SUBSIDIES FOR A CONSERVATION MANAGEMENT PLAN

VILANOVA ARTIGAS BUILDING

School of Architecture and Urbanism of the University of São Paulo (FAUUSP)

Keeping It Modern Program
Getty Foundation
2017

Subsidies for a Conservation Management Plan

Vilanova Artigas Building (School of Architecture and Urbanism of the University of São Paulo - FAUUSP)

Keeping It Modern Program – Getty Foundation

2017

Coordination

Maria Lucia Bressan Pinheiro (general coordinator)

Claudia T. de Andrade Oliveira (vice-coordinator)

Line Coordinators

Task 1 - FAUUSP's Building: transformations, values and guidelines

Beatriz Mugayar Kühl and Silvio Oksman

Tarefa 2 - Roof:

Antonio Carlos Barossi and Rodrigo Vergili

Tarefa 3 - Blind Façades:

Claudia T. de Andrade Oliveira

Collaborator

Norberto Corrêa da Silva Moura

Adviser

Claudia S. R. De Carvalho

Team of Professionals

Ana Paula Arato Gonçalves

Fábio Gallo Júnior

Renata Cima Campiotto

Rodrigo A. Campagner Vergili

Collaborators: Carmen Silvia Saraiva Masseo de Castro

Tatiana Regina Silva Simão

Scholarship Students

Eric Palmeira

Letícia de Almeida Chaves

Luiza Nadalutti

Keeping It Modern

The Getty Foundation

Research Laboratories / Collaborating Companies

DIAPReM - Universidade de Ferrara: laser 3D scan e formation of local team
Centro Dipartimentale Development of Integrated Automatic Procedures for Restoration of Monuments
Coordination: Marcello Balzani
Field work: Guido Galvani e Daniele Sasso Felice
Formation of the local team: Federica Maietti, Luca Rossato e Guido Galvani

Escola Politécnica da Universidade de São Paulo: concrete porosimetry analysis
Departamento de Engenharia de Minas e de Petróleo: Laboratório de Caracterização Tecnológica - LCT
Engineer Guilherme Pinho Nery

Instituto de Pesquisas Tecnológicas do Estado de São Paulo: chemical analyses and materials resistance
Laboratório de Materiais de Construção Civil - LMCC, Centro de Tecnologia de Obras de Infraestrutura - CT-OBRAS
Geologist Priscila Rodrigues Melo Leal
Civil Engineer Rafael Francisco C. dos Santos
Chemical Engineer Sérgio Soares de Lima
Chemist Valdecir Angelo Quarcioni
Laboratório de Corrosão e Proteção - LCP, Centro de Tecnologia em Metalurgia e Materiais - CTMM
Technical manager: Adriana Araújo
Neosvaldo L. de Almeida
Sidney O. Pagotto Junior

Pires Giovanetti e Guardia: concrete cleaning testing
Architect Juca Pires

Podarte: arboreal survey
Agronomist Engineer Lauro Humberto Silva

Polígono Arquitetura e Engenharia: study and application in place of finishing repair mortar
Civil Engineer José Masseo de Castro

Relevo Topografia: metric survey
Technical manager: Paulo Sérgio de Carvalho

SGS do Brasil: polyurea testing
Civil Engineer: Juliana de Carvalho

Cover photo: Rosa Artigas collection. Author and date unknown.

SUMMARY

About the project “Subsidies for a Conservation Management Plan - Vilanova Artigas Building”
Beatriz Mugayar Kühl, Silvio Oksman, Renata Campiotto, Luiza Nadalutti

Introduction 11
Assumptions and goals 11
About the 3 tasks 13

1. Task 1 : Vilanova Artigas Building: transformations, values and guidelines
Beatriz Mugayar Kühl, Silvio Oksman, Renata Campiotto, Luiza Nadalutti, Antonio Carlos Barossi

Introduction 25
Presentation of FAU´s Building 25
Timeline: main events 26
Meaning (Statement of Significance) 29
Main vulnerabilities 29
1.1 Description of the building´s characteristics 31
1.2 Spaces of the building and distribution of functions over time 45
1.3. Cadastral survey 59
1.4. Analyses and Guidelines 73
References 109
Documental Corpus 115

2. Task 2: The roof – Constructive systems and their conservation
Antônio Carlos Barossi, Claudia Terezinha de Andrade Oliveira, Rodrigo Vergili, Eric Palmeira

Introduction 131
Presentation of the original characteristics of Vilanova Artigas Building roof 131
Roof timeline 132
Work method 133
2.1. Constructive characteristics of the roof subsystems 135
2.2. History of interventions and studies conducted on the roof 153
2.3. Survey of the structure and of the waterproofing conditions 169
2.4. Guidelines and recommendations for the implementation of the Conservation Management Plan Analyses and Guidelines 179
2.5. Roof Conservation Management Plan 187
References 197

3. Task 3: Characteristics and conservation of the exposed reinforced concrete of the Vilanova Artigas Building (FAUUSP)

Claudia T. de Andrade Oliveira, Fábio Gallo Jr, Ana Paula A. Gonçalves, Letícia de A. Chaves

Introduction 211
Presentation of the blind façades 211
Blind façades | Timeline 214
Work method 215
3.1. Constructive characteristics of the blind façades 219
3.2. History of interventions in the blind façades 227
3.3. Conditions of access to the external surface of blind walls 239
3.4. Environmental conditions 245
3.5. Physical condition of blind walls 251
3.6. Physical Properties of the concrete 259
3.7. Aspects of the concrete microstructure 267
3.8. Tests for the removal of grafitti 277
3.9. Studies on the chromatic attributes of concrete, and mix design of the finishing mortar 283
3.10. Rebar corrosion 289
3.11. Analyses, recommendations and guidelines 301
References 309
Documental Corpus 315

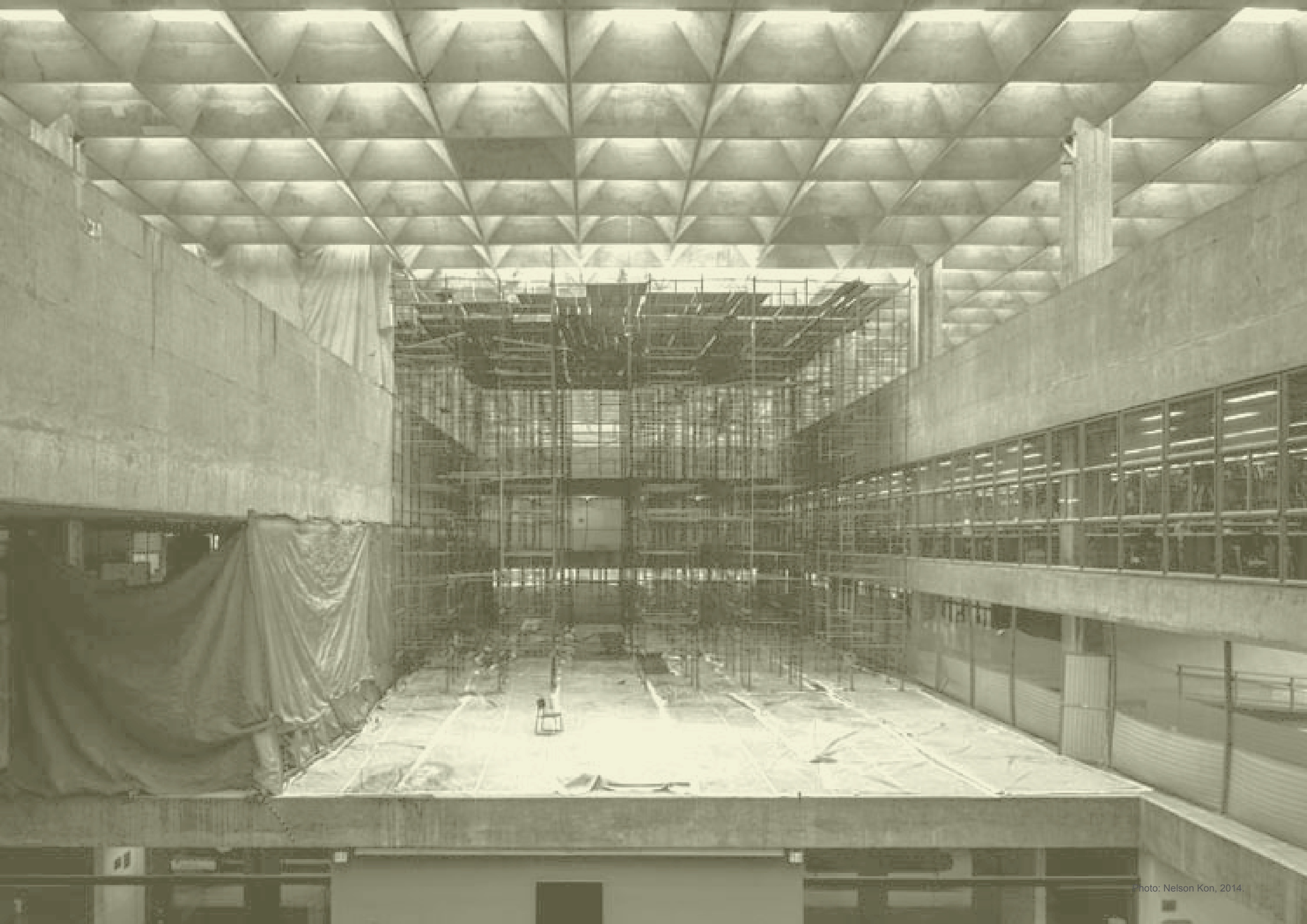


Photo: Nelson Kon, 2014.

ABOUT THE PROJECT

“Subsidies for a Conservation Management Plan - Vilanova Artigas Building

Introduction

The headquarter buildings of the School of Architecture and Urbanism (FAU) of São Paulo University (USP) are examples of architectonic interest of major significance, not only for the University, but also for both Brazilian and the international architecture. This privilege though implies responsibilities, since the School has the obligation to take care of them as best as possible – working irreproachably in regard to the methods and procedures, for being a School of Architecture of a Public university -, because of all the assets under its responsibility, especially those regarded as of cultural interest.

Among the buildings under the responsibility of FAU, two are protected by state and municipal laws: FAU-Maranhão[1], designed by Carlos Ekman for the residence of Penteado Family, completed in 1902 and donated to the School of Architecture in 1949, when the undergraduate course started. The school functioned there until 1968, and today Vila Penteado is the center for graduate courses (Figure 1); and the Headquarter Building in the University City[2], designed by João Batista Vilanova Artigas and Carlos Cascaldi, housing the undergraduate courses of architecture and urbanism, since 1969, and the undergraduate course of design, since 2006 (Figure 2), and named Vilanova Artigas Building in the 1990s. Those buildings are distinguished representatives of different moments of São Paulo architecture history, documents of major relevance, bearing the knowledge of several fields, also being associated to facts, past and present, making those works also significant because of their memorial and symbolic aspects.

Assumptions and goals

This work, supported by Getty Foundation, intends to set up the assumptions for the preventive conservation plan for the headquarter building of the School at the University City.

Aware of the fact that a full plan for the Preventive Conservation of the building would take more time than that stipulated by the grant support rules, and would consume more funds than the limit defined, since the grant request phase, the plan focused on two aspects: control and management of water, shown to be the main degradation agent; proposals to face the effects of repairs made to the concrete blind façades in 2014, resulting in a fragmented image of the building. The interest thus lies in the performance and image of the building protection elements: the roof (Task 2) and the blind façades (Task 3). The plan, though, starts with the assumption that such issues are closely related to the ways of perceiving and apprehending the building over time (Task 1). Therefore, if the primary goal of Task 1 is to document the transformations and the several ways of appropriation of the space throughout time, the task, which cannot be a mere gathering of information, is also intended to analyze the spatial features and to propose guidelines for the use and proper treatment of spaces, respecting their features of composition, understood as a value to be protected, and allowing their proper perception.

Concerning the Roof and the Blind Façades, one of the main concerns guiding the study was checking their performance after the works completed in December 2014[3], since they are the main closing system of the building and its main mediation with the outside, protecting it from the action of the weather. The aim is to establish a monitoring and control plan, and to propose individual repair actions, suiting the technique used in the last work and the intended performance results. A monitoring and management plan will be established, including inspection, cleaning, conservation works, with their periodicity and methodologies defined.

One of the problems emerging from the last intervention, which deserves a special attention, is the repairs done to the blind façades that, in addition to performance and adequacy issues – there are already marks of the reinforcing ironwork corrosion appearing in the surface –, have created a fragmented and pixeled image of the building (Figures 3 and 4). FAU's blind façades, even though being brutalist, explicitly showing the marks of the constructive process that gave origin to them, have always offered a unitary and coherent image of the building, something that was lost with the last work[4]. This topic will be addressed with special care, in order to propose subsidies to guide future research in search of solutions that mitigate the fragmented effect and provide the suite with a renewed unit, respecting its characteristics and time passage marks. New possibilities of intervention will also be attempted to face new possible detachments of the superficial concrete layer. This is not about returning to an idealized original image, but rather about constructing a possibility of intervention coherent with the characteristics of the building, both from the technical and aesthetical points of view. The exposed concrete is both structure and sealing, performing a very important role in the composition and perception of the building, and therefore complete mortar lining and/or total paint should be rejected.

The attempt to mitigate the discrepancy between repairs and the existing blind façade surface should be done carefully, to prevent an exclusively aesthetical approach that is not compatible with the essence of the building. Such solutions will be tried and the results discussed, and only then a phased program will be proposed to gradually tackle the problem.

Figure 1 - Vila Penteado, headquarter of FAUUSP graduate course. (Source: https://projetobrasilfranca.wordpress.com/2010/06/14/vila-penteado-a-maior-mansao-art-nouveau-do-brasil-sao-paulo/)

Figure 2 - Vilanova Artigas Building, headquarter of the architecture and urbanism, and design courses of USP. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team

[1] CONDEPHAAT Resolution of 27/02/1978, protected ex-officio by Resolution no. 05/ CONPRESP/91

[2] CONDEPHAAT Resolution 26 of 23/7/81, protected ex-officio by Resolution no. 05/ CONPRESP/91. FAU´s building was the first modern building protected by CONDEPHAAT, starting a series of protection actions and studies on the modern architecture of São Paulo state.

[3] The works performed in 2014 are described in Tasks 02 and 03. In general, the following was redone: roof waterproofing system, comes were changed, blind façades were treated to remove part of the detaching concrete, iron structure was treated and covered with repair mortar.

[4] The blind walls were concreted with no type of finishing mortar, leaving the marks of the natural wooden molds, granting a varied texture, but a unitary image to the blind façades.

Figure 3 – Main and west lateral façades after the repair works in the blind façades. Photo: Ana Paula Arato Gonçalves, April 2016. Collection: Conserva FAU Team.

Figure 4 – Detail of the building façade blind façade after the repair works. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

That way, the issues of perception, manners of apprehension and performance of the systems will be addressed in an articulated fashion.

The performance of the roof and the blind façades is essential to seal the building, also with reflections in other systems that, despite not being part of the scope of this work, will be listed for the proposition of future actions as the outcome of this plan. One example of that is the water runoff, done through ducts inside the building. The rainwater catchment system was undersized when installed during the roof construction. During the 2014 works, new vertical pipelines were installed contributing to the drainage of waters; however, both in their catchment at the roof and in their conduction to the outside of the building there are issues to be addressed, such as, for instance, the accumulation of rainwater in parts of the roof (Figures 5 and 6). This system has to be better analyzed, especially in which concerns the drainage of water to outside the building and the drainage of the external area, interconnected topics that could affect the stability of the ground and of the foundations. The possibility of articulating actions aiming to reuse rainwater, and the verification and effective separation of the rainfall water system from the sewerage system, should also be analyzed.

Figures 5 e 6 – New vertical piping of rainwater catchment of the roof. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.

From the structural point of view, structure movements and bending of the roof should be taken into consideration. The constructive experimentation in modern architecture, especially with the use of reinforced concrete, was essential to consolidate its own aesthetics, which consecrated this kind of architecture. However, the material, which was believed to be inert and perennial, showed deformations and behaviors that were not foreseen when calculations were done. FAU is not the only building to show this kind of problems; some studies and electronic modeling can already precisely forecast the future behavior of such structures, offering means for conservation and restoration actions in order to prevent certain effects, and such structures should be periodically reevaluated to ensure the effective preservation of those buildings. In some sectors of FAU, it is possible to observe that the deformation of the structure prevents the total water runoff, creating a gradient in the direction of the cantilever structure, rather than in the direction of the vertical piping. Difficult to solve, this issue is fundamental to define the procedures and to select the material for waterproofing, considering that part of the roof remains covered by a water blade most of the time.

Likewise, another proposal to develop the future plan, interconnecting the 3 Tasks, is the study of the vegetation around the building, and the proposal to manage and control such vegetation, because it directly affects the perception of the building – given the unplanned increase of the number and size of trees over the time – and its maintenance. As an example, there is infesting vegetation that affects the blind façades (and even the roof and the columns), which can cause both structural problems, such as big trees growing in structural elements or at the line of the blind façades projection, and the degradation caused by biological films for creating peculiar microclimates in certain sectors. It is also necessary to define the plan to remove leaves from the area surrounding the building – to ensure the proper water drainage into the ground near the building – and on the roof – in order to prevent the accumulation of dirt in and clogging of vertical pipes -, considering the species and their blooming times, loss of leaves, resin, etc. (Figure 7). This step will comprise a survey on the current situation of trees and guidelines for conservation. In the future, it will be possible to propose a management plan that reduces the several interferences of the vegetation with the building: in its perception, in the physical aspects, with the presence of roots and the already mentioned biofilms.

Figure 7 – Big trees behind the building. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

About the 3 tasks

The proposal of Task 1 is to document and analyze, in an articulated fashion, the transformations of the building, of its use, the perception of its spatiality along time, also proposing future developments. Not only guidelines for the use and occupation of spaces are stated, but also parameters for the necessary review of installations (electrical, air conditioning, etc.).

Currently, the demands for new electrical and communication installations are individually met, creating overlapped systems and disorganized installations, resulting not only in efficiency problems, but also in safety problems (Figure 8). It is necessary to survey the existing installations and demands in order to review such systems. An example of that is the illumination system, newly installed at the roof, which ended up generating space perception problems, when creating a plan lower than the concrete grid and illuminating the roof from the bottom to the top (Figure 9). Likewise, other systems, such as the air conditioning system, should be reviewed and rationalized, to prevent harming the building visibility and not physically damaging it (such as, for instance, by breaking the frames) (Figure 10).

Therefore, a rationalization is necessary aiming both at a higher efficiency of the systems, and the safety of the building, both of its assets and of the school´s users. Furthermore, such systems have to be respectfully inserted into the space, according to the physical characteristics of the building, and in a proper way as for their distribution. FAU´s building and its systems should be addressed with the understanding of the whole, and not based on individual demands. The conservation plan will also highlight this type of issue, because they do not only concern the technical and installation problems, but also the problems of space administration and management.

It is also highlighted the need to set up guidelines and to elaborate a plan for the management of risks such as fires, vandalism (Figure 11), inundations – and other water-related problems, such as leakages, infiltrations, sewerage systems -, pollutants, biological attacks, plague control, as the infestation of pigeons, rodents and insects, besides the safety of assets and users.

When addressing space and use related issues, not only the problems of the occupied spaces are discussed. In the case of FAU, the big central void (Caramel Hall) and the circulation system are essential for the comprehension of the space. In this regard, focusing the efforts only on sectoring uses is not sufficient to organize and preserve the spatiality. The circulation around the Caramel Hall, allowing several alternatives of routes and perception of the spaces between galleries, staircases and ramps, should

Figure 8 – Data network wiring in one of the research laboratories. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

Figure 10 – Air conditioners in the north façade laboratories, back. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

Figure 9 – New lamps installed in the studios. Photo: Roberto Souza, July 2016. Collection: Conserva FAU Team.

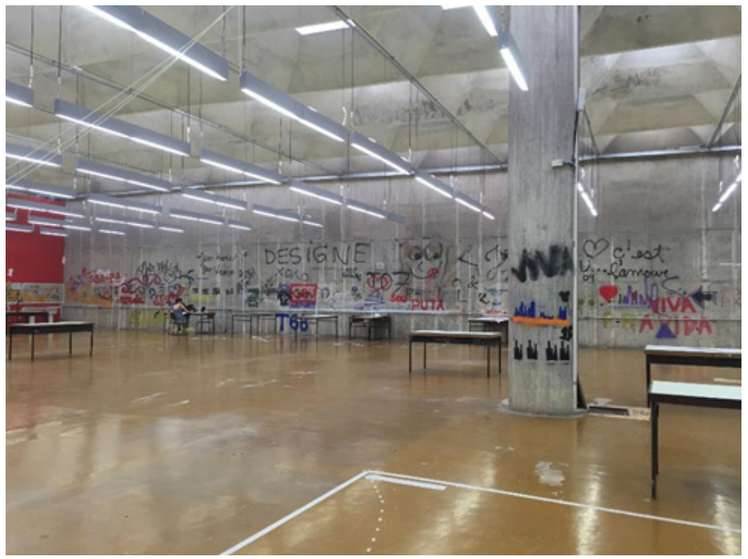


Figure 11 – Pìchações on the internal blind façade and on the pillar of Studio 5. Photo: Renata Cima Campiotto, April 2016. Collection: Conserva FAU Team.

be studied and preserved, prohibiting occupation, even though provisional, that interfere with such system.

The second task of the conservation plan regards the monitoring of the waterproofing system and the development of a preventive maintenance program for the roof. This work should be done based on the constant monitoring of the polyurea[5]-based waterproofing membrane, applied during the last roof recuperation work, through appropriate testing to in order check the performance and state of conservation of such membrane. Furthermore, all the construction interferences with the waterproofing system will be studied, such as tailpieces, domes and roof flashing installation system, protection against atmospheric discharges, dilatation joints, vertical piping for rainwater catchment, etc. Therefore, based on the analysis of the data and information obtained, conservation and preventive maintenance measures will be developed for the system.

The third task focuses on the investigation of the reinforced concrete blind s. It has the aim of understanding the composition of the concrete and its conservation state.

[5] The product used was ViaPolureia 600PP (pure polyurea), of Viapol.

Damages and the location of recently executed repairs were surveyed through laser scanning performed by the team of the Integrated Automatic Procedures for Restoration of Monuments (DIAPReM), of Ferrara University Department of Architecture, which allowed to identify 71% to 88% of the total repair area of the façades, being supplemented by an onsite visual and photograph analysis.

To determine the concrete composition and resistance, onsite tests were performed and samples (specimens) were analyzed in laboratory, with physical and mechanical tests being performed by the technicians of the Technological Research Institute (IPT). The goal of this step is to characterize the microstructure of the concrete, determining its composition, water absorption capacity, volume of voids, specific mass, resistance to compression, and elasticity module. Such tests were performed by sampling, to provide some comparison parameters. The full analysis of the concrete of the blind façades showed to be unfeasible because of the area – too large -, and because the concreting was done in several stages, which would require the removal of a large number of specimens; such tests are destructive and should be restricted to the indispensable minimum in a structure with historical interest, and besides they would interfere too much with the building image. Therefore, four specimens were removed, and provided us with the first understanding of the material. In future specific situations, it could be necessary to remove other specimens for further study.

Another goal of this work front is to appraise the current corrosion situation of the concrete steel structure, by means of the determination and monitoring of electrochemical variables. The results will guide future interventions targeting areas with a higher risk of concrete damage. The intention is thus to minimize intervention areas and to prevent the unnecessary loss of original material.

Those several analyses and studies will provide data that will support, in the future, the elaboration of a maintenance plan for the blind façades concrete surfaces. A deep knowledge of the concrete characteristics will also be important in defining a proper repair mortar, to be used when necessary. More appropriate methods to repair possible detachments of the concrete lining should also be studied, considering the characteristics of composition and also the image of the building.

Since the three tasks have, each of them, many specificities, the work method will be described for each of them in separate.

It is noteworthy that one of the intended results is to use the development of this GCP as a learning opportunity, both for undergraduate and graduate students, and also for those professionals working in the marketplace. It should also serve as reference for the development of other GCPs for cultural assets with similar characteristics in Brazil. The diffusion of such methodology among architects, conservationists, restorers, managers, etc., will be achieved by publishing articles in specialized periodicals, and presentations in scientific meetings, both national and international. Also, it is and will be a great opportunity to engage researchers interested in FAU´s building and in the conservation of the 20th century heritage.

The proposals herein submitted are compliant with the text “FAU Bem Cultural” (KÜHL et all, 2011), annexed to this proposal, part of the justification process of the Participatory Master Plan (PDP) for FAUUSP´s buildings (2011), approved by FAUUSP community – students, technical-administrative staff and teachers, also annexed to this work.

It is important to highlight that the proposals submitted in this work are not the full plan, but rather guidelines and a horizon for reflection. Any action in the body of the building should be studied with its specificities, and approved in the instances inside the School and outside it, such as the USP Physical Space Superintendence, and the public authorities responsible for the cultural heritage preservation by which the building is protected: Council of Defense of the Historical, Archeological, Artistic and Touristic Heritage (CONDEPHAAT), related to São Paulo State Government Department of Culture; and the Municipal Council of Historical, Cultural and Environmental Heritage Preservation of São Paulo City (CONPRESP), related to the Municipal Department of Culture.

There are two surrounding areas restricting the constructions near FAU´s building. One defined by the University itself, a 40-meter radius around the building, on which nothing can be built. The other, defined by the CONDEPHAAT, a 60-meter radius, which does not exclude new constructions within this perimeter, but indicates the need of designs taking into consideration the value of the existing building, and the need of CONDEPHAAT authorization for any intervention to be done in such space.

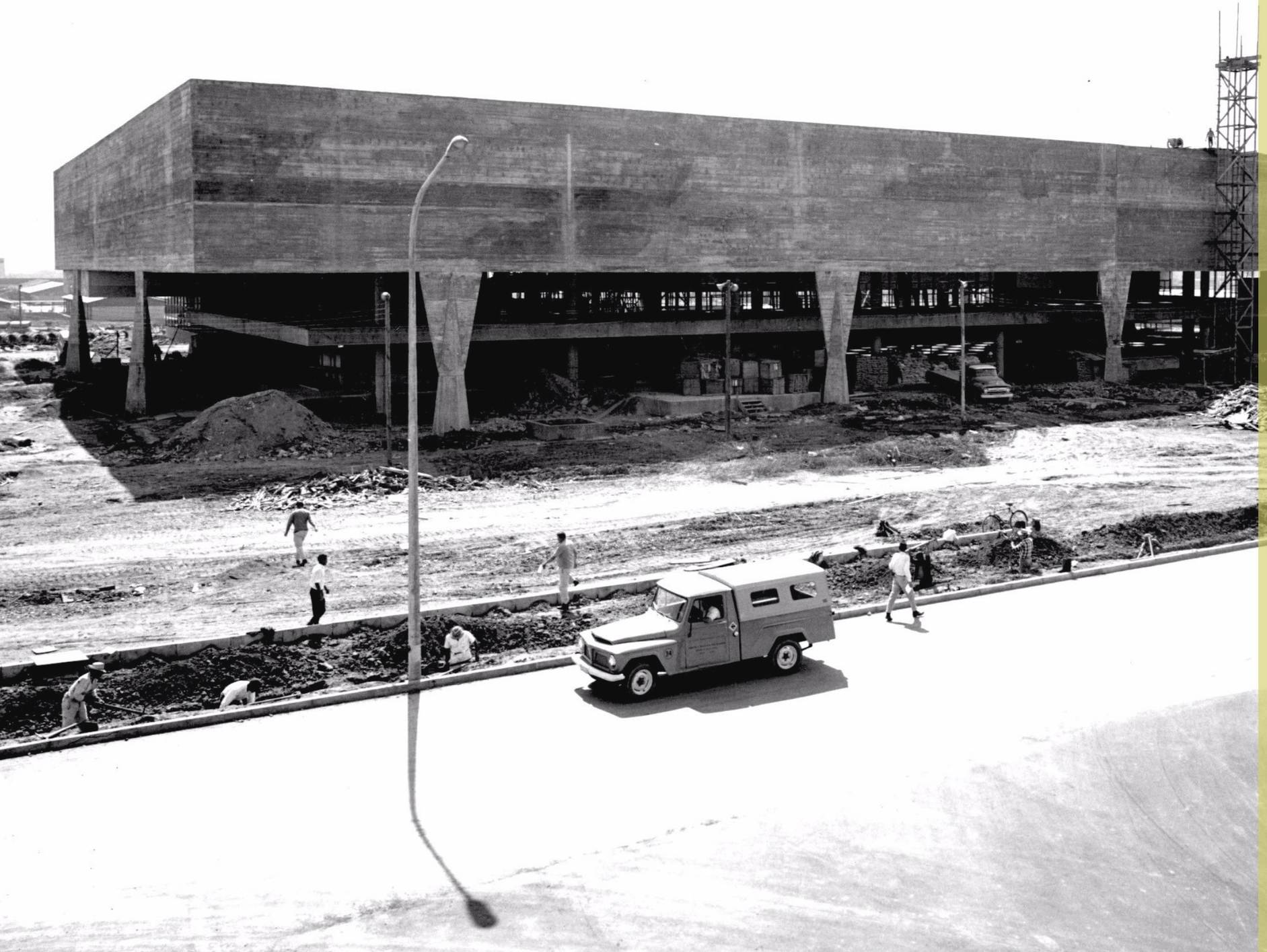
One of the acknowledged values of the building relates to the permeability and intrinsic relation between the indoors and the outdoors, without a precise limit between them. However, from the administrative viewpoint, the School manages the internal area (which is within the perimeter of concrete blind façades) and the Campus prefecture manages the external area, without a constant and structured dialogue between the two, which is a problem for the preservation of the building.

The plan has the main proposal of showing the need to promote the constant monitoring of the building, by means of management instruments, recommending interventions to be regularly done in a correlated fashion, with an adjusted continuous maintenance – with a proper well-determined periodicity for the several systems – and registration process that contribute not only for the systematic documentation, but which are effectively management instruments. In this regard, the problems causes are deeply examined to prevent works having just a palliative character, which only focuses on the effects.

The emphasis is on the tutelage, on the removal of hazards, on ensuring favorable conditions for the building fruition, on ensuring the best condition for the development of teaching activities, controlling the causes of deterioration, or slowing down or even eliminating the processes that cause the decadence, by means of structured, efficient, documented and continuous procedures. It essentially proposes a cultural change in dealing with the building: instead of disconnected emergency actions, the future way of acting will include an articulated design, monitoring and prevention.

VILANOVA ARTIGAS BUILDING

transformation, values and guidelines



Keeping It Modern Program
Getty Foundation
2017

Subsidies for a Conservation Management Plan

Vilanova Artigas Building (School of Architecture and Urbanism of the University of São Paulo - FAUUSP)

Keeping It Modern Program – Getty Foundation

2017

VILANOVA ARTIGAS BUILDING

transformations, values and guidelines

Coordination

Beatriz Mugayar Kühl

Silvio Oksman

Collaborator: Antonio Carlos Barossi

Adviser: Claudia S. R. De Carvalho

Team of Professionals

Renata Cima Campiotto

Ana Paula Arato Gonçalves

Luiza Nadallutti

Source: SEF-USP, author and date unknown.

SUMMARY

1. Tarefa 1 - Vilanova Artigas Building: transformations, values and guidelines

Beatriz Mugayar Kühl, Silvio Oksman, Renata Campiotto, Luiza Nadalutti, Antonio Carlos Barossi

Introduction 23

Presentation of FAU's Building 23

Timeline: main events 24

Meaning (Statement of Significance) 27

Main vulnerabilities 27

1.1. Description of the building´s characteristics 29

Overview 31

1. Context 32

2. Climate 32

3. Applicable legislation 32

4. Site plan and surroundings 32

5. Foundations and structure 32

6. Roof 33

7. Walls and partition walls 34

8. Frames: inside and outside 35

9. Internal lining: floor, wall and ceiling 36

10. External lining 36

11. Finishing: sanitary ware, metal hardware, lamps 36

12. Building infrastructure 37

13. Landscaping 39

14. Furniture 40

15. Library collection 40

Assumptions to any intervention 41

Guidelines 41

1.2. Spaces of the building and distribution of functions over time 43

Uses of the building 45

Timeline: four moments 48

State in the inauguration 50

State in 1983 51

State in 1998 52

State in 2016 53

Chronology of interventions 54

1.3. Cadastral survey 57

About the cadastral survey 59
Site plan 60
Floors -3.00 and -1.10 61
Floors +0.80 and +2.70 62
Floors +4.60 and +6.50 63
Floors +8.40 and +10.30 64
Roof 65
A-A and B-B cross sections 66
C-C and D-D cross sections 67
Southwest and Northeast Façades 68
Northwest and Southeast Façades 69

1.4. Analyses and Guidelines 71

Characterization of the building 73
At elevation -3.00 76
At elevation -1.10 78
At elevation +0.80 80
At elevation +2.70 82
At elevation +4.60 84
At elevation +6.50 86
At elevation +8.40 88
At elevation +10.30 90
Circulation system, accessibility 92
Systems and infrastructure: electrical, illumination, wi-fi 93
Visual interventions and *graffiti* 94
In the outside the building 102
Other systems to be developed in future actions 105

References 107

Documental Corpus 111

Table - Projects 115
Table - Photos 115
Table - Administrative processes 116
Table - Arboreal survey 116
Descriptive sheets of interventions (Ana Paula Arato Gonçalves) 116
Report - Chronology of interventions (Ana Paula Arato Gonçalves, Renata Cima Campiotto) 117
Report - Integrated Diagnostic Survey Methodology (DIAPReM, University of Ferrara) 117
FAUUSP Participative Master Plan 2011-2018 117

Photo: Public Archive of São Paulo State - Public Memory, 1969.

1.

TASK 1

Introduction

This task has the aim of documenting and analyzing, in an articulated fashion, the transformations of the building, of its use, perception of its spatiality over the time, with the goal of evidencing the qualities and meanings of the building. Thus, it is possible to propose guidelines that respect its material, spatial and conformation characteristics. It also proposes developments for future actions, presenting guidelines for the use and occupation of spaces, but also parameters for a necessary review of installations (electrical, air conditioning, etc.), always with the intention to allow the best possible occupation compatible with preservation. A rationalization is necessary aiming at a higher efficiency of those systems, and also the safety of the building, both of its assets and of its users. Furthermore, such systems have to be inserted according to the physical characteristics of the building, and in a proper way regarding their distribution.

To achieve its goals, the task starts with the description of the building, to then presenting the statement of the meaning and main vulnerabilities. Then, the spaces and their transformations over the time are analyzed, examining the current situation, and proposing guidelines for possible future occupations. Subsequently, future developments for the plan are presented, encompassing other systems of the building not comprised in this project.

At last, an annex is enclosed with the documental corpus containing a table with the main transformations performed in the building, about which there is documentation, showing date, subject and the collection to which the pertinent document belongs. Furthermore, when data was sufficient, such transformations were redrawn in AutoCAD, highlighting their location and characteristics in technical drawings. Such floor plans will also be annexed. In the body of the text, synthetic and analytic documents evidencing such transformations will be presented.

In which concerns the method, the work was essentially developed based on:

• Documental research, examination of textual documents and drawings regarding FAU, its construction and transformation, in various collections of the University;

• Iconographic research, especially the images of the FAUUSP´s collection, covering a great series of photos of the construction period, also enriched with images provided by teachers and students throughout time; private collections were also used, since many students, former students and others interested in general have sent photos for the Work Group to supplement the documentation;

• Bibliographic research, encompassing the books on the production by Vilanova Artigas, about modernism in Brazil and São Paulo, monographic works about FAU, in addition to theses and dissertations on these topics;

• Field work, with detailed registration of the current state of the building.

Based on the articulated examination of those varied sources and indications offered by the PDP, in which concerns the quality of spaces and occupation manners, analyses were performed, and the main characteristics of those spaces were pointed out – by means of textual descriptions, plans and schemes, which showed to be very useful instruments of reasoning, discussion and consolidation of results – and guidelines were proposed. The process as a whole resulted in general assumptions and guidelines for the building, and in specific ones for each floor, for the external areas, and for the circulation, accessibility and illumination systems, in addition to bases to tackle the issue of *graffiti*.

Presentation of FAU's Building: Statement of Significance. Description of the building characteristics.

The descriptions presented as follows were based on several works[6], especially on the writings by Antonio Carlos Barossi. Such comprehensive works served as subsidies for the analyses. The statement of meaning was elaborated by Task 1 team.

São Paulo University School of Architecture and Urbanism was created in 1948, when the architecture course became independent from the engineering course, offered by the Polytechnical School. The Polytechnical school was founded in 1893, being subsequently incorporated to the University of São Paulo, created in 1934. During the 1960s, the construction of new buildings to shelter the various schools was intensified in the campus, which construction started in the 1940s, in the western part of São Paulo city. The proposal of the Campus was to gather the several schools of the University, then spread over the city, into a single place. It was under such circumstances that the design for the new headquarter of the School of Architecture started, through the commission of architects João Batista Vilanova Artigas (1915-1985) and Carlos Cascaldi (1918-2010)[7];

Parallel to his professional work, João Batista Vilanova Artigas also dedicated his life to architecture teaching. In 1940, he became a professor at the Polytechnical School, where he graduated from, a position maintained until 1956. When the School of Architecture was founded in 1948, Artigas became part of the teaching staff, and started to intensively taking part of the multiple activities of the school organization.

Such experiences culminated with his major repercussion design: the building of São Paulo University School of Architecture and Urbanism – FAUUSP. The building is a proof of maturity of a unique language developed by Artigas, characterized by the focus on constructive elements and on monumentality, with a minimum, but extremely expressive, vocabulary. Such characteristics had a quick repercussion among the architects of São Paulo, also affecting the national architectonic world.

It is noteworthy that Artigas developed the design of FAUUSP´s building based on the architecture teaching restructuring, known as the 1962 Reform, formulated by Artigas himself. One of the main aspects of the result of such work is the importance of the studio as learning and discussion space, and the didactic and administrative organization into three departments: Design, History and Technology.

This curriculum was materialized by Artigas and Cascaldi in the architecture of FAUUSP, in which different floors are associated to the administrative and curricular structure. The building main feature is a major reinforced concrete roof, composed of a structural grid topped by translucent domes, which allows a great incidence of natural light inside the building. The roof is supported, from the inside, by columns, and delimited, in the outside perimeter, by blind façades supported by pillars. For the whole structure, exposed reinforced concrete was used, with different types of molds that can be identified on a case basis. This major roof configures a peristyle around the whole building. Functions are developed in the building in half-levels, articulated by ramps and staircases, around the large central space, the Caramel Hall.

[6] Description done based on the works: BAROSSI, Antonio Carlos. "O edifício da FAU-USP de Vilanova Artigas", Coleção Obras Fundamentais. São Paulo: Editora da Cidade, 2016; CONTIER, Felipe de Araújo. "O edifício da Faculdade de Arquitetura e Urbanismo na Cidade Universitária: projeto e construção da Escola de Vilanova Artigas", Tese (Doutorado) – IAU-USP, São Carlos, 2015; GIANNECCHINI, Ana Clara, "Técnica e estética no concreto armado: um estudo sobre edifícios do MASP e da FAUUSP", Dissertação (Mestrado) – FAU-USP, São Paulo, 2009; OKSMAN, Silvio. "Preservação do patrimônio arquitetônico moderno: a FAU de Vilanova Artigas". Dissertação (Mestrado) – FAU-USP, São Paulo, 2011, associated to the documental research done at the Superintendence of Physical Spaces of São Paulo University (SEF-USP) and at USP School of Architecture and Urbanism library, and analyses and registration done onsite.

[7] For more about the topic, check CAMARGO, Monica Junqueira de "Inventário dos bens culturais relativos ao Plano de Ação do Governo Carvalho Pinto (1959-1963)", Revista CPC nº21, 1st semester of 2016. Avaliable at <http://www.revistas.usp.br/cpc/article/view/111965> e CPCUSP. "Cidades Universitárias: patrimônio urbanístico e arquitetônico da USP". São Paulo, Edusp, 2005.

1950

1960

1970

Foudation of FAUUSP
(1948)

Curricular reform: creation of the departments of History, Design and Technology (1962)

Foundation of the Graduate Course (1972)

Education Forum
(1968)

Education Forum
(1976)

Inauguration of the University Campus Armando Salles Oliveira
(1968)

Installation of FAUUSP at Vila Penteado
(1950)

Transference of the undergraduate course of Architecture and Urbanism to the Vilanova Artigas Building
(1969)

Revocation of the rights from professors Vilanova Artigas, Paulo Mendes da Rocha and Jon Maitrejean
(1969)

Vila Penteado (residence)

Vila Penteado (teaching institution)

Construction of the Vilanova Artigas Building (1966-1969)

Jean Tschumi Award received by architect Vilanova Artigas, for this contribution to the architecture teaching with the project for FAU (1972)

Directors

Luiz Ignácio de Anhaia Melo
(1948-1951)

Bruno Simões Magro
(1951-1952)

Luiz Ignágio de Anhaia Melo
(1959-1961)

Ariosto Mila
(1968-1972)

Luiz Cintra do Prado
(1953-1954)

Lourival Gomes Machado
(1961-1964)

Nestor Goulart Reis Filho
(1972-1976)

Lysandro Melo Pereira da Silva
(1954-1956)

Pedro Moacyr de Amaral Cruz
(1965-1968)

Lúcio Grinover
(1976-1980)

Pedro Bento José Gravina
(1956-1959)

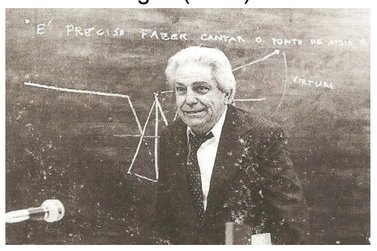
1980

Creation of the Doctorate course (1980)

Protection of the Vilanova Artigas Building as a heritage by CONDEPHAAT (1982)

Return of the professors whose rights were revoked in 1969 (1980)

Contest for full professor of Vilanova Artigas (1984)



Ariosto Mila
(1980-1982)

Lúcio Grinover
(1982-1986)

Ualfrido del Carlo
(1986-1990)

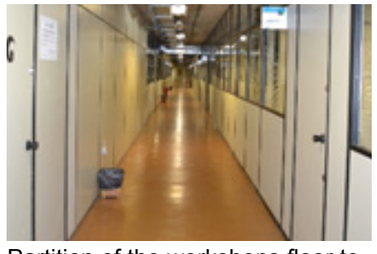
1990

Contest for the Annexed Building (1989)

Protection of the Vilanova Artigas Building as a heritage by CONPRESP (1991)

Renovation of FAUUSP Library (1998)

(1990) LabNav: Laboratory of Ship Design and Technology
(1992) Infurb: Nucleus of Urban Information Research
(1993) LabArq: Laboratory of Collection Digitalization
(1994) NUTAU: Nucleus of Architecture and Technology Research of USP
(1995) LabFAU: Laboratory of Fundaments of Architecture and Urbanism
(1996) LabHab: Laboratory of Housing and Human Settlements
(1998) LABIM: Laboratory of Image and Sound
(1999) LABAUT: Laboratory of Environmental Comfort and Energy Efficiency
(1999) LUME: Laboratory of the Metropolis Urbanism



Partition of the workshops floor to shelter the laboratories

Gilda Collet Bruna
(1990-1994)

Julio Roberto Katinsky
(1994-1998)

Maria Ruth Amaral de Sampaio
(1998-2002)

2000

Start of the Design course (2006)

Transference of the workshops in the main building to the Annex (1997)

Renovation of FAU Maranhão Library (2002)

(2000) LABCOM: Laboratory of Commerce and City

Prohibition of Studio 3 use due to the structural conditions of the roof (2007)

Ricardo Toledo da Silva
(2002-2006)

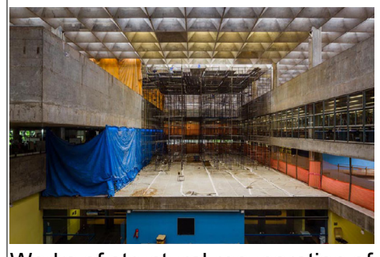
Silvio Sawaya
(2006-2010)

2010

Elaboration of the Master Plan by the Pedagogical Council (2010)

Renovation of the garden, new access staircase and renovation of the direction room (2009)

Construction of departments new areas (2009)



Works of structural recuperation of the roof and blind façades of Vilanova Artigas Building (2013-2015)

Perception of the domes of Caramel Hall after the completion of the works in the Roof (2015)

Start of the elaboration project for the Plan of Conservation Management of Vilanova Artigas Building (2015)

Marcelo Romero
(2010-2014)

Maria Angela Faggin Leite
(2014-current)

MEANING (Statement of Significance)

The building is culturally significant for:

1. Having an exceptional quality from the artistic and form-function relationship points of view;

2. Being on the of the capital works of one of the most important architects of São Paulo and Brazil;

3. For the characteristics of the program development in the space: the proposal is radically innovative in which concerns the teaching program, strictly related to the spatial configuration. The space is characterized by fluidity, by the generosity of free areas, and for allowing the immediate perception of the distribution of functions;

4. For the constructive expressivity that explores the reinforced concrete plasticity as never seen before in the panorama of the Brazilian architecture at that time;

5. For the absence of limits between the external and internal areas, which articulate in an organic and fluid fashion;

6. For the relation of the building, raised in relation to the external floor elevation, with the outside, allowing different ways of apprehension;

7. For the role of landmark in the University City, both from the viewpoint of the architectonic importance and because of its presence in the landscape.

MAIN VULNERABILITIES

1. The performance of the building protection system in relation to the weather: roof (task 2) and blind façades (task 3);

2. The unplanned expansion of activities performed in the building: the number of users increased, as well as the teaching support structures, the academic-administrative and research activities became more complex, the bibliographic and documental collection also increased, requiring more areas;

3. The excessive subdivision of certain spaces, and the occupation of formerly free areas;

4. The lack of a complete design for those transformations: they are frequently performed in an individual and short-sighted way, not taking into consideration the building characteristics as a whole;

5. Accessibility and safety/security related problems, both regarding the assets and the users.

6. The delay in meeting new teaching demands, both from the didactical and technological viewpoints (informatics, 3D printing, etc.); the pedagogical plan is periodically reviewed, and should effectively and respectfully dialogue with the architecture of the building;

7. Management-related problems, concomitantly affecting several instances of decision, many times without the necessary articulation between them, overlapping competences and resulting in the lack of agility[8].

[8] For example, the competence of the School, the Campus Prefecture, the Central University Administration; the protection as cultural heritage in two spheres – State and Municipality – for which there is not necessarily an alignment between the attitudes of such agencies.

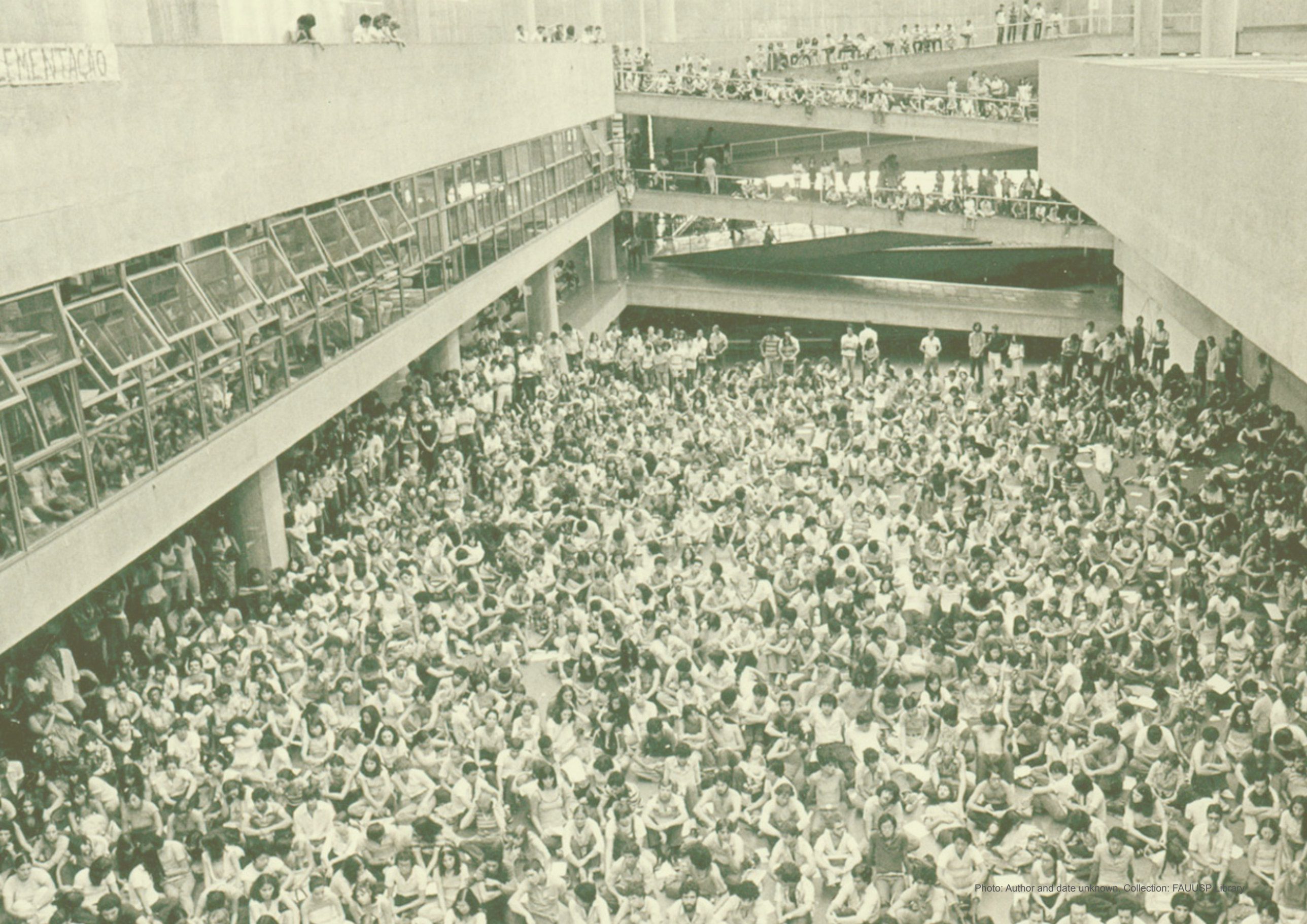


Photo: Author and date unknown. Collection: FAUUSP Library

1.1.

DESCRIPTION OF THE BUILDING CHARACTERISTICS

Overview

The ground floor (elevation +0.80 = elevation 725.8 asl) is the reception, welcome and interaction level. It is organized based on a vast open rectangular space, the so-called Caramel Hall (due to the flooring color), forming a covered square appropriate for big encounters, meetings, exhibitions, assemblies and ceremonies. In this floor, there are the top management and administration rooms. From that space, it is possible to visualize and comprehend the building as a whole. The upper levels are organized around this central space. Floors are positioned in half-levels and interconnected by a set of ramps located to the Northwest of the open central area, and by a set of staircases and an elevator stopping in alternate floors on the opposite side of the Caramel Hall.

The floor half-level below the access elevation (elevation -1.10), semi-buried, in the first phase of the building occupation, housed the workshops (woodworking, metalwork, print shop, etc.). It is currently occupied by the research laboratories, which have good natural light due to the existence of windows opening to the green area surrounding the building.

One level below (elevation -3.00) the access elevation, under the Caramel Hall, there is the Auditorium. Its foyer, popularly called the “moat”, is open, being the only place from where all the building floors can be seen.

The first floor above the access (elevation +2.70) shelters the cafeteria and an open space for the activities promoted by the students, in the so-called Museum, in addition to having the headquarter of the students union, a paper shop and a book shop.

The library is located half a level above (elevation +4.60), and part of the academic administration is located in this same floor.

Going up a stretch of ramp (elevation +6.50), we find the departments, with teachers´ rooms and the Interdepartmental Atelier (IA), an open space for varied academic activities. This is the last level with windows to the outside.

The seventh level is where the 5 studios (elevation +8.40) are located, each for each year of the undergraduate course. Those spaces are under the major roof, and they are divided by low concrete walls (1.90m), allowing the whole visualization of the space.

The last level (elevation +10.30) is occupied with classrooms. Since the last two levels are surrounded by blind façades, the natural light comes from the roof, through the translucent domes, supported on the concrete grid configuring the roof.

Considering that all the floors have a spatial relation with the Caramel Hall, and are clearly interconnected, the building can be fully understood by an observer standing on any point of the building. The building program is clearly reflected in its architecture, composed of a rich and complex suite of volumes. Although, at first, the form enigmatically manifests itself from the outside, when entering the building, there is a feeling of surprise, followed by a sensation of hospitality, despite the rusticity of materials and straight angles of the volumes. The ramps can be read as a continuation of the outside, inviting the user to explore the space in an “architectural promenade”. The spatial continuity is one of the most outstanding guiding principles of this design: internal spaces are continuous, offering multiple ways to circulate among them. In addition, the circulation areas are very generous, as well as the main spaces, eliminating the feeling of corridors or circuits with a single arrival point; it is always possible to continue circulating throughout the building without an “end of the line”.

In FAUUSP’s building, the collective spirit search ford by the architect is expressed by the major roof, providing natural light and shelter for all the activities, and by the articulation and integration of such activities from the central space. The harmonic proportions, the shapes of the blind façade-supporting pillars, and the ingenious structural solutions adopted are other remarkable features of the building.

At last, but not the least, we should remember the main character of the building in which concerns the construction materials: the exposed reinforced concrete. This material showed to be entirely appropriate for this scale of use, not only from the economic point of view, but also in its structural function. The material provides the building with a distinctive texture, which is reinforced by all the prints of wooden moulds that were left in its surfaces. Used in different ways according to the situation, the façade was concreted into wooden board moulds, granting rusticity to the building image. The slabs were concreted into plywood moulds, providing it with a smooth look.

For the innovative use of concrete both from the structural and formal viewpoints, this material is also one of the main challenges for the conservation of the building.

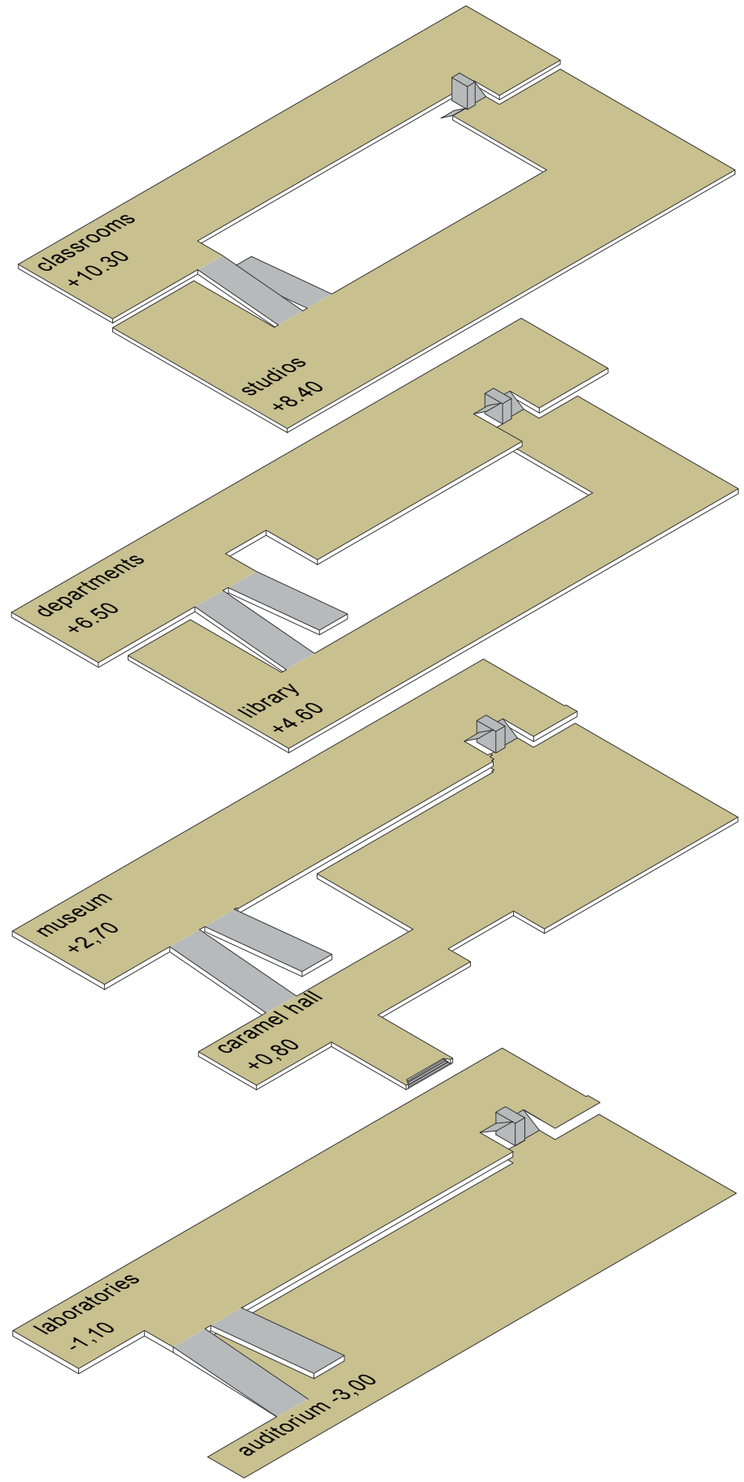


Figure 12 – Identification of floors and elevations of the site plan.

1. Context

The building is located at Rua do Lago, 876, inside the University Campus Armando Salles de Oliveira, in the district of Butantã, city of São Paulo. Exactly for being located inside the University City, which design circumstances do not define occupation lots, the building site plan was not based on metrical limits as in an urban lot.

2. Climate

The geographic coordinates of the building site are 23°33'S of latitude and 46°43'W of longitude. In relation to the climatic data of the region, the weather of São Paulo city is regarded as humid subtropical of the Cfa type, according to Köppen-Geiger climatic classification. The average rainfall recorded in 2015 in the observatory of the Institute of Astronomy, Geophysics, and Atmospheric Sciences (IAG-USP) was 151.61mm. The other information regarding temperature averages and rainfall averages is shown in the following graph and table (Figure 14).

3. Applicable legislation

The Vilanova Artigas building is protected by CONDEPHAAT (Council of Defense of the Historical, Archeological, Artistic and Touristic Heritage of São Paulo State) through the proceeding no. 21736/81. It is also protected, ex-officio, by CONPRESP (Municipal Council of Preservation of the Historical, Cultural and Environmental Heritage of the City of São Paulo) through Resolution No. 05/CONPRESP/91. Therefore, every work or intervention to be done in the building should be authorized by the advisory boards of both agencies. Such regulations do not prevent the occurrence of alterations or improvements, but requires their previous approval, in order not to interfere with the values through which that heritage is known – and so that it is transmitted in the best way possible to the future.

For being located in the University Campus Armando de Salles Oliveira, the building is governed by the campus Master Plan, elaborated in 2013. This document defines the construction and ordering parameters of the university campus spaces, which are compliant with the norms defined by the preservation agencies.

4. Site plan and surroundings

The building was located at the elevation NMM 725.0, three meters above the original land level. Surveys have revealed that this previous elevation (722.0) was obtained through landfill, and that soon below it, the first layer of the land soil is the original one, constituted of 3 to 5 meters of peat, which proves that FAU is located where it used to be the lowest part of Pinheiros river dale, which in that stretch is at the elevation 724.0 asl, despite the proximity to the Biology hill. The groundwater level in the survey month, July 1961, was between 718.0 and 719.0, almost the same level of the original dale at that place.

5. Foundation and structure

Considering the soil conditions, two techniques were used for the foundations: drilled shafts, for the main loads of the floor-supporting pillars, and precast concrete piles, for the secondary loads of the infrastructure and of the structured underground floor. Both drilled shafts and piles were specified with 16 meters of depth in relation to the site elevation (725.0), in order to reach the compact clayey sand layer. There is no load intermediation block between the drilled shaft and the pillar, which work as a single structural piece.

The reinforced concrete structure defines the building as a whole. The exposed finishing resulting from the print of moulds used differentiates the elements according to the expression intended for each situation. In general, it is smooth when the moulds are made of plywood, such as in the internal spaces (ceiling slabs, edge beams, floor pillars, internal face of external pillars, and blind façades). It is also smooth in the pyramid shape portion of the external pillars, in order to differentiate them from the part coinciding with the plan of blind façades supported by them. On the external face of blind façades and in the internal pillars going up to the roof, the concrete has the marks of boards and laths.

The concrete structure in the floors is constituted of a system of unidirectional beams. In addition to the 7-cm thick slabs directly supporting the overload, this system has two types of beams hierarchically distinct in relation to the loads: in the transversal direction, the secondary beams or ribs, and in the longitudinal direction, the main beams. The secondary beams only receive the load from the slabs right on them, transferring it to the main beams that support such slabs, which, in turn, transfer the load directly to the pillars (Figure 16). The system is also comprised of the following elements: distribution and locking beams, edge beams, and ceiling slabs under the beams.

The façade blind façades are big beams vertically stiffened by ribs at each 5.5m, which concordant angles made them practically imperceptible (Figures 17 and 18). The longitudinal blind façades, of the Northeast and Southwest façades, correspond to the main beams, over which the secondary beams of the transversal blind façades (Northwest and Southeast) are supported.

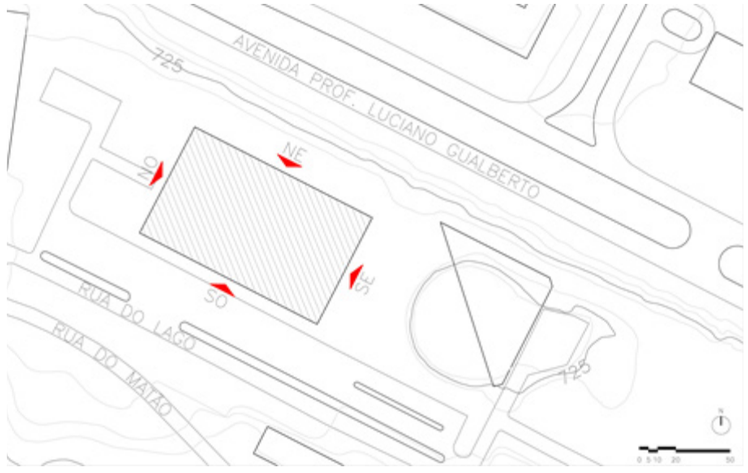
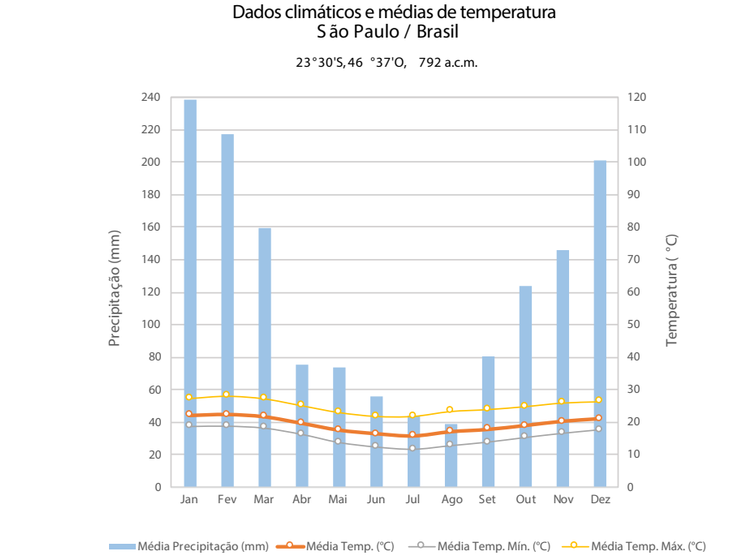


Figure 13 – Building site and identification of façades (Southwest, Southeast, Northeast and Northwest).



Dados climáticos

Médias:	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez		Anual
Precipitação (mm)	238.7	217.4	159.8	75.8	73.6	55.7	44.1	38.9	80.5	123.6	145.8	200.9	Σ	1454.8
Temperatura (°C)	22.1	22.4	21.7	19.7	17.6	16.5	15.8	17.1	17.8	19.0	20.3	21.1	Ø	19.3
Temp. mínima (°C)	18.7	18.8	18.2	16.3	13.8	12.4	11.7	12.8	13.9	15.3	16.6	17.7	Ø	15.5
Temp. máxima (°C)	27.3	28.0	27.2	25.1	23.0	21.8	21.8	23.3	23.9	24.8	25.9	26.3	Ø	24.9

Figure 14 – Weather data and temperature averages in the city of São Paulo. Source: National Institute of Meteorology (climatological normal 1961-1990).

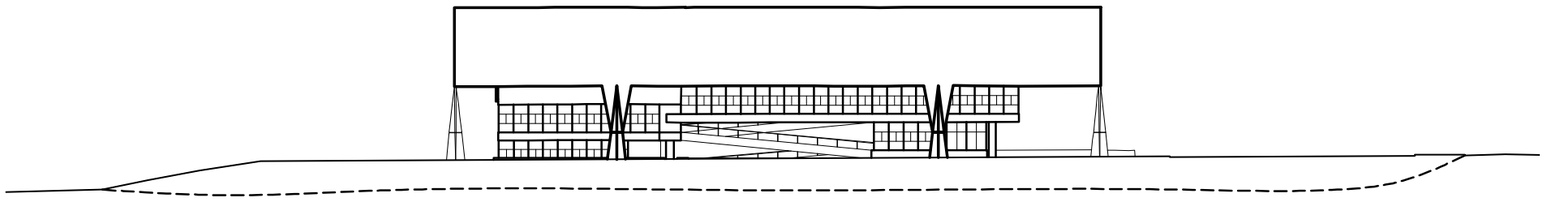


Figure 15 – Building site cross-section on landfill area (original land in hatching).

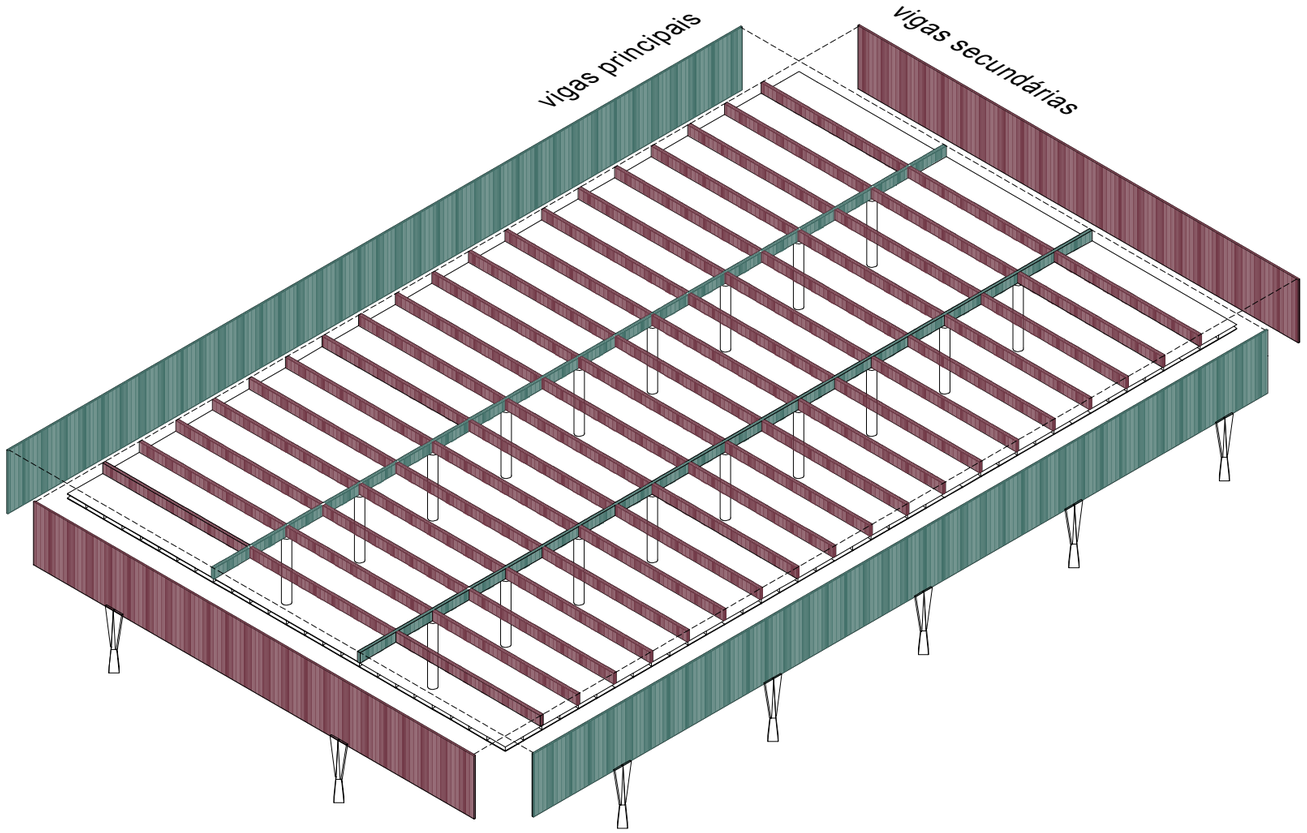


Figure 16 – Scheme of the roof beams and blind façades system. Identification of primary beams (green) and secondary beams (red).

Figures 17 and 18 – Stiffening ribs of the primary blind façades-beams in Studios 2, 3 and 4. To the right, detail of the ribs that coincide with the dilatation joint of the building. Photo: Luiza Nadalutti, March, 2017. Collection: Conserva FAU Team.

The pillars follow a modulation of 11m. The modulation axes of the transversal beams of the floors do not coincide with the pillars, so that they are always between the beams axes. Therefore, the ribs do not coincide with the pillars where the vertical hydraulic piping passes through, especially the rainwater piping, which descends though all the pillars of the central longitudinal axes (Figure 19).

6. Roof

The roof is composed of a concrete grid configuring a single plan, 110 m x 66 m, covering the whole building. Structurally, the roof is composed of the 8-cm thick slab formed by the encounter of the horizontal upper surface of the crossed beams with triangular section with the base up. Those beams lay on the main system of longitudinal and transversal beams. Although continuous, the slab is formed by the crossing of the upper faces of such triangular beams, in a rhythm of 2.75m in both directions, resulting in a mesh of voids through which the natural light comes in (Figure 20). The beams of the roof´s main structural system make up modules of 22m, between the longitudinal beams, versus 5.5m, between the transversal beams. Each of those modules defines a rainfall catchment sector, with design gradient of 0.5% toward the corner that is on the central pillars through which the pipes descend. During the construction, less vertical pipes than planned were executed, which resulted in a low discharge of rainfall. Furthermore, the structure bending largely jeopardizes the roof water drainage. In the system recuperation work, in 2013, the vertical piping was expanded to allow the necessary discharge for the water runoff. Such intervention mitigated the problems of the roof, but did not solve the issue of puddling in some parts, because the gradient problem still persists.

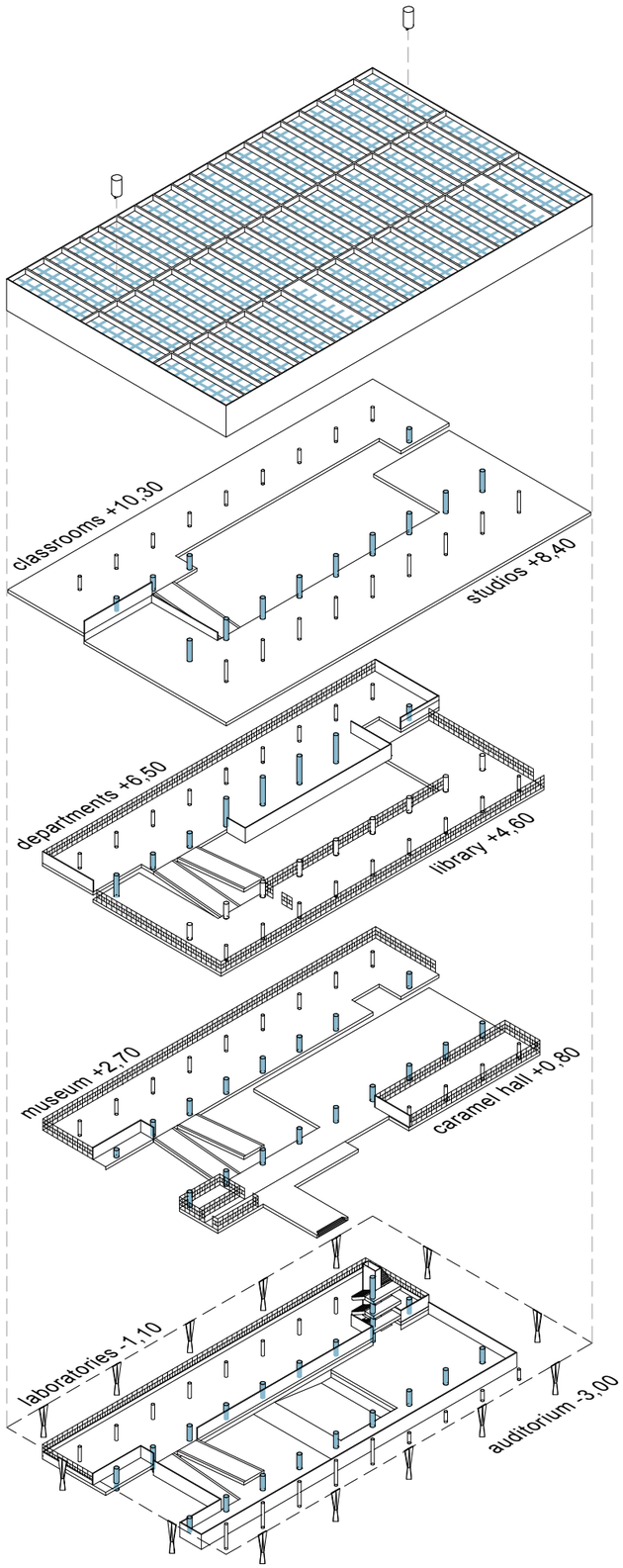


Figure 19 – Collection of rainwater in the roof, and distribution of pipelines through the central pillars of the building, in blue.

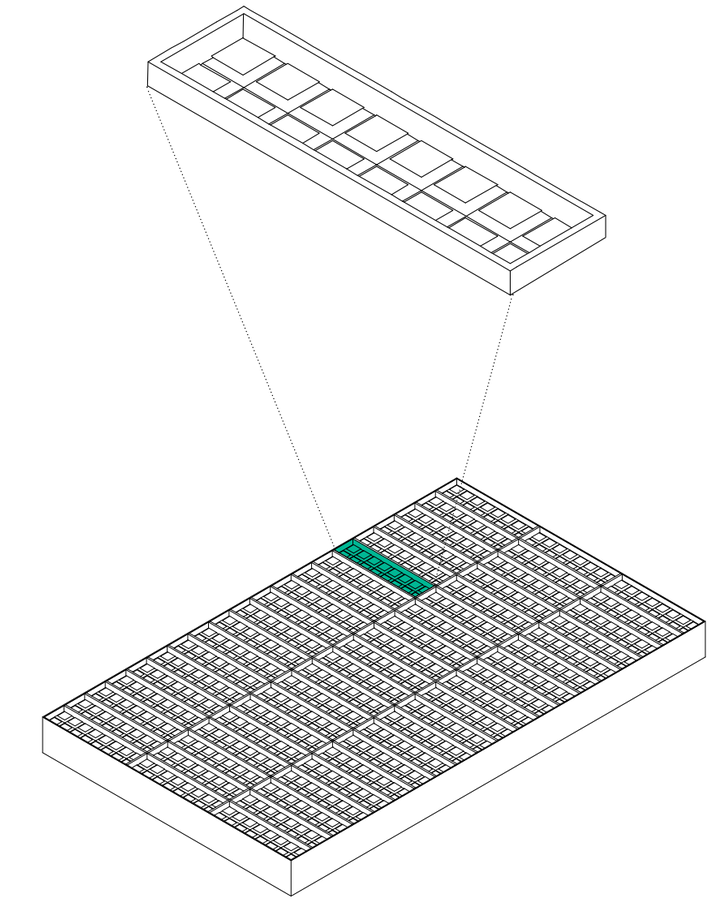


Figure 20 – Roof and blind façades of the building. Above, detail of one of the roof modules.

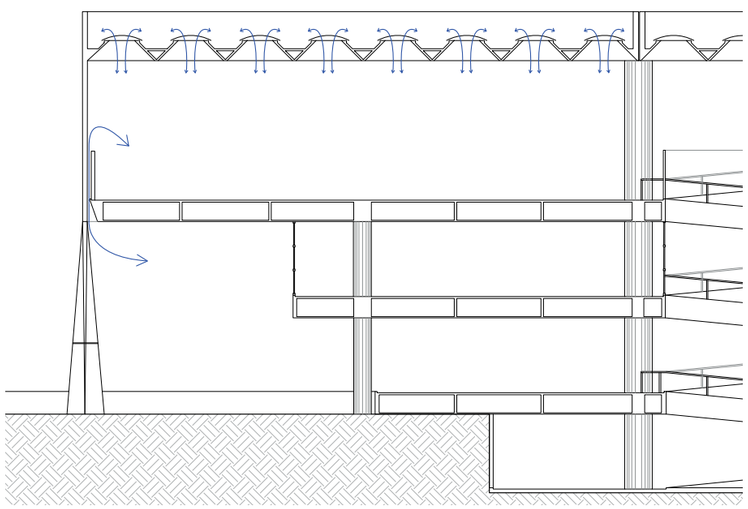


Figure 21 – Schematic cross-section of the natural ventilation system of the building, through the roof domes and the openings next to the blind façades of studios and classrooms.

Originally, the waterproofing system adopted was composed of alternate elastomer layers (commercially called Neoprene and Hypalon), applied to the smoothed slab and over all the exposed surface of the beams. Over the time, some waterproofing works were done over the old systems, already jeopardized. There was a significant overlapping of blankets and smoothing mortars, and therefore an increased load on the roof. Currently, the waterproofing system used is made of pure polyurea membrane, an elastomer applied with heat, which physical-mechanical properties do not require the use of protection mortar. For this application, the previous waterproofing layers were all removed, relieving the accidental load of the roof.

The closing of zenithal openings, with the domes, was designed as self-supporting vaults made of fiberglass-reinforced translucent resin, directly fixed into the concrete. In addition to illumination, they are a permanent ventilation element to the building, since they were fixed to allow air passing openings: they allow the circulation of the air coming in through the open ground floor, mainly in the most central areas of the building, jointly operating with the openings in the floors of the studios and classrooms along the east and west blind façades, for the circulation of air in the perimeter areas (Figure 21). They also ensure the exit of the air through the chimney effect of the toilet ventilation ducts, which entrance is located in the peristyle.

In the 2013 renovation works, the domes installed during the building construction, made of fiberglass, were replaced by acrylic pieces with aluminum structure protecting their edges, in addition to a screen ‘hemline’, which hinders the entrance of rainwater dripping from the slab into the building.

7. Walls and partition walls

The cellular concrete block masonry lined with PVA paint on the outward face, and with melamine laminate on the internal areas (in the case of toilets and scullery) define the two hydraulic volumes of the building, located in each of the longitudinal ends (Figure 22). The low partition walls located in the studios (elevation +8.40) and in the Museum floor (elevation +2.70) are self-supporting and anchored to the floor structure, made of exposed concrete or concrete lined with melamine laminate or plywood.

The light partition walls internally divide sectors that have external limits clearly defined by the circulation inside the building, and which environments are variable according to the circumstances. They are of several types: drywall, plywood lined with melamine laminate and aluminum structure, glass and cement plates. They

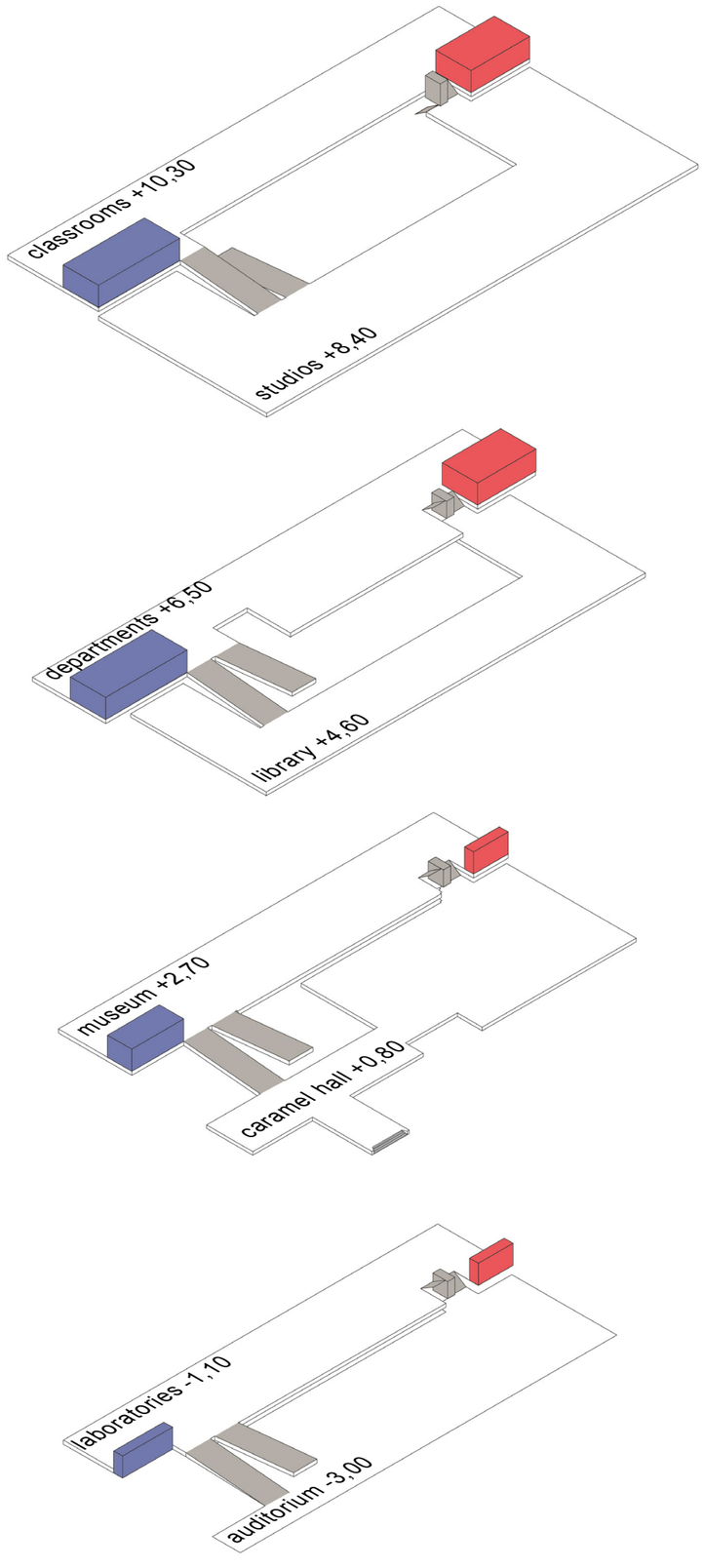


Figure 22 – Location of the two main hydraulic blocks of the building.

are in the laboratories (-1.10), administration (+0.80), library and academic administration (+4.60), departments (+6.50), and in the classrooms (+10.30).

In the toilets, the internal partition walls of the cabins are made of precast plates of exposed reinforced concrete.

The masonry walls in the building are protected with PVA paint applied on the plaster, or with melamine laminate glued onto the cement and sand mortar.

8. Frames: inside and outside

The glass and bent steel plate frames, galvanized and painted, manufactured by the Brazilian Company Fichet & Schwartz Hautmont, are the main closing components of the building environments. Except for the laboratories floor, where there is a windowsill for it being a semi-buried floor, the frames span from the floor to the ceiling, with modulation close to 1.50m between the mountings, serving as element of fixation to the structure, with no upper and lower jambs. They form sets of environments that constitute architectonic units inside the building. There is a portion where those frames were replicated in wood, resulting from the intervention done in the 1970s, with the expansion of the administrative area at elevation +0.80. They have the same dimensions and follow the same modulation, in a low cost copy attempt.

Those frames, when used as windows, have two horizontal divisions forming three frameworks of equal dimensions: the lower one corresponding to the windowsill and the two upper ones compose a double Maxim-Air system of simultaneous and inverted opening, where one counterweights the other through common lateral lever shafts with the axis articulated in the upper third of the mounting. Therefore, the windows open through their own counterweight system (Figures 23, 24 and 25). The vertical division of the central module in the middle of the frame embeds the opening latch, with no need of handles or other external parts. In case of environments where the opening does not span from the floor to the ceiling, the windowsill is the support, and there are only two upper leaves, with the same opening system previously described.

In the doors following this same pattern, the two lower modules form the openings, and the vertical division of the central module corresponds to two leaves (Figure 26).

The other doors are made of wooden leaf lined with melamine laminate, such as in the classrooms and laboratories, or are made of glass, such as in the administration areas (which underwent intervention between 2007 and 2010) or of the main auditorium access, renewed in 1983.

Figures 23, 24 and 25 – Opening system of the glass and folded steel plate frames of the Museum Floor. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.

Figure 26 – Modular glass and folded steel plate frames in the Caramel Hall. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team..

9. Internal lining: floor, wall and ceiling

The predominant flooring of the building is the yellow-caramel epoxy resin (Figure 27). The resin is applied on a 5 cm-thick smoothing mortar, finished on the floor edges by a salience in the concrete structure with the same dimension. In the ramps, rubber plates with anti-slip solution are applied (Figure 28). They are 50cm x 50cm plates, transversally grooved to the flow, and fixed with mortar to the subflooring. At last, applied to the building entrance platform and to the auditorium lobby, there is a Portuguese mosaic flooring (Figure 29). Built with irregular stones of varied colors, beige sandstone was used as the background, and black basalt in the drawing of an organic motif, but with defined geometry, articulating in itself and repeated in different ways.

At elevation +0.00, the flooring is made of precast concrete plates on the sidewalks around the building (Figure 30). Those plates follow the pattern defined by the University Campus Prefecture, measuring 30cm x 65cm, laid in a modulation of 35cm x 70cm. The frontal access esplanade, composed of the square where the “little lake” and the school parking lot are located, is lined with asphalt (Figure 31).

Figures 27, 28 and 29 – Types of flooring in the building: epoxy resin, rubber plates and Portuguese stone mosaic. Photos: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.

Figures 30 and 31 – Types of flooring of the building external areas: precast concrete plates and asphalt. Photos: Luiza Nadalutti, March 2017; Letícia Chaves, August 2016. Collection: Conserva FAU Team.

10. External lining

Externally, the building is composed of its exposed reinforced concrete structure, protected with water repellent, applied during the recuperation work of 2013-2015, and without additional coating elements for its protection. The expressiveness is given by the textures printed by the wooden board moulds.

The floors are closed with frames, concrete partition walls, and masonry with PVA paint previously described.

11. Finishings: sanitary ware, metal hardware, lamps

In relation to sanitary ware and metal hardware, there is no specification justifying preservation works. They are market parts that were replaced several times according to the need.

The artificial illumination of the building is mainly done with tubular fluorescent light bulbs, distributed in the different types of lamps in each floor or environment. Currently, those lamps imply two main issues, described as follows.

In the studios and classrooms, cable conduits fed the bent plate lamps and fluorescent tubular bulbs, close to the roof grid. In the Caramel Hall, the illumination was done by lamps usually used for street lighting, coherent with the building proposal of not setting limits between the inside and the outside, the public and the private.

Those two systems were replaced without duly taking into account those characteristics and proposals of the building. The street lighting lamps were replaced by others, more potent and aggressive spotlights (it is very uncomfortable to look at the light source) (Figure 32). In the studios, lamps were installed anchored to the grid, both illuminating what is below them, the work plans, and what is above them, the structural roof grid (Figure 33). This system results in problems for the building perception: for being loosen in relation to the grid, because of the number of rods, the size and density of lamps, it creates a new plan below the grid, competing with it, and interfering with the spatiality of the building. When bottom-top illuminating the roof, it interferes with the perception of time passing and weather conditions, which was a fundamental factor for the users. The grid thus illuminated impairs such perception. In the other spaces, there is no type of illumination deserving attention, having been adapted according to the need.

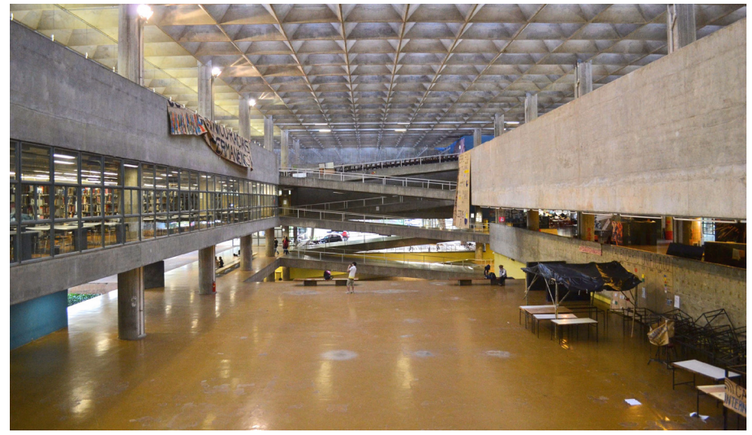


Figure 32 – Artificial illumination of Caramel Hall from the spotlights fixed in the central pillars of the building. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team..

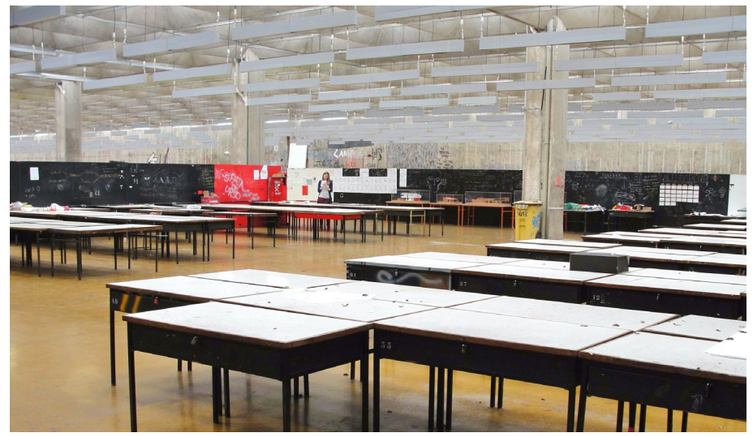


Figure 33 – Artificial illumination of studios 1 and 2. Installed lamps create a second plan under the roof. Photo: Roberto Souza, July 2016. Collection: Conserva FAU Team.

12. Building infrastructure: systems of water supply and sewerage, rainwater catchment, lightning protection, low voltage, telephone, data, fire prevention and fighting, property security, air conditioning, mechanical ventilation, gas, elevators.

The set of building infrastructure is vertically composed of two masonry blocks located in each of the longitudinal ends of the building. Composed of internal shafts, such blocks also house most of the toilets and kitchens (cafeteria and scullery), also containing the raised water tanks, power, illumination and telephone switchboards, and all the general installation vertical piping, such as for water, sewage and sewage ventilation. In the crossing of horizontal and vertical circulations, they distribute the infrastructure through the floors.

- Water supply system: the water connection to the campus network is located near the main building entrance, in front of the Northwest lateral façade (Figure 34). From there, water is conveyed to two 10 thousand-liter water tanks on the roof through vertical piping crossing the sanitary blocks (Figure 35). The water reservoirs do not include reservation for fire fighting.

- Sewerage: toilets are raised in relation to the flooring, allowing the distribution of the sewerage from sanitary vases, urinals, sinks, and drains. The primary sewerage system descends through the internal central pillars to the sanitary blocks, and the sewerage system ventilation is done through the shaft inside such blocks.

- Rainwater catchment: rainwater is collected in the roof and distributed through PVC pipes along the central pillars. During the works done in 2009, pillars were opened to change and insert new vertical pipes. They were originally closed with bricks, which were removed. A prototype was made for the closing of pillars, with light and removable elements, complementing their shape and facilitating maintenance, but so far such closing was not done. Upon arriving in the underground, the rainwater passes through internal galleries until flowing into the public collection network.

- Lightning protection system (LPS): composed of galvanized steel capturing rods, fixed in the ruff flashing on the roof beams. All together, there are 277 rods installed in a 5.50m x 5.50m mesh, and over the water reservoirs. The system grounding is performed through rods connected to the pillar iron reinforcement (Figure 36). The load is transferred to and grounded by the foundation.

- Electrical system: the building is connected to the underground middle voltage grid (13,200V) of the campus through a shielded power inlet substation with two 500Kva transformers, and contained in a closed volume by a concrete wall with continuous and

Figure 34 – Water inlet valve in the building. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.

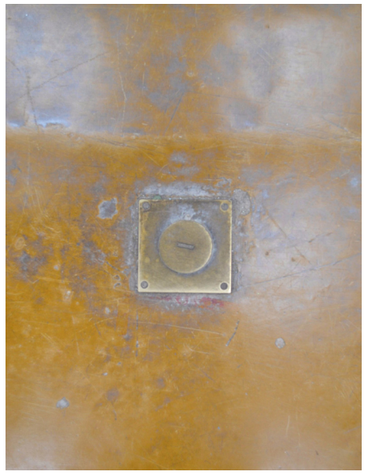
Figure 35 – Water reservoirs on the roof. Photo: Rodrigo Vergili, 2015.

Figure 36 – Capturing rod fixed to the roof flashing of one of the beams, connected to the grounding system. Photo: Rodrigo Vergili, January 2017. Collection: Conserva FAU Team.

Figure 37 – External block where the power inlet station of the building is located. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.

Figure 38 – Power distribution boxes in the block east. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.

Figure 39 – Data network wiring and electrical ducts fixed to the laboratories floor slab. Photo: Ana Paula Arato Gonçalves, July 2016. Collection: Conserva FAU Team.



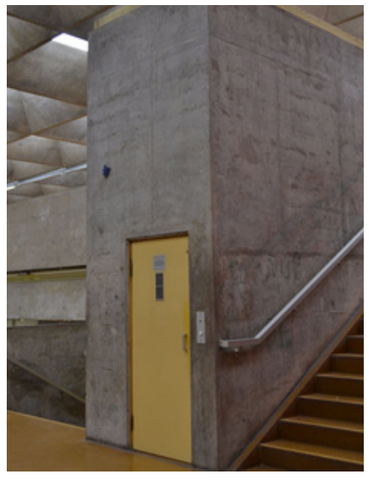
Figures 40 and 41 – Deactivated floor plug sockets in the floor of the Studios. To the right, plug socket closed with mortar. Photo: Luiza Nadalutti, March and August 2017. Collection: Conserva FAU Team.

Figure 44 – Air conditioning condensers and pipelines next to the Southeast façade of the building. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

Figure 42 – Deactivated hydrant located beside the exit of the auditorium state, at level -3.00. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.

Figure 45 – Shelter of the cafeteria bottled gas. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

Figure 43 – Fire extinguisher located in one of the ends of the laboratories corridor, at level -1.10. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.



Figures 46 and 47 – To the left, access to the elevator at level -3.00, beside the machine room, closed with decorative hollow blocks (*cobogós*). To the right, elevator box in the studios floor. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.

curve geometry (Figure 37). The position of power switchboards is in the east block (red) for the odd floors, and west block (blue) for the even floors (Figure 38). The distribution of plug sockets is done through exposed ducts and conduits, fixed to the slabs and walls (Figure 39).

In larger environments, integrated and continuous (auditorium stage, Caramel Hall, Museum Floor, Administrative Area, Interdepartmental Atelier and Studios), plug sockets were embedded into the floor, disposed according to a given rhythm in order to characterize the type of occupation. They are currently disabled, and some of them were covered with the new flooring lining, or were just removed (Figures 40 and 41).

- Fire fighting system: despite hydrants were planned to be placed near the sanitary blocks (Figure 42), they were never properly connected to the hydraulic network, therefore they cannot be regarded as part of the fire fighting system – even because there is no water reservation for the hydrants in the upper water reservoirs. The building has extinguishers in all the floors, according to the implemented fire fighting project (Figure 43).

The only fire fighting project found dates back to 1987. It provided for the construction of a reservoir and a pump house, both external and semi-buried, installation of detectors, alarm system, emergency lights, hydrants and extinguishers system.

- Assets security: the building has security cameras installed in some points. In addition, some rooms (with confidential heritage or archives, such as the administration rooms and the research laboratories) have alarm and motion detectors.

- Air conditioning system: the first air conditioning system of the building was installed in the auditorium in the 1980s. Over the years, several air conditioners were installed, according to individual demands and with no global planning, in the administration rooms and in the laboratories, resulting in a major visual and physical interference with the façades (Figure 44). The condensers – external units of the systems – were improperly fixed to the edge of the slabs, and in some cases, the concrete was broken to let the pipeline pass through.

- Mechanical ventilation: the building ventilation takes place with the circulation of air between the floors through the Caramel Hall, with no doors or physical barriers, allowing the continuous exchange of air: through the domes, which have an opening between the slab and the skylight; through the ducts located next to the studios and classrooms blind façades, and in the toilets, through the openings next to the hydro-sanitary blocks shafts.

- Gas: the only points with gas supply are the cafeteria and the scullery. In case of the cafeteria, the bottled gas is inside a

shelter under the kitchen, at the elevation 0.00 of the building, accessible through the teachers' parking lot (Figure 45). In the employees' scullery, the bottled gas was sheltered in a shelter unknowingly built in the garden, in a volume independent from the building, under the peristyle of the lateral southeast façade, causing an impact in the perception of that façade. Late in 2016, the employees´ scullery oven was replaced by an electrical model, no longer requiring gas. The bottled gas shelter was then demolished.

- Elevator: the elevator provides access to the odd floors (Underground, level 3.00; Caramel Hall, level +0.80; Mezzanine, level +4.60; and Studios, level +8.40), and has the machine house located beside the first stop, in floor -3.00 (Figure 46).

13. Landscaping

Photos of the time of the building inauguration reveal a low vegetation flowerbed in the shape of diamonds next to the northeast façade, indicating a possible design by Artigas for the landscaping surrounding the building (Figure 48). The low vegetation in this flowerbed and the low trees in another garden, just behind, suggest the intention of a free visualization by those standing at the Avenida Luciano Gualberto, from which they could have a full privileged view of the building. More to the north, in that same side, there is a set of newly planted trees out of the viewing angle of the building. Such configuration already appeared in the preliminary design scale model.

To the northwest, there are four regular sequences of palm trees aligned with the building axes, and coordinated with the rhythm of the parking spaces, defining and marking the lateral esplanade (Figure 49). In front of the building, trees mark and delimitate the shadow island where cars are grouped, also in coordination with the parking spaces (Figure 50).

The building site elevation, the way the building perceptions follows one another in the approximation regarding the landscape, the precinct of the square (inserted in the esplanade) configured in a dialogue with the hill in front, the small lake geometrically articulated with the building and ensuring a tradition of the students at the Vila Penteado, the flowerbeds designed to preserve and compose the views towards the city, and those advancing under the building in the peristyle, reducing the limits between the inside and the outside, the alignment and rhythm of the trees coordinated with the building and the parking spaces: everything evidences the design of the surroundings and of the landscaping as the extension and part of the building design.

Currently, the garden under the building frontal façade peristyle

Figure 48 – View of the back façades (Northeast) and lateral façades (Northwest) of the building. To the left, a kind of flowerbed is seen in front of the building. Photo: Author and date unknown. Collection: FAUUSP Library.

Figure 49 – Palm trees aligned on the lawn in front of the Northwest façade. Photo: José Moscardi, October 1969. Collection: Acrópole magazine

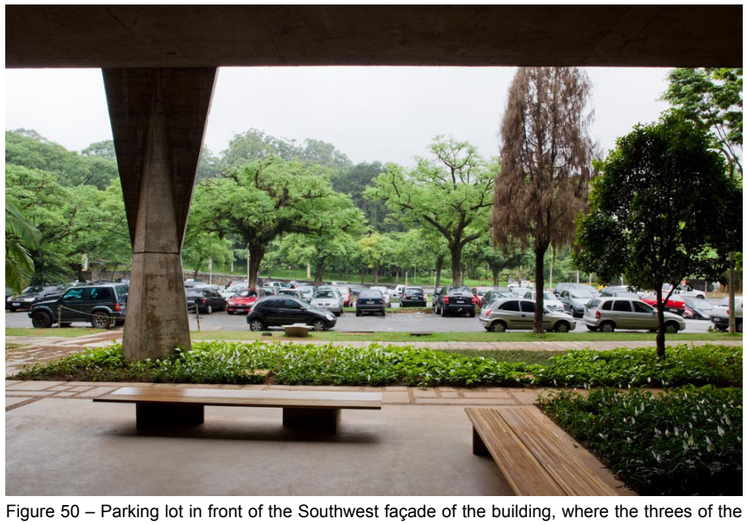


Figure 50 – Parking lot in front of the Southwest façade of the building, where the threes of the median stripes are coordinated with the parking spaces. Photo: Nelson Kon, 2009.

is composed of a large flowerbed with organic outline and native and exotic species, implemented in 2010. In the surroundings, large trees grow without management and conservation plan, resulting in a random disposition around the building – some also in the garden (Figure 51).

In turn, the like lake in front of the building ended up being occupied by cars, losing its meaning as one of the structuring elements of the school´s frontal esplanade (Figures 52, 53, and 54).

Figure 51 – Garden under the peristyle of the building Southwest façade. Photo: Luiza Nadalutti, March 2017. Collection: Conserva FAU Team.

Figures 52 and 53 – Like lake in the parking lot in two moments. To the left, full of water, with stones and public lamps marking the axis of the building frontal esplanade (Photo: unknown author, 1969. Collection: Public Archive of São Paulo State - Public Memory). To the right, little lake used as parking lot (Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team).

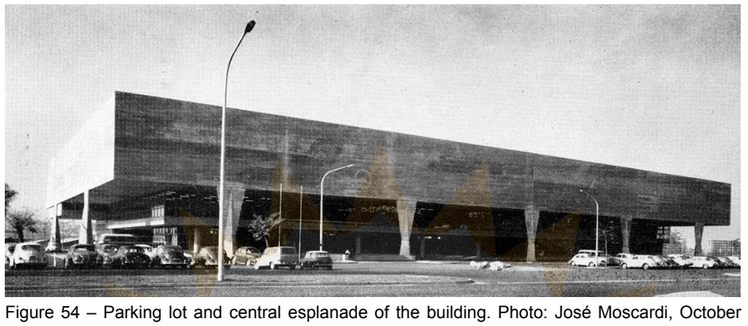


Figure 54 – Parking lot and central esplanade of the building. Photo: José Moscardi, October 1969. Collection: Acrópole magazine.

14. Furniture

The building furniture was specified in the furniture plans of 1968, drawn on the detailed design boards, by the architect and FAU professor Abrahão Sanovicz, and was sent by Artigas to the technical office of FCCUASO (Construction Fund of the University Campus Armando Salles de Oliveira), in August of that year. Among the furniture specified, there are: tables, drawing tables, administrative furniture, chairs and bar stools for the cafeteria. Part of such furniture are still being used, but they were mostly systematically replaced over the decades.

The building has 3 benches made of concrete: one just at the entrance, beside the plug socket of the ramps, at elevation +0.80, called bench of the 'bichos' (new students) (Figure 55), another one in the limit of the library balcony at elevation +4.60 (Figure 56) – both have the same design. The third one is connected to the partition wall configuring the circulation of the classrooms (elevation +10.30) (Figure 57). The bench of the bichos and the one of the classrooms confirm a reading of the building that does not separate coexistence from circulation. On the contrary: generous circulation areas promote the encounter, and benches can be a small support, and in this regard they are always in the direction of the circulation. In the case of the balcony, the bench also limits the space over the lower floor.

In the past few years, several sets of benches were installed: one in the limit of the Caramel Hall to the auditorium moat, which can still be seen as an appropriation of the library bench (Figure 58). On the other side, in the garden, benches 90º between each other were installed, configuring a kind of living space, very different from the proposal of the existing benches (Figure 59). New benches can possibly be installed, but several aspects concerning them should be discussed: from their location in the building, their size and materials – which should not be mimetic to the original one, but rather dialogue with the building architecture.

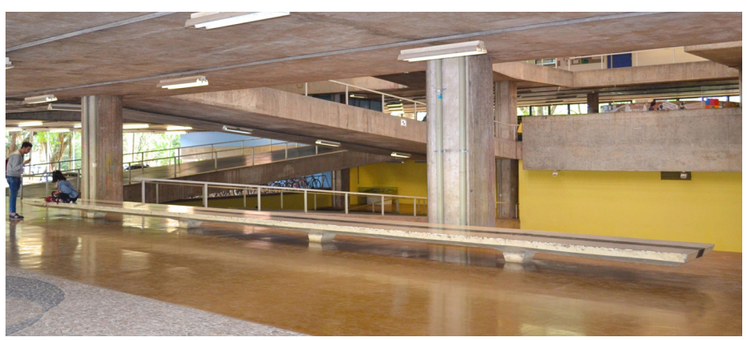


Figure 55 – Bench in front of the main building access, at elevation +0.80, called the newcomers (bichos) bench. Photo: Luiza Nadalutti, August 2017. Collection: Conserva FAU Team.

Figure 56 – Bench in the library balcony, at elevation +4.60. Photo: Luiza Nadalutti, August 2017. Collection: Conserva FAU Team.

Figure 57 – Bench along the classrooms corridor, at elevation +10.30. Photo: Luiza Nadalutti, August 2017. Collection: Conserva FAU Team.

Figure 58 – Wooden bench in the Caramel Hall, at elevation +0.80. Photo: Luiza Nadalutti, August 2017. Collection: Conserva FAU Team.

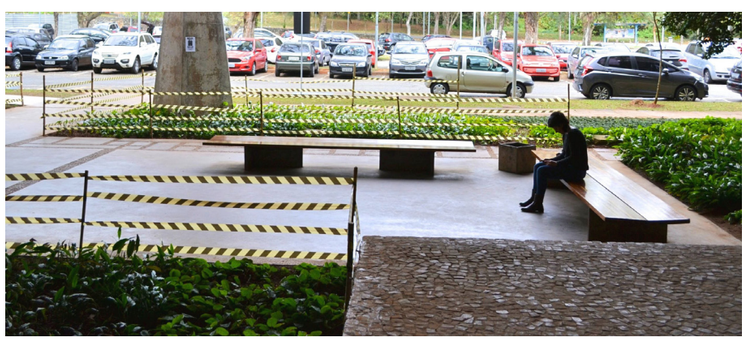


Figure 59 – Living space defined by the two benches placed at a 90° angle from each other, known as "smoking area", at elevation 0.00. Photo: Luiza Nadalutti, August 2017. Collection: Conserva FAU Team.

15. Library Collection

FAU-USP library was created in 1948, simultaneously to the creation of the course of Architecture and Urbanism of São Paulo University. Initially installed in the headquarter-house of the school, Vila Penteado, the collections and the functions intended to provide didactical support to the undergraduate course were transferred to the Vilanova Artigas Building in 1969.

In 1998, the library completed 50 years, and went through a major reformulation of its facilities, in order to house more properly its whole collection, which is now the biggest one in the entire south hemisphere, in the fields of art and architecture. It also houses an expressive collection of photos, glass plate negatives and slides, in addition to a large number of architecture design drawings in paper and digital files, and several other types of iconographic materials (Table 1). The sector of architecture designs preserve the original drawings of important architects and architecture offices of São Paulo, such as the Siciliano and Silva office, or of architects Gregori Warchavichik, Victor Dubugras, Rino Levi, Jaques Pillon. The collection of architect Carlos Millan was the first and inaugural collection of the library.

Type of material		Subtotal	Total
Books	Undergraduate course	37005	49186
	Graduate course	12181	
Graduate Thesis		2134	2134
Series Publications		38137	38137
Micro forms		12	105384
Microfilms		71	
Films		18	
Slides		82150	
Photographs		9236	
Videos		607	
Transparencies		10	
Glass plate negatives		4486	
Slide films		62	
Maps		5995	
CD-Rom		2447	
DVD		82	
Floppy disks		148	
Design drawings		(*) 7305	18403
Catalogue of Materials		617	
Students Works		176	
Library of Periodicals (PG)		3041	
Brochures (PG and G)		6865	
Project Descriptions		331	
Scheduled Works		68	
Grand Total:			213244

Table 1: Contents of the FAU-USP Library collection. Source: http://www.fau.usp.br/fau/secoes/biblio/Collection/index.html. Visualized on 29/03/2017.

ASSUMPTIONS AND GUIDELINES

Assumptions for any intervention

• To respect the material, documental characteristics and composition of the building;

• To act according to the procedures and rules of the University and of the School, strictly respecting the laws applicable to the building, with special attention to the state and municipal laws of heritage protection;

• Any alteration should be preceded by detailed studies, mobilizing knowledge in the various fields, and prefigured by a design

• Every proposal of intervention should be submitted to and approved by competent agencies for the execution of the work.

Guidelines

In which concerns the perception of the space:

• To keep strictly free those spaces designed as such, and that should remain free – circulations, Caramel Hall, Interdepartmental Atelier, studios, auditorium moat, museum;

• To respect the building volumes, internally and externally, with special care when inserting new elements that might interfere with the manners of perceiving the spaces of the building and of its visuals;

• To keep the access, circulation systems clear;

• To respect the limits of the spaces closing – departments, students section;

• To design a light partition wall system, with variants depending on the function and the need of permeability, acoustic isolation, etc., to be implemented in the whole School, imposing a visual coherence to FAU´s light partitions as a whole, not making the mistake of mimicking the existing partition walls. The use of better technology should be considered for several situations;

• To preserve the oneness of the caramel epoxy flooring;

• To respect the vertical hydraulic piping for the implementation of toilets;

• To rationalize systems and infrastructure based on a design developed in articulation with the architecture design: electrical, data network, air conditioning, etc.;

• To forbid the installation of equipment in the internal and external concrete structures, causing ruptures in their structures and framework, and harming the perception of the building architecture;

• To study the plan of management and removal of trees interfering with the perception and preservation of the building;

• To organize the possibilities of demonstrations in the body of the building – *graffiti*, vandalism, and academic announcements;

• To develop designs for all the proposed interventions;

• To have the proposed interventions approved by the heritage protection agencies before starting the works;

• The growth of the program and of the collection areas should occur outside the building, not occupying the free areas;

• The new built areas should be separate, following the restrictions defined by the CUASO prefecture and CONDEPHAAT, in order not to disturb the building reading as an autonomous volume;

• To promote the articulation between the School administration and CUASO prefecture, for the actions taking place in the peristyle and outside it; there is permeability between the internal and external spaces, and currently those spaces are administered by two instances, sometimes with conflict of competence;

• The interconnection with new built elements should be preferably in the open air and at the ground level, or underground.

Photo: Vicente Gil, 2015.

1.2.

SPACES OF THE BUILDING AND DISTRIBUTION OF FUNCTIONS OVER THE TIME

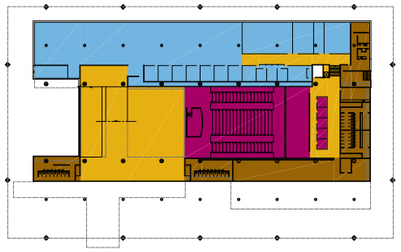
Uses of the building

The floor plans presented as follows were elaborated in 2011, during the studies for the FAUUSP's Participative Master Plan 2011-2018 (PDP), and in June 2016, for the analyzes of the building's Conservation Management Plan. They represent the types of uses of the spaces of Vilanova Artigas Building. In the case of the PDP plants, the analysis was extended to other Faculty buildings, such as the Annex Building and the Experimental Site. By reading and characterizing such occupation, it is possible to appraise how it occurs and whether it is appropriate for the perception of the school spaces. Furthermore, the comprehension of the occupation of those spaces over the years provides clues of the demands and needs the School has had in relation to the changes of the teaching method, to the administration of a public teaching institution, and to the increase of the number of students, employees and teachers. This analysis, already done in the Report on the Vilanova Artigas Building Chronology , was performed according to the alterations of the building physical spaces over the years, evidencing more incisive permanencies and changes in such spaces, which deeply changed the way of reading the building for a given period. To understand the current manner of occupation of the Vilanova Artigas Building, different categories of use, regarding the activities therein developed, were defined (Table 2).

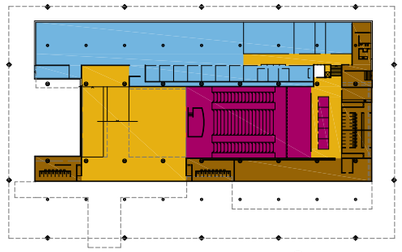
Most of those uses is logically distributed in the building, with the predominance of functions in some floors, except for the spaces that underwent major alterations over the time, as exposed in the Chronology Completion Report. Therefore, the auditorium floor (elevation -3.00), laboratories floor (elevation -1.10), and library/ mezzanine floor (elevation +4.60) are those with a higher diversity of use categories; in some cases, such implementation was not done strictly enough. Likewise, the classrooms floor (elevation +10.30), studios floor (elevation +8.40), departments floor (elevation +6.50), Museum floor (elevation +2.70) and Caramel Hall floor (elevation +0.80) have coherence of functions, with little alteration in their spatial configuration. The expansion of the administration area into the Caramel Hall should be highlighted, raising an important discussion: whether this area was or not absorbed in the perception of the building, and thus whether it should stay or not.

Category of use	Description	Distribution in the building
Academic administration	Administrative activities related to the school teaching, such as the Students Section and the Undergraduate Commission.	Levels -3.00, -1.10, +0.80, +4.60, and +6.50.
Management / Top Administration	Activities of management and guidance of the school, such as the Top Administration.	Levels -3.00 and +0.80.
Didactics support	Support/supplementation of didactic activities, such as the Video Laboratory and the Computer Graphics Laboratory.	Levels -1.10, +4.60 and +6.50.
Assistance and support	Activities of support to the use of the building as a whole, such as the Reception and *Bedelaria* (room for the servants responsible for the students' discipline).	Levels -3.00, -1.10, +0.80, +4.60, and +10.30.
Auditorium	Several types of performances.	Level -3.00.
Library and collections	Collections and areas for consultation and maintenance of collections, such as the library and the sector of maps and digital bases.	Levels -1.10 and +4.60.
Circulation / Get-together	Free areas of passage and get-together, such as the Caramel Hall and the ramps of access to the floors.	Levels -3.00, -1.10, +0.80, +2.70, +4.60, +6.50, +8.40 and +10.30.
Warehouse / storage	Storage of various materials, such as the Storeroom and Deposits of the Library.	Levels -3.00, -1.10 and +4.60.
Didatics	Development of didactic activities, such as Classrooms and Studios.	Levels +8.40 and +10,30.
Research	Research laboratories of the school.	Levels -3.00 and -1.10.
Services	Areas where various services are developed / offered, such as toilets, Scullery and Paper shop.	Levels -3.00, -1.10, +0.80, +2.70, +4.60, +6.50, and +10.30.
Technical areas	Spaces of several installations, such as the condensers shelter and the Rack Room.	Levels -3.00, -1.10 and +4.60.

Table 2: Types of uses distributed through the building floors.

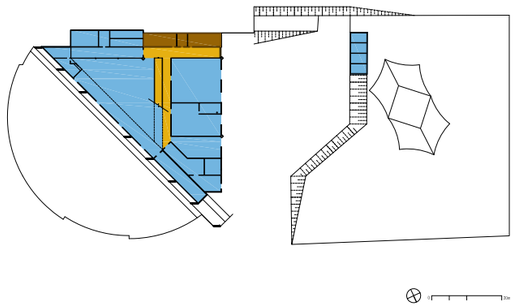


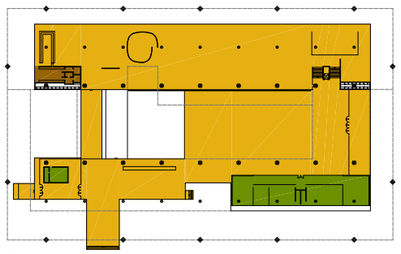
subsolo



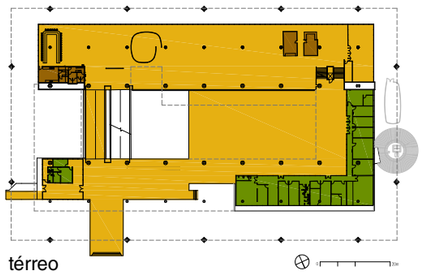
subsolo

subsolo

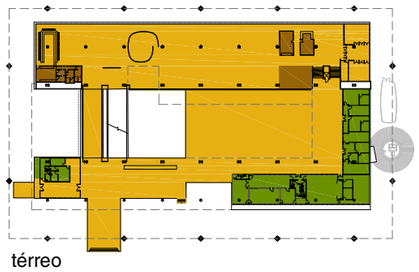




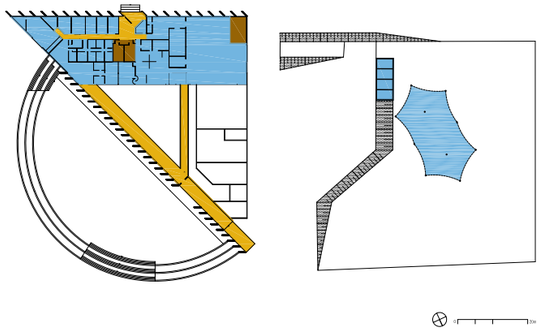
térreo

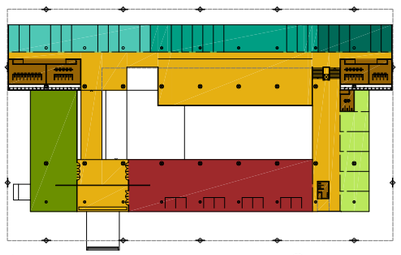


térreo

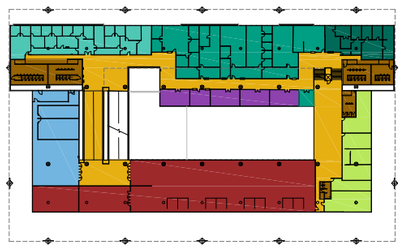


térreo

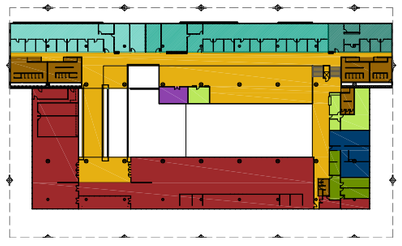




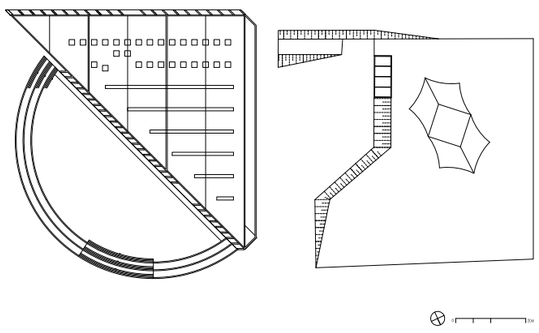
departamentos

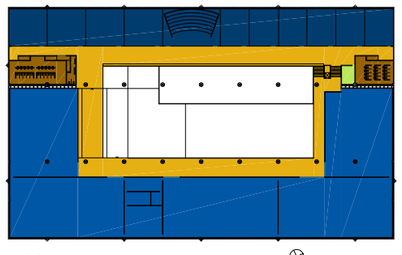


departamentos



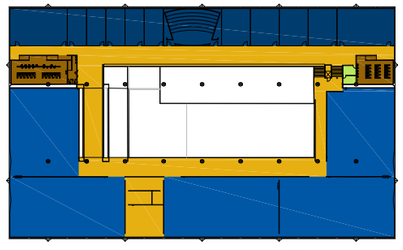
departamentos





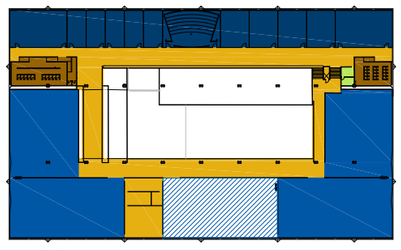
estúdios

FAU Butantã 1969



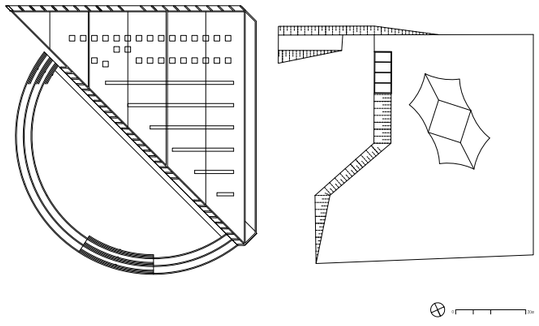
estúdios

FAU Butantã anos 1990



estúdios

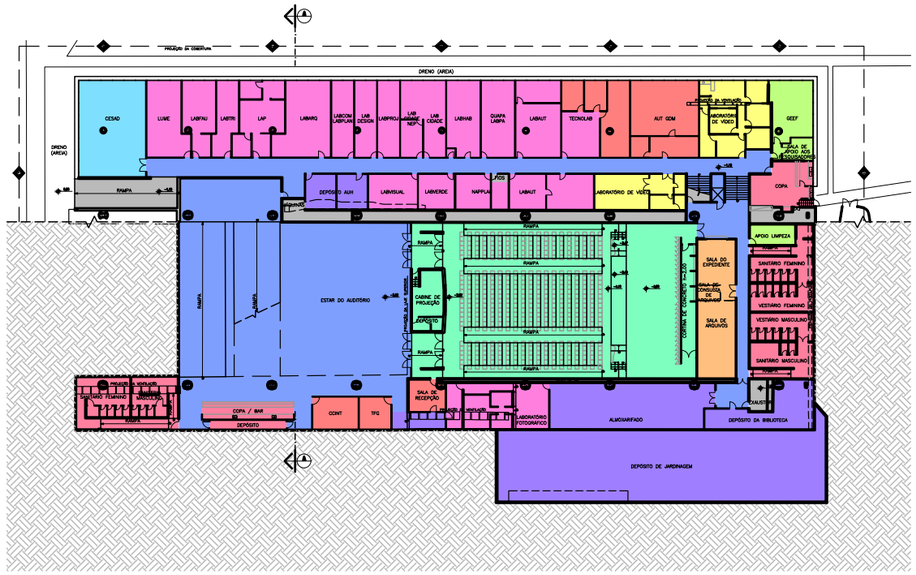
FAU Butantã 2010



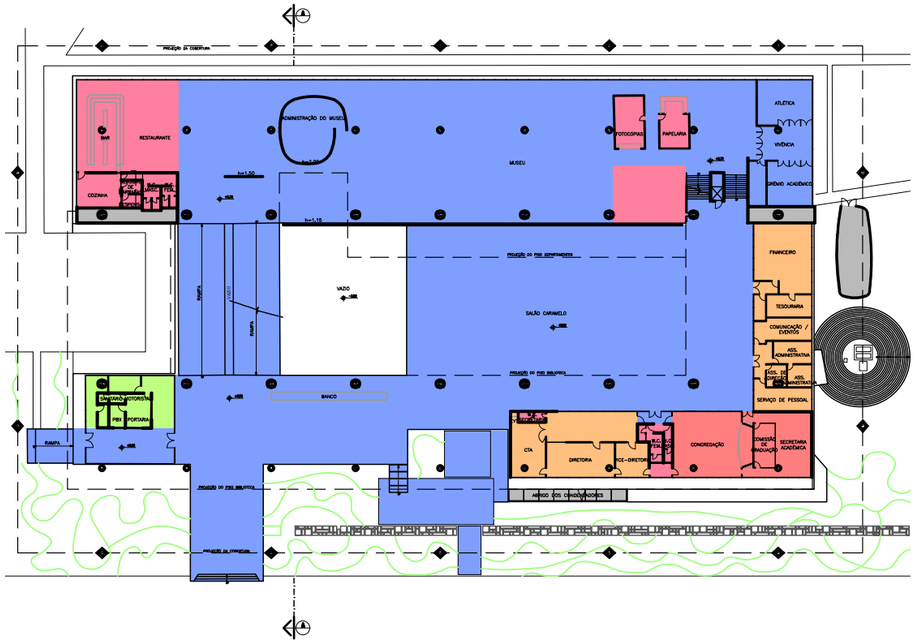
- administração acadêmica
- administração gestão
- auditório
- biblioteca/cesad
- circulação/convívio
- departamento de história
- departamento de projeto
- departamento de tecnologia
- estacionamento
- estúdios
- laboratórios de pesquisa
- laboratórios técnicos de apoio ao ensino
- salas de aula
- serviços

plano diretor participativo

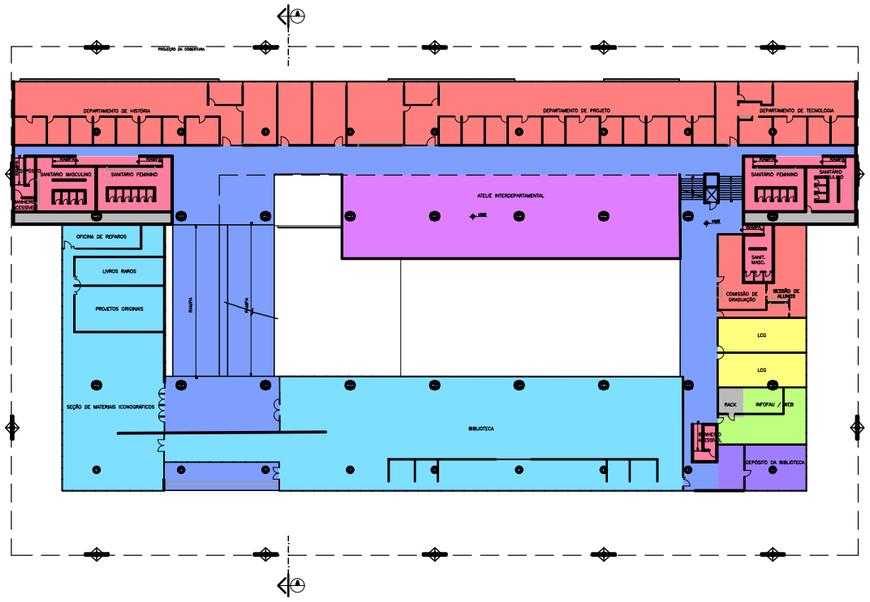
Mapeamento de usos



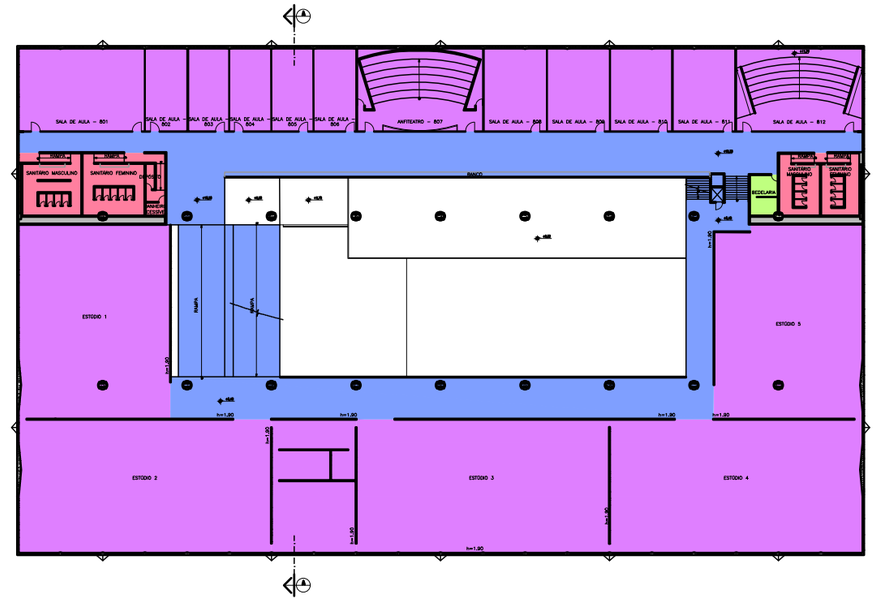
Níveis −3,00 e −1,10



Níveis +0,80 e +2,70



Níveis +4,60 e +6,50



Níveis +8,40 e +10,30

LEGENDA:

- ADMINISTRAÇÃO ACADÊMICA
- ADMINISTRAÇÃO GESTÃO/DIREÇÃO
- APOIO À DIDÁTICA
- APOIO E SUPORTE
- AUDITÓRIO
- BIBLIOTECA/ACERVOS
- CIRCULAÇÃO/CONVÍVIO
- DEPÓSITO/ARMAZENAMENTO
- DIDÁTICA
- PESQUISA
- SERVIÇOS
- ÁREAS TÉCNICAS

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Mapeamento de usos
julho / 2016

FOLHA
1/1

0 5 10 20

TIMELINE

4 landmarks in the chronology

0. Inauguration

Balcony of Caramell Hall and Interdepartmental Atelier

Free spaces. Collection: FAUUSP Library. Estimated date: decade of 1970.

Workshops Floor

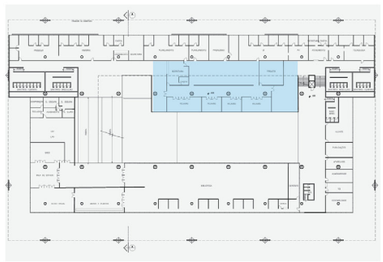
Large space for the workshops. Collection: FAUUSP Library. Estimated date: decade of 1970.

Library Balcony

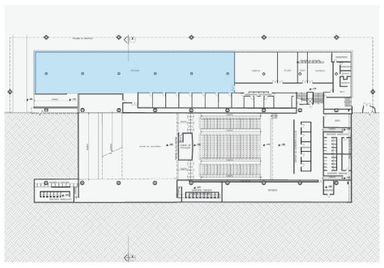
Balcony in continuity with the ramps. Collection: APESP. Date 1969.

1. Since the inauguration until mid 1980's

The first key-moment of the chronology comprises the period between the inauguration of the building and the first renovation of the auditoriu, which drawing boards date back to 1983. The occured changes were the consequence of a strong demand for administrative spaces, of workshops and research spaces, and resulted in the occupation of free areas, as well as of those spaces intended to other activities. The most significant interventions were the closing of the library balcony and of the Caramel Hall balcony, and also the occupation of the Interdepartmental Atelier by the departments.



Floor plan of levels +4.60 and +6.50. Expansion of the departments area, occupying the Interdepartmental Atelier space.



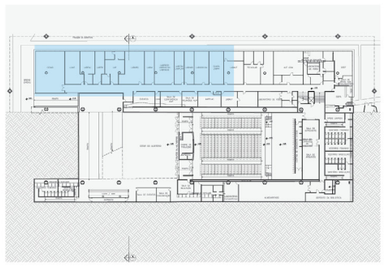
Floor plan of levels -3.00 and -1.10. Large space for the workshops.

Total closing with frame. Collection: Carmen Saraiva. Date: 1983.

2. In 1987 and late 1990's

The second key-moment of the chronology comprises the period between the survey done by PREVENT for the installation of the fire prevention and fight system, dated of 1998.
In this period, we observe the permanence of the non-original occupation of the free spaces, such as the Interdepartmental Atelier. After the construction of the Annexed Building, and of the transference of several activities to that building, the IA space starts to be gradually recovered, as well as the library balcony, which is partially reopened. The research laboratories start to occupy the workshop floor, resulting in a major change in the use of such floor, and in the dynamics of uses proposed in the 1968 design.

Partitioning and loss of free spaces. Collection: FAUUSP Library. Estimated date: between 1998 and 2005.

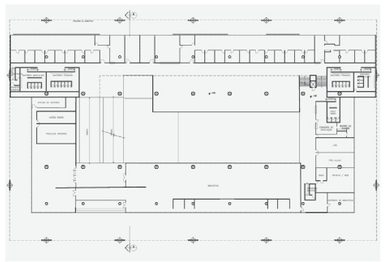


Floor plan of levels -3.00 and -1.10. Space partitioned for the laboratories. Situation from 1998 to date.

Floor plan of levels +4.60 and +6.50. Partial opening of the balcony. Frame recessed in relation to the façade limit. Situation from 1998 to date.

3. Between 2000 and 2011

The third key-moment of the chronology comprises the period between the mid-2000 and 2011, the later for having been the year of publication of the Participatory FAUUSP Master Plan, that marks a change in the way of addressing the interventions in the building. In this period, several campaigns to improve and adapt some environments are observed. Furthermore, the departments retake their original area, completely releasing the space of the Interdepartmental Atelier. However, in the mezzanine, there is an expansion on the circulation area, hiding the masonry wall of the men's toilet, and significantly changing the reading of such area.



Floor plan of levels +4.60 and +6.50. Departments return to their original area, releasing the space of the Interdepartmental Atelier.

Image of the partial opening of the balcony. Author: Nelson Kon. Date: 2009.

4. Between 2011 and today

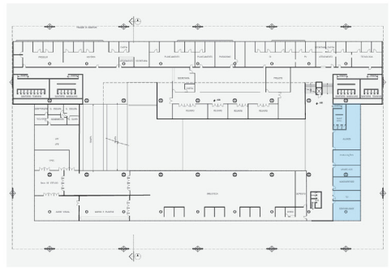
The fourth key-moment of the chronology comprises the year of 2012, with the start of the building roof and blind walls recuperation works, up until now. This period stresses the need to set guidelines for future physical and spatial interventions in the building. The elaboration of the Conservation Plan for the Vilanova Artigas Building, supported by Getty Foundation, is within this context of recovering the importance in planning any new proposed intervention, pointing to cultural change in the building management.

Reopening of the Interdepartmental Atelier. Photo: Conserva FAU Team Date: June/2016.

Space partitioned to shelter the laboratories. Photo: Conserva FAU Team Date: 2016.

