



## FIRE & WIND ON EXTENSIVE GREEN ROOFS

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### Abstract

“Extensive green roofs increase the fire hazard of our buildings and a green roof is a potential risk under windy conditions.” Are these statements true?

The opinions of European and American experts might be different but we all want the same: Safety. How safe are green roofs?

### Fire & Wind On extensive green roofs

Approximately 30 years ago the first “true” extensive green roofs were built in Germany and until today there are at least 2 billion square feet of extensive green roofs built. This equals at least 70 square miles of green roofs plus 4.5 new square miles every years. As it started it was a brand new technique and technology there was nothing like that done before. Sod roofs like Scandinavian sod roofs and the hanging gardens of Babylon have hardly anything in common with modern green roof technology and the building codes were different in former times too. When we continue we need to understand the term “green roof” or extensive green roof first.

As the name “green roof” says the focus has been on the “green” part and to sustain the “green” over the year and over decades. During the last 30 years while green roofs were getting more successful the critical comments about safety issues increased as well. In the nineties first tests were discussed and performed and since the diversity in nature is endless, tests couldn’t be representative. Worst case scenarios were discussed, tests of the vegetated parts, of the components and of the water proofing part were performed and compared. Experts were interviewed and the FLL started with the first drafts of their guidelines – already 25 years ago.

The presentation will show how the topic “Fire and Wind” was approached in Germany, where the differences and the many parallel things are. The lecturer will also explain with examples where he sees the potential risks and what possible solutions will help to increase the trust in green roof technology. Since the nature laws in physics, chemistry and biology are very complex and everywhere the same the question will be raised whether existing standards should be copied and improved for certain unique situations in some extreme climate zone.



Green roofs are offering unmatched and multi level benefits which makes the need of implementation sooner or later mandatory. The responsibility to create useful fire and wind standards is very important since we all want (and need) a safe and affordable green roof.

While in the Nineties in Germany green roofs spread faster than every bush fire the natural human fear of nature caused by green roofs grew as well. As much as fire helped us to step ahead in the evolution as much we are afraid of it and so it didn't take long until the first fire experts spoke out loud their concerns. They pictured scenarios like the big fire of London in 1666 and fueled a hot discussion. The discussion merged down to the following questions: Can one spark ignite an extensive green roof? Can extensive green roofs provide enough fuel to sustain or even propagate fires?

Since my hometown Stuttgart is the leading green roof city in Germany it was no wonder that in 1988 all experts including city, county and state officials agreed to a large fire research program done by the Research and Material testing laboratory of Baden-Württemberg (Government). Before they started with large scale field testing, they did the math or basically they made some burning tests in the laboratory first. It wasn't really surprising that a bituminous waterproofing layer produces 50 kWh/m<sup>2</sup> which is 15 times more than an extensive green roof with dry grasses (3 kWh/m<sup>2</sup>). That means you can heat up your house much better with a bituminous layer as with a grass/green roofs. They also tested PS-insulation and ply wood – we know how this stuff burns. With this knowledge and knowing that it takes much less to set fire on dry plants (grasses) than on a piece of waterproofing the field research begun. During the following months (August until October) they actually tried to start fires on green roofs with a defined setup (with dry wooden wool) which was installed on the roofs and ignited. They expected a glowing of the organic content in the growing media and they also thought that the dry plants will spread the fire immediately all over the roof. Just keep in mind, at this time the organic content of the growing media was typically higher than the values in the actual FLL guidelines and so you also found higher plant varieties with consequently a higher amount of dead and dry plants.

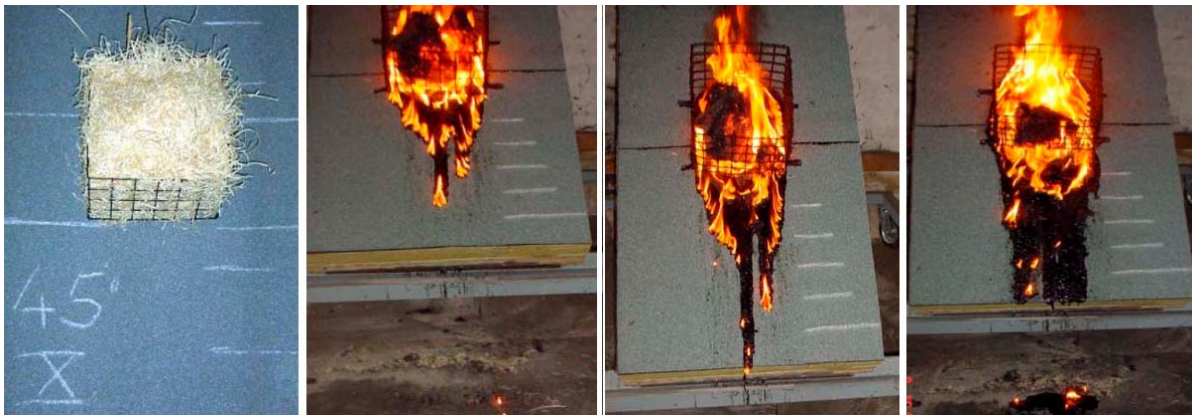
After all this experiments and research just a short answer. It is nearly impossible to set an extensive green roof on fire which spreads over the roof or starts a glowing/burning of the growing media. The risk of fueling fires is 15-20 times higher on bare roofs with fully adhered bituminous waterproofing membranes as on extensive green roofs with grasses, perennials and Sedums. I guess in 1988 I installed approximately 2,000,000 sf of extensive green roofs - all on schools and kindergartens in the south of Stuttgart. Until today the City of Stuttgart still continues with their green roof strategy.



