TECHNICAL REPORT:

VanDusen Botanical Garden Visitor's Centre and Green roof

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Abstract

The new VanDusen Botanical Garden Visitor's Centre has been awarded many times since its completion; it is also recognized as the first Living Building in Canada. In this report, we demonstrate successful elements of the project that helped satisfying requirements for qualification. We will illustrate the holistic system of building and the landscape, putting more focus on its green roof and its technological details.

Key Words

VanDusen Botanical Garden, Greenroof, Zinco, Cornelia Oberlander, Ken Lasson, Living Building Challenge, Vancouver, Perkins + Will, Extensive green roof, Georaster, Floradrain, Floraset, Net Zero energy

Introduction

The new VanDusen Botanical Garden Visitor's Centre, located in Vancouver, Canada, celebrated its second anniversary of operation on 23rd October 2013. Despite the fact this project was completed at a relatively low budget of $21.9 million Canadian dollars, the building has been awarded a number of times for its sustainable design and engineering excellence, since its completion. The building and landscape was designed by the architectural firm Perkins + Will, and landscape architects Cornelia Hahn Oberlander and Ken Larsson.

About the VanDusen Garden

The majority of the project's budget was spent for construction, totaling $14.4 million dollars. Its area consists of 17,000 square meters, of which the total building footprint is 1,765 square meters (Larsson & Oberlander, 2013). From the outset, the design goal was to meet the Living Building Challenge, which is said to be the most rigorous set of requirements for sustainability. The building itself functions as a community oriented center of the Botanical Garden; it contains a cafe, library, volunteer facilities, garden shop, offices, and classroom space for meetings, workshops, lectures and private functions (VanDusen Visitor Centre). The design of the visitor centre was inspired by the form of a picture of a BC orchid plant that is found in the book called "The Alphabet of Plants" by Karl Blosfeldt. Its roofs mimics the "petals" of an orchid sitting a top the "stem", which has translated into the structure of the central atrium and lobby (Larsson & Oberlander, personal communication, April 4, 2014).

The Living Building Challenge

The Living Building Challenge requirements are as follows: net-zero energy, net-zero water, non-toxic, as well as the reduction of a project's embodied carbon footprint utilizing carbon offsets and at least 80 percent recycling of the total construction waste generated on site (Petals + Imperatives, n.d.). In order to achieve such goals, the VanDusen Visitor Centre features a number of energy efficient and sustainable design elements such as green-roof, geothermal heating, solar panels, a water capture system, and an organic water purification system (Figure 1).

Net Zero Water and Ecological Water Flow

First, the facility uses on-site, renewable sources to achieve net-zero energy on an annual basis;

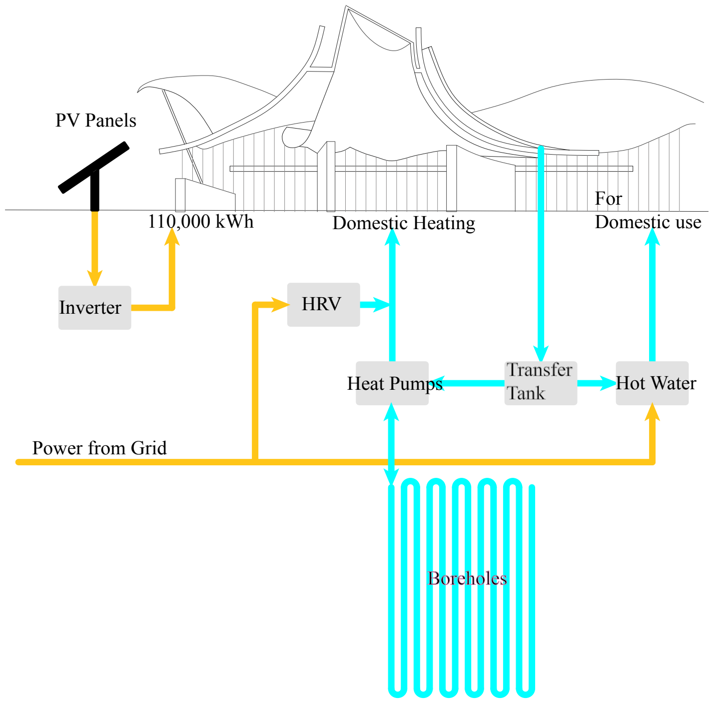

FIGURE 1.
Living Building System of VanDusen Garden Visitor's Centre Diagram Based on (Larsson, Oberlander, Schwenger & Schwenger, p.6)

sequestering enough carbon to achieve carbon neutrality; and uses filtered rainwater for the building's grey-water requirements. The site treats one hundred percent of the centre's black-water utilizing an on-site bioreactor. Rainwater is collected from the green roof, which after undergoing filtration is used as grey-water, most of it for flushing toilets within the building. The black-water treated by the on-site bioreactor is released into a percolation field and garden (Huffman, 2013).

