TEST REPORT

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EVALUATION CENTER

Intertek Testing Services Shenzhen Ltd. Guangzhou Branch
Block E, No.7-2 Guang Dong Software Science Park,
Caipin Road, Guangzhou Science City,
GETDD, Guangzhou, China
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RENDERED TO

SHANGHAI CHIKO SOLAR TECHNOLOGY CO.,LTD.
Bld 1# No. 2439 Gaoshi Road.,Jiading District, Shanghai, China 201811

MANUFACTURER

Same as above

PRODUCT EVALUATED: Model pitched roof mounting system-L

EVALUATION PROPERTY:

BSEN 1990:2002+A1: 2005
Eurocode–Basis of structural design
BSEN 1991-1-3: 2003
Eurocode 1 – Actions on structures – Part 1–3:General actions – Snow loads
BSEN 1991-1-4: 2005
Eurocode 1 : Actions on structures – Part 1–4:General actions – Wind actions

Report of Testing Model pitched roof mounting system-L for compliance with the applicable requirements of the following criteria: BSEN 1990:2002+A1: 2005; BSEN 1991-1-3: 2003; BSEN 1991-1-4: 2005. All samples are normal before test.

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1 Introduction

Intertek has conducted testing for SHANGHAI CHIKO SOLAR TECHNOLOGY CO.,LTD. on pitched roof mounting system-L to evaluate Wind Pressures and Snow Pressures performance. The evaluation was reference to EN 1990:2002+A1:2005, EN 1991-1-3:2003, EN 1991-1-4:2005, including the test of samples according to a defined test protocol. The test values were based on the product design values submitted from the client. This evaluation began on 2013-5-25 and was completed on 2013-8-15.

2 Test Samples

2.1. Sample selection

Samples were submitted to Intertek directly from the client. Samples were not independently selected for testing by Intertek. Samples were received at the Evaluation Center on 2013-4-26.

2.2. Sample description

Submitted samples were named pitched roof mounting system-L, the material of the mounting support is made of Aluminium alloy 6005-T5 (refer to Annex F the material certificate from the client). For detail appearances refer to appendix F.

2.3. Components description

MS: means manufacture specification

Name of component	Material
L feet	6005-T5(MS)
Rail	6005-T5(MS)
Mid clamp and End clamp	6005-T5(MS)
Inner hexagonal screw	Stainless steels 304(MS)

2.4. Sample design parameter

MS: means manufacture specification

Brand name:	Chiko
Type:	pitched roof mounting system-L
Reference no.(Intertek):	S130426028-004
Maximum solar PV module dimension:	1960mm×990mm×50mm(MS)
Maximum install tilt degrees:	60° (MS)

Design Life of Structure:	25 years (MS)
The time of limited product warranty	10 years(MS)

2.5. Exclusions and assumptions

Set-up and instruction Manual

Design which employs the Principles and Application Rules is deemed to meet the requirements provided the assumptions given in EN 1990 to EN 1999 are satisfied

The choice of the structural system and the design of the structure are made by appropriately qualified and experienced personnel

Execution is carried out by personnel having the appropriate skill and experience

Adequate supervision and quality control is provided during design and during execution of the work, i.e., factories, plants, and on site

The construction materials and products are used as specified in EN 1990 or in EN 1991 to EN 1999 or in the relevant execution standards, or reference material or product specifications

The structure will be adequately maintained

The structure will be used in accordance with the design assumptions.

The footing and Foundation which is used to fix pitched roof mounting system-L was not considered, it should be designed and certified by a practical structure engineer

After ten years to be used, some further tests need to be done to verify the structure is still valid.

3 Testing and Evaluation Methods

3.1. Wind velocity and velocity pressure

3.1.1. Basic values

The fundamental value of the basic wind velocity V_{b0} is the characteristic 10 minutes mean wind velocity, irrespective of wind direction and time of year, at 10 m above ground level in open country terrain with low vegetation such as grass and isolated obstacles with separations of at least 20 obstacle heights. V_{b0} is selected from ENV1991-2-4:1995.

