

Dear Reader,

Green Roofs, Eco-Roofs, Skyrise Greenery, Roof Gardens or Living Roofs, there is a wide range of terms to describe the installation of a natural vegetation layer on roof surfaces. Our latest newsletter will present some common features which make the classification of Green Roofs easier.

In addition, we will shine the spotlight on the situation in Spain and Asia, where Green Roofs are well on their way. Some exceptional Green Roof projects like the first Drive-Through Roof Garden in Singapore and the Nature Conservation Centre in the biosphere reserve of Asturia round off the Spring issue of Green Roof News.

Have fun reading!

Wolfgang Ansel
Director IGRA

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A Technical Challenge:

The First Drive-Through Roof Garden in Singapore

Singapore, the modern city state on the outermost peak of the Malayan peninsula, has demonstrated again its leading position as the technical hub of South East Asia. The metropolis of several million inhabitants has become even richer thanks to an unusual but extremely practical attraction.

To make it more tempting to potential customers to buy one of their models, the Motor Image Enterprises Pte Ltd Group has just moved a multi-terrain track onto the roof. During the test drive, the car buyer forgets pretty fast that he is on an approximately 1,300 m² large show-course on top of the six-storey sales building in the centre of Singapore. A waterfall,



Multi-terrain track for all-wheel test-drives

mud passages, as well as lawn areas and palm trees on the side of the road reinforce the impression of being on a real open terrain. This combination of driveways and roof garden wouldn't have been possible without a technically accurate system build-up, especially developed for the prevailing requirements.



Urban jungle on the Subaru Hub in Singapore

The visual core of the rooftop terrain is a waterfall tunnel which you can drive through. Here, the Green Roof build-up ensures on the one hand the safe founding of the construction, on the other hand it drains the large amounts of water.

Of course, the different layers of the build-up, interacting with the applied substrate, also ensure the lasting establishment of the vegetation which is typical for this climate. Next to *Dracaena* and *Sansevieria*, the rubber tree lines the roadsides. Before long, the plants will even make the roof edges invisible to the test drivers.

"Everything that was envisaged in the planning stage has been realized", says project manager Mr Ho Wan Weng, who also leads the Green Roof company ZinCo Singapore Pte Ltd. This is again impressive proof that with the use of a multifunctional Green Roof build-up, almost anything can be realized on the roof that is feasible on the ground level.



The waterfall tunnel, a subtle realization by IGRA member Mr Ho Wan Weng

Green Roof Types: Classification and Characteristics

There are two main options in using Green Roofs. One, as a wonderful roof garden where people can experience nature in direct proximity to places where they live and work. Secondly, as an undisturbed habitat for flora and fauna within the concrete jungle of urban development. The decision on the type of Green Roof is crucial and has to be considered as early as the planning stage.

Client, landscape contractor and architect should use a "language" based on the same set of information. The term "Extensive Green Roof" in Germany for example has nothing to do with the size of the roof. Even the Green Roof on garage can be extensive. In Germany "extensive" merely means "low maintenance". To be on the safe side, it's better to describe the Green Roof type not only by its colloquial name but also by its characteristics with regard to the load bearing capacity, maintenance, plant selection, substrates and the expense budgeting.

Extensive Green Roofs



Extensive Green Roof

Extensive Green Roofs are well suited to roofs with little load bearing capacity and sites which are not meant to be used as roof gardens. The costs are comparatively low. The mineral substrate layer, containing few nutrients, is not very deep but suitable for less-demanding and low-growing plants. Drought-tolerant plant communities, such as those found in mountain crevices, semi-deserts or dry meadows, are clearly adapted to the natural extremes of the local conditions and are preferred Green Roof species. If possible, plant species of the local flora should be considered. Extensive Green Roofs require hardly any external input for either maintenance or irrigation.

Semi-Intensive Green Roofs

Semi-Intensive Green Roofs, in terms of requirements, take an intermediate position between Extensive and Intensive Green Roofs. More maintenance, higher costs and more weight are the characteristics compared to the Extensive Green Roof. A deeper substrate level allows more possibilities for the design; various grasses, herbaceous perennials and shrubs, such as lavender, can be planted while tall growing bushes and trees are still absent.



