LIVING WALLS AND GREEN FAÇADES

By: Professor Piet Vosloo,
Department of Architecture,
University of Pretoria

A CASE STUDY OF THE UP PLANT SCIENCES' VEGETATED WALL

ABSTRACT

The purpose of this paper is to investigate the differences between, and the importance and benefits of, green façades and living walls – both commonly referred to as 'green' walls in urban areas. The paper briefly describes the history of the greening of walls over the past 100 years, and the nature of a vertical habitat for plants is discussed. Some examples of green façades and living walls are presented but, as a case study, specific focus is placed on the living wall at the University of Pretoria's (UP's) Department of Plant Sciences, where an experimental habitat primarily for succulent indigenous cremnophytes has been established. The design, construction, plant-species selection and performance over the past two years of this project are investigated and presented in detail. The research finds that the differences between green façades and living walls are not merely semantic, but that there are essential differences in terms of wall construction, planting methods and appropriate plant species. The value of the research lies in the fact that the often arbitrary and confusing use of the term 'green' wall, which may refer to green façades or living walls, is clarified, and an understanding is shown of the challenges of recreating a cremnophyte habitat; one of the rarest and least-researched plant habitats.

KEY WORDS

Cremnophyte, green façade, green wall, living wall, UP Plant Sciences

INTRODUCTION

The role of green infrastructure in city cooling, reducing energy loads on buildings and improving human thermal comfort has warranted much attention over the last two decades, largely driven by concerns over climate change and urban expansion.

(Cameron, Taylor & Emmett, 2014: 198)

The different forms of green infrastructure that Cameron *et al.* (2014: 198) refer to include urban forests, street trees, parks, turf-grass, gardens and vegetated roofs and walls (commonly referred to as 'green' roofs and walls). They point out that the interrelationships between these in terms of their combined effect on ameliorating the micro-climate in urban areas are not easily discernible or understood. Since there are an abundance of large and high building walls in our urban areas that could lend themselves to greening, Lundholm and Richardson (cited in Francis & Lorimer, 2011: 1430) have proposed that greater consideration be given to '…artificial urban habitats such as walls … as "analogue" habitats that can support species from comparable natural habitats' (in this case vertical rock cliffs). And that these habitats could be improved by using appropriate ecological engineering techniques such as green façades or living walls.

Whereas the concept of plants growing up a wall is many centuries old and mainly relied on the particular climber's ability to cling to the wall surface, e.g. Boston ivy (*Parthenocissus tricuspidata*) and Tickey creeper (*icus pumila*), Dunnett and Kingsbury (2010: 9) suggest that '…modern façade greening refers to the application of modern technologies to support a much wider range of climbing plants to much greater heights'. The University of Pretoria (UP) Department of Plant Sciences building's vegetated wall, in this sense, is not a 'green' wall as such, since few of the plants used are climbers, but can rather be described as a living wall supporting mainly cremnophytes. Cremnophytes are plants that in nature find their foothold on a vertical habitat and which term is derived from the Greek *kremnos* (cliff) and *phyta* (plants).

Larson, Matthes and Kelly (2000: 79) find that natural rock cliffs have traditionally attracted far less research and investigation than other more accessible habitats and as a result cliffs are often seen as '…break-points or transient points in landscapes', leading to cliffs being characterised as edges between different habitats or ecotypes and not necessarily as habitats in their own right. The flora on cliff faces, which include both obligate and opportunistic cremnophytes, is one of the least studied growth forms in the world (Van Jaarsveld, 2011: xvi); this was one of the biggest motivations for creating a man-made cliff at the UP Department of Plant Sciences' building that can resemble a natural 'living' cremnophyte habitat as closely as possible.

