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# RESTORATION COMPOUNDS FOR TERRAZZITE PLASTER ON THE EXAMPLE OF CULTURAL HERITAGE SITES OF THE 20TH CENTURY (RUSSIA)

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**Abstract**

**Inroduction:** Gradual destruction of buildings or structures of historical significance is a natural process that cannot be stopped. Therefore, preservation of architectural monuments is one of the most important areas of restoration activity. Complete replacement of damaged building materials of architectural monuments changes the historical appearance, and thus cultural sites are stripped of their original look. Innovations in the re-creation of historical building materials and technologies help preserve historical continuity. **The purpose of the study** was to develop a number of compounds of terrazzite plaster mixtures for cultural heritage sites of the 20th century, which, from an aesthetic point of view, will not allow the loss of the natural and picturesque appearance of the monument, and will be able to preserve the "patina of time". **As a result** of the research, the authors studied the compositions of the selected samples, proposed restoration compounds of terrazzite plaster, and determined the algorithm for applying an analogue of the historical plaster. In terms of technical and economic indicators, the developed restoration compounds are effective and make it possible to return architectural monuments to their original appearance with minimal costs. Based on the results obtained, conclusions were drawn about the feasibility of using the proposed new components in terrazzite plaster mixtures to increase strength and ensure high-quality adhesion of the old and new plaster layers. The proposed technology contributes to the return of architectural monuments to their original appearance without losing the historical authenticity of the buildings.

**Keywords:** terrazzite plaster, restoration of building facades, cultural heritage sites.

## Introduction

The modern construction market offers a large number of different materials, not only for high-quality work meeting customer needs, but also for restoring any coatings and surfaces to maintain the proper appearance of buildings or structures (Subbotin, 2019).

One of the important problems that arise during restoration is the issue of low-quality restoration of plaster facades, which is primarily associated with an unreasonable and even erroneous choice of mixtures for renovation. It is possible to use materials close to historical ones, but in the case of problematic foundations (e.g., with a high water or salt load), it is quite difficult to achieve a positive result, since corrosive environment can cause damage (Hoła et al., 2017; Knyazeva and Koroleva, 1998; Makarov and Shpolyansky, 2015; Vozniuk et al., 2013).

Many building facades in large cities were made using terrazzite plaster. This is a decorative dry mixture based on lime-cement binder, the main purpose of which is the finishing of facades, walls, columns, and architectural elements. It is used for concrete or brick surfaces.

The terrazzite plaster compounds currently used in construction mainly include the following components: calcium hydroxide (slaked lime), quartz sand, Portland cement, fillers (chips of artificial or natural stone, marble, etc.), mica, and may also contain mineral dyes.

Several types of terrazzite plaster can be distinguished depending on the size of the aggregate corresponding to a certain size grade: K — large chips, granule size 4–6 mm, C — medium chips, granule size 2–4 mm, and M — small chips, granule size 1–2 mm (Blumberga et al., 2016; Kamendere et al., 2016; Khan et al., 2017). In construction, terrazzite plaster is supplied in the form of ready-made dry mixtures and is prepared for application immediately before use (Pastukh et al., 2020).

We examined several historical sites, where construction and restoration included the use of terrazzite plaster mixture.

The construction of the Soviet era building of the State Bank in Yaroslavl was carried out in 1918–1936, as the southern building of Gostiny Dvor was completely destroyed during the Yaroslavl Uprising of 1918 (Dergunov et al., 2021; Panasyuk et al., 2018; Ventolà et al., 2011). Gostiny Dvor consisted of two parts: the northern and southern buildings, which were identical in their layout and located symmetrically. After the end of the Uprising in 1918, the damage was so significant that it was decided to completely dismantle the building.

According to the State Historical and Cultural Expertise, the building dates back to the construction

period of 1929–1936. In 1928, the building was designed by I. I. Knyazev and G. P. Goltz. The architects managed not only to harmoniously fit the building into the surrounding space, but also add some novelty to it (Pastukh et al., 2020; Safonova, 2017).

The State Bank became the first building of neo-Renaissance constructivism style on Komsomolskaya Street (Fig. 1).

The main architectural theme was a heavy rusticated wall with widely spaced windows in the style of Florentine architects. The windows were designed as high and rectangular with arched frames in the form of small niches. The only volumetric element of the flat facade was the entrance made in the form of a four-arched portico (Figs. 2, 3).

