

国际绿色屋顶协会
健康绿色屋顶协会

编

最新国外屋顶绿化

Latest Overseas Green Roofs



华中科技大学出版社

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Preface

序言

随着人们对于生态环境和可持续发展意识的逐渐增强，绿色屋顶也逐渐为人们所熟悉。不管是作为一种概念、技术还是设计范畴，绿色屋顶都有着其独特的意义。然而，绿色屋顶不只是一项趋势，或是某一种风格，更多的是专业性、技术性与艺术性的交汇，以及与景观设计、建筑设计等领域的广泛融合。

此次《国际新景观》携手健康绿色屋顶协会、国际绿色屋顶协会等专业权威组织推出本书，以简明的文字向导和丰富的设计实例来深入剖析绿色屋顶的各个范畴、设计要点和工程技术，力求为读者展现设计绿色屋顶的理论和实践准则。本书更在生态可持续发展的方向上，为设计师朋友提供了一种明智的选择，可谓是一本普及绿色屋顶设计的实用手册。

With the improving awareness of ecological environment and sustainable development, we are more familiar with green roof. Green roof has unique significance itself, whatever it as a concept, a technology or a design field. Nevertheless, green roof is more than a trend or a style; it is an interchange with profession, technology and art, also an extensive fusion referring to the professional fields as landscape design and architectural design.

Now, *International New Landscape* coordinates with authoritative professional organizations, such as the Green Roofs for Healthy Cities and the International Green Roof Association, to publish this book, aiming at deeply analyzing green roof on its categories, design essentials and engineering technologies with concise texts and rich design cases, so as to introduce the designing theories and practical guidelines of green roof to readers. This book also provides designers with a wise choice on ecologically sustainable development. It is a practical handbook on popularizing the design of green roof.



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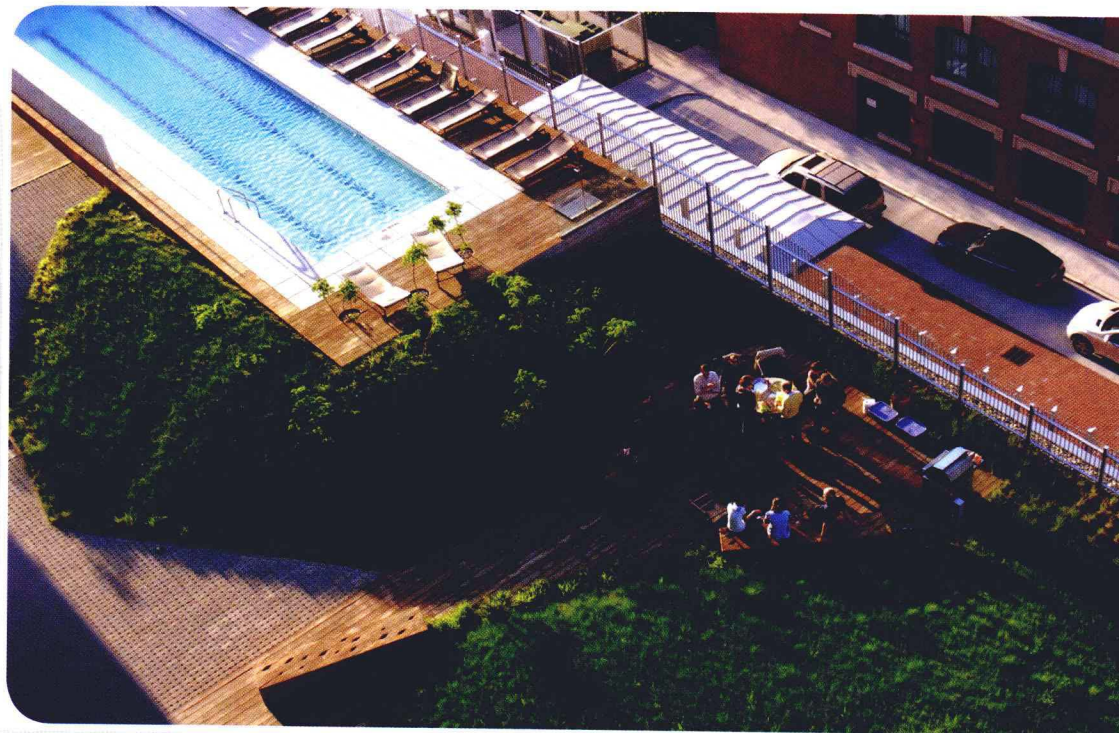
屋顶绿化相关规章与准则

