

Assessment method for buildings' rehabilitation needs. Development and application

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Abstract

The purpose of this study was to develop an assessment method of a building rehabilitation needs. It was considered that a building needs rehabilitation if it would not comply with the functional requirements defined in Portuguese legislation or determined by good practices of design and construction. The functional requirements considered were: safety requirements, health and comfort requirements and use adequacy requirements. Functional requirements may not be satisfied due to design problems, building defects, lack of maintenance or inappropriate use.

It was developed in the Portuguese National Laboratory for Civil Engineering (LNEC) the Assessment Method for Building Rehabilitation Needs (MANR). The following tasks were carried out: analysis of Portuguese and foreign assessment methods for buildings condition; definition of assessment criteria; selection of functional elements of dwellings and buildings; establishment of weighting coefficients for the functional elements; definition of results calculation formula; development of a computer tool; and carry out of a pilot test. After the development phase the method was used to assess a neighbourhood of about 2000 dwellings. This application was done with the support of LNEC, which included the following tasks: training courses to evaluators, accompanying the field work and supervising the results.

The results of this study were: a checklist to register the information obtained during inspections; instructions on how to conduct the inspection and fill in the checklist; a computer tool to record the checklists and suggest the rehabilitation needs in a three level scale (minor, medium or severe rehabilitation).

The main conclusions drawn from the study were: the method is applicable to different dwellings and buildings regardless of use, construction date or construction process; it can be applied by evaluators who receive a short training course; it delivers results that correctly convey the rehabilitation level

Keywords: Assessment method, Rehabilitation needs, Buildings, Pathology

1. Introduction

The management of housing stocks and the definition of rehabilitation policies should be supported on a thorough knowledge of the conservation status of buildings. Based on this information it is possible to set priorities and degrees of buildings' rehabilitation works.

In the beginning of 2007, the Portuguese Institute for Housing and Urban Rehabilitation (IHRU) requested the collaboration of the National Laboratory for Civil Engineering (LNEC) in the analysis of housing conditions on the *Bairro do Alto da Cova da Moura* to define guidelines for a possible future urban rehabilitation. *Bairro do Alto da Cova da Moura* (BACM) is a district that belongs to a city in the metropolitan area of Lisbon. The urban fabric has a development process of illegal origin, started in the 60s of the 20th century, with strong growth from the mid-70. The district occupies an area of about 16.5 ha, with approximately 5,000 inhabitants.

In response to the request an *Assessment Method for Building's Rehabilitation Needs* (MANR) was developed in LNEC.

MANR is a multicriteria assessment method that pretends to establish a set of procedures to determine with accuracy, objectivity and transparency a building's rehabilitation needs to ensure the satisfaction of functional requirements at a level not less than that stated in applicable Portuguese legislation (Diário da República 1951, 1984, 1990, 1997, 1999) or determined by good practices of design and construction.

Functional requirements may not be satisfied due to design problems, building defects, lack of maintenance, inappropriate use or deficient insertion in the urban fabric. The functional requirements analysed are:

- *Safety requirements* – issues related to conditions that ensure the physical protection and on the psychological distress, and provide comfort and trust (structural safety, fire safety, normal use safety and intrusion / attack / theft security);
- *Hygiene, health and comfort requirements* – conditions ensuring hygiene, health and comfort of users (health, air quality, protection from moisture / leakage, protection against noise, visual comfort and thermal performance and energy efficiency);
- *Use adequacy requirements* – aspects related to the existence of spaces with areas, dimensions, equipment and relationships which enhance the efficiency of use, individual identity and social interaction (space and equipment, privacy and accessibility).

So, for the assessment is considered that the satisfaction of functional requirements can be compromised by constructive defects and / or spatial defects. Constructive defects may result from inadequate initial constructive solution, poor execution of construction work, and / or degradation of building elements. Spatial defects may result from an inadequate initial partitioning solution, or modification on the unit partitioning. The assessment method should allow obtaining a result which combines the rehabilitation interventions needed to correct both kinds of defects.

