Durability of the Facades from the Perspective of Architectural Decisions

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ABSTRACT

The aging of buildings is a natural process but it can be accelerated by deficiencies and omissions on construction specifications, resulting in premature need for maintenance and restoration. The objective of this study is to, within a selection of buildings in Brazil, diagnose the diseases found on façades and originated due to bad design practices. The methodology used was to confront the results of post occupancy evaluations, the specifications that were part of the architectural building projects and the maintenance records. The information gathered supported the understanding of the most incident pathological phenomena. The data were mapped accordingly with the type of occurrence, frequency and severity of the problem, making possible the identification of problems related with errors or omissions in the façades design. The results show that there are several problems derived from omission of construction details, specifications, and lack of a schedule for maintenance actions that could be easily improved in order to result more durable and less costly building façades in Brazil.

KEYWORDS

Building façades, durability, building problems, design specifications.

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1 INTRODUCTION

Since the beginning, humankind has been seeking shelter, and modern buildings are but an expression of that protection. Buildings must provide protection against natural phenomena such as rain, solar radiation, changes of temperature, winds, humidity, atmospheric pollution, among others, in order to offer enough conditions to answer the needs of users, as described in the 1984’s ISO-DP 6241.

The façades durability depends on several interdependent factors and how these factors are dealt with along the many phases of construction, especially during design. Many different tools for service life prediction are available to help designers to estimate buildings and components durability, although most architects in Brazil do not make use of them to specify materials and construction solutions for construction of building façades. This article presents discussing the project variability for architecture within the context of 5-floor-building, in the reinforced concrete and joint gasket ceramic masonry, main type of construction in Brazil.

The research took place in the city of Pato Branco, Paraná southwest, (26 ° 13 '44 "S 52 ° 40' 15"), with an average altitude of 760 meters and sub-tropical climate history by applying the method of APO Ornestein [1992]. Thus, we sought to identify, classify and categorize the existing anomalies in the façades originated in the design phase, whether by errors or omissions in specifications and descriptive graphics, maintenance procedures that occurred, their frequencies, so that they would fit within the context described by ISO 15686-7 [2006].

In the investigation of façades diseases we pointed to a phenomenon of similar behavior between the buildings where the highest frequencies and intensities lie on top of buildings and façades in the south, as well as the procedures of premature building maintenance actions triggered by the psychological discomfort users. As we interpreted the façade projects it was identified that the graphics are insufficient to power the production process, so the recommendations point to the need of expanding the variables in the elementary act of project development, and maximize the economic and environmental resources employed in the façades.

2 DURABILITY OF FACADES OF BUILDINGS AND THEIRS INTERFACE WITH ARCHICUNCTURE DESIGN

Despite being negligible the contents of scientific production concerning to approaches of projects in the efficiency of durability [Kumar et all, 2010], an alternative is the appliance of the principle of quality in the project design because it allows that graphic elements to be made concisely with control over the flow of information with required quantification and qualification [CASTELLS e HEINECK, 2001]. The lack of details in design that considers the degradation agents - atmospheric, biological, load, incompatibility and use. [ASTM E632-82,1996], is an influential factor in life reduction of façades materials and components. [Gaspar e Brito, 2005; Pavitt e Gitt, 2003; Romero e Vianna, 2003]. Especially by pathological manifestations originated from the downward flow of rainwater, which penetrate into the shrinkage cracks in the mortar [Gaspar e Brito, 2005]. In this phase should also be considered the agents of degradation on the materials, as the temperature gradient [CHEW 1998], the maintenance actions [Flores-Colen, 2003], among others.

According to [Chew et al 2007], the decisions of façades design interfere in service life as they propose solutions that are resistant to natural aging, it is important to identify materials with improved durability gradient, identified by previously tested methods. However, it is difficult to accurately predict the service life and meet the overall durability of the façade to be composed of several layers and with different thickness [Mendes Silva and Falorca, 2009]. As regards the project of brick nogging walls can be prepared by production method [Pena and Franco, 2004], guidelines, and façades coating [Manechi e Melhado, 2008]. For mortar coating there should be a set of measures in the design phase in order to promote a specific coating as ideal, thus, for (Baía and Sabbatini, 2000;
Ceotto et al (2005) the design of facades coating shall be prepared and be a guiding factor during the production process of this coating.

