Proceedings of International Structural Engineering and Construction
Holistic Overview of Structural Design and Construction
Edited by Vacanas, Y., Danezis, C., Singh, A., and Yazdani, S.

ISSN: 2644-108X

REHABILITATION OF BRICK-WALL FAÇADES

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This abstract seeks to analyze several existing cracking rehabilitation techniques on brick-wall façades. The examples concern to an upper-middle class housing complex, situated in Porto, Portugal. This housing complex holds 4 buildings (190 dwellings) and which construction is near 20 years old. The most significant anomalies that have been checked on this rehabilitation study were the cracks of the lintels over windows and on wall-corners of balconies. Both represent a severe anomaly on brick-wall façades that will have as consequence rain penetration and water infiltration. As result, one found that the horizontal lintel cracks occur as a consequence of conception mistakes due to a reduced armor support and to a poor covering. The lintel deformation will allow rain penetration through walls and water infiltrations into dwellings and provoke the severe deformation of the windows' frames and, hereafter, problems with its opening. Beyond this the vertical wall-corner cracks are a consequence of a wrong procedure performed with the cut of the bricks. Regarding the horizontal lintel cracks, the method for its rehabilitation involves the demolition of the brick-wall façade and the execution of angle brackets before rebuilding the brick-wall. In respect to the vertical wall-corner cracks, the method for the rehabilitation consists on the stapling, using the application of stainless-steel helical pins to provide a strong mechanical solution when patch repairing the brick-wall (patch pin).

Keywords: Anomalies, Repair, Lintels, Wall-Corner, Windows, Balconies.

1 INTRODUCTION

Normally, facing brick masonry walls are used in a double-walled system. This system consists of: i) an interior masonry brick wall (e.g., 30×20×15cm) to which projected or slabs insulation is applied; ii) a hollow camera of around 4cm wide (minimum); iii) finally, from the outside, a second wall - the facing brick masonry. In the context of brick masonry construction, facing brick requires more careful and rigorous application. This material and technique offers the advantages of no plastering and painting work, leading to a finishing of the façades at the moment of its application, with a remarkable durability and aesthetic advantages. The performance of traditional pierced brick façades is identical to that of facing brick in many respects. Construction costs may be a little bit lower (Mesquita 2007).

Portugal has no traditions in the use of facing brick. The most popular material for masonry construction has been the traditional hollow brick, which represents about 90% of the current application in new construction (Carvalho and Sousa 2006). Data collected in the survey conducted by INE (Portuguese Statistic National Institute), Census 2001, show that at the end of the twentieth century, the traditional plaster or "marmorite" represented 59% of buildings

coverings built in Portugal from 1991 to 2001. The faced brick it's part of a group of other materials totaling only 1% of all application (Mesquita 2007).

Following the Guidance on Cracking: Identification, Prevention and Repair masonry walls "(…) consisting of brick or block units (clay bricks or concrete blocks) and their traditional finishes are able of fully meeting their performance requirements for a long period of time (…) these masonry walls (…) often present develop cracking, humidity problems and natural (or accelerated) degradation of materials (aging)" (CIB W023 2011).

2 CASE STUDY

The housing complex named "Império da Prelada", is situated in Porto, in northern Portugal. The complex holds 4 buildings with a total of 190 dwellings (Figure 1).

Figure 1. Site plan. (https://www.google.com/maps/).

Each building comprises one buried floor (destinated to vehicle parking places, storage and technical area) and five stories high (destinated to housing) and has two entries with exterior stairs and access ramps (Figure 2).

Figure 2. General view of the façades.

The buildings walls are made of two rows of bricks, the external row corresponds to the façade - "brick façade" (Figure 2).

The mortars joints between the brick façades are reentrant relative to the external facing.

Some of the vertical joints have lack of mortar fill, possibly for drainage and ventilation of the wall air-chamber.

3 BUILDING PATHOLOGIES

Several and significative pathologies were observed through numerous visits that were done to the four buildings. The present paper mention only two serious structural pathologies, namely:

- Horizontal cracking with decay of the lintel over the windows,
- Vertical cracking on exposed brick-lined wall-corners balconies.

3.1 Horizontal Cracking with Decay of The Lintel Over the Windows

The most serious anomaly occurs as a result of bad conception, or construction mistakes, of the windows lintels.

In some windows opening, due to the lintel deformation, an evident degradation was observed (Figure 3), with infiltrations of water between the frames and the glazed area of the windows, mainly in the windows facing west, note that in Oporto is the side of the sea and from where the wind blows.

Figure 3. Horizontal cracks of the lintels.

