EVALUATION OF CONTEMPORARY TECHNIQUES FOR THE RESTORATION OF STONE IMITATING RENDERS: A BELGIAN CASE STUDY

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Abstract. The aim of the research was to observe and to analyse the repair procedure of a listed façade from the interwar period, finished with a stone-imitating mortar layer. Many theoretical studies have been published about the most diverse aspects of repair mortars for historic buildings, but it is important to know how many of these findings are already implemented in daily restoration practice. Starting from the initial condition, damage typologies were located on the façade surface and linked to their corresponding causes. Subsequently, a specialized contractor was appointed for the restoration process. After cleaning the façade with a soft wet sandblasting method (Torbo) and removal of damaged mortar segments, two repair mortars were applied. A structural repair mortar was attached to the masonry substrate and on the other hand a mixture of commercial mortar powders was used to obtain an imitative top finish. Finally, the used finishing techniques, such as the scratching, simulation of joints and the treatment of ornaments, are discussed and evaluated.
1 INTRODUCTION

Over the last decade, there has been an increased interest in repair mortars for the restoration of architectural heritage. A lot of research has been carried out on this topic in order to support practitioners to attain sustainable restoration campaigns. Scientific literature does not only deal with historic sources [1, 2], but also focuses on experimental analyses, such as mortar characterization [3, 4], the compatibility of modern repair mortars with authentic material [5, 6] and the relation between mortar components, craftsmanship, weathering conditions and damage patterns [7, 8, 9]. However, due to this great diversity of studies all focusing on a specific aspect of a historic or repair mortar, it is rather difficult to put this knowledge into practice [10]. From an objective point of view, it seems necessary to synthesize the available research data in a way that it is accessible for architects, contractors and manufacturers. The aim of this paper is to gain insight into current restoration procedures by monitoring a case study. As a consequence, we can evaluate how restoration architects and contractors nowadays implement standards and scientific recommendations on site.

The case study is a 3 storey residential house from 1924 (Fig. 1), designed by L. Pintelon [11] and situated at the Prinses Clementina Avenue in Ghent (Belgium). Together with other typical Art Nouveau and Art Deco buildings along the avenue, the front façade of the case is listed as ‘townscape’ because of its cultural historical importance [12]. A stone imitating render, applied on a brick masonry support with concrete elements, characterizes the outer surface. This peculiar render finish looks like ordinary sandstone masonry, due to the natural colour and the simulated joints, which create stones of approximately 60 x 30 cm and 30 x 30 cm. Also ornaments are observed above windows, on the bay window and beneath the cornice.

Figure 1 (left): Case study in Ghent with soiled stone imitation cladding (© S. Van de Voorde) - Figure 2 (middle): Close-up of the rather heterogeneous render with pigmented grains – Figure 3 (right): Brick support, rendering layer and top layer (© Y. Govaerts)
Stone imitations were very popular during the interwar period in Belgium. Advertisements in monthly architectural journals show a tendency towards these less expensive alternatives for natural stone. As a consequence, also the middle class could afford a modern stone-like façade [2]. Although such decorative render layers all resemble real stone, most of them have a different composition, making it very difficult to restore. These variations are the result of the on-site mixing of ingredients by skilled craftsmen, according to their own experiences and material suppliers. Only a limited range of commercial ready-mix mortars was available. The general composition formula prescribes white cement with or without slaked lime as binder, and quartz sand with crushed natural stone as aggregates. Additives such as muscovite minerals, starch and oils were often incorporated to improve aesthetical or processing qualities [13]. The mortar finish in Ghent is applied in two different layers (Fig. 3). To flatten the rough masonry support, a cement mortar of 3 cm is applied, followed by a 5 mm imitation top layer. The latter has a light greyish beige colour, with a rather heterogeneous appearance due to the presence of tiny black, brown and pink particles (Fig. 2). Mica minerals were not observed, but it looks similar to the Terranova plaster.

In the next paragraph, a brief overview of the damage patterns will be given to get an idea of the degree of decay. Damage mapping is essential in order to propose durable restoration interventions. Afterwards, the cleaning method and repair mortar composition will be discussed, as well as the used finishing techniques.

2 DAMAGE ASSESSMENT

Scaffolding was attached to the front façade (north-west oriented), allowing an in-depth study of the damage patterns. In particular the blackening of certain mortar areas causes distracting brightness contrasts, spread across the entire façade. There is a noticeable difference between flat surfaces on one hand and sheltered or ornamented areas on the other hand. Whilst flat imitation masonry shows smooth colour gradients, rougher ornaments have to deal with grey and black crusts (Fig. 4-5). Black crusts arise when a render layer contains limestone fragments (CaCO$_3$), which interact with the atmosphere (mainly SO$_2$ and O$_2$) forming dry gypsum efflorescence (CaSO$_4$). Gypsum has originally a white colour, but turns black due to the deposition of air pollutants, such as black carbon (soot) [7, 14]. However, the crusts only appear in areas which are not exposed to heavy rainfall.

