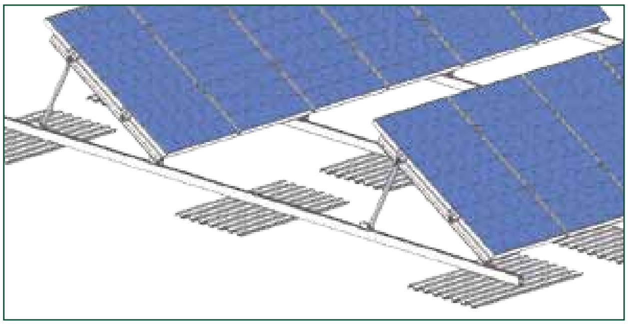
Flat roof mounting

General hints



The spread of photovoltaics means increasing importance of electric parameters, durability, warranty periods, etc. and also the mounting details become more and more important. In the early days of photovoltaic installations, small numbers of modules were installed on roofs, now there are numerous mounting variants for all kinds of roofs and installation forms up to big surface roofs of industrial buildings or open area installations. With the ever increasing number of plants, insurers try to gain influence on the quality standards of the plants due to the statistic increase of damage cases.
Flat roof mountings and especially loading solutions are particularly relevant for the evaluation of damage risks. Whereas mounting faults on pitched roofs that can lead to roof leakages, module damage or yield losses only represent a limited damage risk, insufficient loadings on flat roofs can easily result in damage to third parties, and if the loadings are too heavy, even the danger of structural collapse of the roof has to be taken into account.

The following hints are supposed to help to limit the risks for the planner or installer and allow for a safe and professional project planning.

1 Loading or fastening
General hints on flat roof mounting

In many cases, especially in case of PV-installations on flat roof, the respective roofs are not sufficiently considered from a technical point of view in the process of offer creation. All-inclusive kW-offers often include a standard loading solution without previous determination whether the weight of the loading is realistic or if the respective building can be loaded with the additional weight of the modules and the supporting structure, not to mention additional loads for the fixation of the PV-plant. Often it is not sufficiently considered that loading weights increase the complete load of the construction by a multiple and therefore can not be applied on many roofs.

In the course of a professional offer creation, the fixation of the PV-plant to the roof substructure definitely should be checked first, because it is the better option in most cases. Customers do not have to have any reservations about penetrations of the roof cladding, as the mounting details are ever more professional and include reliable sealing solutions. In fact, the planner should inform the customer about the much bigger risk of faulty project planning respectively the loadings that are really required.

If a loading solution should really turn out to be the better option for the respective object, the loading has to be dimensioned by calculation considering all relevant norms and all individual parameters.
If necessary, an optimization of the mechanical construction details as well as a minimization of the required loading is possible.

Combinations of loading solutions and fastening solutions are generally not recommendable. Due to the elastic defomations in the system, this would require a painstaking structural analysis in each individual case.

Example picture: Module rows damaged by overturning on a flat roof (insufficient loading)
Source: Specialized press

Example picture: Mounting of a flat roof construction with absolutely insufficient loading
Source: Schletter GmbH

2 Technical limits of fastening solutions
Risk potential for the planner and the installer

Whereas mounting faults on pitched roofs represent a limited damage risk in individual cases, **insufficient loadings** on flat roofs can easily lead to dangers to third parties. If the roof is overloaded **by loads that are too heavy,** even the risk of an overloading and collapse of the roof has to be taken into account. Faulty dimensioning of loadings can easily lead to danger for "life and limb" of third parties. Usually such potential damage cases are covered by the liability insurances, but this only applies if there is no case of gross negligence. It can be interpreted as gross neglicence if a flat roof is loaded with concrete weights without a previous check of the structural load-bearing capacity.

Therefore, the specialized company that carries out the installation has to dimension the loading considering all parameters (roof height, wind zone, terrain category, module size, etc.), so that any danger of lift-off, sliding or overturning can definitely be ruled out. Especially in the last years, increasingly extreme weather conditions have shown the top priority of of a technically thorough and safe project planning

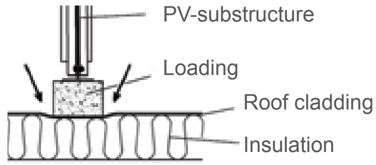
The information compiled here is supposed to demonstrate the possibilies of a professional project planning.

2.1 Allowable point loads

The allowable pressure loads on the roof insulation in combination with the sealing membrane that is laid on it, usually limits the maximum allowable point load (usually in kg/m² or kN/m²). When dimensioning the constructional loading weights, it has to be made sure that the maximum point load is not exceeded.

Possible dangers in case of exceeding the maximum point load are

- Caving in of the insulation
- Sinking in of the loading
- Overstretching of the roof cladding
- Brittling of the roof cladding
- Untightness



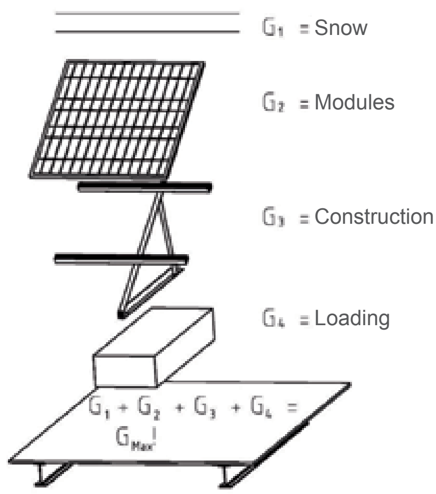
By means of a suitable laminar distribution, the point load can be limited.

