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RESTORATION OF EXTERIOR AND INTERIOR FINISHES OF HISTORICAL MONUMENTS, INNOVATIVE SOLUTIONS WITH MULTI-EFFECT ADDITIVE MORTAR

Petrică-Iulian FOCA[1], Ion SANDU[1,2,3,4], György DEÁK[3], Andrei Victor SANDU[2,4,5], Florina-Diana GHEORGHE[3], Ioan Gabriel SANDU[4,5,*]

[1] Alexandru Ioan Cuza University, Faculty of Geography and Geology, Doctoral School of Geosciences, Domain: Environmental Science, 11 Carol I Blv., 700506 Iasi, Romania

[2] Academy of Romanian Scientists (AOSR), 54 Splaiul Independentei Street, Sect. 5, 050094 Bucharest, Romania

[3] National Institute for Research and Development in Environmental Protection, 294 Splaiul Independentei Blv., 6th District, 060031, Bucharest, Romania

[4] Romanian Inventors Forum, 3 Sf. P. Movila Street, Bloc L11, Sc. A, III/3, 700089 Iasi, Romania

[5] Gheorghe Asachi Technical University of Iași, Faculty of Materials Science and Engineering, 41 Dumitru Mangeron Blvd., 700050, Iasi, Romania

Abstract

The work presents the process of obtaining and applying a light mortar, with thermal insulating, soundproofing and waterproofing capacity, added to activate and induce the self-cleaning properties, intended for the protection and restoration of the exterior and interior wall surfaces of monuments affected in time by urban pollution. The product is made from binders and matrix inserts compatible with historical structures and enhanced with photocatalytic and repatination additives, which contribute to thermophysical, sound-absorbing, flame-retardant and hydrophobic protection, while maintaining aesthetics by improving the dirt deposition effect. The material primarily targets interventions for conserving built heritage but has potential applications in contemporary urban architecture. The next stages of the research include testing under real conditions and adapting the composition for various types of substrates, to expand the use on a large scale. The composition, application procedure, operating principle, technical and functional advantages, laboratory testing and experimental application are detailed, demonstrating its efficiency in reducing deposits and protecting facades. Potential applications in monument restoration, sustainable contemporary architecture and urban furniture are discussed, highlighting their contribution to improving urban aesthetics and heritage preservation.

Keywords*: Architectural monument; Interior and exterior finishes; Restoration; Preservation; Protection; Monitoring; Thermal insulation; Fireproofing; Hydrophobization; Photocatalytic self-cleaning additive, TiO_2/ZnO,*

Introduction

In the current practice of restoring the exterior and interior finishes of historical monuments, additive mortars are often used, which, in addition to the self-cleaning effect of surfaces, must have a volumetric weight below 250kg/m³, a thermal conductivity coefficient below 0.08Kcal/m·h·°C, a mechanical resistance of over 7daN/cm², a good fire-retardant capacity for organic structural and hydrophobization components, that allow good compatibility

* Corresponding author: ioan-gabriel.sandu@academic.tuiasi.ro

with the supporting substrate and through mass coloring before application, do not affect the patina of time [1-8].

Therefore, the materials used in restoration interventions should have multiple implications. In addition to protecting buildings through thermal insulation (thermophysical conservation) and soundproofing (acoustic insulation), they should also provide superficial self-cleaning of deposits, achieve effective fireproofing (fire resistance), and exhibit good mechanical resistance after commissioning. The components should offer high synergy during mixing and allow the mortar used for finishing exterior or interior wall surfaces to be applied either as a pre-dosed composition, which is later dispersed at a scheduled time in the specific aqueous system (tap water) or as a diluted polyvinyl acetate dispersion for construction using tap water or as a freshly obtained aqueous paste from the additive mortar composition before application (commissioning) [9-11].

