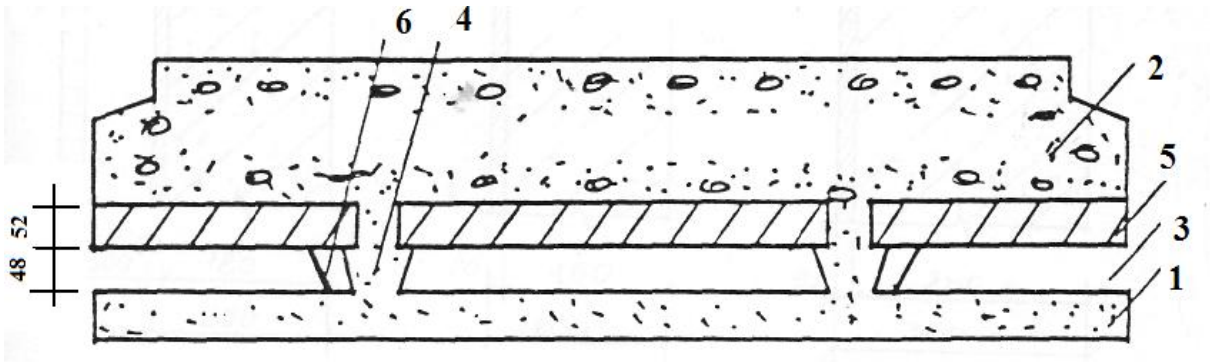
1-asbestos-cement screen; 2-air gap; 3-reinforced concrete slab 4-mineral wool insulation; 5-textured layer.

The heat-shielding properties of lightweight and lightweight wall fences from the effects of solar radiation in the summer in the whole of Belarus have been investigated, and it is recommended to improve the heat-shielding qualities of lightweight panels of prefabricated construction by shielding external wall fences.



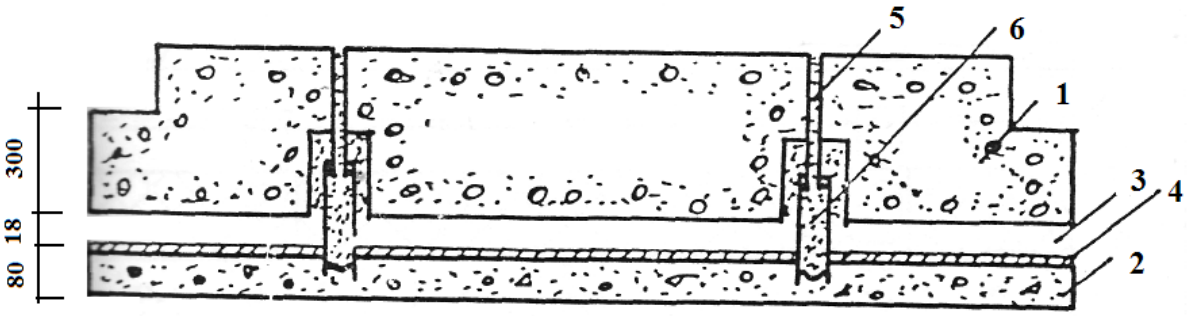
Picture3.Fastening a reinforced concrete screen to the main part of the outer wall panel of a 5-storey residential building in Batumi: 1-main part of the lightweight concrete panel; 2-screen made of reinforced concrete; 3-air gap; 4-window unit

Institute TbilZNIIEP designed a 5-storey large-panel residential building with shielded external walls, which was built in Batumi in 1974 [2] production and installation of the main panels and screens were carried out separately. The screens are made of reinforced concrete 50 mm thick, they are attached to the main panels along the contour of the window opening with concrete ribs (Fig. 3). The experience of factory production, transportation and installation of separately manufactured screens requires additional labor costs. During transportation and installation, a large number of breakdowns of screens take place.



Picture-4. External walls with a screen: (Bogdanov, Kozhan) Kiev. 1-screen; 2-inner layer; Z-air gap; 4-transverse ribs; 5-insulation.

The "Kievorgstroy" trust has developed panels with a screen made in one production cycle (Fig. 4) [3]. The connection of the main panel and the reinforced concrete screen is carried out along the perimeter of the window opening with ribs made of heavy concrete. An air gap is formed in the process of forming by metal inserts by hollow formers, which are removed after the concrete has hardened. The production of such panels requires special molding equipment of the factory technological lines for the production of external wall panels. This design has not yet found industrial application in construction practice.

