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Restoration of the Tile Cladding of a Post-War Modernist Building Complex

Yves Vanhellemont¹

¹ Belgian Building Research Institute (WTCB-CSTC-BBRI), Belgium, yves.vanhellemont@bbri.be

Abstract
The need for compatible mortars does not only apply to old historic masonry, but equally to more recent buildings. The COOVI/CERIA complex in Anderlecht (Brussels region) is a modernist ensemble, created by architect Antoine Courtens between 1950 and 1954. Nowadays the buildings suffer from severe damage of the tiles covering the facades, caused by several types of infiltrations. The choice of architectural details (protections, lack of dilatation joints…) and mortars in those days were the main cause of the degradations. A study and subsequent advices were carried out, based on the survey of the buildings, and based on a (mainly petrographic) study of the mortars. In this study we would like to show that a durable intervention is composed of both a material-approach, combined with an analysis of architectural aspects of the building, and a thorough maintenance plan. The project shows that scientific approach can lead to an ideal solution for restoration problems, but that the constraints of the actual execution of the restoration works can lead to modified solutions, which are in a way compromises, but nevertheless the best solution in the given circumstances.

1 Introduction

The building complex is a design by the Belgian architect Antoine Courtens (1899-1969). He was a student from Victor Horta, and starting from 1926 he was involved as a designer for many important art deco-buildings in Belgium. His style evolved towards modernism, from which the building complex in this study is an important example.

The name of the study object in this paper is COOVI/CERIA. These are the Dutch and French abbreviations of the full name of the complex, namely the Centre for Education and Research of the Food Industry. It consists of many buildings, grouped in a green area. The buildings are characterized by horizontal lines (Fig. 1), with one main exception, the tower.
In 2004, the building complex was split in two, and each half became the property of the Flemish and Francophone community in Brussels. The French part underwent since then a thorough renovation, even though heavily disputed, including the construction of a whole new façade, with thermal insulation in between the old and the new walls. Needless to say that this changes drastically the aspect of the facades: the details in the corners are different, the windows are no longer in the plane of the façade (which is very typical for this style), etc.

For the buildings in the possession of the Flemish community, it was decided to treat the building as if they were listed as a monument (even though this is not the case) because of the high intrinsic qualities of the architecture.

2 Technical aspects of the buildings

2.1 Construction

The buildings consist of a structure in reinforced concrete, with fill-in brick masonry. The structure and masonry are not visible. At the ground level, the facades have a natural stone parament, in a very good condition. This level is very well protected, because of a very broad cornice. Starting from this level and upwards, the facades are covered with ceramic glazed tiles. These tiles are rectangular, with more or less the dimensions of bricks, giving the impression that we are not seeing a cladding, but masonry instead.

At the top of the facades, there are covering tiles (in prefabricated reinforced concrete), laid directly on the masonry. The level of the roof and gutters is lower than the top of the facades, so no roof is visible from the ground level.
There are (as far as we know) no dilatation joints, even though the facades are very large (tens of metres).

Window sills and the borders of doors and windows are constructed in prefabricated ceramic elements, separated by joints. As far as we know, no protection against water infiltration is foreseen under these window sills.

### 2.2 Visual survey of the facades

During construction, the building contractor was also occupied with the maintenance of the facades that were already finished. When the construction finished, hardly any work was carried out on the facades anymore. This results in the aspect of nowadays: quite large surfaces from which the tiles have disappeared (Fig. 2, bottom left). The situation looks more serious than it actually is: also tiles surrounding falling off tiles have been removed preventively.

The buildings are for many people known as having green facades. To prevent tiles falling on people’s heads, the buildings are wrapped in green security nets, giving them a green appearance, seen from a distance.

Micro-crack formation between joints and tiles is very general. This is not surprising: these large surfaces suffer from high thermal dilatations, causing tensile strengths in the facade. Since no dilatation joints are foreseen, the logical consequence is that such joints are formed automatically at random, at the weakest parts, being the interface between tiles and joints.

We see also large damages in window sills, where missing joints between the ceramic tiles are very general (Fig. 2, top right).