The materials used for thermal, acoustic and fire protection of buildings are chosen based on their operation mode (conduction, radiation, convection, diffusion or segregation, ionic exchange, hydrolysis, osmosis etc.), ecological properties (resistance to thermal, water or sound transfer and impact on the surrounding environment), their application (exterior or interior), the form of use (mattresses, panels, films, spray foams, plasters), structural contribution (single or multi-layer cladding, film coating etc.), the nature of the supporting materials they are applied to (concrete, AAC, brick, adobe or wood), the application process, such as plaster or panels with multiple structural-functional implications (thermal insulating, soundproofing and fireproofing), their physical-structural and chemical composition, along with their behavior in time as a summative system (related to component compatibility) and also the price.

For increased efficiency, protection through multi-effect insulation must consider a series of characteristics, including thermal conductivity of less than or equal to 0.10W/(mK), ignition temperature, thermal expansion, dew point, peel strength (strapo extraction), compression, scratch resistance and more. Thus, these materials must possess thermophysical properties, be fireproof and have a high degree of fire resistance, as well as being sound-absorbing and providing substantial sound insulation (serving as noise absorbers). Additionally, these materials should not compromise the building's structural integrity or alter its architecture; in other words, they should meet all the structural-functional requirements of the building.

Among the materials used for restoration, subject to numerous inventions and scientific studies, it should be mentioned [12-39]: expanded or extruded polystyrene, glass mineral wool, basalt mineral wool, wool, jute, hemp, flax, recycled cellulose, finely chopped wool, wood sawdust, cork, straw or reed, eelgrass - *Zostera Marina*, polyurethane foam, aerogel, thermal insulation plaster, vacuum thermal insulation panels, reflective foil with multiple layers of aluminum, as well as modern thermal insulation bricks and construction materials, classic hydraulic binders, fine sand, expanded perlite, expanded vermiculite, expanded ceramics, limestone filler, chalk powder and fire-retardant and photocatalytic self-cleaning additives. These materials present various disadvantages due to the material type, composition/structure, compatibility, method of application etc. For example, *polystyrene* is combustible and can propagate fire; it is also challenging to make it fire-resistant before application, has poor mechanical strength, degrades over time, releases pentane during production— a gas contributing to smog— lacks the ability to "breathe", making it unsuitable for external thermal insulation of facades, it is carcinogenic and non-permissive, resulting in a harmful living environment that continuously emits harmful vapors for health, has very low mechanical strength and a short usage warranty of less than 610 years, among others. *Glass and basalt mineral wool* have the disadvantage that their production process results in unwanted, carcinogenic emissions and the product causes irritation when handled without protection. Additionally, they disperse poorly in hydraulic binder systems and are more expensive compared to other competing materials. They are brittle and soft, requiring more costly adhesives that are harder to apply than polystyrene (i.e. these adhesives significantly reduce water vapor permeability). *Polyurethane foam* must be applied by a team of professionals, ensuring the exact amount is used and the joints, pores or other spaces are perfectly sealed to avoid potential heat loss, reduced mechanical strength, impermeability to water vapor, an inability to withstand fires and the production of toxic gases. Furthermore, among the most desirable is *aerogel*, which has *many advantages* but is a very expensive material.

The materials mentioned have many disadvantages, among which it should be mentioned:

- organic materials do not resist fire or high temperatures (e.g. expanded or extruded polystyrene, reeds and straw, cork) and can allow the spread of fire (e.g. polystyrene, bituminous cork, expanded cork, natural wool, reeds and straw);
- most produce toxic gases and smoke from fire (e.g. expanded polystyrene, straw, reed, cork, wool, polyurethane, mineral wool boards);
- they have low permeability to water vapor and gases (e.g. expanded polystyrene, expanded polyurethane, bituminous cork);
- they have a relatively high thermal conductivity coefficient (e.g. expanded ceramics, expanded glass);
- they have high or very high prices (e.g. vacuum glass spheres, expanded ceramic granules);
- they are not eco-friendly (i.e. expanded polystyrene, polyurethane, mineral wool).

