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Decoration of the Front Ceramic Brick by the Method of Engobing

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Abstract

Introduction. The ceramic face brick, which comes with a range of surfaces, shapes and color palettes, is highly sought in the Russian construction market. Engobing is an effective method of color decoration of ceramic bricks, however, an individual selection of an engobe composition for each type of product in a factory setting is critical considering a raw material base used, production modes and a necessary aesthetic solution. In the context of import substitution, the issue of replacing European manufacturers of decorative coatings and organizing the manufacturing of engobes at Russian enterprises has gained relevance. The aim of the study is a comprehensive investigation of the engobing method in order to obtain face bricks with high aesthetic characteristics, stable performance and its introduction into production in view of the domestic construction market.

Materials and Methods. For the experiments, two types of 1NF face bricks with a smooth surface were selected as the basic products for applying an angular layer: red and brown one produced by means of the plastic molding technology. The compositions of engobes for decoration were developed using frit from the Dulevsky Paint Factory in three main colors: white-beige, brown and graphite. Laboratory studies of engobe coatings, semi-industrial tests of compositions with various options for applying to bricks, as well as of the properties of finished products were performed as part of the research.

Research Results. As a result, 8 compositions of engobes were developed and approved that after burning provided a defect-free and durable coating of the spoon and poke surfaces of the bricks, and methods of applying engobes were set forth for aesthetic expressiveness of the product itself as well as the brickwork.

Discussion and Conclusion. One of the brick factories in the south of Russia was tasked with developing non-ferrous cast compositions considering studies and analysis of global trends in brick design and consumer demand as well as with decorating ceramic face bricks in production conditions. These experiments were successfully implemented in production, which boosted the volume of products sold in the construction market of the south of the Russian Federation, expanded architectural and design possibilities for new planning solutions. The results obtained in the field of brick color decoration are in alignment with the factory parameters, marketing goals as well as economically profitable allowing for expansion of the range of manufactured and sought products in the domestic construction market.

Keywords: brick, engobe, composition, angobirovanie, production technology, color, shade, surface, decorative masonry

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Оригинальное эмпирическое исследование

Декорирование лицевого керамического кирпича методом ангобирования

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Аннотация

Введение. Лицевой керамический кирпич, имеющий варианты разных поверхностей, форм и цветовой палитры в настоящее время очень востребован на строительном рынке России. Ангобирование является эффективным

методом цветного декорирования керамического кирпича, однако необходим индивидуальный подбор ангобного состава для каждого вида изделий на заводе с учетом используемой сырьевой базы, производственных режимов и необходимого эстетического решения. В условиях импортозамещения важным стал вопрос замены европейских производителей декоративных покрытий и организации производства ангобов на российских предприятиях. Целью работы является комплексное исследование метода ангобирования, направленное на получение лицевого кирпича с высокими эстетическими показателями, устойчивыми эксплуатационными качествами и внедрение его в производство с учетом отечественного строительного рынка сбыта.

Материалы и методы. Для проведения экспериментов в качестве базовой продукции для нанесения ангобного слоя выбраны два вида лицевого кирпича формата 1 НФ с гладкой поверхностью: красный и коричневый, производимые по технологии пластического формования. Составы ангобов для декорирования были разработаны на основе фритт «Дулевского красочного завода» в трех основных цветах: бело-бежевый, коричневый и графитовый. В ходе работы были проведены лабораторные исследования ангобных покрытий, полупромышленные испытания составов с различными вариантами нанесения на кирпич, а также исследования свойств готовой продукции.

Результаты исследования. В результате было разработано и утверждено 8 составов ангобов, которые после обжига обеспечивали бездефектное и прочное покрытие ложковой и тычковой поверхностей кирпича, предложены способы нанесения ангобов для достижения эстетической выразительности как самого изделия, так и кирпичной кладки.