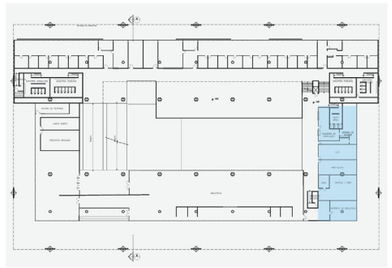
Current situation of the balcony. Photo: Luiza Nadalutti. Date: November/2016.

Mezzanine area



Floor plan of levels +4.60 and +6.50. Initial occupation of the mezzanine by the administration, respecting the toilets alignment. Situation until 1998.

Image of the initial occupation. Photo: Hugo Segawa. Estimated date: decade of 1970.



Floor plan of levels +4.60 and +6.50. Expansion of the administrative area. Situation from 1998 to date.

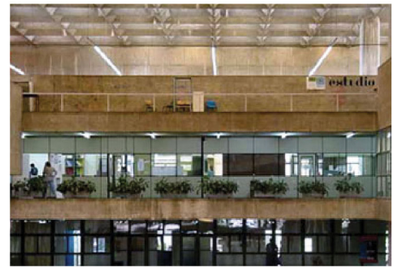


Image of the occupied area expansion. Photo: Fernando Stankuns. Date: 2004.

Current situation of the mezzanine. Photo: Luiza Nadalutti. Date: November/2016.

Domes – Illumination

Artificial illumination provided by a set of lamps in a plan below the roof. Photo: Silvia Valim. Date: unknown.

Some of the domes of Hall Caramel are in a precarious conservation state. Photo: Simões. Date: 2004.

Blue safety canvas, installed in 2010 and removed during the works on the roof in 2015. Photo: Vitor Nisida. Date: 2011.

Perception of the Caramel Hall domes after the completion of the works in the Roof. Photo: Marina Brandão. Date: 2015.

Blind Façades
Close surroundings

The perception of the building façades without the mass of trees. Collection of FAUUSP Library. Estimated date: 1969.

The perception of the building façades without the mass of trees. Collection: Acrópole magazine. Estimated date: decade of 1970.

Occupation of the “small lake” by cars and some small trees. Photo: Silvia Valim. Estimated date: decade of 1990.

Cars occupying the “small lake” of the parking lot. Photo: Nelson Kon. Date: 2009.

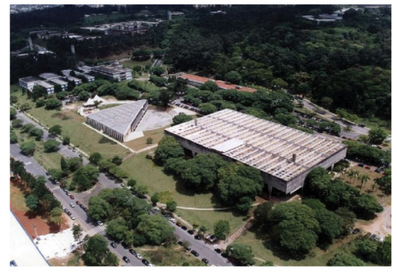
Situation after the recuperation of the blind walls. Photo: Luiza Nadalutti. Date: November/2016.

Expanded surroundings

Several buildings of the campus still under construction; little vegetation. Unknown author. Estimated date: 1969.

The building already functioning, surroundings still under transformation. Photo: Simões.

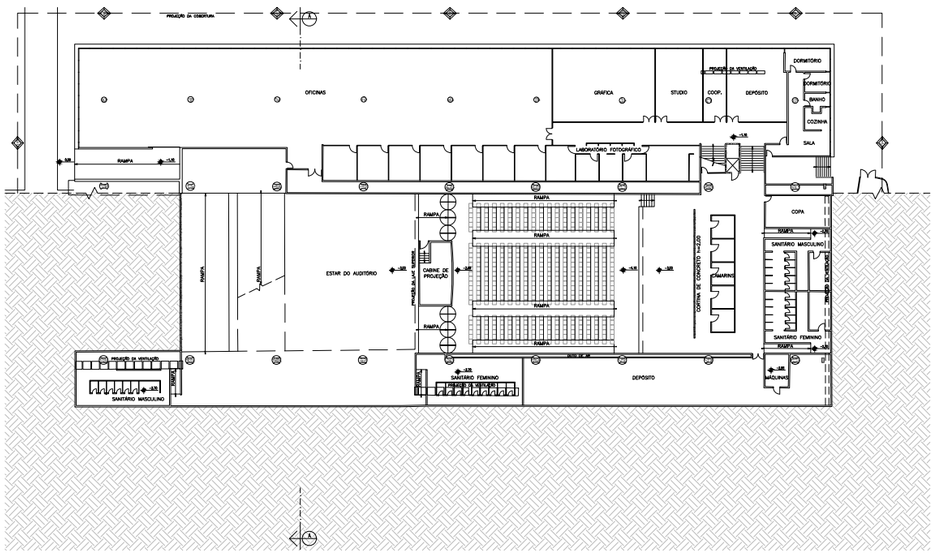
Work of the building Annexed to FAU´s building. Collection: GEEF-FAUUSP. Estimated date: decade of 1990.



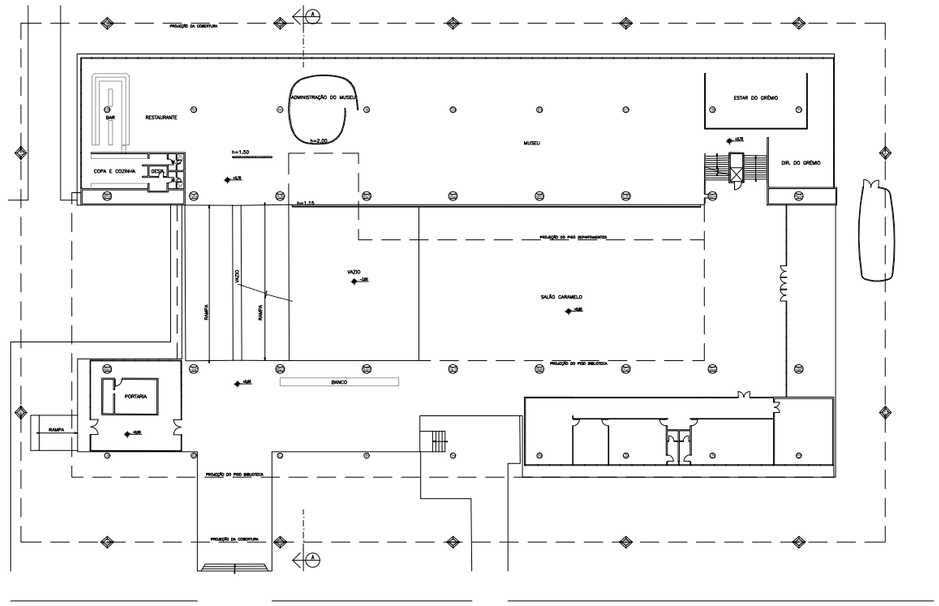
Aerial view of the FAU’s building at the time of the first intervention in the roof. Unknown author. Estimated date: 1998.

Aerial view of FAU’s building with the roof renovation in progress. Photo: Fernando Stankuns. Date: 2013.

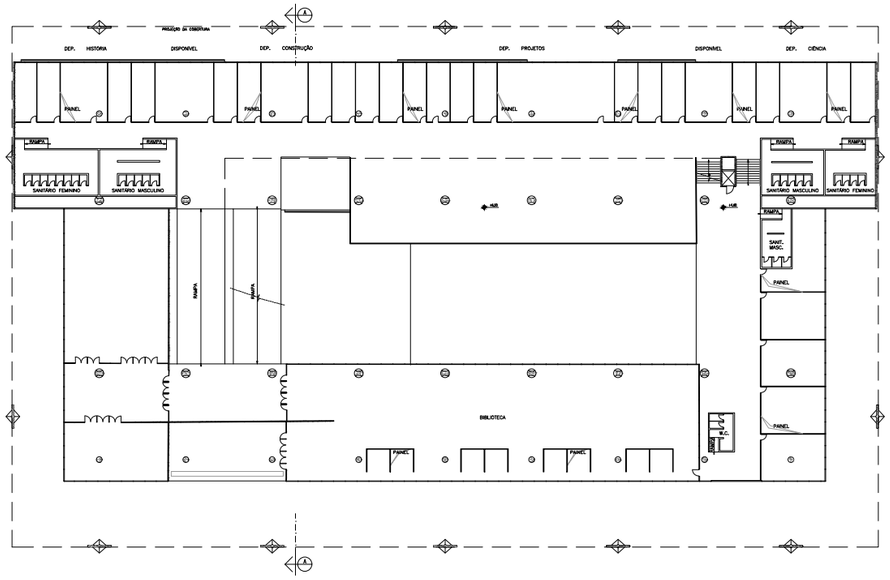
State in inauguration (1968)



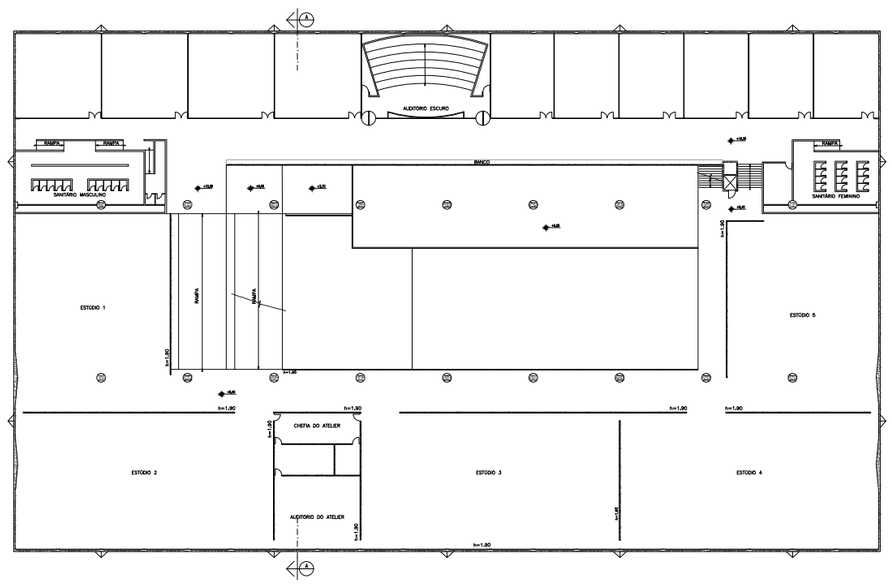
Níveis −3,00 e −1,10



Níveis +0,80 e +2,70



Níveis +4,60 e +6,50



Níveis +8,40 e +10,30

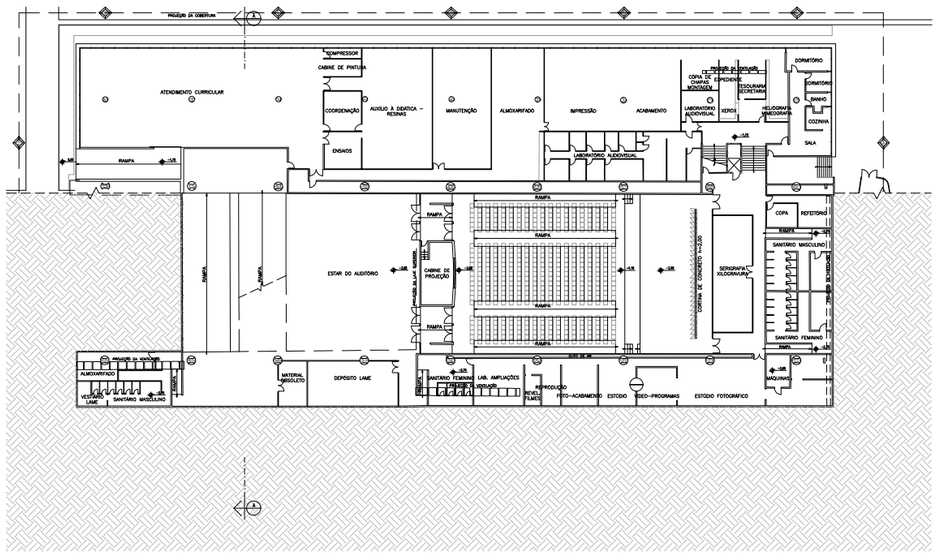
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

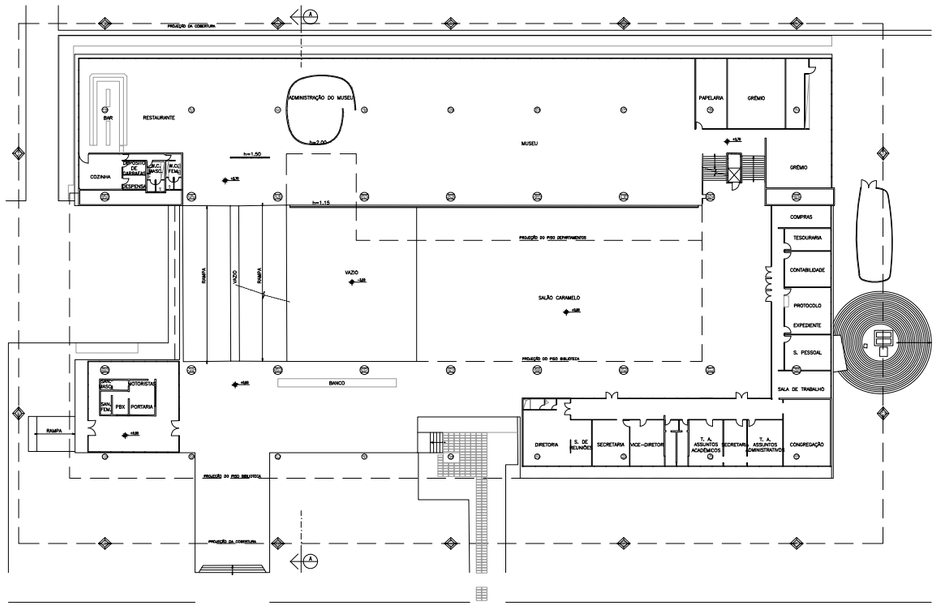
TÍTULO
Cronologia de Intervenções
Estado na inauguração
(1968)

FOLHA
1/4

0 5 10 20

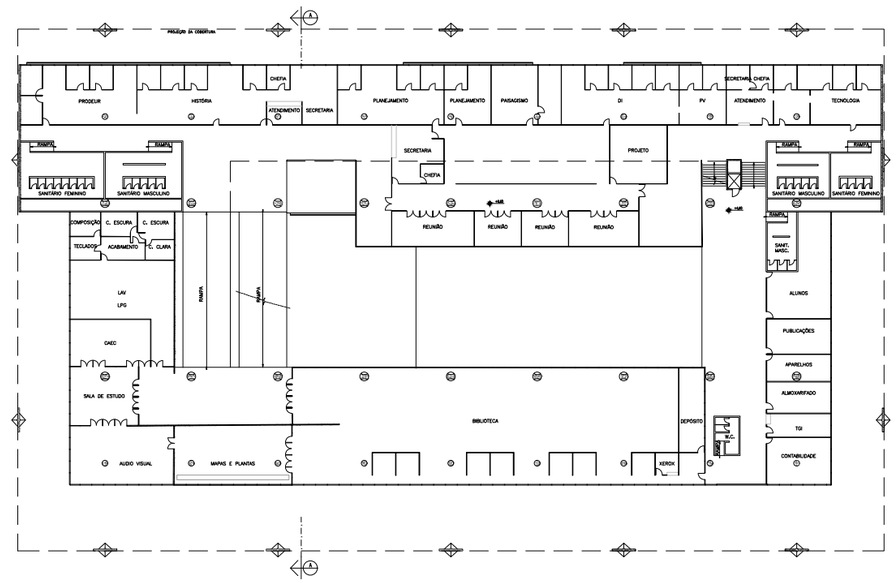
State in 1983

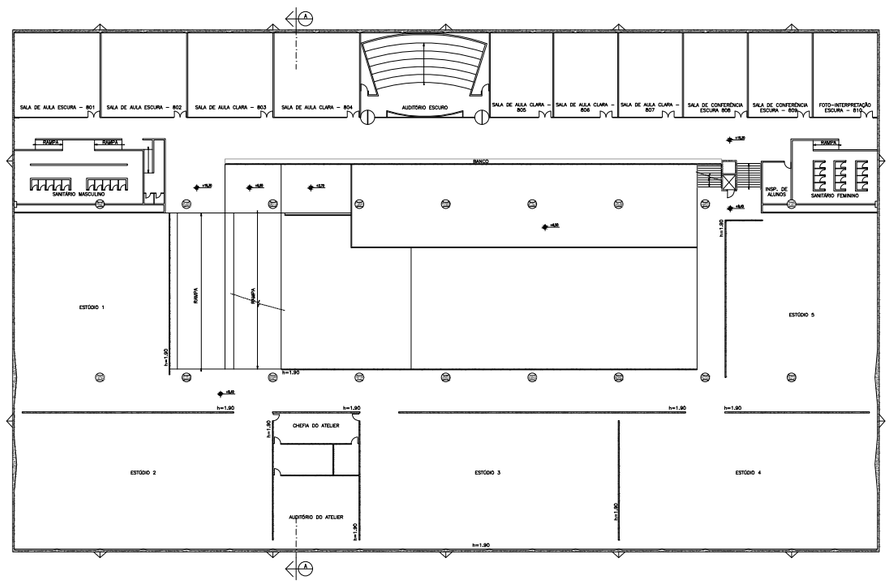




Níveis −3,00 e −1,10

Níveis +0,80 e +2,70





Níveis +4,60 e +6,50

Níveis +8,40 e +10,30

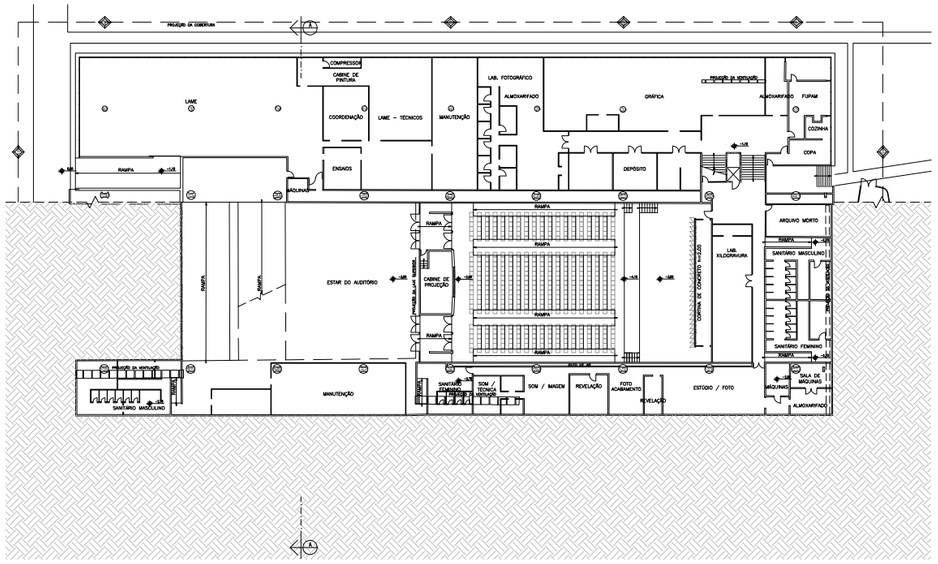
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Cronologia de Intervenções
Estado em 1983

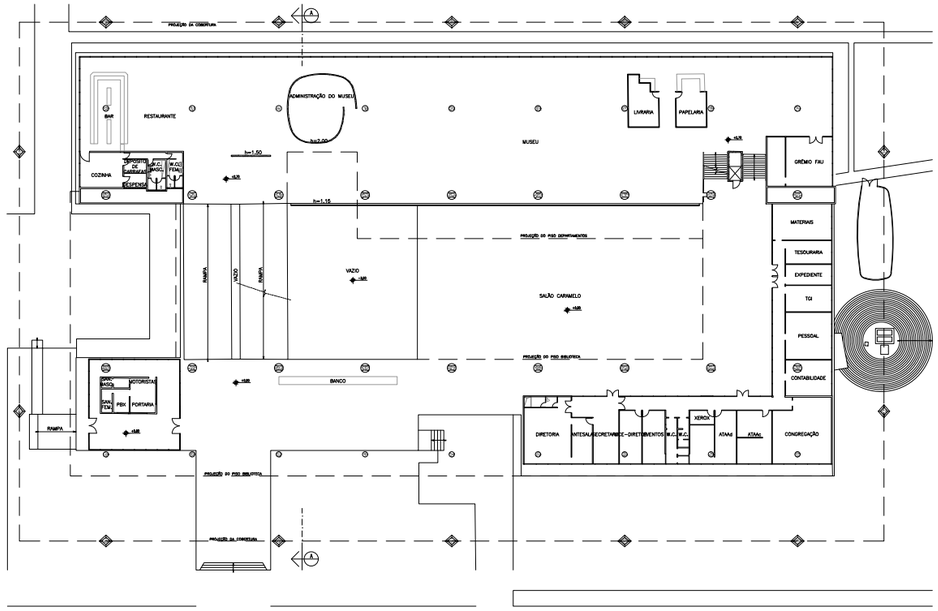
FOLHA
2/4

0 5 10 20

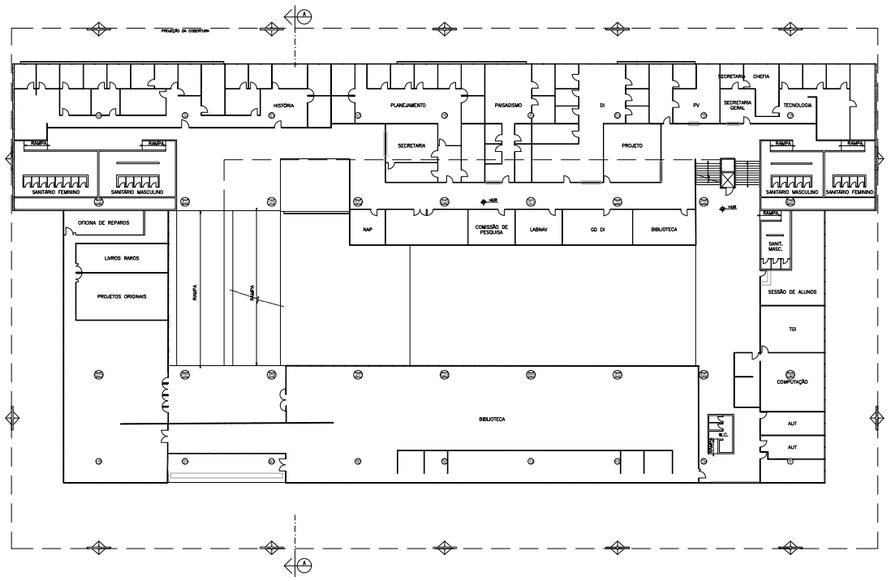
State in 1998



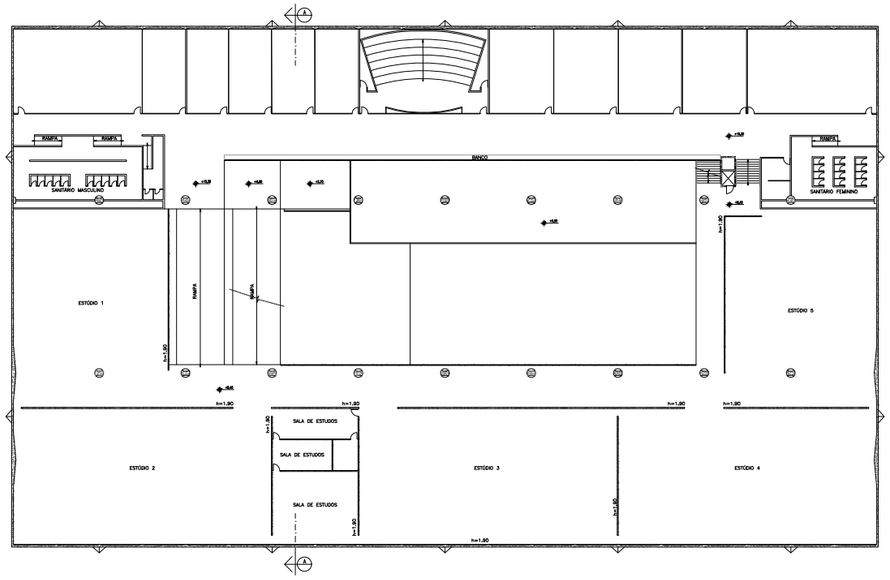
Níveis −3,00 e −1,10



Níveis +0,80 e +2,70



Níveis +4,60 e +6,50



Níveis +8,40 e +10,30

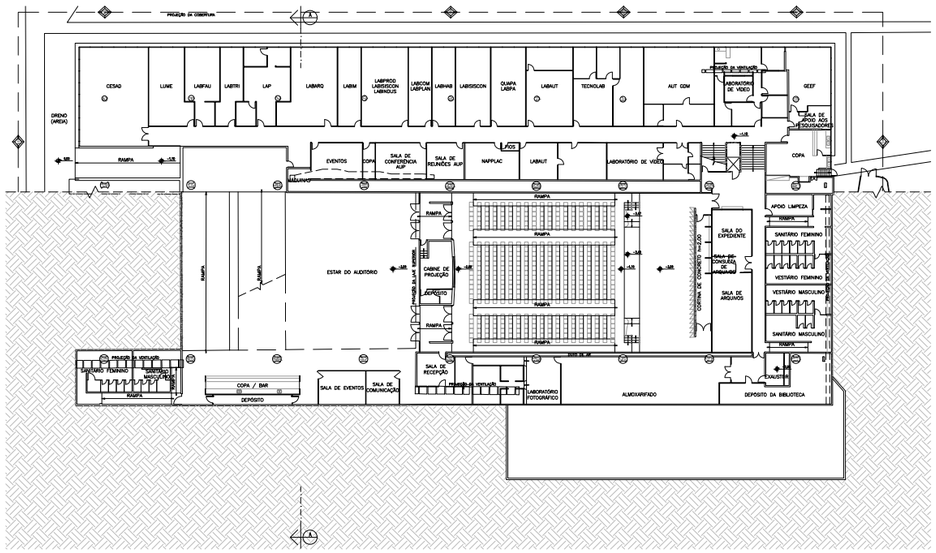
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Cronologia de Intervenções
Estado em 1998

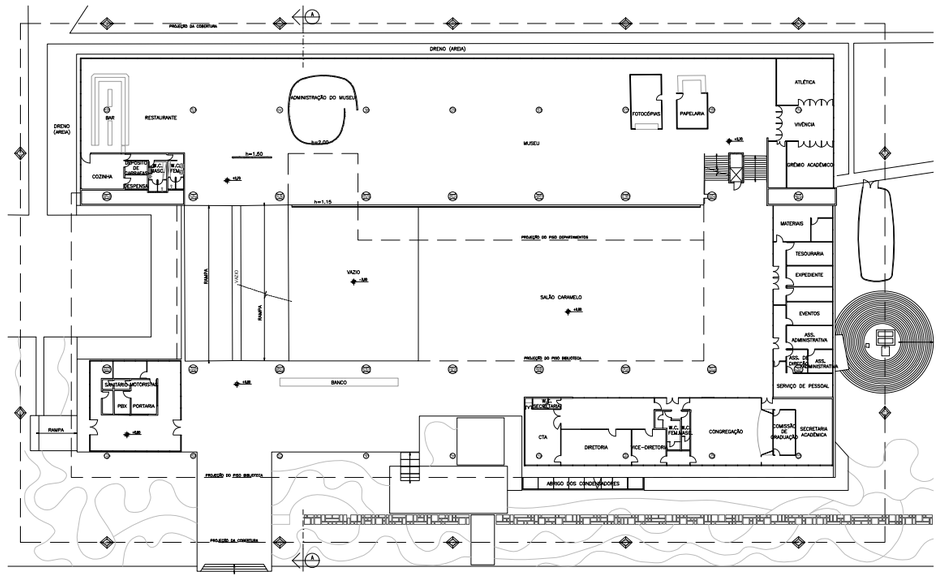
FOLHA
3/4

0 5 10 20

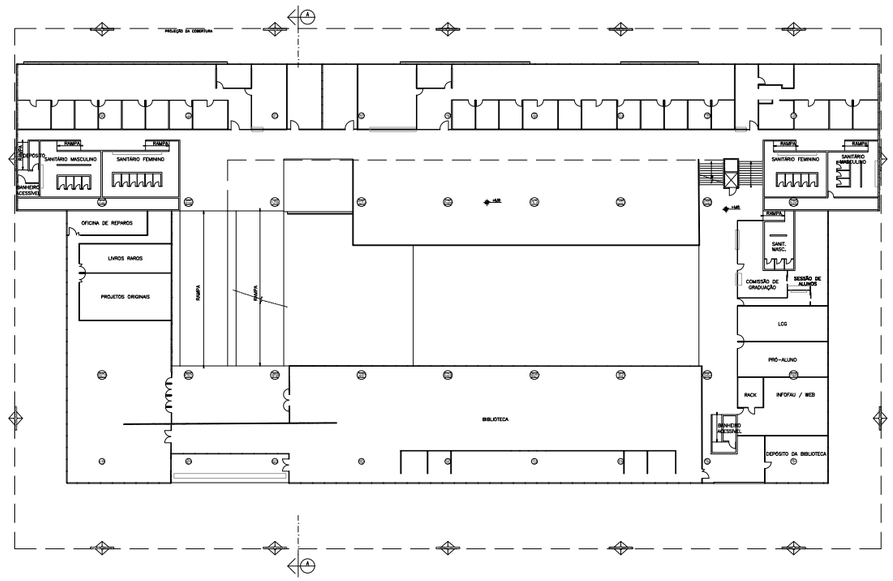
State 2016



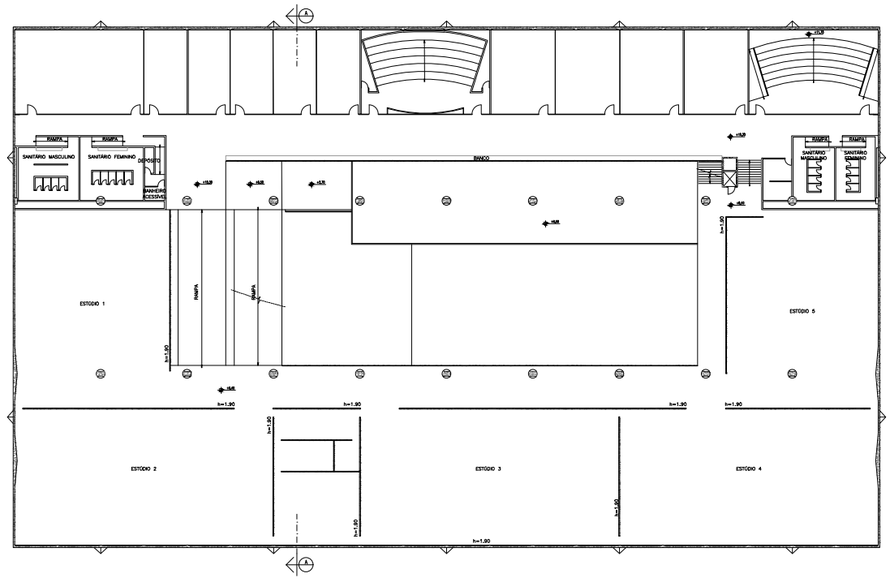
Níveis −3,00 e −1,10



Níveis +0,80 e +2,70



Níveis +4,60 e +6,50



Níveis +8,40 e +10,30

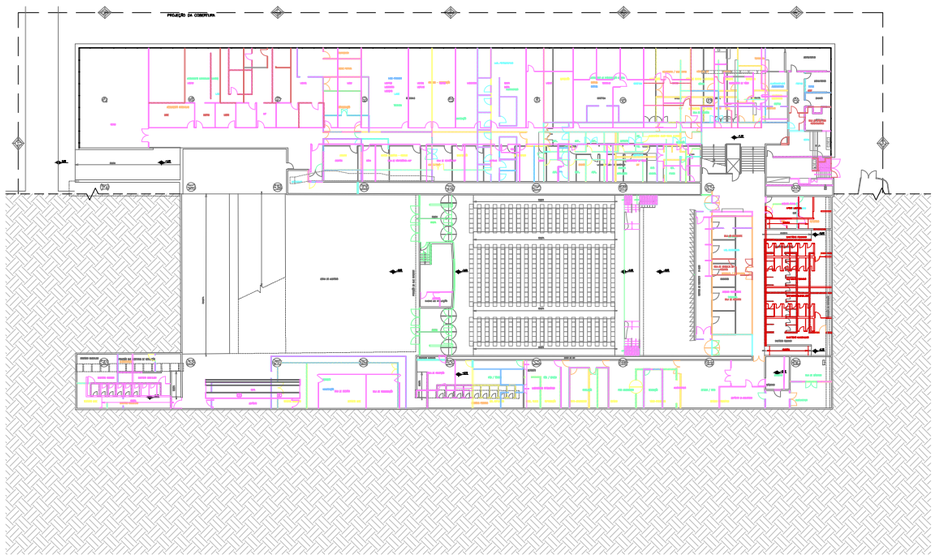
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Cronologia de Intervenções
Estado em 2016

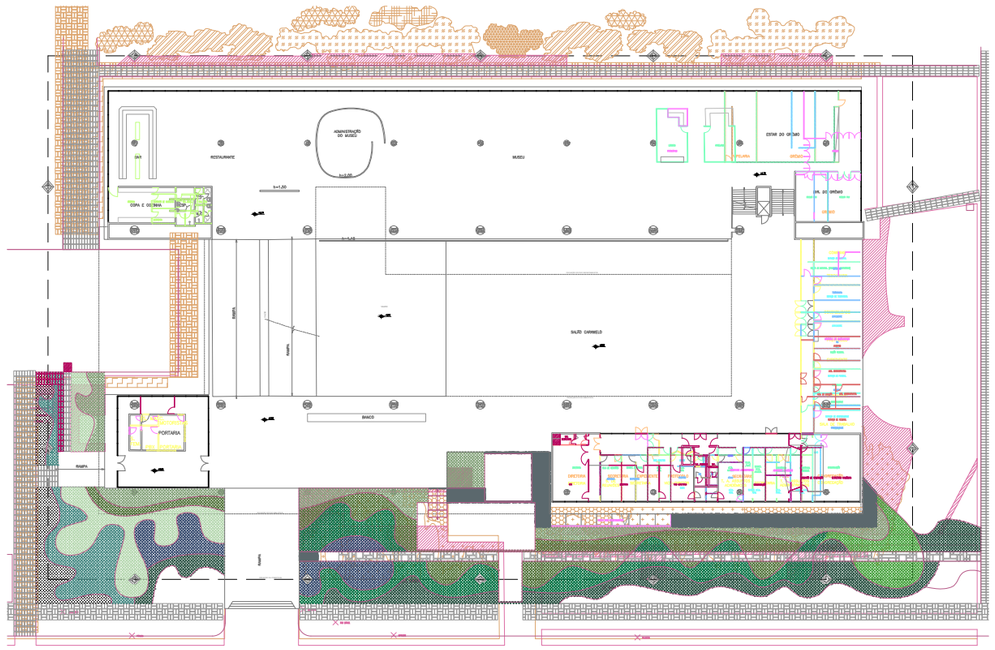
FOLHA
4/4

0 5 10 20

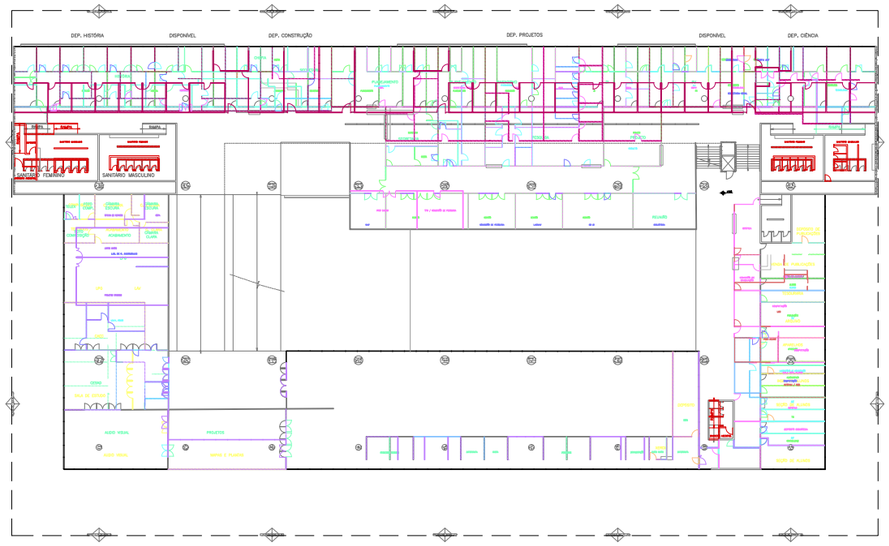
Chronology of Interventions



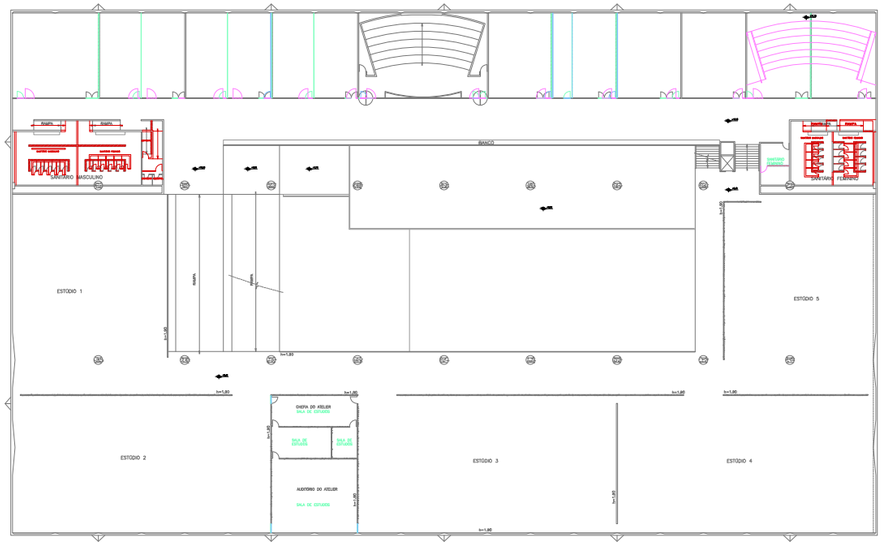
Níveis −3,00 e −1,10



Níveis +0,80 e +2,70



Níveis +4,60 e +6,50



Níveis +8,40 e +10,30

LEGENDA – INTERVENÇÕES:

- 1974 – BANHEIRO DA DIRETORIA
- 1975 – PLANTAS REDUZIDAS
- 1976 – PAISAGISMO
- 1976 – REFORMA
- 1978 – REFORMA DA CANTINA
- 1979 – CESAD / DEPARTAMENTOS
- 1983 – REFORMA AUDITÓRIO
- 1987 – LEVANTAMENTO PREVENT
- 1991 – LEVANTAMENTO INFORMÁTICA
- 1994 – ATUALIZAÇÃO DAS PLANTAS
- 1994 – LEVANTAMENTO INFORMÁTICA
- 1998 – REFORMA DA BIBLIOTECA
- 2002 – ANFITEATRO SALA 812
- 2004 – REFORMA DO AUDITÓRIO
- 2005 – LEVANTAMENTO
- 2006 – LAYOUT DOS LABORATÓRIOS
- 2007 – LEVANTAMENTO DO JARDIM
- 2009 – CALÇADA E ÁREAS EXTERNAS
- 2009 – REFORMA DOS DEPARTAMENTOS
- 2009 – REFORMA DA DIRETORIA
- 2010 – LEVANTAMENTO DO MEZANINO
- 2010 – REFORMA DOS SANITÁRIOS
- 2011 – LABORATÓRIOS DE HISTÓRIA
- 2012 – REFORMA DA COPA
- 2012 – SESSÃO DE ALUNOS E CG
- 2013 – INFORMÁTICA
- 2013 – LAYOUT INFURB
- 2013 – REFORMA DO EXPEDIENTE
- 2013 – DIVISÓRIAS DO GEEF
- 2015 – ACADÊMICA
- 2015 – REFORMA DA BEDELARIA

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Cronologia de Intervenções
Entre 1969 e 2016

FOLHA
1/1

0 5 10 20

Photo: José Moscardi, 1969. Collection: FAUUSP Library.

1.3.

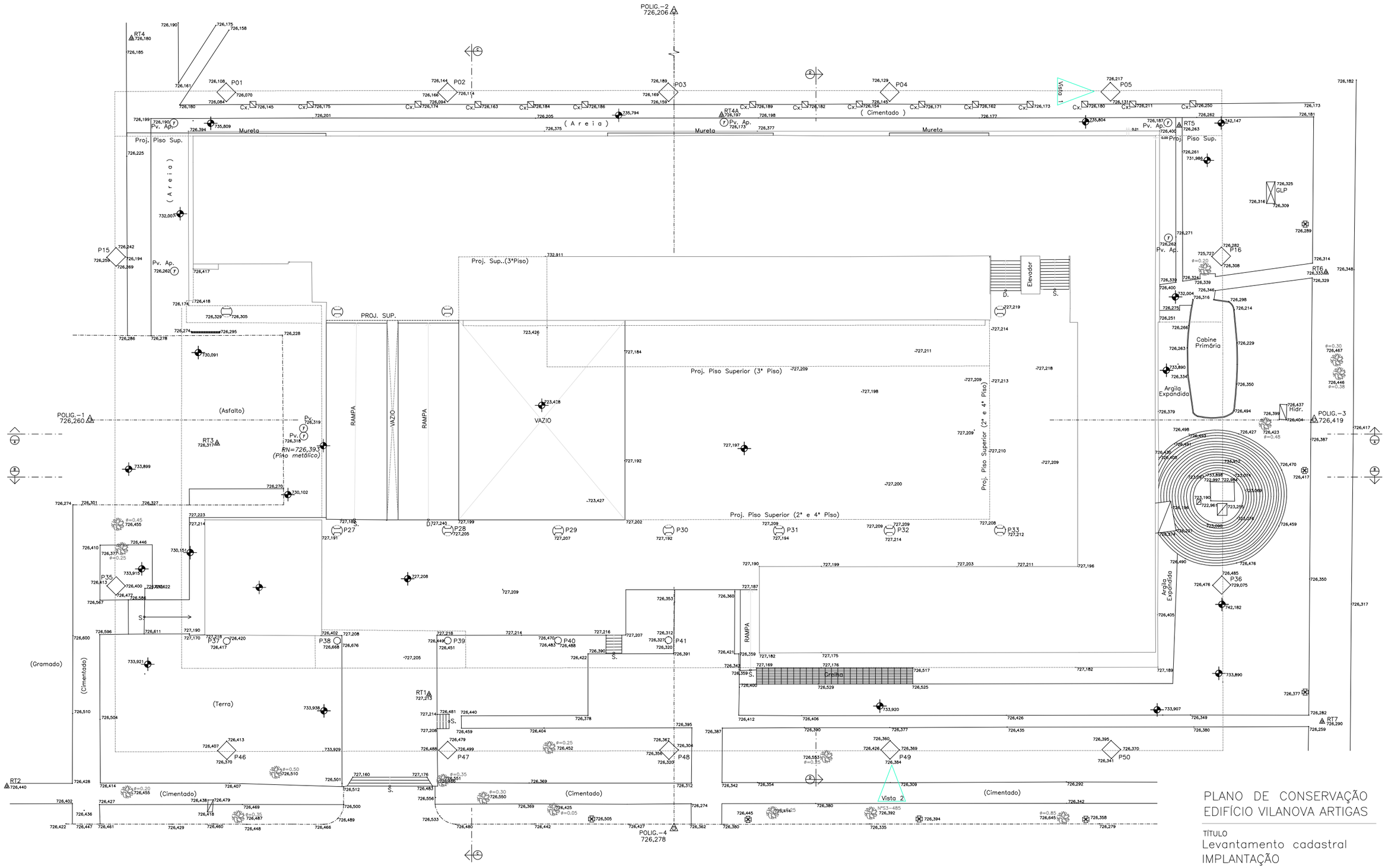
CADASTRAL SURVEY

About the cadastral survey

Understanding the physical attributes that characterize the work is the first step to define a conservation strategy. The documentation on such measurable attributes is a seminal step of the process, ensuring that the knowledge on cultural assets is passed on to the future generations. Thus, the survey of a building should represent the global knowledge of the work, obtained by analyzing its construction rationality. Based on that, it is possible to evaluate formal, spatial, dimensional, perceptive and constructive values of each of the elements composing the building.

In this regard, another branch of Task 1 regards the surveys of the building current state. Since its inauguration, a cadastral survey (as built) has never been performed, so that all the projects and interventions carried out in the building ever since had as base the nominal measurements of the original design, not its actual measurements. Thus, the performance of a metrical-architectonic survey showed to be fundamental, not only to document the current state of the building, but also as the actual base for future projects and interventions that might take place.

Site plan



IMPLANTAÇÃO

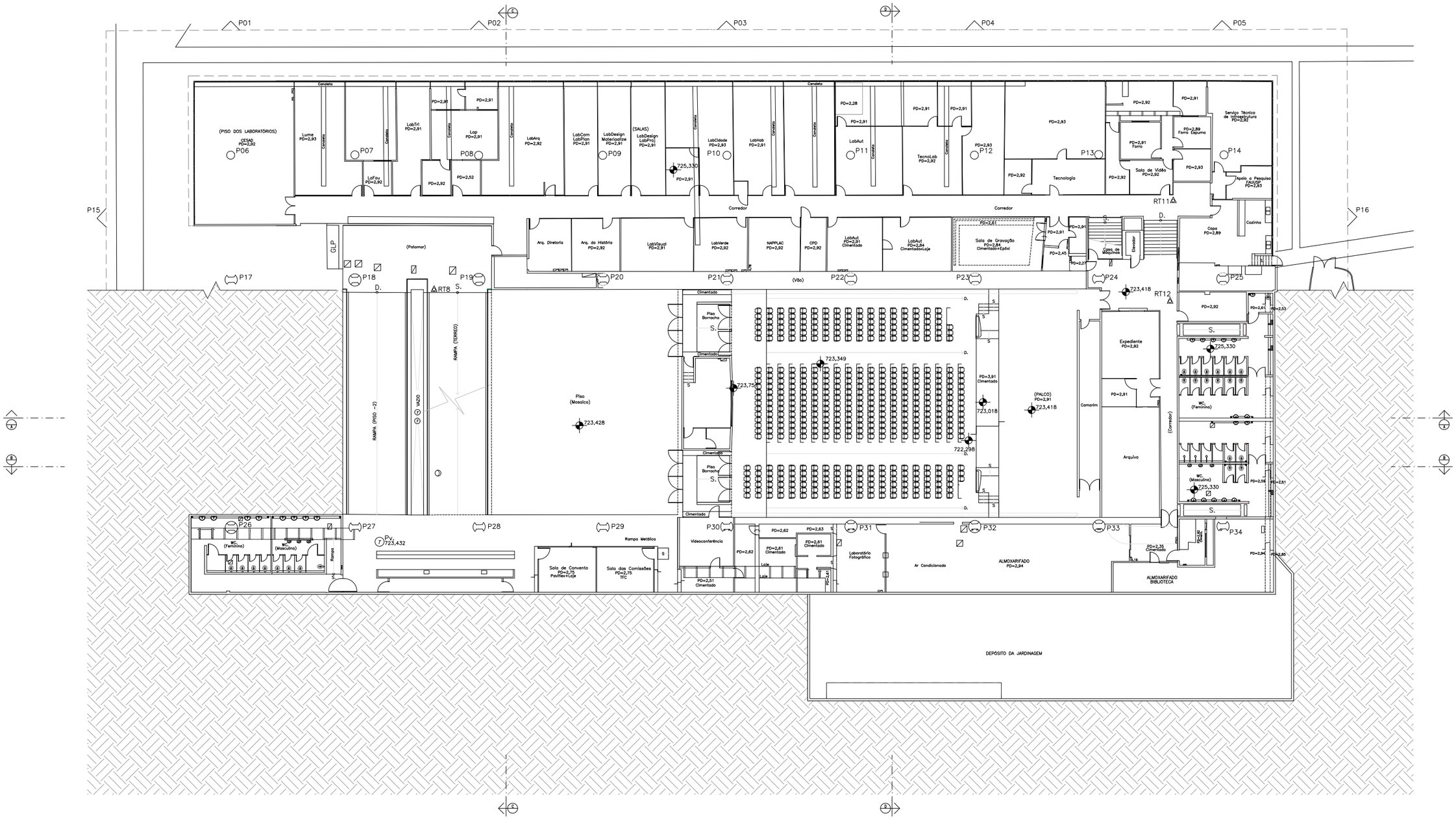
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento cadastral
IMPLANTAÇÃO
maio / 2017

DESENHO
1/10

ESCALA
0 1 5 10

Floors -3.00 and -1.10



PAVIMENTOS −3,00 E −1,10
Pisos do auditório e dos laboratórios

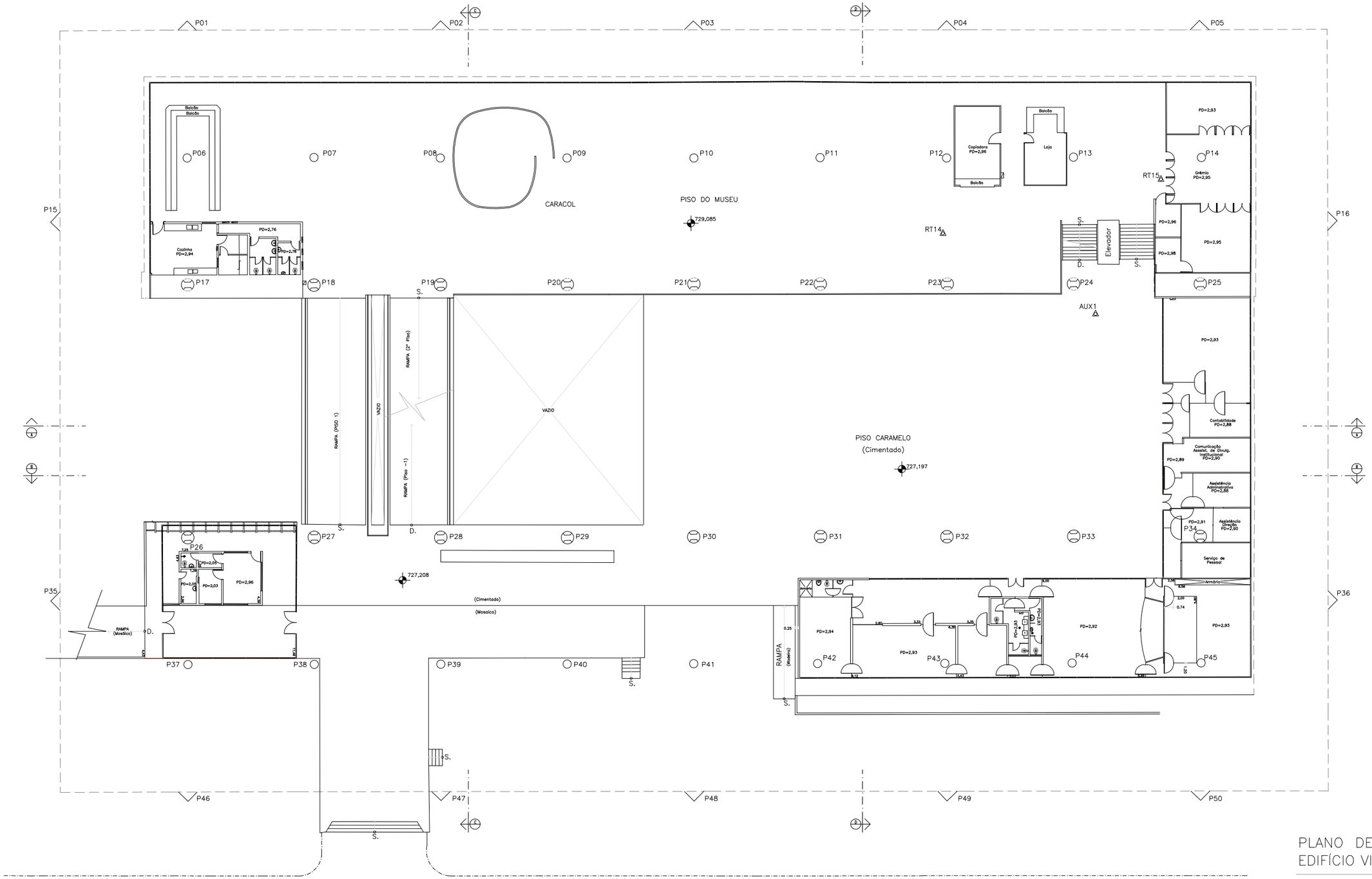
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento cadastral
PAVIMENTOS −3,00 e −1,10
maio / 2017

DESENHO
2/10

ESCALA
0 1 5 10

Floors +0.80 and +2.70



PAVIMENTOS +0,80 E +2,70
Pisos do Salão Caramelo e do Museu

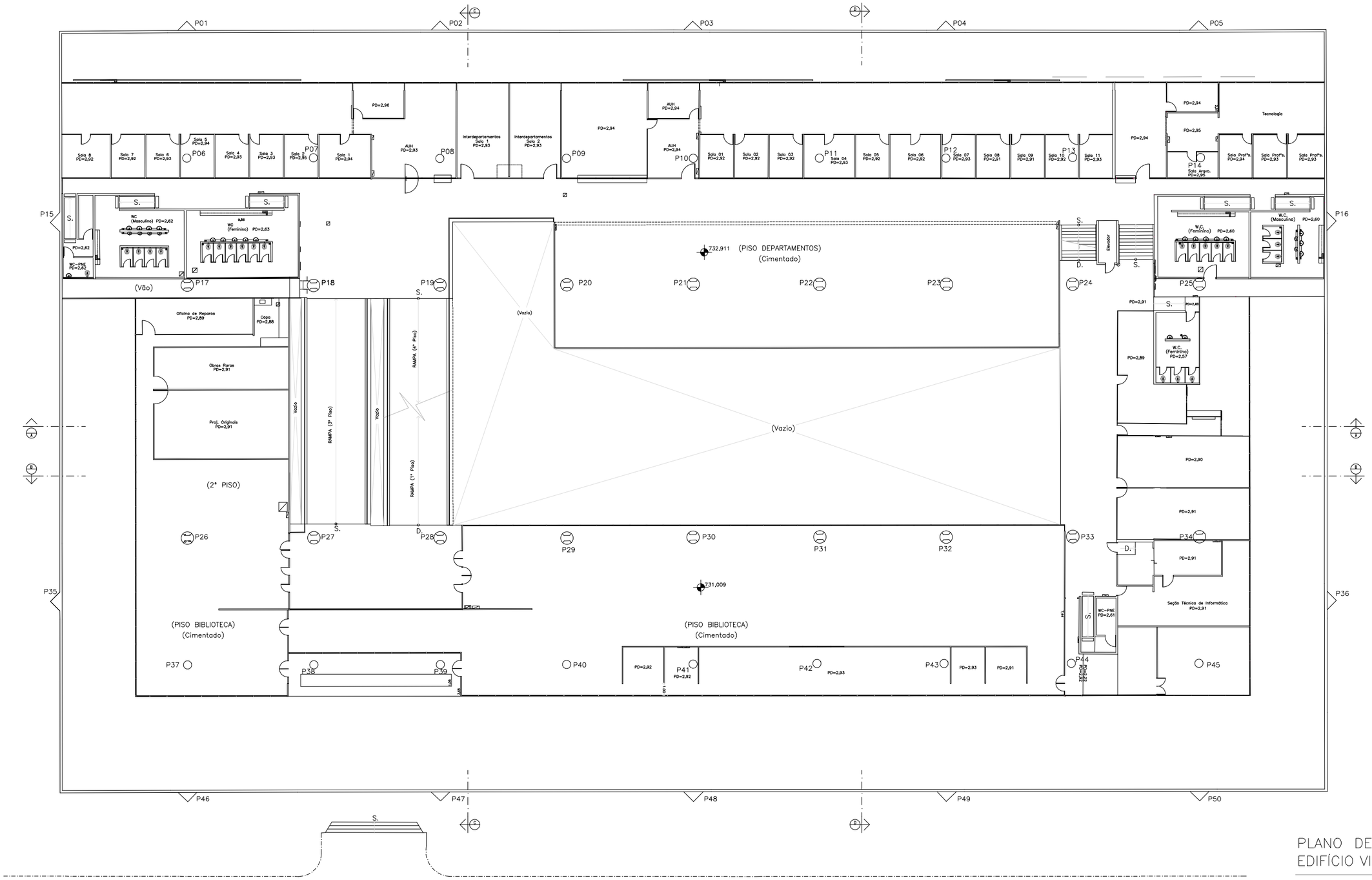
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento cadastral
PAVIMENTOS +0,80 e +2,70
maio / 2017

DESENHO
3/10

ESCALA
0 1 5 10

Floors +4.60 and +6.50



PAVIMENTOS +4,50 E +6,50
Pisos da biblioteca e dos departamentos

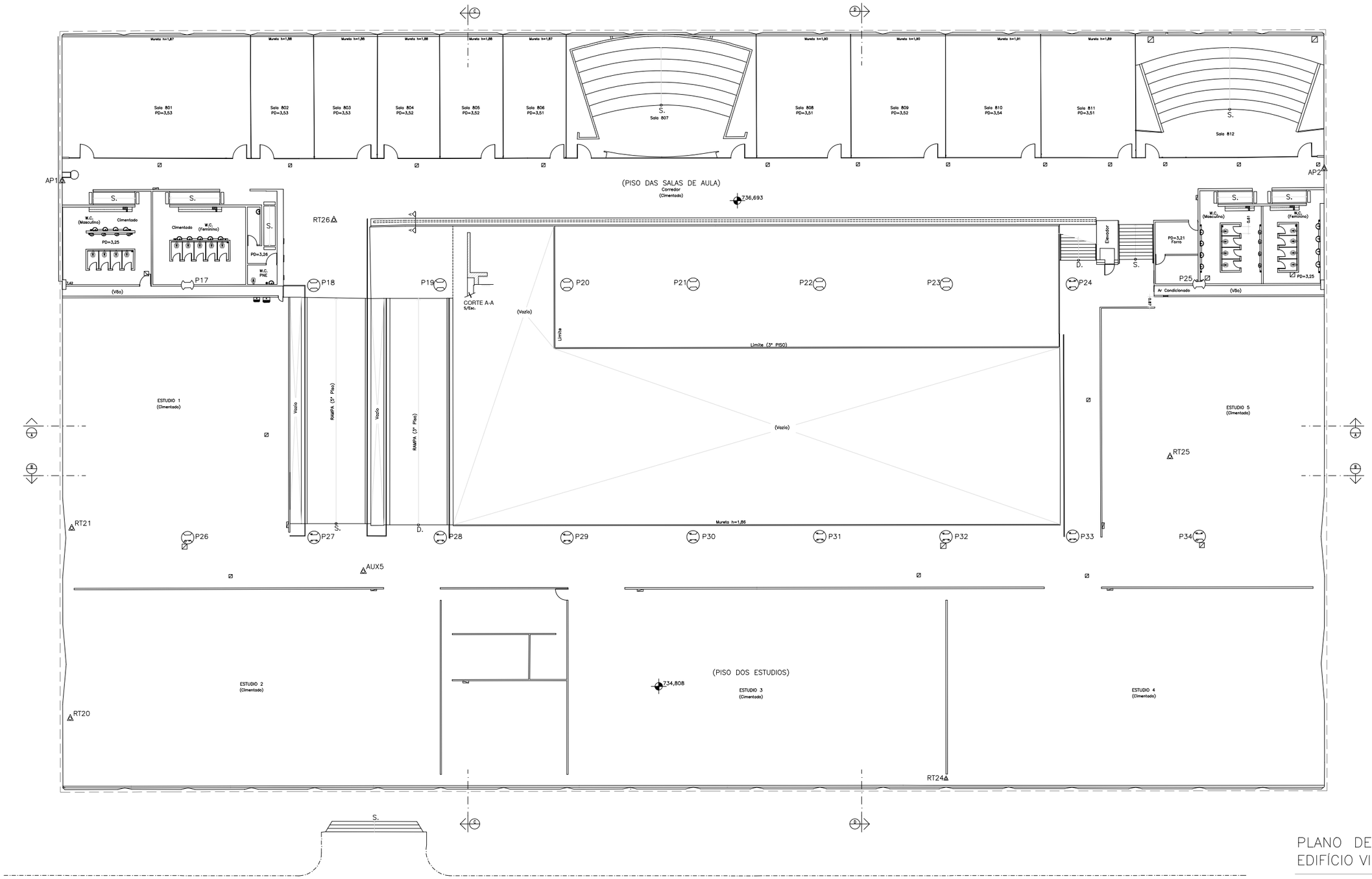
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento cadastral
PAVIMENTOS +4,60 e +6,50
maio / 2017

DESENHO
4/10

ESCALA
0 1 5 10

Floors +8.40 and +10.30



PAVIMENTOS +8,40 E +10,30
Pisos dos estúdios e das salas de aula

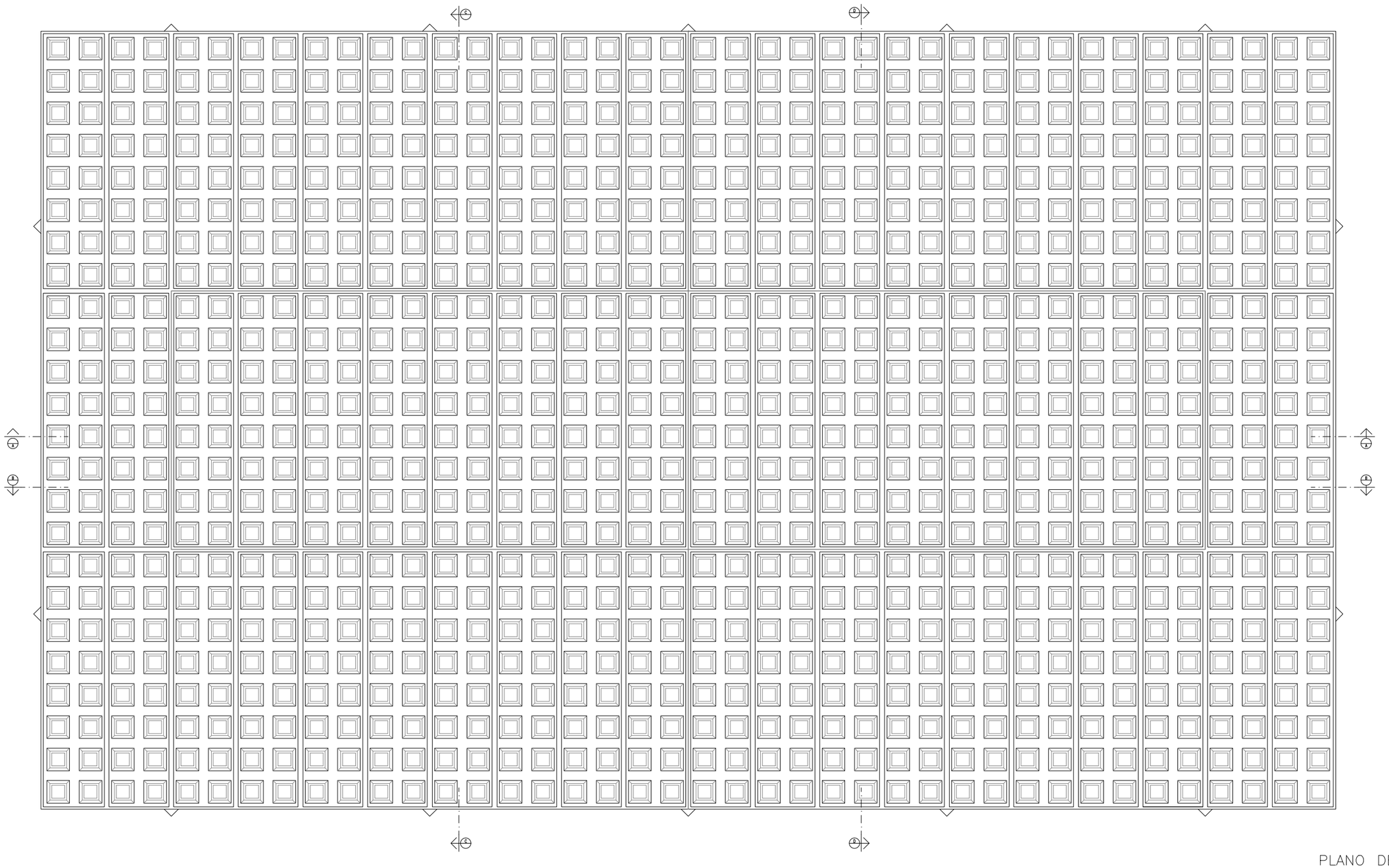
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento cadastral
PAVIMENTOS +8,40 e +10,30
maio / 2017

DESENHO
5/10

ESCALA
0 1 5 10

Roof



COBERTURA

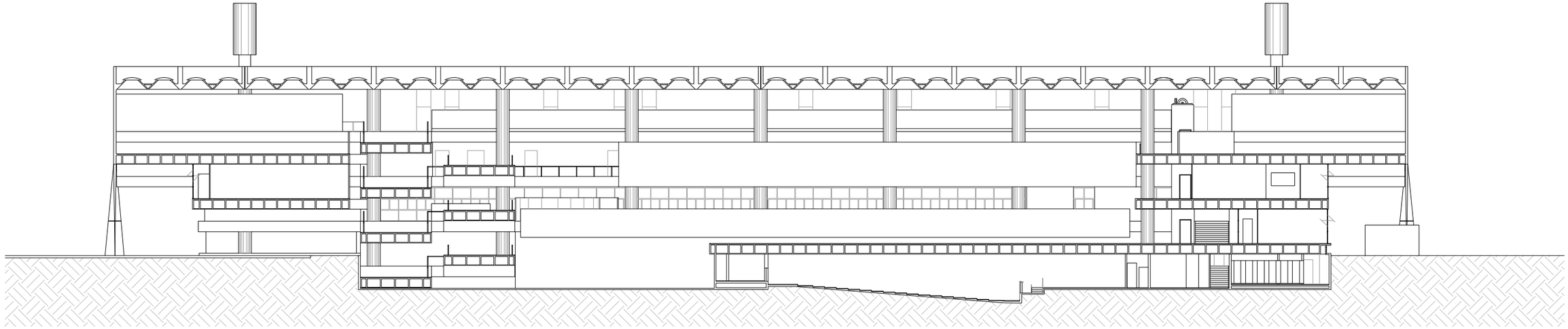
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento cadastral
COBERTURA
maio / 2017

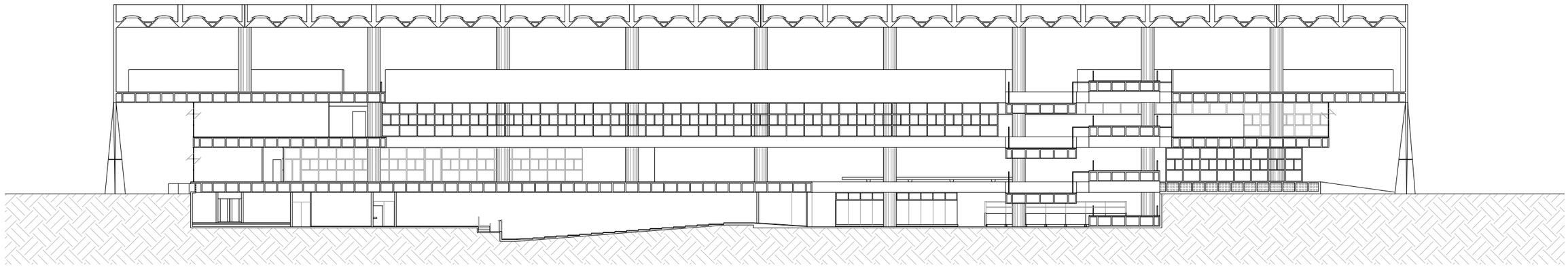
DESENHO
6/10

ESCALA
0 1 5 10

A-A and B-B cross sections



CORTE LONGITUDINAL A–A



CORTE LONGITUDINAL B–B

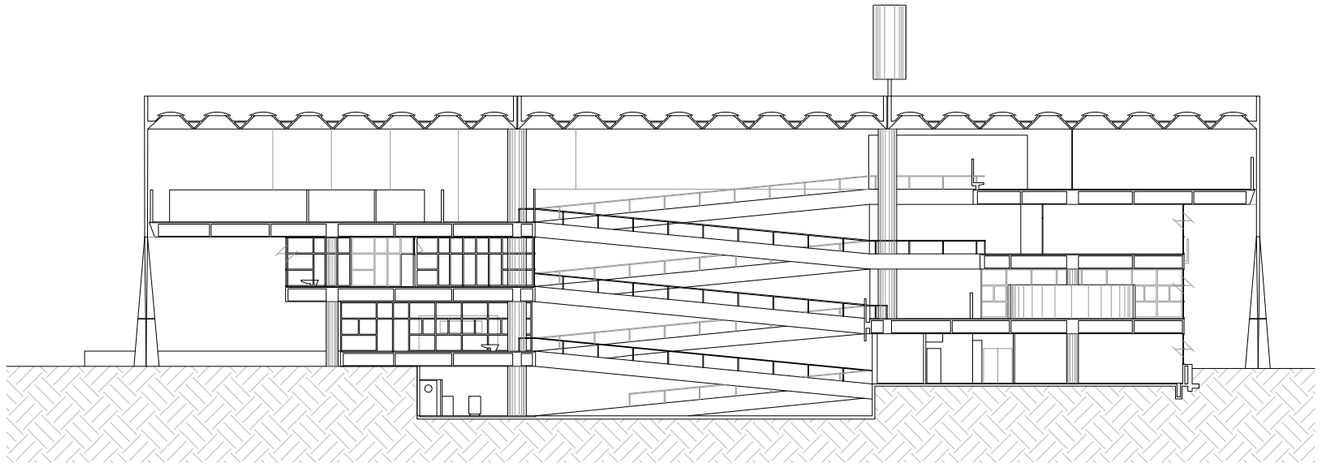
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento cadastral
CORTES A–A E B–B
maio / 2017

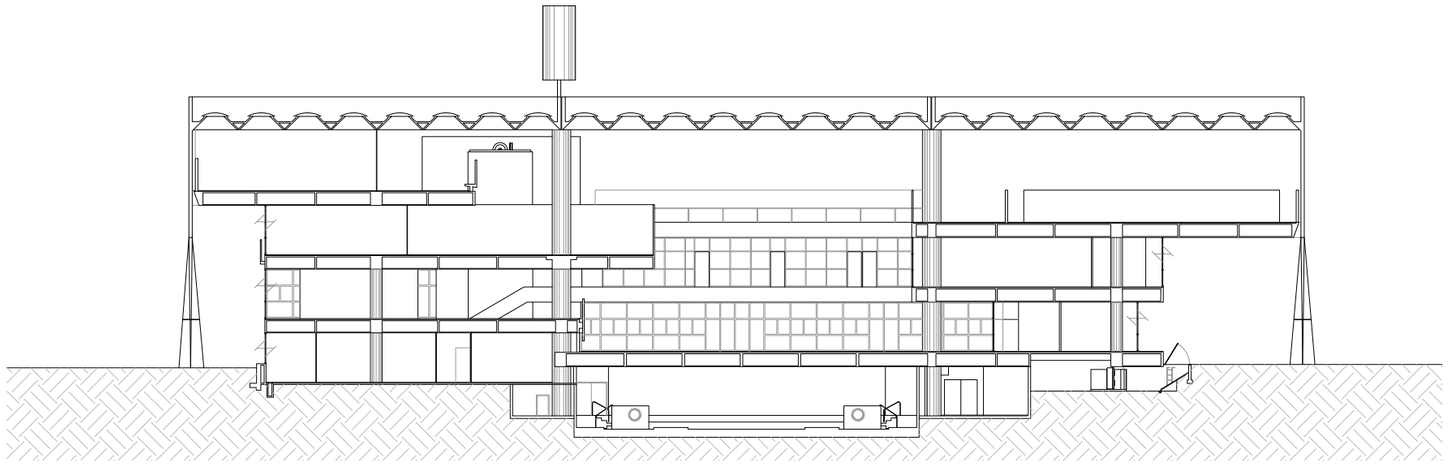
DESENHO
7/10

ESCALA
0 1 5 10

C-C and D-D cross sections



CORTE TRANSVERSAL C–C



CORTE TRANSVERSAL D–D

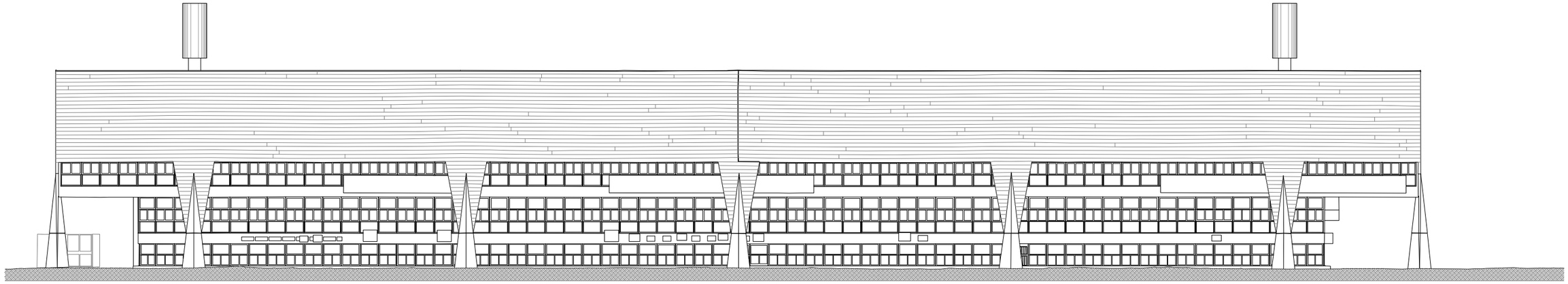
PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento cadastral
CORTES C–C E D–D
maio / 2017

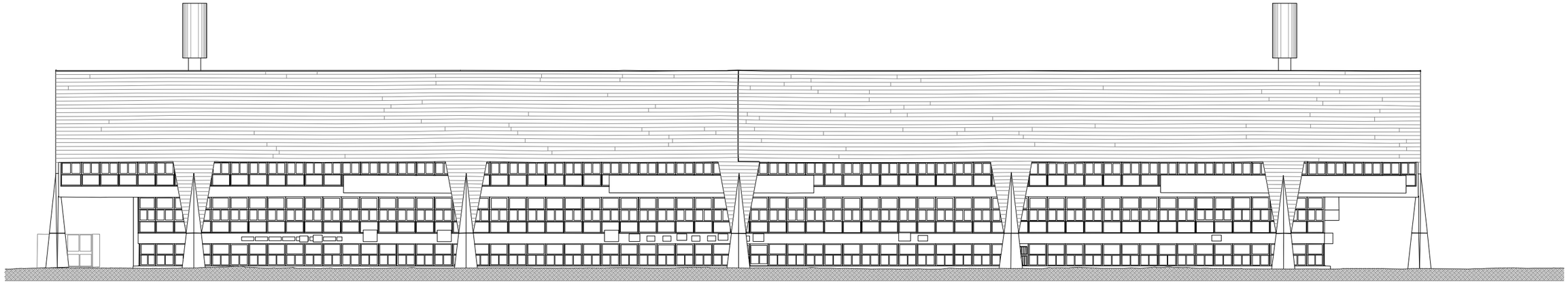
DESENHO
8/10

ESCALA
0 1 5 10

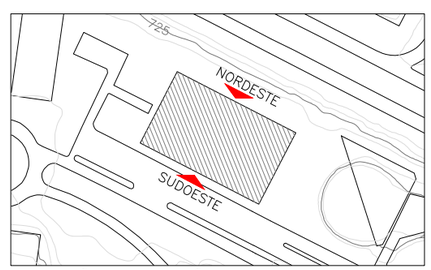
Southwest and Northeast Façades



ELEVAÇÃO 1 – FACHADA SUDOESTE



ELEVAÇÃO 2 – FACHADA NORDESTE



IMPLANTAÇÃO E LOCALIZAÇÃO
ESCALA 1:5000

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

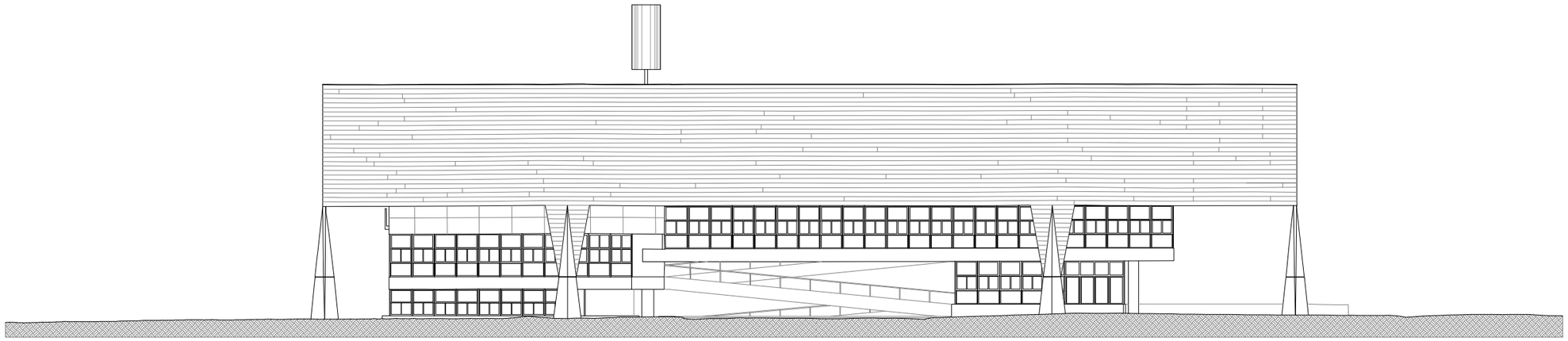
TÍTULO
Levantamento cadastral
FACHADAS SO E NE
maio / 2017

DESENHO
9/10

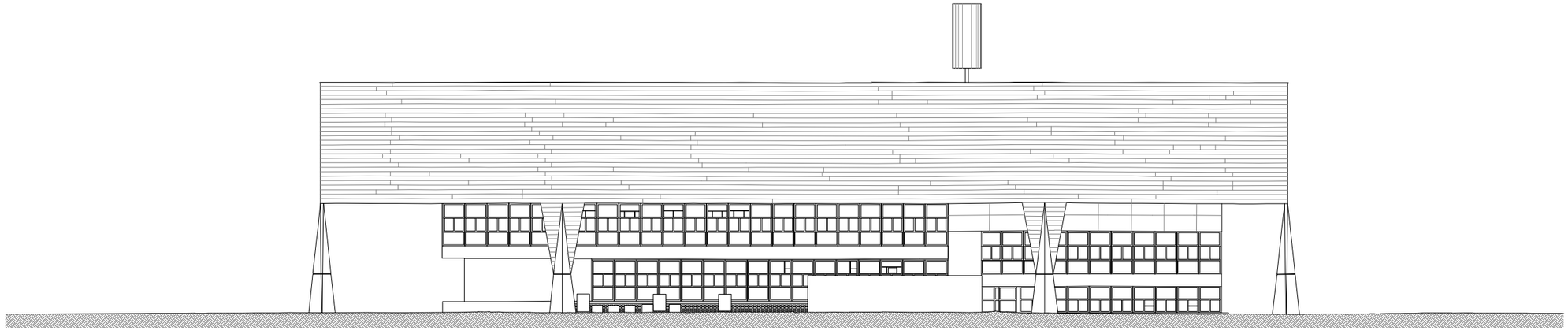
ESCALA
0 1 5 10

N

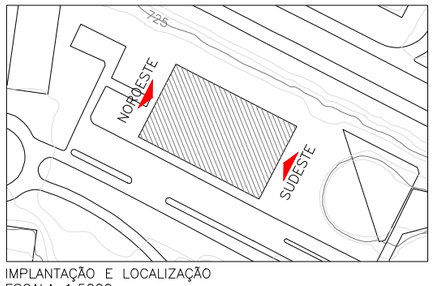
Northwest and Southeast Façades



ELEVAÇÃO 3 – FACHADA NOROESTE



ELEVAÇÃO 4 – FACHADA SUDESTE



IMPLANTAÇÃO E LOCALIZAÇÃO
ESCALA 1:5000

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento cadastral
FACHADAS NO E SE
maio / 2017

DESENHO
10/10

ESCALA

0 1 5 10

N

Photo: Clara Werneck, 2014.

1.4.

ANALYSES AND GUIDELINES

FAU's building is characterized by:

• Large and integrated Spaces (Figure 60);

• Permeability and transparency (Figure 61);

The architectonic concept of the building, with a major central void and the horizontal and vertical circulations surrounding such space, allows long views, crossing several spaces. The continuity of the roof reaffirms such relation between the spaces. The famous phrase by Artigas "*someone shouts inside the building will feel the responsibility for having interfered with the whole environment. Then, the individual is instructed, urbanized, achieve the team spirit*"[9]. This is exactly about this permeability between all the spaces.

• Clarity and rationality in the distribution of functions (zoning);

This visual permeability also allows to comprehending the occupations and uses. Spaces are clearly defined, in simple reading blocks and limits related to the circulation spaces. Over the years, many spaces were inadequately appropriated, such as the IA space or the expansion of the secretary office into the mezzanine. Some of those interventions were removed (such as the IA space), and others need to be tackled with a design.

• Clarity in the accesses and interconnection of the spaces (Figure 62): with perfectly perceivable horizontal and vertical circulations from the entrance; vertical circulations concentrated in two spatiality structuring hubs, making the interconnection between the floors: one by means of the ramps and the other through the open staircase associated to the elevator;

• The diversified way the natural light incidence occurs, adjusted according to the function: in the lower floors – laboratories, administration areas, get-together and exhibition area, library, departments – through window frames aligned in the perimeter of the building, allowing the natural light in; in the upper floors, intended to didactics (studios and classrooms), the blind façade has the role of physical and visual barrier in relation to the outdoors; the whole is illuminated by the roof structural grid with the domes, which also fulfill the metaphoric role of the sky, offering zenithal natural light during the day, and remaining dark at night (Figure 63).

• The rhythm articulated to modulation is present in all the elements, from the window frame to landscaping (Figure 64);

The structural rhythm of pillars and of the roof grid defines all the

[9] ARTIGAS, A função social do arquiteto, 1989: 101.

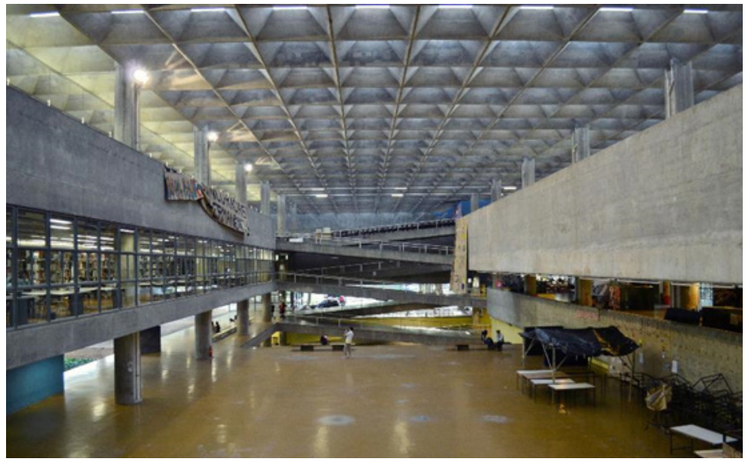


Figure 60 – View of the Caramel Hall and of the ramps of access to the floors. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

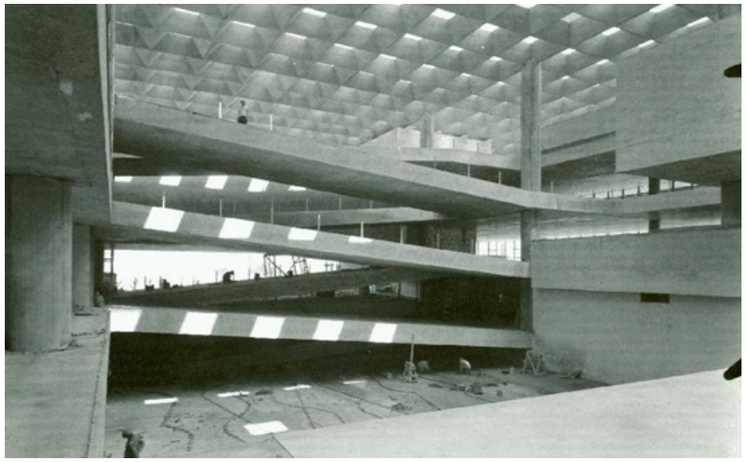


Figure 63 – Building with works: roof domes not yet installed. Photo: José Moscardi, 1968. Collection: FAUUSP Library.

Figure 61 – View of the Caramel Hall from the ramps, with the balcony on the background. Photo: José Moscardi, 1969. Collection: FAUUSP Library.

Figure 64 – Integration between the building outdoors and indoors, from the Caramel Hall. Photo: Nelson Kon, 2010.

Figure 62 – Ramps of access to the Museum and Departments floor from the Library. Photo: José Moscardi, 1969. Collection: FAUUSP Library.

Figure 65 – View of the Studios and part of the Library from the ramp of access to the classrooms floor. Date and author unknown. Collection: FAUUSP Library.

Figure 66 – Main access of the building and garden. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

Figure 67 – View of the main access and part of the garden, without direct illumination, and of the Caramel Hall and the library block, illuminated at night. Photo: Nelson Kon, 2010.

other closings, such as window frames and partition walls. The limits of the closed space area also directly related to the rigor of the structural modulation.

• The continuous circulation in all the half-levels, allowing the varied perception of the space in all the levels of the building (Figure 65);

• The relations between the indoors and the outdoors without the definition of clear boundaries (Figure 66);

The access to the building is not physically restricted. The access proposal is clear, from the staircase in the axe of the ramps, under the library. In the elevations -1.10, +0.80, +2.70, +4.60, and +6.50, the internal spaces are largely related to the outdoors, either to the parking lot, or to the garden of the slope of Av. Professor Luciano Gualberto. Along the trajectory in direction to the upper floors, this relation is reduced until the studios and classrooms floor, where the indoors-outdoors relation exclusively occurs through the roof grid.

• The relation with the great “pure” volume of concrete that comprises some areas with fragmentation; the way the illumination interferes with this reading: during the day, the natural lighting highlights the external volume and the internal area remains in the shade; at night, the major concrete blind façades disappear and reveal the internal spatiality (Figure 67);

Such essential characteristics were for times disrespected in the successive interventions the building has undergone. Only the common get-together/exhibition areas and the didactic spaces of the studios and classrooms have undergone minor interventions. The other spaces were significantly altered over the time (see item chronology of interventions) (Figures 68 to 76).

With the increased number of students in relation to those initially foreseen (originally 300, 750 in the course of Architecture and Urbanism, and 200 in the course of Design), and with the expressive number of teachers exclusively dedicated to teaching and research, in addition to the increasing complexity and multiplication of academic-administrative activities, there was a tendency to fragment some spaces, with the occupation of formerly free areas with collective activities (some of those interventions were then removed), and with the subversion of those principles that have guided the structuring of the building spaces.

Besides, the several transformations in the use of those spaces imposed by the increasing frequent use of digital technologies require to rethinking the organization of spaces and facilities. We are not saying that the building has no conditions to be adapted to the new teaching and research demands in architecture, urbanism and design; it is right the opposite, it is necessary to understand how such updates can be designed and done in consonance with the preservation of the building cultural values.

These successive interventions disturbing the reading of the building should be gradually tacked in the next few years, in the future interventions. The actions, as emphasized in the PDP, should be necessarily based on projects – understood as instruments prefiguring and controlling the intervention. Those projects should be preceded by multidisciplinary studies leading to a cognitive deepening and a precise diagnosis, so that the proposal, in addition to being consistent, is justified considering what motivates the preservation. Projects of intervention in cultural assets are always architecture projects. The designing process should be indissolubly connected to the acquisition of data and analysis, in order to articulate the different inputs from the various knowledge fields involved. Considering the diversity of problems, the building extension and the administrative complexity involved, it is not recommendable to think about the detailed design of a global intervention, but rather about a plan with general guidelines, with the definition of several steps to be gradually tackled in specific projects.

In addition to starting with the essential assumption that studies and designs should precede any intervention, this proposal is also based on the strong belief that careless interventions, aggressions to the materiality of the work and to its perception (such as graffiti, poorly resolved installations, unnecessary fragmentations of the space), speed up and amplify the process of subsequent neglects.

Such perception comes from empirically following up the transformations that are taking place in the School over the years – transformations now documented and systematized in a more orderly way in the following items – and it is supported by propositions and studies related to psycho-sociology[10].

Such pragmatic interventions should be understood within the scope of the modern architecture preservation. It is a relatively recent topic, with a production value recognized as cultural heritage not long ago, and of buildings frequently with programs of daily use, in this case, a school. Many times, the value of the building is only recognized because of its main formal characteristics: the big concrete box, the circulation, the caramel hall. There is though a negligence, or even a difficulty in deepening the reading, in the sense of recognizing other values as important as those above mentioned. The lack of clarity in the occupation of certain spaces, the lack of rationality in the installations, the lack of respect for the role of materiality in the perception of the building, which can also be seen in the profusion of graffiti, add to the lack of comprehension of a valued and public interest asset, leading to actions that can cause its deterioration. That way, the following analyses are intended to define guidelines for the rational occupation of spaces and their maintenance in good conditions.

---

[10] An example are the analyses by Kees Keizer, Siegwart Lindeberg and Linda Steg, (The spreading of disorder, <www.sciencemag.org> SCIENCE VOL 322 12 DECEMBER 2008), which manage to prove the evidence of Wilson and Kelling (BROKEN WINDOWS – 1982), the famous principle of the broken window, whereby every broken window not replaced is an invitation to throwing a stone on the window beside, and soon all the work will be in ruins. The proposal of Wilson and Kelling was criticized for not managing to conclusively prove the cause-effect relation (the first broken window that would result in subsequent damages). Keizer´s team expands the notion of “broken window” to the “diffusion of disorder”: those living in poorly kept spaces, in which several rules or laws are disrespected, tend to violate other types of law. The authors work based on the analyses of several situations comparisons, such as, for instance: in a place where graffiti is forbidden, the team made several graffiti (reversible and authorized) beside the sign saying ‘graffiti forbidden’; then the team leaves leaflets in the bicycles near that place. The number of people throwing the leaflets on the ground instead of in the trash increases. In the condition without graffiti, 33% of them throw the leaflet on the ground; in the situation with graffiti, this number soars to 69%.

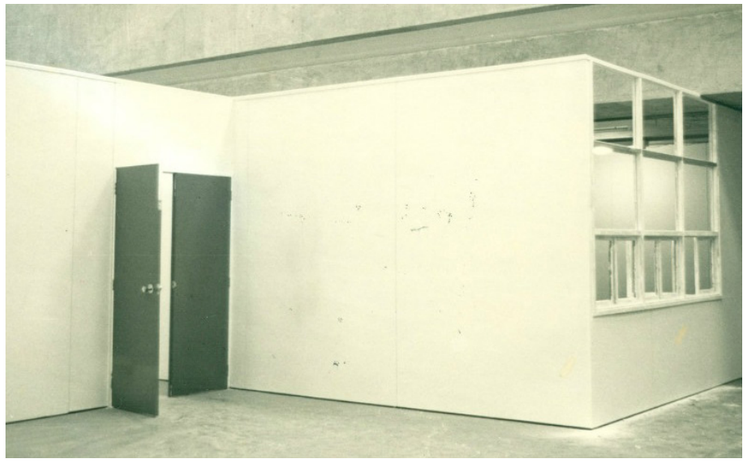


Figure 68 – Installation of partition walls of the Design Department in the Interdepartmental Atelier. Date and author unknown. Collection: SEF-USP.

Figure 71 – Upper view of the Interdepartmental Atelier in three moments after the building inauguration. Author and date unknown. Collection: FAUUSP Library.

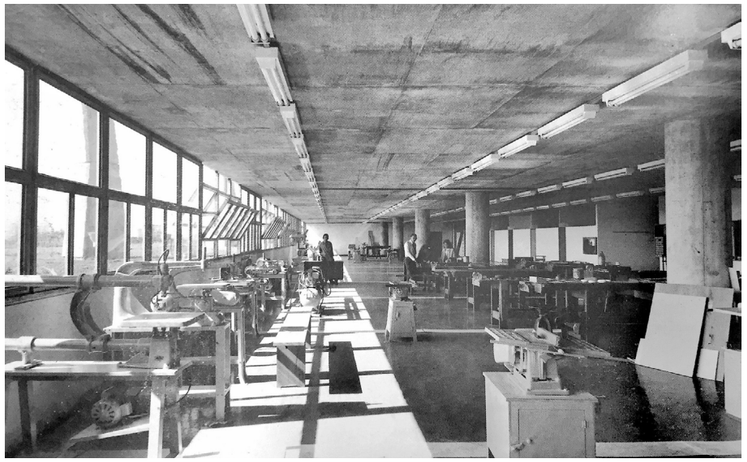


Figure 74 – View of the laboratory of scale models and mockups. Photo: José Moscardi, unknown date. Collection: FAUUSP Library.

Figure 69 – Part of the Design Department occupying the area of the Interdepartmental Atelier. Unknown author, April 2009. Collection: GEEF-FAU.

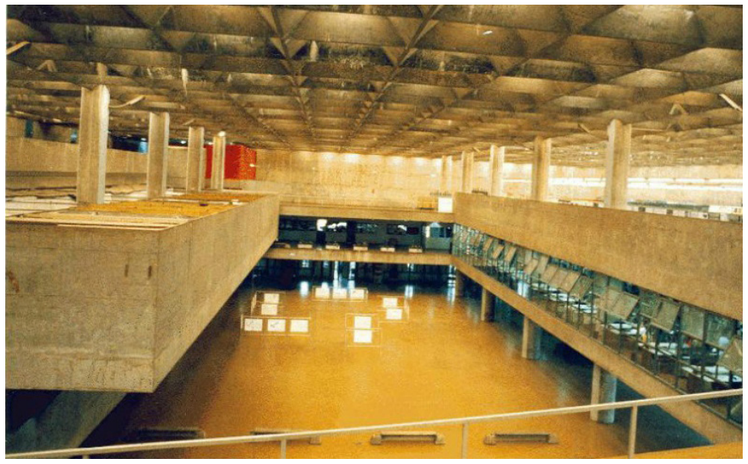


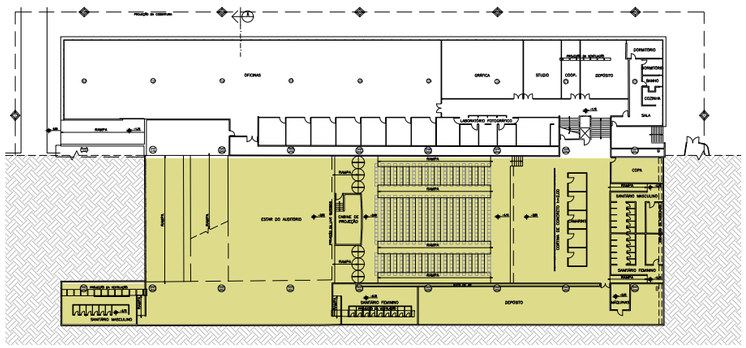
Figure 72 – Occupation of the Departments and research laboratories in the area of the Interdepartmental Atelier. Date and author unknown. Collection: FAUUSP Library.

Figure 75 – Corridor and research laboratories throughout the whole floor of the old workshops. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

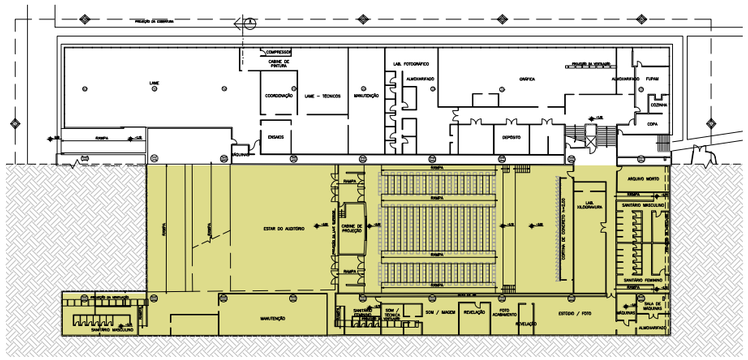
Figure 70 – Partition wall of the departments recessed after the 2010 renovation. Photo: Renata Cima Campiotto, June 2016. Collection: Conserva FAU Team.

Figure 73 – Interdepartmental Atelier after the renovation of departments in 2010. Photo: Renata Cima Campiotto, June 2016. Collection: Conserva FAU Team.

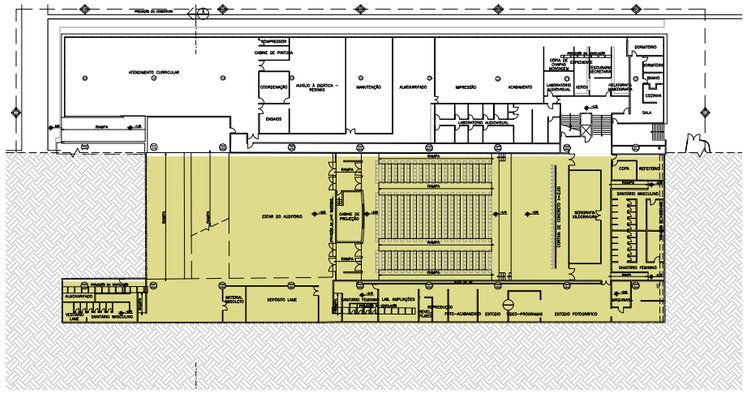
Figure 76 – Corridor and research laboratories throughout the whole floor of the old workshops. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.



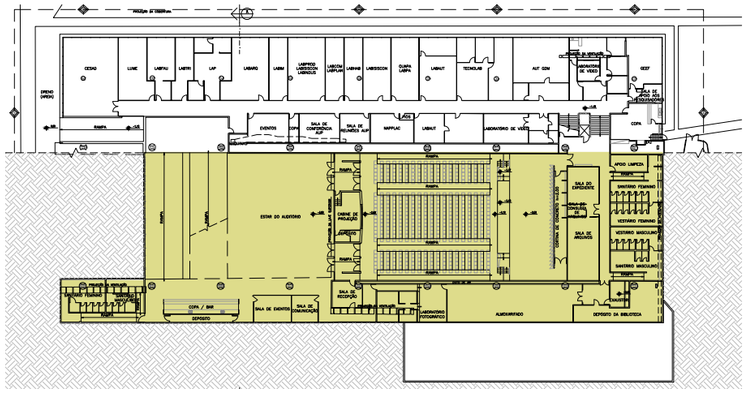
1969, inauguration



1980's



1990's



2016

At elevation – 3.00

• It is the lowest level of the building, being the only one from which it is possible to see all the levels of the School at once;

• It concentrates all the most public activities, because of the use of the Ariosto Mila auditorium. It can be noticed because of the flooring treatment of the area in front of the auditorium, in Portuguese mosaic, the same type of flooring used at elevation +0.80 (access to the building) in the areas of the interface between outdoors and indoors; that is, it is characterized as a public square.

• Over the years, some administration (Commission of Culture and Extension) and students support functions (Commission of International Cooperation) were installed in the free area in front of the auditorium, in light and theoretically provisional structures, to meet the important and increasing demands of such programs for the School;

• Due to the increasing growth of the library and design collections of the School, there is a proposal to transferring part of such collections to a more adequate place, since they are currently in a place with too much humidity and limited ventilation.

Guidelines

•To keep strictly free those spaces conceived as such;

• To adjust the service areas to fulfilling the function of deposit and support in an adequate way, promoting the control of environmental conditions considering the use to be developed in the place, and ensuring the safety and security of users and assets;

• To structure, in the medium and long runs, a building annexed to the Library, which can shelter the increasing expansion of the bibliographic, iconographic and design collections under proper conditions, and also of the necessary specialized services (such as sanitization, conservation and digitalization of the collection) in an efficient way;

• Since the space is characterized by the clarity and rationality in the distribution of functions (zoning), to remove the administration and students support functions and reallocate them in the pertinent levels (see elevation +4.80);

• To design the services of support to the use of the auditorium following general guidelines;

• The auditorium could undergo an intervention aiming to update its infrastructure so that it has better quality equipment to better serve the several activities that might take place.

Figure 77 – Foyer of the auditorium after the building inauguration and before the renovation in the 1980s. Author and date unknown. Collection: FAUUSP Library.

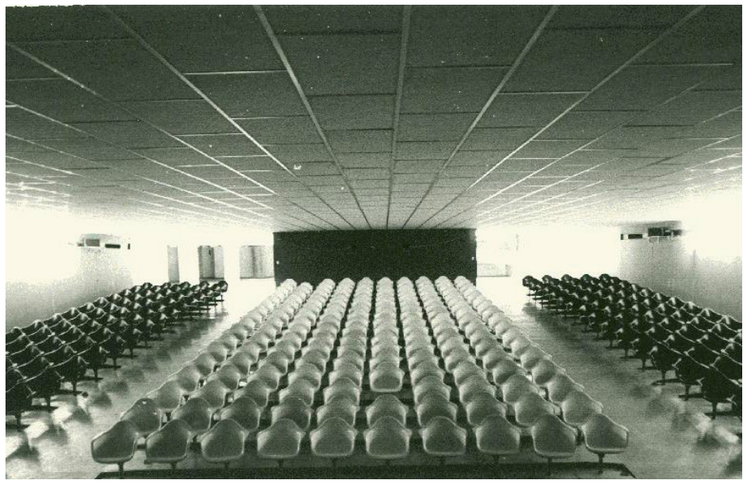


Figure 78 – View of the auditorium audience, with fiberglass chairs, before the renovation in the 1980s. Author and date unknown. Collection: FAUUSP Library.

Figure 79 – Foyer of the auditorium occupied by administrative rooms, such as of the International Cooperation Commission. Photo: Ana Paula Arato, July 2016. Collection: Conserva FAU Team.

Figure 80 – Foyer of the auditorium during an exhibition. Photo: Renata Cima Campiotto, March 2016. Collection: Conserva FAU Team.

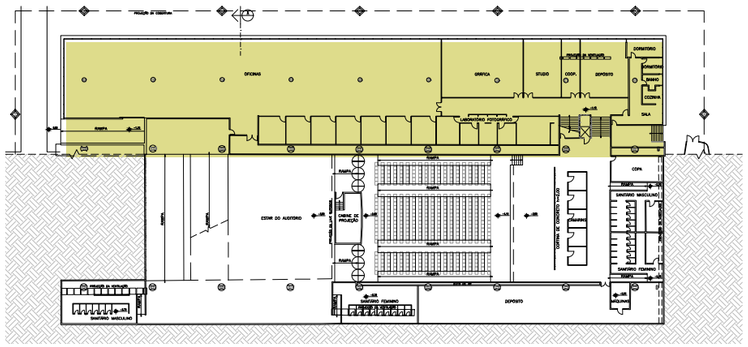
Figure 81 – View of the auditorium audience from the stage after acoustic renovations. Photo: Renata Cima Campiotto, March 2016. Collection: Conserva FAU Team.

Figure 82 – Warehouse of the building. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

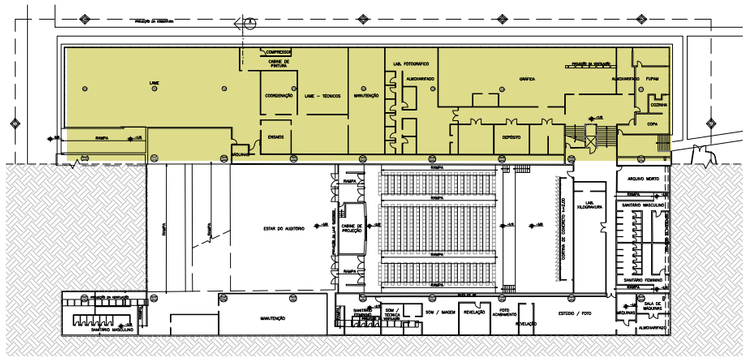
Figure 83 – Foyer of the auditorium occupied by administrative rooms, such as of the International Cooperation Commission. Photo: Ana Paula Arato, July 2016. Collection: Conserva FAU Team.

Figure 84 – Warehouse of the building. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

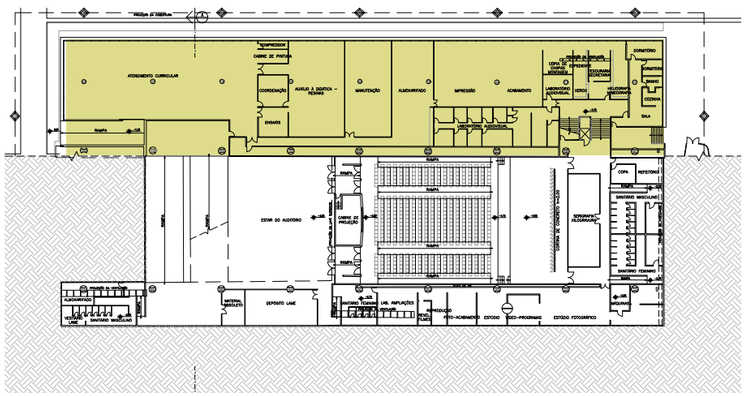
Figure 85 – Foyer of the auditorium during an exhibition. Photo: Renata Cima Campiotto, March 2016. Collection: Conserva FAU Team.



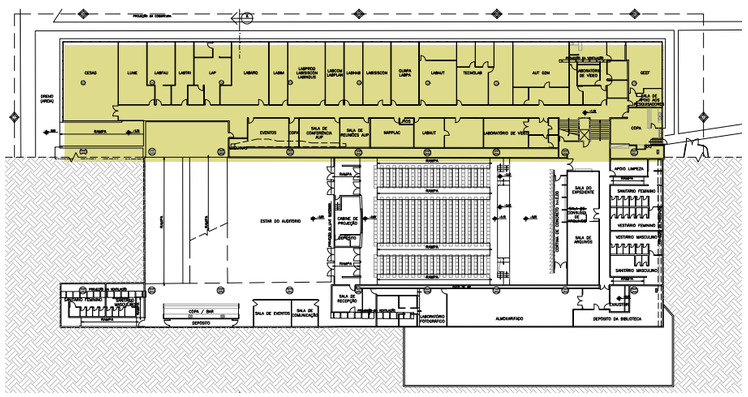
1969, inauguration



1980's



1990's



2016

At elevation – 1.10

• Transformation of the former workshop space – such as the scale model workshop and the audiovisual laboratory, transferred to the annexed building in 1997, - into research laboratories, creating an excessively fragmented space that prevents the perception of its composition;

• The lack of centralized management of the spaces intended to research ends up by creating fragmented and unused spaces. Research projects are dynamic, with teams, flows and periodicities that depend on the characteristics, financing and stage of development of the several researches in progress. In this regard, the space where laboratories are now installed would have full conditions to meet the demands and be modified at each new situation, provided that it was conceived as a design that fulfilled the guidelines below;

• The space of laboratories, as it is configured, is static and does not properly absorb the dynamicity of the investigations in progress; it also creates problems because of the impossibility of fully using such space, and because of the assumption that the demand for spaces is higher than the offer;

• The irrational profusion of air conditioners in the Northeast façade, installed by several research laboratories, without a unifying design, frequently damaging structural elements of the building and changing the image of such façade;

• The logics and data network infrastructure precariously done, meeting immediate demands. In addition to the fragility of the system itself, with loss of functioning quality.

Guidelines

• To keep the spaces as flexible as possible, concentrating the archive area far from the window frames, keeping the working areas open and dynamic according to the possibilities (Figure 77);

• To always keep free the communication between the ramp and staircases, as an unobstructed circulation gallery (Figure 78);

• To search for such goals, concomitantly ensuring the safety and security of assets and users: that is, the permeability of the space shall be pondered along with safety and security issues, with the locking and inviolability of window frames, confined spaces, alarms, movement detectors;

• To rationalize systems and infrastructure based on a design developed in articulation with the architecture design: electrical, data network, air conditioning, alarms, detectors, etc.

LEVANTAMENTO - SITUAÇÃO EXISTENTE
escala 1:50

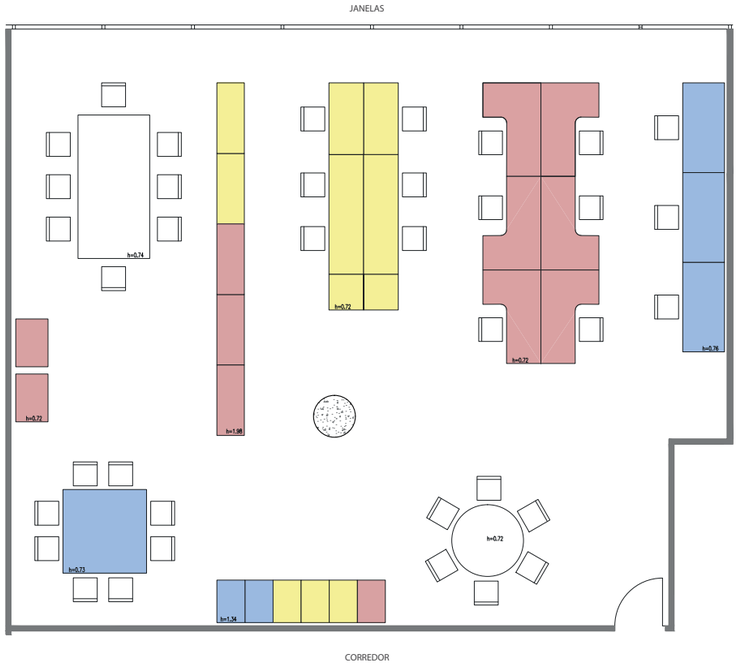
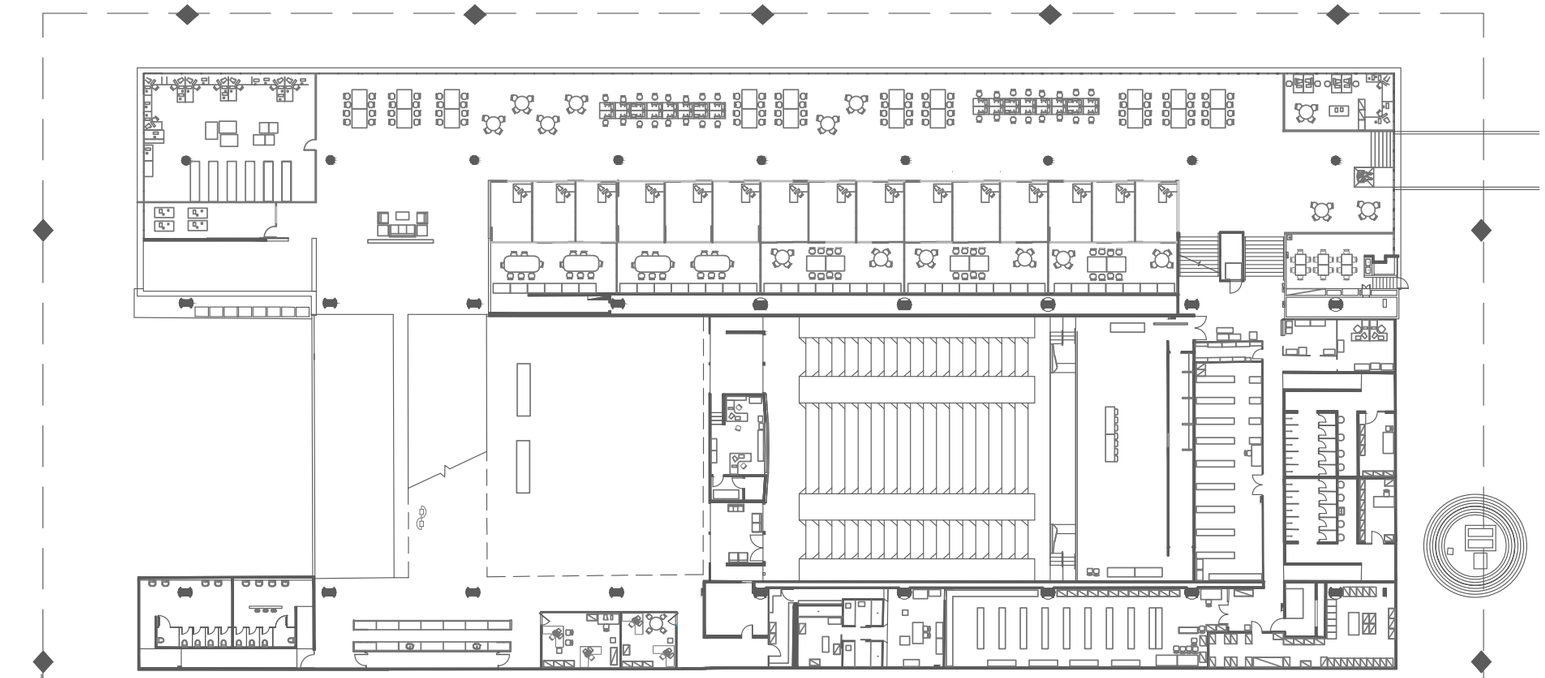


Figure 86 – Survey of the LUME, LABARQ and LABTRI laboratories, of the History Department, and proposal to integrate the laboratories, according to the occupation guideline: flexible space, archives distant from the window frames, and open and dynamic work areas.



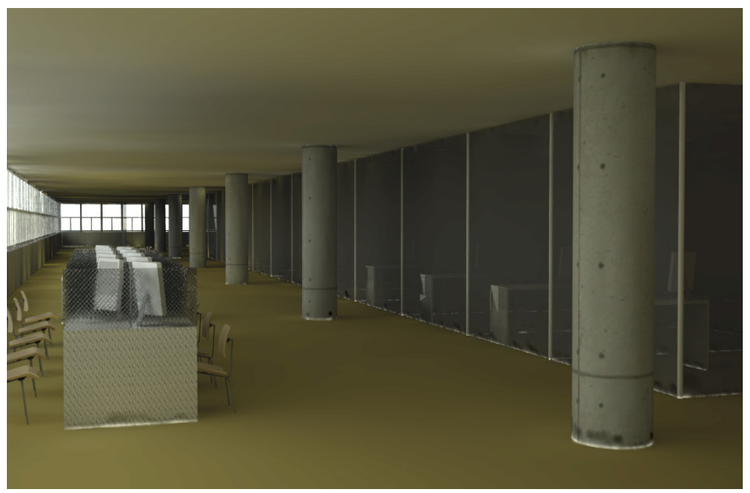
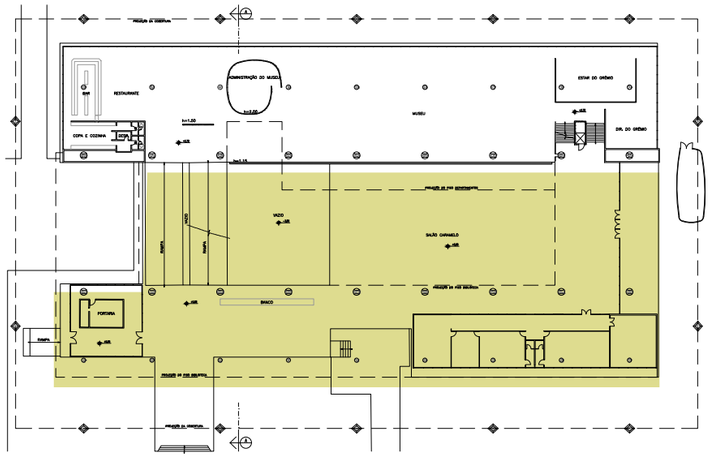
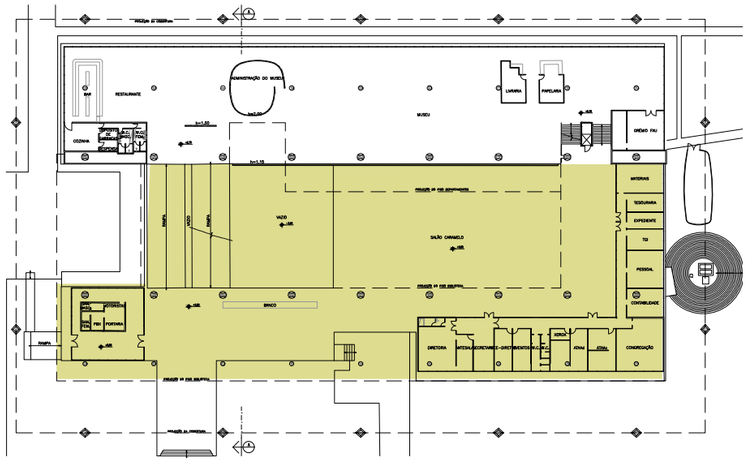


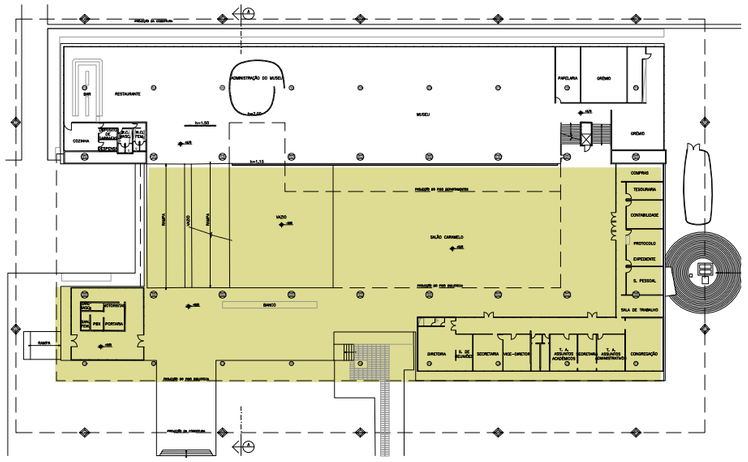
Figure 87 – Example of our design proposal for the laboratories floor elaborated by the students of the interdepartmental subject 1601105 “Investigative and Design Subsidies for the Preservation of the Constructed Heritage” Bárbara Morais, Mariana Vetrone and Susan Ritschel, in 2013. It is a possibility of the floor occupation, based on actual utilization demands, complying with the guidelines presented here.



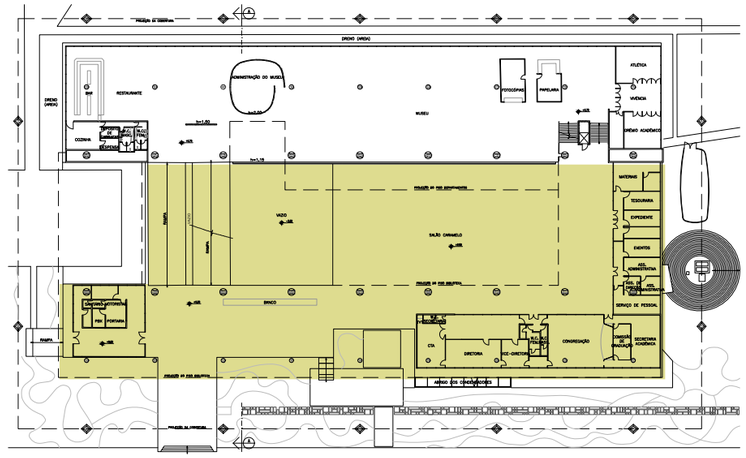
1969, inauguration



1980's



1990's



2016

At elevation +0.80

• The occupation of the caramel hall terrace by administrative functions, creating a visual obstacle/breaking the visual continuity between the caramel hall and the external area; in this floor, at the face oriented to outside, there are replicas of the window frames (some even made of wood) that change the perception of the original spatiality;

• Interventions in the administrative area with the implementation of glass and masonry partition walls have little impact on the perception of the building as a whole. However, it is recommendable that such actions follow a pattern of dialogue with the building, for each and every intervention in the building;

• The difference of level from elevation 0.00 to +0.80 was overcome by the main access staircase and by another masonry one beside the administration. In view of accessibility issues, it should be considered how to properly solve this situation.

Guidelines

• Given that such occupation by administration areas occurred long ago, it became part of the building perception, and given the lack of perspective for the construction of other areas to absorb such functions, in future transformations, better ways to use the space should be search ford to allow the higher possible visual permeability;

• To rationalize systems and infrastructure based on a design developed in articulation with the architecture design: electrical, data network, air conditioning, alarms, detectors, etc.

Figure 88 – Financial department room that occupies part of the old balcony connected to the Caramel Hall. Photo: Ana Paula Arato, July 2016. Collection: Conserva FAU Team.

Figure 89 – Vice-director room, with salmon color walls. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

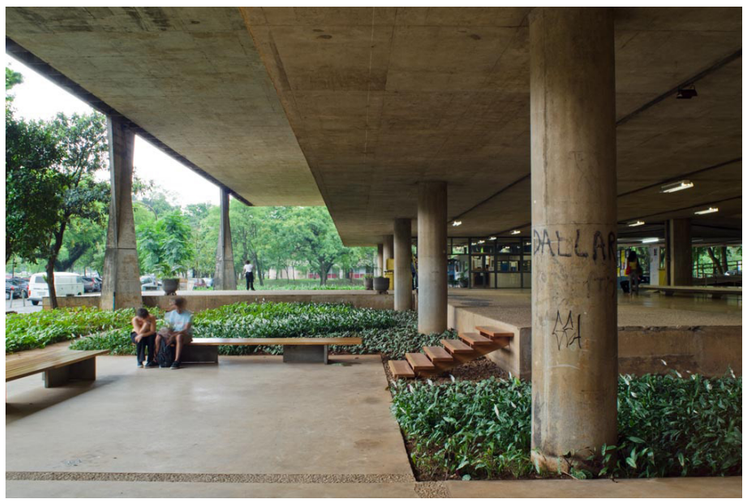


Figure 90 – Part of the garden at elevation 0.00. Lateral access staircase replaced by a wooden staircase. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

Figure 91 – Lateral access to the building through the Caramel Hall. Photo: Ana Paula Arato, July 2016. Collection: Conserva FAU Team.

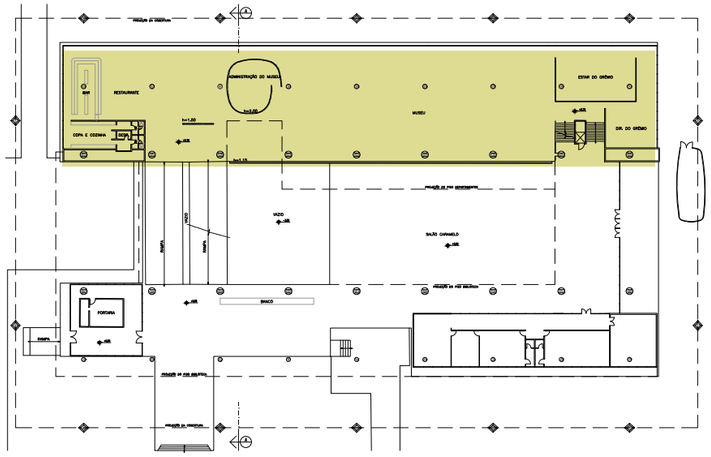
Figure 92 – Arrival and welcome space of the building: Reception and “newcomers bench”. Photo: Ana Paula Arato, July 2016. Collection: Conserva FAU Team.

Figure 93 – View to the Caramel Hall from the lateral access to the building. Photo: Ana Paula Arato, July 2016. Collection: Conserva FAU Team.

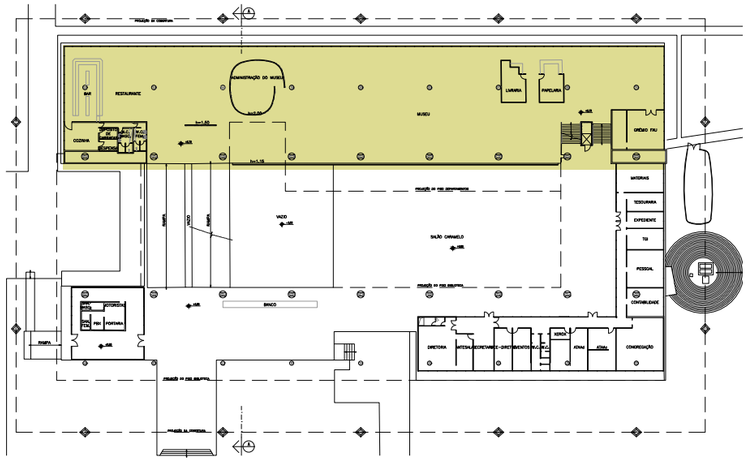
Figure 94 – Block of the administration rooms next to the Caramel Hall. Above, the Library block. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

Figure 95 – Transparent partition walls of the administration rooms installed in the old balcony. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.

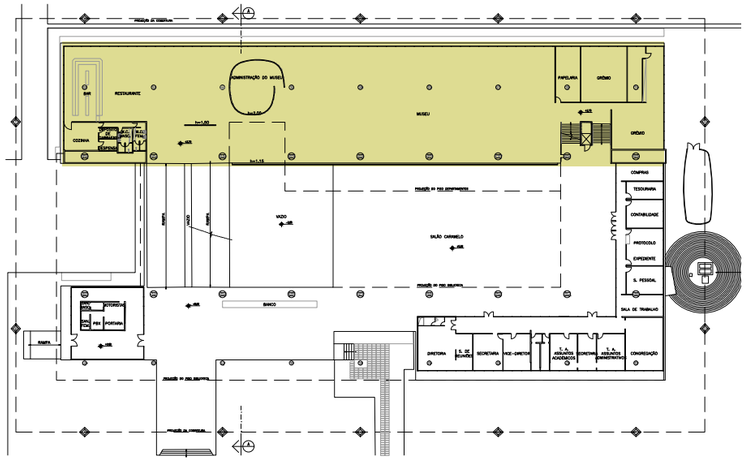
Figure 96 – Interdepartmental Atelier Block on the Caramel Hall. To the right, access to the staircase and elevator. Photo: Renata Cima Campiotto, July 2016. Collection: Conserva FAU Team.



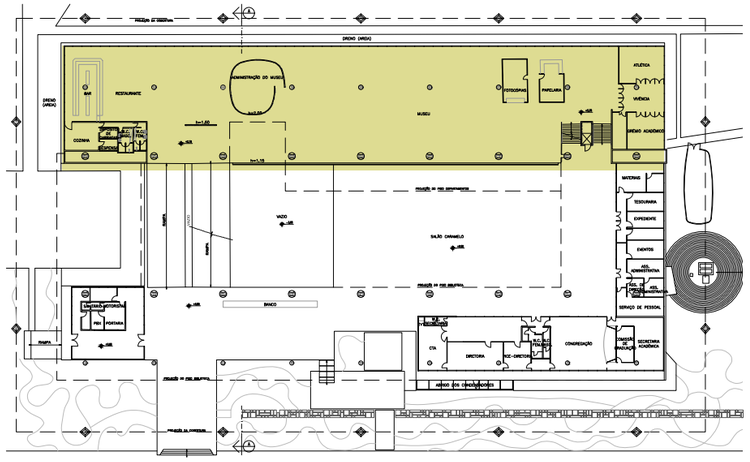
1969, inauguration



1980's



1990's



2016

At elevation +2.70

• The "Museum Floor" was historically managed by the students, and went through several transformations over the years;

• It is a central space for the expression and manifestation of the school life, managed by the students themselves;

• It is also a public space, concentrating several functions intended to a broader public, such as the cafeteria, photocopying service, book shop, paper shop;

• Therefore, students are not the only ones interested in its use, because all the FAU´s community get together there – students, technical-administrative staff, and teachers – and also outside visitors;

• For having large free spaces, it allows several appropriations, according to the need.

Guidelines

• To keep the visual permeability of the floor, including the staircase slope;

• To build, for all the supporting functions – paper shop, photocopying service, bookshop, etc. – light and reversible structures that respect the visual permeability;

• To solve the functional issues related to the cafeteria – supply, garbage removal, etc. – complying with the rules in force regarding hygiene and safety, and respecting the area historically occupied by the cafeteria and the configuration of such space.

Figure 97 – Tables and chairs of the cafeteria in the Museum Floor. Photo: José Moscardi, 1969. Collection: FAUUSP Library.

Figure 98 – Exhibition in the Museum Floor. Unknown author, 1972. Collection: FAUUSP Library.

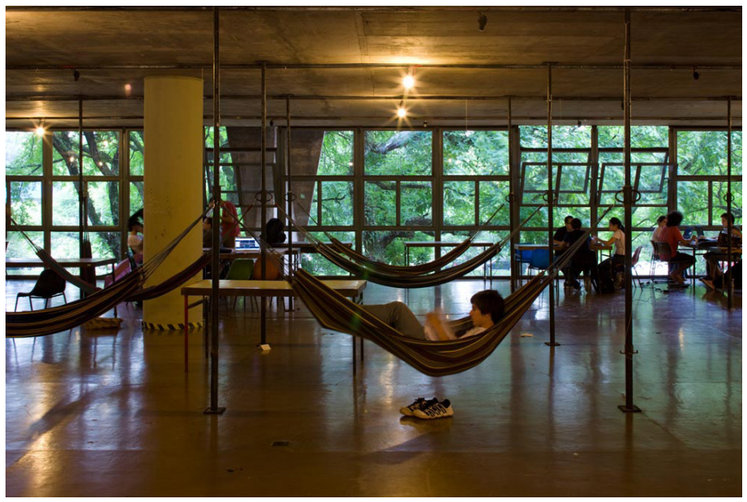
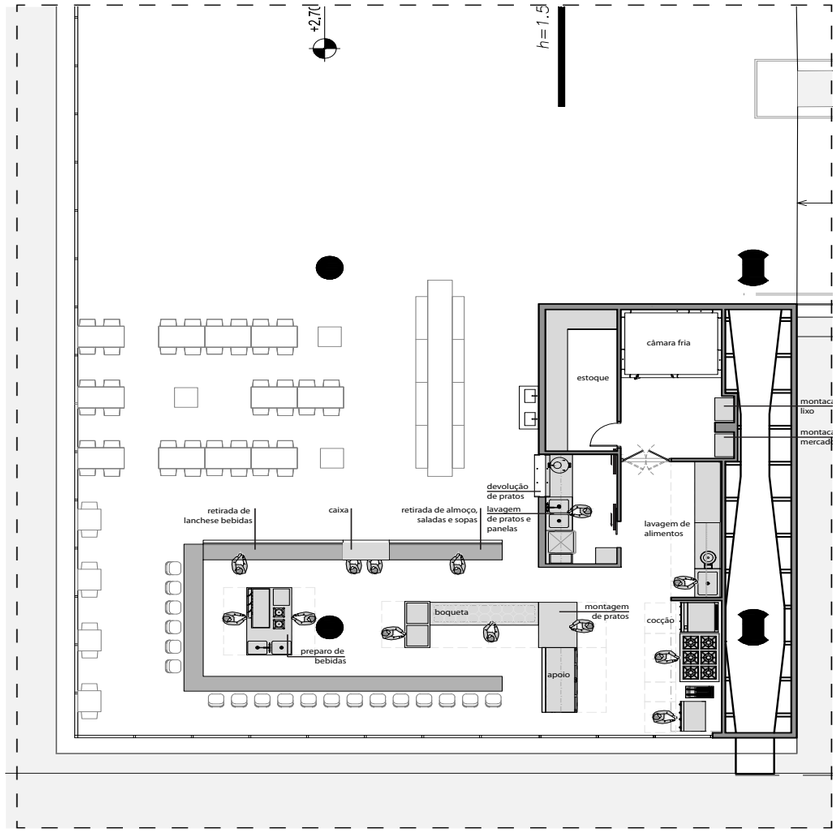
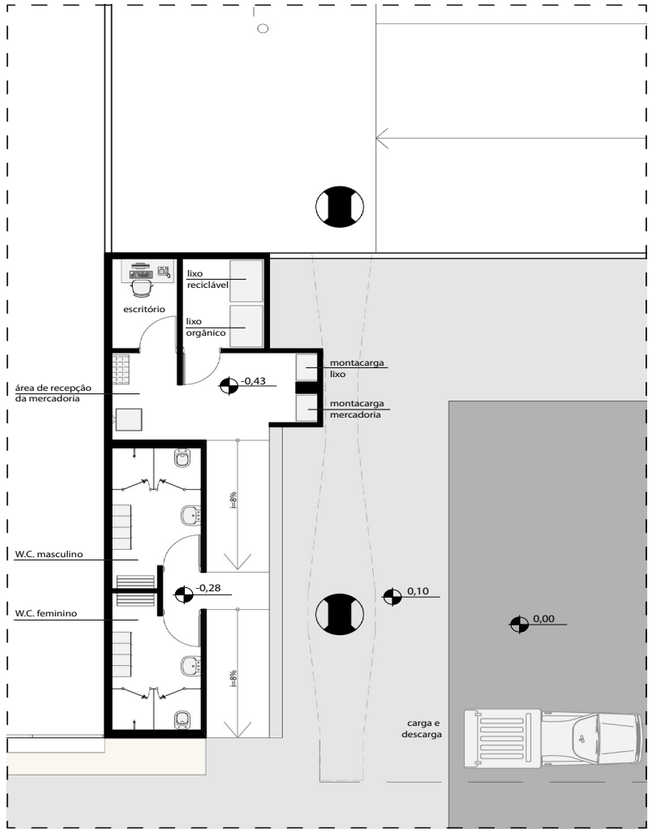


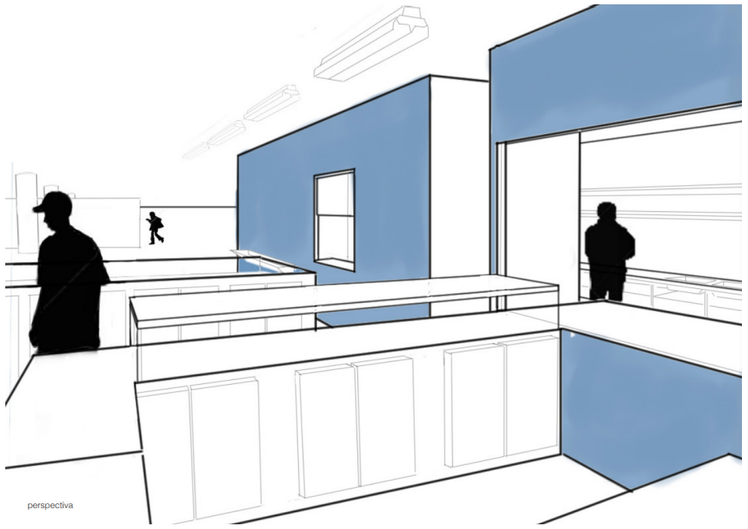
Figure 99 – Nets installed in the Museum Floor. Nelson Kon, 2010.



planta 1º pav. - esc1:100



planta térreo - esc1:100



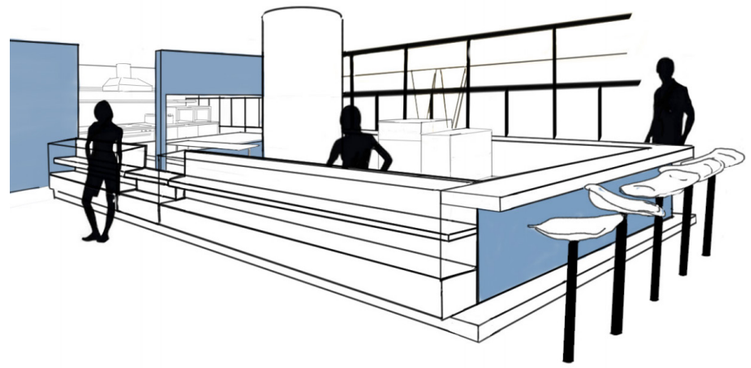
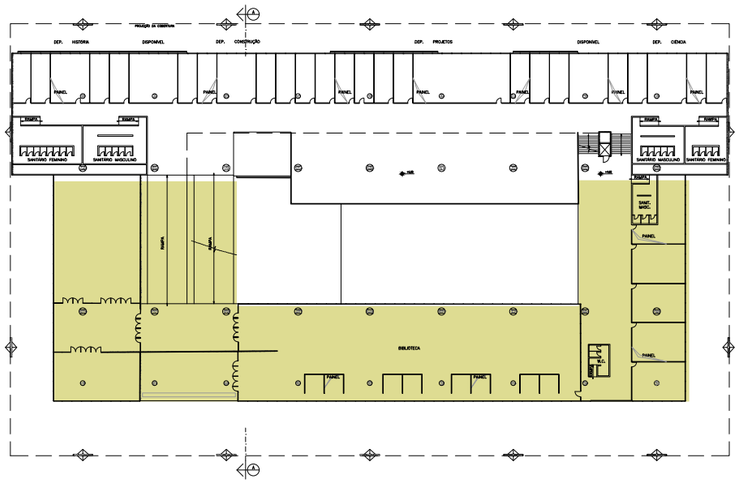
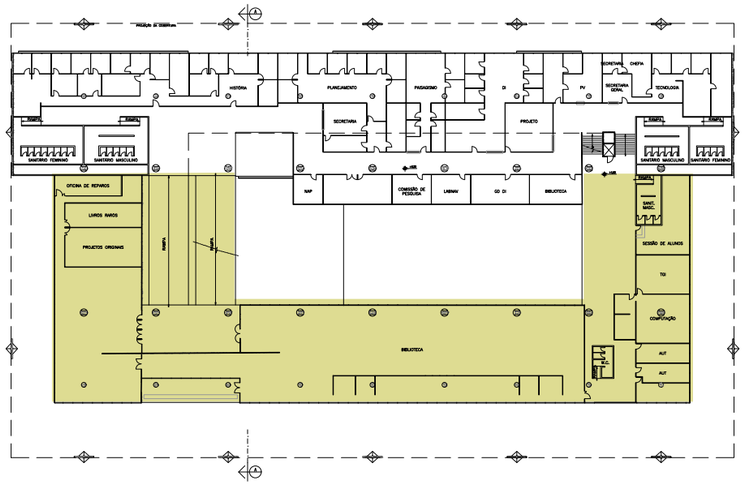


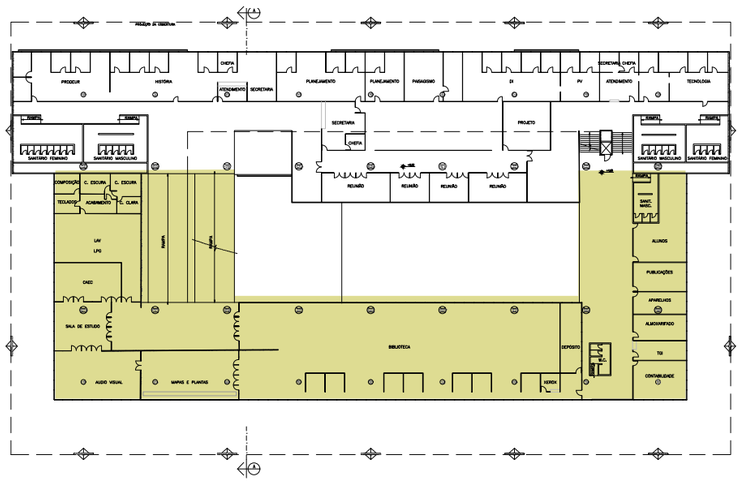
Figure 100 – Example of our design proposal for the laboratories floor elaborated by the students of the interdepartmental subject 1601105 “Investigative and Design Subsidies for the Preservation of the Constructed Heritage” Anna Pancini, Beatriz Carolina de Souza and Karina Loekmanwidjaja, in 2014. It is a possibility of the floor occupation, based on actual utilization demands, complying with the guidelines presented here.