2.2 Allowable distributed loads

The allowable distributed load (usually in kg/m2 or kN/m2) usually relates to the complete roof area or to parts of the roof area. The maximum distributed load is determined by the load-bearing capacity of the structure. It has to be considered that the roof also has to bear the snow load according to the local standards besides the weight of the modules, the substructure and the potential loading weights. On the basis of the structural analysis, the installer has to check thoroughly, whether the roof construction can really bear the additional weight of the PV-plant. After the serious events that took place in the winter 2005/2006, the importance of the dimensioning guidelines should be clear to anybody. It has to be considered that often very heavy loads are required to load a plant according to the guidelines of the new DIN 1055.

Possible dangers in case of an exceeding of the allowable distributed load are

- Partial caving-in of the roof construction
- Complete caving-in of the roof construction
- Collapse of the building
- Damage to persons



Possibilities to limit the distributed load

- Reduction of the number of modules laid
- Purposeful arrangement of the module rows above roof girders
- Optimization of the construction

2.3 Protection of buildings in view of the changing of the standards

Another important aspect after the change of the DIN1055 is the architectural conservation that were planned before the new set of standards was published. According to the new standard, a location in the south of Germany for example now may have to be calculated with a snow load of 1.6 kN/m², instead of 1.2 kN/m² (this corresponds to 120kg/m²) until now. A hall that was built before the standard were changed with a load bearing capacity of 1.4 kN for example, still has architectural protection and does not have to be refitted necessarily.

But if an expert company installs a PV-plant on a roof with architectural conservation, the new load guidelines apply for the structural analysis, the architectural conservation becomes invalid if additional installations or constructional changes are carried out. The whole dimensioning has to be carried out according to the new standards.

3 Dimensioning criteria for loading solutions

3.1 Relevant standards

- DIN 1055 Load assumptions for buildings, part 4: Wind loads, edition 03/2005
- DIN 1055 load assumptions for buildings, part 5: Snow- and ice loads, edition 06/2005
- DIN 1055-100 Impacts on supporting structures, basics of the planning of supporting structures, safety concepts and dimensioning guidelines, edition 03/2001
- Eurocode 1: Impacts on supporting structures, edition 06/2002

3.2 Special wind loads

According to the standards mentioned above, no project plannings based on standard parameters can be carried out for projects in special terrain shapes. This especially applies for loadings, too. In case of such terrain formations (for example building on hills, etc.), a specific individual structural analysis has to be created.

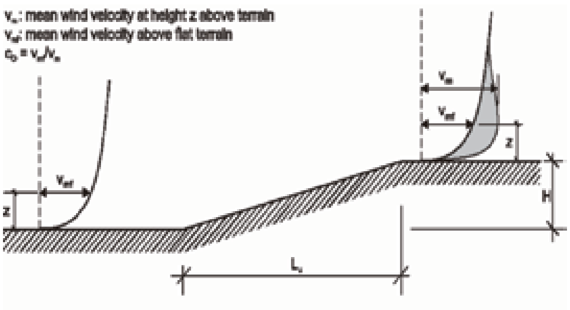


Figure A.1 — Illustration of increase of wind velocities over orography

3.3 Parameters for loading calculation

The required parameters for a loading calculation consist of the construction details of the intended module elevation (support geometry, beam configuration, inclination angle, module arrangement, additional measures for wind resistance, support distance, etc.) and the geographic data of the intendend location:

- Windzone acc. to DIN 1055
- Terrain category acc. to DIN 1055
- Height above sea level
- Ridge height above top ground surface
- Height of roof parapet (if there is any)
- exposed location (if this is the case)

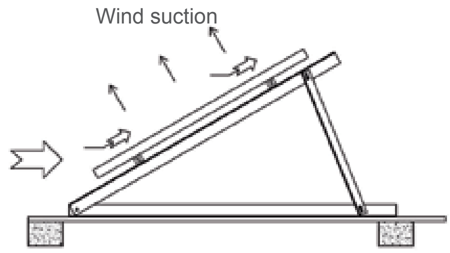
The geographic data must be specified for a calculation (please also see geographic checklist, Schletter GmbH)

3.4 Load determination

The determination of the wind zone according to the norm can only be carried out by means of the accordant wind zone map. But as this is rather unexact and almost impossible with the resolution of the available norm, the Schletter GmbH provides an Internetservice for a load determination that is based on postal codes (wind loads, snow loads)

3.5 Dimensioning of the loading
Load case 1 - wind suction

The dimensioning of a loading against lift-off by wind suction represents a minimum requirement. If an air flow impacts an inclined surface with the respective presumable wind velocity, a dynamic pressure difference is created due to the different flow speeds on the upper and the lower surface. The power that is created by the pressure difference on the surface must be compensated by means of loading, so that the arrangement does not lift off.