OBJECTIVES

The objectives of this paper can be summarised as follows:

- To give a brief overview of the phenomenon of vegetated walls and their history over the past century;
- To describe the benefits of and different approaches to vegetated walls, which for the purpose of this paper are classified as green façades or living walls;
- To describe the fundamental differences between vertical and horizontal plant habitats; and
- To refer to the UP Plant Sciences vegetated wall as a case study in which a living wall and habitat for indigenous cremnophytes has been created, and to reflect on the performance of the wall in meeting all these objectives.

A SHORT HISTORY OF VEGETATED WALLS

Köhler (2008: 427) suggests that about 100 years ago buildings in Europe, mostly residential rental developments, had no final plaster finish on their façades. Instead, '…owners planted Boston ivy or English ivy on the façades all over the developing cities in Central Europe like Berlin, Munich and others…', leading to a long-held belief that the greening of walls was merely a cost-saving measure.

In complementing the green roof movement of Europe in the late 1970s, the focus was also on other types of city greenery – such as investigations into the ecological value of greening the façades (Köhler, 2008: 427). Urban ecologists advanced the ideal of maximum possible vegetation in the urban setting, while some prominent architects such as Friedensreich Hundertwasser (1928 – 2000) supported the idea of vegetated façades and 'green' roofs and incorporated these ideas into their designs.

Francis and Lorimer (2011: 1429) describe the concept of reconciliation ecology (developed by Rosenzweig in 2003) as an approach by which the '…anthropogenic environment may be modified to encourage non-human use and biodiversity preservation without compromising societal utilisation…' and which '…potentially represents an appropriate paradigm for urban conservation…'. In this regard, they find that two habitat-improvement techniques '…with great potential for reconciliation ecology in urban areas are the installation of living roofs and walls, which have been shown to support a range of taxa at local scales' (*ibid*., 2011: 1429).

Köhler (2008: 426) argues that ecological research on woody climbers started in Berlin in the late 1970s, when species such as English ivy (*Hedera helix*), an evergreen species and Boston ivy (*Parthenocissus tricuspidata*), a deciduous species, were planted throughout all the city districts. Köhler's own research (*ibid*., 2008: 426) proved that these ivy species are able to cover huge window-free walls in a few years, with little maintenance.

Despite the earlier perception that vegetated walls were merely a cost-saving measure, research by Bartfelder and Köhler (cited in Köhler, 2008: 426), undertaken in Berlin in 1987 and in Cologne thereafter, also emphasised the capacity of vegetation on walls to trap airborne particulates on their leaves and to ameliorate the building's interior temperature regime. Köhler (2008: 426) holds that this research has contributed largely to new policy guidelines in Germany that promote the greening of walls.

Patrick Blanc (1953 – present), who coined the term *mur vegetal* (green wall) can be regarded as the father of modern vegetated walls. His work, which spans several decades since the late 1970s, includes more than 40 vegetated wall projects worldwide. His background in botany led him to explore and experiment with floristic diversity and ways in which plants exploit vertical surfaces (Dunnett & Kingsbury, 2010:245). It led to a worldwide realisation of the possibilities and advantages of vertical planted walls.

DIFFERENT APPROACHES TO VEGETATED WALLS

The term 'green' wall has become a generic description for almost all building walls covered by, hosting or supporting vegetation. Based on definitions developed by Francis and Lorimer (2011), Dunnett and Kingsbury (2010), Pérez, Rincón, Vila, González and Cabeza (2011), Ottelé, Perini, Fraaij, Haas and Raiteri (2011) and Hedberg (2008), a distinction is drawn in this paper between green façades › and living walls, which is explained further on. Pérez *et al.* (2011: 4855) suggest that as with vegetated roofs, vegetated walls can also be classified as extensive, meaning easy to build and requiring little maintenance, or intensive, referring to systems that are complex to install and will require intensive subsequent maintenance.

These authors (*ibid*., 2011: 4854) also found that while building systems for green roofs are well researched and many standardised construction systems or techniques have been developed over decades, in the case of vegetated façades, i.e. green façades and living walls, there are too many differences between the two approaches to compare their previous experimental results.