Обсуждение и заключение. В рамках проведенной работы с одним из кирпичных заводов юга России была поставлена задача по разработке составов цветных ангобов с учетом изучения и анализа мировых тенденций в области брик-дизайна и потребительского спроса, и проведению работ по декорированию лицевого керамического кирпича в условиях производства. Данные экспериментов успешно внедрены в производство, что значительно увеличило объем продаваемой продукции на строительном рынке юга Российской Федерации, расширило архитектурно-дизайнерские возможности для новых планировочных решений. Полученные результаты в области цветового декорирования кирпича полностью соответствуют заводским параметрам, маркетинговым задачам, экономически выгодны и позволяют расширить ассортимент производимой и востребованной продукции на отечественном строительном рынке.

Ключевые слова: кирпич, ангоб, состав, ангобирование, технология производства, цвет, оттенок, поверхность, декоративная кладка

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Introduction. Brick has been the major building material for many centuries. Its technical and aesthetic characteristics enable architects to convey a range of architectural forms: from simple cube-shaped buildings to those with a changeable facade line. The face brick is employed as a durable structural material with high decorative properties. Its variety of shapes, sizes, colors and textured surfaces allows a unique facade decor to be designed. Even the smooth facade lined with bricks of not the traditional red brick color, but, e.g., with shades of beige or dark gray, already contributes to making the building distinct and stand out. The choice of color is also impacted by the global architectural trends, offering colors, shades, textured "drawings" and their combinations. Let us not forget about the general psychological component of the architectural and spatial environment. Modern urban culture is increasingly lifting people up from the ground: both in terms of number of floors and landscaping [1]. An architect's task used to be fitting the building into the landscape and making it comfortable, whereas there is now a desire to recreate "green" areas in the urban environment, to create environmentally friendly solutions (even the "green architecture" style has emerged) and restore natural harmony by means of color [2].

Since ancient times, color has been given prominence in architecture. The ancient Egyptian and Greek temples, which have been preserved in the color of gray stone or sandstone, were bright and colorful in their authentic form. Facades and architectural decor were covered with murals, stone of a range of colors and shades as well as ceramic cladding were masterfully employed in building decoration. If the color of the stone is inherent in nature, ceramic products were given a stable color by means of different decoration methods: mass staining, gluing, glazing, shotcrete, etc.

Engobing is the oldest way of color-coding the surface of a ceramic product. Engobe is a clay suspension applied in a thin layer to a raw, leathery, or baked product with further burning. It is an excellent coating layer that smooths out surface irregularities lending the product color and texture.

The term "engobe" comes from the French "engobe", from the Italian "ingobbio" meaning "surfacing" or "coating". The ancient masters of Mesopotamia, Egypt, China, Greece and Rome commoly made use of engobe for painting ceramic dishes, sculpture and ceramic architectural decoration (Fig. 1). Engobe as an archaic natural clay-based paint has been used to decorate adobe houses in West Africa (Fig. 2). By adding kaolin, charcoal, or crushed multicolored stone to the angob, Yoruba women paint the walls with sacred patterns of white, black, brown, or ochre [3–5].

Fig. 1. Decorative elements of the roof — antefixes of Maenad and Silenus, Cerveteri, IV century B.C.

Fig. 2. Painted huts of the village of Tibele, Burkina Faso, XXI century

Since antiquity, ceramic bricks, tiles and other architectural ceramics have been covered with colored engobe. White engobe was typically used as a substrate for further painting or glaze coating. Against a white background, all the colors show their full brightness.

According to their composition, engobes are divided into clay-sand, flux and antique varnishes. In manufacturing ceramic products for architectural and construction purposes, a flux angus is used. A glass bead (5–20% of the total weight of the bead) or a colorless glaze is commonly used as a flux. The flux lends a stable, non-fading saturated color to products, improves the adhesion of an engobe layer to the shard and reduces the water permeability of a product. In order to improve the quality of the engobe, frit is added, sometimes up to 50% of the total weight of the angoba. Frit is a granular glass mass obtained by fusing a charge followed by a sharp cooling of the hot glass mass.

It is critical to match the raw materials of engobe and brick so that there are no defects in the form of peeling, caulk, discoloration. The quality of bricks with an engobated coating is also impacted by whether engobe is correctly applied, the thickness of the layer (no more than 0.2 mm), the angle of inclination while spraying the composition, compliance with a drying and burning regime[1] [6].

