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Subject matter: **Non-ballasted on-roof systems**
In this case: **Expert statement**

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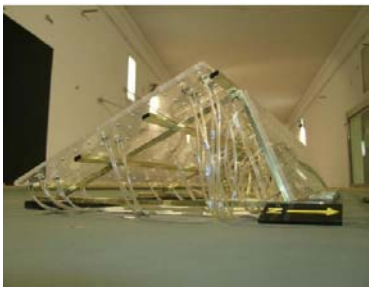
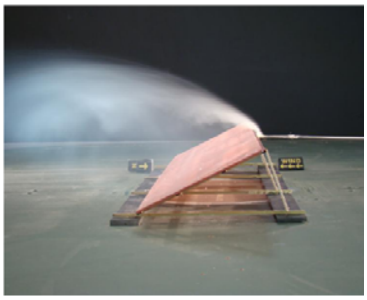
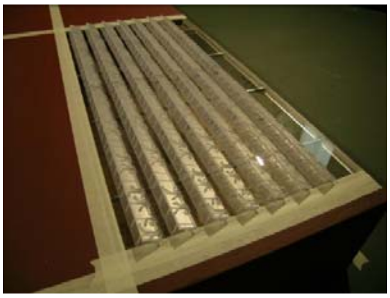
Technical expert statement on ballasted on-roof systems

Elevated installations on flat roof represent a wide range of the possible applications of photovoltaic applications of photovoltaic plants. Especially in the area of large area halls, you will usually find membrane roofs for industrial buildings. The search for suitable mounting systems is mainly based on the results of the examinations of the individual constructional conditions and the load-bearing reserves of the supporting components that are found out. In order to be able to grant permanent roof-tightness, most constructors prefer a mounting system that does not require any perforations of the roof cladding. In view of this requirement, actually only ballasted mounting systems or solutions which imply the gluing of the mounting system to the membrane can be considered. The following explanation is focused on ballasted mounting systems.



Ballasted mounting systems are only technically feasible if both the roof covering and the supporting structure of the hall have sufficient load-bearing reserves. As there are numerous buildings with load bearing reserves within a range from 8 to 25 kg/m², the market has spawned a variety of products that promise a virtually non-ballasted elevation. Under the aspect of safety of both the utilized material and the people within the area of the respective buildings, it is of prime importance to ask the question to what extent non-ballasted systems using „spoiler effects“ meet the normative safety requirements. The following evaluation is based on wind channel tests carried out between November 2008 and June 2009 at the Cermak Institute, Peterka Petersen (CPP) in the United States of America.
In the course of the tests primarily the aerodynamic characteristics with or without a sheet metal covering at the back side within a range between 10° and 30° with incident flows from all sides were examined in detail. In the course of this process, also the effects of air gaps at the metal sheets at the back sides were examined in order to check if any considerable contact pressure can be generated.





On the basis of this large scale tests, small scale tests with complete module fields in different positions on the roof were carried out. Due to these extensive parameter examinations, a comprehensive overview of the influence of the border distances from the outer edges of the roof and the wind load reducing effect on the inner rack rows could be gained. As expected, the position in the slipstream of the outer rows results in a significant reduction of the required ballasting loads.

Within the framework of this study, a classification in the context of European and American load standards was carried out, in order to evaluate the suitability of the normative pressure coefficients for the dimensioning of elevated PV-plants. At the same time, the application of the standards for shedroofs for the reduction of the wind loads on the interior rows could be evaluated.

The results of this examination can be summed up as follows:

A quantification of the ballasting on the basis of pressure coefficients according to DIN 1055 in the edge are can be regarded as narrow, but sufficiently safe. The inner roof area the reduction of the wind forces to 60 % starting from the third row gains a result for slightly unfavourable conditions. On the basis of the wind channel test, a reduction of the ballast of about 10 – 20% would be possible.

Currently, there are promotional brochures available on the market offering absolutely non-loaded elevations on the basis of wind tunnel tests. In comparison with the wind tunnel tests mentioned above, a bit of caution is advisable here. The technical background should be thoroughly examined and if necessary, you should also insist on the wind tunnel test report, as it is a decisive criterion, if all incident flow directions have been tested. An incident flow from the North (with optimum alignment to the South) does not necessarily represent the most unfavourable situation. The much-cited spoiler effects are likely to be mentioned for promotional reasons. Generally, aerodynamics offers the tools to precisely direct airflows in the context of vehicle or aircraft construction. In case of a plane, an uplift is created by means of a designed wing bending at high speed (laminar flow). But with a typical solar elevation, two decisive criteria are different: The airflow is squally and usually turbulent, and therefore a negative uplift by a laminar wind flow can hardly be realized. The geometry of the module is determined as a plane area. The elevation angle and the flat back side sheet metal are no typical flow bodies. The activation of a contact pressure by creating a low pressure could only be observed on a scale of maximum 2-3% in the course of these wind tunnel tests.

Summing up it has to be stated that apart from the verifications against uplift and tilting, also a verification against sliding has to be carried out. In a specific test series under wet conditions on a membrane with surface protection mat, a friction coefficient of $\mu \approx 0.4$ could be determined. An induction of the horizontal power components by friction requires a certain basic weight. In this case the coupling of rows only has a limited effect, because usually the other mounting racks are exposed to wind loads.

Summing up it can be stated that from the author´s point of view a non-ballasted elevation with typical wind velocities and building forms according to the safety requirements seems to be impossible. For a verification of this valuation, extended examinations are currently carried out in cooperation with a renowned institute.

A further aspect that should not be neglected is the transfer of the pressure loads into the roof cladding. The products that are usual in the market may only be loaded with determined allowable pressures in order to avoid damaging or reductions of durability.

With mounting racks for elevated solar plants, apart from the self-weight and the ballast loads, also the pressing wind loads and the snow loads, which would be area loads if it was not for the PV plant, are gathered by the module field and the concentrated load is transferred into the roof cladding. In order not to exceed the allowable pressures onto the insulation, bending-resistant laminar elements are required to evenly divert the loads. The required stiffness generally cannot be obtained by simply folding the sheet metal at an angle of 90° (in order to enlarge the contact surface), because due to resilience the thereby created plates are not relevant regarding the load transfer. In turn, loading elements or specially shaped load containers can be purposefully used for a material-friendly application of the pressure loads.

In the interest of a durable solution and in order to avoid liability claims, also in this respect a thorough verification is mandatory.

Haag, July 14, 2009