The basic wind velocity shall be calculated using the expression 3-1.

$$V_b = C_{\text{dir}} \cdot C_{\text{season}} \cdot V_{b0} \qquad (3\text{-}1)$$

Where

V_b is the basic wind velocity, defined as a function of wind direction and time of year at 10 m above ground of terrain category II

V_{b0} is the fundamental value of the basic wind velocity

C_{dir} is the directional factor, taken 1.0 here

C_{season} is the season factor, taken 1.0 here

3.1.2. Mean wind

The mean wind velocity $V_m(z)$ at a height z above the terrain depends on the terrain roughness and orography and on the basic wind velocity, and should be determined using expression 3-2.

$$V_m(z) = C_r(z) \cdot C_o(z) \cdot V_b \qquad (3\text{-}2)$$

Where

$C_r(z)$ is the roughness factor, calculated using formula 3-3, 3-4

$C_o(z)$ is the orography factor, taken as 1.0 here to simply the calculation, which means the orography will be not significant.

$$C_r(z) = k_r \ln\left[\frac{z}{z_0}\right] \quad \text{for} \quad z_{\min} \leqslant z \leq z_{\max} \qquad (3\text{-}3)$$

$$C_r(z) = C_r(z_{\min}) \quad \text{for} \quad z \leq z_{\min} \qquad (3\text{-}4)$$

Where

z_0 is the roughness length.

k_r is the terrain factor depending on the roughness length z_0 calculated using

$$K_r = 0.19 \cdot \left[\frac{z}{z_{0,11}}\right]^{0.07}$$

Where

$z_{0,11}$ = 0.05 m (terrain category II, Table 3.1).

z_{min} is the minimum height defined in Table 3.1.

z_{max} is to be taken as 200 m.

Table 3.1 Terrain categories and terrain parameters

Terrain category	z_0(m)	Z_{min}(m)
0 sea or coastal area exposed to the open sea	0.003	1
Ⅰ Lakes or flat and horizontal area with negligible vegetation and without obstacles	0.01	1
Ⅱ Area with low vegetation such as grass and isolated obstacles(trees, buildings)with separations of at least 20 obstacle heights	0.05	2
Ⅲ Area with low vegetation such as grass and isolated obstacles(trees, buildings)with separations of at least 20 obstacle heights(such as villages, suburban terrain, permanent forest)	0.3	5
Ⅳ Area in which at least 15% of the surface is covered with buildings and their average height exceeds 15m	1	10
Note: the terrain categories are illustrated in A.1		

3.1.3. Wind turbulence

The turbulence intensity $l_v(z)$ at height z is defined as the standard deviation of the turbulence divided by the mean wind velocity. The turbulent component of wind velocity has a mean value of 0 and a standard deviation σ_v, the standard deviation of the turbulence σ_v can be determined using expression 3-5

$$\sigma_v = k_r \times V_b \times k_l \quad (3\text{-}5)$$

Where

k_l is the turbulence factor, take 1.0 here

And the turbulence intensity $l_v(z)$ at height z can be determined using expression3-6/3-7

$$l_v(z) = \frac{\sigma_v}{V_m(z)} \quad \text{for} \quad z_{min} \le z \le z_{max} \quad (3\text{-}6)$$

$$l_v(z) = l_v(z_{min}) \quad \text{for} \quad z < z_{min} \quad (3\text{-}7)$$

3.1.4. Peak Velocity Pressure

The peak velocity pressure $q_p(z)$ at height z, which includes mean and short-term velocity fluctuations, was determined by expression 3-8

$$q_p(z) = [1 + 7 \cdot l_v(z)] \cdot \frac{1}{2} \cdot \rho \cdot V_m^2(z) = c_e(z) \cdot q_b \quad (3\text{-}8)$$

Where

ρ is the air density, which depends on the altitude, temperature and barometric pressure to be expected in the region during wind storms, take 1.25 $\mathrm{kg/m^3}$ here.

$l_v(z)$ is wind turbulence intensity at height z.

$c_e(z)$ is the exposure factor.

We use the National Annex and wind speed map to determine the area basic wind velocity V_{b0}.

Use equation 3-8 can get the peak wind velocity pressure. And then can get the peak velocity pressure for variable countries.

