Inspection of Historic Building Facades for a Development of Restoration Project

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***Abstract*—The objective of this study was to substantiate the importance of inspection and preliminary tests before the interventions of restoration of historic building. To do this, set up a building listed as Brazilian historical heritage for a case study. Through inspection was possible to identify the proliferation of biofilm as pathology with greater incidence and testing allowed the knowledge of the characteristics of the materials of the facades. Thus, the combination of the two processes was essential for the preparation of the restoration project, indicating the most appropriate therapies to types of pathologies found.**

***Index Terms*—Inspection, facades, pathology, restoration.**

I. Introduction

Protected by CONDEPACC - Defense Council of Campinas Cultural Heritage in May 2011, the building that houses since 1949 a Presbyterian Seminary, had never gone through the restoration process, just for maintenance and internal modifications that could house, beyond the workshop also graduate from a university. However, with the construction of a new building for the university, in 2010 the property came to be used specifically for the training and development of presbyterian pastors.

The construction was made from donations from churches and several faithful and the curious in this building is that the bricks that make up the entire facade remained apparent, without any coating, because there was not enough funds to finish the facade would completely covered with marble, according to the original design of the building, which was prepared following the model of the Princeton Theological Seminary in the United States.

Thus composed of common clay bricks, without any coating that could protect the facades from the weather , and being the oldest evangelical seminary in Brazil and Latin America, the restoration of the building has become essential for the important historical, cultural reference and architectural city of Campinas / SP - Brazil .

II. Methodology of Work

Being a heritage building in question overturned, of great historical, cultural and architectural importance, no feature of the facade can undergo any significant change, thus, prior to completion of the restoration project, the first activity was to conduct an inspection, linked to tests " in situ " and laboratory for identification and analysis of the pathologies that affect the Presbyterian Seminary Fig. 1.

Visual inspection of all facades, areas above 2.00 meters above ground level, the impossibility of fixing balance, was performed with the aid of hydraulic lifting platforms. This preliminary inspection, which also tests were performed percussion - for detection of loose bricks and mortar, and sample collection and measurement of cracks, allowed determination of the most critical and deteriorating facades points and, therefore, would undergo further testing, based on ABNT (Brazilian Technical Standards Association) and, failing that , with reference to international standards.

Fig. 1. Partial view of the building.

A. Preliminary Inspection

Due to the age of the building and the precarious state of conservation, a number of pathologies and non-conformities identified during the inspection of the facades, where Fig. 2 to Fig. 12 illustrate the major anomalies.

The inspection also allowed the development of a mapping project of pathologies of all facades, very useful for the process of determining and quantifying therapies to be adopted for the restoration, as the example of Fig. 13.

Fig. 2. Rising moisture in walls.

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Fig. 3. Proliferation of biofilm.

Fig. 4. Proliferation of biofilm.

Fig. 5. Deterioration of bricks.

Fig. 6. Deterioration of concrete balusters.

Fig. 7. Mortar different from the original.

Fig. 8. Exposed pipes compromising the aesthetics of the facades.

Fig. 9. Deterioration of wooden windows.

Fig. 10. Closing with bricks will differ from the original.

Fig. 11. Damage in metal windows.

Fig. 12. Failures in laying mortar bricks.

Fig. 13. Mapping of the pathologies on the facade.

B. Preliminary Inspection

From visual inspection, held in conjunction with percussion tests, measurements of crack width and sampling, it was determined that further testing would be needed for a better assessment of the conditions and general conditions of the facades will be restored. Thus, we defined the application of grip strength test tensile testing, water absorption by the "method of pipe" on the bricks and cement mortar, pH analysis of biofilm samples and testing of compressive strength of bricks as preliminary tests.

The tensile bond strength – Pull-off assay was performed in order to assess whether the brick walls were old enough to receive the application for recovery or protection systems and portant resistance was done based on the NBR 13528 [1] standards and ASTM D7234 [2] (see Fig. 14).

Were chosen for these test regions which were most critical in terms of porosity, cracking and wear of the bricks, but which were with the smooth surface for the assay to be possible.

Fig. 14. Test of tensile strength – pull-off.

The water absorption test by the "method of pipe" determines the absorption of water and also the permeability of the substrate and was performed on the facades of the Seminar on bricks and cement mortar also. The pipe consists of a graduated glass device in a pipe that is bonded shape with silicone upright and filled to a zero reference. Then readings were held lowering the level of the water column as a function of time, every minute, until it reaches 15 minutes (see Fig. 15).

The assay procedure was based on the technical information note CSTC - Centre Scientifique et Technique de la Construction of Belgium [3].

Biofilms represent complex associations of microorganisms attached to surfaces or interfaces adhered. These organisms tend to grow embedded in a polymer matrix polysaccharide material produced by themselves or by other "primary colonizers", functioning as a support material and adhesion and to protect them against the effects of desiccation, excessive lighting, mechanical damage and erosive effects [4]-[6].

How have acidic pH, biofilms deteriorate most surfaces, by "etching" process, so for this work was convenient analysis of the pH of the biofilm, which is impregnated on the bricks in many areas of the building Fig. 16.

Fig. 15. Water absorption test.

Fig. 16. Biofilm attached on brick.

The age of the building and preservation, evaluation of resistance to compression of the bricks is a very important factor. The samples were taken from all brick facades and varying heights from the floor, always near the most degraded areas, and were separated into 2 categories, with the aim of comparison: bricks with proliferation of biofilm with nomenclature "A" sample and bricks without proliferation of biofilm " B" sample (see Fig. 17, Fig. 18).

Fig. 17. Survey of brick with adhering biofilm - "A" sample.

The preparation of specimens and testing of compressive strength were carried out at the Laboratory of Building Materials, Faculty of Technology, UNICAMP (see Fig. 19),

followed by the ABNT NBR 6460 [7] and NBR 7170 [8] standards.