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Typical fire test of waterproofing materials in Germany. Picture: Universität Paffenwald

Today in Germany are at least 2 billion square foot of extensive green roofs built and there is no fire recorded related to a green roof. This research and further studies showed certain risks (i.e. sparks caused by burning grasses which can spread over the green roof by wind) which are minimized by clear definitions of green roof details and roofing details for green roof. There are considerations in building codes, German and European standards (DIN/EN). The FLL guideline always represents the latest State-Of-The-Art in addition to the above mentioned standards. In Germany you typically get a 10-20% discount on the fire insurance when a seamless extensive green roof is installed.

**Optigrün-Extensivbegrünungen** sind bei Einhaltung der nachfolgend angeführten Bedingungen ebenfalls als ausreichend widerstandsfähig gegen Flugfeuer und strahlende Wärme bewertet.

- Vegetation besteht überwiegend aus niedrigwachsenden Pflanzen wie Sedum, Kräuter, Gräser.
- Substrataufbauhöhe von mindestens 3 cm Höhe.
- Substratanteile an organischer Substanz höchstens 20 Massen-Prozent.
- Gebäudeabschlusswände, Brandwände oder, anstelle von Brandwänden zugelassene Wände, haben einen maximalen Abstand von 40 m und ragen mindestens 30 cm über die Oberkante Gründachaufbau.
- Müssen die vorgenannten Wände aufgrund bauordnungsrechtlicher Bestimmungen nicht über das Dach geführt werden, ist eine Aufkantung aus nicht brennbaren Baustoffen von mindestens 30 cm Höhe vorzusehen oder ein Streifen aus Grobkies bzw. massiven Platten mit einer Mindestbreite von 100 cm anzubringen.
- Vor Öffnungen in der Dachfläche (z.B. Lichtkuppeln) und vor Wänden mit Öffnungen ist ein Streifen aus Grobkies oder massiven Platten von mindestens 50 cm Breite vorzusehen. Ausnahme: die Wandöffnungen befinden sich mehr als 80 cm über der Oberkante Gründachaufbau.
- Im Traufbereich von aneinander gereihten, giebelständigen Gebäuden muss ein mindestens 100 cm breiter Streifen unbegrünt bleiben.
- Mindestens 50 cm vegetationsfreier Abstand gegenüber von aufgehenden Bauteilen und Dachdurchdringungen.

Picture above: Flat roof technology and green roofs as preventive fire protection. Picture: Optigrün

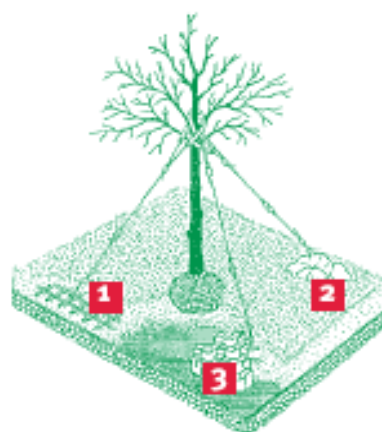
#### Wind loads:

In most cases the fire insurances offer a package which also covers damages caused by wind and storms. An insurance company wouldn't give a discount if there is a higher risk in one of each; however that is only one aspect you can look at wind load topic. To backup my experience of nearly 30 years I contacted some of my friends in Germany. Since decades Dr. Gunter Mann and Dipl.Ing.Martin Henneberg are working for Optigreen and they did uncountable studies together with all major Universities in Germany and published exciting articles about green roofs as well. They maintain a close information network to more than 100 installing companies and partners. It is the biggest information resource I know and which offers a feedback of at least 20 million square foot new green roof construction every year. Speaking about this resource Dr. Gunter Mann was interviewing close to 80 installers about wind loads on green roofs. All interviewed installers look back on more than 15 years of experience and millions of square foot green roofs installed. Based on these experiences and their reports they confirmed my experience that wind erosion can happen on each building regardless the height of the roof or the height of the parapet. Most erosion on roofs below 60 foot is hardly recognized since it typically starts during the establishing phase of the plants (new installations) and the plants usually cover these areas soon. Large organic parts (wood chips etc.) and very lightweight aggregates ( less than 600g/ltr.) are blown away fairly easy and found all the time everywhere on the roof where they shouldn't be. Most of the (hardly to see) wind damage on building below 60 ft is also caused by unique aerodynamics of the buildings itself. All installers agreed that even the smallest wind damage has to be fixed immediately with appropriate solutions to prevent further damage. It shows once more that green roof maintenance requires very high skills, well trained senses and the understanding of working with nature – not against it. Regarding wind loads architects and installers put more emphasis on buildings over 60 ft. height and so surprisingly there are less minor problems recorded.

