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ICT Method for Evaluation of Heritage Buildings Conservation

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Abstract

Historical buildings, such as vernacular architecture typologies, have been threatened by the vulnerability to their status degradation. This problem is not an exception in Portugal, where the few remaining examples of wooden stilt-houses, along Tagus river banks, have been neglected, with the disappearance or abandonment of almost all buildings, weakening the European cultural map. In Europe has been observed a growing concern in order to develop methods, tools and instruments for the management of current buildings stock, especially focused on housing, in order to improve their performances. However, these methods are don't fit in the features of traditional buildings such as wooden houses of vernacular architecture. In this sense, this research presents the detailed methodology used for the creation of an ICT (information and communication technology) method, especially designed for the evaluation of status of historical buildings conservation. It is focused on the explanation of its two main tools: the diagnosis record and the software. The results are an exhaustive survey of buildings features, useful as guideline for spatial planning strategies and instruments to protect this legacy. The proposed ICT method can be used in other similar buildings, and therefore to define best rehabilitation actions.

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Keywords: ICT method; Diagnosis record; Software; Historical Buildings; Heritage conservation;

1. Introduction

Europe observes a growing concern in developing tools for effective management of buildings stock, in order to improve their physical, energetic, economic or social performances. But, these methods are focused on current buildings, especially housing, not suitable for the features of vernacular heritage. Thus, this article presents an ICT method for evaluation of historical houses conservation, which is a database making all calculations automatically,

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showing as results the outlook of houses performance. It is based on visual inspection as a fast and low-cost procedure, and was checked in 89 stilt-houses of Tagus river banks in Portugal. However, the main goal is to describe the methodology of this method design, rather than to the results of its application.

2. ICT method for evaluation of status of historical buildings conservation

2.1. Evaluation method

The evaluation method, which is centred on the assignment of a qualitative level of building degradation considering its constructive elements, was validated based on previously defined parameters. The score of each element is subject to defined weightings according to their importance in building performance, and to other constructive elements. This methodology allows a greater efficiency in its element range as a whole, a further guidance on how to proceed in the analysis, and in obtaining partial (about an element or group of elements) and global results (about the building as a whole). Thus, the method intends to assess the existence of anomalies in the constructive elements and define their severities. The constructive elements to be assessed concerning wooden stilt-houses, comprise five groups: structural condition (EA), non-structural walls type (EB), coverings and finishes types (EC), pans (doors or windows) (ED), and other elements (EE) such as chimneys, gutters or stairs protection [1].

2.2. Evaluation criterion

The proposed criterion for evaluating each constructive element is the severity of anomalies. This depends on the consequences in functional requirements of buildings (visual performance; use and comfort; health and safety of users), and on the type and extent of necessary works in order to quell the anomaly (which could be easy or not to do, including cleanings, repairs or elements replacing). Considering the deterioration process of Portuguese wooden stilt-houses, due to the introduction of structural elements in concrete and brick (pillars, slabs or walls), this method considers most commons anomalies associated with wooden buildings, and particular anomalies of constructive features. The most common are cracking, fractures or gables on the roof structure and walls, biological attacks, coatings with moisture stains, wear of elements, and elements missing, loose or blistered. The particular are deformation, cracking, breakage, wear or breakdown of wooden structure, dust, damp stains, biological attacks, wear or blistering of wooden coatings (plaster, tiles or mosaics). Anomalies levels and their weightings have measurement intervals, using a descendent scale of points (highest number for very slight, and lowest for very serious): very slight (5), slight (4), average (3), serious (2), and very serious (1).

2.3. Weightings scale

In order to facilitate the allocation of building anomalies levels, this method proposes the development of a Score Grid including complementary records (for each building constructive elements), with several indications about how to select the applicable element and guidelines for its evaluation, within each level of rating scale. The weightings scale has measurement intervals in a descendent scale of points, according to the importance of each building element in its performance, and its relation with other elements (highest for a very important element and lowest for least important). It considers three measurement intervals [2]: 6 or 5 points for a very important element, 4 or 3 points for an important element, and 2 or 1 for less important element. It uses the scores of 6 points for structural condition (highest number, considering the most relevant feature of status of buildings conservation), 5 points for coverings / finishes, 3 points for spans, 3 points for other elements, and 2 points for non-structural walls (the lowest for less relevant feature).