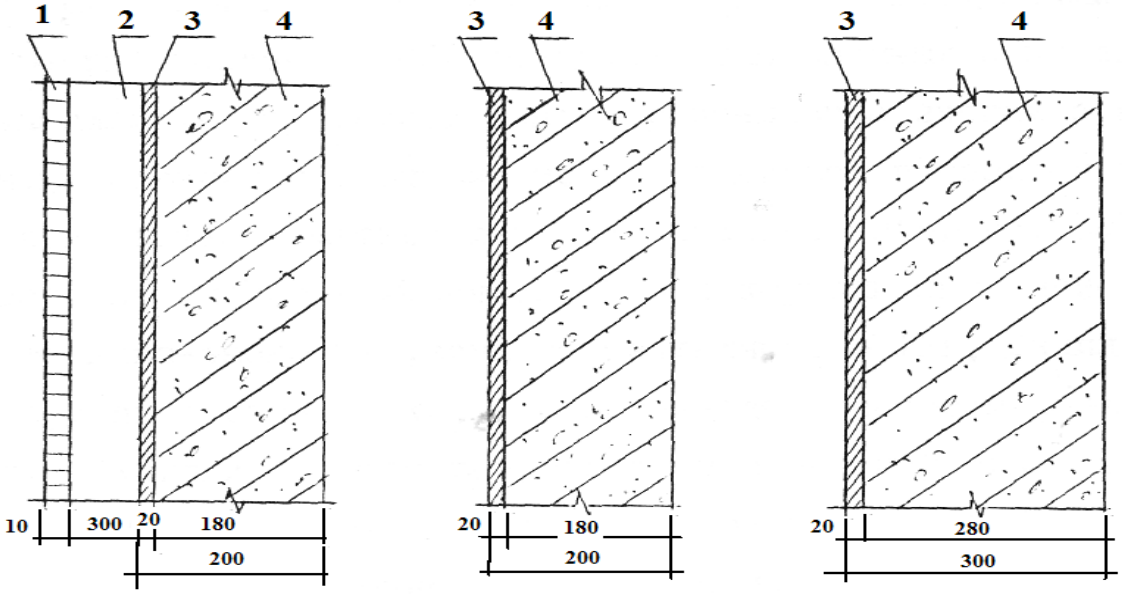


Picture5.External wall panel with a screen on the relative: 1-main part of the panel; 2-screen made of reinforced concrete; 3-air gap; 4-separating layer (sand); 5-telescopic connection; 6-claydite mortar on fast-hardening cement.

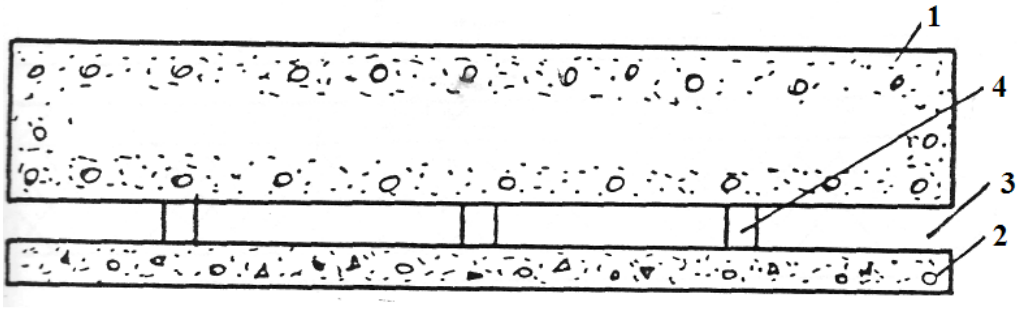
Panels with a screen on telescopic connections were manufactured in one production cycle in existing factory forms and mounted in a five-storey residential building in Vitebsk in 1974 by VV Kharyanov [11]. Moving the screen (fixing) the injection of the cavities of the telescopic connections was carried out during the installation process, which complicates the installation technology (Picture5).

To fill the cavity of vertical joints between the panels, an inventory wooden joint formwork was installed, which was removed after the end of concreting. The joints between the screens remain open, which does not give a certain air movement in the interlayer.

