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Main Functional Elements Having Defects of Illegal Residential Buildings: The Case of Cova da Moura District

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ABSTRACT

The purpose of the paper is to describe the main functional elements with defects in illegal residential buildings. Three research questions are addressed: What are the main functional elements with defects in buildings and in dwellings? What are the main defects found? In which way these defects affect the use of buildings?

The defects were identified during a survey to the building stock of the Cova da Moura District (Amadora, Portugal), carried out in 2008. This district is made of illegal constructions, occupies an area of 16.5 ha and has approximately 5,000 inhabitants. During the survey 833 buildings and 1884 units were inspected.

The main results are: a) only 13% of these building presented defects in the building structure; b) about 60% of the buildings have defects in the roofing systems (e.g., damp and mould, infiltrations); c) more than 84% of the dwellings have defects in the technical installation such as gas or electrical installations most of them classified as severe defects.

The main conclusion is that most of the defects detected configure serious risk scenarios, particularly in terms of the minimum habitability conditions and fire safety. However, defects related to structural stability were not as serious as expected for this kind of construction.

KEYWORDS

Illegal buildings, Functional elements, Defects, Building pathology, Portugal.

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1 INTRODUCTION

In the beginning of 2007, within the Portuguese governmental initiative *Critical Neighbourhoods*, a plan for qualification and rehabilitation of urban areas, the Portuguese Institute for Housing and Urban Rehabilitation (IHRU) requested the cooperation of the National Laboratory for Civil Engineering (LNEC) in the analysis of the condition of housing for those buildings located in the BACM neighbourhood (Bairro do Alto da Cova da Moura) to assess the feasibility of future urban rehabilitation. The BACM neighbourhood is a district located within Amadora, a city within the metropolitan area of Lisbon. The district is, in fact, an illegal urban development that started in the 1960s, with strong growth from the mid-1970s.

In response to this request a study entitled *Analysis of housing conditions of the existing buildings in the Bairro do Alto da Cova da Moura* was developed under the coordination of A. Baptista Coelho (Arch.). This study had three different phases [Coelho 2008; Vilhena & Coelho 2008]:

- (i) First phase: a local analysis was conducted to update and provide details of the existing cartographic support, and an assessment method to determine the buildings rehabilitation needs was also developed;
- (ii) During the second phase an experimental application of the assessment method was carried out, training was provided to inspectors involved in the survey and the fieldwork was conducted;
- (iii) In the third and final phase the results obtained in field work were interpreted and conclusions were drawn.

Over the last few years the LNEC has gained extensive experience in building condition assessment methods and the work published by Pedro *et al.* [2006a; 2006b; 2008] and Vilhena *et al.* [2007] attest to these ongoing developments in this domain... However, the specific type of buildings to be surveyed (*i.e.*, illegal construction) and the type of results required a new approach and methods.

The assessment method developed in the first phase, *Assessment Method for Building's Rehabilitation Needs* (MANR), is a multi-criteria method that pretends to establish a set of procedures to determine with accuracy, objectivity and transparency the rehabilitation needs for the building as a whole, regardless the number of units that compose it or the type of activity developed in them [Vilhena *et al.* 2010].

To achieve those objectives, it is considered that there are rehabilitation needs when the living conditions are compromised. This occurs whenever the functional requirements applicable to that type of buildings are not satisfied, in particular due to the existence of building defects, whether they are constructive defects or spatial defects (spatial defects are defects resulting from defective design of the building spaces).

The assessment was based on a visual inspection of the buildings, including all units and shared parts (where such existed). The survey was carried out by technicians of the IHRU with support of the LNEC. Initially 14 technicians of IHRU were involved in the survey, but during the work it was required to increase this number. All technicians that carried out inspections had specific training on the use of the MANR. Since the method helps verify both constructive and spatial defects, inspections were done by teams of two technicians, a civil engineer and an architect. Some inspections were done by teams of two architects, due to lack of civil engineers.

When assessing the constructive aspects, each functional element in which the building was disaggregated was assessed on the basis of three different factors, recorded sequentially: *severity* of the defect, *extent* and *complexity* of the intervention. For each functional element the assessment begins by determining the existence of defects, classified according to their severity from four categories of scale: *very slight, minor, medium* or *severe*. If the defects found were minor, medium or

severe, the extent and complexity of the intervention needed to complete the repair work were determined. The extent of the repair work took into account the amount of work required, and was assessed in four categories of scale: *localised*, *medium*, *extensive* or *total*. The complexity of the repair work took into account the usual difficulties for carrying out the work, and was assessed on three categories of scale: *simple*, *medium*, *difficult*. The assessment method was presented in more detail in a previous paper [Vilhena *et al.* 2010].