Net Zero Energy

Regarding the heating and energy systems, 400 solar hot water tubes are installed in arrays on roofs of the Visitor Centre and the Floral Hall. The hot water generated on roof is stored in fifty-five, six meters deep geo-exchange boreholes which were dug on the periphery of the Visitor Centre's north end; the thermal energy generated is used for heating the building's water, and in addition, depending on the season for general heating or cooling needs. Photovoltaic panels, installed in the parking lot, are designed to produce 11 KW of power to be used within the facility (VanDusen Visitor Centre).

Sustainable Site

As explained above, the Visitor Centre uses on-site, renewable sources, such as geothermal boreholes, solar photovoltaic cells and solar hot water tubes, in order to achieve net-zero energy on an annual basis. In addition, the building is primarily constructed of lumber harvested from the devastation of the Mountain Pine Beetle, with the remainder sourced from FSC-certified wood products (Huffman, 2013). Furthermore, the reclaimed lumber is later used for its interior doors and partitions (VanDusen Visitor Centre).

Ventilation System

As for Ventilation System, the stem features a wide glass ceiling to allow not only natural light to enter the space, but also to serve as a natural heat chimney, pulling warm air from the interior, helping to maintain a comfortable balance for visitors within (As shown in Figure 2). The oculus of the atrium aids a kind of natural ventilation.

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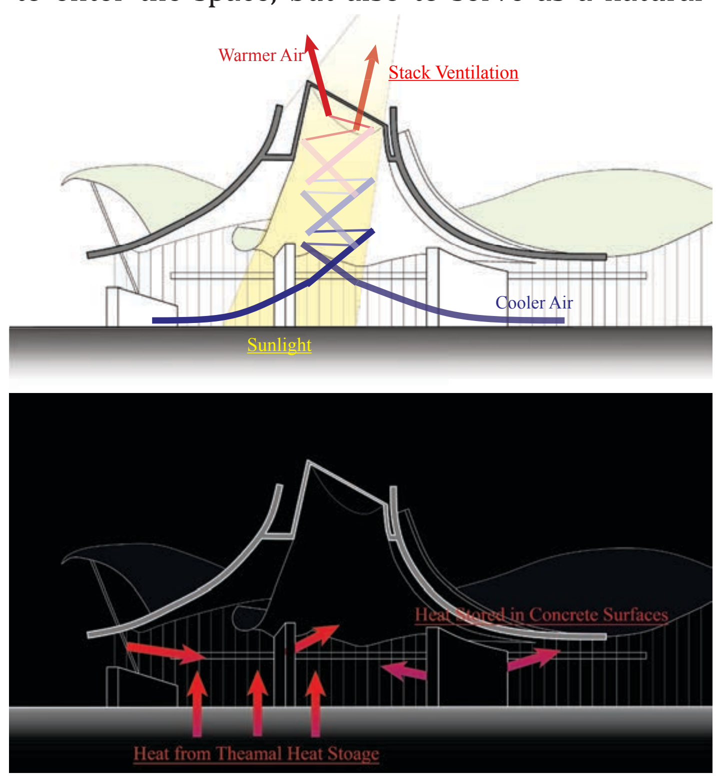

FIGURE 2.
Natural Heating and Cooling Ventilation System of VanDusen Garden Visitor's Centre

heat chimney, pulling warm air from the interior, helping to maintain a comfortable balance for visitors within (As shown in Figure 2). The oculus of the atrium aids a kind of natural ventilation system called stack ventilation; within this ventilation system, cool air from adjacent spaces is drawn into the centre, where it is funneled upward and finally exhausted as the air reaches warmer temperatures. The building is for the most part elongated to encourage cross ventilation of air from space to space (VanDusen LEED'S by example, n.d.). The architects took advantage of characters of the materials to aid natural warming and cooling processes. The concrete foundation and bearing walls absorb heat during the daytime. Following the sunset as temperatures begin to drop, the stored heat within the concrete is released and is mixed with the cooler air, aiding in the relief of the building's energy load. Wood materials, used on the roof, further promote the natural ventilation (Huffman, 2013). Other active systems including solar sinks to heat and distribute water throughout and a geo-exchange system, which collects both hot and cold energy from the ground, moving energy through the building (Vinnitskaya, 2012).