For the same purpose, a series of pre-measured dry mortars are known, which are commercially delivered in bags and mixed with water before use, based on fine inorganic or organic aggregates, mineral binders and polymeric additives to improve the physical-structural, chemical and mechanical performance. Depending on the applications (i.e. mortars for thermal insulation systems, fireproof, soundproof and with self-cleaning effects on exterior and interior wall surfaces, for decorative plasters and the restoration of cultural heritage monuments), the four major components (fine aggregates, additives, hydraulic binders and polymer binders) vary within very wide concentration limits [12-18, 40-42].

These have the disadvantage that during the composition formulation, compatibility and synergy studies were not applied and from a rheological point of view, the pastes obtained from pre-dosed dry powders do not allow for easy commissioning, both manually and with mechanical devices.

Additionally, among the materials mentioned above, some of them involve processes such as cladding with expanded or extruded polystyrene, layers of fiberglass, asbestos or other types of mineral wool, synthetic polymers or natural fibers (e.g. wool, sea grass, hemp, flax etc.) [17, 18, 40-42], which, besides having low fire resistance and being flammable, have many disadvantages, such as: only being applicable for panel cladding and involve complex processes of compositional formulation and shaping into structures with predetermined dimensions, present poor mechanical properties and low hydrophilicity.

Mortars based on Portland cement, gypsum, perlite and fly ash are also known [5,17, 18, 40-42], which have the disadvantage of higher specific weights, higher chemical activity indices, tendencies towards acid hydrolysis and degradation rates under sudden variations in humidity and temperature, reducing the durability of the plasters.

It is also known that the use of power plant ash and calcium oxide for producing heavy or light concrete [5, 12-18] has the disadvantage of requiring differentiated use of these materials and involves selective storage based on the chemical activity index of the ash or calcium oxide.

In general, multi-functional compositions used for thermal and acoustic insulation, as well as fire resistance, also have other disadvantages involving the circular economy and intelligent use of natural resources. Therefore, this type of approach, without justification for the selection, is technically, scientifically and economically erroneous and the impact, by replacing one raw material with another, has negative effects.

The replacement of certain materials is correctly justified in the field of building protection through fireproofing (fire resistance), thermal insulation (thermal conservation) and soundproofing (acoustic insulation), but the selection of components and the development of the mixing protocol and application procedure must be rigorously defined. This aspect reveals a discontinuity in the interdisciplinary research through convergent activities or a unidisciplinary approach. Convergence is replaced with a coarse, quantitative assimilation of substitute products.

Except for hydraulic binders (Portland cement and gypsum) and fine inorganic aggregates, organic additives for plasters are redispersible powders from the group of vinyl, acrylic, cellulose ether polymers or copolymers, among others, which allow, in addition to improving permeability and adhesion to the substrate and increasing the durability of the plasters, to adjust workability to the desired level and by controlling the water content, contribute to modeling the hydration kinetics of the binders and the wall's breathability.

However, the polymer systems used as mortar additives form membrane systems upon commissioning, which affect the wall's breathability and prevent the diffusion of volatile components or the segregation of electrolytes, leading to efflorescence and microbiological contamination.

Most polymeric binders offer good adhesion to substrates; however, they are limited by poor drying characteristics, including high permeability to water vapor and a low water permeability coefficient [3-11].

Additionally, some gypsum-based mortars [5-16] have the disadvantage of high specific weights, a higher chemical activity index, tendencies towards acid hydrolysis and degradation rate to sudden variations in humidity and temperature, reducing the durability of the plasters.

The work aims to develop additive mortars for lightweight plasters, which facilitate a traditional application process with stages adapted to insertion-reinforcement systems, tailored to the specifics of the monument (the nature of traditional materials, architectural-structural complexity, age and state of preservation). These mortars are used for external and internal finishes in restoration interventions, allowing for specific applications of self-cleaning plasters that provide thermal insulation, soundproofing effects, hydrophobization and strong resistance to environmental factors, pollutants and microbiological agents.

