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An Evaluation Method for the Potential of Old Apartment Buildings' Rehabilitation in Brazil

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Abstract: The rehabilitation of older buildings for residential use that started in the last few decades of the 20th century has become recurrent in some Brazilian cities. In São Paulo, for instance, this subject is within the context of the revitalization of its downtown area with the reintroduction of residential occupancy in the region as a consequence of actions taken by public and private groups. However, older buildings were designed based on the technologies and regulations available in the past and applied to meet the lifestyles of the time of their construction. This paper presents a method for the analysis of older apartment buildings, diagnosing their strengths and limitations in adapting to both the new Brazilian regulatory and legislative requirements, and the contemporary domestic demands. Requirements, criteria and methods for evaluation were studied, and defined as well as procedures for the application of a method which allows for a physical and systematic analysis of old apartment buildings. It was found that the proposed method can be an important support tool at the moment of studying the feasibility of rehabilitation processes, guiding and providing grounds for the design and building decisions of the professionals involved in these processes.

Key words: Rehabilitation of older buildings, performance evaluation, apartment buildings.

1. Introduction

In recent years, the real estate market in Brazil has experienced a hectic period involving both new and already-existing properties [1]. In unison, the rehabilitation of buildings has become a recurring subject in major Brazilian cities. As an example, the governments of the two largest metropolises in the country, São Paulo and Rio de Janeiro, have tried for two decades to revamp their run-down central areas by reintroducing residential occupancy there. At present, it is believed that the way to make these areas more valuable again lies through the renovation and utilization of the building stock already in place. Initiatives in this direction have started, but are still incipient and most of them are aimed at the rehabilitation of buildings for occupation as social housing [2].

In São Paulo, the private sector has begun to show interest in the return of the residential occupancy in the downtown area. Both the release of new buildings and the renovation of existing ones have gotten the attention of the market. Corroborating this fact, CEF (Caixa Econômica Federal (Federal Savings Bank)), a public bank and the major provider of funding for housing in Brazil, started allocating resources for the funding of dwellings involving apartments in renovated buildings in São Paulo's downtown area [3] as shown in Fig. 1.

What happens in some Brazilian cities follows the trend of other countries. In North America, important cities such as New Orleans, New Jersey, Cleveland, and Detroit have carried out programs for the revitalization of urban centers and the rehabilitation of existing buildings in an attempt to curb urban exodus, a phenomenon that has been going on since the 1950s [4]. In Europe, there was a quest for the utilization of the building stock after World War II in countries such

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Fig. 1 Building to be rehabilitated released by the real estate market in São Paulo's downtown.
Photo credit: Walter J. F. Galvao.

as England, France, and Italy, but it was only in the 1980s that investments in the sector were really poured in with introduction of big construction companies in the picture. Nowadays, the amount of rehabilitation work in these countries is impressive, reaching 40% of the civil construction business [5]. Therefore, initiatives aimed at the rehabilitation of buildings for residential use are in an advanced stage in the old continent, both in terms of legal aspects and also the practices and technologies applied.

Although the rehabilitation of buildings is already a reality in Brazil, economics constitute a hindrance to its implementation, according to some professionals of the Brazilian civil construction industry, who believe that rehabilitating an existing building is far more expensive than building a new one. Devecchi [6], however, points out that it is a mistake to ascribe the high costs of the rehabilitation processes simply to the fact that reforms are always more expensive than new constructions. According to the author, in fact, the adoption of non-specific renovation techniques in Brazil, consequently taking ordinary intervention procedures to old constructions, results in high cost and little spatial quality.

There are evident differences between new and rehabilitation work. In new ventures, the variables involved are known and there is control over the standardization of procedures and construction techniques. Therefore, reducing the risk of either an increase in costs or loss of quality whereas in rehabilitation work building processes can be complex because intervention in existing buildings demands the adaptation of solutions created in different moments in the past to contemporary principles of quality.

Thus, an initial stage of investigation is of great importance in rehabilitation procedures, as prior knowledge of the building is vital to both the identification of problems and the decisions related to design and construction [7]. Croitor et al. [8] stressed the importance of this initial investigation, which they call "stage of the diagnosis of the rehabilitation work" and report that studies on this phase are still incipient in Brazil. This assessment aims to determine the physical conditions of the building to be rehabilitated and its potential to withstand changes to meet current regulatory and legal requirements as well as the demands related to the new uses of the domestic space resulting from the transformation of the daily lives and family profiles.

It is regarded as necessary in Brazil, therefore, the development of tools for checking the viability of the rehabilitation process of residential buildings such as the EPIQR (energy performance, indoor air quality, retrofit), in the European Community, or the MER HABITAT (méthode d'évaluation rapide des habitations (housing quick evaluation method)), in Switzerland [9, 10]. These European tools for rapid evaluations can address both the current legal and regulatory requirements as well as the technological aspects applicable in rehabilitations. It is noteworthy that, in the tools mentioned above, there is a simplification of analysis procedures through visual inspections which, in most cases, eliminate the initial consultation with experts and the use of more sophisticated devices such as the support of laboratories and the use of equipment that are hard to handle.