目前，世界上只有少数几个国家对屋顶绿化制定了相应的规章和准则。最早的屋顶绿化规章出现于20世纪90年代，是由德国波恩景观与景观发展研究协会制定的FLL测试与德国标准“绿色屋顶实地规划、建造与养护准则”。该准则包括：绿色屋顶的类型、各种植被类型、建造技术要求、屋顶绿化相关步骤以及绿色屋顶的养护与维修。目前的屋顶绿化准则只有英文版，但其内容也同样适用于中欧地区的气候特征，且普遍适用于德国绿色屋顶的系统建设。

无论这份屋顶绿化准则是否存在，各国都应该将屋顶绿

化的相关规章与准则的修订与完善提上议事日程。这些准则应当包括：绿色屋顶建造技术（例如承载能力、抗风保护、防火、防高温、噪声防护等）；以及屋顶建造技术（防水材料及其安装、竖梁、倾斜度、排水装置等）。上述内容在所有现行园林和景观建筑（如土壤、植物、草坪、种子混合物的保养和维护工程等）相关规章与准则的修订中也应予以考虑与补充。此外，根据各个国家的具体情况，应对高层建筑的屋顶安全与屋顶消防安全做出相应的规定。





Regulations and Guidelines for Green Roofs

Only a few countries have regulations and guidelines which apply to Green Roofs. The oldest regulations, which were published in the 1990's, are the German Standard "Guidelines for the planning, execution and upkeep of Green Roof sites", and are from The Landscaping and Landscape Development Research Society e.V. (FLL) in Bonn (Germany). The Green Roof guidelines contain the types of Green Roofs, the various vegetation types, requirements for the building technique, Green Roof procedures as well as upkeep and maintenance for Green Roofs. The Green Roof guidelines are available in English but the content applies to the middle European climate region and the common German Green Roof system build-up.

Whether Green Roof guidelines exist or not, the complementary country regulations and guidelines must also be considered. These guidelines can include: building technique (e.g. load bearing capacity, wind uplift protection, fire protection, temperature, noise protection, etc.); and the roof technique (waterproofing material and installation, upstands, slope, drainage, etc.). Consideration must also be given to any existing regulations and guidelines for garden and landscape architecture (e.g. soil and plants, lawn, seed mixture, upkeep and maintenance works, etc.). High buildings, according to the particular country, require various regulations regarding the security and fall protection on roofs.

总 述

近30年来，绿色屋顶成为了都市可持续发展的一个重要组成部分。人们不断增长的环境意识和显而易见的经济和生态价值推进了绿色屋顶的成功发展。如今，在世界各地的大城市里，各种绿色屋顶、天台花园和屋顶花园随处可见，造福着都市环境和生活在其中的居民。

经过景观美化的屋顶为人们对于生活的美好期许和建筑能量的平衡提供了众多可能。为了保证功能的持久性，自然绿色屋顶、半人工绿化和人工绿色屋顶的建造都应采用以下原则：高质量的材料、专业的设计和施工、科技艺术的适当表现以及被广泛认同的原则和规定。