Because the assessment method implies the verification of both constructive defects and spatial defects, MANR was developed to be implemented by teams of two technicians with complementary skills, a civil engineer and an architect, and with specific training on MANR.

In this papers is described the research methodology, the assessment method, an application of the method, and finally some conclusions are drawn.

2. Research methodology

The development of MANR took advantage on the experience gained at LNEC in the development of assessment methods (Pedro 2006, Vilhena 2007, Pedro 2008a). However, the specific type of building, illegal construction, and the type of results needed demanded changes in the methods already developed.

An analysis of Portuguese and foreign assessment methods for buildings condition was carried out. A first proposal of the method was developed and discussed with several construction and planning experts in order to define limitations and assessment criteria.

Surveys were carried out to different kinds of buildings and units in order to test and validate the method.

3. Assessment method

3.1 Assessment procedure

The assessment is based on a visual inspection of the buildings including where it is possible, visual inspection of all units and shared parts (where such exist). During the survey all the information gathered is registered in checklist according to the criteria defined in the application instructions developed for this purpose (Pedro 2008b).

During the survey, each building is assessed in two different ways: first considered as isolated in the urban fabric; and then how it relates to other buildings, which are contiguous and nearby.

In the assessment of the building considered isolated are verified the defects in the different constituent functional element (e.g. lack of structural resistance for applied charges); the result is expressed by the *Level of Rehabilitation Needs*. This concept refers to the relation between the rehabilitation works needed for maintaining the type and use of spaces and correct the defects found and the construction of a new building with the same capacity and functionality. This indicator may also be used to determine the buildings' rehabilitation and maintenance feasibility.

The assessment of the interrelation between buildings comprises the analysis of problems that may arise from the building's urban insertion, in ways that can hardly be verified by use of the existing mapping (e.g. too much closeness between buildings can affect the natural lighting in main rooms); the result is expressed by the “*Level of defects in the interrelation with other buildings*”.

3.2 Assessment criteria

3.2.1 Level of rehabilitation needs

In order to ensure a rigorous, objective and independent assessment of the building, the survey is divided into the assessment of: (i) the constructive and functional elements; (ii) and the spaces belonging to each building.

In the assessment of the constructive aspects each functional element is assessed in three different factors: *severity* of the defect, *extent* and *complexity* of the intervention. For each functional element the assessment begins by determining the existence of defects and classifying their severity in a four point scale according with the criteria presented in Table 1.

Table 1: Rules for assessing the severity of the construction defects

<i>Very slight</i>	<i>Minor</i>	<i>Medium</i>	<i>Severe</i>
<i>Absence of defects or defects with no expression</i>	<i>Defects prejudicial to aesthetics</i>	<i>Defects prejudicial to use or comfort</i>	<i>Defects that endanger health or safety</i>

If the defects found are minor, medium or severe defects the extension and the complexity of the intervention needed to repair them should be defined. The “extent of the rehabilitation works” is assessed in four categories, taking into account the work that is considered necessary to repair the defects identified (Table 2).

The “complexity of the rehabilitation works” is a concept that pretends to take into account the difficulties of carrying out the rehabilitation in conjunction with the comparison of the cost of this operation of building a new element. The complexity is assessed in three categories as shown in Table 3.

Table 2: Rules for assessing the extent of the intervention

<i>Located</i>	<i>Medium</i>	<i>Extent</i>	<i>Total</i>
<i>Occasional defects affecting the functional element, and its extension not exceeding 25% of the total area</i>	<i>Anomalies affecting limited areas of the functional element, and with extension between 26% and 50% of the total area</i>	<i>Defects affecting large areas of the functional element, and with extension between 51% and 75% of the total area</i>	<i>Anomalies affecting all or almost all of the functional element, and with extension beyond 75% of the total area</i>