Based on the NBR 15575 Brazilian Standard [11], a method for assessing the potential for rehabilitation of old apartment buildings in Brazil is proposed. The results of its application aid the stage prior to the development of reform designs for this type of building in providing an evaluation to justify, or not, the option for the repair of existing buildings and grounding the design and construction decisions for designers.

The method proposed here also considers the universal principles of contemporary architectural and urban quality, to be applied to either new dwellings or the ones to be rehabilitated, and includes the fulfillment of issues such as coexistence and privacy, comfort and well-being, adaptability (or flexibility) and functionality [12]. In addition, this study deals with the growing need for quality management in the production, use, operation and maintenance of residential buildings put into use [13] and their life cycle [14].

2. Methodological Procedures

Rehabilitation is defined as "providing an old building with economic, technological, and functional attributes, equivalent to those required for a new building" [15]. Muelas and Mateo [16] also add that "the ultimate goal of any rehabilitation process of a deteriorated building is to secure its place among the usable assets of the current society". Thus, the verb "to rehabilitate" will be adopted here and it should be added that, in rehabilitation processes, the most important issue is to adapt the building to new uses and needs, harmonizing interventions with the aesthetic principles of the building [17].

Knowing that the ratings of the intervention levels in the rehabilitation of buildings are important in this study and, in this regard, Aguiar et al. [18] present the following classification:

- Level 1—superficial rehabilitation. Performance of small repairs and addition of benefits to the facilities and equipment have already existed in the buildings;
- Level 2—medium rehabilitation. It differs from the superficial rehabilitation because it deals with deeper actions, but actions do not exceed 50% of the cost of a new construction;
- Level 3—deep rehabilitation. This type of intervention includes, in general, the need to make important changes in the distribution and organization of the areas inside the building, which leads to demolitions and significant reconstructions;
- Occupation change—change in the original use of the building;
- Addition—services aimed at providing the building with new parts.

It becomes necessary to define the levels of rehabilitative intervention to which the proposed method will be applied, enabling the classification and defining the qualification of the potential for rehabilitation, as it will be mentioned later. It should also be noted that it will be applied to buildings that will not have their use changed, that is, old apartment buildings that will be reformed for the continuity of their residential use and where their systems and subsystems will be checked to see whether or not they can be reused to comply with the new regulatory and legal demands.

As to the issue of time, the following question is in order: "what characterizes a building as 'old' and the work necessary for its update as rehabilitations?" Lanzinha [19] divides the buildings into four groups:

- Historical buildings are representing particular historical periods of a nation or continent, with significant aesthetic and architectural features;
- Old buildings are being used for over 50 years and whose lifecycle has already ended;
- Recent buildings are divided into buildings that have been used for a period of time between 30 and 50

years and buildings that have been used for a time span between 5 and 30 years, and that already have solutions for optimizing energy consumption;

• New buildings are still within the warranty period, in general, in use for less than 5 years.

In order to define what an old building is, one should review the principles of lifecycle of buildings, defined by the NBR 15575 Brazilian Standard [11] as the period of time during which the building, or its systems, maintains the expected performance when subjected to only the maintenance activities predefined in the design. The standard mentioned above sets the period of 50 years for the minimum design lifecycle as a whole.

In addition, delimiting apartment and building typologies can lead to more accuracy in the actions aimed at rehabilitations because the quantity of requirements and criteria to be analyzed are decreased. However, the methodological procedures developed may serve other typologies with the appropriate adjustments.

Thus, the proposed methodological procedures will be applied to apartment buildings with the following characteristics:

• multi-family and for residential use;

• steel reinforced concrete structure with internal and external masonry partition walls made of ceramic bricks (solid or perforated) or blocks (concrete or ceramic), with the masonry partition walls plastered on both sides;

• number of floors equal to or greater than three (ground plus two upper floors), excluding penthouses, attics and roof terraces. The building may or may not have basements and, from the first story above the ground floor, there must be apartments.

Thus, an apartment and building typology is configured which is not prevalent in old buildings but also present in many of the Brazilian cities. The rehabilitation of this kind of building is part of every forum where the use of old buildings for residential purposes in Brazil is discussed.

After the definition of the typology of the buildings to be evaluated by this method, the steps for its development were determined. The order of the tasks to be carried out was organized as in Fig. 2.

The explanation on the steps presented in Fig. 2 is shown below.

2.1 Development

Rabun and Kelso [20] point out that previous knowledge of the functional and building conditions is the key to evaluating the potential for the rehabilitation of buildings. They also assert that, in any preliminary survey for rehabilitation actions, one should have an early idea of the characteristics of the building, which greatly facilitates the initial examination.

