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STUDY OF THE “ESCOLA SUPERIOR DE TECNOLOGIA DA SAÚDE DE LISBOA”

Lisboa - 2023

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This work was requested by the professors João Gomes Ferreira, João Ramôa Correia, José Dinis Silvestre, Arch. Clara Pereira with the objective of studying the possible pathologies and forms of rehabilitation.

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SUMMARY

1. Introduction

Throughout time and history, Portugal’s buildings have changed and adapted to various stages of construction styles. The country’s buildings faced changes in materials, building techniques and structure, and each phase has been characterized by a certain degree of evolution in the different aspects that constructing a building involves.

The peak of construction development in Portugal was the phase where reinforced concrete started being used for building structures, with sustainability and design durability as a focal point.

According to the European Construction Industry Federation, in 2020 28.8% of the main activities in the building sector in Europe was towards renovation - of buildings and other structures, according to FIEC.

In 2021 there were a total of 277.571 buildings in Portugal built between the years of 1919 and 1945, which characterizes buildings like Gaioleira and a total of 174.200 buildings built before 1919 (PORTADATA, 2022), which can characterize the Pre Pombaline and Pombaline phases. These building phases had little to no focus on durability which helps explain the current need for renovation in the country.

This report aims to apply the theoretical knowledge in Construction Pathology and Rehabilitation by applying it into a real building. The building chosen was “Escola Superior de Tecnologia da Saúde de Lisboa” where a need for rehabilitation was found, after careful analysis of the conditions of the building compound.

Another objective of this paper is to communicate our professional opinion regarding structural and nonstructural pathologies found in this Nursing school. The work is done by stating the best investigation methods and diagnosing the anomalies found by doing the identification process of the anomalies found in the compound, the possible cause (s) of these anomalies, recommending intervention methods and it ends with a suggestion of the best course of action.

It’s important to note that when the credit or origin of the images are not explicit, all pictures were taken by the authors of this report.

2. Constructive Description

2.1 Description of the building

The current buildings are located at Avenue Dom João II, Plot 4.69 01, 1990-096 Lisbon, in the region of Parque das Nações. They are part of the complex of the Escola Superior de Tecnologia da Saúde de Lisboa, inaugurated in May of 2002. As a case study, 2 buildings in the complex will be used, and to identify them both, they'll be called building A and building B, as shown in figures 1 and 2.

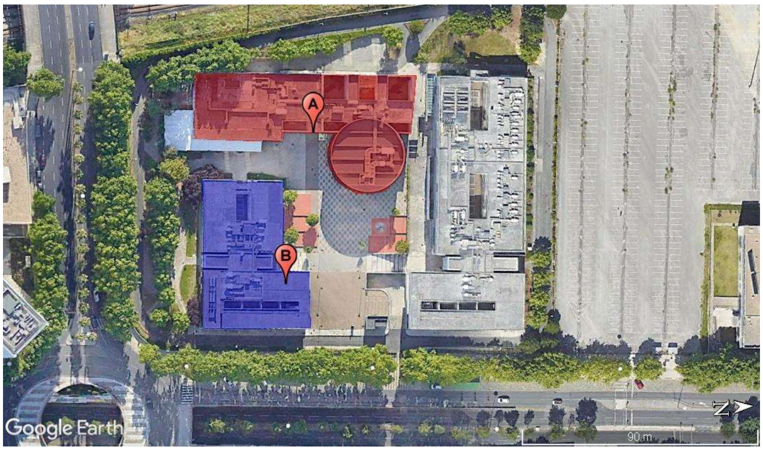

Figure 1: Image of the top view of the complex (Google Earth)

Figure 2: Image of 3D view of the complex (Google Earth)

Building A occupies an area of approximately 2350 m², with two floors, one on the ground floor and one on the upper floor. Made of reinforced concrete and masonry, and contains a canteen, an industrial kitchen, bathrooms, social areas for entertainment, mezzanine, and in the front part of the facade there is a sphere structure made of concrete and rusty metal cladding, which hosts an auditorium.

Moreover, building B occupies an area of approximately 1820 m², because the buildings were made at the same time and for a common purpose, the characteristics are quite similar, there are also two floors and are made of reinforced concrete. The use is for administration, classrooms and it also has a canteen on the ground floor.

2.2 Structural elements: Systems and Materials

Regarding the structural elements of buildings A and B, the following points are perceived: The external walls of both buildings are made of masonry brick; There is a reinforced concrete ramp in building A that connects the ground floor and the first floor. This ramp is secured through steel beams placed under the ramps. One load transmission edge of the beam is attached (bolted) onto a column, while the other edge is connected to a steel rope connected to the beams on the slab structure above.