The points (Pt) of each constructive element are the result of the product in between the number of points associated with the anomaly level (n) and its weightings (Pd) (1). Thus, the final result of the building evaluation depends on of anomalies index (IA) of several groups of elements. It varies from 1 to 5 and results from the quotient in between points sum (∑Pt) and weightings sum (∑Pd), given to the constructive elements of that group (2). There are three levels of indicators: structural quality (ECe), non-structural quality (ECne), and general (structural and non-structural) quality (EC).

$$\mathrm{Pt} = \mathrm{n} \times \mathrm{Pd} \quad (1)$$

$$\mathrm{IA_{group}} = \frac{\sum \mathrm{Pt}}{\sum \mathrm{Pd}} \tag{2}$$

The ECe reflects the status of building structure conservation, regarding only this group of elements "EA - Structural Condition", which relates to group IA converted in percentage (3). The ECne reflects the status of non-structural elements conservation considering all groups, but the "EA - Structural Condition", from 1 to 5. It's the quotient between the aggregation of IA products of the cited groups and their weightings (Pd), and all groups sum weightings (4). The conversion of ECne in percentages follows the equation (5). In order to calculate the EC in percentage, is considered that structural (ECe) and non-structural (ECne) parts are representing 50% each (6).

The final result is converted into a scale of qualitative levels: [0-30[is very bad which means physical ruin with no rehabilitation chance; [30-50[is bad, which means in economic ruin implying deep rehabilitation actions; [50-70[is on average, which means fixing or elements replacement; [70-90[is good, for small repairs or enhance actions; and [90-100] is very good condition, with no needs of reparation. These levels were defined based on an experimental application of the diagnosis record to a sample of buildings, which allowed to test, to improve and to validate them. The identification of needs for immediate intervention is the result of very serious anomalies, putting in danger the safety of users and with no guaranties of use. The selection is based on two warning indicators at the same time on the same building.

$$\frac{(\mathrm{EC_e} - 6) \times 100}{24} \tag{3}$$

$$\mathrm{EC_{ne}} = \frac{(\mathrm{IA_{EB}} \times \mathrm{Pd_{EB}}) + (\mathrm{IA_{EC}} \times \mathrm{Pd_{EC}}) + (\mathrm{IA_{ED}} \times \mathrm{Pd_{ED}}) + (\mathrm{IA_{EE}} \times \mathrm{Pd_{EE}})}{\mathrm{Pd_{EB}} + \mathrm{Pd_{EC}} + \mathrm{Pd_{ED}} + \mathrm{Pd_{EE}}} \tag{4}$$

$$\frac{(\mathrm{EC_{ne}} - 13) \times 100}{52} \tag{5}$$

$$\mathrm{EC} = \left(\frac{(\mathrm{EC_e} - 6) \times 100}{24}\right) \times 0{,}5 + \left(\frac{(\mathrm{EC_{ne}} - 13) \times 100}{52}\right) \times 0{,}5 \tag{6}$$

2.4. Application tools

This evaluation method has as application tools, a diagnosis record with the using instructions; and a software corresponding to an ICT platform [3]. Their applications allow to quote the rate of decay of wood structures and components to a reasonable scientific degree of certainty. The diagnosis record is organized in six parts: record header including the record number (joining each village code to the buildings numbers); identification (address and ownership status); photographs (building and surroundings) and drawings; general features (use, number of floors, type of occupation, volumes, orientation of front facade relating the waterfront, existence of outbuildings, and number of attached historical buildings); constructive features (record of elements and materials); evaluation of status of historical building conservation (performance record).