Table 3.1 the basic wind velocity V_{b0}

country	United Kingdom	Belgium	France	Ireland	Germany	Holland
V_{b0}(m/s)	31	26.2	34	30	32	30
country	Denmark	Finland	Sweden	Greece	Italy	Portugal
V_{b0}	27	23	26	36	31	31

Note: A country has various V_{b0}; we choose the maximum value of V_{b0} to estimate;

The building height is 3m, 6m, 9m, 12m and 15m respectively;

Here given the peak velocity pressure of twelve countries in Europe.

Table 3.2 Calculated peak velocity wind pressure for variable countries

Unit: Pa

Z (m)	United Kingdom					Belgium				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1405	1254	985	769	706	1004	896	704	550	505
6	1623	1483	1224	834	706	1159	1060	874	596	505
9	1757	1625	1373	986	706	1255	1161	981	704	505
12	1855	1729	1483	1099	777	1325	1235	1059	785	555
15	1933	1812	1571	1189	867	1381	1294	1122	850	619
Z (m)	France					Ireland				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1690	1509	1185	925	850	1316	1175	922	720	662
6	1952	1784	1472	1004	850	1520	1389	1146	781	662
9	2113	1955	1651	1186	850	1645	1522	1286	923	662
12	2231	2080	1784	1322	935	1737	1619	1389	1029	728

15	2325	2179	1890	1431	1043	1810	1697	1471	1114	812
Z (m)	Germany					Holland				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1497	1336	1049	820	753	1316	1175	922	720	662
6	1729	1581	1304	889	753	1520	1389	1146	781	662
9	1872	1732	1463	1050	753	1645	1522	1286	923	662
12	1977	1842	1580	1171	828	1737	1619	1389	1029	728
15	2059	1931	1674	1267	924	1810	1697	1471	1114	812
Z (m)	Denmark					Finland				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1066	951	747	584	536	773	690	542	423	389
6	1231	1125	928	633	536	893	817	674	459	389
9	1333	1233	1041	748	536	967	895	756	543	389
12	1407	1312	1125	833	590	1021	952	816	605	428
15	1466	1374	1192	902	658	1064	997	865	655	477
Z (m)	Sweden					Greece				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	988	882	693	541	497	1895	1691	1328	1037	953
6	1142	1043	861	587	497	2189	2000	1650	1125	953
9	1236	1143	966	693	497	2369	2192	1851	1329	953
12	1305	1216	1043	773	547	2502	2332	2000	1482	1048
15	1360	1274	1105	837	610	2606	2443	2119	1604	1169
Z (m)	Italy					Portugal				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1405	1254	985	769	706	1405	1254	985	769	706
6	1623	1483	1224	834	706	1623	1483	1224	834	706
9	1757	1625	1373	986	706	1757	1625	1373	986	706
12	1855	1729	1483	1099	777	1855	1729	1483	1099	777
15	1933	1812	1571	1189	867	1933	1812	1571	1189	867

3.1.5. Wind Forces

The wind force P_w acting on a structure or a structural component may be determined directly by using Expression 3-9

$$P_w = c_s c_d \cdot q_p(z_e) \cdot C_{pe} \qquad (3\text{-}9)$$

Where

$c_s c_d$ is the structural factor .

$q_p(z_e)$ is the peak velocity pressure at reference height z_e .

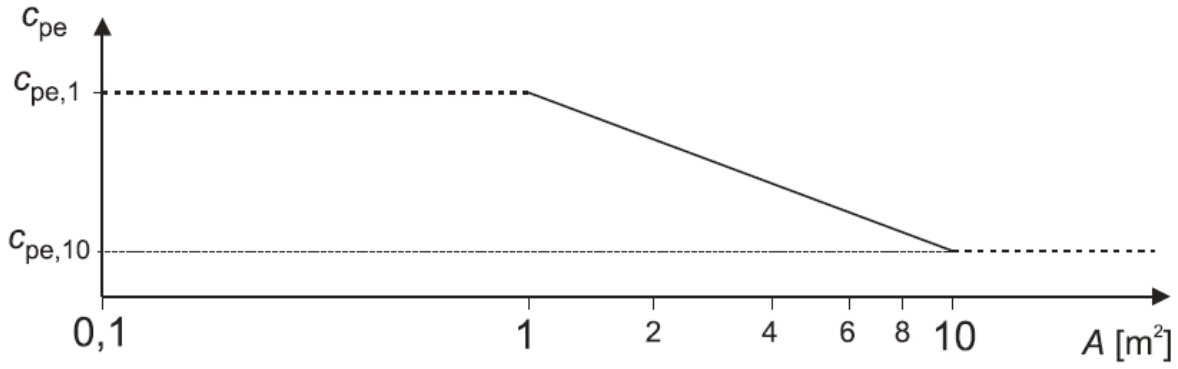
C_{pe} is the pressure coefficient.