In various areas of both buildings it is possible to perceive the use of beams and columns, embedded and not embedded. These are the load bearing structures of the buildings and are made of reinforced concrete. Some examples of areas where the use of columns and beams is clear: The facade structure of building A, where in order to achieve a big entrance span there is the use of beams and columns; In building A, there is a large circular structure made of concrete, where in order to provide large openings in all its' area, columns and beams are used, etc.

In front of building B, there is a set of concrete stairs acting as the connection level access to enter the building. The bottom of the stairs lays upon a common stone block masonry ground. Regarding the connections of this staircase, on one side it is connected to a side part of the building's ground floor, made of concrete and the other side is not supported on the side, but at the bottom (As mentioned above, laying on a common stone block masonry ground).

There is a reinforced concrete internal staircase in building A which connects the ground floor to the first floor.

In connection to building A there is a large round structure made of reinforced concrete that serves as an auditorium. There are openings all along the facade of this structure.

Furthermore, in building B is found a cantilevered structure made of reinforced concrete and stands about 4m above ground.

Both buildings are covered by flat roof structures with a concrete block masonry cladding and they both use concrete slabs as floor partitions.

2.3 Non-structural elements

Non-structural elements are the elements that are not considered to be a part of either the primary or secondary structural elements, including components of the mechanical and electrical ceilings. Considering only the non-structural elements of the building A were analyzed, the description below only regards it.

The main non-structural elements in the study are the ceiling, windows, claddings and coatings, and also some interior walls that don't bear important loads. The building A has a metallic decor in a circular shape on the outside of the building.

Most of the windows in the building are made of glass, the internal walls are made of masonry, the coatings are in most common areas in a white color, and in the wall near the ramp it has an orange color. In the bathrooms and in the kitchen the walls have a ceramic cladding. In the canteen area the suspended ceiling is made of square boards of plasterboard lining attached to each other, while on the outside the ceiling is made of bigger parts of the same material.

In the building there are various types of floors, on the outside of the building the floor is made of prefabricated concrete, in the inside part of the building the floors are mostly made of slate as it is present in the common areas, corridors and in the restaurant, in the wet areas the floor is made of ceramic tiles, meanwhile in the canteen/study room the floor is made of wooden tiles.

2.4 Building's History and past interventions

The ESEL complex was built in parallel to several transformations in the neighborhood. As it can be noted below in figures 3 and 4, in a 12-year time gap ESEL's surroundings were entirely modified after Expo '98, in which Parque das Nações was designed as an Environmental and Urban Requalification Plan, that among many other interventions it included new public spaces and facilities. The expansion of infrastructural projects like construction of Vasco da Gama Bridge and modernization of Moscavide train station also integrated this context.

Figure 3 - Orthophoto from 1995 (GD Território)

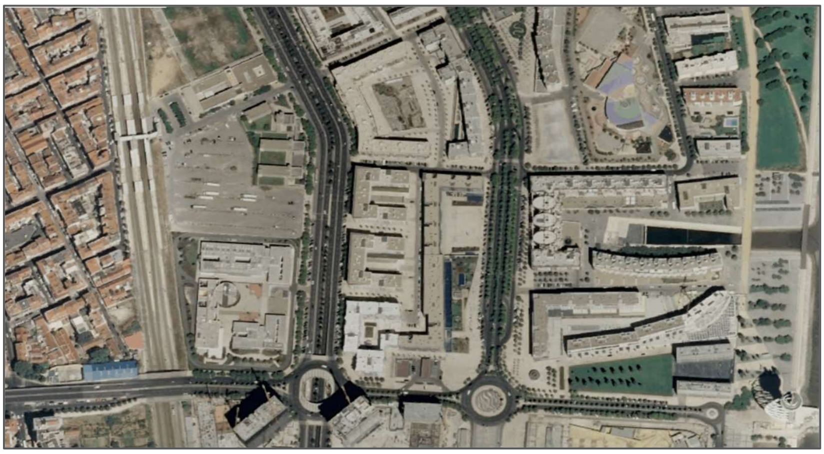

Figure 4 - Orthophoto from 2007 (GD Território)

The campus project itself was conceived to dwell a merge of 4 other public existing nursing institutes in Lisbon until the 1990s (Escola Superior de Enfermagem de Artur Ravara; Escola Superior de Enfermagem de Calouste Gulbenkian de Lisboa; Escola Superior de Enfermagem de Francisco Gentil e Escola Superior de Enfermagem de Maria Fernanda Resende.) For this new upcoming format it required bigger installations that could outgrow its academic potential, such as new pedagogical and administrative rooms, support units and spaces for events, as described in topic 2.1. According to former employees of ESEL, its construction began around 1998/1999 and it was finally opened in 2002 for the new admitted students.