In this paper the BACM is described, as are the primary building defects detected from the survey, and finally, some conclusions are drawn from the overall effort. Lightning

2 MAIN CONSTRUCTIVE DEFECTS

2.1 BACM district

MANR was used to determine the rehabilitation needs of buildings located within the BACM. The BACM was divided into 61 blocks, according to the 2003 geographical map provided by the city council. The survey lasted six months and MANR was applied to 833 buildings and 1884 units. Of the total number of units, 1617 units had residential use (i.e. dwellings) and the remaining 267 had other uses (e.g., shop, warehouse, industry, indoor parking) [Vilhena & Coelho 2008].

The large sample size allowed characterizing BACM's buildings at construction and use levels and identifying the main functional elements with defects. The BACM is characterized by small blocks of buildings with varied compositions generally with few units. There is a similar distribution of buildings with 33% of buildings being single units, 32% with 2 units or 34% with 3 to 6 units; a few buildings were also found with more than 6 units (1%). The verification and analysis of defects were carried out considering for each building different building elements, coverings and equipments either in its existing common parts, or in each of its units.

Being of illegal origin, the buildings in BACM have been built without any design project or observation of rules or applicable legislation; their construction was simply based on the knowledge that the owners themselves had of building construction. This fact, along with the lack of maintenance and repair works has led to a large spectrum of defects to various functional elements, with different degrees and extent of severity that in some instances has led to situations of serious health and safety risk to their users.

2.2 Defects in buildings' common parts

The overall assessment of the buildings and of their respective common parts was carried out considering the following division in functional elements:

- E.1 | Structure
- E.2 | Roof
- E.3 | Salient elements
- E.4 | Walls
- E.5 | Floor coverings
- E.6 | Ceilings
- E.7 | Stairs
- E.8 | Doors and windows
- E.9 | Fall protection devices
- E.10 | Water distribution installation
- E.11 | Sewer installation
- E.12 | Electrical and lighting installation
- E.13 | Telecommunications and intrusion safety
- E.14 | Fire safety installation

Some functional elements presented defects in more than 50% of the buildings, namely: Roof (*e.g.*, lack of water tightness, lack of thermal insulation layer); External walls (*e.g.*, walls without any covering); Stairs (*e.g.*, severely degraded structure and steps unfinished or uncovered showing major deformation); Fall protection devices (*e.g.*, lack of any device). In the majority of the functional

elements the gravity of the defects observed was classified as 'Medium' or 'Severe' (Fig. 1), setting up situations where the use of spaces as well as comfort, safety and health of users are affected.

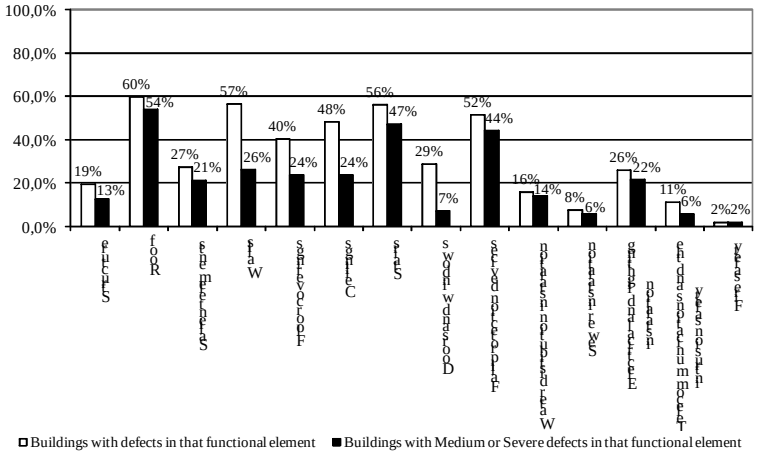

Figure 1. Distribution of defects in the functional elements by gravity.

It should also be noted in a large percentage of cases where the defects occur most elements need extensive or total repairs (Fig. 2). This fact, along with the complexity (Fig. 3) and cost of the rehabilitation intervention, shows that even in functional elements that have low defects rates, such as *Structure* (19%), the extension and the complexity of the intervention must be taken into account.