For a long time, the dimensioning of the loading against lift-off was the only crtiterion for the selection of the loadings. This has partly been tolerated by testing institutes, as this kind of dimensioning results in rather high loads anyway. Structural analysis charts provided by system producers in most cases state this minimum requirement, a chart like that can be sufficient for optimized constructions.
In any case, a chart like that can be used for a rough **determination of the minimum loads.** Using this chart, the installer can determine without painstaking calculation, if the flat roof is suitable for this minimum load, if a a loading solution is reasonable at all, or if an alternative solution has to be chosen in the first place.

Anwendungstabelle die erforderlichen Auflastungen gegen Abheben infolge Windsogeinwirkung

Auflasten		Windzone 2: h ≤ 10 m (q = 0.65 kN/m²)							
		Achsabstand der Stützrahmen [m]							
Modul-höhe	Nei-gung	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.75	20	43	57	72	86	100	115	129	143
	30	52	69	87	104	121	139	156	173
	40	45	60	76	91	106	121	136	151
	45	41	55	69	83	97	111	124	138
	50	37	50	62	75	87	99	112	124
	60	28	37	46	56	65	74	84	93
1.00	20	57	77	96	115	134	153	172	191
	30	69	92	115	139	162	185	208	231
	40	60	81	101	121	141	161	181	202
	45	55	74	92	111	129	148	166	184
	50	50	66	83	99	116	132	149	166
	60	37	50	62	74	87	99	111	124
1.20	20	69	92	115	138	161	184	207	230
	30	83	111	139	166	194	222	249	277
	40	73	97	121	145	169	194	218	242
	45	66	89	111	133	155	177	199	221
	50	60	79	99	119	139	159	179	199
	60	45	59	74	89	104	119	134	149
1.60	20	92	122	153	184	214	245	275	306
	30	111	148	185	222	259	295	332	369
	40	97	129	161	194	226	258	290	323
	45	89	118	148	177	207	236	266	295
	50	79	106	132	159	185	212	238	265
	60	59	79	99	119	139	159	178	198
1.90	20	109	145	182	218	254	291	327	363
	30	132	175	219	263	307	351	395	439
	40	115	153	192	230	268	306	345	383
	45	105	140	175	210	245	280	315	350
	50	94	126	157	189	220	252	283	315
	60	71	94	118	141	165	188	212	235

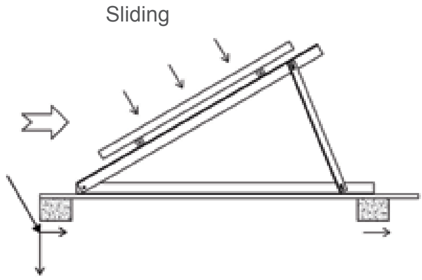
Auflasten		Windzone 2: 10 < h ≤ 18 m (q = 0.80 kN/m²)							
		Achsabstand der Stützrahmen [m]							
Modul-höhe	Nei-gung	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.75	20	54	72	90	108	126	144	162	180
	30	65	87	108	130	152	174	195	217
	40	57	76	95	114	133	152	171	190
	45	52	70	87	104	122	139	157	174
	50	47	63	78	94	110	125	141	157
	60	35	47	59	71	83	95	106	118
1.00	20	72	96	120	144	168	193	217	241
	30	87	116	145	174	203	231	260	289
	40	76	101	127	152	177	203	228	253
	45	70	93	116	139	163	186	209	232
	50	63	84	105	125	146	167	188	209
	60	47	63	79	95	110	126	142	158
1.20	20	87	116	144	173	202	231	260	289
	30	104	139	174	208	243	278	312	347
	40	91	122	152	182	213	243	274	304
	45	84	111	139	167	195	223	251	279
	50	75	100	125	150	176	201	226	251
	60	57	76	95	114	132	151	170	189
1.60	20	116	154	193	231	270	308	347	385
	30	139	185	231	278	324	370	417	463
	40	122	162	203	243	284	324	365	405
	45	111	149	186	223	260	297	334	371
	50	100	134	167	201	234	268	301	334
	60	76	101	126	151	177	202	227	252
1.90	20	137	183	229	274	320	366	411	457
	30	165	220	275	330	385	440	495	550
	40	144	193	241	289	337	385	433	481
	45	132	176	221	265	309	353	397	441
	50	119	159	199	238	278	318	357	397
	60	90	120	150	180	210	240	270	300

Auflasten		Windzone 2: 18 < h ≤ 25 m (q = 1.10 kN/m²)							
		Achsabstand der Stützrahmen [m]							
Modul-höhe	Nei-gung	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.75	20	76	102	127	153	178	204	229	254
	30	91	122	152	183	213	244	274	305
	40	80	107	134	161	187	214	241	268
	45	74	98	123	147	172	197	221	246
	50	67	89	111	133	155	178	200	222
	60	51	68	84	101	118	135	152	169
1.00	20	102	136	170	204	238	271	305	339
	30	122	162	203	244	284	325	366	406
	40	107	143	178	214	250	285	321	357
	45	98	131	164	197	229	262	295	328
	50	89	118	148	178	207	237	266	296
	60	68	90	113	135	158	180	203	225
1.20	20	122	163	204	244	285	326	366	407
	30	146	195	244	292	341	390	439	487
	40	128	171	214	257	300	343	385	428
	45	118	157	197	236	275	315	354	393
	50	107	142	178	213	249	284	320	355
	60	81	108	135	162	189	216	243	270
1.60	20	163	217	271	326	380	434	489	543
	30	195	260	325	390	455	520	585	650
	40	171	228	285	343	400	457	514	571
	45	157	210	262	315	367	419	472	524
	50	142	189	237	284	331	379	426	473
	60	108	144	180	216	252	288	324	360
1.90	20	193	258	322	387	451	516	580	645
	30	232	309	386	463	540	617	695	772
	40	203	271	339	407	475	542	610	678
	45	187	249	311	374	436	498	560	623
	50	169	225	281	337	393	450	506	562
	60	128	171	214	257	300	342	385	428