Since the opening, despite the amount of anomalies identified in the buildings, there are no registers of past interventions with bigger complexity as structural repairs. During the in-site technical visits, a few superficial repairs were noted, like retouching in the walls, in the facade and in the floor (in the case of slate flooring), and injection of epoxy materials in a few cracks.

3. Characterization of the anomalies and probable causes

The methodology used in this chapter regarding the classification of anomalies follows a "Number + Letter" nomenclature, where the anomalies are named after the chapter they are presented in and followed by an alphabetically ordered letter.

3.1 External Walls

For the purpose of clarification, it should be noted that the external walls and structural elements such as columns and beams are approached separately in this report, even though both structures "share" the same areas. It is also important to mention that in this report, facades and external walls are considered to be the same structures.

The external walls in this compound have been affected in various ways and areas. In building A, where the large circular structure is located it is perceivable that on the external wall, all over the structure but more specifically behind the constructions' external metal cladding, there is a reddish, rust-like staining on the white coating covering the plaster. On the ceramic used at the bottom of the windows surrounding the structure (the windows here are as tall as the door to enter the building); And on the aluminum of the windows and door frames as shown in figures 5 and 6.


Figure 5: Anomaly 3.1A zoomed in


Figure 6: Anomaly 3.1A zoomed out

Considering that the metal cladding is attached to the wall by a metal bolted connection, it's safe to assume that the cause for this anomaly is because of rust that developed on the metal and transferred by water (when it rains) to the wall. This also explains the stains on the ceramic floor and aluminum frames, since this color of stain indicates the presence of metal particles which comes from the metal cladding, and can be transferred to the surrounding structures by air or by rain water fall.

Also in building A, the facade has visible signs of tear, with significant vertical, black stains as well as the formation of bubbles under the white coating as shown in Figure 7 and flaking of the paint as shown in figure 8.


Figure 7: Anomaly 3.1B


Figure 8: Anomaly 3.1C

These facade anomalies were all most likely caused by environmental actions and require no in-situ testing. The most likely cause for these three pathologies on this facade is efflorescence and crypto florescence, which characterizes the prolonged presence of moisture or soluble salt in the render. Since there is no draining system on the facade, the rainwater runs down the structure, and overtime, moisture has most likely entered between the surface and the layer of paint of the building, and then, the bubble was formed. Moisture also explains the flaking of the paint since it can cause the adhesion between the paint and the concrete to weaken and consequently peel off.

On the back of building A, where the facade faces North and West, the outer side of the wall has very characteristic ghosting stains, where it is possible to see the structure inside the wall by following the stains patterns. This anomaly presents itself from top to bottom of the facade, with darker stains centered in the middles and white spots surrounding the darker areas, as shown in figure 9. The picture shows the facade facing west, but the facade facing north presents itself with the exact same type of anomalies, leaving space to assume that this is not a localized issue, but something related to structure itself and that the stains are a consequence of thermophoresis. It’s important to mention that the internal part of the left side of the building is an open space with no roof covering. The right side of the building is covered.

Figure 9: Image of Anomaly 3.1E

What is known for this anomaly is that it is most likely caused by temperature differences and particles that move air borne (can be vehicle exhaust, road particles, etc) that attach themselves to the cooler and most moisturized area of the wall, causing staining. Further inspection using a thermostat was used, and it was found that the masonry part of the facade was warmer than the concrete part.

This leads to a number of possible causes: Either lack of insulation in the wall, the structure has air currents that travel inside the cavity causing a difference in temperature between areas or the presence of mold and algae on the masonry part caused by the fact that masonry brick is a more porous material than concrete and more vulnerable to the proliferation of these fungus’ and the sticking of air borne particles that cause staining.

3.2 Structural elements

In the facade of building B, the masonry loaded on the cantilever span presents cracks in the upper part, the union of masonry and the beam, in both external and internal regions. The figures 10 and 11 represent the view of the disconnection from outside and inside, respectively.

Figure 10: Anomaly 3.2A exterior view

Figure 11: Anomaly 3.2A interior view

This crack has a thickness of 5-10mm, as shown in figure 12, and the orientation follows the aforementioned elements. It’s noticeable that the direction of the masonry changed, they are not at the same plane as before, what characterizes a 3D crack, and it is still connected on the bottom part. This is evidence of structural creep settlement, probably, the load was bigger than the beam could handle so it bent.

Figure 12: Anomaly 3.2A crack measuring

The façade of building A presents a similar pathology, probably occurring by the same causes, however the cracks present different patterns. As shown in the figure 13, the upper part of the masonry is still connected and the masonry presents cracks in the surface in addition to the connections.