Plant Details of Cascadia Garden

The green roof and its landscape known as Cascadia Garden, was designed by the collaborative team of landscape architects Cornelia Hahn Oberlander and Ken Larsson (Larsson & Oberlander, personal communication, April 4, 2014). The building is designed in a manner to coexist among the rare trees, shrubs and plants situated in the botanical garden. Additionally, a large amount of plants that are utilized in the landscape design of its green roof were existing plans that were relocated for the design; this aided creating a seamless transition from the designed landscape to nature. Furthermore, Holly trees, which had to be removed but not used for the landscaping onsite, had been sent to other botanical gardens within Canada (Larsson & Oberlander, personal communication, April 4, 2014). According to Cornelia Oberlander, the plant inventory of the VanDusen Visitor Centre green roof landscape are as follows, with each garden representing "distinct ecological zones and from a rainwater garden to woodland to Garry Oak meadow. Each zone has been carefully designed and planted with native plants that flourished when Captain George Vancouver's botanist, Archibald Menzies first began cataloguing this diverse region in 1792. (Oberlander, n.d.)"(Figure 3)

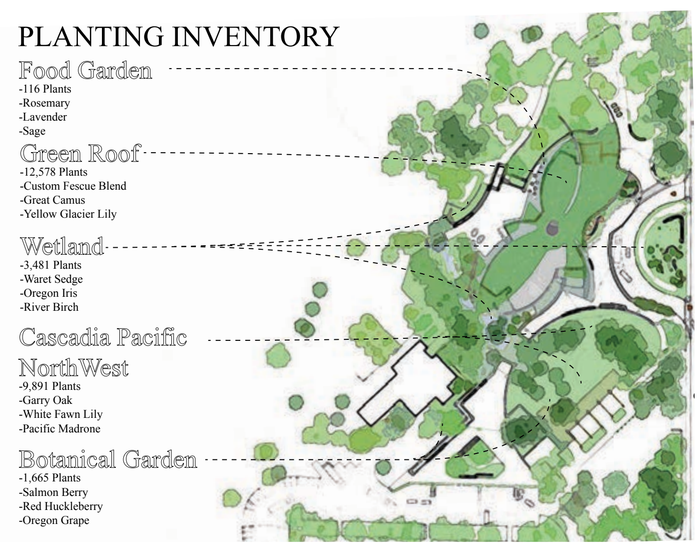

FIGURE 3.
Plant Inventory of "Cascadia Garden"
Diagram Based on (Larsson, Oberlander, Schwenger & Miller, p.12)

- Food Gardens consists of 116 plants including rosemary, lavender and sage. Eco-gardens educate the public on the process of nature and illustrate how these principals can be used in their own backyard (Oberlander, n.d.).
- Green roof includes 12,578 plants that were used to reflect "the Pacific Northwest Coastal grassland community including over twenty species of bulbs and grasses" (Oberlander, n.d.). Planted grasses don't grow taller than 6 inches, which reduces needs for irrigation, fertilization and mowing (Larsson & Oberlander, 2013).
- Rain gardens and wetlands, functions as the infiltration of stormwater runoff from the parking lots and impermeable surfaces, act as public demonstration of the stormwater management plan (Larsson & Oberlander, 2013).
- Cascadia Garden, were carefully designed to include native plants, forming a series of distinct ecological zones; old-growth trees were carefully preserved, facilitating an ecologically balanced system of wetlands, rain gardens and streams.
- Botanical Garden has 1665 plants including salmon berry, red huckleberry, and Oregon grape.

Green Roof Design

The original project proposal included a walkable green roof, which was flush with the edges of the roof. This proposal intended the building's roof to be visible and attractive for the passersby on Oak street, whether they were pedestrian or motorists. Because of security concerns set by Vancouver's building code, green roofs have to be set back from the edges and guarded with parapet walls. Serious attempts were made in order to defend the original design, including flying in Zinco specialists from Germany; however, City of Vancouver declared not to be able to provide warranty in case of sticking to the original idea. (Larsson, personal conversation, April 4, 2014)

The current design obeys the building code, and therefore only the Oculus, the highest part of the building is visible only as green roof from the ground (Figure 4).