Accordingly, the study began with inspections of two apartment buildings designed in the 1950s and still in use in the downtown area of the city of São Paulo with appropriate characteristics for the application of the method proposed and mentioned above.

Between 2009 and 2010, technical surveys, interviews with their managers and employees, in addition to the application of techniques of POEs (post-occupancy evaluations) to check the preferences and wishes of residents, were performed. All the data collected were used in the phase of adjustments of the very first version of the method presented here.

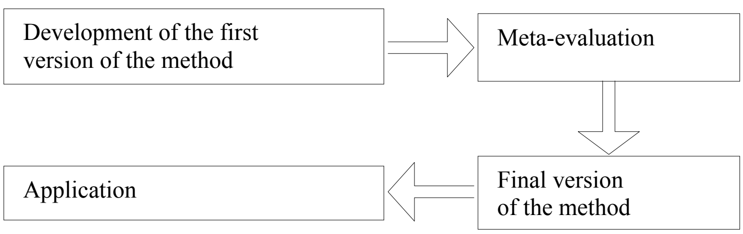

Fig. 2 Flowchart of the activities undertaken to organize the itinerary.

Concomitantly with the surveys and interviews conducted in the buildings, the NBR 15575 Standard [11] was studied in order to verify its indexes and the minimum requirements that these old buildings were supposed to meet today. It should be emphasized that this standard relates to new buildings only and that the comparison is necessary. It is also noteworthy that the NBR 15575 Brazilian Standard was first published in the year 2008 and became effective in the year 2010. However, it immediately went through a revision stage which was concluded in the year 2013 with very few changes in comparison to the previous version. The analyses mentioned here refer to the edition that was effective in the year 2010.

After that, a first version of the items to be evaluated was drafted based on the comparison of the data obtained in the previous inspections of these buildings and the analysis of the NBR 15575 Standard [11]. This first version included the following 12 items to be analyzed: functionality; accessibility; thermal comfort; acoustic comfort; lighting comfort; fire safety; structural and vertical partition elements; electrical installations; hydro-sanitary installations; property security; quality of the blueprint (legal, architectural, complementary and of the changes implemented) and environmental adequacy.

It is worth noting that the NBR 15575 Standard [11] follows the principle of performance evaluation where the indexes are presented in the form of requirements and criteria to be met. Although the main goal of the method is not a performance evaluation of old buildings, but its potential to minimally meet the current regulations, the indexes are based on the requirements and criteria of this standard, taking into account the fact that they do not intend to set the design and building actions in rehabilitations. Those minimum regulatory conditions also entail adaptations to the contemporary demands of the domestic space.

In the theoretical framework for the definition of the requirements and criteria of each item, in addition to the NBR 15575 Standard [11], other parameters were adopted, when more appropriate, such as other Brazilian Standards and, only in their absence, references from academic work and international standards were used.

2.2 Meta-evaluation

After the first version of the method was set up, the phase of meta-evaluation was initiated as a means of checking its validity. Managers of old apartment buildings in use, experts on the issues related to the 12 building performance items and users/residents of old apartment buildings were consulted to validate the method.

Consultations with five managers of apartment buildings constructed in the 1950s in the downtown area of the city of São Paulo and with 11 experts were carried out. Methods and techniques of POE [21-23] were adopted in the individual interviews with residents [24, 25], and in the organization of a group interview.

Based on the considerations of managers and experts, as well as the opinions obtained from users[1], some decisions for the preparation of the final version of the method were made, such as the elimination of items concerning property security and the quality of blueprints. As to the property security item, the concern with the subject is still very recent in the Brazilian civil construction industry, therefore there is a lack of a national regulatory framework on the subject [26]. In addition, the users/residents consulted regarded this item as one of the least important among those presented to them. In relation to the quality of blueprints, many of the experts considered this as "not important in the rehabilitation process". Such absence neither precludes nor diminishes the potential for the rehabilitation of the building under consideration.

The item called environmental adequacy was renamed as location and relationship with the local

[1]Four hundred and sixteen questionnaires were completed and a group interview with 10 residents of buildings with over 50 years of use in the central part of the city of São Paulo was conducted.

infrastructure and waste management and it is composed of sub-items, such as water management, waste management, infrastructure of the surroundings, among others, some of these are already present in other items of the method, such as thermal comfort and hydro-sanitary facilities.