In this context, two lightweight mortars were studied, one for external finishes and the other for internal ones, with compositions tailored for their interaction with the environment (external and internal). The formulation of the *first mortar (I)* includes Portland cement and fine calcium oxide powder (dehydrated lime) as the binder, while the matrix aggregate consists of expanded perlite, recycled cellulose from paper waste, fireproofed with ammonium polyphosphate and zinc borate and reinforced with a fiberglass mesh. This mortar can be applied in a multi-layer plaster over a thin leveling/smoothing plaster of the masonry, each layer including a fiberglass mesh for reinforcement, bonded by plastering on the previously hardened, plastered surface. The working surface to be put into operation will depend on the binder's setting time. Similarly, the thickness in which the mortar paste layer will be applied should not allow the formation of "bulges" on the support. Depending on the wall thickness and the external environmental conditions, two or more such layers will be applied, always using a fiberglass mesh for reinforcement.

The formulation of the *second mortar (II)* includes gypsum as a binder dispersed in a diluted construction-grade polyvinyl acetate emulsion and as an insert: recycled cellulose from waste paper, chalk powder, finely divided eggshell, fireproofed with ammonium polyphosphate and zinc borate, respectively, fiberglass mesh for reinforcement, used for thin plasters (with a single layer of fiberglass mesh for reinforcement) for interior wall surfaces. After a smoothing of the masonry, the mortar paste will be plastered after applying a thin smoothing layer on a working surface expected to be put into operation, depending on the binder's setting time, over which a fiberglass mesh for reinforcement is spread and subsequently a layer of plaster is applied with a thickness that can support the deposited material, to avoid "bulging" and later the surface is finished (smoothed) manually or mechanically. After hardening and drying, both plasters (exterior and interior) will be painted or coated with water-based colors, which will allow, besides improving permeability and adhesion to the substrate, an increase in the durability of the plasters and an adjustment of workability in the intervention area and by controlling the water content, an improvement in the kinetics of mortar hydration and optimal wall breathing.

Both mortars contain well-dosed titanium dioxide, zinc oxide and zinc titanate, which in the presence of UV light act as a catalyst and generate reactive oxygen species (hydroxyl radicals – OH• and superoxide anions – O_2^{-}•), which decompose organic compounds and pollutants on the materials surface. This process has two important effects: the decomposition of pollutants (dust, hydrocarbons, organic compounds) into less harmful products (carbon dioxide and water) and the creation of a superhydrophilic surface, which allows condensation and rainwater to form a thin film and effectively wash away dirt from the facade (the "self-cleaning" effect).

The implementation of this type of mortar offers a series of benefits, both aesthetically and functionally: *reduction of dust and pollutant accumulation* in the long term; *prevention of black crust formation* caused by chemical reactions between pollutants and base materials; *improvement of the durability* of wall surfaces by reducing maintenance cycles; *chemical and aesthetic compatibility* with historical materials, essential in heritage restoration; *antimicrobial properties*, preventing the development of mold and algae biofilms and also having an *ecological character* by reducing the need for aggressive chemical cleaning and indirectly contributing to urban air purification [43, 44].

Experimental part

The experimentally developed mortar is the result of research aimed at creating a material compatible with traditional substrates that exhibits improved performance in polluted environments. The composition of this mortar has been optimized to combine the mechanical and chemical characteristics necessary for consolidating historical facades with the modern functionality of self-cleaning capacity.

Materials, equipments, operations and work steps

The formulated composition of additive mortar for lightweight exterior and interior finishes of buildings, with multiple implications and procedures for its development and application, will eliminate the aforementioned disadvantages as it will allow the creation of plasters with superficial self-cleaning capacity of deposits. In addition, this material will protect buildings through thermal insulation (thermal conservation) and soundproofing (acoustic insulation), also provide effective fireproofing (fire resistance) and good mechanical strength. The mortar will be differentiated for *exterior finishes (Mortar I)* and *interior finishes (Mortar II)* [18].