3. Development of computing programme: ICT platform tool.

The initial page of ICT platform (see Fig. 1.a) allows to open or to create the diagnosis projects (for each village) giving them a name, their localization coordinates and a plan of the village in an interactive Google map (see Fig. 1.b), and a list of buildings of each village giving them a diagnosis record and an identification photograph [4]. In the diagnosis record of each building, are inserted the identification, photographs (see Fig. 1.c), until four units with a maximum of 60 Kb, localization map (see Fig. 1.d), in JPEG format with a maximum of 100 Kb, general characterisation (see Fig. 1.e), constructive characterisation (structure, roof, exterior walls, stairs or ramp, gallery, terrace, spans, chimney and gutters), status of historical buildings conservation (see Fig. 1.f), record of anomalies levels to each constructive element, and automatic calculation of the anomaly index in each constructive group.

After the previous step, is automatically generated the Individual record for each building (in the option project analysis, in the menus bar of initial page), which gives two types of information: analysis 1, needs for immediate intervention with the activated (in red) alert indicators and the corrective actions to make; analysis 2, status of building conservation performance, with data graphs about structural (ECe), non-structural (ECne) and global (EC) quality levels, resulted from the anomalies index of the groups of elements and their weightings.

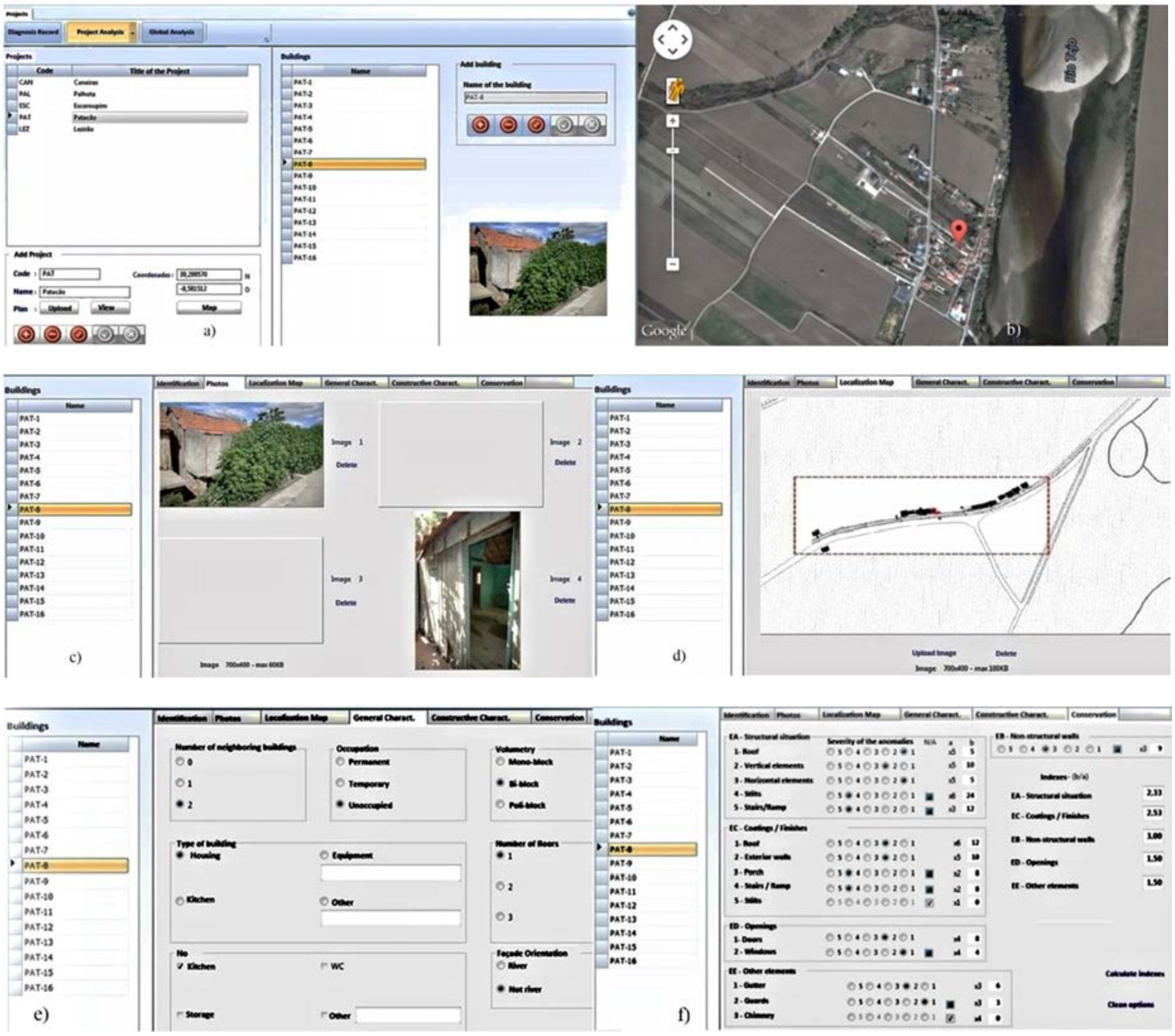

Fig. 1. ICT method for status of historical buildings (a) initial page; (b) interactive google map; (c) photographs; (d) localization map; (e) general characterization; (f) status of historical buildings conservation.