Figure 13: Anomaly 3.2B external view

Considering the disposition of the cracks, it can be concluded that the masonry suffered compression loads, probably caused by the settlement of the beams. Furthermore, it can be observed that in the bottom face of the lower beam there are cracks disposed in a way that can indicate a principle of detaching, this anomaly can be well seen in figure 14.

Figure 14: Anomaly 3.2B bottom view

Another anomaly occurs on the facade of building A, superficial cracks located between the beam and masonry, mostly in an architectural element of the main facade. As can be seen in figure 15, this external element is totally exposed to the environment and its consequences, thermal variations, sun and rain, for example. It’s important to mention that each element, beam and walls, has a thermal dilatation coefficient that makes it grow or shrink in a specific quantity depending on the variation of temperature.

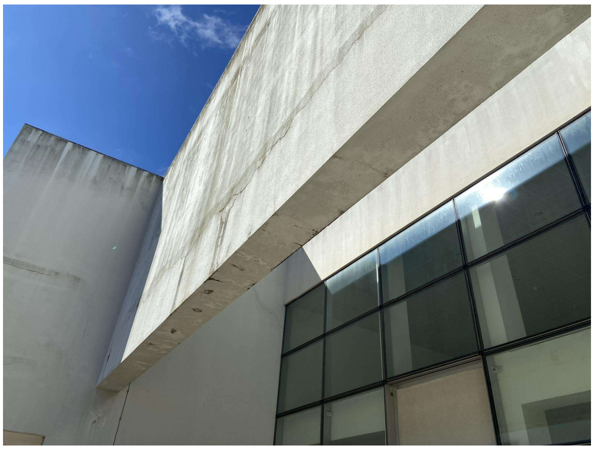

Figure 15: Anomaly 3.2C facade of building A

The cause of this anomaly can be related to high exposure and lack of mechanism that compensates the phenomenon of difference in the coefficient of thermal dilatation between different materials.

It's also notable that there are some irregularities in the coating, located in the bottom of the beam figure 16, and in some points, there is disaggregation of the painting mostly caused by the water path and consequential accumulation of rainwater.

Figure 16: Anomaly 3.2C inside view

3.3 Internal Walls

The internal walls analyzed in this part of the project were all seen in the building A. In most parts of the internal walls it is possible to see cracks in an irregular shape (3.3A), as shown in Figures 17 and 18, that go through the whole area of the wall, this anomaly is presented by the presence of cracks. The anomaly is probably caused by thermal variations or due to shrinkage, when the temperature varies constantly causing the expansion of the coatings of the walls and accordingly causing cracks.

Figure 17: Anomaly 3.3A zoomed out

Figure 18: Anomaly 3.3A zoomed in

In some walls it's possible to see some spalling in the corners (3.3B), as shown in Figure 19, probably due to presence of moisture, which as explained in the external walls can cause the lack of adherence between the walls and the coatings, causing the wall to spall. Or due to the friction of objects in the corner, being in a wall at the start/end of a corridor.

Figure 19: Anomaly 3.3B

In the photo below, it is possible to see a crack in part of the depth (3.3C), as shown in figure 20, well aligned and unique, probably due to a static load caused by the window, leading to stress. This kind of crack happens in the bottom part of the window, all the way to the other end of it.

Figure 20: Anomaly 3.3C

In the walls near doors, it is possible to see the existence of cracks (3.3D), as shown in figures 21 and 22, that seems to be related to the form that the doors were attached to the walls causing the appearance of tensions in different spots. Another possible cause is the presence of temperature changes in the masonry walls, causing the superficial cracks.

Figure 21: Anomaly 3.3D

Figure 22: Anomaly 3.3D

3.4 Internal ground floor

Regarding internal flooring of building A, wooden laminate and slate are the main materials. Both reveal pathologies that indicate correlation with daily use when analyzing the furniture surrounding the affected areas and can be classified with superficial and aesthetic anomalies.

The wooden laminate has stains due to water in the corner of the room. In addition, there are dark spots and wear due to friction of heavy equipment's displacement (coffee machine). It can be also noted wear due traffic and successive washes.

Figure 23: Anomaly 3.4A

Figure 24: Anomaly 3.4A

The slate floor also presents wear due to mechanical actions (friction and impact). As it can be verified in the photos below, areas that suggest concentration of repetitive movements are the most likely to be affected by this pathology. Although it can't be assured for the bottom floor, on the upper floor it's conceivable by its black vibrant color that the slate has been recently coated with dark painting as an attempt to repair the visual defects.