Also the joints in between the concrete tiles on top of the facades are missing (Fig. 2, top left).

These defects are all responsible for potentially large water infiltrations in the facades.
2.3 Sampling of the facades

On selected areas, drilling cores were taken in order to obtain a clearer view on the structure of the façade, and to perform analyses on the materials. These cores (Fig. 3), together with a petrographic analysis on the mortars, learn the following:

- The tiles are put into place in a bedding mortar, directly on the underlying masonry. The binder of the mortar is a mixture of cement and hydrated lime. This is a very traditional and efficient mortar, that is durable (in conditions of ‘normal’ exposition), workable, and does not dry out easily when the weather is warm. This kind of mortar is also more flexible, which is an important property for such large facades with important thermal movements [6].
- The joints in between the tiles are executed with a pointing mortar with cement as main binder.
- The pointing mortar in the joints is usually in good condition (no damage due to frost or other alterations – except for the micro-cracks between mortar and tiles). The bedding mortar used for attaching the tiles to the masonry seems to
be frost-sensitive. This is easily seen through petrographic analysis on mortar taken from damaged areas.

- The tiles exist in two versions. One version is a tile that is coloured in the mass (Fig. 3, left). These tiles have a kind of ‘hook’ on their back, which serves as an anchor in the bedding mortar. On later buildings on the site, the tiles seem to be red on the inside (Fig. 3, right), with a thin coloured glaze on top of the tiles. Both type of tiles seem to have a good resistance to degradation, the tiles are in very good condition.

![Fig. 3](image)

**Fig. 3** Two drilling cores from the facades. On the left a drilling core with tiles that are coloured in the mass, on the right a core from a façade with tiles with a superficial colouring. Note the mechanical ‘hooks’ on the back of the tile (left photo) that ensure a good mechanical adherence. Also note structure of the façade on the left photo, with from right to left the structural masonry (a part of a brick is visible), the bedding mortar, the tile. On the right photo also the pointing mortar between the two tiles is visible.

A very important conclusion of the survey is that water infiltration, combined with frost action, is a major, probably the most important, problem for the facades. This water infiltration comes through the cracks in between tiles and pointing mortar, and through open joints in façade covering stones, and open joints in window sills. When such infiltration happens, humidity is not likely to escape easily the facades. The ceramic glazed tiles are water vapour tight, and so are the dense cement-based joints. Water infiltration, combined with almost no escape possibilities for humidity, and combined with frost action, might cause severe damage on the facades.

The restoration of the facades should therefore be aiming at the reduction, as much as possible, of the water infiltration, and to minimize the possibility of water accumulation in the facades.
3 Recommendations for the restoration

3.1 On the construction level

Because of the fact that the aspect of the facades should be conserved, one is limited in possible solution. On the construction level, there are two main improvements:

- Water infiltration on top of the façade should be stopped. In principle this should be done by the maintenance of the joints between the covering stones on top of the facades. Since such curative maintenance never can stop infiltration (one fixes defect joints who have been open for quite a while), and since one can never be sure that maintenance will be carried out in the future, a more certain measure has to be carried out: placing of a continuous membrane (metal or other) under the covering stones, with a ‘nose’ on both sides of the facades (to prevent from rainwater falling off running over the façade). Even when the joints between the covering stones are open, no water will infiltrate in the masonry under the stones.

- Water infiltration on the level of the window sills should be stopped as well. For the same reasons as above, it is preferable that this is done by inserting a membrane under the sills.

We strongly believe that these improvements are absolutely necessary to reduce the maintenance of the facades in the future. They are also durable interventions, meaning that, even in the worst-case scenario that no maintenance is carried out on the facades, the damage will be reduced drastically.

3.2 On the level of the façade materials

The facades have to be restored, and the question rises if exactly the same materials should be used. We are inclined to say that this is not the best option. First of all from the point of view of authenticity: exactly the same tiles cannot be found anymore (tiles with the same aspect are still available, but they do not have anymore the typical anchor at their back). It was therefore decided that we are also not obliged to make exact copies of the mortars.