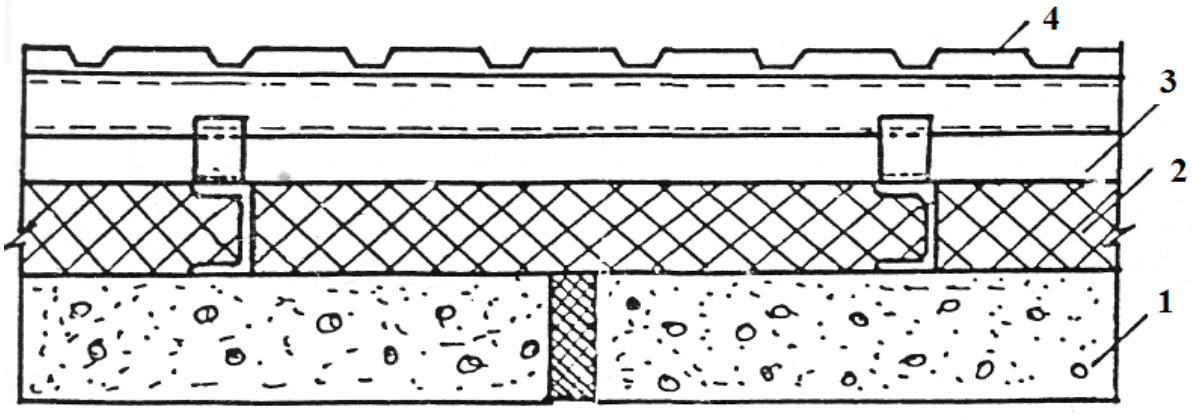
In the design, the screens made in 1981 at the Chirchik Combine of Building Materials and Structures were made of flat asbestos-cement sheets (Fig. 6) [10].



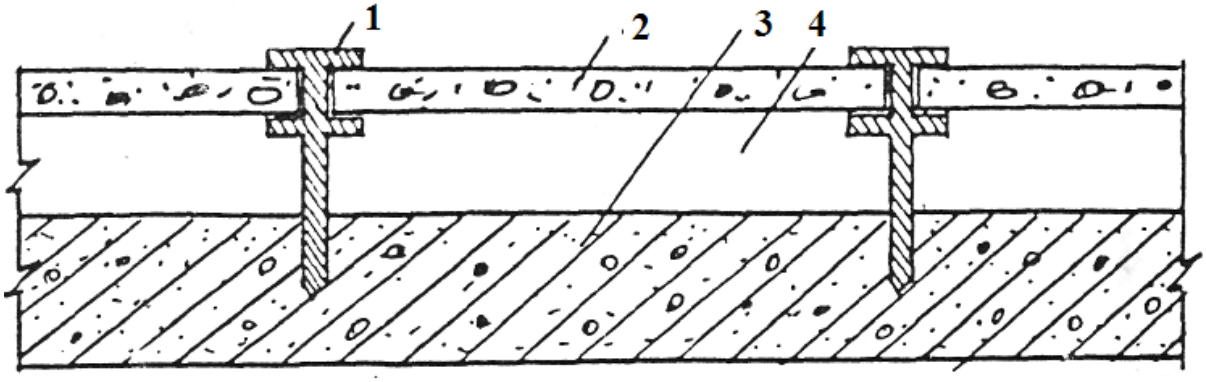
Picture6Sections of the studied panels: 1-asbestos-cement sheet; 2-air gap; 3-textured layer of cement-sand mortar (ρ=*1700* кг/м^3); 4-expanded clay concrete (ρ =1200 кг/м^3).