Figure 4 (left): Black crusts at non-exposed areas and gypsum efflorescence - Figure 5 (right): Cracked and soiled ornaments on a concrete support (© Y. Govaerts)
Although gypsum formation is removed through rain runoff, colour gradients are still visible on flat exposed surfaces. Presumably, this is due to a slightly different roughness of the mortar texture. Because deeper grooves and pores are protected from rain, a small gypsum layer can locally appear in the pores, creating an overall darker ‘patina’ (Fig. 6). A black crust can detach together with some authentic material, or contribute to ettringite precipitation, which expands and results in severe stress within the pores of the mortar structure [8].

A large number of cracks are observed which can be classified according to different causes. At first, hair cracks arise because of dry shrinkage right after application or when ice particles create an expansion in the top layer. Fine cracks are also caused by the cyclical character of daily temperature fluctuations, allowing cracks to grow and expand [15]. Furthermore, most cracks are formed at the border between the concrete support of the bow-window and the brick masonry support. Not only a different thermal expansion coefficient causes cracks, but also corrosion of the underlying concrete has a detrimental influence, reducing the adhesion between concrete and render layers (Fig. 7). Finally, cracks appear between authentic material and former reparations, because the repair mortar is not compatible. Moreover, previously applied repair renders have a completely different appearance and affect the historic façade image (Fig. 8, 10).

Local pale colours are observed just above the plinth. Presumably these veils can be characterized as lime, arising from unbound lime hydrate, which is derived from the render binder [15]. Most painted joints are still intact because of a good adhesion with the top layer. Apparently these light grey imitation joints contain a part of calcium carbonate, which is transformed into gypsum, making the joint rougher and easier subjected to rain and wind. As a result, paint layers are locally eroded (Fig. 9), especially in the architect’s inscription grooves.
3 RESTORATION PROCEDURE

Unlike most case studies in literature, this building is not publicly tendered and belongs to a private owner. As a consequence, the architect needs to present a document to the authorized heritage conservation services, in which future restoration interventions are described. Based on a list provided by the heritage services, the architect chooses a specialised contractor. During the restoration campaign, the contractor has to adjust his work and methods to the available budget and the opinion of his customer, without on-site inspection from a heritage organization.

3.1 Cleaning method

On the recommendation of the authorized contractor, the Torbo technique was chosen to clean the soiled render areas. Also the Flemish services (Flanders Heritage Agency) are in favour of the Torbo technique but they advise preliminary test-strips. Torbo is a wet abrasive blasting system, which is commonly used in the renovation sector, independent from the cladding material. For restoration purposes the parameters can be adjusted to obtain a soft cleaning method under low pressure (maximum 2 Bar), reducing the dirt without damaging the original material. Water (95%) and sand (5%) are mixed and projected onto the surface. Because the blasting sand is enveloped with water, the development of dust is substantially reduced. At first, the exterior joinery is taped to protect the paint layers. Next, the wall surface is cleaned from the top down by a skilled labourer, since it is essential to keep an equal distance between similar soiled areas and the blasting head. Apparently only the most contaminated surfaces are cleaned, leaving less prominent stains behind. Afterwards the façade is rinsed with water to remove remaining sand particles. Since Torbo creates saturated render layers, it is not recommended to use before or during winter conditions. The absorbed water will gradually move to the surface through capillary action where evaporation takes place.

The cleaning process succeeded to eliminate most dark stains, but it also included detachment of render layers. In addition, a very pale spot surrounded by splash stains is observed, which is probably originated from a former cleaning technique. This pale area contains considerably more cracks than surrounding areas.

On behalf of the heritage services, the contractor was only allowed to use Torbo cleaning if some preliminary tests on the specific material were performed successfully. Presumably this technique was chosen because of the contractor’s experience in similar cases. Other monumental buildings which are tendered by the government seem to require more preliminary research. Depending on the case, Torbo is not always a logical choice. This can be illustrated by the restora-
tion protocol used in the Saint-Joseph Coloma church in Mechelen, where the interior is finished with a smooth imitation plaster. To choose the most appropriate cleaning method, small surfaces were cleaned at first with chemical gels, hard sponges and the Sponge Jet system [16].

Evaluation after cleaning indicates that Torbo was not the best solution. A more uniform result would be obtained when using for instance Rotec, which is similar to Torbo but the blasting head contains a rotational airflow. As a result, the blasting beam is deflected to avoid a perpendicular impact to the surface, creating a gumming effect, which is less harmful to the patina. However, the cleaning of a listed façade is rarely recommended in reports of Heritage Preservation [17]. Since improper cleaning procedures are often chosen, damage might increase. Cleaning is allowed, but this asks for further research on the behaviour of materials after application of diverse cleaning methods.