For building with a height less than 15m the value of $c_s c_d$ may be taken 1

The pressure coefficient C_{pe} depend on the size of the loaded area A, witch is the area of the structure, the pressure coefficient are given for loaded areas A of $1m^2$ and $10m^2$ in the tables for the appropriate building configurations as $C_{pe,1}$,for local coefficients, and $C_{pe,10}$,for overall coefficients, respectively. $C_{pe,1}$ and $C_{pe,10}$ can be obtained from Appendix B.

The procedure for calculating the pressure coefficient C_{pe} is given in figure 3.1.

Figure3.1 Recommended procedure for determining the pressure coefficient C_{pe}



The figure is based on the following:

For $1m^2<A<10m^2$ $\quad C_{pe} = C_{pe,1} - (C_{pe,1} - C_{pe,10}) \log_{10} A$

Pitched roof mounting system-L will be installed on the pitched roof according to manufacture's install manual, which is similar to the pitched roof wind resistance. So we evaluated wind pressure of pitched roof mounting system-L according to pitched roof evaluation described in clause7.2.4 and 7.2.5 of EN1991-1-4:2005 directly.

We evaluated pitched roof mounting system-L considering the wind blow the module on wind direction from 0° 180° and 90° (refer to Appendix B), and choose the minimum structural unit to test; the minimum structural unit has four solar panels. C_{pe} is affected by the angle and wind direction, it is variable, in order to simplify the calculation, we choose the most unfavorable values. The wind pressure P_w acting on the minimum structural unit can be calculated, and listed in the below table.

Table 3.3 Calculated peak velocity wind pressure for monopitch roof (positive pressure)

Unit: Pa

Z (m)	United Kingdom					Belgium				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	983	878	689	538	494	702	627	492	385	353
6	1136	1038	857	584	494	811	742	612	417	353
9	1230	1138	961	690	494	878	813	686	493	353
12	1298	1210	1038	769	544	928	865	742	549	389
15	1353	1268	1100	833	607	966	906	786	595	434

Z (m)	France					Ireland				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1183	1056	829	648	595	921	822	646	504	463
6	1367	1249	1030	703	595	1064	972	802	547	463
9	1479	1368	1156	830	595	1152	1065	900	646	463
12	1562	1456	1249	925	655	1216	1134	972	720	510
15	1627	1526	1323	1002	730	1267	1188	1030	780	568
Z (m)	Germany					Holland				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1048	935	735	574	527	921	822	646	504	463
6	1211	1106	913	622	527	1064	972	802	547	463
9	1311	1212	1024	735	527	1152	1065	900	646	463
12	1384	1290	1106	820	580	1216	1134	972	720	510
15	1442	1351	1172	887	647	1267	1188	1030	780	568
Z (m)	Denmark					Finland				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	746	666	523	408	375	541	483	380	296	272
6	862	788	650	443	375	625	572	471	322	272
9	933	863	729	523	375	677	626	529	380	272
12	985	918	788	583	413	715	666	571	423	300
15	1026	962	834	632	460	745	698	605	458	334
Z (m)	Sweden					Greece				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	692	618	485	379	144	1326	1184	930	726	667
6	799	730	603	411	348	1532	1400	1155	788	667
9	865	800	676	485	348	1659	1534	1296	931	667
12	913	851	730	541	383	1751	1632	1400	1037	734
15	952	892	774	586	427	1824	1710	1483	1123	819
Z (m)	Italy					Portugal				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	983	878	689	538	494	983	878	689	538	494
6	1136	1038	857	584	494	1136	1038	857	584	494
9	1230	1138	961	690	494	1230	1138	961	690	494
12	1298	1210	1038	769	544	1298	1210	1038	769	544
15	1353	1268	1100	833	607	1353	1268	1100	833	607