FIGURE 4.
Entry to the VanDusen Botanical Garden's Visitor's Centre. Photo by Oliver Szelesky.

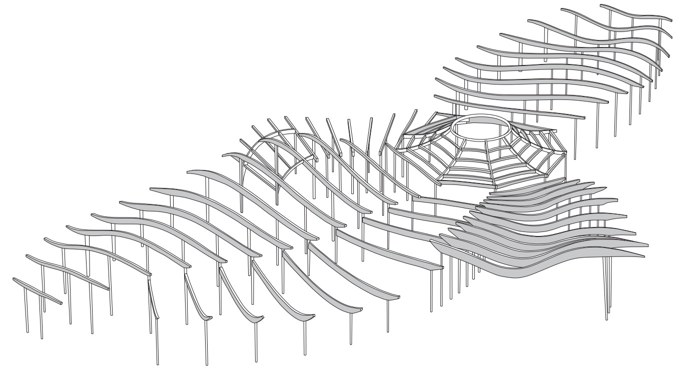

FIGURE 5.
Structure. Drawing based on (Palibroda, p. 19)

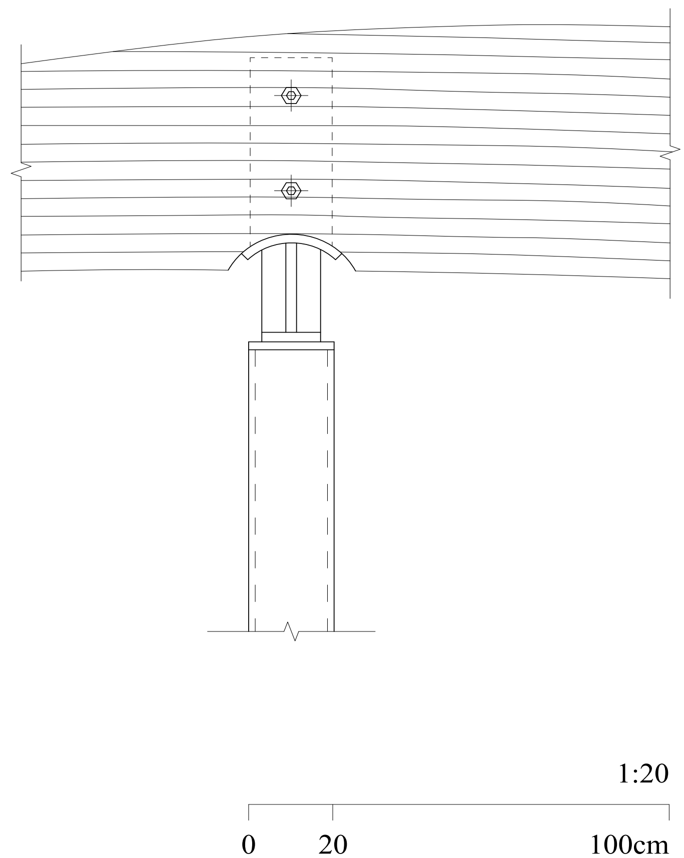

FIGURE 6.
Typical Column-Beam Connection Drawing Based on (Palibroda, p.19)

Roof Structure

The total roof area of the visitor's centre is 20 000 ft2; of this, 16 000 ft2 are planted and the rest 4 000 ft2 has gravel ballast on it. To be able to support its extensive green roof, the structure was designed to withstand 45 pounds per ft2 load.

The structure consists of sustainably harvested FSC fir glulam beams that are all uniquely shaped; the beams rest on steel-core wood columns (Figure 5 and 6). For ease of construction, and because of the complexity of its geometry, the roof was broken down to panels that were fabricated offsite. These panels contained lighting conduits, sprinkler lines, insulation, air/vapor barrier and acoustic liner/ply ceiling strip finish already when transported to site (Figure 7).

The structure also has to provide against the green roof slipping off as it accommodates 5% to 50% slopes; shear barriers within the deck and membrane systems were installed. (Larsson & Oberlander, 2013).

Green Roof

The visitor's centre has a traditional, non-inverted green roof: the insulation is found under the waterproofing layer, embedded in the prefabricated panels. It is an appropriate approach considering of the complexity of the project's form, assembly and construction time.

The lightweight growing medium is six inches deep at average; after the panels and Zinco systems were placed in place, growing medium was sprayed on.