3 BUILDING FACADES CHARACTERIZATION AND ITS CONSTRUCTION SYSTEM

The objective was to select buildings with characteristics of modern architecture, 5 floors and about 10 years old, and significant amount of pathology on the facades, and from this, diagnose what are the interference that the architectural design cause in them durability. The building system of these buildings is traditional from Brazil, made of concrete structure, seals usually with masonry of hollow ceramic blocks of red clay, setting with the holes in the horizontal with physical characteristics governed by [ABNT 15270-1, 2005]. The seals also are built less frequently by concrete blocks, governed by [ABNT 7173, 1982], and limestone-block [ABNT, 14974-1, 2005]. All set with cement mortar, lime and sand, and additives. The set of layers below are regularization – roughcast, and mortar of plaster, of connection or settlement - plaster and finishing - usually through acrylic paints, acrylic texture, and textured finish (grafiato), and less frequently, by finishing in ceramic and glass tiles, granite, marble and composed aluminum, as shown in Figure 1.

Figure 1. Process constructive of façade of building traditional in the Brazil

Figure 2. Characterization of the facades of buildings surveyed
3 INVESTIGATION, RESULTS AND DISCUSSIONS.

The investigation was based on constructive pathologies was appropriate for each plan (Table 1), pre-established in order to qualify and classify the identified anomalies.

Table 1. Roadmap for data collection in buildings

<table>
<thead>
<tr>
<th>Evaluation of pathology at the interface</th>
<th>Intervention maintenance</th>
<th>no</th>
<th>yes</th>
<th>t=</th>
<th>Tipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of building: ______________________</td>
<td>number</td>
<td>number of floors</td>
<td>age of building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roofing ▶ Terrace ▶ Inclined ▶</td>
<td>Tile cement</td>
<td>Tile clay</td>
<td>Tile metal</td>
<td>other</td>
<td></td>
</tr>
<tr>
<td>nº of facade ( ), tipe of inspection ( ), indoor ( ), outdoor ( ) research field ( ) sun, ( )cloudy ( ) with rain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar orientation of the facade M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Number of pathology at this point along this facadeº:</td>
<td>punctual</td>
<td>generalized</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Tipe of frame at the point G</td>
<td></td>
<td></td>
<td>J1</td>
<td>J2</td>
<td>J3</td>
</tr>
<tr>
<td>Dripping</td>
<td>no</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Cladding of finish▶</td>
<td>Acrylic</td>
<td>texture</td>
<td>grafiato</td>
<td>ceramics</td>
<td>Ceramic insert</td>
</tr>
<tr>
<td>5) Nº of balcony in facades</td>
<td>N° of flower Box in</td>
<td>Drainage</td>
<td>Dran. int condom</td>
<td>without</td>
<td></td>
</tr>
<tr>
<td>6) Construtive solution contained in the original design, or as</td>
<td>yes</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Interaces with analysis of plant buildings and pictures of each facade

Figure 1 – Analysis point along all facades

The rains prevalent in in the city of Pato Branco PR are SO in order to southwest – notheast NE- source: SIMEPAR PR.

All facades have been mapped in the interfaces of materials and components, as described in Figure 1. Sections with letters represent sensitive and potentially fragile sites, susceptible to diseases for compatibility of materials, as well as single or associated causes of degradation agents. The investigation indicates the materials and building components, the intensity and severity of diseases (by height, by solar orientation) and, analyzes the solutions for architectural projects in these damaged spots.