Table 3.4 Calculated peak velocity wind pressure for monopitch roof(Negative pressure)

Unit: Pa

Z (m)	United Kingdom									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1530	1365	1072	838	769	3866	3452	2711	2117	1944
6	1767	1615	1332	908	769	4466	4082	3367	2296	1944
9	1913	1769	1495	1073	769	4835	4472	3778	2713	1944
12	2020	1883	1615	1196	846	5105	4759	4082	3024	2139
15	2104	1973	1711	1295	944	5319	4986	4324	3274	2386
Z (m)	Belgium									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1093	975	766	598	549	2762	2465	1936	1512	1389
6	1262	1154	952	649	549	3190	2916	2405	1640	1389
9	1366	1264	1068	767	549	3454	3195	2699	1938	1389
12	1443	1345	1153	854	605	3647	3399	2916	2160	1528
15	1503	1409	1222	925	674	3799	3562	3088	2338	1704
Z (m)	France									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1840	1643	1290	1008	925	4651	4152	3261	2547	2339
6	2126	1943	1603	1093	925	5373	4911	4051	2762	2339
9	2301	2128	1798	1291	925	5816	5380	4545	3263	2339
12	2429	2265	1942	1439	1018	6141	5724	4910	3637	2573
15	2531	2373	2058	1558	1136	6398	5998	5201	3938	2870
Z (m)	Ireland									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1433	1279	1004	784	720	3621	3232	2538	1983	1821
6	1655	1512	1248	851	720	4183	3823	3154	2151	1821
9	1791	1657	1400	1005	720	4528	4188	3538	2541	1821
12	1891	1763	1512	1120	793	4781	4457	3823	2832	2003
15	1971	1847	1602	1213	884	4981	4670	4049	3066	2235
Z (m)	Germany									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1630	1455	1143	893	820	4120	3678	2888	2256	2072
6	1883	1721	1420	968	820	4759	4350	3588	2447	2072
9	2038	1885	1593	1144	820	5152	4765	4026	2891	2072
12	2152	2006	1721	1275	902	5440	5071	4349	3222	2279
15	2242	2102	1823	1380	1006	5668	5313	4607	3488	2543
Z (m)	Holland									
	Zone H or I					other zone				
	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain

	0	I	II	III	IV	0	I	II	III	IV
3	1433	1279	1004	784	720	3621	3232	2538	1983	1821
6	1655	1512	1248	851	720	4183	3823	3154	2151	1821
9	1791	1657	1400	1005	720	4528	4188	3538	2541	1821
12	1891	1763	1512	1120	793	4781	4457	3823	2832	2003
15	1971	1847	1602	1213	884	4981	4670	4049	3066	2235
Z (m)	Denmark									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1160	1036	813	635	583	2933	2618	2056	1606	1475
6	1340	1225	1011	689	583	3388	3097	2554	1742	1475
9	1451	1342	1134	814	583	3668	3393	2866	2058	1475
12	1532	1428	1225	907	642	3873	3610	3096	2294	1623
15	1596	1496	1298	982	716	4035	3782	3280	2483	1810
Z (m)	Finland									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	842	752	590	461	423	2128	1900	1492	1165	1070
6	973	889	733	500	423	2459	2247	1854	1264	1070
9	1053	974	823	591	423	2662	2462	2080	1493	1070
12	1112	1036	889	658	466	2810	2619	2247	1664	1178
15	1158	1086	942	713	520	2928	2745	2380	1802	1314
Z (m)	Sweden									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1076	961	754	589	541	2720	2428	1907	1489	1368
6	1243	1136	937	639	541	3142	2872	2369	1615	1368
9	1346	1245	1051	755	541	3401	3146	2658	1908	1368
12	1421	1324	1136	841	595	3591	3347	2871	2127	1505
15	1480	1388	1203	911	664	3741	3507	3042	2303	1679
Z (m)	Greece									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	2063	1841	1446	1130	1037	5214	4655	3655	2855	2622
6	2383	2178	1797	1225	1037	6023	5505	4541	3097	2622
9	2580	2386	2016	1447	1037	6521	6031	5095	3659	2622
12	2724	2539	2178	1613	1141	6885	6417	5505	4078	2885
15	2838	2660	2307	1747	1273	7173	6724	5831	4415	3218
Z (m)	Italy									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1530	1365	1072	838	769	3866	3452	2711	2117	1944
6	1767	1615	1332	908	769	4466	4082	3367	2296	1944