Mortar I consists of 3 parts by weight of a mixture with Portland cement and calcium oxide ground to a fineness of 6...10% residue on a 4900 mesh/cm² sieve, in a gravimetric ratio of Portland cement:calcium oxide = 2:1 and 2 parts by weight of a mixture of expanded perlite (with a grain sizes smaller than 0.10mm) and recycled cellulose, in a gravimetric ratio of perlite/cellulose = 6:4 and additive with 0.2 parts of a fireproofing mixture made of ammonium polyphosphate and zinc borate, in a gravimetric ratio of 5:1. After thorough mixing, the entire powder system is homogenized in a 1.5:1.0 weight ratio with an additive system made of ZnO, TiO_2 and three different colored fired clay ceramics (red, brown and black), in a gravimetric ratio of perlite:egg shell:ZnO:TiO_2:colored ceramics = 6.00:3.60:0.16:0.04:0.20 [17]. For the final mixture, the content of ZnO, TiO_2 and the three colored ceramics is pre-optimized to adjust the mixture color to an average, background color given by the patina of time (antiquity), involving CIE L*a*b* reflection colorimetry, modifying the addition rate of eggshell powder with a reformulated percentage for each colored ceramic powders. For this, very fine powders (with a granulation of less than 0.01mm) will be used from the three fired clay ceramics (reddish, brown - burnt umber and black). Subsequently, the entire system is mixed with 2.5 to 4.8 parts by weight of water (a ratio imposed by the rheology of the paste depending on the type of substrate, antiquity, state of preservation etc.), which contains a dispersed acrylic binder (in a gravimetric ratio of water:binder = 2:8). After preparation, it can be applied to the facades of historical monuments in form of paste, depending on the state of preservation of the apparent structures.

When applying the mortar, two operations can be used: for surfaces without lacunar areas but with chromatic degradation and thick entrenched deposits, a thin layer is spread with a spatula on a fiberglass mesh or in the case of damage with deep lacunar areas, a simple mortar based on river sand, expanded perlite, Portland cement and water in a gravimetric ratio of sand:perlite:cement:water = 2:1:2:5 will be applied first and after it hardens, a thin layer of the first mortar will be applied on a fiberglass mesh.

Mortar II for interior finishes consists of a 5-part weight mixture made of gypsum, chalk powder, fine eggshell powder (ground to a fineness of 10...15% residue on a 4900 mesh/cm² sieve) and recycled cellulose, in a gravimetric ratio of gypsum: chalk powder:fine eggshell powder:recycled cellulose = 4:1:2:3. The additive introduced will consists of 0.1 parts fireproofing mixture made of ammonium polyphosphate and zinc borate, in a gravimetric ratio of 5/1, which will be subsequently homogenized, using a concrete mixer. The entire powder system is mixed with 4.9 parts by weight of water and construction-grade polyvinyl acetate emulsion, in a gravimetric ratio of water:polyvinyl acetate emulsion = 9:1. The additive for photochemical protection with a self-cleaning effect and repatinating uses a composition formulation and application operations identical to those for *Mortar I*.

These pastes will be applied differently, hence: for external *wall surfaces* in the form of *multi-layer plaster*, reinforced with fiberglass mesh *Mortar I* will be used. The working surface to be applied will be dependent on the setting time of *Mortar I* and the thickness of the plaster, which must be bearable with the wet mortar load, so it doesn't form "bulges," and depends on the wall thickness and external environmental conditions. After the previously prepared support has hardened, two or more layers can be applied, always using fiberglass mesh for reinforcement. In contrast, for *internal wall surfaces*, after a thin layer of second type of mortar (II) is applied on the masonry (support) for smoothing, a thicker layer of *Mortar II* paste will be applied over a fiberglass mesh for reinforcement on the hardened support, on a surface and in a thickness layer allowed by the setting time of mortar II, so it doesn't form "bulges," then it is finished (smoothed) manually or mechanically. Lastly, after drying and curing through hydration and carbonation, both plasters (external and internal) can be either traditionally whitewashed with one or two coats of fine lime milk dispersion or a permeable colored water-based film, which will ensure the desired color. These structures, in addition to improving permeability and adhesion to the substrate, provide good resistance to fungal attack, increased durability of the plasters and enhanced workability in the intervention area. By controlling the water content, they also improve the hydration kinetics of the mortar and ensure optimal wall breathability, preventing the formation of damp.