Thus, the 10 items that make up the final version of the method are the following:

- functionality—dimensions of the environments in the apartments and the possibilities of layout adaptations;
- accessibility—use of the building and apartments by people with disabilities;
- thermal comfort—adequacy of the external elements and openings in the apartments to the local weather;
- acoustic comfort—acoustic conditions of the external elements, windows, and walls between apartments as well as the level of noise in the surroundings of the building during the night;
- lighting comfort—natural lighting in the environments of the apartments;
- fire safety—hazards for a fire breakout, existence of firefighting equipment and the quality of escape routes;
- structural and vertical partition elements—apparent stability of structural elements and vertical partitions;
- electrical installations—conditions to meet the contemporary demands of electrical consumption and the adjustments to current safety issues in the handling and use of electrical installations;
- hydro-sanitary installations—adequacy of the storage and distribution systems of cold water to current standard conditions and the appropriate conduction of the discharges to the right destination;
- location and relationship with the local infrastructure and waste management—existence of some infrastructure in the surroundings that minimizes the use of automobiles and enables the building to have selective waste collection.

2.3 Application

After the items contained in the final version as well as the theoretical references for the definition of requirements and criteria of each item were determined, evaluation procedures to corroborate the diagnosis were specified and detailed.

An application form was developed in which all the indexes, based on the determined criteria, were presented as closed-ended questions to the interviewer. This resource had already been adopted by Pedro et al. [27] who justify the need to guide the inspection of buildings and record the information collected by field technicians.

Concerning the ratings methods, Lanzinha et al. [5] present a qualitative classification based on construction problems found, by its severity, as "meaningless" (no significant anomaly or malfunction), "lightweight" (anomaly that impairs the appearance), "medium" (anomaly that impairs the use or comfort) and "severe" (anomaly that endangers health or safety). On the other hand, Marco et al. [10] define the building conditions in order to identify the rehabilitation actions, proposing a quantitative classification as Code 4 (good condition), Code 3 (slight deterioration, easily repairable), Code 2 (significant deterioration, more difficult to repair) and Code 1 (subject to replacement). Here, in the proposed method, due to its objective (expeditious evaluation), the answers of the application form are based on whether or not the index presented in each question has been satisfied. The response options are presented in Table 1.

The example of one of the items to be checked by the method is presented in Table 2. Further details about the chosen items and the evaluation criteria are presented in Section 3.

Thus, the classification of the potential for the rehabilitation of the building is given by the percentage of requirements met, out of the 92 questions presented, combining qualitative aspects (classifications) with quantitative aspects (percentage of items met). The proposed classification criterion is presented in Table 3.

Although the results given by this method have no labeling purposes, the tabulation of results was adopted as set out in the conformity assessment of the INMETRO (Brazilian National Institute of Metrology Standardization and Industrial Quality) [28], where the technical features of a product are informed based on testing and inspections results. This feature is directly linked to the product's ability to meet pre-established requirements. In the method presented here, the requirements to be met are represented by current regulatory and legal aspects mentioned in Section 3.

As it also has the intention of guiding and substantiating the design and building process, the diagnosis, when positive, shows that not many actions would be needed in order to rehabilitate the building to meet the contemporary demands. On the other hand, a negative diagnosis does not cripple the rehabilitation process, but shows that it can be expensive.

For each one of the 10 major items, a field for additional open-ended comments is proposed. It can be freely filled by the interviewer, with justifications that may reinforce an answer or reports of relevant observations or not included in the form. In addition, there is an empty field for the insertion of photos or informal drawings to give support to some answers or complementary comments.

When several elements must be checked in order to satisfy one requirement, if one of these elements does not meet the defined criterion, it is considered that the whole building does not satisfy such requirement.

In the last part of the form, the 92 questions must be tabulated and the frequencies added to assess the potential for the rehabilitation of the building. After the result, a field is reserved for the written presentation of the application of the method where

Table 1 Response options of the proposed method.

Options	Meaning
Meets	The requirements related to the index were fully met.
Does not meet	The requirements related to the index were either partially met or not met.
Not checked	For some reason, the methods necessary to check whether or not the requirements related to the index were met were not applied.
Not applicable	The index object of inquiry is not present in the building under consideration.

Table 2 Application form regarding the lighting comfort item.

Lighting comfort item		Meets	Does not meet	Not checked	Not applicable
32	All bedrooms have an average level of natural illuminance equal to or greater than 60 Lux.	☐	☐	☐	☐
33	The living/dining room has an average level of natural illuminance equal to or greater than 60 Lux.	☐	☐	☐	☐
34	The kitchen has an average level of natural illuminance equal to or greater than 60 Lux.	☐	☐	☐	☐
35	All bathrooms have an average level of natural illuminance equal to or greater than 60 Lux.	☐	☐	☐	☐
36	All bedrooms have devices of illuminance control, such as shutters, connected to the windows.	☐	☐	☐	☐

Table 3 The proposed classification of the potential for rehabilitation based on the number of requirements met by the building.

Requirements met (%)	Classification
Up to 20% of the requirements met	Very poor: potential for rehabilitation
Between 20% and 40% of the requirements met	Poor: potential for rehabilitation
Between 40% and 60% of the requirements met	Fair: potential for rehabilitation
Between 60% and 80% of the requirements met	Good: potential for rehabilitation
Between 80% and 100% of the requirements met	Excellent: potential for rehabilitation

the potential for the rehabilitation of each item can be displayed, and additional comments made during the application of method can be detailed. Additionally, recommendations for the design can be made or even the inclusion of additional observations not contained in the method, but important for the rehabilitation process, can be recorded.