9	1913	1769	1495	1073	769	4835	4472	3778	2713	1944
12	2020	1883	1615	1196	846	5105	4759	4082	3024	2139
15	2104	1973	1711	1295	944	5319	4986	4324	3274	2386
Z (m)	Portugal									
	Zone H or I					other zone				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1530	1365	1072	838	769	3866	3452	2711	2117	1944
6	1767	1615	1332	908	769	4466	4082	3367	2296	1944
9	1913	1769	1495	1073	769	4835	4472	3778	2713	1944
12	2020	1883	1615	1196	846	5105	4759	4082	3024	2139
15	2104	1973	1711	1295	944	5319	4986	4324	3274	2386

Table 3.5 Calculated peak velocity wind pressure for duopitch roof (positive pressure)

Unit: Pa

Z (m)	United Kingdom					Belgium				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	983	878	689	538	494	702	627	492	385	353
6	1136	1038	857	584	494	811	742	612	417	353
9	1230	1138	961	690	494	878	813	686	493	353
12	1298	1210	1038	769	544	928	865	742	549	389
15	1353	1268	1100	833	607	966	906	786	595	434
Z (m)	France					Ireland				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1183	1056	829	648	595	921	822	646	504	463
6	1367	1249	1030	703	595	1064	972	802	547	463
9	1479	1368	1156	830	595	1152	1065	900	646	463
12	1562	1456	1249	925	655	1216	1134	972	720	510
15	1627	1526	1323	1002	730	1267	1188	1030	780	568
Z (m)	Germany					Holland				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1048	935	735	574	527	921	822	646	504	463
6	1211	1106	913	622	527	1064	972	802	547	463
9	1311	1212	1024	735	527	1152	1065	900	646	463
12	1384	1290	1106	820	580	1216	1134	972	720	510
15	1442	1351	1172	887	647	1267	1188	1030	780	568
Z (m)	Denmark					Finland				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	746	666	523	408	375	541	483	380	296	272
6	862	788	650	443	375	625	572	471	322	272
9	933	863	729	523	375	677	626	529	380	272
12	985	918	788	583	413	715	666	571	423	300
15	1026	962	834	632	460	745	698	605	458	334
Z	Sweden					Greece				

(m)	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	692	618	485	379	144	1326	1184	930	726	667
6	799	730	603	411	348	1532	1400	1155	788	667
9	865	800	676	485	348	1659	1534	1296	931	667
12	913	851	730	541	383	1751	1632	1400	1037	734
15	952	892	774	586	427	1824	1710	1483	1123	819
Z	Italy					Portugal				
(m)	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	983	878	689	538	494	983	878	689	538	494
6	1136	1038	857	584	494	1136	1038	857	584	494
9	1230	1138	961	690	494	1230	1138	961	690	494
12	1298	1210	1038	769	544	1298	1210	1038	769	544
15	1353	1268	1100	833	607	1353	1268	1100	833	607

Table 3.6 Calculated peak velocity wind pressure for duopitch roof (negative pressure)