Example chart for loadings against wind suction - system structural analysis Schletter GmbH

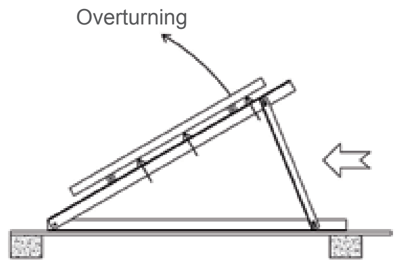
3.6 Dimensioning of the loading
Load case 2 - sliding

Besides the uplifting force, the air flow creates an impact pressure on the inclined surface. By vectorial subdivision of the arising pressure force, a pressure force that is parallel to the surface can be determined. In case of a complete loading solution, this pressure force must be compensated only by the friction on the roof surface in order to make sure that the module rows are not shifted on the roof. Due to the fricition coefficients of the roof cladding that are often unfavourable and uncalculable, the required load can amount up to a multiple of the load against wind suction.
The need for this additionally required load can possibly be avoided by securing the rows or by connecting the rows.



3.7 Dimensioning of the loading
Load case 3 - overturning

Especially in case of wind from behind, if the support base is short, or a high center of gravity, a single row on the roof can overturn. In order to make sure that wind from the north does not become a problem, this case also has to be considered thoroughly. The required load to avoid overturning can amount to a multiple of the load against wind suction. A minimization of the required loadings for the individual row can be carried out by means of well distributed loads, wide ground contact areas or wind deflectors, another constructional possibility is the coupling of several rows.

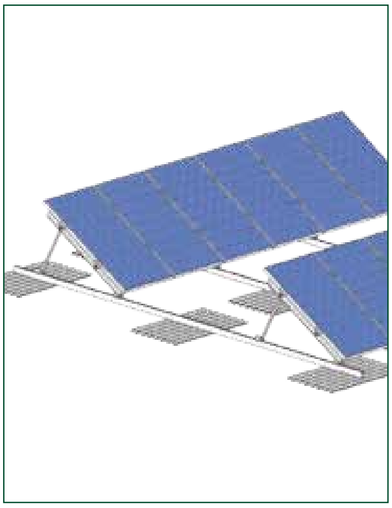


4 Optimization of the loadings
Constructional options

The laoding values determined according to the standards mentioned above are often not feasible due to the limited load-bearing capacities of the roofs. A limitation of the required loadings can be realized by means of different constructional modifications.

4.1 Interconnection of single rows

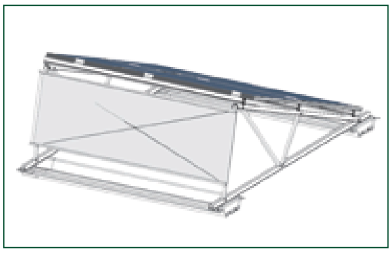
(Construction example Schletter CompactVario)



By the interconnection of the single rows with load distribution beams, the overturning of single rows can completely be ruled out. The loading against tilting can be completely ignored in this case. The load distribution beam has to be dimensioned in such a manner that the the potential tilting moment of a single rows can be absorbed without plastic deformation. The risk of sliding of individual rows is also reduced with this construction, due to the mutual wind shading of the rows, the loading against sliding could be reduced by 20% and possibly even by 40%, depending on the specific number of rows. A dimensioning solely with the loading against wind suction is only possible, if gliding can be prevented by constructional securing on the roof (for example by direct contact of the load distribution beam to the roof parapet).

4.2 Optimization of the angle and prevention of overturning by means of wind deflectors.

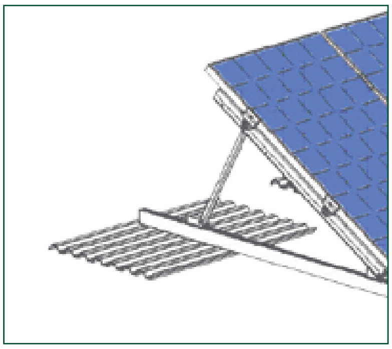
(Construction example Schletter WindSafe)



The dimensioning of a loading against tilting is not required for rows that are closed at the back, because "wind from below" is avoided in these cases. Moreover, the required load can be further minimized by optimizing the inclination angle.

4.3 Optimization of geometry and load distribution

(Construction example Schletter SolRack)



If the loads are placed in the gravel bed of a flat roof, the consideration of the sliding case can be omitted. Moreover, the proneness to overturning is reduced by the bigger support base which reduces the calculated loading against keeling over. A further reduction can be achieved by an unsymmetric distribution of the load burden (back 2/3, front 1/3). Thus, also in this example, loads that can still be carried by the roof are sufficient for the loading.