After the form was prepared, its field application came next. A team composed of two professionals, an architect and an assistant (an architecture student), was formed, as Pedro et al. [27] recommend so as to try out the effectiveness of an expeditious method, without the need of specific training for its application.

The chosen team was provided with the application form, as well as the guidelines for its completion, with basic information on how to fill it out and how to apply the evaluation method, such as the handling of apparatuses and measurement procedures. The team was also supplied with the tools necessary for the application of the method. After that, there was a first visit to the building and, from then on, the team was given the goal to apply the method within a month.

3. Regulatory and Legislative References

Next, the regulatory and legislative references that substantiated the requirements, criteria and methods for each item of the proposed method are presented.

3.1 Functionality

The rooms' minimum dimensions, as set in NBR 15575 [11], as well as in the Manuals of Engineering and Architecture organized by CEF, SINDUSCON (Sindicato da Indústria da Construção (Trade Union of the Construction Industry)) and the CDHU[2]/2008 Design Manual were considered.

In the method, the highest values of the minimum usable area (floor area of the environment) found in those manuals were adopted, which are: 9 m^2 for the first bedroom; 8 m^2 for the second and third bedrooms; 12.5 m^2 for the living/dining room; 5 m^2 for the kitchen; and 2.8 m^2 for the bathrooms and laundry areas.

For the multifunctional spaces of studio apartments [29][3], the minimum of 16 m^2 was adopted, in accordance with the resolution of the sanitary code of the State of São Paulo (Decree No. 12.342/78), since none of those manuals presented recommendations for this kind of environment.

There are also requirements for ceiling heights, which are something necessary to ensure adequate air volumes in the environments. After considering the recommendations, the minimum values of ceiling height of 2.60 m for rooms in general, 2.50 m for kitchens, and 2.30 m for bathrooms were adopted.

3.2 Accessibility

Fundamentally, the NBR 15575 [11] recommends that private and common areas should anticipate the necessary adaptations for its use by people with disabilities, which is something optional in private areas, but mandatory in common ones, suggesting the NBR 9050 Standard [30] as the guide for these adaptations.

3.3 Thermal Comfort

The NBR 15575 [11] has as a requisite for this item, the satisfaction of the thermal demands of users, depending on the region where they are located and takes into account the Brazilian bioclimatic characteristics defined by the NBR 15220 [31].

As the try-out of application was carried out in the city of São Paulo, the strategies that suit the bioclimatic zone of the city were verified.

[2]Companhia de Desenvolvimento Habitacional e Urbano do Estado de São Paulo (Housing and Urban Development Office of the State of São Paulo).

[3]Defined as an apartment where the social (living and dining rooms) and intimate (bedrooms) areas merge into a single environment. In Brazil, this kind of apartment, also called "kitchenette", has been popular since the 1950s.

3.4 Acoustic Comfort

For external and internal partition walls, the figures for the insulation of airborne sound are recommended in the NBR 15575 [11]. In this case, the values are presented in *D*2nTw (weighted standardized level difference of 2.00 m), *D*nTw (weighted standardized level difference) and *Rw* (weighted sound reduction index). As in the case of slabs, the performance of measurements in laboratories or in the field is also recommended, as shown in Table 4.

The NBR 15575 does not address the acoustic performance of windows, therefore, the performance of bedroom windows is not particularly analyzed, but the L11032 Standard [32] will be used as a parameter, which evaluates the noise levels inside the rooms with the windows closed, compared to external noise levels. According to this standard, the level of noise measured inside the environment with a common window must always be 15 dB (A) lower than the external noise.

3.5 Lighting Comfort

The NBR 15575 Standard [11] presents 60 Lux of natural lighting as the minimum illuminance level for the living room, bedroom, pantry/kitchen, bathroom and laundry area. However, for common areas of the building and enclosed areas which have no openings to the outside, there are no recommendations as to natural lighting.

Thus, the appropriate levels of natural lighting in living/dining rooms, kitchens, bedrooms, and bathrooms of the apartments (minimum of 60 Lux) are to be checked, and also, the control elements of natural lighting connected to windows in bedrooms, such as shutters. It should be emphasized that the analysis of artificial lighting is not dealt with in the method.

3.6 Fire Safety

The NBR 15575 Standard [11] also presents the requirements and regulatory criteria for fire safety including the compliance with specific items, such as the existence of lightning rods, safe electrical and gas installations, escape routes and fire resistance of the materials that make up the building. Those requirements will be used as a parameter in the method, added to the guidelines of the regulations for the installations of gas set forth by COMGAS (Companhia de Gás de São Paulo, São Paulo's Gas Company) and the TI (technical instructions) by the CBESP (São Paulo's Fire Department).