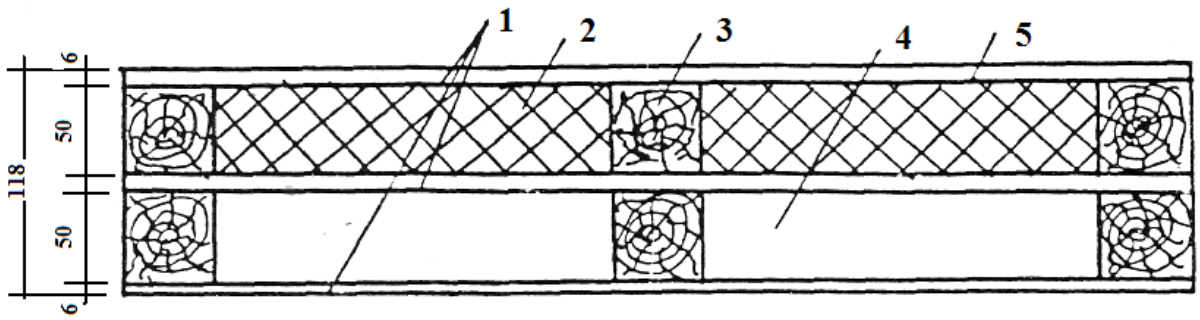
Picture7Shielded wall panel with a ventilated air gap formed by a polystyrene layer (England): 1-main part of the panel; 2-screen; 3-air gap; 4-links..



Picture8. Multilayer wall with a continuous air gap (industrial building): 1-concrete slab; 2-insulation; 3-bed or channel; 4-outer screen.



Picture 9.Cladding of wall panels on the side (Mesropyan et al.) Installation scheme for flat anchors with I-beams: 1-anchor; 2-facing plate; 3-concrete; 4-air gap.



Picture10. Ventilate dair cushion panel:

1-asbestos-cement sheet 6mm thick; 2-mineral felt 50mm thick; 4-ventilated airgap 50mm thick; 5-vapor barrier.

Analyzing the foreign experience in the construction of buildings with shielded external walls, one can be convinced of a wide variety of materials used for screens, the choice of which determines their physical, mechanical and decorative properties, as well as technical and economic indicators. In Germany, Denmark, Holland and other countries, such walls are erected using the method of element-by-element assembly. In England, there are developments of external wall panels with a screen, manufactured in one production cycle with bringing them to full readiness in the factory.(Picture7).

In hot countries (India, United Arab Republic, Egypt), screens with significant heat capacity are preferred, while the walls themselves are made extremely light.

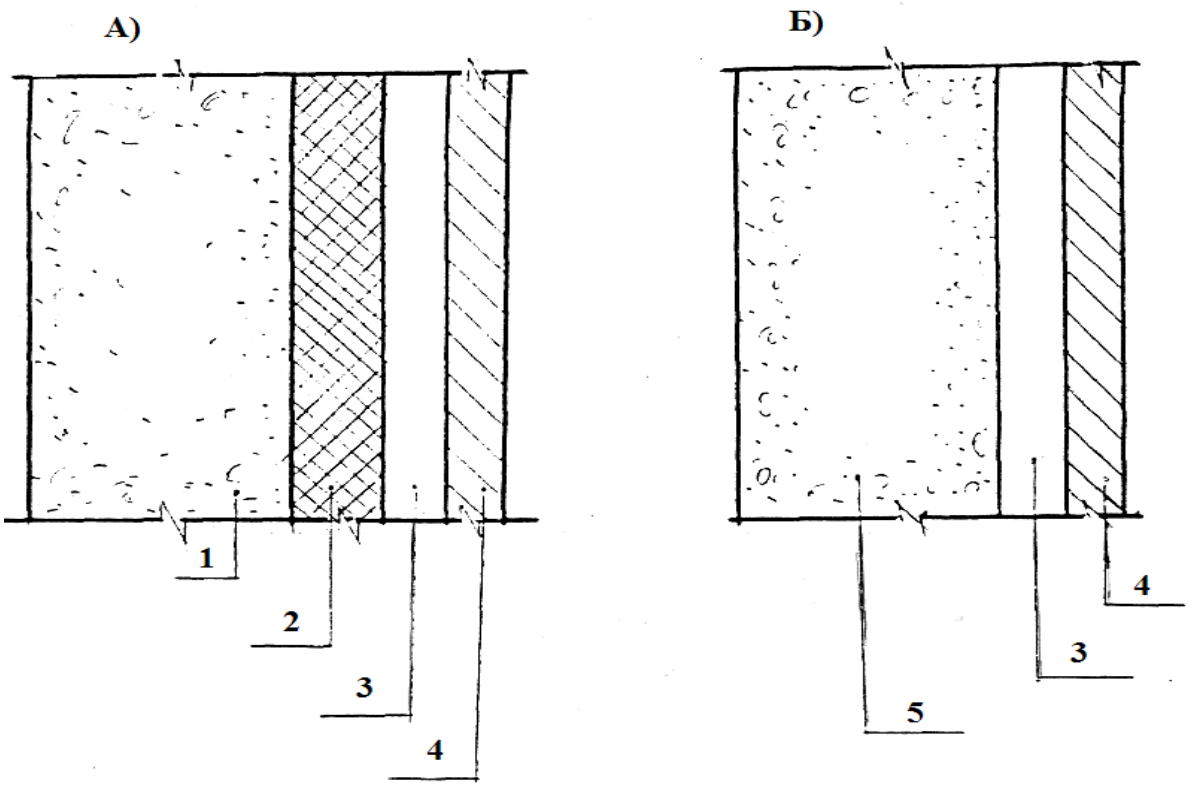
The work of M.L. Wagneur [19] provides for the thermal insulation of walls with air gaps and the choice of a method for warming the outer masonry. Additional insulation can be removed in three ways:

-it can be applied on the inner surface of the bearing masonry;

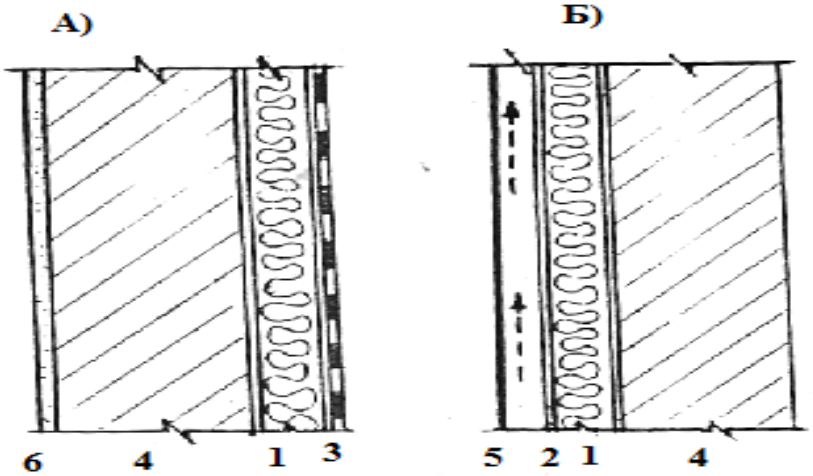
- it can partially fill the air gap;

- it can fill the air gap.

In the work of H. Canis [21], protective heat-insulating screens are described as a second wall cladding. Thermal insulation applied outside, open structure and pores is applied. The thermal insulation layer is protected by a second shell, ventilated from the inside.



Picture11. Schematic illustrations of wall structures with an air gap. a) with a heat-insulating layer, b) without a heat-insulating layer. 1-bearing layer; 2-thermal insulation layer; 3-air gap; 4-façade layer (rain protection); 5-bearing and heat-insulating layer.



Picture 12.Placement of the advantage of the thermal insulation layer located outside. A - outside; B-inside: 1-thermal insulation layer; 2- layer of wind protection; 3-vapor barrier; 4-bearing layer of the wall; 5-shell "on the relative" / facing /; 6-external plaster.

Erich Jizlelski's work [16] highlights measures to ensure ventilation in the outer walls: a multi-layer wall with profiled heat-insulating elements, an outer wall made of structural lightweight concrete with pipe-shaped ventilation ducts, as well as a number of design measures to ensure the geometric parameters of the ventilated space.

Ventilated concrete exterior walls are economical only if manufactured as an element. Additional fastening of the cladding shells of the screen plate leads to economically unsatisfactory solutions.

Reduction of heat input is of particular importance, since the thermal parameters of light external walls are calculated for the winter and summer periods by A. Berit [14].

The temperature on the inner surface of the light outer walls increases with an increase in the angle of deflection of the direction of the air flow in the exhaust openings.

In the work of K. Gertis [17], the influence of air flow in the air layer on the heat-shielding properties of the outer walls was investigated. The calculations were based on flow velocities from 0.2 to 2 m / s. For a long time, on average, lower flow velocities are effective: from 1 m / s and below.