To comply with the Living Building Challenge, only recycled water is allowed for irrigation purposes that the Visitor's Centre collects and treats for itself. Potentially, larger cistern and treatment facility could have been built for use of the adjacent buildings but was rejected because of budget restrains.

Water is collected from the blue roof; green roof water is diverted to gutter spouts, the stream and wetland areas. (Larsson & Oberlander, 2013)

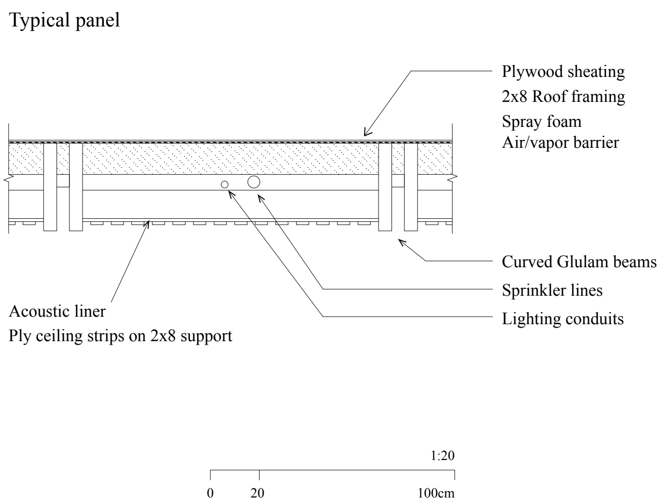

FIGURE 7.
Typical panel
Drawing based on (Palibroda, p. 22)

Roof Types

The roof could be divided to four zones (Figure 8): the Oculus, Petals, Landramp and the Blue Roof area. These areas have different slope conditions and planting requirements; these areas define what Zinco system they are built on.

- The Landramp, being the most gentle, uses Floradrain FD40-E (Figures 9 and 10). Maximum angle is 8 degrees.
- The Petals area is planted on Floraset FS-75 (Figures 11, 12 and 13), on slopes of 10 to 25 degrees.
- Finally, the Oculus is the steepest with 20-35 degree angles - here a layer of Georaster (Figures 14, 15 and 16) system keeps the growing medium in place.
- Floradrain FD40-E and Georaster are made of recycled polyethylene; Floraset FS-75 is produced CFC free (Zinco Canada, 2012).

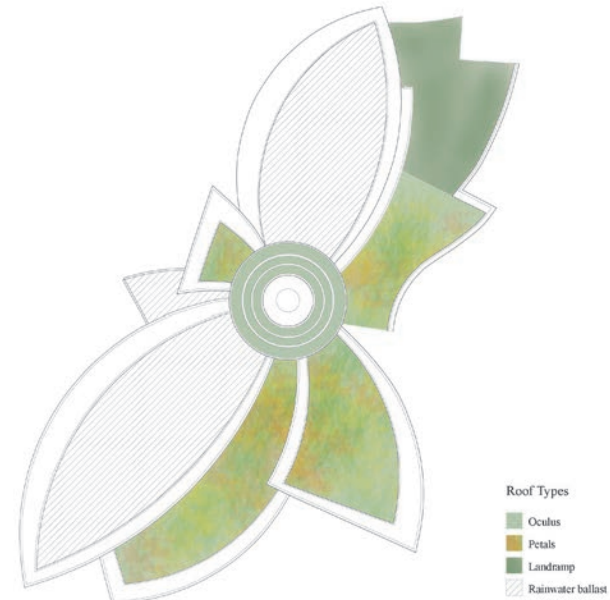

FIGURE 8.
Diagram based on (Larsson, Oberlander, Schwenger & Miller, p.14)

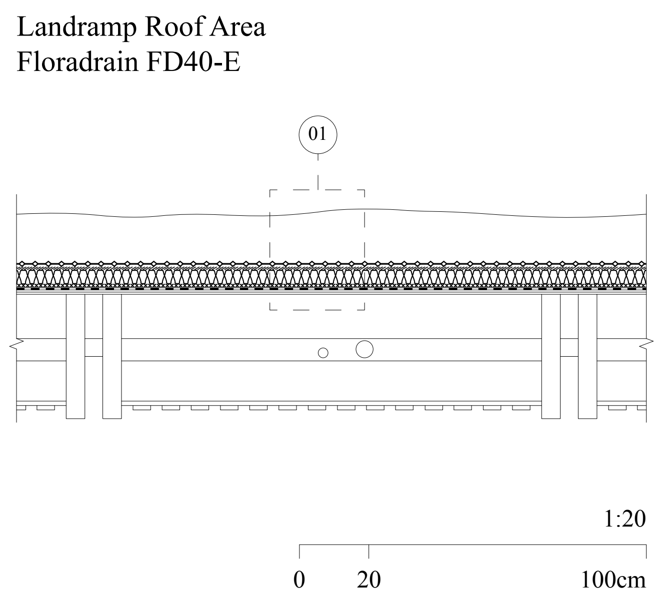

FIGURE 9.
Floradrain FD40-E on typical panel in Landramp roof area, section Drawing based on (Larsson, Oberlander, Schwenger & Miller, p.15)