From the technical point of view, an adaptation of the repair mortars was even more necessary. Because of the lack of the anchor at the back of the new tiles, the adherence of the tiles to the façade might come somewhat problematic with the original bedding mortar. Moreover, we know that water infiltrations inside the façade can be reduced seriously, but it cannot be stopped (because of the lack of dilatation joints, causing cracks between tiles and pointing mortar). And we know that the presence of the cement-bound pointing mortar was one of the causes of
water accumulation in the bedding mortar. Therefore the composition of the pointing mortar should be adapted as well.

In the end, the following solution was accepted:

- Only the damaged tiles on the facades will be restored. All tiles that are intact will stay in place. The same goes for the pointing mortar: when the pointing mortar is intact, it will not be changed. The latter would cause enormous amounts of work and a serious increase of the budget, but also the risk of damaging the tiles adjacent to the mortars was too large (especially the vertical joints, that are only a few millimetres in width) [2, 3]. The following prescriptions should also be followed when repairing damage to the façade cladding in the future.
- In the damaged zones, the bedding mortar will be removed entirely.
- On such a ‘cleaned’ surface, a mortar (cement-based for a good adherence, and polymer-modified for a better deformability) for smoothing the masonry will be applied [4].
- On this cement-layer, the new tiles (with a flat back!) will be glued using a mortar-glue for exterior use. This glue is not supposed to take up water when hardened, and should therefore be frost-resistant. This will enable a better adherence to the façade. And moreover, the elastic properties of the glue will give better resistance to the unavoidable thermal dilatation [6].
- The joints between the tiles should be repaired with a pointing mortar that is water vapour permeable and also less rigid than cement mortars. The choice has been made to use a mortar with hydrated lime as a binder (with a small amount of cement). The chance of creating micro-cracks between tiles and pointing mortar will therefore be reduced. And for the zones where only the pointing mortar has to be repaired, this new pointing mortar will allow a better drying out of the original bedding mortar, when it gets wet [1].

There has been a discussion with respect to the application of a cement-based mortar for smoothing the underlying masonry. It was stated that this smoothing layer should be water vapour permeable as well. This is however an irrelevant demand. Firstly because the nowadays façade cladding is not water vapour permeable at all (cement-based pointing mortar, with glazed ceramic tiles at the surface), and furthermore glueing tiles to the smoothing mortar will make it water vapour tight anyhow. So whether the smoothing layer is water vapour tight or not, this will not make any difference.

3.3 Modifications during execution

A restoration advice, based on a scientific research, is one thing, but the reality is something completely different and might change things a lot. The most important change had to be made because of an inconvenient planning. The application of the pointing mortar in newly restored zones, and the repair of the
damaged pointing mortars, had to be carried out in late autumn, winter and early spring. The risk of frost damage is therefore very high, and that risk increases spectacularly when applying a mortar based on hydrated lime [7]. A compromise had to be found, and it was therefore decided to use a mortar based on hydraulic lime. That way the joints would still be somewhat more ‘flexible’ than the original cement-based joints. Moreover, also the risk of micro-cracking between the joints and the tiles would still be less. This situation will however be less favourable than the original hydrated lime solution, but it is still better than the original situation with a dense and rigid cement-based pointing mortar.

A discussion on how to stop all water infiltrations in the façade followed this compromise. A solution with a water repellent agent was proposed. In this specific case not a good solution:

• From the technical point of view, one can be almost certain that a water repellent agent will not stop the water infiltrations in the façade. Even with the most favourable choice for a pointing mortar (being a mortar based on hydrated lime), the risk of micro-cracking cannot be excluded. And it is generally known that water repellent agents not always are able to stop water infiltration in cracks [5, 8].

• From the practical point of view, it is almost impossible to apply a water repellent agent on the pointing mortar, and not on the tiles. The application of such a product on the tiles should be avoided at all costs: these tiles are glazed, and the application of a product on these tiles will surely result in stains and changes in colour and gloss. In principle one should apply the product with a fine brush on the joints, which is an almost impossible task.