In another approach, by Sheweka and Magdy (2011: 594), vegetated walls are divided into three fundamental types, according to the species of the plants, types of growing media and construction method (see Table 1):

TABLE 1. COMPARISON OF THREE VEGETATED WALL METHODS

Type	Plants	Growing media	Construction type
Wall climbing	Climbing plants	Soil on the ground or in planter box	Minimal supporting structure is needed
Hanging down	Plants with long, hanging-down stems	Soil in planter box at every storey	Planter boxes and supporting structure should be built at according storey
Module	Short plants	Lightweight panel of growing media (such as compressed peat moss)	Supporting structure for hanging or placing modules should be built on façades

(taken from Sheweka & Magdy, 2011: 594)

In terms of the distinctions drawn between green façades and living walls, Type 1 from Table 1 (wall-climbing plants) would occur both on green façades and living walls, whereas Type 2 (hanging plants) and Type 3 (module short plants) would typically occur on living walls.

GREEN FAÇADES

This term mainly refers to climbing plants, such as the ivy species, typically *Hedera helix* or *Parthenocissus tricuspidata* and *P. quinquefolia*, that are encouraged to grow up and along the walls of buildings (mainly on a wire or trellis framework or directly on the wall surface itself) to form a vegetation covering, although the roots of the plants are still contained in a substrate at the base of the wall or planted in natural ground.

Pérez *et al.* (2011: 4855) differentiate between different green façade systems; i.e. '…traditional green façades, where climber plants use the façade material as a support' (direct green, see Figure 1) and a '…double-skin green façade or green curtain, with the aim of creating a double-skin or green curtain separated from the wall' (indirect green, see Figure 1). In the case of double-skin green façades, climbing plants grow on lightweight metal trellises that are fixed onto the building's walls, with a cavity between the plants and the wall structure for waterproofing and wall-maintenance purposes.

Dunnett and Kingsbury (2010: 191) further maintain that self-clinging façade greening, where climbers attach themselves directly to the wall surface, carries the possibility of root damage and the difficulty of later wall maintenance; thus concluding that modern practice is to hold the planting away from the wall.

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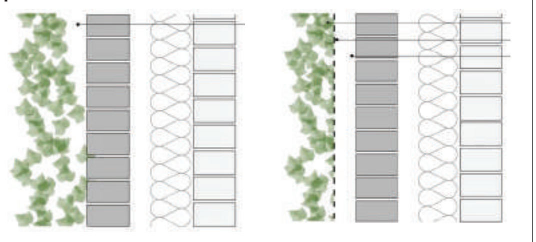

LIVING WALLS

This term refers to a wall that incorporates vegetation into its structure or onto its surface, and which does not require the plants to be rooted in a substrate at the base of the wall as with green façades. Most living-wall systems are modular and consist of an encased growing medium (a planter) placed onto the wall surface but kept separate from the wall via a waterproof membrane or a cavity; or, as Pérez *et al*. (2011: 4855) state, consist of a system that can support non-climbing plants that are secured in pockets provided in a vertically hanging geotextile mat or panels, and which are supplied with irrigation water and nutrients in solution (refer to Figure 2):

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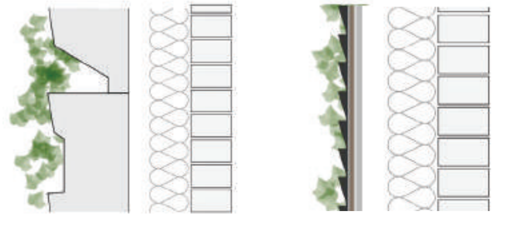

1 *Direct and indirect green façades (taken from Ottelé, Perini, Fraaij, Haas & Raiteri, 2011: 3421)* **2** *Living wall systems (taken from Ottelé, Perini, Fraaij, Haas & Raiteri, 2011: 3425)*

Living-wall systems are not dependent on a limited range of climbing plants to the same extent as green façades; this allows for a far greater range of species to be utilised. The living-wall approach thus increases the potential to utilise vegetated walls for reconciliation ecology and biodiversity. ›