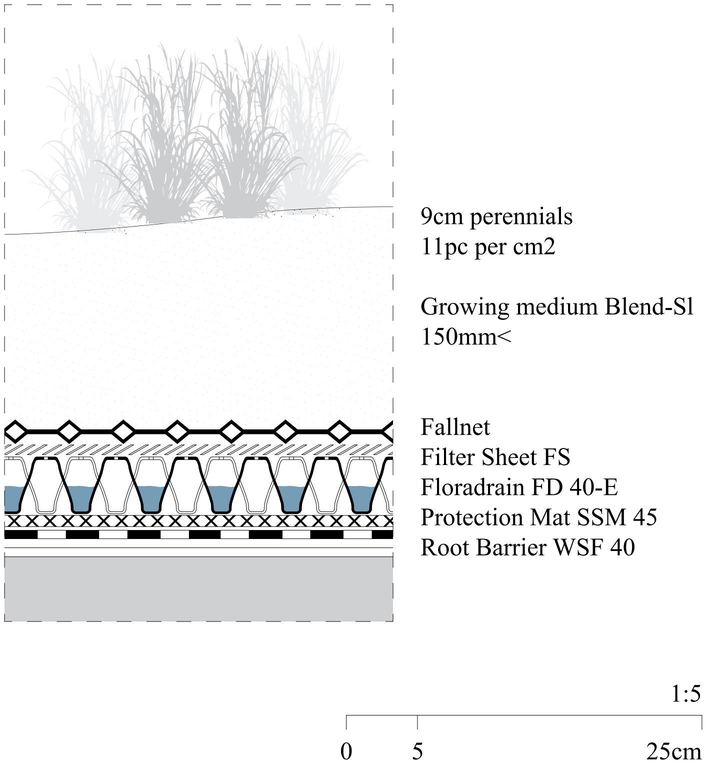

FIGURE 10.
Floradrain FD40-E Detail
Drawing based on (Larsson, Oberlander, Schwenger & Miller, p.15)

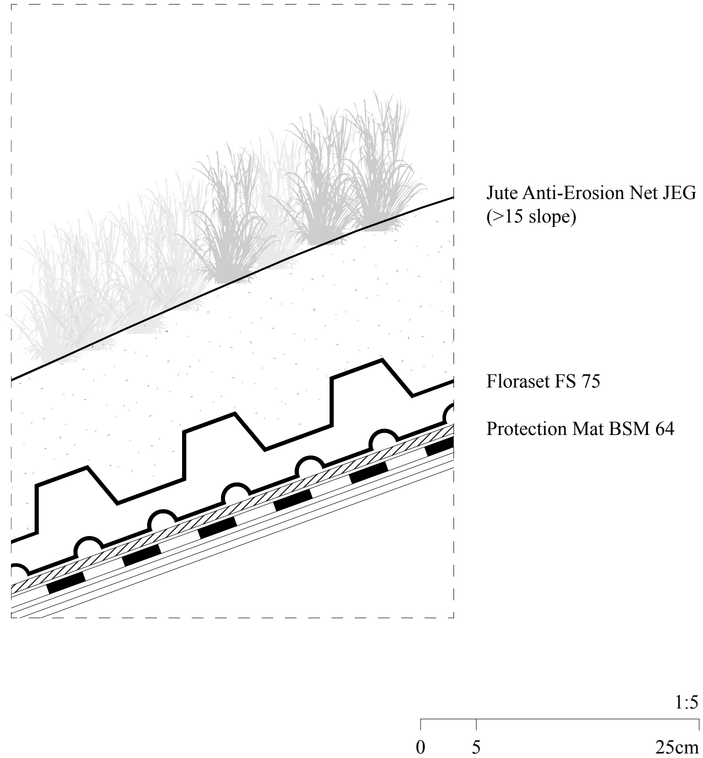

FIGURE 12.
Floraset FS 75 Detail. Drawing based on (Larsson, Oberlander, Schwenger & Miller, p.16)

