New Life of Traditional Finishing Materials in Architecture of Facades of Modern Buildings.

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Abstract. The emergence of new finishing materials in the construction market has long been commonplace. However, traditional finishing materials of natural origin are still in demand for the consumer due to their proven environmental friendliness and relevant in the construction of elite architecture. Science offers new innovative developments based on traditional natural finishing materials. This article provides an overview of some of these proposals, which have been tested and gradually introduced into the construction business. The aim of the article is to reveal the properties of new composite finishing materials, where the basis is natural, environmentally friendly components, in terms of their effective and reasonable application in architectural practice. Taking into account the new forming properties of such materials, the article gives some recommendations for their use in the creation of architectural solutions of building facades. This task is relevant due to the fact that the right choice of the most suitable building material by the architect is the key to the most worthy combination of expressive architectural design with rationality and efficiency of its implementation.

1. Introduction
For centuries, the search for an original architectural form was accompanied by a difficult choice of suitable construction and finishing material. The process of interaction of architectural forms and building materials has always been not simple. This has progressively stimulated the development and expansion of the palette of both structural and finishing materials. In the industrial and post-industrial era, the process of improving building materials intensified due to the development of complex and high-precision technologies of their production. A lot of artificial composite materials appeared, surpassing traditional natural materials in their physical, technical and aesthetic properties. Modern innovative technologies expand the range of application of traditional materials, giving them new, even more attractive qualities. Improvement of building ceramics, of materials based on wood and natural stone, of fiber-concrete, is most clearly manifested in the appearance of buildings and their facades.

Achievements of the construction industry in the field of structural systems, materials and technologies give modern architects extremely high opportunities to create creative architecture that forms both new architectural complexes and objects in protected areas of historical cities. Innovative building materials involved in the formation of building facades, the vast majority – familiar materials
with a long history, but improved, endowed with new useful qualities that make these materials even more popular.

2. Overview, suggestions and recommendations

There are a number of different traditional finishing materials, which as a result of innovative technological developments of their production have acquired new qualities that have expanded the range of possibilities of these materials and their applications.

The most popular finishing facade materials based on materials of natural origin are still ceramics: ceramic and porcelain-stoneware tiles, ceramic panels and, of course, facing bricks. But progress does not stop there.

Spanish developers introduced to the construction market an innovative flexible ceramic material Flexbrick, which opens up great opportunities in the decoration of creative architectural curved surfaces. The material consists of small blocks of baked clay, which are fastened together with metal wire in rolls or flexible sheets. The ways of mounting the ceramic blocks in the coils can form a continuous dense coating or through structure in the form of decorative ceramic grids. Mesh made of ceramics intended for shading open or glazed rooms or for creating conditionally enclosing structures. The color range of the Flexbrick coating is quite wide, thanks to the pigment added to the light clay in the production of ceramic blocks. This allows you to create a variety of solutions of architectural compositions of building facades [1].

![Figure 1. Flexible ceramic material from the Spanish firm Flexbrick.](image)

Definitely innovative finishing material should be considered to have appeared on the market material called "flexible ceramics" or "ccflex". The material consists of a split modified clay (83%) applied to a reinforcing base of a glass-mesh with the addition of polymer binders and other fillers and baked. Then material is covered by a transparent, elastic protective layer. The result is a material with unique properties, combining environmental friendliness, breathability, surface strength and durability (at least 20 years), incombustibility, resistance to moisture and freezing, the formation of dirt, mold and fungus, characteristic of natural ceramic products, and at the same time elasticity, resistance to thermal deformation, crack resistance, thinness (about 4 mm) and relatively low weight (4-5 kg/sq.m), characteristic of fabric and polymer materials. Flexible ceramics is produced in the form of rolls (0.7 x 25 m) on the type of thick Wallpaper or in the form of large-format tiles (the most popular size is 580 x 280 x 4 mm) on the type of tiles. The decorative layer usually depicts of facing ceramic brick and tile, glossy and matte, as well as veneer stone with a homogeneous structure is limestone or sandstone. The material is glued to the lined and primed facade surfaces with special elastic adhesives for external works on the basis of cement. The attractiveness of this material is determined by two factors. First, they can decorate any non-linear surface - round columns, slopes of rounded openings, arches, and other forms. Secondly, "flexible ceramics" is glued to any mineral bases (all types of concrete, brick, sheet material containing cement or magnesite, etc.), as well as to the slab insulation (density of at least 80 kg/sq. m, including facade polystyrene), without the use of substrates and bearing substructures. They can also paste over the existing old facade covering during repair, reconstruction or restoration works [2].
"Flexible ceramics" or "ccflex" - lighter in weight and easy to install alternative to natural ceramic cladding.