Table 3: Rules for assessing the complexity of the intervention

<i>Simple</i>	<i>Medium</i>	<i>Difficult</i>
<i>Work done in a single operation and with the involvement of only one specialty</i> <i>Cleaning, painting or surface rehabilitation of building elements</i> <i>Work requiring the demolition or removal of functional part, without the subsequent reconstruction</i>	<i>Works carried out in several operations which require the intervention of different specialties</i> <i>Jobs that require the demolition or removal of coatings to allow the intervention and subsequent reconstruction</i>	<i>Technically complex works, requiring the application of non-current procedures, materials and / or technologies</i> <i>Works for a functional element required to meet the functional requirements</i> <i>Demolition or removal of a functional element, and subsequent reconstruction</i>
<i>Works with a cost far less than building new functional element</i>	<i>Works with a lower cost than building a new functional element</i>	<i>Works with a similar or greater cost than a new functional element</i>

The assessment of spatial aspects was divided into two factors: *severity* and *feasibility* of the intervention. Initially the defect severity is assessed on a scale equal to that used for the functional elements defects, but according to the rules defined in applicable legislation and in minimum thresholds, essentially dimensional, below which it was considered that the health and safety are severely compromised (Table 4).

Table 4: Rules for assessing the severity of the spatial defects

<i>Very slight</i>	<i>Minor</i>	<i>Medium</i>	<i>Severe</i>
<i>Satisfies the general legislation in force</i>	<i>Does not satisfy the general legislation in force</i>	<i>Does not satisfy the requirements of specific regulations for illegal buildings</i>	<i>Does not satisfy an absolute minimum, compromising the health and safety of persons</i>

If a spatial defect is classified as “Medium” or “Severe” is necessary to define which functional elements must be intervened to repair the defect, indicating for each one the extent and the

complexity of the intervention. These interventions are additional to those needed to repair constructive defects.

After the definition of the interventions needed in the different functional elements of the building to repair spatial defects, should be pointed out the feasibility of the intervention in the following scale of complexity: “in the building”, “in the building lot”, “in the premises of other buildings”, “in contiguous lots” “in the public road”.

It should be noted that:

- 1) When a functional element or building space has defects with different severity levels should be indicated the most serious;
- 2) The assessment of the defect severity is done taking into account the level of expected performance for the functional requirements of each space and / or construction element (e.g. a compartment used for storage or a garage have lower thermal comfort requirements than bedrooms, living rooms or kitchens).

The *Level of rehabilitation needs* is defined in three categories: *Slight*, *Medium* and *Severe*. It should be noted that although the *Level of rehabilitation needs* may be calculated by applying a formula (see 3.3), but the surveyors training and experience is essential in all this process and the final result is defined by them according to the criteria presented in Table 5.

Table 5: Criteria for assessing the level of rehabilitation needs

<i>Slight rehabilitation</i>	<i>Medium rehabilitation</i>	<i>Severe rehabilitation</i>
<i>Includes:</i> - Execution of coatings repairs; - Minor repairs on building's premises; - Localized repairs and of reduced complexity in the primary and / or secondary elements.	<i>Includes:</i> - Replacement of coatings; - Repair and creation of new facilities; - Localized repair, replacement or reinforcement of primary and / or secondary constructive elements.	<i>Includes:</i> - Repair, replacement or reinforcement of primary and / or secondary constructive elements.

3.2.2 Level of defect in the interrelation with other buildings

The analysis of how each building interrelates to the surrounding buildings results in the *Level of defect in the interrelation with other buildings*. To obtain this level five different aspects that could not be easily verified by use of existing mapping are assessed:

The aspects assessed are: (i) existence of parts of contiguous buildings above or under the building assessed; (ii) distance between façade openings of the assessed building and façade openings of other near buildings; (iii) distance between the building's roof (when it does not has

fire resistance) and façade openings in surrounding buildings; (iv) existence of façade openings of the building assessed on the edge of an adjacent lot; and (v) obstacle-free distance in façade openings of main rooms.