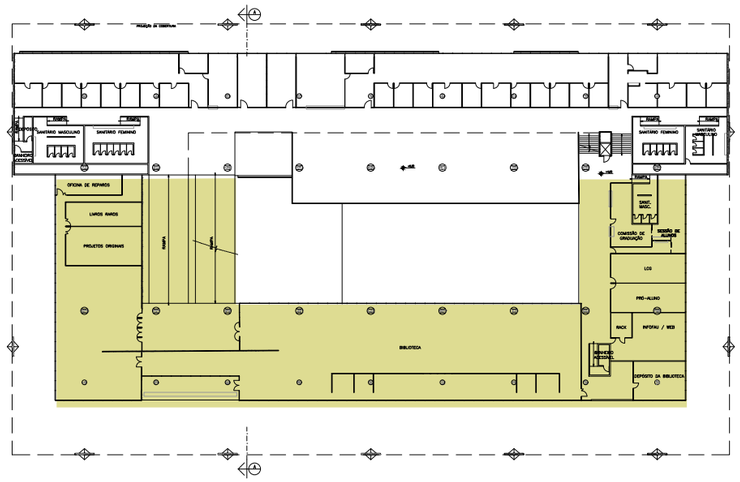
1969, inauguration



1980's



1990's



2016

At elevation +4.60

• On the floor, there was the volumetric unification of the stretch that connects the library to the space formerly intended for the congregation – now iconographic section, repair workshop and rare books collection of the library; by using a replica of the original window frames, elements before different are united. Especially on the wall that finalizes the ramp and that articulates what were two clear volumes before: buildings inside the building, one of the emblematic characteristics of the spatiality of FAU;

• In the mezzanine, there is a lack of rationality in the distribution of spaces for the secretary offices intended to serve the undergraduate students, as well as the underutilization of certain areas. There is also an important lack of alignment of the secretary offices perimeter with the staircase.

Guidelines

• To set the limit for the closing of the secretary offices space in the mezzanine, aligning it with the staircase; to set the closing pattern;

• To use a system of light partition walls, varying depending on the function and permeability need, mentioned before, to be implemented in the entire School;

• To respect the consolidated space of the library; in future interventions, to think about the possibility of favoring the reading with two volumes with more autonomy.

• To develop, according to the institutional plan for the collection expansion, the design of the annexed building so that it can receive certain specialized functions of the Library, though keeping a significant part of its collection in the Vilanova Artigas Building.

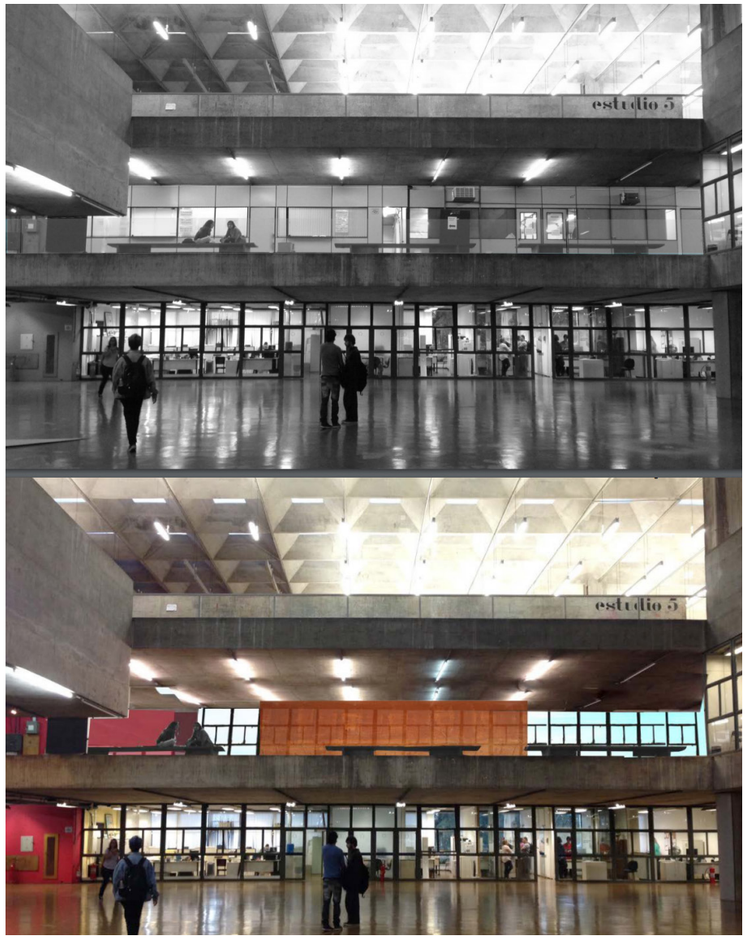


Figure 101 – Comparison between the current condition and the design proposal for the mezzanine reorganization. Design elaborated by the students of the interdepartmental subject 1601105 “Investigative and Design Subsidies for the Preservation of the Constructed Heritage” Julia Galves, Leila Tanaami and Thomas Pesce, in 2014. It is a possibility of the floor occupation, based on actual utilization demands, complying with the guidelines presented here.

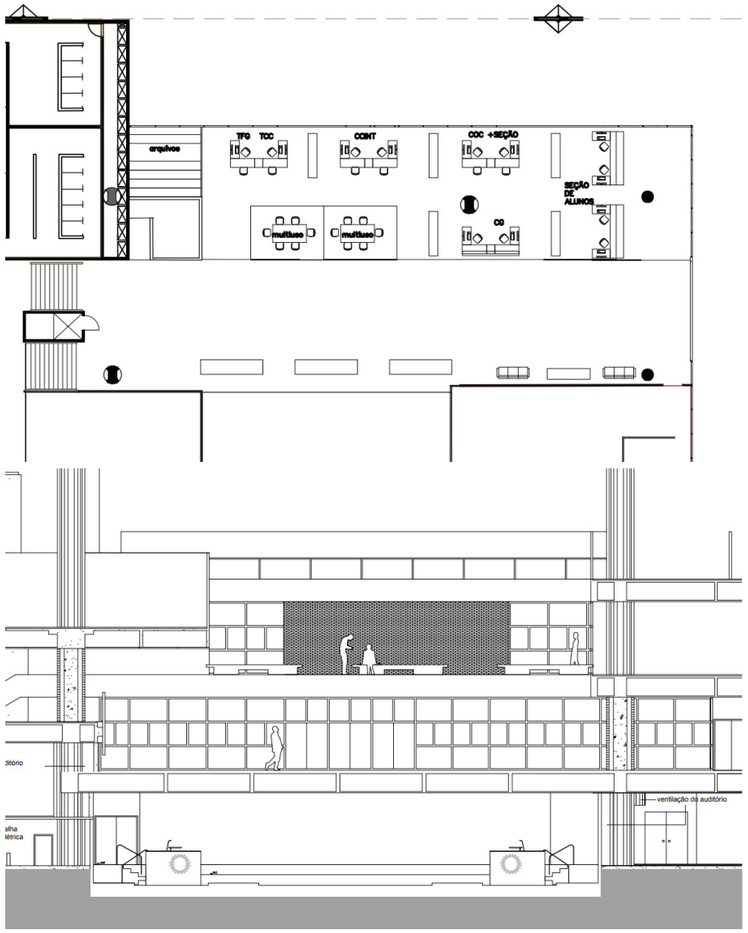


Figure 103 – Example of the design proposal for the reorganization of the mezzanine, with the allocation of all students support functions in the floor, based on the study of the actual demand for such area. Design elaborated by the students of the interdepartmental subject 1601105 “Investigative and Design Subsidies for the Preservation of the Constructed Heritage” Julia Galves, Leila Tanaami and Thomas Pesce, in 2014.

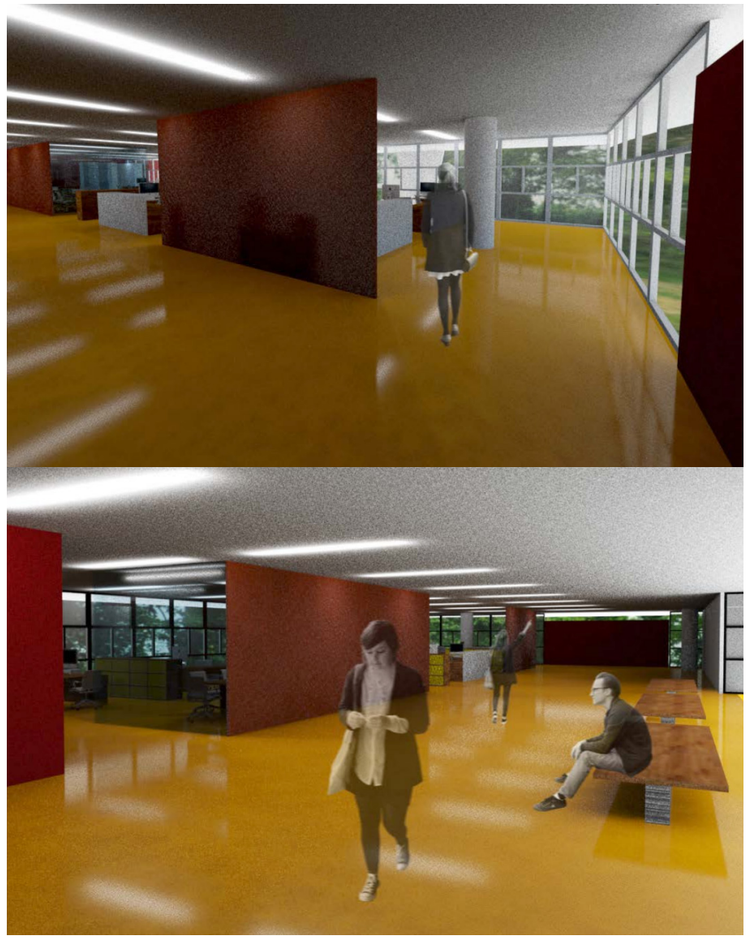


Figure 105 – Example of the design proposal for the reorganization of the mezzanine, with the allocation of all students support functions in the floor, based on the study of the actual demand for such area. Design elaborated by the students of the interdepartmental subject 1601105 “Investigative and Design Subsidies for the Preservation of the Constructed Heritage” Julia Galves, Leila Tanaami and Thomas Pesce, in 2014.

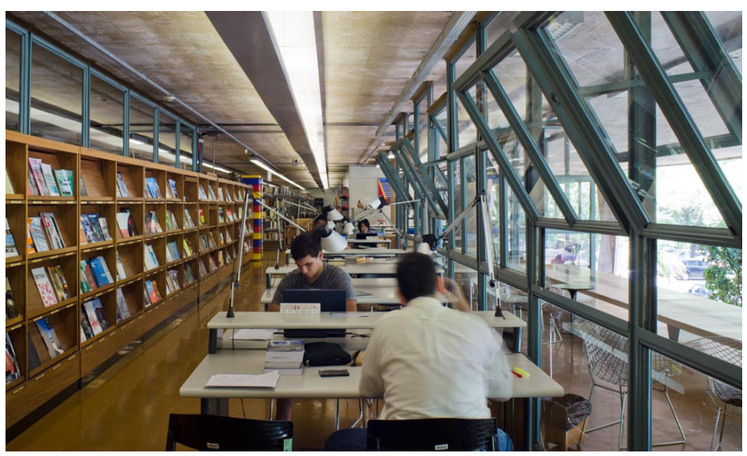


Figure 102 – Stretch of the library spaces unification, where magazines and periodicals are exposed. To the right, the balcony. Nelson Kon, 2010.

Figure 104 – Level between the ramps, in front of the main access to the library. Photo: Renata Cima Campiotto, June 2016. Collection: Conserva FAU Team.

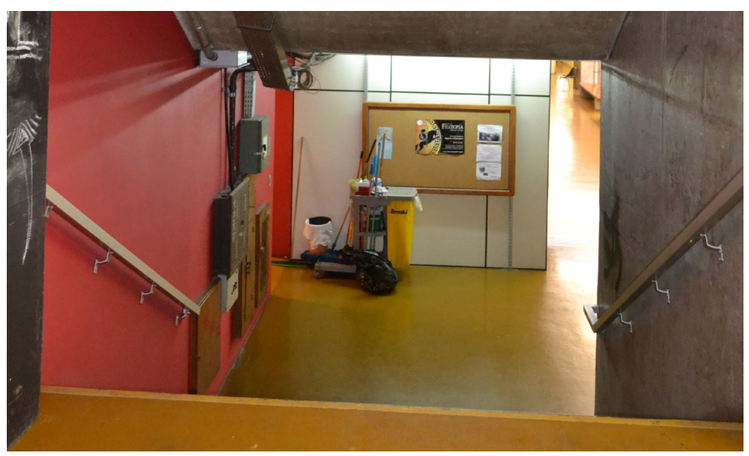
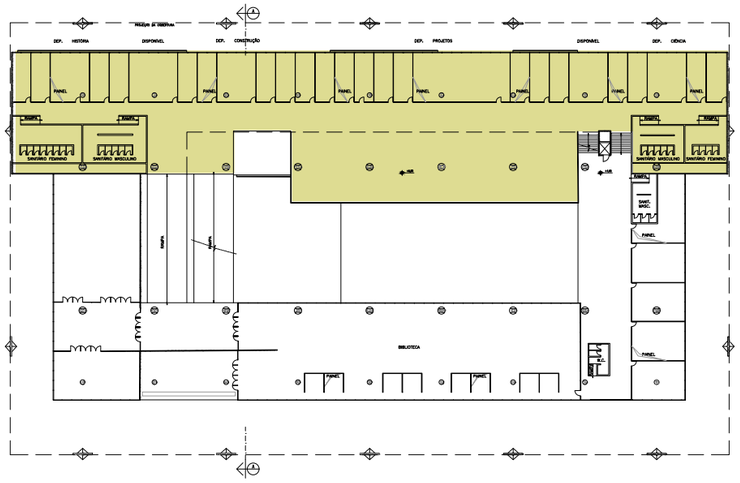
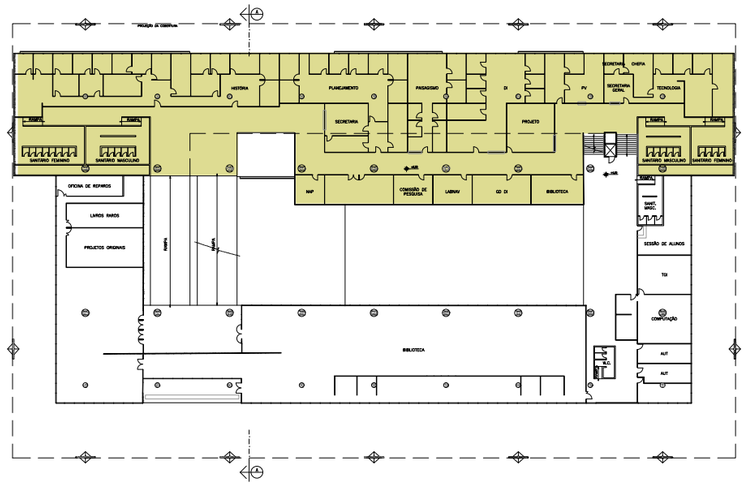


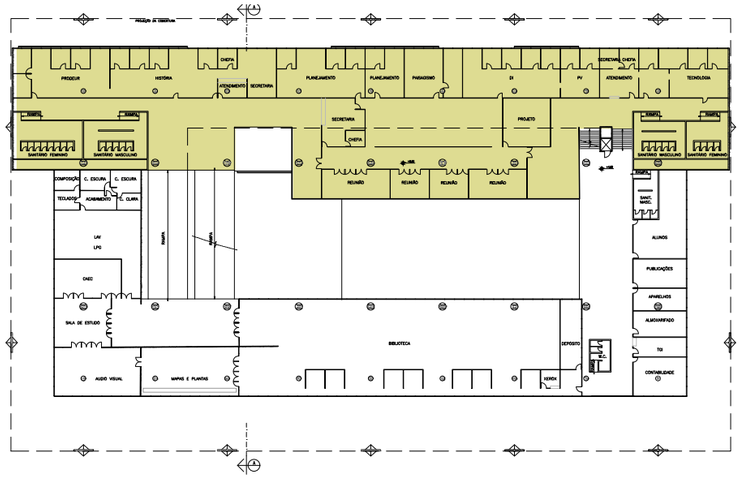
Figure 106 – Expansion of the secretary and computer graphics rooms on the alignment of the mezzanine floor. Photo: Renata Cima Campiotto, June 2016. Collection: Conserva FAU Team.



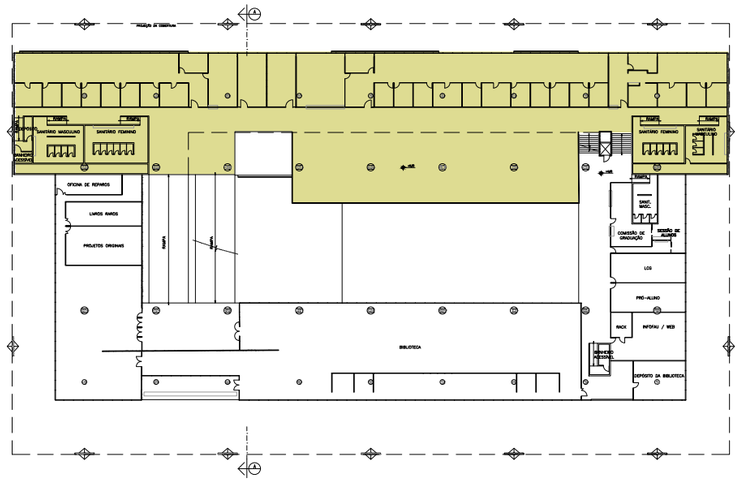
1969, inauguration



1980's



1990's



2016

At elevation +6.50

• The departments floor went through several interventions, some of them beneficial, such as the removal of the "little slum", freeing the area intended to IA, which ever since is complying with it important didactic function of common work space for students and teachers;

• However, the space inside the departments remains very fragmented, with the attempt of inserting several rooms for the teachers in a number incompatible with the area available. This has to do with the major increase in the number of teachers at FAU, especially of those with full time exclusive dedication to teaching and researching. Instead of realizing that there is not enough area for individual rooms for all the teachers, there was an attempt to accommodate groups of 3 to 6 teachers in rooms, resulting in a profusion of small cubicles in the part oriented to inside the building; and the placement of archive-lockers in the areas nearest to the window frames. The ideal would be to keep the material in spaces with less light (oriented to inside the building), and keep the area near the windows the more open as possible;

• The implementation of several sculleries throughout the building;

• The quality and quantity of partition walls and window frames are not compatible with the concept of using few constructive elements repeated throughout the building.

Guidelines

• In future interventions, to search for spaces the most permeable, flexible and open as possible, respecting the needs of each department;

• To concentrate the collection and material in spaces with less light (oriented to inside the building), and keep the area near the windows the more open as possible;

• To use a system of light partition walls, varying depending on the function and permeability need, to be implemented in the entire School;

• The permeability of the space shall be pondered along with safety and security issues, with the locking and inviolability of window frames, confined spaces, alarms, movement detectors;

• To rationalize systems and infrastructure based on a design developed in articulation with the architecture design: electrical, data network, air conditioning, alarms, detectors, etc.

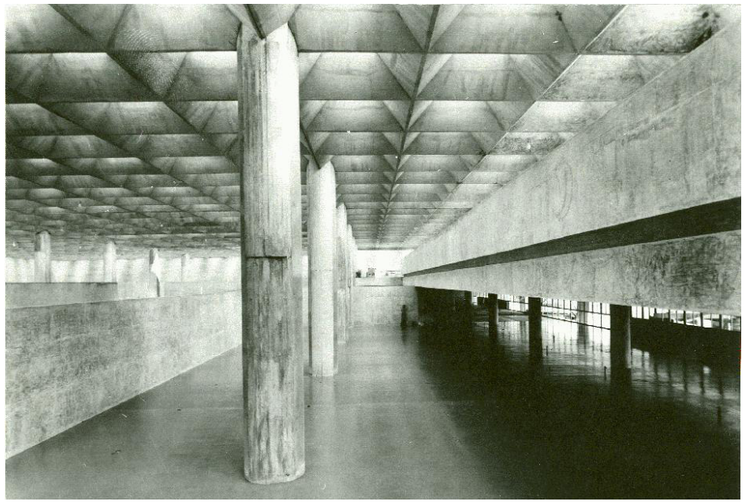


Figure 107 – Departments floor before the installation of partition walls. Photo: José Moscardi, 1968. Collection: FAUUSP Library.

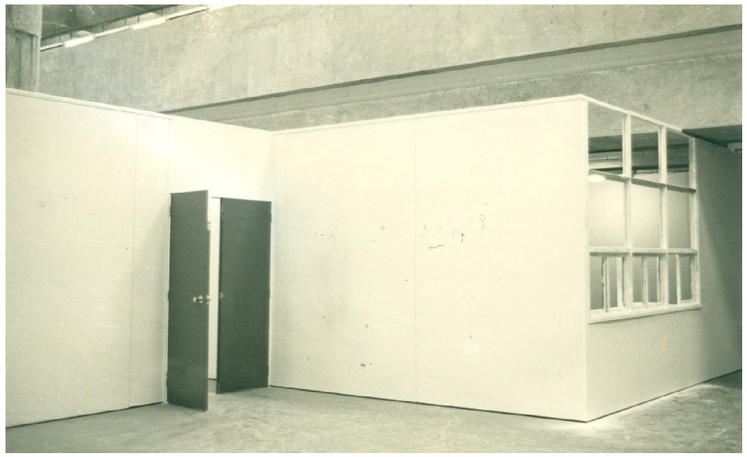


Figure 108 – Installation of rooms and laboratories of the Design department, known as “little favela”, in the area of the Interdepartmental Atelier, blocking the circulation in the floor. Photo: unknown author, 1979. Collection: SEF-USP.

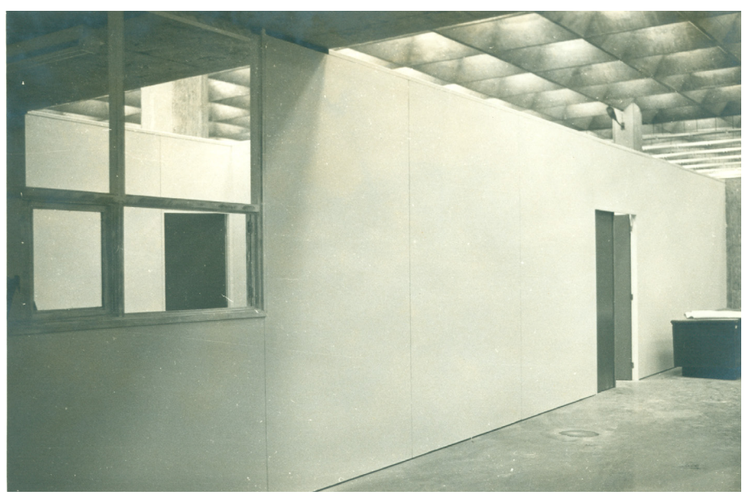


Figure 109 – Installation of rooms and laboratories of the Design department, known as “little favela”, in the area of the Interdepartmental Atelier, blocking the circulation in the floor. Photo: unknown author, 1979. Collection: SEF-USP.

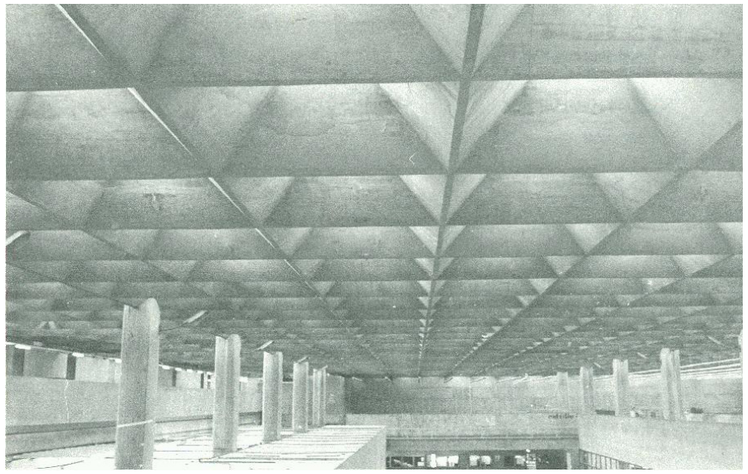


Figure 110 – View from the roof and Studio 5. To the left, in the area of the Interdepartmental Atelier, classrooms roof and laboratories installed in the floor can be seen. Photo: Author and date unknown. Collection: FAUUSP Library.

Figure 111 – Departments floor, with white chipboard partition walls. In the space of the Interdepartmental Atelier, profusion of research laboratories and department rooms. Photo: Author and date unknown. Collection: FAUUSP Library.

Figure 112 – Hoarding installed during the departments renovation, resulting in the emptying of the Interdepartmental Atelier area. Photo: Nelson Kon, 2010.

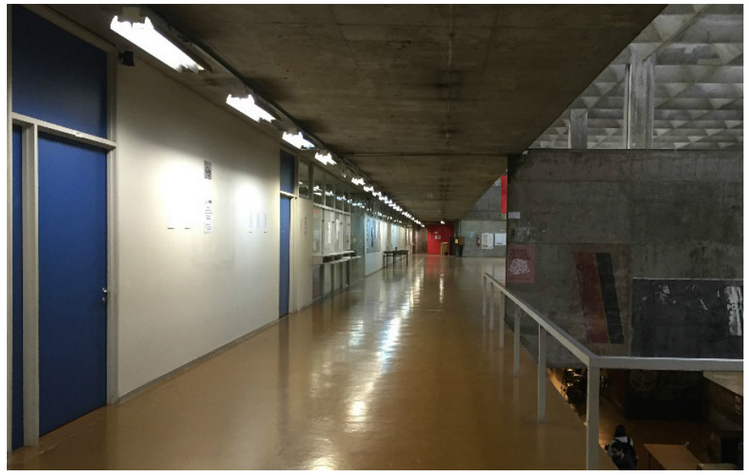
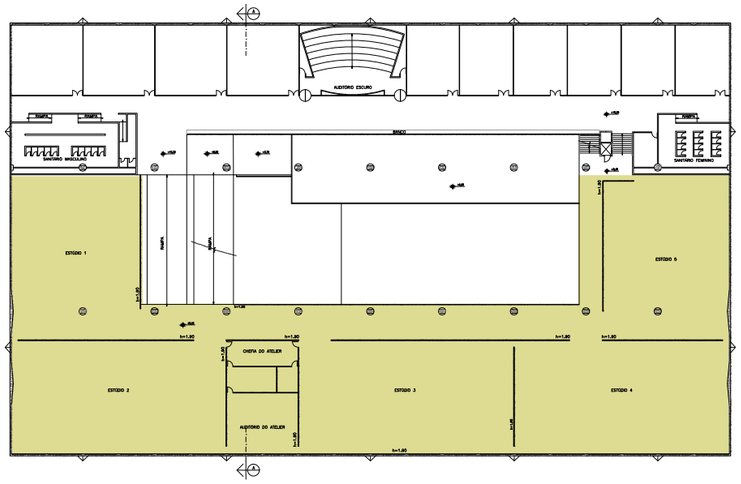


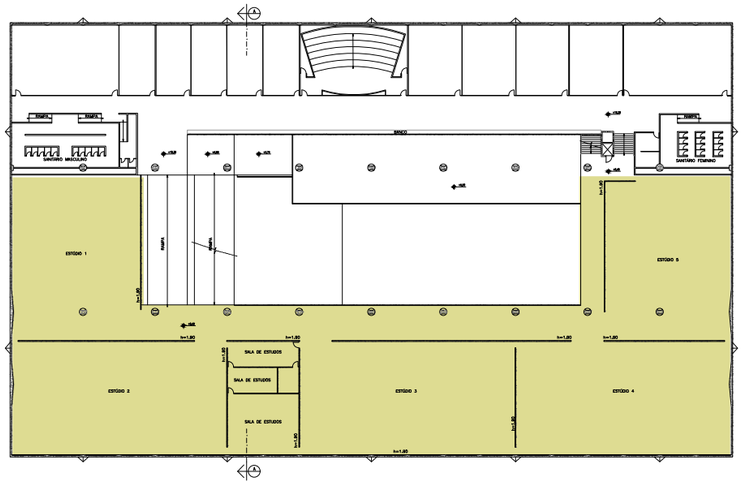
Figure 113 – Alignment of the departments after the renovation and reoccupation of the Interdepartmental Atelier space. Photo: Renata Cima Campiotto, June 2016. Collection: Conserva FAU Team.

Figure 114 – Design Department after the 2010 renovation. Photo: Renata Cima Campiotto, June/2016. Collection: Conserva FAU Team.

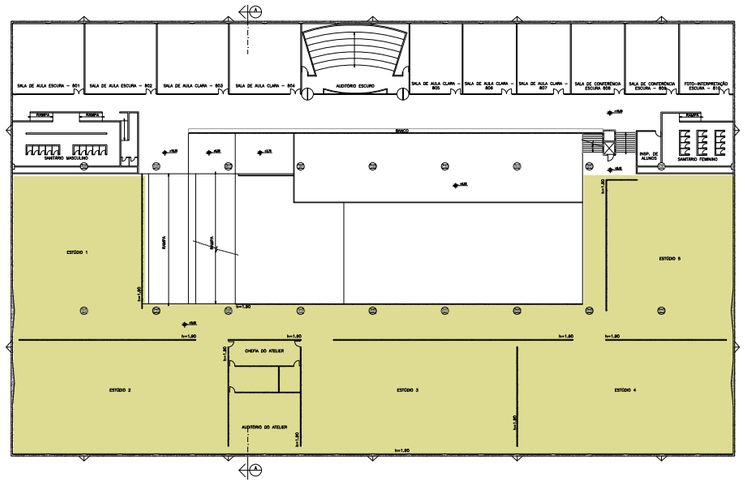
Figure 115 – Interdepartmental room installed between the departments of History and Design for meetings and various events. Photo: Roberto Souza, June 2016. Collection: Conserva FAU Team.



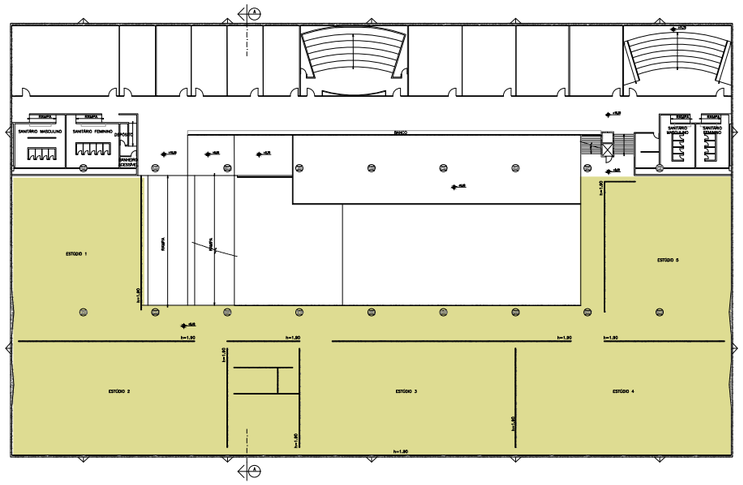
1969, inauguration



1980's



1990's



2016

At elevation +8.40

• The floor where the studios are has suffered less alterations of its physical space, keeping its main characteristics;

• However, it was deeply affected by the new teaching dynamics and by the increasing computerization of the activities, suffering with the lack of proper installations for the development of activities – electrical, data network, wi-fi – and of a layout with the necessary flexibility for diversified uses;

• It is also the place where the issues subsequently pointed out regarding the new illumination become more evident and harmful for the space perception.

Guidelines

• The design should allow different ways of occupying the space, with movable furniture;

• Efficient electrical installation and data network allowing a flexible use;

• Regarding the illumination, to respect the guidelines in item "Illumination System" as follows, remembering that the design of lamps should not jeopardize the reading of the continuous plan formed by the roof structural grid, nor create a new plan competing with it.

Figure 116 – View of Studio 1 with works exhibited on the blind wall. Photo: Author and date unknown. Collection: FAUUSP Library.

Figure 117 – View of Studio 1. In the background, panel “Virado à Paulista”. Photo: Roberto Souza, June 2016. Collection: Conserva FAU Team.

Figure 118 – Electrical installation in the passage between studios. Photo: Roberto Souza, June 2016. Collection: Conserva FAU Team.

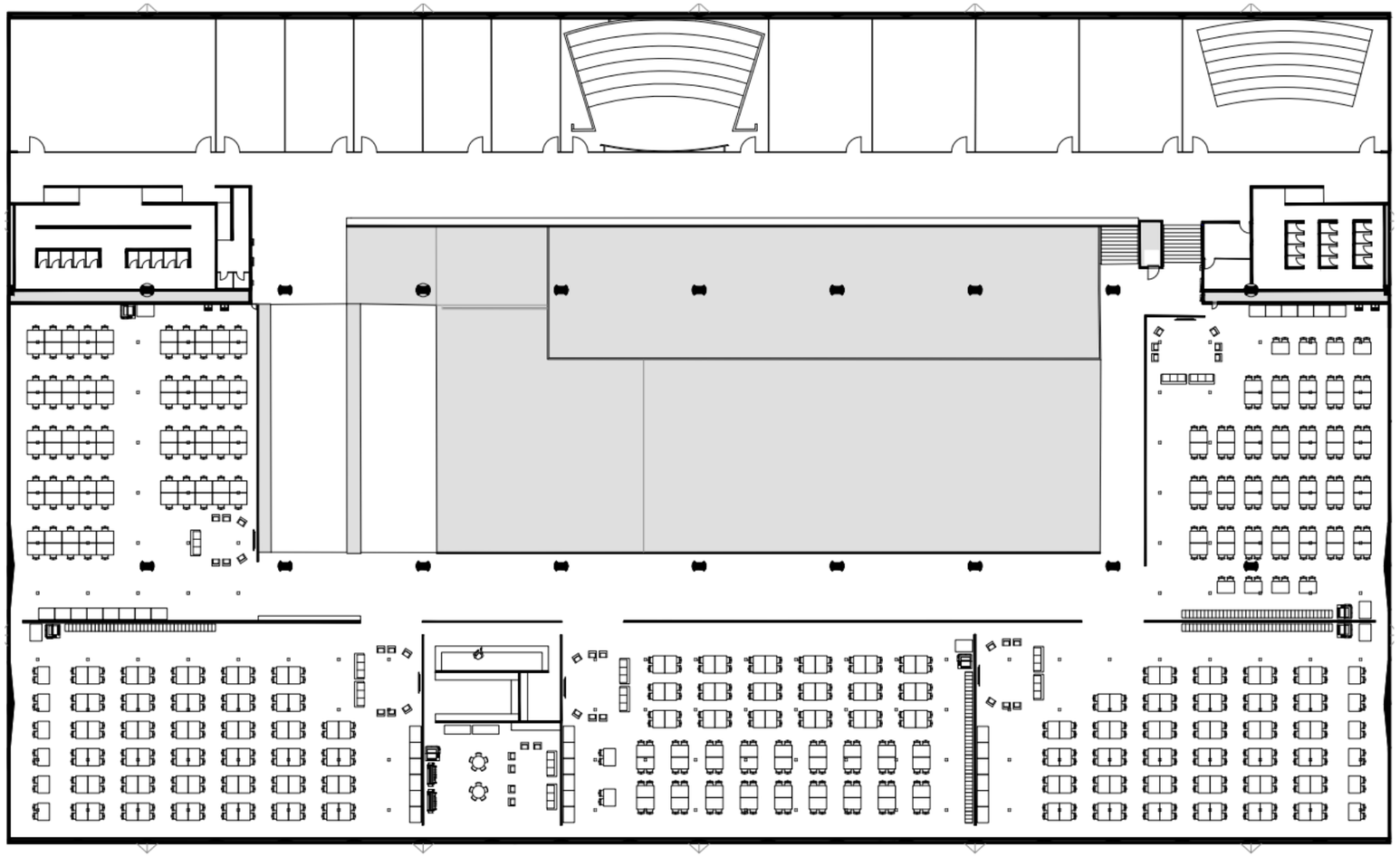


Figure 119 – Example of our design proposal for the laboratories floor elaborated by the students of the interdepartmental subject 1601105 “Investigative and Design Subsidies for the Preservation of the Constructed Heritage” Aruã Wagner e Carolina R. Boaventura, in 2013. It is a possibility of the floor occupation, based on actual utilization demands, complying with the guidelines presented here.

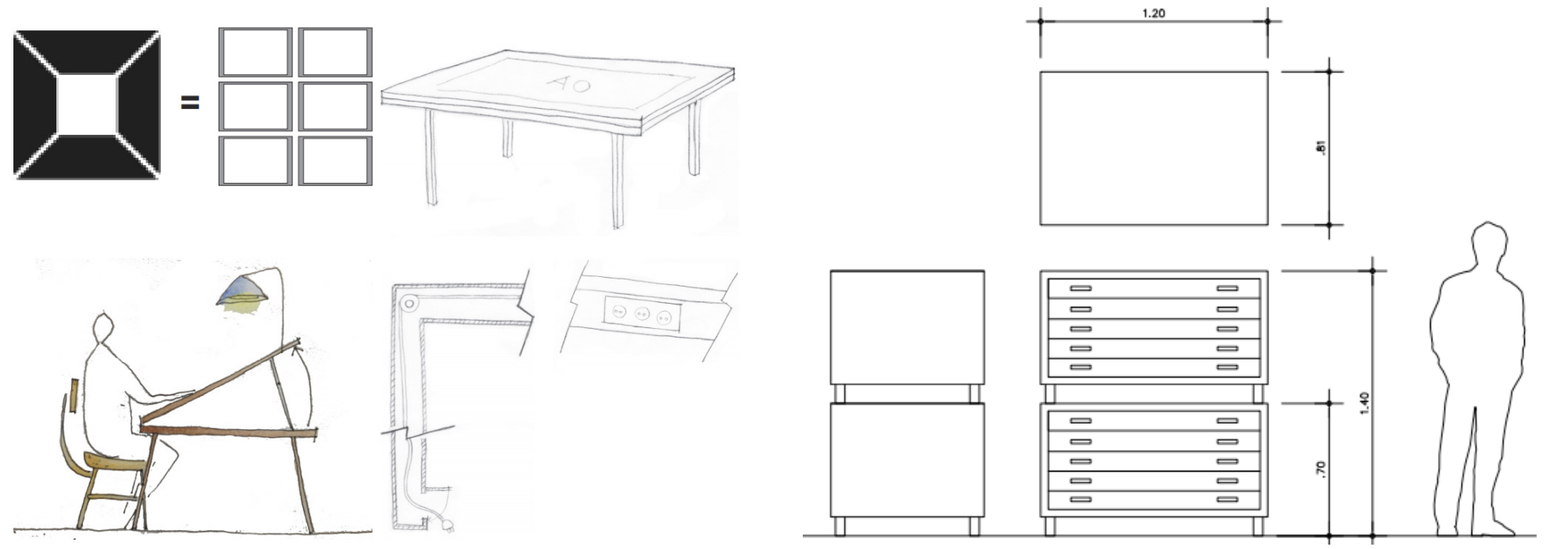
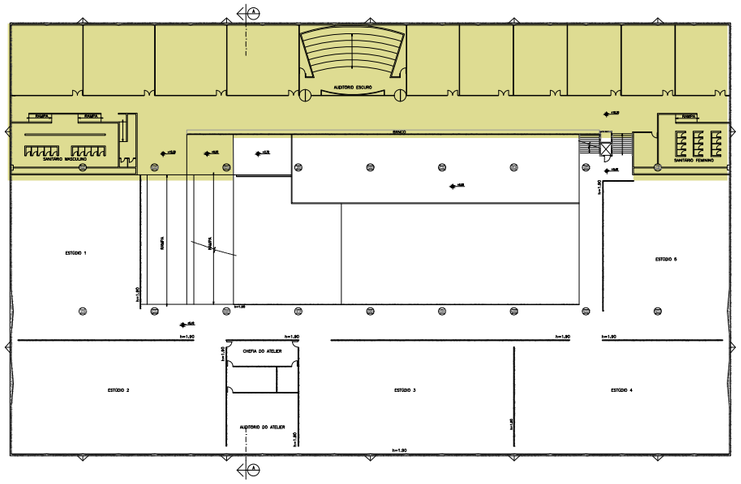
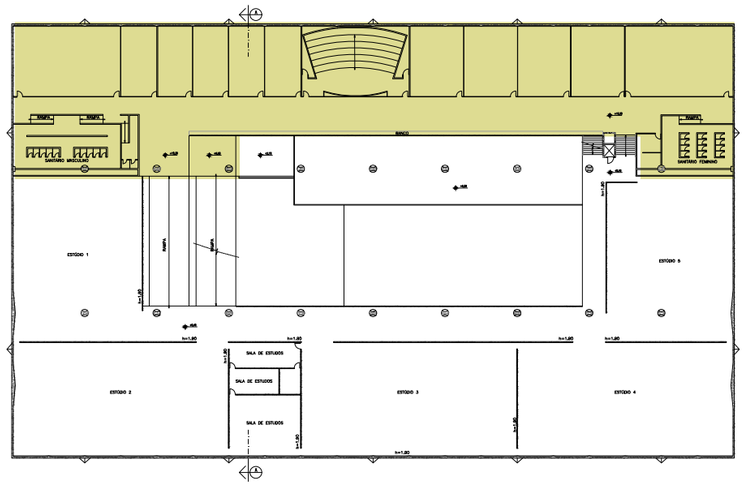


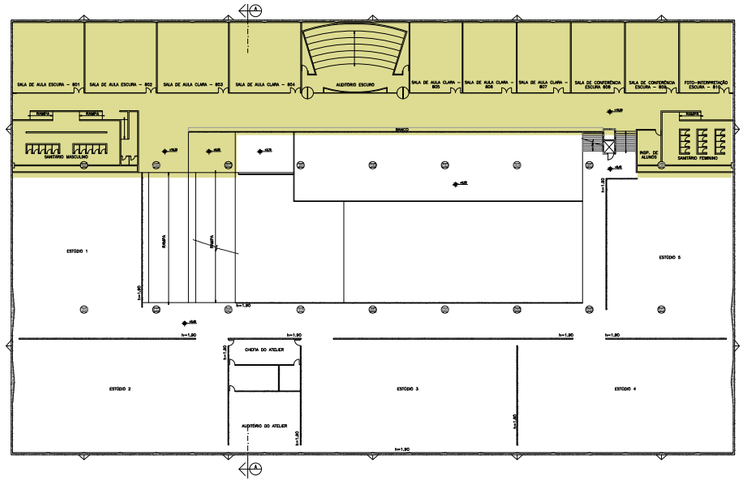
Figure 120 – Study of furniture (drawing tables, map cabinets and individual lockers) of the design proposal for the readjustment of studios for studios, elaborated by the students of the interdepartmental subject 1601105 “Investigative and Design Subsidies for the Preservation of the Constructed Heritage” Aruã Wagner e Carolina R. Boaventura, in 2013



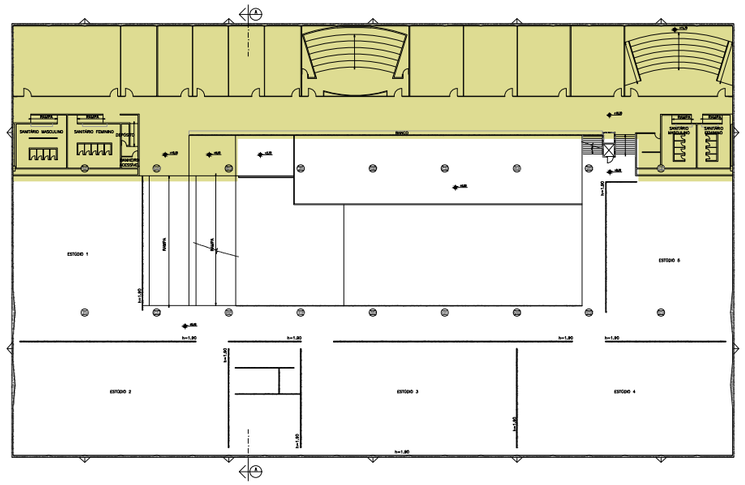
1969, inauguration



1980's



1990's



2016

At elevation +10,30

• The classrooms have variable sizes, serving for different sizes of students groups, but they are not easily changeable spaces;

• There are luminosity problems inside the classrooms, not being possible to control the light passing through the domes, sometimes creating too bright classrooms for the projection of images, or entirely dark ones, only depending on the artificial lighting, in the classrooms with opaque domes.

• Noise leaks from one classroom to the other, and the acoustics inside classrooms require a big effort by the person speaking;

• The ventilation control system is improperly installed, and does not allow a more efficient control;

• Thermal comfort has to be improved.

Guidelines

• To respect the alignment between classrooms and circulation;

• To search for ways to implement some more flexible environments, based on movable partitions that offer the possibility of creating larger or smaller spaces, depending on the need;

• To search for more acoustic efficiency in the classrooms and acoustic isolation between rooms;

• To search for systems more efficient in controlling the roof luminosity into the classroom, allowing a more adequate modulation, depending on the need;

• More efficiency in the ventilation control systems.

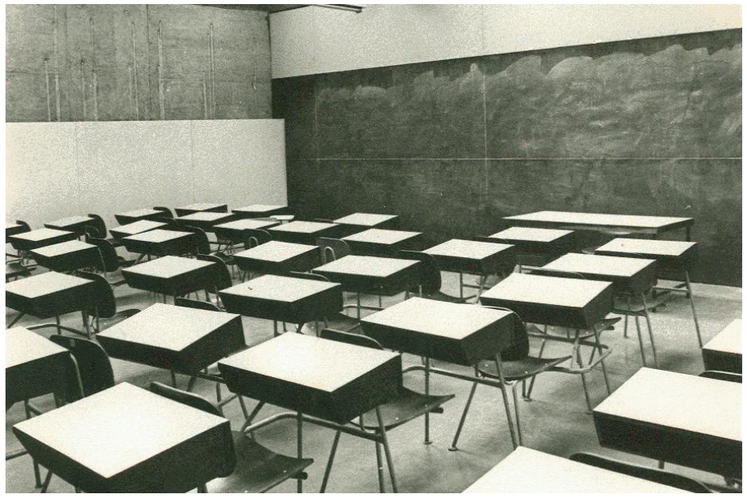


Figure 121 – Classroom with white chipboard partition walls and blackboard paint. Photo: Author and date unknown. Collection: FAUUSP Library.

Figure 124 – Corridor of classrooms after the inauguration of the building. Photo: José Moscardi, 1969. Collection: FAUUSP Library.

Figure 127 – Classrooms corridor with the exhibition of students´ works. Photo: Fernando Stankuns, 2006.

Figure 122 – Classroom with white chipboard partition walls. Photo: Author and date unknown. Collection: FAUUSP Library.

Figure 125 – Classrooms corridor, white chipboard partition walls. Photo: Author and date unknown. Collection: FAUUSP Library.

Figure 128 – Classroom. Photo: Renata Cima Campiotto, April 2016. Collection: Conserva FAU Team.

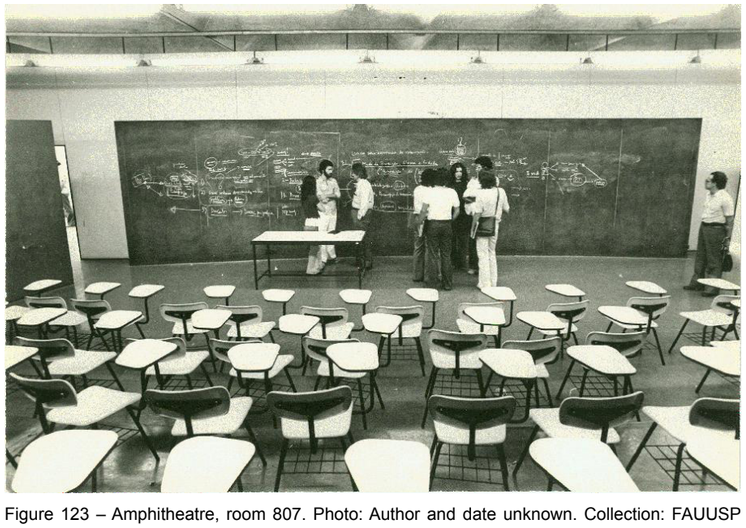


Figure 123 – Amphitheatre, room 807. Photo: Author and date unknown. Collection: FAUUSP Library.

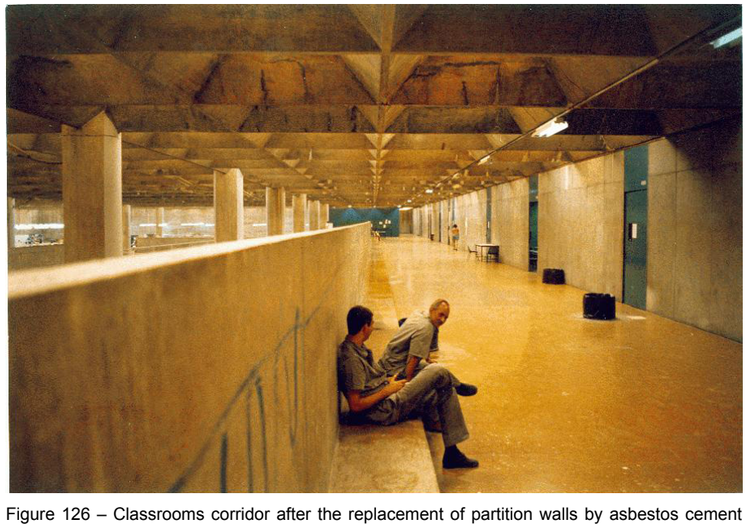


Figure 126 – Classrooms corridor after the replacement of partition walls by asbestos cement plates. Photo: Author and date unknown. Collection: FAUUSP Library.

Figure 129 – Room 812, adapted as an amphitheater in 2002. Photo: Roberto Souza, June 2016. Collection: Conserva FAU Team.

Circulation system, accessibility

The circulation system is regarded as one of the valuable elements of the building, since it is based on the circulation (ramps, staircases, circulation galleries) that the space is configured and organized. Despite the full condition of using the building based on such system, the new universal accessibility rules should be observed, and as much as possible, complied with. This issue should be carefully addressed. Some actions were executed a little too careless, such as the implementation of the wooden ramp and staircase to provide access to the Caramel Hall at elevation 0.80.

Because the building is a protected heritage, the accessibility rules should be interpreted according to the building characteristics, pursuing the identity of the effect, that is, to meet the rules goals, which should be interpreted with the necessary flexibility for this being a protected heritage. Therefore, the original ramps, which do not comply with the current rules, cannot have their gradient changed, and the number of handrails required by the rule should also be carefully interpreted. Firstly, a plausible solution is to check the possibility of opening the elevator door for both sides, at each half level, solving the access problem to all the floors.

Guidelines

• To strictly respect the logics of the building circulation system, keeping its configuration and clarity;

• To meet the universal accessibility demands based on respectful designs that become part of the space, not competing with nor changing its characteristics, pursuing the identity of the effect, that is, to meet the rule goals.

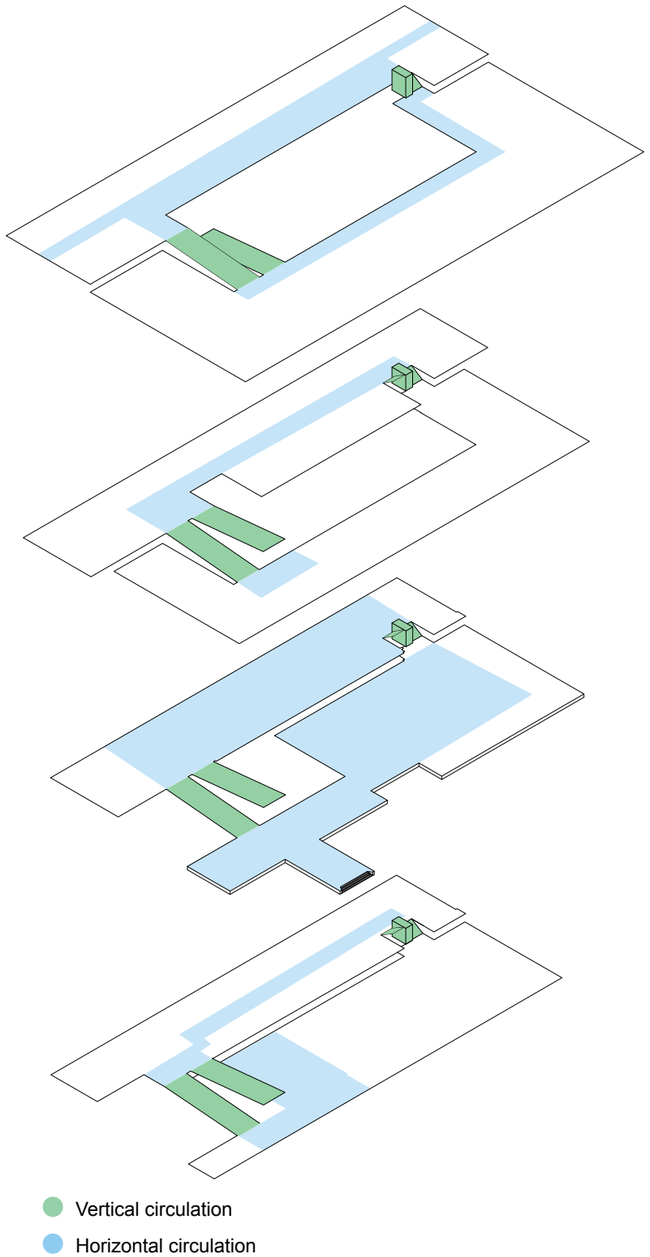


Figure 130 – Organization of the circulation between the building floors.

Figure 131 – Wooden ramp implemented to provide wheelchair users with access to the Caramel Hall, next to the top administration block. Photo: Luiza Nadalutti, August 2017. Collection: Conserva FAU Team

Figure 132 – Staircase of access to the mezzanine, in the Museum Floor. Photo: Renata Cima Campiotto, June 2016. Collection: Conserva FAU Team.

Figure 133 – Circulation occupied by the expansion of administration rooms and computing laboratories, in the mezzanine floor. Photo: Roberto Souza, June 2016. Collection: Conserva FAU Team.

Systems and infrastructure: electrical, illumination, wi-fi

• Electrical, illumination, data network, etc., installations are now highly disorganized, resulting in efficiency and safety problems, and in interferences with the space;

• The recent change of the building illumination system, in addition to problems of fixation to the concrete, also raised issues for the perception of the spaces upon creating a plan lower than the concrete grid;

• The new illumination creates a competing plan, obstructing and disturbing the roof view; there is also a huge visual pollution generated by multiple support and power cables, in bigger amounts, due to the system and to the smaller length of the lamps, which also have a bigger body than the previous ones;

• The new illumination system projects a light beam into the roof, generating a fragmented reading of the big plan. The perception of the roof and of the “chiaroscuro” inside the building was always possible thanks to the natural light intensity (or the lack thereof);

• When illuminating the roof from the bottom to the top, the new illumination system interferes with the perception of time passing and weather conditions, which was a fundamental factor for the users.

• The new illumination of the Caramel Hall, with much more potent and aggressive spotlights, replaced the symbolic original and symmetric street lights, which before contributed to affirm its urban nature (a covered internal square) and to mark the building void.

Guidelines

• To rationalize systems and infrastructure based on a design developed in articulation with the architecture design: electrical, data network, air conditioning, etc. It is necessary to reorganize them as a whole, even regarding the repetition of the wi-fi signal, to prevent the visual disturbance and the space obstruction.

• To rethink the illumination system, to be inserted in the space in a lighter way, with smaller bodies, without the profusion of supporting and power cables, to prevent the creation of a plan competing with the roof plan;

• The new system should only illuminate the lower part, providing luminosity for the circulation and work plans, not throwing light to their upper part, i.e., in direction to the roof, so that the perception of time passing and weather changes are not harmed;

• To search for, for the Caramel Hall, an illumination system that resume the proposal of addressing the space as a covered public square, with lamps not causing glare.

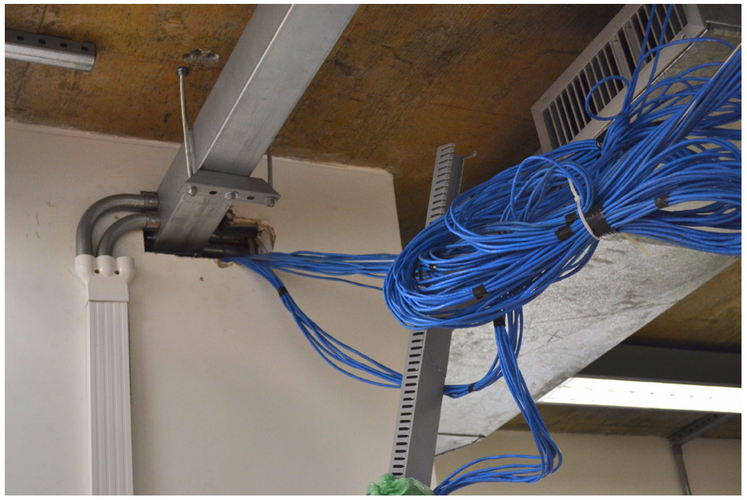


Figure 134 – Data network installation in one of the research laboratories. Photo: Renata Cima Campiotto, June 2016. Collection: Conserva FAU Team.

Figure 135 – View of the Studio 3 with lamps installed during the roof recuperation work, completed in 2015. Photo: Marina Brandão, 2015.

Figure 136 – Lamps installed during the roof recuperation work, completed in 2015. Photo: Roberto Souza, June 2016. Collection: Conserva FAU Team.

Visual interferences and *graffiti*

• As already mentioned, one of the problems resulting from the last intervention is the repairs done to the concrete blind façades in 2014 that, in addition to performance and adequacy issues (topic addressed in Task 3), resulted in a fragmented and pixeled image of the building.

• To that picture, other problems are added, such as the already mentioned profusion of systems and infrastructure – electrical, data network, air conditioning -, without articulated designs that take into consideration the characteristics of the work, and the *graffiti*.

• There are countless *graffiti* that are occupying new surfaces with an alarming velocity, harming the building and disturbing the architecture reading, generating elements that break the continuity and clarity of the surfaces;

• The building walls become the support for the most varied types of manifestation, with no control, and in general the result of immediate reactions to some sort of dissatisfaction;

• There is no reflection on the part of those who make the *graffiti*, of what this means for the building perception, which does not belong only to the students or to the FAU's community, but is rather a public asset of collective interest, in which the common wellbeing, the broader interest of the society, considering the long run, should prevail.

• Historically, FAU's walls were used for several types of manifestation. Still now it is possible to see drawings and graffiti produced decades ago. Such manifestations were restricted to the studios areas. Now, the whole building became the target of *graffiti*, which far from being students manifestations, are now acts of vandalism and destruction.

• The recent discussions about *graffiti* and art are not addressed in this work. We have no competence to assign a value to that. In this regard, it is not about saying what type of manifestation is licit or not. It is just about restricting any type of manifestation on surfaces considered as essential for the perception of the building.

Guidelines

• Regarding this, guidelines and hierarchies of spaces are proposed, indicating where and how such manifestations can occur. It should be understood that the building can and should be the support for various manifestations, provided that they do not harm it, sometimes irreparably.

• Therefore, we suggest that such manifestations concentrate in the areas of studios and on the light partition walls, never on the concrete blind façades or on structural elements such as pillars, roof, external and internal blind façades, slab edges, which could occasionally have posters and wheat-paste posters on them, temporarily, which would then be fully removed with no damage whatsoever.

• This is a topic of difficult and delicate discussion at this moment; this proposal is only a draft that should be further discussed in an ample debate with the whole community, requiring clarity and transparency in treating public assets and in respecting the laws applicable to the building.

• As already mentioned, to rationalize systems and infrastructure based on a design developed in articulation with the architecture design: electrical, data network, air conditioning, etc.

• See Task 3, for the guidelines to orient solutions that mitigate the fragmented effect and provide the building suite with a renewed unit, respecting its characteristics and time passage marks.

Figure 137 – Studio 4 with posters glued to the blind façade and the ventilation partition wall. Photo: Author and date unknown. Collection: FAUUSP Library.

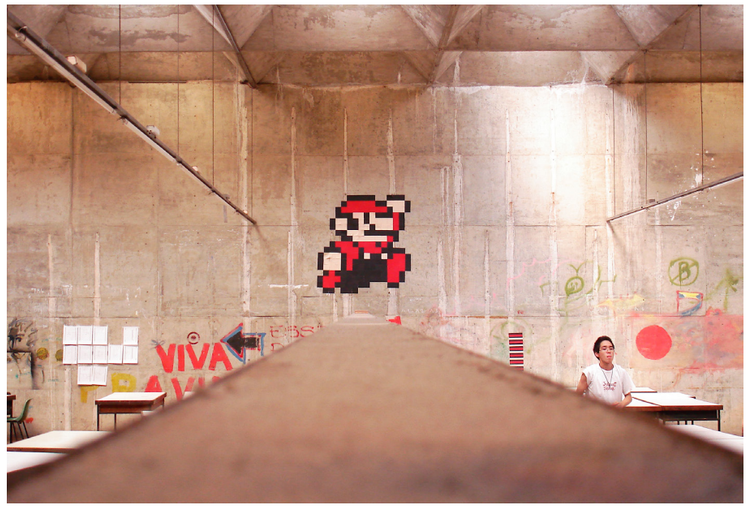


Figure 138 – Intervention with gluing on the blind façade between studios 4 and 5. Photo: Vitor Nisida, 2008.

Figure 139 – Intervention with gluing on the blind façade of Studio 1. Photo: Vitor Nisida, 2010.

Figure 140 – Intervention on the blind façade of the Interdepartmental Atelier block, on the surface oriented to the Museum Floor and Caramel Hall. Photo: Vitor Nisida, 2010.

Figure 141 - “Virado à Paulista” panel in the hydraulic block oriented to the Studio 1. Photo: Renata Cima Campiotto, April 2016. Collection: Conserva FAU Team.

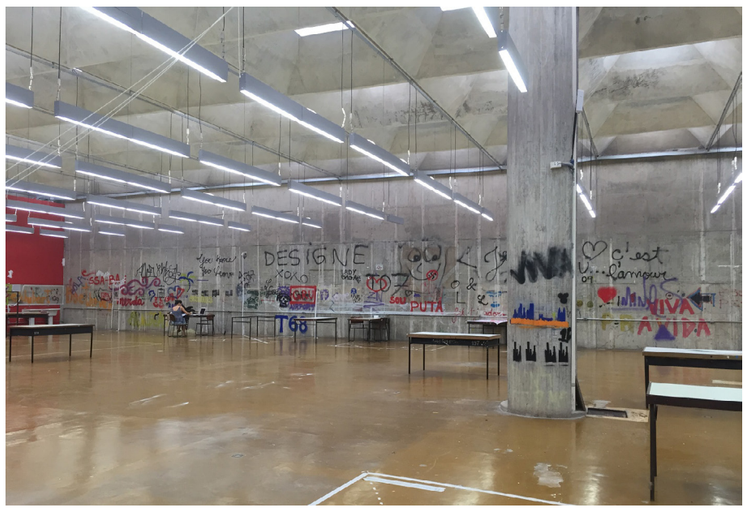


Figure 142 – Generalized pìchações on the blind wall of Studio 5. Photo: Renata Cima Campiotto, April 2016. Collection: Conserva FAU Team.

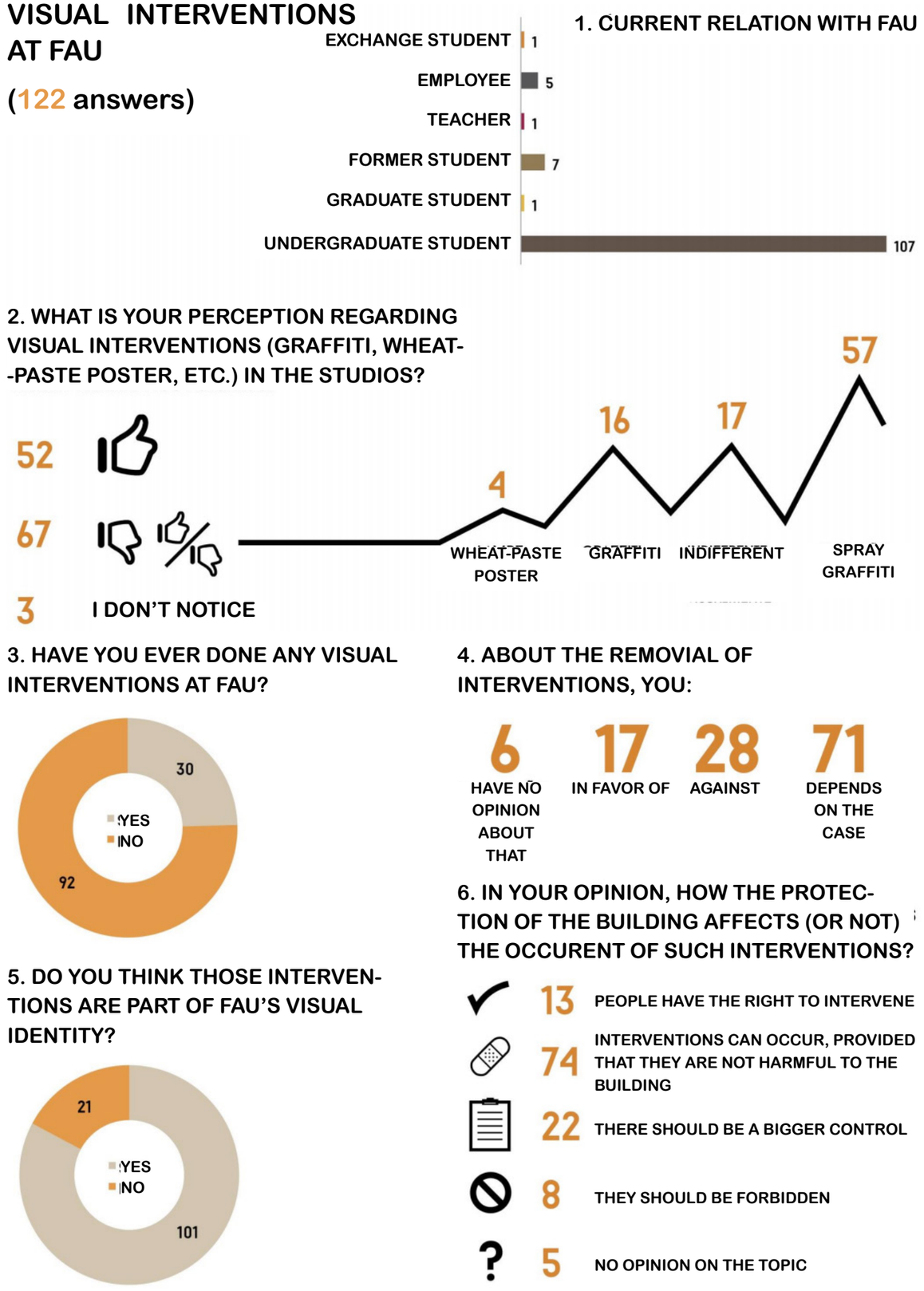
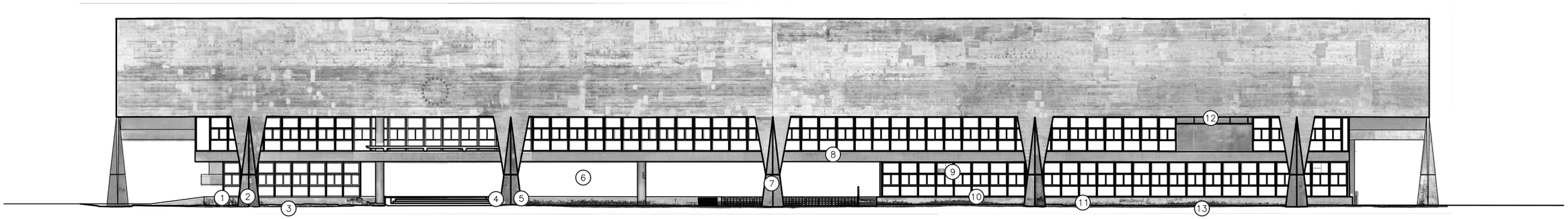


Figure 143 – Result of the survey conducted by the students of the interdepartmental subject 1601105 “Investigative and Design Subsidies for the Preservation of the Constructed Heritage” Aruã Wagner e Carolina R. Boaventura, em 2013, regarding the visual interventions done in the building.

Mapping of interferences in the façades of the Building: Southwest Façade



FACHADA SUDOESTE
Mapeamento das interferências

1. Abrigo do relógio d'água
Foto: DSC_1375, julho/2016

4. Quebra do revestimento da escada de acesso por raízes de árvore
Foto: DSC_1389, julho/2016

7. Pichações no pilar interno
Foto: DSC_1395, julho/2016

10. Cano de irrigação do jardim
Foto: DSC_1410, julho/2016

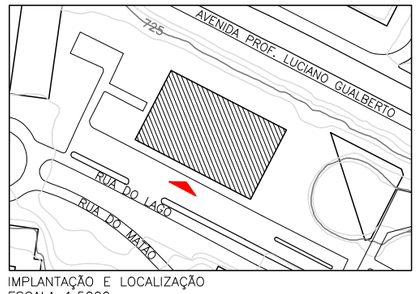
13. Árvore de grande porte em frente o edifício
Foto: DSC_1429, julho/2016

2. Cano de irrigação do jardim
Foto: DSC_1379, julho/2016

5. Lixo de concreto e colagens no pilar
Foto: DSC_1388, julho/2016

8. Esquadrias enferrujadas e colônias de insetos
Foto: DSC_1398, julho/2016

11. Pichações e armaduras expostas
Foto: DSC_1415, julho/2016



IMPLANTAÇÃO E LOCALIZAÇÃO
ESCALA 1:5000

3. Árvores de grande porte em frente o edifício
Foto: DSC_1378, julho/2016

6. Árvore sob o peristilo do edifício
Foto: DSC_1392, julho/2016

9. Aparelhos de ar-condicionado e tubulação
Foto: DSC_1409, julho/2016

12. Gradil de fechamento do vão
Foto: DSC_1418, julho/2016

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

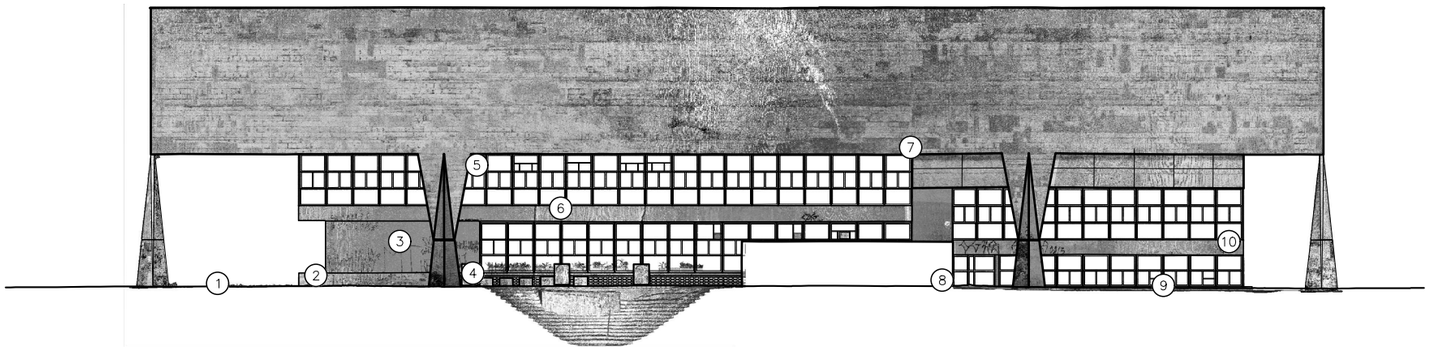
TÍTULO
Interferências nas fachadas
FACHADA SUDOESTE
julho / 2016

DESENHO
1/4

ESCALA
0 1 5 10

N

Mapping of interferences in the façades of the Building: Southeast Façade



FACHADA SUDESTE
Mapeamento das interferências

1. Caixa com instalação no jardim
Foto: DSC_0388, julho/2016

4. Aparelhos de ar-condicionado espalhados
Foto: DSC_0390, julho/2016

7. Armaduras e fissuras na laje
Foto: DSC02161, julho/2016

10. Pichações na fachada
Foto: DSC02158, julho/2016

2. Armaduras expostas
Foto: DSC_0384, julho/2016

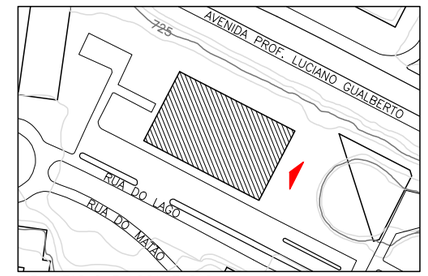
5. Tubulação de ar-condicionado fixada na fachada e atravessando caixilho
Foto: DSC_0392, julho/2016

8. Instalação fixada na fachada
Foto: DSC02171, julho/2016

3. Pichações e fissuras
Foto: DSC_0389, julho/2016

6. Aparelhos de ar-condicionado e tubulações diversas
Foto: DSC02178, julho/2016

9. Abrigo de butijões de gás
Foto: DSC02156, julho/2016



IMPLANTAÇÃO E LOCALIZAÇÃO
ESCALA 1:5000

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

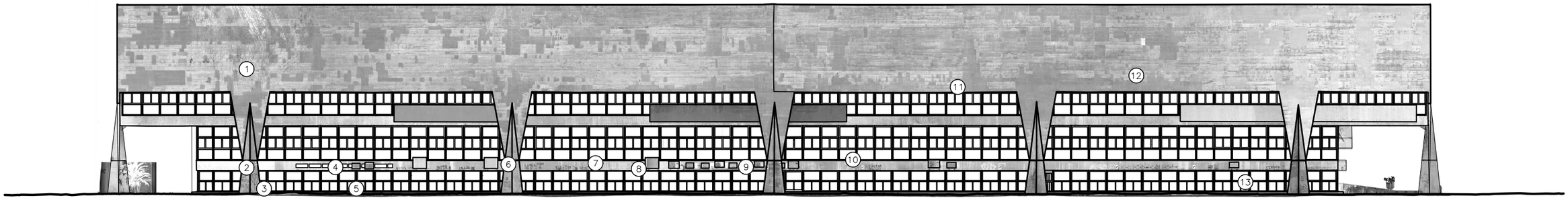
TÍTULO
Interferências nas fachadas
FACHADA SUDESTE
julho/2016

DESENHO
2/4

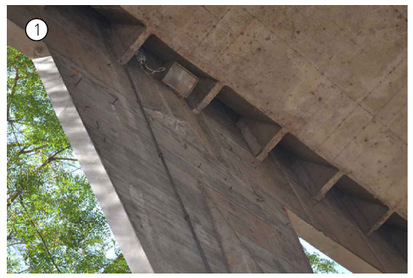
ESCALA
0 1 5 10

N

Mapping of interferences in the façades of the Building: Northeast Façade



FACHADA NORDESTE
Mapeamento das interferências



1. Holofote fixado no topo do pilar
Foto: DSC_0375, julho/2016

4. Aparelhos de ar-condicionado na fachada
Foto: DSC_0363, julho/2016

7. Pichações na lateral da laje
Foto: DSC_0354, julho/2016

10. Aparelhos de ar-condicionado na fachada
Foto: DSC_0330, julho/2016

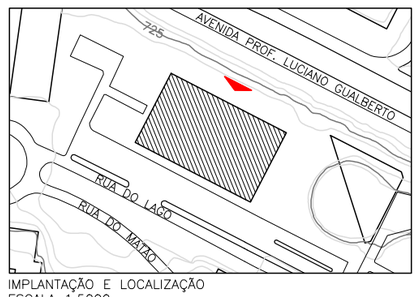
13. Calçamento irregular
Foto: DSC02135, julho/2016

2. Pichações na face interna do pilar
Foto: DSC_0371, julho/2016

5. Tubulação da pia do laboratório de vídeo
Foto: DSC_0366, julho/2016

8. Tubulação de ar-condicionado atravessando o caixilho
Foto: DSC_0357, julho/2016

11. Colônias de insetos no holofote
Foto: DSC02139, julho/2016



IMPLANTAÇÃO E LOCALIZAÇÃO
ESCALA 1:5000

3. Calçamento irregular e com placas faltantes
Foto: DSC_0379, julho/2016

6. Pichações na face externa do pilar
Foto: DSC_0345, julho/2016

9. Caixa de passagem, conduítes e canos fixados na fachada
Foto: DSC_0331, julho/2016

12. Eletrocalha passando pelo caixilho
Foto: DSC02142, julho/2016

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

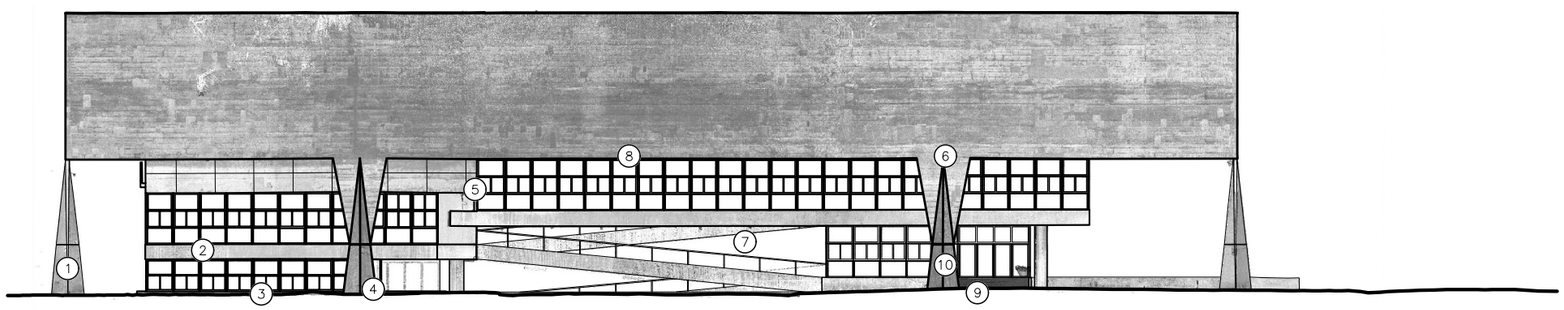
TÍTULO
Interferências nas fachadas
FACHADA NORDESTE
julho / 2016

DESENHO
3/4

ESCALA
0 1 5 10

N

Mapping of interferences in the façades of the Building: Northwest Façade



FACHADA NOROESTE
Mapeamento das interferências

1. Pichações no pilar externo
Foto: DSC_0443, julho/2016

4. Cano d'água e torneira fixados no pilar externo
Foto: DSC_0444, julho/2016

7. Instalações elétricas e conduítes
Foto: DSC02199, julho/2016

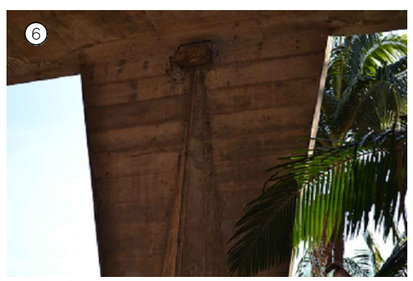
10. Pichações e colagens no pilar externo
Foto: DSC_0421, julho/2016

2. Pichações e riscos nos caixilhos e na lateral da laje
Foto: DSC_0437, julho/2016

5. Saída de fios pela abertura de ventilação dos sanitários
Foto: DSC_0426, julho/2016

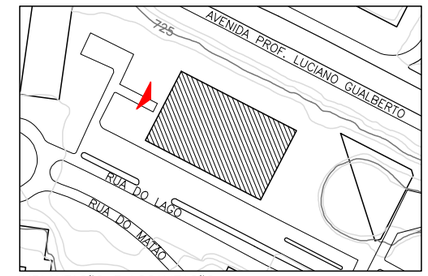
8. Marca das armaduras das vigas na laje
Foto: DSC02202, julho/2016

3. Árvores de grande porte próximas à fachada
Foto: DSC_0424, julho/2016



6. IColônia de insetos e ninhos de pombas sobre as luminárias
Foto: DSC_0422, julho/2016

9. Caixa de inspeção, cano exposto e conduíte
Foto: DSC_0419, julho/2016



IMPLANTAÇÃO E LOCALIZAÇÃO
ESCALA 1:5000

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

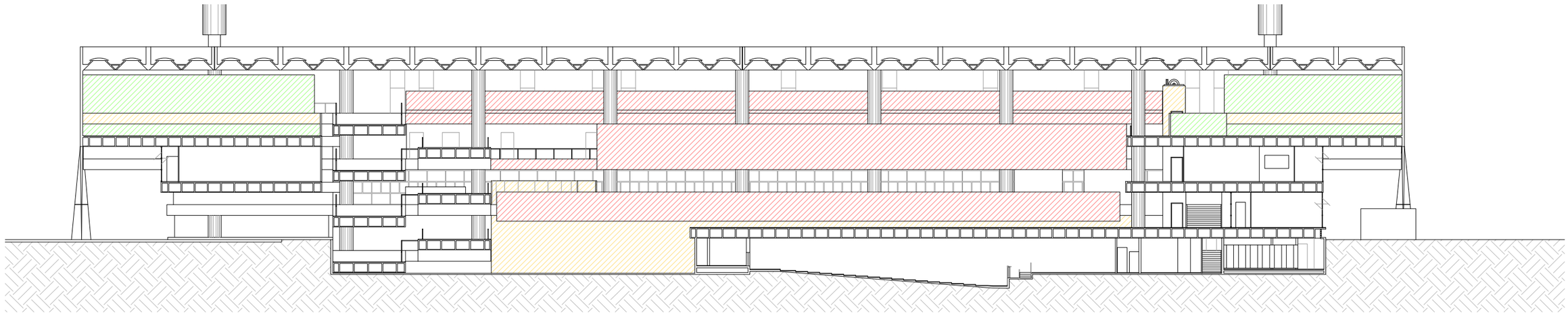
TÍTULO
Interferências nas fachadas
FACHADA NOROESTE
julho / 2016

DESENHO
4/4

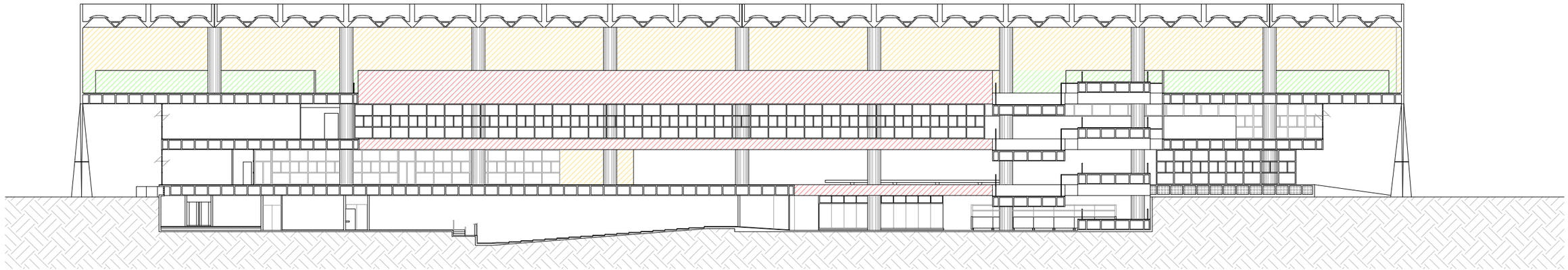
ESCALA
0 1 5 10

N

Zoning proposal for visual interventions



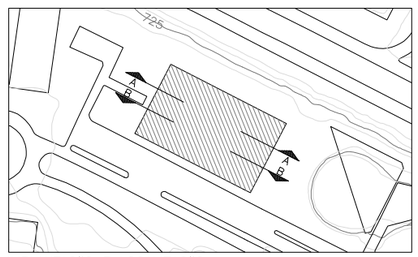
CORTE LONGITUDINAL A–A



CORTE LONGITUDINAL B–B

LEGENDA – HIERARQUIAS PARA INTERVENÇÃO:

- Intervenções permitidas;
- Intervenções permitidas – com restrição;
- Não é permitido qualquer tipo de intervenção com tinta permanente; permite–se eventualmente manifestações temporárias e plenamente removíveis sem danos ao prédio, como cartazes e lambe–lambes.



IMPLANTAÇÃO E LOCALIZAÇÃO
ESCALA 1:5000

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

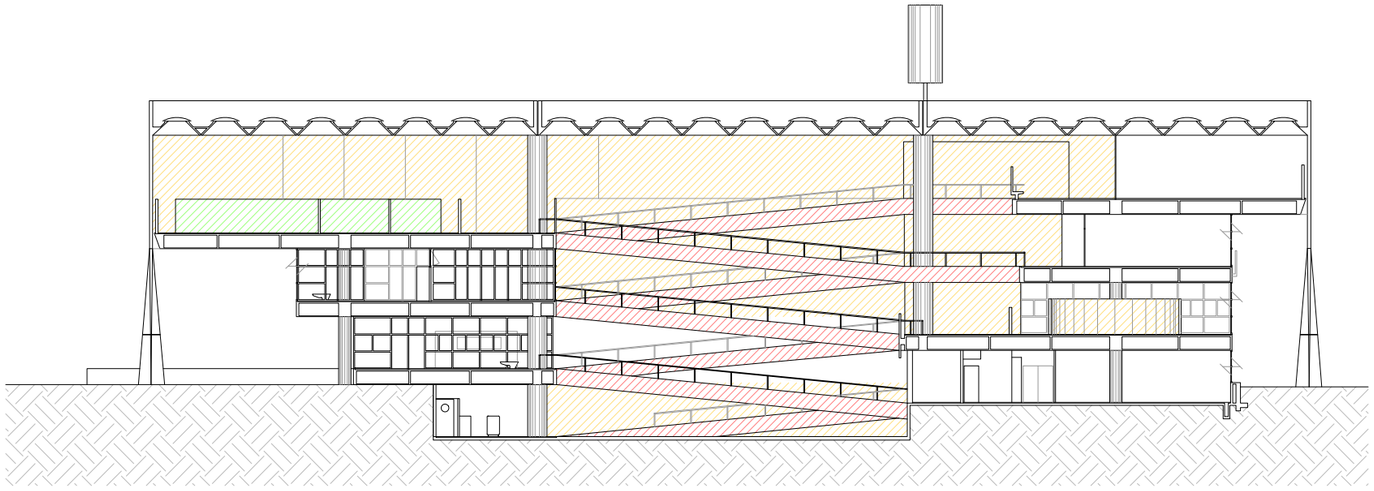
TÍTULO
Hierarquias p/ intervenção
CORTES A–A E B–B

DESENHO
1/2

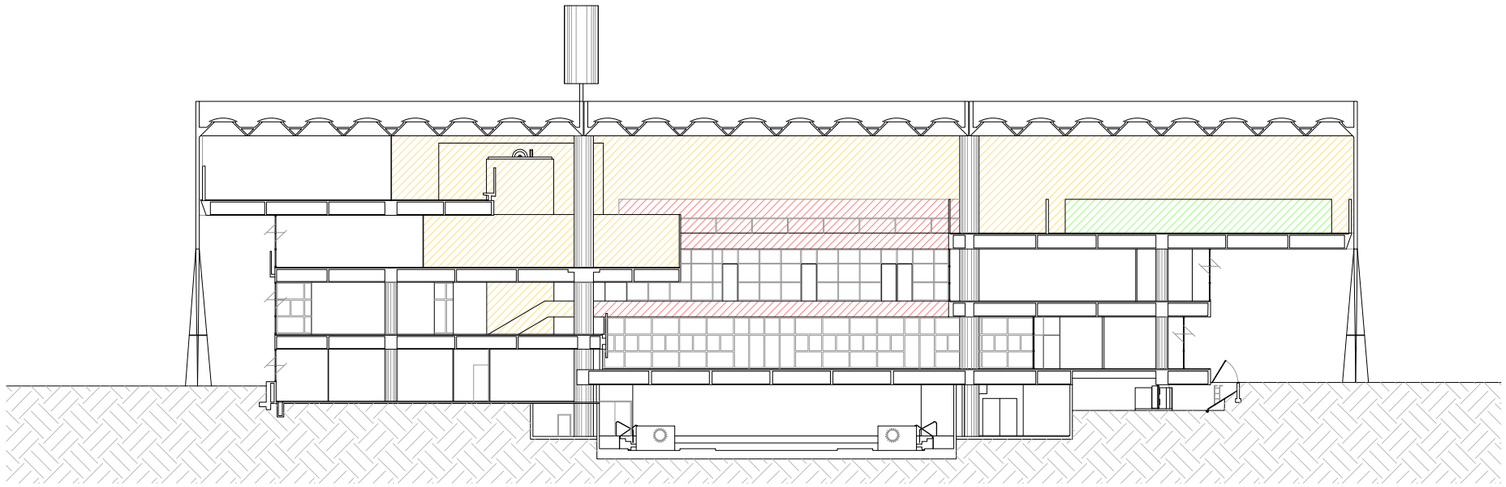
ESCALA
0 1 5 10

N

Zoning proposal for visual interventions



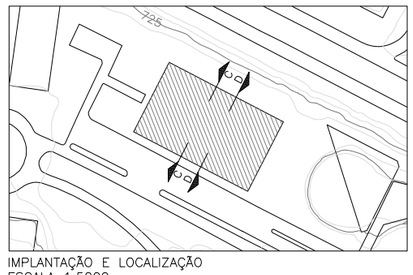
CORTE TRANSVERSAL C–C



CORTE TRANSVERSAL D–D

LEGENDA – HIERARQUIAS PARA INTERVENÇÃO:

- Intervenções permitidas;
- Intervenções permitidas – com restrição;
- Não é permitido qualquer tipo de intervenção com tinta permanente; permite–se eventualmente manifestações temporárias e plenamente removíveis sem danos ao prédio, como cartazes e lambe–lambes.



IMPLANTAÇÃO E LOCALIZAÇÃO
ESCALA 1:5000

PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Hierarquias p/ intervenção
CORTES C–C E D–D

DESENHO
2/2

ESCALA

0 1 5 10

N

In the area outside the building

• The paved circulation path in the peristyle, created by the landscaping transformations done in 2009, uses pebbles as paving material. This material is traditionally used in paved streets of the Brazilian colonial period, but it is alien to the logics of the building composition. This new path transforms a peristyle, i.e., a continuous colonnade that characterizes the building perimeter, making the transition between the outdoors to the indoors, in a space covered for the circulation of pedestrians, generating perception problems;

• Creation of a new entrance, which was shaped as a living area, an external square, removing the emphasis of the original entrance core; this generates a duplicity of accesses, reducing the clarity of functions reading and the importance of the original access; in addition, the staircase and the ramp were implemented not coherently dialoguing with the building architecture;

• Change of the flags position, changing an image that is shown in one of Artigas' most emblematic sketches, where the flag image, having the concrete blind façade as background and beside the access, contributed to affirm his vision of the world: austere, nationalist and republican;

• The installation of the gas cabin to serve one of the sculleries, below the blind façades, in a place that should have remained free from any constructions;

• Vegetation: palm trees of the teachers' parking lot, regular and aligned with the axes of the building and modulated according to the parking spaces (one for each 3), were jeopardized because of the indiscriminate growth of other trees;

• The access square, which disappeared in the midst of a sea of cars parked on an improper place, with the little lake in the center, and is configured by the interruption of the parking lot, also coinciding with the building axes, and marked by the position and direction of illumination posts (changed and placed in function of the cars) and of trees, also modulated according to the parking spaces (one for each 6);

• The low vegetation flowerbed appearing in the inauguration photos at the east façade, with signs of having been designed by Artigas because of its similarity with the mosaic flooring design; it suggests the desire of a free vision, both for those inside looking to the university city, and of those at the avenue, from where there was a privileged view of the whole building, because of the distance and for being in an elevation below the building elevation. This condition was changed by randomly growing trees;

• This area next to the east façade is also shown unobstructed in the original scale model of the preliminary project, which on the other side shows a mass of vegetation moved to the north in relation to the building, exactly where the same is seen in the construction photos: a dense group of newly planted plants.

Guidelines

• To reestablish the building access logic, developing a universal accessibility project according to its characteristics;

• To reestablish the idea of a peristyle around the building, with the new treatment for the flooring, and a flowerbed design more compatible with its architecture;

• To establish again, as much as possible, a rhythm for the vegetation, making use of tree management instruments;

• To reestablish the meaning of the little lake and the idea of public square, keeping the area in front of the building access staircase free from cars;

• To that purpose, to make a compatible illumination design, intended to this space conceived as a public square;

• The external illumination projected to the façade should be avoided, allowing that, during the night, the great concrete volume disappears, and the internal illuminated volumes stand out.

• The illumination should be oriented downward, and ensure a good visibility and safety/security for the passersby;

• To ensure the maintenance of the flooring, so that pedestrians can safely circulate.

Figure 144 - View of the garden and of the access to the building through the lateral staircase. Photo: José Moscardi, 1969. Collection: FAUUSP Library.

Figure 145 – Lawn with palm trees aligned and spaced according to the parking spaces of the teachers' parking lot, nest to the Northwest façade. Photo: Author and date unknown. Collection: SEF-USP.

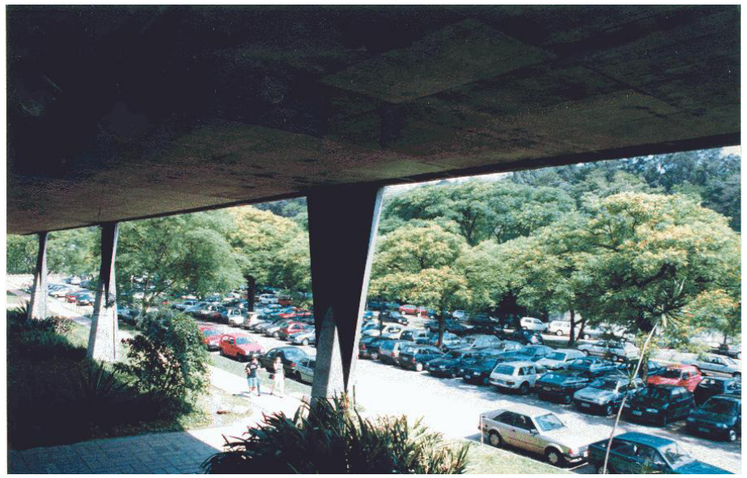
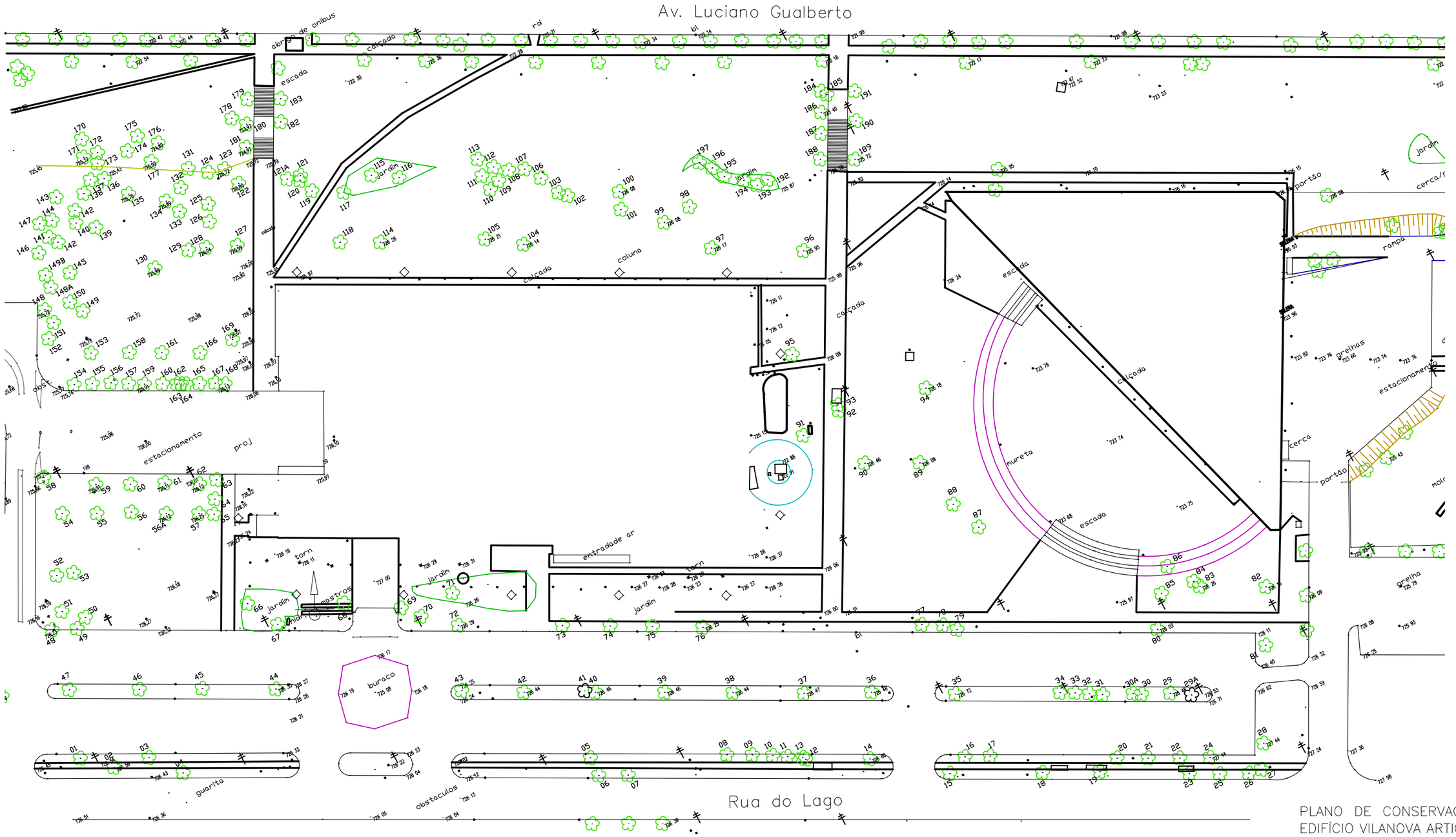


Figure 146 – Garden under the peristyle of the frontal façade and trees in the median strip of the parking lot aligned with the parking spaces. Photo: Author and date unknown. Collection: FAUUSP Library.

Figure 147 – Garden under the peristyle of the frontal façade after the implementation of the 2010 design, with the creation of the covered sidewalk in the middle of the garden. Photo: Nelson Kon, 2010.

Arboreal survey (February 2017)



PLANO DE CONSERVAÇÃO
EDIFÍCIO VILANOVA ARTIGAS

TÍTULO
Levantamento arbóreo
IMPLANTAÇÃO
fevereiro/2017

DESENHO
1/1

ESCALA
0 5 10 20 30

Other systems to be developed in future actions

To develop a complete Preventive Conservation Plan, other systems should be gradually investigated, according to the possibilities of the institution.

The topics that should be necessarily addressed are listed as follows.

Note that the first 4 items are associated to the scope of concerns and proposals of the Environmental Management Superintendence (SGA) of the University, and which can benefit from integrated actions between FAU and SGA.

Concerning the vegetation management plan, relevant for the perception of the building, and also for its conservation (see the previous item and the implications of vegetation to the roof and to the blind façades in Tasks 2 and 3), an important step was taken with the Trees survey and the vegetation phytosanitary estate presented herein.

• Water drainage – sewerage and rainwater – to map

• Survey of the drainage and irrigation network

• Sewerage and rainwater network: conservation state

• Rainwater reuse

• Risk Management

• Property Security

• Fire Prevention and Fight

• Pollutants

• Biological attacks

• Light/radiation

• Vegetation management plan

• Plagues: insects, animals (rodents, pigeons, etc.), infesting vegetation

Source: Rosa Artigas, author and date unknown

REFERENCES

American Concrete Institute. “ACI 214.4R-10 Guide for obtaining cores and interpreting compressive strength results. Reported by ACI Committee 214.” 2010. 17.

ASTM International. “C823- Standard Practice for Examination and Sampling of Hardened Concrete in Constructions.” 2007.

BALZANI, Marcello, Nicola SANTOPUOLI, Alessandro GRIECO, e Nicola ZALTRON. “Laser Scanner 3D Survey in Archaeological Field:the Forum of Pompeii.” International Conference on Remote Sensing Archaeology. Beijing, China, 2004.

BAPTISTA, Maria Lucia Vianna. “Documenting a Complex Modern Heritage Building Using Multi Image Close Range Photogrammetry and 3D Laser Scanned Point Clouds.” International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXIV International CIPA Symposium. Strasbourg, France, 2013.

BAROSSI, Antonio Carlos. Ensino de projeto na FAUUSP: Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo. Tese de Doutorado (FAU-USP), 2005.

_____ (org.). O edifício da FAU-USP de Vilanova Artigas. [Série Obras Fundamentais, v. 2]. São Paulo: Editora da Cidade, 2016.

BIAGINI, Carlo, Pietro CAPONE, Vincenzo DONATO, e Nora FACCHINI. “IT Procedures for Simulation of Historical Building Restoration Site.” 32st International Symposium in Automation and Robotics inConstruction - ISARC. Oulu, Finland, 2015.

BRASIL. Ministério da Cultura. Manual de Elaboração de Projetos de Preservação do Patrimônio Cultural. Instituto do Programa Monumenta, 2005.

BRITEZ, Carlos, e Rodrigo VERGILI. “Consultoria Especializada para Acompanhamento Técnico dos Serviços de Reabilitação da Estrutura de Concreto Armado do Edifício Vilanova Artigas da FAUUSP.” Relatório Técnico, São Paulo, 2015.

BRITISH COLUMBIA HERITAGE BRANCH. Conservation Planning Methodology: developing policies for the conservation of historic places. British Columbia, Canadá. Disponível em: <https://www.for.gov.bc.ca/ftp/heritage/external/!publish/web/Conservation_Pl aning_Methodology.pdf>.

CABRELLES, M., S. GALCERÁ, S. NAVARRO, J. L. LERMA, T. AKASHEH, e N. HADDAD. “Integration of 3D Laser Scanning, Photogrammetry and Thermography to Record Architectural Monuments.” 22nd CIPA Symposium. Kyoto, Japan, 2009.
CAMP, Géraldine, Pierre CARREAUD, e Hervé LANÇON. “Large Structures: Which Solutions for Health Monitoring?” International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXIV International CIPA Symposium. Strasbourg, France, 2013.

CLARK, Kate. “Conservation Plans: Benefit or Burden?” English Heritage, 2000.

Conselho Curador da Faculdade de Arquitetura e Urbanismo de São Paulo. “Plano Diretor Participativo FAUUSP 2011-2018.” Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo. 2012. http://www.fau.usp.br/fau/administracao/congregacao/planodiretor/data/jornal_pdp_2012.pdf (acesso em 18 de Janeiro de 2016).

CONTIER, Felipe de Araujo. O Edifício da Faculdade de Arquitetura e Urbanismo na Cidade Universitária: projeto e construção da escola de Vilanova Artigas. São Carlos: tese de doutorado do IAUUSP, 2009.

DE LA TORRE, Marta. Assessing the Values of Cultural Heritage: Research Report. Los Angeles, CA: Getty Conservation Institute, 2002.

DEZEM-KEMPTER, E., L. SOIBELMAN, M. CHEN, e A.V. MÜLLER. “Escanemaneto 3D a Laser, Fotogrametria e Modelagem da Informação da Construção para Gestão e Operação de Edificações Históricas.” Gestão e Tecnologia de Projetos 10 (2015): 113-124.

DOCCI, Mario; MAESTRI, Diego. Manuale di rilevamento architettonico e urbano. Roma: Editori Laterza, 2009.

English Heritage. Grafitty on Historic Buildings and Monuments: Methods of Removal and Prevention. London, 1999.

EPPICH, Rand, ed. Recording, Documentation, and Information Management for the Conservation of Heritage Places: Illustrated Examples. Los Angeles: The Getty Conservation Institute, 2007.

GIANNECCHINI, Ana Clara. Técnica e Estética do Concreto Armado: um estudo sobre os edifícios do MASP e da FAUUSP. São Paulo: tese de mestrado da FAUUSP, 2009.

GIUDICE, Matteo Del, e Anna. OSELLO. “BIM for Cultural Heritage.” International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXIV International CIPA Symposium. Strasbourg, France, 2013.

GONÇALVES, Ana Paula A. Corrosion Prevention in Historic Concrete - Monitoring the Richards Medical Laboratories. University of Pennsylvania, Philadelphia, PA, 2011.

Grupo Executivo de Gestão dos Espaços Físicos da Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo. Atividade de Manutenção e Reformas dos Edifícios da FAUUSP período janeiro/2007 a janeiro/2009. São Paulo: FAUUSP, 2009.

Haworth Tompkins Ltd. “Conservation Management Plan for the National Theatre.” London, 2008. Heritage Branch. Conservation Planning Methodology: Developing Policies for the Conservation of Historic Places. Province of British Columbia, s.d.

HICHRI, N., C. STEFANI, L. DE LUCA, P. VERON, e G. HAMON. “From Point Cloud to BIM: a survey of existing approaches.” International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXIV International CIPA Symposium. Strasbourg, France, 2013.

KERR, James Semple. “The Conservation Plan: a guide to the preparation of conservation plans of European cultural significance.” Australia ICOMOS. 2013. http://australia.icomos.org/wpcontent/uploads/The-Conservation-Plan-7th-Edition-reduced-file-size.pdf (acesso em 18 de Janeiro de 2016).

LERMA, José Luís, Talal AKASHEH, Naif HADDAD, e Miriam CABRELLES. “Multispectral Sensors in Combination with Recording Tools for Cultural Heritage Documentation.” Change Over Time (University of Pennsylvania Press) 1, n. 2 (2011): 236-250.

LETELLIER, Robin. Recording, Documentation, and Information Management for the Conservation of Heritage Places: Guiding Principles. Los Angeles: The Getty Conservation Institute, 2007.

LIRA, José Tavares Correia de (org.). Patrimônio Construído da USP: preservação, gestão e memória. São Paulo: EDUSP, 2014.

LOGOTHETIS, S., A. DELINASIOU, e E. STYLIANIDIS. “Building Information Modelling for Cultural Heritage: a review.” ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 25th International CIPA Symposium. Taipei, Taiwan, 2015.

LOWINGER, Rosa. “Vandalism (Miami Style): Graffiti as a Tool in Preserving the Marine Stadium.” Change Over Time (University

of Pennsylvania Press) 5, n. 1 (2015): 136-151.

MEZZINO, D., W. PEI, M. QUINTERO, e R. RODRIGUEZ. “Documenting Modern Mexican Architectural Heritage for Posterity: Barragán’s Casa Cristo, in Guadalajara, Mexico.” ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 25th International CIPA Symposium. Taipei, Taiwan, 2015.

MURPHY, M., E. MCGOVERN, e S PAIVA. “The Processing of Laser Scan Data for the Analysis of Historic Structures in Ireland.” The 7th International Symposium on Virtual Reality, Archaeology and Cultural Heritage. Nicosia, Cyprus, 2006.

OKSMAN, Silvio. Preservação do Patrimônio Arquitetônico Moderno: a FAU de Vilanova Artigas. São Paulo: tese de mestrado da FAUUSP, 2011.

QUINTERO, M., e K VAN BALEN. “Rapid and Cost-Effective Assessment for the World Heritage Nominations.” 22nd CIPA Symposium. Kyoto, Japan, 2009.

QUINTERO, Mario Santana, e Ona VILEIKIS. “Heritage Recording and Information Management in the Digital Age.” Change Over Time (University of Pennsylvania Press) 1, n. 2 (2011): 156-164.

REMONDINO, FABIO. “Advanced 3D Recording Techniques for the Digital Documentation and Conservation of Heritage Sites and Objects.” Change Over Time (University of Pennsylvania Press) 1, n. 2 (2011): 198-214.

STYLIANIDIS, E., P. PATIAS, e M. QUINTERO, . CIPA Heritage Documentation: Best Practices and Applications. ICOMOS, 2011.

TEZA, Giordano, Antonio GALGARO, e Francesca MORO. “Contactless Recognition of Concrete Surface Damage from Laser Scanning and Curvature Computation.” NDT&E International (Elsevier), n. 42 (2009): 240-249.

TINOCO, Jorge Eduardo Lucena. “Planos de Conservação: do ensino à prática, da academia aos canteiros de obras.” Centro de Estudos Avançados da Conservação Integrada. 2013. http://www.ceci-br.org/ceci/br/publicacoes/59-textos-para-discussao/635-plano-de-gestaoda-conservacao.html (acesso em 18 de Janeiro de 2016).

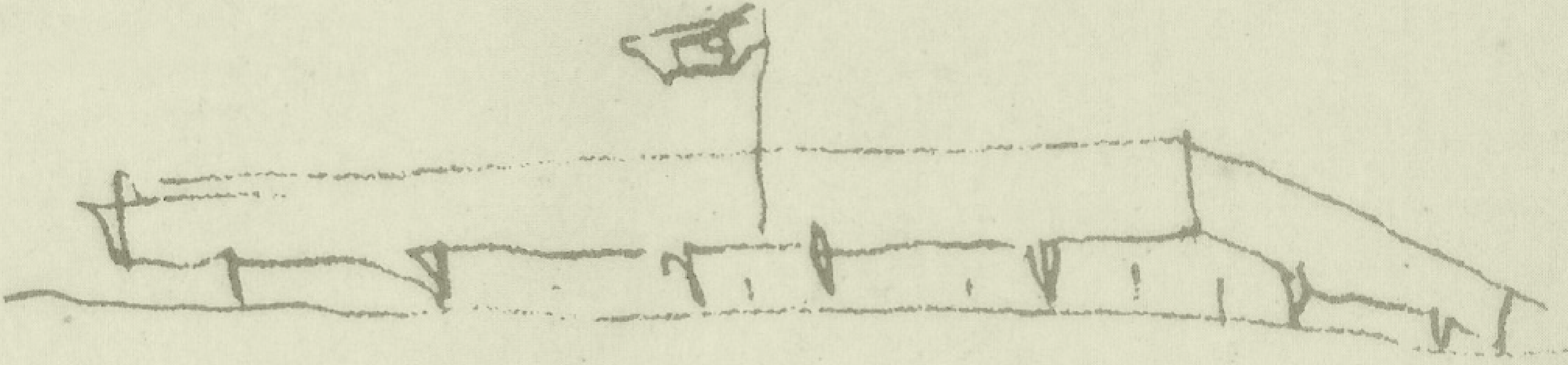
URQUHART, Dennis C. M. “Historic Concrete in Scotland. Part 3: Maintenance and Repair of Historic Concrete Structures.” Edinburgh: Historic Scotland, 2014.

VAN WAGENEN, Haley West. Building Information Modeling and Historic Buildings: How a Living Model Leads to Better Stewardship of the Past. University of Pennsylvania, Philadelphia, PA, 2012.

WALDHÄUSL, Peter, e Cliff OGLEBY. “Photogrammetric Capture: the 3x3 Rules.” Slose Range Techniques and Machine Vision, ISPRS Commision V Symposium. Melbourne, Australia, 1994.

WALKER, Meredith, e Peter MARQUIS-KYLE. The Illustrated Burra Charter: good practice for heritage places. Burwood: Australia ICOMOS Inc, 2004.

WEAVER, Martin E. “Removing Graffiti from Historic Masonry.” Edição: U. S. Department of the Interior. New York, 1995.



Source: “Original Sketches Notebook”, 1998

DOCUMENTAL CORPUS

Corpus Documental

As part of the scope of activities developed in Task 1, several processes of searching for documentation and producing new information about the building were essential for developing a solid knowledge base.

To do so, the first step was to consult several collections that contain material on the design of the building and on the interventions that have occurred over the years. Knowing these changes allows us to understand what the demands and needs were, as well as the ways in which they were adopted. In this documental corpus are detailed the collections consulted and the database organized from them, both of the project designs, photographs and administrative processes.

Another stage of this work front concerns the elaboration of surveys. In addition to the metrical-architectural survey presented previously (Cadastral Survey), other surveys were carried out, such as a photographic survey of each of the internal environments, arboreal surveying, surveying of uses, laser surveying of façades, among others. The annexes for these products, which are of great importance for the understanding of the building and the establishment of guidelines for its conservation, will be presented below.

Guidelines:

• In order for the metric-architectural survey to be always up-to-date, future interventions should use it as a project basis. In this way, the set of drawings will always be true to reality and its previous versions will serve as a document of the building's change history;

• Similarly, future surveys to be carried out should be based on previous surveys;

• Regarding administrative processes, it was found that many volumes are being incinerated based on the University's own temporality policy, without a systematic record of its contents. In this way, it is recommended to digitize all the processes that are contemplated by such policy, so that they can be consulted later in electronic form and so that there are no gaps in the historiography of the building.

Project designs

One of the goals of the Vilanova Artigas Building Conservation Management Plan project is to develop a unified database containing information on each of the existing designs of the building, in order to organize and catalog the existing collection in electronic media, so that consultation is facilitated. This process presents itself as a challenge, since, in several cases, copies of the same design are distributed in different collections or even different designs of the same project are located in diverse collections, with independent classification or naming and not unified.

In addition to the sketches, which contain Artigas's initial traces for the building, the designs relating to the first studies, the architectural and complementary designs implanted (such as hydraulics, electrical and structures), and to each intervention carried out or proposed are currently in different collections: from the Iconographic Materials Section of the FAU-USP Library, from the Superintendence of Physical Spaces of USP (SEF-USP) and also from the Technical Service of Infrastructure of FAU-USP (former Executive Group of Management of Physical Spaces, GEEF).

So far, 786 drawings produced between 1961 and 2004 were cataloged. Additionally, electronic designs, produced and stored by FAUUSP's Infrastructure Technical Service, were consulted in order to complement the chronology of the building until the most recent interventions.

In the table below, each of the designs found in the consulted collections is specified. In this sense, it is important to reiterate that the information obtained on the collection of the Superintendency of Physical Spaces of USP (SEF-USP) was obtained through the research developed by the Center for Cultural Preservation of USP (CPC-USP) for the book "Patrimônio construído da USP: preservação, gestão e memória" (Built Heritage of the University of São Paulo: preservation, management and memory), organized by José Tavares Correia de Lira, in 2014. This is also why these designs, which are mostly original documents, state also their conservation status.

Designs Table (Annex 1)

Photographs

With the goal of preserving the photographic records of the Vilanova Artigas Building, a database of photographs was created that register several building moments, as well as assisting in the understanding of its various uses, historical layers and appropriations over time.

Numerous digitized historical photographs and contemporary digital photographs were obtained from various collections, such as the Iconographic Materials Section of the FAU-USP Library, the collection of well-known architecture photographers who documented the construction at different times, and personal archives. In the same way that it was organized with the architecture projects, a unified database was created, in order to facilitate future research. Over the months, this archive has been continuously complemented, mainly by external contributions from students, alumni, and staff. To date, a total of 1192 photographs have been obtained, of which 125 are duplicated and only 668 have a definite date.

Photographs Table (Annex 2)

Administrative processes

Another collection of information consulted was that of administrative processes of the University of São Paulo whose subject matter was related to the construction or maintenance of the Vilanova Artigas Building. In addition to helping to situate the progress of interventions more precisely, since they document chronologically the bureaucratic operations performed, the administrative processes also helped in understanding the methods and in identifying the groups responsible for each stage of the work.

In total, 142 processes were found, dating from 1965 to 2010, whose subjects deal with the construction or interventions carried out in the building. Of this total, 79 were consulted. Those that contained relevant information that contributed to the development of the chronology of the building were recorded in photography. Of the others, 3 were lost and 60 were incinerated, according to the policy of temporality adopted by the University.

Administrative processes Table (Annex 3)

Arboreal survey

After an initial observation of the surroundings of the building, it was considered important to complement the cadastral survey with an arboreal survey. In the service scope, the following activities were specified: identification and location of all surrounding trees, evaluation of the phytosanitary status of the specimens and guidelines for their future management. The management of the surrounding masses of trees is an important part of the conservation efforts of this building due to the proximity of branches that can affect the roof, clogging the drainage pipes, and the blind façades of apparent reinforced concrete, darkening them. The work started in the second week of December and was finalized in February 2017.

Of the 197 specimens identified, it was recommended to prune 163, cut 14 and remove 3. It is important to note that since the conclusion of this survey, removals of several specimens were carried out, besides the replacement of a palm tree by an arboreal species. In this way, it is necessary to update the survey with a certain regularity, so that management is effective.

Arboreal survey Table (Annex 4)

Interventions descriptive sheets

In the drafting of the Conservation Management Plan of the Vilanova Artigas Building, it was proposed to complement the chronology already accomplished by the FAU-USP Master Plan, identifying each of the interventions and project proposals for the building from the location of the designs and the analysis of what was actually implemented. Thus, it was possible to identify when, how, where and why each intervention took place.

Along with the design of each AutoCAD intervention, descriptive files were produced, which were obtained through project designs, administrative processes and historical photographs. This systematization of information also allowed the elaboration of the chronology of interventions of the physical spaces of the building, resulting in the report presented below. In all, records were found on 41 interventions, between works executed and not performed, and 5 surveys.

Interventions descriptive sheets (Annex 5)

Report: Chronology of interventions

This report presents the process of identifying and analyzing the interventions that caused physical changes in the building from its inauguration to the present.

The analysis and reconstitution of the chronology of the building allow the recognition of possible values of the interventions in this heritage and the identification of original elements of the construction that are still present. This knowledge is essential in the foundation of conservation guidelines and policies for any historical heritage, as evidenced in international references, such as James Semple Kerr's "*Conservation Plan - A Guide to the Preparation of Conservation Plans for Places of European Cultural Significance*". In addition, this information is important for the development of intervention projects according to the methodology established by the Monumenta Program adopted by IPHAN, a reference for the development of restoration projects at the national level. This work was also carried out in order to facilitate the access of future researchers to the consulted documents.

Report: Chronology of Interventions in the Vilanova Artigas Building (Annex 6)

DIAPReM (Centro Dipartimentale Development of Integrated Automatic Procedures for Restoration of Monuments) - University of Ferra:

Coordination: Marcello Balzani

Field work: Guido Galvani e Daniele Sasso Felice

Formation of local team: Federica Maietti, Luca Rossato e Guido Galvani

Report: Integrated Diagnostic Survey Methodology (DIAPReM, Unife)

The report on the integrated diagnostic survey methodology for the façades of the Vilanova Artigas building was produced by DIAPReM's technical team, a research center linked to the Architecture Department of the University of Ferrara. The work results from the laser scanning survey, which was conducted in August 2016 with the purpose of obtaining metric-morphological data about building's apparent reinforced concrete façades.

This survey allowed the creation of point cloud model of the external surfaces of the FAUUSP, which served as the basis for the investigation of the geometric and surface formal features of the elements that compose the façades. Handling and retrieving data from the point cloud was possible using the Cyclone software.

In addition to the raw point cloud and the elevations of the façades generated by the software, the Ferrara team produced an integrated diagnostic survey analysis report, combining the metric-morphological data with the reflectance data of the building materials, adding information about its characteristics.

Report: Integrated Diagnostic Survey Methodology (DIAPReM, Unife) (Annex 7)

FAUUSP Participative Master Plan 2011-2018

The FAUUSP Participative Master Plan (PDP) Forum was held on May 31 and July 3, 2011 and had the participation of students, former students, teachers, former teachers, employees and former employees who debated and voted the text summarizing the PDP, drafted during the year 2010 and early 2011 by the College Curator Council. The text was completed after months of studies on FAUUSP buildings in their physical and historical dimensions and establishes principles, procedures and guidelines for future space interventions in these buildings. The participation of the FAU community was fundamental in identifying the needs and desires of the users of the buildings and in proposing guidelines that will serve as a basis for the improvements to be carried out over the next eight years.

For the preparation of the Plan, three work fronts were organized:

• technical reading: survey of the physical conditions of the buildings;

• participatory reading: discussion with users of the buildings about the problems and potentialities of the spaces in question;

• heritage reading: survey of changes in the use and occupation of the buildings over time, as well as issues related to its protection and its deontological issues.

After the synthesis of the readings, made through seminars and open meetings, a pre-proposal of the Master Plan was elaborated. After being presented and debated in the FAU Councils and Commissions, this pre-proposal received amendments, formulated by the members of the FAU community, to be discussed and voted on again at the Forum. From it, the modifications to the basic text of the Plan came out and consolidated the proposals present there. Thus, the Forum reached its goal of establishing agreed guidelines for future interventions, which may point to a change in the management culture and reform of school buildings.

In the Plan, the physical-spatial intervention actions of the FAUUSP buildings were placed on a timeline and classified as priority and medium or long-term, in addition to defining their character as ordinary maintenance, extraordinary maintenance or restoration and expansion (according to the principles contained in the Venice Charter and the ICOMOS documents). Thus, no direct actions were proposed, but procedures and needs for future interventions, which must be monitored permanently through the implementation of an Office-Academic Workshop.

One of the first actions foreseen in the Master Plan is the elaboration of a Mass Plan, spatializing its proposals. The

general structure of the spaces is classified in Annex 04 of the Plan according to the following criteria:

• areas for pragmatic activities: it comprises all the areas currently available for the allocation of functional activities of the program;

• consolidated areas to be maintained: areas occupied with functions compatible with the nature of the place where they are located and in a manner consistent with the provisions of the original project and are relatively adequate, requiring no immediate interventions, and adequate maintenance;

• consolidated areas to be adapted: areas occupied by functions compatible with the nature of the place where they are located, consistent with the provisions of the original project and requiring adjustments and new requirements;

• areas to be redefined: these are non-consolidated areas, which do not necessarily present problems, whose occupation must be redefined considering the principles, guidelines and program requirements established by it;

• free areas: these are free and open areas which, along with the ramps, stairs, hallways and corridors, include living areas, as well as free and unnamed areas for exhibition and all those temporary activities and unpredictable, but legitimate.

The Plan also provides for the elaboration of a Maintenance Plan. Thus, the text of the PDP serves as a theoretical-instrumental basis for future interventions in FAUUSP's buildings and not as finished projects or proposals. Breaking away from a culture of isolated projects that take into account only the immediate / practical needs posed by the use of buildings is a virtue the PDP can bring to college.

The Participative Master Plan is the basis on which the first studies were developed for the Conservation Management Plan (CMP) of the Vilanova Artigas Building. This is because the CMP deepens into the issues raised by the PDP, especially regarding technical issues of conservation of materials and architectural elements. We have always recognized that the construction of the meaning of historical heritage is only valid when done in a collective, participative way. The Conservation Plan does not replace or modify the PDP, it will only deepen and serve as an instrument for implementing the guidelines defined in it.

FAUUSP Participative Master Plan 2011-2018 (Annex 8)

THE ROOF:
CONSTRUCTION SYSTEMS AND THEIR CONSERVATION

Keeping It Modern Program
Getty Foundation
2017

THE ROOF:
CONSTRUCTION SYSTEMS AND THEIR CONSERVATION

Coordination
Antonio Carlos Barossi
Rodrigo Vergili
Collaborator: Claudia T. de Andrade Oliveira

Team of Professionals
Rodrigo Vergili
Eric Palmeira

Source: Rosa Artigas Archive.

SUMMARY

2. Task 2: The roof – Constructive systems and their conservation

Antônio Carlos Barossi, Claudia Terezinha de Andrade Oliveira, Rodrigo Vergili, Eric Palmeira

Introduction 131

Presentation of the original characteristics of Vilanova Artigas Building roof 131

Roof timeline 132

Work method 133

2.1. Constructive characteristics of the roof subsystems 135

1. Structure 137
2. Waterproofing 141
3. Roof flashings 142
4. Lightning system 143
5. Rainwater drainage 145
6. Skylights 147
7. Water supply and sewerage 148
8. Exhaustion system 149
9. Electrical installations 150
10. Access and transit 150

2.2. History of interventions and studies conducted on the roof 153

1. From the construction until 1980 156
2. Interventions between 1980 and 1991 158
3. Studies and experiments 1992-1996 160
4. Interventions between 1997 and 2002 162
5. Interventions between 2001 and 2003 163
6. Studies in 2005 and 2006 164
7. New proposals and interventions between 2007 and 2010 166
8. Interventions between 2012 and 2015 167
9. Commentary 167

2.3. Survey of the structure and of the waterproofing conditions 169

1. Vertical displacements of the structure 171
2. Inspections on the polyurea membrane 175
3. Polyurea Characterization tests 177

2.4. Guidelines and recommendations for the implementation of the Conservation Management Plan Analyses and Guidelines 179

1. General Guidelines 181
2. Guidelines for maintenance considering the risk factors of materials deterioration 181
3. National standards and current legislation 182
4. Preliminary adjustments 183

2.5. Roof Conservation Management Plan 187

1. Maintenance and Periodic Inspections Program 189
2. Description of Maintenance Activities and Periodic Inspections 189
3. Repair program 192
4. Players responsible for the implementation of the Conservation Management Plan for the roof 192
5. Work schedule 194

References 197

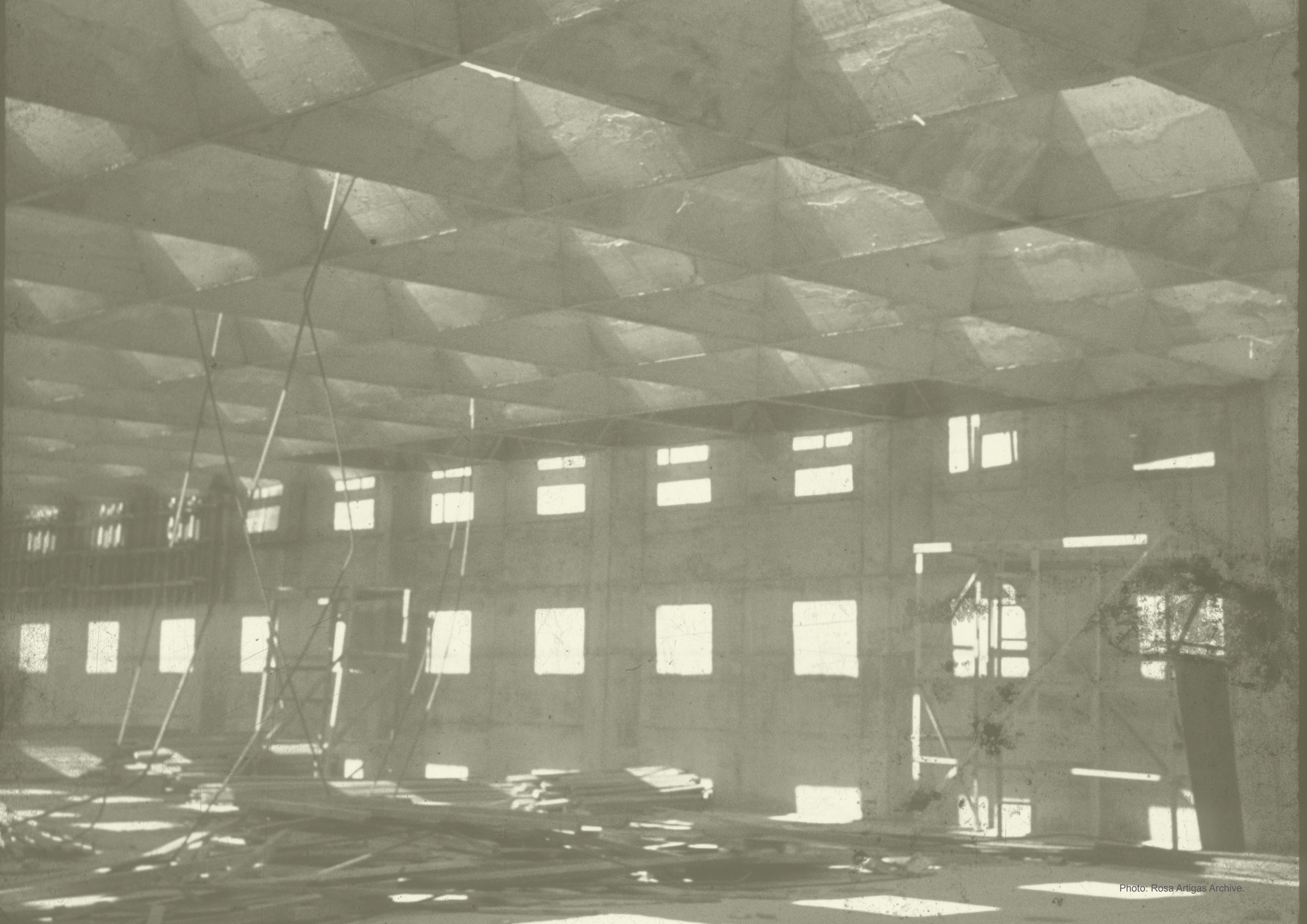


Photo: Rosa Artigas Archive.

2.

TASK 2

Introduction

The roof is one of the systems most vulnerable to the action of time and degradation agents, besides being, from the technical viewpoint, the system requiring attention regarding its structural performance in the service limit state and in the last limit state.