Figure 25: Anomaly 3.4B

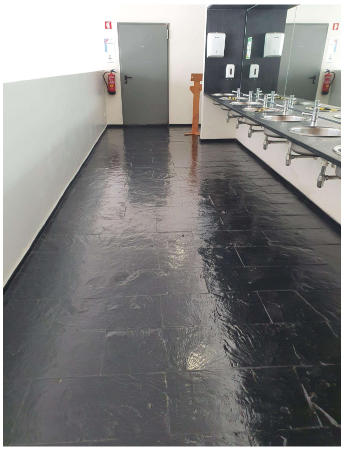

Figure 26: Anomaly 3.4B

3.5 Floor partition (slabs)

The analyzed slabs of both buildings were only the visible ones, because in the majority part of the ambience there is a ceiling that covers the view from the slabs. In general, the visible slabs didn't present severe anomalies. Otherwise in building A, there are some stains in the bottom of slabs as shown in figure 27 and 28.

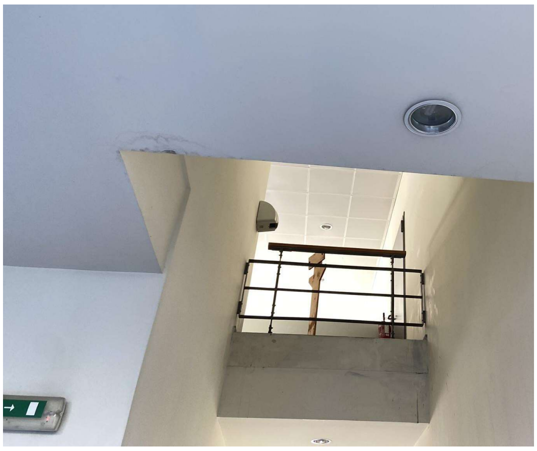
Figure 27: Anomaly 3.5A place 1

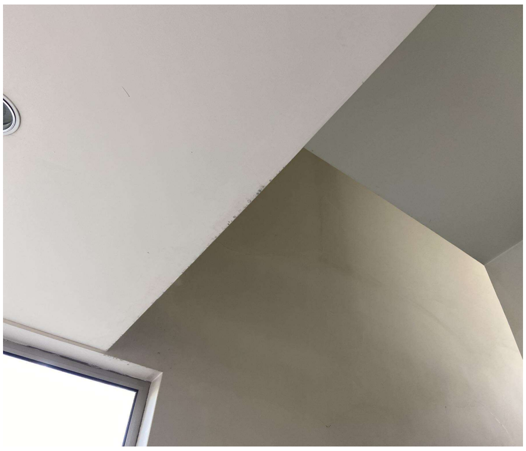
Figure 28: Anomaly 3.5A place 2

The stain is caused during the use of the building, precisely in the cleaning, when the water, from the washing the coating of the upper floor, drops and accumulates in the bottom of the slab.

3.6 External floor

The outside ground structure consists of prefabricated concrete blocks assembled as masonry. In various areas surrounding trees, the same type of pathology is perceived, which is the detachment and pushing of the blocks of concrete towards the outside, as shown in figures 29 and 30.

This anomaly is caused by the growth of the surrounding vegetation, more specifically the extension of the tree roots that started out in the center but have overgrown with time. With the overgrowth of the tree roots under the concrete blocks on the ground, the same blocks are consequently pushed outwards and by that looking misplaced and overlapping each other.

Figure 29: Anomaly 3.6A

Figure 30: Anomaly 3.6A

3.7 Ramp

In the ramp it is possible to see some cracks that go through the whole depth, and are repetitive in some parts of it, as it's possible to see in Figures 31 and 32.

Figures 31: Anomaly 3.7A

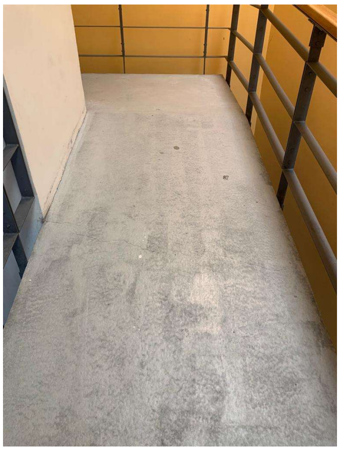

Figure 32: Anomaly 3.7A

The cracks were probably caused by the shrinkage of the concrete, that happened due to the existence of temperature changes, that can cause the expansion and contraction of the concrete. And also can be related to factors such as humidity and the presence of sunlight, since there is a window in the upper part of the ramp, and the doors of the building are constantly open.

3.8 External Stairs

The external stairs leading access to Building B are made of reinforced concrete and are exposed to few pathologies. Its most important one is the crack due to relative displacement of supports on both sides.

In the figure 33, the coating suggests a previous attempt of repair that could not effectively solve the problem. The crack is reappearing and following its former path, since the root cause lies in a deformation of the structure. In the figure 34, it's notable the cracks reaching the drain, which tends to bring damage to the drainage system in the future and promote new pathologies to this structure.