Before applying the mortars, both the exterior and interior surfaces must be mechanically cleaned by wiping, sanding or brushing and by washing with compatible aqueous systems to remove crusts, efflorescence and other deposits, ensuring that the well-preserved original material is not affected. The substrate should be dry, adherent and porous to facilitate good adhesion.

Additionally, when obtaining the mortars, the components are mixed homogeneously in a construction or laboratory mixer, by strictly following the formulation. Water is added gradually until a plastic consistency, easy to spread, is achieved. The obtained mortar is applied manually with a trowel, in a thin or medium layer, depending on the needs of the facade. A brush or a fine trowel can also be used for sculpted details or decorative profiles.

After application, the surface must be protected from rain, direct sunlight and frost for at least 24-48 hours. The full bond is achieved in a few days, depending on the layer thickness and the weather conditions.

Laboratory testing

In the research phase, the mortar components and the prepared mortar were subjected to several tests, in a system of co-assistance and corroboration between interdisciplinary techniques, in order to:

- *Determine the physical-chemical characteristics of binders* (Portland cement, gypsum, expanded perlite, fine eggshell powder, calcium oxide/dehydrated lime, chalk powder and as a matrix aggregate: expanded perlite, recycled cellulose from waste paper, pre-washed and finely chopped wool), *self-cleaning additives*, *colored fired clay ceramics for repatinating* (involving CIE L*a*b* reflection colorimetry);
- *Optimize the thermal insulation product obtained from recycled cellulose and wool* (bulk density or specific weight, thermal conductivity, humidity before use, thermal characterization of the material, technical and economic optimization);
- *Evaluate the mechanical resistance* (compressive and flexural strength) – to confirm that it can replace traditional mortars without structural compromises;
- *Assess the adhesion to typical substrates* (stone, old brick, lime plaster) – essential for restorations;
- *Assess the water vapor permeability* – to allow the "breathing" of historical walls;
- *Assess the photocatalytic activity* – tested by the degradation of the standard reference compound (e.g., methylene blue), under controlled UV exposure conditions;
- *Evaluate the resistance to freeze-thaw cycles* – simulating severe urban climate conditions.

Results and discussions

The laboratory tests enabled the correlation with the quality characteristics of commercial products, based on which a compatibility evaluation protocol (through artificial aging) was developed and the compositions used to obtain the mortar pastes were established. Following these experiments, the results indicated an excellent balance between mechanical performance and surface functionality, with an organic pollutant degradation rate of over 60% after 48 hours of UV exposure in standardized tests.

The correlation curve area $\lambda_{10,uscat} = f\left(\rho_{material}\right)$ shows a significant slope, meaning that with the increase in material density, the thermal insulation properties of the two lightweight materials with thermal insulation and soundproofing capabilities are noticeably improved [17, 18, 40-42].

The optimal zone is characterized by a shallower slope of the curve $\lambda_{10,uscat} = f\left(\rho_{material}\right)$ and similar thermal conductivity values of the products, as the values obtained from testing the two products nearly overlap, which highlights the consistency in this density range and will subsequently ensure a consistent repeatability of these characteristics.

By exceeding the optimal range, for densities greater than 35kg/m^3 (150 and 220kg/m^3), an additional increase in the material's density can be observed, which leads to a negligible change in the thermal conductivity coefficient, with the correlation curve asymptotically approaching the x-axis. Regardless of the compositional formulation variant, the two lightweight materials in unconventional structures for exterior or interior finishes of old buildings and during commissioning should not exceed 40%.