The color of the building material is a major component in architectural and construction design. Ceramic materials have a long-lasting color coating due to a manufacturing and decoration technology with further color-fixing burning. The choice of color for decoration and coating schemes depends on consumers' demand, marketing research and recommendations, fashion trends and definitely the technical capabilities of an enterprise interacting with scientific teams in the field of modern ceramics [7, 8].

The major suppliers of engobes and glazes for the Russian ceramic industry were enterprises from Italy and Spain, however, due to the sanctions, they were forced to reduce supplies resulting manufacturers of ceramics, mostly of bricks, facing the problem of a lack of high-quality engobe compounds on the market causing a reduction in the product range and the task of developing their own formulations based on available raw materials being set. In order to address the problem, it was necessary to develop scientifically solid recommendations on compositions of engobes, burning modes, and the use of engobing technology in order to modify the appearance of bricks, improve their technical and operational characteristics in order to further expand the range and increase the competitiveness of manufactured brick products.

The staff of the Department of "Building Materials" of DSTU with many years of experience in the field of scientific research for the ceramic industry, the development of coating compositions for ceramic tiles, bricks and tiles along with top enterprise for ceramic bricks production under their belt, carried out scientific and production experiments to solve the urgent problem of manufacturing engobes and methods of their application. The existing formulations of engobe coatings and their component composition were systematized, the optimal parameters of the technological process (the

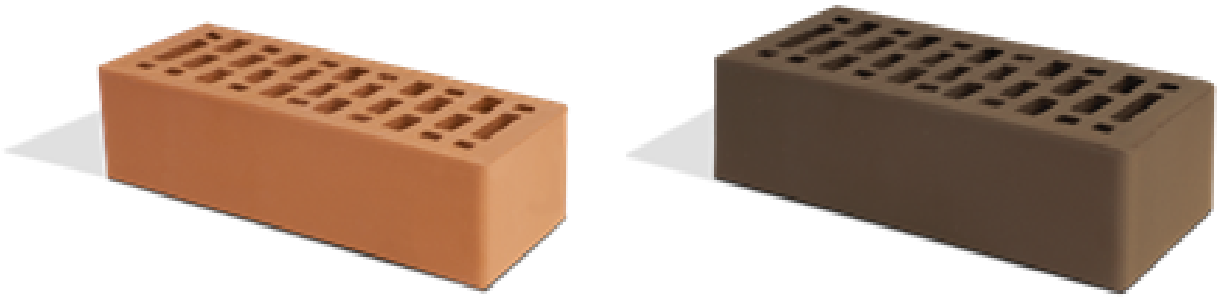
[1] Zakharov AI *Fundamentals of Ceramics Technology: a Textbook.* Moscow: Russian Chemical Technology. D.I. Mendeleev University; 2001. 79 p.

method of applying an engobe, the drying and burning mode) were identified, the decorative and protective possibilities of engobing were examined, and a comparative analysis of the economic efficiency of the engobing method was performed considering environmental safety in modern production conditions.

The color trend in Pantone's architectural design in 2024 was graphite gray, white, and peach. Dark grey and white are currently relevant and sought as well as highly popular colors widely used in exterior and interior design. In 2025, according to the Pantone Color Institute, Mocha Mousse, a light brown or chocolate—brown color that embodies natural harmony, is trending. It was exactly the shades of these colors that we set forth to develop for decorative decoration of the front brick.

Materials and Methods. Two types of 1NF format products with a smooth surface were selected as the face brick for engobing: red and brown one produced using plastic molding technology followed by drying and burning (Fig. 3). The brick in its appearance and physical and mechanical characteristics is in compliance with the requirements of GOST 530-2012 "Ceramic Bricks and Stones. General Technical Conditions" for face bricks: strength grade M150; frost resistance grade F75; water absorption of at least 5% and no more than 10%; initial water absorption rate is 0.90–1.35 kg/(m^2·min). The brick is hollow, the voidness is 40%, it has 3 front surfaces: 1 spoon and 2 pokes, with a chamfer.