5 Software-aided calculation on the basis of the valid standards - calculation examples

After the introduction of new norms and numerous parameters, a professional project planning of fastening solutions on flat roofs is now only possible by using software tools. Here are a few examples to illustrate the way the system works. All examples are only for information without claiming technical correctness.

See attachment for example calculations.

Comparison of the calculation examples

The examples are supposed to illustrate the application of the loading data and the possibilities of constructional optimization.

In all examples, the other parameters (postal code, element height, module inclination, roof height, support distance, terrain category, etc.) are constant, in order to make other construction options possible.

Example 1

For example 1, a simple one-row elevation has been chosen.

- For a verification against uplift, 2x77.2 kg per support (according to chart at the front and at the back) would be required; this is also the value that is stated in a simplified form in the charts acc. to 3.5.
- The verification against sliding requires 2x129.5 kg.
- The verification againgst overturning requires 141.2 plus 251.4 kg. With a chosen support distance of 1.4 m that would be about 280 kg per running meter module row.
- The maximum load of these three verifications is the required loading.

Example 2

In example 2, "horizontal fastening" and "coupling of the module rows" are applied. This corresponds to the construction according to item 4.1.

- Only a loading of 2x77.2 kg per support has to be applied, this corresponds to about 110kg per running meter/ module row.

Example 3

In contrast to example 1, in this case no individual weights are used, but a fixed weight is applied centrically below the support. In this case, the subdivision of the weight that was already optimized in example 1 must be compensated by an additional weight.

- In this case, 502.8 kg are required for the verification against overturning (instead of 141.2 plus 251.4 like in example 1). With a chosen support distance of 1.4 m that would be about 360 kg per running meter of module row.

Example 4

Example 4 corresponds to example 2, but in example 4 there is an additional wind deflector.

- Only a loading of 2x77.2 kg per support has to be applied, this corresponds to about 53 kg per running meter/ module row.

The reduction of the load due to constructional optimizations is obvious in this case.