Semi-Intensive Green Roof

Intensive Green Roofs / Roof Gardens

Lawn, perennials, bushes and trees are possible on Intensive Green Roofs. Walkways, benches, playgrounds or even ponds can be established as additional features on the roof. There are almost no limitations in design and individuality, but a few specifications must be considered. The Intensive Green Roof system build-up and the selected plant communities have to be harmonious with one another. In addition, the amount of maintenance



Roof Garden

for Intensive Green Roofs is higher than for Extensive Green Roofs and permanent irrigation and fertilization have to be ensured.

Overview

	Extensive Green Roof	Semi-Intensive Green Roof	Intensive Green Roof
Maintenance	Low	Periodic	High
Irrigation	Low	Periodic	Regular
Plant communities	Mosses, Sedums, Herbs and Grasses	Grasses, Herbs and Shrubs	Lawn or Perennials, Shrubs and Trees
System build-up height	60 - 200 mm	120 - 250 mm	150 - 400 mm, on underground garages > 1000 mm
Weight	60 - 150 kg/m ²	120 - 200 kg/m ²	180 - 500 kg/m ²
Costs	Low	Middle	High
Use	"Ecological protection layer"	"Designed Green Roof"	"Park like garden"

Focus Spain:

Green Roofs in Madrid

A popular sentence in colloquial talk among the people from Madrid is: "From Madrid to heaven." By this they mean you cannot see anything better in the world. In last two decades we may add "through the Green Roofs". The new movement called "naturación" (that is, to include nature in your life) is mainly referred to Green Roof and facades.



Green Roof at the Plant Production Pavilion, E.T.S.I.A, Madrid

The German experience and the collaboration of Humboldt University of Berlin served as an incentive to establish the Spanish Association for Urban Naturation (PRONATUR), with headquarters at the ETSI Agronomos, Universidad Politecnica de Madrid (UPM). The participants in the research activities are from different institutions: universities, research centers and private companies, with a great variety of activities. Research has been developed through three experimental Green Roofs, two of them located at UPM in Madrid, and the other in Colmenar Viejo, sponsored by Intemper. As well, two PhD dissertations and some Master's and undergraduate

theses have been conducted on the role of Green Roof in urban life. Several international and national seminars have taken place in Madrid, Rio Janeiro, Havana and Berlin with the publication of the proceedings, in coordination with other international institutes. A book has been published under the title "Naturación Urbana. Cubiertas Ecológicas y mejora medioambiental" (Mundiprensa. 2004. Madrid), with the collaboration of well-known experts.

Last but not least, our goal has been to extend the application of Green Roofs in Spain. Although no accurate data are available, we recognize that more than one hundred Green Roofs have been constructed on public and private buildings. Recently in Madrid, two of the biggest Green Roofs in the world have been developed: The parking garage at the T4 in Barajas Airport and the Financial City of Santander Bank in Boadilla del Monte (see Green Roof News Issue Winter 2005).

The project in Barajas Airport was designed by the architecture office of Lamela and Associates.

The complete surface covers 54,000 m². The area is composed of two layers with a waterproof membrane, several draining and moisture retention mats, over which different substrates are placed, and finally the vegetal substrate.

Apart from giving beauty to the building, it provides functional improvements to the building and the environment. The Green Roof recuperates thousands of litres of rain water. On the other hand, the Green Roof improves the thermal behavior of the building and the photosynthesis of the plants reduces the emission of gases.

Professor Julian Briz,
Universidad Politecnica Madrid

Photos: Courtesy of Professor Julian Briz



Green Roof at the Department of Economics, E.T.S.I.A, Madrid



Green Roof at Barajas T4 Terminal airport parking, Madrid

Picture Gallery of Green Roof Projects in Spain:



Roof Garden in the center of Terrassa



Extensive Green Roof in Barcelona



Semi-Intensive Green Roof in Manresa

Photos: Courtesy of Artur Pereira Fernández

A real treat:

The Nature Conservation Center in Cangas del Narcea, Asturias

Muniellos, in the southwestern-most part of the Asturias Province, is one of five Spanish biosphere reserves on the UNESCO list. In the steep and rugged slopes of the mountainous landscape, the biggest oak woods of the Spanish peninsula are located. The reserve also provides shelter for some of the most endangered animal species of the Cantabrian fauna, e.g. the brown bear, the wolf and the cappercaillie. In order to keep the impact of tourists within the core area of the biosphere at a minimum, only 20 persons a day are allowed to visit this highly-sensitive region.