The engobing process consists of applying a thin colored front angob layer to a freshly formed or dried brick with an airbrush enhancing or masking the structure and color of the shard after burning.



a) *b)*

Fig. 3. Ceramic face brick approved for operation: *a* — 1 NF red smooth; *b* — 1 NF brown smooth

While developing engobe compositions for a specific ceramic mass, the following factors are considered:

– desired decorative effect (color, shade, volume, etc.);

– coefficient of linear thermal expansion of the shard (CLTE);

– technological modes and capacities of the production line;

– economic factors.

As arranged with the manufacturer, the major task was to develop engobe coatings of a specific color palette: white, beige, brown, dark gray and achieve the effect of degradation (transition from a light to a dark shade) on the front surface of the brick, as well as to develop schemes of Bavarian decorative masonry (multiclaying) with the obtained color options.

The compositions of engobes for decorating white-beige, brown and dark gray colors were developed based on the frit from the Dulevsky Paint Factory using microcline, colemanite, zinc oxide, kaolin, clays from JSC Vladimirovsky Quarry of Refractory Clays of grades HCN and VKS, very fine quartz sand of Class I, barium carbonate and ceramic pigments.

The method of airbrushing was chosen as for applying engobes to the brick surface. For a decorative degrade effect, light shades of an engobe coating are applied to the brick that subsequently gradually overlap with the dark ones. It is necessary that the front surface of the brick has a color stretch from a light to a dark shade. Such a smooth color transition can be expressed horizontally, vertically or diagonally on the painted front surface.

The plan of the research at the first stage was to develop the engobic compounds in the laboratory and test them on tile samples made from the molding masses of the factory. The drying and burning modes in the laboratory were as close as possible to the technological ones. The second stage was engobing in the laboratory followed by burning in a laboratory furnace of the bricks selected after drying on the line, and testing it. At the third stage, the brick was tested in production conditions with an expert assessment and approval of the appearance as well as a set of physical and mechanical tests for all the indicators in compliance with the requirements of GOST 530-2012. Masonry schemes were developed and set forth for the approved variants of the engobed face brick.

Research Results. According to the technical and economic indicators, flux brackets are the most suitable coatings for ceramic bricks considering a single burning. According to the technical specification, the main color palette of bricks should be from white-beige to dark brown and graphite, and there should also be color "stretches" from light to dark shades. The face brick must have 2 front engobed surfaces — 1 spoon and 1 poke.

Based on the investigated and selected raw materials, the compositions of flux engobes were developed as shown in Table 1.

Table 1

Laboratory compositions of fluxic engobes

Engobe code	Color	Composition, % by weight per dry substance
B-0	White	Frit — 30, microcline — 20, colemanite — 10, kaolin — 20, HCN — 10, TiO_2 — 10
B-1	Beige	Frit — 30, microcline — 20, colemanite — 10, $BaCO_3$ — 5, ZnO — 5, kaolin — 20, HCN — 10
B-2	Beige 1	Frit — 30, microcline — 20, colemanite — 10, burnt kaolin — 25, HCN — 15
K-1	Brown Chestnut	Frit — 30, microcline — 20, colemanite — 10, $BaCO_3$ — 5, ZnO — 5, kaolin — 10, HCN — 10, red iron oxide pigment — 10
K-2	Brown Chocolate	Frit — 30, microcline — 20, colemanite — 10, $BaCO_3$ — 5, ZnO — 5, kaolin — 10, HCN — 10, red iron brown pigment — 10
K-3	Brown Terracotta	Frit — 30, microcline — 20, colemanite — 10, $BaCO_3$ — 5, ZnO — 5, kaolin — 10, HCN — 10, Mn_3O_4 — 10
K-4	Brown Cinnamon	Frit — 30, microcline — 20, colemanite — 10, $BaCO_3$ — 5, ZnO — 5, kaolin — 10, HCN — 10, iron scale — 10

The engobe compounds were applied by airbrushing to the dried product. The thickness of the angular layer was 0.5–1 mm. A layer which is too thick might cause the engobe to peel off during burning. It is important to keep a watchful eye on the pneumatic spray gun so that the head does not clog, the spray gun itself must be kept at a distance of 25–30 cm from the brick. In laboratory conditions, when applied to tile samples and to bricks, the developed compositions were in agreement with the declared parameters in terms of color solutions and the quality of the front surface.

