Building and Environment 48 (2012) 101–106

Contents lists available at SciVerse ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Use of rubber crumbs as drainage layer in experimental green roofs

A. Vila[a], G. Pérez[a], C. Solé[a], A.I. Fernández[b], L.F. Cabeza[a,*]

[a] GREA Innovació Concurrent, Pere de Cabrera s/n, Universitat de Lleida, 25001 Lleida, Spain
[b] Department of Materials Science & Metallurgical Engineering, Universitat de Barcelona, Martí i Franqués 1, 28028 Barcelona, Spain

ARTICLE INFO

Article history:
Received 21 February 2011
Received in revised form
17 August 2011
Accepted 19 August 2011

Keywords:
Sustainable construction
Green roof
Drainage layer
Rubber crumbs
Plant species

ABSTRACT

Green roofs have become a sustainable construction building system that offers interesting environmental advantages over traditional roofing solutions. However green roofs design is still based on conventional materials. This article begins a research which considers both the study of the functional benefits of green roofs but also the goodness of their own construction. Specifically in this paper the possibility of using rubber crumbs as drainage layer in green roofs instead of the porous stone materials currently used in some commercial solutions (such as expanded clay, pumice, natural puzolana, etc) is suggested. This solution would reduce the consumption of these natural materials, which also require large amounts of energy in their transformation process. Moreover it would provide a solution to the problem of waste tires. Since the purpose of the drainage layer is the optimum balance between air and water in the green roof system, first the ability for draining of rubber crumbs was studied and was compared with that offered by stone materials. The new solution using rubber crumbs is also studied, with experimental trays, to test if it would keep the same insulation properties that the green roof with stone materials. Early results obtained in the experimental trays show that rubber crumbs are a good substitute for stone materials used as drainage layer.

1. Introduction

One of the main ways for sustainable construction is the development and application of systems allowing integration of natural environmental processes in construction. Green roofs are a constructive solution designed with the goal of building more sustainable and environmentally friendly buildings. Green roofs offer interesting advantages over traditional solutions, for example the reduction of surface runoff in large cities [1] the improvement of the urban environment due to the reduction the urban heat island effect [2–5], and the filtration of air pollutants [6]. Also is one support to biodiversity [2,3,7], improving the durability of waterproofing materials protecting them from solar radiation [8,9] and decreasing the transmission of sound [9–11]. Green roofs can reduce the thermal fluctuation, since their thermal capacity is higher. Green roofs can keep cooler the air temperature in the underneath room in summer and warmer in winter; this fact does reduce the energy consumption for heating and cooling the building [8,9,12].

However green roofs design is still based with conventional materials such as polypropylene or polyester geotextiles membranes, polyethylene or polystyrene panels, expanded clay, natural puzolana, and bitumen or PVC membranes. Thus, besides studying the functional benefits of green roofs, the goodness of the construction system itself must be also studied.

On the other hand, today the environment is deteriorating. Increasing green spaces, as are green roofs, is a well accepted practice because plants and growing media help to clean air of pollutants and also contribute to capture and reduce levels of CO_2 [13].

Green roofs are usually formed by the following layers and construction materials [14]:

- *Vegetation layer*
- *Substrate layer*: Usually topsoil or especially growing media. It is the physical support for the plants. Moreover, it provides nutrients and should have capacity to retain water.
- *Filter layer*: Usually polypropylene or polyester geotextiles membranes. It allows the water to cross but not of the substrate small particulates that could clog the cavities in the drainage layer.
- *Drainage layer*: Its objective is to obtain an optimal balance between air and water in the green roof system. It has the function of recreating natural growing conditions for vegetation is accumulating water, but it also has to allow the drainage

* Corresponding author. Tel.: +34 973 003576; fax: +34 973 003575.
E-mail address: lcabeza@diei.udl.cat (L.F. Cabeza).

0360-1323/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.buildenv.2011.08.010

of excess water and to ensure aeration of the substrate and roots. Today, mainly two types of drainage layer are used:

- Polyethylene or polystyrene nodular panels, where water accumulates, while allowing the evacuation of excess water and ensuring good ventilation.
- Porous stone materials with some water retention capacity, such as expanded clay, expanded shale, pumice, natural puzolana, etc.

- *Protection layer*: Usually geotextiles polypropylene or polyester membranes. It provides mechanical protection to lower layers, especially to the waterproofing layer.
- *Root barrier and waterproofing layer*: It protects the building from the roots and water. Usually bitumen or PVC membranes, reinforced with polyester, fibreglass, plastics, and mineral granules are used. Also synthetic rubber or polyethylene can be found.