3.7 Structural Elements and Partitions

Only requirements and criteria for structural elements are addressed in the NBR 15575 Standard [11]. For the method, the elements that constitute partition walls were also added to this item.

As mentioned before, the method aims at analyzing buildings which have been in use for 50 years or more, where the resistance of the structural system has already been consolidated, in terms of both permanent and variable loads.

Table 4 Weighted sound reduction index (*Rw*) of the building components (adapted from the NBR 15575 [11]).

Partition walls	Weighted sound reduction index—*Rw* (dB)
Living room and kitchen walls between a dwelling and corridor areas, halls, and stairs on standard floors	35 to 39
Bedroom walls between a dwelling and common areas of occasional circulation, such as corridors, halls and stairs on standard floors	45 to 49
Walls between a dwelling and common areas where people stay for longer periods of time and practice leisure and sports activities , such as home theater rooms, exercise rooms, party rooms, game rooms, restrooms and lockers, kitchens and laundries	50 to 54
Walls between autonomous housing units (paired wall)	45 to 49

Thus, the existence of cracks with openings larger than 0.6 mm, in addition to edge cracks in windows and doors, is checked as well as the occurrence of the carbonation of concrete, that is, the chemical reaction generated by the oxidation between the reinforcement and the concrete and the presence of apparent structural reinforcement elements, whether or not experiencing an oxidation process.

3.8 Electrical Installations

In Ref. [33], there will always be the need for the replacement of electrical installations in rehabilitation processes. Thus, the status of the conductors (electrical wires and cables) is not checked in the method, with the suggestion for their complete replacement in the rehabilitation process.

Furthermore, the adequate number of GPO (general purpose outlets) for the satisfaction of the new demands for electrical energy is verified as well as the power factor of the buildings, that is, the ratio between the active power (utilized) and the apparent power (total) of the electrical system. In order to do that, the precepts of the NBR 5410 [34] will be adopted for the first item and the Provision # 95 of the Resolution # 414 by the ANEEL (National Agency for Electrical Energy) dated September 9, 2010, for the second, defining that the minimum power factor for apartment buildings must be 0.92.

3.9 Hydro-sanitary Installations

As parameters of the method, the specific standards of this item, such as the NBR 5626 [35] and the NBR 8160 [36], were used. Some guidelines of the design manual by the CDHU [37] were adopted. Finally, in the case of the water supply for fire fighting, the values recommended by the TI 22 of the Corpo de Bombeiros do Estado de São Paulo (Fire Department of the State of São Paulo) [38] for residential buildings, which relates the built area of the building to the amount of water stored, were adopted. In the method, the amount of water necessary for fire fighting purposes is added to the amount of daily consumption.

The sanitary sewage system must be separated from the system that drains rain water and there must be exclusive pipes for kitchen sinks, dishwashers and washing machines, with ventilation and discharges into common grease traps. There must be vent pipes in the facilities and/or the possibility of replacement or expansion of the system so as to meet the demands of gas discharges. The main venting system must be on the top of the building, with a minimum distance of 4 m from any window and a minimum height of 2 m from the top, with a device that prevents the entry of rainwater.

3.10 Location and Relationship with the Infrastructure and Waste Management

Environmental compliance is the name that the NBR 15575 Standard [11] gives to the subject of sustainability. The recommendations range from the selection and consumption of the materials used in the production of the building to the energy consumption in its use and occupancy, addressing water consumption and the discharge of the sewage. Besides these, indexes of adjustments to the principles of sustainability, such as the American LEED (Leadership in Energy and Environmental Design), are used in the method. As already mentioned above, this item is called "location and relationship with the infrastructure and waste management" in this proposed method. Thus, the method evaluates whether, within a 400 m radius from the building, a medical center, a fire department, a laundromat, a pharmacy, a police station, a restaurant, a supermarket and a post office branch can be reached. Within 800 m, areas that encourage the practice of physical activities, such as squares or parks, bus stops and subway stations should be located as well. In addition, there must be a predetermined area for the storage of solid waste in the building, affording easy access and circulation in its interior and capable of storing the waste produced weekly by the building occupants.

4. An Example of the Application of the Method and Results

The building used in the method's try-out, shown in Figs. 3-5, was built in the downtown area of the city of São Paulo in the 1950s. Its only basement is used as car parking as well as support areas for the administration of the building, such as locker rooms for the staff, storage rooms, among others. On the ground floor, there is a small shopping center connected to an upper floor, called a mezzanine, with rooms used as offices. Restrooms are also provided in these two floors.

In the building, there are 322 apartments of one, two or three bedrooms distributed in two towers of 24 floors each. On the roof, there is a leisure area with a pool, a playground, and an open area for the practice of exercises. There are 109 parking spaces for cars on the basement as well as 18 elevators for residents and two elevators for automobiles. The site where the building was constructed has 3,634 m^2 and, in total, the built area takes up 46,570 m^2.