THE NATURE OF A VERTICAL PLANT HABITAT

The verticality of a green façade or living-wall habitat affects its environmental conditions in many ways, some of which are listed here (Larson *et al*., 2000: 43):

- On level ground a habitat's gravity is perpendicular to the surface, tending to stabilise it, whereas on a vertical habitat gravity tends to destabilise it, removing rock, organic litter, soil, plant nutrients and water;
- The amount of direct solar radiation received on the surface;
- The amount of moisture (in the form of precipitation) received and retained;
- The effect that cliff faces have on the speed, pattern and turbulence of localised winds;
- Depending on aspect, slope and the geology of the rock face, the temperature of the rock face can vary drastically from surrounding level-ground surfaces. Larson *et al.* (2000: 44) find that '…an exposed rock surface of any given slope or aspect can represent a more extreme thermal environment than a soil-covered surface with the same exposure'; and
- The topographic heterogeneity of the cliff face itself; cliff faces are rarely a homogeneous flat vertical rock face but are heterogeneous in terms of ledges, undercuts and crevices, which can result in microclimate variances.

Blanc (2008: 75) postulates that the walls of old buildings or site structures often host floral communities comparable to what is found on natural cliff faces. Some of the plants thus referred to, especially in the tropical regions, have a destructive impact on the structures, e.g. the strangler fig species. He finds that in temperate climatic regions, the colonising species is often herbaceous or consists of small shrubs from families such as Graminae and Crassulaceae. In tropical Asian countries, such as India, two Ficus species – i.e. *F benghalensis* and *F. religiosa* – cause major damage to walls and natural rock formations, and similarly in SA, Ficus species such as *F. ilicina*, *F. ingen* and *F. tettensis* are well known for their rock-breaking ability.

BENEFITS OF GREEN FAÇADES AND LIVING WALLS

The benefits and inherent value of green façades and living walls have been researched and expounded by numerous authors, such as Dunnett and Kingsbury (2010), Aragonés and Olivieri (2010), Cameron *et al.* (2014), Sheweka and Magdy (2011) and Ottelé *et al.* (2011), since the late 1970s. Some of these benefits include:

- Ameliorating the effect of urban pollution, such as trapping dust, recycling CO2 and sequestering carbon, and breaking down many gaseous pollutants such as volatile organic compounds;
- Absorbing some of the heat trapped in city environments, i.e. ameliorating the so-called Urban Heat Island effect caused by the trapped heat in 'urban canyons', reradiated heat from building materials with a high thermal capacity, the greenhouse effect caused by heat trapped in polluted urban atmospheres, as well as anthropogenic heat sources such as air conditioners, cars and industrial combustion. Sheweka and Magdy (2011: 592) find that ambient temperature in urban areas can be as much as 6°C warmer than the air in surrounding rural areas;
- Acting as a shading device on sun-exposed walls or to a lesser extent as a thermal insulating barrier to building façades. In their study on the effect of the thermal and illuminance performance of a vegetated wall, Ojembarrena, Chanampa, Rivas, Olivieri, Aragonés, González and Frutos (2013: 262), as well as Sheweka and Magdy (2011), found that a vegetal layer on the building façade ameliorates the inside temperature due to the vegetation's shading effect and the cooling influence of evapotranspiration from leaves; these effects reduce the temperature of outside air being introduced into the structure, and in the process the vegetal layer helps to ameliorate uncomfortable summer conditions. Research by Cameron *et al.* (2014) has shown that in terms of wall-cooling potential, certain species e.g. *Fuchsia* spp. promote evapotranspiration, whereas shade cooling is more pronounced with plants such as the *Jasminum* and *Lonicera* species;
- Increasing the biodiversity in urban contexts;
- Absorbing noise and providing some sound insulation; and
- Improving the visual and aesthetic aspects of city buildings.