As a less concerning pathology, there is evident parasitic vegetation along the steps that could be easily solved by removal.


Figure 33: Anomaly 3.8A


Figure 34: Anomaly 3.8B

3.9 Internal Stairs

There are internal stairs in both buildings, but only the stair located on building A will be analyzed because that one presents some cracks. The stair is completely made of reinforced concrete and it's possible to check the conservation state of its structure. Out of that fact, it's visible superficial cracks on the surface, as shown in figure 35, these cracks were probably caused in the moment of fabrication, in the process of curing, and present no risk for users.

Figure 35: Anomaly 3.9A

The handrail, made of steel and timber, presents some stains in the palm rest made of timber, pictured in figure 36. These stains probably are a consequence of some execution failure of painting, or it's caused by the daily use, by the interaction between the varnish and water drops, cleaning products or chemicals.

Figure 36: Anomaly 3.9B

3.10 Suspended Ceiling

This suspended ceiling pathology, found in building A in the canteen area, consists of dark stains that are apparently distributed evenly across 7 ceiling blocks laid besides each other. The rest of the ceiling is clear and free from anomalies, which suggests a localized cause that is affecting a specific area.

This type of anomaly indicates the presence of a leak in the ceiling structure. In this case water can cause moisture stains and be an ideal spot for mold and mildew if not solved.

Figure 37: Anomaly 3.10A

To fully diagnose this pathology, a pre-intervention inspection is needed: A team specialized in water leakage should proceed with a “damage survey” where they will be able to push open the suspended ceiling in the localized area of the pathology and look for leakages or any other condition inside the ceiling structure that would explain this anomaly and proceed to the intervention strategy.

3.11 Roof

It is possible to see in the roof of the building B the presence of vegetation all through its space, as shown in figure 38 and also in some places there was a detachment of the tiles, as shown in figure 39. The pathology is probably caused by water damage, because of its location, it is susceptible to rainwater constantly, and without the proper drainage, the water intrusion can cause the concrete to weaken and detach. With the detachment of the concrete and the presence of water and moisture, the vegetation grows between the tiles causing more noticeable detachments.

Figure 38: Anomaly 3.11A

Figure 39: Anomaly 3.11B

4. Diagnosis of the state of degradation of the building

4.1 Overall analysis of the state of degradation

As stated by former employees of the institution, technical inspections and interventions were not very usual during the past 20 years. Routine inspections were made and even some anomalies have been fixed, but not the most of them. As demonstrated, most of the pathologies found in-site are non-structural, which is expected since the time between regular maintenance is shorter, the exposure is higher, and most of the connected elements can influence each other. In most cases, the anomalies could have been avoided by regular maintenance.

Although most of the observed anomalies do not present actual risk to the users, it’s highly recommended a structural assessment considering there have been found some signs of degradation that can be rehabilitated now to avoid higher costs for repairs in the future.

In general, regarding the age of the building and its lack of inspection history, the general degradation state can be considered as regular. It must be subject to maintenance as soon as possible to avoid higher damages and functional deterioration and guarantee the expected service life.

4.2 Identification of intervention priorities

After diagnosing each anomaly, stating the cause (s) and characterizing them, it is possible to determine the intervention priorities, even before determining the intervention proposals. The intervention priorities consider economic and structural factors in order to determine where the focus should be at. This is done by analyzing each anomaly stated in chapter 3 stating the risk it imposes to the building and its users and considering a low repairing budget.

Highest priority: 3.2A, 3.2B, 3.2C;

Medium priority: 3.3A, 3.3C; 3.7A; 3.8A, 3.8B

Lowest priority: 3.1A, 3.1B, 3.1C, 3.1D, 3.1E; 3.3B, 3.3D; 3.4A, 3.4B; 3.6A; 3.10A; 3.11A, 3.11B; 3.2C; 3.9A, 3.9B; 3.5A

5. Intervention Proposal

5.1 External walls

3.1A Considering how standard and common this type of anomaly is, this case requires no testing, nor a further inspection in order to produce a diagnosis. Since this pathology imposes no risk to its' users, nor intervenes with the functionality of the area or building, the intervention proposal here is to let it be the way it is, giving it a standard paint coating regularly to keep the aesthetics of the building in order if desired. Here the superficies should be cleaned and sandpapered and then painted.

3.1B/3.1C The issues presented in this facade are common anomalies originated by the lack of an appropriate drainage system and the normal process of age of a structure. No specific testing is required to diagnose these pathologies and find an appropriate intervention proposal, other than a visual inspection.

This is not a structural problem, but considering that the wall coating is not just there for an aesthetical purpose, but it also serves as protection from external agents, the proposal here is to use repair techniques that could be cover-up or protection.