In production conditions, after decoration, the bricks were moved to a tunnel kiln for burning at a maximum temperature of 940°C (Fig. 4). After burning, the investigated bricks were sent for visual inspection in order to analyze the result. The engobe compounds B-0, B-2, K-3 and K-4 performed well on the brick and distributed evenly, there was no technological defect on the surface, and the color corresponded to the identified technical specifications. The engobe compositions B-1, K-1 and K-2 did not match the color scheme, this decorative layer was not concealable and not sufficiently baked. Hence technological defects and fingerprints were found on the front surface of the bricks.

The production experiment showed that due to the difference in the cross-section of the furnace, for the brick surface to be concealed better, it is necessary to increase the burning temperature to 970°C or adjust the compositions. Analyzing the data and carrying out a technical and economic calculation, it was decided to adjust the compositions B-1, K-1 and K-2 and develop an additional graphite-colored engobe composition (Table 2).

For the second stage of the factory testing, it was decided to reapply the B-0, B-2, K-3 and K-4 engobe compounds and the newly developed B-1, K-1, K-2 and G-1 compositions. The decorative compositions were also applied by means of airbrushing. The decoration of the brick, depending on the planned decorative effect, was complete or partial, one or two faces were covered, and there was also an angled or straight color filling.

Fig. 4. Engobing by means of airbrushing in the factory setting

Table 2

Engobe correction compositions

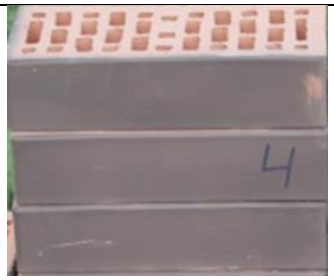
Engobe code	Color	Composition, % by weight per dry substance
B-1	Beige	Frit — 40, microcline — 15, colemanite — 10, HCN-2 — 15, ZnO — 5, kaolin — 20, TiO — 10, glue — 1
K-1	Brown Chestnut	Frit — 45, microcline — 10, colemanite — 15, VKS — 20, coloring pigment — 10, glue — 1
K-2	Brown Chocolate	Frit — 40, microcline — 15, colemanite — 10, VKS — 20, coloring pigment — 10, glue — 1
G-1	Dark grey Graphite	Frit — 40, microcline — 10, colemanite — 10, VKS — 15, copper oxide — 15, iron scale — 5, iron oxide — 5, glue — 1

Burning was in a factory furnace at a temperature of 940–950 °C. After burning, the engobed bricks were sent for visual inspection. Table 3 shows the main conclusions made following the semi-factory tests.

