The Living Envelope of the Buildings, Between Myth and Reality

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Abstract
In the near past we have been shelled with information about the benefits of green roofs, green walls, living walls. New systems and techniques are developing, aiming to provide different solutions, custom or tailored made, to accommodate all our needs for a better indoor or outdoor air, for a less polluted environment, for contributing to the wellbeing of the urban population.
Furthermore, the living layer – the plant layer – brings new, extra functions to the building envelope: energy saving and, on a smaller scale, food.
As we generally look towards the future, it may, occasionally, be interesting to take a glimpse into the past.
A renown Romanian historian, Nicolae Iorga, said that "He who doesn't know the past can neither understand the present nor see the future". He also said "He who forgets does not deserve".
This paper presents the contemporary living components of the building envelope from a historic point of view.

Keywords: buildings, green roofs, green walls, living walls

1. Back into the history

1.1 Roof top gardens

According to John Magill [1] we owe the modern green roofs to a German roofer, H. Koch. As at the end of the nineteenth century Germany was experiencing rapid industrialization and, in consequence urbanization. One unfortunate consequence of the massive residential building development was the fire hazard of the inexpensive housing, as tar was used to cover the roofs. Koch's idea was to cover the tar with sand and gravel substrate. Shortly, seed colonization occurred and formed meadows. It seems that fifty of these original roofs can still be seen in Germany.

Rooftop gardens were occasionally built in cities in the thirties. In modern architecture, probably the best known example of a historic rooftop garden may be the Rockefeller Center in New York, designed by Raymond Hood (1930 – 1939).

It is stated that the waterproof membrane is still the original one [2], although the life span of such a building component is supposed to last about 15 years, if well designed (the appropriate structure and material), installed and protected (Fig. 1).

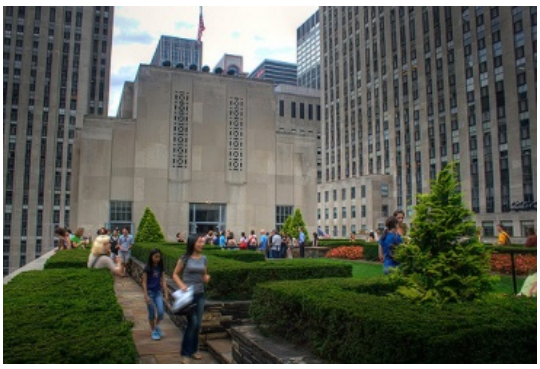

Fig. 1. Rockefeller Center Rooftop Gardens. Rian Castillo

The history of the green roofs is, however, very much older, going back almost 3000 years ago, in the ancient city of Babylon. Everyone has heard about the Seven Wonders of the Ancient World: the Hanging Gardens of Semiramis are one of them. And they are also the oldest relic of green roofs.

It may be worth opening a page on Robert Koldewey (10 September 1855 – 4 February 1925). He was the archaeologist who discovered, in the Marduk Ziguratte and the Gate of Ishtar in Babylon (Fig. 2). He also saw in some ruined arches and a well in the neighborhood that seemed to have had a specific functionality, the remains of the famous Hanging Gardens.

Fig. 2. Ancient Babylon, Library of Congress, Public Domain

Strabo describes the Gardens as follows: “The garden is quadrangular in shape, and each side is four plethra in length. It consists of arched vaults, which are situated, one after another, on checkered, cube-like foundations. The checkered foundations, which are hollowed out, are covered so deep with earth that they admit of the largest of trees, having been constructed of baked brick and asphalt – the foundations themselves and the vaults and the arches. The ascent to the uppermost terrace-roofs is made by a stairway; and alongside these stairs there were screws, through which the

water was continually conducted up into the garden from the Euphrates by those appointed for this purpose, for the river, a stadium in width, flows through the middle of the city; and the garden is on the bank of the river" [3]