According to the design, the building included not only administrative and technological premises, but also residential ones. The architectural rational solution was based on the flexible use of space.

It was decided to use the southern part of the building as a living area of six apartments. Also, service buildings were provided on the territory adjacent to the building. Construction of the main building of the State Bank was completed in 1936. With minor changes, the interior of the building has been preserved to this day (Fierascu et al., 2020; Yevseyev, 2016).

In February 1995, the entire State Bank complex was declared a cultural heritage site, and by order of the Department of Cultural Heritage Site Protection of the Yaroslavl Region, the building was given the status of a cultural heritage site of federal significance.

In 2021, it was decided to restore the facade, interior, and also organize access for people with limited mobility to the building.

The second site under study is the building of the Main Treasury in St. Petersburg (Fig. 4). The building was designed in the neoclassical style by architects D. M. Iofan and S. S. Serafimov and built by civil engineer S. S. Korvin-Krugovsky in the period from 1913 to 1915. The building consists of four parts: the main facade building, the central part of the building, and two wings adjacent to the central part on both sides. The central part of the facade building is adorned with decorative pilasters and


Fig. 1. Fragment of a drawing from the newspaper “Severny Rabochiy”, 1929. Design of a new building of the State Bank


Fig. 2. Fragment of the main facade of the State Bank, Yaroslavl

Fig. 3. Fragment of the north-eastern facade of the State Bank, Yaroslavl

Fig. 4. View of the main facade of the Main Treasury, St. Petersburg

columns, and an attic runs above the cornice. The central part of the building is covered with a dome (Chainikova, 2022; Crinson, M. and Williams, 2019; Saifullina, 2014; Šahmenko et al., 2015).

The internal space of the building consists of not only administrative premises, including a spacious lobby and operating room (with an area of more than 3000 $m^2$), offices, cash desks, but also residential premises, for example, managers' apartments.

During the Great Patriotic War, a bomb hit the building and destroyed the interior, but later it was restored.

In 2022, it was decided to restore the facade building.

**Materials and methods**

In our work we used the following methods and equipment: scanning electron microscope (SEM), material moisture meter VIMS-2.12 and strength meter for building materials IPS-MG4.03, diffractometer Bruker AXS D8 ADVANCE (model D8, manufacturer: Bruker Optik GmbH, Germany).

To study the composition and physical and technical properties, the customer provided samples of building materials selected at the sites.

Fig. 5 indicates the location for sampling the material from the building of the Yaroslavl Central Bank, and Fig. 6 shows a sample of terrazzite plaster on the facade of the said bank.

Fig. 7 shows the sampling location of the Main Treasury building in St. Petersburg, and Figs. 8–11 show samples of terrazzite plaster of the same facade.

The study of the SEM microstructure and X-ray phase analysis of the presented terrazzite plaster samples allows us to conclude that at the research site during construction, as well as during further

Fig. 5. Location of material sampling from the building of the Yaroslavl Central Bank

Fig. 6. Sample No. 1 of the plaster of the facade of the Yaroslavl Central Bank building

Fig. 7. Location of material sampling from the Main Treasury building in St. Petersburg

Fig. 8. Sample No. 2 of the plaster of the Main Treasury building in St. Petersburg

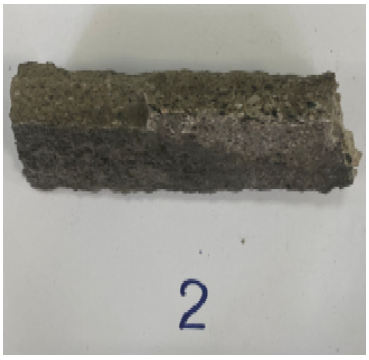


Fig. 9. Sample No. 3 of the facade plaster of the Main Treasury building in St. Petersburg

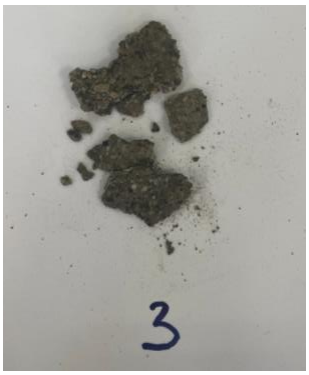


Fig. 10. Sample No. 4 of the facade plaster of the Main Treasury building in St. Petersburg


Fig. 11. Sample No. 5 of the facade plaster of the Main Treasury building in St. Petersburg

reconstruction of the building, the composition used contained lime, dolomite, sand and clay as the main components.