External wall constructions with optimal thermal protection are provided in the work of H. Hebgen., F. Heck [18]. Air-cushioned exterior walls are traditionally used in rainy areas with stormy winds (German, Dutch and Danish coastal areas). In this case, the enclosing walls consist of an internal load-bearing wall made of conventional building materials, an external screen wall with a thickness of 11.5 cm from clinker or facing stones and a continuous air gap formed between these two walls with a thickness of 5-7 cm.

In the work of K. Liersh [20], external walls with a ventilated layer and a heat-insulating layer located outside are a good design for heat insulation in the summer (Picture 12).

From foreign studies of walls with screens, one should note the work of G.C. Borel [15], which describes the results of field studies of various types of wall shading. The work was carried out in the Sahara in 1962. Solid vertical screens 3 m high and 1.5 m wide, parallel panels and screens consisting of wooden plates were investigated. The preferred distance between the wall and the screen was set equal to 30-40 cm. With these thicknesses of ventilated air layers, the air temperatures at the wall surfaces behind the screen did not differ from the outside air temperature.

Analysis of the review of research works, domestic and foreign experience in the design and construction of buildings indicates that in the field of industrial construction there is an urgent need to eliminate significant defects in the enclosing ability of panel external walls to achieve effective thermal protection of walls, taking into account energy costs in winter for heating and in summer for microclimate conditioning in buildings.

Of all the possible design solutions for panel walls and the most reliable means of improving the enclosing ability of external walls, a wall structure consisting of a sunscreen separated from it by an air gap communicating with the outside air through slots and openings can be used.

One of the main obstacles to the spread of external wall shielding, invisibly, is the complexity of the proposed structures and their production technology.

According to the structural and technological feature of possible solutions, external wall panels with a screen can be divided into two types:

- a panel with a separately manufactured screen with its subsequent separate installation at the building;

- a complex wall panel with a screen, manufactured in one technological cycle.

The existing works do not have recommendations for constructive and technological solutions, which, in combination with the above measures, provide a significant improvement in the thermal regime of apartments in conditions of summer overheating, as well as energy conservation in winter.

At the same time, the data presented indicate insufficient development of the technology for the manufacture and design of panel walls with screens. There are not enough specific ideas for the design of panel walls with screens and their further operation.

To achieve this goal, it is necessary to solve the following tasks:

1. Justify and experimentally develop structural elements of a panel outer wall with a screen.

3. To investigate the technological processes of manufacturing the structure of the panel with the screen.

4. Justify and develop a targeted structure of expanded clay concrete for use in the developed structure.

5. Make experimental samples and fragments and test designs in factory and building production.

6. Experimentallyandtheoreticallydeterminetherationalthicknessoftheventilatedairgapandscreeninthewallstructure.

7. Conduct theoretical studies of the quantitative effect of shielding lightweight concrete panels in the hot season.

8. To design and manufacture prototypes and industrial designs and mount them in a large-panel residential building.

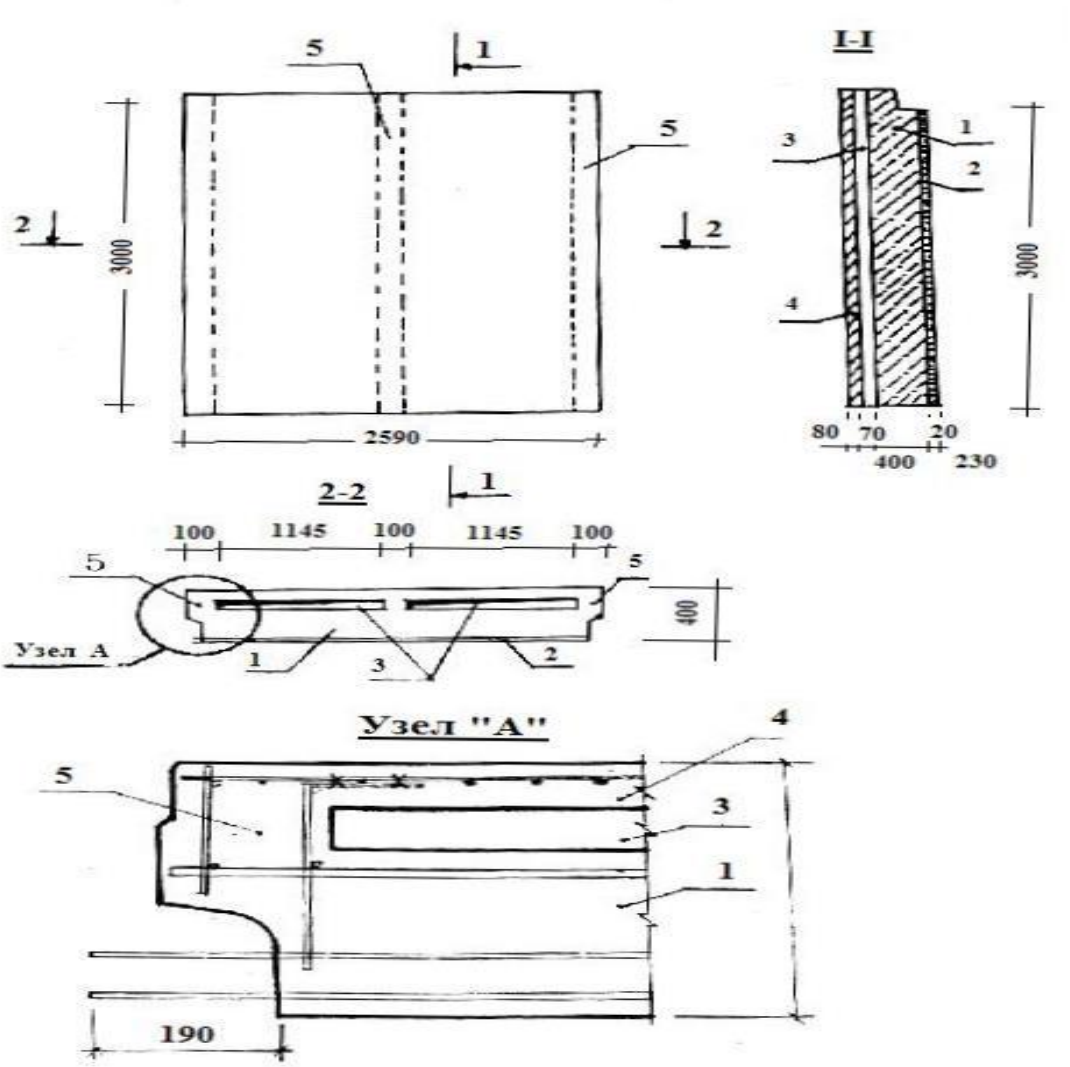
9. Make observations and evaluate the performance characteristics of the outer wall structure with a screen in summer and winter conditions.

10. Obtain experimental data on the distribution of temperatures in the sections of a wall with an interlayer and the amplitude of temperature fluctuations on the inner surface.

11. Carry out feasibility studies and develop recommendations for the design and construction of the structure of lightweight concrete external walls with a screen.

As a result of design studies, with the participation of the author, carried out in the TsNIIEP of the dwelling, a fundamentally new structure of a lightweight concrete panel of the outer wall with a concrete screen was created, manufactured in a single technological cycle.

Experimental and production check of external wall panels with a screen, manufactured in a single technological cycle, their installation on the end wall of a 5-storey 60-apartment residential building series III-146, was carried out in Bukhara. (Picture13)



Picture 13.Experimental panel construction: 1-main part of the wall; 2-inner finishing layer; 3-air gap; 4-screen;5-connecting ribs.

On the basis of the proposed study of lightweight concrete large-panel walls with a screen for hot climates, a method was created for constructing walls with a screen that would improve the operational mode of living in houses under construction in areas of hot climates.

Thus, the study allows us to draw the following conclusions on the design of external walls with a screen and an air gap.

1 The described study by the method of experimental design and experimental production of sample fragments confirmed the possibility of manufacturing panels with a screen and an air gap in a single technological cycle.

2. Analysis of the results of theoretical calculations shows that walls with vertical screens and a ventilated air gap are a fairly effective means of reducing the impact of solar radiation on buildings and reducing the cost of cooling the premises.

3. The choice of the type of screen and the thickness of the interlayer should be decided in each case when designing the walls of the building: if the screen is part of the panel, the thickness of the interlayer should not exceed 5-10 cm. Removing the screen over long distances is impractical, since it will not reduce the temperature ...

4. The results of calculations show that to improve the heat-shielding qualities of the investigated enclosures of structures, it is advisable to use screens with a ventilated air gap.

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