"Flexible stone" has similar finishing characteristics and represents the thinnest cut of natural stone (as a rule, Sandstone), pasted on a flexible basis – glass-mesh and produced in the form of a roll up to 2.8 m long or in the form of plates of various sizes close to the size of natural finishing stone slabs. The disadvantage of this material is the complexity of its production and, accordingly, the high price comparable to the price of a stone of standard thickness. This fact limits the use of "flexible stone". However, its physico-technical and aesthetic properties, characteristic for natural finishing stone, as well as low weight (3-4 kg/m²), flexibility and the ability to lie on curvilinear surfaces make it attractive in the decoration of presentation buildings in which the structural system is not designed for large loads of facade cladding.

Figure 3. "Flexible stone" is a lighter in weight and easy to install alternative to natural stone cladding.

However, more often used cheaper, and therefore more popular production technology "flexible stone". It provides for the application of a composite coating on the glass-mesh. The coating consists of a crumb of natural finishing stone (usually marble), water acrylic copolymers, pigments and auxiliary additives. This material is also available in the form of plates up to 600 mm in size and a thickness of 3 mm or in the form of rolls of Wallpaper type with a width of about 1 m and a length of up to 2.5 m, creating the effect of seamless cladding. The appearance of this finish looks less noble than the cut of natural stone, but nevertheless is in demand due to the peculiar beauty, relative cheapness, low weight and ease of installation [3].

Facade cladding panels on the basis of "liquid wood", or rather – on the basis of wood-polymer composite, in its structure contain crushed to the state of flour wood (more than 60%) and specially selected polymers subjected to high temperatures and pressure. The result is a composite eco-friendly material that combines the properties of natural and synthetic fillers: aesthetic appearance of natural wood, its realistic imitation, high thermal insulation and durability (up to 30 years), resistance to moisture and biological effects, and most importantly - to fire. Such panels in the overwhelming majority externally create the effect of wooden siding and are mainly used in houses of small and medium-story level as facing of a ventilated facade. In addition, "liquid wood" is used in finishing as a paint material to create durable and wear-resistant coatings that mimic wood [4]. The use of this material in other areas (for example, in sculpture) shows that the plastic capabilities of "liquid wood" have not yet been fully disclosed in construction.
Another material of interest to architects in terms of its shaping potential is fiber-cement. Fiber-cement (or fiber-concrete), known to us since the beginning of the 20th century, initially has such valuable qualities for architecture as strength and durability, lightness and plasticity, resistance to cracking, fire, chemicals, biological and climatic influences. One of the main advantages of fiber-cement products over reinforced concrete is their thinness (only 6-18 mm, taking into account the finishing layer), due to the lack of metal in their structure, which requires a protective layer (30 mm) from corrosion and fire. Replacement of reinforced concrete on fibrocement in facing of a facade allowed to reduce significantly their weight, to save on their transportation, to save on labor costs of production and installation, on materials. This also allowed the use of load-bearing structures designed for lower loads, and thus significantly reduce the cost of construction as a whole [5].

Currently, as a result of scientific developments and technological innovations, fibro-cement has overcome such a significant drawback as hygroscopicity. This significantly increased its competitiveness in a number of facade cladding. As a result of the replacement of the original asbestos fiber as a reinforcing material with other types of fiber – steel fiber, alkali-resistant glass fiber, ordinary glass fiber, synthetic fiber, - this material has become more environmentally friendly and interesting for interior decoration.

A special place in the number of varieties of fiber-cement is glass-fiber-cement, where the main materials used superfine durable fiberglass or glass-polymer fiber, fine high quality cement (mainly alumina) and mineral filler. This material has exceptional plastic and strength characteristics, allowing to make products from it with forms of increased complexity and with relief surfaces, which made it a worthy alternative to natural stone, concrete and gypsum in the production of architectural decorative elements of facades. As a result, architectural decorative products made of glass-fiber-cement were called "architectural concrete", "artificial stone" [6]. In their aesthetic and strength qualities they are not inferior to products made of natural stone, and, in addition, they are cheaper and easier. Such architectural elements are made thin-walled and hollow inside, regardless of their geometric dimensions, no matter how large they are. This made it possible to reduce their weight many times and made it possible to use them not only with the traditional load-bearing outer wall, but also in combination with frame systems of hinged facades, which is especially important for modern architecture.
In addition, the complex stylistic architectural decor of glass-fiber-cement is very popular in the restoration work of the facades of historical buildings, as well as in the new construction of buildings in the protected area of old cities, where new buildings should maintain the existing specific retro environment.

However, fibrocement found the greatest application in architecture of facades as sheet panels. They are used as an independent facing of ventilated facades or as an integral part of composite, multilayer insulated facade panels. Fiber cement panels are also successfully used in pitched roofs, simulating a ceramic shingles and slate, and they show much less fragility and heaviness than the simulated material.