º t= time in month that the maintenance was performed;
5 Information obtained from the liquidator;
6 For each type – crack, corrosion, etc – a facade of pathology notes Will be prepared a survey with this script.;
7 The characterization of pathology is understood by the researcher as the performance loss of the product or component in relation to the requirements and criteria;
8 G1-Squarely aligned with the inner side of the with dripping; G2-Squarely aligned with the inner side of the without dripping; G3-Squarely aligned with the center of the wall with dripping; G4-Squarely aligned with the center of the wall without pin. D1- Interface between bricks and mortar; D2 – intercafe between Masonry and plaster; D3 – Interface between Plastering and painting; D4 – others.
9 Structural elemento f the sill: J1-masonry, J2 –aluminum, J3 –wood, J4 – metal,
10 Stormwater rufoff through a pipe sticking out in front – dripping;
11 Stormwater runoff through a pipe embedded in the masonary falling rain – it is not apparent;
12 No stormwater runoff on the balcony through drip pan pipes on pipes or rain: the water is released into the façade.
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3.1 Behavior Painting Coverings

The finishing touches on the facades of buildings were mostly of acrylic texture and acrylic paint, on plaster smoothing, without the existence of joint work of the mortar substrate. The paints were the most affected by the pathological manifestations. The severity and intensity of these problems were classified and characterized by Cincotto [1988] and real estate firms specialized in paint, by pointing pathologies of: spots, blisters, craters; separation; detachment; efflorescence; wrinkles; spots due to air pollution; saponification; crack and differences of tone.

When analyzing the severity and location of the pathological manifestations of the paintings, it was made for solar orientation and heights - floors, so when apply to analysis of variance with 95% confidence, it was found that there is no significant influence between the floor and the orientation of the facade, however, allowed to extract some considerations:

a.1) The influence of the facades is not significant, however, the south facades have the greatest numbers of diseases, indicating the presence of increased moisture by the absence of sunlight and decrease in the durability of the material, being dirt from the atmosphere, cracking and stains for fungi, the most significant.

a.2) Only the influence of the storeys is significant. It allows us to make some observations on the downside of the facades. The points described below are those of figure 1.

a.2.1) In Section A1,B and B1 - platband - the most frequent pathologies are the spots of fungi mold and dirt from the atmosphere, with aspects of bleeding in the downward direction on the walls, especially in buildings 1, 2 and 3. This is because of the constant presence of moisture from dew and rainfall retained in the absence of materials protected by eaves (metal or stone) to ward off the flow of water from the walls, and that the thermal cycles develop microorganisms. See photo 1.

a.2.2) In Section D - Body of walls - the diseases largely result from the fissures and cracks in paints caused in the mortar, which eventually result in the reaching of the paints, thus allowing water infiltration.

a.2.3) In Section E - where walls meet the ground - the diseases in the presence of moisture, caused by the splashing of rain and cleaning water, can reach a height of 1 (one) meter with impregnated dirt, but also by moisture from the soil which, by capillary materials, reach up to 2 meters high, fading and creating bubbles in the paints also being able to detach the plaster.

a.2.4) In Section G - areas of the masonry below the position of windows - areas of flat and sloped sills susceptible to deposition of dust from the atmosphere, causing bleeding in the facades with the flow of rainwater in the position of the drip pan, by construction errors or lack of them in many buildings, which did not allow adequate drainage of the flow of water circulating through the facades.

<table>
<thead>
<tr>
<th>Table 2. Equation linear of pathologies in paints</th>
<th>Photo 1. Treatment of top of building</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Graph showing pathologies vs. floor" /></td>
<td><img src="image" alt="Photo of building top" /></td>
</tr>
</tbody>
</table>
The conditions explained from the viewpoint of a linear equation estate that the loss of durability the facades suffer is significant at the height. The linearity of the pathological phenomenon (Table 2) is possible up to the fourth floor through the line “y = -8.2911 +65.819 x”, however, the last values are significantly larger in numbers and severity of diseases, indicating that these sites are more sensitive to degradation agents.

3.2 Behavior of Mortar Coatings

The pathological manifestations of this coating is structured by the severity and intensity, depending on the classification and characterization of Cincotti [1988], which identifies the most frequent manifestations, while Santos Filho [2004] classifies them as to severity by the size of the openings as reference in Table 1, along with steamed zone, crack, mapped fissures, with dustiness detachment, detachment with blistering and detachment on boards.

