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Green roofs in Mediterranean areas – Survey and maintenance planning

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ABSTRACT

This paper addresses green roof maintenance in Mediterranean areas. A field survey is presented, describing building and roof systems of eleven case studies in Portugal, anomalies, causes and maintenance actions. The most affected system components were the vegetation layer, followed by the drainage system, substrate and paths. All inspected green roofs have regular maintenance, mainly concerning gardening operations, but a large dispersion in terms of frequency and type of maintenance actions was identified. The study confirmed that some design recommendations were not followed, especially the ones associated with singular points, accesses and safety measures. In-situ results were then used to propose a maintenance plan, structured for each system component, corresponding service life prediction and type of maintenance action. The inclusion of the real needs of in-service green roofs in Mediterranean climate, with specific requirements for irrigation and cleaning, led to a more accurate definition of the maintenance actions and their frequency. The responsible person for each maintenance action is indicated. That helps to minimize overall costs, pathology and risks.

1. Introduction

Green roofs were long-established due to their ornamental value while other positive contributions of this constructive solution have been neglected. In the last decades, green roofs have become more popular and various studies now focus on the benefits associated with this roof constructive solution, e.g., the critical analysis of Berardi [1] for a general review. This integrated system can help to achieve high performance buildings and sustainable built environments, since green roofs absorb rainwater [2], air [3] and noise [4] pollutions, provide additional insulation [5], low urban air temperatures [6] and create a habitat for wildlife [7], among other local and urban benefits.

In order to assure green roofs benefits, this constructive solution should be correctly designed and maintained along its life cycle [8]. This also helps minimizing risks, such as fire [9,10] and ensures the longevity of the constructive system [11].

Several technical documents define the need of accurate design and predict maintenance actions for green roofs. Most of them follow the recommendations defined in the FLL Roof Greening Guideline [12] from Germany, widely accepted abroad, e.g., UK [10,13], Canada [8,9,11], Semi-Arid and Arid West [14], France [15] or Australia [16]. *Normas Tecnológicas de Jardinería* NTJ [17] are also based on FLL with application to Mediterranean areas (Spain).

These references identify the need of a maintenance plan for owners, users and building managers to assure the good in-service performance of a green roof. Some define regular maintenance measures of the roof [9], such as cleaning or watering. The need of distinct maintenance requirements in extensive and intensive green roofs is also referred [12]. However, a detailed maintenance plan, with a description of maintenance actions and their frequency, is rarely found in the literature, standards or guidelines. This situation does not help the dissemination of green roofs constructive solutions, since owners and decision-makers will not feel comfortable in choosing this constructive solution.

Maintenance varies from one region to another according to the local climate [18]. Green roof technology in Mediterranean regions is not stabilized as in continental Europe or the US. In fact, popular misconceptions are commonly referred e.g. in Malta, Italy or France [19,20]. Particular specifications of Mediterranean climate, such as hot and dry summers and mild to cool wet winters, high wind and solar radiation exposures or irregular rainfall pattern, should

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influence local green roof construction and maintenance strategies [21]. E.g., the irrigation system should be regularly evaluated to assure the adequate conditions for the vegetation and, simultaneously, minimizing watering costs. Guidelines FLL [12] are adequate for central Europe climate and generally adopted abroad Germany. However, they are not directly adapted to Mediterranean areas. NTJ [17] answered to this challenge but more studies are needed to enhance maintenance planning in this area.

This paper addresses green roofs maintenance in Mediterranean areas. Eleven green roofs built in Portugal in the period from 1990 to 2013 were inspected. According to Köppen climate classification, Portugal is representative of the Mediterranean climate and characterized as Csa, Csb [22]. The survey includes post-implantation, maturation and maintenance phases. Also, extensive, semi-intensive and intensive green roofs are covered. Furthermore, a maintenance plan was developed, complementing information from technical documents with the results of the in-situ survey. This plan is based on maintenance source elements, each one associated to a maximum service life and an adequate list of maintenance actions. The frequency and responsibility of each maintenance action is highlighted.

2. Methodology

The methodology used in the field assessment is schematically illustrated in Fig. 1. The information was obtained through visual inspection, complemented, when possible, with data available in technical documents from owners, designers, installers and maintenance technicians.

The inspection sheet is herein divided in three main parts: (i) weather conditions and building/roof data; (ii) constructive system, anomalies and causes; (iii) maintenance actions.