Since the first decade of use of the building, there are reports of problems due to recurrent flaws in the roof waterproofing system, which have potentiated the degradation of the concrete and required, over the decades, reactive treatments that, despite being very invasive, have not mitigated the consequences of such flaws, which resulted from multiple causes. Therefore, the main object of Task2 is to monitor the roof waterproofing system with the aim of proposing guidelines for a preventive maintenance program.

For the fact that it is entirely coated with the current polyurea waterproofing system, the concrete and steel reinforcements of the roof beams were not inspected as done with the blind walls. However, investigations about the strength and other characteristics of the concrete cores extracted from a beam of the roof were included in the experiments of Task 3; the results are presented along with the results of the characterization of the blind walls concrete.

The cadastral survey, the results of tests and inspections performed onsite, as well as the analysis of the construction track record and interventions done in the blind walls, allowed to consolidate a rational base of data through which inferences and estimations can be done about the performance of the roof, provided that the cycles of preventive maintenance are respected.

Presentation of the original characteristics of the Vilanova Artigas Building roof

The roof is a unique and translucent plan that covers the entire building. The light emitted, pressed into the hollow of blind walls, takes shape and materializes the medium below it, thus acquiring a special quality.

From a constructive point of view, the roof itself consists of the 8cm-thick continuous slab integrated with the pyramid trunks that form the skylights. This slab is supported by the main system of longitudinal and transverse beams described in detail in item 2.2.1. Although continuous, the slab is perforated each 2.75 m , resulting in a mesh of voids through which zenith light enters, amounting to 16% of the roof area.

The beams of the main structural system of the roof circumscribe modules measuring 22 m x 5.5 m.

Each of these modules defines a rainwater collection sector with a 0.5% slope towards the central pillars through which descend the drainage pipes.

The slope for the collection of rainwater was executed on the structure itself, and not on the regularization finish, as usual.

A flexible waterproofing system, molded in situ, and made up of alternating layers of commercially elastomers named Neoprene® and Hypalon®, was applied on the regularization layer of the slab, and on the entire exposed surface of the beams. As specified by the manufacturer, the product did not require mechanical protection, and was expected to have a ten-year durability. In Brazil, at that time, it was one of the newest and most advanced products on the market.

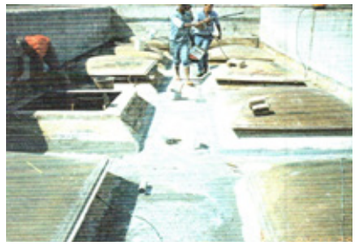
The skylights that cover the slab openings were originally made of self-supporting translucent fiberglass vaults directly fixed to the concrete. The design provided for steel angle brackets positioned on the concrete edge of the openings (probably during concreting) where the translucent domes, also structured with steel angle brackets, would be fixed.

Figure 1 - Internal view of Vilanova Artigas, 1969. Source: Arquigrafia.

1967-1968
Building construction and waterproofing of the roof

1970-1990
Successive corrective interventions after the emergence of water-proofing failures

1992-1994
Inspection, studies, and prototypes for corrective intervention



1996-2002
Corrective interven-tion and new water-proofing of the roof

2005-2006
Inspection, studies, and prototypes for corrective intervention

2009-2015
Corrective intervention and new waterproofing of the roof

Work method

The methodological approach employed in this task consisted in the development of four large sets of activities: identification of the elements that make up the roof; history of the interventions and experiments performed on the roof; current conditions of the structure and waterproofing, and guidelines and recommendations for implementation of the Roof Conservation Management Plan.

Identification of the roof elements

This set of activities sought to identify all the elements that make up the roof system and its interfaces with the waterproofing system. This was done through surveys in situ and analysis of technical documents (designs, descriptive memories). The results are presented in item 2.2 of this work, containing the physical and functional description of the elements and the details of design materials and solutions.

History of interventions and studies conducted on the roof

In parallel with the history of the interventions and studies carried out throughout the work, the constructive chronology of the roof was detailed. This activity, although not initially foreseen, was considered essential for the understanding of the transformations occurred in the roof elements. The roof performance, especially in terms of water tightness, can be better understood through the knowledge of important corrective steps and decisions made since the construction of the building. The results of these studies are presented in item 2.3.

Current conditions of structure and waterproofing

The monitoring of the waterproofing system was supported by the work carried out by the team that prepared the as built survey of the building. With this field survey, the main vertical displacements of the roof were recorded; in combination with visual inspections and tests performed in situ, it was possible to prepare the diagnosis of the current state of conservation of the roof.

The visual inspection is considered as a first approach in the area of inspection and surveys and a very important practice for the evaluation of systems of any nature. In the case of the polyurea waterproofing system, it is possible to identify the existing faults. Mapping of the roof condition was performed, to identify possible areas of water puddling. The results are presented in the form of drawings, and they will be important in identifying areas of greater risk of failure. These results will serve as a basis for comparison, and as a guide for the future monitoring of areas at risk.

The test performed for the detection of discontinuity was carried out in a tentative manner on some modules of the roof, and allowed to identify faults not observed in the visual inspection. The method proved to be feasible for future monitoring and detection of waterproofing faults.

These studies included characterization and natural aging tests, up to one year, of the polyurethane.

The results of this activity are found in item 4 of this work.

Development of preventive maintenance measures

Finally, from the results of the surveys and trials, and based on the technical guidelines of the Brazilian standards, system deficiencies were raised, and corrective and preventive maintenance procedures proposed.

Considering that the most recent repair of the waterproofing system has just completed 3 years, this is the right time to implement a preventive maintenance program based on consistent knowledge of the elements and their materials. The inspection protocols, containing the detailed procedures of periodic inspection to identify initial damages and their remediation, as well as the inspections and interventions in all the other roof subsystems are presented in items 5 and 6.

Photo: Rodrigo Vergili.

2.1.

CONSTRUCTIVE CHARACTERISTICS OF THE ROOF SUBSYSTEMS

2.1.1 Structure

The roof of FAU-USP is delimited by the building own façades, measuring 66 x 110m (nominal dimensions between axes). Its structural system is composed of inverted beams 1.9m high and 0.4m wide, located at each 5.5m in the longitudinal direction, and 22.0m in the transversal direction. The peripheral inverted beams coincide with the façade concrete blind walls, as observed in Figure 2.

This main structure is complemented by a 2.75 x 2.75m mesh of inverted “V” shaped secondary beams, 48.5cm high, constituting an inverted “V” shaped slab, partially hollow, since only the secondary beams supported on the internal pillars have full concrete sections; the others are hollow, as shown in Figure 3. The slab itself is 8cm thick.

The full section beams supported on the 18 internal pillars are integrated into the peripheral part of the façade blind walls. For purposes of identification, each space delimited by the full section inverted beams is regarded as a module of the roof. That way, there are 60 modules equally distributed in three ranges: frontal, intermediary and posterior, as observed in Figure 4. In each module, Figure 5, there are 16 zenithal openings of 1.1 x 1.1m, covered by translucent domes.

Because of its dimensions, the roof structure is divided into four parts by two dilatation joints that allow for the movements resulting from the thermal dilatation of the concrete. The main dilatation joint divides the roof transversally in half, in two symmetrical parts. This joint reaches the blind walls of the northeast and southwest façades. The second has a rectangular shape, segregating the central modules and intersecting the transversal joint in two points, as observed in Figure 6. The constructive detail of Figure 3 shows the cross section of a full inverted “V” beam intersected by the transverse joint.

The superficial protection of the concrete slab is the waterproofing system itself, which coats the external surface, and will be described in item 2.2.2.

There is no record of any original technical specification of the dilatation joints protection system. Until the recuperation campaign of 2009-2010, the horizontal joints were protected by a butyl blanket positioned on top of the beam, very deteriorated at the time. In 2010, the butyl blanket was replaced by a treatment with polyurethane sealing, and the beam was subsequently covered by aluminum roof flashing.

In the campaign of 2012-2015, the roof flashings were provisionally removed, and the top of beams were covered by the polyurea membrane. Currently, the joints are successively protected by the polyurethane sealing, by the polyurea membrane, and by the aluminum roof flashing.

Figure 2 - Aerial view of Vilanova Artigas building. Jorge Murata, 2007.

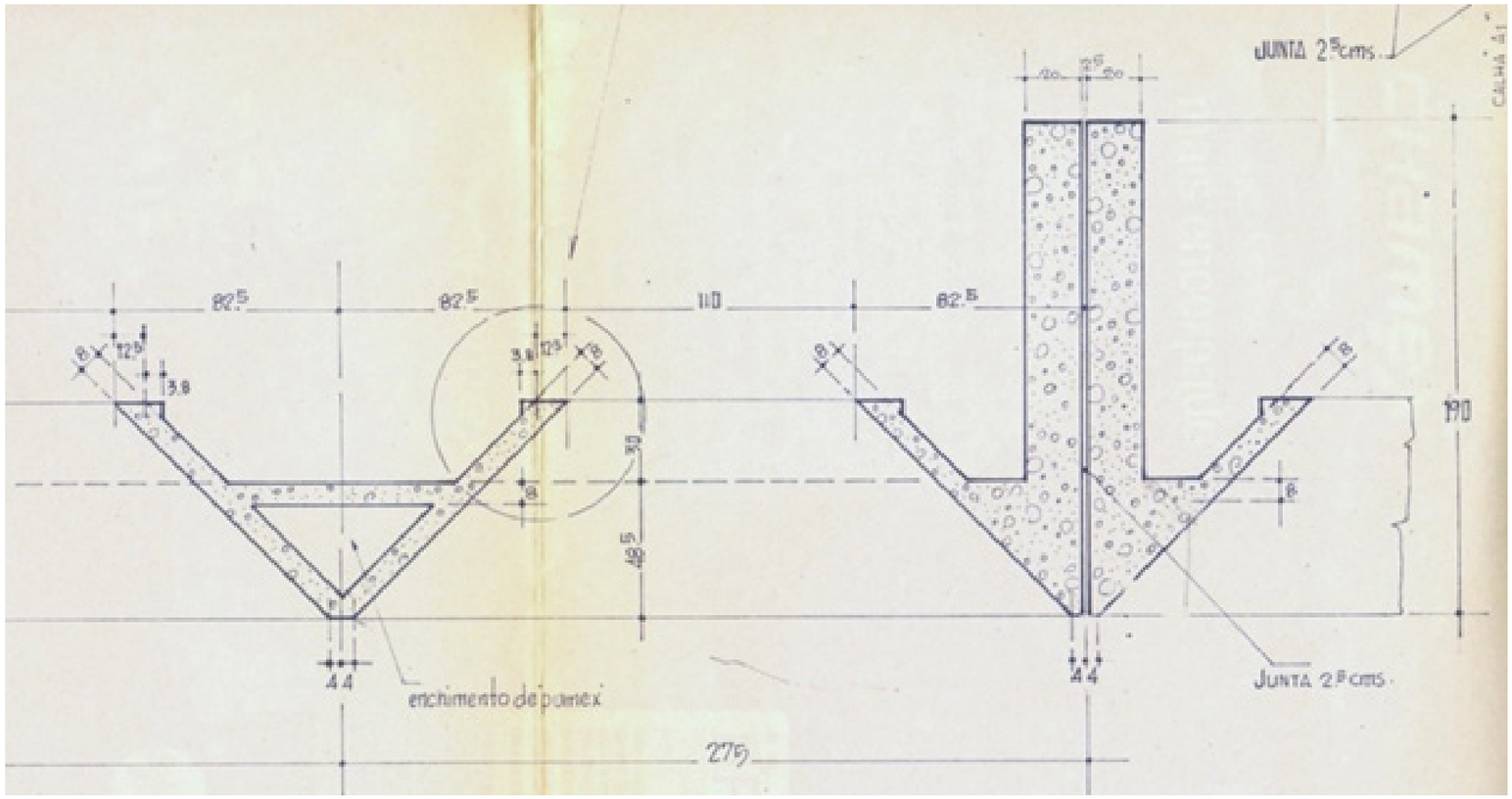


Figure 3 - Detail of the structural design by Figueiredo Ferraz Technical office, with the cross-section of the reinforced concrete beams of Vilanova Artigas building roof.

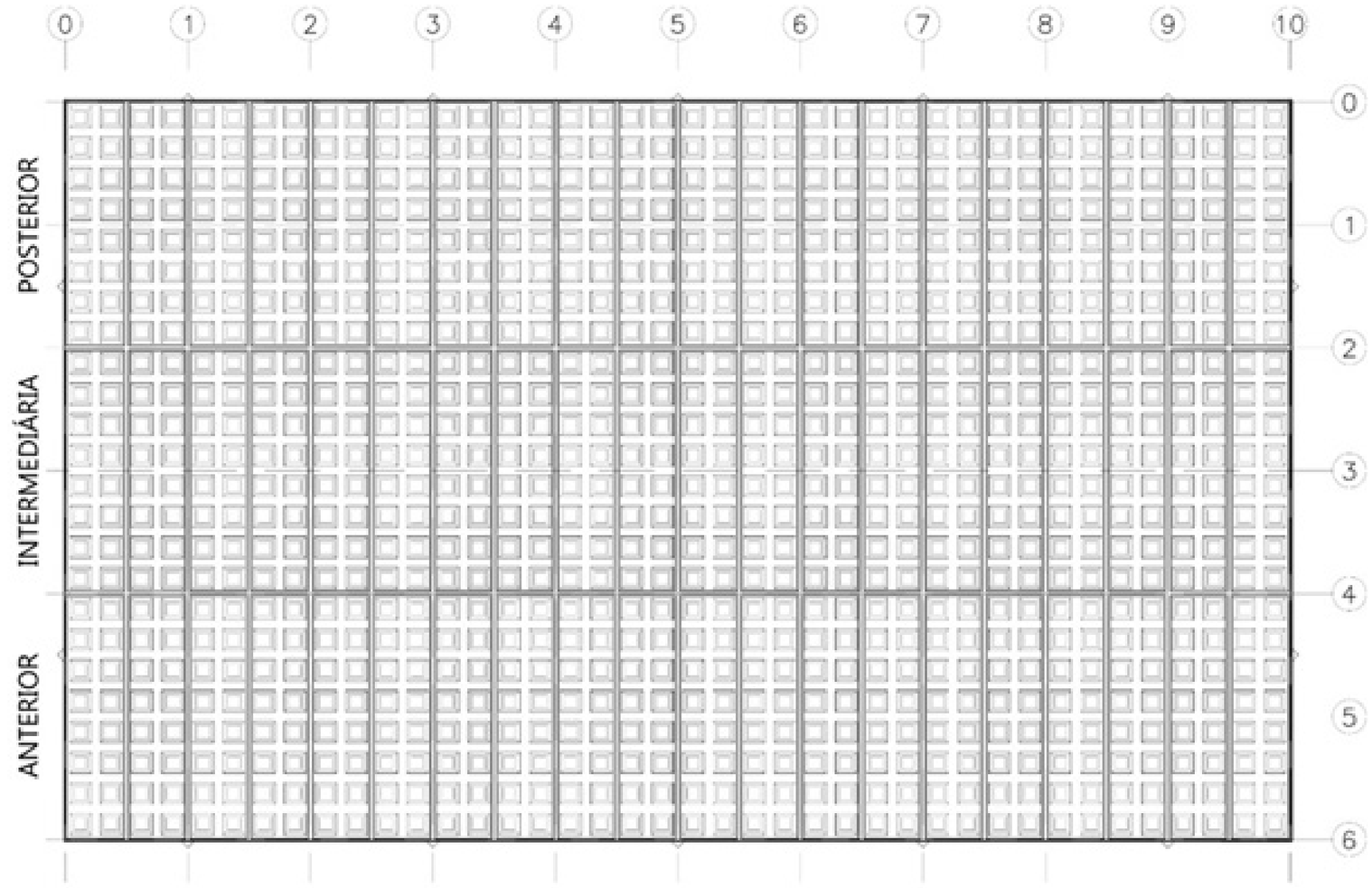


Figure 4 - Representation of the roof beams and its modules.

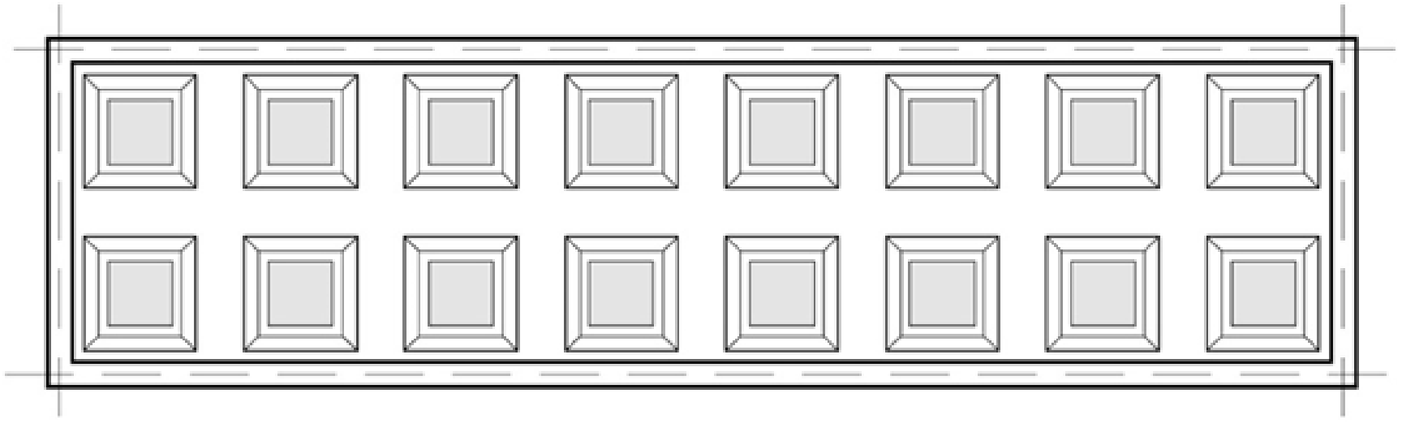


Figure 5 - Representation of one roof module.

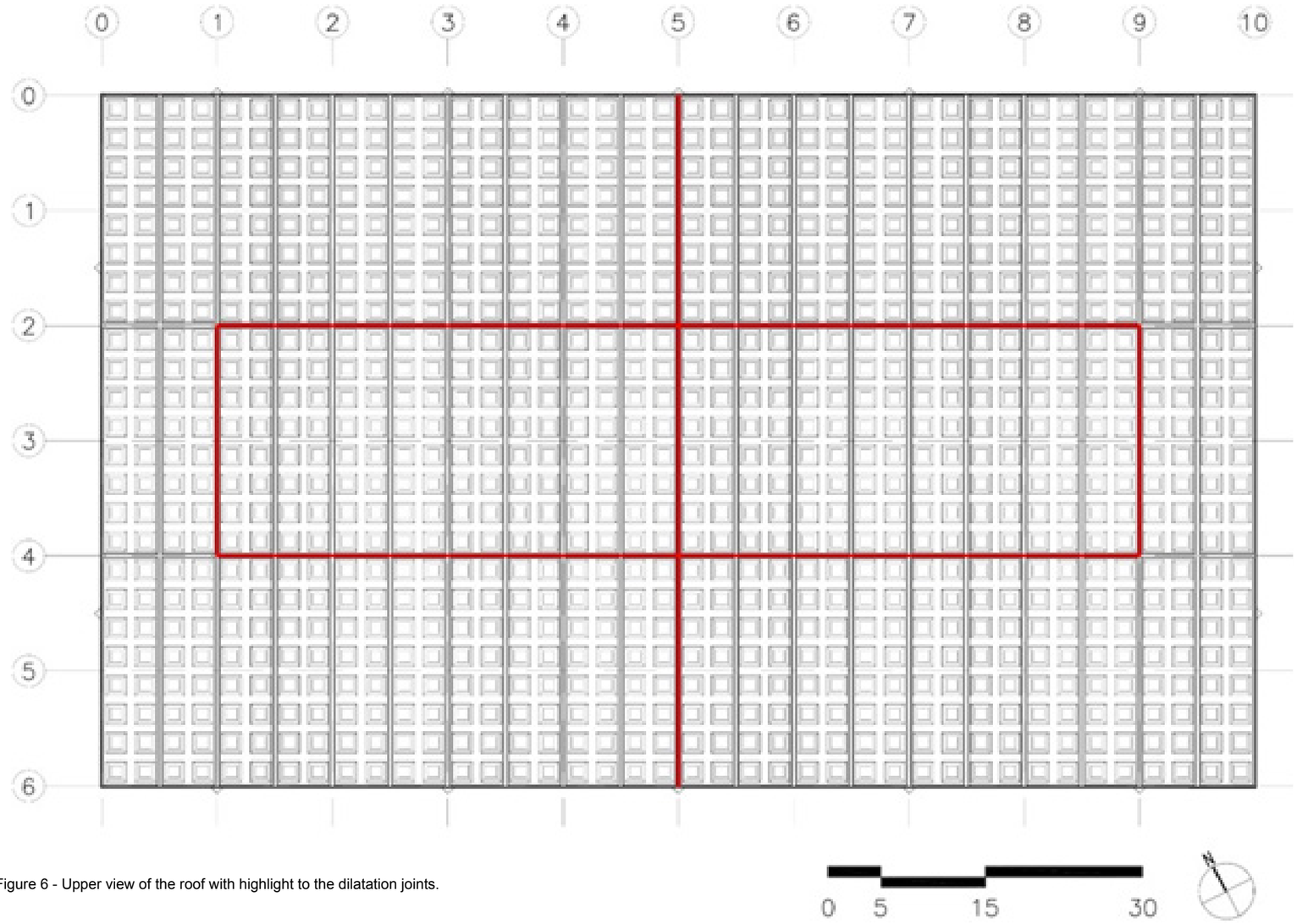


Figure 6 - Upper view of the roof with highlight to the dilatation joints.

Identification of the roof modules

For identification purposes, each module is sequentially numbered from 1 to 20 (from the Northwest façade to the Southeast one), followed by the letter corresponding to the range it belongs: A for frontal, I for Intermediary, and P for posterior.

Before the beginning of this project, the modules were identified by two letters, the first indicating the longitudinal position of the module in the roof, from A to T (in the inverse direction of the new nomenclature, from the Southeast to the Northwest façade); the second letter determined the range A, I or P.

This change was made to facilitate the location of modules during maintenance works, as well as to prevent errors in elaborating records and reports, since the inversion of the two letters was quite common, causing confusion in the identification, especially in the case of modules AI, IA, AP, PA, PI, and IP.

Table 1 - Table of correspondence between the old and new nomenclature of roof modules.

Frontal Modules		**Intermediary Modules**		**Posterior Modules**	
Old ID	New ID	Old ID	Old ID	New ID	Old ID
AA	20A	AI	20I	AP	20P
BA	19A	BI	19I	BP	19P
CA	18A	CI	18I	CP	18P
DA	17A	DI	17I	DP	17P
EA	16A	EI	16I	EP	16P
FA	15A	FI	15I	FP	15P
GA	14A	GI	14I	GP	14P
HA	13A	HI	13I	HP	13P
IA	12A	II	12I	IP	12P
JA	11A	JI	11I	JP	11P
KA	10A	KI	10I	KP	10P
LA	09A	LI	09I	LP	09P
MA	08A	MI	08I	MP	08P
NA	07A	NI	07I	NP	07P
OA	06A	OI	06I	OP	06P
PA	05A	PI	05I	PP	05P
QA	04A	QI	04I	QP	04P
RA	03A	RI	03I	RP	03P
SA	02A	SI	02I	SP	02P
TA	01A	TI	01I	TP	01P

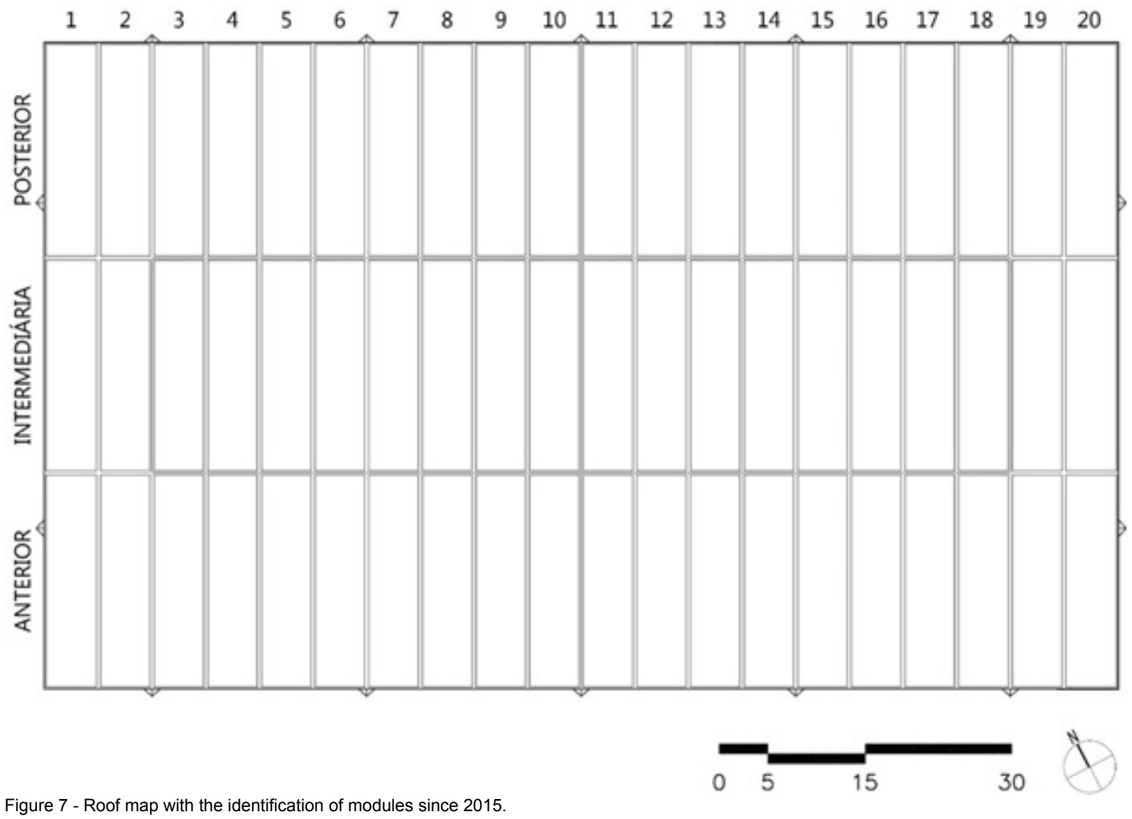


Figure 7 - Roof map with the identification of modules since 2015.

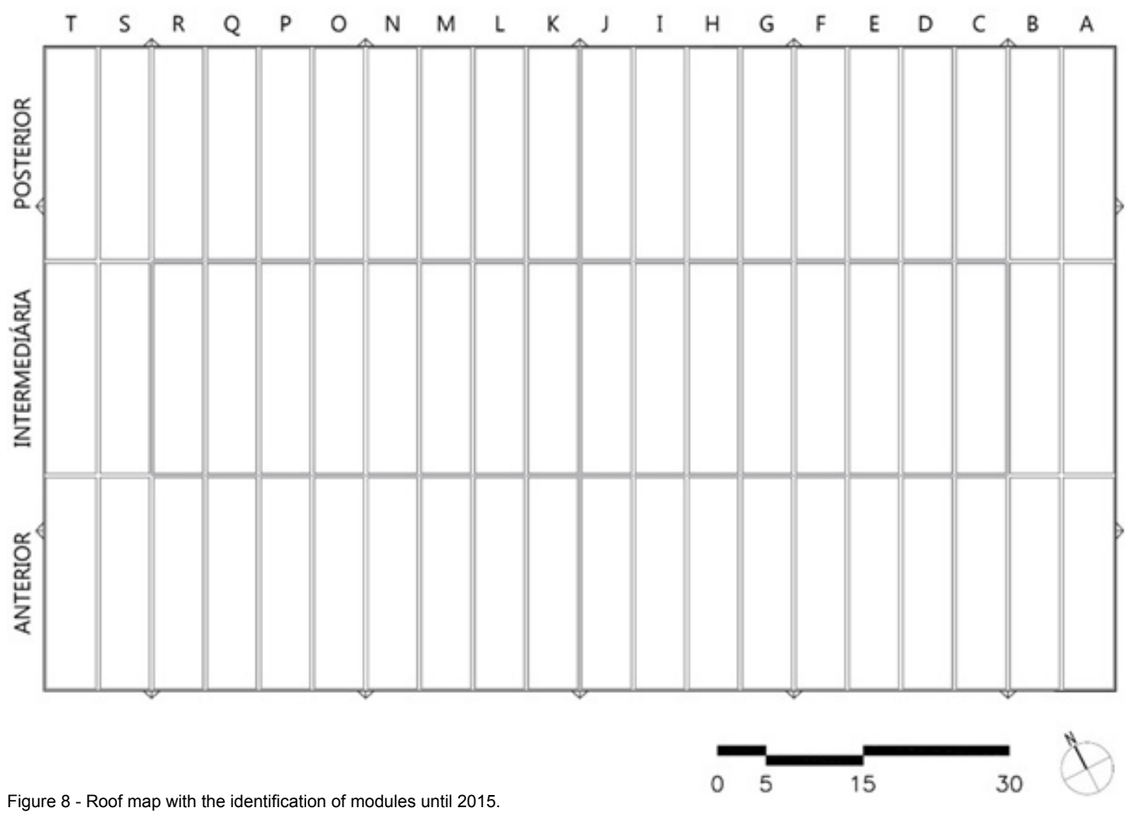


Figure 8 - Roof map with the identification of modules until 2015.

2.1.2 Waterproofing

The waterproofing system originally applied to the roof consisted of an elastomeric membrane of polychloroprene and chlorosulphonated polyethylene, commercially known as Neoprene-Hypalon®, prepared onsite, directly applied to the concrete substrate, protecting both slab and inverted beams (lateral and top).

This type of waterproofing has been frequentely used in Brazil since the 1960s to meet the requirements of big architectonic projects demanding a light waterproofing, which could be exposed to the weather. It consisted of a system of multiple polychloroprene layers (Neoprene®) applied with a roller and interleaved with structuring nylon screens, which ensured the waterproofing. At last, a finishing layer of chlorosulphonated polyethylene (Hypalon) granted the waterproofing with a good resistance to ultraviolet rays, with no need of mechanical protection.

In the partial roof recuperation campaign started in the 1990s, the Neoprene-Hypalon® waterproofing was replaced by a mixed system of structure crystallization combined with an acrylic waterproofing, predominantly composed of emulsified acrylic polymers, applied in interleaved layers with a polyester or polyamide screen.

In the recuperation campaign of 2012 to 2015, the entire roof waterproofing was replaced by a polyurea waterproofing system, which consists of a pure adhered polyurea elastomeric membrane, directly applied on the concrete substrate. It is approximately 2.5mm thick and covers the whole external surface of the slab and inverted beams, forming a continuous protection coating on the roof, of approximately 10,900m².

The product used was ViaPoliUreia 600PP of Viapol, a company belonging to the Euclid Group. According to the manufacturer, it is a bi-component product (isocyanate and polyamine), 100% composed of polymers, with no addition of solvents. It is applied hot by using a high pressure spray machine with temperature control, and the mixture takes place at the end of the application nozzle. It results in an impermeable coating with high mechanical, chemical and thermal resistances. Table 2 below shows some technical characteristics.

It is noteworthy that, regardless of the performance of the materials used, the concept for the selection of the waterproofing system was maintained over the years. The three systems used - polychloroprene and chlorosulphonated polyethylene, acrylic emulsion and polyuria - can be considered as belonging to the same family of waterproofing materials, because they are prepared onsite and are constituted of synthetic polymeric membranes.

Table 2 - Technical Characteristics of ViaPoliUreia 600 PP

Characteristic	Specification	Unit
Density	1.110	g/cm³
Gel time *	40	seconds
Final cure	15	minutes
Hardness	50	Shore D
Tear strength	430 (75.30)	pli (N/mm)
Stretching	600	%
Tensile strength	> 18	MPa
Adhesive strength	> 3 (concrete flaw)	MPa

Source: Data Sheet of ViaPoliUreia 600 PP, June 2013, Viapol Euclid Group.

(*) Gel time – It is the time needed, during the polymerization reaction, for the polymer to start to show a given mechanical resistance.

2.1.3 Roof flashings

Until the 2009-2010 structural recuperation campaign, the top of the roof inverted beams had no specific protection; despite being a region more weather exposed and susceptible to deterioration, it was protected only by the waterproofing membrane used in the rest of the roof.

Although no records of reapplication or even maintenance of such protection (on the beam) were found, until the mid 1980s it was visually still in good conditions, with local flaws evidenced by the corrosion of some rebar, as observed in Figure 9.

However, in the subsequent years, in view of the deficient maintenance services affecting the whole roof, and particularly the waterproofing system, the conditions of the inverted beams progressively deteriorated. Early in the 2000s, the superficial protection of the beams was already deteriorated, and the structure rebar had generalized corrosion, as observed in Figure 10.

This situation was only reverted at the end of the 2009-2010 recuperation campaign, when the structural recuperation of those elements was done, and a roof flashing system was installed on top of the the inverted beams.

The installed roof flashing is constituted of folded aluminum plates 2mm thick; the pieces are 3m long, except for those located at the ends and in the crossings of inverted beams. They have a variable overlapping of 3 to 7 cm.

The roof flashing is fixed to the structure with screw anchor bolts, 2” long and ¼” thread, made of galvanized steel, positioned in pairs at each 1.5m, approximately. In the “double” beams, where the dilatation joints are, they are fixed only to one of the beams to allow the structure to move without damaging this system.

Figure 9 - Inspection of the roof of Vilanova Artigas building. Estimated date: 1986. Author Unknown. Source: Arquigrafia.

Figure 10 Upper view of the roof with detail of the inverted beams deterioration and rebar corrosion, 2004. Photo: João Roberto Leme Simões.nown. Source: Arquigrafia.

2.1.4 Lightning system

Originally, the lightning system consisted of a radioactive captor, positioned in a 13m high pole (measure estimated by photogrammetry) located on the inverted beams at the position of pillar P21, as shown in Figure 11.

Not many records were found about this first system, and the little information available is based on photographs of the 1980s, where the electrical interconnection of the pole with naked metallic conductors is identified, running across the longitudinal beam as for as its descent subsystem, probably located in pillars P15 and P16, as schematized in Figure 12.

This system remained on the roof until mid 1994, when the Campus Prefecture, upon request from FAU, elaborated a new design to replace it, which consisted of substituting the radioactive captor by a Faraday mesh, composed of catchment terminals 0.4m high, distributed at each 8m, transversally to the building, on a mesh of 11m x 22m of naked copper cable, fixed on the inverted beams, with descents located in the 14 peripheral pillars, as shown in Figure 13.

However, due to the constant evolutions in the field of atmospheric discharge protection, in the yearly 2000s, the installed system was already obsolete according to the new technical standard requirements in effect, especially regarding the distribution of captor rods, which should be denser, and the number of grounding descents, which should also be bigger.

Therefore, in 2007, a new design was developed by USP Institute of Electrotechnique and Energy (currently, Institute of Energy and Environment), which was executed in the 2012-2015 recuperation campaign.

Figure 11 View of the roof in 1986 (estimated date). At the background, the the radioactive captor pole of the system of protection against atmospheric discharges. Author Unknown. Source: Arquigrafia.

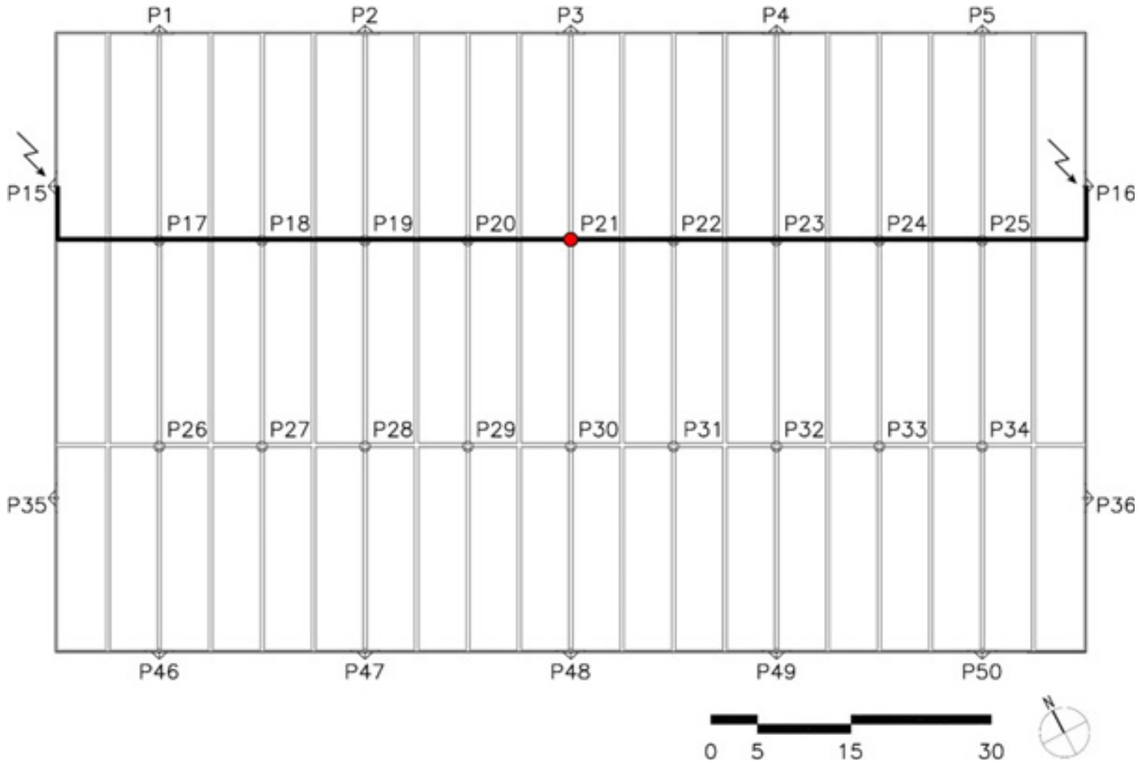


Figure 12 Scheme of the first system of atmospheric discharge protection of the roof, existent between 1969 and 1994. In red, the location of the pole, on pillar P21.

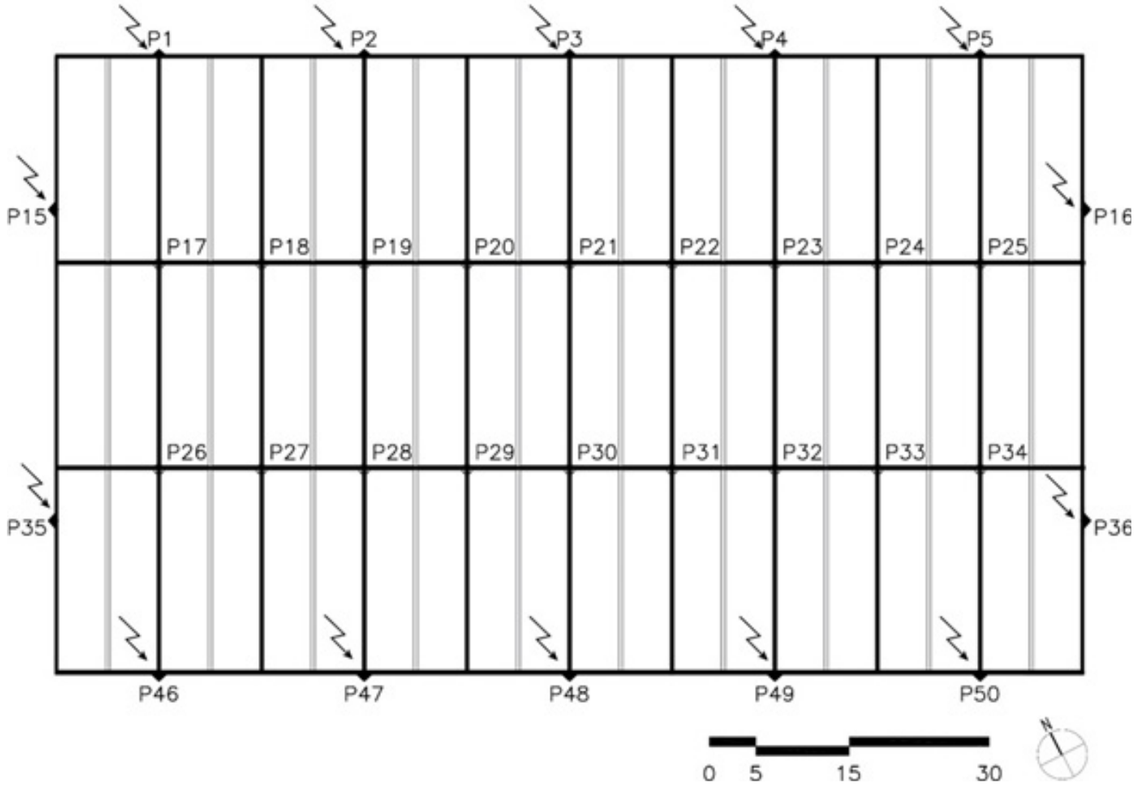


Figure 13 Scheme of the second system of atmospheric discharge protection of the roof, existent between 1994 and 2012.

Currently, the Lightning System installed in the roof of Vilanova Artigas building is an hybrid system, combining the Faraday Method and the Electromagnetic Method. In such system, the catchment subsystem is composed of 271 galvanized steel rods 60 cm high, with nominal diameter of 5/16”, distributed in a 5.5 x 5.5m mesh, directly interconnected with the aluminum roof flashings, which are part of the system. They are fixed to the sides of the roof flashing, with stainless steel hexagon-headed self-broaching screws, 1” long and thread of 5.5mm.

In the positions coinciding with water tanks, 3 catchment rods are installed on each of the tanks, connected to the system by naked copper cables of 50mm², totalizing 277 aerial terminals.

The descent subsystem, in turn, uses the structure steel reinforcement to interconnect to the grounding subsystem, composed of the building foundation. The connection occurs through tinned brass connectors and naked copper cable of 50mm² intertwined with the roof flashings and the rebar, as shown in Figure 15.

Figure 14 - Aerial terminal. Author: Rodrigo Vergili.

The alternative of using the structure reinforcement to connect with the descent subsystem, instead of the exposed copper cables, in addition to allowing for the increase of the number of descents, as observed in Figure 15, also eliminated the use of copper cables next to the façade concrete blind walls, which caused greenish stains resulting from the metallic copper corrosion.

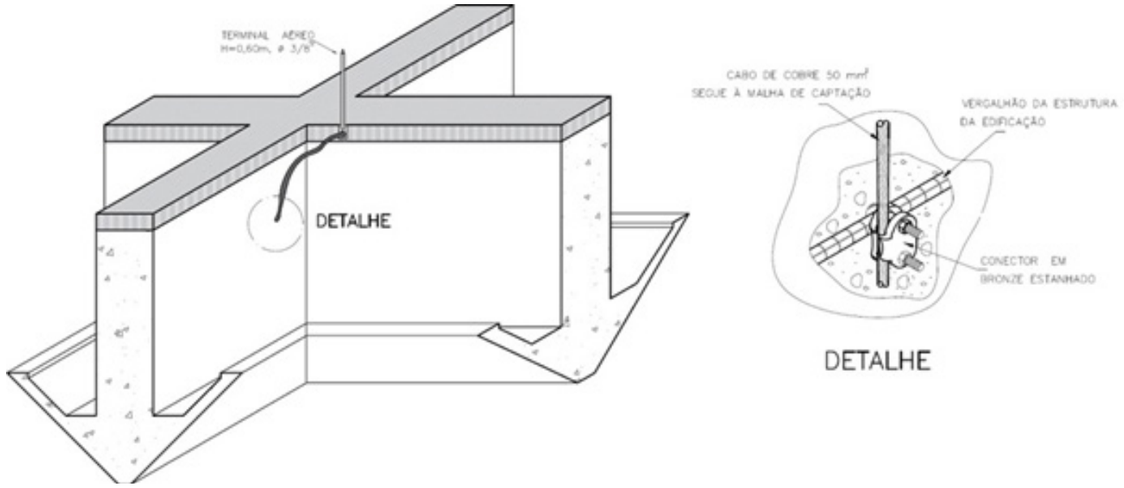


Figure 15 - Detail of the interconnection of the lightning system to the structure rebar.

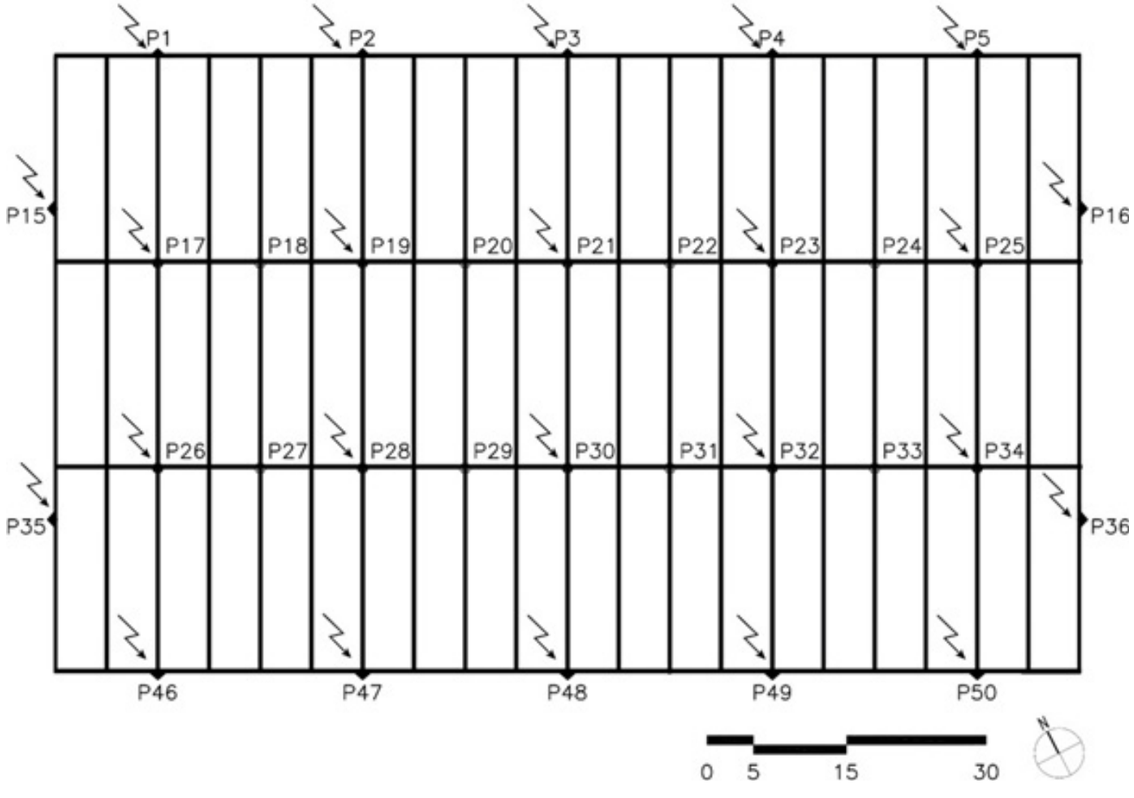


Figure 16 - Roof plan with the current lightning system.

2.1.5 Rainwater drainage

Based on the architectonic and structural concept of the roof, the rainwater drainage should take place through the waterproofed slab itself, which works as a big collecting gutter. The own concrete structure was designed in “inclined plans” in, with the rainwater running towards the drains, so that the slab would not need regularization layers to create the gradient.

The design of hydro-sanitary facilities of 1961, elaborated by the Homero V. M. Lopes Technical Coordination Office, provided for 72 drainage points directly connected to vertical pipes positioned inside the internal pillars, which “tie-shaped” cross section was designed to allocate the hydraulic facilities of the building, as observed in Figure 17. The whole system was composed of cast iron conductors and hemispheric grates.

In this configuration, the modules 1A, 1I, and 1P, and 20A, 20I, and 20P, located next to the Northwest and Southeast façades, and which are not directly supported by the internal pillars, would not have drains according to Figure 17. The water coming from such places should flow to the adjacent modules by means of holes opened across the whole section of the inverted beams that limit these modules from their neighbors.

Probably to meet such demand of runoff at the extremities, the drains and vertical pipes located at the “corners” of the roof would have a nominal diameter of 6”, instead of the diameter of 4” of the others, which can also be observed highlighted in red in Figure 18.

However, for unknown reasons, only half of the rainwater drains and vertical pipes was actually executed. The elimination of half of the vertical conductors, possibly arbitrarily, resulted in a very big disparity in the distribution of the drainage points: while some modules had two drains, others were at a distance of two modules from the closest drain, as modules 20P, 20I, and 20A, as shown in Figure 19.

Before the roof recuperation campaign of 2012-2015, FAU asked for an evaluation of the installed discharge, and according to the need and executive feasibility, the duplication of the existing vertical pipes would be included in the scope of the work.

According to the building installations office Serife Engenharia, consultant of Jatobeton Engenharia Ltda., which was responsible for the execution of works, at least one extra point of catchment and corresponding vertical pipe would be necessary for each roof module to comply with the standard ABNT NBR 10844 – Rainwater building facilities.

Therefore, new 4”-diameter drains were executed by vertically drilling the concrete of the structure near the pillars, in the positions originally defined in the 1961 design of hydro-sanitary installations. In 1968, during the construction of the building, the vertical pipes and the pipe joints that connected them to the slab drains were positioned inside the pillars before the roof concreting. This was of course impossible in the roof recuperation campaign of 2012-2015. As a result, the addition of drains and vertical pipes was limited by some technical executive aspects, especially when the “new” rainwater vertical conductors had to share the space inside the pillars with other existing hydro-sanitary installations (cold water and sewage). That way, despite the increase of the drainage capacity, as shown in Figure 20, this capacity remained still below the requirements set forth in the standard, in view of the impossibility of installing new drains in all of the runoff points. During the works, the whole cast iron pipeline was replaced by a PVC one as far as the rainwater gallery, except for the segments embedded in the roof structure, which could not be replaced.

In the intermediary modules receiving new drains, the new vertical pipe was interconnected to the existent contiguous vertical pipe, as observed in Figure 20, thus allowing to keep the ratio of one drainage vertical pipe per module. In the other cases, a new vertical pipe was installed as far as the rainwater gallery, in the basement of the building, as seen in Figure 22.

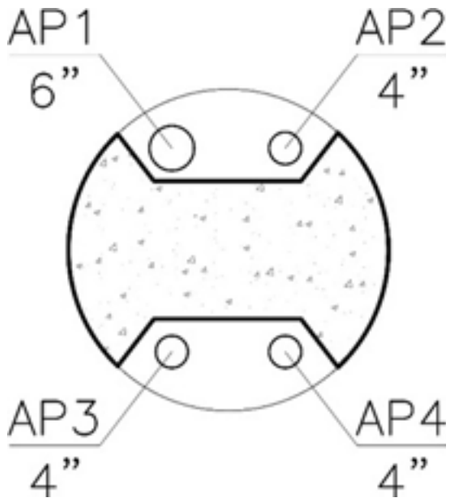


Figure 17 - Tie-shaped cross-section of pillar, with the scheme of drains according to the design of installations, adapted from the design of the Homero V. M. Lopes Technical Coordination Office, of 1961.

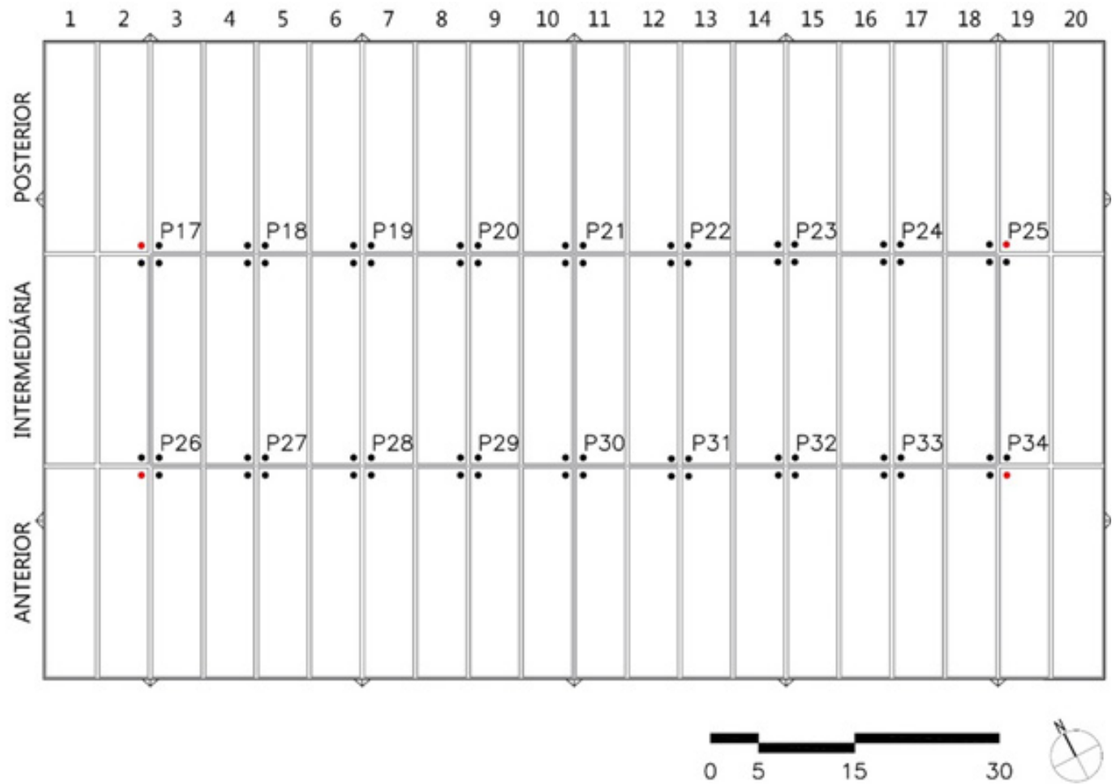


Figure 18 - Graphic representation of the rainwater facilities design elaborated by the Homero V. M. Lopes Technical Coordination Office. The four 6”-diameter conductors at the “corners” of the roof are highlighted in red.

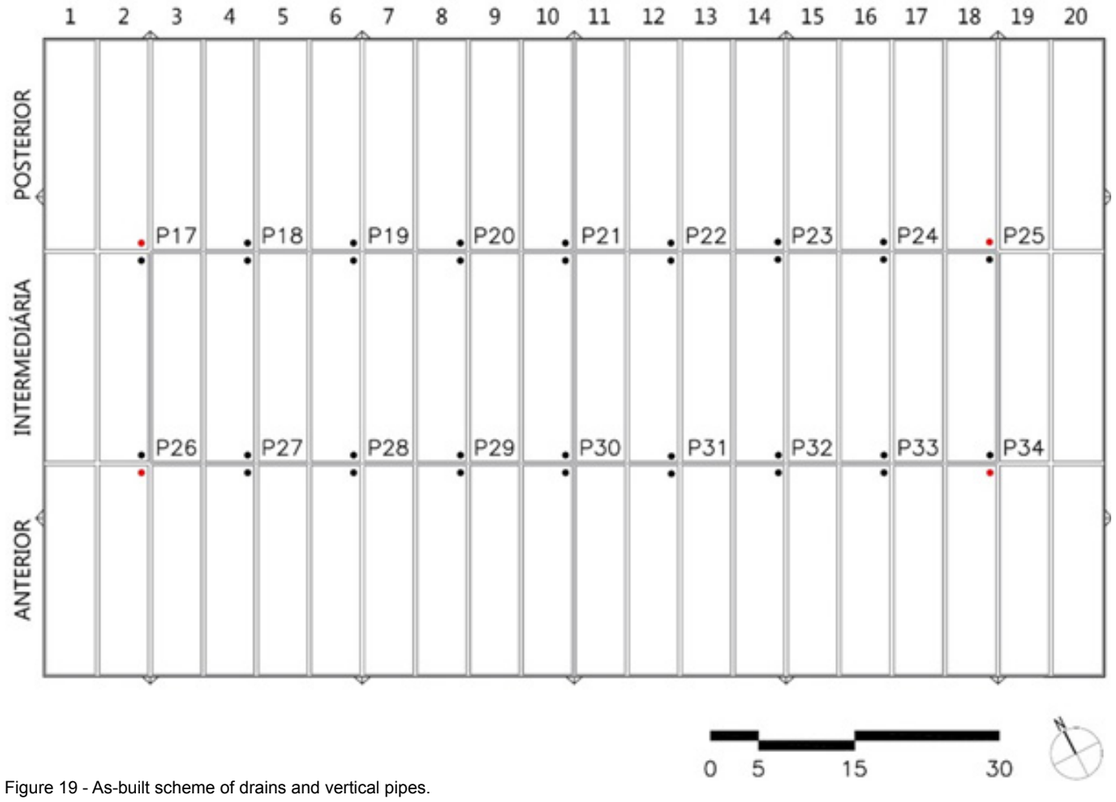


Figure 19 - As-built scheme of drains and vertical pipes.

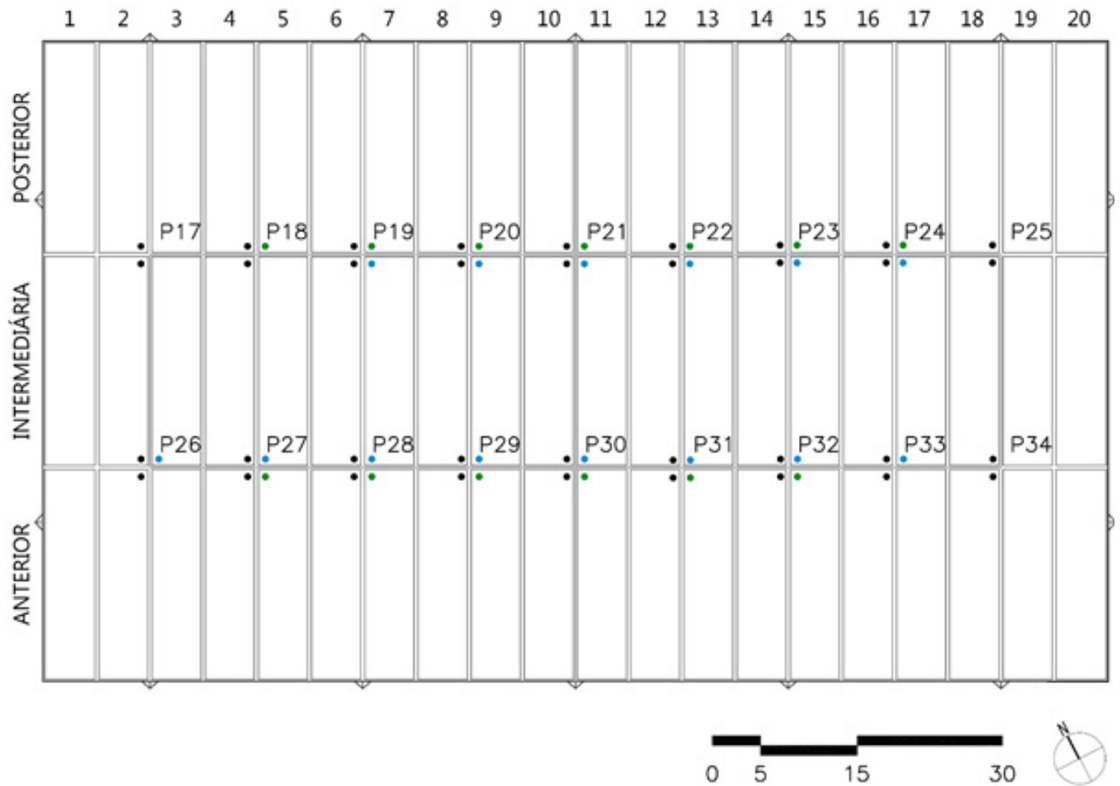


Figure 20 - Detail of the new layout of the rainwater drainage system. In black, the pre-existent drains and their respective vertical pipes; in blue, the drains added with shared vertical pipes; and in green, new drains and vertical pipes.

Figure 21 - Rainwater vertical pipe in the intermediary range of modules. Detail of the interconnection of drains in a single rainwater vertical pipe. Photo: Rodrigo Vergili.

Figure 22 - Rainwater vertical pipe in the posterior range of modules. Detail of the duplication of rainwater vertical pipes. Photo: Rodrigo Vergili.

2.1.6 Skylights

The skylights, popularly known as “domes” in the Vilanova Artigas building, were originally made of polyester resin, reinforced with fiberglass screen, with dimensions of 1.60m x 1.60m in plan. They were placed with flat bars directly fixed to the resin and on the side of the pyramid trunk, interfering with the slab waterproofing.

In the 1990s, the skylights were already deteriorated. The continuous exposure to sunlight and weather had caused an intense yellowing of the resin and loss of superficial mass, leaving the fiberglass exposed and vulnerable to biological colonization, mainly by fungi.

The first intervention in those elements took place early in the 2000s, when of the total 960 skylights, 430 were replaced by new ones, and 150 were recuperated during the roof waterproofing recuperation works. The remaining 380 skylights of the roof had to await financial resources to be recuperated or replaced, as observed in Figure 23 and Figure 24.

Only during the recuperation campaign that occurred between 2012 and 2015, the skylights went through a new intervention, and all of them were replaced. The new pieces were specified as translucent white acrylic with the main purpose of contributing to improve the thermal and luminous performance of the building, Figure 25.

They were fixed with folded aluminum profiles positioned at the upper face of the inverted “V” slab beams, in order not to jeopardize the waterproofing. However, this new position, which also increased the natural ventilation area by elevating the skylights, contributed to let the rainwater inside the building due to splashes on the inner part of the slab beams.

It is noteworthy that this water inlet mechanism already took place, with smaller intensity, before the intervention in this system. However, to solve the problem, a screen was installed around the skylight, not visible from the inside of the building, working as a physical barrier to rainwater splashing, as observed in Figure 26.

Figure 23 - Internal view of the roof in 2004, highlighting the deterioration of some skylights. Photo: João Roberto Leme Simões.

Figure 24 - Detail of the skylight condition in 2004. Photo: João Roberto Leme Simões.

Figure 25 - View of the roof during the replacement of skylights, during the intervention works between 2012 and 2015. Detail of the difference of appearance between the new acrylic skylights on the background and the resin ones on the foreground. Photo: Rodrigo Vergili.

Figure 26 - Blue screen installed around the skylight to prevent the entrance of rainwater inside the building, because of splashes on the slab. Photo: Rodrigo Vergili.

2.1.7 Water supply and sewerage

On the roof, there are two elevated exposed reinforced concrete reservoirs, for the supply of cold water of the building. They are positioned on pillar P17 and P25, 1.0m from the inverted beams, and are 4.4m high per a 1.95 m diameter, with approximate volume of 10,000 L each, as observed in Figure 27.

The reservoirs are interconnected, and all the horizontal distribution of cold water takes place at the roof level, with branch pipes originally descending by pillars P17, P20, P25, P26, P33, and P34.

There is evidence that the original cast iron pipelines were supported on rectangular openings at the sides of the beams, provided during the concreting work, as observed in Figure 28. However, in the late 1980s (after 1987, according to documental research, item 2.3.2.), with the replacement of such pipeline by a PVC one, which is more fragile and does not resist to bridge 5.5m spans as occurred with the cast iron pipeline, such openings were no longer used, Figure 29. Currently, the pipelines are directly supported on the inverted beams, Figure 30.

The sewerage system on the roof consists of the outcrop of the bathrooms ventilation pipelines at the slabs next to pillars P17, P25, P26, P30, P34. These cast iron pipelines are approximately 20cm high, as observed in Figure 31.

There are no records of major alterations or interventions in the cold water supply and sewerage systems over the years. During the 2012-2015 recuperation campaign, a hydraulic adjustment was made to the reservoirs interconnection.

Figure 27 - View of the reservoir located on pillar P17. Photo: Rodrigo Vergili.

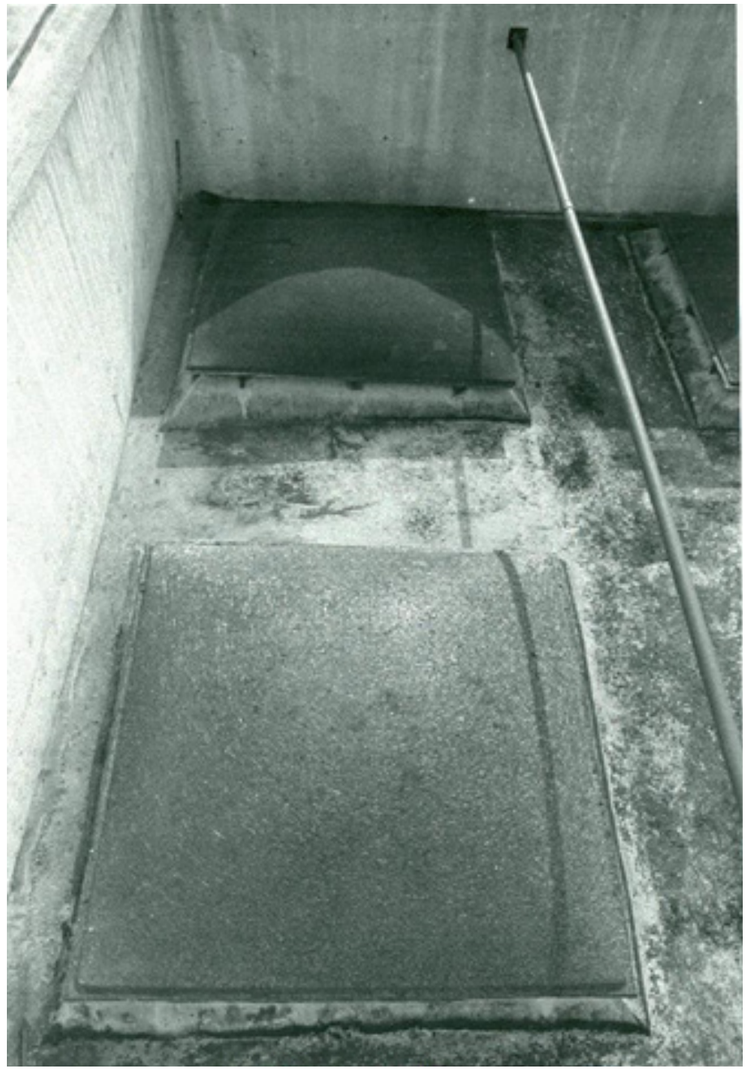


Figure 28 - To the right, detail of the cold water distribution branch pipe passing through an opening in the inverted beam in 1986. Author unknown. Source: Arquigrafia.

Figure 29 - General view of the roof, with detail of the successive openings in the inverted beams to let the pipeline pass through, in 2017. Photo: Rodrigo Vergili.

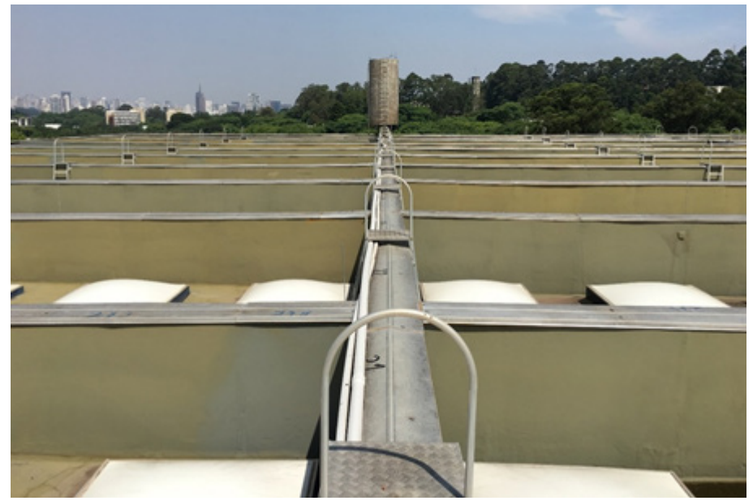


Figure 30 - Detail of the reservoirs interconnection pipeline positioned on the inverted beam, in 2017. Photo: Rodrigo Vergili.

Figure 31 - Outcrop of sewerage ventilation vertical pipe, beside the rainwater drain. Detail of the obstruction of the ventilation terminal. Photo: Rodrigo Vergili.

2.1.8. Exhaustion system

The forced ventilation system comprises an industrial ventilator, located in module 3I of the roof, to exhaust the vapors of the cafeteria´s kitchen, located in the fourth floor of the building.

As observed in photos taken little after the inauguration of the building, this ventilator was not installed then; however, no information was found regarding when that happened.

The first records of the existence of the exhaustion system were photos of the roof in 1986, where it is possible to observe the chimney positioned on one of the slab openings, Figure 32.

It can be observed that the equipment had a metallic base and was fixed to the slab regularization mortar, as shown in Figure 33, jeopardizing both the waterproofing system and the physical integrity of the structure, which became susceptible to corrosion.

This system was replaced in the last recuperation campaign of the roof, following the guidelines set forth by FAU, specifying that the equipment should not remain positioned directly on the slab, in order not to jeopardize the waterproofing system.

The system currently installed under the responsibility of Jatobeton Engenharia Ltda. is positioned on one of the roof hollows, replacing one of the skylights, as observed in Figure 34.

The chimney, the only element observable from the roof slab, is constituted of an aluminum fairing and sealed with polyurethane sealant.

Figure 32 - View of the exhaustion equipment on the roof slab, in 1986. Author Unknown. Source: Arquigrafia.

Figure 33 - View of the old exhaustion equipment located on the roof. Detail of the fixation directly on the slab and the deteriorated condition of the fairing. Photo: Claudia Oliveira.

Figure 34 - View of the exhaustion system chimney, located in module 3I. Photo: Rodrigo Vergili.

2.9 Electrical installations

There is no electrical installation on the roof, although it is considered essential to perform any activity in such floor. In all the interventions previously performed, it was always necessary to install a provisional energy feeding from the electrical panel at the entrance of the building, or from other electrical panels located in the floors just below the roof (classrooms and studio floor). Those provisional power connections are obtained by passing electrical conductors through the ventilation space of the roof skylights.

2.10. Access and transit

Originally, the access to the roof to perform inspection or even corrective maintenance services occurred through a mobile wooden ladder, positioned by FAU's maintenance team next to one of the roof skylight opening, inside the building. This form of access, probably used since the inauguration of the building, was very precarious and insecure.

The current system of access and transit was installed in 2010, after a campaign to recover the roof inverted beams. It consists of a fixed, sailor-type stairway that allows access from the top floor of the building, at the classrooms level, to the roof. This ladder is located in the module 01P, at the end of the transit area, adjacent to the northwest façade, between classroom 801 and the toilets. Consisting of aluminum profiles of square section, the ladder has 14 steps that cover a height of 4.40m.

At slab level, under one of the roof openings, there is a trapdoor in the place of the skylight that guarantees access control to the roof, as observed in Figure 35; the opening and closing operation is performed only from the inner side of the building.

The inverted beams, which are 1.4m high, constitute a physical barrier for the transit between modules; thus, transposition ladders have been installed in all beam segments, as shown in Figure 36, totaling 97 ladders.

Prior to this intervention, the horizontal transit between modules occurred by walking on the beams, which are 40cm wide. Despite guaranteeing the transit with relative ease and safety, the ladders cannot be considered a viable means to carry out maintenance services, because to access the module most distant from the trapdoor, it is necessary to transpose 21 beams.

The access to the reservoirs is made possible by another fixed ladder positioned on their sides, installed in the 2012-2015 recovery campaign . This ladder, made of painted steel, can only be reached from the inverted beam, despite the fact that it is located at at a height of one meter from the beam, like the reservoir itself, as shown by Figure 37.

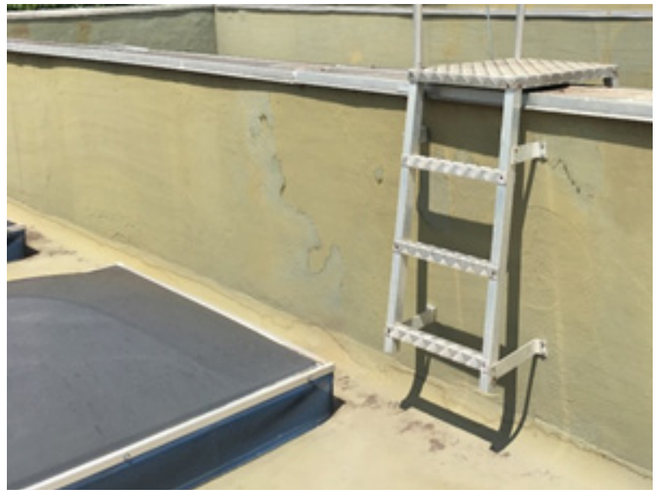


Figure 36 - View of the transposition ladder of the inverted beam. From the slab, the beam is 1.4m high. A ladder is installed for each segment of beam, totaling 97 ladders.

Figure 37 - View of the access ladder to the reservoir on the P17 pillar.

Photo: Arquigrafia

2.2.

HISTORY OF INTERVENTIONS AND STUDIES CONDUCTED ON THE ROOF

2.2. History of interventions and studies conducted on the roof.

To address the interventions that occurred on the roof, it was considered pertinent to analyze the history of occurrences since the construction of the building to the last work of structural recovery, completed in 2015.

After the construction of the building, the interventions and maintenance actions performed on the roof were made under the responsibility of different institutions of the University, according to the time, the political interest, and the availability of financial resources.

Although the construction of Vilanova Artigas building was sponsored by the University Construction Fund “Armando de Salles Oliveira” (FCCUASO), initially pertaining to the Rectory of the University, the daily routine maintenance of the building was the responsibility of FAU-USP itself, with its own building maintenance team and budget. When not outsourced, repairs, specialized maintenance, or major interventions were carried out , by the former FCCUASO s own staff, which was renamed FUNDUSP in 1969.

According to records, until the 1990s, most of the interventions on the roof were carried out by FUNDUSP’s own construction team, sometimes with the assistance of the work teams of Campus Prefecture. In 1994, FAU took over the management of the interventions in the building, contracting externally the necessary works, and formalizing the creation of a specific sector to manage these interventions, the GEEF - Executive Group of Management of the Physical Spaces of FAU, in 2004.

It is important to note that, given its public nature, all USP’s units must prepare administrative processes for each job contracting and materials acquisition, which are archived and, since the end of the 1990s, have been made available for computerized consultation by the Proteossystem, thus facilitating their location.

On the other hand, the documents related to Vilanova Artigas building are scattered across different USP archives, according to their origin, among them: The Rectory of the University of São Paulo, FAU-USP (School of Architecture and Urbanism), SEF-USP (Superintendence of Physical Spaces, former FUNDUSP), Campus Prefecture and CPC-USP (Cultural Preservation Center). It was found, however, that each unit has its own filing policy, and that older documents, mainly from SEF-USP, which was responsible for the major maintenance works until the 1990s, were eliminated under the Table of Retention of Documents of the University of São Paulo.

During research for the preparation of this chronology, no records were found for works on the roof in the 1970s. For the 1980s, in turn, although dockets were located in the Proteos System, most of the respective files have been eliminated. For the decades of 1990 onwards, physical documents remain available for consultation in their respective archives.

2.2.1 From the construction until 1980

According to records published in the Diário Oficial do Estado de São Paulo(Official Gazette of the State of São Paulo), the company Construtora ANR - Alberto Nagib Rizkallah Ltda. was hired on December 15, 1966 for the performance of the reinforced concrete structure of the Vilanova Artigas building. Contier (2015) indicates that the services were only started in December 26, 1966, so that completion of the work was scheduled for end--January 1968 (400 days from the start of services).

According to the latest revisions of the structural design of the roof (Plate Nr. 132 - Frame of the roof beams, of the Figueiredo Ferraz Technical Office) dated February 1968, it is possible to say that there was a little delay in the construction work. However, nothing indicates significant stoppages of concreting fronts that could cause damages regarding the future performance of the reinforced concrete structure.

Unfortunately, the absence of documentary information on this period prevents our tracing a more precise history of the construction work. However, it is possible to admit that the experimental nature of its design with inclined surfaces, zenith openings, large structural spans and a working height which could easily surpass 15m, led to construction challenges. In fact, the complexity and constructive limitations of the roof probably contributed to one of the major failures identified shortly after the demoulding of the structure, as described by Contier and illustrated in the following figures.

“This design imposed that the concreting be done in two stages: the first up to the top level of the slab; the second up to the summit of the mouth of the dome [Figure 38]. This generated a visible mark inside the building [Figure 39] that Artigas reportedly lamented. To try to improve the appearance, the team of the Fund [University Building Construction Fund] sanded the concrete manually, with the aid of suspended scaffolds [Figure 40], which did not solve the problem.”

Figure 38 depicts a detail of the Structure Design by Figueiredo Ferraz Technical Office showing the cross-section of the slab and the inverted beam of the roof, highlighting the two concreting stages in different colors. As can be observed, a horizontal concreting joint coincident with the slab level inevitably resulted from this construction process.

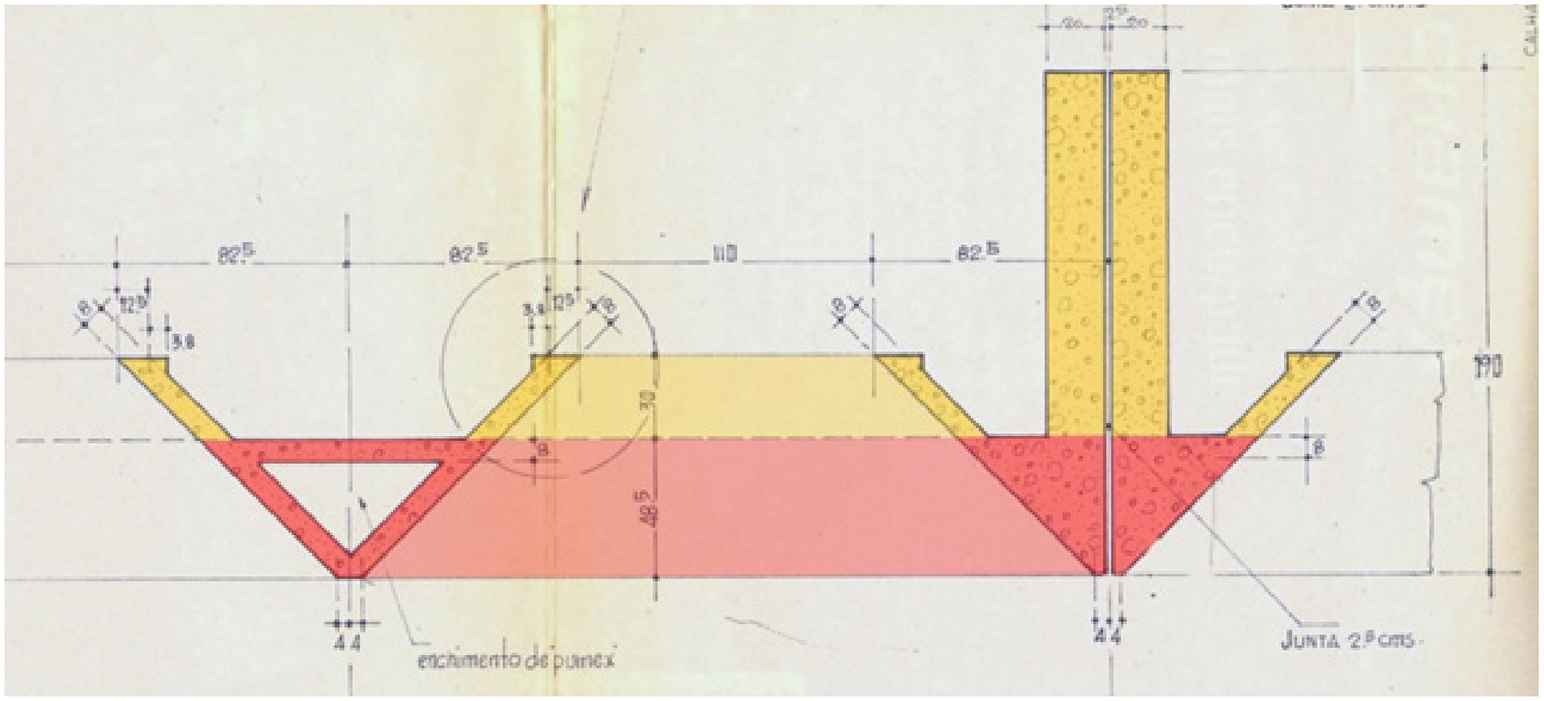


Figure 38 Schematic cut of the reinforced concrete structure of the roof, with a color highlight for the two stages of concreting. Source: Sheet #132 of the Structural Design by Figueiredo Ferraz Technical Office, modified by Rodrigo Vergili.

Figure 39 shows the result of the second concreting stage, just after demoulding, with emphasis on the superficial imperfections of the inclined surface of the zenith openings.

Figure 40 illustrates the work on suspended scaffolding carried out by the FCCUASO team to mitigate the imperfections of the demoulding; however, the treatment measures could hardly be limited to sanding, as Contier says, considering the need to fill the superficial concrete imperfections to smooth the exposed concrete. Figure 41 shows the result of this work, where it is possible to observe darker spots near the concrete joints, indicating the need of repairs for the surface regularization.

In the second semester of 1968, the waterproofing services started. According to the records published at the Official Gazette of the State of São Paulo on July 4, 1968, the company Isoterma

Figure 39 - Wooden formwork recently removed from the roof, in the first semester of 1968. The image shows the color difference between the two concreting phases of the roof and the imperfections on the inclined surface of the apparent concrete. Source: Arquigrafia.

Figure 40 - Works carried out by the team of the Construction Fund of the University Campus, 1968. Source: Arquigrafia.

Comércio Indústria e Representações Ltda. was contracted to carry out this work, with completion expected in 45 days. Again, there are no records or details of the progress in the execution of the service.

As previously mentioned, the original waterproofing system consisted of an elastomeric membrane of polychloroprene and chlorosulfonated polyethylene, commercially known as Neoprene--Hypalon®, directly applied to the concrete substrate, protecting both the slabs and the inverted beams (side and top), as can be observe in the Figure 42.

The official inauguration of the Vilanova Artigas building took place in February 1969 and until 1980 no documents were found that indicated problems related to the roof.

Figure 41 - Roof of the FAU USP building in 2017. Photo: Rodrigo Vergili.

Figure 42 - Aerial view of the newly opened Vilanova Artigas building in 1969. Notice the waterproofing, in white, which covered the sides and tops of the inverted beams. Photo: João R. L. Simões.

2.2.2. Interventions between 1980 and 1991

The first mention of some kind of problem related to the roof dates back to June 1980, when the Principal of FAU, Prof. Ariosto Mila, asked FUNDUSP for an inspection of the building due to the deformation of the partition walls of the classrooms, caused by the probable vertical displacement of the structure, which prevented the doors from working properly.

As seen in Figure 43, the partition walls of the classrooms, located on the last floor of the building, span the whole height of the floor up to the roof beams. The occurrence of a supposed deformation of this wall suggests that the transition element between the roof and the partitions was not able to prevent that the displacements of the beams would affect the partitions, thus causing the wall to buckle.

Unfortunately, the documents subsequent to this request have been eliminated, and knowledge about any developments is not possible; no photographic record was found to show these flaws, either. The same occurred with most administrative files of the 1980s, which, although included in USP's computerized database, were not located. Despite this, it was possible to establish an intervention chronology from some remaining records, as listed below:

1982 - FAU, through the Rectory of USP, requests FUNDUSP for a design to repair the waterproofing system and the cost estimation for its execution, among other services.

1985 - FUNDUSP opens a tender for the acquisition of "vedalaje" (commercial name of an acrylic membrane waterproofing system), to be used at Vilanova Artigas buildings, as well as other campus buildings. There is no evidence whether the material was ever purchased or used but, if applied, it would present an inferior performance than the original Neoprene-Hypalon® waterproofing.

In March 1986, FUNDUSP opens a new tender for the acquisition of "vedalaje"; at the time, the Brazilian Waterproofing Institute warns that acrylic waterproofing was not yet standardized, that the parameters required for the material were incompatible with the materials available in the national market, and that the execu-

Figure 43 - Classrooms floor, 1969. Detail for the meeting of the lightweight partitions with the reinforced concrete roof. Source: Arquigrafia

tion should be carried out by a specialized company. Finally, the tender was canceled due to both the bidders' error in quoting the lowest price, as well as in the justification for acquisition of the best performing material.

In June of the same year, a bid was opened for the acquisition of Neoprene-Hypalon®, which outcome remains unknown, since the respective documents were not found.

For the subsequent years, only a few records remain in the Proteos system, as follows:

1987 - FUNDUSP opens a tender for the acquisition of PVC pipes concerning Vilanova Artigas building waterproofing works.

1988 - FAU requests FUNDUSP for a technician to inspect the structure of the last floor, which has undergone deformation.

1990 - FAU requests technician to inspect the building again.

The various attempts at offering tenders concerning the recuperation of the roof waterproofing system in the 1980's are consistent with the water pooling in some roof modules that can be observed in photographic records of the period. Some of these photos also show the cast iron pipes of the cold-water supply system, before their replacement with PVC, probably after 1987.

Therefore, despite many gaps and lack of consolidated information, there are strong indications that a new waterproofing system for Vilanova Artigas building was provided by FUNDUSP between 1986 and 1987, including at least partial replacement of the cold-water pipeline located on the roof. At that time, FAU also carried out the replacement of the light partitions of the classrooms, which had already undergone buckling caused by the vertical displacement of the roof.

In 1988, according to Proteos system, concerns about the "deformation" of the roof are reiterated by FAU to FUNDUSP and, since 1991, the exchange of correspondence regarding this subject becomes more frequent, including negotiations with the Figueiredo Ferraz Technical Office for a pronouncement in this regard, but these documents are no longer available.

Figure 44 View of the 10P module with water pooling, 1986 (estimated date). In the background, the mast of the old system of protection against atmospheric discharges (item 2.2.4.). Author unknown. Source: Arquigrafia.

Figure 45 - View of roof modules with water pooling, 1986 (estimated date). In the foreground, detail for the cast iron pipe running through the inverted beam (Item 2.7.). Author unknown. Source: Arquigrafia.

2.2.3 Studies and trials 1992-1996

Most of the information obtained since 1992 came from the file “91.1.9000.82.0 - Study for the implementation of a reform of the roof of the School of Architecture and Urbanism”, found both in CPC-USP and FAU archives. It is noteworthy that, from this moment on, the School started to show a more active participation in the maintenance of the roof, as will be seen in this item.

In 1992, as an alternative to roof infiltration problems, FUNDUSP proposed the installation of an over-roof made of aluminum tiles mixed with translucent tiles. However, CONDEPHAAT (Council for the Defense of Historical, Archaeological, Artistic and Tourist Heritage of São Paulo), which had listed the building as a landmark in 1981, presented an unfavorable opinion to this preliminary study in December of the same year.

At the time, the roof overload problems, although not yet quantified, were already reported by FUNDUSP engineers and used as one of the justifications for the installation of an over-roof. Possibly, FUNDUSP considered that a new waterproofing, on top of the previous layer of waterproofing – a practice that had been carried out until then -, was no longer feasible in view of the overload of the roof; and that the cost to remove these layers and the application of a new waterproofing layer would be much higher than the cost of installing an over-roof. Also, there is a perceptible discredit by FUNDUSP regarding the waterproofing solution that, if maintained, would require constant maintenance, unlike the over-roof of tiles, seen as a “definitive solution”, according to the technical opinion of the FUNDUSP engineer, Fausto Tarran:

“The proposed solution: covering the entire structure with some kind of roof, even if not approved by CONDEPHAAT is the only one that can solve the problem safely and definitively.”

In August 1993, in a meeting with the FUNDUSP staff, FAU accepted CONDEPHAAT’s opinion, and dismissed the over-roof solution, suggesting that, in view of the difficulties of assessing the costs of recovery services, a more detailed diagnosis should be contracted through of a “pilot test” in one of the modules, with removal of all waterproofing layers and application of new waterproofing system on the slab.

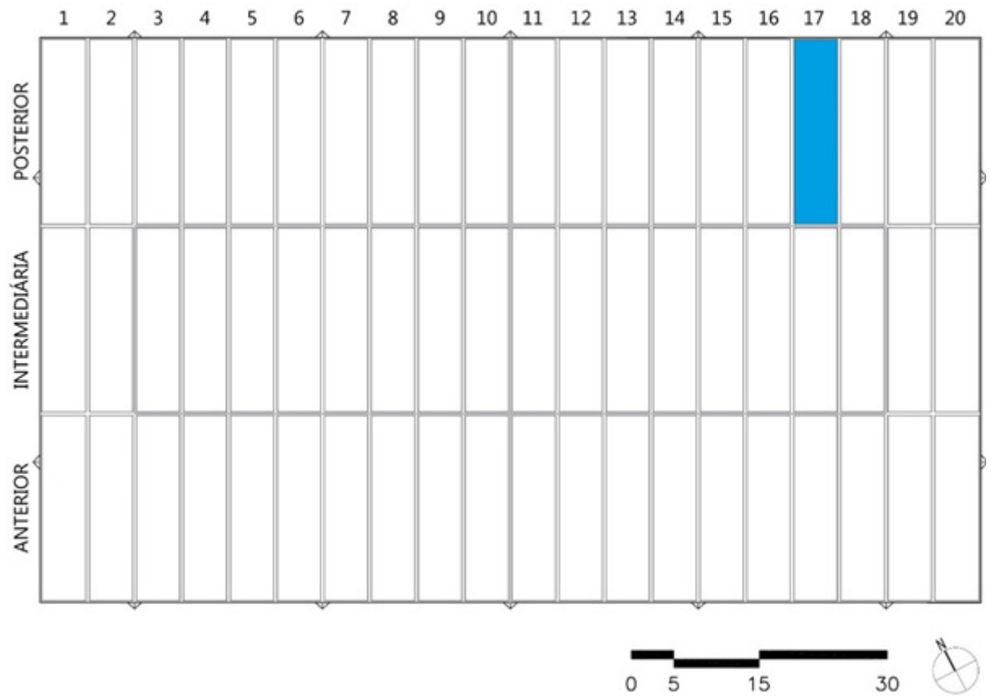


Figure 46 - Module 17P, where the waterproofing test was carried out in 1994.

However, the realization of this “pilot test” was not started until October 1994, with the hiring of Xavier Haddad Projetos e Construções Ltda. At the time, module 17P (known as module DP at the time), located over one of the classrooms, Figure 46, was chosen as site for the services, due to its proximity to the vertical circulation block formed by the building staircase and lift , besides the proximity of the roof to this floor.

Although the objective of this testing was to evaluate in a practical way the best alternative for the recovery and waterproofing of one module, the work carried out can be considered as the first technical inspection of the roof.

During the preliminary services of scarification and removal of the waterproofing, the existence of more than one layer of regularization and waterproofing was identified, confirming the execution of successive corrective maintenance services on old and deteriorated layers, causing an overload not originally foreseen.

Also, according to report by Prof. Dr. Paulo Valentino Bruna, who followed up these works, the punctual and accidental breaking of the slab between the skylight openings that occurred during the works made it possible to verify that the hollows inside the beams were full of water and the original wooden formwork was rotten.

It was also verified that the “hollow reinforced concrete beams were constructed by strips of plywood shored by rigid septa every 0.40m”, which segmented the inner void of the structure and hampered the attempts to drain the inside water, as the water “removed formed a void which very slowly was filled again by the water that percolated between the septa.”

Continuing the in situ experiments, works such as concrete surface repairs, crack treatment and surface regularization were performed, followed by the application of an acrylic membrane waterproofing system, trademark Hey’di, currently owned by Viapol.

In his evaluation of the services performed, Dr. Paulo Bruna considered that the solution of the problems surpassed the simple replacement of the waterproofing system of the roof, since, in addition to the overload caused by the successive layers of regularization, the previously infiltrated water was retained in the hollows and the perforations in the lower part of the beams did not ensure the complete drainage of the inner water.

Also, although not mentioned explicitly in the report, after the removal of the regularization layers and the application of the waterproofing directly on the concrete substrate, as was done du-

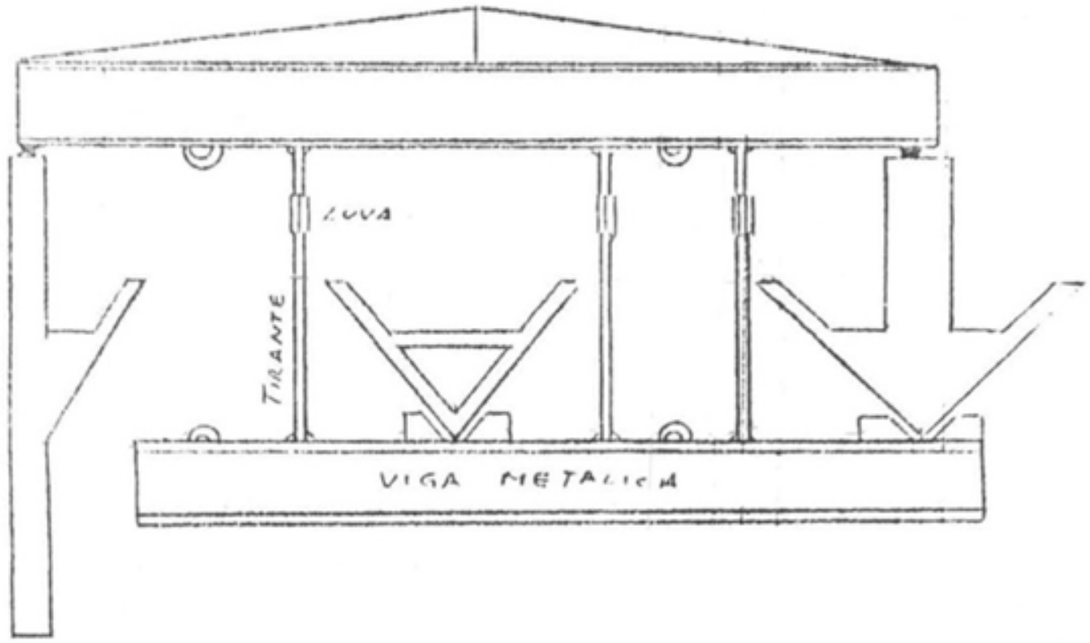


Figure 47 Shoring system proposed by Eng. Aluízio Fontana Margarido for the demolition and reconstruction of the roof slab.

ring the construction of the building in 1968, puddling occurred in the central region of the module due to the vertical displacements of the structure.

In view of these conditions, in January 1995, a second experiment, more invasive than the previous one, was proposed, consisting, in addition to the removal of the old waterproofing, in the demolition of the upper face of the slab, the removal of all wooden formwork from the hollows, followed by the subsequent cleaning and drainage of the accumulated water and reconstruction of the slab.

To carry out the services, FAU Prof. Aluízio Fontana Margarido, Engineer of the Figueiredo Ferraz Technical Office, proposed a bracket shoring system, as shown in Figure 47. This shoring would guarantee the structural stability of the roof for the demolition of the slab and the implementation of the necessary services, until the moment of its reconstruction.

For the reconstruction of the slab, prefabricated panels of reinforced mortar would be used instead of the in situ concreting; at the same time, a slope of 1% was specified for the drainage of the rainwater[2], eliminating the need for a thick layer of regularization and solving the problems related to overloading and puddling. For the repair of concrete surfaces and waterproofing, the same procedures of the pilot experiments would be used.

a kind of skirting was built around each opening. The bidding for this second phase of experimental construction took place in March 1996, and again it was won by Xavier Haddad Projetos e Construções Ltda. In July of the same year, the works were completed and there are no further reports about the performance of the services.

Apparently, the experiments met the technical requirements , the only exception being the rebuilding of the slab with a 1% gradient, which elevated the slab level at the opposite end to the water outlet, surpassing the level of the skylight openings, as outlined in Figure 48. In view of this situation, to prevent the entry of water through the roof openings, a kind of skirting was built around each opening.

This solution, despite solving the problems that had arisen from the rebuilding of the slab, caused a visual interference in the roof, since the skirtings are visible from the inside the building, at the classroom level, Figure 49.

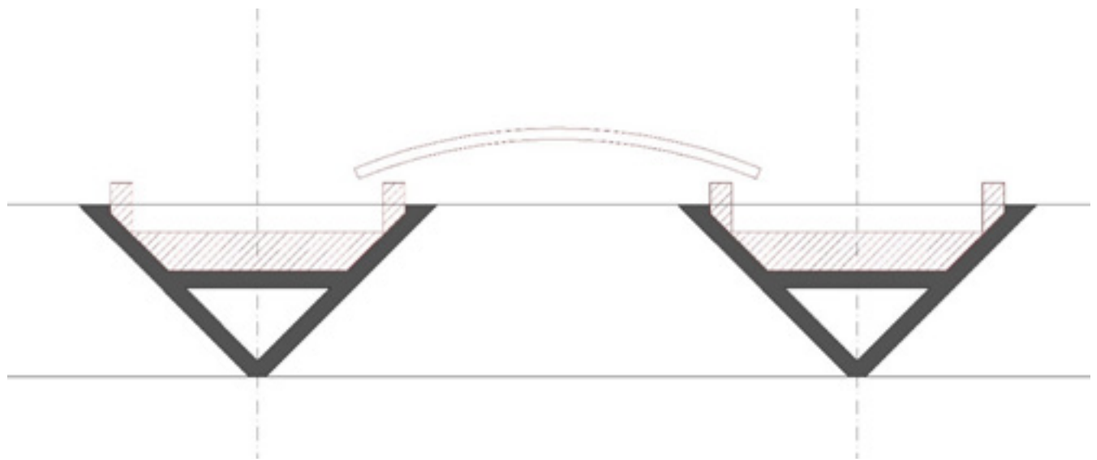


Figure 48 - Scheme of the demolition and reconstruction of the slab, with the need of building skirtings around the roof openings to prevent entrance of rainwater.

Figure 49 - Skirtings visible from the inside the building. Photo: Rodrigo Vergili.

2 The predicted slope in the design was 0.5%.

2.2.4. Interventions between 1997 and 2000

As the second experimental procedures carried out in module 17P solved, in a way, the overload problem caused by the regularization mortars, eliminated the water accumulated inside the beam hollows and provided the slab slope required for the drainage of the rainwater, FAU chose to replicate the solution in the rest of the roof, maintaining the construction of the skirting around the slab openings.

Probably to increase the productivity of the works, the refurbishment of the modules was planned in two at a time, and for that purpose, it was necessary to purchase a new metallic shoring set, provided at the beginning of 1997 by the company Espanbras Esquadrias Metálicas Ltda.

The works resumed on the opposite range of modules from the southeast façade, in modules 20P, 19P, 18P, and 16P (formerly called AP, BP, CP, and EP). The services were carried out by Tecnipol Recuperação e Reforço Estrutural Ltda. which won the bidding process, and began work in April 1997, finishing it around September of the same year.

In March 1998, the works continued with the hiring of Xavier Haddad Projetos e Construções Ltda, who won a bidding for the renovation of the following four modules, 15P, 14P, 13P and 12P (known at the time as FP, GP, HP, and IP, respectively). According to the contracting records, an addition was made to include modules 11P and 10P in the scope of the works, with the completion of the work occurring around September 1998.

Although the bidding process for the subsequent stage, modules 09P, 08P, 07P, 06P, 05P, and 04P was started in 1999, the effective hiring of the services occurred only in 2000. The Xavier Haddad company won the tender again, starting the services in January and finishing them in November of the same year.

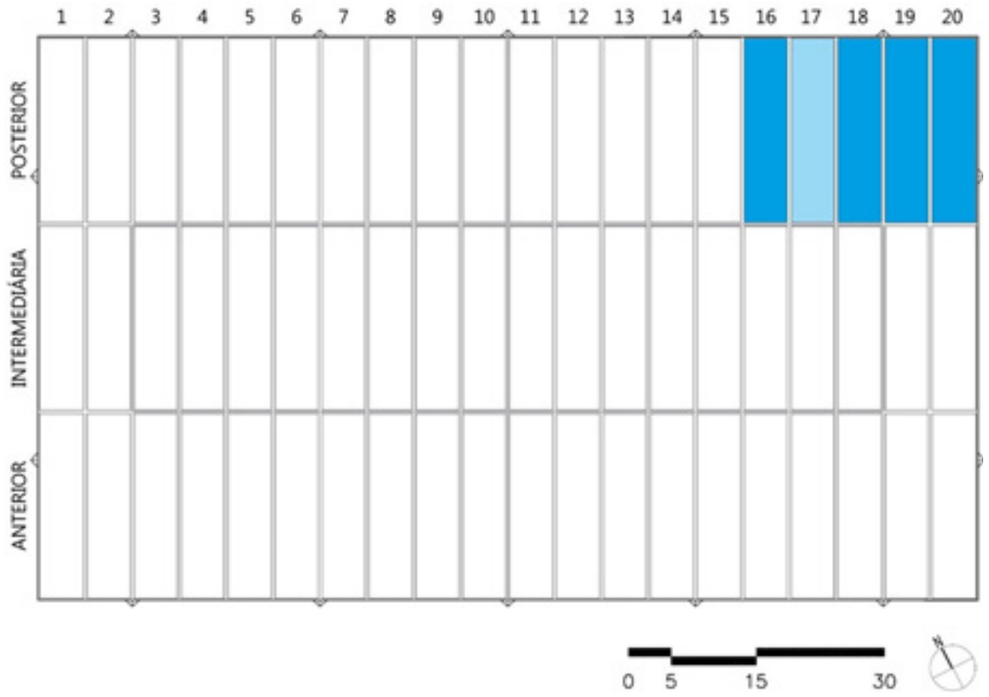


Figure 50 - In dark blue, the Modules 16P, 18P, 19P, and 20P, refurbished in 1997 by Tecnipol Recuperações e Reforço Estrutural Ltda.

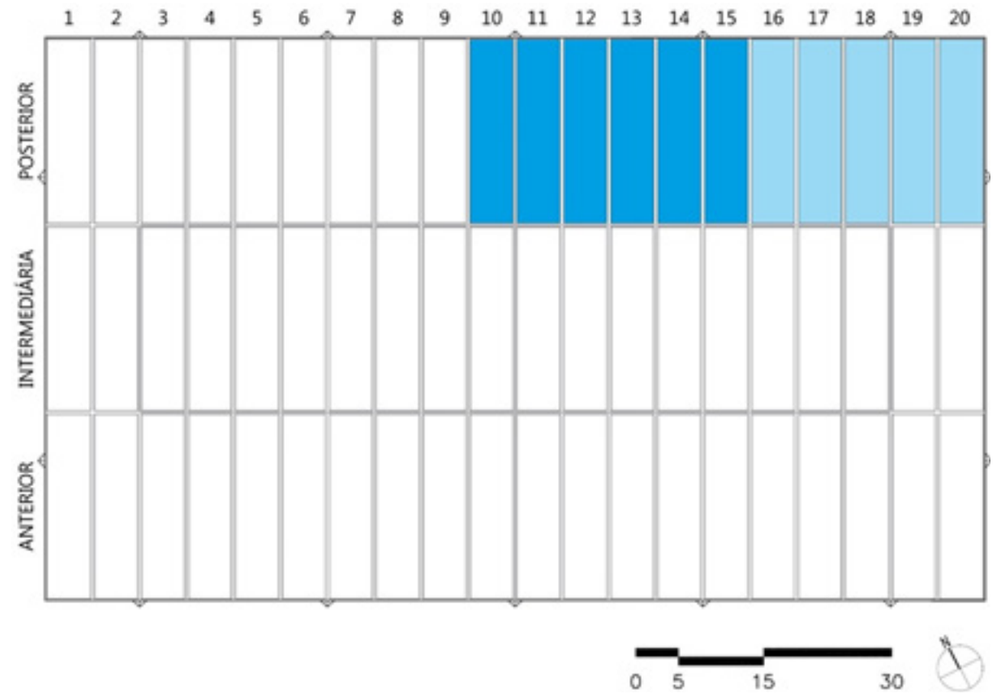


Figure 51 - In dark blue, the Modules 10P, 11P, 12P, 13P, 14P, and 15P, refurbished in 1998 by the company Xavier Haddad Projetos e Construções Ltda.

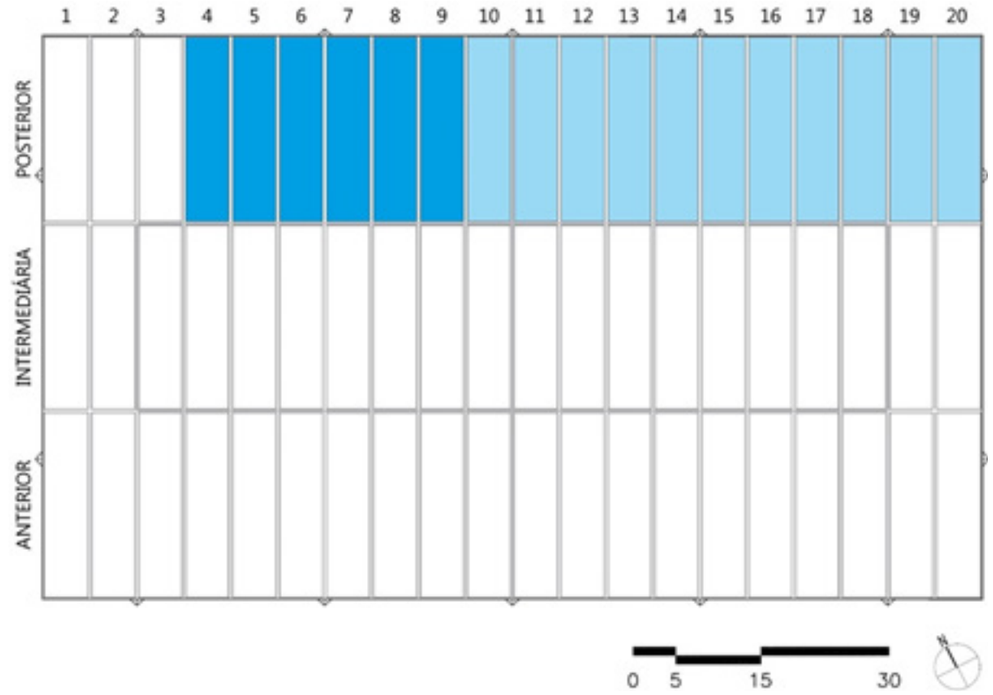


Figure 52 - In dark blue, the Modules 04P, 05P, 06P, 07P, 08P, and 09P, refurbished in 2000 by the company Xavier Haddad Projetos e Construções Ltda.

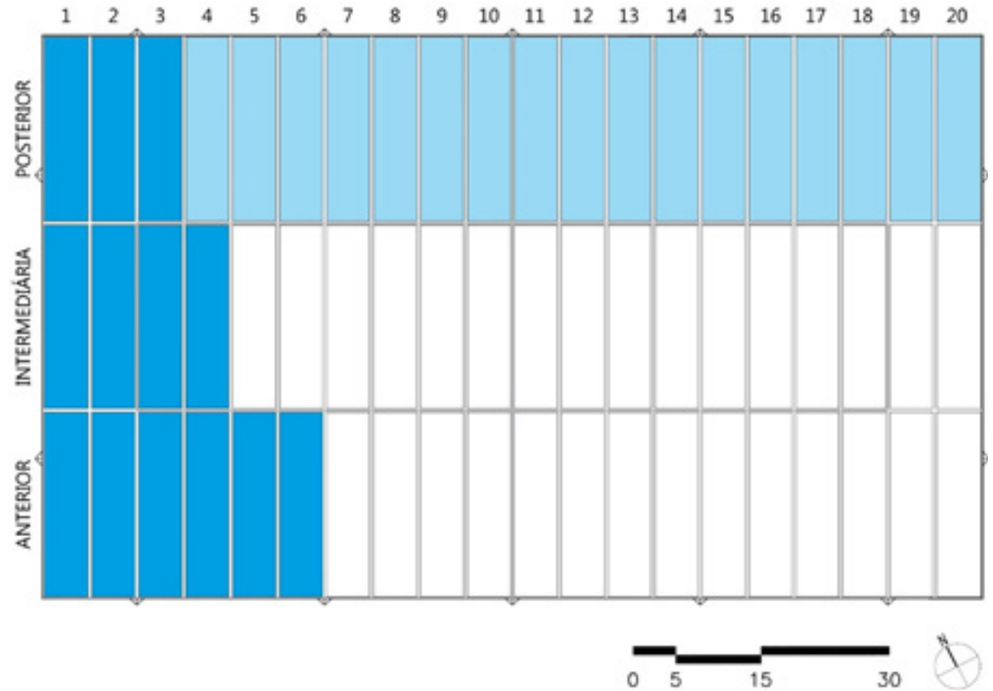


Figure 53 - In dark blue, the modules refurbished in 2002 by the company Isoterma Construções Técnicas Ltda.

2.2.5. Interventions between 2001 and 2003

Different from previous budgetary availability, in 2001, FAU obtained significant resources coming from the “Program of Recuperation and Renovation of USP Buildings Roofs”, which allowed for the continuity of the roof intervention in a larger area, totalizing thirteen modules, as well as the substitution of 580 skylights.

Therefore, the reconstruction and new waterproofing of the roof slab, were continued with the contracting, in 2002, of the company Isoterma Construções Técnicas Ltda., the same company that performed the first waterproofing of the building, back in 1968.

However, contradicting the bidding terms and the services previously performed, Isoterma chose to execute the service with Neoprene Hypalon® as waterproofing material, under the justification that this material shows a better performance than the acrylic membrane waterproofing system, which had been specified. .

The works were completed in December of the same year, comprising the posterior modules 1P, 2P, and 3P, intermediary modules 1I, 2I, 3I, and 4I, and frontal modules 1A, 2A, 3A, 4A, 5A and 6A, as shown in Figure 53. Therefore, at the end of that campaign, originally started in 1996, the renovated modules already totalized half of the roof modules.

In 2003, FAU requested new financial resources for COESF to continue the works, but, under the justification of lack of available funds for the current year, the request was denied.

2.2.6. Studies in 2005-2006

The debate about the recuperation of the roof was resumed only in 2005, based on a GEEF report reiterating the existence of infiltration problems n the non-renovated modules, and pointing out signs of infiltration in the modules that had already been renovated.

Although there was no indication of which renovated modules showed problems, it is noteworthy that the first roof recuperation works were about to complete 10 years, which is a standard time reference concerning the service life of waterproofing systems in civil construction. At the same time, there is no evidence of the performance of any maintenance services in the renovated modules that could have postponed, or even prevented, the waterproofing degradation and the occurrence of new infiltrations.

In this scenario, the elaboration of a diagnosis of the roof constructive conditions was proposed, in the *"pursuit of more effective and less costly solutions than those so far adopted for that area."*

In that same year, the office PhDesign Concreto, Construção e Reabilitação Ltda. was hired to undertake the proposed diagnosis. Initially, a visual inspection was performed, which identified the presence of efflorescences on the internal surface of the roof, resulting from the leaching of the concrete calcium hydroxide, caused by the infiltration of water due to the deterioration of the waterproofing system. Such efflorescences were already clearly observable by the users inside the building, as seen in Figure 54.

On the upper face of the roof, rainwater puddles was observed in several modules due to the lack of gradient in some segments of the roof slab, as well as the corrosion of the inverted beams rebar, which were already exposed.

The next step of the inspection comprised the evaluation of the slab conditions, for which purpose concrete cores were extracted. These samples showed up to four successive layers of regularization mortar and waterproofing. In the four concrete cores extracted, the total average thickness of the regularization layers was approximately 9cm, according to the PhDesign report, as shown in Figure 54.

The following inspection checked the reinforced concrete conditions in view of the prolonged accumulation of water inside the hollow reinforced concrete beams. No occurrence of corrosion was identified in the rebar.

Based on these surveys, PhDesign proposed as main guideline for future interventions, the demolition of the regularization layers and the new waterproofing of the entire roof, directly on the concrete substrate, with no need of any slab demolishing and reconstructing.

It is noteworthy that, under such conditions, the full runoff of rainfall would become impossible because of the vertical displacement already suffered by the roof. Nevertheless, this solution was justified based on the assumption that during the building service time, the gradient of the slab was never sufficient to drain such water, and that the subsequent regularization layers applied had only worsened the structure deformations.

Therefore, it would be preferable to have rainwater accumulation than having the overload from the regularization mortar. However, this solution should entail the permanent drainage of rainwater by mechanical means, as well as the implementation of a preventive maintenance program to be carried out by a specific maintenance team.

At last, three waterproofing systems were proposed: PVC blanket, sodium silicate and polyurea, which should be experimentally applied in different modules of the roof for evaluation. Along with the technical specification, the advantages and disadvantages of

Figure 54 - Internal view of the roof with calcium carbonate efflorescence, caused by rainwater infiltration. Photo: Cláudia Oliveira.

3 Administrative Official Letter GD/147 from FAU USP, September 23, 2005.

Figure 55 - Reproduction of the PhD report, where it is possible to observe the four concrete extractions of the slab with identification of the layers of mortar.

each system were exposed, as follows:

- PVC membrane system – consists of a non-adhered PVC membrane that withstands the movements of the structure; however, in case of possible infiltrations, it is very difficult to find out the leaking point in the blanket. For FAU´s case, the installation of the membrane depends on highly specialized manpower, considering the countless cuts, folds and sewing, needed to coat the complex roof beam mesh. It has low abrasive strength.

- Sodium silicate crystallization system – consists of an adherent rigid system, directly applied onto the concrete surface, being cheaper that the other solutions; it does not withstand structural movements, and thus any possible post-application fissures will be subject to the entrance of water; the reapplication of the system is limited, because it depends on the chemical reaction with the concrete compounds.

- Polyurea system – consists of an adhered elastomeric membrane, shaped onsite through airless hot application; it can only withstand slight structural movements, and requires specialized manpower for application. In view of the high cost of equipment mobilization, possible repairs are done in cold with polyurethane. High chemical and abrasive strength.

However, in view of the high mobilization costs to waterproof a small area, the polyurea system could not be tested. In July 2006, FAU chose the sodium silicate alternative under the justification that it was the most cost-effective system regarding implementation and easy maintenance.

3.7.New proposals and interventions between 2007 and 2010

In 2007, with the beginning of a new administration for FAUUSP, the previous studies and experiments for the roof waterproofing no longer continued, in benefit of a new proposal: the alternative execution of an over-roof, an idea that had already been suggested in the late 1980s, under the justification of being the most economically feasible alternative.

In this case, the whole roof would undergo a new intervention, which would be divided into three executive stages: structural recuperation of the inverted beams, execution of the over-roof and, at last, the recuperation of the internal surfaces of the roof.

In 2009, the first stage of intervention on the roof – which consisted of the structural recuperation of the inverted beams – was started, following the procedures for the concrete repair of defined by PhDesign in 2006.

Meanwhile, at least two proposals for an over-roof were presented by FAU administration: one consisting of a metal structure designed by Kurkdjian Fruchtengarten Engineering office, shown in Figure 56; the other consisting of a tensioned membrane, designed by architect Pedro Paulo de Melo Saraiva, Figure 57.

In 2010, the works of recuperation of the inverted beams were completed; in addition, metallic roof flashings were installed to protect the top of the beams. At the same time, the over-roof alternative was dismissed, both because of internal divergences among FAU personnel, and because such alternative was denied by CONPRESP, the municipal preservation commission.

At that same year, FAUUSP resumed the waterproofing solution proposed by PhDesign in 2006, requesting also the revision of the technical specifications to proceed with the works. This resulted in a new technical report, thus starting the preparatory debate about the intervention that would take place in 2012.

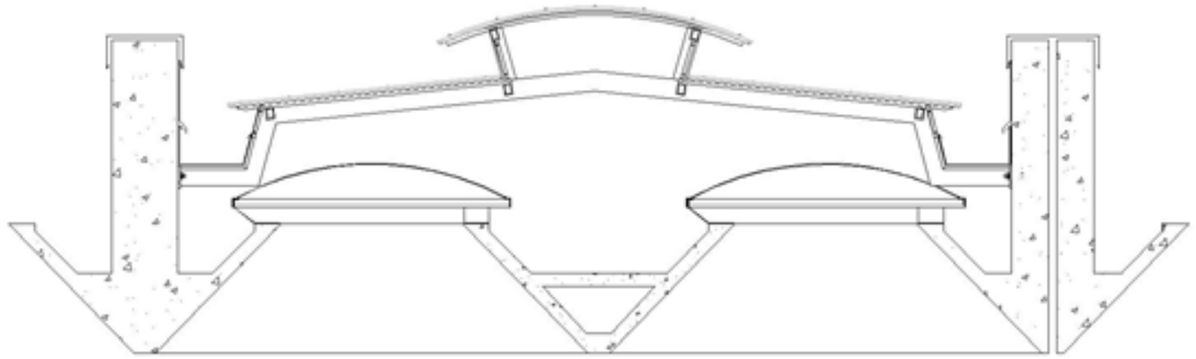


Figure 56 - Detail of over-roof designed by Kurkdjian Fruchtengarten Engeneering office.

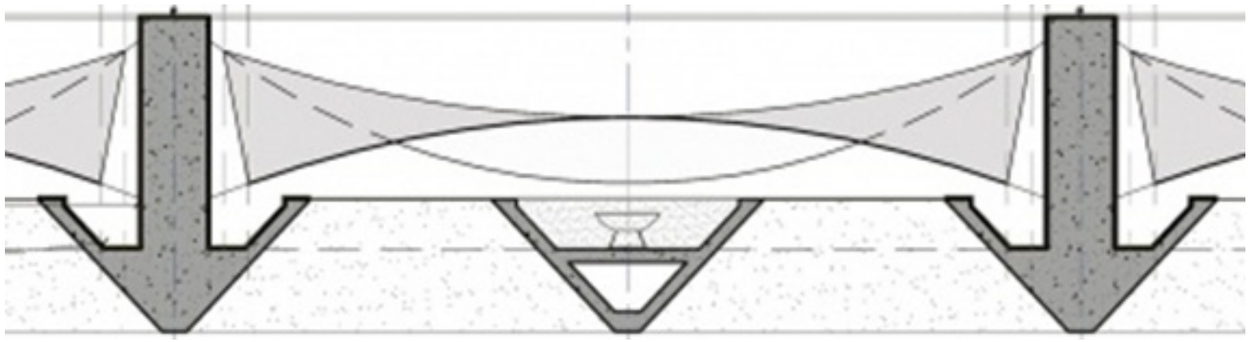


Figure 57 - Detail of over-roof designed by architect Pedro Paulo de Melo Saraiva.

Figure 58 - Overview of the roof after the 2009-2010 campaign. Author: Rodrigo Vergili.

Figure 59 - Overview of the roof after the 2009-2010 campaign. Author: Rodrigo Vergili.

3.8. Interventions between 2012 and 2015

In 2010, PhDesign, under the new name PhD Engenharia Ltda., was hired again to review the technical specifications for the roof intervention proposed in 2006, according to the new guidelines established by FAU's administration, which defined polyurea as the waterproofing system, complementing the studies and diagnosis carried out in 2006.

The main objective of the roof intervention was to substitute the slab's waterproofing system, extending it also to the lateral surfaces of the inverted beams. Besides that, GEEF-FAUUSP included additional specifications regarding the other roof systems that would also require intervention, enlarging the scope of the works.

The new interventions included doubling the drains and descents in the rainwater drainage system, substitution of all 960 skylights and their mounting and fixation system, updating of the protection system against atmospheric discharges and replacement of the cafeteria exhaust system.

It is noteworthy that the addition of these services in this campaign was quite valid because, regardless of the advanced state of deterioration and obsolescence of some of these systems, any subsequent intervention would end up interfering, directly or indirectly, in the new waterproofing system to be applied.

Concerning the waterproofing service itself, PhD Engenharia's Technical Report determined the removal of all existing layers of regularization, the drainage of water accumulated inside the beam hollows through holes in the underside of the roof, and the application of waterproofing with polyurea directly on the concrete slab. The work was completed in the first half of 2015.

3.9. Commentary

The first fact to be considered in the analysis of the history of roof interventions is the enhancement of its function and importance in relation to the building as a whole: from a simple constructive element, aiming to cover and protect the building, to a technical pavement, where several building systems are present and act in an integrated way, allowing the building directly below to operate properly.

Despite of the complexity of its structural design, the roof performance could be considered quite simple at the time of its construction; however, in view of the increasing demands on the constructive and technical operation of building systems, several elements not planned originally had to be added over the years. On the other hand, most of the interventions aimed at solving problems related to infiltrations caused by the degradation of the waterproofing system, seriously impaired by inadequate construction and maintenance faults. However, the general absence of a building conservation culture, as well as the lack of specific maintenance and repair methodologies, were decisive for the state of deterioration reached by the roof.

Photo: Rosa Artigas Archive.

2.3.

SURVEY OF THE STRUCTURE AND OF THE WATERPROOFIND CONDITIONS

2.3.1 Vertical displacements of the structure

The survey proposed for this subsystem consisted in measuring, by means of a total station, the bottom elevations of the roof´s inverted beams, with the aim of qualifying the vertical displacements of such elements, and to appraise the possible correspondence of such measurements with the external conditions of the slab, such as, for instance, pooling.

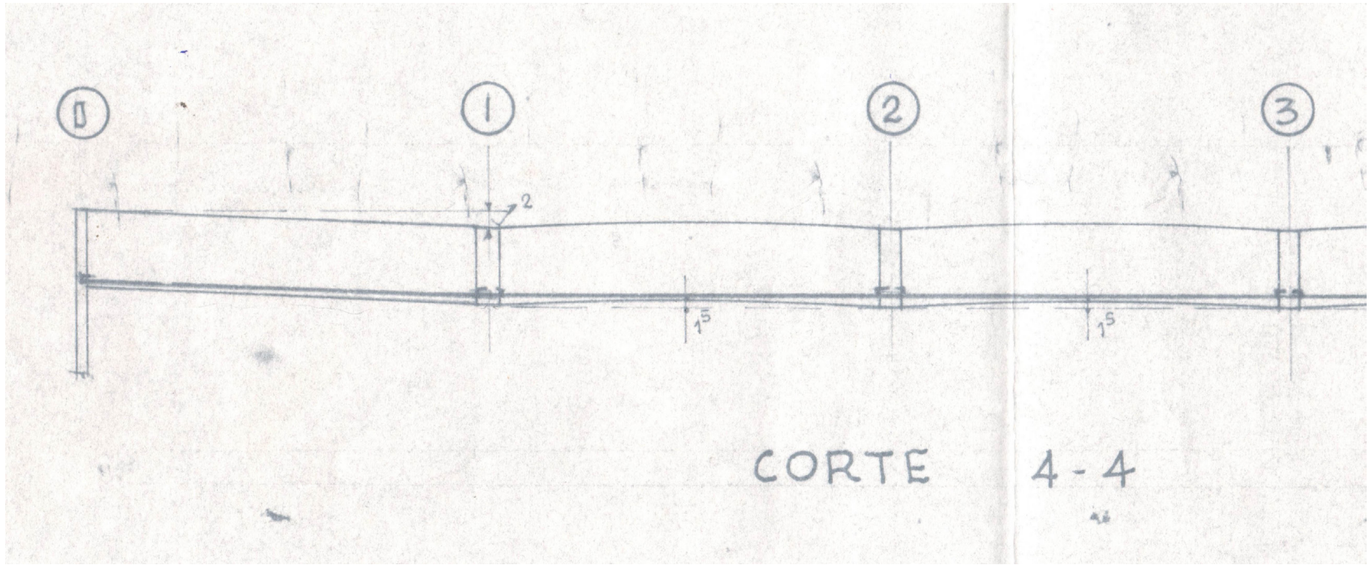
However, it is important to highlight that, according to blueprint 130 of the Structural Design of Figueiredo Ferraz Technical Office, the roof concreting should have been done in “inclined plans” and in camber: the top elevations of the top ofcentral longitudinal beams would should be 4cm below the top elevations of the top of peripheral longitudinal beams of peripheral segments (frontal and posterior), while the transversal beams, in the intermediary segment, would have a camber of 7cm, and in the frontal and posterior segments, a camber of 2cm, as observed in the constructive detail of Figure 60.

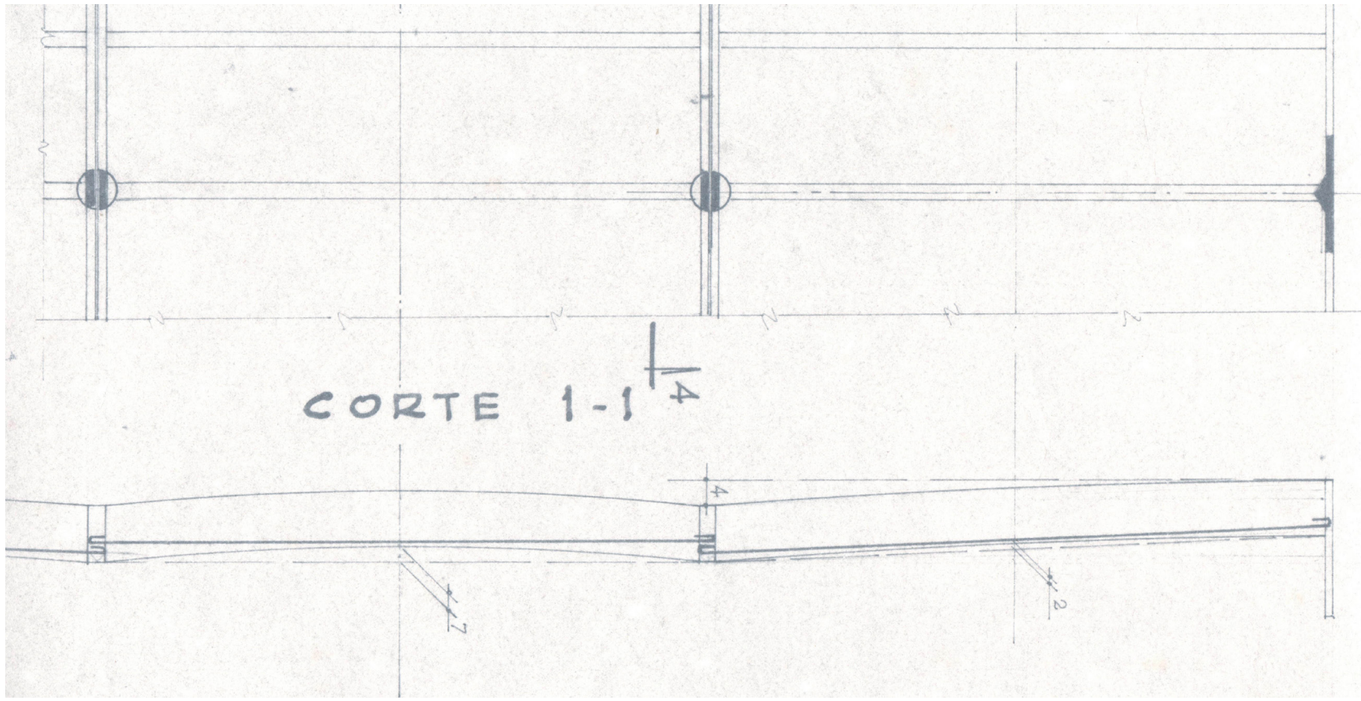
It was also expected that the top elevation of the transversal beams coinciding with the main axes of the building (transversal axes 1, 2, 3, 4, 5, 6, 7, 8, and 9), which are directly supported by the internal pillars, coinciding with thewhere the rainwater descents floor drains of rainwater catchment are located, should be in an elevation 1.5cm below the top elevations of the other transversal beams, located in between axes.

Apparently, such constructive details provided for the inclination of the structure aimed only to direct rainwater to the draining points, next to the internal pillars. However, there is no further information indicating the provision of cambers to offset the immediate vertical displacements (when the structure starts to operate), and those caused by the long-term loading, related to the slow deformation or fluency of the concrete.

The inexistence of structural cambers was always pointed out as one of the main causes of the degradation suffered by the roof by the professionals, who, directly or indirectly, took part of inthe Vilanova Artigas building construction works., as one of the mains causes of the degradation suffered by the roof.

The architect and retired professor of FAU, João Roberto Leme Simões, PhD, employee of the Construction Fund of “Armando Sales Oliveira” University City (FCCUASO) during the building construction, affirms states in his post-doctoral thesis that one of the major problems of the roof design was “the lack of not having provided for a compatible camber to absorb the deformation of the reinforced concrete”.





Another problem reported by Simões is that “the execution of the work fell short, for the fact that the concrete roof was demolded before the total cure of the reinforced concrete, aiming to comply with political deadlines for the completion of the work”.

Although the bending of roof beams is currently visible at naked eye, it is not possible to relate it directly to possible execution errors, especially because of the track record of undue interventions that overloaded the structure with successive layers of smoothingregularization mortar, and favorably contributinged to such displacements.

Therefore, a secondary objective of the present survey was also to search for constructive evidences of constructive nature that could prove or refuse such allegations.

To that end, the company Relevo Topografia Ltda. performed the survey measurement of the bottom elevations of the crossings both of the inverted beams and the hollow reinforced concrete beams. This measurement resulted in elevations distributed in a 2.75m x 2.75m mesh, which values were transferred in according to a chromatic scale to a the roof plan, as shown in Figure 62.

In this survey, it is possible to identify that the highest elevations (in yellow shades) are located in the central region of the intermediary modules close to the Northwest and Southeast façades, and this characteristic is not maintained for the intermediary modules delimited by the dilatation joints. It is also possible to observe that the modules of the frontal and posterior ranges show a bigger displacement (reddish shades) than the intermediary modules (orange shades).

Such results, despite generating distrust as for the validity of the survey, corroborate the hypothesis of the roof concreting according to the as foreseen in the design, and as previously commented – in inclined plans and small cambers to direct rainwater.

To evidence such hypothesis, the roof was “modeled” based on the elevations and nominal inclinations of the structural design, resulting in the chromatic representation of Figure 63, where the longitudinal beams, highlighted in reddish shades, present the lowest elevations of the roof.

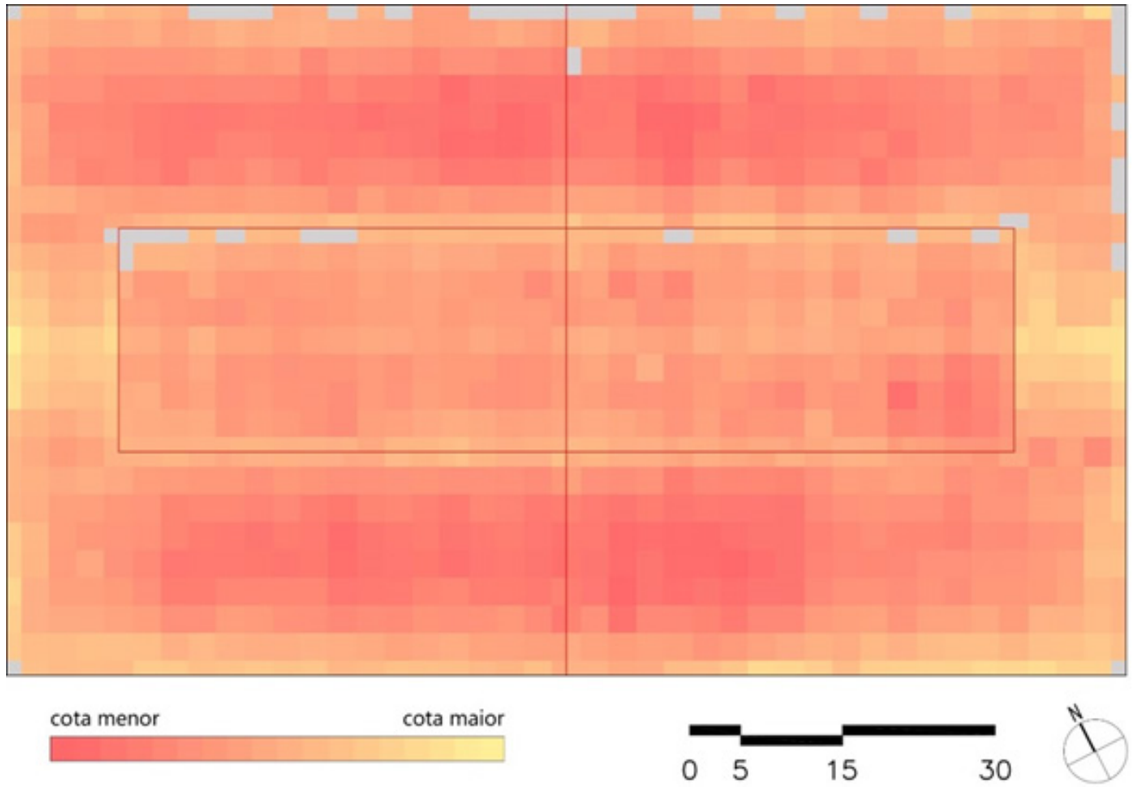


Figure 62 - Roof plan, with representation of the bottom elevations of the beams, in chromatic scale, obtained by a topographic survey. Author: Rodrigo Vergili.