3.2 Towards a repair mortar

After cleaning, an extensive visual inspection of the façade condition is carried out. Despite the general restoration philosophy prescribes to preserve as much as original material as possible, large parts of render surfaces are removed (Fig. 11). Initially, incompatible grey cement-based repair renders from a former restoration campaign are removed up to the masonry support (Fig. 12), carving a surface corresponding to the appropriate imitation stone. This is to reduce colour differences within one imitation stone. Also improper restored grey ornaments, which vary in texture and geometry, are cut away. Likewise, mortar areas characterized by significant colour differences (through deposition of lime hydrate), by cracks or a lack of adhesion are removed up to the rough rendering layer (Fig. 13). If this base layer shows damage as well, such as cracks or blistering, or the roughness is not suitable in order to guarantee a good adhesion with the new top layer, removal is required. Whilst carving the two mortar layers, some attached bricks often come off. Consequently, it is important to throw away all loose mortar and brick parts before applying a new mortar. The bow-window contains structural concrete elements, which are subjected to concrete decay. Carbonation processes result in a lower pH value, causing corrosion to the reinforcement bars in the concrete beams. Volume expansion of rust leads to deterioration of the concrete surface. Therefore, loose concrete pieces are removed and the exposed reinforcement bars are cleaned using a steel wire brush.

Figure 11 (left): Large surfaces of authentic material are removed - Figure 12 (middle): Carving up to the brick masonry – Figure 13 (right): Exposed original base layer after removal of a decorative element (© Y. Govaerts)
Next, a fibre-reinforced structural repair mortar with low shrinkage rate and sulphate resistance is used as a substitute for the carbonated concrete. Also broken rendering layers are treated with the product in order to ensure a good adhesion and to increase the tensile strength to reduce cracks. Moreover, the fibres improve the mortar’s resistance to weather conditions. The substance is prepared by blending 15% water with 85% powder and mixing mechanically during 3 minutes. In addition, another bucket is used to compose a mixture of water with a small fraction of the repair mortar powder. The obtained liquid is spread out over the exposed supports using a brush. As a result, the dry brick masonry absorbs the moisture content until saturation (Fig. 14). Leak traces have to be avoided because they could harm lower intact surfaces from an aesthetical point of view. Without this humidification the bricks would absorb the water from the repair mortar, preventing it from curing properly. Even though specifications prescribe to wet the substrate at least 12 hours in advance [18], the structural repair mortar is already applied after a few minutes. The mortar is manually compressed to a thickness of about 1-2 mm above the authentic imitation top layer (Fig. 15). Afterwards, this protruding coating is scraped off in all directions by means of a sharp aluminium lath, increasing its roughness. Missing parts of carved window-sills and damaged ornaments are filled with the same repair mortar. Temporarily fixing wooden elements enables to reshape these decorations (Fig. 16). After a hardening period of 1 or 2 days, simple linear grooves are manually customized using the aluminium tool (Fig. 17-18). Intact rendering mortars are not covered with the structural mortar.

![Figure 14](image1.png) (left): Moistening the substrate – Figure 15 (right): Applying a new base layer (© Y. Govaerts)

![Figure 16](image2.png) (left): Large surfaces of authentic material are removed - Figure 17 (middle): Carving up to the brick masonry – Figure 18 (right): Exposed original base layer after removal of a decorative element (© Y. Govaerts)
Since every imitation ‘simili’ render has a slightly different composition and appearance, it is a challenge for contractors to make their repair render match with the cleaned surface. Especially comparing and evaluating a newly mixed wet mortar with the current cladding seems rather impossible, because the colour of the repair render will change after drying. Therefore, the contractor carries a few hardened samples with him (Fig. 19). Comparing the samples with important parts of the façade learns that none of them matches the exact colours of the rendering. Since the target colour always lies in between, one of the craftsmen started to prepare new compositions, based on the ingredients of the dry samples.

![Figure 19: Samples of hardened commercial repair renders (© Y. Govaerts)](image)

According to the contractor, exterior stone imitations are usually restored with standardized pigmented powders, which are developed for plastic repair of real natural stone. These mortars have a rather similar appearance and apparently it is more convenient to use these ready-mix mortars instead of composing various binders and aggregates on site of which the properties and long term behaviour is not known. In this case, a repair mortar is obtained by adding 2.5 volume parts of crushed natural stone powder to 1 volume part of liquid (mineral binder), without the addition of water. The powder is available under a range of at least 16 natural stone colours and is well known in Europe. Several mortar types were examined in the Royal Institute for Cultural Heritage in Brussels to evaluate their properties [19]. It was found that none of the predefined mixtures contains a dangerous concentration of soluble salts. Moreover, every sample shows different characteristics, such as different cohesion factors and durability, but no damage is observed, even after 52 freeze-thaw cycles.