**Results**

Fig. 12 shows the results of X-ray phase analysis of sample No. 1 of terrazzite plaster on the facade of the Yaroslavl Central Bank building.

Table 1 presents a number of developed terrazzite plaster compounds for the restoration of the facade of the Yaroslavl Central Bank building.

Table 2 presents the compounds of terrazzite plaster for the restoration of the facade of the Main Treasury building in St. Petersburg.

**Results and discussion**

The results of studying the macrostructure of terrazzite plaster samples using scanning electron microscopy (SEM) are presented in Figs. 14–16:

The structure of sample No. 3 of the Main Treasury building in St. Petersburg is a porous material with cavities from 50 to 100 microns (Fig. 14).

The macrostructure of sample No. 4 of the Main Treasury building in St. Petersburg is homogeneous, with inclusions of metallurgical slag up to 1 mm in size (Fig. 15).

The macrostructure of sample No. 5 (Fig. 16) of the Main Treasury building in St. Petersburg is heterogeneous, characterized by strongly open cracks and voids [Khan et. al., 2017].

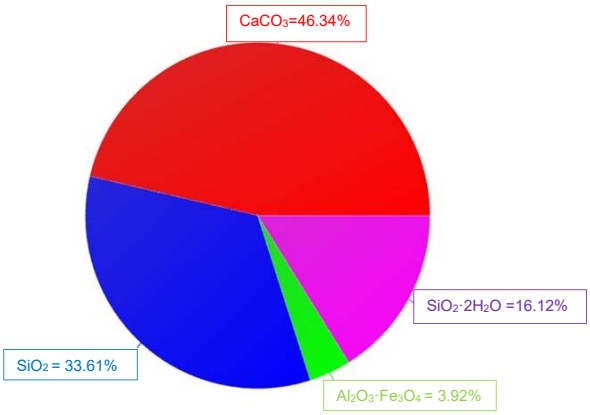


Fig. 12. Results of X-ray phase analysis of sample No. 1 of terrazzite plaster on the facade of the Yaroslavl Central Bank building

Table 1. **Compounds of terrazzite plaster mixtures for restoration of the facade of the Yaroslavl Central Bank building**

| No. | Composition / Components | $R_1$ | $R_2$ | $R_3$ | $R_4$ | $R_5$ |
|---|---|---|---|---|---|---|
| | | Components, wt% | | | | |
| 1 | Super white cement CEM I 52.5 R ADANA OYAK CIMENTO | 16 | 12 | 13 | 14 | 15 |
| 2 | Slaked lime | 25 | 24 | 24 | 25 | 20 |
| 3 | Quartz sand | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| 4 | Foam glass microgranules fraction 0.25–1.0 mm Density 400 kg/m$^3$ Strength 2.5 MPa | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| 5 | Granite chips d=6–8 mm | 20 | 25 | 26 | 16.5 | 24.5 |
| 6 | Mica GOST 10698-80 | 6 | 5 | 4 | 2 | 3 |
| 7 | Plasticizer P-17 | 5 | 7.5 | 5 | 6 | 5 |
| | **Pigment** | | | | | |
| 8 | Minium | 1.5 | - | 0.5 | 1 | 0.5 |
| 9 | Fired clay (ochre) | 10 | - | 10 | 15 | 10 |
| 10 | Soot | 1.5 | - | - | - | - |
| 11 | Umber | - | 10 | 2.5 | 5 | 5.5 |
| 12 | Manganese dioxide | - | 1.5 | - | 0.5 | 1.5 |
| Strength (MPa) | | 10–12 | | | | |
| Water absorption (%) | | 4–6 | | | | |
| Porosity (%) | | 8–10 | | | | |

The technology for preliminary surface preparation consists of the following operations:

1) Removal of loose and exfoliated destruction products.

2) Cleaning of the restored surface with hard brushes without leveling.

3) Dust removal of the area where the renovation compound is applied.