These aspects took into account functional requirements for safety, with particular emphasis on fire safety, intrusion security, and health. The assessment of each of these aspects is carried out at the four level scale adopted for the severity of the defects (Table 1). The result of the *Level of defect in the interrelation between buildings* for each building is expressed by the level of more serious defect obtained.

3.3 Calculation formula

The *Rehabilitation level* is determined in accordance with the procedure described below.

- The extent and complexity of the intervention needed due to constructive defects and/or spatial defects are converted to values for each functional element (Table 6).

Table 6: Conversion values of the extent and complexity of the intervention

<i>Extent</i>	<i>Located (0,25)</i>	<i>Medium (0,50)</i>	<i>Extended (0,75)</i>	<i>Total (1,00)</i>
<i>Complexity</i>	<i>Simple (0,4)</i>	<i>Medium (0,8)</i>	<i>Difficult (1,2)</i>	

- For each functional element are calculated separately, the values of rehabilitation needs for constructive defects (Ic) and spatial defects (If), multiplied by the respective values of extension (Ei) and complexity (Ci) of intervention.
- The score (Pt) of each functional element is determined by the product between the weighting coefficients (Pd) assigned to each functional element and the sum of the rates of rehabilitation motivated by constructive defects (Ic) and spatial anomalies (If). The sum of the values of rehabilitation needs (Ic + If) has the maximum value of 1.2.
- The sum of the weights (ΣPd) is the sum of all weights of the functional elements verified. The sum of the scores (ΣPt) is the sum of the scores (Pt) of the different functional elements. The “Index of the rehabilitation needs” (Inr) is obtained by the quotient between the sum of scores (ΣPt) and the sum of the weights (ΣPd) multiplied by 100.

The weights used were defined using the cost structure of construction of new single-family and multifamily housing buildings with 3 to 4 floors as reference, with some adaptations to allow the definition of weights for all functional elements considered.

Partial rehabilitation needs indexes are calculated separately for “Structure, Roof and Protruding elements”; “Other shared parts”, and each “Unit”. In the calculation of the index of rehabilitation needs of the all building (*Inr*) is considered that the partial index for “Structure, Roof and Protruding elements” represent 30% and the remaining values represent 70%. The values for “Other shared parts” and for each “Unit” are weighted taking into consideration the respective floor area.

The *Level of Rehabilitation Needs* of the building is determined by classifying *Inr* according to the scale shown in Table 7.

Table 7: Scale of classification for the Level of Rehabilitation Needs

<i>Index</i>	$0 \geq Inr \geq 33$	$33 > Inr \geq 66$	$66 > Inr \geq 120$
<i>Level</i>	<i>Slight rehabilitation</i>	<i>Medium rehabilitation</i>	<i>Severe rehabilitation</i>

3.4 Application tools

For the implementation of MANR three different tools were developed: an assessment form for rehabilitation needs (FANR); application instructions and a computer tool. These tools were developed with the participation of different researchers and experts from the Buildings Department of LNEC.

The FANR (Figure 1) is a checklist used to register all the information gathered by the technicians during the survey, and has three different sheets:

- the first sheet contains the identification of the building, and indicates the level of rehabilitation needs that results from the assessment and provides the constructive characterization of the building;
- the second sheet is used to characterize the building and make an assessment of the functional elements that constitute the shared parts;
- the third sheet is used to characterize the unit surveyed and make an assessment of the functional elements that constitute it; this sheet is repeated for each unit existing in the building.

The aim of the instructions is to ensure that the different survey teams apply the assessment method correctly and thus attain consistency in the results. This document includes the presentation of the method with its purpose and survey procedure; a description of the assessment criteria; a list of frequent defects for each constructive element classified according to level; and the explanation rules for determining the level of rehabilitation.

The computer tool is a spreadsheet, with a look at all similar to the assessment form, used to record the checklists data and suggest the Level of rehabilitation needs in a three level scale.