3.4 Consequences of the choice of the mortar

Evidently the new mortar will behave differently from the original mortar, and will have a different effect. Luckily, otherwise it would not be very useful to use another mortar recipe.

It has been suggested to test the water absorption of the new mortar, and to compare this with the old mortar. This has not been done because of the following reasons:

• We know very well that the water absorption will be different. The difference in water absorption between cement-based mortars and lime-based mortars has already been confirmed in numerous other cases.

• The measurement of water absorption of a joint on site is not evident: the width of the joints is in the order of a cm, so a Karsten pipe always has to be placed on the border between a tile and the mortar. Especially on the original cement joints it is almost impossible to find a place where there are no cracks between the tiles and the joints. A Karsten measurement will always be faulty.
The capillary water absorption of the new joints is a parameter that is not very important. It is much more important that the facade is tight, by which we want to say that no cracks will develop between mortar and tiles, and that is why another mortar composition has been chosen. Also the fact that a more ‘open’ mortar will enhance drying of the bedding mortar of the tiles, is in favour of the choice of a lime mortar.

We realize that any choice of mortar has advantages and disadvantages. An as-built document and a maintenance manual therefore has to be drawn up. A regular monitoring of the facade, and regular repairs, are the conditions to obtain a facade that continues to be in a good shape. This advice has been communicated towards the architect of the restoration and towards the owner of the building.

4 Conclusion

The need for a compatible repair mortar does not only apply to ancient heritage, but equally well to more recent heritage. Also there we encounter specific problems that need a suitable solution.

In the discussion what kind of mortar to use, there are always two main options: going back to the historical situation, or change the mortar recipes to avoid (or at least diminish the risk of) damage. It is our opinion that ‘authenticity’ is an illusion, when replacing old mortars by a new one (the new mortar is simply not the same as the old one). Regarding the fact that restoration works are partially at the cost of the community, and regarding the fact that some ancient mortars are technically not always the best choice, we think that the option for a technically compatible mortar is the better to ensure a maximum durability for the building as a whole. Regarding the fact that the restored situation will be quite far from the original situation (the anchor at the back of the tiles being the most important witness of this), the choice has been made to change the application method of the tiles, and to change the recipe of the pointing mortar. In this specific situation, it might sound a bit awkward that a more original ‘modern’ mortar has been replaced by a (at first sight) ancient mortar. But it is technically a better solution.

We have indicated that the material aspects should never be seen separately from the architecture and structure of a building. Even the best materials behave badly when they are incorporated into a poorly (from the technical point of view) designed building. Restoration problems are always to be considered in their technical context, and material research should never be seen separated from the architecture and the exposition of the building.

As a final remark in this conclusion, we would like to point out that a restoration is not finished when the scaffoldings are taken away and the bills have been paid. Especially in this case, the restoration continues afterwards. During the restoration, only the visibly damaged parts of the facades have been restored. One can be almost completely sure that there are still damaged parts (weathered
bedding mortar) that gave not yet rise to visible damage. It might well be the case that in the near future these areas will be damaged as well. The option of completely removing the original tile cladding might solve this problem, but this will be time- and money-consuming, and even more important, this way we are very far from what is be considered as a restoration. It is therefore very important that the restoration improves the building as much as possible, but leaves intact the parts that show no problems. It is therefore also important that the owner of the building afterwards regularly carries out an inspection and regular maintenance of the façade. With the improved protection against water infiltration, we estimate that the damage will be reduced in the near future, or in the best case, will not appear again.

We do not claim that the works as they are carried out are the best solution, but they are definitely one of the best solutions in the given circumstances.

5 Acknowledgements

This study and its results are a product of a fruitful collaboration between the actors involved in this project. The BBRI acted as a research institute, but the test programme and the advice are the product of the discussions between the main architect, Xaveer De Geyter, the architect responsible for the restoration works, Barbara Van Der Wee, the main building contractor, Strabag Belgium, and the suppliers of the products, Cantillana, Seiffert and Arte Constructo.

6 References

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