3.2 Vertical Cracking on Exposed Brick-Lined Wall-Corners Balconies

This anomaly is a consequence of a poor connection of the bricks coating to the existing pillars of the wall-corners balconies and is caused by the differences of the building thermal movements (Figure 4).

Figure 4. Vertical cracks of the brick wall-corners balconies.

4 REHABILITATION PROJET

4.1 Introduction

A rehabilitation project is based in a previous analysis of the pathologies and in a background knowledge, fundamentally scientific (Lourenço 2008, Molnár *et al.* 2008, Terpeluk *et al.* 2008), but in rehabilitation is also important, in many of the situations, the field knowledge, that is only possible to get during several professional works (Mendes da Silva 2013, Abrantes 2019) and the experience of Tramo (2019).

4.2 Rehabilitation of Lintels Over the Windows

All the lintels that present decay and significative cracking should be demolished and substituted by new similar bricks cladding and should be fixed to the existent structure.

After the brick removal, between the windows aperture area and the top of the level of the overlying layer of the concrete slabs, the following procedures shall be executed: application of the stainless steel "Pach Pin" (Tramo 2019), application of a strong wire-mesh (stainless or galvanized steel), then reprofile with structural mortar and finally the application of the ceramic bricks and the close of the joints (Figures 5 and 6).

Figure 5. Bottom view of the support of the exterior coating of the masonry double wall.

Figure 6. Mesh of mechanical pinning and remedial tying system "DryFix".

4.3 Cracking Rehabilitation on Exposed Brick-Lined Wall-Corners Balconies

The rehabilitation of this type of anomalies starts with the demolition of all the cracked bricks and contiguous zone, the strengthening with "HeliBars" in "L" shape and, finally, the reapplication of the bricks with an application of mortar to seal the joints (Figure 7).

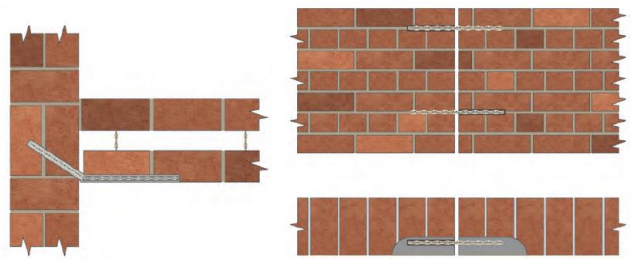

Figure 7. HeliBar stainless steel helical bars (creation of remedial movement joints).

5 CONSTRUCTION/EXECUTION

5.1 Rehabilitation of Lintels Over the Windows

After the demolition of the brick wall, it was verified the existence of an iron rod and shall have been the oxidation of the iron rod that have caused the cracks (Figure 8).

A study to the non-cracked lintels has been done and it has been verified that those, non-cracked, do not have the iron rod.

Since the cracks are related with the corrosion of the metal rod and not to the deficient support of the brick-façade, it has been decided to demolish the existent surface, remove the iron rod and apply an Aisi 315 steel plate of 1.5 m, fixed to the roller-blind box that will serve as seating base for the demolished surface (Figure 9).

Figure 8. Existent iron rod in cracked lintels.

Figure 9. During the rehabilitation work.

5.2 Rehabilitation of The Exposed Brick-Lined Wall-Corners Balconies

After starting the demolition of the cracked bricks, it has been verified that cracking occurs in the area where the bricks were cut in order to fit into the pillars. The abrupt change of section-brick is the main cause for cracking (Figure 10). It also was verified that in other areas where the complete brick passes in the front of the pillars there is no cracking anomalies.

Figure 10. During rehabilitation work.

It has been decided to execute an expansion joint, to substitute the "L" rod format by helical bars "Helifix movement joints", every 3 rows, and to apply a simple rod DryFix on the orthogonal face, which function will be to limit/reduce the building movements, since the new expansion joint removes the existing clamping of the wall (Figure 11).

Figure 11. During (left) and at the end of the work (right).

6 CONCLUSIONS

It is extremely difficult to execute a building façade rehabilitation project without previously proceeding with a survey in the anomaly zone. But sometimes those surveys do not take place, because the owner does not want to spend more money, or because the survey, when destructive, will cause unrest to inhabitants namely once they do not know the rehabilitation work will take place. Thus, it is always necessary to have different solutions to act in time and during the rehabilitation work is being executed.

This happened in this study-case, and at the end with a reasonable saving cost.

Only a few months have elapsed after the rehabilitation, but, so far, the results are positive indeed there is no crack on the rehabilitated sites.

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