An innovative feature of using the two developed materials for both exterior and interior finishes addresses the absorption of high levels of humidity and chemicals (for example, carbon monoxide and dioxide, hydrogen sulfide, sulfur and nitrogen oxides, formaldehyde), with the product serving as a buffer that reduces variations caused by sudden emissions of pollutants.

Color optimization to adjust the chromatic tone to that of the patina of time is achieved by using specialized software and CIE L*a*b* reflection colorimetry. For this, facades surfaces with an untouched patina, unaffected by environmental factors and agents, were chosen and tested at multiple points. Subsequently, the content of zinc oxide, titanium dioxide and the three differently colored ceramics was modified, to the detriment of the eggshell, until a shade equal to the average chromatic deviations (ΔE*) determined on the facades was obtained, also using CIE L*a*b* reflection colorimetry on bulk powders pressed planimetrically [37-39, 43, 44].

For validation under real conditions, the mortar was experimentally applied to *segments of wall surfaces undergoing restoration.* Between 6 and 12 months from the application of the mortar, the following were monitored: *the evolution of thermal, acoustic and waterproofing capacity, the degree of accumulation of polluting particles; the visual aspect (color, deposits, mold); the layer's resistance to weathering and color deviation.*

The application of this procedure highlights a series of innovative advantages, as follows:

- economically integrates a new composition for materials with multiple effects, such as thermal insulation, fireproofing and soundproofing;
- the materials were selected through compatibility and synergy studies, in correlation with the physical-structural, chemical and rheological characteristics of conventional or unconventional materials that allow for the compositional formulation of pastes for mortars used in construction, both for exterior and interior finishes;
- for the development of these mortars, initially were tested the characteristics of a wide spectrum of materials for integrated multi-effect compositions: photochemical self-cleaning capacity, thermal protection, soundproofing and fireproofing, including those with a binding role through hydration or carbonation, which offer ease of use and adequate mechanical strength. The specific weight was evaluated and the thermal properties of the materials under study were highlighted, aiming to increase thermal efficiency by minimizing the percentage of high thermal conductivity and those of sound absorption that allow for effective sound insulation in the final product;
- through specific tests were selected both raw materials and various mineral or hydraulic binders (Portland cement, calcium oxide and gypsum) and organic binders (construction adhesive), chalk powder, fine eggshell powder, expanded perlite compatible and with a synergistic effect, differentiated by formulation/composition, specific weights, hardness, thermal conductivity, acoustic absorption, permeability to water vapor, air and other gases, with the optimal range of each one being selected at any time, to obtain a material with photocatalytic self-cleaning capacity, thermal insulation, sound absorption, fireproofing and effective insect-fungicidal properties.

Conclusions

The paper presents the development of lightweight mortars with thermal, acoustic and waterproofing capabilities, enhanced with self-cleaning properties, intended for the protection and restoration of the exterior and interior wall surfaces of monuments affected by urban pollution. The product was developed considering binders and matrix inserts compatible with historical structures and enhanced with photocatalytic and repatinating additives, which contribute to thermal, sound-absorbing, fire-retardant and hydrophobic protection, while maintaining aesthetics by reducing dirt deposition. The materials primarily target interventions for the conservation of built heritage, but they also have potential applications in contemporary urban architecture. The next stages of the research include testing under real conditions and adapting the compositions for various types of substrates, to expand its widespread use.

The commissioning process follows certain steps: (a) weighing and dosing the quantities of materials, (b) intimate mixing, (c) improving the composition with self-cleaning, antimicrobial additives, (d) obtaining mortar pastes, (e) superficial cleaning of the supports, (f) applying single and multi-layer reinforced plasters and adherent to the previously prepared support, (g) whitewashing or polychrome painting of wall surfaces, (h) monitoring the behavior of the finishes.

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