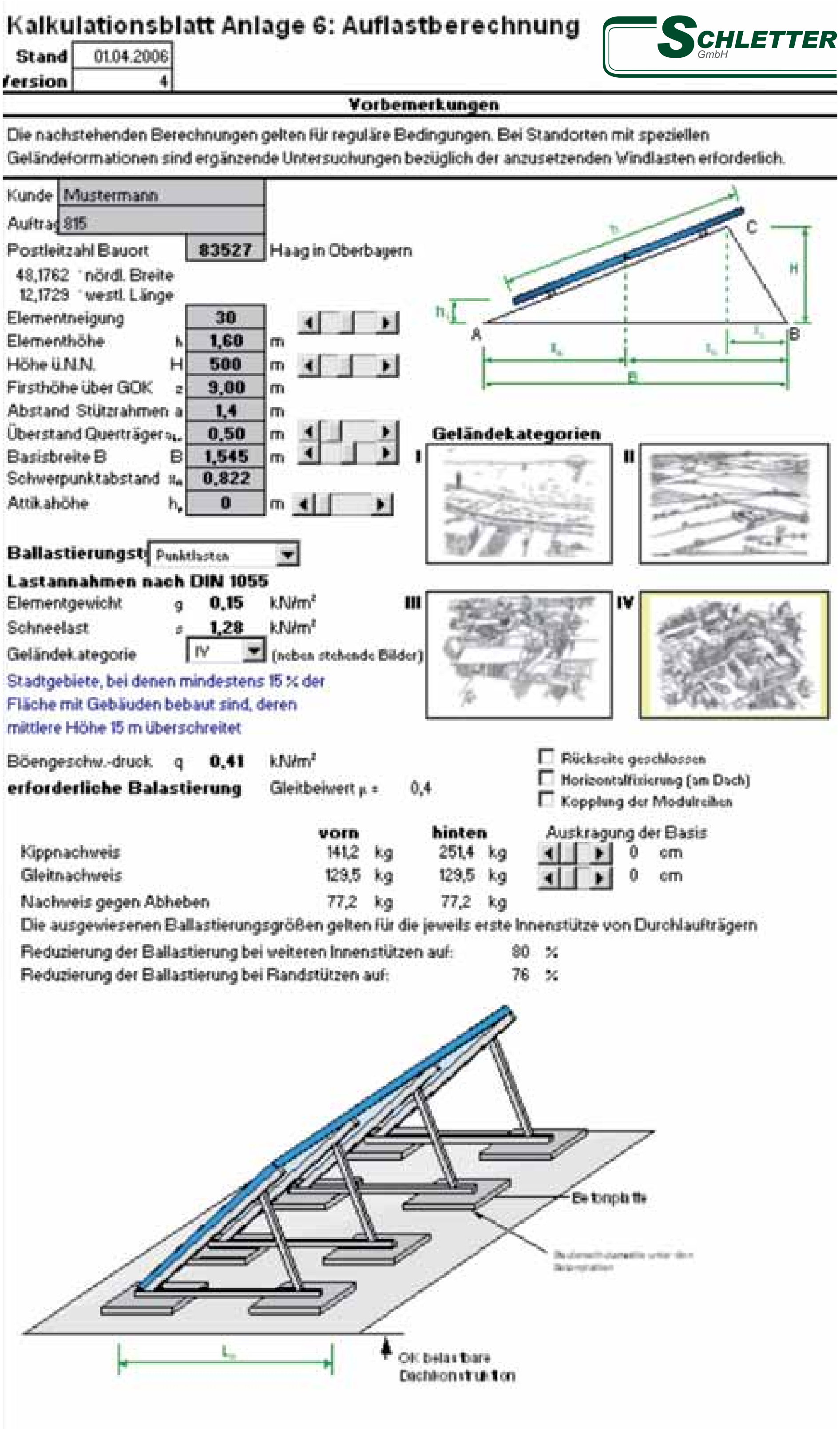
6 Summary

The present project planning aid is supposed to facilitate the selection of suitable fastening options on flat roofs. To limit the risks both for the planner and the installer, an absolutely professional project planning is compulsory especially in case of flat roofs! But in many cases it has to be taken into account that flat roof fixations by means of loading solution are impeded by the limited load bearing capacity in spite of the possibility to optimize the construction, and thus definitely must not be implemented! In such cases, either a fastening solution has to be chosen as an alternative, or some projects simply cannot be realized.

It has to be the aim of all common efforts, to improve the quality of mounting in the long run, to reduce the liability risk of the plant installer as far as possible and especially to keep up the high level of acceptance of solar energy plants in public.

7 Attachment - calculation examples (this program is also available in English)

Example 1



Kalkulationsblatt Anlage 6: Auflastberechnung SCHLETTER GmbH

Stand	01.04.2006
Version	4

Vorbemerkungen

Die nachstehenden Berechnungen gelten für reguläre Bedingungen. Bei Standorten mit speziellen Geländeformationen sind ergänzende Untersuchungen bezüglich der anzusetzenden Windlasten erforderlich.

Kunde		Mustermann	
Auftrag		815	
Postleitzahl Bauort		83527	Haag in Oberbayern
48,1762 ° nördl. Breite			
12,1729 ° westl. Länge			
Elementneigung		30	
Elementhöhe	h	1,60	m
Höhe ü.N.N.	H	500	m
Firsthöhe über GOK	z	9,00	m
Abstand Stützrahmen	a	1,4	m
Überstand Querträger	$s_{\ddot{u}}$	0,50	m
Basisbreite B	B	1,545	m
Schwerpunktabstand	s_B	0,822	m
Attikahöhe	h_a	0	m

Geländekategorien

I II III IV

Ballastierungsstr Punktlasten

Lastannahmen nach DIN 1055

Elementgewicht	g	0,15	kN/m²
Schneelast	s	1,28	kN/m²
Geländekategorie		IV	(neben stehende Bilder)

Stadtgebiete, bei denen mindestens 15 % der Fläche mit Gebäuden bebaut sind, deren mittlere Höhe 15 m überschreitet

Böengeschw.-druck	q	0,41	kN/m²

erforderliche Balastierung Gleitbeiwert μ = 0,4

☐ Rückseite geschlossen
☐ Horizontalfixierung (am Dach)
☐ Kopplung der Modulreihen

	vorn		hinten	
Kippnachweis	141,2	kg	251,4	kg
Gleitnachweis	129,5	kg	129,5	kg
Nachweis gegen Abheben	77,2	kg	77,2	kg

Auskragung der Basis: 0 cm; 0 cm

Die ausgewiesenen Ballastierungsgrößen gelten für die jeweils erste Innenstütze von Durchlaufträgern

Reduzierung der Ballastierung bei weiteren Innenstützen auf: 80 %

Reduzierung der Ballastierung bei Randstützen auf: 76 %

Example 2

Kalkulationsblatt Anlage 6: Auflastberechnung

SCHLETTER GmbH

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Auftrag		815	
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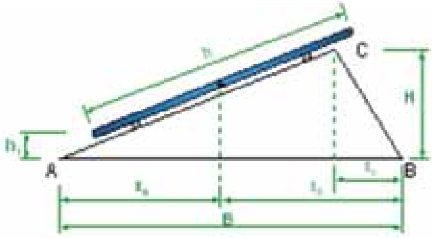
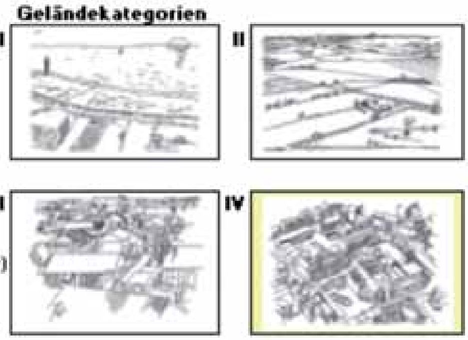
48,1762 ° nördl. Breite			
12,1729 ° westl. Länge			
Elementneigung		30	
Elementhöhe	h	1,60	m
Höhe ü.N.N.	H	500	m
Firsthöhe über GOK	z	9,00	m
Abstand Stützrahmen	a	1,4	m
Überstand Querträger	a_{Ue}	0,50	m
Basisbreite B	B	1,545	m
Schwerpunktabstand	x_a	0,822	
Attikahöhe	h_r	0	m