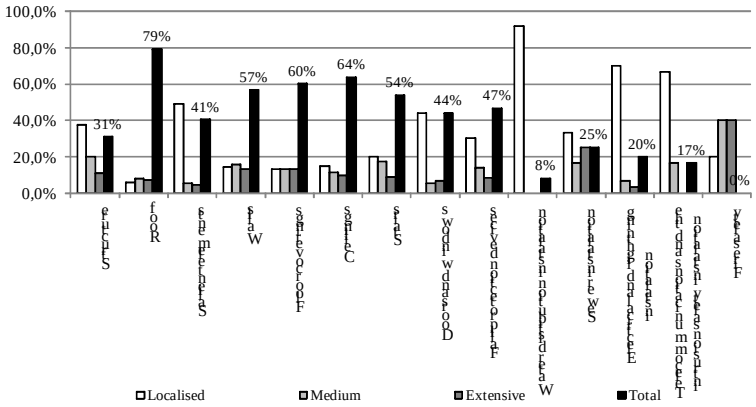

Figure 2. Distribution of defects in the functional elements by extension of the intervention.

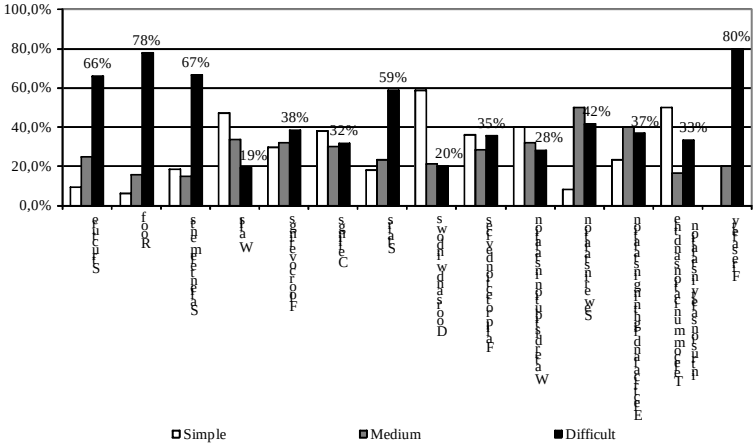

Figure 3. Distribution of defects in the functional elements by complexity of the intervention.

In the case of the functional element *Structure*, although the results of occurrence of defects show a reasonable maintenance condition of structures, building structures with damaged elements (Fig. 4) or lack of mechanical resistance were found. It is recalled that the survey was done by means of visual inspections, registering only the visible defects through evidences either in structural elements or other elements that could be affected by the structure, like walls.

Roof is the functional element that contains defects in a larger number of buildings. This fact is associated with a high rate of cases requiring total assistance, or complete replacement of the existing system. Being an element of the building envelope it is a constructive element with great impact in the living conditions, contributing to the occurrence of many defects in other functional elements (*e.g.*, walls, ceilings, electrical installation). Many of the observed defects are often due to lack of completion in case of flat roofs (Fig. 5), poor construction quality, particularly in pitched roofs, and lack of maintenance and repair works. In the functional element *Stairs*, it was observed stairs are frequently built in places with very small areas, and are often unfinished (Fig. 6); many of them present serious defects both at constructive and dimensional level.

Figure 4. Column with detached concrete covering and insufficient transverse reinforcement.

Figure 5. General appearance of a flat roof, without thermal insulation, waterproofing or any coating.

Figure 6. Stairs of poor construction quality.

The occurrence of defects in the functional element *Fall protection devices* presents very high values (52%). Most of these defects are related to lack of railings to ensure this function in areas where they would be compulsory due to the risk of a fall hazard to users.

2.3 Defects in building units

As performed in the buildings' common parts, the units' survey was done by inspecting the following 20 different functional elements.

- U.1 | External walls
- U.2 | Internal walls
- U.3 | External floor coverings
- U.4 | Internal floor coverings
- U.5 | Ceilings
- U.6 | Stairs
- U.7 | External joinery
- U.8 | Internal joinery
- U.9 | Shutters and blinds
- U.10 | Fall protection devices
- U.11 | Sanitary ware
- U.12 | Kitchen equipment
- U.13 | Water distribution installation
- U.14 | Sewerage installation
- U.15 | Gas installation
- U.16 | Electrical and lighting installation
- U.17 | Telecommunications and intrusion safety
- U.18 | Ventilation system
- U.19 | HVAC system
- U.20 | Fire safety installation

A large number of defects were found in the different functional elements. In more than 50% of the units it was possible to find defects in the following functional elements (Fig. 7): External walls; Internal walls; Ceilings; Gas installation; Electrical and lighting installation; and Ventilation system. In some of these elements (e.g., Stairs, fall protection devices, kitchen equipment, gas installation, electrical and lightning installation, ventilation system), most defects are of 'Medium' or 'Severe' gravity (Fig. 7), with serious consequences to users' comfort or health and safety.