IN 1993, THE RENOWNED CHILEAN LANDSCAPE ARCHITECT JUAN GRIMM, WITH ARCHITECTS HENRY BROWNE AND BORJA HUIDOBRO, DESIGNED A VERTICAL SUN-SCREENING LIVING WALL FOR THE WESTERN FAÇADE OF THE CONSORCIO NACIONAL OFFICE BUILDING IN SANTIAGO

Pérez *et al.* (2011) suggest that when considering vegetated walls as passive energy-saving measures, four mechanisms should be kept in mind:

- Shading of solar radiation by the vegetation. This will be determined by the plant species and density of the foliage;
- Thermal insulation provided by the vegetation as a second building skin. The air cavity between the plant screen, covered with leaves in the summer, and the building façade act as an insulation layer, whereas in the winter months and with deciduous plants, solar radiation is allowed in to heat up walls with a high thermal capacity;
- The cooling effect around a building façade caused by evapotranspiration from the vegetated wall's ›

foliage and evaporation of moisture from the plant containers; and

- Screening or blocking of winds by the vegetated screen. The effect is mostly applicable in colder climates, and is determined by the foliage density and the façade's orientation in terms of the wind direction.

SOME VEGETATED WALL EXAMPLES

In 1993, the renowned Chilean landscape architect Juan Grimm, with architects Henry Browne and Borja Huidobro, designed a vertical sun-screening living wall for the western façade of the Consorcio Nacional office building in Santiago. The design consists of planting on a metal trelliswork in three horizontal tiers, with the lowest screening four office floors, the second three floors and the top tier two floors, each.

The plants are planted in concrete troughs at the bottom of each tier and climb up the trelliswork, which is 1.4m away from the primarily west-facing glass façade. Whereas the planting, mainly consisting of *Bougainvillea spp* and the SA *Plumbago capensis*, is used as a sun-screening device, the aesthetic value of the plants that change colour over the seasons was a major consideration (refer to Figure 3).

LIVING WALLS REFER TO WALLS THAT INCORPORATE VEGETATION INTO THEIR STRUCTURE

Chanampa, Rivas, Ojembarrena and Olivieri (2010) propose a vegetated wall system that they term a *vegetal gabion façade*, and which is perhaps the closest in design to the principles established via the UP Plant Sciences living wall.

3 *The vertical living sun-screening wall of the Consorcio Nacional building in Santiago designed by Chilean landscape architect Juan Grimm (image by author).* **4** *The north-western living wall of the UP Plant Sciences building (image by author).*

Their system consists of 550mm thick galvanised steel wire-mesh rock baskets (gabions) filled with rocks, but with their inner faces stacked with 265mm thick polypropylene cells filled with a suitable water-retaining growth medium. The gabions are tied to each other and fixed to the building wall behind with steel struts, with an extruded polystyrene insulation layer and a 200mm air gap in between. Vegetation is planted in the plastic cells and finds its way through voids in the rocks to the light on the outer face of the wall. Irrigation is provided by drippers on the back face of the gabions. Unfortunately, the authors do not present examples of where their *vegetal gabion façade* system has been implemented. An accessibility problem may arise for this system when plants have to be replaced or treated for disease, or when the soil has to be replaced or replenished.

Bill Watts and Sean Affleck (2008: 78), respectively the architect and engineer of the proposed experimental Algae Tower project in Leeds UK, propose a concept of cladding a building with clear polycarbonate tubes containing an algae suspension that intercepts solar radiation before it can enter the building. This encourages rapid algae growth, which can then be harvested and processed into a biofuel that is able to power the building's systems. Although an extreme example, it does fall into one of the categories described earlier; their proposal hints at future directions of utilising vegetation in a vertical application against building façades to achieve other ecological benefits.

THE UP PLANT SCIENCES LIVING WALL

This project on the UP's main campus was designed by kwpCREATE Architects and Landscape Architects, and was completed in 2013. It has two living walls – one a 'dry wall' on the northern wing facing north and primarily west, and the other a 'wet wall' on the southern wing, facing west.

