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Urban fire risk: Evaluation and emergency planning

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ABSTRACT

The management, prevention and mitigation of urban risks are assumed as priority actions within the framework of any rehabilitation and requalification process at the urban scale, particularly in the case of the rehabilitation and refurbishment of old city centres. In the most specific domain of urban safety, seismic and fire risk, which can cause serious consequences, are part of the collective memory of several communities and must be inevitably highlighted. The severity of the resulting damages is a more than valid reason to strongly value prevention, planning and mitigation strategies, limiting their consequences and guaranteeing permanent improvement actions. In the view of the abovementioned, and in the scope of a research project carried out, a new urban fire risk assessment methodology was developed and applied to the old city centre of Seixal. This simplified methodology is based on a preestablished method designated ARICA. Over 500 buildings were assessed using this methodology, and the results were spatially analysed using an integrated geographical information system tool (GIS). It is worth noting that the integration of the risk results into a GIS platform is a valuable step towards the risk mitigation at a urban scale, allowing city councils or regional authorities to plan interventions on the basis of a global spatial view of the site under analysis leading to more accurate and comprehensive risk mitigation strategies that support the requirements of safety and emergency planning in case of urban fire.

1. Introduction

1.1. Framework

Old city centres are particular areas of vital importance due to their valuable historical, architectural, cultural and social heritage, which should be preserved and constantly valued. In this sense, it is essential that institutions responsible for safeguarding this heritage and the population who benefit from it, join forces and work together on the prevention of fire risk within these areas [1].

The unique features of old city centres and its building stock are clearly distinct from recent urban areas, favouring the ignition and propagation of a fire. Several factors have been identified as potential contributors for increasing fire risk in these areas: combustible materials present in traditional buildings, the high density of buildings in old city centres with narrow unobstructed street widths, the wall sharing between adjacent buildings, the inadequate adaptation of buildings to non-residential purposes, the proliferation of unoccupied or derelict buildings frequently storing large amounts of combustible materials and mainly, the existence of old electrical installations with lack of maintenance, which is one of the main causes of fire risk of old building stock [2].

Throughout world history, there are multiple devastating fire examples with catastrophic consequences in both economy and heritage. The 1666 great fire of London, and the 1871 fire of Chicago, are two of the most significant urban fire events, leading to the nearly collapse of both cities and to human loss scale with no precedents in history. In Portugal, the 1988 Chiado fire, affecting this important warehouse and commercial area of Lisbon (see Fig. 1), remains as one of the most marking fire event in the country, leading inclusively to the creation of the first Portuguese Ministerial Order No. 426/89 of 6th December, entirely dedicated to this matter [3]. Although, no other similar or comparable event has occurred,

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Fig. 1. Chiado fire during both propagation and extinction phase [8,9].

fire risk in old city centres is recognised by citizens and responsible entities as a serious problem. In 2010, Coelho has developed a comprehensive work on building conservation and rehabilitation from the point of view of fire safety, identifying the most common issues found in our building stock and suggesting some solution to overcome those deficiencies [4]. Although fire risk assessment methodologies continue at an early stage of development in respect to large-scale assessment an important contribution was recently given by Magalhães [5] which may enhance development and bring attention to fire safety in buildings within urban areas, through the development of an IT tool designated FIREcheck, geared towards the organisation, planning and data storage of fire surveying and inspection work of buildings. Moreover, a handbook containing guidelines and procedures to carry out during fire safety surveying work has also been developed by [5]. This tool was comprehensively reviewed and optimised by Barral [6] to incorporate the self-protection practices and measures defined in the latest national fire safety code [7].

1.2. Research aims

The main goal of this research work is focused on developing a large-scale supporting tool for emergency planning directed mainly towards to old city centres. In a first phase, the Seixal case study allowed to identify and collect the main fire risk vulnerability sources and then, in a second phase, to use these data as input for the development and application of the new methodology to assess urban fire risk. The first phase of identification and data collection was performed through a group of coordinated field inspections identifying the principal safety factors against fire risk in historical buildings, which were stored in a linked database used in a GIS tool environment.

2. Method of research: fire risk index

Fire risk assessment methodologies currently available are scarce and the great majority of them were developed exclusively for the evaluation of single and recently-built buildings, therefore being unsuitable for application to old masonry buildings or at larger scales. Even though, four different existing methodologies should be listed due to their characteristics, which can be in a broad sense approximated to the old city centres reality: the Gretener method; the FRAME method; the FRIM method and the ARICA method [10]. All the referred methodologies have their applicability scale as a common denominator, which is directed to single buildings or at most to building aggregate assessment. Nevertheless, ARICA method presents a clear advantage when compared with the remaining ones, it is much more flexible in terms of methodological formulations allowing that, with some modifications, it can be used to assess either old or recent buildings. This is the whole point of developing an expeditious methodology on the same base as the scoring

Table 1
Global factors, sub-factors and partial factors definition.

Global factors	Sub-factors	Partial factors, PF_{ij}
Global risk factor, *FGR*	Fire ignition, SF_I	Building conservation state (A1)
		Electric installations (A2)
		Gas installations (A3)
		Fire load nature (A4)
	Fire propagation, SF_P	Gap between aligned openings (B1)
		Safety and security teams (B2)
		Fire detection, alert and alarm (B3)
		Fire compartmentalisation (B4)
		Fire loads (B5)
	Evacuation, SF_E	Evacuation and escape routes (C1)
		Building properties (C2)
		Evacuation correction factors (C3)
Global efficiency factor, *FGE*	Fire combat, SF_C	Building external fire combat factors (D1)
		Building internal fire combat factors (D2)
		Security teams (D3)

methodology developed by Vicente for the seismic vulnerability assessment of old masonry buildings at the urban scale [11], which is essentially based in qualitative criteria. Aiming the mentioned goals, a new simplified proposal has been developed with basis on the same principles of the original ARICA method, but this time adapted to the already identified needs.

By exploiting information and research collected during the extensive inspection phase, it was possible to determine the fire risk index, FRI among other indicators. Please note that with this new proposal the authors do not want to disregard the original ARICA method, but assume it as a large-scale reworked and redefined assessment tool, performing an initial and reliable estimation, and highlighting constraints in need of more detailed assessment methodologies. Thus, as the original ARICA method, the new fire risk simplified methodology is based on two main factors: the global risk factor, *FGR*, and the global efficiency factor, *FGE* (see Table 1). The first is divided in three sub-factors devoted to evaluating the fire ignition phase, the propagation phase and the building evacuation phase. The global efficiency factor, *FGE*, is associated just to one sub-factor evaluating the fire combat phase. The four sub-factors have the same numerical weight in the calculation of the Fire Risk Index (FRI). However, the mentioned sub-factors approach the generality of the aspects related to fire prevention in old masonry buildings, following the whole event from the fire ignition, propagation and evacuation capacity, to fire combat and extinguishing. The sub-factors breakdown into the partial factors that assume numerical values in