Geländekategorien



Ballastierungstyp Punktlasten

Lastannahmen nach DIN 1055

Elementgewicht	g	0,15	kN/m²
Schneelast	s	1,28	kN/m²
Geländekategorie		IV	(neben stehende Bilder)

Stadtgebiete, bei denen mindestens 15 % der Fläche mit Gebäuden bebaut sind, deren mittlere Höhe 15 m überschreitet

Böengeschw.-druck	q	0,41	kN/m²

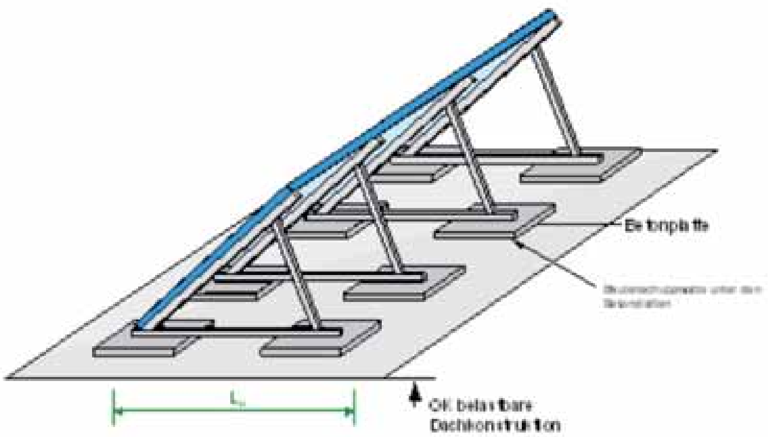
erforderliche Balastierung Gleitbeiwert μ = 0,4

☐ Rückseite geschlossen
☑ Horizontalfixierung (am Dach)
☑ Kopplung der Modulreihen

	vorn		hinten		Auskragung der Basis	
Kippnachweis					0	cm
Gleitnachweis					0	cm
Nachweis gegen Abheben	77,2	kg	77,2	kg	erf W = 10	cm³ (Grundträger)

Die ausgewiesenen Ballastierungsgrößen gelten für die jeweils erste Innenstütze von Durchlaufträgern

Reduzierung der Ballastierung bei weiteren Innenstützen auf: 80 %
Reduzierung der Ballastierung bei Randstützen auf: 76 %



Example 3

Kalkulationsblatt Anlage 6: Auflastberechnung

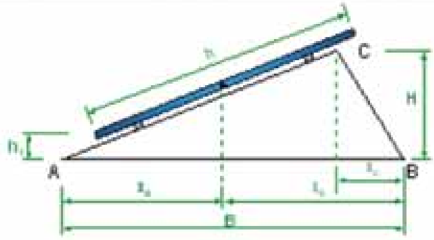
SCHLETTER GmbH

Stand	01.04.2006
Version	4

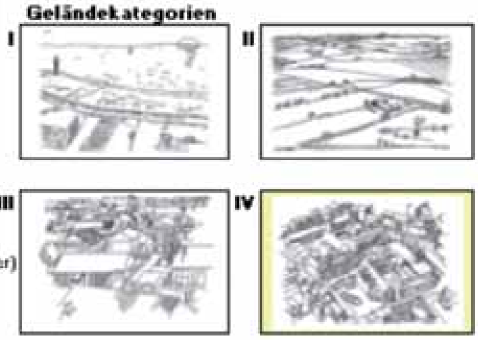
Vorbemerkungen

Die nachstehenden Berechnungen gelten für reguläre Bedingungen. Bei Standorten mit speziellen Geländeformationen sind ergänzende Untersuchungen bezüglich der anzusetzenden Windlasten erforderlich.

Kunde		Mustermann	
Auftrag		815	
Postleitzahl Bauort		83527	Haag in Oberbayern
48,1762 ° nördl. Breite			
12,1729 ° westl. Länge			
Elementneigung		30	
Elementhöhe	h	1,60	m
Höhe ü.N.N.	H	500	m
Firsthöhe über GOK	z	9,00	m
Abstand Stützrahmen	a	1,4	m
Überstand Querträger	$a_{ü}$	0,50	m
Basisbreite B	B	1,545	m
Schwerpunktabstand	x_a	0,822	
Attikahöhe	h_a	0	m



Geländekategorien



Ballastierungsst Streckenlasten

Lastannahmen nach DIN 1055

Elementgewicht	g	0,15	kN/m²
Schneelast	s	1,28	kN/m²
Geländekategorie		IV	(neben stehende Bilder)

Stadtgebiete, bei denen mindestens 15 % der Fläche mit Gebäuden bebaut sind, deren mittlere Höhe 15 m überschreitet

Böengeschw.-druck q 0,41 kN/m²

erforderliche Balastierung Gleitbeiwert μ = 0,4

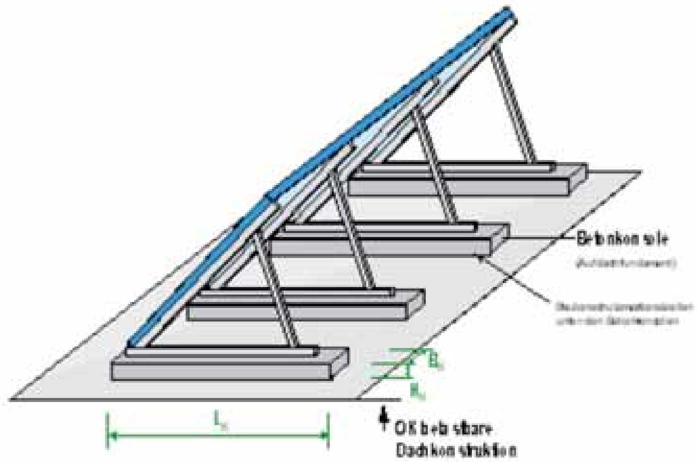
☐ Rückseite geschlossen
☐ Horizontalfixierung (am Dach)
☐ Kopplung der Modulreihen