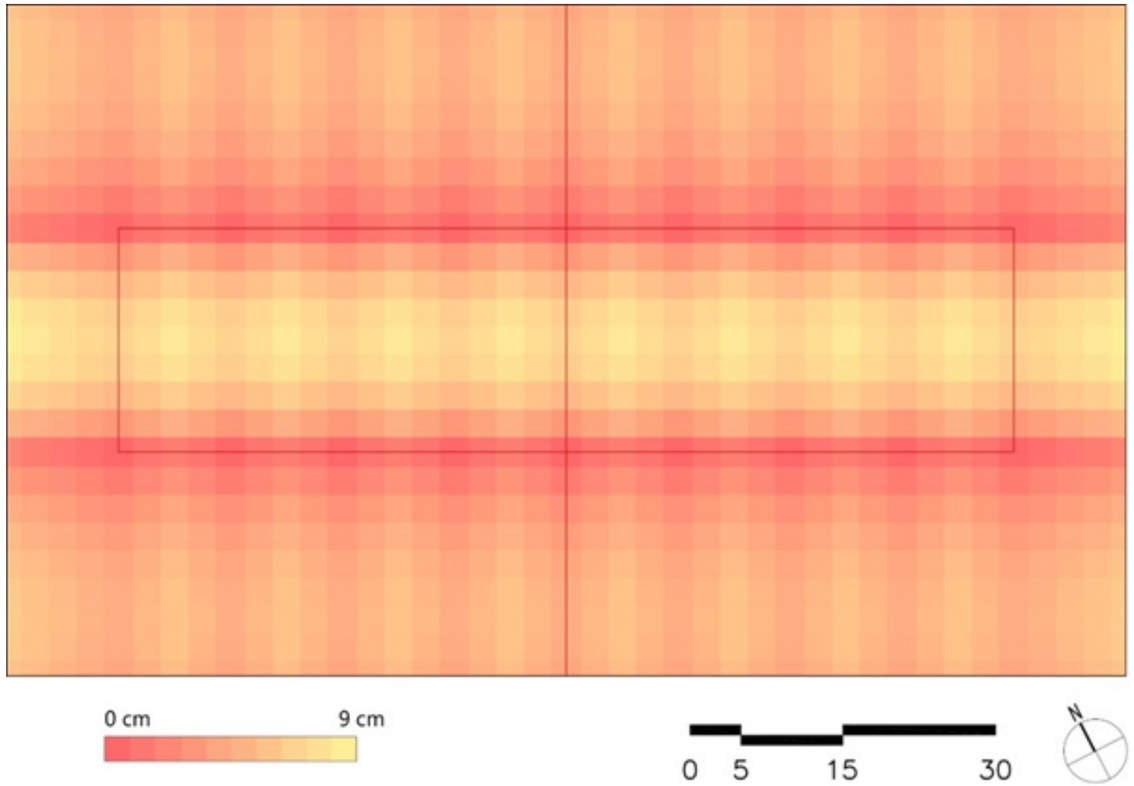


Figure 63 - Roof plan, with representation of the bottom elevations of the beams according to the constructive details of the structure design. Author: Rodrigo Vergili.

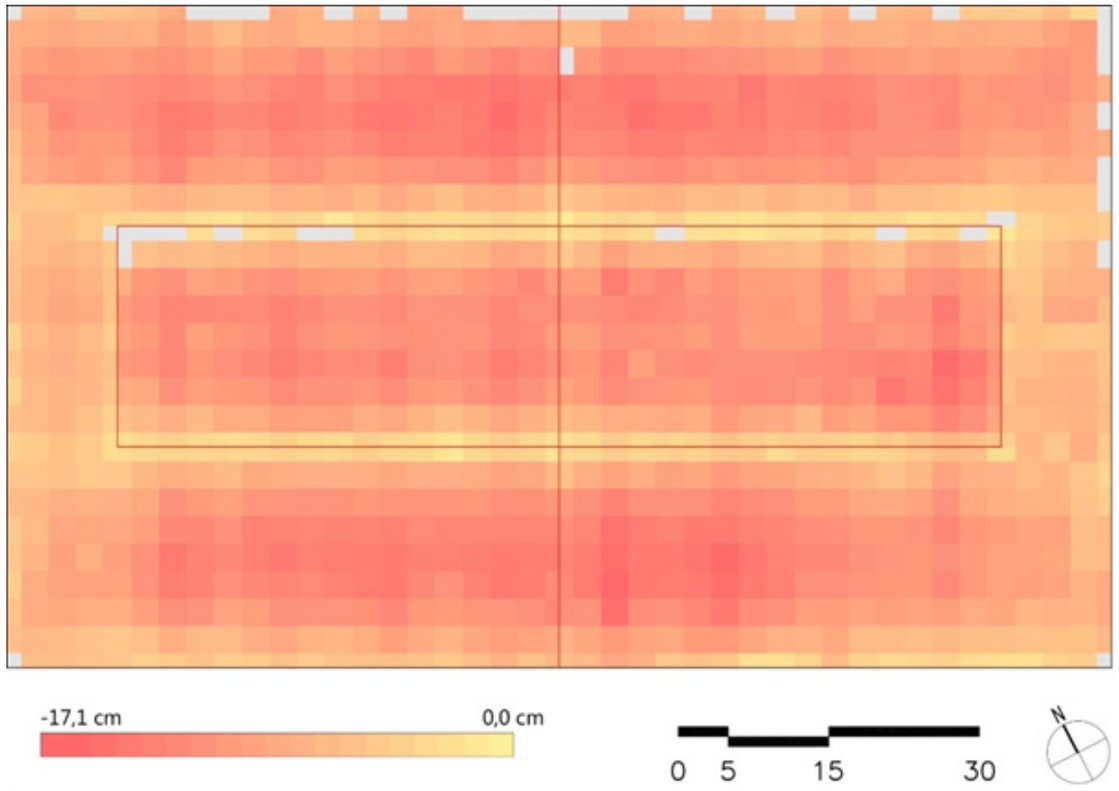


Figure 64 - Vertical displacements of the roof, based on the subtraction of values obtained by the topographic survey from the values indicated in the structural design. PhotoAuthor: Rodrigo Vergili.

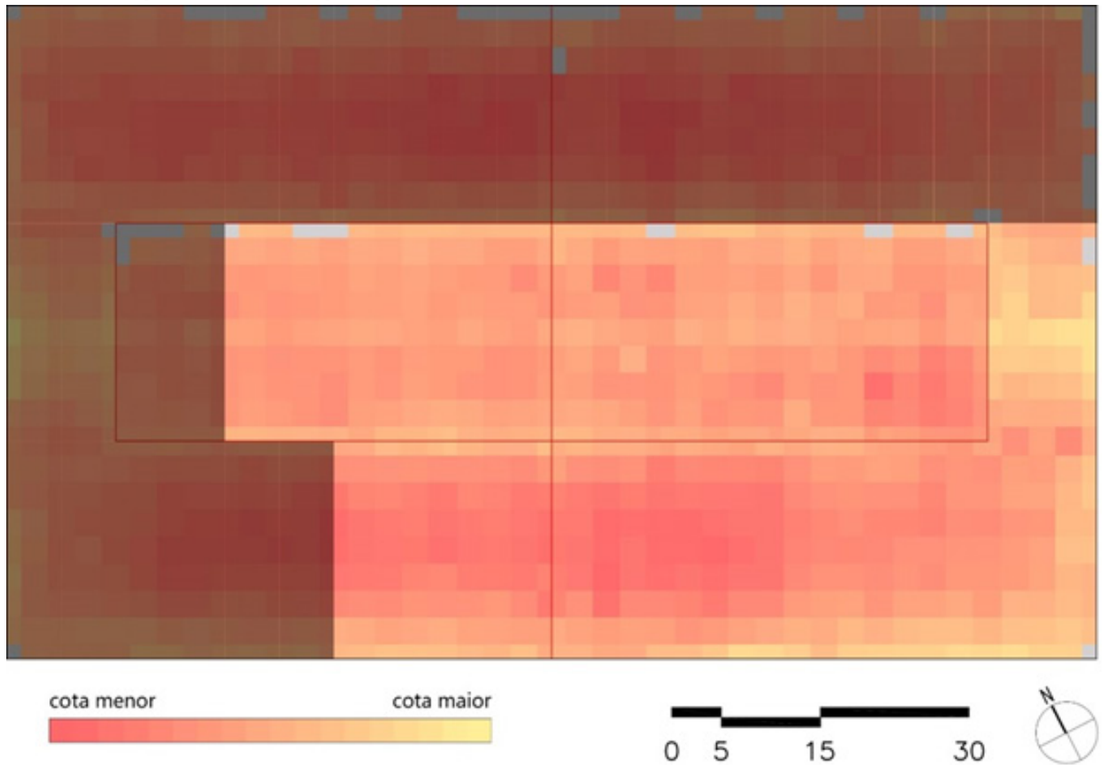


Figure 65 Roof plan, with representation in chromatic scale of the bottom elevations of the beams, in chromatic scale, obtained by a topographic survey, assuming the its correspondence with the bone elevations of the slab. The dark area highlighted with dark transparency represents the modules where the ich slabs was ere rebuilt, and no longer reflect correspond to the conditions elevations obtained by the survey. PhotoAuthor: Rodrigo Vergili.

Based on this analysis, the values obtained by from the structural design (ideal or nominal elevations) were subtracted from the values obtained by the survey with the total station (actual elevations), in such a way that, if the structure hypothetically had not suffered any displacement, the result of such subtraction would be zero, while any different value would represent its absolute vertical displacement. The result of such analysis, in chromatic scale, can be observed in Figure 64.

Compared to the gross survey (actual elevations) shown in Figure 62, Figure 64 shows a more uniform chromatic variation between the frontal, intermediary and posterior ranges, with the prevalence of orange shades. It is also observed that, compared to the “0.0” reference elevation, located next toalong the longitudinal beams – which are supported by the pillars -, the whole structure has suffered a downward vertical downward displacement, with no higher elevations in other regions, different from what is observed in Figure 62, thus reflecting a more predictable and expected behavior of the reinforced concrete.

Such data reinforce the signs that the roof was built as per the existing designs, and that the stipulated cambers were insufficient to offset the total vertical displacements.

While the information of on Figure 64 is valid to identify the absolute vertical dislacements, While the information of Figure 62 faithfully represents the current elevations of the structure (bottom of beams). Therefore, it would also be possible to establish a correspondence between the bottom elevations of beams and the bone elevation of the slab, admitting that the structural height of the slab is invariably maintained.

However, for half of the roof, this correspondence would not be valid, since, in previous interventions, the horizontal slab was demolished and rebuilt with a gradient of 1% in previous interventions, resulting in the condition represented by in Figure 65.

Based on this analysis, it is possible to identify four areas with different characteristics related regarding to rainwater puddles, which also reflect the conditions observed in field surveys, as represented in Figure 66.

Area A represents the modules where the slab was reconstructedthat suffered intervention with the reconstruction of the slab, and show no water pooling.

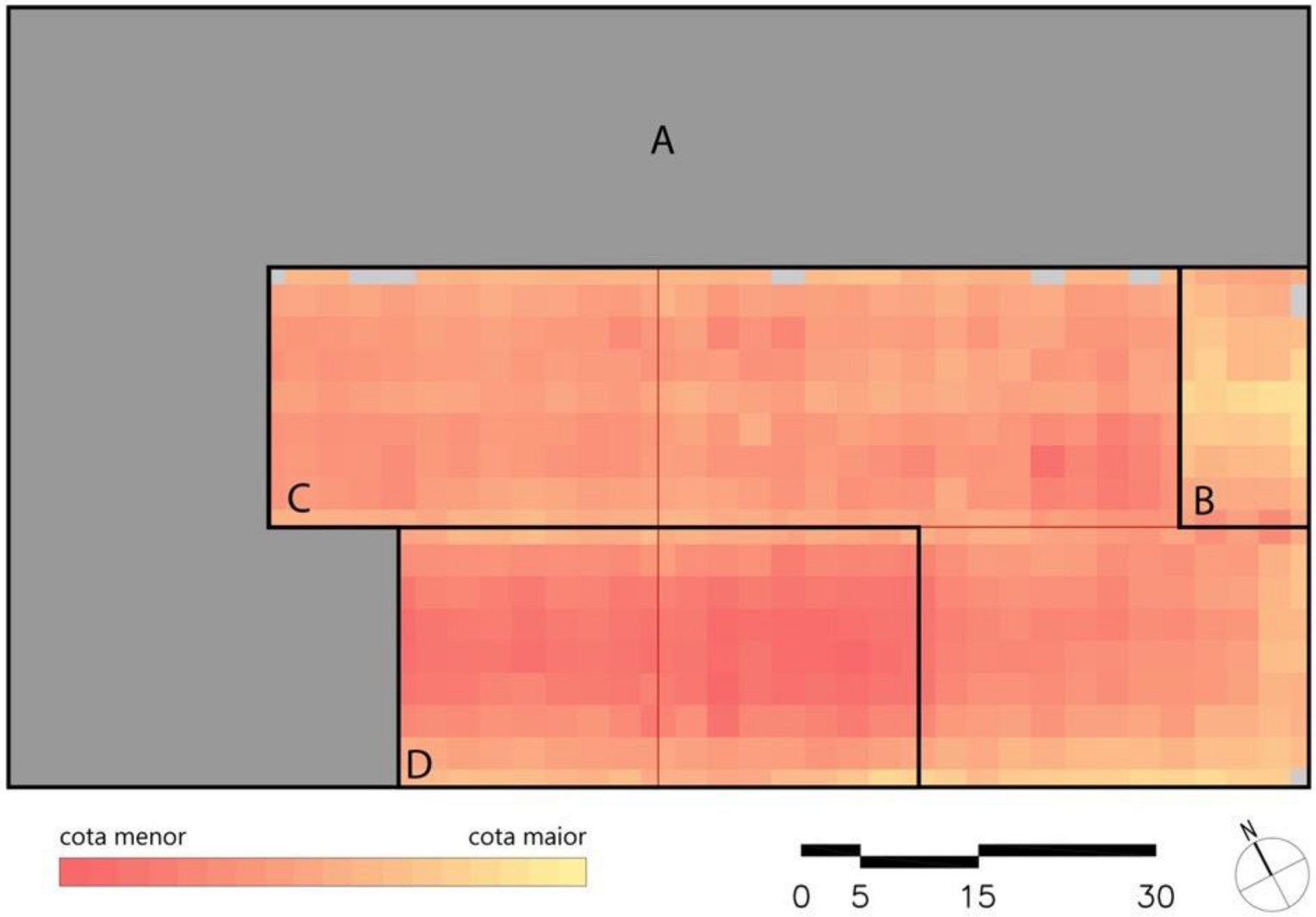
Area B, comprising modules 19I and 20I, is the only one where the elevation of the central segment of the slabs is higher than in its extremities, even although it didn't suffer not having been the object ofany previous intervention. Despite the difficult superficial water runoff , both because of the insufficiency of the existent 0.6% gradient, which of 0.6% is smaller than the standard requirement[3] (minimum of 1%), and because of the meandering connection route to the drainage pointsis very complicated, the formation of water blades was not identified, but only the superficial and residual rainwater puddles. Although far from being ideal, the natural evaporation showed to be sufficient, in this case, to deplete the water.

Area C, comprising the other intermediary modules and frontal modules 15A, 16A, 17A, 18A, 19A, and 20A, located over Studio 4, shows water puddles, with the formation of a continuous water blade, approximately 5cm thick, which occasionally manages to evaporate.

Area D, comprising frontal modules 7A, 8A, 9A, 10A, 11A, 12A, 13A, and 14A, mainly located over Studio o3, shows water puddles, with the formation of a continuous water blade, with maximum thickness of approximately 10cm.

Both area C and area D are characterized by the uninterrupted permanence of water accumulated on the slabs during and after the rainy seasons. Area D is regarded considered as the most critical because of the water blade thickness, which directly affects the time interval spent nEcessary for natural evaporation.

As previously commented, the result of the topographic survey is convergent to the observations done in the onsite inspections, and was fundamental to understand the behavior of the structure, since its construction up until the current conditions of the slab.



[3] ABNT NBR 9575:2010 – Waterproofing: Selection and Design

2.3.2. Inspections on the polyurea membrane

Visual inspections of the polyurea membrane were carried out by the research team to identify possible waterproofing flaws or signs of performance loss. During the activity, the following problems were visually identified:

Delamination between layers

Delamination between layers is the loss of adhesion between layers of polyurea due to flaws in the application of the product. It occurs when the inferior layer of polyurea exceeds the maximum time of coating at the moment of the application of the superior layer, as observed in Figure 67, Figure 68 and Figure 69.

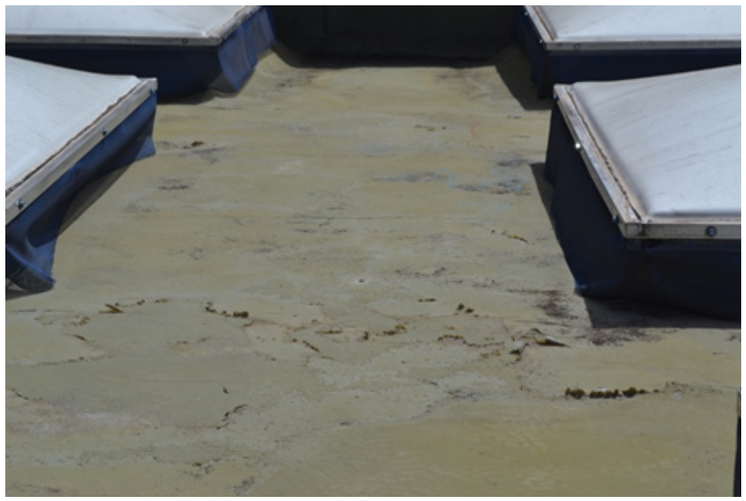


Figure 67 - View of roof module showing general delamination of polyurea layers applied to the slab. Photo: Rodrigo Vergili.

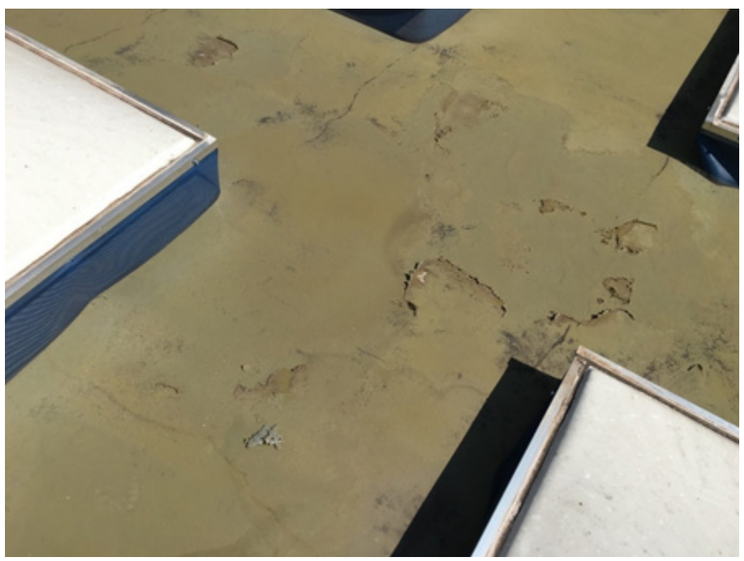


Figure 68 - Detail of delamination of polyurea layers. Photo: Rodrigo Vergili.

Figure 69 - Detail of delamination of polyurea layers. Photo: Rodrigo Vergili.

Cracking on the polyurea membrane

Cracking is the rupture of the membrane caused by movements of the substrate, as observed in Figure 70 e Figure 71, due to two different causes:

- Cracking caused by disaggregation and displacement of concrete substrate, possibly due to execution flaw during regularization of the surface of the slab, since displacement by reinforcement corrosion was not identified. This tipology is characterized by the identification of a hollow sound next to the cracking.

- Cracking caused by slab movement, pathological manifestation more evident on the slabs reconstructed in the recuperation campaigns between 1996 and 2002, coincident with the position of precast reinforced plates utilized as concreting formwork.

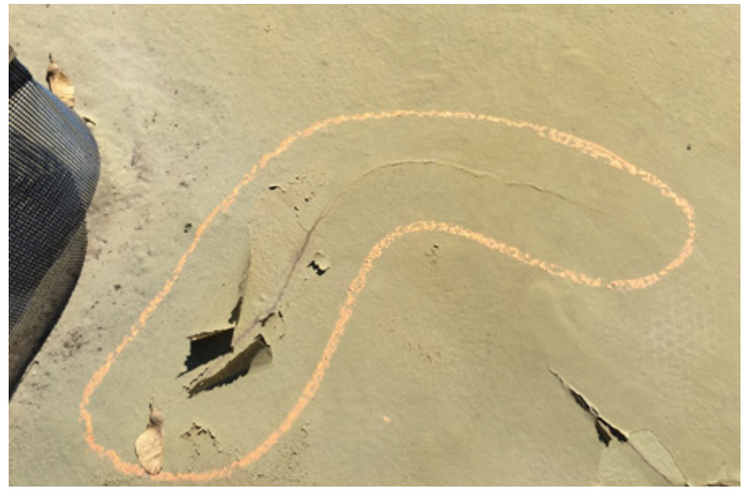


Figure 70 - Cracking identified on the waterproofing membrane applied to the slab. Photo: Rodrigo Vergili.

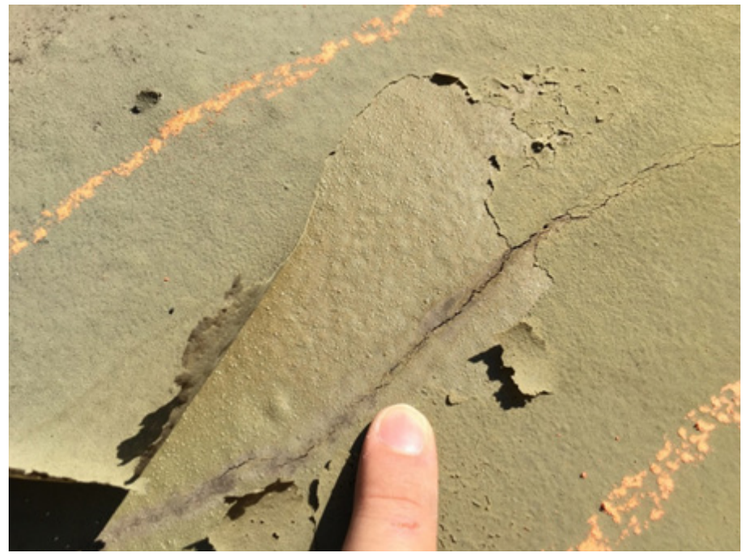


Figure 71 - Detail of Figure 68. Photo: Rodrigo Vergili.

Protuberances

Pathological manifestation due to flaws in the application of polyurea, causing excessive oozing of the material, associated with problems in the substrate regularization, more frequently found in slab corners and skirtings and near exposed vertical pipes, as observed in Figure 72.

Flow stains and color alteration

Execution flaws due to problems during application and reaction of polyurea components. They are characterized by wavy stripes on polyurea surface and yellowing of the material, as observed in Figure 73 and Figure 74.

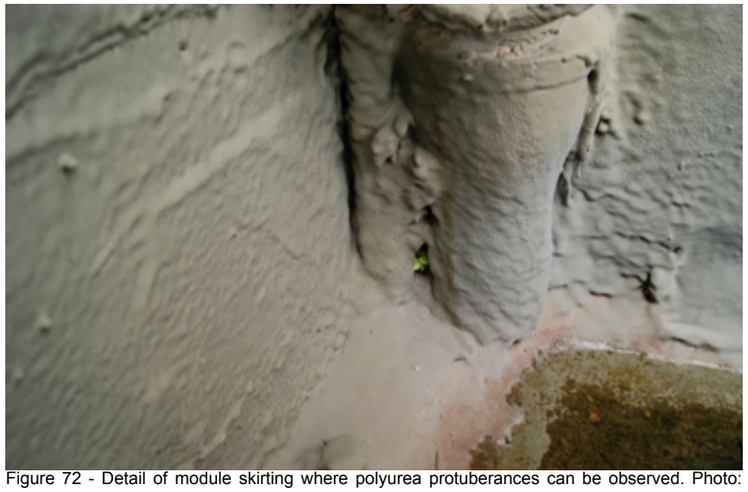


Figure 72 - Detail of module skirting where polyurea protuberances can be observed. Photo: Rodrigo Vergili.

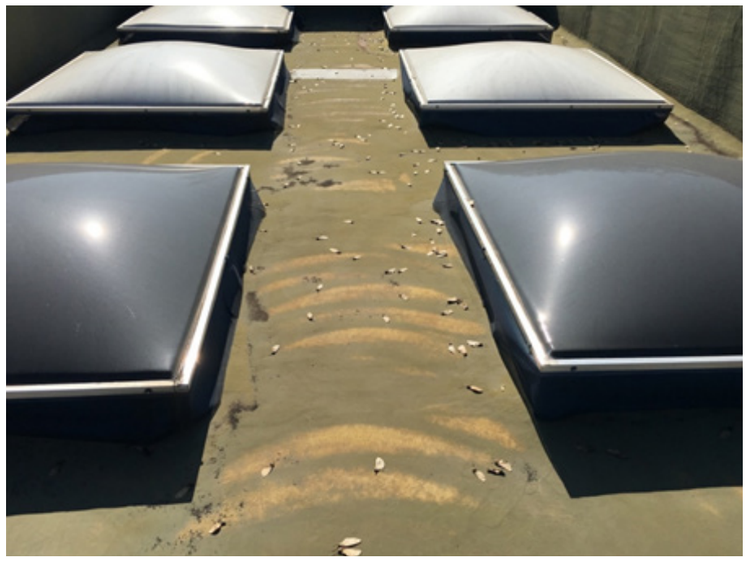


Figure 73 - Slab showing wavy stripes and yellowing on polyurea surface. Photo: Rodrigo Vergili.

Figure 74 - Detail of the previous figure. Photo: Rodrigo Vergili.

2.3.3. Polyurea Characterization tests

Polyurea test specimens were submitted to natural aging (submerged in water) for a period of 12 months, simulating waterproofing real conditions in the modules in which rainwater accumulates due to drainage problems.

The tests were performed at room temperature (23ºC; RH 50%) and Table 3 gives the results of tensile and tear resistance tests.

The reference results (membrane stored indoors, protected from light) indicate that, although the tensile and tear resistance exceed the manufacturer's data, and are higher than the Brazilian standard, the elongation at the tensile rupture is below the value indicated by the manufacturer. However, the obtained elongation of 274.9% is within the range of typical values for liquid-applied waterproofing system water-based, and the loss of elongation at break after aging was reduced by approximately 14%. The tear resistance loss of approximately 17% is also at the same level.

The tensile strength of the reference sample is above the value indicated by the manufacturer and also above the criterion of the Brazilian standard, however, it is possible to observe that there was a reduction of approximately 37% of the tensile strength for the test specimens subjected to natural aging age of 12 months.

It should be noted that the values after natural aging of 12 months, period equivalent to 10% of polyurea membrane design life, are still above the criteria of the Brazilian standard. However, in the inspections made in the waterproofing system, cracks in the membrane were detected in several modules.

For membranes adhered to the substrate, typical measured elongation values are, as a rule, sufficient to accommodate the opening of pre-existing cracks as long as they are compatible with the elongation capacity. For accommodation of larger displacements, it is recommended to desolidarize the membrane at the crack site, to ensure free movement of the material (installation of a bond breaker 5 mm on either side of the crack, e.g., to extend the movement of the membrane over the crack).

However, when fissures form after application, the membrane adhered to the substrate will extend with serious necking of the membrane across the recent formed gap reduce its film thickness over the crack. Opening of hairline cracks, non-measurable to the naked eye, such as concrete plastic retraction can be accommodated; however, with the movement of the fissure the membrane tends to rupture regardless of its flexibility and elongation capacity.

For structures in service exposed to weathering it is still necessary to consider the loss of properties of the material by fatigue, in the case of active cracks, associated with the effect of natural aging.

Despite the better performance of the blankets as to their ability to accommodate larger cracks (pre-formed waterproofing membranes generally perform better than liquid-applied membrane as it can span cracks better), the use of molded membranes in situ, and adhered to the substrate is still preferable for complex geometry surfaces with much interference, such as the roof slab of the Vilanova Artigas building.

Based on the studies carried out, the complementation of polyurea membrane studies concerning the effect of membrane thickness is indicated, taking into account the magnitude of the substrate deformations, and the variation of the properties of the membrane over time, notably, elongation and tear and tensile strengths.

Table 3 - Results of tensile and tear resistance tests and elongation at tensile rupture

Property	**Nominal value (product data sheet 2013)**	**Test method**	**Brazilian standard criterion NBR 16545/2016[5] (concrete substrate)**	**Reference sample (standard deviation)**	**Aged sample (standard deviation)**
Ultimate tensile strength (MPa)	> 18	ASTM D638-14[6]	> 10	21.0 (1.96)	13.2 (2.23)
Elongation at ultimate strength (%)	600		> 200	274.9 (22.31)	238.1 (26.48)
Tear strength (N/mm)	>75	ASTM D624-17[7]	> 35	72.8 (9.32)	60.6 (3.52)

5 NBR 16545/2016 High thickness coatings of polyurea and hybrid polyurea/polyurethane systems — Performance requirements

6 ASTM D638-14 Standard Test Method for Tensile Properties of Plastics

7 ASTM D624-12 Standard Test Method for Tear Strength of Conventional - Vulcanized Rubber and Thermoplastic Elastomer

Photo: Rodrigo Vergili

2.4.

GUIDELINES AND RECOMMENDATIONS FOR THE IMPLEMENTATION OF THE ROOF CONSERVATION MANAGEMENT PLAN

2.4. Guidelines and recommendations for the implementation of the Roof Conservation Management Plan

2.4.1. General Guidelines

As previously explained, the original waterproofing system applied to Vilanova Artigas building did not need any regularization layers to provide rainwater flow, which would be due to the gradient of the structure. However, the beams and roof slabs have undergone an irreversible vertical displacement, caused by successive design, execution, and maintenance flaws. Nevertheless, the last intervention work still adopted an adhered membrane waterproofing system, without execution of any regularization layers.

This solution, although it cannot prevent water puddling, can be considered as one of the most technically adequate alternatives, given the track history of roof occurrences. Despite the problems already identified in the waterproofing, the polyurea membrane is a high-performance coating, and has superior technical features compared to the waterproofing systems previously used in the building.

Therefore, as main guideline, the Conservation Management Plan of the roof proposes to keep the waterproofing solution with the polyurea system, guaranteeing its proper maintenance through periodic preventive inspections and the realization of repairs immediately after the identification of any leakage failure of the system.

For the other roof subsystems (item xxx), adjustments are prescribe for the correction of nonconformities, but without significant change of their components and elements.

2.4.2. Guidelines for maintenance considering the risk factors of materials deterioration

To establish a hierarchy in the priority of the maintenance and conservation services, the roof subsystems were qualified according to the probability of failure in their elements that could compromise the functionality of the subsystem, based on field surveys and inspections, and the track history of occurrences.

The probability of subsystem failures was classified into three levels: high, medium, and low. In view of the extensive history of water tightness failures, including active occurrences as previously mentioned, the waterproofing subsystem was the only one classified with high probability of failure.

The systems for protection against atmospheric discharges, drainage of rainwater and skylights were classified with an average probability of failure, due to problems already observed in some of their elements. The other systems were classified with low probability of failure.

The subsystems were also evaluated according to their technical importance for the use, operation, and maintenance of the building, that is, how much a failure in a particular subsystem affects the activities of the building itself. Three levels of liability were also adopted: high, medium, and low, according to the criteria described below:

High - interferes with the safety of building use and user, and jeopardizes the physical integrity of the building.

Medium - interferes with safety of building use and user, but does not jeopardize the physical integrity of the building.

Low - does not interfere with the safety of the building use and user, and does not compromise the physical integrity of the building as well.

Table 4 comprises all subsystems analyzed, with their respective building impairment and probability of failure.

From the results of Table 4, the systems were hierarchized based on the incidental impairment of the building in case of failure in each system, resulting in structural systems, waterproofing, and rainwater drainage as the most critical regarding this criterion.

Given the fact that any failure in the access and transit system will directly interfere in the performance of other maintenance activities, it is considered that it should always remain in proper conditions of use, therefore the maintenance priority of this system was not included in the table.

Table 4 - Probability of failure associated with each system

Roof system	Probability of failure	Impairment in case of failure
I. Structural system	Low	High
II. Waterproofing system	High	High
III. Flashing system	Low	Low
IV. Lightning system	Medium	Medium
V. Rainwater drainage system	Medium	High
VI. Skylight System	Medium	Medium
VII. Water supply and sewage system	Low	Medium
VII. Exhaust system	Low	Low
IX. Electrical installation system	NA	Low
X. Access and transit system	Low	High

Table 5 - Hierarchization of the roof subsystems regarding maintenance priority, based on the probability of failure associated with each subsystem

1st.	Waterproofing system
2nd.	Drainage system
3rd.	Structural system
4th.	Lightning system
5th	Skylight System
6th.	Water supply and sewage system
7th.	Flashing system
8th.	Exhaust system
9th.	Electrical installation system

2.4.3. National standards and current legislation

Table 6 lists the roof systems, their main elements and respective national standards and the legislation applicable to each one. All maintenance services must comply with the applicable standards.

Table 6 - Survey of applicable technical standards and legislation by roof subsystem

System	Components / elements	Applicable standards and legislation
Structure	- reinforced concrete	ABNT NBR 6118:2014 - Design of Concrete Structures - Procedure;
Waterproofing	- polyurea membrane	ABNT NBR 9574: 2009 - Implementation of waterproofing; ABNT NBR 9575:2010 - Waterproofing - Design and Selection; ABNT NBR 16545: 2016 - High thickness coatings with polyurea and polyurea hybrids / polyurethane systems - Performance requirements. ABNT NBR 16172: 2014 - Anticorrosive coatings - Determination of discontinuity in anticorrosive coatings applied on metal substrates (Holiday Detector)
Flashing	- aluminum casing; - fasteners	ABNT NBR 6118:2014 - Design of Concrete Structures - Procedure; ABNT NBR 14331: 2009 - Aluminum and alloys - Tiles and accessories - Requirements, design, and installation.
Rainwater drainage	- semi-spherical grids; - water spillways (cast iron and PVC).	ABNT NBR 10844: 1989 - Rainwater building facilities - Procedure
Lightning system	- lightning rods; - casings (catchment system); - cables; - connectors - structure reinforcement (descent system).	ABNT NBR 5419: 2015 - Protection against atmospheric discharges Part 1 - General principles; Part 2 - Risk management; Part 3 - Physical damage to structures and life hazards; Part 4 - Internal electrical and electronic systems in the structure;
Water supply and sewerage	- reservoirs; - float valve; - faucets / valves; - pipes; - fasteners; - vent terminal pipes of sewerage systems	ABNT NBR 5626: 1998 - Cold water installation; ABNT NBR 5648: 2010 - PVC-U pipes and fittings with weldable joint for cold water systems - Requirements; ABNT NBR 8160: 1999 - Sanitary sewage systems - Design and implementation. ABNT NBR 5688: 2010 - PVC-U pipes and fittings for rain water systems, sanitary sewer and ventilation - Requirements; ABNT NBR 15579: 2008 - Building systems - Cast iron pipes and fittings with tips and accessories for storm water and sewer systems - Requirements.
Access and transit	- ladder to the roof slab; - trapdoor - roof ladders to overlap of inverted beams; - fasteners.	ABNT NBR 9050”2015 - Accessibility to buildings, furniture, urban equipment and spaces. MTE NR 18 – Work conditions and environment in the construction industry; MTE NR 35 - Working at height; MTE RTP1 - Protection measures against falls from height; MTE RTP4 - Ladders, ramps, and walkways.
Electrical installations	Non-existent facilities, but required for roof maintenance activities	NBR 5410:2004 - Low Voltage Electrical Installations.
Exhaust system	- chimney - fan; - fasteners;	ABNT NBR 14518: 2000 - Ventilation systems for professional kitchens MTE NR 12 - Occupational safety in machinery and equipment

2.4.4. Preliminary adjustments

There are technical, operational and safety adjustments necessary to correct design and construction flaws in the roof subsystems, which, by their own nature, could not be corrected during maintenance works, so they must be adjusted prior to the implementation of the Conservation Management Plan.

It is advisable to contract a specific design, by a specialized company, to adapt and implement the following systems, according to the following guidelines:

Adequacy 1 - Access and transit system

Given the unique characteristics of Vilanova Artigas building roof, the current status of its subsystems and the requirements for its maintenance, one of the systems that requires initial attention is the Access and Transit System for the roof, since the other services are directly dependent on it.

Although this system does not currently present significant performance losses, to the point of damaging the functionality of its elements and components, its situation is considered to fall short regarding operational and safety aspects in relation to current national standards.

Roof Access

Access to the roof is possible by a fixed ladder of the sailor type located on the last floor of the building, under one of the roof skylight openings. Although it has a trapdoor at its top, it is recommended that the ladder be positioned in a more reserved place, preferably in an antechamber, to avoid access by third parties during maintenance work. As a suggestion, the current inspectors' room, located near the vertical transit block formed by the staircase and elevator, could be adapted for this use.

The ladder should be replaced by another with circular section rails to facilitate the grip during use. The trapdoor shall allow the opening and closing from both the inside and outside to prevent people from being locked on the roof. Handling of the metal trapdoor lid should be adjusted, as it currently requires a 180° movement to open and close; besides, as the lid is exposed directly to the sun, it often gets too hot to handle, thus handicapping the operation.

Finally, support rails should be provided on the inverted beam next to the access of the trap door, to be configured as a continuity of the ladder, to assist in the bridging the gap between the ladder and the slab.

Vertical cargo transit

It is recommended to install an electric hoist, positioned on a removable skylight, adjacent to the trapdoor. A fastening and removal system for this skylight should be provided.

Horizontal transit

For the horizontal transit between modules, a technical walkway should be installed on the inverted beams, wide enough for transit of people and equipment, with guardrails, in order tot ensure fast and safe access to all the modules of the roof. Horizontal transit inside the modules must be guaranteed by lifelines.

Access to reservoirs

The reservoirs sailor ladder shall be reached from the technical walkway; its first step must be located at a compatible height for the use of the ladder. A protection cage shall be installed two meters from the walkway floor, extending one meter beyond the upper elevation of the reservoir, where a guardrail shall also be provided.

Adequacy 2 - Cold water supply and sewerage system

Although the water supply system had undergone interventions in recent years: in 2010, during the renovation of the toilets and hydraulic plumbing, and in the recent 2012- 2015 roof recuperation campaign, , when the reservoirs were interconnected, these works were not carried out in a systemic way. In fact, the inspections just conducted indicate that, at each time, the interventions aimed only at solving immediate, specific problems, without observing the functionality of the water supply system as a whole.

Water Distribution System

The water distribution system currently exhibits too many ramifications, typical of overlapping piping interventions, which make it difficult to understand their correct functioning and hamper maintenance services.

Thus, it is recommended the hiring and execution of a new water distribution network design based on the survey of the current conditions, including the replacement of the current gate valves with globe valves.

Protection Paint

Currently, almost all Vilanova Artigas building cold water distribution network is made of PVC piping, which isexposed directly to ultraviolet radiation. Although manufacturers incorporate additives to the PVC resin that reduce degradation by ultraviolet radiation, prolonged exposure of the material causes discoloration and dryness of the outer surface of the pipeline. Under these conditions, the pipe becomes more susceptible to cracking and to rupture by external impacts.

Brazilian Standard of Installation of cold water (ABNT NBR 5626:1998, Annex D, item D.3.3.1), recommends the protection of these elements: *"Prolonged exposure to ultraviolet radiation can degrade the PVC resin. [...] Pipes installed permanently exposed to ultraviolet radiation must be adequately protected from such actions."*

In this way, as the existing pipes already show advanced signs of deterioration, it is recommended that they be completely repla-

ced and subsequently painted with synthetic enamel paint in the color ‘emblem green”, according to ABNT NBR 6493: 1994 - Use of colors for identification of pipes.

Water flow identification

When receiving the protection and identification paint in the color ‘emblem-green’, the pipes should also receive signalling indicating the direction of the water flow, evenly distributed along the pipe and, especially, before and after each valve. The valves shall be identified on their handles according to the normal operation positions, CLOSED or OPEN only, and identified by painting the handles.

Fastening elements

Currently the pipes are simply supported on the top of the inverted beams and on holders located on the side of the beams. The distribution pipes remain suspended below the reservoirs, without any kind of fastening.

This situation should be reviewed, as the absence of fastening allows unplanned movement of the water distribution network, especially near the valves, where the opening and closing operations can generate efforts not bearable by the pipeline, with risks of damage and network breakdown. Therefore, fastening should be provided for in the new water distribution design. The possibility of taking advantage of the existing openings in the inverted beams for the pipeline to go through should be considered, returning to the original concept of water distribution and fastening of the pipeline next to the technical walkway, foreseen in the previous item.

Water faucets

Water faucets should be provided near the distribution pipes, under each reservoir and in the distribution branches, near the pillars P21, P26, P30 and P34.

Reservoir Lid

The concrete lids of the raised reservoirs should be replaced with aluminum lids with rubber seal.

Sewage Terminals

The current sewage ventilation terminals, which currently emerge close to the roof slab elevation, should be extended with PVC pipes up to a minimum height of 2.0m above the slab, topped with a chimney-type finish, according to ABNT NBR 8160: 1999 - Sanitary sewage systems - Design and execution, item 4.3.6:

“4.3.6 The open end of a primary ventilation tube or ventilation column:

[...]

b) must be at a minimum height of 2,00 m above the roof, in the case of slab used for purposes other than roofing; otherwise, this height must be at least 0,30 m; “

[...]

(d) shall be provided with a chimney-type terminal, T-type connection or other device which prevents the entry of rainwater directly into the ventilation pipe”.

In Vilanova Artigas building, the ventilation terminal should be raised to 2.0m in height, since the slab is understood as a continuous and permanent working environment, that is, a technical floor, not just a roof.

This extension of the ventilation column should be painted in black synthetic enamel paint, according to the general understanding prevailing in the building maintenance field of ABNT NBR 6493: 1994 - Use of colors to identify pipes, which defines the use of black color for flammable products.

Adequacy 3 - Electrical installations

An electrical installation design should be contracted, providing for the installation of a panel with shielded plugs at roof level. To this purpose, it is suggested to use a deactivated cold-water passage, located on pillar P20, for the electric conduits to pass through.

The use of electrical equipment throughout the roof shall be provided for, with the use, for that purpose, of electrical extensions, provided that they are planned and specified in the design.

Photo: Rodrigo Vergili

2.5.

ROOF CONSERVATION MANAGEMENT PLAN

2.5. Roof Conservation Management Plan

The conservation of the Vilanova Artigas building's roof is associated to a set of activities and resources directed to the maintenance and recovery of its subsystems, within parameters related to performance, service life, functionality and serviceability, combined with the management of costs and deadlines.

Given the importance of the building, another concept that guides its conservation is the need to keep track of all records, controls, and maintenance activities, with the objective of a continuous re-evaluation process of these activities.

Thus, the periodic collection of information and its evaluation are essential to the efficiency of maintenance interventions, contributing to the analysis of the causes and origins of nonconformities, and to rationalize and adapt the existing procedures, avoiding rework or even damage to this heritage building.

The Conservation Management Plan for the roof of Vlanova Artigas building consists of the implementation of two complementary programs: The Maintenance and Periodic Inspections Program and the Interventions Program, which will be described below.

2.5.1. Maintenance and Periodic Inspections Program

The Maintenance and Periodic Inspection Program consists of the definition of the essential maintenance activities, their frequency, those responsible for their implementation and the necessary resources.

Its objective is to act preventively on the subsystems of the roof, through cleaning services, revision of the fixation of elements and the periodic inspection of subsystems.

The activities foreseen for the Maintenance and Periodic Inspections Program are listed on Table 7.

Table 7 - Activities of the Maintenance and Periodic Inspections Program.

Activity	Frequency
1. Inspection of the structural system and water tightness of the waterproofing	Annual
2. Visual inspection on polyurea waterproofing system	Annual
3. Inspection with Holiday Detector in the polyurea waterproofing system	Biannual
4. Cleaning and review of the casings fasteners	Annual
5. Lightning fixation review	Annual
6. Cleaning of drains, slabs, and drain pipes	Monthly
7. Skylights cleaning	Quarterly
8. Revision of fastening and sealing of skylights	Biannual
9. Cleaning of water reservoirs	Semiannual
10. Water valves inspection	Semiannual
11. Revision of the water supply and sewage system	Annual
12. Revision of the fastening of the access and transit system	Annual
13. Cleaning the cowl system of the mechanical exhaust system and checking of seals	Annual
14. Checking and review of electrical installations	Annual

2.5.2. Description of Maintenance Activities and Periodic Inspections

1. Inspection of the structural system and water tightness of the waterproofing

It consists of the annual visual inspection of the underside (internal side) of the roof structure, from the floor closest to the section to be inspected.

This activity aims to identify possible infiltration of water and damage to the structure of reinforced concrete, and consists of annual inspections, by modules, to be carried out, preferably, after the rainy season of each year, between March and April.

Incidentally, in the identification, at any time, of an anomaly not identified in the annual inspection, a new inspection in the affected module should be performed. However, the following annual inspection should not be dismissed.

The identified nonconformities should be indicated in a roof plan, in the Field Inspection Sheet, and photographed for insertion of the images in the Final Inspection Sheet. Visible cracks to the naked eye, drips, efflorescence stains, rebar corrosion spots, termite presence, among other pathological manifestations that may arise, should be recorded.

Inspection services should preferably be performed by a team of two people, one responsible for inserting the information in the inspection sheet, and the other responsible for the photographic records. For modules located in the intermediate range of the roof, it is recommended to inspect with binoculars.

It is recommended that on-site inspections should be done in the morning, followed by the consolidation of the data by digitization and computerized completion of the records, preferably later on the same day.

Upon completion of the inspection of the 60 modules, a technical report describing the conditions of the roof should be produced, indicating the modules with evidence of waterproofing impairment and comparison of the data with the inspection of the previous year.

Services to be performed:

- Internal visual inspection of the roof;

- Manual filling of the inspection form (Field Inspection Sheet);

- Photographic recording;

- Scanning of the Field Inspection Sheet;

- Transcription in digital form of the Field Inspection Sheet, with insertion of photographic records (Final Inspection Sheet);

- Final report of the activity.

2. Visual inspection on polyurea waterproofing system

It consists of inspections on the upper (external) aspect of the roof slab and the sides of the inverted beams, which are coated with polyurea waterproofing.

These inspections aim to identify faults in the waterproofing membrane that affect the integrity of the concrete structure of the roof, through annual inspections, by modules, carried out between September and October, before the rainy season of each year.

Two visual inspections per module should be performed. The preliminary visual inspection will document the physical conditions of the module before the beginning of the services, identifying areas of water puddling, organic material accumulation (foliage) and dirty surfaces.

Subsequently, the module should be prepared for the second inspection, when incidental cracks, perforations, spots, membrane shedding, substrate displacements, among other pathological manifestations will be recorded.

To carry out this second inspection, all the water incidentally puddled should be drained by suction by means of a submerged pump; the foliage must be removed by sweeping or suctioning, and the entire surface must be washed with water hydroblasting at low pressure. During the hydroblasting service, care must be taken to prevent water from entering through the ventilation slit of skylights.

After the cleaning procedure, the puddle water, resulting from the hydroblasting service, should be suctioned by pump, according to previous procedures. The inspection will start only upon the complete drying of the polyurea-coated surfaces.

The identified nonconformities should be indicated on a plan, in the Field Inspection Sheet, and photographed for insertion of the images in the Final Inspection Sheet. Fissures visible to the naked eye, previous repairs, coating with adhesion failure (peeling off), regions with color change, among other pathological manifestations should be recorded.

The services described in this item should preferably be performed by a team of four people, two in charge of cleaning and preparing the physical conditions of the modules, two others responsible for completing the inspection form and photographic records.

Upon completion of the inspections in the 60 modules, a technical report describing the conditions of the roof should be produced, indicating the modules with evidence of waterproofing impairment and comparison of the data with the inspection of the previous year.

Services to be performed:

- Preliminary visual inspection of the polyurea coating;

- Manual filling of the preliminary inspection form (Field Inspection Sheet I);

- Photographic recording;

- Drainage of rainwater by submerged pump and sucking, if any;

- Removal of foliage accumulated on the slab, if any;

- Cleaning the polyurea coating with water hydro blasting at low pressure;

- Drainage of water resulting from hydro blasting, with pump and suction, if necessary;

- Await drying of polyurea-coated surfaces;

- Visual inspection of the dry polyurea coating;

- Manual filling of the visual inspection form (Field Inspection Sheet II);

- Photographic recording;

3. Inspection with Holiday Detector in the polyurea waterproofing system

Every two years, together with the visual inspection described above, an inspection shall be carried out using the equipment known as Holiday Detector (discontinuity detector) on the roof polyurea membrane;, there is no need to carry out this inspection on the sides of the inverted beams.

The inspection method shall comply with the reference standard ABNT NBR 16172: 2014 - Anti-corrosion coatings - Determination of discontinuity in anticorrosive coatings applied to metallic substrates, item 4.2.2:

Device with a voltage exceeding 5,000 V (thicknesses above 1,000 µm):

a) using a voltage corresponding to 5 V / µm thickness;

b) properly ground the device;

c) carry out the test on the entire surface, with a speed of less than 20 cm / s;

d) the sound alarm and the formation of a more intense spark indicate the existence of discontinuity in the coating.

For inspection with Holiday Detector, the skylights shall be provisionally removed in the module to be inspected, to allow for the proper operation of the equipment. Under this condition, the skylight openings should be protected with a physical shield, according to RTP1 - Protection measures against falls from height, of the Ministry of Labor and Employment.

In the identification at any time of leaking in the inner side of the roof, the respective module must be inspected visually and with the use of Holiday Detector in. The next annual scheduled roof inspection should be carried out normally.

The services described in this item should preferably be performed by a team of four people, two in charge of cleaning and preparing the physical conditions of the modules, two others responsible for completing the inspection form, the operation of the

Holiday Detector, and the photographic records.

Services to be performed in conjunction with the visual inspection activity:

- Removal of skylights;

- Installation of physical protection in the roof openings;

- Preliminary visual inspection of the polyurea coating;

- Manual filling of the preliminary inspection form (Field Inspection Sheet I);

- Photographic recording;

- Drainage of rainwater by submerged pump and suctioning, if necessary;

- Removal of foliage accumulated on the slab, if any;

- Cleaning the polyurea coating with water hydroblasting at low pressure (500psi);

- Drainage of water resulting from hydroblasting, with pump and suction, if necessary;

- Await for drying of polyurea-coated surfaces;

- Visual inspection of the dry polyurea coating;

- Inspection with the use of Holiday Detector equipment on the roof slab;

- Manual filling of the visual inspection form (Field Inspection Sheet II);

- Photographic recording;

- Removal of the physical protection from the roof openings;

- Reinstallation of skylights;

- Scanning of the Field Inspection Sheets I and II;

- Transcription in digital format of the Field Inspection Sheets I and II, with insertion of the photographic records (Final Inspection Sheet).

4. Cleaning and review of the flashing fasteners

It consists of the annual cleaning by hydroblasting at low pressure (500psi) of the upper surface of the flashings, totalizing an approximate expansion of 1,826m. This activity should be followed by the review of the fastening system, consisting of approximately 2,500 anchor bolts of 2” in length and 1/4” thread in galvanized steel.

The loose anchor bolts should be retightened or replaced so as to remain fixed, and those that show signs of corrosion should be replaced immediately.

5. Lightning system review

It consists of the annual inspection of the elements to verify electrical continuity faults, fixation and corrosion faults, to identify any fault that might impair the physical integrity or the electrical continuity of the system. Re-tightening of all bolts and replacement of all elements showing signs of corrosion shall be performed. It is recommended to perform this activity together with the revision of the flashing fasteners.

6. Cleaning of drains, slabs, and drain pipes

It consists of the monthly sweeping of the slabs, followed by the cleaning of the respective drains and drain pipes. Incidental water puddling should be drained with the aid of pumps and suction, prior to cleaning.

8. Skylights cleaning

It consists of the quarterly cleaning of the external surface of the skylights with the use of hydro blasting at low pressure (500 psi). It is recommended, however, that at the time of first cleaning, the most suitable working pressure for the removal of the dirt deposited on the surface of these elements should be checked.

9. Revision of fastening and sealing of skylights

It consists in the retightening of the structural screws and fasteners of the skylights, every two years, after the inspection of the waterproofing with the use of the Holiday Detector, when the skylights will be provisionally removed. Waterproofing sealants should also be inspected and replaced as necessary.

10. Water valves inspection

It consists of semiannual inspection in the cold-water valves, with their full opening and closing, to avoid jamming and to keep them in good conditions of use and operation.

11. Revision of the water supply and sewage system

It consists of the annual inspection of the exposed cold-water piping and sewage ventilation to detect breaks, clogging, loss of tightness and fastening, restoring its integrity where necessary. A visual inspection of the water reservoirs will also be carried out, to identify incidental faults in the waterproofing.

12. Revision of the fastening of the access and transit system

It consists of the annual inspection and complete re-tightening of the fasteners of all elements of this system, consisting of ladders, walkways, guardrails, lifelines, etc.

13. Cleaning the fairing system of the mechanical exhaust system and checking of seals

It consists of the annual cleaning of the chimney of the exhaust fan and the inspection of the sealing sealants, to be replaced if needed.

14. Checking and review of electrical installations

It consists of the annual check of the electrical installations with the revision of the insulation of the wire splices and the retightening of sockets and other connections of the system.

2.5.3. Repair program

The Repair Program establishes corrective procedures for the roof systems that are faulty. At present, this program consists only of the technical specification for repairing the waterproofing system, but in the future, it should cover other repair procedures that are necessary for the conservation of the roof.

1. Waterproofing repair with removal of polyurea.

In the identification of the impermeability failure of the polyurea waterproofing system, caused by rupture of the substrate, the repair must be performed according to the procedure determined by the manufacturer Viapol Ltda., detailed below:

Step 1: Identification of the fault and delimitation with cutting disk, forming square or rectangular geometric figures, of the area to be repaired.

Step 2: Removal of polyurea from the delimited section.

Step 3: The cracks should be treated through U-shaped opening, using the cutting disc, with a width of 15mm and a depth of 6mm. Subsequently, the area should be cleaned by aspiration, followed by filling the fissure with polyurethane sealant. Wait 24 h for curing the sealant.

Step 4: Perform the sanding of the surface to be repaired, extending it at least 10cm above the adhered polyurea. Clean the area with a vacuum cleaner and clean the sanded polyurea with cloth dosed with polyurethane thinner.

Step 5: Apply one coat of Vulkem Primer 191® to the entire sanded area with a wool roll, including on the polyurea.

Step 6: Homogenize the Vulkem 350NF® with drill and propeller coupled. When the primer is in “durex” touch point, apply coat of Vulkem 30NF using wool roll.

Step 7: Glue a screen or polyester veil strip of 80g / m² on the repair, and reapply another coat of Vulkem 350NF®.

Step 8: After a period of between 6 and 12 hours from the application of Vulkem 350NF®, apply one coat of the Vulkem 346 with wool roll and hand-spray the aggregate # 50 as evenly as possible and repass the roll so that the grains are covered by the product.

2. Waterproofing repair without removal of polyurea.

In the identification of the impermeability failure of the polyurea waterproofing system, caused by external damage, provided that the substrate is whole, the repair must be performed according to the procedure determined by the manufacturer Viapol Ltda., detailed below:

Step 1: Perform a sanding of the surface to be repaired, clean the area with a vacuum cleaner and clean the sanded polyurea with cloth dosed with polyurethane thinner.

Step 2: Apply one coat of Vulkem Primer 191® to the entire sanded area with a wool roll.

Step 3: Homogenize the Vulkem 350NF® with drill and propeller coupled. When the primer is in the “durex” touch point, spread the Vulkem350NF® using a notched trowel, and then pass on it the same wool roll.

Step 4: After a period of between 6 and 12 hours from the application of Vulkem 350NF®, apply one coat of the Vulkem 346 with wool roll and hand-spray the aggregate # 50 as evenly as possible and repass the roll so that the grains are covered by the product.

2.5.4. Players responsible for the implementation of the Conservation Management Plan for the roof

According to the organization chart in force on the School website at this date, the sectors, players, and respective responsibilities for the conservation of the building’s roof by order of responsibility are:

- Congregation: Maximum instance of the school.

Responsible for the analysis, evaluation, proposition of adjustments and approval of this Management Plan, to legitimize it for the mandatory implementation of the procedures established by the operational instances.

- FAU-USP Heritage Curator Council: Although not included in the organization chart mentioned above, this body, approved by the Congregation through FAU ordinance 002/2013, is active. It is responsible for discussing and proposing guidelines for preservation, conservation, maintenance, repair, restoration, and adaptation, among other assets, of the Vilanova Artigas building; to organize related participatory processes, and analyze the projects prepared according to the established guidelines; and forward to the decision-making and executive instances of FAUUSP the measures deemed necessary to comply with these guidelines.

In this plan, its attribution is to submit it to the Congregation, together with those responsible for its elaboration, and to follow up its implementation through specific and regular periodical reports made by the Technical Section of Institutional Advice and Dissemination (DIVINST-16).

- Board of Directors (FAU Board): Among other attributions, it is the ultimate executive responsible for all actions concerning the physical infrastructure of the school.

In relation to the present plan, it is responsible for the implementation of the attributions of each one of the administrative sectors, and to follow up the actions carried out in accordance with these assignments. Submit to the Curator Council and the Congrega

tion, the decisions that imply structural changes, either in relation to the plan itself, or in relation to actions on the building that go beyond the routine established by it.

• Administrative Technical Assistance (ATAD-16) which comprises:

- Clerical Service (SVEXP-16): file, attendance, and protocol. It is responsible for the control, collation, and progress of dockets and filed documentation of the entire FAU, being responsible for sending, receiving, and distributing mail.

In the case of the present plan, it is responsible for logging, in accordance with the norms and procedures of the University and the Unit, all actions related to interventions on the building, whether routine or exceptional, from the start (proposal, design, request, demand, requirement, complaint, etc. ...) until its end (receipt, acceptance, technical verification, etc...).

- Personnel Service (SVPES-16): subordinate to the Administrative Technical Assistance, it is responsible for the management of the staff.

In the case of the present plan, it is responsible for appointing the employees responsible for the actions specified therein, according to their function and availability, formalizing their duties and performing the necessary training.

- General Activities Service (SVATGER-16): to manage the continuous activities carried out at the Unit.

In this case, this sector should manage the actions defined by the plan, harmonizing them with all the sectors involved, unfolding the agenda of the general actions defined in work orders, with identification of people, assignments, and deadlines to be performed by the Operational Sector, and providing specific technical instructions for each activity (drawings, memorials, standards, safety, etc.).

- Operational Sector - FAU-CUASO (OPER-CUASO): support for continuous direct activities.

In relation to the plan, the employees assigned to this sector are those who will carry out the actual operational tasks, according to the established technical instructions, from the planning defined by SVATER-16 based on this Plan.

- Technical Infrastructure Service (SVINFRA-16): to plan, develop, monitor and / or design projects for small interventions, corrective maintenance, restoration, and preservation of the physical spaces of the Unit's buildings.

The operational actions of this Plan correspond to the characteristic activities of this sector which, according to the decision of the Congregation, must implement them as its own, based on the adjustments determined.

- Infrastructure Support Section (EFSF); to provide support in the development of bid notices, technical surveys, request of necessary materials / equipment for activities developed by the Technical Service, in addition to the ordinary maintenance for the conservation of the Unit's Buildings.

The Plan is precisely the necessary support that this sector must carry out, and that will have as its task to incorporate it in what concerns the conservation of the roof and gables of the FAU Building, adjusting the forms of acquisition and contracting to the rules, detailing and instrumenting technically these procedures.

• Technical and Financial Assistance (ATFIN-16) Financial Assistance is responsible for planning, developing, and organizing activities in the financial area.

It is responsible for the insertion of this Plan within this process, analyzing the needs and making them compatible with the priorities and strategies of the management, as well as the legal and normative requirements to meet the minimum conditions for the full functioning of the Institution.

- Materials Service (SVMAT-16); make feasible the acquisition of goods and / or services - control of material and patrimony.

The Plan indicates different works to be carried out, which demand material, tools and, if any, services for their materialization. This is the sector responsible for ensuring the flow determined by those demands, with the specifications, quantities, and deadlines established herein, making the purchases and contracts under the conditions defined by the University and the Unit norms, and / or making available from the inventory or warehouse, previously supplied from a specific plan.

- Tendering Sector (SLICONT-16): conducting bids for the purchase of goods and / or services.

In the same way as SVMAT-16, this sector is responsible for purchasing and acquiring as established by AFIN-16, in what is outside the scope of SVMAT-16, in accordance with the purchasing and hiring rules of the University, to ensure the continuity of the conservation works defined herein.

• Technical Support Service for Education, Research, Culture and Extension (APEPE-16), which among other technical sections comprises:

- Technical Advisory Section and Institutional Disclosure (DIVINST-16).

The attribution of this sector in relation to the Plan is essential because its responsibility according to the organization chart is: *"... the communication process through a greater interaction of FAU with FAU, FAU with USP and with society ... to elaborate electronic information and graphic materials ... to control and monitor the different internal and external communication channels, including social networks and the USP portal."*

One of the requirements for the consequent implementation of the plan is its transparency. Both for the community at large and for the sectors responsible for its implementation, in particular the Congregation, the Board of Directors and the Curator Council. This transparency is natural, if the management system of the conservation management process itself is also conceived as an instrument of dissemination and sharing. Without mediation, selectivity, or presentation as a specific purpose. In this way, the subordination of all players to the governing bodies, as well as the interaction between them will not require any bureaucracy, because the actions will be permanently known, monitored, assessed, and incidentally corrected through public access within their own processes.

2.5.5 Work schedule

System	ACTIVITY	Frequency	Duration	1st Semester												2nd Semester											
				1st Quarter								2nd Quarter				3rd Quarter				4th Quarter							
				January				February				March				April				May				June			
				01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Structural and waterproofing systems	1. Inspection of the structural system and water tightness of the waterproofing	Annual	1 month																								
Waterproofing system	2. Visual inspection on polyurea waterproofing system	Annual	1 month																								
	3. Inspection with Holiday Detector in the polyurea waterproofing system	Biannual	3 months																								
Flashing system	4. Cleaning and review of the casings fasteners	Annual	2 weeks																								
Lightning system	5. Lightning fixation review	Annual	1 week																								
Drainage system	6. Cleaning of drains, slabs, and drain pipes	Monthly	2 weeks																								
Skylight system	7. Skylights cleaning	Quarterly	2 weeks																								
	8. Revision of fastening and sealing of skylights	Biannual	3 months																								
Water supply and sewage system	9. Cleaning of water reservoirs	Semiannual	1 day																								
	10. Water valves inspection	Semiannual	1 day																								
	11. Revision of the water supply and sewage system	Annual	1 day																								
Access and transit system	12. Revision of the fastening of the access and transit system	Annual	2 weeks																								
Exhaustion system	13. Cleaning the cowl system of the mechanical exhaust system and checking of seals	Annual	1 day																								
Electrical installations system	14. Checking and review of electrical installations	Annual	1 week																								

Source: Rosa Artigas, author and date unknown

REFERENCES

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS – ABNT. NBR 5626: Instalação predial de água fria. Rio de Janeiro. 1998.

_____ . NBR 5674: Manutenção de edificações – Rquisitos para o sistema de gestão da manutenção. Rio de Janeiro, 2012.

_____ . NBR 6118: Projetos de estruturas de concreto – Procedimentos. Rio de Janeiro, 2014.

_____ . NBR 8160: Sistemas prediais de esgoto sanitário – Projeto e execução. Rio de Janeiro, 1999.

_____ . NBR 9574: Execução de impermeabilização. Rio de Janeiro. 2009.

_____ . ABNT. NBR 9575: Impermeabilização – Seleção e projeto. Rio de Janeiro, 2010.

_____ . NBR 10844: Instalações prediais de águas pluviais. Rio de Janeiro, 1989.

_____ . NBR 16172: Revestimentos anticorrosivos – Determinação de descontinuidade em revestimentos anticorrosivos aplicados sobre substratos metálicos. Rio de Janeiro, 2014.

_____ . NBR 16545: Revestimentos de alta espessura com sistemas de poliureia e híbridos de poliureia/poliuretano – Requisitos de desempenho. Rio de Janeiro, 2016.

ASTM INTERNATIONAL. D412 – Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomers – Tension. 2006.

_____ . D638 – Standard Test Method for Tensile Properties of Plastics. 2014.

_____ . D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates

BARBOSA, Paulo Eduardo; PEREIRA, Maria Fernanda. Edifício Vilanova Artigas, Prédio da FAU USP – Diagnóstico da laje de cobertura. Relatório Técnico 219/P2/2006. São Paulo: PhDesign, 2005.

_____ . Edifício Vilanova Artigas, Prédio da FAU USP – Projeto, especificação de materiais/sistemas e procedimentos para reabilitação do edifício, com previsão orçamentária. Relatório Técnico 219/2006. São Paulo: PhDesign, 2006.

BAROSSI, Antônio Carlos (org.) O edifício da FAU-USP de Vilanova Artigas. São Paulo: Editora da Cidade, 2016.

BRITEZ, Carlos Amado; ANTUNES, Juliana da Silva. Faculdade de Arquitetura e Urbanismo FAUUSP – Edifício Vilanova Artigas. Projeto e especificação técnica dos serviços de reabilitação da estrutura de concreto armado do edifício Vilanova Artigas da Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo. Relatório Técnica 136/2010. São Paulo: PhD Engenharia. 2010.

BRITEZ, Carlos; VERGILI, Rodrigo. Consultoria especializada para acompanhamento técnico dos serviços de reabilitação da estrutura de concreto armado do edifício Vilanova Artigas da FAU USP. Relatório Técnico 236.00-18. São Paulo: PhD Engenharia. 2013.

BRUNA, Paulo Valentina. Estanqueidade e recuperação do concreto da cobertura. Relatório dos serviços executados. São Paulo: Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo. 1995.

CONSELHO CURADOR DA FAU USP. Plano Diretor Participativo FAUUSP 2011-2018. São Paulo: Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo. 2012.

CONTIER, Felipe de Araújo. O Edifício da Faculdade de Arquitetura e Urbanismo na Universidade de São Paulo: projeto e construção da escola de Vilanova Artigas. São Carlos: Instituto de Arquitetura e Urbanismo da Universidade de São Paulo. 2015. (Tese de doutorado).

DEPARTAMENTO DO PATRIMÔNIO HISTÓRICO. Análise técnica e parecer, processo 2009-0.051.973-4. São Paulo, 2009.

FACULDADE DE ARQUITETURA E URBANISMO DA UNIVERSIDADE DE SÃO PAULO. Memorial descritivo de materiais e serviços: execução de rufo nas vigas invertidas e recuperação do concreto da cobertura do edifício Vilanova Artigas da FAUUSP. São Paulo, 2008

_____ . Restauro e recuperação no edifício Vilanova Artigas, no Anexo e no edifício Vila Penteado. São Paulo: Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo, 2009.

_____ . Edifício Vilanova Artigas: reformas programadas e em andamento. São Paulo: Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo, 2009.

_____ . Restauro e recuperação no edifício Vilanova Artigas: cobertura. São Paulo: Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo, 2009.

GIANNECCHINI, Ana Clara. Técnica e estética do concreto armado: um estudo sobre os edifícios do MASP e da FAUUSP. São Paulo: Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo, 2009. (Dissertação de mestrado)

GRUPO EXECUTIVO DE GESTÃO DOS ESPAÇOS FÍSICOS DA FAU USP. Memorial descritivo de especificação técnica dos serviços de recuperação da cobertira do edifício Vilanova Artigas da Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo. São Paulo, 2012.

JATOBETON ENGENHARIA. Manual de operação, uso e manutenção do edifício Vilanova Artigas. Recife, 2015.

MINISTÉRIO DO TRABALHO E EMPREGO. Norma regulamentadora 18 – Condições e meio ambiente de trabalhos na indústria da construção. Disponível em: <http://trabalho.gov.br/images/Documentos/SST/NR/NR18/NR18atualizada2015.pdf> Acesso em 27/ de novembro de 2017.

_____ . Norma regulamentadora 35 – Trabalho em altura. Disponível em < http://trabalho.gov.br/images/Documentos/SST/NR/NR35/NR-35-2016.pdf> Acesso em 15 de janeiro de 2016.

_____ . Recomendação técnica de procedimentos – Escadas, rampas e passarelas. São Paulo: FUNDACENTRO, 2002.

_____ . Recomendação técnica de procedimentos – Medidas de proteção contra quedas de altura. São Paulo: FUNDACENTRO, 2003.

PICCHI, Flávio Augusto. Impermeabilização de coberturas. São Paulo: PINI, 1986.

PIRONDI, Zeno. Manual prático da impermeabilização e de isolação térmica. São Paulo: PINI, 1988.

SIMÕES, João Roberto Leme. Patologias – Origens e reflexos no desempenho técnico construtivo de edifícios universitários da CUASO USP. São Paulo: Faculade de Arquitetura e Urbanismo da Universidade de São Paulo, 2004. (Tese de livre docência).

SIMÕES, João Roberto Leme. Relatório dos serviços executados na cobertura do edifício Vilanova Artigas. FAUUSP – CUASO. São Paulo: Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo, 2003.

SUETA, Hélio Eiji. Relatório de inspeção técnica do sistema de proteção contra descargas atmosféricas da Faculdade de Ar-

quitetura e Urbanismo da USP – Edifício Vilanova Artigas. São Paulo: Instituto de Energia e Ambiente da Universidade de São Paulo, 2014.

_____ . Projeto de proteção de edificação contra descargas atmosféricas. São Paulo, 2008.

SUETA, Hélio Eiji; CAIRES, Luis Eduardo. Relatório de análises das instalações elétricas do edifício Vilanova Artigas da Faculdade de Arquitetura e Urbanismo da USP. São Paulo: Instituto de Eletrotécnica e Energia da Universidade de São Paulo, 2011.

SUETA, Hélio Eiji; CAIRES, Luis Eduardo; TSUTSUMI, Sérgio. Relatório de análises das instalações elétricas do edifício Vilanova Artigas da Faculdade de Arquitetura e Urbanismo da USP. São Paulo: Instituto de Eletrotécnica e Energia da Universidade de São Paulo, 2005.

UNIVERSIDADE DE SÃO PAULO. Processo 1986.1.23631.51.9 – Aquisição de material impermeabilizante para execução de impermeabilização dos edifícios FAU e EP. São Paulo: Universidade de São Paulo, 1986.

_____ . Processo 1991.1.9000.82.0 – Estudo para execução da reforma da cobertura do prédio da Faculdade de Arquitetura e Urbanismo. São Paulo: Universidade de São Paulo, 1991.

_____ . Processo 1994.1.377.16.9 – Aquisição de serviço de impermeabilização da laje e cobertura. São Paulo: Universidade de São Paulo, 1994.

_____ . Processo 1996.1.50.16.1 – Recuperação de um módulo da cobertura do edifício da FAU USP. São Paulo: Universidade de São Paulo, 1996.

_____ . Processo 1996.1.378.51.0 – Solicita providências para reserva orçamentária para as obras de recuperação e impermeabilização de 04 módulos da cobertura. São Paulo: Universidade de São Paulo, 1996.

_____ . Processo 1996.1.435.16.0 – Aquisição de montagem da estrutura metálica de apoio da cobertura do edifício FAU CUASO. São Paulo: Universidade de São Paulo, 1996.

_____ . Processo 1997.1.29.16.3 – Aquisição de despesas com serviços de recuperação e impermeabilização. São Paulo: Universidade de São Paulo, 1997.

_____ . Processo 1997.1.382.16.5 – Contratação de empresa prestadora de serviços da cobertura do edifício da FAU USP. São Paulo: Universidade de São Paulo, 1997.

_____ . Processo 1999.1.61.16.6 – Serviço para impermeabilização de parte da grelha estrutural da FAUUSP. São Paulo: Universidade de São Paulo, 1999.

_____ . Processo 2001.1.93.16.8 – Auxílio financeiro para continuidade as obras de recuperação da cobertura do edifício FAUUSP/CUASO. São Paulo: Universidade de São Paulo, 2001.

VIAPOL. Ficha técnica ViaPoliureia 600PP. 2013.

XAVIER, Ivan Silvio de Lima; FALQUEIRO, Mariana. Acompanhamento técnico e fotográfico da obra de recuperação da laje plana de cobertura da FAU-USP. São Paulo: Isoterma Construções Técnicas, 2003.

CHARACTERISTICS AND CONSERVATION OF THE EXPOSED REINFORCED CONCRETE OF THE VILANOVA ARTIGAS BUILDING (FAUUSP)

Keeping It Modern Program
The Getty Foundation
2017

CHARACTERISTICS AND CONSERVATION OF THE EXPOSED REINFORCED CONCRETE OF THE VILANOVA ARTIGAS BUILDING (FAUUSP)

Coordination
Claudia T. de Andrade Oliveira

Team of Professionals
Ana Paula Arato Gonçalves
Fábio Gallo Jr.
Letícia de Almeida Chaves
Collaborators: Carmen Silvia Saraiva Masseo de Castro
Tatiana Regina Silva Simão

Source: Conserva FAU Team, 2016.

SUMMARY

3. Task 3 - Characteristics and conservation of the exposed reinforced concrete of the Vilanova Artigas Building (FAUUSP)

Claudia T. de Andrade Oliveira, Fábio Gallo Jr, Ana Paula A. Gonçalves, Letícia de A. Chaves

Introduction 211

Presentation of the blind façades 211

Blind façades | Timeline 214

Work method 215

3.1. Constructive characteristics of the blind façades 219

Blind façades concreting sequence 221

3.2. History of interventions in the blind façades 227

Intervention in Pillar 3 in 1981 229

Intervention in the Pillar P48 in 1999/2000 230

Inspection of 2004 231

Inspection of 2010 232

Intervention from 2012 to 2015 233

3.3. Conditions of access to the external surface of blind walls 234

3.4. Environmental conditions 245

Atmospheric pollutants 247

Exposure to weathering 247

Shaded areas 249

3.5. Physical condition of blind walls 251

Repair areas 253

Wetting areas 253

Absorption of water on the surface of the apparent concrete 254

Characteristic stains of deposits of corrosion products 255

Rebar coating 256

3.6. Physical Properties of the concrete 259

Exploratory study of compressive strength 261

Compressive strength of concrete cores 262

Elasticity modulus of the concrete cores 262

Water absorption, index of gaps, and specific mass of concrete cores 263

Reconstitution of the concrete recipe 263

3.7. Aspects of the concrete microstructure 267

Aggregates characteristics 269

Mercury intrusion porosimetry 269

Morphological aspects of concrete microstructure 272

Identification of phases 274

3.8. Tests for the removal of grafitti 277

Test 1: hydroblasting 279

Test 2: chemical removal 279

Test 3: inorganic abrasive blasting 280

Conclusions 281

3.9. Studies on the chromatic attributes of concrete, and mix design of the finishing mortar 283

Methodological procedures 285

Tests of finishing mortars application 286

3.10. Rebar corrosion 289

3.11. Analyses, recommendations and guidelines 301

Analyses and recommendations on operational and administrative aspects 303

Analysis and recommendations on the monitoring of the blind walls physical conditions 303

Analyses and guidelines on the continuity of studies about the concrete 303

Guidelines for the treatment and rework of repairs 304

Analyses and recommendations about treatment to reduce the corrosion rate 304

References 309

Documental Corpus 315

Annex A: Survey of Artigas Building façade areas shaded by surrounding trees 317

Annex B: Survey of Artigas Building façade areas repairs with structural repair mortar, during the structural recuperation intervention of 2012-2015 323

Annex C: Survey of Artigas Building façade areas subject to wet staining after rainfall 329

Annex D: Survey of Artigas Building façade areas subject to staining by accumulation of corrosion products 335

Annex E: Results of microstructural analyses XRD, TG/DTG. and petrography 341

Source: SEF-USP, date and author unknown.

3.

TASK 3

Introduction

The objective of Task 3 was to characterize the blind façades and their immediate surroundings, that is, the concrete and the rebar condition, the conditions of the external surface, and the environmental conditions that interfere with the degradation and future actions of blind façades conservation.

The choice of blind façades as the object of analysis of Task 3 done due to their historical and cultural meaning, and also for the fact that they are part of the structural system of the building, being one of the sets of elements more vulnerable to the impacts of the predominant pathological manifestations. Based on the track records of the construction and previous interventions, the initial hypothesis adopted was that the corrosion of the rebar induced by carbonation is the prevailing pathological manifestation in the degradation of the exposed concrete blind façades.

In addition to the hypothesis that de corrosion of rebar induced by carbonation is the main mechanism of deterioration of the blind façades, another hypothesis surveyed is that only one class of concrete was specified for the whole building. In the historic documents, there is only mention to the concrete with σ_{C28} = 320 kgf/cm^2 (~32MPa. That is why investigations on the resistance and other characteristics of the concrete in a sampling region of the roof beams were included in the experiments. The onsite inspections and tests in the roof beams, as elements also vulnerable to the action of the weather, as not part of the study because they are entirely lined with a polyurea-based membrane cast onsite, as already explained in Task 2.

Based on this picture, inspections and testes were planned. In the first step, historical data and previous interventions were surveyed, in addition to the performance of some initial inspections and exploratory tests. In the second step, onsite inspections and tests were systematically performed, in addition to tests for the characterization of concrete and rebar. Additionally, tests of graffiti removal from the concrete were performed, besides studies on the dosing and application of mortars as alternative for the finishing of future repairs on the blind façades; a first approximation to mitigate the effect of the visual fragmentation of the blind façades.

Presentation of the blind façades

The last floors of the building, regarding the studios (level +8.40) and the classrooms (level +10.30), are protected from the outside by reinforced concrete walls. Those walls, lacking openings – also called blind façades – have, in addition to the function of sealing, structural function, because they transfer loads coming from the floors and roof to the external pillars of the building.

To identify the blind façades, the building orientation was used as reference, as illustrated in Figure 12, in which its four blind façades are presented: northeast (NE), southeast (SE), southwest (S) and northeast (NO).

All the blind façades have nominal thickness of 20 cm. Supported on five pillars, the longitudinal NE and SW blind façades have externally 110.20 of nominal length, and each of them has a vertical dilatation joint that divides them in two equal parts. In the case of transversal NO and SE blind façades, the nominal external length is 66.20 m, and each of them is supported on a pair of pillars. The nominal height of blind façades is 8.15 m, except for blind façade NE which height is 7.25 m.

The total surface, measured through the results of the 3D laser scanning done in 2016, is 3,079.60 m2. The blind façades are supported on 14 pillars of pyramidal-trunk geometry, also made of exposed concrete, although cast in plywood to obtain a smoother surface. Figure 2 illustrates the SO, NO and NE blind façades of the newly inaugurated building, in 1969.

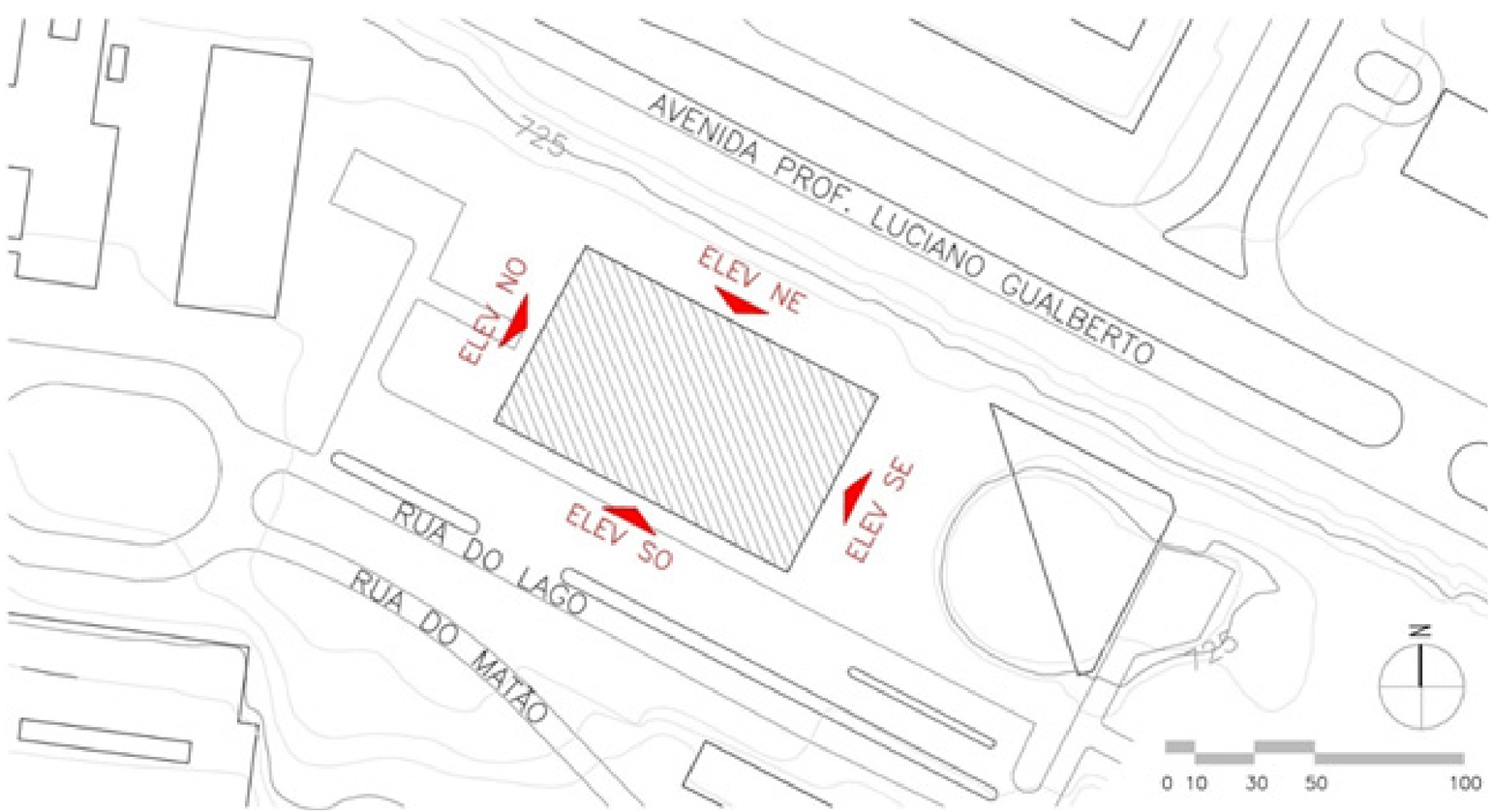


Figure 12: Site plan of Vilanova Artigas building with the orientation of elevations Northwest (NE), Southeast (SE), Southwest (SO) and Northwest (NO).

The images of Figure 13 evidence that, since the completion of the work, there are significant chromatic variations on the blind façades because of the materials used for the composition of the concrete recipe. The variations in their appearance might also have been influenced by the construction method.

In addition to the chromatic variation, another expressive characteristic results from the printing of the pinewood boards grains, with nominal width of 30 cm, used horizontally in the mould for concreting (Figure 14). The consequent rustic and porous textures provides the external surface of blind façades with a heterogeneous surface. On the blind façades, superficial cavities are also visible, in addition to regions with aggregates concentration, remarkably in the concreting joints and in the interfaces of the mould boards. The lack of precision in positioning the pinewood boards also produces reliefs and discontinuities in the layout of moulds.

Figure 13: Newly inaugurated building, in 1969. Above: blind façade of the main building façade (blind façade SO) supported on 5 pillars, and the lateral blind façade (blind façade NO) supported on two pillars. Below: blind façade NO and blind façade NE supported on 5 pillars. (Source: José Moscardi, 1969. Collection: FAUUSP Library).

Figure 14: Characteristics of the blind façades external surfaces: printing of wooden boards grains (width of 30 cm), chromatic variations between the concreting stripes, fissures, cavities and discontinuities on the concrete surface and in the concreting joints, concentration of aggregates, relief in the layout of the pinewood boards. Source: Conserva FAU Team collection, 2016.

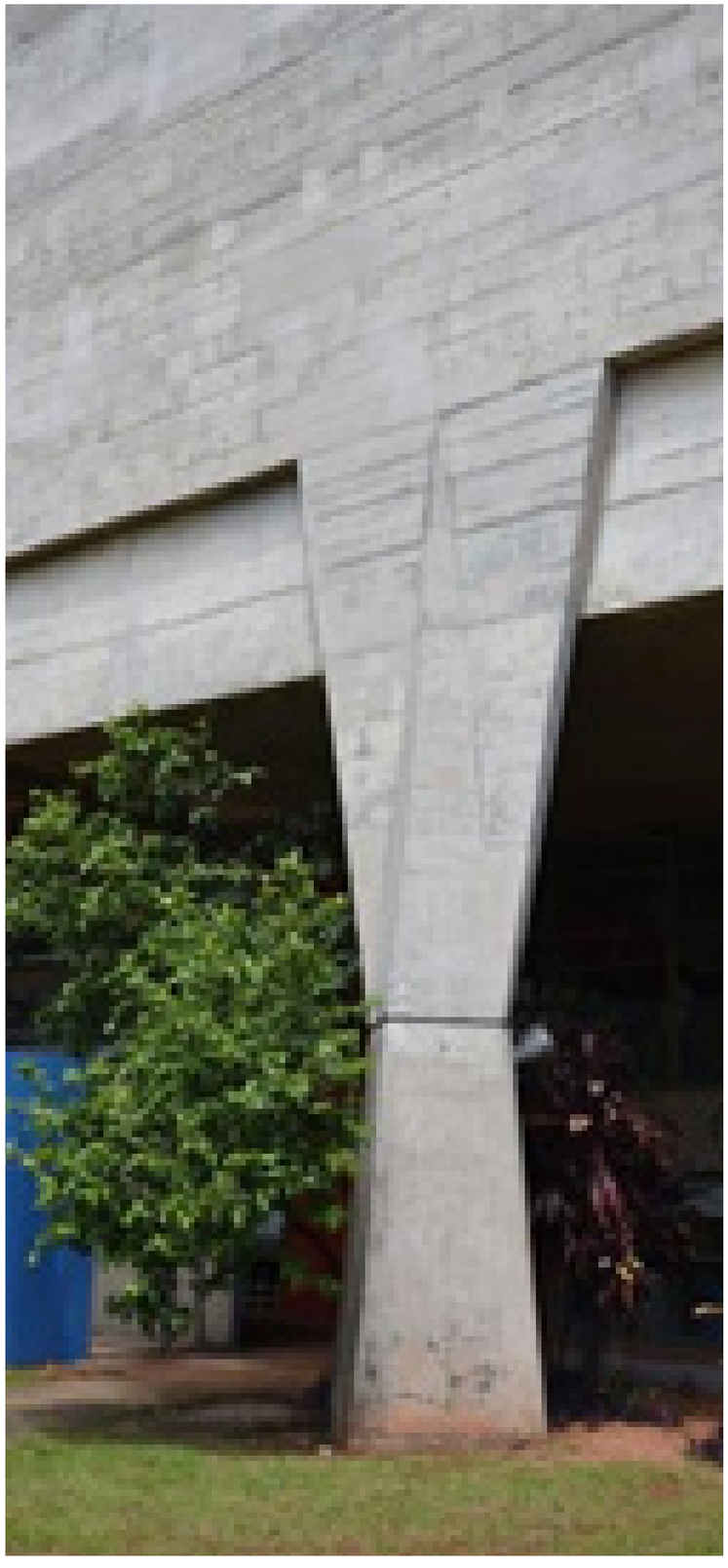


Figure 15: External pillar with pyramidal base, and upper section cast with long wooden board mould as extension of the blind façade (Source: C. A. Oliveira, 2017).

Another characteristic of the blind façades are their extension in the shape of an inverted triangle until the intersection with the pyramidal base of external pillars, as shown in Figure 15, which meaning interpretation is given by Barossi (2016, p. 123).

The perspectives of the blind façades, in the current condition, with the characteristics of their immediate surroundings, are illustrated in Figure 16.

Blind façade NE

Blind façade SE

Blind façade SW

Blind Façade SW

Figure 16: Perspectives of the blind façades of Artigas building in the current condition (Source: Conserva FAU Team, 2016).

1967-1968

Construction of the structure

1981

Intervention in the pillar P3 blind façade NE: recuperation of the reinforced concrete and change of the supporting device

2000

Intervention in the pillar P48 blind façade SO: recuperation of the reinforced concrete and change of the supporting device

2004 and 2010

Visual inspections for the qualification of the blind façades conservation conditions

2012-2015

Intervention in the blind façades for structural reuse

Work method

The activities of the experimental program are briefly included in Table 1.

The sampling plan to remove specimens is a special step. After analyses of possible sampling plans, the proposal for the extraction of specimens and tests, and subsequent closing of gaps in the blind façades and the roof beam, was submitted to the analysis and approval by the heritage protection agencies[6].

Initially, a first approximation of the possible blind façade concreting steps was done, considering the formation of sampling batches with volumes between 8 and 50 m3, based on the provision of the Brazilian standard governing the extraction and compression test of concrete specimens, NBR 7680-1 (ABNT, 2015). The possible scenario of blind façades division was defined in 14 concreting batches. A second approximation has considered the division of blind façades into segments, of approximately the same length (~30 m). It resulted in 10 sampling batches. For the sampling of beams, the initial proposal was of locating two batches, in beams located in the two ends of the roof (NW and SE faces), which hypothetically are representative of different steps of the roof construction, in addition to allow the analysis of the influence of climatic factors as, for example, the effect of rain directed to the concrete surface. However, the project team decided to choose a more conservative sampling, considering the minimum intervention in the building. The final sampling was made up of 3 regions: 2 sampling regions in the blind façades limited to extract 4 specimens with 50 mm diameter, and 1 sampling region in the roof with no limitation of number of specimens and diameter.

The regions of specimen extraction of the blind façades were defined based on the following criteria:

• blind façades with the biggest and smallest area of structural repairs (blind façades NE and NO);

• regions with smaller density of main rebar;

• areas that are less subjected to structural loads; for the location of the extraction region, the references contained in the Brazilian standard for the reinforced concrete structures design NBR 6118 (ABNT, 2014) were used;

• easy access to the extraction place and minimum necessary space to safely position the lifting equipment (platform) and to operate the specimen extraction machine;

• criteria for the extraction of specimens of NBR 7680-1 (ABNT, 2015).

This previous analysis resulted in the location of the holes in the roof beam (Figure 17) and the regions for the extraction in the Northwest NE blind façade (Figure 18) and in the NW blind façade (Figure 19).

Table 2 summarizes the tests selected to characterize the concrete of blind façades and of the roof beam.

Table 1: Summary of the experimental program for the study of concrete and rebar: activities, levels of investigation, objectives and variables, and characteristics of interest of the study.

Activity	Level of investigation as per chapter 2	Objective	Variable and characteristic of interest
Data survey and surroundings reconnaissance	Environmental characteristics	To identify potential risks to the structure favored by climatic variables	Temperature, relative humidity, total rainfall, wind intensity and direction
	Characteristics of the surroundings	To identify the best and less invasive ways to access the blind façades and roof for inspections, onsite tests and removal of specimens	Ground stability and moving of lifting platforms, places allowed for moving machines, obstructions, places for possible fixation of lifting equipment
Inspection of blind façades	Naked eye inspections or using binoculars, and measurements done based on measurements already done in the blind façades (laser scanning)	To detect alterations and characteristics in the surface: structural repairs done in the 2012-2015 intervention, “defects” of the surface, pathologic manifestation not yet recorded, own characteristics of the concrete surface	Area and perimeter of the structural repairs, superficial cavities, discontinuities of concreting, stains, elements inserted into the concrete, superficial patterns left by the rough wood mould
	Tests/measurements in the surface of blind façades	To check the level of protection of rebar allowed by the concrete parameters and physical conditions	Rebar lining thickness, superficial absorption of water, humidity stains
Sampling and tests of concrete specimens	Removal of specimens from the blind façades and the roof beam, and performance of laboratory tests	To determine the essential properties of the concrete (from blind façades and roof beam)	See details in Table 2
Tests with the rebar	Scarifications done on the structural repairs, and measurement of electrochemical and carbonation variables	To determine the rebar condition, the condition of the mean (concrete) and vulnerability to corrosion	See details in Table 3

[6] CONDEPHAAT: Official Letter UPPH 1818/2016 – Process 77607/2016.
CONPRESP: Official letter 0018/Conpresp/2017 – Process 2016.0.251.412-3.

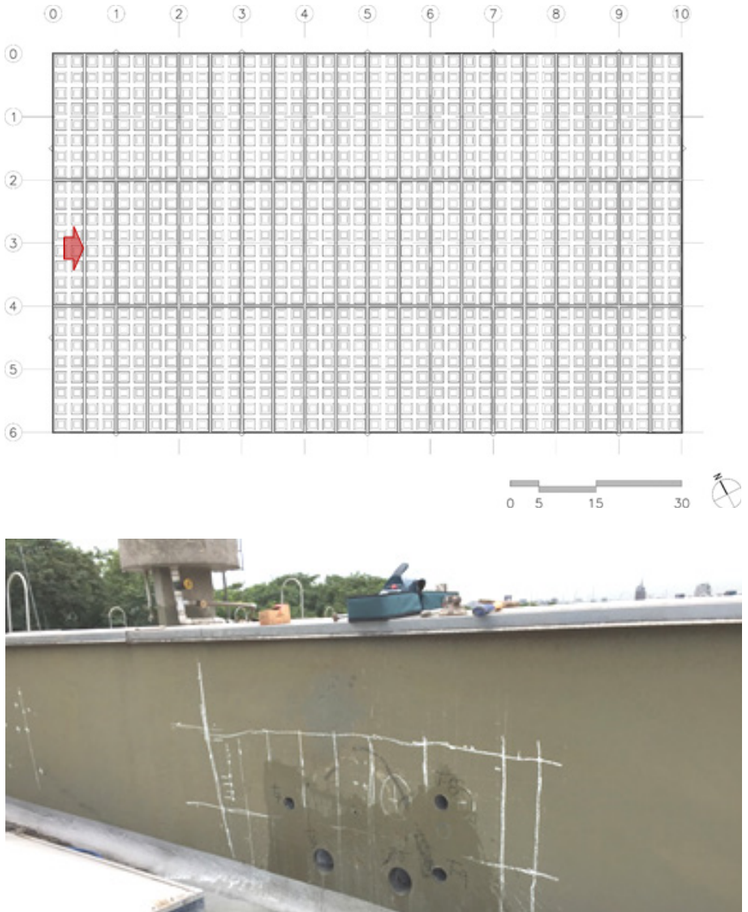


Figure 17: Location of the roof beam holes. Above, in the roof plan, the red arrow indicates the central structure and the face of the beam where the sampling regions was located. Below, the location of the holes made in the central region of the beam structure (Photo C.A. Oliveira, 2017).

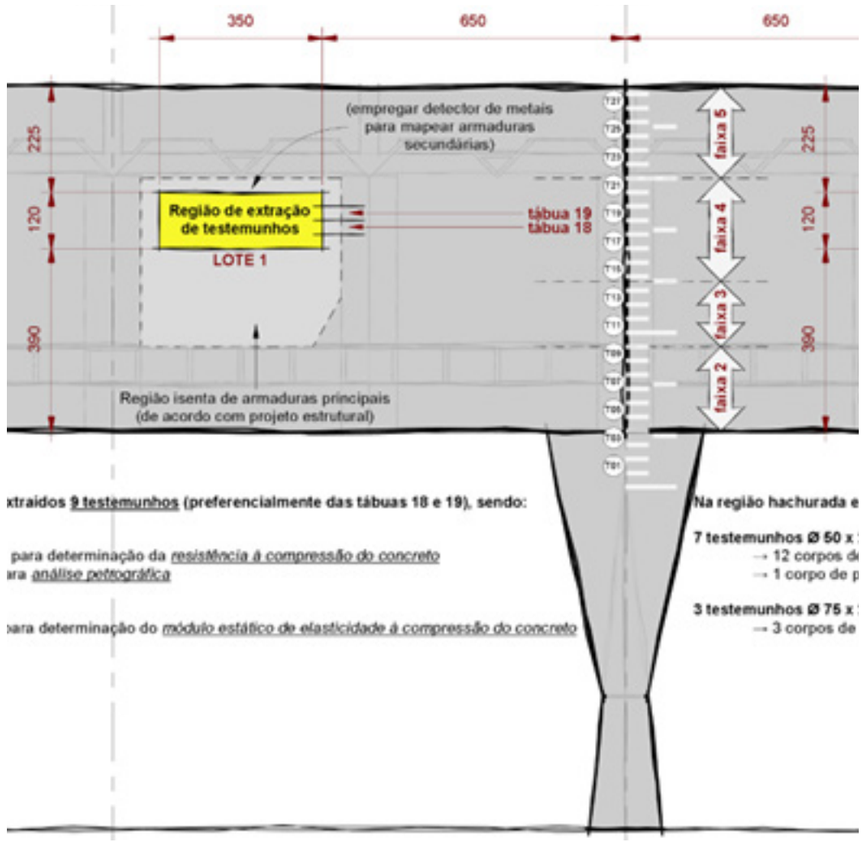


Figure 18: Region of specimens extraction in the northeast blind façade (NE). Schematic drawing with measures in cm.

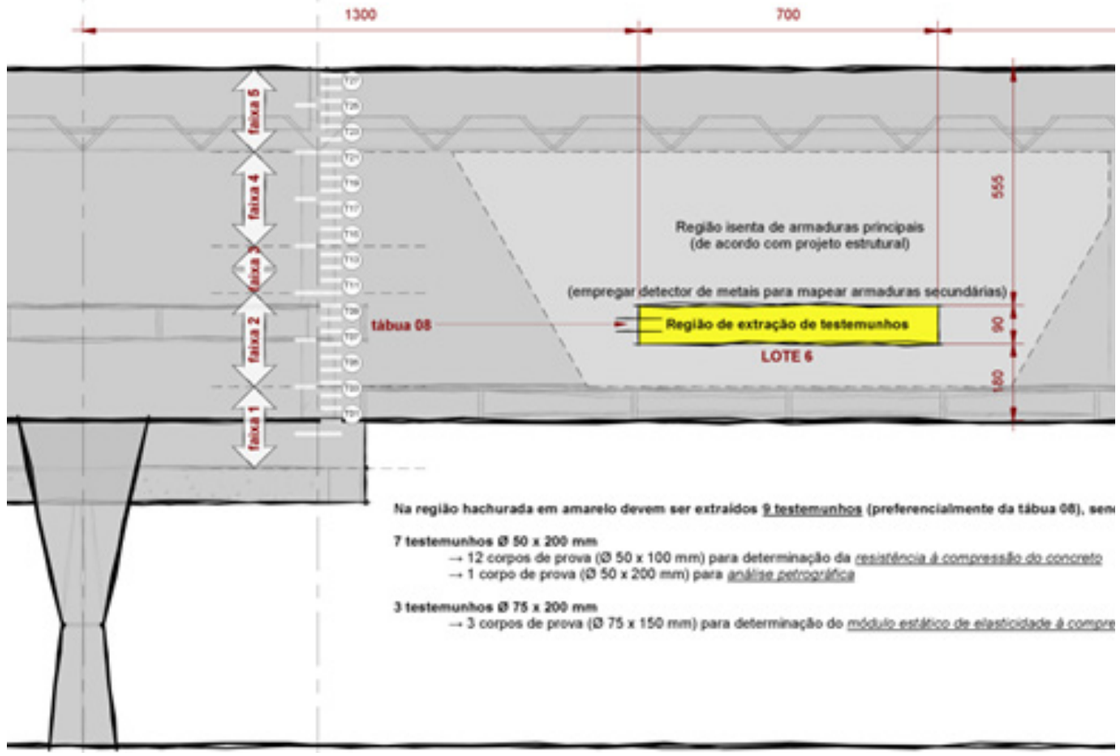


Figure 19: Region of specimens extraction in the northwest blind façade (NO). Schematic drawing with measures in cm.

Concrete tests, for each sampling batch, were limited by the number and diameter of specimens. For this reason, for instance, the elasticity modulus of blind façades concrete was not determined given the restriction of removing the total of 4 specimens with the maximum diameter of 50mm from the blind façades, as already explained.

The indicators of corrosion occurrence in the rebar, different from the concrete characterization, could be obtained by means of on-site tests using non-destructive or low impact techniques. Table 3 shows the sampling areas and the tests performed in the blind façades. As the roof beams are waterproofed, tests were only performed in the blind façades.

The methods and procedures adopted for the onsite inspections and tests, as well as for the materials characterization tests, are described along with the obtained results.

Table 2: Concrete characterization tests

Test	Specimen		Number of the sampling area	Place of extraction
	Characteristics	Quantity		
Compressive strength (f_c)	Cylindrical d(*)=50mm 1.5 < h/d(**) ratio < 2	2/area	1	NE façade
			2	NW façade
		12/area	3	Beam
Static modulus of elasticity in compression (E_{ci})	Cylindrical d=100mm h/d ration= 2	3/area	3	Beam
Specific mass, water absorption, and volume of gaps	Cylindrical d=100mm h/d ration= 2	2/area	3	Beam
Reconstitution of the concrete recipe	Mass of 1kg/area based on the residues of specimens submitted to the f_c and E_{ci} tests		1	NE façade
			2	NW façade
			3	Beam
Test	**Specimen**		**Number of the sampling area**	**Place of extraction**
	Characteristics	**Quantity**		
Petrography	Remaining part of the cylinders from which the specimens for the compressive resistance test were obtained	1 blade	1	NE façade
			2	NW façade
			3	Beam
Thermogravimetry (TG)		cube edge 10mm/area	Same areas of the petrography test	
Diffractometry of X ray (DRX)		cube edge 10mm/area	Same areas of the petrography test	
Scanning electron microscopy (SEM)		Fracture section Prism with maximum dimension of 20mm/area	Same areas of the petrography test	
		Polished section Prism with maximum dimension of 20mm/area		
Mercury intrusion porosimetry (MIP)		Cube edge 10mm/area (carbonated and not carbonated regions)	Same areas of the petrography test	

Notes: (*) d: nominal diameter of the cylindrical specimen extracted from the concrete structure.
(**) h/d: height/diameter ration of the cylindrical specimen.

Table 3: Investigation of structure rebar through electrochemical methods

Test	Characteristics	Number of the sampling area	Place of measurement
Concrete electrical resistance	Onsite measurements on the surface of blind façades, non-destructive technique	1	Blind façade NE
		2	Blind façade NW
		4	Blind façade SE
		5	Blind façade SW
Superficial humidity and deep humidity	Onsite measurements on the surface of blind façades, non-destructive technique	Same areas of the concrete electrical resistance test	Same places of measurement of the concrete electrical resistance
Corrosion potential and corrosion rate	Scarifications located on the repair mortar (two for each sampling area, sufficient for the connection with the rebar), destructive technique	Same areas of the concrete electrical resistance test	Same places of measurement of the concrete electrical resistance

[7] According to NBR 8522 (ABNT, 2008) the specimens to determine the modulus should have a diameter 4 times bigger than the maximum dimension of the aggregate.

Photo: date and author unknown. Source: Rosa Artigas.

3.1

CONSTRUCTIVE CHARACTERISTICS OF THE BLIND FAÇADES

Constructive characteristics of the blind façades

The constructive characteristics of blind façades were identified based on previous studies performed by members of the Conserva FAU team, and also based on the consultation of 294 structural design drawings, among which there are several drawings of the building foundations, elaborated by the Figueiredo Ferraz office.

Drawings dated between 1961 and 1968 were used as reference, since the building design started in 1961, and the structure was built between 1967 and 1968. Countless of such drawings have illegible parts, and the numeric sequence of drawings has several gaps. Given such gaps in the sequence of drawings, also with several drawings with no issue date, we concluded that the consulted drawings do not represent the full design; also it cannot be affirmed that the consulted drawings, although the annotations of drawing replacement were considered, are the final versions of the structure detailing. Although the existence of some inconsistencies, the detailed analysis of such drawings allows to identify, for instance, the position of main rebar in the structural elements, key information for the identification of concrete specimens extraction places in the beams-walls, and in the inverted roof beam. Despite the consultation done to several archives and databanks, no documents containing the calculation reports and detailed specifications of the materials and construction process of Artigas building structure were found.

In this item, the formal characteristics of blind façades are illustrated, and the hypothesis of successive stripes and sequence of blind façades concreting are presented.

Both longitudinal blind façades and the transversal ones have vertical stiffening elements oriented to inside the building, which span from the lower face of the blind façade to the lower face of the roof (level +13.85). Figure 20, in floor plan, indicates the position of some blind façade stiffeners, the position of the already mentioned dilatation joints in blind façades NE and SW, and the numbering of external pillars.

In the case of the longitudinal NE blind façade, the vertical stiffeners have an approximate length of 5.35 m, and their positions coincide with the inverted transversal beams of the roof, that is, they receive the concentrated loads coming from the building roof at each 5.50 m throughout their length. In addition to the loading of the roof in its lower portion, the blind façade also receives the loads transmitted by the slab ribbing of the classrooms floor – spaced at each 1.10 m – in its lower portion, as shown in Figure 21.

Like NE blind façade, the position of the SW longitudinal blind façade also coincides with the position of the inverted transversal beams of the roof, spaced at each 5.50 m. However, since in this case the blind façade height is bigger, the vertical stiffeners length is approximately 6.25 m, as shown in Figure 22. Like in the case of the NE blind façade, the figure shows that the SW blind façade, in addition to the loading on its upper portion (regarding the roof), also has loads on its lower portion, in this case transmitted at each 1.10 m by the slab ribbing of the studios floor.

In the case of the transversal NW and SE blind façades, the vertical stiffeners symmetrically positioned in relation to the axe of pillar P36 (in the case of blind façade NW) or of pillar P36 (in the case of the blind façade SE) have an approximate length of 6.25 m, and their positions coincide with those of the longitudinal beams of the studios floor. Therefore, in addition to receiving concentrated loads of that floor, one of the stiffeners also receive loads from the inverted longitudinal beam of the roof, as shown in Figure 23

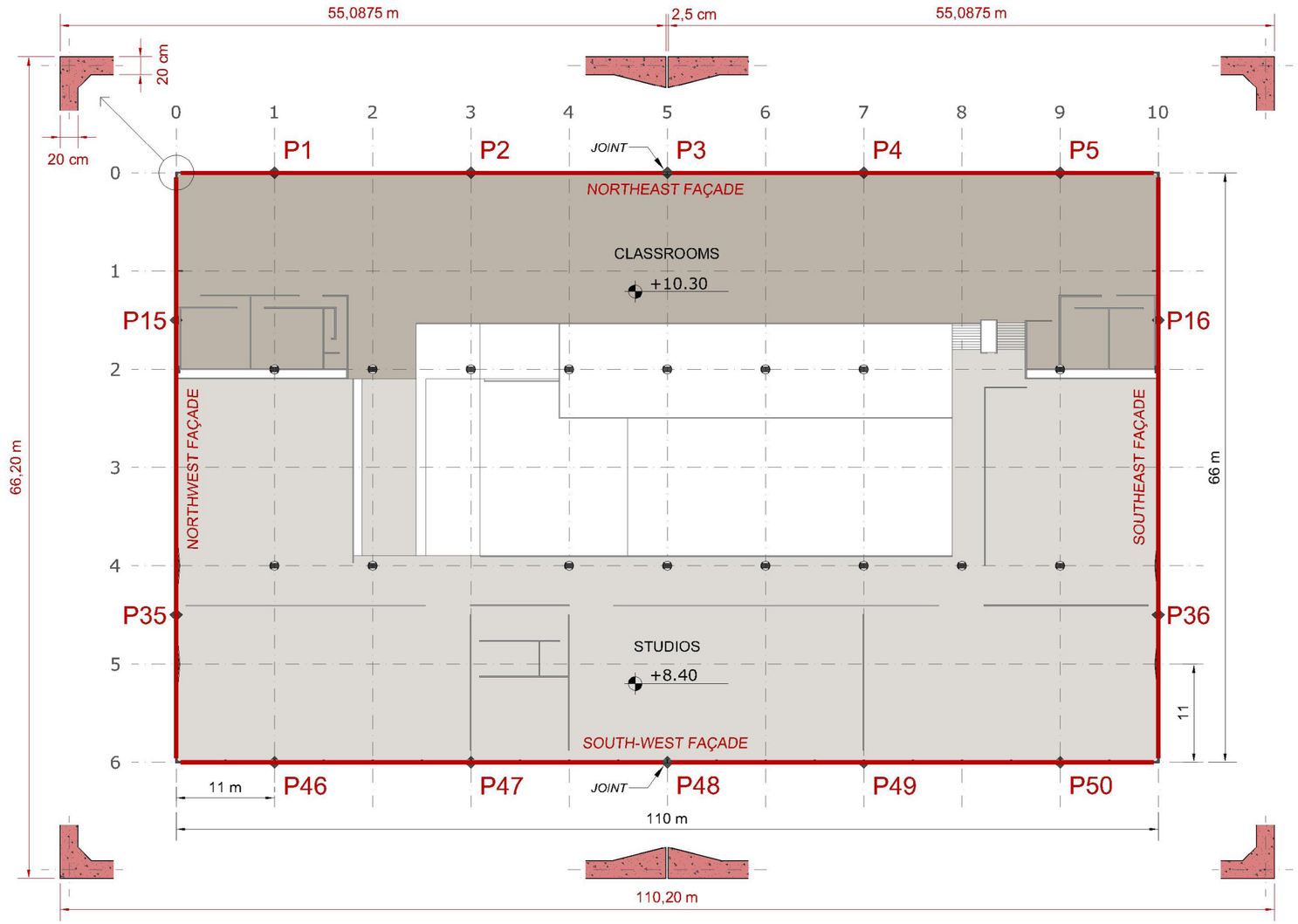


Figure 20: Floor plan of levels +8.40 (studios) and +10.30 (classrooms) over which there are indications of thickness, length, dilatation joint, and positions of blind façades supports of the Vilanova Artigas building.

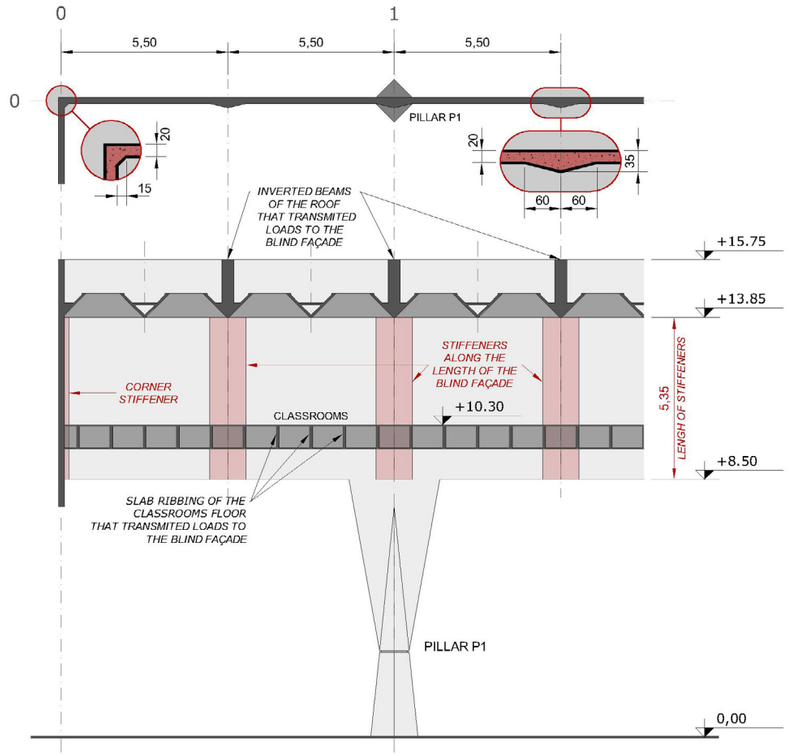


Figure 21: Floor plan and internal view of the longitudinal NE blind façade of Vilanova Artigas building: highlight to the vertical stiffeners 5.35 m long, spaced at each 5.50 m throughout the blind façade extension.

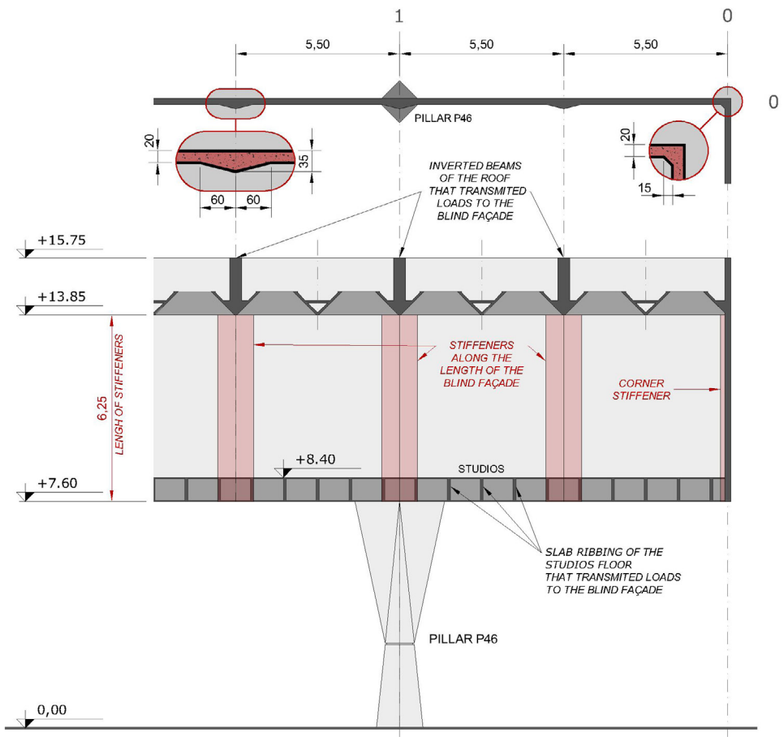


Figure 22: Floor plan and internal view of the longitudinal SW blind façade of Vilanova Artigas building: highlight to the vertical stiffeners 6.25 m long, spaced at each 5.50 m throughout the blind façade extension

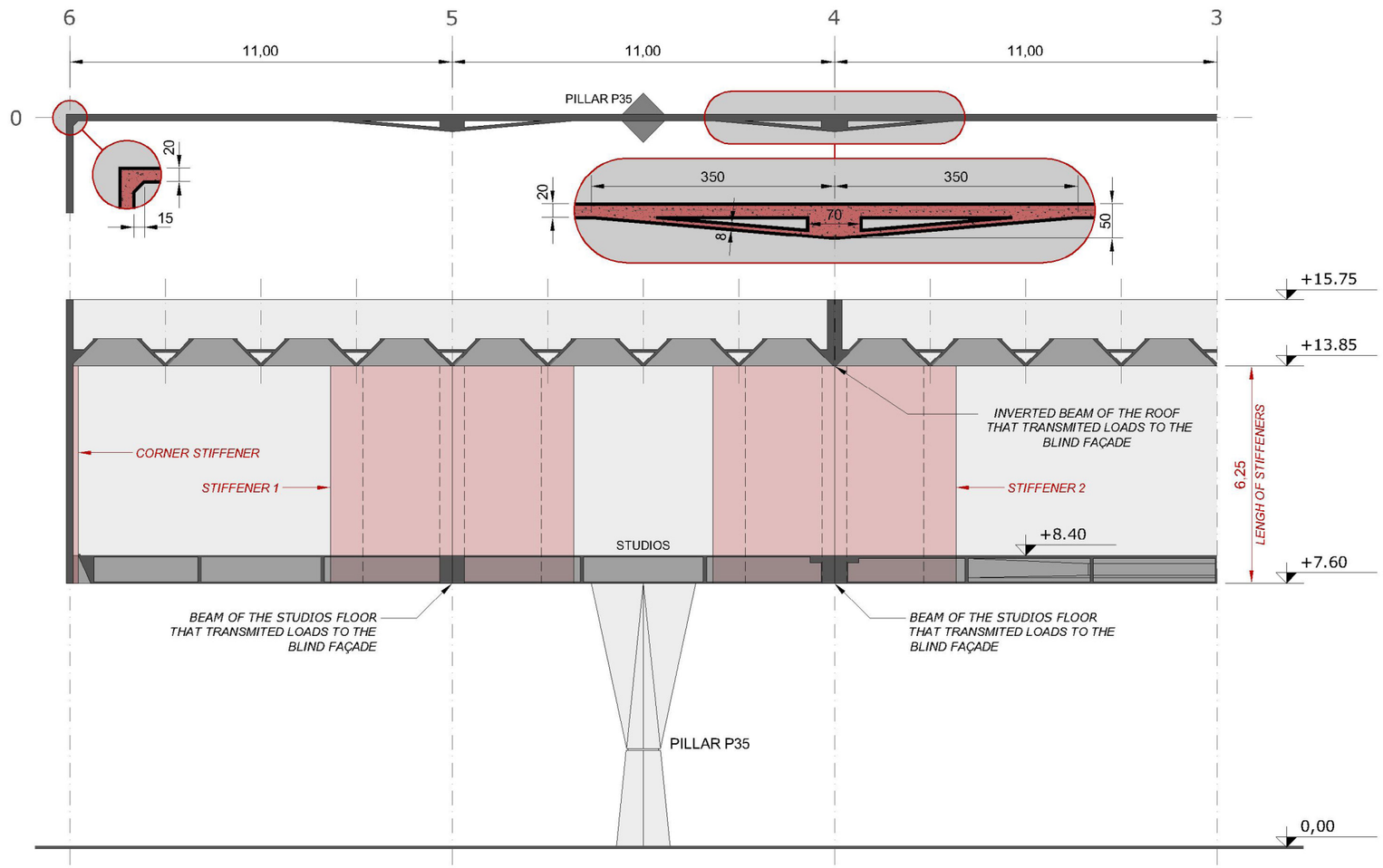


Figure 23: Floor plan and internal view of the transversal NW blind façade of Vilanova Artigas building next to the studios area: highlight to the vertical stiffeners spaced at each 11 m.

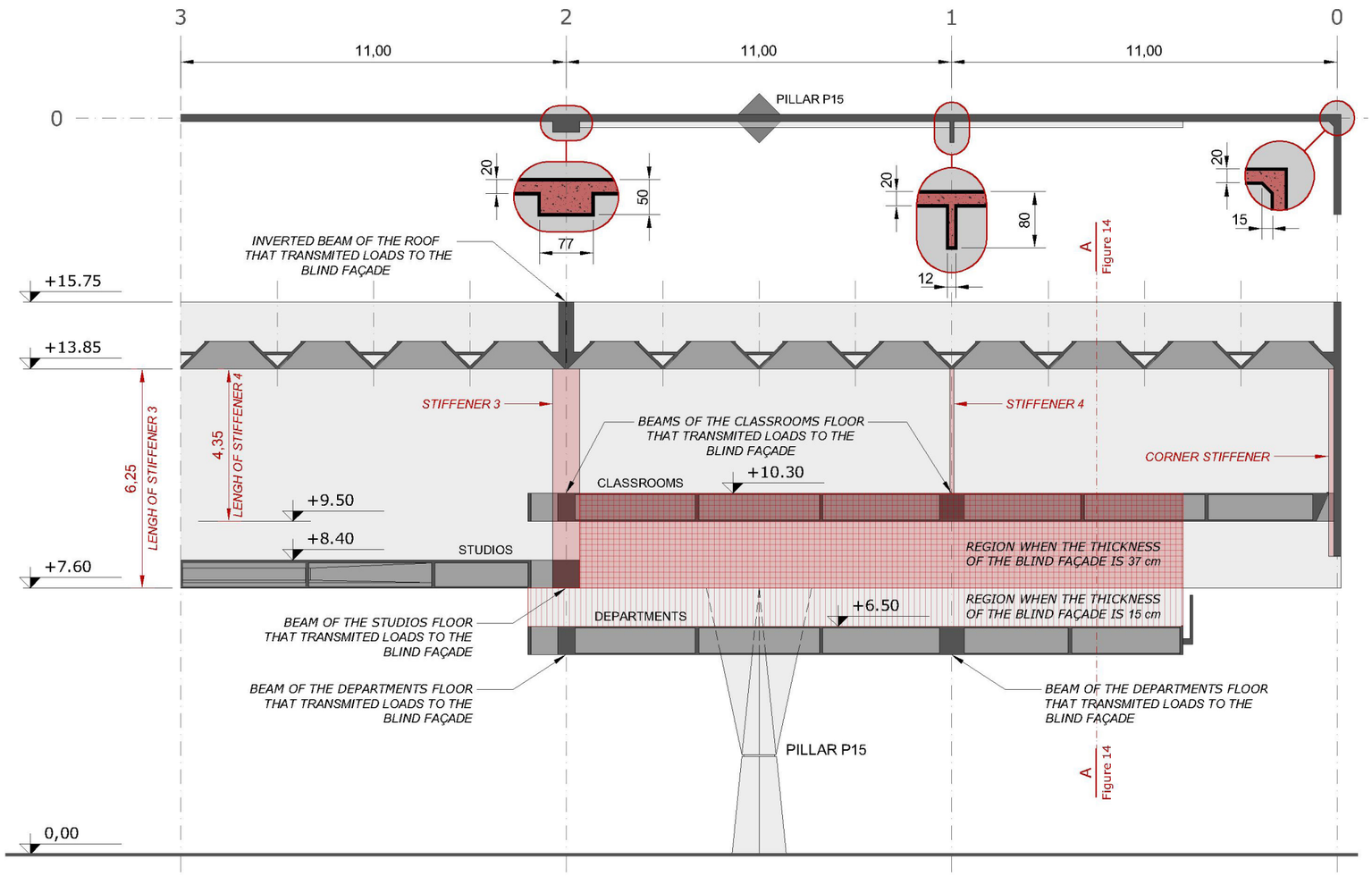


Figure 24: Floor plan and internal view of the transversal NW blind façade of Vilanova Artigas building next to the departments region: highlight to the vertical stiffeners spaced at each 11 m, and to the regions where there is blind façade nominal thickness variation.

Next to the classrooms region, the transversal blind façades have vertical stiffeners symmetrically positioned in relation to the axe of pillar P15 (in the case of NW blind façade) or of pillar P16 (in the case of SE blind façade) with approximate length of 6.25 m and 4.35 m, as shown in Figure 24. In this region, the blind façade is submitted to loads in its upper, middle and lower portions, respectively regarding: roof; classrooms and studios floor; and departments floor. Cross-section A indicated in Figure 24 and presented in Figure 25 shows the thickness variation of the blind façade in this region.

Blind façades concreting sequence

The study of the joints printed on the external and internal surfaces of blind façades allowed to identify the possible stripes and sequence of concreting. Figure 26, Figure 27, and Figure 28 show the concreting stripes and sequence considered in this study; the identification is individually done for the longitudinal NE and SW blind façades, and jointly done for the transversal SE and NW blind façades.

Based on this identification, and considering that sampling batches formed might have volumes between 8 and 50 m^3, based on the provisions of the Brazilian standard governing the extraction and compression test of concrete specimens, NBR 7680-1 (ABNT, 2015), it is possible to map the probable batches adopted in the blind façades concreting for future investigations of the concrete properties.

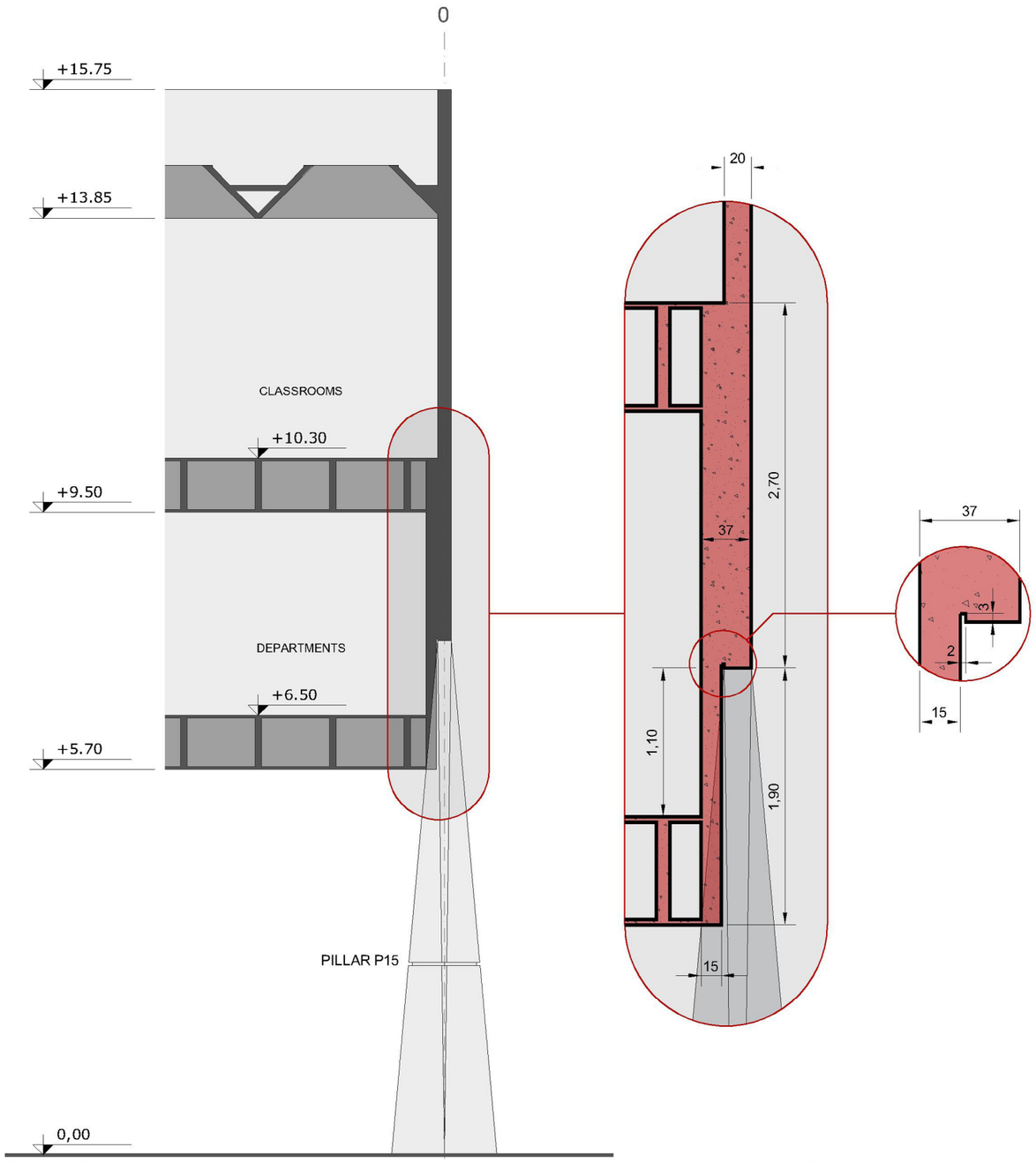


Figure 25: Cross-section of NW blind façade of Vilanova Artigas building next to the departments region, as indicated in Figure 13: highlight to regions where there is blind façade nominal thickness variation

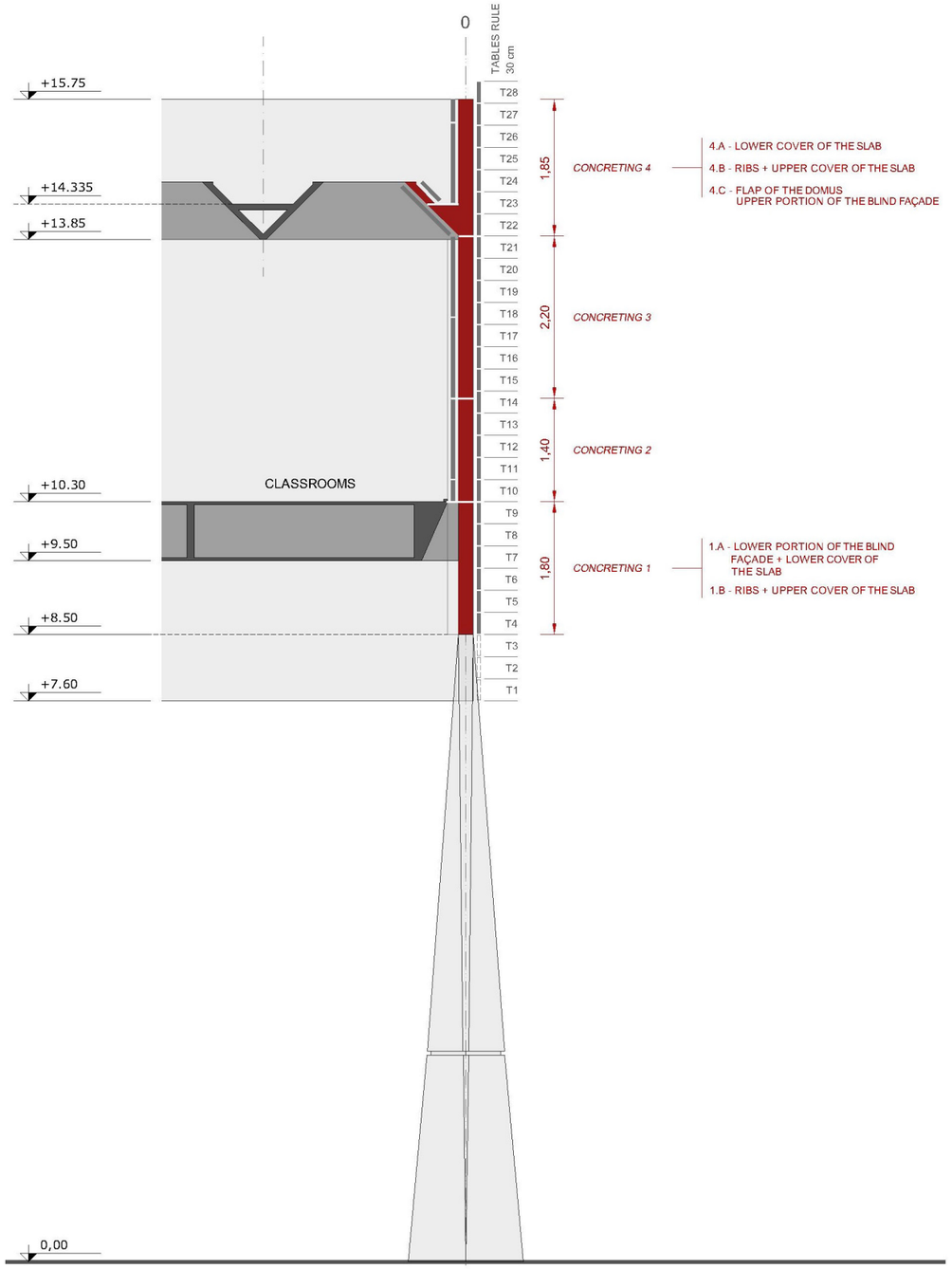


Figure 26: Concreting sequence of longitudinal NE blind façade.

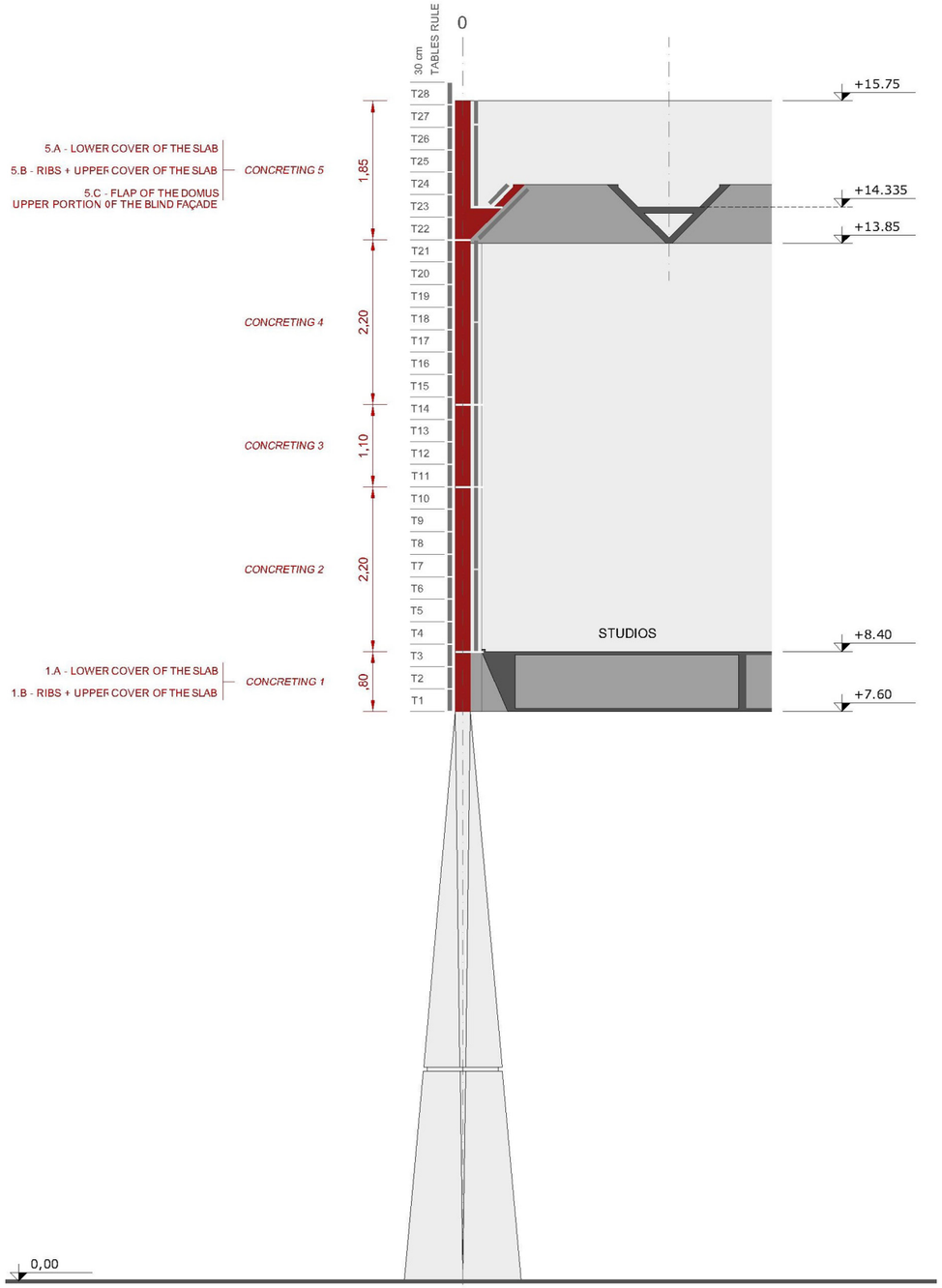


Figure 27: Concreting sequence of longitudinal SW blind façade.