ANÁLISE DAS CONDIÇÕES DE HABITABILIDADE EXISTENTE NO MANTO DO ALTO DA COLINA NOVA - UNIC - IIRRU
FICHA DE AVALIAÇÃO DAS NECESSIDADES DE REABILITAÇÃO

A. IDENTIFICAÇÃO

B. OBSERVAÇÕES

C. REABILITAÇÃO

D. REABILITAÇÃO

E. REABILITAÇÃO

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Figure 1: MANR’s checklist – first sheet (a), building shared parts assessment (b) and unit assessment (c)

4. Application

MANR was used to determine the rehabilitation needs of the buildings of BACM. BACM was divided into 61 blocks (Figure 2), according to the 2003 geographical map provided by the city council.

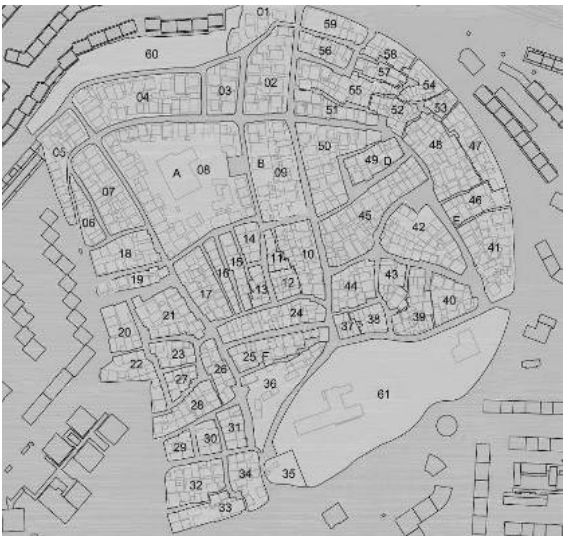


Figure 2: Blocks division of BACM

The survey lasted six months and MANR was applied to 833 buildings and 1884 units. It allowed characterizing BACM's buildings at construction and use levels and identifying the main functional elements with defects.

The use of a GIS tool in conjunction with the database built with data from the survey allowed for mapping the different parameters (e.g. building uses - Figure 3 -, main defects, severity of defects).



Figure 3: Dwellings

As a final result was drawn in each block the percentage of building with different levels of rehabilitation needs (Figure 4).

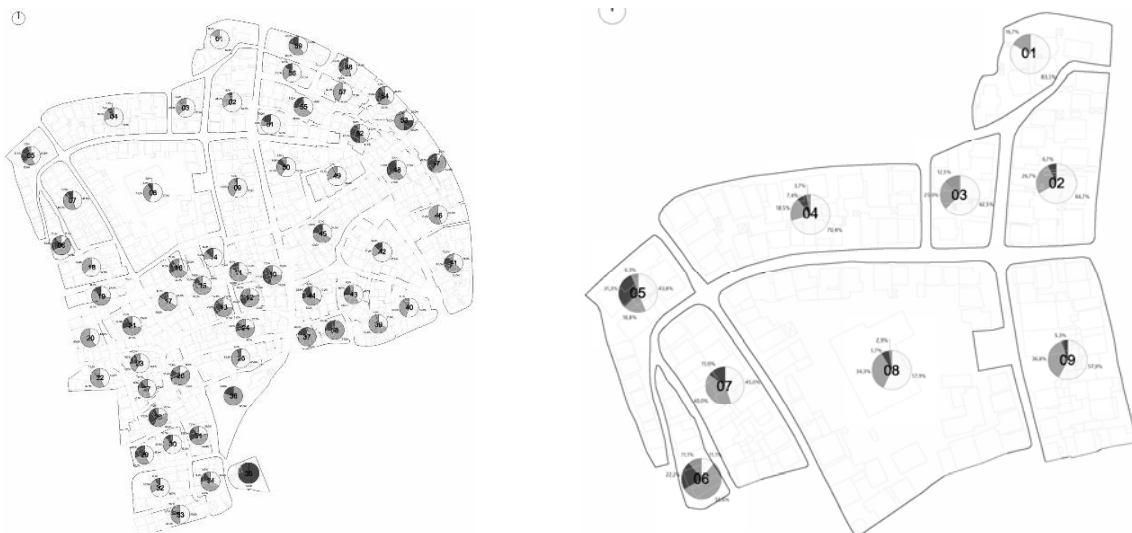


Figure 4: Example of distribution of buildings with different rehabilitation needs

5. Discussion

The assessment criteria appear to be suitable for the type of the existing building in the BACM and the proposed objectives for the survey.