The motivation for the living walls was to provide an artificial habitat for indigenous cremnophytic plants, since such natural habitats are relatively rare in urban contexts, contain rare and threatened flora, and should therefore form a useful addition to UP's Botanical Garden on campus (refer to Figure 4).

Of the 37 plant species introduced on the 'dry wall' section, 29 species have adapted well since 2013. This is however not the case at the 'wet wall', where only nine out of 21 species have been successfully introduced to date. This can be attributed partly to delays in completing the water-cascade system, and partly to an exceptionally cold first winter season during which the wall planting had to become established.

Sourcing of indigenous cremnophytic plants proved difficult since these are, as a rule, not available commercially and the project relied heavily on specimens sourced from botanical gardens and speciality growers. ›

THE CONSTRAINT OF LIMITED RESOURCES AVAILABLE TO CREMNOPHYTES ON NATURALLY OCCURRING CLIFF FACES, SUCH AS RESTRICTED GROWTH SPACE AND LIMITED SOIL AND MOISTURE, HAVE BEEN LARGELY ELIMINATED ON THE UP PLANT SCIENCES WALL

CONSTRUCTION

The design of the living wall consists of a rock-filled gabion screen, supported on a steel frame four storeys high, and with soil-filled planters in 11 rows over the total height behind the rock wall. Access for maintenance of the planters is via an 800mm wide workspace between the rock wall and the building's external wall (refer to Figure 5). Mainly cremnophytes are planted in the planter boxes, and led through the rock screen to the outside via uPVC pipes cut open to allow for stem growth. Cremnophytic aloes, such as *Aloe hardyii*, are planted in soil-filled inclined uPVC pipes and grounded in the planters behind them (see Figure 6).

Although gabions or rock-filled baskets are not considered ideal planting structures, since there are usually large voids between the rocks in the gabion (Dunnett & Kingsbury, 2010: 251), this aspect has been used as an advantage in the UP living wall where the cremnophytes have been encouraged to occupy such voids when growing from the planters behind the gabion screen wall. The constraint of limited resources available to cremnophytes on naturally occurring cliff faces, such as restricted growth space and limited soil and moisture, have been largely eliminated on the UP Plant Sciences wall, where the only significant remaining environmental constraint is the gravitational pull associated with a vertical habitat.

In considering the north- and west-facing aspects of the UP living wall, a method had to be found to ensure moisture availability to the plants. Whereas cliffs generally receive slightly less sunlight than horizontal surfaces, Van Jaarsveld (2011: 30) finds that the reverse is true in the winter months when peak radiation levels on north-facing cliffs are slightly higher. West-facing walls receive about half the radiation of north-facing walls. He (*ibid*., 2011: 2) finds that north- and west-facing cliffs result in higher exposure to sun (north throughout the day and west during the hot afternoons), and therefore do not hold moisture as long as the cooler south-facing walls.

Larson *et al.* (2000) find that another difference between natural and man-made cliff faces is the moisture-holding capacity of naturally weathered rock faces, which is much higher than the fresh, unweathered rocks one would normally use when creating a man-made rock wall as a habitat for cremnophytes. The colour of the rock face also ›