4) Thorough rinsing of the surface under restoration with water.

5) Spraying the terrazzite compound before applying the plaster mixture to the prepared and primed surface.

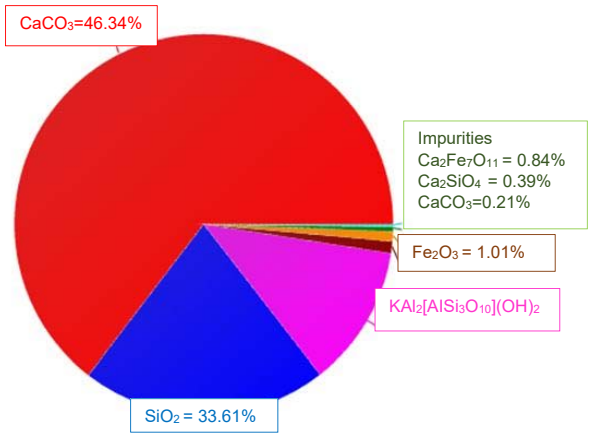


Fig. 13. Results of X-ray phase analysis of sample No. 2 of terrazzite plaster of the Main Treasury building in St. Petersburg

Table 2. **Compositions of mixtures for terrazzite plaster of the Main Treasury building in St. Petersburg**

| No. | Composition / Components | $R_1$ | $R_2$ | $R_3$ | $R_4$ | $R_5$ |
|---|---|---|---|---|---|---|
| | | Components, wt% | | | | |
| 1 | Super white cement CEM I 52.5 R ADANA OYAK CIMENTO | 16 | 12 | 13 | 14 | 15 |
| 2 | Slaked lime | 25 | 24 | 24 | 25 | 20 |
| 3 | Quartz sand | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| 4 | Foam glass microgranules fraction 0.25–1.0 mm Density 400 kg/m$^3$ Strength 2.5 MPa | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| 5 | Granite chips d=6–8 mm | 20 | 25 | 26 | 16.5 | 24.5 |
| 6 | Mica GOST 10698-80 | 6 | 5 | 4 | 2 | 3 |
| 7 | Plasticizer P-17 | 5 | 7.5 | 5 | 6 | 5 |
| | **Pigment** | | | | | |
| 8 | Minium | 1.5 | - | 0.5 | 1 | 0.5 |
| 9 | Fired clay (ochre) | 5 | - | 5 | 5 | 3.5 |
| 10 | Soot | 6.5 | 4 | 5 | 10 | 6.5 |
| 11 | Umber | - | 6 | 2.5 | 5 | 5.5 |
| 12 | Manganese dioxide | - | 1.5 | - | 0.5 | 1.5 |
| Strength (MPa) | | 7–11 | | | | |
| Water absorption (%) | | 5–6 | | | | |
| Porosity (%) | | 8–10 | | | | |

The technology for applying terrazzite plaster includes the following steps:

1) Spraying the surface to be restored with the terrazzite compound. Exposure for 1–5 hours.

2) Applying a given number of primer layers to the area under restoration taking fillers into account. Leveling and compacting the resulting surface with the impact of a trowel.

3) Preparing the renovation compound from dry fillers and a cement-pigment mixture, and mixing it thoroughly.

4) Adding the required amount of water while constantly stirring the mixture.

5) Forming a given texture and appearance of the surface by processing it with various tools.

6) Protecting the surface under renovation with covering material from precipitation, dirt, etc., within 24 hours, starting from the moment of applying the

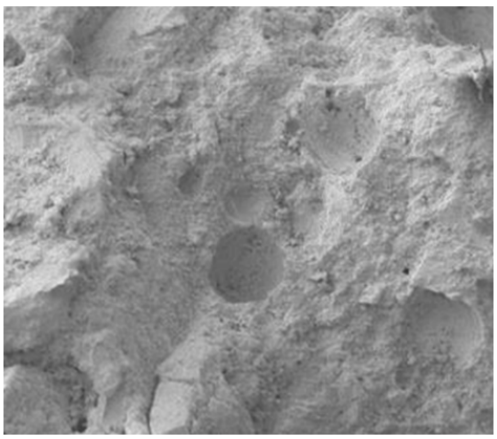

Fig. 14. Structure of plaster sample No. 3 of the Main Treasury building in St. Petersburg