The most outstanding description was – in our opinion – made by Diodorus Siculus, in the first century B.C [4]: "The park extended four plethra on each side, and since the approach to the garden sloped like a hillside and the several parts of the structure rose from one another tier on tier, the appearance of the whole resembled that of a theatre. When the ascending terraces had been built, there had been constructed beneath them galleries which carried the entire weight of the planted garden and rose little by little one above the other along the approach; and the uppermost gallery, which was fifty cubits high, bore the highest surface of the park, which was made level with the circuit wall of the battlements of the city. Furthermore, the walls, which had been constructed at great expense, were twenty-two feet thick, while the passageway between each two walls was ten feet wide. The roof above these beams had first a layer of reeds laid in great quantities of bitumen, over this two courses of baked brick bonded by cement, and as a third layer of covering of lead, to the end that the moisture from the soil might not penetrate beneath. On all this again earth had been piled to a depth sufficient for the roots of the largest trees; and the ground, when levelled off, was thickly planted with trees of every kind that, by their great size or other charm, could give pleasure to the beholder. And since the galleries, each projecting beyond another, all received the light, they contained many royal lodgings of every description; and there was one gallery which contained openings leading from the topmost surface and machines for supplying the gardens with water, the machines raising the water in great abundance from the river, although no one outside could see it being done. Now this park, as I have said, was a later construction". Diodorus's description was confirmed by archeology of the early twentieth century.

Permanent sprinkling of The Gardens was provided from the Euphrates by a hydraulic pump that led water to the vegetation. Even today it is not clear how the system works but in the ruins which are believed to be of the gardens, three adjacent wells were found, one central, of square shape and two oval, placed laterally, which remind of a hydraulic machine.

1.1.1 When were the Gardens built?

It is said that queen Amytis the wife of Nebuchadnezzar II of Babylon was longing for her homeland - a territory of the contemporary Iran – that was covered with woods. Seeing her sadness the king ordered the builders to re-create a familiar landscape for her: a terraced construction planted and irrigated artificially rose in the city.

According to another legend, the king offered his wife something he already had: the Gardens were there already, built by the founder of Nineveh and Babylon, king Ninius, for his wife, Semiramis. Nevertheless, the Gardens existed and are probably the first example of green roof / rooftop garden in history [5].

1.2 Sloped Green Roofs

Green roofs have been used in the Northern Europe since the viking period [4]: the vernacular Scandinavian dwelling roofs were protected with sod; the vegetation layer has a double role: to ballast the roof shingles against wind and to provide additional thermal insulation (the sod and vegetation layer providing an important thickness) [6].

From the Vikings the technology was adopted on both shores of the Atlantic, sod roofs being seen in Scandinavia, Scotland and France as well as in Canada and French examples of sod roofs, in Newfoundland and Nova Scotia.

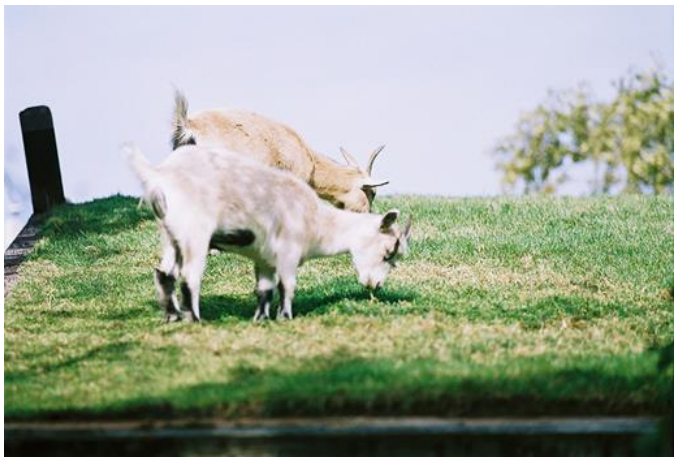

Fig. 3 Goats on a sloped roof, at Al Johnson's Swedish Restaurant, Sister Bay WI: Door County Photo Ky

2. Green Roofs Today

A roof represents 6-10% of a buildings' costs. Unfortunately in most cases it cannot be seen from the sidewalk or the surrounding buildings (unless it is surrounded by higher natural or built elements). Therefore many roofs develop… ponds or vegetation which, undersigned on purpose, distro the waterproof system of the roof.

Specific layers are provided, in order to discourage the root penetration into the waterproof membrane. At first made of mortar and metal grid, today contemporary materials 9 including recycled ones) allow for the growth media as well as the roof protection, not only to survive but also to protect and emphasize one another.

Seeds are transported by wind and birds and the plants develop wherever they find cracks, sand, earth (Fig. 4). This was how the green roofs appeared in the 1880s and this is still a means for "greening" the roofs, provided that the waterproof layer(s) is well protected against the roots and the chemical aggression produced by the decayed plants.

Fig. 4. Roofs in Bucharest. Photos Alexandru Stan & Ana-Maria Dabija

In other words, one should not be happy if a tree grows on ones' façade or roof, because the roots in fact destroy the structure of the nonbearing elements of the building, that are in its' neighborhood.