After the forms were filled, the value of 61% of the requirements met (54 out of the 88 checked) was obtained, meaning "good potential for rehabilitation". Amongst the items not met, those related to accessibility were regarded as those of greatest complexity, especially in terms of the minimum width of circulation areas, since those are, in general, between elevator columns, stairways, and structural axis. The adaptation of escape routes is also an item of concern because it has external access only through the basement and also due to the presence of many obstacles on its way.

The application team informed that six apartments were visited, located on the 7th, 14th, 16th, 21st, and 24th floors, besides the common areas of all floors. Furthermore, it was informed that the total time spent on the application of the method was 30 h and 30 min.

The team also offered the following suggestions for improving the method:

- Some items that seem to be more difficult for rehabilitation should not have the same number of requirements as those that can be corrected fairly easily;

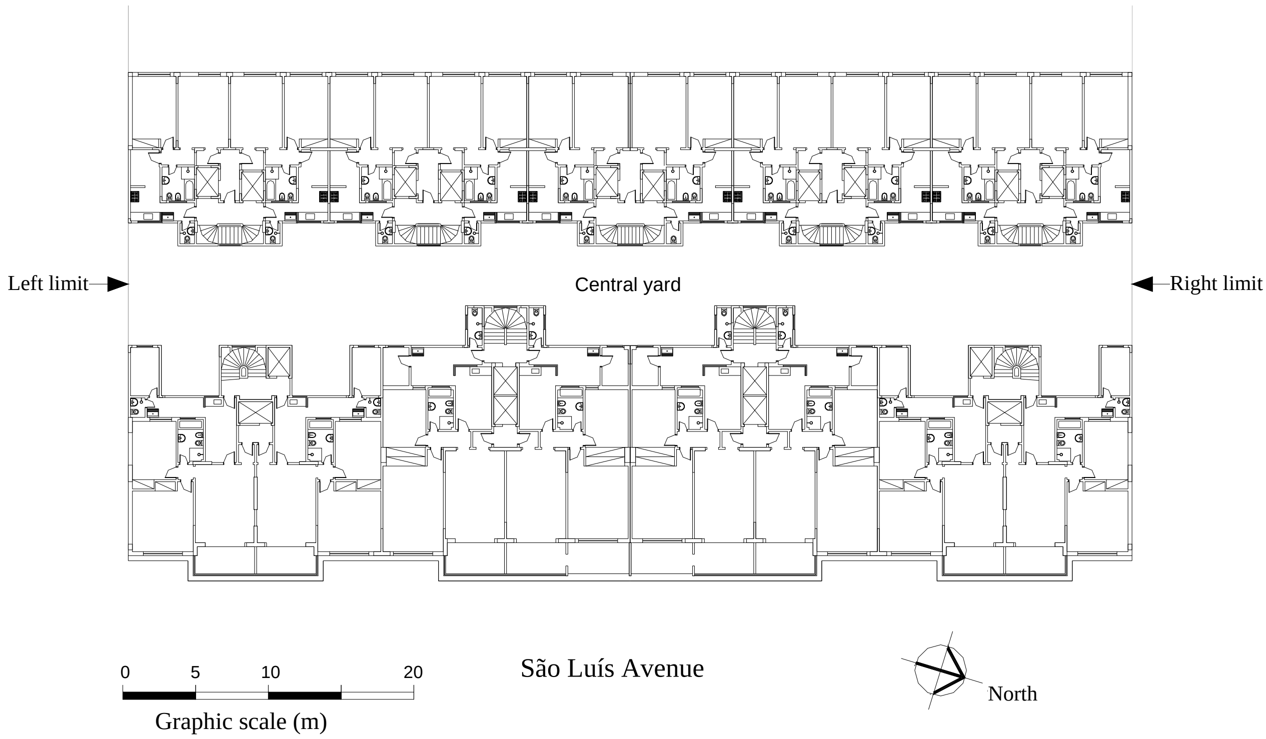

Fig. 3 Typical floor plan.

Fig. 4 View of the building where the try-out was carried out.

Photo credit: Tiago Franco and Valéria Bonfim.