#### Typical problems



#### and solutions:





A few big issues are well known and I like to share one true story with you:

Together with four landscape companies we installed in 1997 a 560,000 square foot extensive green roof on an over 60 foot high building. The building was also in an open field on top of a hill. I guess it was Storm "Lothar" just around Christmas with wind speeds up to 140 miles and wind gusts up to 180 miles. During this storm some large areas of the famous Black Forest were gone and 0.8% of the green roof on this big box, too (4000 sf). Sounds like a disaster? Yes and No.

Yes, because we knew about the exposed location of the building and that a green roof is vulnerable when plants are in the establishing phase.

No, because the green roof was designed according to the existing standard and the FLL guideline to withstand very high wind loads however all solutions (incl. concrete pavers etc) weren't enough to keep things in place.

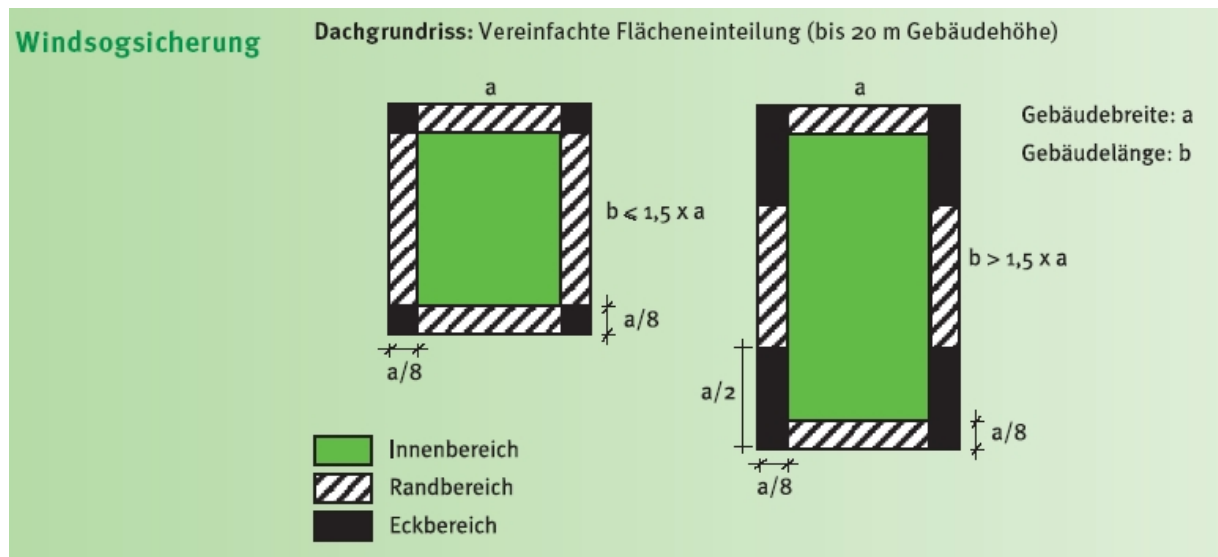


Picture: Jörg Breuning

It wasn't a disaster either since the overall design was responsible that all components of the green roof remained on the roof and nothing felt down or was blown off the roof. Actually the insurance company paid for fixing the green roof since they were also happy that the force of the storm went into the green roof and not into the waterproofing or the lightweight

steel deck. At the same time other wind damages on green roofs were recorded however all of them were minor (less than 1% of the "greened" area), nobody was hurt by falling Sedums but by falling trees, flying roof tiles or plywood sheets.

Regarding fire and wind load green roofs fit into all German strict regulations and building codes and green roofs are accepted because they work like a crash zone of a building. However green roofs have to meet relevant standards and guidelines like the FLL. Custom made solution for each green roof layer or components, unnecessary components or products and less experience or understanding of living components increase the risk and require an independent test in Germany. In nearly all cases it is too expensive and hard to insure.



In the USA most laboratory tests are different to tests in Europe however people know how to analyze and compare the results. With the first American green roof guidelines, standards and recommendation from different associations I can see lots of elements from the German FLL are already included. It seems just a matter of time and more experience until worldwide guidelines are merging to 85%-95% to what the FLL is right now.

#### Conclusion:

When green roofs are designed, installed and maintained with expertise and experience the safety standard of the building is improved. A building with a green roof is in the German experience safer than a building without green roof because the consideration of a green roof in the design phase will already address safety concerns early and more intense. With available standardized components it is easy to custom tailor a wall-to-wall or seamless green roof for maximum safety and protection.

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