Fig. 18. Survey of brick without adhering biofilm - "B" sample.

Fig. 19. Evaluation of compressive strength of bricks.

III. Results

A. Preliminary Inspection

A preliminary inspection with the mapping done on the facades, enabled the raising of the main pathologies in percentage, so that subsequently, during the restoration project, it was possible to quantify the types of treatment and materials required for the rehabilitation of the building (see Fig. 20).

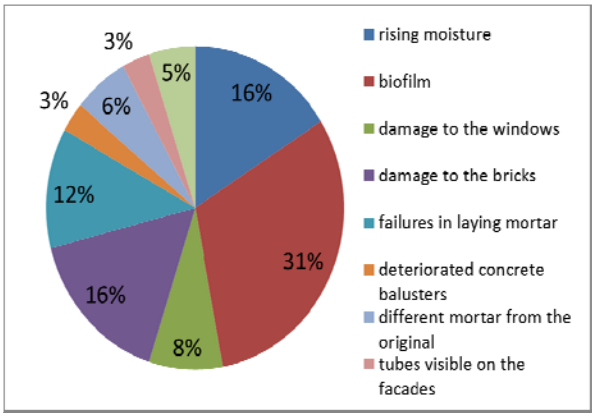

Fig. 20. Main pathologies.

B. Tensile Bond Strength – Pull-off

To be considered with sufficient tensile strength, the RA value (pullout strength) of the test is ≥ 0.30 MPa, in other words, the same required for the adhesion of mortar to receive an external painting value, according to ABNT NBR 13528 [1] standard .

Only the specimens taken from the highest points in relation to the floor, did not meet the minimum strength of 0.30MPa, it is possibly due to the higher degradation observed in these areas. The other witness was sufficient to receive the repair procedures (Table I) resistance. Another point to be noted is the small thickness torn by the assay, ie, they did not break the bricks at greater depths, only superficially highlighted with small thicknesses (with caliper measurements).

TABLE I: Tensile Bond Strength

Sample	Location/Floor height	Stress (MPa)	Break Type	Thickness (mm)
1	Facade left side/9.10m	0.37	Break in brick	1.01
2	Facade left side/7.00m	0.31	Break in brick	0.34
3	Facade left side/7.00m	0.39	Break in brick	0.65
4	Posterior Facade /5.50m	0.45	Break in brick	0.88
5	Posterior Facade /10.20m	0.57	Break in brick	1.76
6	Front Facade /6.50m	0.34	Break in interface adhesive/brick	1.11
7	Front Facade /11.00m	0.10	Break in brick	2.13
8	Front Facade /1.30m	0.56	Break in interface adhesive/brick	2.05
9	Facade right side/7.00m	0.37	Break in brick	0.81
10	Facade right side/6.30m	0.30	Break in brick	0.92
11	Posterior Facade /1.10m	0.77	Break in brick	1.62
12	Posterior Facade/11.80m	0.06	Break in brick	0.37

TABLE II: Water Absorption by the "Method of Pipe"

Sample	Location/Floor height	Surface	Absorption (g/cm²)
1	Front Facade /1.04m	Brick	0.61
2	Facade right side/2.35m	Brick	0.70
3	Posterior Facade /3.12m	Mortar	0.70
4	Facade left side/2.15m	Mortar	0.70
5	Facade left side/8.40m	Brick	0.31
6	Facade left side/9.62m	Brick	0.33
7	Front Facade /10.58m	Brick	0.23
8	Posterior Facade /10.73m	Brick	0.28
9	Facade right side/6.63m	Brick	0.33
10	Posterior Facade /7.78m	Brick	0.70
11	Front Facade /1.82m	Brick	0.31
12	Facade right side/4.15m	Mortar	0.35

C. Water Absorption by the "Method of Pipe"

For absorption be acceptable for external walls, which are subject to the weather, it should be ≥ 0.30 g/cm².

The pipes numbers 7 and 8, which were fixed on whole bricks with low porosity, were the ones who showed absorption below the maximum acceptable value, and the pipes numbers 1, 2, 5, 6, 9, 10 and 11 which were fixed on porous bricks, showed high uptake.

The pipes paragraph 3, 4 and 12 were set on the bedding mortar and also showed high uptake (see Table II).

D. Analysis of Biofilm pH

Samples were collected at 16 points of facades and analyzed in the laboratory, which revealed the average pH value of 5.2 - confirming its acidity.

E. Evaluation of Compressive Strength of Bricks

The mean compressive strength was 8.3 MPa for Sample "A" and 9.3 MPa for Sample "B" can be considered as good resistance since the bricks are assayed sealing elements and non-structural bricks, however, we note that the group of bricks that had suffered attack biofilm resistance 10.75% lower than the unaffected by biofilm group.

IV. Conclusion

Through inspection and tests carried out, it was possible to identify the proliferation of biofilm as pathology with greater incidence, which possibly occurs by the high porosity of the substrate and absorbing than recommended water, approximately 83 % of the tested points. The very architecture of the building with several recesses, their age and location - urban environment with high concentration of vehicular traffic - make it be susceptible to biofilm formation on their facades.

The grip strength test tensile (pull-off) showed the possibility of applying repair or protection on the facades materials, provided that they are properly and thoroughly cleaned.

Although average compressive strength of the bricks have been appropriate, it should be borne in mind that , to be tested, the samples were of whole bricks , but there are regions in all fronts where the bricks are too deteriorated and must be replaced or filled with material that reproduces them in terms of aesthetics and strength .

It is important to note that this inspection work was fundamental to the next step, which will be the restoration project, indicating the most appropriate therapies. It may also occur the need for additional testing, for example, characterization of putty on the bricks.

References

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