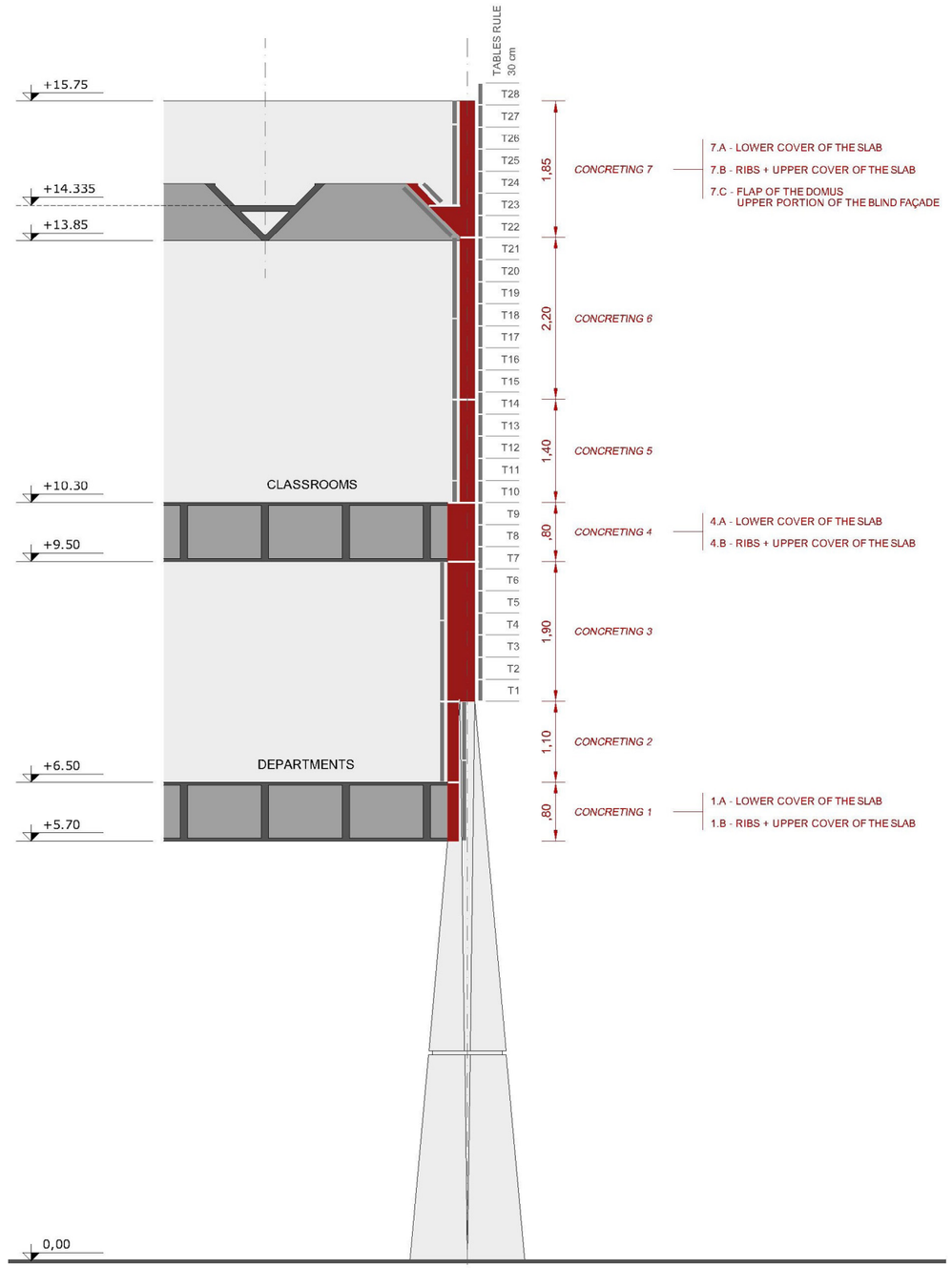


Figure 28: Concreting sequence of transversal SE and NW blind façades.

Photo: Rodrigo Vergili, 2014.

3.2

HISTORY OF INTERVENTIONS IN THE BLIND FAÇADES

History of interventions in the blind façades

Historically, the blind façades underwent two interventions located in pillars P3 and P48, respectively, in the years of 1981 and 1999/2000, in addition to the last repairs campaign in the whole extension of the blind façades external faces between 2012 and 2015. Besides those interventions, visual inspection campaigns, with commented photographic registrations, were performed in 2004 and 2010. Except for the abovementioned interventions and inspections, there are no records of preventive maintenance activities for the conservation of blind façades.

Intervention in Pillar 3 in 1981

In 1981, the structural recuperation of Pillar 3 head, supporting NW blind façade, was performed, with the replacement of the support device. Lateral and frontal splitting of the support device resulted in crushing the pillar head concrete. There are no photographic registrations of the work, but Figure 29 shows the area of intervention in the head of Pillar 3, just below the yellow line indicating the place of the support device installation.

The solution adopted was to remove the damaged concrete, and to introduce steel bars and plate as complement to the pillar rebar, with subsequent concreting and installation of a new support device made of synthetic elastomer (commercial brand Neoprene). The support device was glued with epoxy-based adhesive to the beam-wall. The reconstitution of the concrete was done by using a wooden mould with a pipe type opening; there is no registration of the concrete recipe used, but the characteristic resistance to the specified compression was 15MPa. In the specification of services, the aesthetical aspects of the original concrete were not considered. However, it is mentioned that the exposed concrete surface treatment should be done with cement and sand mortar, trying to reproduce the color and texture of the surrounding concrete.

Due to the corrosion of the plate installed as reinforcement of the pillar rebar, which consequences are shown in Figure 30, part of the repaired areas was derived of its characteristics, and it had to be again lined with structural repair mortar in the intervention of 2012-2015.

For being a plate with the same width of the pillar section, and given its structural reinforcement function, the place demands regular inspection and preventive actions whenever a sign of steel corrosion is detected.

Figure 29: Pillar 3 at NE blind façade. Place of intervention in the mean-wall support marked with yellow line. The red line indicates the dilatation joint. This image is recent and was only used to indicate the intervention place (Source: C. A. Oliveira, 2017).

Figure 30: Pillar 3 at NE blind façade. Steel plate with superficial corrosion and detachment of the lining concrete layer during the last repair campaign of 2012-2015 (Source: C. A. Oliveira, 2014).

Figure 31: Pillar 48 at SW blind façade Place of intervention in the mean-wall support marked with yellow line. The red line indicates the dilatation joint. This image is recent and was only used to indicate the intervention place (Source: C. A. Oliveira, 2017).

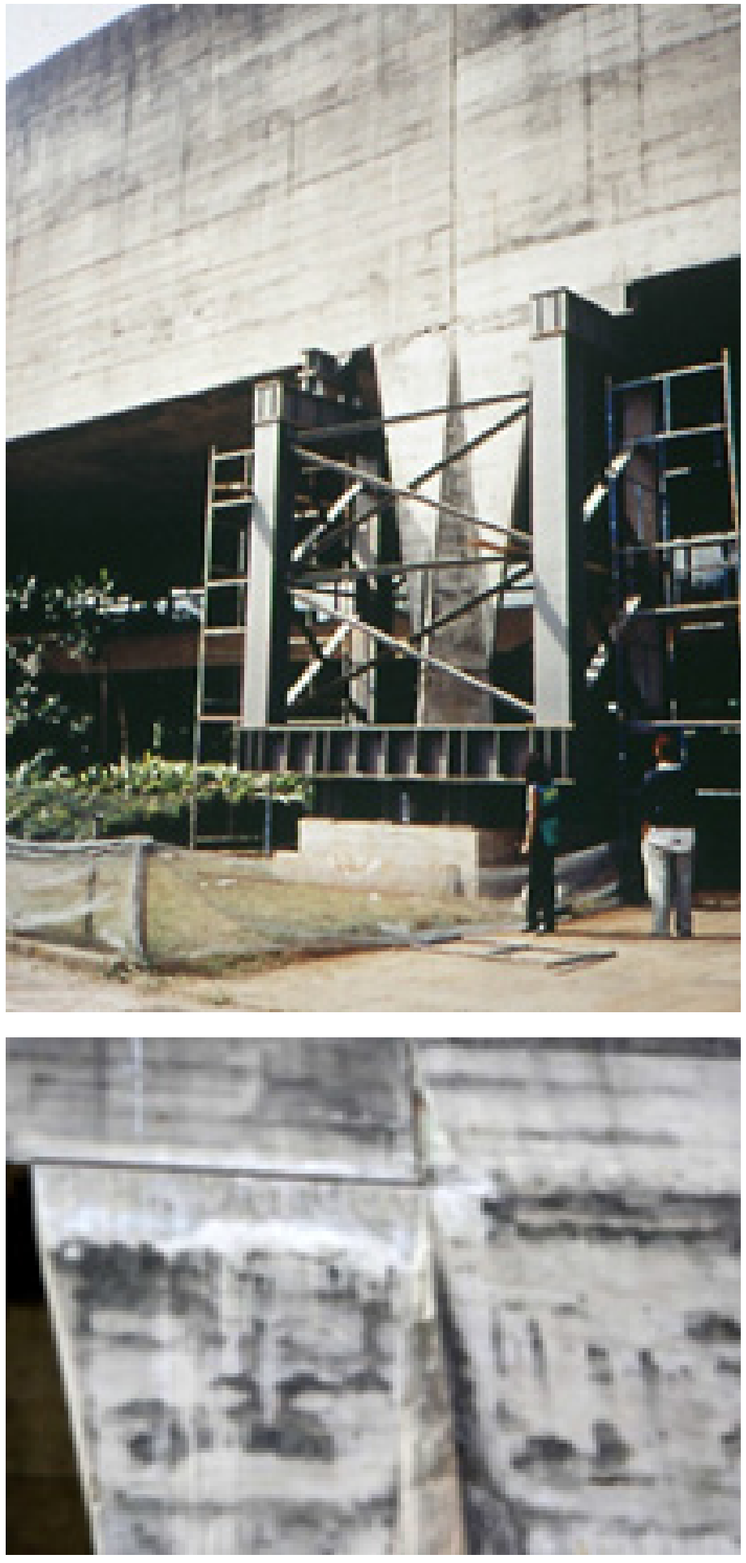


Figure 32: Left and center: registration of the SW façade intervention for the replacement of the support device located in pillar 48, and sign of concreting done in the head of the pillar, in 2000 (Source: João Roberto Leme Simões, 2000). Right: current appearance of pillar 48 (Source: C. A. Oliveira, 2017).

Intervention in the Pillar P48 in 1999/2000

In 2000, the same type of intervention - reinforced concrete recuperation and support device replacement – was performed in symmetric pillar of the Southwest façade, Pillar 48 (Process no. 2000.1.263.51.8 opened on May 15, 2000). Figure 31 shows the area of intervention in the head of Pillar 48, just below the yellow line that indicates the place of installation of the support device.

Although the technical specifications of the services and materials were the same as used for the recuperation of Pillar 3, a careful inspection (Process no. 99.1.232.51.3 opened on May 19, 1999) performed by engineer Aluísio Fontana Margarido, then professor of FAUUSP, occurred before the work. This inspection resulted in the following conclusions:

• the examination of the movable beam joint revealed that the region showed concrete breakdown due to the corrosion of the pillar peripheral rebar, a condition worsened by the easy accumulation of rainwater because of the part geometry;

• the consequent exposure of the rebar made the support more vulnerable to collapse because of the reduction of the beam support area;

• in view of the deformations observed in the support device (neoprene plate), it was concluded that the device probably was not an Elastomeric Laminated Bearing one did not have steel plates inside

• in addition to the corrosion of the pillar head rebar, the technical inspection also registered an accelerated process of corrosion of the pillar bars, as well as of the rebar of other regions of the external face of the building blind façades.

It is noteworthy that the administrative process that initiated the inspection prior to the recuperation of pillar 48 was the first document containing recommendations for the performance of structural repairs in the blind façades, followed of the application of surface protection that would not change the characteristics of the protected building, such as, for instance, opaque silicone. In this document, professor Aluísio Fontan Margarido also recommends the following maximum deadlines to start interventions: six months for the recuperation of the pillar, and 12 months for general repairs in the blind façades.

Figure 32 shows the ancillary metallic structure used during the work to lift the beam and to allow the execution of services in 2000, in addition of the visible layer of concrete for the recuperation of the pillar head and of the beam bottom. To the right, the current appearance of pillar 48 that shows signs of recuperation done in 2000, in the upper left corner.

Inspection of 2004

In 2004, when the structure of Artigas building celebrated 36 years (the structure was finished in early 1968), Simões (2004) performed a major inspection of the building blind façades as part of an academic research. Figure 33 show signs of some pathologic manifestations detected.

Typical stains of efflorescence are the consequence of the concrete exposure to rainwater percolation, resulting in leaching (dissolution and transport) of alkaline compounds (especially hydrated lime/calcium hydroxides and magnesium) to the concrete surface where they react with atmospheric carbon gas. This results in the formation of carbonates that provide a whitish color to the concrete surface. The compounds leaching also results in the increase of concrete porosity, and consequently the entry of gases and liquids is facilitated.

Simões (2004) warns that the efflorescence stains are visible signs since the completion of the building, which can be observed in the images of the building still under construction. Stains appear in the fissures, in the interfaces of the wood board prints, and in the concreting joints, especially in the joint of the last concreting stripe in the intersection with the roof slab. This can be the result of lack of protection of the concrete surface, both the roof slab concrete and the blind façades concrete. Despite the specification of the roof waterproofing system and of the application of water repellent on the external surface of the blind façades, there is no record of the time elapsed between the roof and blind façades concreting and the application of such protections.

Another noteworthy detail is the lack of protection on the top of blind façades. Originally, the top of blind façades, as well as top of all roof beams, was not protected with roof flashing or another constructive solution, which made the last stripe of blind façades concreting more vulnerable to the entrance of rainwater.

The images of Figure 34 show the top of roof beams before the installation of metallic roof flashing (aluminum roof flashing installed between 2009 and 2010). The concrete porosity and the lack of protection of the horizontal surface potentiate the penetration of rainwater, and consequently the corrosion of rebar in the upper surface of beams.

The surface darkening predominantly results from the build-up of particulate matter (PM) that, according to CETESB (2017), can be constituted of dust, smoke and every type of solid and liquid matter suspended in the atmosphere. The impregnation of particulate matter is favored by the high superficial porosity of the concrete which, at the time of the inspection, did not show signs of being lined with water repellent. Along with the humidity stains, also reported by Simões (2004), but not visible in the image of Figure 33, the concentration of particulate matter can worsen the phenomenon of rebar corrosion.

QWhen the façade surface is not protected against water entrance, the appearance of humidity stains is influenced by the directed rainfall index, factor conditioned by the rainfall intensity and by the dominant wind intensity and direction. The directed rainfall index (DRI) is thus a factor of interest for the analysis of vulnerability of the building blind façades. In addition to humidification, the surface can be washed, carrying the particulate matter (PM). This conveyance can result in localized staining of other surface areas. Furthermore, it is noteworthy that if rainwater is retained in the PM, the time of wet surface is increased. This effect is very discussed in the segment of metallic construction, because the water retention, sometimes contaminated with atmospheric pollutants, results in the intense and localized corrosion of rebar.

It is noteworthy that the blind façades darkening, especially of the last concreting stripe, is observed throughout the history of the building. Figure 35 shows this fact.

In addition to the reasons already pointed out that might explain the darkening of surfaces, Simões (2004) also suggests that it can be the consequence of the presence of biofilms (colony of fungi, algae, lichens), which are present in humid and hot environments such as the region of São Paulo. The hydrophilic nature of the exposed concrete surface, in addition to its excessive superficial porosity, worsens the situation, according to the analysis done by Simões (2004).

In the inspection performed in 2004, the more serious pathologic manifestation, and which was already pointed out as a criticism in the inspection performed in 1999, is the generalized breakdown of the blind façades concrete, as the result of rebar corrosion (Figure 36).

Although at the time, the rebar corrosion was not associated to the concrete carbonation, because there was no registration of the carbonation depth, one of the conditions verified by Simões (2004) for the corrosion worsening was the small lining of the structural elements rebar, of approximately 0.5 to 1.0 cm thick.

Figure 33: SE blind façade with signs of main pathologic manifestations detected by Simões: efflorescence; surface darkening, especially of the last concreting stripe in the top of blind façades (Source: J. R. L. Simões, 2004).

Figure 34: Top of the last concreting stripe of blind façades with signs of deterioration (porous surface and with exposed rebar). The photo was taken before the installation of metallic roof flashing (Source: C. A. Oliveira, 2007).

Figure 35: NW blind façade, in the forefront, and part of SW blind façade with signs of darkening of the last concreting stripe (top of blind façades) after 7 years from the inauguration of the building (Source: Hugo Segawa, 1976).

Figure 36: Concrete breakdown as the result of rebar corrosion (Source: J. R. L. Simões, 2004).

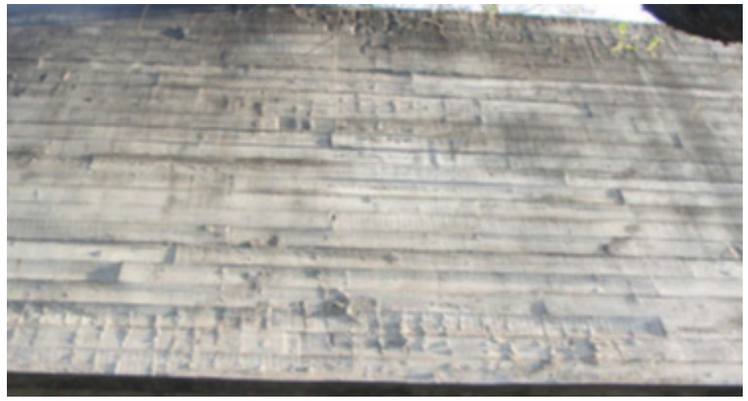


Figure 37: To the left: blind façade regions with signs of concrete detachment due to the rebar corrosion. To the right: piece of concrete detached from the top of the blind façade with deposit of steel corrosion products (Source: HELENE; BRITEZ; ANTUNES, 2010).

Inspection of 2010

In 2010, with the visible worsening of the blind façades condition, the top management of FAUUSP contracted technical services to issue an expert report about their conservation state.

Even without the performance of laboratory tests or onsite tests, the team of engineers, specialists in concrete structures recuperation, came to the same results obtained by Simões in 2004, and ratified Margarido´s recommendations in 1999, as for the state of necessary interventions.

The main pathologic manifestations identified by the experts were:

• generalized detachment of concrete causing, in several points, the rebar exposure (see Figure 37);

• presence of calcium carbonate efflorescence;

• high concentration of acid soot deposited on the concrete surface;

• rebar corrosion.

In short, the porous and unprotected surface of the concrete favors the leaching of soluble compounds which, combined with the external action of carbon gas and acid rain, make the rebar chemically active and promote the corrosion of rebar steel.

As direct consequences of the pathologic manifestations, the experts pointed out the inevitable detachment of concrete and the risk of injuries for people walking outside, in the surrounding of the building. In addition, the progress of the corrosion process can jeopardize the structural performance of the reinforced concrete.

Given the vast experience of those professionals, and as the result of the 2010 inspection, guidelines and specifications for the materials and techniques of rebar and concrete recuperation were elaborated (HELENE; BRITEZ; ANTUNES, 2010), with the express recommendation for the urgent execution of structural repairs. Those results initiated the planning of 2012-2015 interventions.

Intervention from 2012 to 2015

The last intervention started in November 2012 and lasted until April 2015, and was carried out by Jatobeton Engenharia Ltda., a company with experience in structural recuperation works, however with no tradition in conservation of protected heritage.

The specifications of materials and services were based on the prior experience of the specialists of PhD Consultoria, contracted in 2010 to inspect the blind walls, who decided to use solutions largely employed by engineering in repairing reinforced concrete. It is noteworthy that no previous investigations were done to characterize the concrete and evaluate the blind wall rebar corrosion before the work. PhD Engenharia was contracted to technically advise FAUUSP during the works. PhD Engenharia contract started in July 2013 and lasted until January 2015.

Although the recuperation of reinforced concrete had the peculiarity of belonging to a historical importance building, the invitation to bid did not require that involved companies and their professionals proved prior experience in restoration of historical materials, only requiring experience in repairing reinforced concrete.

It is noteworthy that the work was done in a critical moment, since many segments of the reinforced concrete were detaching from the external surface of the blind walls, exposing the building users to the risk of injuries, and exposing part of the building structure to new cycles of deterioration. The result of interventions satisfactorily fulfilled the aim of restoring the acceptable levels of safety requirements to the structural use and safety, however not meeting aesthetic requirements of a protected heritage.

Based on the documental analysis of the technical documents of the design and of the work, the main steps of the blind walls structural repair are presented and commented, comparing the specifications (materials and techniques) to the what was actually executed (see Table 4). Based on the analysis of such technical records, the impacts of the materials and services specifications and of the procedures adopted in the work are pointed out. Additionally, some rebar characteristics are presented by means of observations done during the work.

Figure 38 briefly illustrates the several steps of the concrete recuperation.

Table 5 shows the recipes of repair mortars with additives to adjust color.

(a) Step 1

(b) Steps 2, 3, 4 and 5

(c) Step 5

(d) Step 6

Figure 38: Part of the SW blind wall during the concrete recuperation. The steps of Table 4 are briefly illustrated in the presented images: (a) before and after pressurized water jet cleaning; (b) scarification and removal of the loose concrete and cleaning and/or replacement of corroded rebar; (c) application of structural repair mortar added with pigments and other additives; (d) situation after the application of cement paste added with pigments to mitigate the effect of chromatic differences between the repairs and the original concrete.

Table 4: Summary of the bidding process specifications (materials and techniques) versus activities performed during the work (materials used and techniques adopted) of the Artigas building blind walls recuperation, between 2012 and 2015.

Step	Specified	Performed
(1) First cleaning of the exposed concrete surface	Washing with potable water jet (pressure between 1000 and 1500 psi or 7 to 10.5 MPa) to remove particulate matter and contaminants deposited on the surface. Loose concrete parts would be removed with the washing.	As specified, however with no records of the pressure used.
(2) Cleaning with chemicals	Removal of corrosion stains with oxalic acid solution (10%). Removal of efflorescence stains with 5 to 10% solution of muriatic acid or 10% solution of phosphoric acid.	Manual cleaning done with steel bristle brush before the application of repair mortar.
(3) Second cleaning of the exposed concrete surface	Idem to the first washing.	The fulfillment of this step was not detected in the records of the work.
(4) Removal of loose concrete and preparation of the hollow	Percussion tests and visual identification to determine areas to be recuperated. Delimitation of areas with the cutting disk with minimum cutting depth of 5 mm; scarification of the disaggregated concrete with low impact driver (5 kg).	Activities fulfilled according to the specification, however with cuts done without controlling the orthogonality of the corners, and with no respect to the modulation of boards. Delimitation of areas to be recuperated with cutting depth close to the thickness of the rebar coating.
(5) Rebar repair	Cleaning of rebar to remove corrosion products and replacement of bars when a loss of more than 10% of the cross section is measured.	Apparently, activities fulfilled according to the specification.
(6) Acquisition of repair mortar	Cement-based mortar modified with polymers and reinforced with fibers, commercially available in the marketplace with the brand EMACO S88 of BASF or equivalent product.	Cement-based mortar of the commercial brand Viaplus ST, bicomponent product composed of Portland cement, fine selected aggregates, special additives, acrylic polymers, and fibers.
(7) tests to adjust color and texture	There is no specification of the methodology for color and texture adjustment; there is only an indication that the repair mortar should be added with white lead, white cement or white grout. Additionally, there is indication that the samples of recipes should have been submitted to Inspection within 45 days from the start of the work, and the Inspection would have up to 4 months to indicate the recipe to be used.	Tests started soon after the beginning of the recuperation works, which resulted in the interruption of the work, and eventual demolition of repairs already done because of the noncompliance of the repairs with the test samples. There was no method for dosing the mortar nor to evaluate the produced samples. Apparently, a single recipe was used for all the blind walls, with no consideration to the chromatic differences of the concrete. See Table 5.
(8) Application of repair mortar	The manual application of layer with maximum thickness of 20 mm on the saturated substrate with dry surface. Interval between application of successive layers between 6 and 24h, until the maximum thickness of 100 mm. There is no specification for the application of anticorrosion paint on the rebar. The indicated mortar manufacturer, BASF - EMACO S88, recommends the application of zinc-rich primer on the rebar.	The application of mortar seems to have been done according to the specifications; no anticorrosion paint was applied on the rebar. The selected mortar manufacturer (Viaplus ST) recommends the application of anticorrosion paint ((Viaplus Ferroprotec) on the rebar.
(9) Humid cure	Humid cure by sprinkling water for 4 days.	Apparently, activity fulfilled according to the specification.
(10) Surface treatment	Step not specified.	Surface treatment with cement laitance added with pigment and acrylic adhesive, with the aim of mitigating the chromatic variation between repairs and the original concrete. See Table 5.
(11) Surface protection with water repellent	Silane/siloxane concrete sealer diluted in solvent. Application conditions: relative air humidity below 80% and superficial substrate humidity below 5%.	Application supposedly done according to the technical specification, however with conflicts in the order of execution of activities, that is, with the application of water repellent before the surface treatment – to mitigate the chromatic variation – which should precede it.
(12) Surface protection with varnish	Application of pure (with no styrene) acrylic varnish after applying the water repellent.	Upon recommendation of FAUUSP representatives, the application of varnish was eliminated.

Table 5: Recipes of mortar for the recuperation of the blind walls

Dates	Components			
	Viaplus ST		Bayferrox Lanxess pigment (yellow)	White Portland cement
	Liquid	Powder		
April/2013 (Jatobeton Report)	814g (powder + liquid)		4g	9g
April/2013 (PhD Engenharia Report)	100g	814g	4g	9g
July/2013 (1)	100g	680g	4g	15g

(1) Recipe adjusted to comply with the repair mortar ratio between the liquid component (A) and the power component (B), A/B = 1/ 7, according to the manufacturer.

Table 6: Recipes for the treatment of blind wall surface

Dates	Components				
	Cimpor Portland Cement CPII-F-32	Grout		Acrylic adhesive	
		White (Weber--Quartzolit)	Caramel (Weber--Quartzolit)	Murafan 39	KZ Viapol
March 2014	1000g	(MC Bauchemie)	---	810g	---
September / October 2014	500g	1000g	76g	---	800g

Figure 39: Comparison between images evidences the difference between the concrete characteristics (left) and the repair mortar (right), regarding texture and chromaticity (Source: Conserva FAU Team collection, 2016).

Among the impacts of the materials and services specifications and of the adopted procedures on the work, the following can be highlighted:

• **Planning to perform dosing tests to adjust the concrete mortar color:** tests were performed with no planning and simultaneously to the initial steps of the repair work, not respecting the technical specifications. This fact worsened the work delay problems, interrupting the services, and demolition of repairs already done for not meeting the reference of the aesthetic requirement.

• **Method for the tests with pigmented mortars and selection of recipes:** the pigmented mortars were produced without a consistent methodological approach. Test mortars were applied on different substrates (wooden plates, pillar surfaces), curing times were not standardized, the opinion on the adequacy or not of the color appearance was given by people consulted merely based on the visual comparison between samples over the blind wall, with no analysis parameters that could reduce the impact of the individual judgment subjectivity;

• **Repair texture:** records indicate that the mortar samples were printed with wooden boards, however, there are no records in the work reports, nor evidences on the blind walls, that confirm whether the boards were actually used. Among the reasons for the non-performance of such step, there is the inexistence of non-destructive means to allow fixing wooden boards on the blind walls, and the absence of procedures determining the needed contact time to allow the material to acquire the desired texture, simultaneously not harming the curing process. Opposed to the recommendation of printing the wood texture on the repairs, there are descriptions of using other materials on the mortar surface to provide them artificially with a texture that would be compatible with the original one, also accomplished without reaching the desired result. In addition, in the repairs there are artificial textures that try to mimic the line of division between the blind walls concreting boards, done by drawings made with sharp objects that clearly contrast with the original texture, showing to be very inadequate for the context of the rest of the construction (see Figure 39 and Figure 40);

• **Repairs geometry:** technical specifications do not define the procedures of repair on adjacent board surfaces; this missing specification allowed for the conflicting execution of artificial lines between boards. As for the shape of repair execution, it was observed that countless recuperated parts did not follow the specifications about repair geometry. According to the specifications, all the cuts in the concrete surface should have orthogonal

sides and respect the lines of division between boards, however many of the executed repairs did not follow this rule. Part of such repairs, with geometries different from those specified, were redone; other remained visible (see Figure 39 and Figure 40);

• **Treatment of repairs surfaces: t**he perceptible difference between the blind walls repairs color is a sign that there were probably random variations in the recipes used or in the application manners, probably resulting from the lack of rigor in controlling the mixtures and in executing the services (see Figure 39 and Figure 40);

• **Varnish on blind walls:** the decision to not applying acrylic varnish on the blind walls was made by FAUUSP top administration based on recommendations of the school professors. This recommendation was based on the evident alteration of the blind walls appearance with the formation of a continuous film. The lack of in-depth studies on the method of varnish application on the surfaces at issue (with surface fissures and irregularities) and the implications, still unknown, to the maintenance (frequency and cost of varnish reapplication) also contributed to that decision at that point. The decision made is defendable since, in the future, the use of varnish or another physical barrier can became feasible if satisfactory results on the application methods are obtained. The major impact of not applying the varnish results from the assumption adopted for the materials and services specifications. Since in typical engineering solutions the concrete surface is protected with paint or varnish, the specification did not consider the use of mortar as corrosion inhibitor or the application of anticorrosion paint on the rebar, also not considering the need of proving the repair mortar resistance to carbonation. Such facts probably influenced the current rebar condition.

During the 2012-2015 work, it was possible to register images of several segments of the blind wall rebar, their conservation state, positioning and thickness of concrete coating. Most of the rebar was exposed after the first cleaning with pressurized water jet, with the removal of loosen parts of the concrete.

Constructive faults in positioning the rebar inside the moulds – and their permanence in that position during the casting process – resulted in a coating thinner than the minimum needed, and the lack of clearance between bars; this makes difficult to involve the steel with concrete causing undeniable prejudices to the structure, above all to the exposed concrete. The correct positioning of the rebar was also one of the mains challenges in the production of most of the concrete structures, in the Modern period of the 20th century, as reported by researchers of the topic. Obviously, no substantial errors are observed in the rebar positioning, otherwise the structural safety would have been jeopardized even before the first signs of rebar corrosion.

(a) P1 after removing the loose concrete

(b) P1 after applying repair mortar without the differentiation of horizontal joints between boards

Figure 40: Pillar P1 during the recuperation works (Source: C. A. Oliveira, 2013 e 2014).

In some segments, the concrete detachment was intense to the point of exposing bending rebar at the lower edge of the beam. We can observe that the bars of the main rebar structure (bars with 25 mm diameter) are not spaced. The corroded rebar was replaced, and the beam cross section was recomposed according to the design specifications. The lack of precision in positioning the rebar is shown in Figure 40.

Based on the observations made during the work (Figure 42), rebar with thinner coating, and therefore more prone to corrosion are those rebar for fissuring control (skin rebar) that, as a rule, are disposed in an orthogonal mesh with nominal spacing between bars of 10 to 20 cm, according to the consultation made to the structural design drawings. Radial rebar of pillars, coming from the pyramidal base and spanning on the blind walls surface, are also prone to atmospheric corrosion.

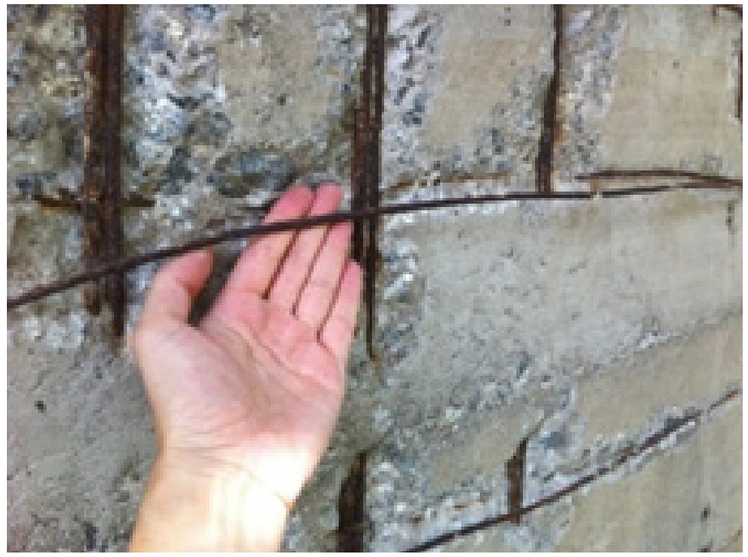


Figure 41: Corroded rebar after the concrete scarification (Source: C. A. Oliveira, and R. Vegili, 2013).

Figure 42: Evidences of the rebar positioning. Left: radial rebar in the transition between pillar and beam-wall. Above: skin rebar disposed in orthogonal mesh. (Source: C. A. Oliveira, 2013).

Photo: Conserva FAU Team, 2016.

3.3

CONDITIONS OF ACCESS TO THE EXTERNAL SURFACE OF BLIND WALLS

Conditions of access to the external surface of blind walls

The access to blind walls was one of the important conditions for the planning of activities. In this item, we make some comments on how the conditions of access will affect future works, the routine maintenance and regular inspections of blind walls, which are highly recommended.

The most practical solution of access to the blind walls is through lifting equipment that should, as a general rule, be fixed in anchoring structures, previously tested as their strength and stability capacity, on the roof of the building. However, in the design of Artigas building anchoring structures were not foreseen for the fixation of lifting equipment and the typical ways of fixing such structures, commercially available in the Brazilian market, and thus it is necessary to drill holes in the structural elements of the roof.

In view of this situation, the solution of lifting equipments was not considered feasible, at the time of inspections and activities of this research, due to the polyurea lining on the whole extension of the roof. The possible loss of guarantee of the waterproofing system, of the work that has just been delivered, would not allow the drilling holes in the structural elements, where the anchoring structure fasteners would be naturally installed to support the lifting equipment. Furthermore, the preferential solutions for heritage conservation works should adopt the criterion of minimum intervention, and search for a solution other than drilling holes in the structure.

The characterization already presented in this text is regarded as the starting point to plan the access to the blind walls.

In addition to the external dimensions, it is necessary to know the distances of the base and top of blind walls from the ground, in order to define the minimum and maximum spans to be reached by the equipment possibly positioned at the elevation of the surroundings. In such case, the equipment specification also requires considerations regarding the surface over which it should be supported, such as, for instance, its gradient, superficial roughness, and the strength and rigidity of the material of which it is made of, in addition to underground pipelines and structures (water supply, sewerage, electricity).

In the case of using movable equipment such as self-propelled lifting platforms (proper for conservation works because they do not need anchoring structures and fixations into the building), it is also necessary to consider of access and the movements of the equipment around the building, as well as the necessary clearances because of pre-existing obstacles.

In Figure 43, the surrounding characteristics considered in selecting the lifting equipment to perform inspections and tests in the blind walls are shown. Figure 44, Figure 45, Figure 46, and Figure 47 show the cross-sections that show the conditions of access regarding each blind wall, as indicated in Figure 31.

As illustrated in Figure 44, all the extension of NE blind wall can be accessed by means of equipment positioned along the lawn parallel to the blind wall, approximately 20 m wide. However, to define the equipment route, a safe clearance should be considered in relation to the slope crest, and detours from the existing tree trunks. In addition to those aspects, it is recommendable to avoid inspections after periods of intense rainfall (summer) due to the soil saturation, and the equipment becoming consequently stuck in the mud.

In the case of SE blind wall, it is possible to access it throughout its whole length by moving the equipment on the lawn that is approximately 20 m wide, between Vilanova Artigas building and the annexed building. Depending on the size of the equipment (mass), it is recommendation to avoid the traffic on the not reinforced pavement that serves as sidewalk for pedestrians in order to prevent its rupture. Considering this assumption, the proposal is to consider the horizontal minimum clearance of 12.70 m between the equipment and the blind wall, as shown in Figure 45. To outline the route, attention should be paid to the obstacles represented by the trunks of trees, and when performing inspections, the same recommendations are valid to avoid rainfall periods to minimize the risks of the equipment becoming stuck in the mud.

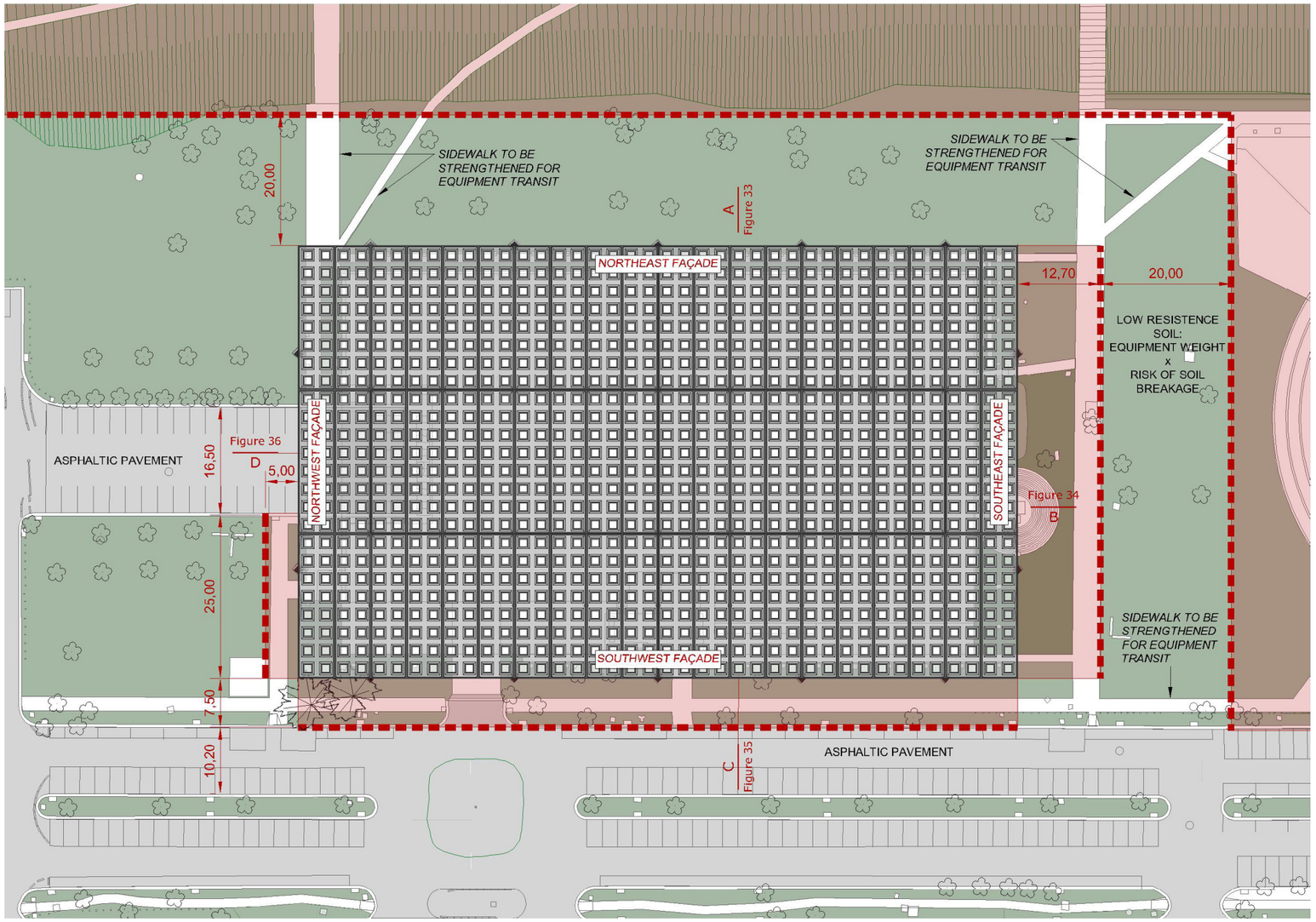


Figure 43: Conditions of access to the external surface of blind walls: surrounding characteristics relevant to the selection of the lifting equipment to perform inspections in the blind walls

As shown in Figure 46, the whole length of SW blind wall can be accessed by moving the equipment on the asphaltic pavement of the parking area parallel to the blind wall. In this area, in order the equipment operation takes place within the stripe of 10.20 m corresponding to the width of the way, the minimum and maximum horizontal clearances are limited to 7.50 m and 17.70 m, respectively. To ensure the safety of users when moving the equipment, as well as its moving agility, it is recommendable to block the parking spaces and the traffic of vehicles on this way throughout the blind wall extension.

As shown in Figure 47 as follows, part of the NW blind wall extension (approximately 16.5 m of its length – see Figure 43) can be accessed by moving the equipment on the asphaltic pavement of the teachers parking area. In such case, it is recommendable to block parking spaces and the traffic of vehicles, as presented for the case of SW blind wall. The access to the other areas along the blind wall extension is possible only by moving the equipment on the lawn. In this case, the obstacles represented by tree trunks and restrictions regarding the performance of inspections and tests during the rainy season should be considered, as already discussed in the cases of NE and SE blind walls.

Table 4 gathers the nominal dimensions of blind walls, the vertical spans and minimum and maximum horizontal clearances relevant for the selection of the lifting equipment to perform inspections and tests in the blind walls.

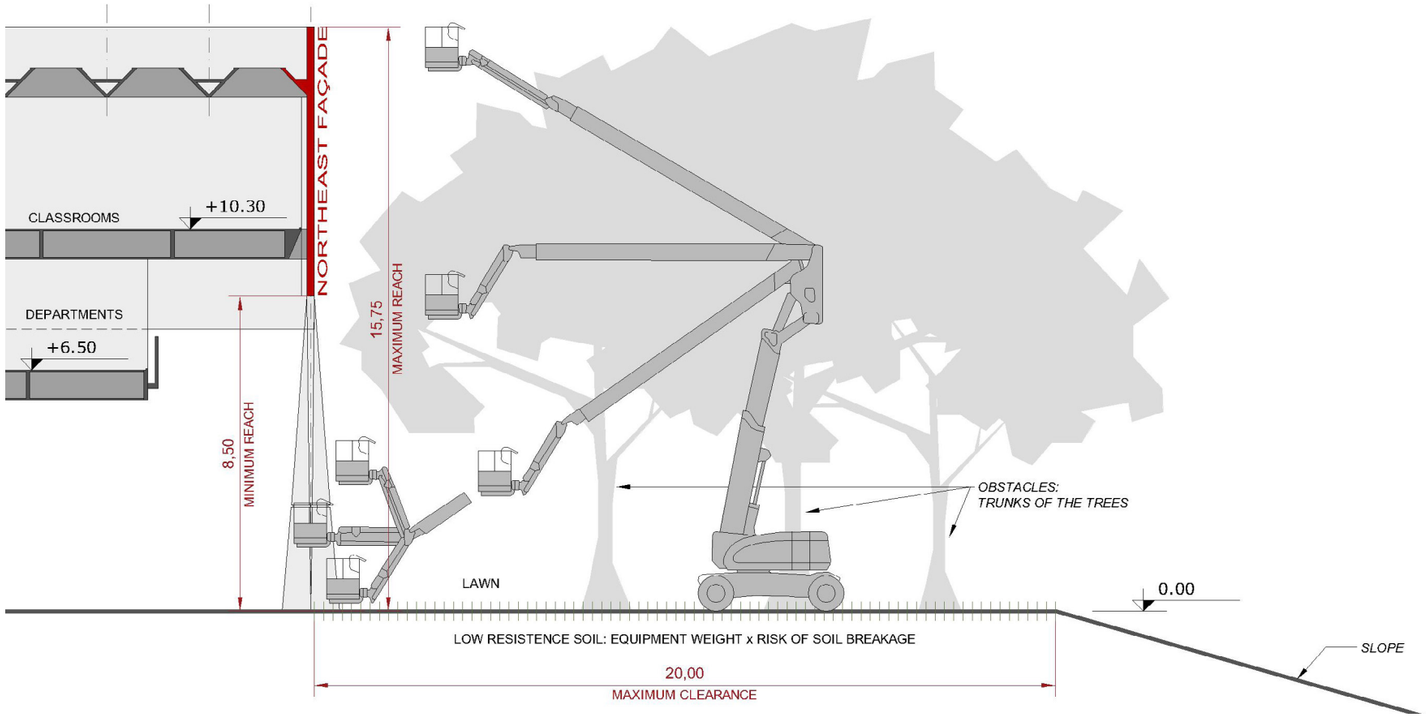


Figure 44: Conditions of access to the external surface of the Northeast blind wall (Cross-Section A as indicated in Figure 43).

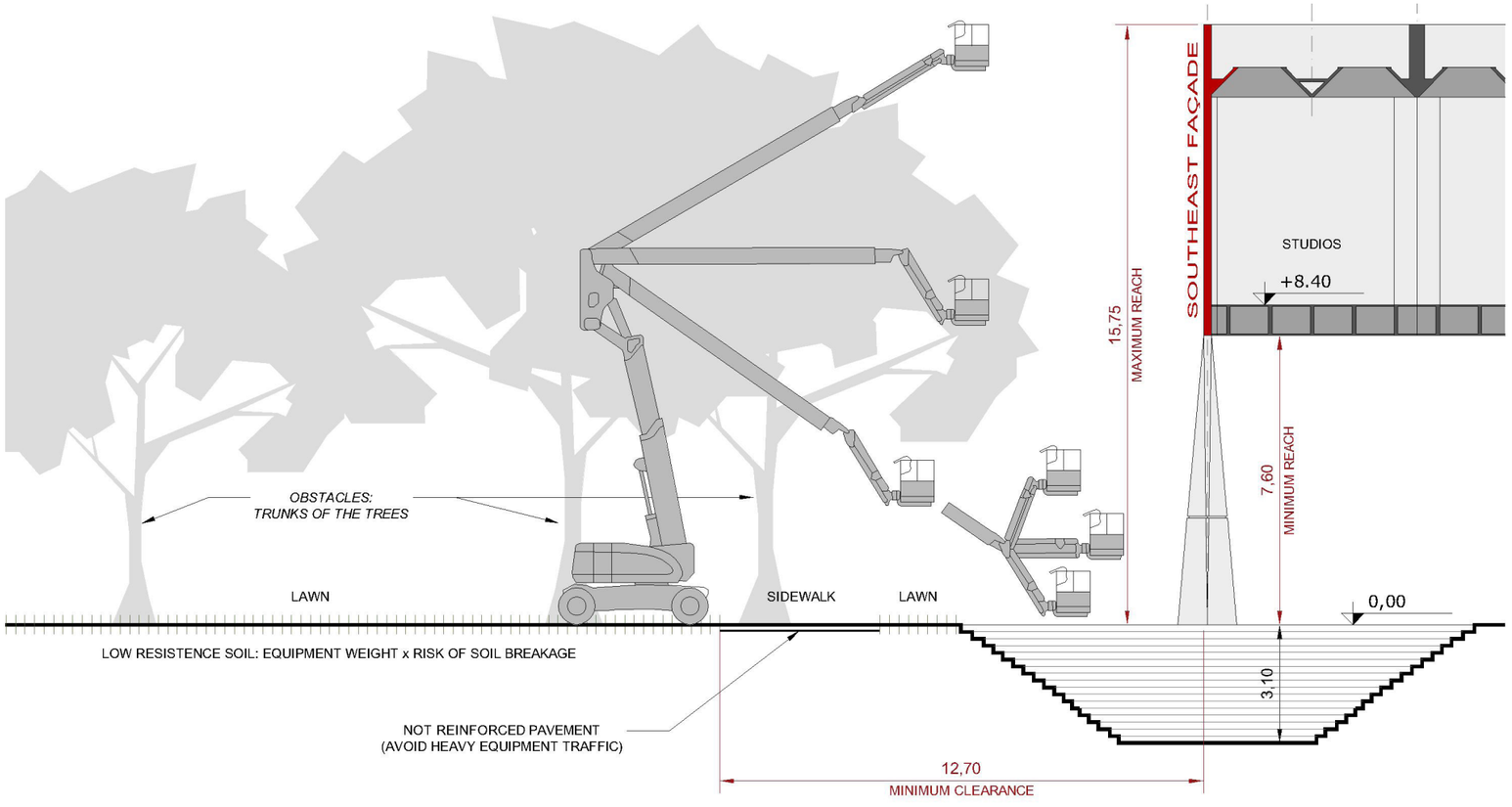


Figure 45: Conditions of access to the external surface of the Southeast blind wall (Cross-Section B as indicated in Figure 43).

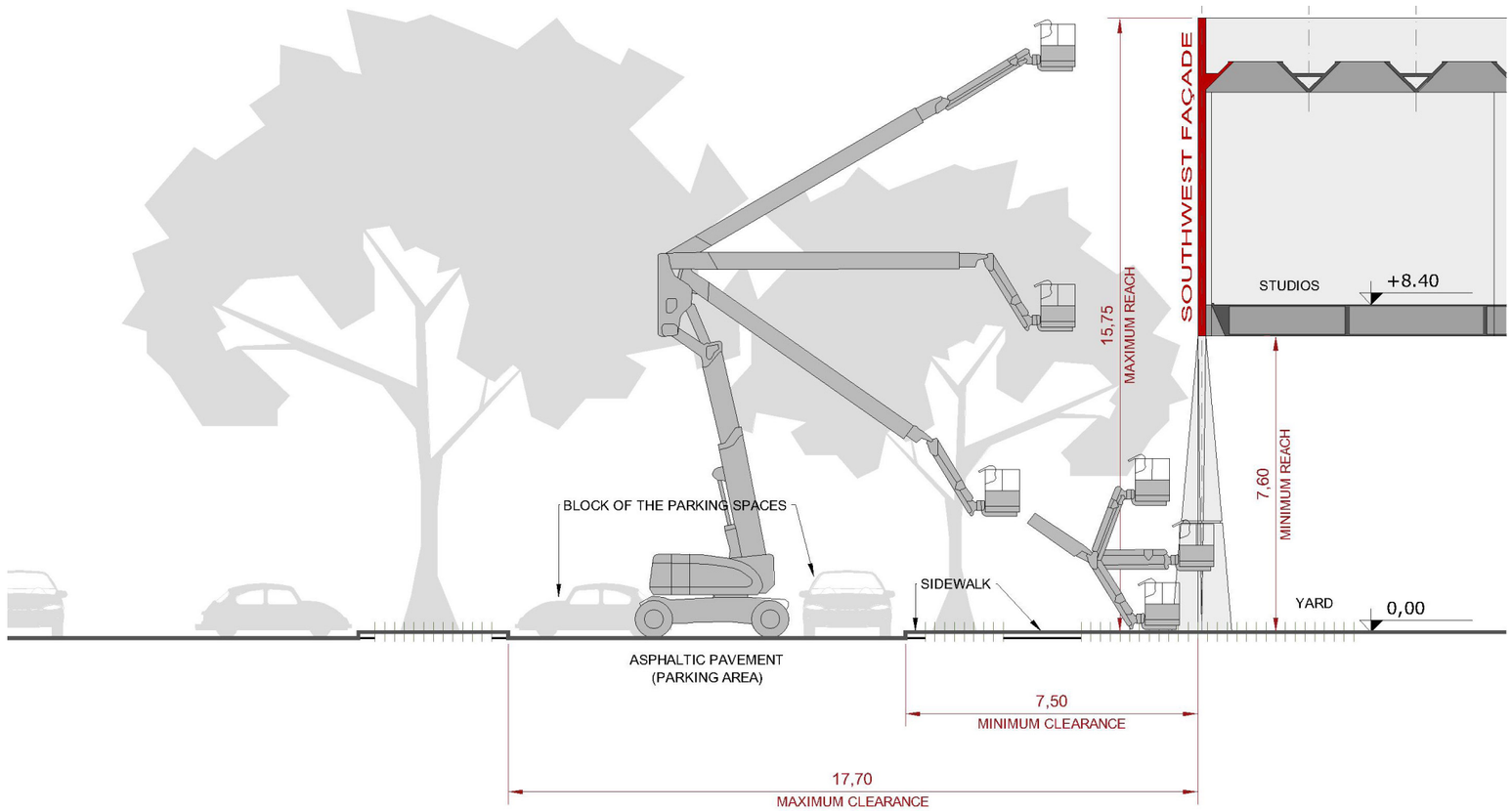


Figure 46: Conditions of access to the external surface of the Southwest blind wall (Cross-Section C as indicated in Figure 43).

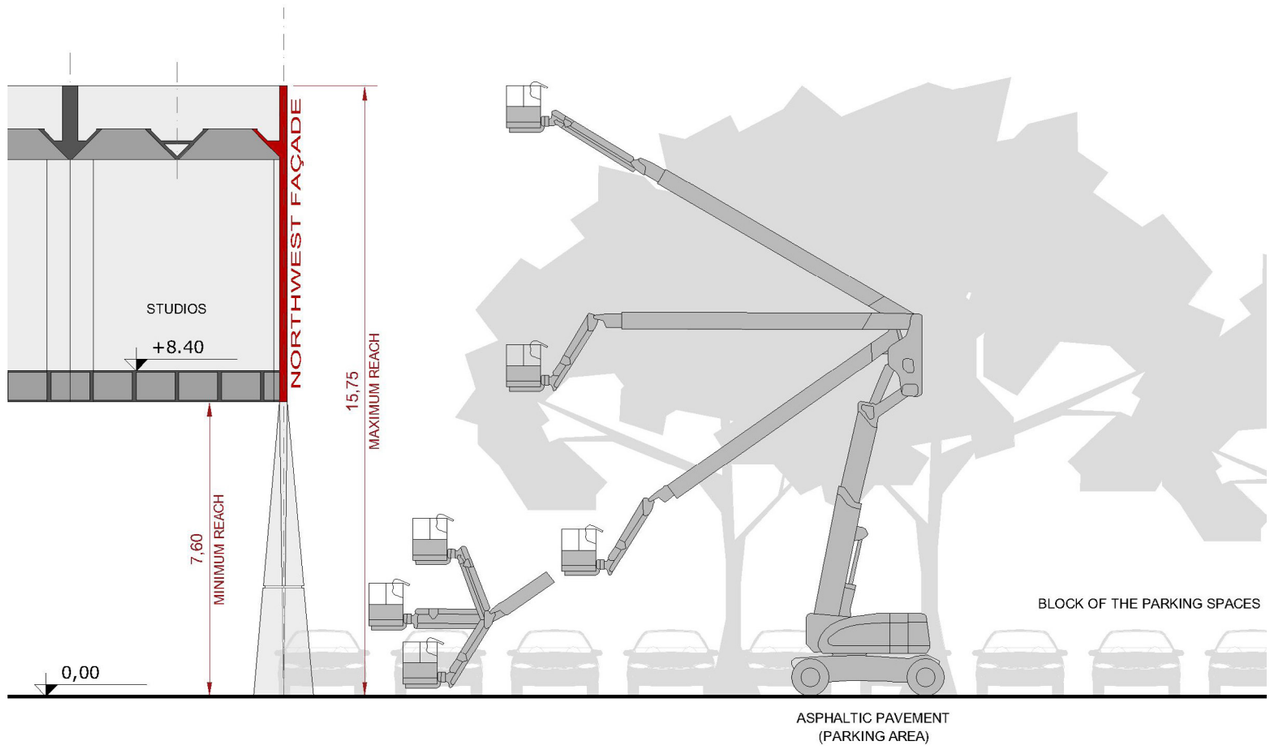


Figure 47: Conditions of access to the external surface of the Northeast blind wall (Cross-Section D as indicated in Figure 43).

Table 7: Dimensions of blind walls, spans and minimum and maximum horizontal clearances relevant for the selection of the lifting equipment to perform inspections and tests in the blind walls.

Blind Wall	External dimensions of the blind wall		Equipment reach (in the vertical direction)		Equipment clearance (in the horizontal direction)	
	Length	Height	Minimum	Maximum	Minimum	Maximum
NE	110,20	7,25	8,50	15,75	---	20,00
SE	66,20	8,15	7,60		12,70	32,70
SW	110,20				7,50	17,70
NW	66,20				5,00	---

Dimensions in meters.

Photo: author and date unknown. Source: Arquigrafia.

3.4

ENVIRONMENTAL CONDITIONS

Environmental conditions

The environmental conditions to which the blind walls are exposed are presented, that is, atmospheric pollutants, weather conditions (room temperature, relative humidity, rainfall intensity), and the relation with the surrounding vegetation.

Such conditions influence the alterations the external surfaces of such blind walls undergo, with significant impacts on the durability of the reinforced concrete, on the performance of blind walls as structural elements, and on their appearance.

Atmospheric pollutants

In practical terms, it is usually observed that in the design stage of a new concrete structure, a subjective evaluation of the environment where it will be built is carried out (meteorological conditions and pollutants), while regarding an already installed structure, the conditions of exposure to which the different parts of the structure are exposed are also evaluated, as well as material is collected to determine the presence and profile of contaminants penetration in representative elements of the structure. Mathematical models are also used to forecast the useful life of new and existing structures.

It is noteworthy that the analysis of the insertion environment is usually an easy task, usually adopting reference values obtained in regions closer to the study site to evaluate possible current and future environmental aggressiveness. For instance, the determination of atmospheric pollutants, which type and concentration significantly vary over time according to the presence of new generating sources, alteration of the topography, and meteorological parameters are mentioned as items of analysis.

In this work, literature data (BRUNI et al, 2013) and data from the pollutants databank of CETESB (Environmental Company of São Paulo State) are used as reference, considering the reports on the quality of air in São Paulo State in the period between 1985 and 2014.

Figure 48 shows the results of pollutants monitoring in São Paulo state between 2009 and 2012 (BRUNI, A.C. et al, 2013). It is admissible that 60 % of the amount of each pollutant is concentrated in the macro metropolis of São Paulo, which corresponds to the agglomeration of the metropolitan regions of São Paulo and the cities of Campinas, Baixada Santista, Vale do Paraíba, Sorocaba, Jundiaí, and Piracicaba. This result is a reference for the atmosphere at USP, located between such regions. In Figure 48, the results for the following pollutants are presented: carbon monoxide (CO), non-methane hydrocarbons (NMHC), nitrogen oxides (NO_x), particulate matter (PM), methane (CH_4), aldehydes (RCHO), sulphur dioxide (SO_2), and equivalent carbon dioxide ($CO2_{eq}$).

By reading the data of Figure 48, we observe that between 2009 and 2012 there was a significant increase of CO_2 in the atmosphere, which indicates the increasing potential of this agent to chemically activate the rebar of concrete structures. As for the other pollutants, no significant variation over the analyzed years is observed. Among them, the particulate matter (PM) and the sulphur dioxide (SO_2) are highlighted for the following reasons: the first increases the wet time of the exposed concrete surface, and the second is responsible for the formation of acid rain, as well as the dissolution of CO_2 in rainfall water. According to the evaluation of those two pollutants done by Chaves (2017), there was a decrease of their concentration in the West and Central regions of São Paulo, considering data of atmospheric monitoring of CETESB atmospheric stations of Lapa, Pinheiros and Cerqueira Cesar, between 1961 and 2015.

Exposure to weathering

This item presents data from historical series (ambient temperature and relative humidity) and recent data of rainfall intensity to analyze the impact of these variables on the phenomena related to the main pathological manifestations already verified in the blind walls.

The historical series of meteorological data were obtained from the archives of the National Institute of Meteorology (INMET) at Mirante de Santana station, in São Paulo, from 01/01/1960 to 01/01/2016. The data of interest was mean relative humidity and mean temperature compensated.

The analysis of the influence of directed rain was done with data of the total rainfall of the year 2016. For that, data from the Solarimetric Station of the Laboratory of the Energy Group of the Department of Energy Engineering and Electric Eutomation of the Polytechnic School of the University of São Paulo was used. The said solar radiation measurement station is located in the campus of the University City of São Paulo, distant approximately 600 ms from the Artigas building. In the solar radiation measurement station, the measurement of the wind is made at approximately 10 m of height.

With the rainfall data, the wind direction and intensity were calculated using the Guided Rain Index (DRI), an indicator of the influence of rainwater combined with wind action on the deterioration mechanisms of the material. The indicator has been used to analyze the influence of rainfall on aging, staining or wetting of façades, among other applications (CHOI, 1999; MELO JUNIOR; CARASEK, 2011). This index has been taken as a reference for the planning of preventive maintenance activities in buildings in general, and may be useful, in this case, when compared to the conditions of the most affected surface.

For each blind walls orientation the Guided Rain Index (DRI) was calculated according to the Equation 1.

$$ICD = V \times \frac{P}{1000}$$

where:

DRI = directed rainfall index (m² / s);

V = average wind speed (m / s);

P = total rainfall (mm).

The historical series of average relative humidity and average compensated temperature are, respectively, illustrated in Figure 49 and Figure 50..

CBased on the presented data, it can be considered that the average relative humidity is in the range between 65 and 85% and the average compensated temperature in the range of 15°C to 25°C.

The moisture content in porous solids results from the interaction with the relative humidity of the environment (UR). Once the material is also subjected to temperature variations, the moisture diffusing into the solid in the form of water vapor precipitates by reducing the temperature, and fills in whole or in part the pores of the material depending the distribution and size of these pores. Thus, even in small amounts, for large extensions of exposed surfaces, differences in porosity (distribution and pore size) lead to the heterogeneous distribution of condensed moisture and pores filled with air. According to Quenard and Sallee (1992), this condition - water condensed and dispersed in the porous media - can amplify the diffusion of the vapor when the material has a large number of pores with apertures of less than 1 μm, as in the case of concretes.

The relationships established in this equilibrium with the ambient humidity are complex, and the prediction by theoretical or empirical models must always be accompanied, whenever possible, by the verification on site to know the extent of these influences.

In turn, the influence of water in the liquid state can be estimated by means of the Directed Rain Index (DRI m^2/s). Probably, the

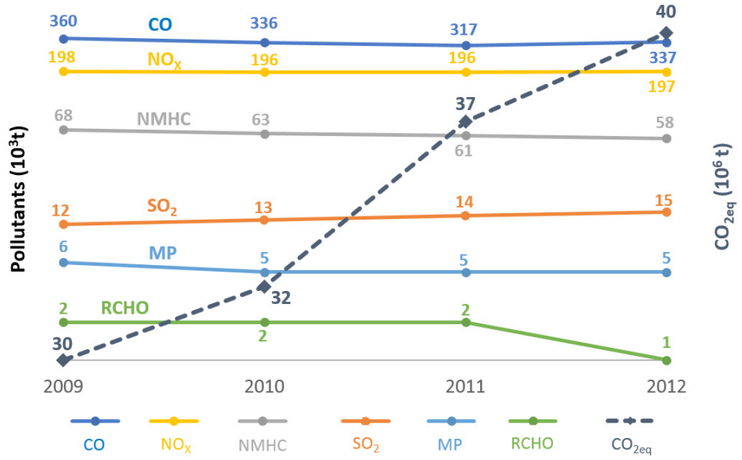


Figure 48: Annual monitoring of atmospheric pollutants between 2009 and 2012 for São Paulo State. Source: Bruni, a.c. et al. (2013).

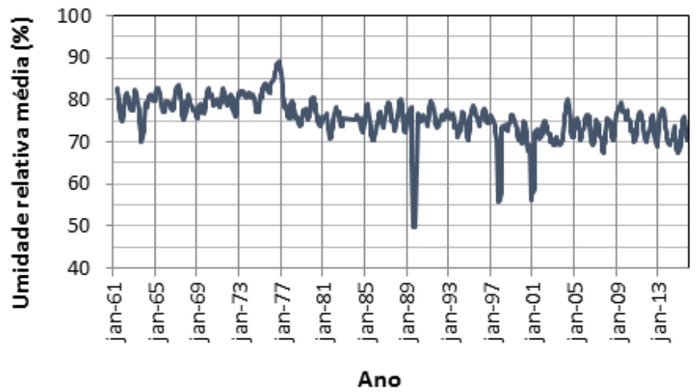


Figure 49: Moving average of the historical average relative humidity series (Source: INMET, Mirante de Santana Station, São Paulo).

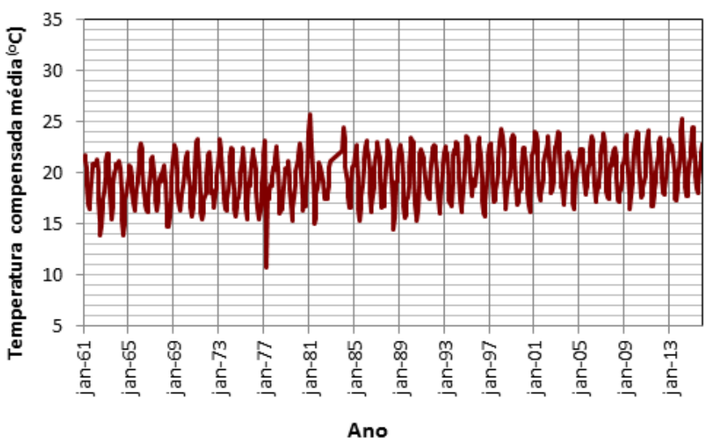
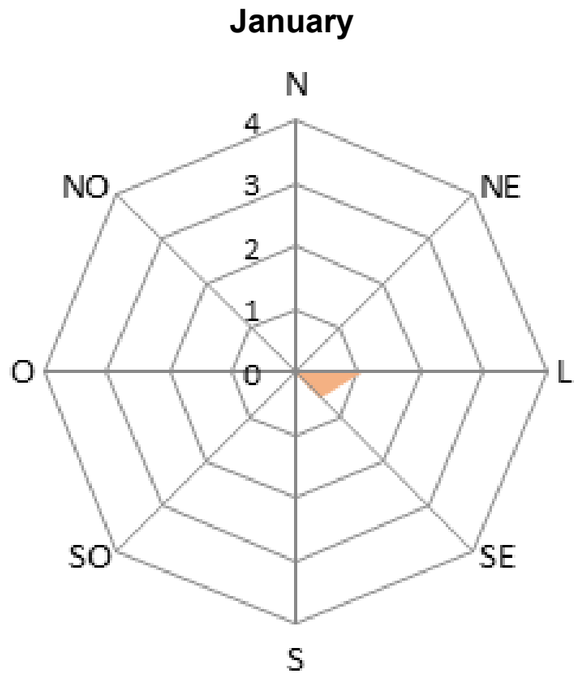
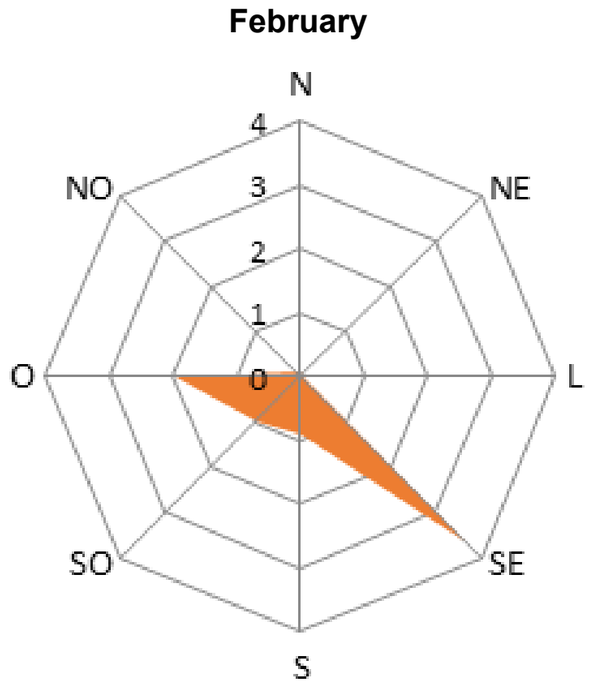
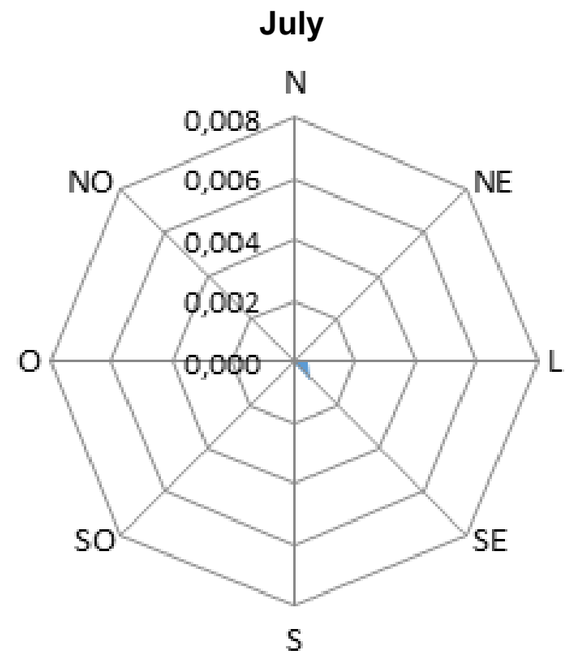


Figure 50: Moving average of the historical average compensated temperature historic series (Source: INMET, Mirante de Santana Station, São Paulo).







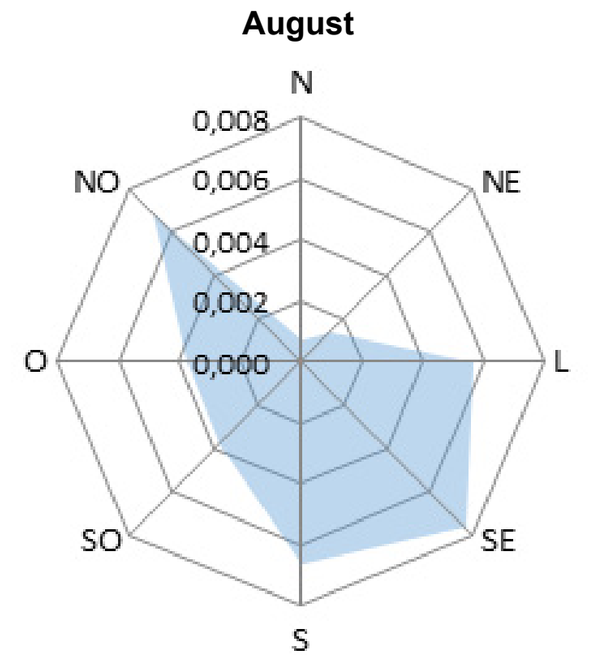


Figure 51: Directed rainfall index (DRI m^2/s) for the months of January, February, June and August 2016 (Source: Solar radiation measurement station located in Cidade Universitária, São Paulo).

higher the DRI, the greater the impact on the deterioration of the material due to rainfall.

The rainfall index obtained for the months of January and February and July and August of 2016 appear in Figure 51. The selected months represent the periods of the year with the highest and the lowest rainfall, respectively, in the summer and winter months.

In the charts of Figure 51 it is observed that the SE blind wall is the most affected in summer months. In winter, rain affects SE and NW blind walls, but it should be noted that, in absolute numbers, the DRI in winter is 3 magnitude orders lower than in summer. The conclusion is that, for the analyzed data, the SE blind wall would potentially be the most subject to mechanisms of deterioration by the humidification of the concrete due to its exposure to rainwater.

The relative humidity and conditions of exposure to rainwater determine the internal moisture of the concrete, and thus control the rate of corrosion of the rebar. As the previous inspections indicated the removal of chemical passivity of the rebar of the blind walls because of its low carbonate concrete cover, the analysis of these parameters is important for the evaluation of the corrosion rate of this rebar in an active state of corrosion.

Considering the RH as determinant of the moisture content of concrete, its concentration can be related to the corrosion rate of the rebar, and for RH ranges between 70% and 90%, the corrosion rate of the carbon steel rebar should be significant (loss of steel section above 2 µm / year to approximately 10 µm / year); with the increase and maintenance of RH up to 98%, the corrosion rate can increase significantly (loss of the steel section between 10 µm / year and approximately 100 µm / year) (BERTOLINI et al., 2004). Therefore, according to the results of Bertolini et al.'s (2004) investigation with respect to the atmospheric RH, it can be assumed that in the next years this RH range is maintained, the gable reinforcement may lose section above 2 µm / year (up to about 10 µm / year). Added to this are the consequences of the advance of corrosion, which result in the appearance of new pathological manifestations, in particular the disintegration of the covering concrete, which is a pathology that ends up facilitating the access of the water and, thus, the loss of section of the local rebar. In addition, the natural loss of the effectiveness of the protection provided by the hydrophobe in the coming years should be considered, as well as the current presence of application failures and limited efficiency in areas with voids and surface cavities, as well as constructive failures in the surface of blind walls concrete.

It should also be considered that the natural intermittent precipitation is a suitable condition for the advancement of the corrosion process; in the period of less humidification, the resistance of the concrete to the corrosion current flow is diminished; while in the period without occurrence of rainfall the access of the oxygen (oxidizing agent of the corrosion reactions) is increased. This last period, without rainfall, associated to the atmospheric RH between 50% and 75% results in the partial filling of the concrete pores, which is an ideal condition for the entry of CO_2 and, therefore, for the advancement of the carbonation front.

Shaded areas

The areas of gables shaded by the surrounding trees are shown in the figures in Annex D. The tree survey is also included in Annex D. The records portray the existing condition in the second half of 2016.

The proximity of the large trees changes the microenvironment in the immediate surroundings of the gables, especially of the NE face, increasing the time of wetting of the surfaces, favoring the formation of biofilm and potentiating the deterioration mechanisms of the concrete.

Photo: author and date unknown. Source: Rosa Artigas.

3.5

PHYSICAL CONDITION OF BLIND WALLS

Physical condition of walls

This item presents the surveys done on site, through inspections or tests, to characterize the current physical condition of the gables.

Repair areas

The repair areas are mapped and presented in Annex B. Table 8 shows the areas and the perimeter of repairs and their relation with the gable areas.

Note that the blind walls presenting the highest and lowest percentage of repairs are the NE and NW blind walls, respectively. Therefore, both were selected for the extraction of concrete cores, as explained in chapter 3.

The SE blind wall has the second highest percentage of repairs, 23.93% of the blind wall area. Perhaps this has been enhanced by the fact that it the blind wall is more vulnerable to rain, as indicated by the Directed Rain Index (DRI). However, the NE blind wall is the most affected, with more than a third of the original concrete being replaced with structural repair mortar.

Wetting areas

Rainwater wetting areas were identified shortly after a period of moderate intensity rainfall and long duration, about 8 hours, with brief periods of drought. Such spots are visible to the naked eye, and they are probably signs of the ineffectiveness of the water repellant. In the NE blind wall, the wetting areas are larger, although in the SW blind wall the areas are more distributed on the surface. The SE and NW blind walls have less accumulation of water. Annex D contains the boards with the location of these wetting spots.

In order to test the validity of a nondestructive technique, a portable thermal camera, commercial brand Flir model E40 was used to detect traces of moisture after apparent surface drying. Although standardized by NBR 15424 (ABNT, 2016), the description of the details of the technique and its limits and potentialities in the study of the patrimony is worthwhile. The details follow below.

Observations made by Lerma, Cabrelles and Portalés (2011), which show the heat exchanges of the surfaces with the environment, have practical meaning in the use of the technique:

• wet surfaces are cooler in the morning;

• throughout the day, the temperature of wet surfaces increases gradually but more slowly than the temperature of dry surfaces;

• in the dusk, the humidity of the wet surfaces is more slowly cooled than hot surfaces;

• at night, wet surfaces are warmer or have a similar temperature to dry surfaces;

• temperature fluctuation is greatest on dry surfaces.

From the operational point of view, and considering the passive thermography (where the solar radiation is the source of heat) the measurements should preferably be made in the first hours of the morning in the shortest time possible.

The equipment used is a thermal camera of the brand name FLIR model E40 that operates in the range of the spectrum of the infrared radiation between 7.5 and 13 μm. The camera has a resolution of 0.07° C to 30° C; temperature measuring range between -20° C and + 120° C; accuracy of ± 2° C of the surface temperature reading in the range of 10° C to 35° C. The camera provides multi-spectral dynamic imaging (MSX) screen capture generation thermal imaging with highlighted contrasts, which facilitates analysis of the region of interest in the image. The equipment allows measurements at a mean distance of 0.40 m and maximum of 50 m. The emissivity used for the measurements was 0.92, which is the emissivity suggested by the equipment manufacturer (FLIR SYSTEMS, 2010, p.179) for common concrete in general terms, valid for the entire spectrum of wavelengths in the which the equipment operates.

AThe measurement of the surface temperature of the elements of the building, through thermography, has a level of uncertainty in view of the simplifications made to make the measurements viable on site and the intervening variables. Depending on the purpose of the test, the measurement error must be known under the test conditions, taking as reference methods of reliable confidence estimation (NUMIZ, 2014). However, if the interest is qualitative and comparative analysis, the results are useful, provided that the indicated care and restrictions of the technique are observed.

After a rainy period, several regions of the blind walls are observed, to a greater or lesser extent, with signs of humidification. Figure 53 illustrates these spots of moisture in the SW blind wall.

Table 8: Blind wall areas and perimeters of repairs performed in the interventions of 2012-2015.

	SW blind wall	SE blind wall	NE blind wall	NW blind wall
Blind wall area (m²)	992,90	588,14	909,92	588,62
Repairs				
Perimeter (m)	945,76	686,13	1349,66	577,09
Number	295	146	305	194
Area (m²)	162,71	140,72	333,36	94,20
% repair area over blind wall area	16,39	23,93	36,64	16,00

Figure 52: Portable thermal camera (Photo: V. Chagami)

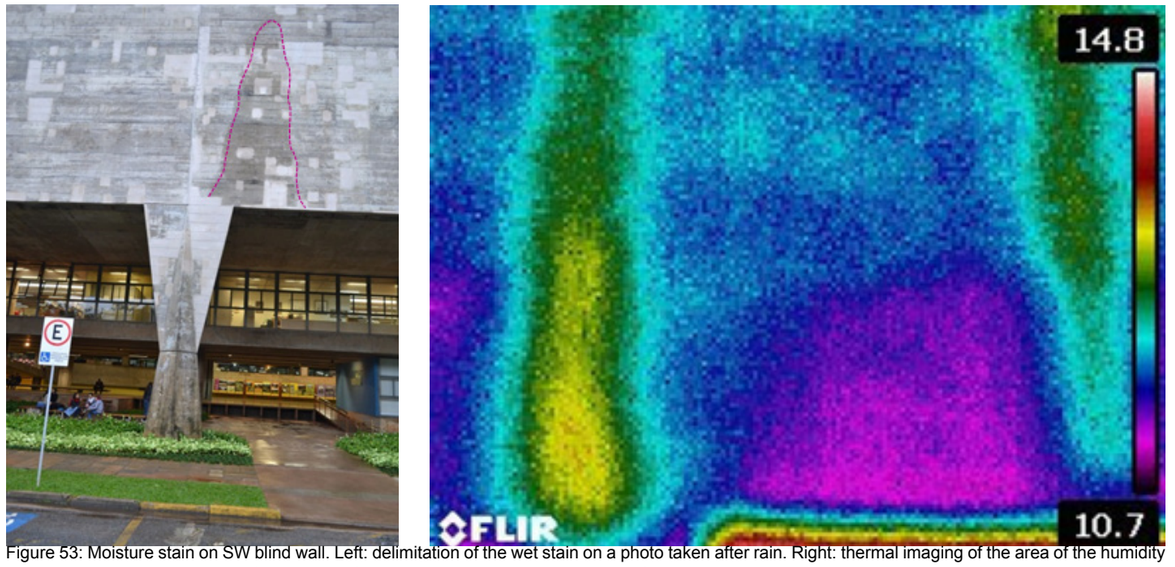


Figure 53: Moisture stain on SW blind wall. Left: delimitation of the wet stain on a photo taken after rain. Right: thermal imaging of the area of the humidity spot, image recorded 48 hours after the end of the rainy period, on an unshaded surface, considering the ambient temperature measurement parameters 20oC and relative humidity 70%.

The image of Figure 53 to the left shows a spot of moisture detected at the visual inspection, one hour after the end of a moderate but long lasting rainfall (about 8 hours). The image to the right illustrates the infrared radiation spectrum emitted by the gable surface at the same location, and was taken 36 hours after the rain was over. The purple color in the thermal image is associated with the presence of a higher moisture content, when compared to the adjacent area. Although the surface of the concrete, 36 hours after the end of the rainfall, did not show any detectable humidity signals in the visual inspection without instruments, the use of the camera that captures infrared radiation was sensitive to identify differences of humidity in the analyzed region. In view of the uncertainties of the temperature measurements, the useful information is the temperature difference and not the individual values indicated in the color scale. The records suggest that the water repellant is no longer limiting the entry of rainwater onto the surface of the concrete, and that traces of surface moisture caused by moderate rainfall, at least at some points, persist for more than 24 hours. In the thermal imaging, the region to the left (green color) represents the expansion joint of the blind wall filled with polymeric material and which, by analogous reasoning, shows no signs of surface moisture. The region on the right (also green) suggests the existence of a region also less susceptible to wetting, probably due to the action of the water repellant.

Although such wetting is probably the result of flaws in the application process of the water repellant, there are also other probable explanations, such as the ineffectiveness of the water repellency action due to the presence of cracks and irregularities of the concrete surface (cavities, gravel pockets, cold joints, etc.) detected on the surface of concrete and repairs. The irregularities have already been illustrated in other figures in this text; cracks in concrete and repairs appear in Figure 54.

Experimental tests (MEIER; WITTMANN, 2011) suggest that cracks with apertures greater than 0.3 mm should be treated (or filled) prior to application of the water repellent. Other authors (RAUPACH; BÜTTNER, 2014) indicate that cracks with apertures greater than 0.1 mm must be filled before the application of the surface protection system.

It is possible that areas with retention of surface moisture, after rain, are areas with higher occurrence of surface faults and cracks. Irrespective of the investigation of the irregularities and cracks, it is necessary to reapply the water repellent as a preventive action, considering the recommendations of the manufacturers of application on cracked surfaces, very porous and with constructive faults.

The survey of cracks and irregularities of the external surface of blind walls should be part of the continuity of the work, considering the negative impact on the surface tightness and the durability and safety of the structure.

Absorption of water on the surface of the apparent concrete

By means of onsite tests, it was tried to measure, comparatively, the capacity of the concrete and the repair mortar to absorb water. The absorption of surface water is determined by the phenomenon of capillarity and allows the inference of properties of the surface of the material.

As indicated by Raupach and Büttner (2014), when it is not possible to extract material from the structure for gravimetric laboratory tests, one resorts, for example, to the test known as the Karsten tube test originally described in RILEM (1980); non--destructive test that determines the surface water absorption of the material. The test stars as of the moment when the tube is pre-filled with water. The decrease in the water level of the tube should be recorded over time, noting down, usually in intervals between 5 and 30 min. The result is given in kg / m²$h^{0.5}$.

From the different attempts, the arrangement made in the NE blind wall is presented, where two tubes (a) were fixed on the surface of the repair mortar, and (b) on the concrete surface as shown in Figure 55. The tubes were fixed with silicone which, after the test, was removed with hot water, neutral detergent, and mechanical action with brush with nylon bristles.

At the initial 30-minute interval, during which the water level reduction readings should be made, no measurable meniscus movement was detected at the naked eye. After two hours of observation, with no record of water movement, the tubes were left at the test site overnight, because of the need to demobilize the access equipment. After 20h30min of the start of the test, the following day, the reduction of the volume of water measured on the concrete and the mortar was of 1,6mL and 0,1mL, respectively. It is noteworthy that during the test period (20h30min) no rainfall was recorded. The difference between the measurements can be explained by the composition of the repair mortar and by the treatment of the surface of the repair, both containing acrylic emulsion, which probably interfered in the porosity, thus reducing the water absorption.

The test done on the blind wall did not make it possible to obtain the expected result, that is, the water absorption over time. As the researchers caution regarding these trials, they are usually calibrated for laboratory conditions, and performed with dry concrete.

Due to the strong influence of the ambient temperature and the moisture content of the concrete, Mohammadi (2013) suggests that different methods of testing the surface water absorption under different temperature and humidity conditions of the concrete should be tried for the purpose of determining the procedure which would result in useful measures for the desired analysis. It

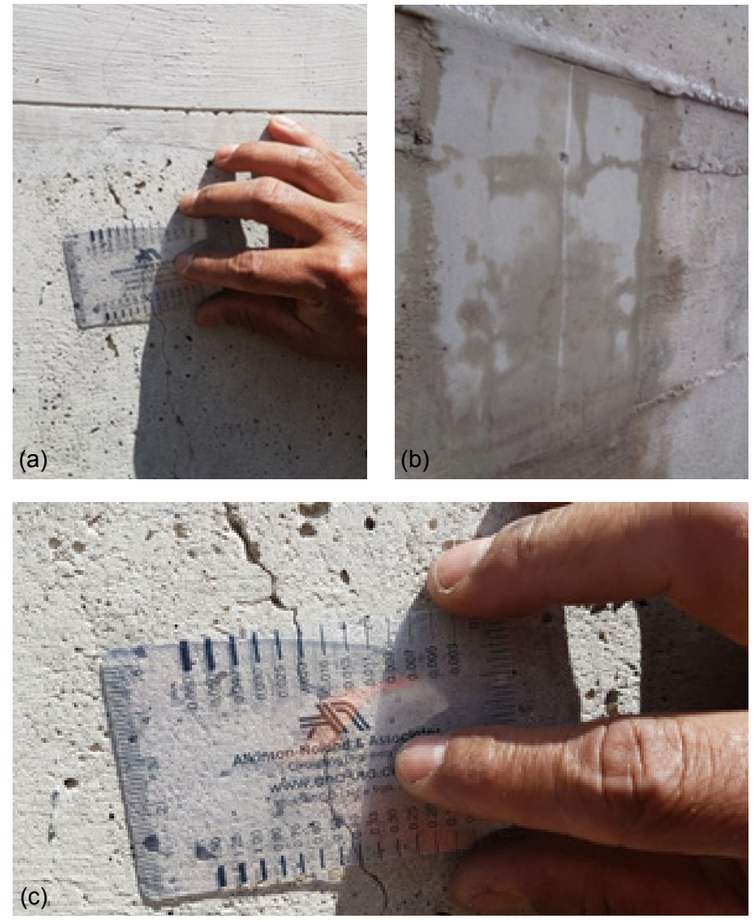


Figure 54: (a) probable active fissure of the concrete that resumed propagation on the repair; (b) cracking of the concrete between approximately 1.5 mm (0.06 in) and 0.5 mm (0.02 in); (c) cracks on repairs that become visible when the surface is wetted by rain or during testing.

Figure 55: Karsten tubes fastened with silicone to the NE blind wall. (Photo: Conserva FAU Collection, 2016).

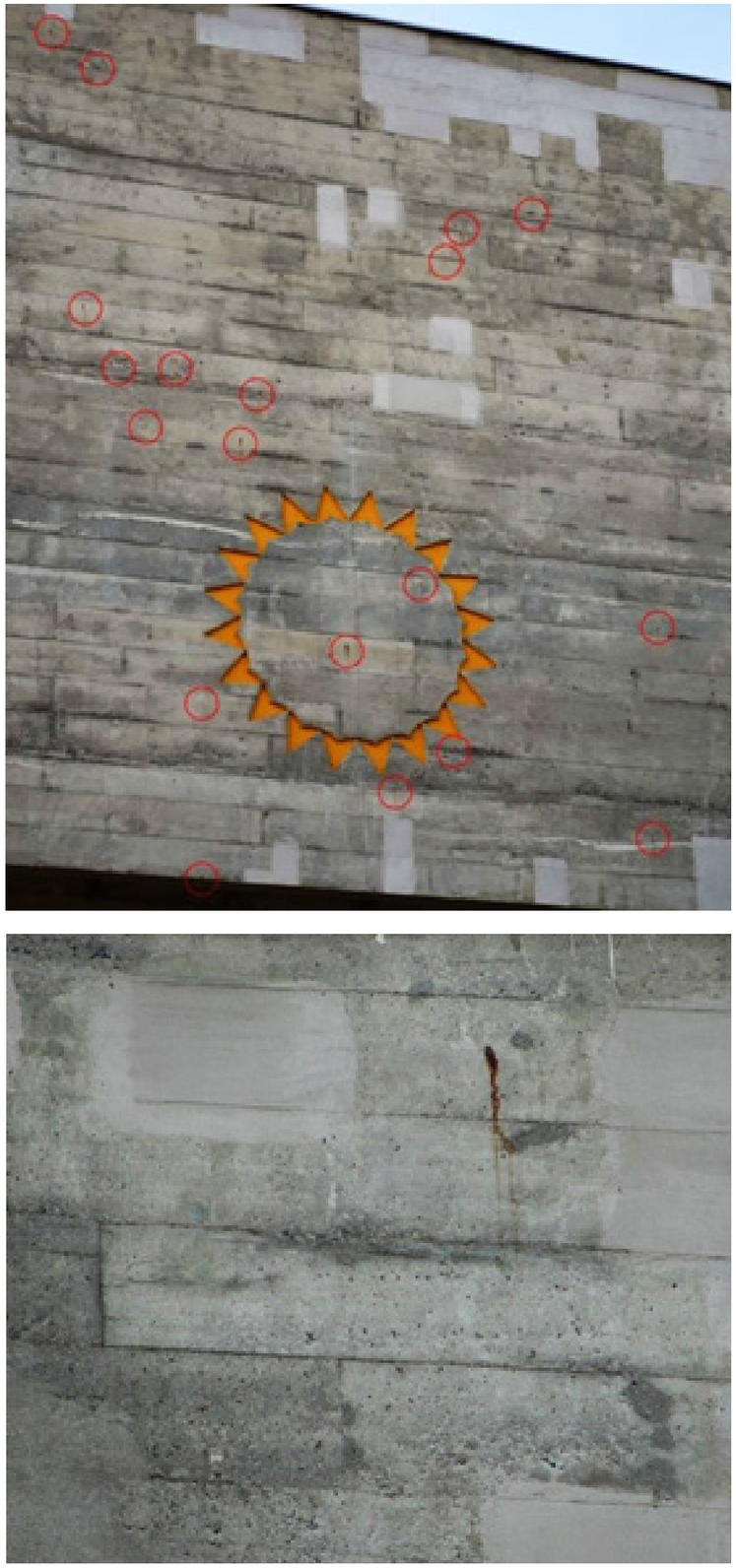


Figura 56: Characteristic stains of deposits of corrosion products on the SW Blind wall. Above: L. A. Chaves, 2016. Below: A. P. A. Gonçalves, 2016. Source: Conserva FAU Team, 2016.

should be noted that, given the scale of the structure in question, the performance and calibration of such tests become impractical without infrastructure that guarantees access to blind walls with relative ease.

Characteristic stains of deposits of corrosion products

The characteristic stains of deposits of corrosion products can now be seen scattered on all blind walls. It was not possible to establish with certainty a pattern of occurrence of these spots, which began to be observed in the months after the delivery of the works of 2012-2015. Figure 56 illustrates some spots on the blind walls, and Annex B brings the general mapping of these spots on all blind walls.

For the analysis of the surveys, the density of points per m² was calculated in each one of the analyzed blind walls. The results were expressed in Table 9, which shows the number of points per blind wall and the density, in points of corrosion per square meter, and in the Table 10, which shows the amount of corrosion points on each external pillar.

It is noticeable that, although the SW blind wall presents the highest absolute number of corrosion points (153), its density (0.169) is lower than the NW blind wall (0.241).

In Table 10, the numbers of the pillars refer to the structural plan used for the construction of the building. A higher concentration of corrosion points can be observed in the pillars of the SW and NE blind walls, see pillars 49 and 4.

The first hypothesis is that new outbreaks of corrosion of the rebar are emerging. As the visual manifestation of these spots happens after internal changes, such as loss of grip between steel and concrete, the picture inspires caution. The continuity of the corrosion tests will allow the understanding of this manifestation.

Other hypotheses have been raised and may explain, in part, this manifestation. One of them is the possible inclusion of pyrite in the coarse aggregate.

Surface stains on the concrete with a typical comet-tail type pattern may be evidence of the occurrence of the phenomenon. According to Jana (2008), the reddish brown tone originates from the contaminated aggregate and lengthens by centimeters (between 3 and 6 in). Pereira et al. (2016) and Jana (2008) describe the manifestation as a result of pyrite oxidation (FeS_2) that is found as a contaminant of the aggregates. The FeS_2 in contact with oxygen and moisture form $FeSO_4$ and H_2SO_4 which, in the presence of water, decompose the products of the cement paste into $CaSO_4$. $2H_2O$ and FeO.OH. The expansive products of these reactions cause microcracking and staining on the concrete surface.

The images of the Figure 57 are similar to those described by Jana (2008) and Figure 58 brings evidence of inclusions of pyrite in the large aggregate of the blind walls, according to the micrographs obtained in the petrographic analysis.

According to Douglas's (2016) records, at the National Theatre, in London, stains on the surface of the apparent concrete associated with pyrite inclusions in the coarse aggregate (pyrite staining) were also detected.

A third hypothesis is that the stains are associated with the corrosion of rebar of the blind walls exposed by failure of concreting or corrosion of pins or steel bars used for the stabilization of the formwork for the molding of the concrete. The images of Figure 59 provide evidence for this hypothesis.

The continuity of inspections in the blind walls will allow the gathering of more evidence and an updated mapping of these manifestations.

Table 9: Corrosion points on blind walls raised by visual observation (naked eye and with the help of binoculars). Condition recorded in the first half of 2016.

Blind Wall	Area (m2)	Total corrosion points	Corrosion points density (spots / m²)
Southwest	907,5	153	0,169
Southeast	544,5	58	0,107
Northeast	808,5	71	0,088
Northwest	544,5	131	0,241
Total	2805	413	0,147

Table 10: Total corrosion points in the external pillars. Condition recorded in the first half of 2016.

Blind Wall	Nr of the pillar	Total corrosion points
Southwest	49	10
	50	4
Southeast	36	4
Northeast	5	4
	4	8
	2	1
	1	2
Northwest	35	1

Figure 57: Left: example of comet tail stain, reddish brown on the NE blind wall. Right: detail of the point of irradiation of the spot with zoom of, approximately, 15X evidencing alterations of the concrete surface due to the corrosive process (Source: CA Oliveira, 2016).

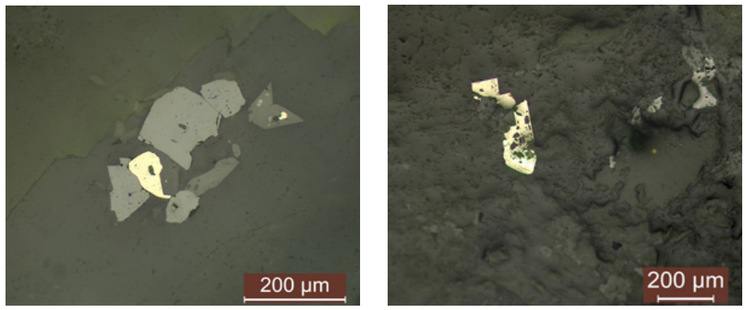
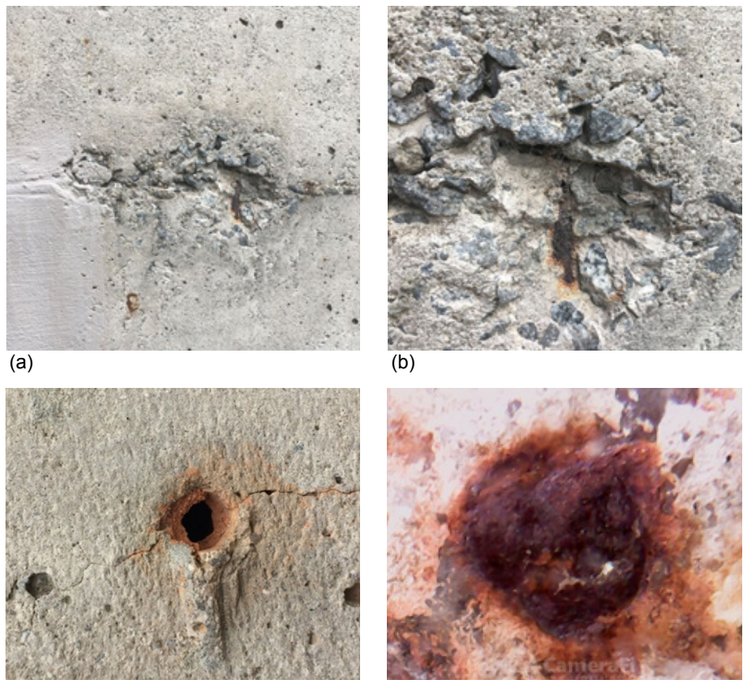


Figure 58: Evidence for the presence of pyrite in optical microscope observations in petrographic analysis. The micrographs were taken from samples of concrete cores from the blind walls.



(a) (b) (c) (d)

Figure 59: AAbove, in the photos (a) overview and (b) detail of corrosion products in the exposed crack control reinforcement rebar in a gravel pocket fault. Below, in the photos (c) overview and (d) detail of corrosion residues left by device (pin or steel bar) used for fixing the mold for the concrete. (Source: CA Oliveira, 2017).

Rebar Coating

The Brazilian Standard for the Calculation and Execution of Concrete Structures in force at the time of the design of the Artigas Building, NB-1 of 1960 (ABNT, 1960), referred to the minimum cover of the rebar, without indicating execution tolerance. The current norm, NBR6118 (ABNT, 2014), in turn, recommends the nominal covering of the rebar associated to the class of environmental aggressiveness. The nominal cover is the minimum coating plus a value of 10 mm (Δc) as execution tolerance. In addition, the current standard also establishes the correspondence between the relation r/c and the class of concrete resistance as a function of the aggressiveness of the environment. Table 8 brings the recommended comparative values in standard for the covering of the rebar. The table includes only the aggressiveness class III due to the consideration made in the technical report of Helene, Britez, and Almeida (2010) that the Artigas building is located in an urban environment with class of aggressiveness III, where the risk of deterioration of the structure is great.

According to foregoing, on the item regarding the last intervention made between 2012 and 2015, the most corrosion-prone rebar for cracking control reinforcement and the transitional rebar between pillars and beam-wall, arranged radially as of the pyramidal base of the pillars.

In the documents consulted, there is no explicit record on the covering of the rebar. However, from the analysis of the available plans of the structural design, it can be deduced that the minimum coverage of crack control reinforcement is 1.0 cm. The rebar designed for the soliciting stresses on the blind walls generally have a greater thickness of cover. The rebar for cracking control has a diameter of 8 mm, according to measurements made on site during the present testing campaign.

Among the regions to which the access was made possible by the articulated platform, an area was chosen at each blind wall for the survey of the cover of the rebar by means of the metal detector. According to the manufacturer, the equipment detects steel bars in depth up to 150 mm, but in the range of up to 50 mm the measurements are less susceptible to reading errors of the equipment.

Figure 60 shows an example of a grid drawn with chalk, indicating the approximate position of the rebar with the notes of the depth of the bar relative to the surface of the concrete at each point where the bar was detected by the equipment. The selected areas comprise 4 concreting strips; each strip is named according to the concreting sequence identified in the figures of item 3.1.

Figure 62 brings the distribution of rebar cover measurements taken on site.

It appears that on the NE blind walls, there is a balance between coverings in the range of 10 and 20 mm, in addition to measurement of coverings in the range of 30 to 40 mm. In the SE and SW blind walls, the results suggest a smaller amplitude of the coverings, while in the SE blind wall an increase of the minimum covering measurements (10 mm band) exists when compared to the SW blind wall. The heterogeneity of the measured coatings results in non-negligible differences in the moisture concentration in the surface layer of the concrete, compromising the protection of the steel. The situation is aggravated by the measurements obtained, with values predominating in the intervals of 10 and 20 mm, short of the 40 mm cover, currently recommended by NBR8116 for the structure at hand.

Table 11: Comparison between the recommendations of standards regarding the coating of rebar of reinforced concrete structures.

NB 1 (ABNT, 1960)			**NBR 6118 (ABNT, 2014)**		
Component or structural element	Place	Minimum cover (mm) **(*)**	Component or structural element	Class of environmental aggressiveness	Nominal cover (mm)
Slabs and walls	Interior of buildings	10	Slab	III	35
Slabs and walls	Outdoors	15			
Beams, pillars and arches	Interior of buildings	15	Beam and pillar **(**)**		40
Beams, pillars and arches	Outdoors	20			

(*) In the article 41 of NB 1 (1960) it is emphasized that the minimum cover applies to all the bars of the rebar, whether it be the main rebar or not.
(**) For aggressiveness class III, the concrete must have a resistance class of at least 30 MPa and r / c ratio of at most 0,55.

[8] Technical report containing technical specification of the rehabilitation services of the reinforced concrete structure of the Artigas building. At the time, the Brazilian standard of concrete structures design, NBR6118, in force was the 2007 release. In the current 2014 release, the recommendations regarding environmental aggression classes were maintained.

Figure 60: Example of a reference grid that indicates the approximate positioning of the rebar in the blind walls, and the depth in which they are in relation to the surface of the concrete. The image illustrates the inspection done on a concrete strip, in this case in the southwest blind wall (SO).

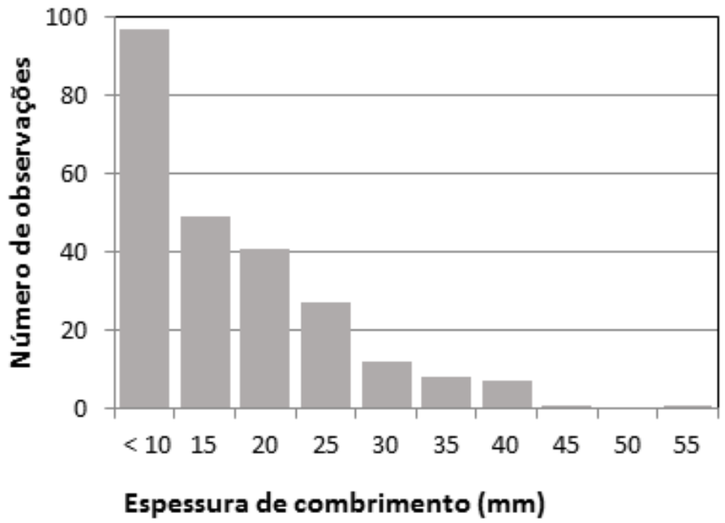


Figure 61: Cover thicknesses ranges of the rebar of the blind walls from 393 measurements made with metal detector (covermeter) on the NE, SE, SW blind walls, in 2017.

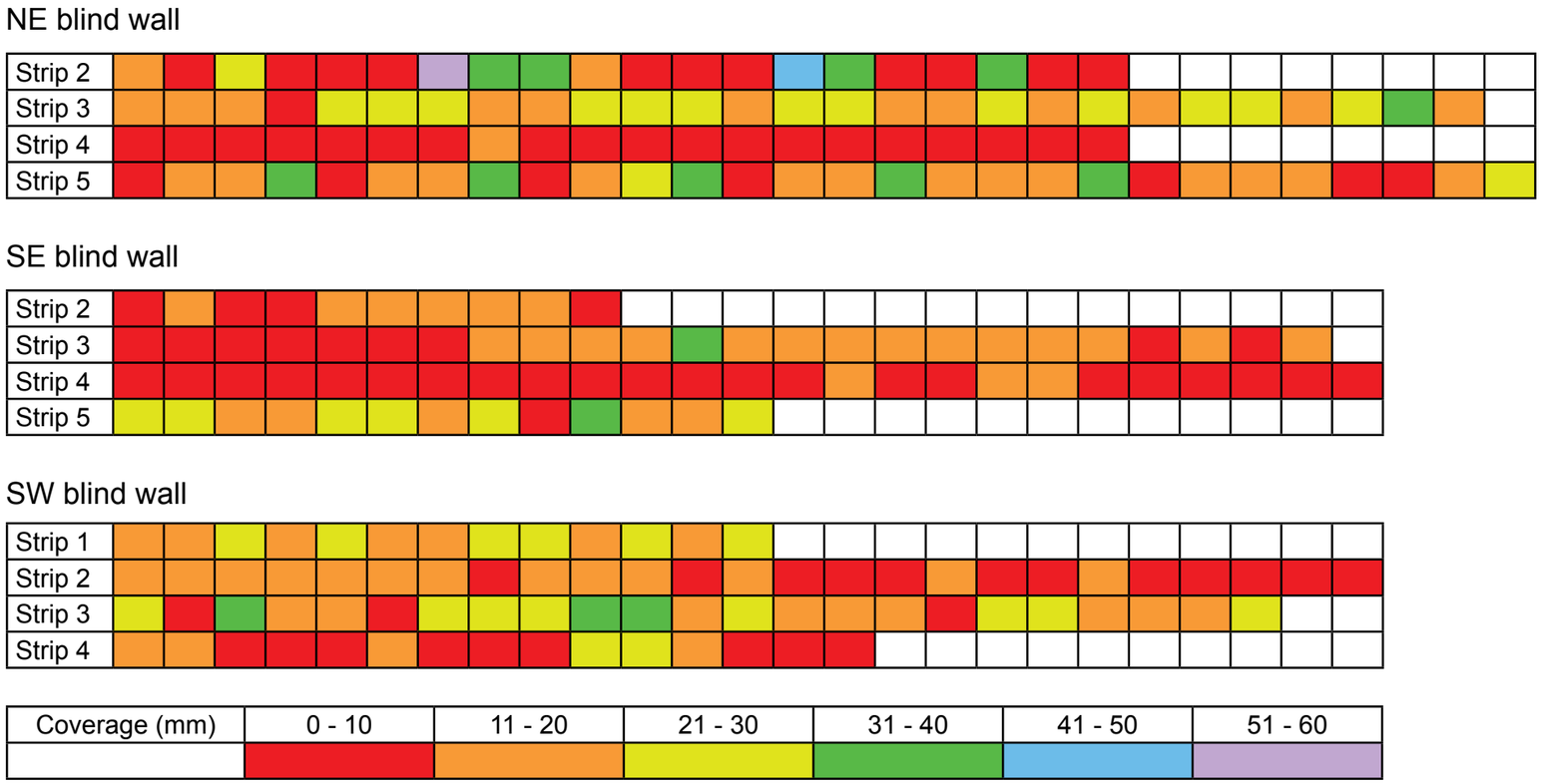


Figure 62: Sampling of the measures of the covering of the rebar in sections of the NE blind wall (above), SE blind wall (in the middle) and SW blind wall (below). The results obtained in the survey of the NW blind wall are incomplete and should be redone, therefore, they are not presented.

Photo: author and date unknown. Source: Rosa Artigas.

3.6

PHYSICAL PROPERTIES OF THE CONCRETE

Physical properties of the concrete

Based on the consultation of the documents available, it is possible to ascertain the characteristic strength of the concrete of the Vilanova Artigas building. The building was specified with a characteristic strength σ_{C28})[9] of 320 kgf/cm^2, according to the letter of Figueiredo Ferraz, structure designer, sent to the Fund for the Construction of São Paulo University – FUNDUSP, extracted from the thesis of Contier (2015, p. 293). In units currently used, the characteristic strength of the specified concrete can be considered as being approximately 32 MPa.

In the letter of Figueiredo Ferraz, it is clear that the specification of concrete for the foundation, underground slaps, curtain walls and retaining walls is different from the specification of the concrete he calls “structural”, therefore we conclude that the concrete of blind walls and roof beams would have the same specifications.

Giannechini (2009, p. 233) identified in this research that the concrete for the construction of FAUUSP building was provided by Holcin do Brasil (Holderbank Group), which started its operations in Brazil in 1951. However there is no explicit statement that the concrete has been produced in a batch plant, as in the construction of the Museum of Art of São Paulo (MASP[2]). However, the use of ready-mix concrete in the Vilanova Artigas building is possible because both buildings, FAUUSP and MASP, were designed and built approximately at the same period of time[11].

In Giannecchini´s dissertation (2009), there is indication of the concrete recipe used to cast the pillars of MASP. The concrete recipe, indicated in the volume proportions, will be used after conversion in relation to mass, based on the parameters indicated as follows. The concrete recipe obtained by means of this theoretical calculation is compared to the possible recipes of the Artigas building structured, obtained by means of chemical analyses.

Exploratory study of compressive strength

There was an opportunity to determine the compressive strength of a single concrete specimen extracted from the roof during the work done in the Vilanova Artigas building, between 2012 and 2015. According the specifications of the work bidding process, the specimen[12] was removed from a segment of a roof beam.

Before the test, the base and top of the specimen were mechanically rectified, a procedure stipulated in NBR5738 (ABNT, 2015) to obtain parallelism between the top and the base, and perpendicularity between the top and base, and specimen generatrix. The specimen measures were immediately taken before the test: diameter (d) of 75 mm and height (h) of 125 mm.

The compression test was performed according to NBR7680-1 (ABNT, 2015), applying the following coefficients of correction to the result: k1 = - 0.03 (h/d= 1.66) ; k2 = 0.09 (d=75 mm); k3 = 0 (extraction direction, the same of the concreting; and k4=-0.04 (specimen air-dried). The result of the test was the tensile strength of 60MPa. Applying the correction coefficients (fci,ext = [1+(k1 + k2 + k3 + k4)] × $f_{ci,ext,inicial}$), the inferred strength is 61.2MPa. Figure 63 shows the specimen before and after the test.

Although the shape of rupture (approximately columnar, as stipulated in Annex A of NBR5739, ABNT, 2007) can suggest some influence of the specimen preparation, the result is above the expected one. The visual analysis of the Specimen evidences the concrete compactness with few air bubbles detected.

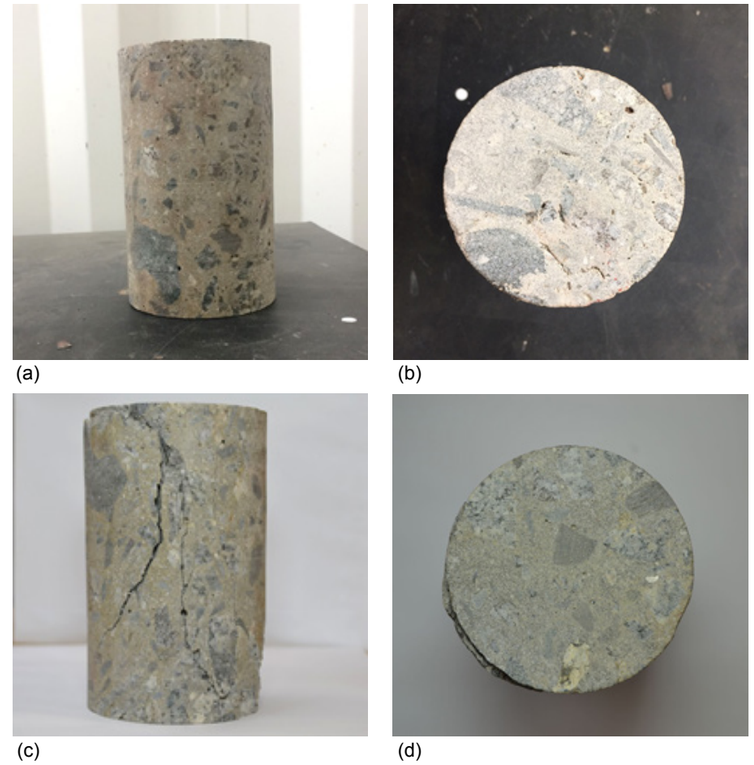


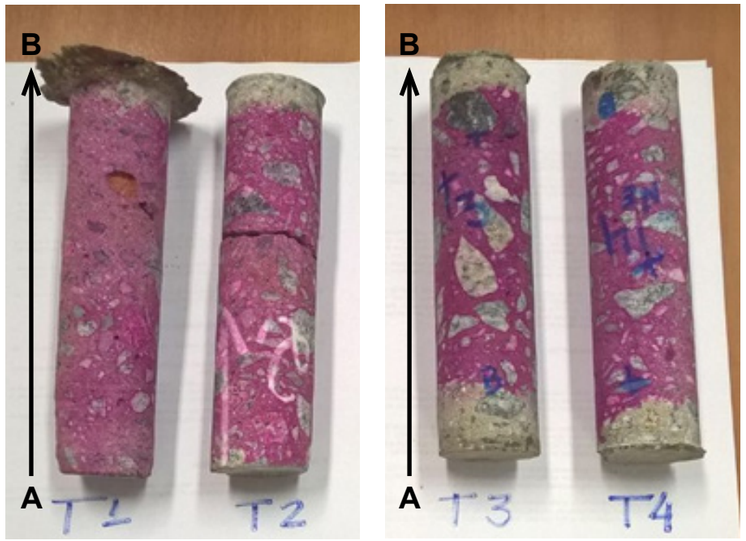
Figure 63: Concrete specimen of the roof beam, extracted during the 2012-2015 work, used for the exploratory test of compressive strength: (a) front view and (b) upper view of the specimen before the compression test; (c) front view and (d) upper view of the Specimen after the compression test. In (d), the type of rupture can be observed.

[9] σC28: notation used in the Brazilian Standard. 1 (NB-1:1960) (ABNT, 1960) to designate the average concrete compressive strength, determined in cylindrical specimens at 28 days of age, based on statistical criteria applied to the results of tests of concrete quality control.

[10] Architectonic design by Lina Bo Bardi, concrete structure calculation (reinforced and prestressed) by José Carlos de Figueiredo Ferraz Engenheiros Consultores, and concrete supplied by Concretex company (GIANNECHINI, 2009, p. 151).

[11] MASP design started in 1957, and the construction was done between 1960 and 1969 (GIANNECHINI, 2009, p. 11, p. 155, and p. 157).

[12] According to the design specifications (Process.) the system originally designed for the vertical rainfall draining pipeline should be executed. This required to drill holes in part of the roof beams, from which concrete cores with diameter 75 mm and variable length, depending on the drilling site, were extracted. Only one concrete core was preserved for being intact; the others were discarded during the work.



NW blind wall: specimen T1 and T2 NE blind wall: specimen T3 and T4

Figure 64: Concrete cores extracted from blind walls: to the left NW blind wall; to the right NE blind wall. The arrow indicates the direction of the machine moving during the specimen extraction. For the T1 and T2, the end (A) represents the external face of NW blind wall. For the T3 and T4, the end (A) represents the external face of NE blind wall.

Figure 65: Depth measures of the carbonation front taken from specimen T3, extracted from NE blind wall: internal depth of approximately 30 mm; external depth of approximately 20 mm.

Compressive strength of concrete cores

The concrete cores extracted from the blind walls are shown in Figure 64. The solution of phenolphthalein was sprinkled on the surface of the concrete cores as soon as they were removed from the blind walls. For the T1 and T2 concrete cores, the end (A) represents the external face of NW blind wall (the extraction was done from outside to the inside). For the T3 and T4 concrete cores, the end (A) represents the external face of NE blind wall (the extraction was done from the inside to the outside).

Concrete cores T1 and T2 of NW blind wall, in the external A ends, does not show signs of carbonation in the limit detected by phenolphthalein. In turn, in the internal B ends, the carbonation front is at approximately 15 mm of depth.

Concrete cores T3 and T4 of NE blind wall, in the external B ends, tend to present carbonation front of the same intensity, or a little smaller than the carbonation front of the internal A ends. The internal average is approximately 30 mm, and the average depth of carbonation at the external face of NE blind wall is approximately 22 mm. Figure 65 shows the depth averages of the carbonation front in specimen T3, extracted from NE blind wall.

This tendency of bigger depth of carbonation in internal environments, protected from rainfall, is in accordance with the technical references (RAUPACH; BÜTTNER, 2014), due to the smaller contents of concrete humidity that allows higher carbonation rates. In the same internal conditions, the extension of corrosion is not significant because of the unavailability of water.

The compressive strength of specimens prepared based on the concrete cores, with values already corrected by coefficients k1, k2, k3 and k4, are in Table 12.

Considering the dismissal of values located ±15% outside the average interval, as per item 6.2 of NBR 7680-1 (ABNT, 2015), only the average value of the beam concrete strength is directly reduced, from 50 MPa to 49.3 MPa. The average values suggest that the concrete of the sampling regions of NW and NE blind walls, statistically have the same strength.

From the literature specialized in the study of concrete strength, such as, for instance, Tango (1990), it is possible to infer that the tendency of increasing concrete strength over the time can be explained by the continuous hydration reactions in the hardened concrete. Such correlation is valid for experimental verifications in specimens stored in controlled temperature and humidity conditions. However, as a rule, in the structure the strength increase is offset by the effects of the slow deformation of the concrete, weather action, and other factors reducing its strength. Thus, it is not possible to affirm that the higher strength reached by the concrete extracted from the beam (49.3 MPa) is the effect of time on the increase of strength of a concrete with characteristic strength of 32 MPa. Therefore, the results suggest that, in principle, it cannot be affirmed that the structure was cast with a concrete dosed based on a single characteristic strength. Complementary analyses should be done to clarify the issue.

The issue of determining the strength to be considered in the analytical verification of the structure safety is a topic for further research. Additional investigations, considering the program of non-destructive tests, such as, for instance, ultrasound wage propagation, are in progress and should provide, along with other possible extractions of concrete cores (in other concreting stages), provide a broader picture to determine the calculation strength with lesser uncertainty.

Elasticity modulus of the concrete cores

The static modulus of elasticity of the concrete cores removed from the beam was determined based on NBR 8522 (ANBR, 2008), using methodology A, with fixed strength (0.50 MPa), and loading plan with nominal strength of 30% of the compression tensile strength of concrete (50MPA of average strength, as per Table 13).

Table 13 contains the results obtained in the test to determine the elasticity modulus.

The average value of 29GPa, or even the relation of this value with the estimated compression strength, should be analyzed based on the results obtained in similar conditions. The use of expressions usually suggested by technical codes and standards, used to estimate the elasticity modulus, is also not indicated because, in general, the expressions are applicable to ages of 28 days.

Table 12: Result of the compression test of specimens with 50 mm diameter, prepared based on the concrete cores removed from NW, NE blind walls, and from the beam.

Place of extraction	Specimen	$f_{ci,ext}$	$f_{ci,ext}$ ±15% (*)
NW blind wall	1A	33,6	
	1B	39,1	
	2A	42,0	
	Average	38,2	38,2
	Standard deviation	4,3	
	Variation coefficient	11,3	
NE blind wall	3A	34,6	
	3B	35,4	
	4A	44,1	
	Average	38,0	38,0
	Standard deviation	5,3	
	Variation coefficient	13,9	
Beam	8	37,7	
	8A	48,2	
	8B	49,0	
	9	51,3	
	9A	49,7	
	9B	59,5	
	12	59,2	
	12A	45,1	
	12B	54,8	
	13	49,2	
	13A	48,5	
	13B	48,1	
	Average	50,0	49,3
	Standard deviation	5,92	
	Variation coefficient	11,8	

(*) Average values corrected considering the provisions of item 6.2 of NBR 7680-1 (ABNT, 2015); values with divergence of ±15% in relation to the average were removed.

Table 13: Results of the compressive strength and elasticity modulus of specimens obtained from the concrete cores extracted from the roof beam.

Number of the concrete core	Compressive strength after tests of the modulus (MPa)	Elasticity modulus (GPa)
5	35,0	30,6
6	35,3	28,9
10	29,6	27,4
Average	33,3	29,0

Table 14: Results of tests to determine the physical properties of specimens obtained based on the concrete cores extracted from the roof beam.

Absorption (%)	Index of gaps (%)	Specific mass of the dry sample (g/cm³)
6,0	13,5	2,25

Water absorption, index of gaps, and specific mass of concrete cores

The physical properties values were obtained by means of tests with the concrete extracted from the beam, as per NBR 9778 (ABNT, 2005), and are shown in Table 14.

The results of the gaps index will be used to compare with the porosity determined by mercury intrusion porosimetry.

Reconstitution of the concrete recipe

The possible concrete recipes were for the samples of NW blind wall, NE blind wall, and roof beam, according to the procedures presented in chapter 3. However, here the parameters used in the calculation of the cement consumption were repeated:

• specific mass of cement: 2.91g/cm³;

• specific mass of aggregates: 2.65 g/cm³;

• specific mass of water: 1.00g/cm³;

• water/agglomerant ration: 0.5;

• index of gaps: 2%.

As comparison, as already mentioned, the recipe for the cast of MASP pillars is used, according to registration by Giannccchini (2009, p. 163). To convert the mass recipe to volume, exposed in Table 15, the following parameters were used, in addition to those of specific mass already pointed out in the previous paragraph:

• dry unit mass of sand: 1.431 kg/L;

• unit mass of gravel 1: 1.338 kg/L;

• unit mass of gravel 2: 1.352 kg/L;

• humidity contents of sand: 3.0%;

• sand swelling: 30%.

The concrete recipes of Vilanova Artigas building, obtained through chemical analysis, along with the theoretical reference of MASP recipes, are presented in Table 15.

The coherence between the individual values obtained by the calculations done based on the 3 parameters used (insoluble residue, silicic anhydride, and calcium oxide), suggests that the average recipe calculated can be used as reference. The cement consumption above 400kg/m³ was, in a way, expected based on the visual analyses of the specimen used in the exploratory test of compressive strength. The results suggest that the recipes of places investigated in NW blind wall and beam have an average cement consumption of 424 and 425 kg/m³, respectively, above the consumption calculated for NW blind wall, which average value is 409 kg/m³. The values of the aggregate/cement ratio (in mass) are very close for the 3 recipes, between 3.0 and 4.1.

The recipes used in MASP, according track records in Giannecchi (2009), suggest that the recipe of MASP pillar is more similar to the recipes used for the analyzed samples of Artigas building. The cantilever recipe, according to the calculations done, is richer because it has a cement consumption above 500 kg/m³. The values of the theoretical calculation seem coherent with the information contained in the dissertation by Giannecchini (2009, p.139) of consumption of 565 kg/m³ for the concrete used to cast the cantilever.

The a/c ratio of 0.50 of the Artigas building concrete is a parameter used in the analysis, as detailed in the test procedures. A new consumption calculation can be done, considering a possible a/c ratio below 0.50, such as the values used in the recipes of MASP.

Table 15: Reference of the recipe in volume obtained in Giannecchini (2009, p.163) in mass calculated based on the presented parameters and assumptions. Concrete of pillar and cantilever of MASP building. In these recipes, the contents of chemical additive were omitted.

	Component	Recipe in volume		Recipe in mass	
		Unit	Qty	Unit	Qty
PILLAR	Votoram cement	cement bag	1	kg	1
	Jacareí sand	L	66		1,453
	Cantareira gravel (50% gravel 1 and 50% gravel 2)	L	94		1,258
					1,271
	Water	L	19		0,424
CANTILEVER	Votoram cement	cement bag	1	kg	1
	Jacareí sand	L	23,6		0,52
	Cantareira gravel (gravel 1)	L	78,7		2,16
	Water	L	15,5		0,33

Table 16: Results of the reconstitution of the concrete recipe of Artigas building, and reference of the comparison of the concrete used in the construction of the Museum of Art of São Paulo - MASP.

		Artigas building Results of the recipe reconstitution			MASP (*)
		NW blind wall	NE blind wall	Beam	Pillar
Calculation based on the insoluble residue (IR)	Cement (%)	19,8	19,7	19,9	
	Siliceous aggregate (%)	80,2	80,3	80,1	
	Recipe (cement:aggregate)	1:4,1	1:4,1	1:4,0	
	Cement consumption (kg/m^3)	412	411	414	
Calculation based on the silicic anhydride (SiO2)	Cement (%)	20,6	20,6	22,6	
	Siliceous aggregate (%)	80,2	80,3	80,1	
	Recipe (cement:aggregate)	1:3,9	1:4,2	1:3,5	
	Cement consumption (kg/m^3)	424	403	450	
Calculation based on the calcium hydroxide (CaO)	Cement (%)	21,4	19,8	19,6	
	Siliceous aggregate (%)	80,2	80,3	80,1	
	Recipe (cement:aggregate)	1:3,7	1:4,1	1:4,1	
	Cement consumption (kg/m^3)	434	413	411	
Average values	Cement (%)	20,6	19,5	20,7	
	Siliceous aggregate (%)	80,2	80,3	80,1	
	Recipe (cement:aggregate)	1:3,9	1:4,1	1:3,9	1:3,9
	Cement consumption (kg/m^3)	424	409	425	432
a/c		0,50 **(**)**			0,42 **(***)**

(*) Free theoretical exercise of conversion of the recipe from volume to mass, based on the data on the original recipe (in volume) registered in GIANNECCHINI (2009, p 163).
(**) parameter adopted for the calcium of cement consumption in the reconstitution of the concrete recipe of Artigas building.
(***) water/cement ration inferred from the correction of humidity of MASP concrete sand.

Photo: author and date unknown. Source: Rosa Artigas.

3.7

ASPECTS OF THE CONCRETE MICROSTRUCTURE

Aspects of the concrete microstructure

As explained in chapter 3, the results of the petrographic analysis are still in the exploratory stage. Therefore, preliminarily and according to the provisions of standards NBR 7389-1 (ANBT, 2009) and NBR 7389-2 (ANBT, 2009), the results suggest for the analyzed samples

Aggregates characteristics

As for small aggregates:

• angular and subangular grains;

• high and low sphericity;

• grain size between 0.15 mm and 2.5 mm, with predominance of coarse sand fraction (approximately 0.7 mm) at the Wentworth scale;

• mineralogical composition, in decreasing order of abundance: quartz, mesopertitic microcline, polycrystalline quartz, opaque, actinolite amphibole, biotite, and muscovite;

• in principle, the can be considered as potentially non-reactive;

As for coarse aggregates, according to NBR 7389-2 (ANBT, 2009):

• subangular grains with low sphericity.

• lithologic composition: rock 1: gneissic metamorphic (gneisse actinolite), composed of fine quartz (50 to 150 micrometers), actinolite, green biotite, epidote, titanite, brown biotite and opaque; granonematoblastic texture;

• lithologic composition: rock 2: altered gneissic metamorphic (gneisse biotite), composed of strongly sericitized plagioclase, mesopertitic microcline, quartz with sutured edges, pistachite epidote, titanite, apatite, interstitial carbonate filling microfissures; granoblastic texture;

• aggregate nature: metamorphic;

• probable maximum diameter of gravel reaching 30 mm;

• so far, the natural hydrothermal alteration of the rock was observed (seritization); however, the possible presence of sulfides and their degree of alteration still have to be verified;

• the presence of potentially reactive fine quartz was observed.

The risk posed by fine quartz, potentially reactive, should still be better analyzed along with other data. But the probable presence of sulfides, if confirmed, can reinforce the hypothesis of contamination of the coarse aggregate.

Mercury intrusion porosimetry

As shown before, the mercury intrusion method provides uncertainty about the actual size of pores and about their distribution. However, the results herein presented are important to understand the patterns found for the studied concretes, as well as for its qualitative analysis, when comparing carbonated concrete with non-carbonated concrete, and also when compared to the data of other experimental researches.

The red line in the graphs of the following Figures indicates the minimum limit (0.1 μm or 100nm) of the size of pores that have a strong influence in the transportation of mass in the concrete, according to Meng (1994). The interest is to analyze the mesopores volume variation due to their bigger interference with the concrete behavior, especially regarding the compressive strength.

The curves relating the volume of mercury introduced in the concrete and the opening of the pore, given by its equivalent diameter, are shown in Figure 66 and Figure 67, respectively, for NE blind wall and NW blind wall.

The curves of Figure 66 (a) show that the carbonated region has, in general, a volume of pores smaller than that of the non-carbonated region. The curves of Figure 66 (b) show that the carbonation strongly influenced the reduction of porosity in the range between 3 μm and 0.6 μm (600 nm), practically eliminating the porosity in that range. From this point, the curves go on approximately parallel indicating that the carbonation has no major influence on the reduction of the volume of pores with diameter smaller than 0.6 μm. (600 nm).

Similar analysis can be done for the NW blind wall sample, but with changed range of diameters influenced by carbonation. In the curves of Figure 67, results evidence that carbonation seems to exert a bigger a higher in the reduction of porosity in the range of diameters approximately between 0.3 μm (300 nm) and 0.03 μm (30 nm).

Such remarks are in accordance with the specialized literature of the field that indicates that carbonation can lead to the reduction of porosity of Portland cement-based matrices.

Figure 68 shows the data of test done with samples removed from the roof beam. In this in case, the situation is inverted. Carbonation seems to increase the volume of pores for the diameter range approximately smaller than 2 μm (2000 nm)[13].

[13] The tests were repeated for the beam and the tendancy of the increase of the porosity with the carbonation was again detected

Since the difference between porosities seems to increase with smaller diameters, a hypothesis is that C-S-H carbonation, and consequently the resulting retraction and fissuring, as seen before. Even though the MIP is limited to comparative analyses, and is not the most adequate to study nanoporosity, it is recommendable to investigate this hypothesis. Furthermore, despite the validation or not of such hypothesis, an in-depth investigation of the effects of calcium silicates carbonation is necessary, given their influence in changing the C-S-H matrix stability.

Table 17 summarizes the numerical data of porosity in the range of diameters above and below the limit of approximately 0.1 μm (100 nm). The value used as reference was the 0.108 μm diameter that corresponds to the level of pressure measured for all the samples.

As already pointed out, the results of the test of mercury intrusion in the blind wall samples are in accordance with the literature data that indicate, in general, the reduction of the total porosity with carbonation. The beam samples are exceptions, which study needs to be deepen.

Another way to interpret the results of the test of mercury intrusion porosimetry, and which allows comparing such results with the others from literature, is the construction of accumulated porosity curves versus diameter, and of the variation of the introduced volume/variation of diameter logarithm versus diameter. From this later curve, the critical diameter representing the diameter of the pore that forms a continuous channel in the material can be extracted. As already mentioned, Garboczi (1990) uses the critical diameter to define the volume with pores with diameter bigger than the critical diameter (dc) as being the portion exerting strong influence in the permeability of the porous material. Such curves for the NE and NW blind walls samples are represented in Figure 69 and in Figure 70, respectively. It is noteworthy that the curve of accumulated porosity indicates, in its upper end, the total porosity of the tested sample, and which can be read in the ordinate axis. The values of total porosity and critical diameters (d_{crit}) are also presented in Table 18.

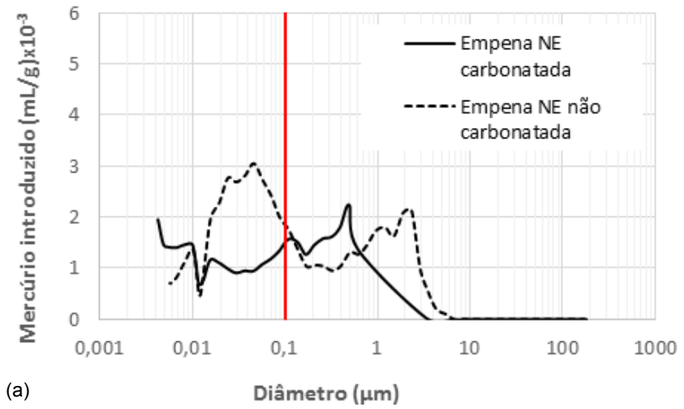


Figure 66: Concrete samples, carbonated and non-carbonated, removed from NE blind wall. (a): curve of mercury introduced versus opening of pores given by their equivalent diameter. (b): curve of the accumulated mercury volume.

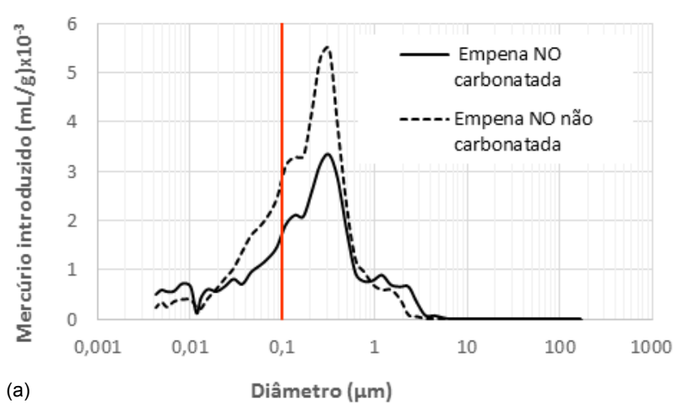


Figure 67: Concrete samples, carbonated and non-carbonated, removed from NW blind wall. (a): curve of mercury introduced versus opening of pores given by their equivalent diameter. (b): curve of the accumulated mercury volume.

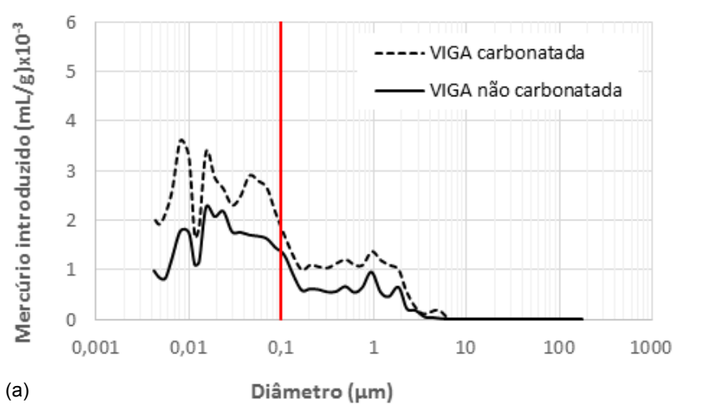


Figure 68: Concrete samples, carbonated and non-carbonated, removed from the roof beam. (a): curve of mercury introduced versus opening of pores given by their equivalent diameter. (b): curve of the accumulated mercury volume.

Table 17: Volume of mercury introduced in the samples removed from blind walls (mL/g) x 10^{-3}.

Diameter (µm)	NE blind wall		NW blind wall		Beam	
	Carbonated	Non carbonated	Carbonated	Non carbonated	Carbonated	Non carbonated
d > 0,108	12,810	21,745	23,698	32,613	16,033	8,753
d ≤ 0,108	21,772	30,763	14,069	18,326	45,111	27,619
Total (d ≥ 0,004)	34,581	52,508	37,767	50,93965	61,144	36,372

Table 18: Porosity and critical diameter of samples removed from blind walls and the roof beam. Data obtained through the test of mercury intrusion porosimetry, based on ΔV/ΔlogD curves versus equivalent diameter, and accumulated porosity versus equivalent diameter.

	NE blind wall		NW blind wall		Beam	
	Carbonated	Non carbonated	Carbonated	Non carbonated	Carbonated	Non carbonated
Porosity (%)	7,5	11,9	9,1	11,6	13,2	8,7
Critical diameter (d_{crit})(µm)	0,5 * 0,01 **	2,0 * 0,05 **	0,3	0,3	1,0 * 0,05 ** 0,01 ***	1,0 * 0,01 **

Notes: * Considering the first inflexion point of the accumulated porosity curve.
** Considering the second inflexion point of the accumulated porosity curve.
*** Considering the third inflexion point of the accumulated porosity curve.