关于绿色屋顶思想和技术的国际交流不仅是一种趋势，更是有效环境策略的基本需求。

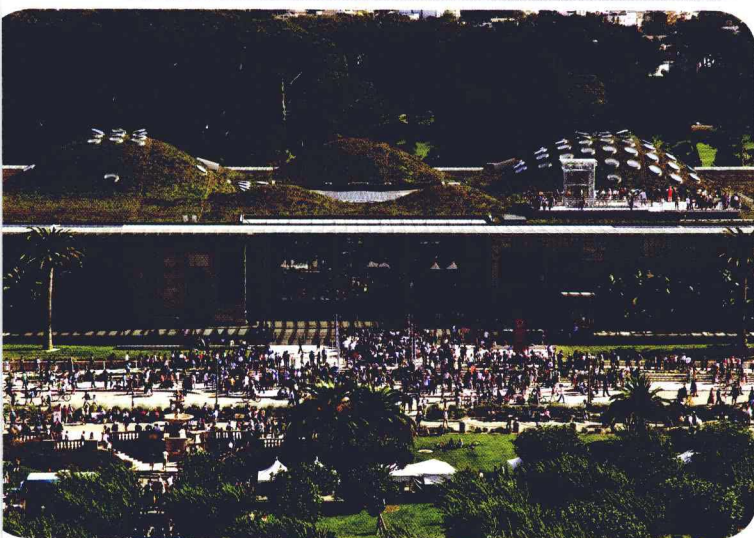


Introduction

Green Roofs have become a very important component of sustainable urban development within the last 30 years. Growing environmental awareness and the striking economical and ecological advantages are the driving forces for this great success. At present, Green Roofs, sky gardens and rooftop gardens can be found in nearly all big cities around the world, benefiting the urban environment and their inhabitants.

Finally, landscaped roofs provide many positive effects for the life expectancy and the energy balance of a building. In order to guarantee lasting function, Extensive Green Roofs, Semi-Intensive Greening and Intensive Green Roofs are all based on the same principles: high quality materials, professional planning and installation, state of the art technology and acknowledged guidelines.

An international exchange of ideas and technologies within the Green Roof sector, therefore, is not only desirable, but simply a necessity with regard to efficient environmental strategies.



绿色屋顶的效益

时至今日，绿色屋顶的重要性仍然未得到人们的足够重视。屋顶的“自然景致”只是有关绿色屋顶的广泛争论中一个显而易见的优点。绿色屋顶的深层次价值并未被人们广泛认知，这其中包括防水性、保水性、隔热、改善气候环境，以及对动植物生长的自然生态环境的保护。

除了绿色屋顶，没有其他类型的建筑形式可以为建筑、居民和环境提供如此广泛的益处。因此绿色屋顶能够形成一种兼顾经济和生态双重利益的可持续性发展。

普通的屋顶或是铺设了沙砾层的屋顶的生态功能几乎为零。与绿色屋顶相比，这些屋顶的建筑造价非常低廉。这种经济效益的比较实际上是对短期效益的微弱论证。事实上，按照长久估算，这种普通的赤裸屋顶的维护和修理费用远远大于绿色屋顶。屋顶是建筑中极易耗损的部分，这一点也应考虑在内。如果缺乏防护措施和质量上乘的材料，普通屋顶的问题将会迅速暴露。