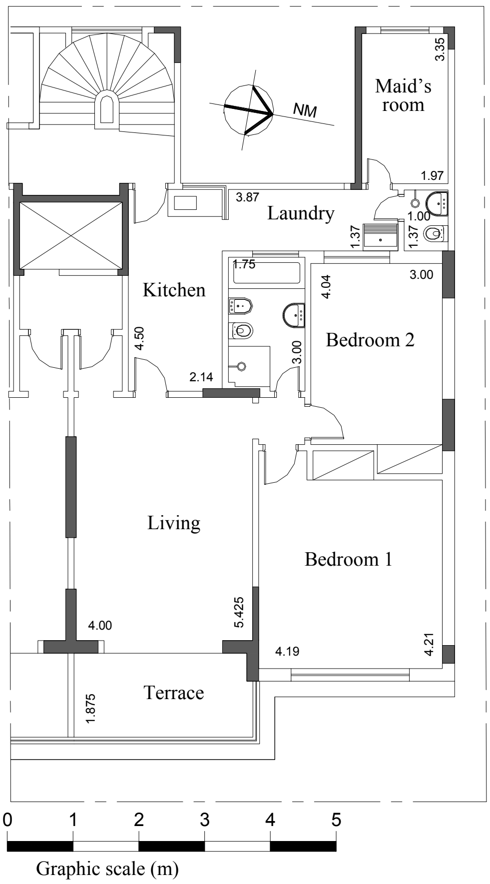

Fig. 5 A floor plan of a two-bedroom residential unit.

• A short summary of the method could be added so as to give a quick overview before the start of its application;

• Items such as "escape routes" and "lightning rods" could be better detailed and explored because in this try-out, some fundamental qualitative issues could have gone unnoticed. An inattentive team could have ignored the fact that the escape route is complex, for instance. As to lightning rods, something similar happened because the existent lightning protection system was grounded, but many parts of it were at odds with regulatory guidelines.

5. Final Remarks

As already mentioned, the issue of rehabilitation of buildings is still an incipient one in Brazil and, although the research on the subject is enjoying an expansion phase, the professionals in charge of design, management, administration, and implementation of the production process do not have, in many cases, the adequate professional qualification to perform this kind of intervention. The rehabilitation actions, unlike the vast European experience, such as the work in progress in Portugal [18, 39], are dealt with in Brazil in the same fashion as new work, discarding or treating carelessly the diagnosis of the building to be rehabilitated. And this little professional experience in the subject of rehabilitation in the country also applies to the difficulties of separating it from the repairing process as well as its adequacy to the principles of low environmental impact, and therefore, of sustainability [40]. The potential for the building to be rehabilitated to meet the domestic contemporary needs is, many times, unknown and the applicability of design solutions is only checked while the work is already in progress.

The intention of the method presented here was to develop a tool that could assist the initial phase of the rehabilitation process, providing the design decisions with greater technical and scientific bases and also substantiating studies of economic and technical feasibility, however neither making the process more expensive nor extending the time length for its application. The principle of the expeditious evaluation was adopted, with the organization of a system that was quick, friendly to the user and offered an inexpensive implementation.

Due to the fact that this is a first approach, the diagnosis deriving from the application of the method may need, in some cases, the assistance of more complex procedures of confirmation of certain relevant factors. However, this diagnosis already demonstrates the level of habitability of the building evaluated, indicating the necessary actions for the improvement of its environmental conditions. In this sense, the method proposed here is similar to the European tool mentioned previously, but it is adapted to the Brazilian reality because it adopts as the ultimate paradigm in its indexes the NBR 15575 Standard [11] aiming at the regulation of quality standards in Brazilian dwellings.

It should be added that time needed for the application of the method demonstrates that the phase of preliminary studies will not contribute to the increase of time necessary for the implementation of the next phases. It remains to be mentioned that the application was carried out in an occupied building which created difficulties for the inspection of residential units. If the building had not been an occupied one, access to common areas and apartments would have been easier because permissions for entry from owners of autonomous units would not have been needed. This could have further reduced the total application time.

The carried out application shows that the form is comprehensible and feasible for use and the problems reported by the application team do not cripple the structure of the tool because, for the most part, they can be solved with simple alternatives, such as the introduction of a glossary of terms or a short summary so as to make the document easier to read.

Some aspects related to the framework suggested in this study should be discussed and analyzed. Initially, as mentioned before, even considering that the proposed method is valid for buildings with predefined functional and building characteristics and also a certain classification of rehabilitation proposal, its principles can be adapted to other categories of buildings and classifications of rehabilitations. There is, however, in this case, the need for the adaptation of the indexes and a new theoretical discussion about them.

It should be pointed out that the constant updating of parameters and indexes is a fundamental condition for the credibility of the results. It is also worth noting the possibility of expansion of the items that make up the method in order to enable the analysis of other parts of the building, such as to ascertain whether or not the facades are in good repair and the status of the waterproofing elements of common areas exposed to weather elements. However, the fundamental principle of the tool proposed here should not be forgotten which is to obtain an expeditious diagnosis that can substantiate design decisions and building actions, with the facilitation of evaluation methods in their application and, only if needed, more complex, additional procedures should be implemented.

Lastly, it should be pointed out that even if the result deriving from the application of the method shows a good potential for the rehabilitation of the building analyzed based on the standard indexes met, likewise the necessary services for the adoption of indexes should be informed. If the costs of these services are calculated and inserted into the method, the results can be expanded from a diagnosis to be used in the study of technical alternatives, to an evaluation method of the economic feasibility of the rehabilitation.

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