Fig. 15. Structure of plaster sample No. 4 of the Main Treasury building in St. Petersburg

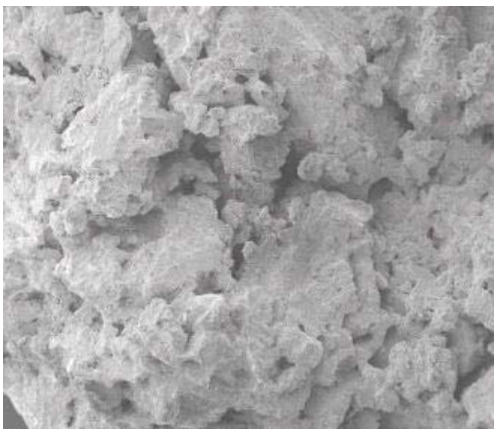

Fig. 16. Macrostructure of plaster sample No. 5 of the Main Treasury building in St. Petersburg

renovation compound. During hot periods, protection of the surface from exposure to direct sunlight for 48 hours and wetting of the surface with water.

7) After the final setting of the compound, rinsing the surface with water to reveal significant texture elements (grains, stone).

In the process of the work, we studied selected samples of historical plaster and, on their basis, developed authentic restoration compositions of terrazzite plaster mixtures.

A step-by-step technology for restoration work on the historical facade was developed.

As a result of the research, a conclusion was made about the effectiveness of using the proposed new components in the composition of terrazzite plaster to increase strength (up to 7–12 MPa) and ensure high-quality adhesion of the old and new plaster layers. Thus, it is possible for an architectural monument to look authentic again without losing its historical appearance. One of the main goals of this work was to create a color scheme for historical sites. Therefore, as a result of the variability of pigments, the optimal amount of processing was achieved to form a palette of unique shades.

**References**

Blumberga, A., Kass, K., and Kamendere, E. (2016). A review on Latvian historical building stock with heavy walls. *Energy Procedia*, Vol. 95, pp. 17–21. DOI: 10.1016/j.egypro.2016.09.004.

Chainikova, O. O. (2022). *Reconstruction of architectural monuments in modern restoration practice (case study of the Saint Petersburg region)*. PhD Thesis in Architecture. Saint Petersburg State University of Architecture and Civil Engineering.

Crinson, M. and Williams, R. J. (2019). *The architecture of art history: a historiography*. London: Bloomsbury, 185 p.

Dergunov, S. A., Serikov, S. V., Satyukov, A. B., and Serikova, O. V. (2021). *Dry construction repair mix*. Patent RU2751180C1.

Fierascu, R. C., Doni, M., and Fierascu, I. (2020). Selected aspects regarding the restoration/conservation of traditional wood and masonry building materials: a short overview of the last decade findings. *Applied Sciences*, Vol. 10, Issue 3, 1164. DOI: 10.3390/app10031164.

Hoła, A., Matkowski, Z., and Hoła, J. (2017). Analysis of the moisture content of masonry walls in historical buildings using the basement of a medieval town hall as an example. *Procedia Engineering*, Vol. 172, pp. 363–368. DOI: 10.1016/j.proeng.2017.02.041.

Kamendere, E., Grava, L., Zvaigznitis, K., Kamenders, A., and Blumberga, A. (2016). Properties of bricks and masonry of historical buildings as a background for safe renovation measures. *Energy Procedia*, Vol. 95, pp. 119–123. DOI: 10.1016/j.egypro.2016.09.032.

Khan, M. I., Abbas, Y. M., and Fares, G. (2017). Review of high and ultrahigh performance cementitious composites incorporating various combinations of fibers and ultrafines. *Journal of King Saud University - Engineering Sciences*, Vol. 29, Issue 4, pp. 339–347. DOI: 10.1016/j.jksues.2017.03.006.

Knyazeva, V. P. and Koroleva, T. V. (1998). *Actual trends in the development of quality management systems for restoration design (based on the system of ISO-9000 standards)*. Moscow: Department of State Control for Protection and Use of Monuments, 134 p.

Makarov, N. A. and Shpolyansky, S. V. (eds.) (2015). *Archaeology of the Vladimir–Suzdal Land: Proceedings of the Research Workshop*. Issue 5. Moscow: Institute of Archaeology of the Russian Academy of Sciences, 288 p.