MANR allowed a great assessment criteria uniformity among the different teams involved in the survey.

The division in the different functional elements allowed a thorough survey of the buildings and the recording of the main existing defects.

The main difficulty felt by the survey teams to determine which functional elements should be intervened to correct the spatial defects. This difficulty was quickly overtaken after the training courses and some practice.

Despite the favourable evaluation, attention needs to be drawn to the limitations of the assessment method. Thus, the rehabilitation needs are defined based on a visual inspection of the defects of the building and the units that constitute it at a certain time. Hence, it should be noted that:

- a) the assessment takes into account the conditions at the time of the survey, assuming that those conditions can change in a short period of time;
- b) the assessment is not a guarantee of maintaining the conservation status of any item verified;
- c) the survey does not ensure that all existing defects in the building and units have been detected, assuming that there might be some defects that are hidden or do not show any visible sign;
- d) the assessment does not guarantee all the minimum conditions of safety, comfort, use, or aesthetics, since the assessment focuses on the building's functional elements, and the insertion on the urban fabric is assessed only regarding aspects unlikely to verify on existing maps;
- e) the assessment of rehabilitation needs of the building does not replace the building's legalization process to be undertaken by competent authorities;
- f) tools and procedures were established to enable accurate and rigorous application. However, the quality of the results depends heavily on the competence of the surveyor team. Hence, the special training course is important to achieve the desired assessment objectives.

Acknowledgement

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References

Diário da República (1951) “Decreto-Lei n. 38 382”, 7 August 1951, Lisboa, Imprensa Nacional.

Diário da República (1984) “Portaria n. 243/84”, 17 April 1984, Série I, 91/84 : 1260, (available online <http://dre.pt/pdf1sdip/1984/04/09100/12601260.pdf> [accessed 2010-01-29]).

Diário da República (1990) “Decreto-Lei n. 64/90”, 21 February 1990, Série I, 44/90: 722-738, (available online <http://dre.pt/pdf1sdip/1990/02/04400/07220738.pdf> [accessed 2010-01-29]).

Diário da República (1997) “Portaria n. 1063/97”, 21 October 1997, Série I-B, 244/97; 5689-5694, (available online <http://dre.pt/pdf1sdip/1997/10/244B00/56895694.pdf> [accessed 2010-01-29]).

Diário da República (1999) “Decreto-Lei n. 368/99. 18 September 1999, Série I-A, 219/99; 6470-6480, (available online <http://dre.pt/pdf1sdip/1999/09/219A00/64706480.pdf> [accessed 2010-01-29]).

Pedro, J. Branco et al. (2006) “Proposta de uma metodologia de certificação das condições mínimas de habitabilidade.” *Report n. 397/2006 – DED/NAU*, Lisboa, LNEC.

Pedro, J. Branco et al. (2008a) “Portuguese method for building condition assessment.” *Structural Survey Journal*. Emerald Group Publishing Limited, Vol. 26, 4: 322-335.

Pedro, J. Branco et al. (2008b) “Colaboração do LNEC na análise das condições de habitabilidade do edificado no Bairro do Alto da Cova da Moura. Método de avaliação das necessidades de reabilitação. Conceção, aplicação experimental e formação de técnicos avaliadores.” *Confidential report n. 267/2008 – DED/NAU*, Lisboa, LNEC.

Vilhena, A. et al. (2007) “Apoio do LNEC na reavaliação do estado de conservação dos imóveis da fundação D. Pedro IV.” *Report n. 251/2007-DED/NAU*, Lisboa, LNEC.