个人效益 延长屋顶寿命

一般说来，即使有专业的维护，普通的屋顶寿命也只有15到



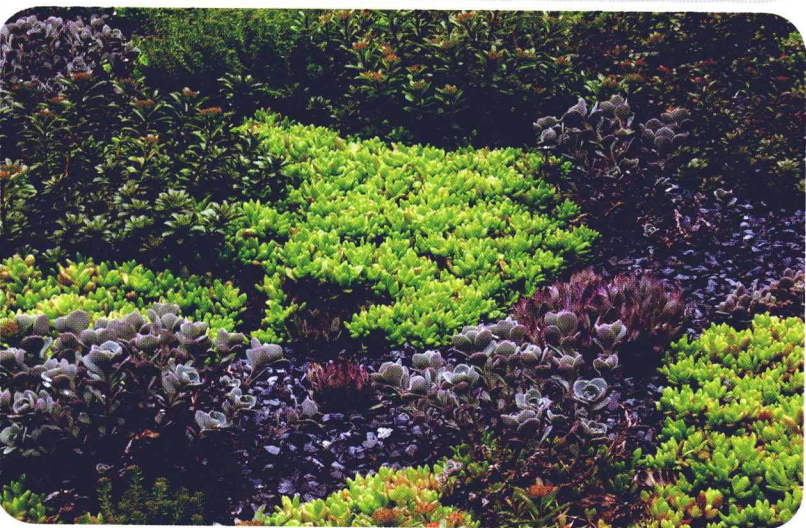
25年。随着时间的积累，屋顶表面/防水层所承受的物理、化学和生物性压力都将造成屋顶的损耗。一般来说，屋顶将承受超过100℃的年均温差和超过日均60℃的温差。紫外线辐射和较高的臭氧层比率都是加速防水层老化的主要因素，最终逐渐导致材料的损坏、收缩、裂缝的形成和渗漏。绿色屋顶能够为防水层提供防护，植被层能够减缓不同季节中温度变化对屋顶的破坏。铺设了植被层的屋顶所承受的年温差不会超过35℃，日温差最大也仅有15℃。除此之外，绿色屋顶还将为防水层形成保护，能够避免冰雹、大风、人为破坏和烟花爆竹带来的物理损伤。

减低噪音

绿色屋顶能够减少3分贝的噪音，并能够帮助隔音层减少8分贝以内的噪音。这些对于居住在机场、娱乐场所和工业园区附近的人们是至关重要的。另外，植被层还能有效保护电磁波的传送。

隔热作用

绿色屋顶还可被看作是另外一层隔热层，因此它可以减少对于主要能源的消耗，这是一种众所周知的经济效益。过去，这种效用或是将绿色屋顶纳入建筑能量体系都是不大可能的。这些技术的空白在20世纪的90年代初得到了填补。德国建设工程学院制定的热变电阻价值，即R价值，证明了特别绿色屋顶的建造在绝热方面的作用。通过绿色屋顶的建造，原本依赖于原始绝热材料的屋顶得到了改



善，每平方米的面积可以节省1到2升的石油需求量。

热量阻隔

在夏季时节里，绿色屋顶可以通过蒸腾作用来降低室内的温度。根据Drefahl于1995年的测试，有绿色屋顶覆盖的公寓顶层的微气候与普通公寓底层公寓相差无几。由植被层覆盖的绿色屋顶可以避免顶楼空间的过热情况，并由此减少对于空调和能源的消耗。

空间延伸

绿色屋顶为我们提供了各种各样的空间使用方式，其中包括：昆虫和植物的自然栖息地、休闲屋顶花园、屋顶咖啡区和运动区域。如果建筑的技术和建造要求允许，屋顶的景观设计将没有界限：多年生植物、小树、露台或花园都可以出现在绿色屋顶之中。如果屋顶空间得到充分的利用，建筑业主也可以节省下购买更多地面的费用。同时，绿色屋顶还带来其他的附加价值，优美的景致、新鲜的空气和足够的私密性。屋顶花园提升了工作环境的同同时，还为人们营造了附近的娱乐空间，这在大都市中是非常有益的。

公众效益

天然栖息地

人们的建筑活动对于自然景观的替代对生态系统和栖息地



有着消极作用，在土地面积被大范围覆盖的城市中尤为明显。绿色屋顶的实施可以弥补城市化中流失的绿色空间。在钢铁森林的城市中，绿色屋顶营造了清新活力的绿色空间，在城市中心为动植物连接起众多被隔离的栖息地。低维护成本的绿色屋顶更能够促进生物的多样性，在这里可以发现许多罕见和保护物种。植物生长的自然循环、自我播种和自然选择都能赋予生态系统独特的意义。