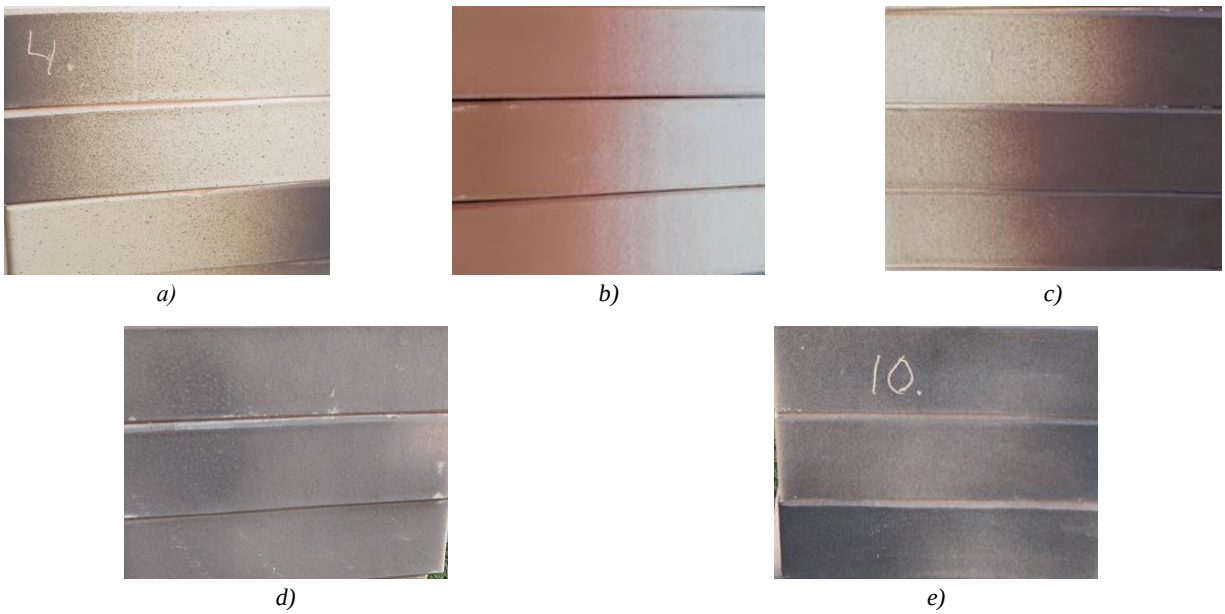
Table 3

Results of the second stage of the semi-factory tests

Engobe code	Color	Photo of an engobed brick	Result of the factory tests
B-0	White		Uneven layer, there is a factory defect (chips, scuffs), the color corresponds to the planned tone, not suitable for a solid coating, can be used for color transitions as an additional color.

Engobe code	Color	Photo of an engobed brick	Result of the factory tests
B-1	Beige		A smooth, concealable engobe layer, the color corresponds to the planned tone, and there is no factory defect on the surface
B-2	Beige with a yellow shade Beige 1		A smooth, concealable engobe layer, the color corresponds to the planned tone (there is a yellow shade), there is no factory defect on the surface
K-1	Brown Chestnut		A smooth, concealable engobe layer, the color corresponds to the planned tone (brown), there is no factory defect on the surface
K-2	Brown Chocolate		An even, sheltering engobe layer, the color corresponds to the planned tone (brown, dark brown), there are areas of the non-baked engobe layer, but these areas are not visible at a distance of 1 meter and do not impact the durability of the layer
K-3	Brown Terracotta		A smooth, concealable engobe layer, the color corresponds to the planned tone (red-brown), there is no factory defect on the surface
K-4	Brown Cinnamon		A smooth, concealable engobe layer, the color corresponds to the planned tone
G-1	Dark gray Graphite		A smooth, concealable engobe layer, the color corresponds to the planned tone (dark gray)

By combining the developed angobic compounds, a range variety of color solutions is obtained. While decorating bricks, it is important to have prior understanding of the scheme of applying the engobe to the front surface. Fig. 5 shows the options for combining angobic compounds to achieve a degrade effect on the front surface of the brick.



a) *b)* *c)* *d)* *e)*

Fig. 5. Brick decoration options with the degrade effect based on the developed engobe compositions: *a* — B-0 + K-1; *b* — *B*-1 + color of the burned brick; *c* — B-2 + K-3; *d* — K-1 + K-2; *e* — K-2+G-1

The next step was to develop decorative masonry schemes made of the engobed bricks based on Bavarian masonry, which seems reasonable in terms of combinatorics and design. It is possible to achieve the effect of Bavarian masonry using degrade-colored bricks by combining bricks of the same color or different ones by laying them in a few ways: by connecting spoons of the same shade, alternating light and dark shades. Using a range of decorative masonry (chain, Old Russian, Flemish, cross, etc.), it is possible to increase the variants of combinatorial solutions. Only one spoon-shaped masonry with an offset of ½ brick was examined.