In this case the technique suggested would be to first scrap the area using a scraper or wire brush and then make sure that the areas affected are dry and clean. Afterwards a filler should be applied in order to regain the original formation. Proceed to apply paint or wall finish. Additionally, a gutter drain should be installed in order to avoid this issue happening in the future.

3.1D/3.1E Like the previous anomalies, these ones do not impose a risk to the building or its users and they are mainly an aesthetic and protective issue. The course of action in this case is to remove any loose paint flaking, clean the surface, make sure the wall is dry and apply a new paint coating. Additionally, a gutter drain should be installed in order to avoid this issue happening in the future.

5.2 Structural elements (beams and columns)

3.2A Considering the average of the crack, its width, location and exposure to environmental factors, repairs will be necessary. It's important to gather more information about the crack in order to have a better understanding of its properties. For instance, there's an urge to make more tests to check if the crack is alive or dead, which means if the structure is still moving or if it is stabilized. Based on these results, the intervention strategy will be determined.

In the case that the structure stopped moving, a repair should be made only in the masonry located between the inferior and superior beam. For filling the cracks voids it is advisable to use mortar due to the width of the crack. If it’s concluded that the structure is still settling it is necessary to make more tests, to check the quality of concrete and the resistance of the structure, and define what are the real causes of this problem, because based on the life expectancy, with no different uses and loads, the structure designed should be enough.

3.2B As the superior intervention, it will be needed to check if the structure is still moving; in case of denying, the render of masonry should be repaired, so it will be needed to be completely dry to fill the cracks void with epoxy and then apply another layer of painting coating. And for the bottom of the beam it is necessary to check the depth of the crack; if it is superficial, the solution is to fill the cracks with epoxy resin and then apply a layer of painting coating.

In the case of it being more incisive, it’s necessary to extract the concrete cover to check the real state of the reinforced steel. In case it is still functional the adopted procedure should be making a void in the concrete until the complete exposure of the reinforcement, plus a space to guarantee the adherence of the new concrete. Then it will be necessary the saturation of the concrete to guarantee that cold joins won’t appear, and then fill all the voids with concrete supported by specific formwork, and then let it cure by applying water.

In case the bars are not well conserved it’s necessary to replace them or increase the number of bars. If it is still moving, same as the upper one, it’s necessary to make the tests to check what elements are affected and present failure to be certain repaired.

3.2C To fix the pathology and avoid more cracks located between the beam and masonry it's necessary to make an incisive repair. The first step would be to cut the render committed by cracks in a region of 15 centimeters around it and replace it using a reinforced mesh for the render, so it can be capable of resisting the tensions of this area. To follow the process, a new coating should be applied afterwards. For the bottom of the beam, the recommended method to avoid the pathology is to put a metallic profile in the edges working as a drip pan after a new painting coating. As a result, the rainwater in the wall will drop, preventing the accumulation in that place.

5.3 Internal walls

3.3A Most of the cracks due to thermal variation have a small width, but in some cases where the width is bigger it is necessary to seek the aid of a professional. To confirm that this is the real case can monitor the temperatures. But in the majority of the cases the procedure is cleaning the crack, filling the crack with a sealant able to withstand the thermal expansion without cracking, wait for the proper cure of the sealant and paint the area to match with the surrounding surface.

3.3B Knowing that spalling is a common pathology and is mostly superficial, no further tests need to be made, because it’s localized in a small area. To repair the pathology, first it’s necessary to remove the loose material and clean the surface, after that it is possible to repair by filling the damaged area with a mortar mix and after the cure, paint and do the finishes.

3.3C Because of the existence of a static load, it would be necessary to do the analysis of the crack to know if it has already stabilized. If it’s not stable, it may be necessary to strengthen the wall, to avoid more severe cracks to appear, but the strengthening may not be necessary, because the cracks won’t affect any other area directly. If it has already stabilized, it is necessary to clean the crack, then prepare the crack to help with the adherence of the material, then fill the crack with a high-strength epoxy, wait for it to cure and then do the finishes on the surface.

3.3D This pathology is similar to the 3.3A, but due to the fact that it can be related to the installation of the door, it has to be inspected for a period of time to see if it is already stable. If so the proposal of intervention is the same as 3.3A, and if not, it is necessary to test the wall to see its strength, and make sure it can take the stress caused by the door, but the probable fix would be the repair by injection.

5.4 Internal ground floor

3.4A There’s no alternative to these pathologies but replacing the parts of wooden laminate that are damaged, which does not require high complexity intervention. Concerning the areas affected by water, nevertheless, it’s equally important to avoid situations that could promote this kind of pathology. Considering wood is highly prone to be affected by water, moving the water filter to a more appropriate location is recommended, like external areas or internal wet areas with porcelain flooring. This strategy could eliminate the cause and it can also avoid the appearance and proliferation of fungi.