The living "layer" is only one component of the mechanical IR and UV protection of the roofing system.

However, the need to provide the additional layers, the nutrients, the appropriate soil type and thickness for the type of plants that are to be installed on the roof led to the legend that these are fastidious systems. Furthermore, if the buildings are not protected against winds and if the trees are high, they may be overthrown. Therefore the designing of rooftop gardens is a delicate approach, that needs a multidisciplinary team, in which the architect, the botanist, the structure engineer must be included.

2.1. Green roof types

According to the type of plants that form the living component, there are three main types of green roofs: extensive, intensive and semi-intensive. The types of plants are strongly connected to the thickness and characteristics of the substrate (soil).

While the extensive roofs require 4-10cm for sedum (mainly) to grow, intensive roofs – rooftop gardens – need thick layers of earth (40 – 100cm) that accommodate the growth of high trees. They are real gardens (as seen in the case of Rockefeller Center –Fig. 1 - or in the Montparnasse Railway Station in Paris - Fig. 5) with alleys, benches and all the necessary street furniture that is needed or requested in a park.

Furthermore, the designing of such gardens is independently carried out for each season, as different plants reach their aesthetic potential in different seasons. Landscape architects and botanists team in this approach.

Fig. 5. Gare de Montparnasse in Paris. Rooftop garden. Photo Ana-Maria Dabija

Like all living creatures plants need time to grow and mature. Therefore it takes time until a green roof reaches its' beauty. It is the case of most pitched roofs where sod and grasses need to grow stronger. Terraces may accommodate container systems, an "all-in-one" product that comes with all components that are requested over a waterproof membrane. They can be easily manipulated and replaced, if necessary.

3. Living facades

The concept is not new either. Many country houses (or old urban houses, with courtyards) have beautiful vine vaults that provide "coolth" in the hot summer days. As their leaves fall in autumn, the sun warms the walls in the wintertime… At least this is the romantic approach.

In reality the ivy and vine that cover facades in the historic cities represents vulnerability for the wall. Their "tentacles" thrust in the substance of the walls and, like in the story of the Sleeping Beauty, take over and overgrow the entire building (Fig. 6).

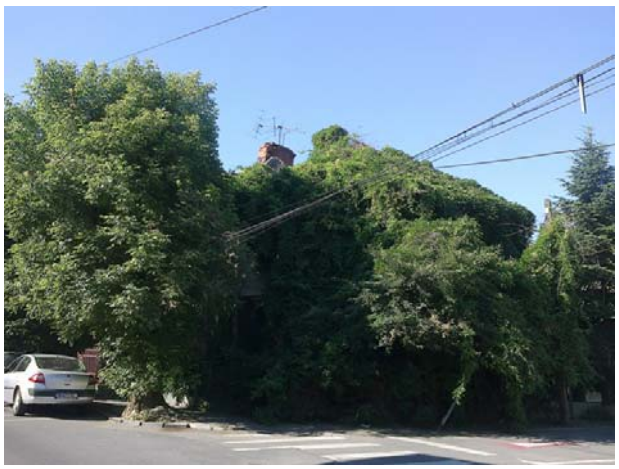

Fig. 6. Building in the "old" Bucharest. Photo Ana-Maria Dabija

Due to the humidity kept by the plants that lean against the facades, the walls may become damp. In order to prevent the accumulation of humidity in the façade, the contemporary living walls are raised on strayed structures. This way the built facade is naturally ventilated, the humidity is removed and the wall has more chances of staying dry. Using the traditional buildings with the climbing ivy as example, the principle of green façade has been developed.

The living walls derive from the ventilated façade systems: panels on a substructure. Panels may be made of wood (that was the beginning), stone, metal, glass and - why not – panels with a growing media that accommodates some types of plants. The growing substrate is usually of a spongy or fibrous origin, that allows the plants to develop roots. There are systems that provide "pockets" with soil, appropriate for indoor, not high walls, in countries with no seismic hazard.