Unit: Pa

Z (m)	United Kingdom									
	Zone H /I/J					Zone F and G				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1613	1440	1131	883	811	3637	3247	2550	1992	1829
6	1863	1703	1405	958	811	4201	3840	3168	2160	1829
9	2017	1865	1576	1132	811	4548	4207	3554	2552	1829
12	2129	1985	1703	1261	892	4802	4476	3839	2844	2012
15	2219	2080	1804	1365	995	5003	4690	4067	3079	2245
Z	Belgium									
(m)	Zone H /I/J					Zone F and G				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1152	1028	808	631	579	2598	2319	1821	1423	1306
6	1331	1216	1003	684	579	3001	2743	2263	1543	1306
9	1441	1332	1126	808	579	3249	3005	2539	1823	1306
12	1521	1418	1216	901	637	3430	3197	2743	2032	1437
15	1585	1486	1288	975	711	3574	3350	2905	2200	1603
Z	France									
(m)	Zone H /I/J					Zone F and G				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1940	1732	1360	1062	975	4375	3905	3067	2396	2200
6	2241	2048	1690	1152	975	5054	4619	3810	2598	2200
9	2426	2244	1896	1361	975	5471	5061	4275	3070	2200
12	2561	2388	2048	1517	1073	5777	5384	4619	3421	2421
15	2669	2502	2169	1643	1197	6018	5642	4893	3704	2700
Z	Ireland									
(m)	Zone H /I/J					Zone F and G				
	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain	Terrain

	0	I	II	III	IV	0	I	II	III	IV
3	1510	1348	1059	827	759	3406	3041	2388	1865	1713
6	1745	1595	1315	897	759	3935	3596	2967	2023	1713
9	1889	1747	1476	1060	759	4260	3940	3328	2390	1713
12	1994	1859	1594	1181	836	4497	4192	3596	2664	1885
15	2078	1948	1689	1279	932	4686	4392	3809	2884	2102
	Germany									
Z	Zone H /I/J					Zone F and G				
(m)	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1718	1534	1205	941	864	3875	3460	2717	2122	1949
6	1985	1814	1497	1021	864	4477	4092	3375	2302	1949
9	2149	1988	1679	1206	864	4847	4483	3787	2719	1949
12	2269	2115	1814	1344	951	5117	4770	4091	3031	2144
15	2364	2216	1922	1455	1061	5331	4998	4334	3281	2392
	Holland									
Z	Zone H /I/J					Zone F and G				
(m)	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1510	1348	1059	642	315	3406	3041	2388	1865	1713
6	1745	1595	1315	897	559	3935	3596	2967	2023	1713
9	1889	1747	1476	1060	717	4260	3940	3328	2390	1713
12	1994	1859	1594	1181	836	4497	4192	3596	2664	1885
15	2078	1948	1689	1279	932	4686	4392	3809	2884	2102
	Denmark									
Z	Zone H /I/J					Zone F and G				
(m)	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1223	1092	858	670	615	2759	2463	1934	1511	1387
6	1413	1292	1066	727	615	3187	2913	2403	1639	1387
9	1530	1415	1196	858	615	3450	3191	2696	1936	1387
12	1615	1506	1292	957	677	3643	3396	2913	2158	1526
15	1683	1578	1368	1036	755	3795	3558	3085	2336	1703
	Finland									
Z	Zone H /I/J					Zone F and G				
(m)	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	888	792	622	486	446	2002	1787	1404	1096	1007
6	1026	937	773	527	446	2313	2114	1744	1189	1007
9	1110	1027	868	623	446	2504	2316	1956	1405	1007
12	1172	1093	937	694	491	2643	2464	2113	1566	1108
15	1221	1145	993	752	548	2754	2582	2239	1695	1236
	Sweden									
Z	Zone H /I/J					Zone F and G				
(m)	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1134	1013	795	621	570	2558	2284	1794	1401	1286
6	1310	1198	988	674	570	2955	2701	2228	1519	1286