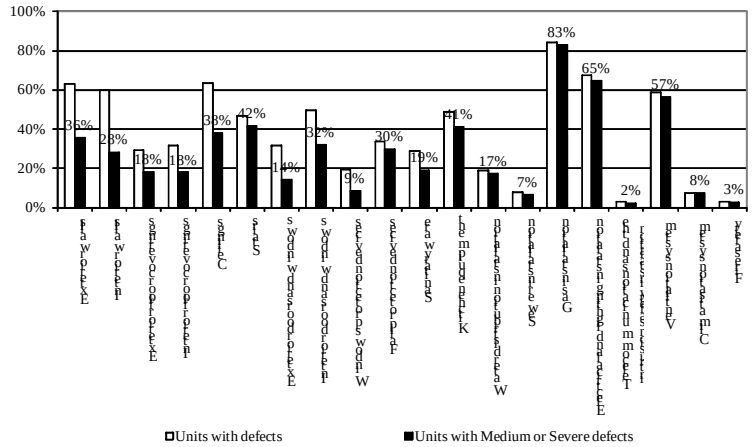

Figure 7. Distribution of defects in functional elements by gravity (units).

Taking into account the extent (Fig. 8) and complexity (Fig. 9) of the rehabilitation works needed, that there are more functional elements requiring attention than those mentioned, like the water distribution installations or the sewer installations, that present serious need for rehabilitation. A good portion of the dwellings had no kitchen equipment or a defined space for preparing meals, the usual being to use a makeshift space for this purpose.

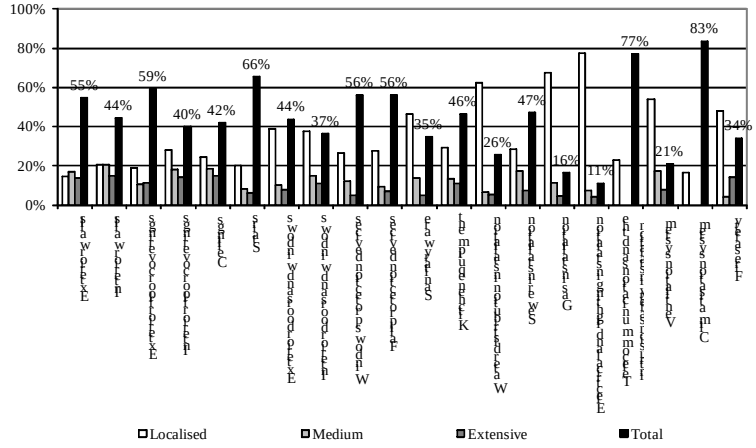

Figure 8. Distribution of defects in functional elements by extent (units).

It was also frequent to find severe defects in the electrical and lightning installation. The main defects found in this functional element included: dwellings without any installation; elements under tension installed in wet areas or in direct contact with water; electric cables under tension accessible to people.

There were serious situations detected in relation to gas installations. In fact, about 83% of the units presented defects classified as 'Medium' or 'Severe'. The most common defects detected, and that stand out for being a hazard for the use of space, are the existence of out of date rubber gas hoses or hoses with very long lengths; gas cylinders installed in unventilated cupboards; absent flue pipes connecting to combustion appliances or pipes with negative slope.

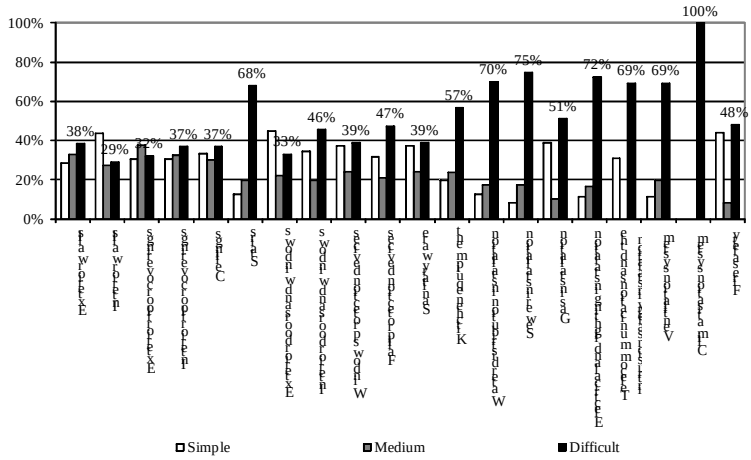

Figure 9. Distribution of defects in functional elements by complexity (units).