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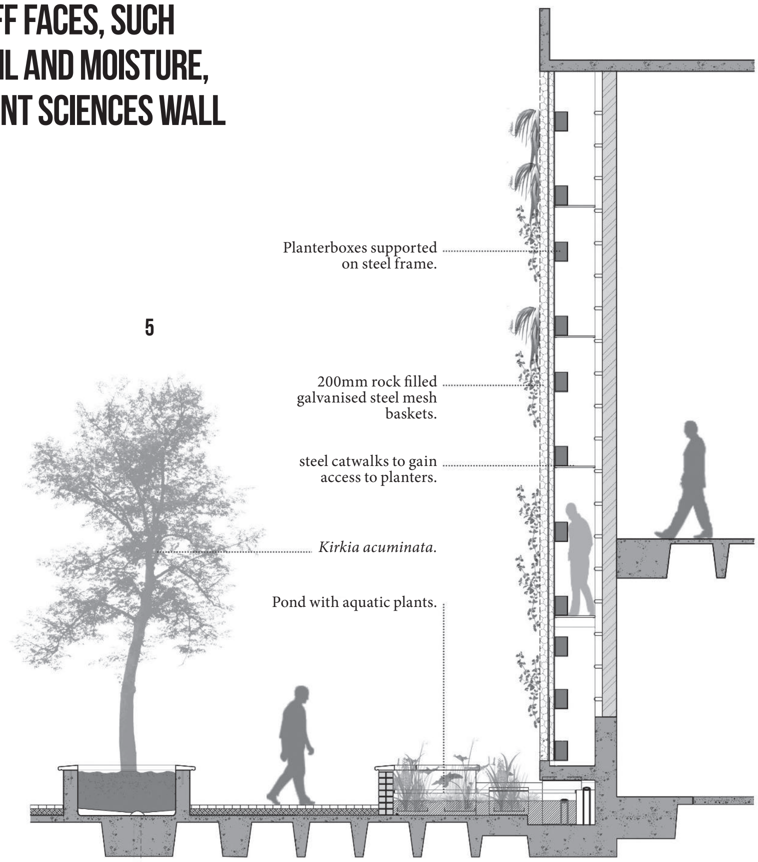

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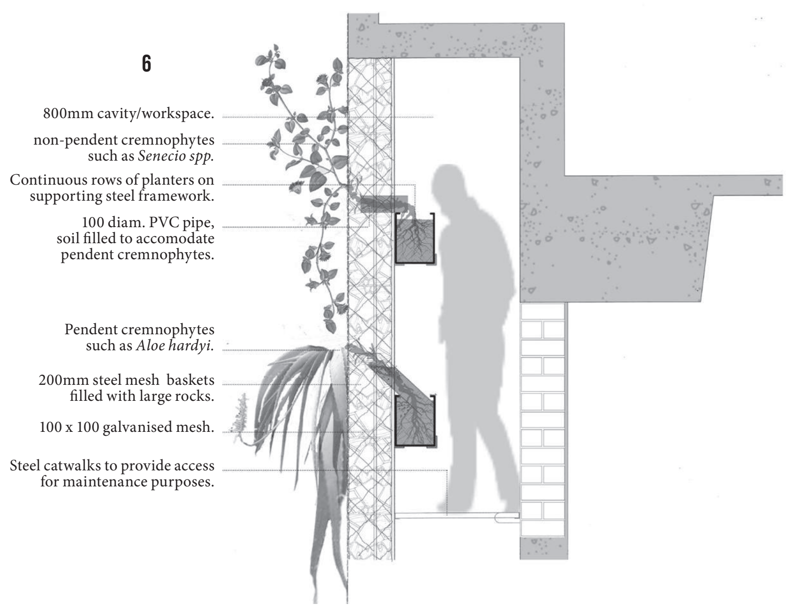

5 *Section through the rock-face wall with pond at bottom (Courtesy of kwpCREATE Architects & Landscape Architects).* **6** *Detail section through the rock-face wall (Courtesy of kwpCREATE Architects & Landscape Architects).*

determines its temperature; dark-coloured rock, like some granites found in South Africa, have an albedo (the ratio of light reflected from a surface to that received by it) as low as 0.05, with a resultant high absorption of solar energy, whereas white limestone could have an albedo value as high as 0.7 (Larson *et al.* 2000).

The quarzitic rock used in the UP Plant Sciences wall varies from light greyish-yellow to light brown in colour. Whereas cognisance was taken of Van Jaarsveld's (2011:21) finding that obligate cremnophytes' endemism to a specific rock type (i.e. occurring only on such rock types) is high and geology therefore plays an important role, the possibility of displaying cremnophyte endemism on the UP Plant Sciences wall, based on a specific cliff-face geology, could not be entertained.