减少水土流失

绿色屋顶在防止当地的洪水泛滥方面是非常重要的设施。





根据绿色屋顶系统和生长媒介深度的不同，直接的雨水流失可以减少50%到90%。这些水大部分通过蒸发或蒸腾作用，直接进入自然水循环系统。多余的雨水则随着时间的积累逐渐流走或排掉。这有助于在降水高峰季节或平时减轻灌溉系统的负担，如此只用安装较少或更小尺寸的排灌系统。通过与其他现代雨水处理系统的结合，如存储箱或贮留沟渠系统，雨水可以更好地渗透至建筑所在的区域。在降水处理方面，绿色屋顶在不同的城市都能营造效益，如降低雨水税等。

缓解热岛效应

全球性气候变暖、被覆盖的地球表面的增加、住宅建筑、工业和交通散发的剩余热量都在都市区域内导致温度的上升。城市和郊区之间的温差就是都市中的热岛作用。夏季，这种温差甚至达到10℃。这种热岛效应对生活质量和城市居民的健康有着负面的影响。被誉为“自然空调”的绿地和公园可以吸收其中80%的热量，然而，在人口密集的地区绿色空间是非常稀少的。经过景观绿化的屋顶表面是非常好的选择，它们可以通过蒸腾作用和湿润干燥空气来减少城市热岛效应。这些都能为附近的公寓和建筑提供较好的气候环境。

减少灰尘烟雾

过去数年中，众多研究结果都表明城市中的空气污染将对人们的身体产生危害。尤其是一些氧化氮、一氧化碳、

挥发性有机化合物和柴油废气燃烧造成的有害物质，这些废气物质的组合对城市居民的健康造成了危害。植物可以提高空气的质量。1平方米的绿色屋顶每年可以过滤大约0.2千克的尘土和烟雾颗粒。另外，这些植物生长媒介还可减低空气中或降水中产生的硝酸盐等有害物质。

城市和景观

绿色屋顶可以在视觉上提升城市中的环境质量。已经生长茂盛的绿色屋顶仿佛岛屿般为单调的灰色城市展现了绿色景致，有助于人们的精神和身体健康的协调。绿色屋顶不仅适用于城市，在农业区和郊区也是很好的选择，把工业建筑与自然景致和谐地统一起来。





Benefits of Green Roofs

Even today the opportunities of Green Roofs are still underestimated. The "natural look" is only one obvious credit within the broad range of arguments for Green Roofs. Further benefits of Green Roofs include the protection of waterproofing, water retention, thermal insulation, improvement of the climatic environment as well as new natural habitats for flora and fauna.

No other architectural style provides such a wide range of positive effects for buildings, inhabitants, and the environment. Thus, Green Roofs meet one of the essential conditions of sustainable development, the reconciliation between economy and ecology.

It is very difficult to find positive arguments for bare or gravelled roofs. Lower building costs for "Non-Green Roofs" in comparison to a Green

Roof, are weak arguments considering it is only a short term calculation. Long term costs of maintenance and repairs of 'naked roofs' are much higher than that of Green Roofs. It has to be considered that roofs belong to the most strained parts of a building; if no precautions are taken and product qualities lack, problems arise quickly.

Private Benefits

Increased Roof Life

The life expectancy of a "naked" flat roof is only 15 to 25 years, even with professional installation. This is due to the physical, chemical and biological stress on the roof skin/ waterproofing over the years. Temperature differences of more than 100°C during the year and 60°C over 24 hours are not unusual. UV-radiation and high Ozone ratios accelerate the ageing process of the waterproofing; which results in, material fatigue, shrinking, crack formation, and leakage. Green Roofs provide protection for the waterproofing. The vegetation layer buffers the temperature stress during summer and winter,



and temperature differences of, 35°C during the year and 15°C over 24 hours are not usually exceeded. In addition, the Green Roof creates a protection layer for the waterproofing in case of mechanical damage like hail, wind, vandalism, and fireworks.