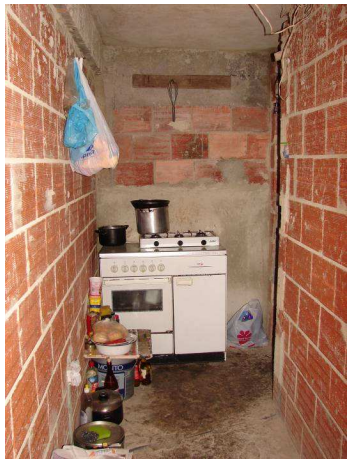

Figure 10. Improvised kitchen.

Many units presented serious health risks due to defects in external walls, ventilation system and/or roof. Most external walls are single brick masonry walls of 0.11 to 0.15 m of thickness, and that does not ensure appropriate water tightness or thermal insulation. Such construction practices allowed condensation problems to appear and the subsequent and rapid development of mould in interior finishes. In addition, it was common to find poor ventilation systems (natural or mechanical) and lack of roof watertightness, which gave rise to high relative humidity environments in the enclosed spaces. Regarding the "ventilation system" it was often found the absence of smoke gathering over the stove or even any extraction system of the products of combustion of the stove to the exterior.

3. FINAL REMARKS

The survey of the maintenance condition of the buildings in the Bairro Alto da Cova da Moura (BACM) was performed using an assessment methodology developed specifically for this purpose (MANR); this methodology intended to define the rehabilitation needs of the buildings in an objective, rigorous and independent way. The methodology implementation was carried out by teams of experts with experience in construction and with specific training in the assessment method. Along with these factors, the survey covered all buildings of BACM, allowing a very reliable picture of the maintenance condition of the buildings and units.

It was found that buildings, though built in a self-construction regimen without any design, do not present serious structural defects, in contradiction with what would be expected. In the external

envelope of buildings, the most affected functional element was the roof that showed defects in 60% of buildings. In many units the functional elements had defects with particular relevance to the electrical and gas installations that in most cases made up a hazard to the safety and health of users.

It should be remembered that this survey was based on visual inspections and it is possible that not all existing anomalies were detected.

The level of regulatory building performance is set in the context of the prevailing cultural, social, climatic, economic and technological conditions in a particular society. The general Portuguese building legislation is geared to construction of new housing. However these buildings fail to fulfil even the basic requirements set out in specific regulations for the regularization of illegal buildings. Therefore, the units that did not meet these basic requirements must be either demolished or made fit to live in.

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REFERENCES

Coelho, A. B. 2008, *Análise das Condições de Habitabilidade do Edificado Existente no Bairro do Alto da Cova da Moura – Organização geral do estudo e pré-análise*, LNEC, Report no. 247/2008 – NAU, Lisboa .

Pedro, J. B., Aguiar, J. & Paiva, J. V. 2006a, *Proposta de uma metodologia de certificação das condições mínimas de habitabilidade*, LNEC, Report no. 397/2006 – DED/NAU, Lisboa.

Pedro, J. B., Paiva, J. V., Raposo, S. & Vilhena, A. 2006b, *Proposta de um método de avaliação do estado de conservação de edifícios: Discussão e aplicação experimental*, LNEC, Report no. 185/2006 – DED/NAU, Lisboa.

Pedro, J. B., Paiva, J. V. & Vilhena, A. 2008, Portuguese method for building condition assessment, *Structural Survey*, 26[4], 322-335.

Vilhena, A., Pedro, J. B. & Paiva, J. V. 2007, *Apoio do LNEC na reavaliação do estado de conservação dos imóveis da fundação D. Pedro IV*, LNEC, Report no. 251/2007 – DED/NAU, Lisboa.

Vilhena, A. & Coelho, A. B. 2008, *Colaboração do LNEC na análise das condições de habitabilidade do edificado no Bairro do Alto da Cova da Moura. Avaliação das necessidades de reabilitação do edificado. Relatório de síntese*, LNEC, Relatório n.º 266/2008-DED/NAU, Lisboa, Novembro.

Vilhena, A., Pedro, J. B. & Paiva, J. V. 2010, 'Assessment method for buildings' rehabilitation needs. Development and application', Proc. '*CIB World Congress 2010 – Building a Better World*', The Lowry, Salford Quays, United Kingdom, 10-13 May 2010, pp. 99.