Apart from the wonder of nature, the reserve's visitor center is also worth seeing. The building, which is situated in Tablizas in the township of Cangas del Narcea, is a real treat. It was the top priority of architect Félix Gordillo to blend the complete building harmoniously into the environment. As a result, the building was constructed in a closed stone pit and the sloped roof (18°) received an ecological roof covering. The plant species on the 800 m²

Green Roof reflect the natural vegetation of the surroundings. As well, the interior of the building demonstrates the architect's intention. The supporting columns (in tree-style design) are illuminated in a natural way by the pointed rooflights.



Untouched: The biosphere reserve Muniellos

The center houses a permanent exhibition on the reserve's natural environment and offers information about trails and routes of the vast territory (500 km²). Visitor services also include multimedia presentations, a small library, a café and a shop. The center which is assigned to the principality of Asturias is opened all year round and entrance is free. In 2006 more than 10,000 people from Asturias and other parts of Spain visited the center. The total budget of the project was 1.8 million euros.

Roofing Contractor: AIMAD S.L. (www.aimad.es) has a lot of technical expertise with Green Roofs in Spain. The company is dedicated to high quality installations and was also involved in the Banco de Santander project (~ 100,000 m² of Green Roofs).

Green Roof System: VICOM S.L. (www.vicom-cubiertasecologicas.com) has been pushing the Green Roof Market in Spain since the 90ties. The company provides clients with performance based Green Roofs systems, which are designed to meet the requirements of extensive and intensive landscape designs, different roof constructions and climatic considerations.

Photos: Courtesy of VICOM S.L., Madrid



An architectural highlight: the Nature Conservation Center

Towards a Green Living Environment: Eco Buildings Conference 2007 in Singapore

Urbanization is a global challenge. Urban heat island effect, stormwater problems and the loss of biodiversity are reducing the quality of life for the town's inhabitants. Singapore, although well-known as a "Garden city" with a high green spaces ratio, takes the issue of sustainable urban development very seriously. The local Eco Buildings Conference 2007 presented innovative ways to enhance site ecology, energy and water efficiency and the quality of the environment. Due to their high ecological and economic value, Green Roofs played an important role in the presentations and discussions.



The Eco Buildings Conference aroused a lot of interest

The Eco Buildings Conference 2007 in Singapore was organized by the local Housing and Development Board (HDB). The event attracted more than 400 participants from the public and private sector, thus demonstrating the need to find comprehensive solutions by bringing experts from different disciplines together. Several regional and international speakers presented papers at the

conference to share knowledge and experience on environmentally sustainable technology and initiatives. The accompanying Eco-Carnival generated public awareness and provided information on how people can play their part for the environment.

A milestone in Green Building Technologies: Treetops@Punggol

HDB is the largest housing developer in Singapore. Its leading role in promoting and developing Green Building Technologies cannot be underestimated.



Launch of the Eco-Precinct Treetops@Punggol (from left to right): HDB chairman Dr. Aline Wong, Minister of National Development; Mr Mah Bow Tan, Dr. Johnny Wong Liang Heng

On the occasion of the conference the Guest of Honour, Mr Mah Bow Tan, Minister of National Development, unveiled what is to be the first public housing eco-precinct. "Treetops@Punggol" comprises seven residential blocks with 712 units on a 2.9 hectares plot. In order to create a building which meets the needs of the inhabitants and guarantees environmental sustainability at the same time, special emphasis was laid on enhanced site ecology, reduced energy consumption and efficient

water and waste management. Vertical greenings, extensive Green Roofs and community gardens will help to create a living green environment and optimize the usage of the natural terrain. The "ECO-Deck", an intensive Green Roof on top of the carpark, will serve as the communal center and "green lung" of the precinct. HDB expects that the green spaces of the ECO-Deck will reduce the temperatures within the precinct by three to four degrees and reduce the use of air conditioning.

A key factor: Green Roofs

Like a central thread, the subject of Green Roofs was also apparent in the presentations of many speakers during the conference.

Dr Tan Puay Yok, Assistant Director of the research division at the National Parks Board (NParks), described the efforts of his organization to promote skyrise greenery in Singapore and generate public awareness. Together with the city's groundspace green infrastructure of parks and streetscapes, skyrise greenery is an essential element in NParks' "City in a Garden" vision.

Dr Johnny Wong Liang Heng, Deputy Director of the Building Technology Department (BTD) at HDB, presented the results of an R&D study on Green Roofs in Singapore. The experiences made are reflected in the planning and design of the extensive Green Roofs and themed landscaped courtyards of the eco-precinct at Punggol.

