INTRODUCTION TO THE GERMAN FLL-GUIDELINE FOR THE PLANNING, EXECUTION AND UPKEEP OF GREEN-ROOF SITES

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Abstract
As the development of the North American green roof market picks up speed, more and more people are designing, specifying, installing, maintaining and evaluating green roofs. Unlike in Germany, where green roofs are highly standardized already, most projects in the United States are custom made solutions. The individual evaluation of research results and technical information of manufacturers and material suppliers is very difficult though, especially without availability of commonly accepted definitions, requirements and testing methods. While American Standard Testing Methods (ASTM) regulations in this field are still missing, existing standards developed in Europe could possibly be used. The goal is to provide a common basis and to avoid failures, as failures could impede further growth to the American green roof market. The objective of this paper is to give an introduction to the German FLL-Green Roof Guidelines and to discuss their relevance for the American Green Roof Market.

The German Landscape Research, Development and Construction Society (FLL) is an independent non-profit organization. It was founded in 1975 by eight professional organizations for “the improvement of environmental conditions through the advancement and dissemination of plant research and its planned applications”(1). The FLL green roof working group is only one of 40 committees which have published a long list of guidelines and labor instructions.

The FLL has been working on standards for green roof technology for 25 years. Their ‘Guideline for the Planning, Execution and Upkeep of Green-Roof Sites’ (FLL-guidelines) reflects the latest developments in German acknowledged state-of-the-art technology. Although the guidelines don’t give solutions for all green roof problems it is a basic tool for the construction of reliable and high quality green roofs not only Germany.

The latest edition dating January 2002 has been released in an English version in 2004. From the legal standpoint this German guideline cannot substitute or stop future American standards, but they are a very good source of reliable information which is based on the experience of almost one billion square feet of green roofs built.

The development of the German green roof market has been much slower compared to the one in the North America, because the technology itself had yet to be developed. There has been enough time to develop standards simultaneously to the technological progress. For the American market foreign green roof technology is available instantly but developing North American standards, definitions, requirements and testing procedures will take time.

Until now the FLL is mostly mentioned in connection with the requirements for granular drainage materials and vegetation substrates as well as for the root resistance of the waterproofing membranes. But the guidelines have much more to offer.

Instead of strictly following the table of contents, I will look at the guidelines from various stand points and explain what the different users can expect to get out of it. Additionally I want to mention that I am not always sticking to the literal translation as it appears in the English version. For example I am using the term “Test Methods for media and granular drainage materials” instead of “Methods to be employed when investigating plant substrates and aggregate-type drainage materials used at roof-greening sites”. The words of the English translation may sometimes be quite awkward for American readers, but nevertheless it can be a very helpful tool for many purposes.

If you want to learn more about the basics of green roofs you can find definitions of the different types of green roofs and the appropriate kind of vegetation for intensive, semi-intensive and extensive green roofs. Extensive greening for example is defined as a ‘virtual Nature’ landscape which requires hardly any maintenance and where “vegetation stock will undergo a natural process of change, including new types of plants which enlarge the flora stock in the course of time”(2). This reflects the long term experience that a floral design of an extensive roof can only be kept with a very high maintenance effort, which is in conflict with the primary ecological function. Paying attention to this fact can avoid future frustration of designers and building owners who might like the idea of a long lasting and constant appearance of their roof. Extensive green roofs especially are more a piece of nature than a part of architectural design.

If you have to identify and evaluate the site conditions for vegetation of a specific roof the list of determining factors will be helpful for you. “If roof-greening is to be a lasting success, it is absolutely essential that site conditions are identified to see if they are suitable for vegetation.”(2) The list distinguishes climate and weather-dependant factors, structure dependant factors and planning-dependant factors which have to be taken into account. Used as check list it can help to avoid errors and failure.

For those who are more interested in the benefits of green roofs rather than in details the guideline provides a catalog of functions and effects, which is divided into aspects of city planning, ecology and economy. The listed functions and effects can also be used in the context of environmental impact regulations.

In the chapters ‘**Requirements related to Construction and Materials’** and ‘**Technical Requirements for the Roof Construction**’ architects will find answers to the question, what has to be considered when constructing a roof which will be greened.

For example:

- what roof slopes are appropriate
- how design loads have to be adjusted
- how the drainage and watering facilities are affected
- that green roofs must be accessible for maintenance staff
- that protection devices must be provided, if there is a potential danger of falls
- that green roofs need a root resistant membrane
- how the membrane can be protected against mechanical impact
- how roof outlets should be constructed
- how high the membrane has to be brought up above the surface of the green roof

- how hot or cold air from vents or AC-units or exhausts from chimneys will affect the green roof
- how wind loads effect different areas of a roof
- when a green roof can be considered fire-resistant
- when sloping roofs need special measures to prevent slipping of the green roof
- how paved areas should be constructed

The chapter "**Construction of Vegetation Areas**" first defines the different working courses of a green roof and then provides a list of factors, which need to be taken into account, when determining the size of the vegetation support and drainage course. If you are looking for any product names or material sources, than the FLL guideline will disappoint you. What you can find though is a list of material groups and types and a very precise description of material specifications and performance requirements for every course. Furthermore you will find instructions for the installation of every course which makes it a very helpful tool for everyone who has to specify or build a green roof.

Special attention should be paid to the vegetation support course, since the media is the main component of every green roof. For those who design and specify engineered soils and for those who want to be sure about the quality of a specific blend the FLL guideline provides detailed requirements and reference values for the different types of green roofs.