![Figure 6.](image)

**Figure 6.** The most common method of application of fiber-cement panels in the ventilated facade with insulation.

The possibilities to vary the decorative characteristics of the front layer of fiber-cement panels are very large. The panels can be smooth, colored—with a painted front surface or painted in the mass, with film coatings with a pattern and photo effects. They can be textured, with a relief pattern. The front layer can imitate traditional natural materials—brick cladding, natural stone, wood, realistically conveying their color and texture.

However, the inventors are not limited to simply expanding the palette of decorative properties of the coating of fiber-cement panels and set themselves tasks aimed at feasible solution of actual environmental problems. At the beginning of the XXI century was invented photocatalytic concrete with photocatalysts such as titanium dioxide in its finishing layer. This allowed not only to achieve a dazzling whiteness of the wall panels and their self-cleaning, but also to reduce the concentration of pollutants in the ambient air. Such paint compositions and dyes-plasters of concrete surfaces are used in recent years in Italy, France, Japan, Belgium, the USA. Under the influence of sunlight, such materials are able to purify air up to 70% near of 2.5 m, which is especially important for the design of facades of buildings along city highways [7, 8].

Japanese manufacturers of fiber cement panels offered unique coatings such as hydrophilic-ceramic and photo-ceramics, which give panels the ability to self-cleaning and additional resistance to ultraviolet radiation. In addition, the photoceramic coating containing photocatalysts neutralizes bacteria and harmful chemical compounds falling on the panel, decomposing them under the influence of ultraviolet, and thus beneficially influences the environmental environment.

![Figure 7.](image)

**Figure 7.** The use of photo-ceramic facade of the Japanese company KMEW area of 170 m2 cleans the air as efficiently as 12 poplars.
High variability of finishing properties of fiber-cement panels allows to significantly expand the range of creative possibilities of architects in the formation of a variety of architectural solutions of building facades. This is especially true in mass residential development, when on the basis of the same or similar space-planning and structural solutions of residential and public buildings are a variety of options for their facades using the same cladding material, but with a modified front layer. These options may differ on the subject of compositional solutions, the nature of the rhythmic system, the scale of the divisions, the degree of dynamism, depending on the overall artistic solution of the architectural complex.

Figure 8. The use of fiber-cement panels with different color-texture finishing layer allows solving complex architectural-compositional town-planning tasks.

Depending on the compositional role of the building in the system of the architectural complex, the building can be given the appearance of an accent or background through the use of combinatorial capabilities of different in shape, size and color-textured finishing of fiber-cement cladding panels. Certain color-textured combination of facade elements can, if necessary, create the impression of changes in the shape, size and proportions of the building, to achieve the effect of its deformation, optical correction and thereby increase its architectural and artistic expressiveness. The nature of these combinations, based on the contrast or nuance of relations, on a rigid rhythm or picturesque arrhythmia can regulate the emotional mood of perception of the formed urban environment [9].

Fiber cement panels, along with metal cladding, are widely used in the so-called parametric architecture. Modern digital technologies make it possible to design buildings of the most complex shapes, where curved surfaces form overflowing spaces, lose the significance of walls and roofs, form a single whole like a complex abstract futuristic sculpture. With the help of graphic and engineering programs, these forming surface-shells in the project are cut into their constituent segments and then in reality are assembled on a complex constructive basis of load-bearing framework meshes, curved trusses and beams according to the calculated specifications. Fibro-cement light thin-walled panels are made for any shape and size, perfectly suitable for segment elements in the formation of such surfaces. A worthy example of their application in parametric architecture is the construction of the Heydar Aliyev cultural center in Baku under the project of Zaha Hadid.

Figure 9. Panels made of glass fiber-reinforced concrete are the main material used to form the curvilinear enclosing shell of the Heydar Aliyev Center, designed by Zaha Hadid.

In this object, "the Structure contains about 15,000 panels, each of which has a unique geometry, can reach 1.5 m wide and 7 m long, and none is like the other. Under the panels are 40 000 m of metal pipes designed in 3D-programs. Each of the pipes has a unique size and a unique place in the
construction, which allows you to precisely join the panels and fix its positions», - Thomas Winchester, lead engineer of the Heydar Aliyev center project, told [10, 11].

3. Conclusions
The emergence of innovative features of traditional building materials allows you to take a fresh look at the process of form creation in architecture. Projects that seemed frankly fantastic a few decades ago are being implemented. The usual attitude to gravity, to the rhythmic laws of form organization, to the interaction of spaces and to the surfaces that form them is changing. Not only the approach to the formation of buildings in the urban environment is changing, but also the perception of architectural spaces. A new aesthetic is born. And all this is done largely due to the development of innovative technologies of building structures and materials.

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