Panasyuk, V. V., Marukha, V. I., and Sylovanyuk, V. P. (2018). Efficient injection materials and the technologies of restoration of the serviceability of damaged building structures intended for long-term operation. *Materials Science*, Vol. 54, No. 2, pp. 154–162. DOI: 10.1007/s11003-018-0169-0.

Pastukh, O., Gray, T., Golovina, S. (2020). Restored layers: reconstruction of historical sites and restoration of architectural heritage: the experience of the United States and Russia (case study of St. Petersburg). *Architecture and Engineering*, Vol. 5, No. 2, pp. 17–24. DOI: 10.23968/2500-0055-2020-5-2-17-24.

Safonova, T. R. (2017). Change of the functional purpose as an alternative method of preserving fragments of archtectural monuments. *Austrian Journal of Humanities and Social Sciences*, No. 3–4, pp. 3–8. DOI: 10.20534/AJH-17-3.4-3-8.

Šahmenko, G., Aispurs, S., and Krasnikovs, A. (2015). The use of high performance cement composite in renovation and restoration of architectural elements of buildings facades. *Procedia Engineering*, Vol. 117, pp. 317–324. DOI: 10.1016/j.proeng.2015.08.256.

Saifullina, L. S. (2014). History and methodics of restorations. Some problems of modern theory and practice. *News of the Kazan State University of Architecture and Engineering*, No. 2 (28), pp. 70–77.

Subbotin, O. S. (2019). Features of the building materials use in architectural and urban heritage restoration. *IOP Conference Series: Materials Science and Engineering*, Vol. 698, Issue 3, 033045. DOI: 10.1088/1757-899X/698/3/033045.

Ventolà, L., Vendrell, M., Giraldez, P., and Merino, L. (2011). Traditional organic additives improve lime mortars: New old materials for restoration and building natural stone fabrics. Construction and *Building Materials*, Vol. 25, Issue 8, pp. 3313–3318. DOI: 10.1016/j.conbuildmat.2011.03.020.

Vozniuk, G., Kavalerova, E., Kryvenko, P. V., and Petropavlovsky, O. (2013). Physical and chemical properties of adhesives based on geocement for restoration and rehabilitation of building materials. *Advanced Materials Research*, Vol. 688, pp. 123–129. DOI: 10.4028/www.scientific.net/AMR.688.123.

Yevseyev, E. (2016). Evolution of construction technologies in the context of the 19th century architecture history: restoration aspect. *The World of Art: Bulletin of the International Institute of Antiques*, No. 3 (15), pp. 86–92.

# РЕСТАВРАЦИОННЫЕ СОСТАВЫ ДЛЯ ТЕРРАЗИТОВОЙ ШТУКАТУРКИ НА ПРИМЕРЕ ОБЪЕКТОВ КУЛЬТУРНОГО НАСЛЕДИЯ XX ВЕКА (РОССИЯ)

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**Аннотация**

**Введение:** Постепенное разрушение зданий или сооружений исторического значения – это естественный процесс, который остановить, к сожалению, невозможно. Но инновационные материалы способны в значительной степени этот процесс замедлить. Сохранение памятников архитектуры – одно из важнейших направлений реставрационной деятельности. Замена подвергнувшихся разрушениям строительных материалов памятников архитектуры снижает их историческую значимость, происходит утрата культурных ресурсов. Современные строительные материалы и технологии помогают сохранить историческую преемственность. **Цель исследования** состояла в разработке сеток составов смесей терразитовой штукатурки для объектов культурного наследия XX века. **В результате** проведенных исследований были определены составы отобранных образов и составлены сетки составов смесей терразитовой штукатурки, а также определена технологическая последовательность выполнения нанесения терразитовой штукатурки для реставрации фасада здания. По своим технико-экономическим показателям разработанные реставрационные составы позволяют с минимальными затратами вернуть памятникам архитектуры первозданное состояние. Сделаны выводы на основе полученных результатов о значимости для строительной отрасли разработок в области реставрационных строительных материалов, позволяющих вернуть памятникам архитектуры первозданный вид без потери исторической значимости.

**Ключевые слова:** терразитовая штукатурка, реставрация фасада зданий, объекты культурного наследия.