One of the main features is the chapter about the granulometric distribution for green roof media. It provides charts showing the grain percentage by mass in percent of the total volume in relation to the grain diameter. This method to describe the grain size distribution is basically the same as telling the percentage of material being retained by different sieves as is common in the USA. The interpretation of the test results is much easier though. Anybody can see, whether the grading curve of a substrate is within the required range or not.

The FLL-guideline also sets clear limits to the content of organic matter within substrates, because too much organic matter might cause shrinkage of the vegetation support course and endanger the long term success of the whole roof. But even being aware of this fact the values might seem to be surprisingly low, like 6.0 % by mass or less for an intensive green roof media with a volume weight above 0.8 g/cm^3. The reason is that the value mentioned is not equivalent to the amount of compost for example, which the media should contain. The organic content is determined by incinerating the completely dry test sample at 550° C in a special oven and to measure the weight loss due to burning. But if you want to calculate how much of a specific organic material has to be added to achieve a certain organic content of the media, it is not sufficient merely to determine the burn rate, because the constantly changing water content and compaction of the material have to be considered too.

Furthermore you will find chapters about the following media requirements:

- Frost –resistance
- Structural and bedding stability
- Water permeability
- Water-storage capacity
- Air content
- pH-value
- Salt content
- Nutrient content

- Weed seeds and foreign substances

One of the biggest differences between the German and the American green roof market is the fact that Germany has many suppliers of certified standard substrates while in the United States custom made solutions still prevail. Custom made soils may also work, but they bear a rather high risk of failure as long as they are not tested before installation. Fortunately American institutions like Penn State University adopted the FLL testing methods and procedures and made them available in the USA.

The big advantage of the FLL-guideline is the combination of setting clear reference values and defining precise testing methods and procedures, which guarantee the comparability of results. Any media fitting to the requirements of the FLL guideline will work properly as a component of a corresponding green roof system irrespective of where it is located. But the green roof system and the most important of all, the plant selection has to be adjusted to local conditions. So your green roof might fail, even though all components fit to FLL standards. For example the best system doesn't help, if you select the wrong plants. As it is pointed out in the 'Notes for the User' the "FLL guidelines are an important source of expertise for professional behavior in standard working situations. They can, however, not include all types of special cases for which additional or restrictive measures may be required."(2) Nevertheless by following the FLL requirements a lot of potential sources of failure can be eliminated.

For those interested in plants, the guideline also has a lot of information – just don't expect plant lists. What you will find though are recommendations for seeding, planting and spreading cuttings and a detailed list of maintenance requirements. The chapter 'Readiness for handover' for example explains very precisely the acceptance criteria for extensive green roofs. If you have to define, when the task of the contractor ends, these regulations may be very helpful for you even if you take them only as an inspiration for your own definitions.

For those being more interested in the scientific side of green roofs the guideline contains for all types of green roofs

- Charts showing which properties are relevant either for suitability testing or inspection testing
- Charts listing the required reference values for the different properties

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There is a detailed list of methods to be used in determining properties and reference values of media and granular drainage materials but one of the handicaps is the quotation of other German regulations and standards which are not available in an English version. Another hurdle for the American user may be the use of the metric system. Nevertheless the definition of properties and reference values in combination with an exact description of testing methods and procedures guarantees high usability and comparable results.

Structural engineers might be interested in the reference values for design loads which are listed for all different groups and types of drainage materials and substrates as well as for the various forms of vegetation.

The guideline also contains reference values for the annual water retention depending on the depth of the construction and the form of vegetation.

Especially membrane manufacturers might be interested in the '**Procedure for investigating resistance to root penetration at green-roof sites**', which was elaborated "in order to exclude

vegetation-dependant structural damage due to roof-greening" (2). The test procedure which is highly acknowledged in the green roof industry has been revised for the last time so far in 1995. At that time a new two year test method has been introduced, which is considered to be equal to the previous 4 year test. The two year test has to be run in a climate-controlled greenhouse where plants can grow all year long, while the 4 year test takes place outdoor, where plants are dormant for several months each year. In Germany only membranes with a FLL-certificate for root resistance have a chance to participate in the green roof market. Approximately 70 membranes have passed the test already, some of which are also available in the United States and Canada. American membrane manufacturers should consider the fact, that a FLL test certificate for root resistance can be a big advantage, when bidding for green roof jobs and sooner or later may even be a generally acknowledged requirement. As far as I know the test is offered by Penn State University in the meantime too.

For landscape architects and green roof designers it is also very important to know, that a differentiation has to be made between 'root-resistance' and 'rhizome-resistance'. A membrane which has been certified 'root-resistance proofed' possibly still can be penetrated by rhizomes. Therefore the use of plants developing rhizomes like coach grass or bamboo requires special measures to avoid damage.

Conclusion

The FLL-Guideline for the Planning, Execution and Upkeep of Green-Roof Sites has been developed during the last 25 years in Germany and represents the widely acknowledged state-of-the-art technology. Although the guidelines cannot substitute American standards and regulations they nevertheless can provide a lot of very helpful information about green roofs. Whether you are a first timer or a scientist, a manufacturer or installer, an architect or a specifier studying the guidelines could possibly be most profitable for you.

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(1) General Information about the FLL, http://www.fll.de

(2) Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V., Guideline for the Planning, Execution and Upkeep of Green Roof Sites, Release 2002