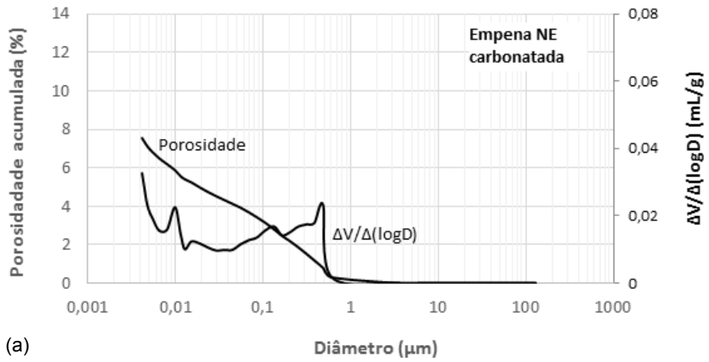


Figure 69: Curves representing the relation between pores opening (given by their equivalent diameter), the accumulated porosity, and the variation of the introduced volume by the variation of the diameter logarithm (ΔV/ΔlogD). Above (a): sample removed from the carbonated region of NE blind wall. Below (b): sample removed from the non-carbonated region of NE blind wall.

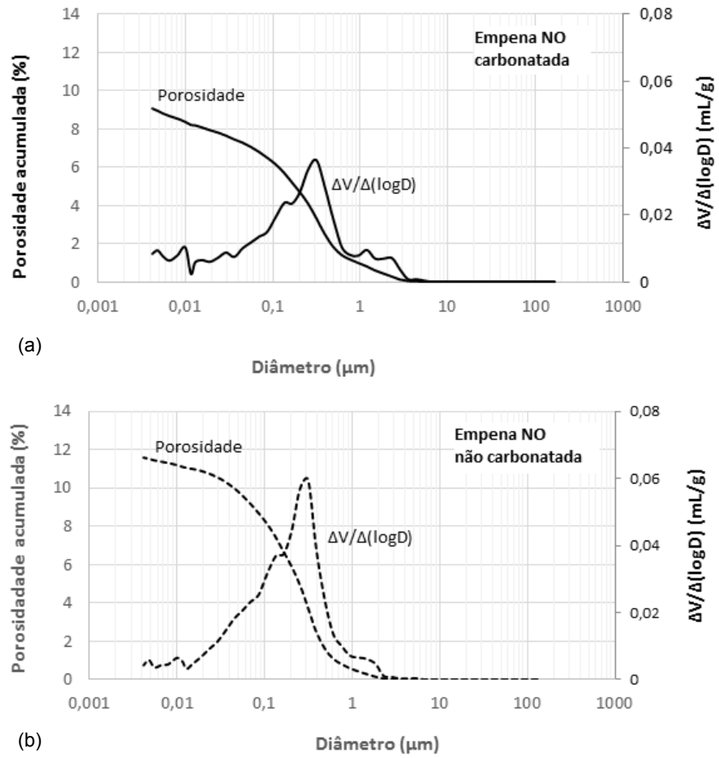


Figure 70: Curves representing the relation between pores opening (given by their equivalent diameter), the accumulated porosity, and the variation of the introduced volume by the variation of the diameter logarithm (ΔV/ΔlogD). Above (a): sample removed from the carbonated region of NW blind wall. Below (b): sample removed from the non-carbonated region of NW blind wall.

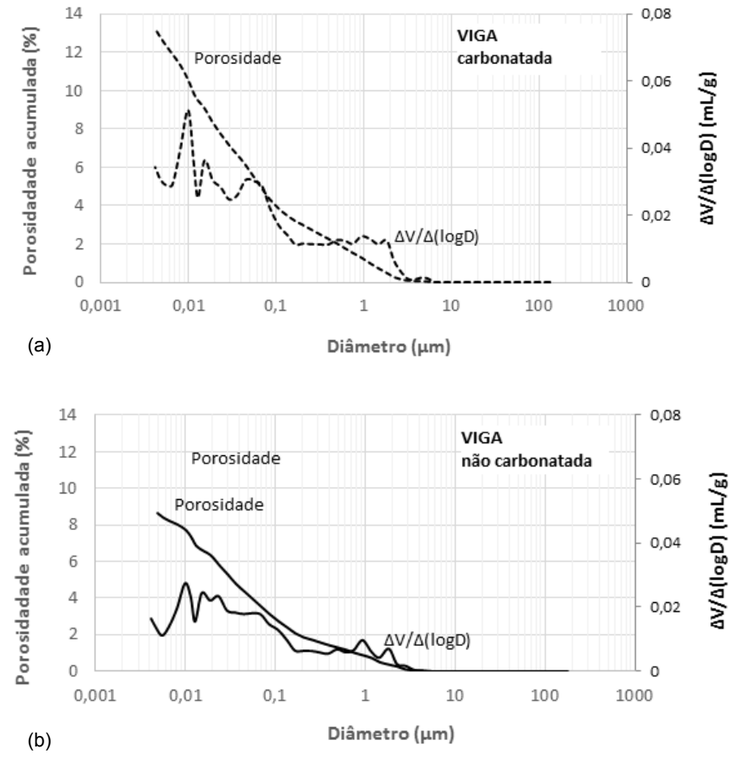


Figure 71: Curves representing the relation between pores opening (given by their equivalent diameter), the accumulated porosity, and the variation of the introduced volume by the variation of the diameter logarithm (ΔV/ΔlogD). Above (a): sample removed from the carbonated region of the roof beam. Below (b): sample removed from the non-carbonated region of the roof beam.

The observation of data related to NE blind wall evidences that in the carbonated region sample, the peak (first peak from the right to the left) is dislocated to the range of smaller diameter, from 2.0 to 0.5 µm. According to the literature data, the fact evidences the so-called “refinement” of pores. The total porosity is reduced with carbonation, varying from 11.9 to 7.5% (see Table 18).

In the curve of Figure 70 that represents the curve for the NW blind wall sample, carbonation seems not to influence the position of the critical diameter, however, the peak intensity is reduced resulting in the reduction of the total porosity from 11.6 to 9.1%.

For the curves related to the beam samples, the different behavior is confirmed. In Figure 71, the increase of porosity with carbonation, from 8.7 to 13.2%, is clear. The value of 8.7% for the non-carbonated region of the beam seems to be coherent if compared to the index of gaps of 13.5% also measured for the beam concrete, because water penetrates smaller pores than mercury. In such curves, the critical diameter is difficult to define. The distribution of pores seems to adjust to a two-sided distribution, as called by some authors, and this can represent a characteristic of the material that has two different sets of pores, or it can represent the rupture of the internal structure by the pressure exerted by mercury. In this later hypothesis, the new volume of mercury introduced in the sample occupies a porous space that was isolated before because of the precipitation of products hydrated over time. Regardless of the justification, for the beam samples, carbonation seems to increase porosity, opposite to the tendency observed in the blind walls concrete.

Table 18, as already explained, contains values regarding total porosity and critical diameter. The bar graph of Figure 72 was elaborated based on such data.

The data presented in Figure 72 allow for a partial conclusion that the permeability of tested samples, for the concrete of NE blind wall and for the beam, is not significantly affected by carbonation. For NW blind wall, data suggest that the carbonated concrete has a larger amount of pores with diameter bigger than the critical one, which can theoretically increase permeability.

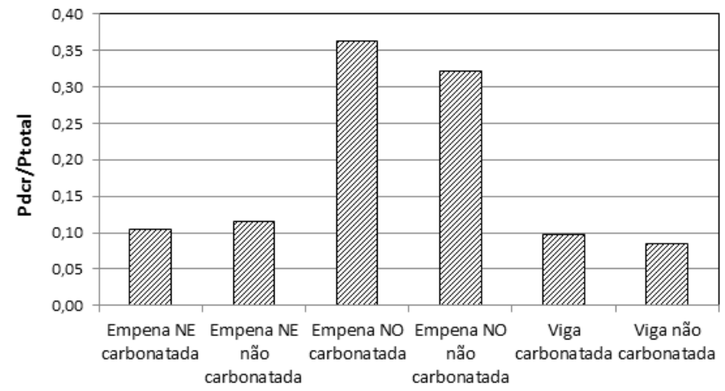


Figure 72: Relation between accumulated porosity corresponding to the critical diameter and the total porosity.

Morphological aspects of concrete microstructure

The image of Figure 73 possibly shows the trace of a wooden fiber found in the specimen removed from the carbonated region, and thus from the external face of the NE blind wall. The suspicion can be corroborated by the detection of small chips during the visual inspection of blind walls, and by the high contents of carbon indicated in the elementary analysis done with energy-dispersive X-ray spectroscopy (EDS). As in the inspections done so far, the presence of such residues seem to be discrete and not jeopardize the durability of the structure, and their removal is not recommendable because of the inevitable marks left on the concrete surface.

In the micrographs obtained in the analysis of the fracture sections presented as follows, some characteristics of the internal structure of the tested samples are shown. The usual notation of the cement chemistry[14] is used to indicate the compounds.

The internal structure of the non-carbonated region of NW blind wall is in Figure 74. In Figure 74 (a), we observe in the smaller magnification (5,000X) the black voids; with magnification of 10,000X, the features of the hydrated compounds are no longer distinguishable, and with bigger magnification (20,000X), it is possible to observe the main hydrated products of the Porltand cement paste, the hydrated calcium silicate (C-S-H) composed of low crystallinity of fibrous or alveolar habit (ZAMPIERI, 1993) and the Porltandita or calcium hydroxide (CH).

In Figure 75, the fracture section of a sample of the carbonated region of the concrete extracted from NE blind wall is shown.

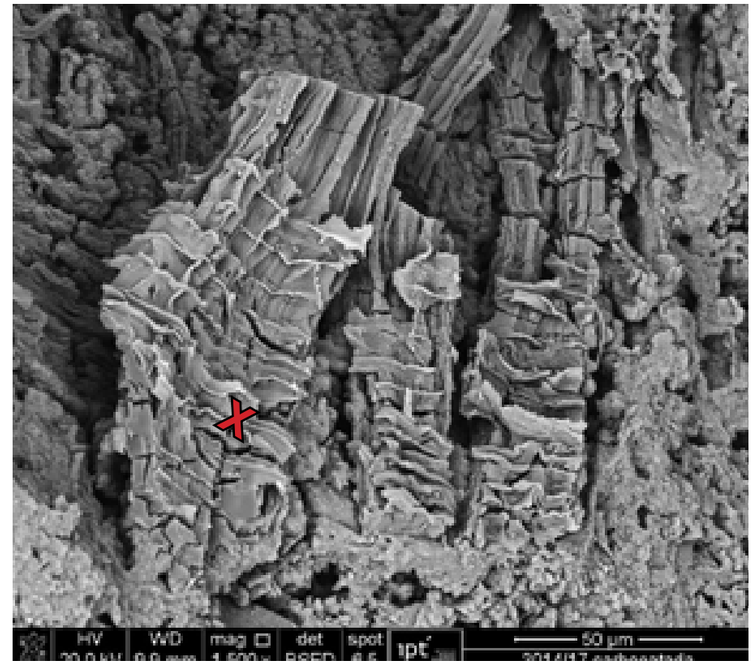
In Figure 75, in the bigger magnification, calcium carbonate ($C\bar{}C$) compounds can be observed, evidencing the effect of carbonation, $C\bar{}C$ precipitates, rectifying the voids of the paste, potentially producing the effect of porosity reduction, as shown by the results of the mercury intrusion porosimetry test.

The C-S-H structure of fibrous habit can be seen in the micrograph of the fracture section shown in Figure 76. The sample was obtained from the non-carbonated region of the beam and shows, in the smaller magnification (5,000X) a structure apparently more compacted that than seen in the same magnification of the micrograph of the non-carbonated region of NW blind wall concrete.

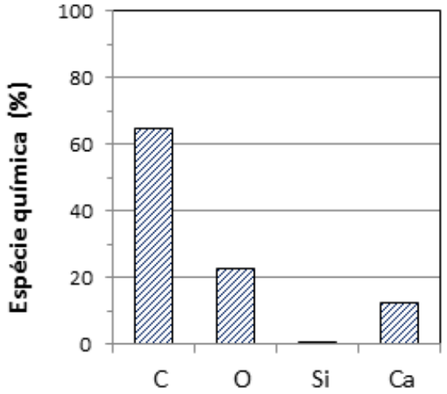
The C-S-H structure (20,000X magnification) showed in Figure 76 corresponds to the structure found in literature like the one in Figure 77 (a). According to the authors (WALSH et al, 1974), this C-S-H interaction is responsible for the paste strength; the formation occurs by the C-S-H growth from cement grains, and is also mentioned by Bishnoi and Scrivener (2009).

The EFigure 78 shows two observations made in the analyzed samples of NW blind wall.

To the left of Figure 78 in (a) we can observe the calcium hydroxide in the carbonated region of the NW blind wall concrete, showing that the CH can coexist with the precipitated $C\bar{}C$, depending on the local chemical balance. To the right (b) anhydrous or partially hydrated grains can be seen, the so-called belite zones (CENTURIONE, 1999).



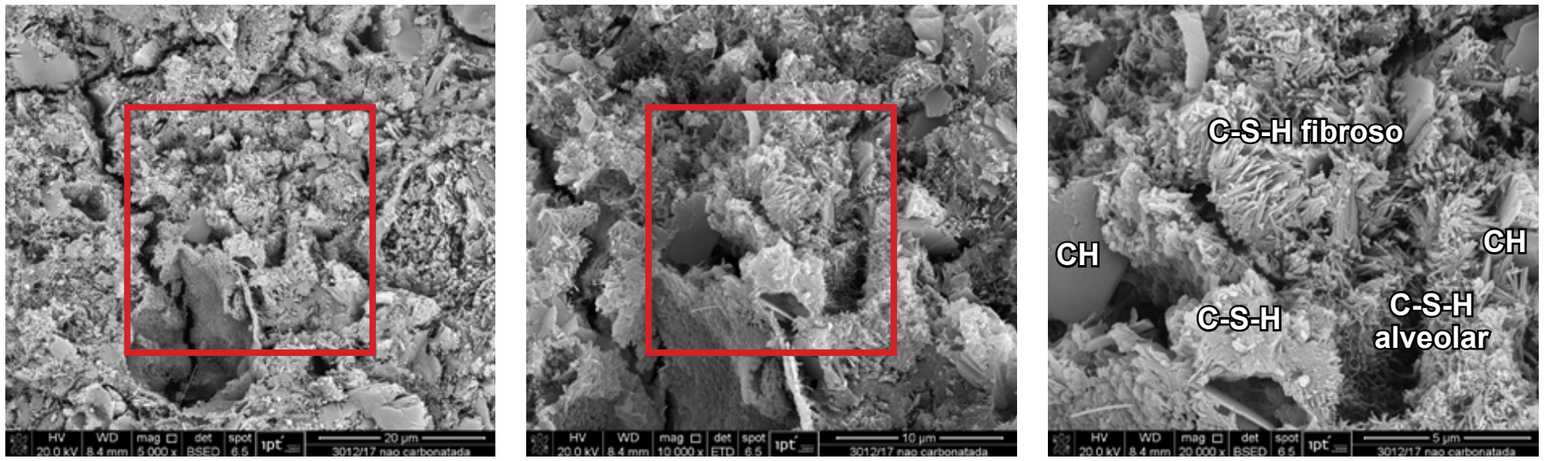
(a) 1,500 X magnification



(b) Percentage in mass of chemical species present in the point signed with the red cross in (a)

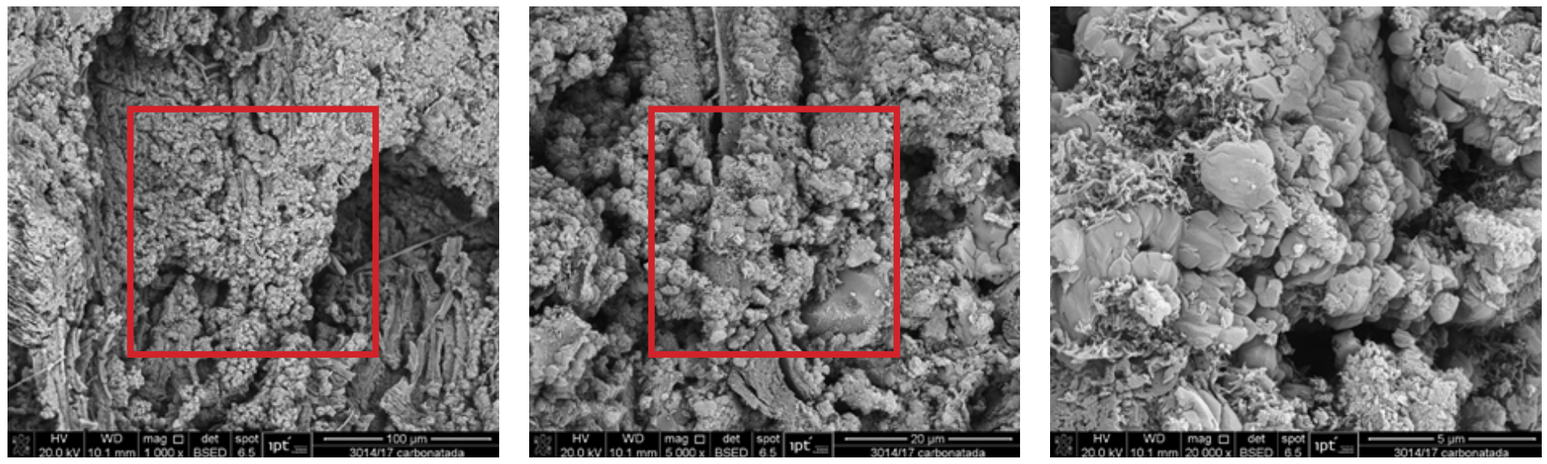
Figure 73: Visualization of the fractured section. (a) Possible trace of organic matter (coming from the wooden mould) in the specimen removed from the carbonated region of NE blind wall, and (b) quantification of species present of the material surface by EDS (see red sign in the image).

[14] C = CaO ; S = SiO_2 ; A = Al_2O_3 ; F = Fe_2O_3 ; H = H_2O ; S = SO_3; $\bar{}C$ = CO_2 ; K = K_2O ; N = N_2O ; M = MgO ; AFm = aluminatos ; C-S-H silicato de cálcio hidratado.



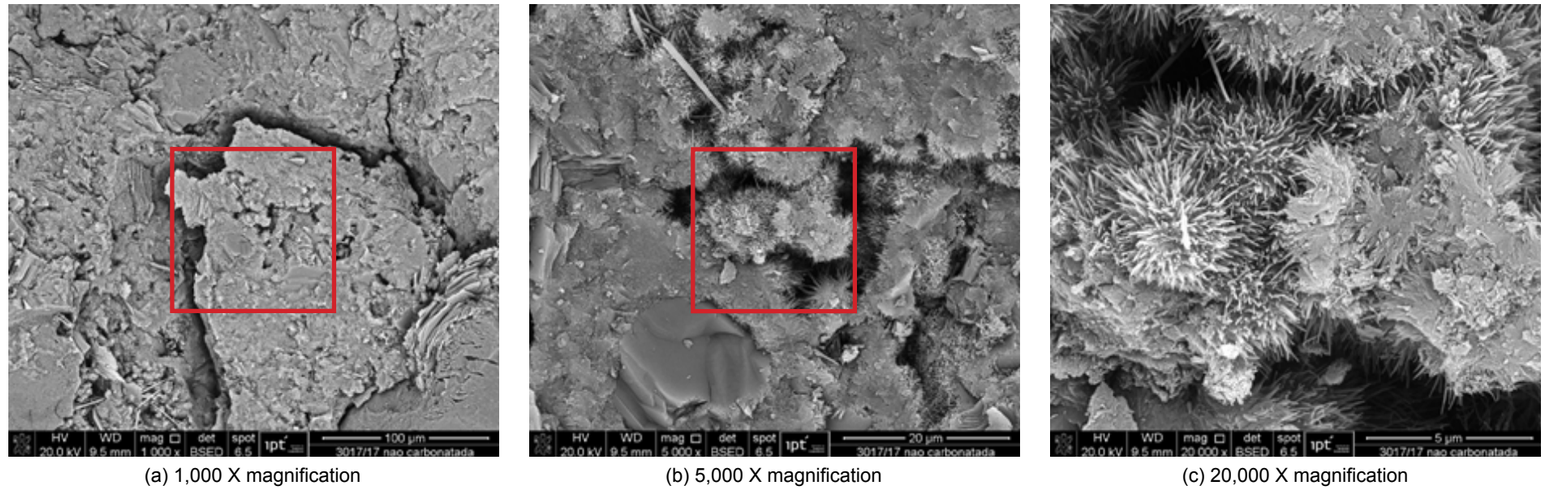
(a) 1,500 X magnification (b) 10,000 X magnification (c) 20,000 X magnification

Figure 74: Visualization of the fractured section. Specimen removed from the non-carbonated region of the concrete core extracted from NW blind wall.



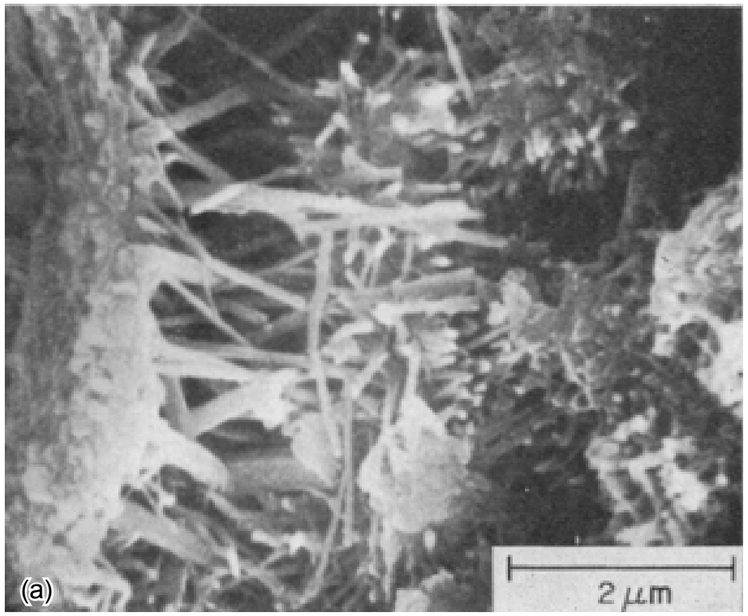
(a) 1,000 X magnification (b) 5,000 X magnification (c) 20,000 X magnification

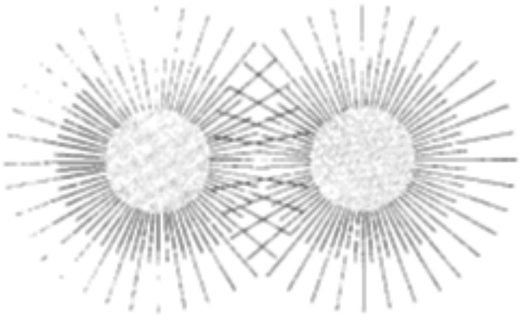
Figure 75: Visualization of the fractured section. Specimen removed from the carbonated region of the concrete core extracted from NE blind wall.



(a) 1,000 X magnification (b) 5,000 X magnification (c) 20,000 X magnification

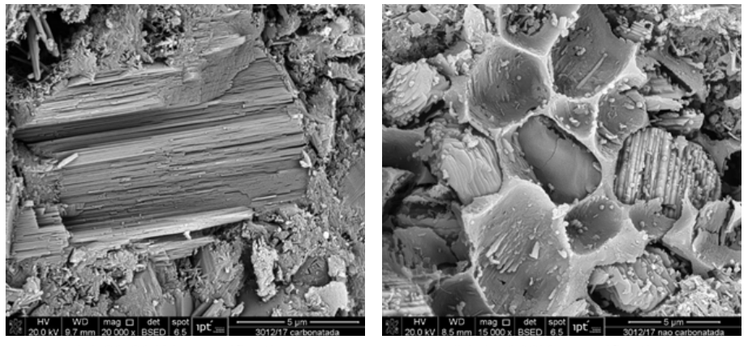
Figure 76: Visualization of the fractured section. Specimen removed from the non-carbonated region of the concrete core extracted from the roof beam.





(b)

Figure 77: (a) View of the region of C-S-H structures interlacing. (b) Schematic sketch presented by the authors to represent the interaction of C-S-H (based on WALSH et al, 1974).



(a) 20,000X magnification
NW blind wall, carbonated region

(b) 15,000X magnification
NW blind wall, non-carbonated region

Figure 78: Visualization of the fractured section. Specimens removed from (a) carbonated region, and (b) non-carbonated region of the concrete core extracted from NW blind wall.

Identification of phases

The images obtained during the analysis of polished sections are shown in the following figures. Figure 79 shows the polished section of the concrete from NE and NW blind walls, and from the beam.

The observation of EFigure 79 (a) and (b), with 500X magnification, allows for the identification of possible traces of leaching in the black color areas surrounding the aggregate indicated by AG. The possible sign of leaching seems stronger in the concrete of NE blind wall. In the beam concrete, leaching signs are not perceptible.

The Figure 80 shows details, with 1,000X magnification, of the region of interface between paste and small aggregates. It is noteworthy that the edges of aggregates are intact, with no significant signs of deterioration, which can be a sign of paste sanity, at least in the observed areas.

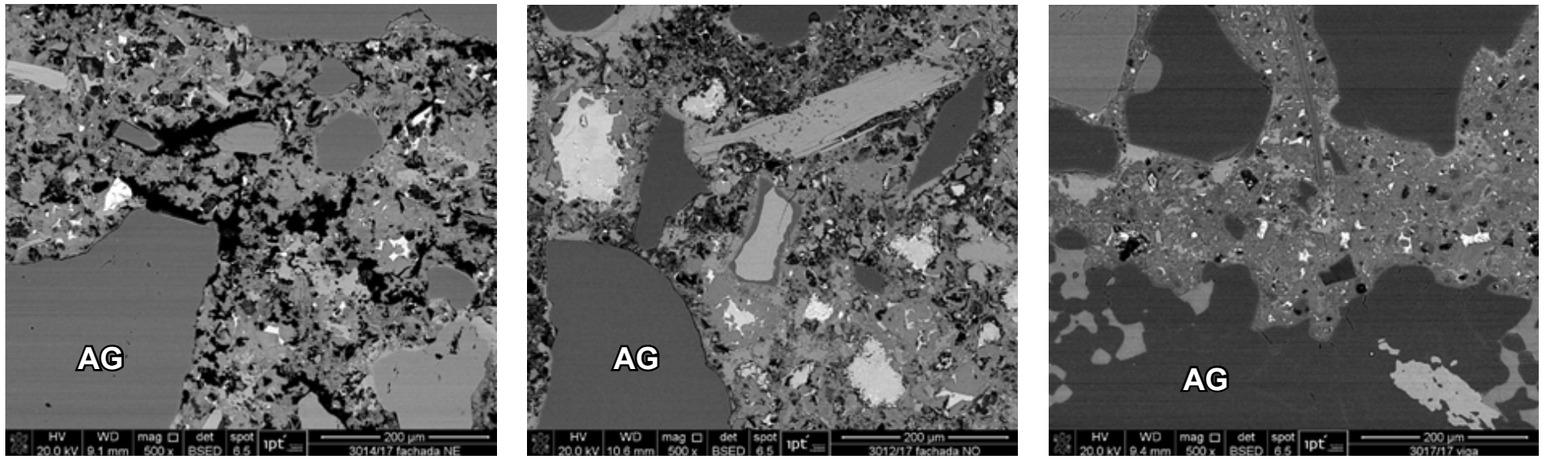
In the micrographs of Figure 81, we observe that the concrete paste of the beam seems denser, with less pores (black color regions) than the concrete pastes of blind walls. In the micrograph of NW blind wall concrete, there are evidences of belite zones (B).

An exercise of elementary counting of Ca and Si, by chemical microanalysis (EDS), was done for the NW blind wall concrete sample. In Figure 70 (a) a grain with the (C-S-H) hydration halo is shown, where it is possible to distinguish the internal products (IP) from the external products (EP).

The analysis on a single measure has not representativeness, but the intention is to point out the usefulness of such elementary measures to better understand the C-S-H structure, with the aim of studying their durability. As already mentioned, Chen; Thomas and Jennings (2006) have identified the decalcification of C-S-H by carbonation, which can jeopardize the stability of the compound. Therefore, very low C/S rations can be a sign of undesirable alterations in the paste. Furthermore, the atomic counting can indicate the C-S-H degree of polymerization, which relates to its degree of hydration or maturation. Rossen and Scrivener (2017) suggest that 100 points, manually and randomly selected, are sufficient for the atomic characterization of what the authors call C-S-A-H, a more general abbreviation of the calcium silicate gel. As such counting is a time consuming activity, it is not always used because of the cost of using electronic scan microscopes.

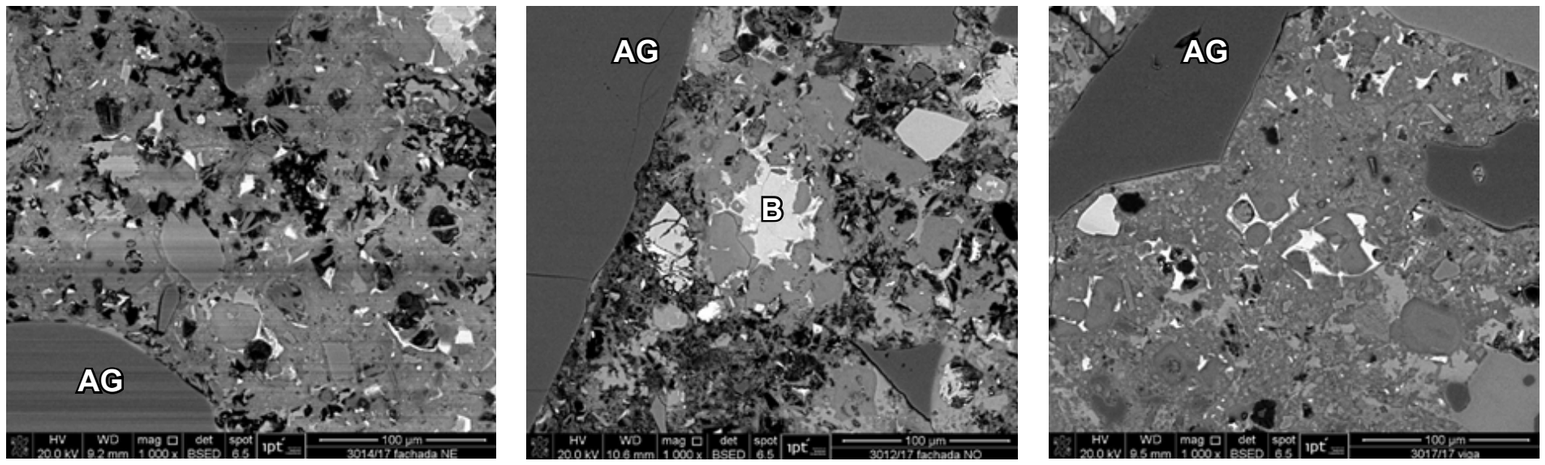
To record another occurrence detected during the analysis, the micrograph of Figure 82 suggests the presence of blast furnace slag in the sample of NW blind wall concrete.

The micro analysis has detected manganese, which suggests the presence of slag in the cement. The result suggests the use of cements with slag at the time of the building construction.



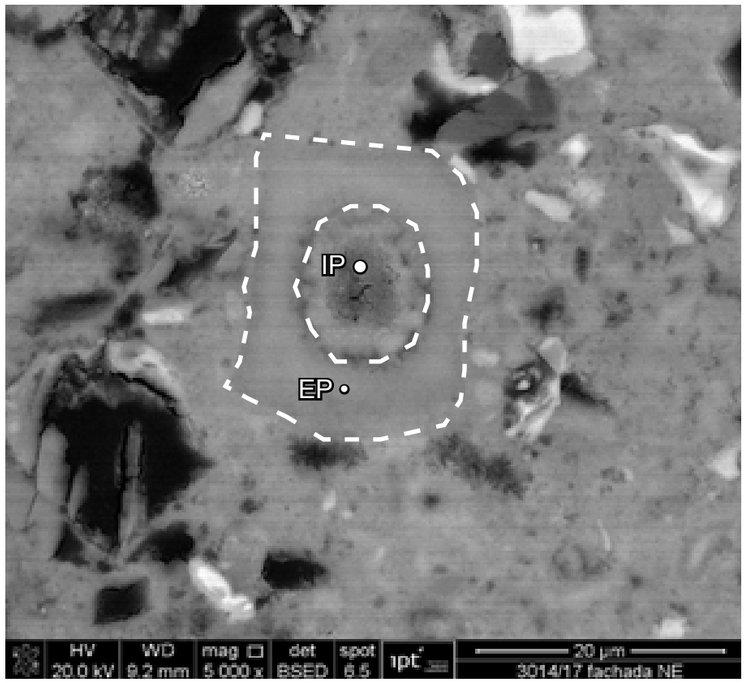
(a) NE blind wall; 500X magnification (b) NW blind wall; 500 X (c) Beam; 500 X magnification

Figure 79: Polished section of samples: (a) of NE blind wall; (b) NW blind wall; (c) beam. AG: aggregate.



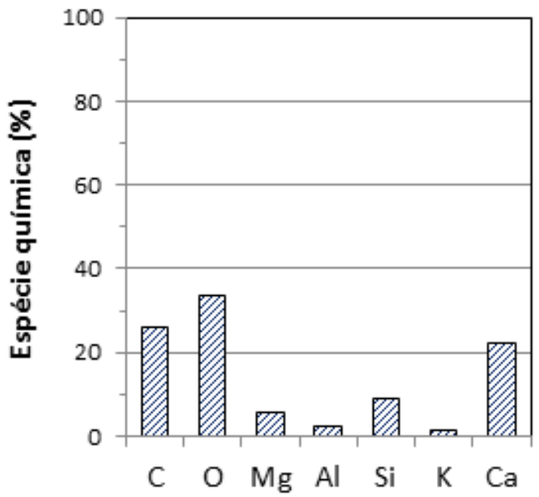
(a) NE blind wall; 1,000X magnification (b) NW blind wall; 1,000X magnification (c) Beam; 1,000X magnification

Figure 80: Polished section of samples: (a) of NE blind wall; (b) NW blind wall; (c) beam.AG: aggregate / B: belite zone.

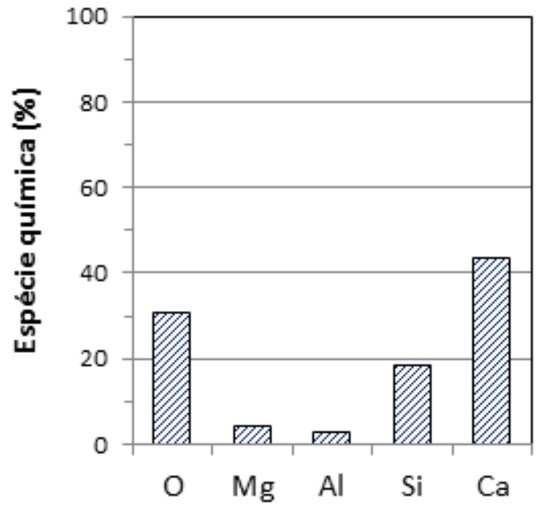


(a) IP ●: internal product; PE •: external product. Magnification 5.000 X.

	Elementary relation (%)	
	Internal Product (IP ●)	External Product (EP •)
Ca / (Si + Al)	1,94	2,04
Ca / Si	2,45	2,37
Si / Ca	0,41	0,42
Al / Ca	0,11	0,07

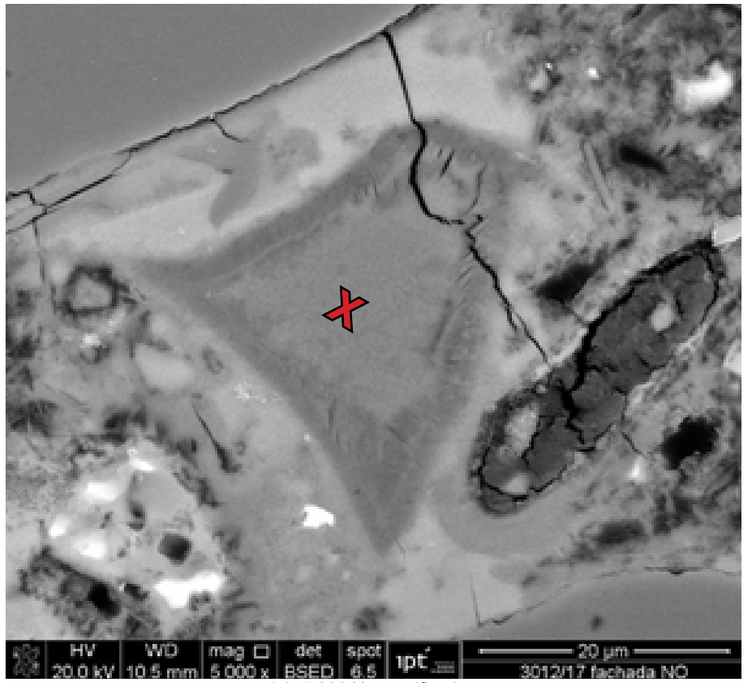


(b) Internal product

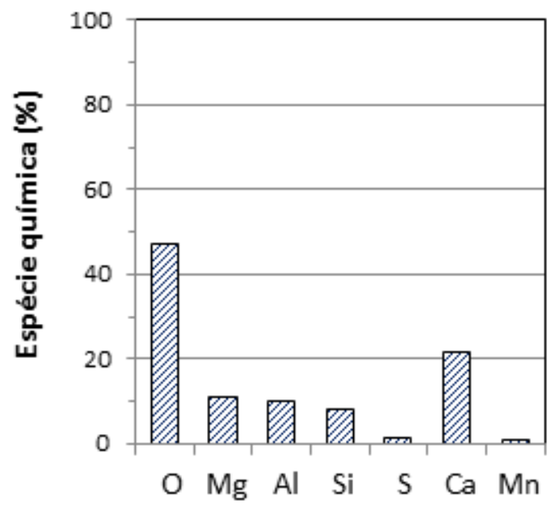


(c) External product.

Figure 81: Detail of the hydration products halo around a grain, in a sample extracted from NW blind wall.



(a) 5,000 X magnification



(b)

Figure 82: ASample removed from the concrete core extracted from NW blind wall, with signs of blast furnace slag.

Photo: author and date unknown. Source: Rosa Artigas.

3.8

TESTS FOR THE REMOVAL OF GRAFFITI

Tests for the removal of graffiti

So far, no graffiti was observed on the surface of the blind walls concrete. As already reported, graffiti was done on the internal and external surfaces of the smooth texture concrete. Therefore, the reported testes have the aim of selecting the less invasive method to the possible removal of graffiti done with black spray paint on the exposed concrete with smooth texture.

Three (3) methods were evaluated: hydroblasting, chemical removal, and inorganic abrasive blasting. Tests were performed on the faces of the pyramidal base of external pillar P5, on February 2 and 3, 2017.

Test 1: hydroblasting

The test was performed on the south face of pillar 5. The equipment used, of the commercial brand Cinojet 400, has 20 HP of power, 400 bar (5800 psi or 39.2 MPa) of operation pressure, and 22L/min of discharge. To perform the test, three-phase electrical installation and water at the approximate temperature of 20°C were necessary. As protection measures, the workers have to wear the following personal protection equipment (PPEs): safety goggles with side protection, leather gloves, safety clothing and shoes to protect the skin. Hydroblasting was done at an approximate distance of 1m from the surface. The service cost estimate (Nov/2017) is approximately R$ 25.00/m^2.

The concrete was visibly affected by the test. The damage could be observed at naked eye, and evidenced with magnifying lens (30x). The superficial wear has caused the removal of the cement paste, thus exposing the aggregates. The damage, evidenced with the help of magnifying lens (~15X), was regarded as unacceptable and the test was interrupted (see Figure 83).

The hydroblaster pressure is not adjustable, therefore we suggest the use of equipment with lower levels of pressure. The smaller pressure would probably result in more time to remove the paint, with the consequent increase of water consumption. Despite the high pressure used for the test (400 bar or 5800 psi or 39.2 MPa), the cold water hydroblasting only partially removed the paint demonstrating it is not the most proper procedure.

The overheated water is an option, according to the recommendations contained in the Concrete publication of the series Practical Building Conservation (ODGERS, 2012). According to the specialists, the traditional cleaning with cold water under pressure of 100 bar (1450 psi or 9,8 MPa), with fan-shaped jet at an angle of 30°C at a distance of 1 m, is already capable of superficially removing the cement paste. To remove the graffiti using water, the specialists recommend overheated water to remove more flexible paints, such as the acrylic paints. The initial application of chemicals to dissolve the paint is preferable, because it allows to use lower pressures, thus less harmful to the substrate.

Test 2: chemical removal

The test was performed on the south and west faces of Pillar 5. The remover used was of the commercial brand Sparlak Pintoff manufactured by Akzo Nobel. According to the product datasheet, issued by the manufacturer[15], it is a “product based on saturated paraffinic hydrocarbonates, aromatic solvents, alcohols, ketones, in addition to additives. It does not contain caustic soda, acid products or corrosive substances”. The product is available in 1 or 5-liter packages. To perform the test, it was necessary to have access to cold water. The equipment pieces used were as follows: paintbrush or brush for application, tow for removal, nylon bristle brush and steel bristle brush and neutral detergent for the final cleaning. As protection measures, the workers have to wear the following personal protection equipment (PPEs): safety goggles against chemical splashing, protective gloves against chemicals, safety clothing and shoes to protect the skin, respiratory protection against chemicals. The service cost estimate (Nov/2017) was approximately R$ 60.00/m^2, not considering a possible neutralization of the remover, an activity that should be considered if the work is done in a large scale. Figure 84 and Figure 85 show the steps of the chemical removal test.

The chemical remover was directly applied with a paintbrush on a dry surface (west face of the pillar) and on another wet surface (south face of pillar where the hydroblasting test was performed), followed by a manual brushing with steel bristle brush, and the removal of the paint with tow. This process was repeated several times, and it was easier to remove the paint from the dry surface than from the wet surface. The work was finalized by washing to remove residues with the nylon bristle brush and neutral detergent.

In addition to this method, the application of chemical remover with paper plaster protected with plastic was also tested. After 12 hours, it was observed the partial dissolution of the paint layer.

The test performed on the west face of the pillar (dry surface) had a reasonably satisfactory final result, since the test done on the south face of the pillar (wet surface) showed an irregular results with more stains, especially because of the difficult removal of the

Figure 83: Test performed with the chemical remover on the west face of Pillar 5 (dry face). Left: brushing with steel bristle brush on the place where the remover was applied (Sparlak Pintoff). Right: final appearance of the concrete surface after the completion of the test, evidencing slight stains of paint still visually perceptible (Source: Conserva FAU Team collection, 2017).

Figure 84: Test performed with the chemical remover on the south face of Pillar 5 (wet face). Left: appearance of the concrete at the beginning of the chemical removal process (Sparlak Pintoff remover). Right: final appearance of the concrete surface after the completion of the test (Source: Conserva FAU Team collection, 2017).

[15] Akzo Nobel Ltda. “Boletim Técnico Sparlack Pintoff” 03/2015, available at http://sparlack.com.br/files/BT%20-%20Pintoff%2003.2015.pdf; Akzo Nobel Ltda. “Ficha de Informação de Segurança de Produtos Químicos Sparlack Pintoff” 30/04/2015, available at http://sparlack.com.br/files/Pintoff.pdf.

paraffinic residues of the remover. Damage to the concrete by the chemical action of the remover was not observed. However, the use of steel bristle brush, needed to remove the paint, left scratches on the smooth surface of the concrete.

The removal of graffiti by using chemicals containing volatile organic compounds poses serious risks to the health and to the environment, therefore all the precautions recommended by the manufacturer should be adopted, particularly in regard to the ventilation of environments and use of PPEs. The absorption of the product by the concrete surface required that it was removed soon after application, opposed to the applications recommendations by the manufacturer. The use of the above mentioned paper plaster was not efficient to remove the paint; other types of plaster with higher absorption capacity could be tested. Chemical residues can also be removed with pressurized hot water, according to the recommendations contained in the book Concrete of the series Practical Building Conservation (ODGERS, 2012).

Test 3: inorganic abrasive blasting

The test was performed on the east face of Pillar 5. The equipment used, of the commercial brand Microjet of Metalplan, has a 5 HP power, 0.2 (2.84 psi or 0.0196 MPa) to 7 bar (99.49 psi or 0.68 MPa) of operation pressure, 1500 L/min of compressed air feeding discharge, and 25 L of abrasive reservoir capacity. To perform the test, a three-phase electrical installation was necessary. As protection measures, the workers have to wear the following personal protection equipment (PPEs): safety goggles with side protection, leather gloves, respiratory protection against the power, safety clothing and shoes to protect the skin. The service cost estimate (Nov/2017) is of approximately R$ 130.00/m^2, considering the reuse of an abrasive cycle.

The abrasive material used was the mineral Garnet, free from free-silica, with two grain sizes Mesh 80 (characteristic particle size of 0.177 mm) and Mesh 120 (characteristic particle size of 0.125 mm), and 8.0 Mohs hardness. The abrasive was projected at a distance of approximately 1 m from the surface. The pressure used in the test varied between 2 (28.4 psi or 0.196 MPa) and 4 bar (56.8 psi or 0.39 MPa). The nozzle used (standard nozzle with internal diameter of 5.5 mm) creates a conic jet.

The first test was performed with Garnet Mesh 120 in an area of the east face of the pillar. Then, Garnet Mesh 80 was used in another area of the same pillar face. The removal of graffiti with bigger particle garnet (Mesh 80) was faster, removing paint from a larger area with the same amount of material. The estimated consumption of material was 0.5 kg/m^2 for Garnet Mesh 80, and 0.6 kg/m^2 for Garnet Mesh 120.

To reuse the material, it will be necessary to isolate the site so that the material is collected with the smaller possible percentage of loss.

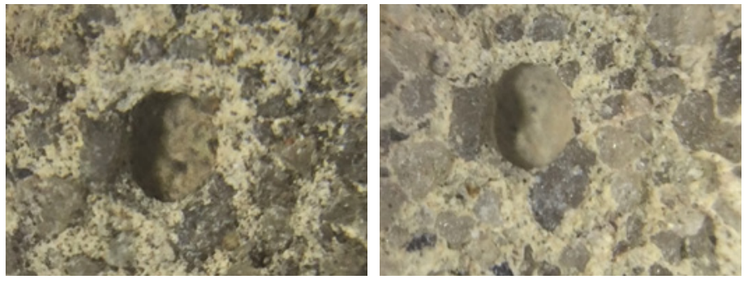
Figure 86 illustrates the state of the surface before and after the inorganic abrasive blasting.

The blasting easily removed the spray paint layer. This method caused less damages than the hydroblasting, however still removed a little of the cement superficial layer. However, the level of loss is less perceptible, because it is similar to the segments of the surface where the aggregate is exposed because of natural wear and tear (Figure 87). Therefore, the method efficacy and the risk posed, especially by the reapplication, should be carefully considered. Furthermore, it would be necessary to evaluate the possibility of using other less aggressive abrasives, or with smaller Garnet grain sizes. It is possible to use materials with different grain sizes, from 0.038 mm (Garnet 350 Mesh) to other abrasives with 1.8 mm particle diameter and with different specific weights, from the natural mineral Garnet to sodium bicarbonate, calcium carbonate, magnesium carbonate, microspheres of glass and inert vegetal abrasives.

According to recommendations contained in the book Concrete of the series Practical Building Conservation (ODGERS, 2012), abrasives are effective in removing less flexible paints, and particles with characteristic diameter between 0.200 mm and 0.500 mm can be used.

Figure 85: Test performed with the chemical remover on the south face of Pillar 5 (wet face). Left: appearance of the concrete at the beginning of the chemical removal process (Sparlak Pintoff remover). Right: final appearance of the concrete surface after the completion of the test (Source: Conserva FAU Team collection, 2017).

Figure 86: Test performed with inorganic abrasive (Garnet) blasting on the east face of pillar 5. Left: part of the paint already removed with Garnet Mesh 120. Right: appearance of the pillar surface after removal with Garnet Mesh 80 (Source: C. A. Oliveira, 2017).



(a) before the mineral abrasive blasting (b) after the mineral abrasive blasting

Figure 87: Aspect of the concrete before and after hydroblasting and mineral abrasive blasting. Magnifying of approximately 15X (Source: C. A. Oliveira, 2017).

Conclusions

Paint removal with hydroblasting was slower and more aggressive to the substrate than the removal with Garnet inorganic abrasive blasting using the tested grain sizes (Mesh 80 and Mesh 120). Furthermore, the abundant use of water in the hydroblasting method should be analyzed regarding its appropriateness for the use in indoor environments, because of the difficult water drainage. As for the chemical removal, despite being easy to apply, having low cost and effectiveness in removing the paint, the remover residues cleaning method should be improved to leave the surface free from stains. In addition, it is a method requiring the abundant use of water for washing, and which products release volatile organic compounds, making it difficult to use the chemical removal technique in large scale services performed inside the buildings. The test with inorganic abrasive (Garnet) blasting seemed to be the method causing fewer damages to the concrete, being more appropriate for indoors use, provided that the safety conditions and the particulates dispersion control are ensured. Whatever is the method selected, the manpower should be qualified and trained. The capacity of the applicator to evaluate the moment when the concrete starts to be damaged is determinant to attain the desired results, that is, paint removal with the smaller possible impact to the substrate.

Photo: Vitor Nisida, 2011.

3.9

STUDIES ON THE CHROMATIC ATTRIBUTES OF CONCRETE, AND MIX DESIGN OF THE FINISHING MORTAR

Studies on the chromatic attributes of concrete, and mix design of the finishing mortar

The in the visual perception of repairs on the blind walls of Artigas Building, the experience of color, and their appearance outlined by light, is influenced by texture, brightness, spatial location, adjacent surfaces, depth, and complemented by the geometry of such repairs. Therefore, in view of the contrast between the appearance of repairs, done in the last work of 2012-2015, and the original concrete tissue, the activities herein described were developed, as a first approach, to mitigate the visual fragmentation of blind walls in future interventions in the building blind walls.

The experimental study considered the data obtained by means of instruments capturing colorimetric attributes, via tristimulus colorimeter, associated to the perceptive qualitative evaluation by observers.

The opening of gaps in the blind walls needed to remove concrete cores used in the concrete characterization tests, and the scarifications done for the tests of potential rebar corrosion, allowed the experimental study of the application, selection and formulation of structural repair and superficial finishing mortars.

Methodological Procedures

The experimental study for the aesthetic approximation of the surfaces of materials filling the gaps and the original concrete focused on issues of texture and color of the finishing mortars. The colorimetry was used to obtain objective data to evaluate and compare colors under given illumination conditions and observer characteristics, therefore interconnecting the three key-elements for the perception of color: the object, the light and the observer.

The selections of composition materials and the recipe of the finishing mortar prepared in the worksite were done after the colorimetric survey described as follows.

Based on studies prior to this work, the necessary bases to obtain colorimetric data of the cementitious materials surfaces, such as concrete and mortar, were determined with the Capsuer X-Rite tristimulus colorimeter. The parameters established for the equipment were the use of the space of CIE L*a*b color, D65 illuminant, which is the average of day light with temperature of 6504K color, observer 10° (Comission Internationale de L'Eclairage CIE 2004), opening of 8mm diameter of the equipment reading head. The calculation of the minimum measures number was done by stabilizing the accumulated data averages, resulting in 13 measures to be taken in a delimited area of 64 cm^2 (actually, this number of measures became 10 because of the limit of data storage in the equipment).

Data of colorimetric attributes of concrete surfaces in the surrounding of areas to be repaired were obtained, such as in the example of Table 19.

Then, mortar samples with varied inorganic pigment colors proportions and with no pigment were prepared. The materials used were: Portland Cement PC II 32 (with calcareous filler addition from 4 up to 6% mass proportion and resistance class 32 MPa at 28 days), sieved sand, acrylic adhesive, superplasticizing additive, yellow, red, and black inorganic pigments, wooden pattern textured vinyl blade. The mix proportion used was 1:3.61:0.65 (in mass).

After the cure, colorimetric data were obtained from the finishing mortar samples, and the visual evaluation was made with the samples showing results closer to the concrete and surface of the concrete cores available, by the method described in NBR ISO 105 A02 Textile – Color solidity tests Part A02: Grey scale for the evaluation of color alteration (Brazilian Association of Technical Standards 2006), and the American standard ASTM D2616-96 Standard Test Method for Evaluation of Visual Color Difference With a Gray Scale (American Society for Testing and Materials 2003).

In the example of Table 20, the chromatic attributes of sample 5C were closer to those of the surface next to the gaps to be filled at the Northwest Façade.

The results of the visual evaluation also elected the same sample as the most adequate to execute this repair.

In regard to the appearance, the gaps were filled with finishing mortars with formulations having aesthetic result more compatible with the original material that surround them, and the texture was obtained by printing the texture of a vinyl blade surface on the still fresh mortar.

The aim of selecting the appearance of mortars were to reach the color, grain size and texture of finishing mortar as close as possible, in terms of appearance, of the surfaces next to the repair. It is not about trying to mimic the exposed concrete, but that the new material becomes less perceptible in the visual reading of the gap.

Table 19: Colorimetric data of the surface neighboring the place for the removal of concrete cores T1 and T2 (NW).

	L*	a*	b*	Visual reference
Reference color	59,80	1,2	12,8	
	65,70	1	10,9	
	57,80	1,6	9,8	
	62,00	2,1	6,9	
	62,00	1,3	9	
	64,40	2,6	8,5	
	60,30	0,9	10,4	
	63,1	1,9	10,3	
	62,5	0,1	14,5	
	62,00	1,3	9	

Table 20: Comparative results between colorimetric data of samples of mortar for superficial finishing and of the original concrete.

	L*	a*	b*	ΔE*
Reference color of the surface next to the repair in the NW façade	62	1,3	9	
SAMPLE 5C	62,4	2,2	9,2	1,00
SAMPLE 10	64,7	2,2	2,9	6,78
SAMPLE 13	50,5	0,4	12,2	11,97
SAMPLE 14	46,7	-1,7	16,4	17,26
SAMPLE16	58	2,1	10,8	4,46

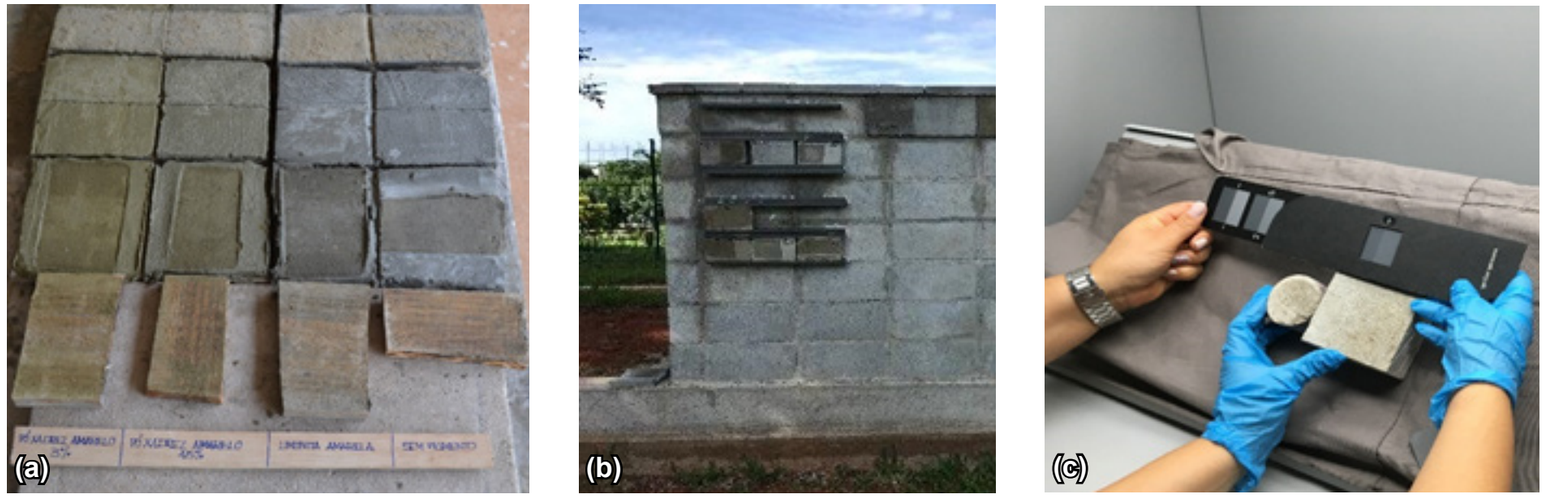


Figure 88: Elaboration of samples and visual evaluation (a) samples (b) samples applied in the concrete (c) visual evaluation between samples and fragment of the original concrete surface.

Tests of finishing mortars application

The drilling sites were filled with the dry-pack method, that is, introduction of industrialized repair mortar alternated with small stones, and pressed for densification. The filling was made in order to create a recess 10mm below the blind wall surface, so that the rest could be filled with finishing mortar.

The filling of gaps in the scarified areas was performed in two steps. As the gap reached at least 20 mm of depth (10% of the blind wall cross-section), and uncovered part of the rebar, the indication is that the first layer is made of industrialized repair mortar, with properties for structural restoration, low permeability, and containing anticorrosion additive.

Places to be repaired were opened and leveled, with the help of a cutting disk, rectangular shape, with the width, depth and height of the previous repair, not removing the original concrete. The surfaces that would have contact with the repair material were rough to improve their physical adherence. The exposed rebar was brushed with steel brush. The procedure was the same adopted in the 2012/2015 renovation, except for the superficial treatment. The repair mortar was manually applied after wetting the substrate. Again, this material was provided with a rough superficial finishing, and the same recess was done, as in the previous case and for the same purpose. After the application, the material was covered with plastic to maintain the humidity during the cure.

After wetting and applying the acrylic adhesive to the substrate surface, the finishing mortar was applied, with a builder´s trowel. The material was smoothened with a leveling trowel, facing the concrete surface. Then the repair was covered, under pressure, with a blade of the vinyl material with texture similar to the texture of rough wooden boards, simulating the use of a stamp on the fresh material. This blade was covered with plastic to preserve the humidity of the place for curing. After 28 days, the material was removed and its color will be evaluated after 4 months of its execution. The sequence is shown in Figure 89.

Figure 89: Steps of gap filling in the experimental study (a) application of acrylic adhesive diluted in water on the industrialized repair mortar (b) application of finishing mortar (c) smoothening of the surface (d) application of textured vinyl blade (e) protection with plastic in the curing phase (f) repair after three days from its execution.

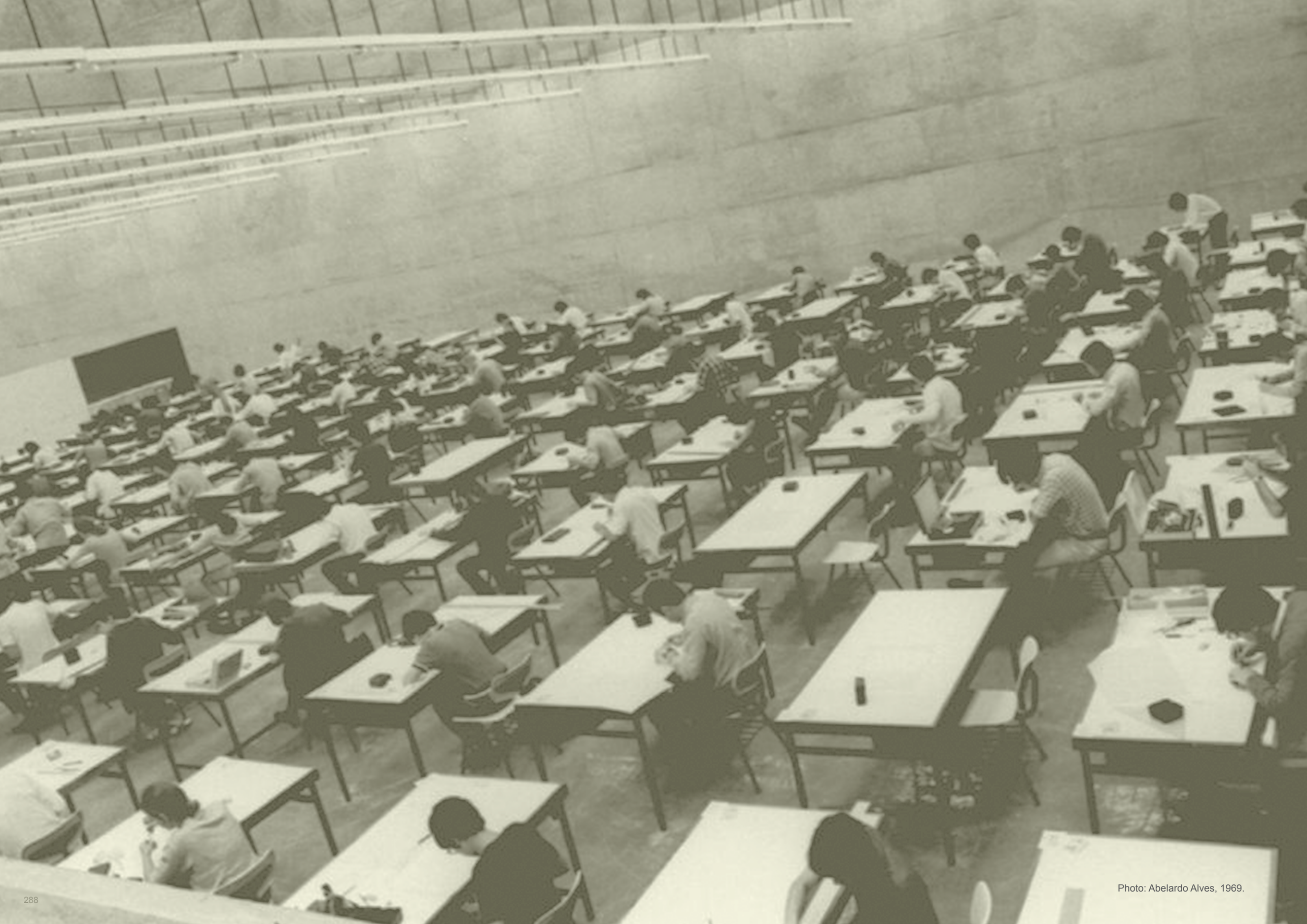


Photo: Abelardo Alves, 1969.

3.10

REBAR CORROSION

Rebar corrosion

Table 21 shows the results obtained in the inspection of the repaired concrete area recently fractured with the exposure of the blind walls skin rebar. Figures 90 to 98 complement this table showing the visual aspect of rebar and of the repair mortar, or of the concrete exposed by the local fracture.

Through Table 21, we can observe that the coating concrete thickness of the exposed segment of rebar varied a lot among the inspected areas, however, most of the skin rebar showed the same diameter (8 mm). The exception was the exposed bar of Area 2 of the SW Blind Wall repair, showing a smaller diameter (6 mm), as well as the presence of pressure marks in its surface (see Figure 93a). It is believed that this bar was inserted during the recuperation works, because of the loss of transversal section above 10% of the bar previously existent in the site, as defined in the technical specification of the 2010 inspection. Regarding the visual aspect of this and the other exposed bars, all of them have stains indicating corrosion, an active state of corrosion.

This active state of corrosion can be attributed both to execution flaws in the repair procedure and to the low quality of mortar used in such repairs. Besides, it was observed a variation in the coating of rebar exposed in the repairs, most with less than 20 mm of thickness, as shown in Table 21, and the discussed superficial heterogeneity of blind walls concrete, resulting in different humidity contents, as well as in the depth of the carbonation front.

As shown in Table 21, in general, the depth of the carbonation front (mm) was very significant in the repair mortar. Some individual values obtained in the carbonation front (in red in Table 21) indicate that this carbonation has reached the rebar embedding region, which is worrisome regarding the repair durability and efficiency, considering the short time elapsed from their execution (around four years). The concrete carbonation is also worrisome, because, as shown in Figures 90 to 98, part of the perimeter of the exposed rebar of most of the repairs was embedded in carbonated concrete, having an accumulation of corrosion products in the interface (Figure 91a, 92a, 95a, and 96a). This was not expected in reason of the determination contained in the 2010 specification of the whole exposure of the perimeter of the rebar segment with signs of corrosion, their cleaning and coating with repair mortar. The only exception was Repair 2 of SE blind wall, in which the exposed concrete was not carbonated, and the whole rebar perimeter was embedded in repair mortar, non-carbonated in the rebar embedding region. In this rebar, the corrosion was attributed to the mortar fissuring, place of penetration facilitated by aggressive agents, such as water (see internal humidity stains in the fissure region in Figure 90a).

The Repair 2 of Area 1, of SW blind wall, is noteworthy. We observe that the repair mortar had only 3 mm thick, and therefore the original concrete under it was fractured, until exposing the rebar. As shown in this table, both materials were carbonated, maximum individual value of 38 mm of depth for the concrete, and the rebar was in active state, with apparent intense corrosion. This can be observed in Figure 80a, in which the bar surface is very irregular and with the accumulation throughout its interface with the concrete, both characteristic aspects of intense carbon--steel corrosion.

Also in the case of concrete carbonation, the data in Table 21 also points out that there is a great variation in the progress of its front into the blind walls, most reaching the region of rebar embedding, except for two repairs, both Repairs 1, of Areas 1 and 2, of SW blind wall. Based on the rebar coating thickness obtained in these two repairs, 29 mm in Area 1 and 10 mm in Area 2, and the other results shown in Table 21, we can assume that segments blind walls rebar with coating less than 10 mm thick should be chemically active due to carbonation. For bigger depths, until the maximum individual value obtained of 38 mm of concrete carbonation (Repair 2, Area 1, of SW blind wall), the rebar, embedded in deeper depths, should also be chemically active, though this occurs non uniformly, because of the non--uniform values obtained, including those for the concrete cores extracted from the blind walls. This is a typical picture for large extensions of heterogeneous exposed concrete surface, such as the blind walls that have a rustic and porous texture, which leads to the non-uniform penetration of water and CO_2.

Table 21: Inspection of the reinforcement in a newly fractured concrete area and determination of the depth of the carbonation front.

Description			SW blind wall				NW blind wall		NE blind wall		SE blind wall	
			Área 1			Área 2						
			Repair 1 (external)	Repair 2 (external)	Repair 3 (internal)	Repair 1 (external)	Repair 1 (internal)	Repair 2 (external)	Repair 1 (internal)	Repair 2 (external)	Repair 1 (external)	Repair 2 (external)
Reinforcement	Covering (mm)	Individual values	29	30	33	10	14	15	11	12	7	20
			-	-	-	10	15	15	8	-	8	20
			-	-	-	10	17	15	10	-	8	20
		Average (DP)	29 (-)	30 (-)	33 (-)	10 (-)	15 (2)	15 (-)	10 (2)	12 (-)	8 (1)	20 (-)
	Diameter (mm)		8	8	8	6 w/ dent	6	8	8	8	8	8
	Coloring		Brown / orange	Black / orange	Brown / black / orage	Grey / orange	Grey / orange	Brown / orange	Grey / orange	Brown / orange	Grey / orange	Grey / orange
	Apparent electrochemical state		Active	Active	Active	Active	Active	Active	Active	Active	Active	Active
Depth of carbonation (mm)	Repair	Individual values	16	3	30	6	4	5	3	15	5	9
			8	-	34	8	7	5	15	15	7	10
			7	-	24	6	5	3	10	12	5	9
			4	-	27	9	4	8	7	11	8	8
			5	-	28	5	-	6	-	-	8	7
			11	-	-	8	-	-	-	-	10	7
		Average (DP)	9 (4)	3 (-)	29 (4)	7 (2)	5 (1)	5 (2)	9 (5)	13 (2)	7 (2)	8 (1)
	Concrete	Individual values	17	34	33	Carbonated (20mm)	16	Carbonated	Carbonated	Carbonated	Carbonated	Non carbonated (26mm)
			15	38	34		19					
			22	17	26		11					
			14	32	25		25					
			-	21	-		-					
			-	27	-		-					
		Average (DP)	17 (4)	28 (8)	30 (5)	-	18 (6)	-	-	-	-	-

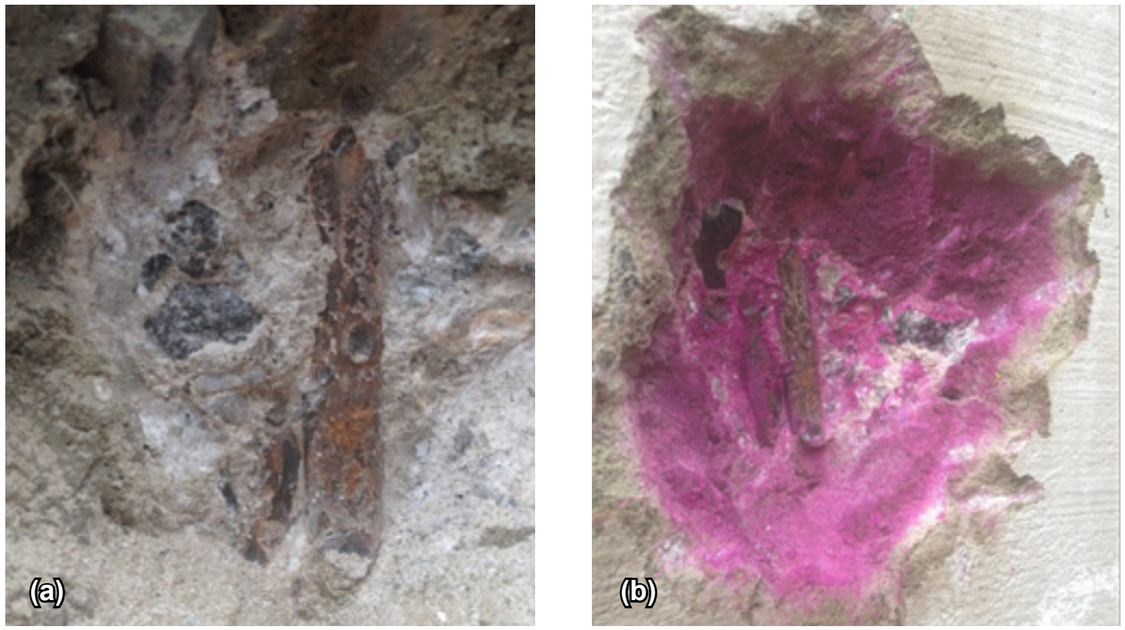


Figure 90: SW Façade: Visual aspect of newly exposed reinforcement in fractured area in Repair 1 (Area 1) (a) and general aspect soon after pH indicator sprinkling (carbonation trial) (b). The exposed external rebar presented a brownish color with area of accumulation of corrosion product of orange color. After the sprinkling of the solution, the rebar did not become pink, only the surrounding concrete. Carbonation of exposed concrete was partial.

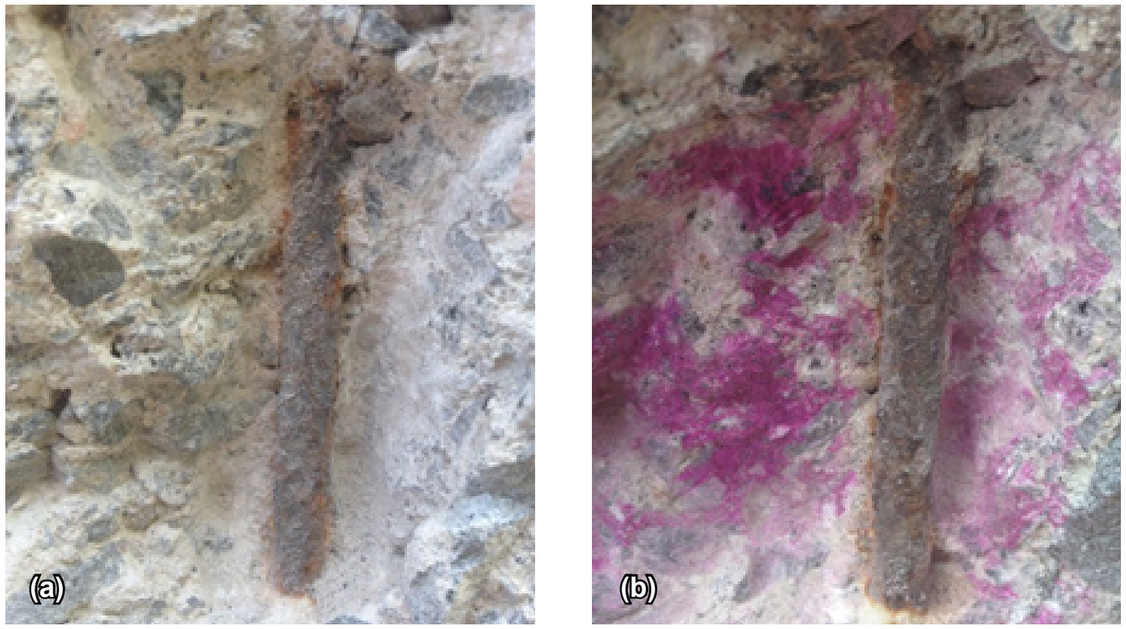


Figure 91: SW Façade: Visual aspect of newly exposed reinforcement in fractured area in Repair 2 (Area 1) (a) and general aspect soon after pH indicator sprinkling (carbonation trial) (b). The exposed rebar presented a very irregular surface due to intense corrosion, with black color and accumulation of orange colored corrosion product along the concrete interface. After the sprinkling of the solution, the rebar did not become pink, nor its interface with the surrounding concrete. Carbonation of exposed concrete was partial.

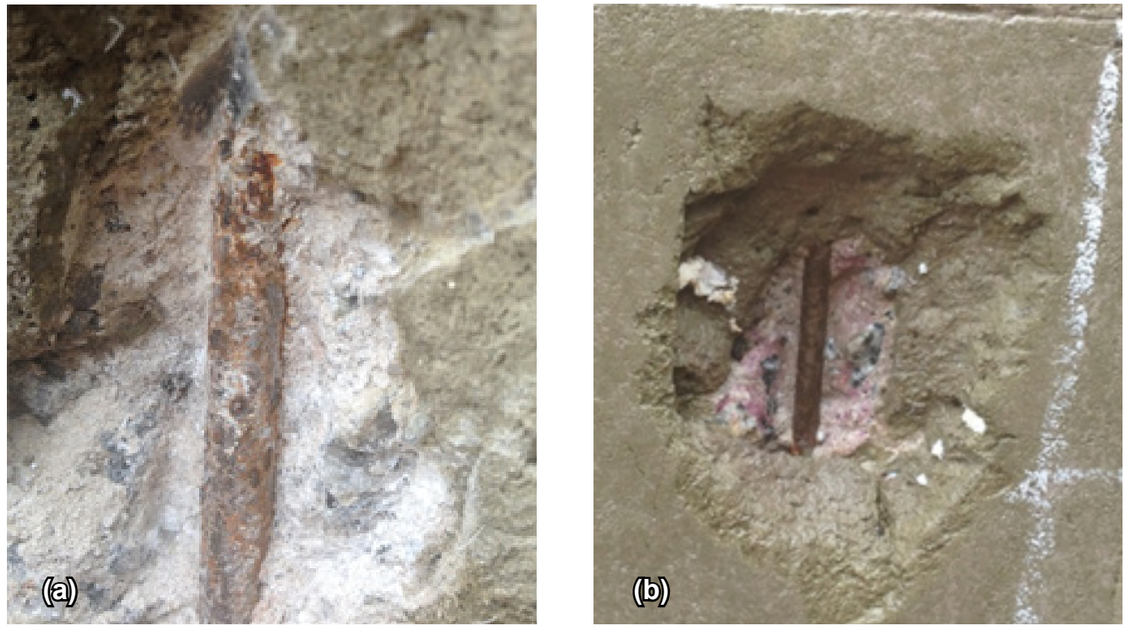


Figure 92: SW Façade: Visual aspect of newly exposed reinforcement in fractured area in Repair 3 (Area 1) (a) and general aspect soon after pH indicator sprinkling (carbonation trial) (b). The exposed rebar presented a brown and black color with area of accumulation of corrosion product of orange color, also along its concrete interface. After the sprinkling of the solution, the rebar did not become pink, nor its interface with the surrounding concrete. Carbonation of exposed concrete was partial.

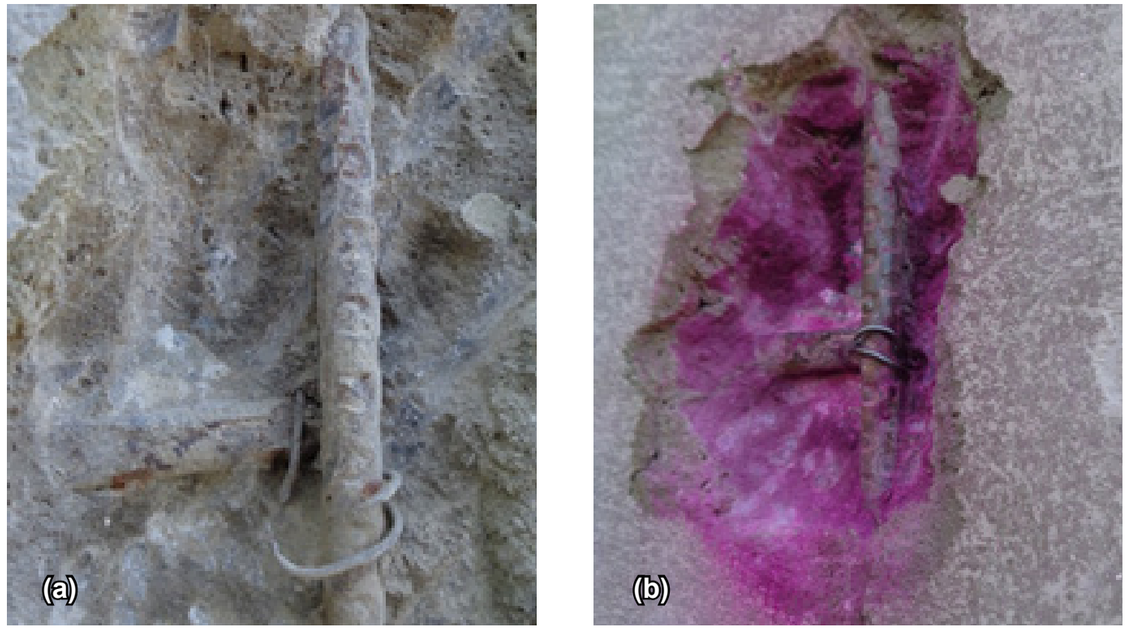


Figure 93: SW Façade: Visual aspect of newly exposed reinforcement in fractured area in Repair 1 (Area 2) (a) and general aspect soon after pH indicator sprinkling (carbonation trial) (b). The external exposed rebar presented a predominantly grey color with areas of accumulation of corrosion product of orange color, with presence of dents. The internal exposed rebar presented the same aspect, without dents. After the sprinkling of the solution, the major part of the rebar did not become pink, only the surrounding concrete (exposed base of 20 mm not carbonated).

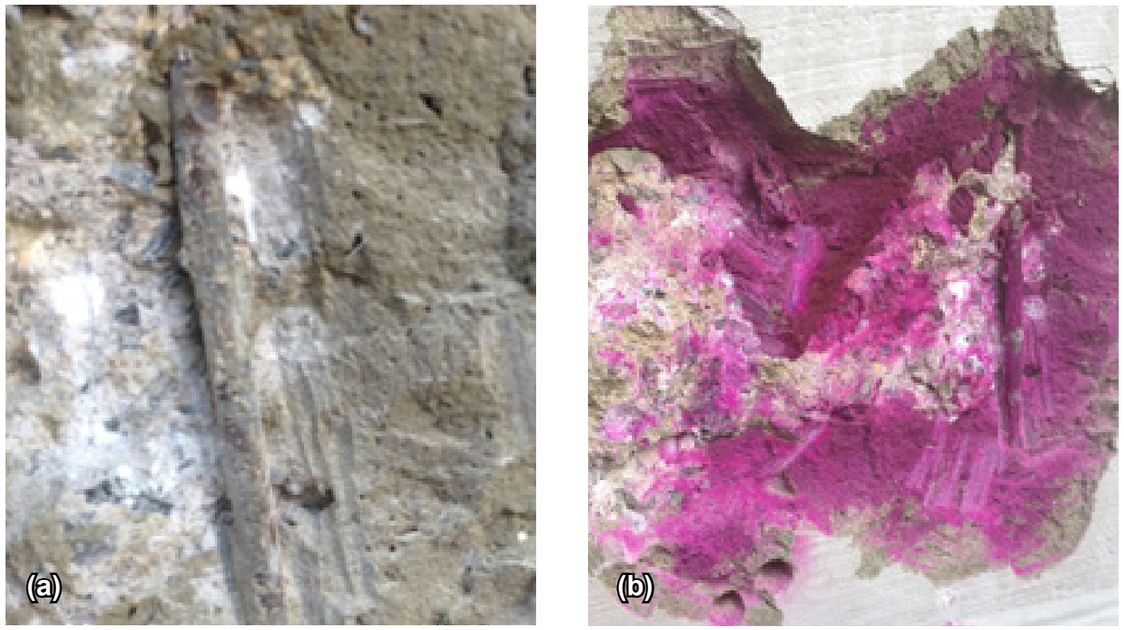


Figure 94: NW Façade: Visual aspect of newly exposed reinforcement in fractured area in Repair 1 (a) and general aspect soon after pH indicator sprinkling (carbonation trial) (b). The external exposed rebar presented a predominantly grey color with areas of accumulation of corrosion product of orange color. After the sprinkling of the solution, part of the rebar did not become pink, nor its interface with the surrounding concrete. Carbonation of exposed concrete was partial.

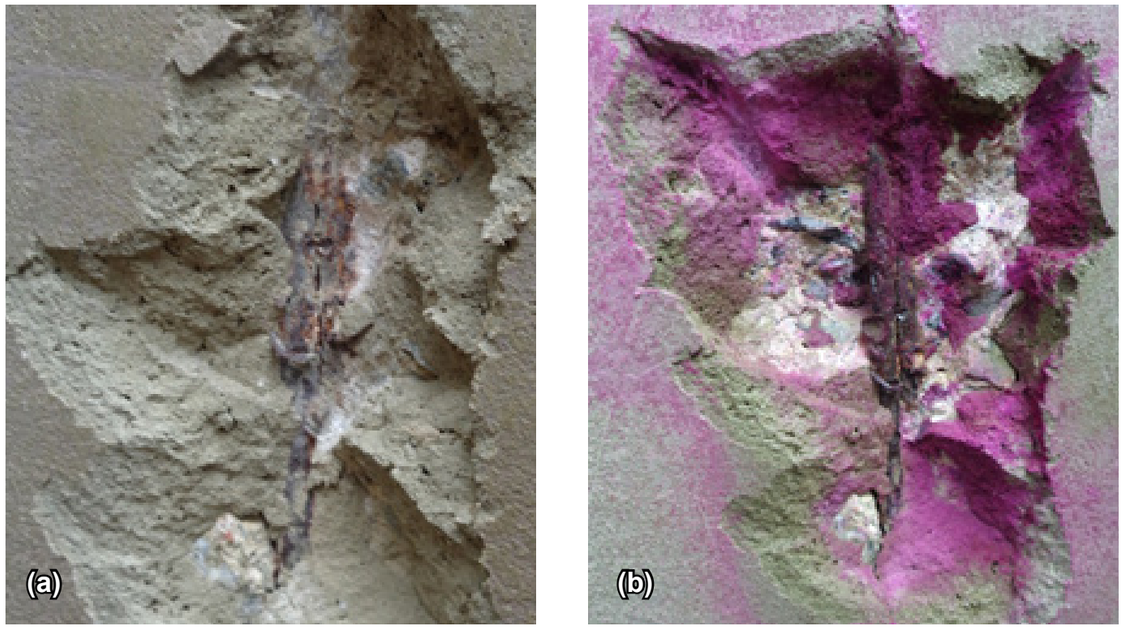


Figure 95: NW Façade: Visual aspect of newly exposed reinforcement in fractured area in Repair 2 (a) and general aspect soon after pH indicator sprinkling (carbonation trial) (b). The united external exposed rebars presented a brownish color with area of accumulation of corrosion product of orange color, also along its concrete interface. After the sprinkling of the solution, part of the rebar did not become pink, nor its interface with the surrounding concrete (carbonated).

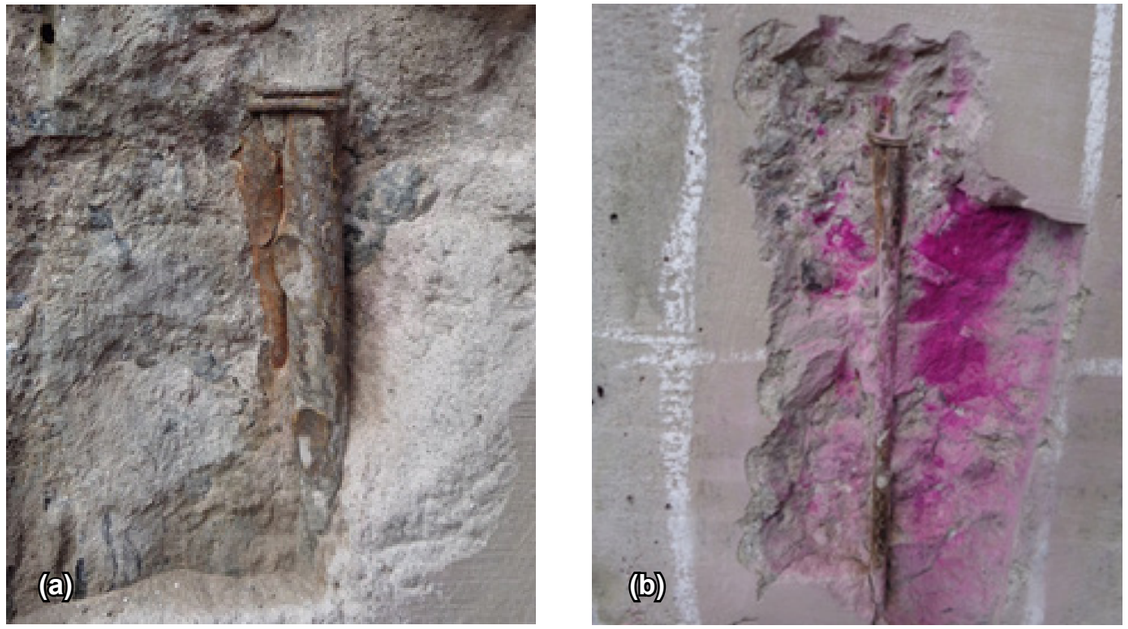


Figure 96: NE Façade: Visual aspect of newly exposed reinforcement in fractured area in Repair 1 (a) and general aspect soon after pH indicator sprinkling (carbonation trial) (b). The exposed rebars presented a grey and brown color with area of accumulation of corrosion product of orange color, also along the concrete interface. After the sprinkling of the solution, part of the rebars did not become pink, nor the interface with the surrounding concrete (carbonated).

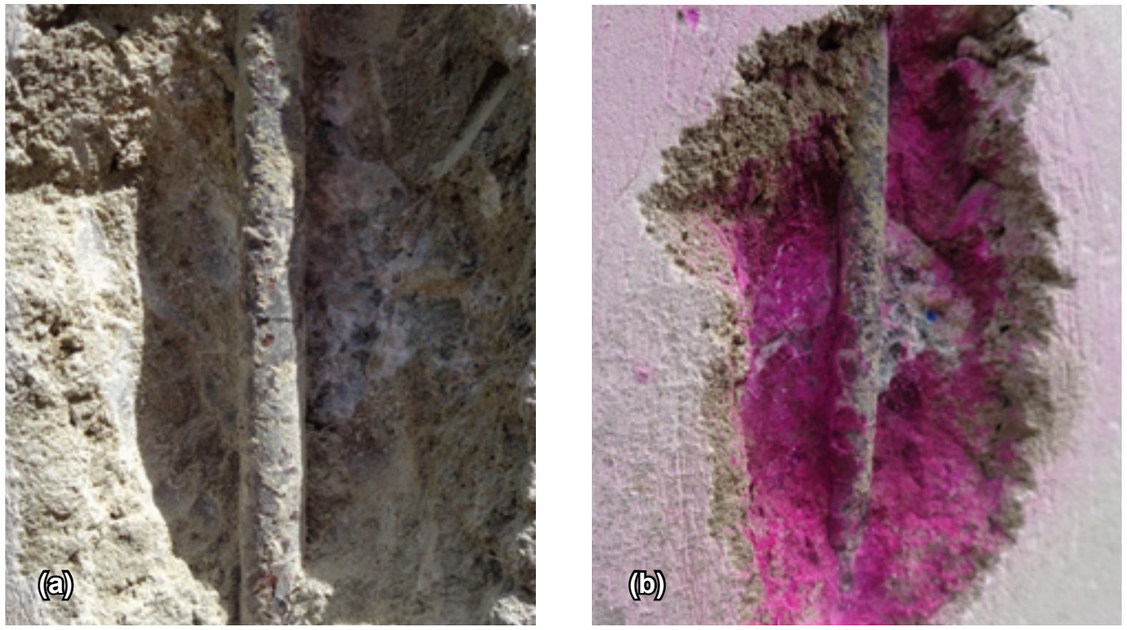


Figure 97: SE Façade: Visual aspect of newly exposed reinforcement in fractured area in Repair 1 (a) and general aspect soon after pH indicator sprinkling (carbonation trial) (b). The external exposed rebar presented a predominantly grey color with areas of accumulation of corrosion product of orange color. After the sprinkling of the solution, the major part of the rebar did not become pink, nor the interface with the surrounding concrete (carbonated).

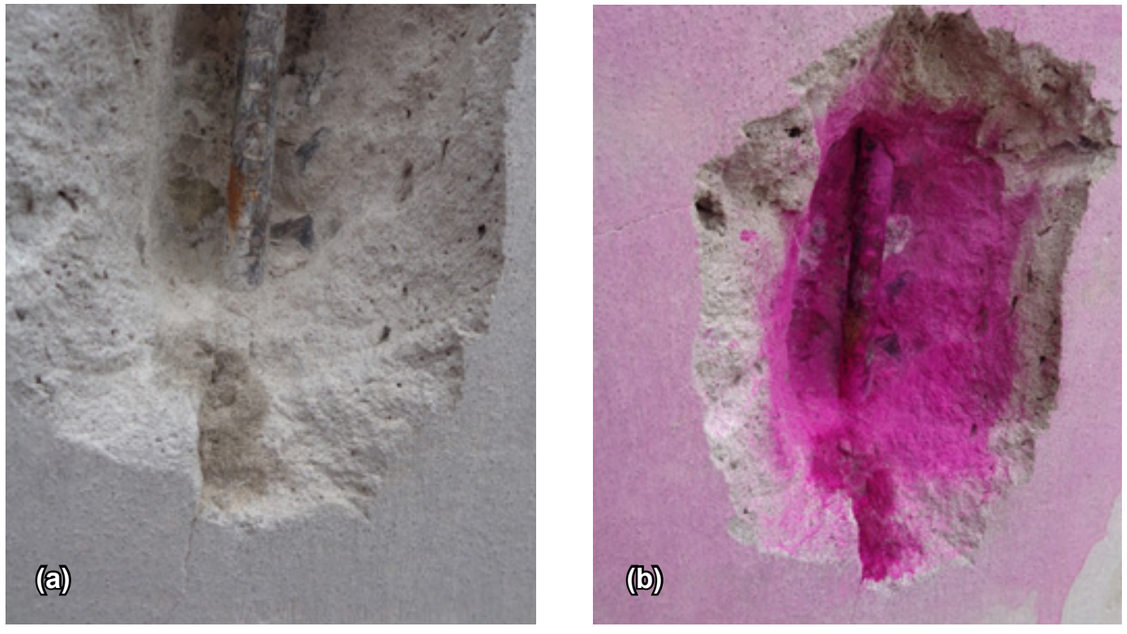


Figure 98: SE Façade: Visual aspect of newly exposed reinforcement in fractured area in Repair 1 (a) and general aspect soon after pH indicator sprinkling (carbonation trial) (b). The exposed rebar presented a predominantly grey color with areas of accumulation of corrosion product of orange color in the cracked repaired area (region next to the inner wet stain). After the sprinkling of the solution, the major part of the rebar became pink, as well as the surrounding concrete (exposed base of 26 mm not carbonated).

Table 22: Estimation of total carbonation of the coating mortar repair layer of the reinforcement.

Description	SW blind wall	NW blind wall		SE blind wall
	Area 1			
	Repair 1 (external)	Repair 1 (external)	Repair 2 (external)	Repair 2 (external)
	Argamassa de reparo			
Estimated exposure time (t, years)	4	4	4	4
Average depth of carbonation (mm)	9	5	5	8
Reinforcement inlay thickness (mm)	29	15	15	20
Carbonation coefficient (K)	4	3	3	4
Estimation of total carbonation of the coating repair mortar layer of the reinforcement (t, years)	47	38	31	31

Based on the results previously presented in Table 21, Table 22 shows the estimation of total carbonation of repair mortar until reaching the surface of the rebar, embedded in deeper depths (≥ 20 mm), and thus with the carbonation front not currently reaching their embedding region. In this table, it was considered that the repairs were executed four years ago.

Through Table 22, we observe that the time in years in all the repairs is above 30 years, the longest period obtained for the mortar of Repair 1, SW blind wall. However, if the value of 16 mm obtained in a segment (see Table 21) is considered, the estimated time would be of 13 years. In any case, the results presented in Table 2 can be considered as indicative that the rebar coating thickness value is significant in time for it to become chemically active, and that if the repair had been executed as per the procedure generated by the 2010 inspection, the repair rebar could again had become chemically inactive, thus with no corrosion signs, currently and for the coming decades.

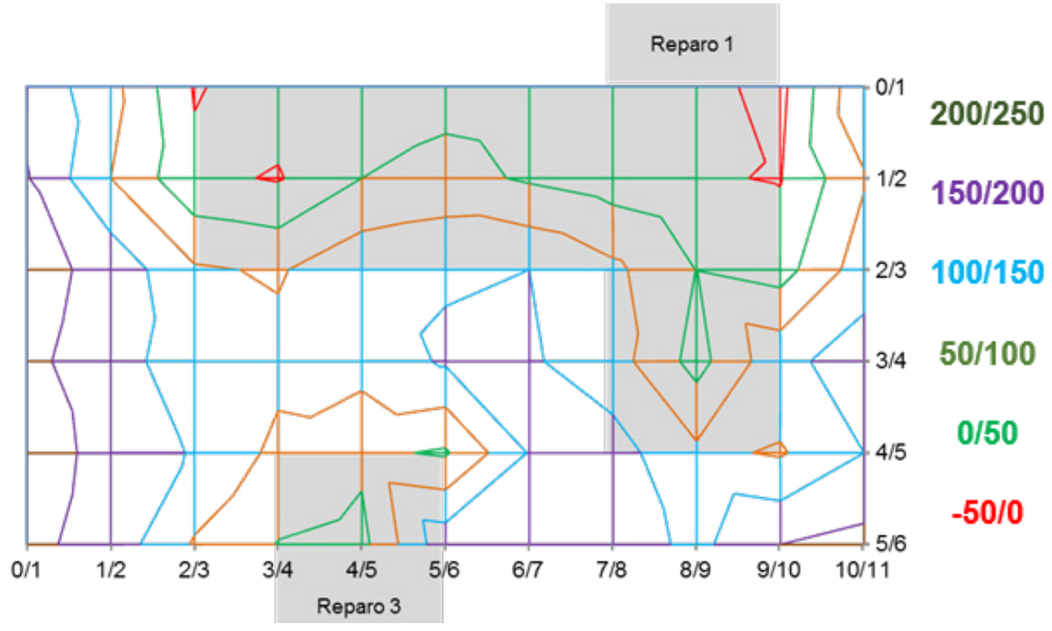
Figure 99 to 103 show the mapping of corrosion potential gradients (E_{corr}) and respective absolute values obtained in each of the areas inspected in the blind walls. For this electrochemical measure, the CorrMap equipment, comprised of a silver chlorine reference electrode - EPCP (Ag/AgCl/KCl sat.), was used. Therefore, all the Ecorr values presented refer to this electrode.

In Figure 99 to 103, we observe that, except for Area 2 of SW blind wall, all the other areas had a significant variation of potential gradients, indicating the presence of regions with possible active state of corrosion. This was expected because the active state of corrosion had already been verified by the visual inspection of exposed rebar in the study areas, and considering the average small coating thickness of many of them, and their embedding in carbonated concrete. In the mentioned Area 2, of SW blind wall, the same visual inspection has shown the presence of a single localized corrosion area (see Figure 93a), and that the exposed face of the concrete was not carbonated, beyond 20 mm (see Table 21). Possibly the region rebar was embedded in deeper depths, and thus was not chemically active.

In relation to the absolute values, we observe that only in Area 1 of SW blind wall, and in NW blind wall area, negative E_{corr} values were obtained. For this last one, representative values of the corrosion in wetted carbonated concrete were obtained, considering the range of values converted to the reference electrode used (CorrMap) from 209 mV to -291 mV, range of values referenced by ELSENER et al. (2003). The other values obtained are almost all within the carbonated concrete, but little wetted, range (309 mV to 109 mV), a range also referenced by ELSENER et al. (2003). Such results confirm the known interference of the concrete electrical resistivity, which in the case of carbonated concrete is very high, with the introduction of a significant ohmic drop in the E_{corr} measures, raising and thus assuming more positive values. Furthermore, the interference of pH reduction by carbonation reactions should also be considered, which also raises the E_{corr} values. Added to that, the impregnation of concrete with water repellent, which significantly contributes to reduce the concrete humidity contents, especially of the superficial layer, and thus also implies the increase of E_{corr} values.

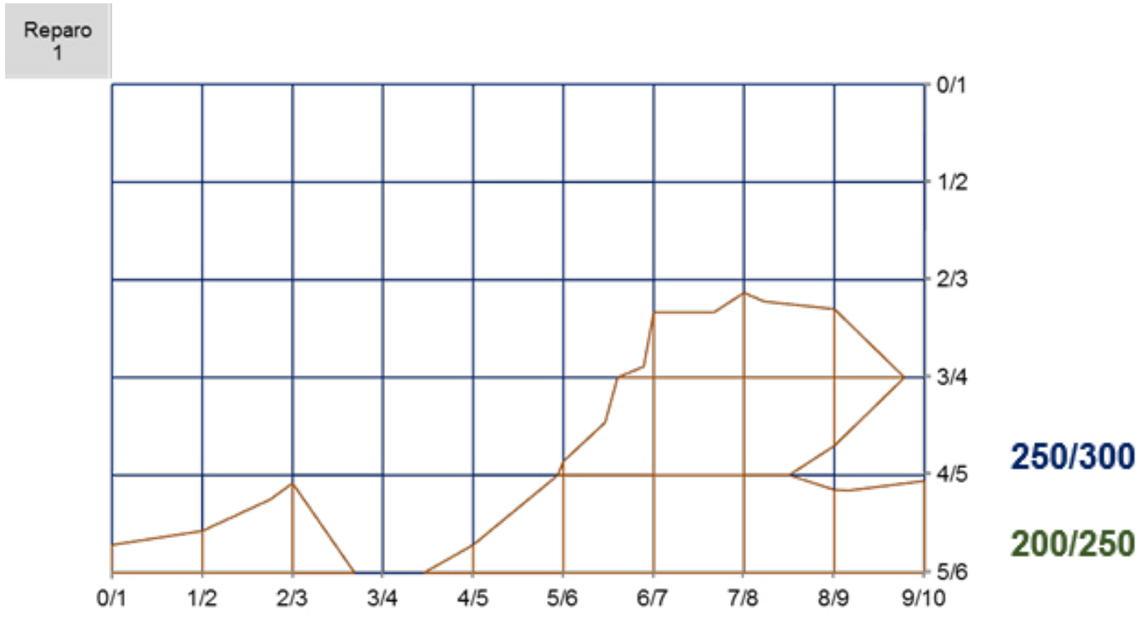
The mentioned interference of the carbonate concrete electrical resistivity and the impregnation of concrete with water repellent have also affected the corrosion rate measure – i_{corr}. After several attempts with no i_{corr} results, it was decided to evaluate only some pre-selected segments (repair areas). In these segments, the surface was intensively sanded aiming to remove part of the protection provided by the water repellent, and then intensively wetted, also with the use of a nylon bristle brush wetted with neutral detergent aqueous solution, to facilitate the penetration of water into the concrete.

Figures 104 to 110 show the i_{corr} values obtained, simultaneously with the E_{corr} ones, as well as the values of the coating concrete electrical resistivity. Although these last two are not discussed, they are presented because they were obtained simultaneously with the i_{corr}, sometimes the later with no reading. In this figures, we can observe that most of the individual and average values of i_{corr} were above 1.0 µA/cm² (section loss of 10 µm/year), which according to Andrade et al. (2004), indicate a severe corrosion of the rebar. However, it is believed that this seriousness is related to the described activities of concrete sanding and wetting, which naturally raises the rebar corrosion rate. Therefore, such values are only representative for the rebar in areas in which the surface has impregnation flaws, and is exposed to the humidification condition of the rebar coating concrete. Thus, these would be the critical areas to be monitored or to be prioritized in future maintenance interventions.



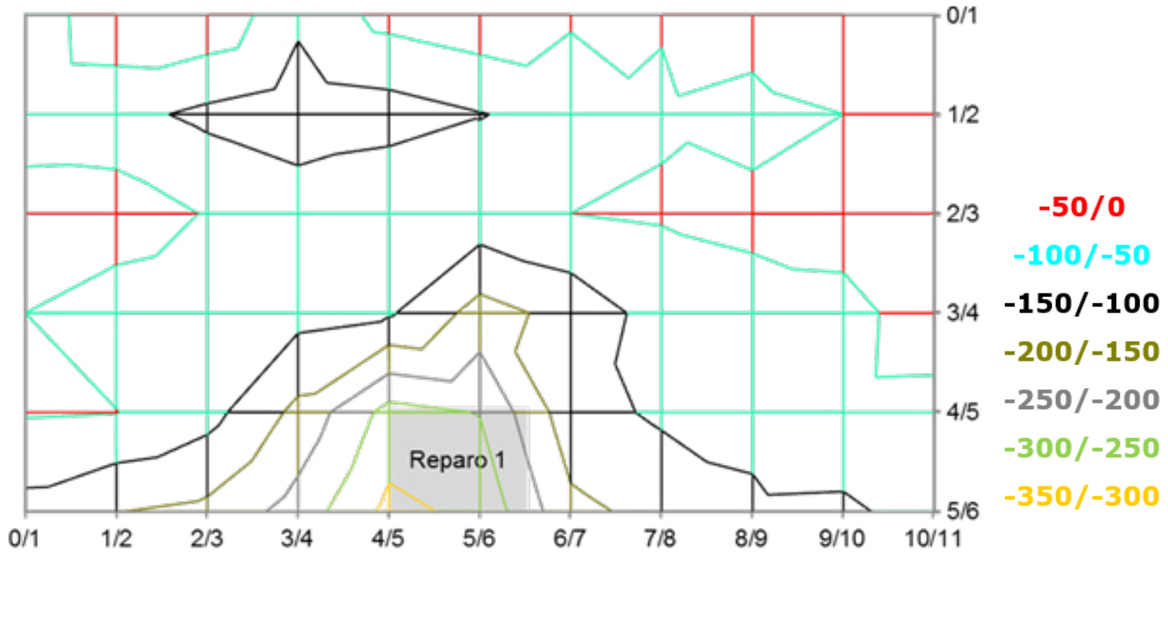
Axis	0/1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10	10/11
0/1	185	117	-4	23	21	33	27	36	14	-14	146
1/2	203	100	11	-4	50	66	44	25	5	-3	95
2/3	219	184	106	95	136	146	150	111	49	29	127
3/4	212	172	120	114	119	156	156	122	32	136	175
4/5	215	190	145	88	60	44	153	170	110	95	150
5/6	212	180	95	48	36	183	198	179	137	200	215
Minimum	-14										
Maximum	219										
Average	108										
DP	69										

Figure 99: Blind wall SW: Potential map (Ecorr) and respective potential data Area 1.



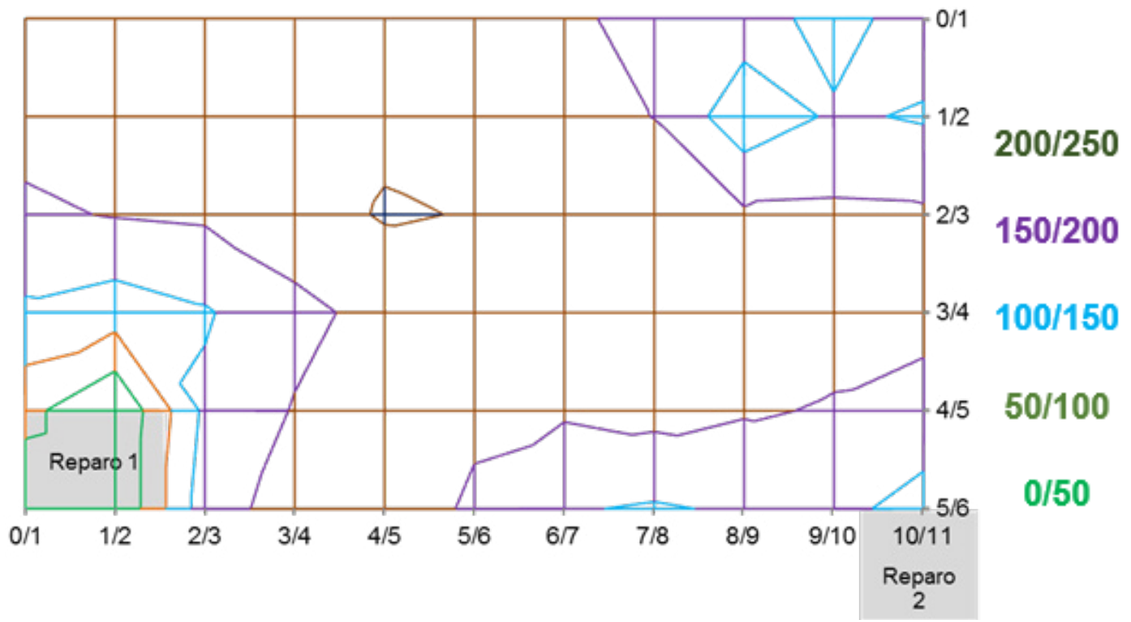
Axis	0/1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10
0/1	256	265	266	273	269	271	274	270	277	271
1/2	266	272	264	263	267	278	256	254	256	268
2/3	261	277	269	261	273	282	252	252	253	262
3/4	250	263	252	256	259	256	246	237	243	252
4/5	255	254	251	262	265	249	243	247	253	251
5/6	248	247	239	255	244	227	219	225	233	237
Minimum	219									
Maximum	282									
Average	257									
DP	14									

Figure 100: Blind wall SW: Potential map (E_{corr}) and respective potential data Area 2.



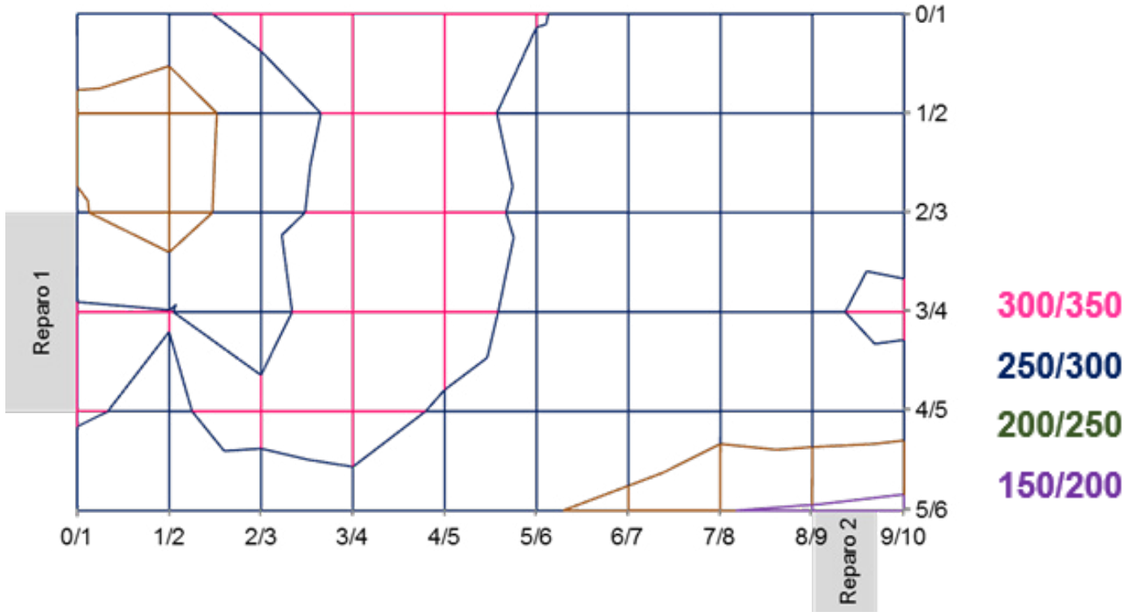
Axis	0/1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10	10/11
0/1	-84	-13	-9	-89	-33	-15	-43	-48	-32	-4	-3
1/2	-88	-85	-111	-131	-122	-102	-83	-54	-63	-50	-38
2/3	-16	-22	-53	-71	-54	-69	-50	-46	-40	-31	-24
3/4	-50	-76	-87	-84	-94	-169	-134	-79	-65	-63	-30
4/5	-46	-49	-82	-163	**-268**	**-248**	-120	-92	-87	-61	-62
5/6	-117	-149	-162	-221	**-313**	**-288**	-162	-136	-108	-110	-78
Minimum	**-313**										
Maximum	**-3**										
Average	**-88**										
DP	**67**										

Figure 101: Blind wall NW: Potential map (Ecorr) and respective potential data.



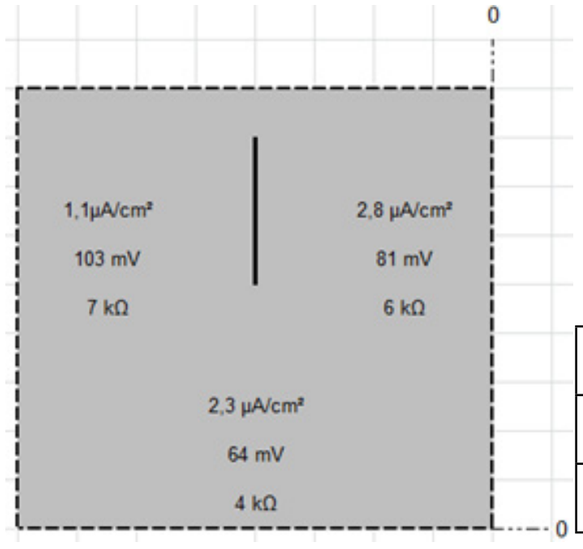
Axis	0/1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10	10/11
0/1	217	206	216	204	205	208	213	178	176	129	177
1/2	212	209	206	222	240	235	219	199	117	157	145
2/3	194	202	207	229	254	248	244	238	207	209	207
3/4	141	124	145	187	215	219	227	228	222	213	211
4/5	**65**	**0**	160	203	222	213	206	215	204	197	187
5/6	**13**	**0**	176	223	241	189	154	145	156	167	127
Minimum	**0**										
Maximum	**254**										
Average	**187**										
DP	**54**										

Figure 102: Blind wall NE: Potential map (Ecorr) and respective potential data.



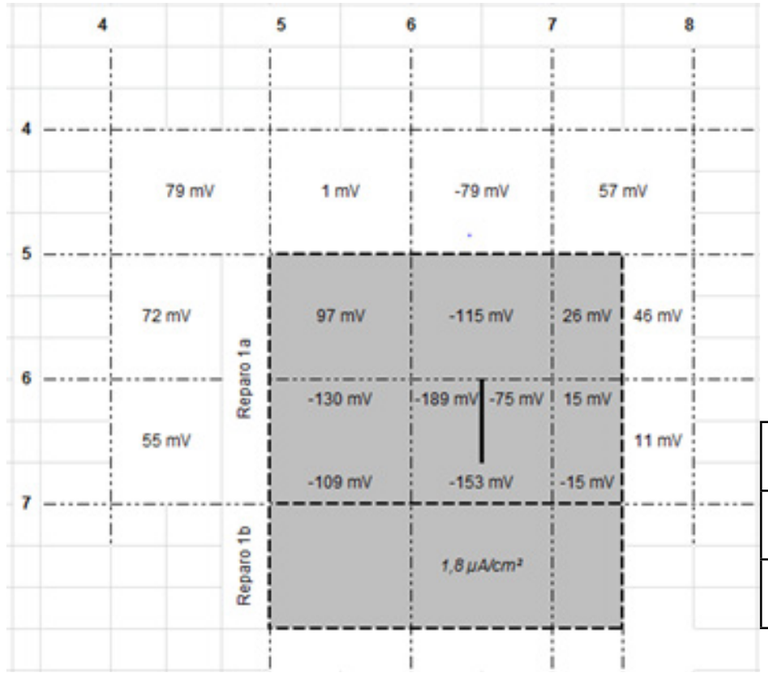
Axis	0/1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9/10
0/1	296	292	309	322	319	302	286	295	271	272
1/2	236	212	285	308	317	287	283	269	270	275
2/3	255	216	288	313	312	294	272	278	287	282
3/4	305	301	279	341	318	287	299	294	295	309
4/5	302	296	312	319	295	279	295	274	281	277
5/6	289	282	280	285	260	256	235	201	195	185
Minimum	**185**									
Maximum	**341**									
Average	**282**									
DP	**32**									

Figure 103: Blind wall SE: Potential map (Ecorr) and respective potential data.



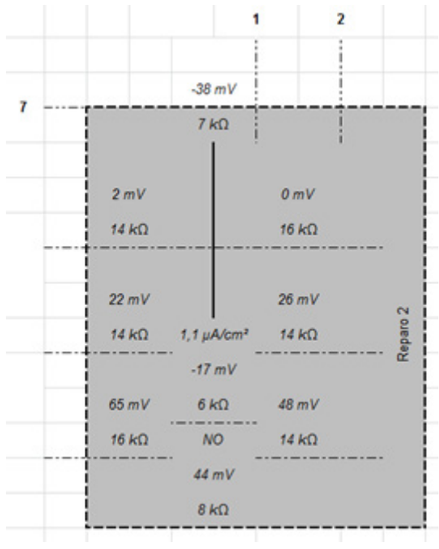
Corrosion rate *- average value*	***2,1 µA/ cm²***
Corrosion potential *- average value*	***83 mV***
Electrical resistance *- average value*	***6 kΩ***

Figure 104: Blind wall SW: Corrosion rate (icorr), corrosion potencial (Ecorr) and electrical resistance for Area 2, in the surface of mortar repair 1.



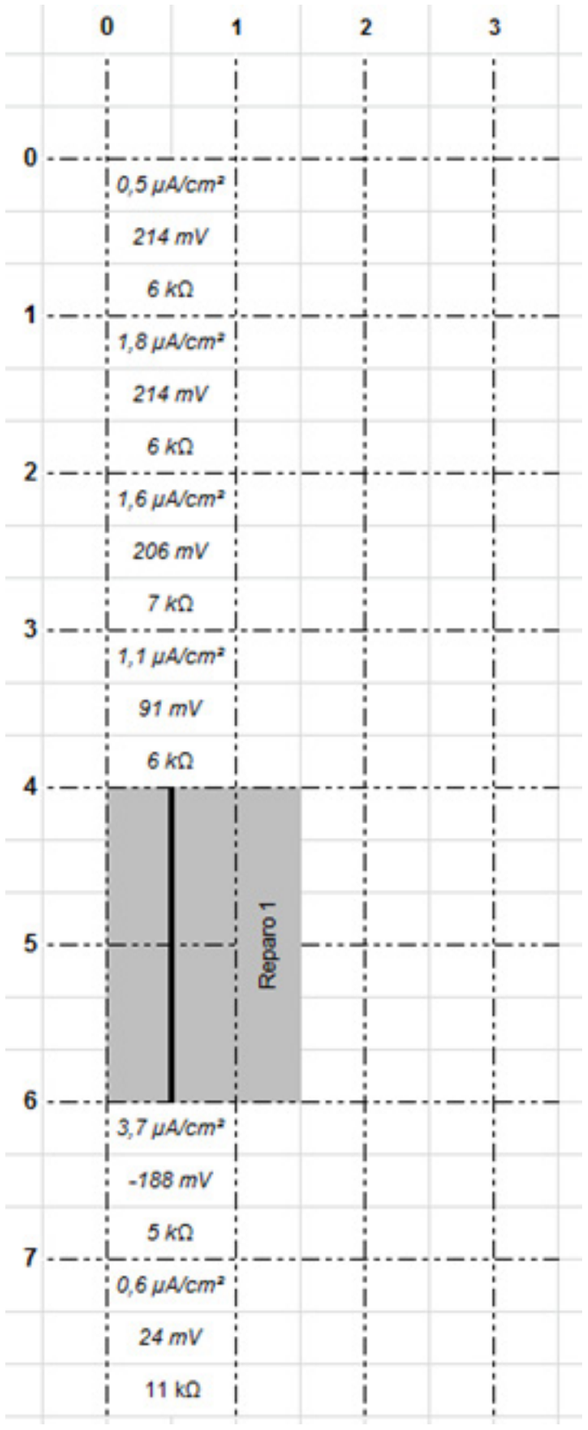
Corrosion rate *- average value*	***1,8 µA/ cm²***
Corrosion potential *- average value*	***-23 mV***
Electrical resistance *- average value*	***- kΩ***

Figure 105: Blind wall NW: Corrosion rate (icorr), corrosion potencial (Ecorr) and electrical resistance in the surface of the mortar repair 1.



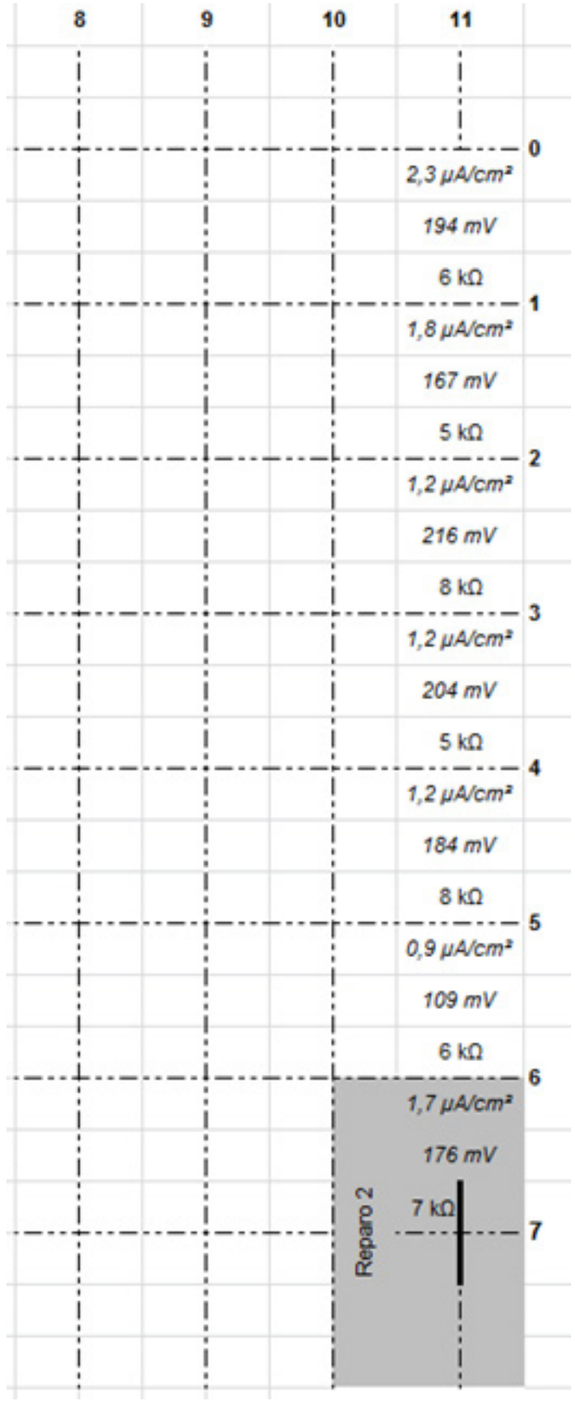
Corrosion rate *- average value*	***1,1 µA/ cm²***
Corrosion potential *- average value*	***21 mV***
Electrical resistance *- average value*	***13 kΩ***

Figure 106: Blind wall NW: Corrosion rate (icorr), corrosion potencial (Ecorr) and electrical resistance in the surface of the mortar repair 2.



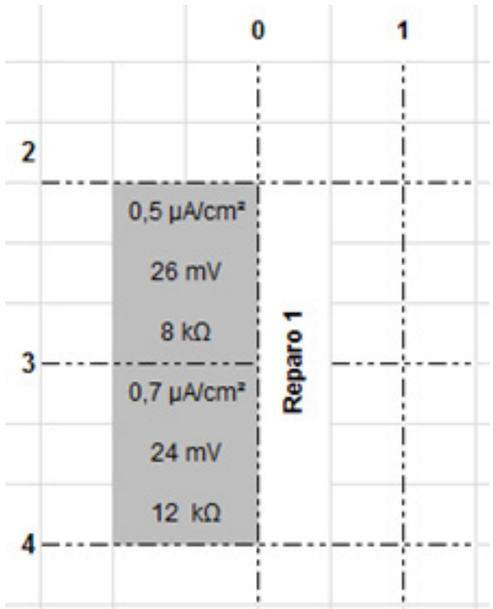
Corrosion rate *- average value*	***1,6 µA/cm²***
Corrosion potential *- average value*	***94 mV***
Electrical resistance *- average value*	***7 kΩ***

Figure 107: Blind wall NE: Corrosion rate (icorr), corrosion potencial (Ecorr) and electrical resistance in the surface of the mortar repair 1 and the adjacent concrete area.



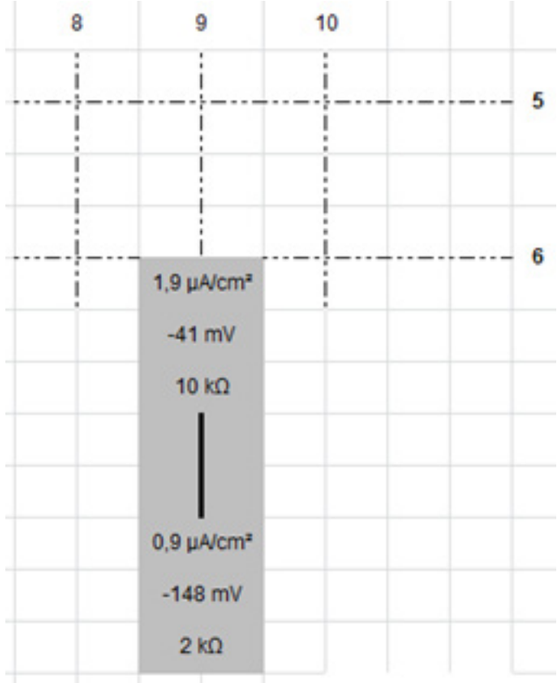
Corrosion rate *- average value*	***1,5 µA/cm²***
Corrosion potential *- average value*	***179 mV***
Electrical resistance *- average value*	***6 kΩ***

Figure 108: Blind wall NE: Corrosion rate (icorr), corrosion potencial (Ecorr) and electrical resistance in the surface of the mortar repair 2 and the adjacent concrete area.



Corrosion rate *- average value*	***0,6 µA/ cm²***
Corrosion potential *- average value*	***25 mV***
Electrical resistance *- average value*	***10 kΩ***

Figure 109: Blind wall SE: Corrosion rate (icorr), corrosion potencial (Ecorr) and electrical resistance in the surface of the mortar repair 1.



Corrosion rate *- average value*	***1,4 µA/ cm²***
Corrosion potential *- average value*	***-95 mV***
Electrical resistance *- average value*	***6 kΩ***

Figure 110: Blind wall SE: Corrosion rate (icorr), corrosion potencial (Ecorr) and electrical resistance in the surface of the mortar repair 2.

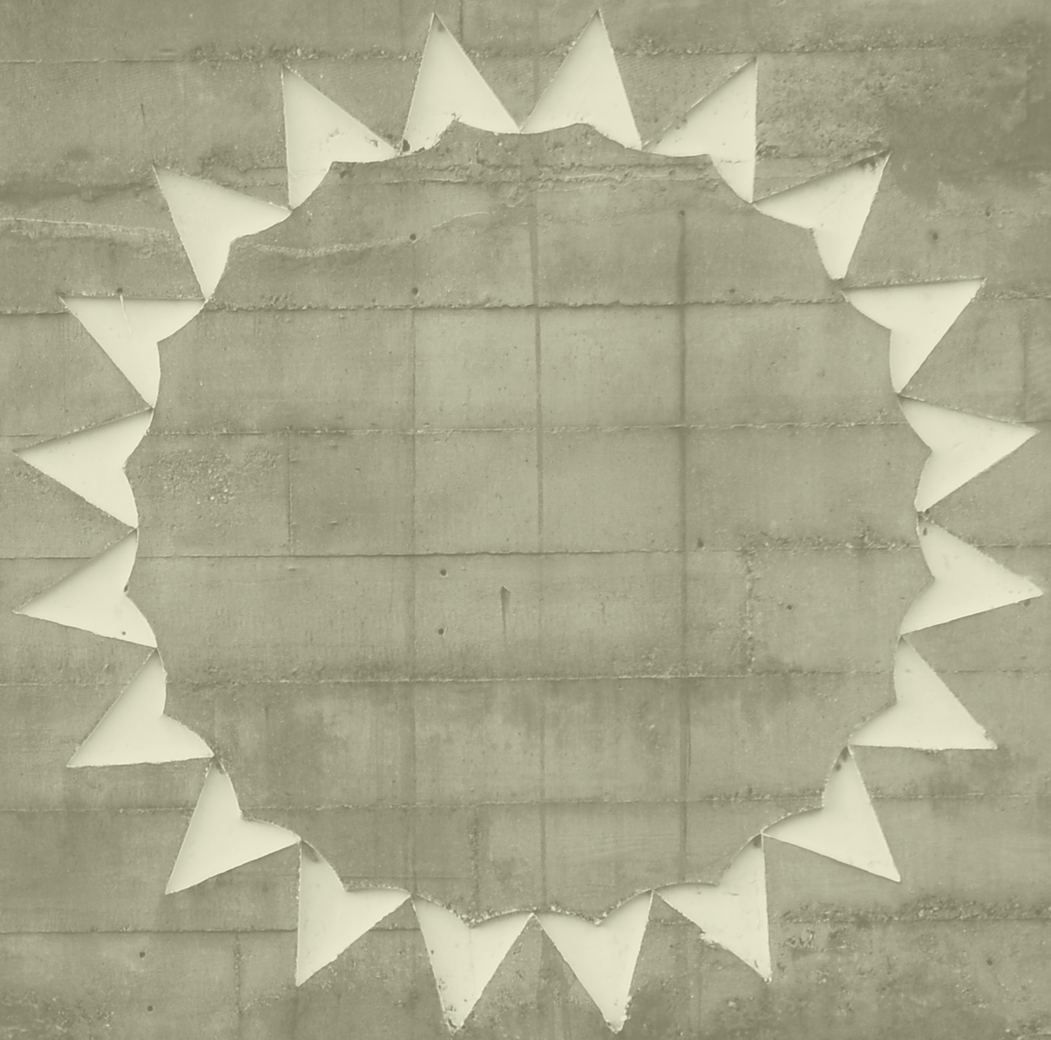


Foto: autor e data desconhecidos. Photo: Vitor Nisida, 2012.

3.11

ANALYSES, RECOMMENDATIONS AND GUIDELINES

Analyses, recommendations and guidelines

Based on the surveys and tests, it was possible to estimate the state of conservation and the impacts of pathologic manifestations in the requirements of functionality, safety and durability of blind walls, which allowed for the proposition of guidelines for the future conservation plan, considering preventive and corrective actions, and the factors of risk to the integrity of the reinforced concrete as the structural material and as essential part of a heritage to be protected.

Besides the consensus about the inadequacy of the repairs in relation to the esthetic characteristics of the building, test results have shown that the performance of theses repairs also does not meet requirements that impact the durability of the façades.

Therefore, regarding the proper conservation of the blind façades, the following lines of action are proposed, based on the collected field evidence:

The first line of action comprises a new repair inspection and monitoring campaign (total area 730,99m^2); inspection of the blind façades to map cracking and superficial discontinuities, and also to identify possible new corrosion points. Depending on the results of these inspections, the second line of action prescribes the rework of the repairs and, eventually, the execution of new repairs, followed by the application of a surface protection system (corrosion inhibitor and water repellent). A parallel line of action suggests the continuity of studies on the concrete properties that have a direct impact on the efficay of surface treatments and, consequentely, on the durability of the structure. Another parallel line of action prescribes the continuity of investigations and adaptations of new repair techniques, as well as studies for the mitigation of the fragmented effect caused by the façade repairs.

The following recommendations and guidelines are grouped in 4 themes related to the above mentioned lines of action, and also operational and administrative aspects that should be observed for the conservation of the blind façades.

Analyses and recommendations on operational and administrative aspects

The operational issues of access to the blind walls show to be limiting factors in some moments during this research activity, and thus require attention to allow not only for new campaigns of tests and repair works, but above all routine activities of inspection and preventive maintenance.

The less invasive way of accessing the external surface of blind walls is through an articulated lifting platform, as described in the previous item of this report. Therefore, a recommendation to turn the work infrastructure feasible is the design and construction of an area surrounding the building with stability and capacity to support the load from articulated lifting platforms; technical solutions for stabilizing base or sub-base of pavements can be used, such as geogrid technology for the accommodation of granular material covered with garden area.

The alternative recommendation is to develop a design, along with the company providing equipment for restoration works, of lifting equipment provided with counterweights and other devices that do not require the drilling of the roof beams. The walkways of such lifting equipment should have a width close to 11 m (half of the distance between external pillars).

The challenges of administrative nature, in addition to those of technical and operational nature, should also be considered. Conservation has to be thought in terms of possible, and probable, management-related limitations, that is, the availability and continuity of human, financial and infrastructure resources flow. The successive administrations of these buildings assuming such commitment is also another challenge. This commitment, above all in the public sector, is sometimes impossible due to the bureaucratic and impeditive conditions in which processes are addressed, for instance, contracting of services and intervention works, or even the maintenance of such buildings.

Another important recommendation relates to the contracting of services, either of preventive or corrective maintenance. In the invitations to bid to contract design and work services, clauses regarding the need of proving prior experience with restoration works or conservation of protected heritage should be ensured.

The local manpower should also be trained by a team of specialists for the operations of blind walls cleaning or inspection, if such activities are performed with human resources of the university itself.

Analysis and recommendations on the monitoring of the blind walls physical conditions

The inspection of repairs has revealed fissures already visible on the surface of such areas, in addition to the carbonation depth already reaching more than on centimeter of depth. For the fact that this is a significant area in comparison to the total blind wall area, the situation of such repairs should be inspected.

New investigations and monitoring campaigns for the blind walls are recommended in the short term, that is, in the next 18 months, with the following objectives:

• to inspect repairs regarding their soundness, adherence to the substrate, and signs of corrosion of the rebar;

• to inspect stains of corrosion products to check the hypothesis of contamination of the aggregate by pyrite, and to map the deposits resulting from the corrosion of steel parts used in the stabilization of concrete casting moulds;

• to test and adjust methods to determine the superficial water absorption by blind walls;

• to map the concrete surface characteristics (cavities, gravel pockets, cold joints) and the fissures (in the concrete and in the repair mortar); the detailed mapping is necessary to analyze the interference of such flaws with the effective action of surface protection systems. Academic studies in progress, about historical exposed concrete superficial protection systems, can support those activities;

• to map new areas in the blind walls for the detailed registration of rebar coating. The adoption of the procedures described in chapter 9 (Basis for the Statistical Evaluation of Measured Cover Depths in Reinforced Concrete Structures) from a recent document published by Rilem – State of Art Report Rilem TC 230-PSC (BEUSHAUSEN; LUCO, 2016) is recommended. These procedures enable the survey and estimation of the minimum reinforcement coverage.

It is noteworthy that the recommended surveys and monitoring will demand investments from the institution to contract the infrastructure and professionals to perform such surveys. These are activities demanding highly trained and qualified manpower to perform the work. The results of such services are needed for the recuperation of structural repairs that show signs of early aging, and to protect the concrete surface.

Analyses and guidelines on the continuity of studies about the concrete

The results suggest that the blind walls might have been cast with concrete with characteristic strength different from the concrete used to cast the roof beams.

It is recommendable to remove concrete cores from the still not investigated blind walls, SE and SW, to know with more details the properties of the concrete representative of several stages of the concreting process, and exposed to different levels of aggressiveness, especially regarding the ICD. Measures of inference in the deformation modulus by means of non-destructive techniques, and their correlation with the concrete strength, are also interesting for the continuity of the studies.

The probable traces of concrete calculated with the use of classical parameters are coherent, and can be considered as references for the study of concrete recipes for structural repairs.

In view of the assumption adopted, the results presented in this research allow to suggest the superficial porosity of the concrete as one of the variables to be more explored in further studies. The choice is justified, as usual, by the influence of porosity on the water transportation phenomena, and of other elements that are potentially harmful for the concrete. Furthermore, it is possible to intervene with the superficial porosity of the concrete to limit or control the entrance of water and the exit of water vapor. To that end, the property of transportation should be deeply studied by means of isotherms of sorption, along with other non-destructive techniques, such as gamma radiation attenuation.