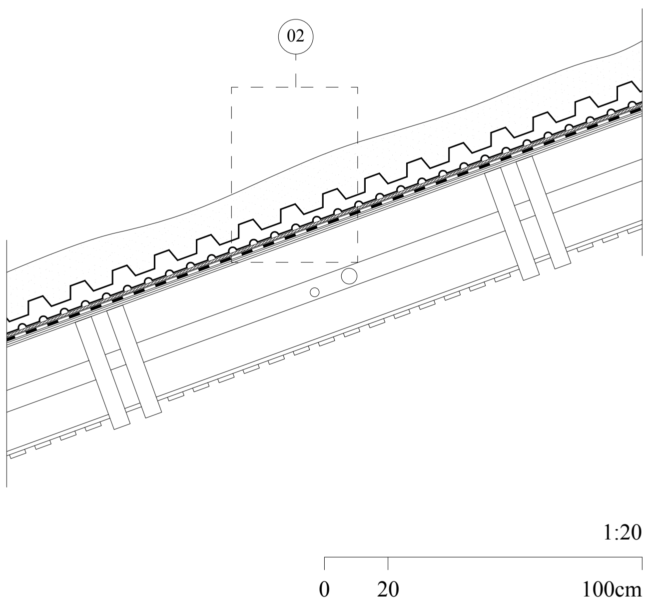

FIGURE 11.
Floraset FS 75 on typical panel in Petals roof area, section

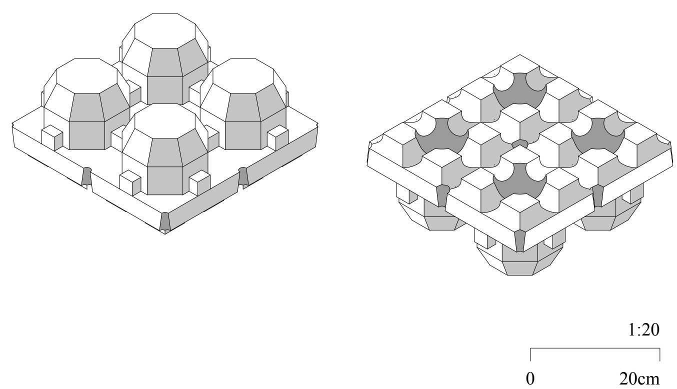

FIGURE 13.
Floraset FS 75, Isometric view, top, bottom
Drawing based on (Larsson, Oberlander, Schwenger & Miller, p.16)

Stormwater Retention

The stormwater retention capacity was calculated using the SCS method based on annual average precipitation broken down to an average rainy day in Vancouver, provided by Statistics Canada (Environment Canada, 2007) and an online calculator (Pr. Patel, 2013), using the formula , where and .
(Q = runoff, P = rainfall, Ia = Initial abstraction, S = potential maximum soil retention after runoff begins, CN = Curve Number)

Average rainfall on a rainy day equals to 0.3 inches. The Curve Number for the green roof is chosen to be 75; the drainage area, which is the roof area, is 0.367 acres.
The calculation outcome tells us that the Potential Maximum Retention is ‘S’ = 3.33 inches; Initial Abstraction is ‘Ia’ = 0.67 inches; Runoff is ‘Q’ = 0.05 inches and Runoff Volume is ‘Qv’ = 0 acre-ft.
This outcome suggests that the Green Roof is an important part of the VanDusen Botanical Garden’s stormwater retention system.

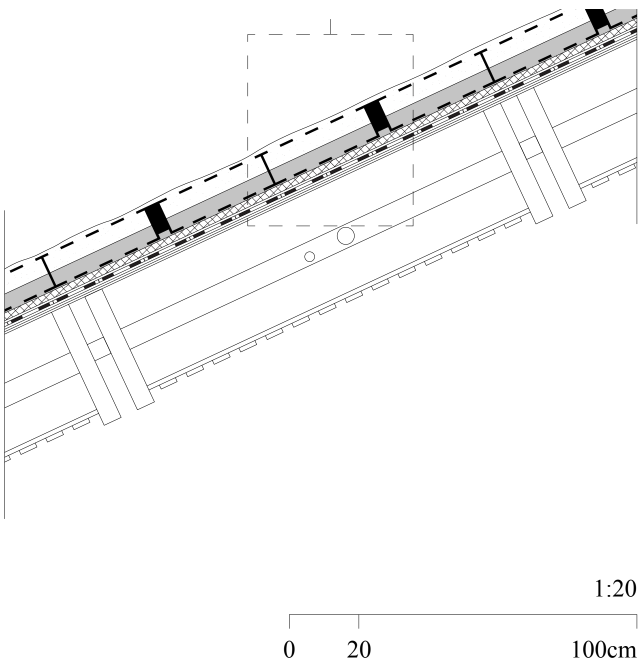

FIGURE 14.
Georaster on typical panel in Oculus roof area, section
(Larsson, Oberlander, Schwenger & Miller, p.16)