Bavarian brickwork is a special type of decorative masonry based on the principle of chaotic combination of several shades of the same color. In this case, the main tone should be about half of the scheme, and auxiliary colors are used for the remainder of the styling. There should be no separate dark and light spots in the facade cladding, they should alternate instead creating smooth transitions of color shades throughout the facade with no crowding of one color to emphasize the overall harmony of the front masonry and fit it into the architectural space. Bricks of the same shade should not be replicated in the masonry, but alternate with the other shades, thus generating a feeling of chaotic, "spontaneous" facade masonry or look like arbitrary color spots [9, 10].

Taking into account the principles of "Bavarian" masonry and the resulting color palette in the form of angob compounds, Figure 6 shows the developed masonry using angobated ceramic bricks with the degrade effect. As can be seen from Fig. 6, the main color in this "Bavarian" masonry is red-brown (K-3), and the auxiliary color is graphite (G-1). The main task in the development of this masonry is not to overload the future facade. The combination of dark brown and red-brown appears to be interesting in its decorative characteristics, but it might be difficult to take in a complete facade. Therefore, it was decided to develop a "lighter" color version of the "Bavarian" masonry (Fig. 7).

Fig. 6. Bavarian masonry using the engobated ceramic bricks (acid composition G-1, K-3 + the color of the baked brick)

Fig. 7. Bavarian masonry using the engobated ceramic bricks (similar composition of K-2, K-3 + own brick color)

As can be seen in Fig. 7, the combined bricks are half decorated with an engobe coating — there is a rich brown color to the edge of the brick, and the main shade remains "natural". This color technique is attained by means of the airbrushing technique of applying an engobe. As can be seen, there are already three shades where the main color is the one of the baked clay itself, and the auxiliary engobe layers are K-2 and K-3.

Interesting color transitions can be attained using the degrade effect in the masonry itself, where bricks with the same coating effect alternate. Fig. 8 and 9 show the color transitions from dark brown to beige and from brown to light beige. In the masonry in Fig. 8, the color decoration of the brick itself can be observed, where there is a different intensity of brown color in filling the front side of the brick, which lends the masonry a unique character.

Fig. 8. Decorative bricklaying using the degrade effect (B-3, K-2, K-4 engobe compositions)

Fig. 9. Decorative bricklaying using the degrade effect (engobe compositions B-2, K-4)

Based on Fig. 9, the main color in the developed masonry is beige (B-2), the additional one is brown (K-4). As can be seen, brown is not intense in terms of tone saturation, thereby it does not overload the masonry.

Fig. 10 shows the Zebra decorative masonry on contrasting solutions, where beige is the main color, while dark brown and graphite are auxiliary ones. However, due of the richness of dark brown and the layout of the pattern, it draws attention to itself, thereby emphasizing the pattern of the masonry.

Fig. 10. Decorative bricklaying (engobe compositions B-2, K-4 and G-1)

There can be an infinite number of color variaties of artistic brickwork, the main thing is to stay on top of the latest global trends and accommodate consumers' needs, or to create and promote new trends in the brick market of southern Russia.

Discussion and Conclusion. Ceramic bricks have been and still are a high-quality, durable, environmentally friendly and aesthetically attractive building material with a steady demand in the construction market. It is ceramic bricks that can be as changeable as they are traditional. This shows in the aesthetic appearance of the brick and its price. Brick decoration is a relevant task, as brick is no longer only a structural material, but has been promoted into the category of elite building materials with a wide range of possibilities in the field of color and textured surface design. A brick design direction has been formed to identify new and expand the traditional aesthetic possibilities of ceramic bricks [11, 12]. The active development of the ceramic industry in the Russian Federation calls for a joint coordinated effort of managers and technologists of enterprises with scientific organizations, marketers and distributors. Such a professional tandem will make it possible to release successful brick collections, be ahead of the latest trends in brick design and timely prepare raw materials and technological equipment for production of face bricks with specific aesthetic characteristics. Using the example of our team's work on introducing engobed bricks into a technological process of an operating enterprise, the consistency and effectiveness of the chosen schemes, laboratory and semi-factory testing methods considering financial capacities of an enterprise have been proven. The results have been implemented, the company has been able to launch the production of engobed bricks and has formed a new stable cluster for producing decorative face bricks with specific aesthetic characteristics in the southern Russian market.

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