The tests of mercury intrusion porosimetry were useful to know the general porosity of the studied concrete. However, new MIP tests, associated to the already mentioned techniques of water vapor sorption isotherms and attenuation of gamma radiation, and the investigation of C-S-H alterations, are needed to solve doubts and incongruent results so far obtained.

Although the use of phenolphthalein is useful to measure the carbonation in critical pH for the carbon steel corrosion, carbonation depth measures should be taken with the use of other indicators as turning points in pH above that of the phenolphthalein. Such measures will be useful for the registration of the carbonation front in the blind walls, with the aim of studying these possible influences of carbonation in the properties of the concrete paste.

The carbonated regions should be investigated with more details regarding the possible structural alteration of the C-S-H due to carbonation.

The survey of the state of fissures in the blind walls, especially of fissures indicating efforts working on the concrete in more demanded regions (especially in the areas typical of poor rebar adherence), will be valid for academic studies in progress, about the analytical verification of the safety of the Vilanova Artigas building structure.

Guidelines for the treatment and rework of repairs

The possibility of intervention should be coherent to the characteristics of the building, both from the technical and the aesthetical points of view. The exposed concrete is both structure and sealing, performing a very important role in the composition and perception of the building, and therefore complete mortar lining and/or total paint, not based on consistent research, should be rejected.

The recommendations to mitigate the discrepancy between repairs and the existing blind wall surface should be done carefully, to prevent an exclusively aesthetical approach that is not compatible with the building´s fabric. Some solutions already tried should be monitored over time; only then theplanning of a phased program should be proposed to gradually tackle the problem.

From a technical viewpoint, some characteristics of the repaired areas and construction particularities of the blind façades should be pointed out.

The main pathological manifestation observed, reinforcement corrosion induced by carbonation, resulted in a great number of repairs scattered throughout the façades; 940 repair regions, of varied dimensions, were identified, in a total area of 730,99 m2 and a perimeter of 3558,64 m (interface between the repair mortar and the concrete). In total, 23,7% of the concrete surface was substituted by repairs, which is equivalent to an area bigger than the smaller façades (NO and SE).

The nominal thickness of the façades is 20 cm. With heights that vary from 7,25 and 8,15 m, these wall-beams are slender and densely reinforced.

The results of the first study on concrete parameters influencing the visual perception, and on the recipe and application of finishing mortars, were presented. Based on the evaluation of such results over time, the proposed methodological approach can be updated, revised or complemented to serve as the base for future repairs. The studies of a possible treatment of repairs surface to mitigate the visual effect is in progress.

Based on the results obtained, we start with the assumption that the repairs of the external face of blind walls should be done by using industrial cement-based repair mortars, modified by polymers and with compensated retraction. Those repairs should be finished with a 1 cm thick mortar layer moulded in loco. This assumption is based on the described patterns of pathological manifestations and on the construction particularities of the blind façades, and is supported by the following reasons:

• the small thickness of repairs executed so far, most close to 20 mm and not exceeding 40 mm; furthermore, the current stage of knowledge and domain of the structural repair technology allows, for works such as those of Artigas building, the study of mortar recipes jointly with the manufacturers, with the aim of meeting the aesthetical requirements.

• the use of concretes or grouts, instead of industrial mortar, to fill such hollows would require the development of special recipes, and especially a system of moulds non-invasive to the building structure, and feasible in the current technical and operational conditions.

• the chromatic variability of the façade demands one-off studies to determine the finishing mortar shades, considering the random pattern of emergence of degraded areas.

Naturally, new research and development projects can support new approaches for the execution of such repairs and for the conservation of the building blind walls in the future. One of the possibilities, given the significance of the building, is the study of the mix design for repair mortars together with manufacturers interested in providing a product that meets the necessary aesthetic requirements. Another possibility is the development of special moulding systems to make feasible the use of traditional repair formwork with concrete and grouts.

Analyses and recommendations about treatment to reduce the corrosion rate

The reduction of the corrosion rate in progress in the blind walls rebar is the main focus of the recommendations described as follows. Furthermore, the recommendations are made considering the small thickness of the rebar coating, the superficial porosity of the concrete surface, and the limited efficiency of the superficial protection by impregnation and the local repairs executed, in addition to the environmental aggressiveness, all of them previously discussed.

It is noteworthy that the recommendations are restricted to those regarded as essential for the conservation of blind walls, preventing actions that result in changes to the original concrete aspect.

Based on the inspection already recommended previously, the recommendations are follows:

• rework of repairs already showing visible signs of deterioration, such as with fissures, and having a hollow sound; such repairs should be redone with structural mortar added with corrosion inhibitor, and manually applied. The usual repair procedure should be followed, with highlight on the exposure of the whole perimeter of the rebar segment with visible presence of superficial stains indicating corrosion. In addition, the primer usually applied to the rebar should be compatible with the mortar, and thus also added with corrosion inhibitor. It is mentioned that the mortar used can have its color adjusted along with the supplier, to minimize the contrast with the concrete color;

• impregnation of the whole external surface of blind walls with corrosion inhibitor compatible with that used in the repair system;

• superficial treatment by high performance water repellent impregnation.

Due to the complexity or possible alterations of the blind wall surface appearance, the following recommendations are made with an investigative nature, for further study:

• re-alkalinization of the rebar coating concrete: Complying with standard BSI BS EN 14038-1:2016, and following Principle 7.4: electrochemical re alkalinization, with imposition of current and alkaline solution, following the standard EN 1504-9 (2008). There is the option of re alkalinization with no imposition of current, only with the application of the alkaline solution, which naturally spreads in the environment, also turning the rebar chemically inactive;

• filling of areas of hollows and fissures on the blind wall surfaces: done with colorless aliphatic polyurethane resin or cement paste added with acrylic polymers with color similar to the existing one, both industrialized and complying with the essential properties, such as, for instance, low water (liquid and vapor) and gases (CO2) permeability, and no alteration of the appearance over time (color and uniformity);

• use of open circuit potential reference electrode (in the concrete and in the repairs), and galvanic sensor or corrosion rate sensor (in the repair) in area of future recuperation interventions. The functioning of such sensors requires a reading box fixed in the site of extreme contact wire with central reading terminal (manual or wireless). The use of electrodes and sensors is important to monitor the performance of protection methods described in Table 21, thus being important to plan future maintenance, especially periods for reapplication of water repellents and the corrosion inhibitor. It is possible that the data obtained by sensors might be used for modeling the residual useful life of blind walls and repairs. To that end, it is important to know the local environmental conditions of the exposure, as well as the time blind walls remain wet, and the relative atmospheric humidity.

The specifications on the method and principles of treatments recommended are presented in Table 21, following the principles of protection and recuperation of structures of standard EN 1504-9 (2008).

The following tables (Tables 24, Tables 25, Table 26) show the requirements, criteria and respective test methods to check the properties of products to be applied in the future for the treatment of blind walls and the superficial treatment by hydrophobic impregnation; to the structural and non-structural repairs, and to the impregnation with corrosion inhibitor.

Table 23: Recommendations to reduce the corrosion rate of blind wall rebar of Vilanova Artigas building, according to the principles of EN 1504-9 of 2008.

Method	Principle	Protection	Remark	Determinant conditions of the application on blind walls
Superficial treatment by hydrophobic impregnation (EN 1504-2)	Principle 1: Protection against entrance - EP Principle 2: Humidity control - HC Principle 8: Resistivity increase - RI	Property repellent to liquid water (usually rainfall and from infiltrations) to the concrete surface, without restricting the evaporation of water contained in the environment. The control of the internal concrete humidity raises its electrical resistivity, and thus there is a reduced risk of corrosion or the reduction of the rate of corrosion in progress. Furthermore, it can prevent staining the surface, by restricting it becoming wet by water and deposit of particulate matter (PM), as well as preventing the chemical attack resulting from the leaching of compounds, and by the proliferation of microorganisms by water, if it is acid.	It does not work as protection against the entrance of gases and water as vapor and under pressure. It can speed up the advance of carbonation. There is limitation of impregnation in regions of hollows, fissures and other recesses of the surface.	Porous surface of the exposed concrete. Repairs with fissures. Rebar corrosion in repair areas.
Structural and non-structural repair with thixotropic industrialized mortar (EN 1504-3)	Principle 3: Structural and non-structural repair - R Principle 7.2: Preservation or restoration of the chemical inactivity – PR – Replacement of the carbonated concrete	Reconstitution and chemical inactivation of the segment of the rebar previously treated, as part of the concrete recuperation system in repair areas located at low depth.	As part of the repair system, its use is associated to the application of adherence bridge, and to the treatment of exposed rebar. Since the repair can result in the formation of incipient anode in the segment next to the repair, its protection should also be part of the repair system. The mortar color can be defined with the manufacturer, with guarantee of complying with the essential requirements of protection performance.	Rebar corrosion in repair areas. Repair mortar with significant advance of the carbonation front, and not comprising the whole perimeter of the rebar. Points of corrosion at the concrete surface.
Impregnation of coating concrete with corrosion inhibitor and incorporation into the repair mortar	Principle 11: Control of the anodic area - AC	Reduction of the corrosion rate, acting in the anodic and/or cathodic reaction	The same type of inhibitor should be applied to the concrete surface, and incorporated to the mortar of new repairs to be done. The protection efficiency depends on the concentration existing in the rebar surrounding, thus requiring evaluations to check the effectiveness of the adopted concentration	Rebar corrosion in repair areas. Repair mortar with significant advance of the carbonation front, and not comprising the whole perimeter of the rebar. Points of corrosion at the concrete surface.

Table 24: Properties and limit values for selection of surface protection system by hydrophobic impregnation (EN 1504-2, 2004).

Properties	Application and limit values
Water absortion rate (EN 13580)	Rate < 7,5 % compared to untreated specimen Rate < 10% after immersion in saline solution
Depth of penetration of impregnation (EN 1766 and EN 13579)	Class I: depth < 10 mm Class II: depth ≥ 10 mm
Drying rate (EN 13579)	Class I: drying time > 30% Class II: drying time > 10%

Table 25: Repair mortar performance requirements (EN 1504-3).

Test	Method	Principles of protection and testing	Requirements (1)			
			Non-structural		Structural	
			Class R1	Class R2	Class R3	Class R4
Compressive strength	EN 12190 (1998)	Required for repair, restoration and reinforcement	≥ 10 MPa	≥ 15 MPa	≥ 25 MPa	≥ 45 MPa
Adhesion	EN 1542 (1999)	Required for repair, restoration and reinforcement. Adoption of EN 1766 (2000) substrate. In the case of applications on underside, such as bridge beams, adopt EN 13395-4 (2002)	≥ 0,8 MPa		≥ 1,5 MPa	≥ 2,0 MPa
Retraction / Expansion	EN 12617-4 (2002)	Required for repair, restoration and reinforcement. Adoption of EN 1766 (2000) substrate. Not applicable when performing cyclic test and for projected mortar	–	≥ 0,8 MPa	≥ 1,5 MPa	≥ 2,0 MPa
Resistance to carbonation	EN 13295 (2004)	Required to verify durability in repair, restoration and reinforcement of reinforced concrete when there is no efficient surface protection. Adoption of EN 1766 (2000) substrate	–		dk ≤ to control concrete	
Modulus of elasticity	EN 13412 (2006)	required for reinforcement	–		≥ 15 GPa	≥ 20 GPa
Thermal compatibility	EN 13687-1, 2 e 4 (2002)	Recommended test to check the durability of any protection principle. Adoption of EM 1766 (2000) substrate	Visual inspection	≥ 0,8 MPa	≥ 1,5 MPa	≥ 2,0 MPa
Slip resistance	EN 13036-4 (2003)	Recommended test for repair, restoration and reinforcement of floors with traffic	Class I: > 40 UM (humid condition) Class II: > 40 UN (dry condition) Class III > 55 UN (humid condition)			
Thermal expansion	EN 1770 (1998)	Recommended test to check the durability of any protection principle. Can be replaced by the thermal compatibility or thermal cycle test	-			
Capillary absorption	EN 13057 (2002)	Recommended test for any principle, depending on the exposure conditions	–	≤ 0,5 kg/m-2.h-0,5		

(1) Structural recovery considers the need for replacement and / or complementation of reinforcement and / or increase of reinforced concrete elements section or its recomposition, usually with thicknesses greater than 25 mm. Non-structural recovery considers only geometric and aesthetic aspects of the reinforced concrete to be recovered, being usually adopted for repair with a thickness of less than 10 mm.

Table 26: Requirements for identification of repair coatings (EN 1504-3).

Test	Test method	Tolerances in relation to the value of technical bulletins
Granulometry of dry components	EN 12192-1 (2002)	Values and tolerances declared by the producer
Infrared analysis	EN 1767 (1999)	Confirmation by comparison of signs of composition
Compressive strength	EN 12190 (1998)	≥ 80% of the value declared by the producer
Volumetric mass	EN 12190 (1998)	± 5 %
Hardening time	EN 13294 (2002)	Values and tolerances declared by the producer
Workability	EN 13395-1, 2 e 3 (2002)	Values and tolerances declared by the producer
Thermogravimetric analysis	EN ISO 11358 (1997)	Confirmation by comparison of signs of composition
Epoxy equivalent	EN 1877-1 (2002)	± 5 %
Amine function	EM 1877-2 (2000)	± 6 %
Working time	EN ISO 9514 (2005)	± 20 %
Volatile / non-volatile matter	EN ISO 3251 (2008)	± 10 %

Photo: author and date unknown. Source: Rosa Artigas.

REFERENCES

ALMEIDA, N.L.; PANOSSIAN, P. Corrosão atmosférica 17 anos. Secretaria da Ciência e Desenvolvimento Econômico do Estado de São Paulo. 1999. 130 p.

AMERICAN CONCRETE INSTITUTE (ACI). ACI 201.2R: guide to durable concrete. In: ACI Manual of concrete practice. Michigan, 2008. 38 p.

AMERICAN CONCRETE INSTITUTE (ACI). ACI 201.2R: guide to durable concrete. In: ACI Manual of concrete practice. Michigan, 2008. 38 p.

AMERICAN CONCRETE INSTITUTE (ACI). ACI 201.2R: guide to durable concrete. In: ACI Manual of concrete practice. Michigan, 2008. 38 p.

AMERICAN CONCRETE INSTITUTE (ACI). ACI 201.2R: guide to durable concrete. In: ACI Manual of concrete practice. Michigan,. 38p. 2008.

AMERICAN CONCRETE INSTITUTE (ACI). ACI 201.2R-01. Guide to durable concrete - Manual of concrete practice. ACI, 2001. Michigan: 2001. 41 p.

ANDRADE, C.; SARRÍA, J.; ALONSO, C. Relative humidity in the interior of concrete exposed to natural and artificial weathering. Cement and Concrete Research, v.29, p. 1249-1259. 1999

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS (ABNT). ABNT NBR 6118: projetos de estruturas de concreto – Procedimentos. Rio de Janeiro, 2014. 238 p.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS (ABNT). NBR 12.655: concreto de cimento portland: preparo, controle e recebimento: procedimento. Rio de Janeiro. 2015. 29 p

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS (ABNT). NBR 12.655: concreto de cimento portland: preparo, controle e recebimento: procedimento. Rio de Janeiro. 2015. 29 p.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS (ABNT). NBR 6118: projetos de estruturas de concreto – Procedimentos. Rio de Janeiro, 2014. 238 p.

ASSOCIÇÃO BRASLEIRA DE NORMAS TÉCICAS – ABNT. NBR-15965-3: sistemas de classificação da informação– Parte 3: Processos da construção. Rio de Janeiro, 2014.

ASSOCIÇÃO BRASLEIRA DE NORMAS TÉCICAS – ABNT. NBR ISO 12006-2: construção da edificação – Organização da informação da construção – Parte 2: Estrutura para classificação da informação. Rio de Janeiro, 2010.

ASSOCIÇÃO BRASLEIRA DE NORMAS TÉCICAS – ABNT. NBR-15965-1: sistemas de classificação da informação – Parte 1: Terminologia e estrutura. Rio de Janeiro, 2011.

ASSOCIÇÃO BRASLEIRA DE NORMAS TÉCICAS – ABNT. NBR-15965-2: sistemas de classificação da informação– Parte 2: Características dos objetos da construção. Rio de Janeiro, 2012.

ASSOCIÇÃO BRASLEIRA DE NORMAS TÉCICAS – ABNT. NBR-15965-7: sistemas de classificação da informação– Parte 7: Informação da construção. Rio de Janeiro, 2015.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS – ABNT. NBR ISO 105-A02 Têxteis- Ensaios de solidez da cor Parte A02: Escala cinza para avaliação da alteração da cor. Associação Brasileira de Normas Técnicas, 2006

BACK, A.J.; HERDT, G. Índice de chuva dirigida para a região de Urussanga, SC. Revista Brasileira de Climatologia. v. 13, p. 270-284, 2013.

BALESTRA, C.E.T. et al. Parâmetros ambientais e materiais que afetam a penetração de cloretos em estruturas de concreto – estudo de caso da ilha dos arvoredos. Revista Eletrônica de Engenharia Civil. v.13, n. 1 p. 270-282. 2017.

BAROSSI, Antonio Carlos (Org.). O edifício da FAU-USP de Vilanova Artigas. São Paulo: Editora da Cidade. 2016. 208 p. (Obras Fundamentais; v.2).

BERTOLINI, L.; ELSENER, B.; PEDEFERRI, POLDER, P.R.B. Corrosion of steel in concrete: prevention, diagnosis, repair. Weinheim, KgaA: Wiley-VCH Verlag GmbH, 2004. 393 p.

BEUSHAUSEN, Hans; LUCO, Luiz Fernandez (Editors). Performance-Based Specifications and Control of Concrete Durability. State-of-Art-Report RILEM TC 230-PSC. 1st Edition, Springer, 2016.

BRUNI, A.C. et al. Emissões veiculares no estado de São Paulo 2012. CETESB, São Paulo, 2013. 108 p.

BUILDING SMART Model View Definition Summary. 2008-2017b. Disponível em: <http://www.buildingsmart-tech.org/specifications/ifc-view-definition> Acesso em: 10 de maio de 2017.

BUILDING SMART. IFC overview summary. 2008-2017a. Disponível em: <http://www.buildingsmart-tech.org/specifications/ifc-overview/ifc-overview-summary> .Acesso em: 10 de maio de 2017.

CHAVES, L.A. Recuperação do concreto armado das empenas do edifício Vilanovas Artigas: relatório final. Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo, São Paulo. 2017. (Relatório de Iniciação Científica à Fundação para o Amparo da Pesquisa do Estado de São Paulo - FAPESP).

COMISSION INTERNATIONALE DE L'ECLAIRAGE CIE. CIE 15:2004 Technical Report: Colorimetry 3rd Edition. 2004

COMPANHIA AMBIENTAL DO ESTADO DE SÃO PAULO (CETESB). Qualidade do ar: informações. Disponível em: <http://sistemasinter.cetesb.sp.gov.br/Ar/ar_saude.asp> Acesso em: 24 out. 2017

CONTIER, F.A. O edifício da Faculdade de Arquitetura e Urbanismo da Cidade Universitária: projeto e construção d escola de Vilanova Artigas. Instituto de Arquitetura e Urbanismo da Universidade de São Paulo, São Carlos. 2015 (Tese doutorado).

DAVIS,D.; KARLSHØJ, J.; SEE, R. An Integrated Process for Delivering IFC Based Data Exchange. BLIS Consortium and buildingSMART International, 2012. 53p. Disponível em: <http://iug.buildingsmart.org/idms/methods-and-guides/Integrated_IDM-MVD_ProcessFormats_14.pdf/view> Acesso em 24 de outubro de 2017.

DEUTSCHES INSTITUT FUR NORMUNG (DIN). DIN EN ISO 9223: Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, determination and estimation (ISO 9223:2012), English version, DIN. Berlin, 2012. 24 p.

DOUGLAS, Stephen. A concrete performance: conservation at the National Theatre. Engineering History and Heritage. Volume 169, Issue EH1. p. 36 – 41, 2015. Institute of Civil Engeneerings – ICE. Avaiable at: http://dx.doi.org/10.1680/jenhh.15.00009. Access: January 29th 2017.

FUSCO, P.B. Estruturas de concreto: solicitações normais, estados limites últimos: teoria e aplicações. Guanabara Dois: Rio de Janeiro, 1981. 464 p.

HANSSON, C.M.; POURSAEE, A. JAFFER, S.J. Corrosion of reinforcing bars in concrete. The Masterbuider. v.106, p.106-125, 2012.

HEINEMANN, Herdis A.; VAN HEES, R. P. J.; NIJLAND, T. G.; ZIJLSTRA, H. The Challenge of a perpetual service life: the conservation of concrete heritage. In: van Breugel, K., Ye, G., & Yuan, Y. (Eds.), Service Life Design for Infrastructures, Delft: RILEM Publications S.A.R.L, 2010, p. 1-9. Disponível em https://www.researchgate.net/publication/303924116_The_Challenge_of_a_Perpetual_Service_Life_The_Conservation_of_Concrete_Heritage. Acesso em 01 jun. 2017.

HELENE, P.; BRITEZ, Carlos A., ANTUNES, Juliana da S.

Faculdade de Arquitetura e Urbanismo FAUUSP – Edifício Vilanova Artigas. Projeto e especificação técnica dos serviços de reabilitação da estrutura de concreto armado do Edifício Vilanova Artigas da Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo, situado na Rua do Lago 876, Butantã, Cidade Universitária, São Paulo, SP. Cobertura, teto e fachada. São Paulo: PhDesign, Agosto 2010, 110 p. (Relatório Técnico n.136/2010).

HUET, B.; L´HOSTIS, V.; MISERQUE, F.; IDRISSI, H. Electrochemical behavior of mild steel in concrete: influence of pH and carbonate content of concrete pore solution. Electrochimica Acta, v.51, p. 172-180, 2005.

INSTITUTO DE ASTRONOMIA, GEOFÍSICA E CIÊNCIAS ATMOSFÉRICAS DA UNIVERSIDADE DE SÃO PAULO (IAG). Estação meteorológica do IGA-USP: 63° Boletim - Setembro/2017. Disponível em: <http://www.estacao.iag.usp.br/boletim. php> Acesso em: 03 nov. 2017.

MA, Y. P. et al. Parametric workflow (BIM) for the repair construction of traditional historic architecture in taiwan. 25th International Cipa Symposium 2015, v. 45, n. W7, p. 315-322, 2015

MAUBERTEC. Inspeção do concreto: Glossário técnico, conceituação, visão sistemática e relação, causas e efeitos básicos das anomalias. São Paulo: Maubertec Engenharia e Projetos. p. 85-137, 1998 (Relatório Técnico MANUME10.doc)

MEIER, S. J.; WITTMANN, F. H. Water Repellent Surface Impregnation of Concrete: Guidelines and Recommendations. In: ASMES International Workshop. Basic Research on Concrete and Applications Proceedings… Editors: Wittmann Folker H. and Mercier Olivier. Aedificatio Publishers Freiburg, Germany, 2011, p. 49 – 66.

MEIRA, G.R., PADARATZ, J.D. Efeito do distanciamento em relação ao mar na agressividade por cloretos. In: Congresso Brasileiro do Concreto 44, Belo Horizonte. Anais em CD. IBRACON, São Paulo, 2002.

MELO JUNIOR, Carlos Mariano; CARASEK, Helena. Índices de chuva dirigida direcional e análise do nível de umedecimento em fachadas de edifício multipavimentos em Goiânia, GO. Ambiente Construído. Porto Alegre , v. 11, n. 3, 2011, p. 23-37.

MERSCHBROCK, C.; FIGUERES-MUNOZ, A. Circumventing obstacles in digital construction design - a workaround theory perspective. 8th Nordic Conference on Construction Economics and Organization, v. 21, p. 247-255, 2015,

MOHAMMADI, Babak. Development of Concrete Water Absorption Testing for Quality Control Master thesis (Master of Applied Science). 2013. 109 p. Department of Building, Civil, and Environmental Engineering, Civil Engineering, Concordia University. Montréal.

NIBS - National Institute of Building Sciences .FactSheet. 2015. Disponível em <https://www.nationalbimstandard.org/files/NBIMS-US_FactSheet_2015.pdf>. Acesso em 12 de abril de 2017.

ODGERS, David (Org.). Practical Building Conservation: Concrete. English Heritag, Farnham: Ashgate, 2012.

OLIVEIRA, C.T.A. et al. O restauro do moderno: o caso do edifício Vilanova Artigas da FAUUSP. 7 Seminário Docomomo Brasil. Porto Alegre. 2007. 12 p.

PENTTILÄ, H.; RAJALA, M.; FREESE, S. Building Information modelling of modern historic buildings. In: eCAADe2007.Anais… Frankfurt: ECAADE, 2007. p. 607– 613.

PEREIRA et al. Oxidação da pirita e seus efeitos em argamassas de cimento Portland sujeitas ao ataque por sulfatos de origem interna. Revista Matéria. pp. 342-354, 2016. (artigo 11705).

PERRONE, R.A.C. Vilanova Artigas e o edifício da FAU USP. Disponível em: < http://www.vitruvius.com.br/revistas/read/arquitextos/16.191/6004> Acesso em: 16 out. 2017.

RAUPACH, Michael; BÜTTNER, Till. Concrete repair to EN 1504: diagnosis, design, principles and practice. Boca Raton: CRC Press. Taylor & Francis Group. 2014. 270 p.

SIMÕES, João Roberto Leme. Patologias - origens e reflexos no desempenho técnico-construtivo de edifícios: análise das origens das patologias e seus reflexos no desempenho técnico-construtivo de edifícios universitários da CUASO-USP/SP utilizando-se de edifícios da ISSO-6241 e procedimentos da APU - avaliação pós-uso. Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo, São Paulo. 2004. (Tese livre docência).

SUCCAR, B. Building information modeling framework: a research and delivery foundation for industry stakeholders. Automation in Construction, v. 18, 2009. p.357–375.

VAN WAGENEN, H. W. Building Information Modeling and Historic Buildings: How a Living Model Leads to Better Stewardship of the Past. 102p. Thesis (Historic Preservation). University of Pennsylvania, Philadelphia, 2012.

VENUGOPAL, M. et al. Semantics of model views for information exchanges using the industry foundation class schema. Advanced Engineering Informatics, v. 26, n. 2, p. 411-428, Feb. 2014.

VIAPOL. Silicone Viapol K-154. Disponível em: <http://www.viapol.com.br/ produtos/prote%C3%A7%C3%A3o-de-superf%C3%ADcie/silicone-viapol-k-154/> Acesso em: 26 out. 2017.

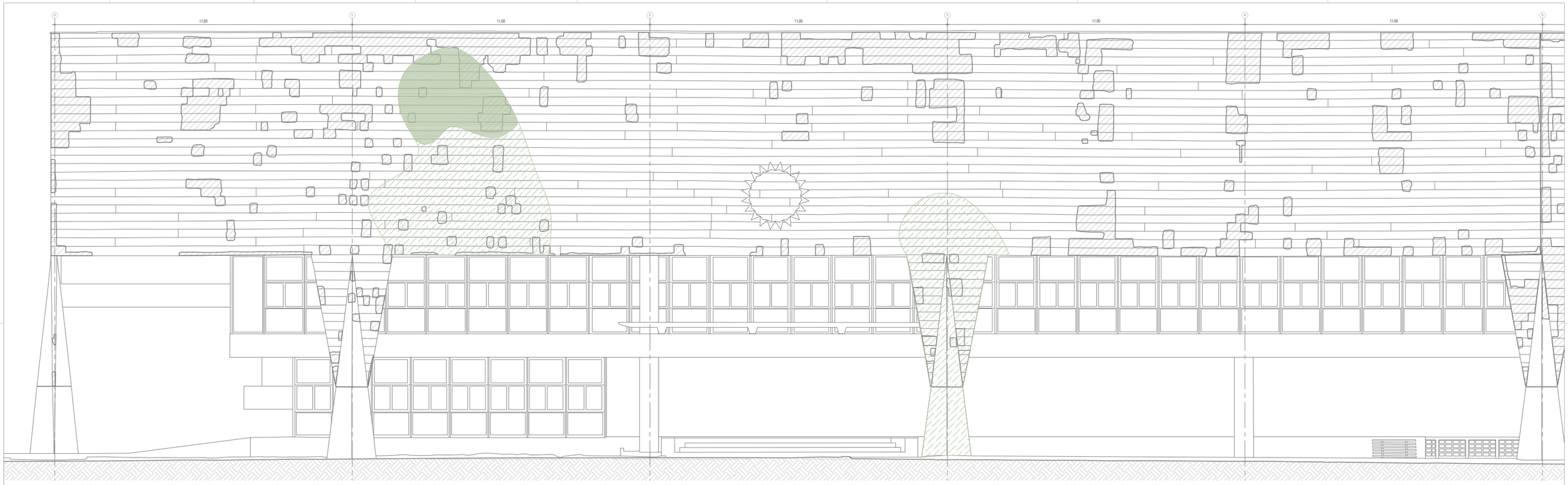
VIAPOL. Viaplus ST. Disponível em: < http://www.viapol.com.br/produtos/ recupera%C3%A7%C3%A3o-e-refor%C3%A7o/argamassas/reparo/viaplus-st/> Acesso em: 26 out. 2017.

VOLK, R.; STENGEL, J.; SCHULTMANN, F. Building Information Modeling (BIM) for existing buildings - literature review and future needs. Automation in Construction, v. 38, p. 109-127, Mar 2014.

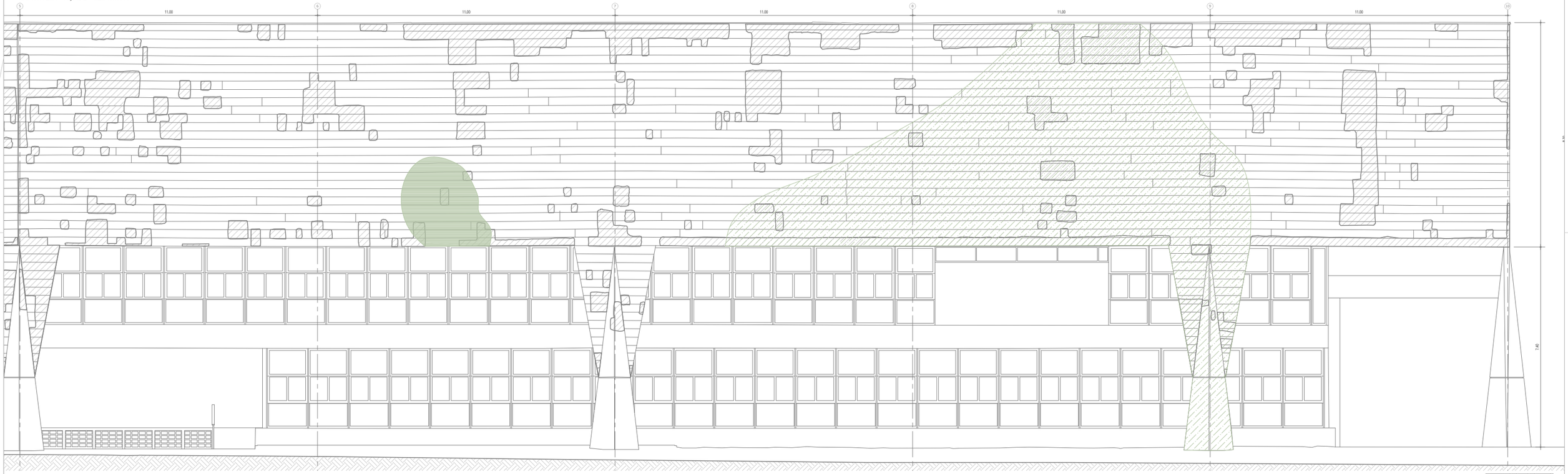
Photo: author and date unknown. Source: Rosa Artigas.

DOCUMENTAL CORPUS

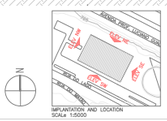
ANNEX A - SURVEY OF ARTIGAS BUILDING FAÇADE AREAS SHADED BY SURROUNDING TREES



SOUTHWEST FAÇADE - SECTION A



SOUTHWEST FAÇADE - SECTION B



PERMANENT SHADOW

TREE BRANCHS IN CONTACT OR ON THE FACADES

Project
CONSERVATION MANAGEMENT PLAN - VILANOVA ARTIGAS BUILDING FAUUSP AND THE GETTY FOUNDATION

Titulo
SOUTHWEST FAÇADE
SURVEY OF AREAS IN PERMANENT SHADOW

Etapa
TASK 3

Drawing / Resquester
RENATA C. CAMPIOTTO, ANA PAULA A. GONÇALVES / CLÁUDIA T. DE ANDRADE OLIVEIRA

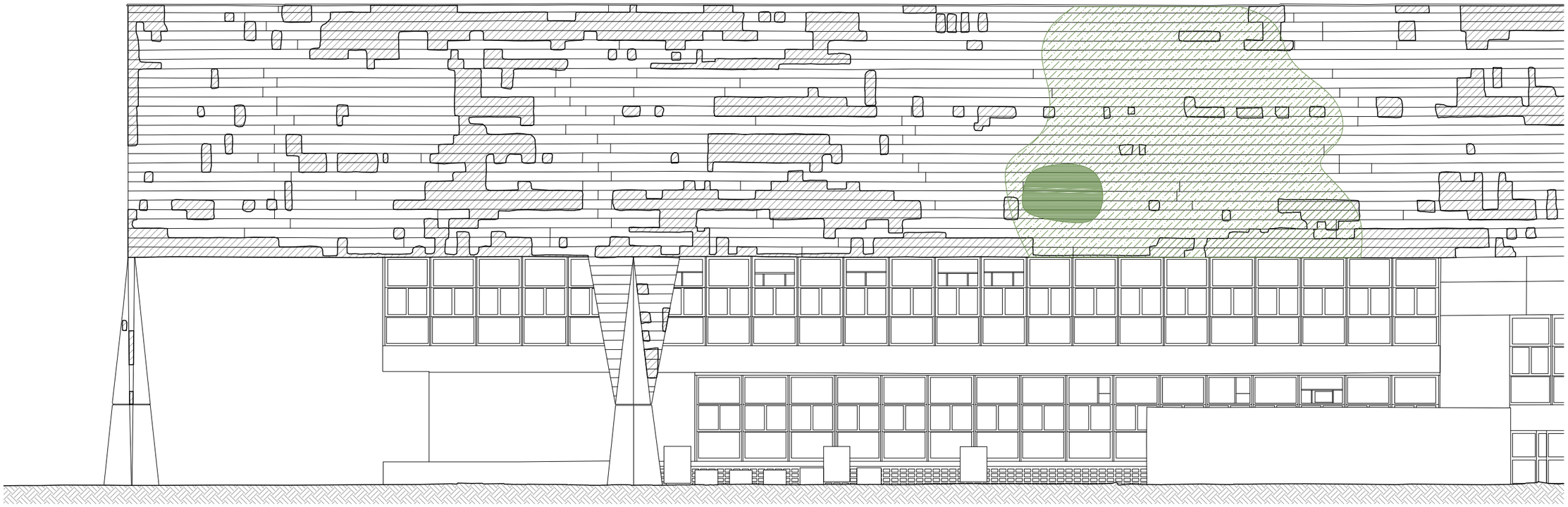
Archivo
FAU-PGC-AR-LV-FCH-01SO-SOMBRAS-R00.dwg

Sheet
01/04

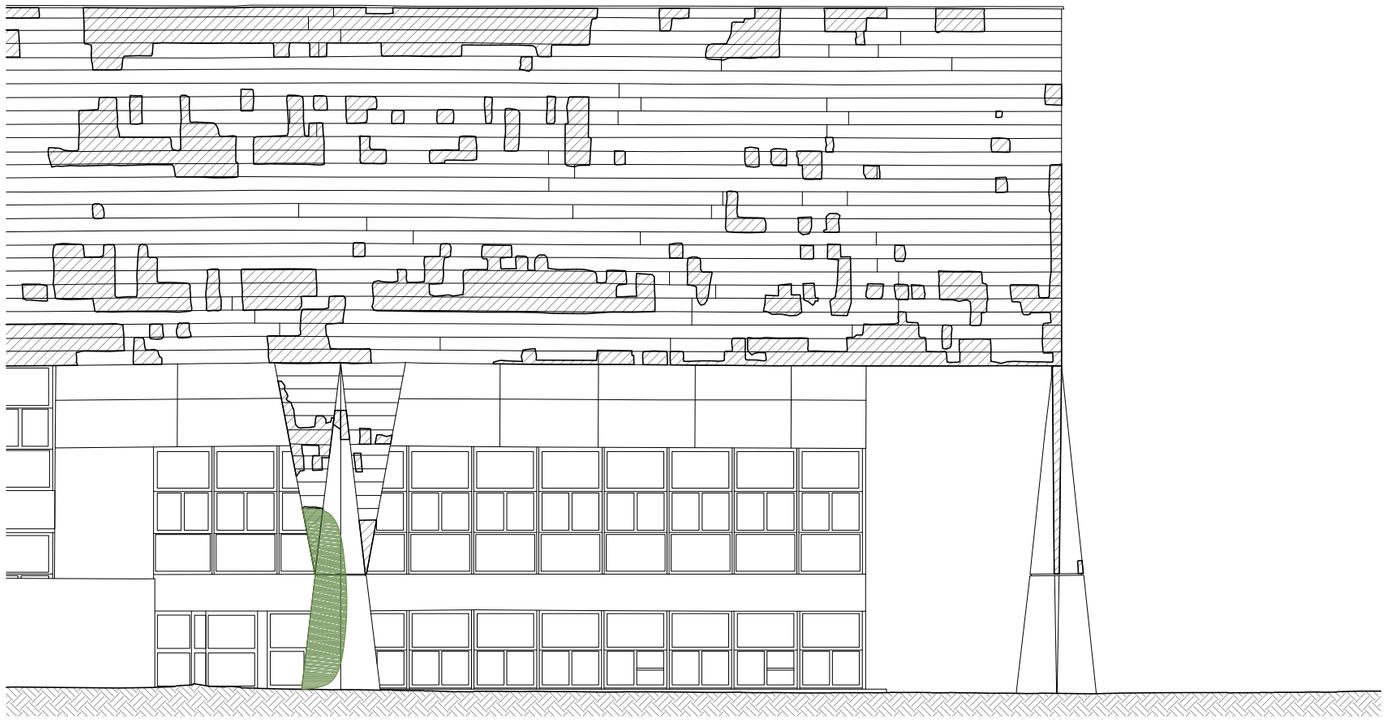
Scale (meters)
1:50

Date
02 / 01 / 2017

Revision
Revision 0



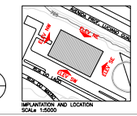
SOUTHEAST FAÇADE - SECTION A



SOUTHEAST FAÇADE - SECTION B

PERMANENT SHADOW

TREE BRANCHS IN CONTACT OR ON THE FACADES



IMPLANTATION AND LOCATION
SCALE 1/5000

Project
CONSERVATION MANAGEMENT PLAN - VILANOVA ARTIGAS BUILDING
FAUUSP AND THE GETTY FOUNDATION

Titulo
SOUTHEAST FAÇADE
SURVEY OF AREAS IN PERMANENT SHADOW

Sheet
02/04

Etapa
TASK 3

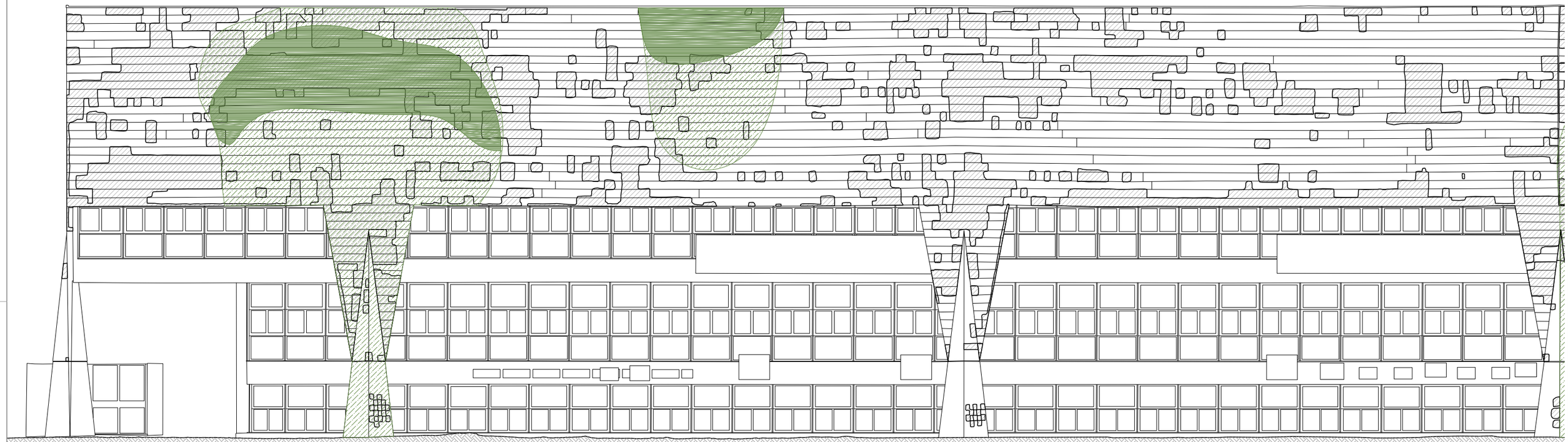
Scale (meters)
1:50

Drawing / Resquester
RENATA C. CAMPIOTTO, ANA PAULA A. GONÇALVES / CLÁUDIA T. DE ANDRADE OLIVEIRA

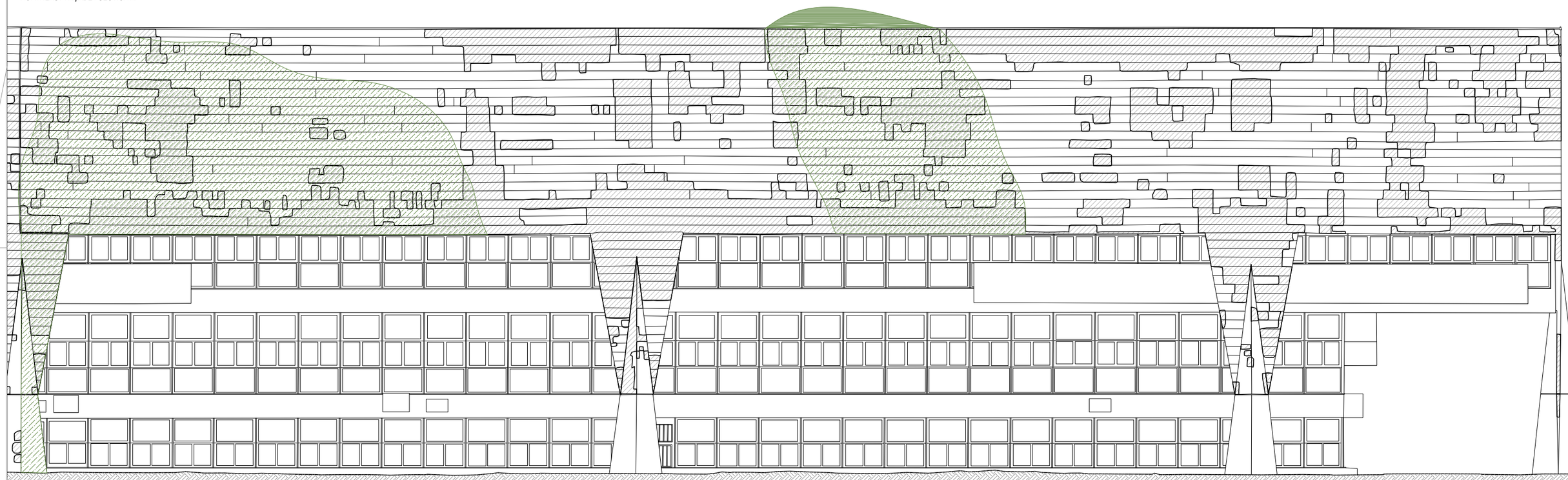
Date
02 / 12 / 2019

Archive
FAU-PGC-AR-LV-FCH-02SE-SOMBRAS-R00.dwg

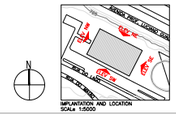
Revision
Revision 0



NORTHEAST FAÇADE - SECTION A



NORTHEAST FAÇADE - SECTION B



PERMANENT SHADOW

TREE BRANCHS IN CONTACT OR ON THE FACADES

Project
CONSERVATION MANAGEMENT PLAN - VILANOVA ARTIGAS BUILDING
FAUUSP AND THE GETTY FOUNDATION

Título
NORTHEAST FAÇADE
SURVEY OF AREAS IN PERMANENT SHADOW

Sheet
03/04

Etapa
TASK 3

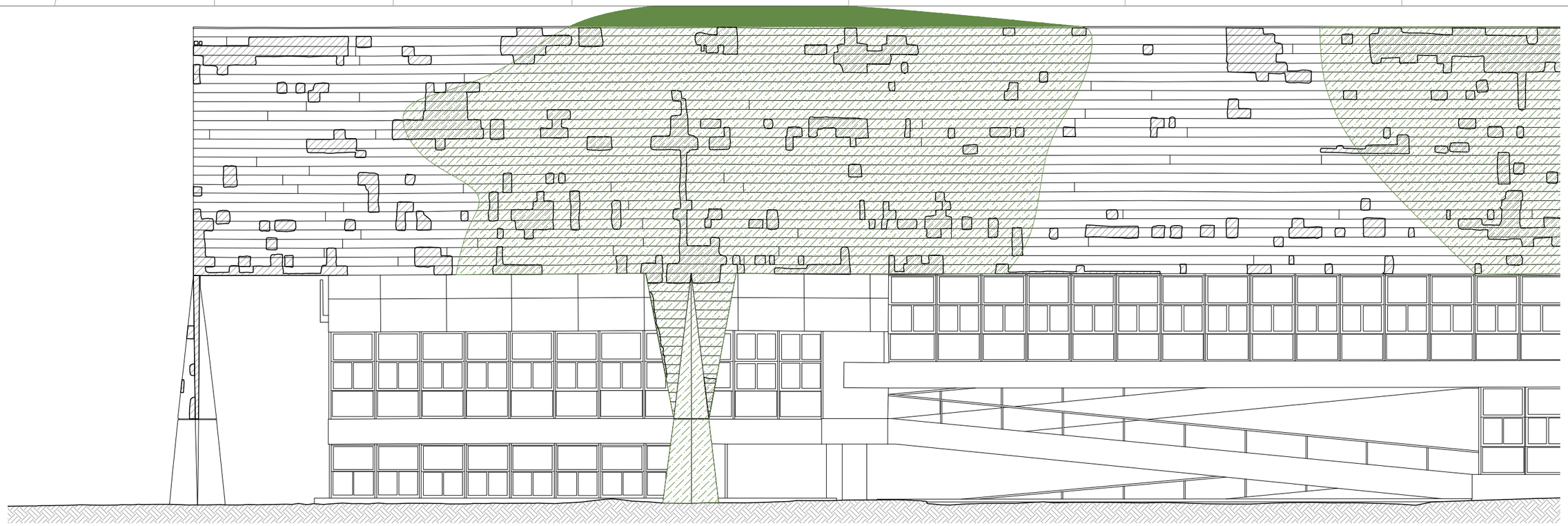
Scale (meters)
1:50

Drawing / Resquestor
RENATA C. CAMPIOTTO, ANA PAULA A. GONÇALVES / CLÁUDIA T. DE ANDRADE OLIVEIRA

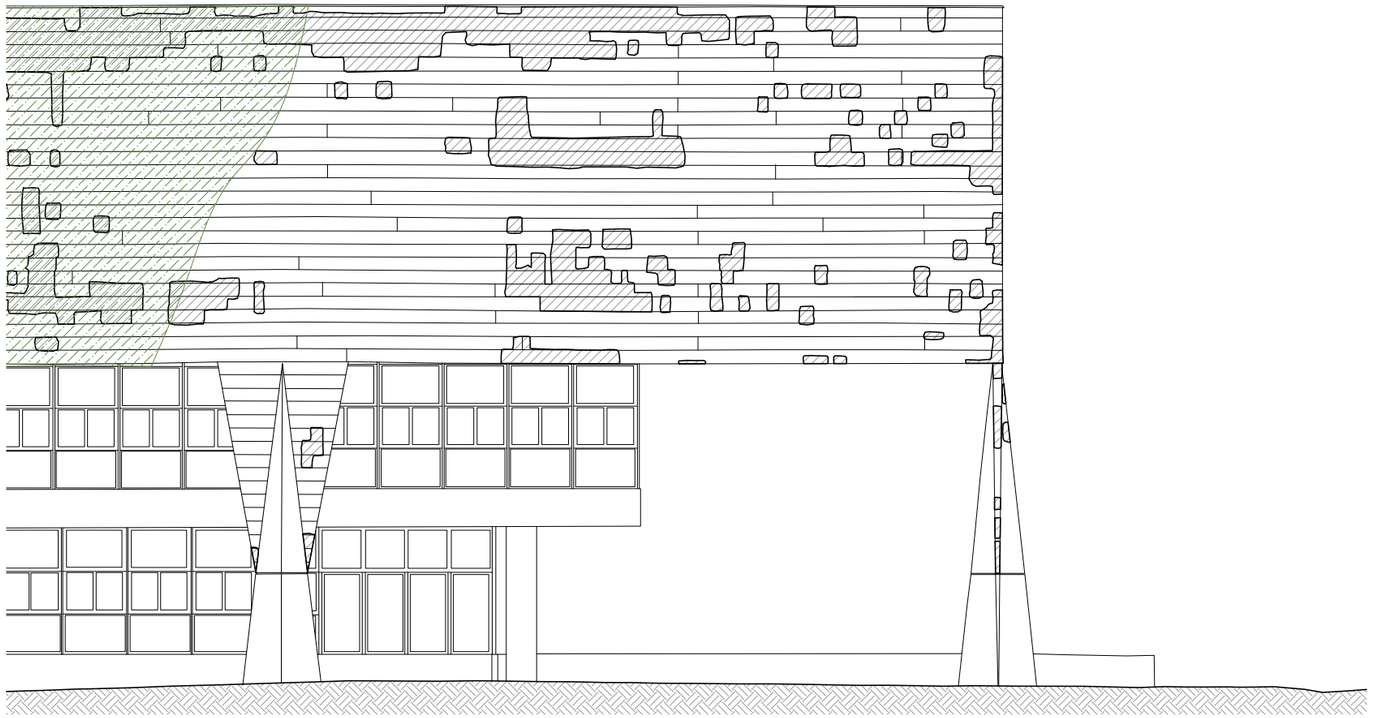
Date
02 / 01 / 2017

Archive
FAU-PGC-AR-LV-FCH-03NE-SOMBRAS-R00.dwg

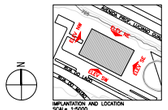
Revision
Revision 0



NORTHWEST FAÇADE - SECTION A



NORTHWEST FAÇADE - SECTION B



PERMANENT SHADOW

TREE BRANCHS IN CONTACT OR ON THE FACADES

Project
CONSERVATION MANAGEMENT PLAN - VILANOVA ARTIGAS BUILDING FAUUSP AND THE GETTY FOUNDATION

Título
NORTHWEST FAÇADE
SURVEY OF AREAS IN PERMANENT SHADOW

Etapa
TASK 3

Drawing / Resquester
RENATA C. CAMPIOTTO, ANA PAULA A. GONÇALVES / CLÁUDIA T. DE ANDRADE OLIVEIRA

Archive
FAU-PGC-AR-LV-FCH-02SE-SOMBRAS-R00.dwg

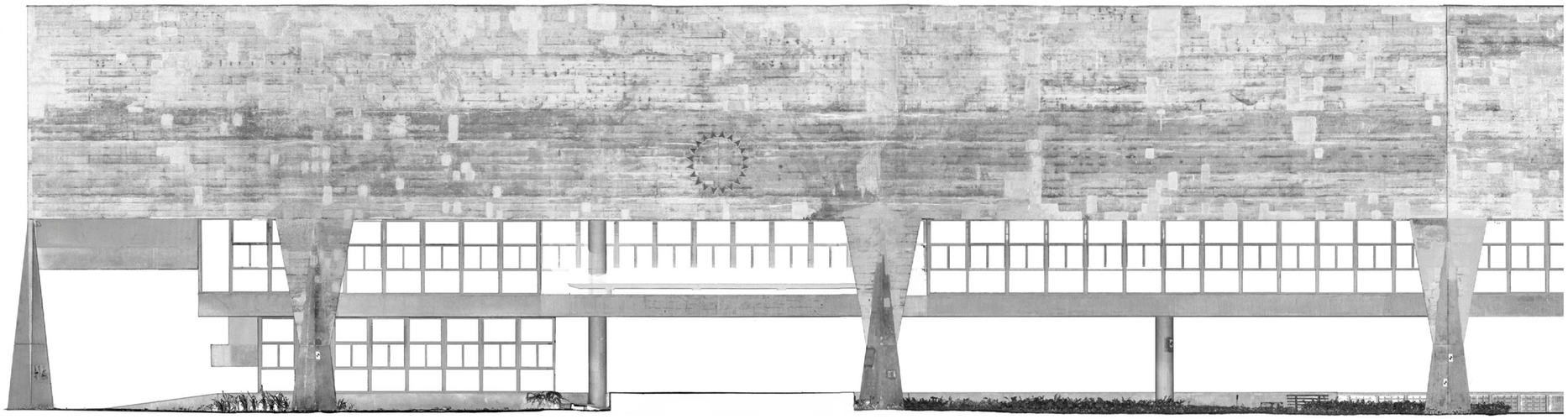
Sheet
04/04

Scale (meters)
1:50

Date
02 / 07 / 2021

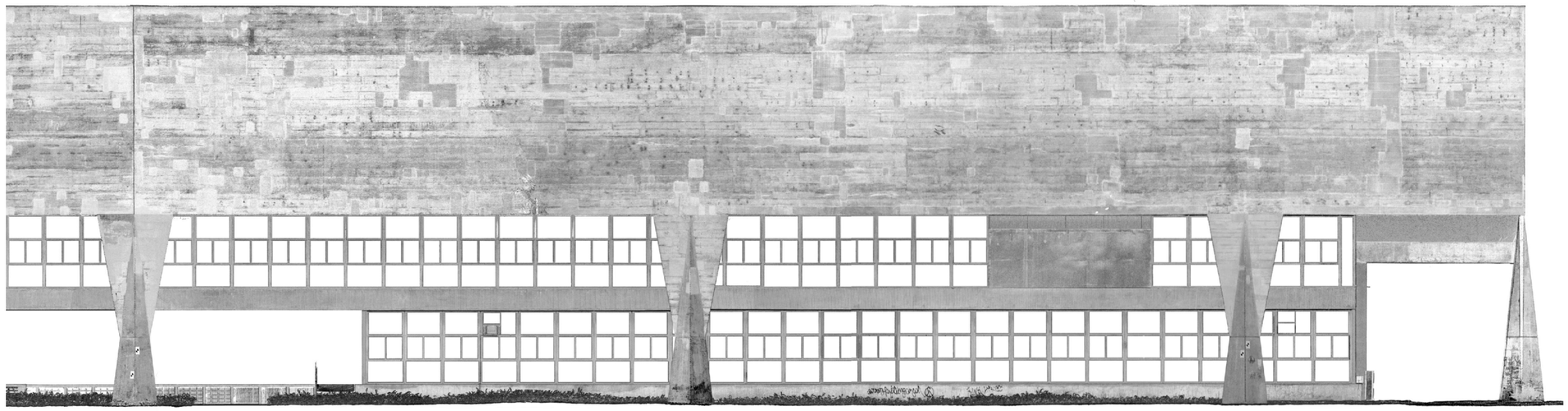
Revision
Revision 0

ANNEX B - SURVEY OF ARTIGAS BUILDING FAÇADE AREAS REPAIRS WITH STRUCTURAL REPAIR MORTAR, DURING THE STRUCTURAL RECUPERATION INTERVENTION OF 2012 - 2015



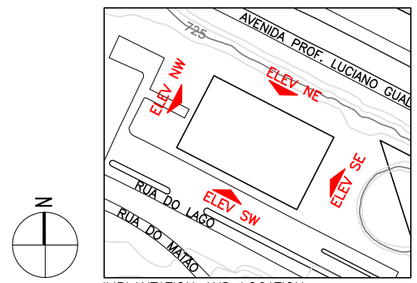
1 SOUTHWEST FAÇADE – SECTION A

scale 1:200



2 SOUTHWEST FAÇADE – SECTION B

scale 1:200



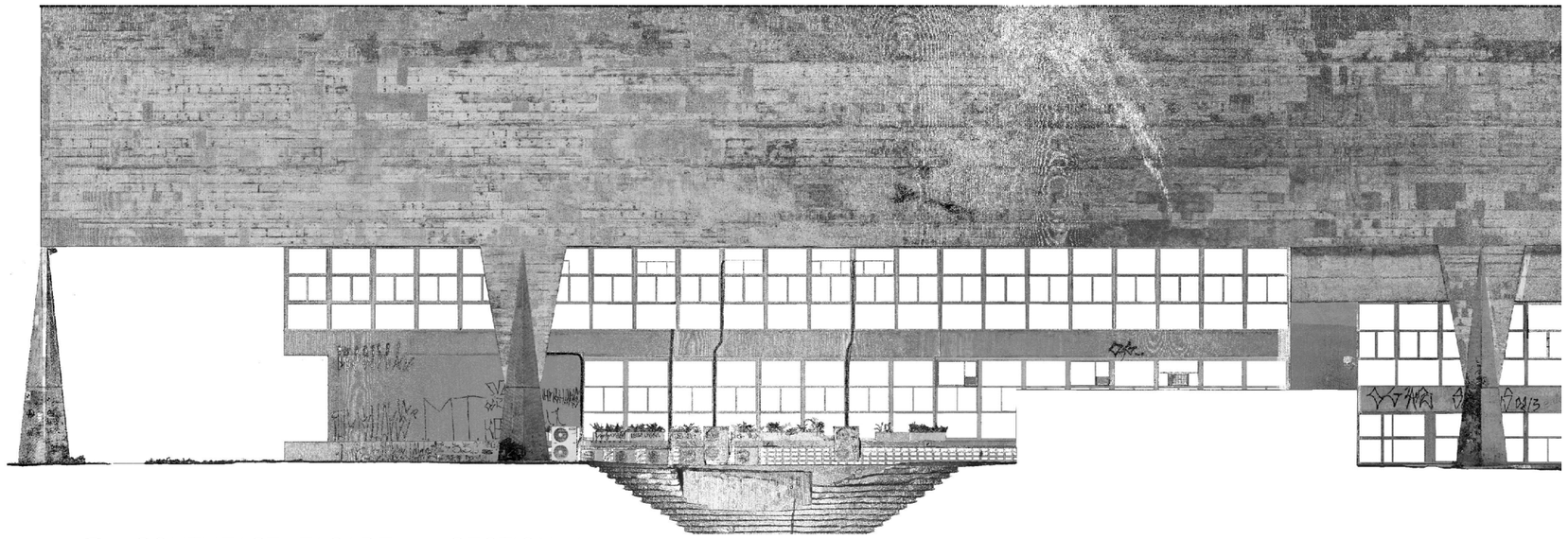
IMPLANTATION AND LOCATION
SCALE 1:5000

TITLE
Laser scan survey
Vilanova Artigas Building

DESIGN
Southwest façade
1/4

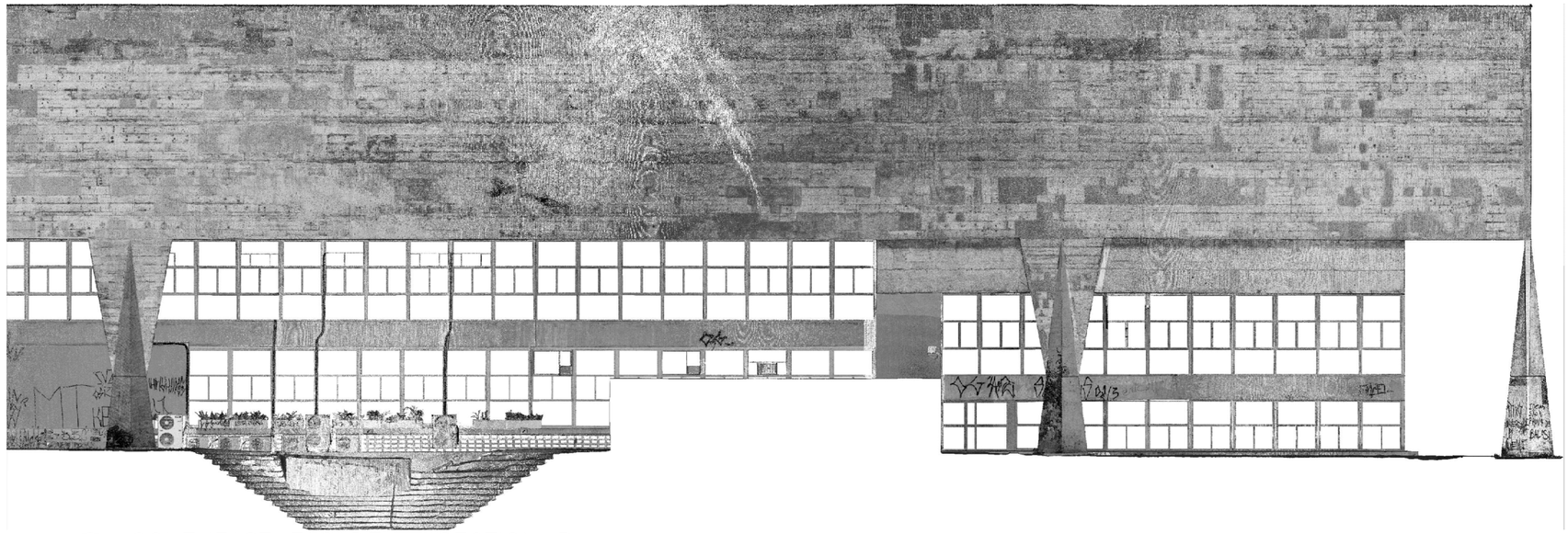
SCALE (meters) 1:200

0 1 5 10



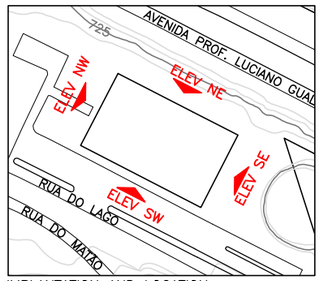
1 SOUTHEAST FAÇADE – SECTION A

scale 1:200



2 SOUTHEAST FAÇADE – SECTION B

scale 1:200



IMPLANTATION AND LOCATION
SCALE 1:5000

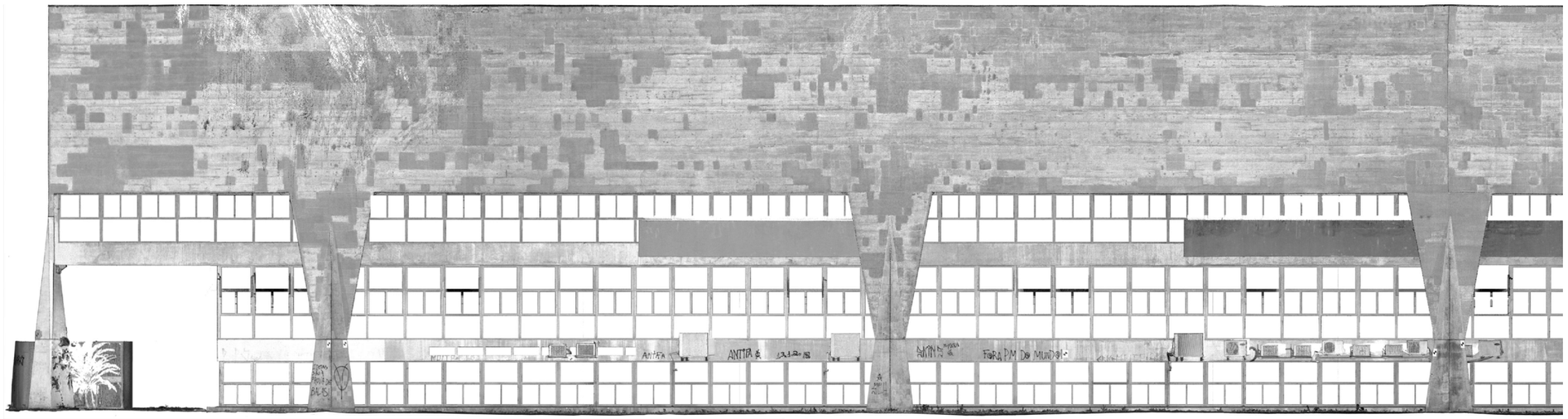
N

TITLE
Laser scan survey
Vilanova Artigas Building

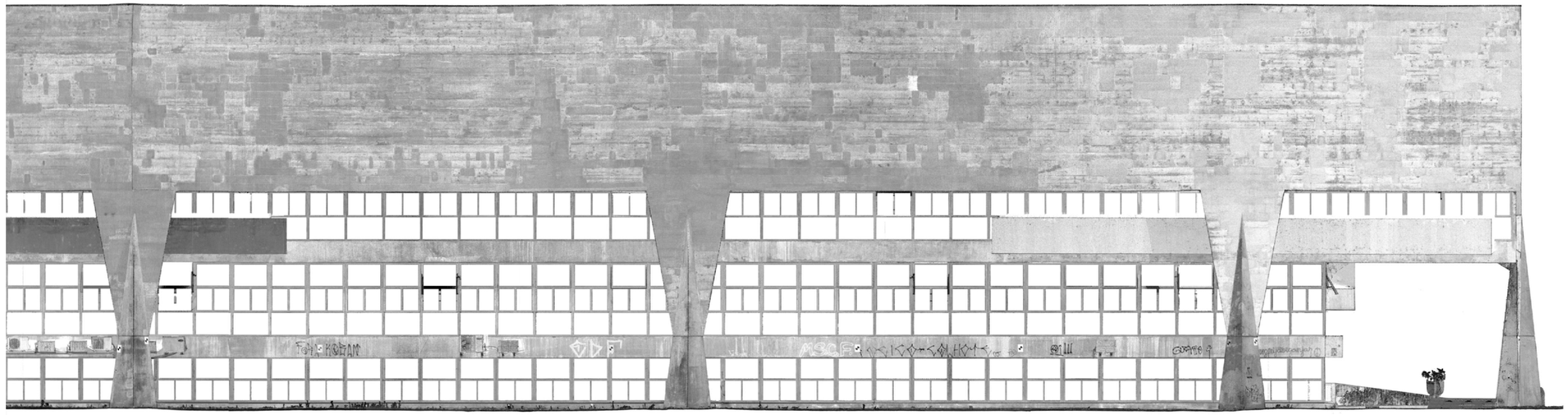
DESIGN
Southeast façade
2/4

SCALE (meters) 1:200

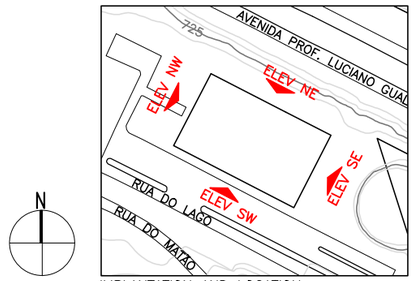
0 1 5 10



1 NORTHEAST FAÇADE – SECTION A
scale 1:200



2 NORTHEAST FAÇADE – SECTION B
scale 1:200



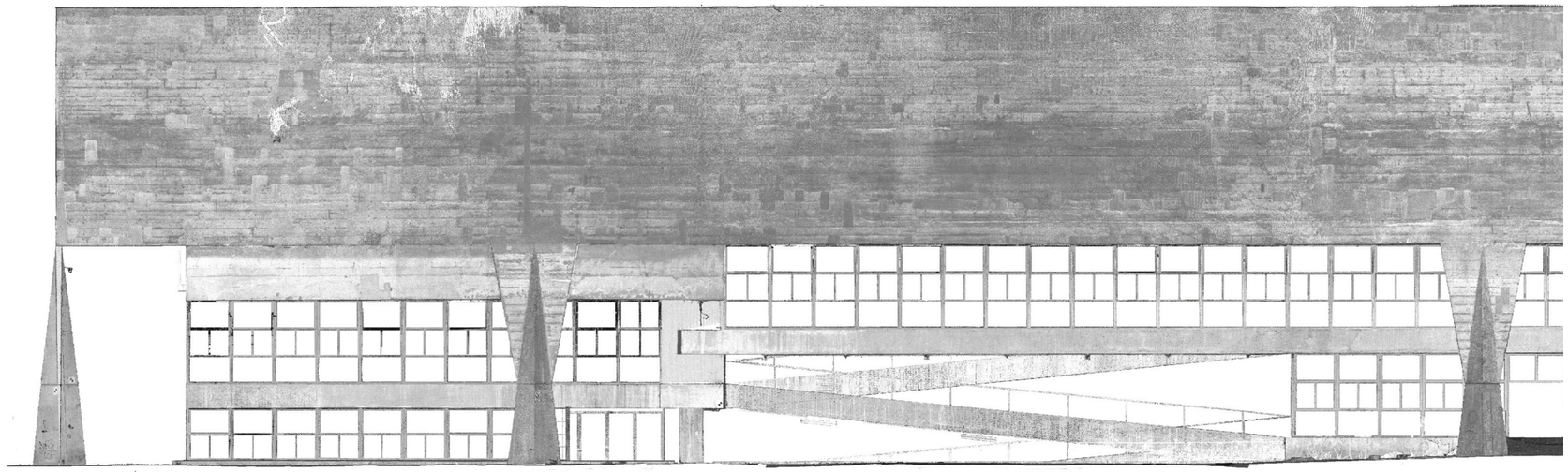
IMPLANTATION AND LOCATION
SCALE 1:5000

TITLE
Laser scan survey
Vilanova Artigas Building

DESIGN
Northeast façade
3/4

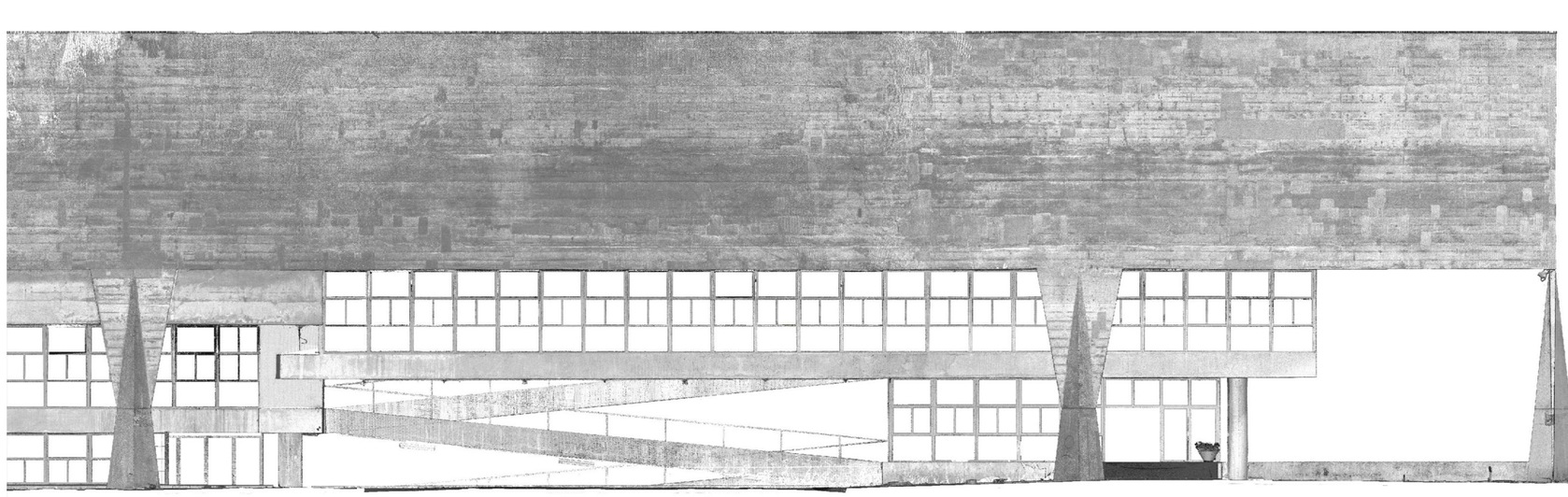
SCALE (meters) 1:200

0 1 5 10



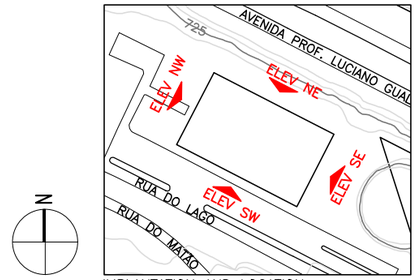
1 NORTHWEST FAÇADE – SECTION B

scale 1:200



2 NORTHWEST FAÇADE – SECTION B

scale 1:200



N

IMPLANTATION AND LOCATION
SCALE 1:5000

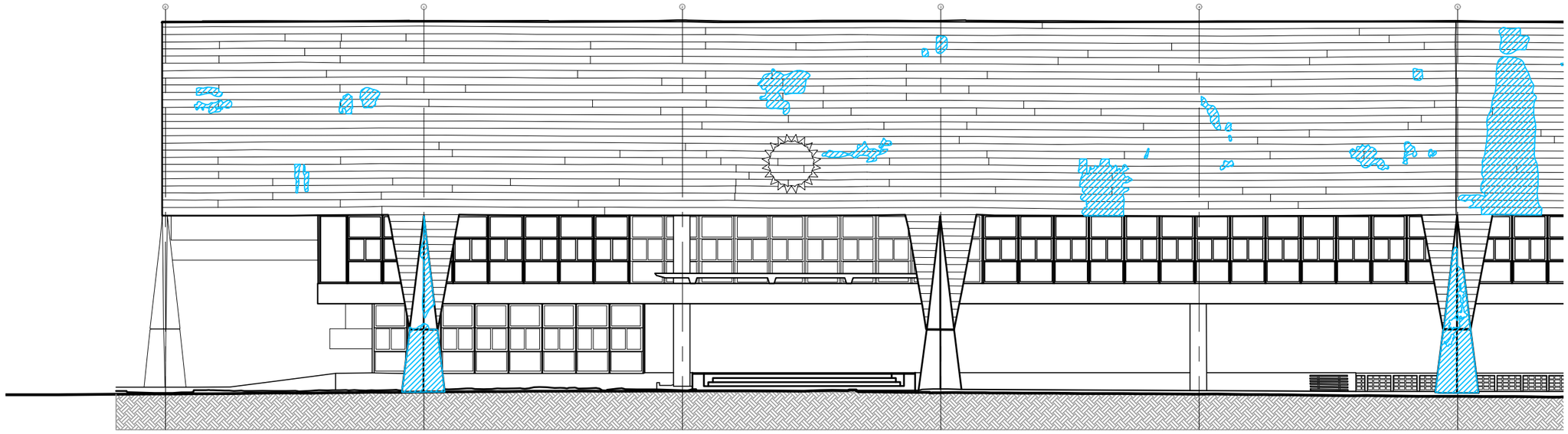
TITLE
Laser scan survey
Vilanova Artigas Building

DESIGN
Northwest façade
4/4

SCALE (meters) 1:200

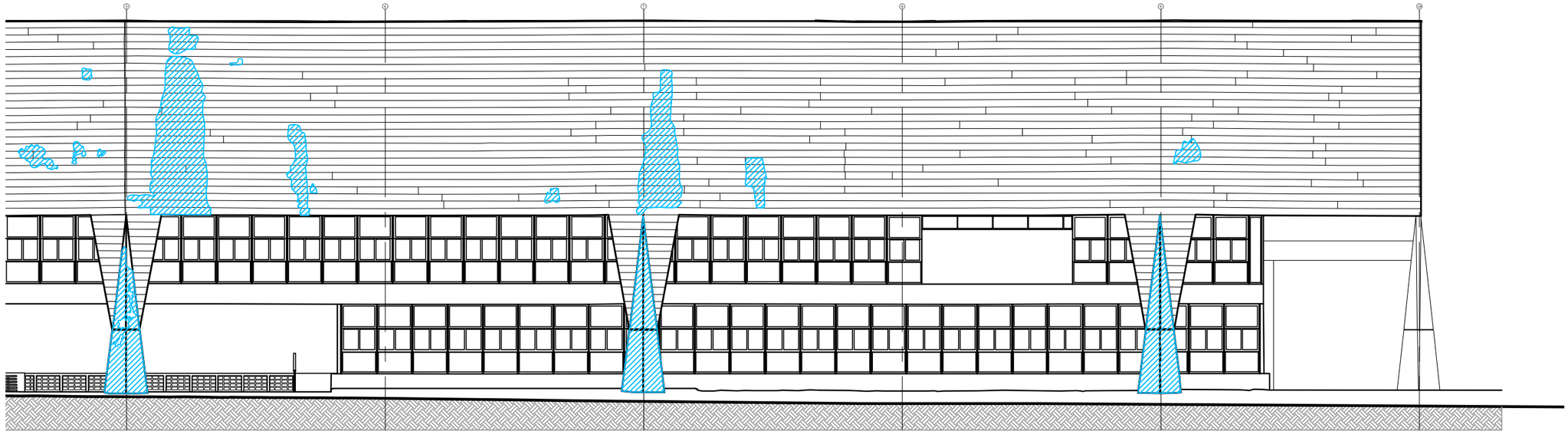
0 1 5 10

ANNEX C - SURVEY OF ARTIGAS BUILDING FAÇADE AREAS SUBJECT TO WET STAINING AFTER RAINFALL



1 SOUTHWEST FAÇADE – SECTION A

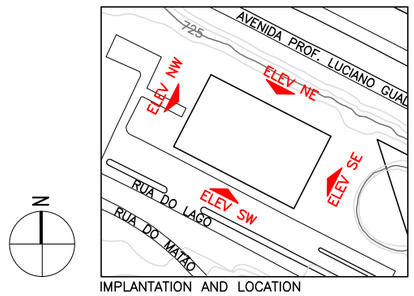
scale 1:200



2 SOUTHWEST FAÇADE – SECTION B

scale 1:200

Stains of moisture after rain



N

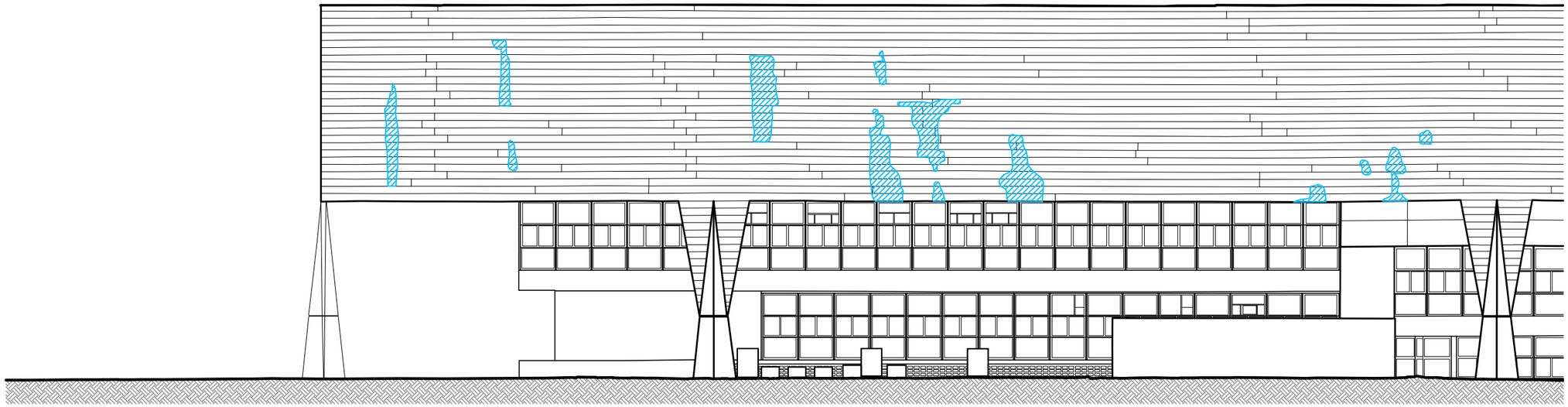
IMPLANTATION AND LOCATION
SCALE 1:5000

TITLE
Moisture stain on façades
Vilanova Artigas Building

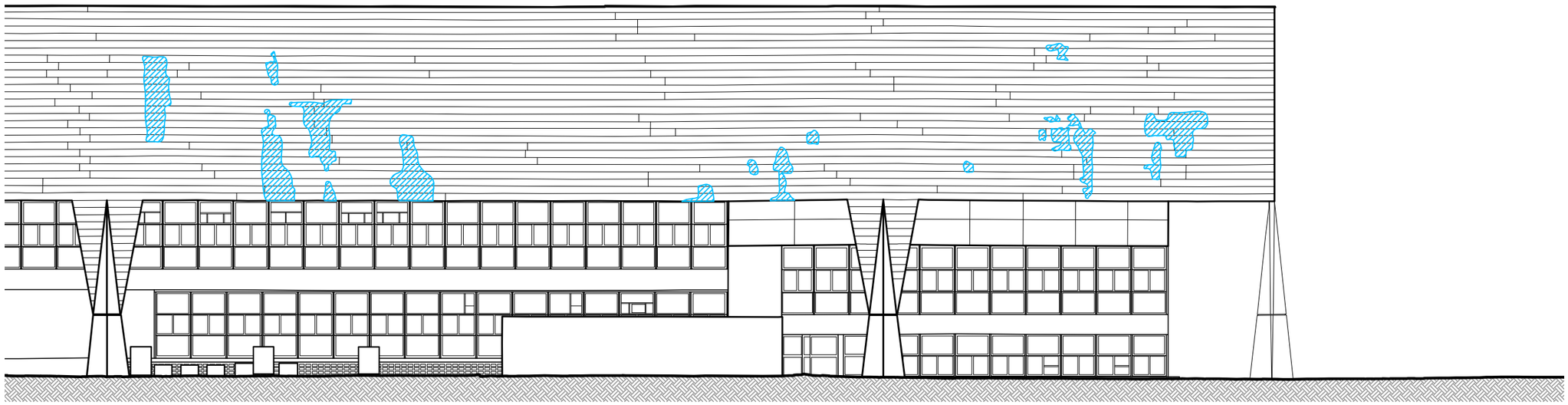
DESIGN
Southwest façade
1/4

SCALE (meters) 1:200

0 1 5 10

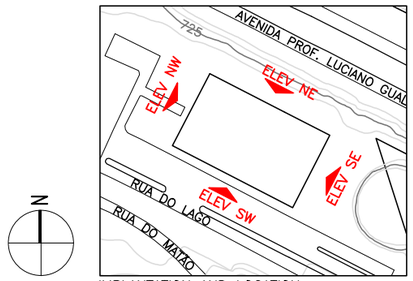


1 SOUTHEAST FAÇADE – SECTION A
scale 1:200



2 SOUTHEAST FAÇADE – SECTION B
scale 1:200

Stains of moisture after rain

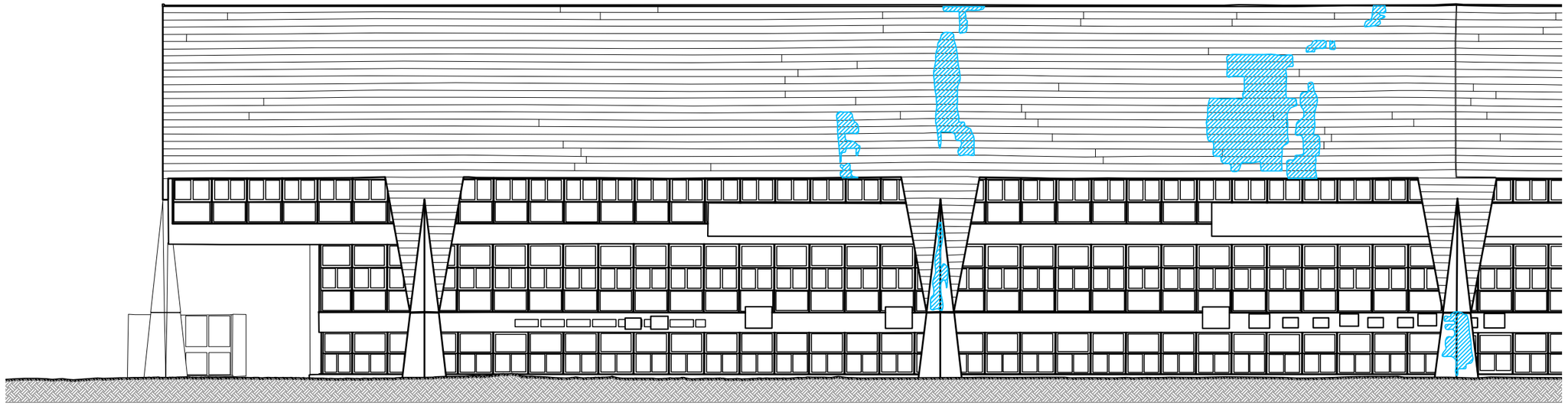


IMPLANTATION AND LOCATION
SCALE 1:5000

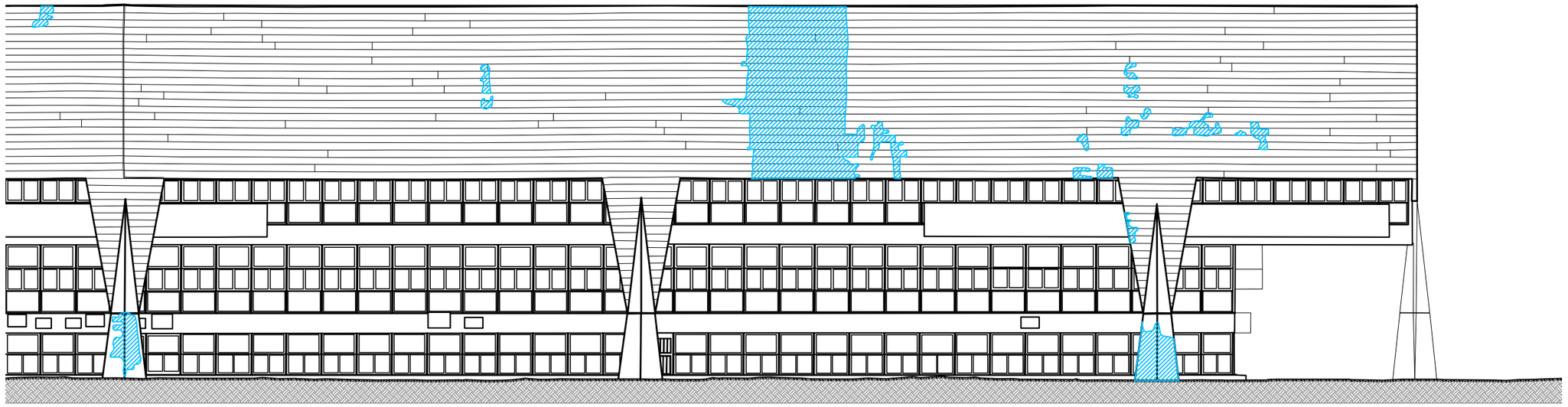
TITLE
Moisture stain on façades
Vilanova Artigas Building

DESIGN
Southeast façade
2/4

SCALE (meters) 1:200
0 1 5 10

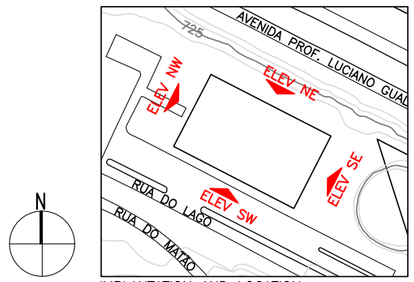


1 NORTHEAST FAÇADE – SECTION A
scale 1:200



2 NORTHEAST FAÇADE – SECTION B
scale 1:200

Stains of moisture after rain



IMPLANTATION AND LOCATION
SCALE 1:5000

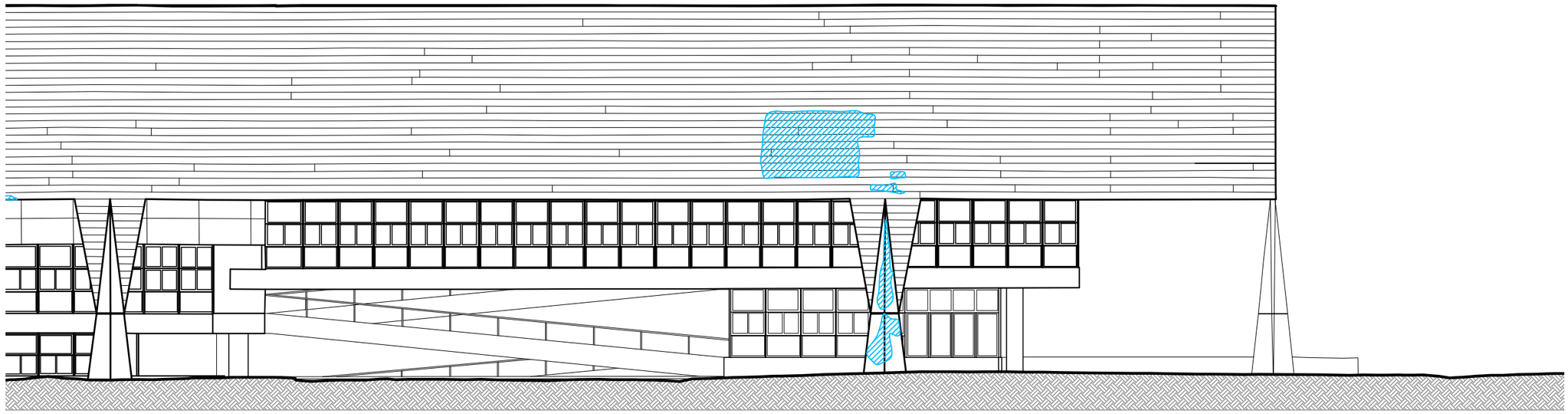
TITLE
Moisture stain on façades
Vilanova Artigas Building

DESIGN
Northeast façade
3/4

SCALE (meters) 1:200

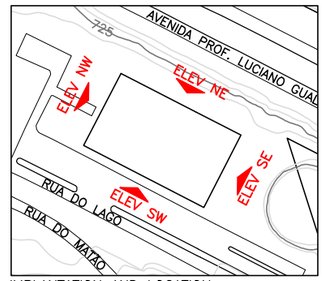
0 1 5 10

1 NORTHWEST FAÇADE – SECTION A
scale 1:200



2 NORTHWEST FAÇADE – SECTION B
scale 1:200

Stains of moisture after rain



IMPLANTATION AND LOCATION
SCALE 1:5000

N

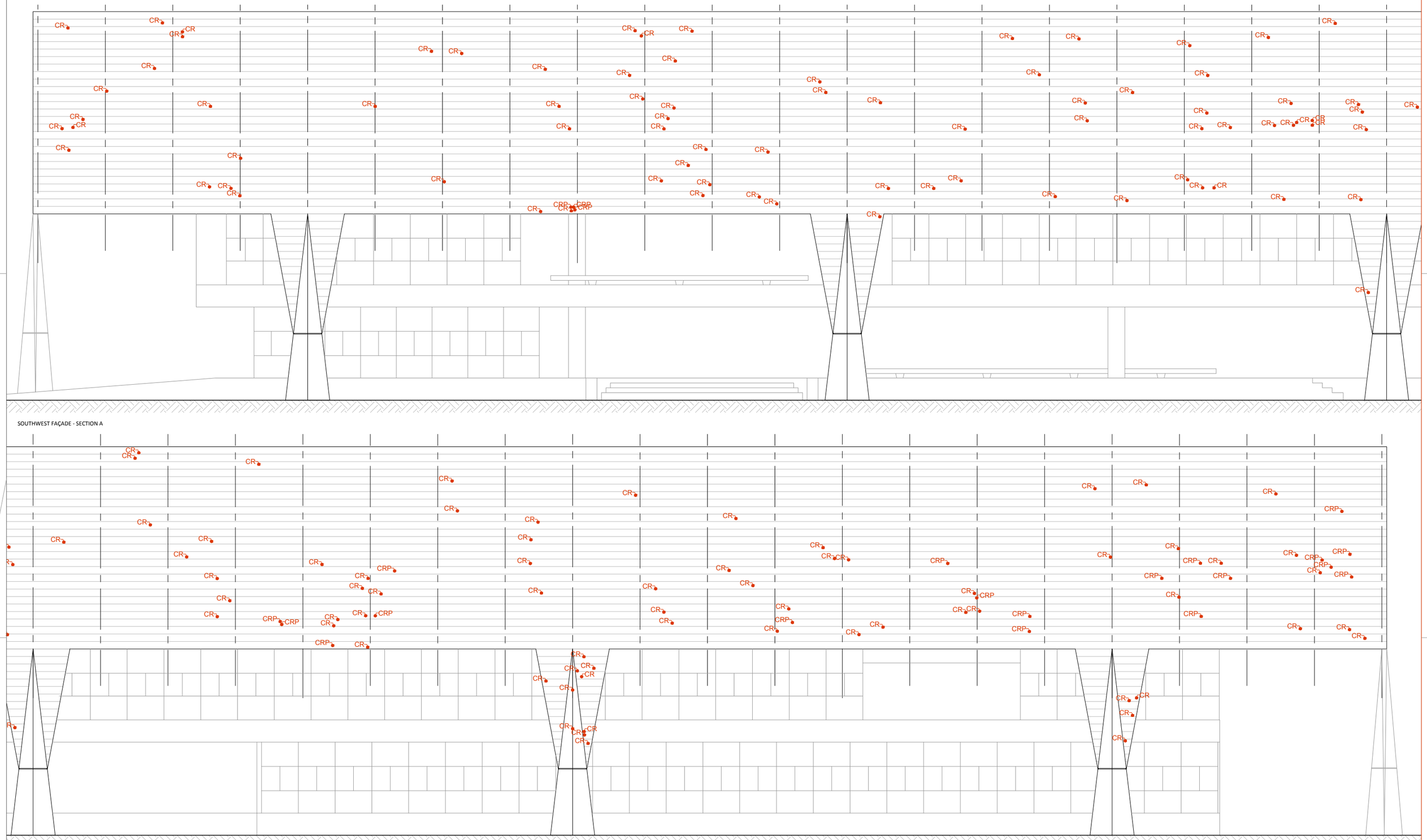
TITLE
Moisture stain on façades
Vilanova Artigas Building

DESIGN
Northwest façade
4/4

SCALE (meters) 1:200

0 1 5 10

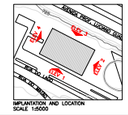
ANNEX D - SURVEY OF ARTIGAS BUILDING FAÇADE AREAS SUBJECT TO STAINING BY ACCUMULATION OF CORROSION PRODUCTS



SOUTHWEST FAÇADE - SECTION A

SOUTHWEST FAÇADE - SECTION B

CR - deposit of corrosion products
CRP - deposit of corrosion products (not visible to the nacked eye)
AR - exposed rebar



Project
CONSERVATION MANAGEMENT PLAN - VILANOVA ARTIGAS BUILDING FAUUSP AND THE GETTY FOUNDATION

Title
SOUTHWEST FAÇADE
SURVEY OF DEPOSITS OF CORROSION PRODCTS

Sheet
01/04

Task
TASK 3

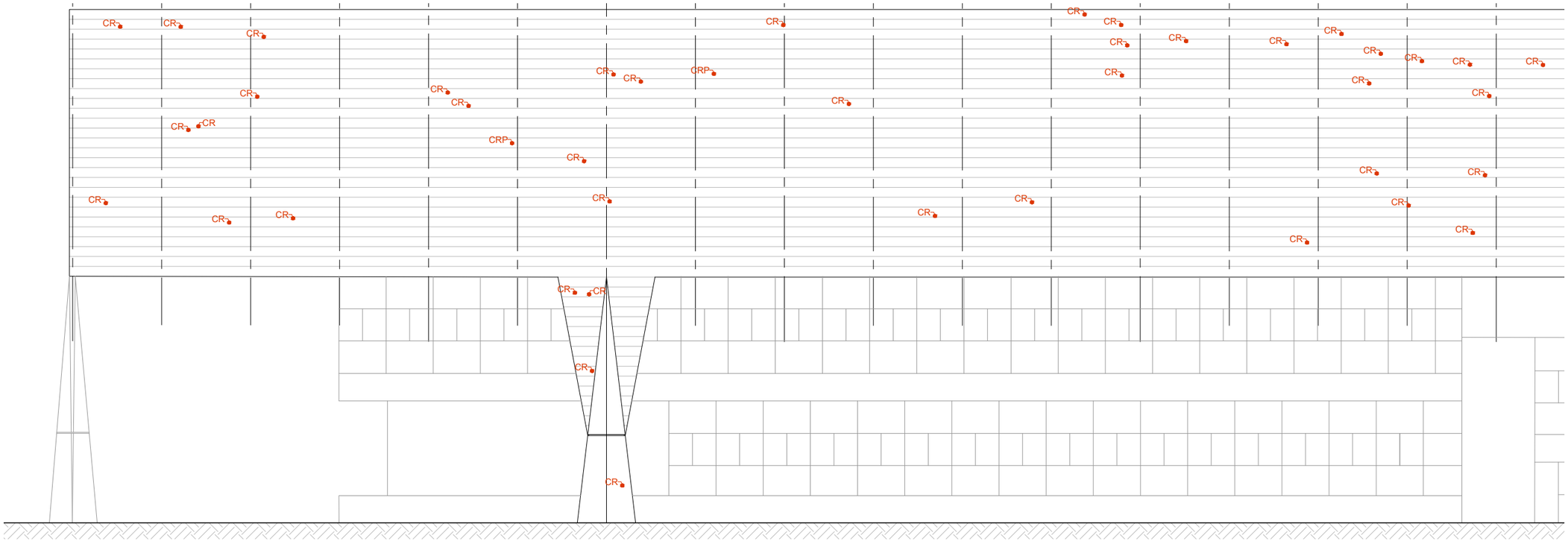
Scale
1:50

Drawing / Requester
LETÍCIA CHAVES, ANA PAULA A. GONÇALVES / CLÁUDIA T. DE ANDRADE OLIVEIRA

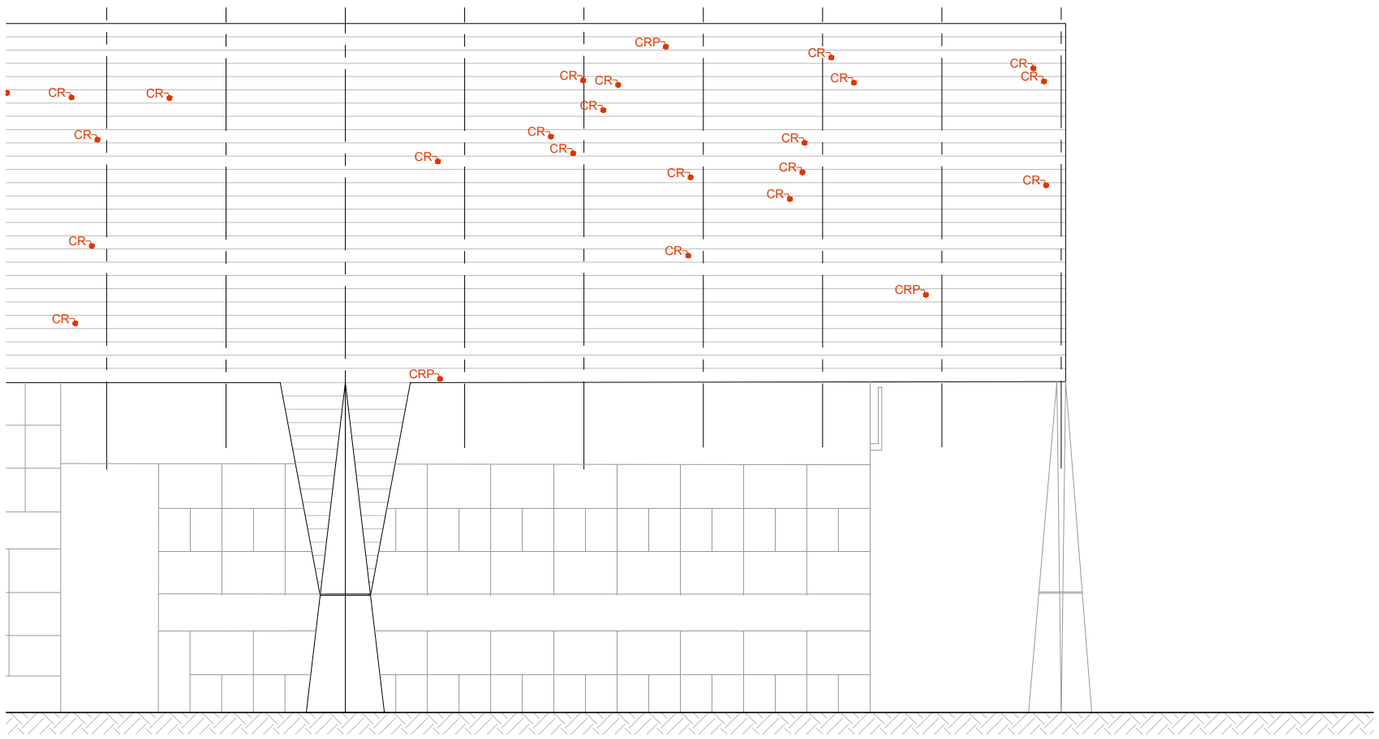
Date
28 / 09 / 2016

Archive
FAU-PGC-AR-LV-F01-R00.dwg

Revision
Revision 0

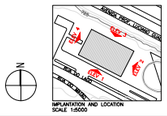


SOUTHEAST FAÇADE - SECTION A



SOUTHEAST FAÇADE - SECTION B

CR - deposit of corrosion products
CRP - deposit of corrosion products (not visible to the nacked eye)
AR - exposed rebar



IMPLANTATION AND LOCATION
SCALE 1:5000

Project
CONSERVATION MANAGEMENT PLAN - VILANOVA ARTIGAS BUILDING FAUUSP AND THE GETTY FOUNDATION

Title
SOUTHEAST FAÇADE
SURVEY OF DEPOSITS OF CORROSION PRODCTS

Task
TASK 3

Drawing / Requester
LETICIA CHAVES, ANA PAULA A. GONÇALVES / CLÁUDIA T. DE ANDRADE OLIVEIRA

Archive
FAU-PGC-AR-LV-F01-R00.dwg

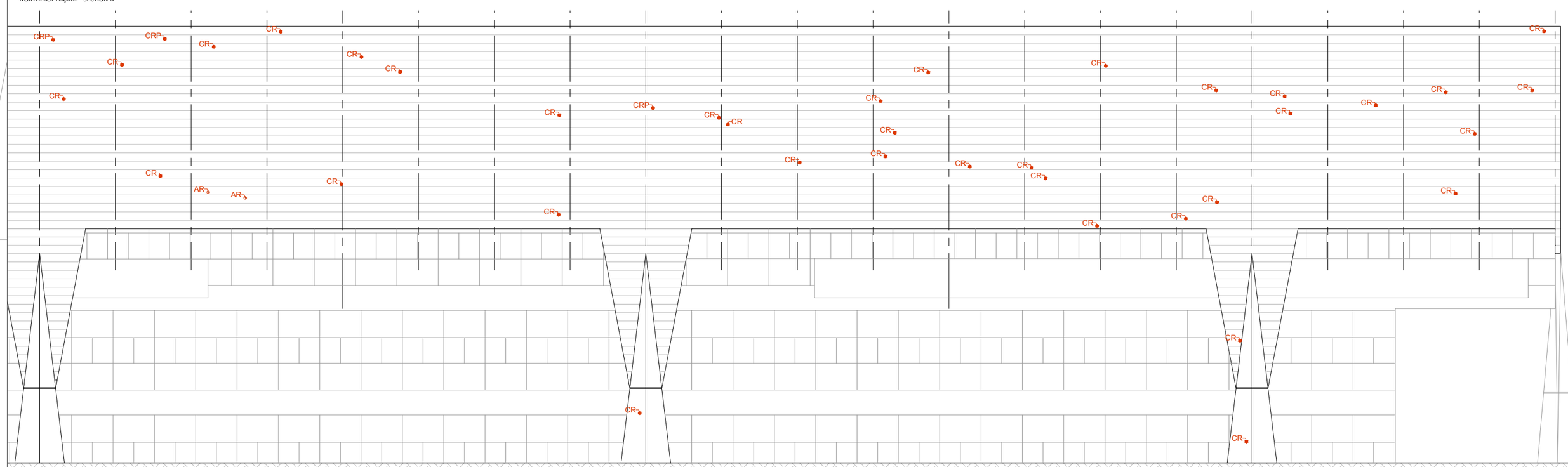
Sheet
02/04

Scale
1:50

Date
26/02/2017

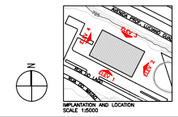
Revision
Revision 0

NORTHEAST FAÇADE - SECTION A



NORTHEAST FAÇADE - SECTION B

CR - deposit of corrosion products
CRP - deposit of corrosion products (not visible to the nacked eye)
AR - exposed rebar



Project
CONSERVATION MANAGEMENT PLAN - VILANOVA ARTIGAS BUILDING
FAUUSP AND THE GETTY FOUNDATION

Title
NORTHEAST FAÇADE
SURVEY OF DEPOSITS OF CORROSION PRODCTS

Task
TASK 3

Drawing / Requester
LETICIA CHAVES, ANA PAULA A. GONÇALVES / CLÁUDIA T. DE ANDRADE OLIVEIRA

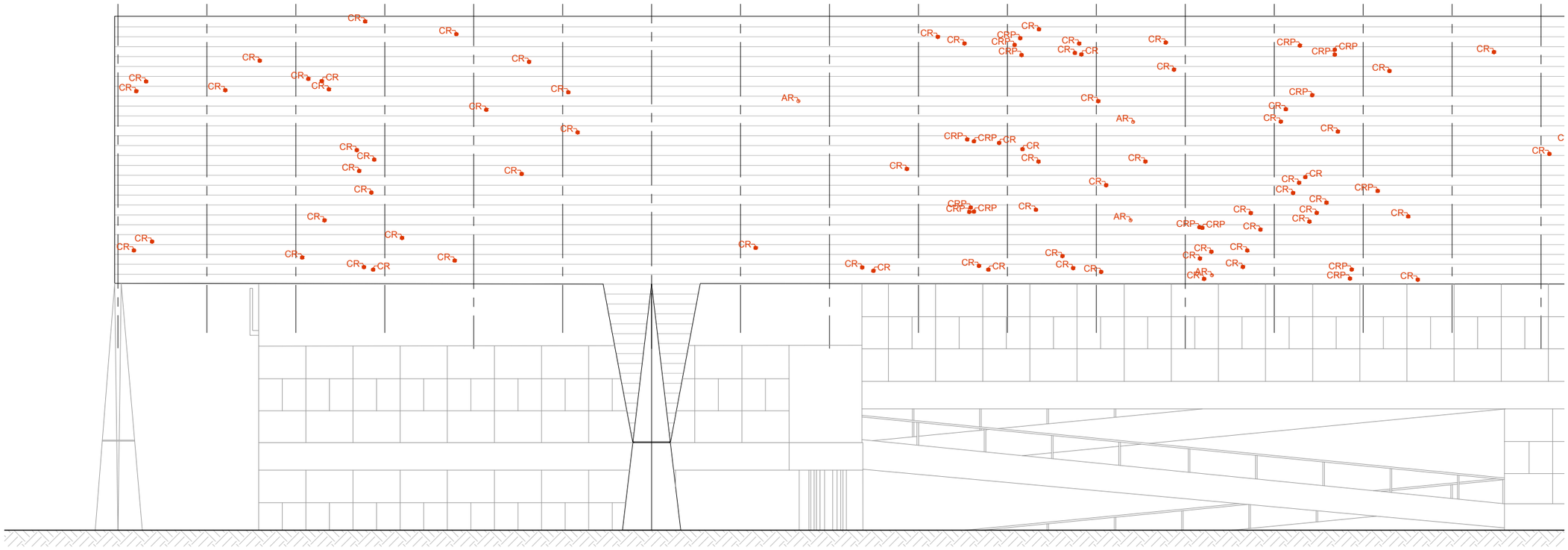
Archive
FAU-PGC-AR-LV-F01-R00.dwg

Sheet
03/04

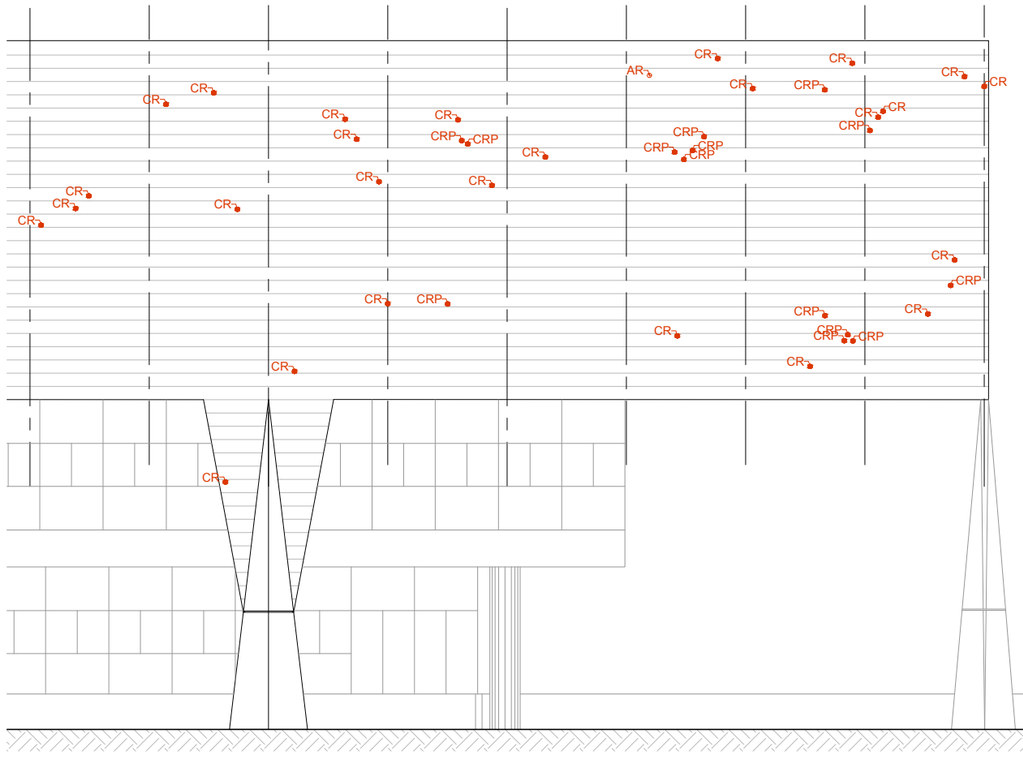
Scale
1:50

Date
28 / 09 / 2016

Revision
Revision 0

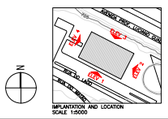


NORTHWEST FAÇADE - SECTION A



NORTHWEST FAÇADE - SECTION B

CR - deposit of corrosion products
CRP - deposit of corrosion products (not visible to the nacked eye)
AR - exposed rebar



Project
CONSERVATION MANAGEMENT PLAN - VILANOVA ARTIGAS BUILDING FAUUSP AND THE GETTY FOUNDATION

Title
NORTHWEST FAÇADE
SURVEY OF DEPOSITS OF CORROSION PRODCTS

Task
TASK 3

Drawing / Requester
LETICIA CHAVES, ANA PAULA A. GONÇALVES / CLÁUDIA T. DE ANDRADE OLIVEIRA

Archive
FAU-PGC-AR-LV-F01-R00.dwg

Sheet
04/04

Scale
1:50

Date
28 /0[illegible]/2019

Revision
Revision 0

ANNEX E - RESULTS OF MICROSTRUCTURAL ANALYSES XRD, TG/DTG, AND PETROGRAPHY

ANNEX E – Results of microstructural analyses XRD, TG/DTG, and petrography

X-ray diffractometry (XRD)

Table 1 X-ray diffraction analyses

Specimen	Location	Phase identification
T1	Blind façade NW	Quartz; portlandite; hydrated aluminum silicate; feldspar (alkaline and plagioclase); tricalcium aluminate (C3A); calcite; calcium carboaluminate; ettringite (hydrous calcium sulfoaluminate) (AFt); tricalcium silicate and dicalcium silicate (C2S and C3S); hydrated calcium aluminate; hydrated calcium silicate (C-S-H) (katoite and oyelite); brownmillerite (C4AF); gypsum ($CaSO_4.2H_2O$)
T3	Blind façade NE	Quartz; portlandite; feldspar (alkaline and plagioclase); calcite; hydrated aluminum silicate; calcium carboaluminate; tricalcium silicate and dicalcium silicate (C2S and C3S); ettringite (AFt), gypsum (CaSO4.2H2O); brownmillerite (C4AF); brucite [Mg(OH)2]; hydrated calcium silicate (C-S-H) (katoite and oyelite)
T5	Roof beam	Quartz; portlandite; hydrated aluminum silicate; calcite, brucite [Mg(OH)2]; feldspar (alkaline and plagioclase); brownmillerite (C4AF); ettringite (AFt); calcium silicate hydrate containing aluminium (C–A–S–H) (katoite); calcium carboaluminate; tricalcium silicate and dicalcium silicate (C2S and C3S); gypsum (CaSO4.2H2O)

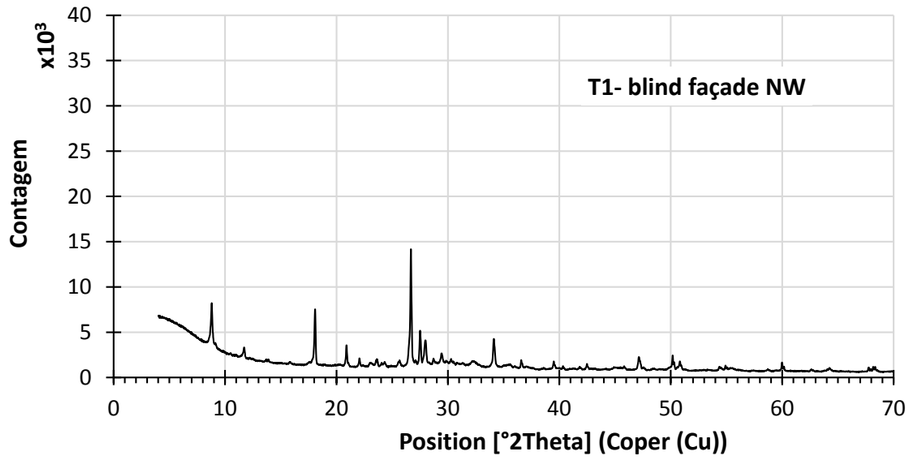


Figure 1 XRD scan Specimen T1 blind façade NW

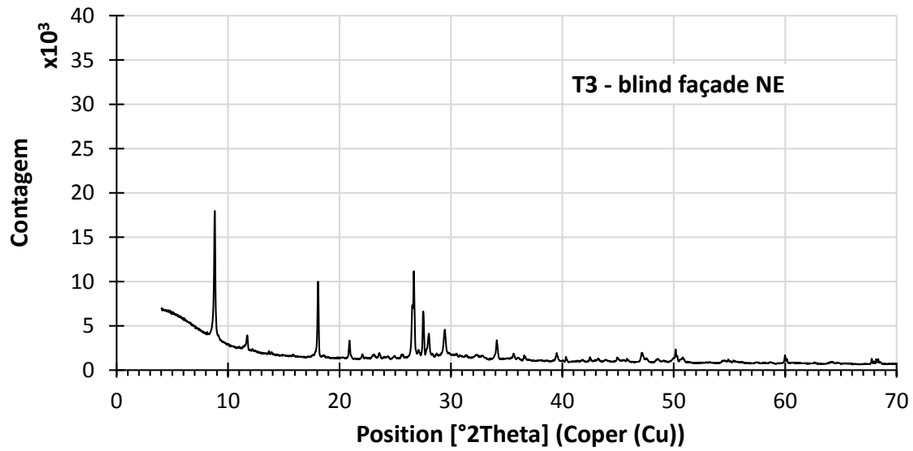


Figure 2 XDR scan Specimen T3 blind façade NE.

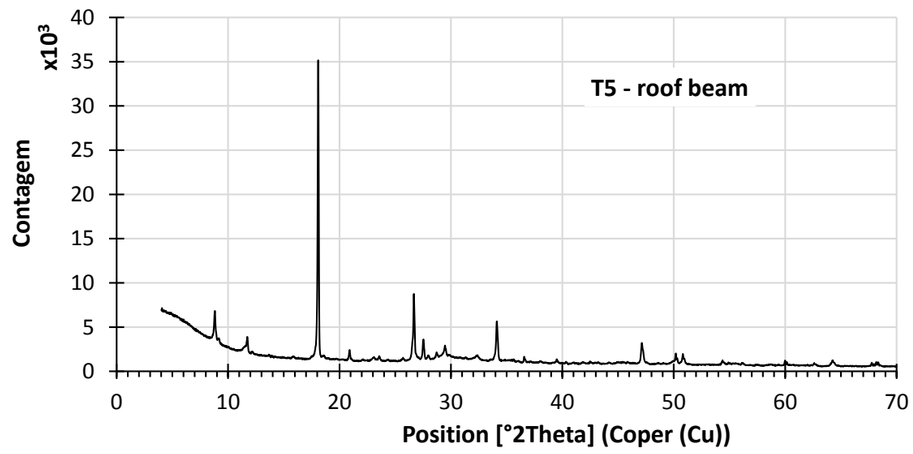


Figure 3 XDR scan Specimen T5 roof beam.

Thermogravimetry (TG) and differencial thermogravimetry (DTG)

Table 2 Thermogrametric (TG) and differential thermogravimetric (DTG) analyses

Specimen	Location	Weight loss (%) at temperature range						Residue (%)
		23 to 230°C	230 to 325°C	325 to 410°C	410 to 515°C	515 to 650°C	650 to 1000 C	
T1	Blind façade NW	-2.60	-0.60	-0.44	-0.65	-0.87	-0.90	93.94
T3	Blind façade NE	-2.61	-0.51	-0.53	-0.50	-0.95	-1.46	93.44
T6	Roof beam	-4.20		-0.70	-0.55	-0.73	-0.83	92.99

Phase identification as a function of temperature at which the thermal reactions occur:

- from 23 to 230°C: loss of the free water, decomposition of the hydrated aluminum silicate, loss of the C-S-H interlayer water, dehydration of the ettringite and calcium carboaluminate;
- from 230 to 325°C: decomposition of the calcium aluminate;
- from 325 to 410°C: dehydroxylation of the brucite [Mg(OH)2] from specimens T3 and T6; decomposition of the e decomposition of the hydrated calcium aluminate from specimen T1;
- from 410 to 515°C: dehydroxylation of the portlandite [Ca(OH)2];
- from 515 to 650°C: first weight loss due to decarbonation (amorphous calcium carbonate and calcium carboaluminate decarbonate);
- from 650 to 1000°C: second weight loss due to decarbonation (well crystallized calcium carbonate mainly coming from carbonate rocks affected by some diagenesis or metamorfism degree).

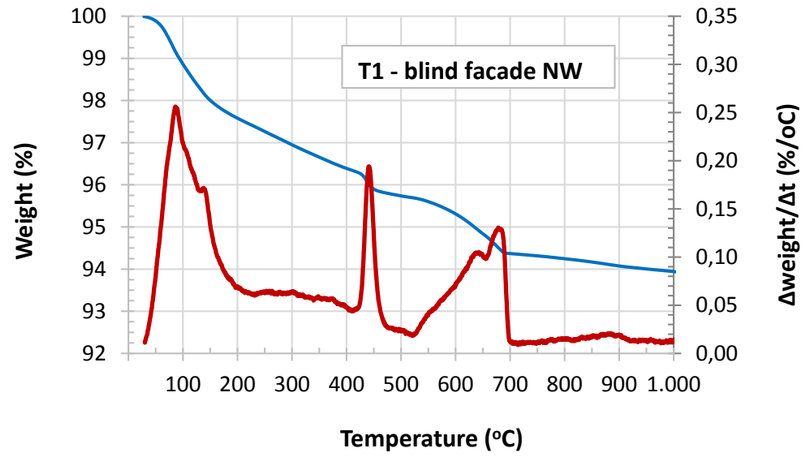


Figure 4 TG/DTG Specimen T1 blind façade NW.

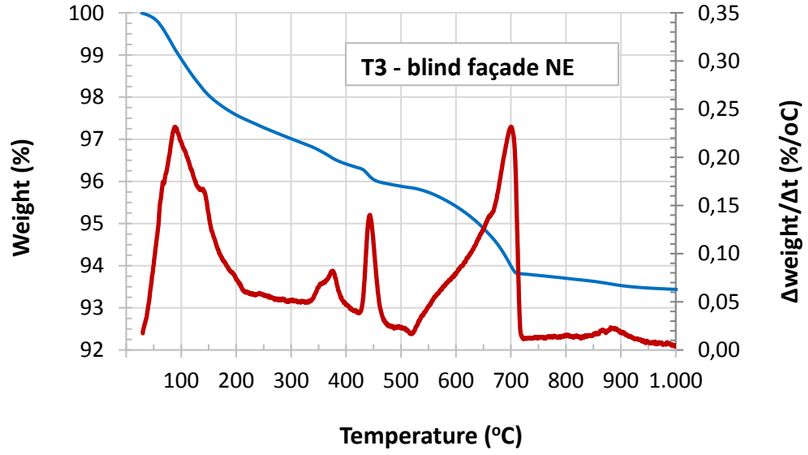


Figure 5 TG/DTG Specimen T3 blind façade NE.

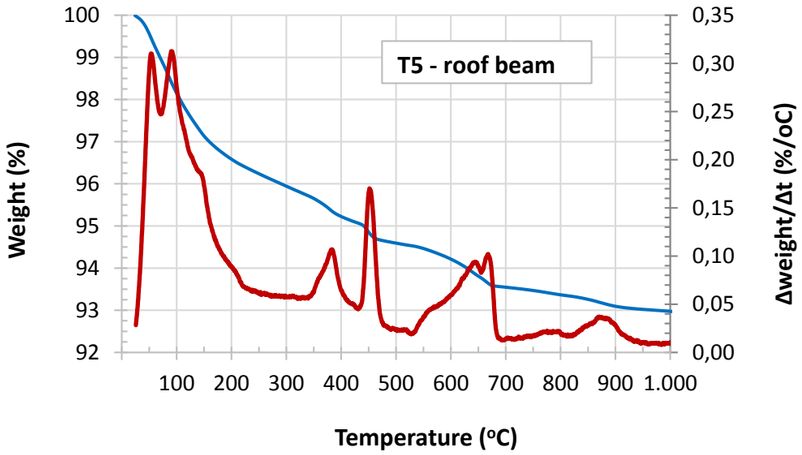
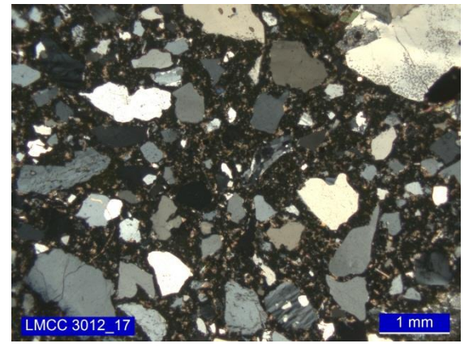


Figure 6 TG/DTG Specimen T5 roof beam

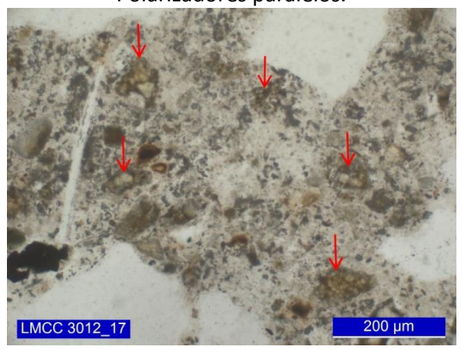
Table 3 Petrographic investigations. Thin section specimen T1 - blind façade NW.

LMCC 3012-17

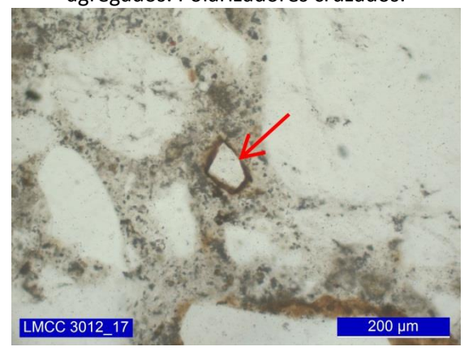
Fotomicrografia 1 – Agregado graúdo. Polarizadores paralelos.



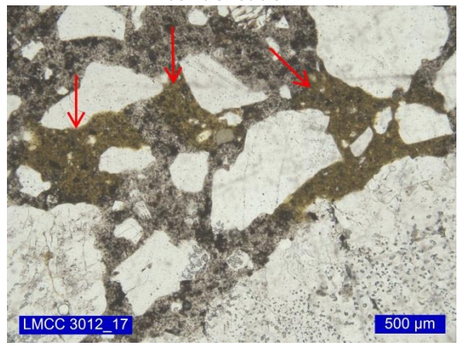
Fotomicrografia 2 – Aspecto geral da pasta e agregados. Polarizadores cruzados.



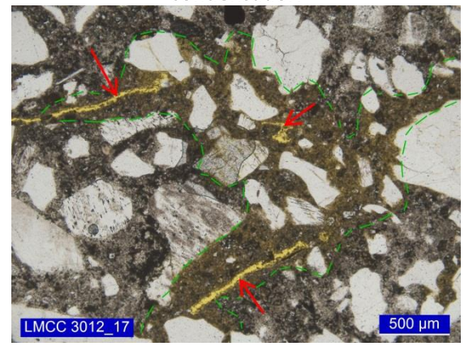
Fotomicrografia 3 - Abundantes núcleos anidros de clínquer (indicados por setas vermelhas). Polarizadores paralelos, com condensador.



Fotomicrografia 4 - Ao centro da imagem, indicada por seta vermelha, escória com halo ferruginoso. Polarizadores paralelos, com condensador.



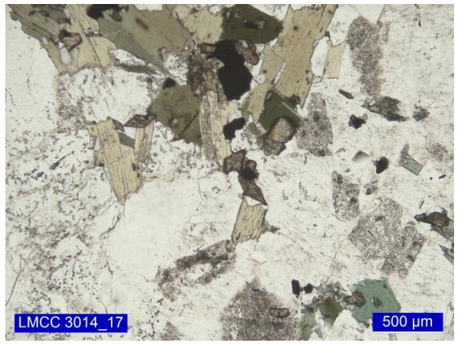
Fotomicrografia 5 - Zonas de microporosidade, indicadas por setas vermelhas e evidenciadas por coloração amarelada (impregnação por fluorsceína). Polarizadores paralelos, com condensador.



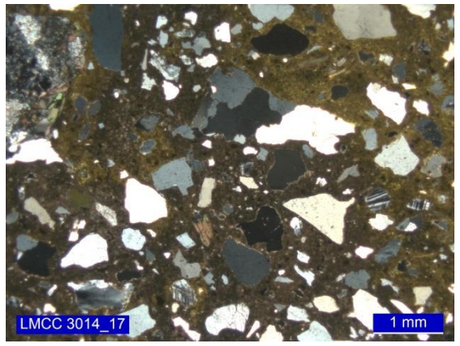
Fotomicrografia 6 - Micorfissuras na pasta (indicadas por setas vermelhas) associadas a microporosidade na pasta (delimitada por pontilhado verde). Coloração amarelada deve-se a impregnação por fluorsceína. Polarizadores paralelos, com condensador.

Table 4 Petrographic investigations. Thin section specimen T3 - blind façade NE.

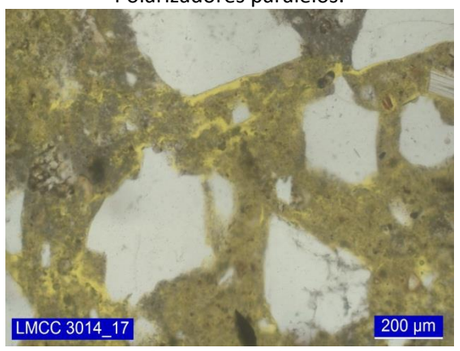
LMCC 3014-17



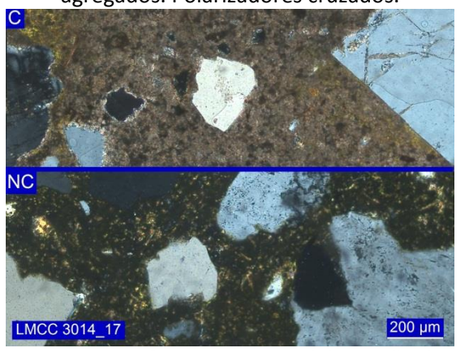
Fotomicrografia 7 – Agregado graúdo. Polarizadores paralelos.



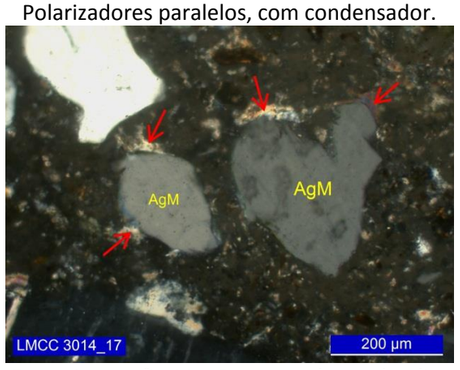
Fotomicrografia 8 – Aspecto geral da pasta e agregados. Polarizadores cruzados.



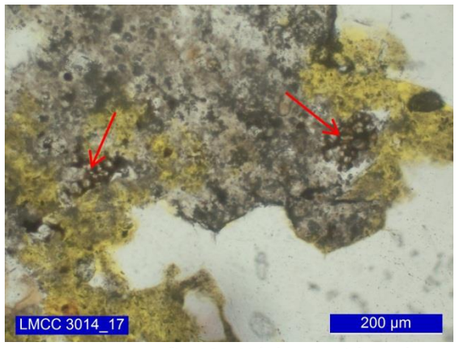
Fotomicrografia 9 – Indicadas por coloração amarela (impregnação por fluorsceína), microporosidade na pasta, com presença de microfissuras sem preenchimento. Polarizadores paralelos, com condensador.



Fotomicrografia 10 – No topo (C), porção da lâmina onde a pasta acha-se carbonatada. Abaixo (NC), pasta não carbonatada. Polarizadores cruzados.



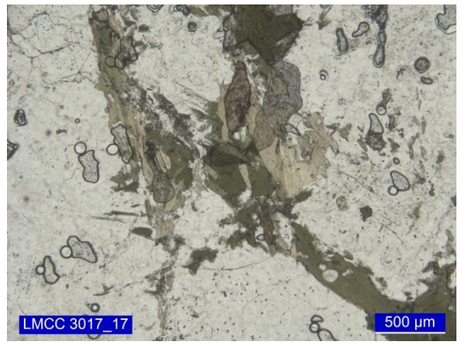
Fotomicrografia 11 – Presença de portlandita (indicada por setas vermelhas) em zona de interface da pasta com o agregado miúdo (AgM) Polarizadores cruzados, com condensador.



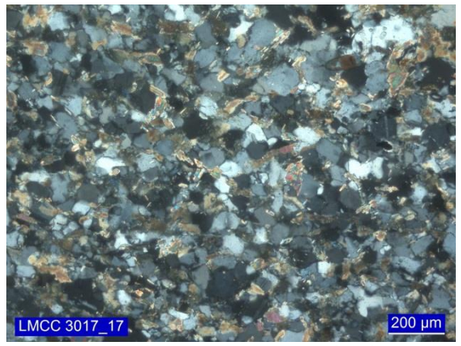
Fotomicrografia 12 - Núcleos anidros de clínquer (indicados por setas vermelhas). Coloração amarela (fluorsceína) evidencia microporosidade na interface pasta-agregado. Polarizadores paralelos, com condensador.

Table 5 Petrographic investigations. Thin section specimen T6 – roof beam.

LMCC 3017-17

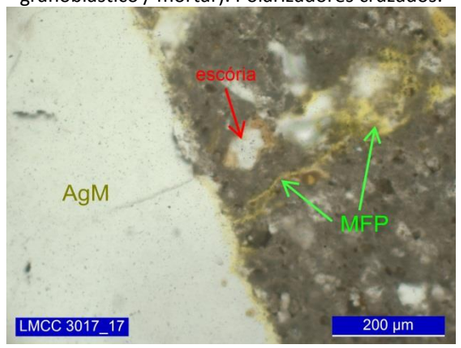


Fotomicrografia 13 – Agregado graúdo (gnaisse nemato-granoblástico). Polarizadores paralelos.



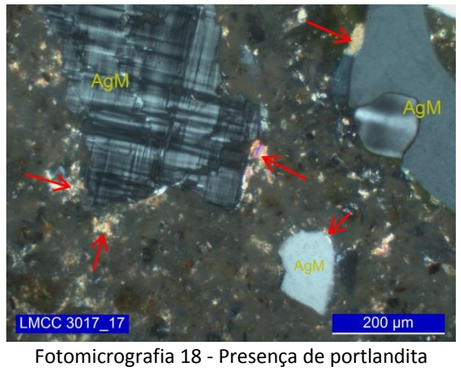
Fotomicrografia 14 – Agregado graúdo (gnaisse granoblástico / mortar). Polarizadores cruzados.

Fotomicrografia 15 – Aspecto geral da pasta e agregados. Polarizadores cruzados.



Fotomicrografia 16 – Indicada por seta vermelha, escória com halo ferruginoso. Presença de microfissura na pasta (MFP), interligada a agregado miúdo (AgM). Polarizadores paralelos, com condensador.

Fotomicrografia 17 – Ao centro da imagem, indicado por seta vermelha, núcleo anidro de clínquer. Polarizadores paralelos, com condensador.



Fotomicrografia 18 - Presença de portlandita (indicada por setas vermelhas) em zona de interface da pasta com o agregado miúdo (AgM). Polarizadores cruzados, com condensador.