The comments seek to establish a relationship between solar orientation and height of the facades for the emergence of diseases, thus when applying the analysis of variance with 95% confidence, was obtained:

- The influence of solar orientation of the facades is significant, and the south facade is most affected with 29% of the total, while the north facade is less affected with 21% of outbreaks.
- In this context, the points with highest incidences were pathological: D with 18%, 13% B, B1 and C with 12% each.
- The influence of the storeys is significant, in that tall buildings gain pathologies increased with an exponential scale on the last floor.
- The pathological implications in mortars by "intensity" were observed respectively due to cracks in several directions, horizontal fissures, cracks and horizontal cracks. Since the horizontal planes were unprotected sites with higher incidence of infiltration of moisture, and greater presence of these pathologies.
- The pathological incidences in mortar coatings with the severity criterion showed the highest incidences were in the top floor: horizontal cracks in the zones of wedging, cracks, holes and cracks on the pavement terraces, areas of deployment, especially at the ends of parapets.
- Areas with a high incidence of cracks at 45 degrees were observed in the vicinity of openings in casings, both in the position of wicker, rattan and counterinsurgency.

3.3 Procedures Relating to Maintenance of the Facades were Observed

The collection of data from apartment manager showed that there is not structured format (planned actions, preventive maintenance) maintenance actions, the lack of spaces destined to archive projects and managing the building when it is in use and operation, beyond:

- All maintenance actions that occurred were triggered by visual discomfort owners. In 64% of the time without professional technical guidance, 24% of the interventions were repeated diseases, 8% of the time the liquidators were able to identify the period of early manifestation. The conditions with higher recurrence were on the last floor (ledge) in particular to the extremities, where even the structure of reinforced concrete (slabs and pillars) had fissures and cracks.
- Diagnoses of therapy do not appear as corrections were performed, since there is no documentary record, not even the basic designs and projects or as built.
- In 50% of cases of pathological reincidence, there were broken parts, cracks and moisture, being higher in those buildings where there is the presence of roof terrace.

3.4 Analysis of Architectural Design of these Buildings Facades

The set of graphic elements of the facades and specifications provided by the architects for the other designers of the subsystems, and for the production stage of the handiwork show some similar characteristics with each other, in other words:
• The facades graphics in all basic architectural designs were abstract figures with geometric configurations of the desired form, and with some general specifications, as well as in the description techniques for the building. They had more the function of comply with legal formalities than properly to guide the activities of the execution phase of handiwork. In a few cases were observed construction details indicating the selection of material to be used, like bricks and finishings.
• When crossing the diagnosed point in the facades with high rates of disease due to lack of drainage of rainwater flow and surface condensation, few solutions are presented in the graphics. Related to graphics solutions, where the diseases were more severe, there was also lack of detailing.
• In the approach with architects, designers of these buildings in question about the importance given by them in the graphics solutions for their projects related to durability of the facades. May observe that professionals does not hold a domain of the basic concepts of the topic, as well as service life, obsolescence, as well as a further and domain of degradation agents. However, all agree with the importance and nobility that have the facades.

4 FINAL REMARKS

Regarding the finishing touches on paint, it is known that the most significant pathologies were respectively the dirt from the atmosphere, cracking, staining fungi and bacteria, more difference in tone (fade), which together accounted for 88% of the diseases. The most affected points are A1, G, H, I, L, which have horizontal planes as the top of walls and slabs. The architectural solutions adopted by designers for these points shown as disabled did not allow efficient drainage of the facades. This can be verified through research with these designers and graphic material specifications evaluated for these points. However, it would be possible, during the project design, provide much more detailed decisions for constructive solutions that incorporated storm water drainage of the facades. Apply drippan and casings, included on horizontal planes, drip pan facade on each floor independently of the existence of frames, take actions such as specification, detail chart due to repeated standardized solutions for facades (structures, fences and window frames) for new buildings, and monitoring the implementation phase, because many cases were designed drip pan, but lack this element in the facade, or had faulty construction in the "grooves" of the lower parts without creating a discontinuity in order to place the drip of water off the facade.

The specifications for paint project are insufficient, with a focus on material cost, however, should opt for more durable types of paint, or replace it with more durable finishes such as ceramic inserts, stony coating. They have extremely low levels of water absorption, and when constructed in accordance with the regulatory rigor to show infinitely more life and lower maintenance procedures, although apparently it shows the highest costs in the production phase. Conclusively, it is essential for the compression of the architects of the phenomena of degradation and lifetime of materials for facades, to review the design procedures.

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