The Green Mark Scheme which certifies buildings on their level of environmental friendliness, was introduced by Mr Tan Tian Chong, Director of the Building and Construction Authority (BCA). The assessment criteria will also consider Green Roofs. The supporting Green Mark Incentive Scheme for private sector developers (\$20 million over the next three years) should encourage the construction of more green buildings and create a demand in green building technologies.

The final speech was given by Mr Wolfgang Ansel, Director of the International Green Roof Association (IGRA). His presentation "A political and technical guideline to Green Roofs" featured the key factors for the successful Green Roof Story in Europe with special consideration of the situation in Germany. If we sum up the results of the conference, the prospects are quite good that the development of the Singaporean "City in a Garden" concept will also take place on roof level.



Wolfgang Ansel (right), Director of IGRA, presented Green Roof experiences from Europe

Fotos: Courtesy of HDB, Singapore

Science and Research:

Pioneering Research Green Roof at the University of Hong Kong

Green Roofs are rarely established in Hong Kong despite the presence of many thousands of barren flat roofs in the humid subtropical city with a population of seven million. Setting up a research Green Roof could furnish objective data on its environmental benefits, and serve as a demonstration site to convince the government and the private sector to adopt the idea. Green Roofs could improve the aggravating urban heat island effect, and provide valuable amenity green spaces that are lacking in the city.

An extensive Green Roof was retrofitted on the four-storey Runme Shaw Building at the University of Hong Kong in June 2006, denoting the first Green Roof devoted to research purposes in Hong Kong. It covers about 200 m² of flat roof space, divided into three equal square plots planted respectively with turf-grass (*Zoysia tenuifolia*, Korean Velvet Grass), groundcover vine (*Arachis pintoi*, Perennial Peanut) and shrub (*Duranta repens*, Golden Dewdrops).

The exceptionally strong reinforced concrete roof slab has a load bearing capacity of 10.5 kPa/m². The waterproof membrane and insulation layer of the rooftop were completely renovated just before Green Roof installation. The concrete tiles covering the rooftop were kept in situ. The multiple-layer design of the Green Roofs is based on a 2.5 cm thick dimple-type composite plastic drain layer placed at the bottom. It was manufactured with a geotextile filter glued on the upper side and a protection and separation geotextile sheet on the lower side. It was then covered by a 4 cm thick water storage layer made of rockwool boards. A soil mix composed of local decomposed granite mixed with mature compost was spread on the surface. To

meet the differential rooting needs of the three vegetation types, soil thickness varied with 3.5 cm for grass, 5 cm for groundcover, and 8 cm for shrubs. A timer-controlled sprinkler irrigation system with its own water tank, pumps and fertigation portal was also installed.

A series of environmental monitoring sensors were installed, including: (1) three air temperature sensors with radiation shields at 20, 60 and 200 cm levels; (2) an infrared sensor detecting the surface temperature of the bare tile at the control plot and of the vegetation surface at the experimental plots; (3) a composite radiometer measuring the incoming and outgoing short-wave and long-wave radiation; (4) temperature sensors of the thermocouple type were buried in the soil, rockwool and below the drainage layers; (5) soil moisture sensors that measure volumetric water contents employing the time domain reflectometry principle were buried in the soil and rockwool layers; and (6) infrared sensors were also installed on the ceiling of the top floor office

space below the three vegetated plots and the control plot to assess the heat flux through the reinforced concrete roof slab. All the sensors were synchronized to take readings at 15-minute intervals, and the data were stored in weather-proof digital loggers.

The objectives of the study were to evaluate and compare the three Green Roofs with different vegetation types and a control plot with respect to: (1) evaporative cooling of air temperature; (2) surface temperature reduction; (3) thermal insulation effect; (4) radiation energy budget; (5) heat flux to the indoor space below the roof slab; and (6) air-conditioning energy conservation. The research also gathered experience towards establishing and maintaining extensive Green Roofs using different vegetation types. The author is trying to initiate a Green Roof movement in Hong Kong with the help of scientific research and a publicity campaign.

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Raising awareness for Green Roofs in Hong Kong:
IGRA member Professor Dr C.Y. Jim



Environmental monitoring on
three different types of vegetation

The next IGRA-newsletter will feature the following topics:

- Green Roof Policies: Approved practices and current trends
- Revisited: The Green Roof at the Mashantucket Pequot Museum and Research Center
- Thermal insulation properties of Green Roofs: A review

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The International Green Roof Association (IGRA) is a global network for the promotion and dissemination of Green Roof topics and Green Roof technology.

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