	Streckenlas		Auskragung der Basis	
Kippnachweis	502,8	kg	0	cm
Gleitnachweis	259,0	kg	0	cm
Nachweis gegen Abheben	154,4	kg		

Die ausgewiesenen Ballastierungsgrößen gelten für die jeweils erste Innenstütze von Durchlaufträgern

Reduzierung der Ballastierung bei weiteren Innenstützen auf: 80 %

Reduzierung der Ballastierung bei Randstützen auf: 76 %



Example 4

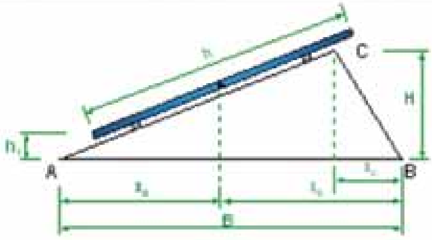
Kalkulationsblatt Anlage 6: Auflastberechnung

Stand	01.04.2006
Version	4

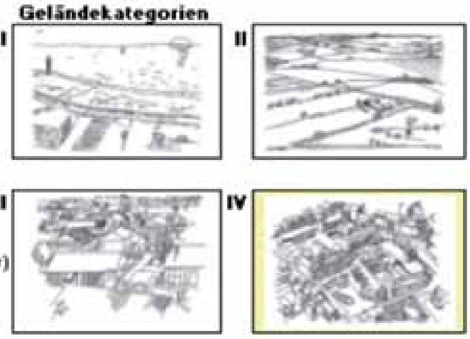
Vorbemerkungen

Die nachstehenden Berechnungen gelten für reguläre Bedingungen. Bei Standorten mit speziellen Geländeformationen sind ergänzende Untersuchungen bezüglich der anzusetzenden Windlasten erforderlich.

Kunde		Mustermann	
Auftrag		815	
Postleitzahl Bauort		83527	Haag in Oberbayern
48,1762 ° nördl. Breite			
12,1729 ° westl. Länge			
Elementneigung		30	
Elementhöhe	h	1,60	m
Höhe ü.N.N.	H	500	m
Firsthöhe über GOK	z	9,00	m
Abstand Stützrahmen	a	1,4	m
Überstand Querträger	$x_{ü}$	0,50	m
Basisbreite B	B	1,545	m
Schwerpunktabstand	x_s	0,822	
Attikahöhe	h_v	0	m



Geländekategorien



Ballastierungstyp Punktlasten

Lastannahmen nach DIN 1055

Elementgewicht	g	0,15	kN/m²
Schneelast	s	1,28	kN/m²
Geländekategorie		IV	(neben stehende Bilder)

Stadtgebiete, bei denen mindestens 15 % der Fläche mit Gebäuden bebaut sind, deren mittlere Höhe 15 m überschreitet

Böengeschw.-druck q 0,41 kN/m²

erforderliche Balastierung Gleitbeiwert μ = 0,4

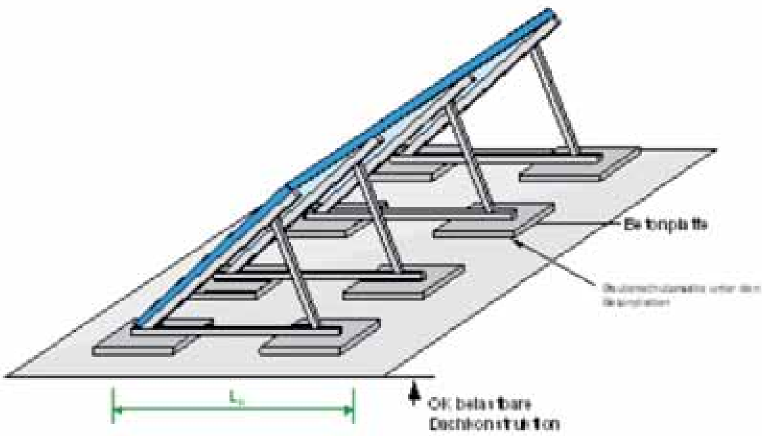
☑ Rückseite geschlossen
☑ Horizontalfixierung (am Dach)
☑ Kopplung der Modulreihen

	vorn		hinten		Auskragung der Basis
Kippnachweis					0 cm
Gleitnachweis					0 cm
Nachweis gegen Abheben	37,3	kg	37,3	kg	erf W = 2 cm³ (Grundträger)

Die ausgewiesenen Ballastierungsgrößen gelten für die jeweils erste Innenstütze von Durchlaufträgern

Reduzierung der Ballastierung bei weiteren Innenstützen auf: 80 %

Reduzierung der Ballastierung bei Randstützen auf: 76 %



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