IRRIGATION

The introduction of obligate cremnophytic succulents on the UP living wall was a prime consideration, however, and in an attempt to also provide for opportunistic cliff dwellers, other species, not strictly succulents, have been introduced – thus requiring an artificial irrigation supply system. This has been achieved by the provision of a PVC dripper line to each row of planter boxes and can be regulated either automatically or manually, depending on the amount of rainfall received.

Irrigation is supplied at an average of 2-4l/m²/day of vertical surface. In other not necessarily cremnophyte-focused living-wall systems, plants are planted onto a geotextile membrane or in pockets between two layers of geotextile; the wetted geotextile acts as the irrigation supply and the plants root onto the geotextile (refer to Figure 2).

This technique requires irrigation at 3 to 5l/m²/d depending on season, aspect and wind (Blanc, 2008: 98). In these systems, the essential plant nutrients are dissolved in the irrigation supply water at 0.2 to 0.3g/l; the technique was developed in 1991, in France, by Patrick Blanc. At the UP living wall, nutrients are provided in the soil medium and regular soil tests should indicate when additional fertilisation is required.

WET WALL

In an attempt to mimic the vegetation habitat of a natural waterfall and its immediate surrounds, a 'wet wall' section of a living wall was created at the southern west-facing wing of the building (refer to Figure 7). On the middle section of the wall, slightly set back, two horizontal water-supply pipes were installed – one at the top and the other halfway up. From these two dripper pipes, a constant discharge creates a habitat for hydrophilic cremnophytes. ›

7 *The west facing wet living wall of the UP Plant Sciences building (image by author).*

8

Water is collected in a pond at the bottom and recirculated (refer to Figure 8); hydrophytic companion plants have been provided here.

FINDINGS

The research undertaken on the different approaches to constructing green façades or living walls indicates that the differences are not merely semantic, but fundamental in terms of appropriate wall construction methods to support specific plant species, as well as maintenance requirements; where green façades typically require extensive (little) maintenance, living walls require intensive and often complex maintenance.

The research furthermore finds that there are essential differences, benefits and constraints of creating a vertical as opposed to a horizontal plant habitat. The case study of the vegetated wall at the UP Plant Sciences building shows that in terms of the described categories and associated characteristics, it can best be described as a living wall. The case study also indicates that there are constraints in recreating or mimicking a natural vertical cliff face that can support indigenous cremnophytes.

CONCLUSIONS AND RECOMMENDATIONS

Green façades or living walls pose many challenges in terms of appropriate construction methods, plant selection, maintenance and sustainability. Cameron *et al.* (2014: 199) express their concern that some 'green' wall systems do not meet other sustainability criteria, e.g. not being wasteful of water, nutrients and energy usage to pump irrigation water to the wall planting.

Over the past 40 years, there have been various approaches worldwide towards designing and constructing green façades or living walls, each with its own advantages and disadvantages and with some more or less sustainable.

Whereas many vegetated-wall construction methods can support a wide variety of plant species, recreating or mimicking a natural vertical rock wall to support cremnophytes remains problematic in terms of the specific requirements of such plant species and the difficulty of sourcing indigenous cremnophytes.

The project at the UP Plant Sciences' living wall, intended to mimic a cremnophyte habitat and populated only by indigenous species, must be seen as a first of its kind and an experiment in progress. It is recommended that, despite some problems with the initially selected plant species, new cremnophytic species should be introduced on an ongoing basis and the success of the existing plants should be monitored by the curator of the Botanical Garden on the UP main campus, of which the Plant Sciences' living wall forms a part. In the process, a unique habitat will be created that will support these relatively rare species and will serve as an educational and research opportunity. ■

8 *Pond at the bottom of the wet living wall of the UP Plant Sciences building (image by author).*

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