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<th>Table 1: Overview of the applied repair render compositions</th>
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Seven mortar mixtures were composed out of the standard imitation powders, according to the preferred colour and the experience of the skilled contractor (Table 1). Preparing only one repair
render composition, relying on the appearance of a confined façade area, would not be useful. This is because there are still some gradual colour differences noticeable after cleaning. Therefore, their restoration philosophy is to approach the same colour aspect as the colour of the surrounding cleaned surfaces. Table 1 shows the 7 used powder mixes, based on the standard Chauvigny, Euville, Savonnière and Balegem crushed stones and Top powder. Top powder is also available under a range of colours and is included to simulate the texture surface of natural stone. Composing the mortars is a time-consuming trial-and-error process.

In case the original rendering layer has a low roughness appearance, additional grooves are drawn to improve the adhesion properties. Then this surface is treated with a liquid coating to start a chemical etching process. In a next step the appropriate mortar composition is applied to a thickness of 1 to 2 mm above the surrounding top layers. Depending on the outdoor temperature, the paste is sufficiently cured after 10 to 25 minutes, making it possible to equalize the repair render (Fig. 20-21).

3.3 Finishing techniques

The hardening process involves a remarkable darkening after 24 hours, which is due to a polymerization reaction [20]. Finally, all surfaces are scratched with an aluminium lath to match with the surrounding texture. At last, the finishing of joints and ornaments is discussed.

In order to resemble a masonry structure, also the simulated joints need to be restored. When large surfaces are subjected to replacement, including imitation joints and depth differences are erased. Joint positions are remembered by making sketches in the base mortar layer. Whilst applying the top layer, grooves are drawn to a depth of about 8 mm (Fig. 23). This depth is required to prevent erosion of the painted joints and to guarantee a durable restoration. At the end, the grooves are carefully filled with a blended lime-cement mortar. When repairing small surfaces, contractors rely on the surrounding joints. Authentic imitation joints and decorative elements are protected with tape to avoid stains of the repair mortar.

Severely damaged ornaments in the centre of the bow-window have been removed. For their reconstruction, a mould is made from an intact ornament on the side of the bow-window (Fig. 25).
As a consequence, a new ornament is cast by means of a more fluid version of the predefined compositions (table 1). After hardening, the element is glued on top of the imitation render and the contact joints are finished using the same render to obtain a homogeneous appearance. Preserved ornaments on the other hand are repaired (cracks are filled) and finished by means of ‘colour washing’ (Fig. 24). Colour wash is a technique in which the ornaments are covered or painted with ‘mortar milk’, comparable to the low consistency of paint (Fig. 22). Mortar milk consists of a small amount of render powder dissolved in a considerable amount of mineral binder liquid.

4 CONCLUSIONS

This paper sheds light on the restoration procedure of a listed façade, finished with a stone imitating render. Monitoring the construction site for 8 weeks enabled to study how contractors deal with damage patterns and aesthetical aspects. Although the restored façade looks clean and intact from a distance, closer inspection calls for some remarks.

The new repair render has a more homogeneous appearance in contrast to the original finish, which contains a variety of pigmented particles and aggregates of different sizes. Because of this contrast, repairs on ground level may disrupt the historical harmony. Also the ‘colour washing’ technique has to be prevented on ground level since a brush leaves paint stripes, which harms the artificial stone aspect. Moreover, it has not been proven yet that the used repair render is a durable material. Each standardized powder mixture, representing a specific natural stone colour, has been tested. However, the effect of mixing several powders together, each with their own chemical components, can have an unexpected outcome on the long run.
It is also interesting to observe that the thickness of new renders varies. Whilst a 5 mm repair render is always applied on intact original base layers, new base layers are covered with only a 2 mm repair render. This might have an influence on the development of future damage patterns.

Most harmless shrinkage cracks are preserved in order to keep a façade image, which reminds to its age and historical value.

Six months after the restoration procedure, the finishing is evaluated again. Damage has not been developed, but first visual observations show that the render cladding has turned back to a greyer appearance. Moreover, authentic areas seem to age faster than the surfaces with a repair render. New parts still have a pale colour while the old parts seem to be more subjected to air pollution. According to the manufacturer ‘s lab analysis of the standard mixtures, the ageing would be similar to the ageing of natural stone. Although an appropriate target colour was found during restoration, the ageing of both materials leads to larger colour differences. Further research on the effect of cleaning methods, ageing experiments and compatible repair mortars for stone imitating renders seem necessary to improve current restoration strategies.

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