Reduced Noise Levels

Green Roofs reduce sound reflection by up to 3 dB and improve sound insulation by up to 8 dB. This is important for people who live near airports, noisy discotheques, or industrial parks. Additionally, electromagnetic waves from transmitting stations can be effectively shielded by the vegetation layer.

Thermal Insulation

Green Roofs can be regarded as additional thermal insulation, thus, reducing the use of primary energy. This is a well known economic benefit; however, in former times it was not possible to quantify this effect and integrate Green Roofs into the building energy balance. This gap was closed at the beginning of the nineties when special Green Roof build-ups were



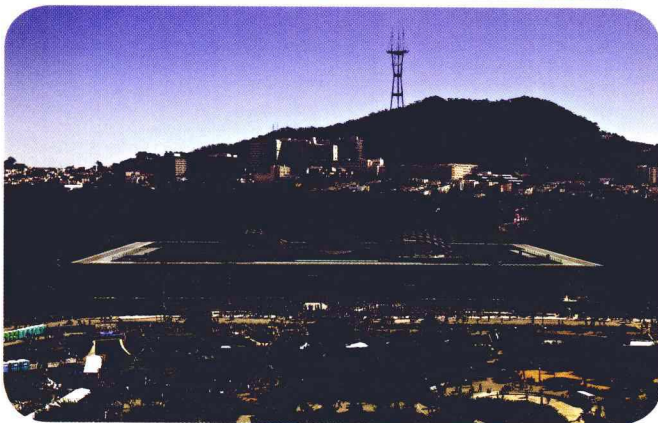
officially credited with thermal resistance values (R-Values) by the German Institute for Construction engineering. Depending on the original thermal insulation, an amount of 1-2 L/m² of oil can be saved with this additional thermal insulation.

Heat Shield

During the summer months Green Roofs reduce indoor temperatures through transpiration. According to tests from Drefahl (1995), the microclimate of an apartment underneath a Green Roof is comparable with one on the base floor. The typical overheating of attic flats in summer can be avoided with vegetated roofs; therefore, decreasing the use of air conditioning and energy consumption.

Use of Space

Green Roofs offer various possibilities for usage, including: natural refuges for insects and plants, recreational roof gardens, roof cafés, and sporting areas. If the technical and construction requirements of the building are met, there are virtually no limits for landscape designs with



perennials, small trees, terraces, or gardens. Due to the utilization of the roof property, the building owner can save costs from purchasing additional land at ground level. A gorgeous view, fresh air, and privacy are also included in the price. Roof gardens increase the work environment enormously and offer nearby recreational areas, even in conurbations.

Public Benefits

Natural Habitat for Animals and Plants

The sealing of the landscape by human building activities has several negative effects on the ecosystem and the human habitat. This applies in particular for urban areas, where a large share of the total land area is sealed. Vegetated Roofs can compensate for lost green areas. As "step-stone habitats", they create lively and vigorous places and connect isolated refuges for flora and fauna within sterile city centres. Low maintenance extensive Green Roofs especially



promote biodiversity, as wild bees, butterflies, and beetles find food and shelter there. Even rare and protected species can be found on Green Roofs. The natural cycle of plant growth, self-seeding and stress-selection leads to ecological systems with unique character.

Stormwater Retention

Green Roofs are very important instruments in preventing local flooding. Depending on the Green Roof system and the depth of the growing medium, the immediate water run-off can be reduced by 50-90%. Most of this water returns directly into the natural water cycle by transpiration/evaporation of the Green Roof. The excess rainwater is filtered and drained off with a temporal delay. This leads to reduced stress on the sewer system during the year and at peak flow periods. As a result less or smaller dimensioned sewerage systems can be installed. In combination with other forms of modern rain water management (for example, storage tanks or retaining trench-soaking hole-systems) the rainwater can be entirely infiltrated on