Building data correspond, e.g., to its location, use, year of construction and number of elevated floors. Roof data include green roof area, type, slope and accessibility. The first part of the inspection sheet also identifies specific aspects that influence the performance of green roofs in real service conditions and consequent maintenance actions. According to [12,17], vegetation and substrate should be 30–50 cm apart from the perimeter of the

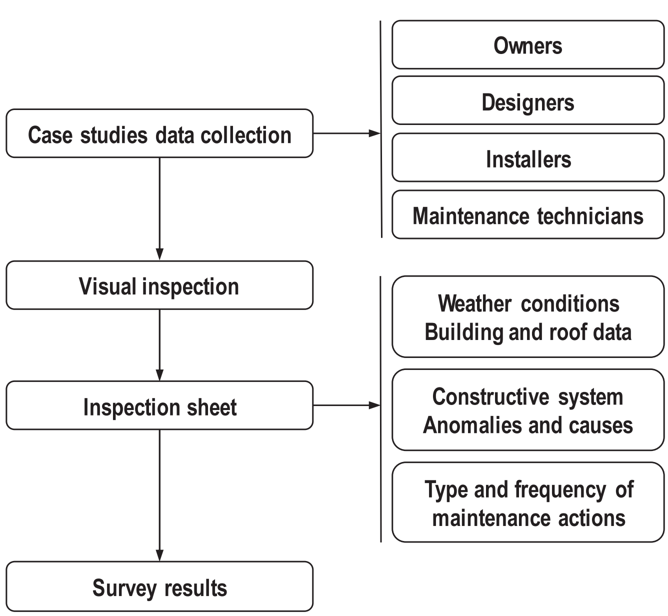

Fig. 1. Field inspection methodology.

roof and 15 cm from the drainage system boxes. These design options define circulation paths that facilitate inspections and repairs, safeguard the vegetation from high winds and prevent the spread of vegetation fire. It is also important to verify any shaded areas or obstacles against precipitation of the green roof, since these will contribute to vegetation growth and conservation.

Green roof systems can be grouped into two distinct technologies [12]: a single layer system, with all functions included, and a multi-layer system, in which each layer is individually applied. A multi-layer system is at present more used, usually with eight functional layers [14,17,23], namely: support, waterproofing membrane, root-resistant membrane, waterproofing membrane protection, drainage/retention layer, filter layer, substrate and vegetation. In some cases, a thermal insulation is also incorporated in this roof system. The root-resistant membrane repels the growth of roots, avoiding perforation of the waterproofing membrane. The waterproofing membrane protection may act as water and nutrients retainer or as a separation layer. The drainage/retention layer should manage water runoff, regulate the retention and the excess water drainage, as well as aerate the substrate and roots. The filter layer prevents fine particles and sediments of the substrate blocking the drainage layer with water runoff, while maintaining the integrity of the substrate and vegetation. The substrate provides support, nutrients, air and water to plants.

The second part of the inspection sheet identifies all the previous layers and also the drainage and irrigations systems and singular points, such as expansion joints, trims or parapets. For each layer, the most common anomalies are listed.

Examples of anomalies in the system support layer are infiltrations and the collapse of the structure [24]. The rupture of waterproofing membrane, blockage of the drainage layer and clogging of the filter layer pores are the most serious anomalies [17,25]. At the substrate level, waterlogging anomalies can arise due to insufficient slope or drainage or inadequate drainage layer system. The vegetation layer can provide dry areas, weed vegetation or fallen vegetation due to the lack of anchorage [12,14,15]. Drainage system may have clogged drains and accumulation of water or debris along the pipe [25].

For each relevant component of the green roof system, several probable causes are enumerated in the inspection sheet, allowing a quick fulfillment of the checklist during the inspection. Degradation agents such as external atmospheric factors, pollution or inappropriate human activities are among the most common causes [26]. Compared with conventional roof solutions, the degradation due to intense solar radiation and temperature gradients is less significant in green roofs since the vegetation protects other system elements. However, strong wind is more relevant in green roof solutions where suction forces can cause abnormalities such as dragging of substrate, vegetation and erosion [12,17].

The checklist of the existing maintenance for each roof includes, e.g., the following actions [12,14,17]: cleaning, watering, fertilizing, pruning, unwanted vegetation removal, addition of substrate, replenishing the protection layer against erosion, replanting sites, pest control, anchorage control of tall vegetation, removal of dry vegetation and debris. The cleaning of the drainage system components should be carried out beside the replacement of drainage filters. Inspections are also covered in maintenance actions, namely structural elements, waterproofing, drainage and irrigation systems, anchors, trim and water supply systems. Frequency of maintenance actions and previous interventions are also registered during the inspection, as suggested e.g. by Ref. [15].

Fig. 2 shows an extract of the inspection sheet developed for the field inspection assessment performed in this work.