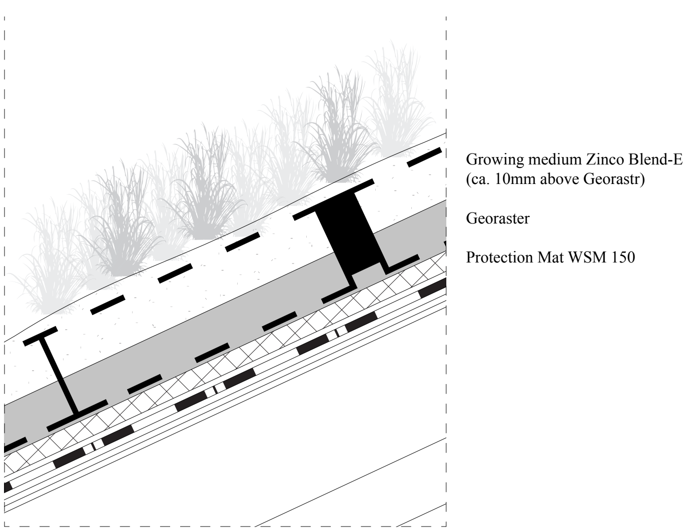

FIGURE 15.
Georaster Detail
(Larsson, Oberlander, Schwenger & Miller, p.16)

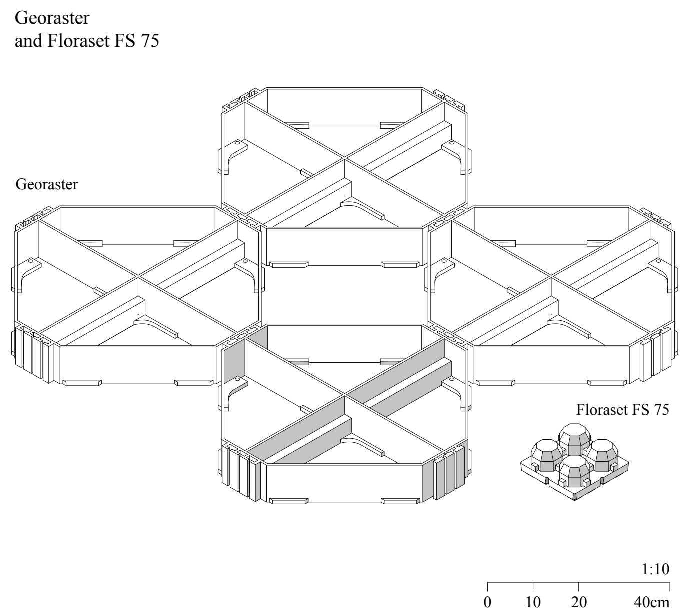

FIGURE 16.
Georaster and Floraset FS 75, Isometric view
Drawing based on (Larsson, Oberlander, Schwenger & Miller, p.16)

Conclusion

Regarding the green roof, the Oculus was one of the most expensive and problematic parts of the design, with its steep slopes and unusual shape. Since it the only visible part of the vegetated roof, and is inaccessible to visitors, it leads to question the necessity of planting in the Petals and Landramp zones.
One could argue that instead of a living roof, already in place L.I.D. systems could have served similar purposes while avoiding higher costs, and the failure to fulfill original expectations. It is stuck between two roads: it is inaccessible to people, therefore they can’t get involved with its fine design. On the other hand, it’s too precious to be just an average extensive roof.
Seeing the overarching theme of the project, however, one can reason otherwise. It was a project of rejuvenation of the Botanical Gardens, involving highly inspired concepts by Cornelia Oberlander and Ken Larsson that turned the building into a flagship of excellence qualifying for the Living Building Challenge, first in Canada. Its green roof is not just a design element, but fundamental part of the holistic system that unites architecture with its very site.

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