The partial and global results are put into the Global Record (in the option Project Analysis), including the activated indicators, the Anomalies Indexes and the percentage resulted from the status of building conservation. This results are useful for a comparative analysis in between buildings [5], allowing the definition of strategies and intervention priorities. The Global Record (see Fig. 2.a) is the result of the statistics analysis for each village (option Project Analysis), comprising the sorted table of the buildings performance, from the highest to the lowest number of active warning indicators and from the best status of building conservation to the worse (with a synthesis table and a circle graph) (see Fig. 2.b).

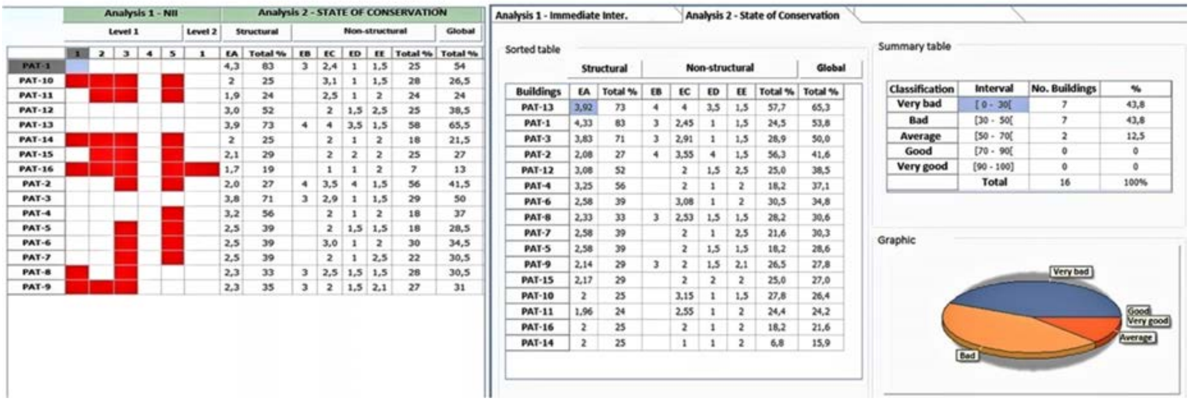

Fig. 2. ICT evaluation method for status of buildings conservation (left) global record; (right) table and circle graph of buildings performance.

4. Conclusions

The presented ICT method allows the analysis of two types of results, the needs for immediate intervention in the analysed buildings and the performance of status of buildings conservation. These results are expressed in percentages, which are converted to a scale of qualitative levels (very bad, bad, average, good or very good condition). This method is used as an intuitive, friendly and mobile ICT platform, able to insert the data in situ easily, concerning the goals of the user, including getting more detailed or more general output for one single building or for a set of buildings, belonging to one single village or to several villages. It is available to be used as cloud-computing tool, and its results are the first survey of the vernacular heritage of river banks in Portugal.

Finally, this knowledge is ready to be transferred from the scientific research to the business environment. In this sense, is crucial to engage software companies in order to improve this method, regarding the input from the enterprise environment, and its experience in terms of commercial applications and distribution channels, promoting the development of its expertise.

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