The "inventor" of the green wall is Stanley Hart White, a landscape architect and a professor at the University of Illinois at Urbana – Champaign. It seems that in 1937 he patented the "Botanical Bricks" and in 1938 the "Vegetation Bearing Architectonic Structure and System". In this last patent he describes a method " for producing an architectonic structure-of any buildable size, shape or height, whose visible or exposed surfaces may present a permanently growing covering of vegetation. Another object is to provide a vegetation-bearing structural unit therefor. A further object is to provide such a unit that maybe irrigable, portable and interchangeable. Another object is to provide such a unit-of sufficient flexibility to enable it to be bent, curved or warped into various shapes. Another object is to provide such a unit that may be permanently plant-bearing and plant-nourishing. A further object is to provide fixed, flexible or portable architectonic compounds of such units. Additional objects will more plainly appear from the detailed specification and drawings presented herewith in exemplification but not in limitation of the present invention […] The underlying principle of the present invention is to provide the architectural profession and related industries with an efficient and inexpensive method and means for utilizing a novel medium for ornamental and useful architectonic construction, in various forms of units and compounds having vegetation-bearing surfaces. For example one purpose of these surfaces may be to build decorative backgrounds or screens for masking eyesores or for concealing people or properties - in such a way as to avoid painted camouflage or the heavy cost of ordinary hedges there in a few days, if permanently constructed" [7]. It seems that Stanley Hart White has seen only a tiny part of the potential of the benefits of the living walls .

There is a connection – like in the case of green roofs – between the type of substrate (growing media) and the type of plants. The mastermind in the case of living walls is the botanist who can make arrangements that lead to colours, textures, images.

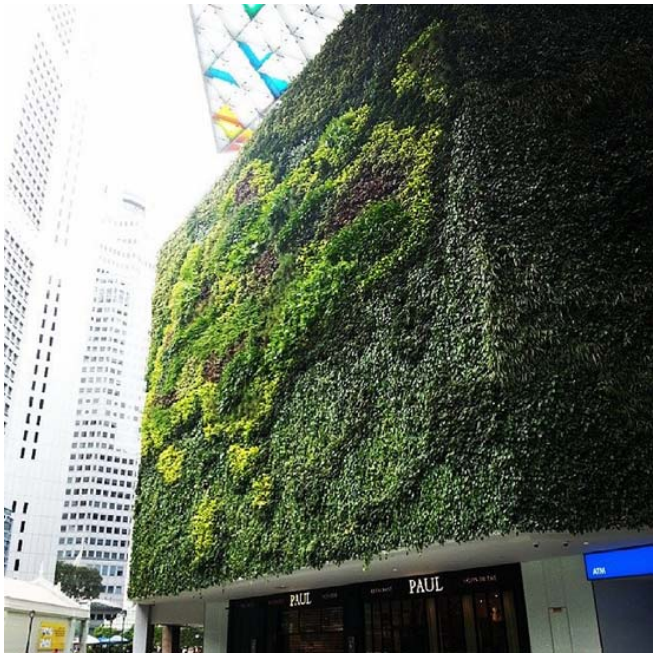

Fig. 7 Massive greenwall with a Singapore island map. Photo Jonathan Choe

3. Benefits of the living envelope

As mentioned before, the first and most important role of the living roof was to protect the membrane from aggressive agents: fire, oxidation, IR,UV, overheating and later to accomplish a mechanical protection.

However, the overall assembly is proven to fulfill other major tasks for the occupants of the building, for the neighborhood and the city.

At the domestic level , the green roof systems provide more thermal comfort as the thickness of the substrate adds to the overall thermal “blanket” but also, a reduced summer energy consumption (as air conditioning is no longer needed). The acoustic comfort in the spaces beneath the roof increases in the case of green roofs.

The process of evapo-transpiration of the plants humidifies the air, decreasing temperature peaks in the summer and landing the dust.

Plants consume carbon dioxide and eliminate oxigen. Plants absorb electromagnetic radiation [8]. Therefore the use of plants at a large scale – a roof scale – contributes to diminishing the pollution of the cities and diminish the heat island effects.

The return of the plants in the cities is also followed by the restoration and diversification of the ecosystems. Plants contribute to the wellbeing and health of all living creatures.

It is obvious why countries like Germany or Switzerland encourage, through legislation, the development of green roofs. Germany for instance has installed a total of 86.000.000 sqm green roofs (data from 2014) [9].One of the advantages of the living and green walls is that in the summer the vegetation shadows the wall while in winter, as the leaves fall, the sun warms the correspondent part of the facade.

The benefits of the green roofs for the building and the city applies to the vertical component of the living envelope as well (green and living walls). Plants filter the air, therefore living walls help in the process of air recirculation in HVAC systems. Their performance is, however, unquantified.

In some countries the plants that are used for the green roofs are not ornamental but different types of vegetables. The concept of urban farm appeared, adding yet an extra function to the envelope: food provider.

Fig. 8. Rooftop farm, Greenpoint. Photo: Lila Dobbs

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