3.4B During the in-site visit, no slate flooring debonding was observed. A wear process was the most visible pathology, which in this case can be more like an aesthetical issue than a concerning pathology. The most reliable strategy for this case is usually repairing the flooring with polishing or replacing the most damaged slates.

5.5 Floor partition (slab)

3.5A The presence of stains caused by water accumulation is an indicator of the beginning of a possible severe aggression, because the cleaning water is full of chemicals that can react with the coating and affect the concrete, so for protect the coating, before it start to flaking it should be applied on the upper floor, some barrier in the border to avoid the water to drop. In addition, the stain should be cleaned and checked if it is only superficial or not. If it is superficial, only the cleaning will be enough, if the stain already affects the coaling, a paint repair should be made in the affected areas.

5.6 External floor

3.6A No additional testing is required in this case the cause is clear to diagnose. The intervention proposal for this structure's anomaly varies according to the wish of the property owner. It is true that this pathology does not put the users of the building in imminent danger, but it can cause small accidents because it unlevel the ground in this area. The intervention here could be to just leave it as it is, but if the choice is to repair workers should cut the trim the roots of the trees and re-attach the concrete blocks. This should do periodically to avoid the same issue recurring (Pete & Ron's tree service inc., 2015)

5.7 Ramp

3.7A The issue that happened is common in places with big thermal variations. But can also be related to the cure of the concrete.

The reasonable way to repair the crack is by injection of epoxy into the crack filling it and preventing further cracking. But in cases of cracking due to shrinkage it's not a permanent fix, so it's important to look further to address the cause of the crack.

5.8 External stairs

3.8A At first, it's recommended to check the evolution of the width of the crack along a predetermined period of time in order to verify whether it's an active or inactive crack. If it's still an on-going settlement process, a strengthening methodology would be the most appropriate. This topic requires further investigation, but as a first hypothesis the enlargement of the existing foundation could be considered the initial strengthening approach, considering this solution fits less complex cases and offers lower costs.

If it's already a dead crack, there is no need for interventions in the foundations and it's possible to repair by different approaches. In this case, considering the crack has w > 1 cm, a repair by injection with cement grout would be the most effective.

3.8B In the case of proliferation of vegetation, this anomaly can easily be cleaned by regular maintenance.

5.9 Internal stairs

3.9A Due to the fact of the cracks being only superficial and having characteristics of dead cracks, and considering in that point it does not affect the use and the security, it is recommended to just let it be as it is at the structural level. For aesthetic and security objectives, it would be necessary a new paint coating to make it look similar to the initial design and to keep the superficial roughness and avoid accidents.

3.9B For the timber of the palm rest in the handrail, it should be given a new varnish coating, removing the old one, to avoid future stains and the degradation of timber, which can take another level of cost.

5.10 Suspended ceiling

3.10A Considering that this pathology could represent a risk to the ceiling structure in case of leakage, it is important for this structure to undergo further inspection, as mentioned in chapter 3.10. The team performing the further inspection should check the ceiling structure from the inside and from the outside, observing surrounding areas, checking for signals of leakage or moisture that would confirm the diagnosis. In general, the intervention in this case is to eliminate the leak cause and replace the acoustic ceiling blocks where needed.

5.11 Roof

3.11A Considering that this pathology could represent a risk to the internal structure, it is important to search for the exact cause of the problem. After acknowledging the cause, it is necessary to clean the detached area removing loose debris and dust, repairing the part of the substrate that is damaged, to only then apply the bonding agent and the repair material, matching the concrete. And after the proper cure of the material apply a suitable sealer to avoid a future moisture penetration.

3.11B It is also necessary to clean the area because of the presence of vegetation that can be another factor that causes the detachment of the concrete.

6. Conclusions

This report, combined with the classes and the laboratory sessions show the relevance of a well-designed project, as well as the materials and the monitoring of all the steps of construction/execution. It also highlights the importance of inspections during the service life of a building, in order to analyze and repair possible problems, avoiding the emergence of high-risk building issues.

Most of the pathologies shown in this paper are related to the lack of maintenance of the building and the wrong usage of the elements, as shown in the internal floors pathologies.

In a practical context, this report would be used as an initial approach for a rehabilitation project, followed by possible further analysis and testing and concluding with intervention proposals. In such a practical context, the set budget for the rehabilitation project would be considered, in order to determine which pathologies need immediate repair, taking into account that a restoration process can be expensive.

Acquiring knowledge on the rehabilitation of buildings is crucial for engineers and architects because of the demand and necessity of such skills in the current and future construction market.

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