As it can be seen in this previous description, one of the common solutions used as drainage layer is porous stone materials. The demand and consequent extraction of these stone materials lead to a large environmental impact; landscape destruction, environmental impact, deficit in the waste management, and other impacts arise from the later processing of the materials. Only the European aggregates demand is 3 billion tonnes per year. The aggregates sector is by far the largest amongst the non-energy extractive industries. 90% of all aggregates produced are from natural resources extracted from quarries and gravel pits [15].

On the other hand, nowadays a large volume of waste products of difficult management are produced, therefore it is interesting to find alternatives such as recycling and re-use of these materials. A clear example is waste tires. In 2009 the EU27 was faced with the challenge of managing, in an environmental way, more than 3.2 million tonnes of out of use tyres. After sorting, around 2.6 million tonnes of end of life tyres (ELTs) remained on the EU market for recovery and recycling. Tyre Derived Aggregate is a product obtained from used tyres. It is used as foundation for roads and railways, as draining material replacement for sand and gravels, landfill construction, subgrade fill and embankments, backfill for walls and bridges and subgrade insulation for roads. It is 30–50% lighter and provides eight times better insulation than gravel, and drains ten times better than well graded soil [16]. Preliminary studies show that the use of recycled rubber from tires, or rubber crumbs, are no dangerous for human health neither for environment [17].

In this paper the two issues discussed above are considered and the possibility of using rubber crumbs as drainage layer in green roofs is suggested, substituting the porous stone materials currently used (such as expanded clay, expanded shale, pumice, natural puzolana, etc). That was done by means experimental trays which simulate a green roof system. Previously, a study of laboratory, of these drainage materials, had been done.

The system used corresponds to an extensive green roof with a drainage layer of 4 cm of natural puzolana directly below the layer of substrate, with 5 cm thickness [18]. Unlike usual solutions, between these two layers no filter layer was placed. In this climate and for extensive green roofs, irrigation during the summer months is recommended.

Three actions were carried out:

a) Since the purpose of the drainage layer is the optimum balance between air and water in the green roof system, first the ability for draining of recycled rubber granules was studied and compared with the offered by puzolana (comparison of hydraulic conductivity).
b) The new solution mounted in trays was tracked in order to see if the recycled rubber affects the plants development, and while also observing the evolution of the rubber used as drainage layer (experimental green roofs in trays).

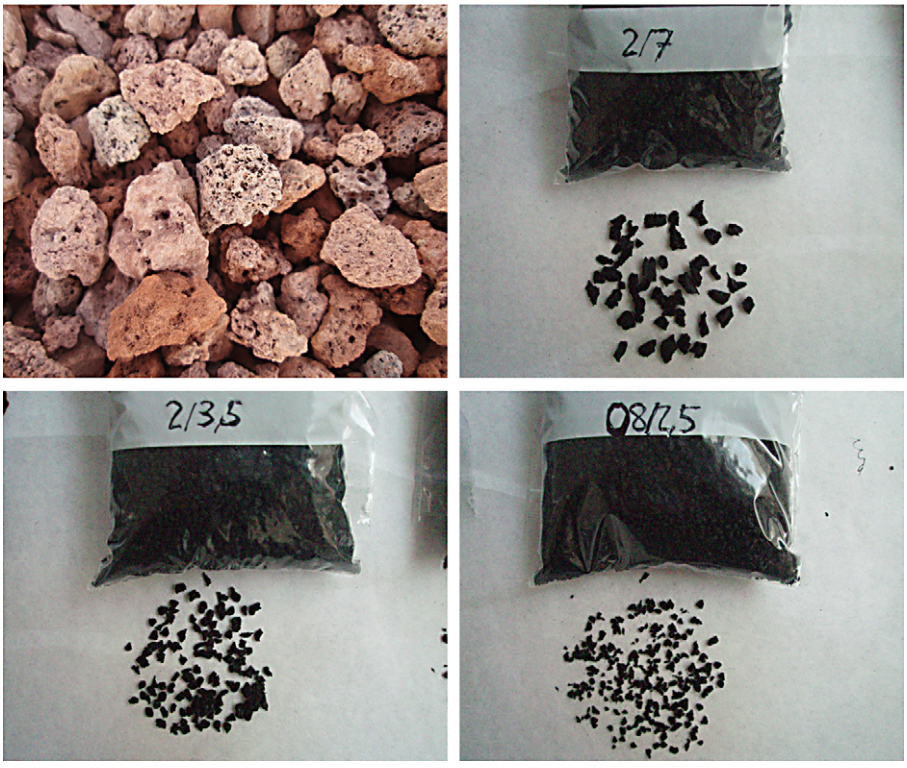

Fig. 1. Drainage layer materials. Puzolana and three different particle sizes of rubber crumbs.