9	1419	1312	1109	796	570	3199	2959	2500	1795	1286
12	1498	1396	1198	887	628	3378	3149	2701	2001	1416
15	1561	1463	1269	960	700	3519	3299	2861	2166	1579
Z (m)	Greece									
	Zone H /I/J					Zone F and G				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	2175	1942	1525	1191	1094	4905	4378	3439	2686	2466
6	2512	2296	1894	1292	1094	5666	5179	4272	2913	2466
9	2720	2516	2125	1526	1094	6134	5673	4793	3441	2466
12	2872	2677	2296	1701	1203	6476	6037	5178	3836	2714
15	2992	2805	2432	1841	1342	6747	6325	5485	4153	3027
Z (m)	Italy									
	Zone H /I/J					Zone F and G				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1613	1440	1131	883	811	3637	3247	2550	1992	1829
6	1863	1703	1405	958	811	4201	3840	3168	2160	1829
9	2017	1865	1576	1132	811	4548	4207	3554	2552	1829
12	2129	1985	1703	1261	892	4802	4476	3839	2844	2012
15	2219	2080	1804	1365	995	5003	4690	4067	3079	2245
Z (m)	Portugal									
	Zone H /I/J					Zone F and G				
	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV	Terrain 0	Terrain I	Terrain II	Terrain III	Terrain IV
3	1613	1440	1131	883	811	3637	3247	2550	1992	1829
6	1863	1703	1405	958	811	4201	3840	3168	2160	1829
9	2017	1865	1576	1132	811	4548	4207	3554	2552	1829
12	2129	1985	1703	1261	892	4802	4476	3839	2844	2012
15	2219	2080	1804	1365	995	5003	4690	4067	3079	2245

3.2. Snow pressures

According to the standard BSEN 1991-1-3:2003, Snow load shall be determined by using Expression 3-10:

$$S = \mu_i C_e C_t S_k \tag{3-10}$$

Where

S is the Snow load [KN/m^2].

μ_i is the snow load shape coefficient .

C_e is the exposure coefficient.

C_t is the thermal coefficient.

S_k is the characteristic value of snow load on the ground.

3.2.1. The snow load shape coefficient μ_i

Pitched roof mounting system-L is similar to the pitched roof on snow load, the snow load shape coefficient μ_i can determined as follows:

The snow load shape coefficient μ_i is given in Table 3.4 and shown in Figure 3.1 and Figure 3.2. μ_1 is the snow load shape coefficient for undrafted snow load on the roofs; and μ_2 is coefficient for drifted snow load on the roofs. We consider the snow load may be influenced by some factors such as wind, and the snow load is considered as drifted snow load, so we choose μ_2 as the snow load shape coefficient.

Figure 3.1 Snow load shape coefficients

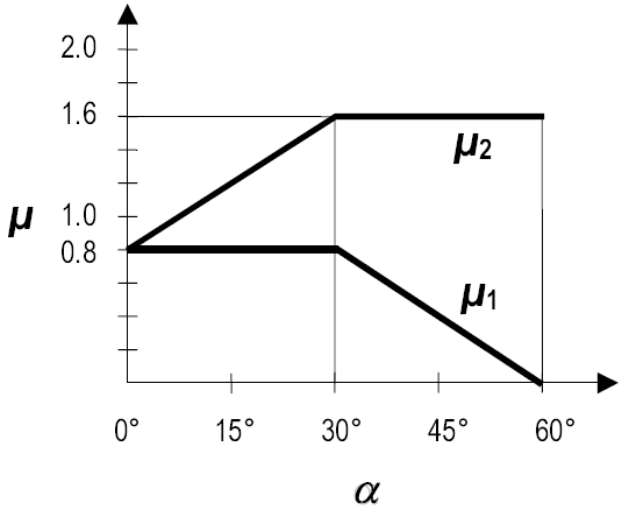
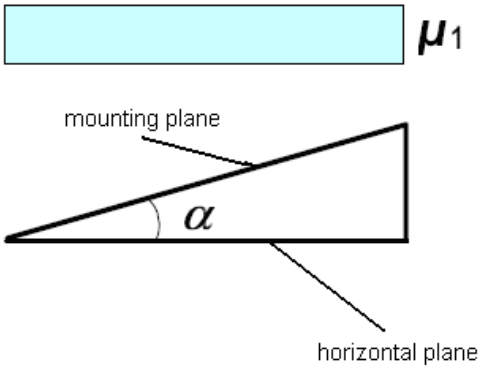


Table 3.4 Snow load shape coefficients

Angle of pitch of α	0° ≤α≤30°	30° <α<60°	α≤60°
μ_1	0.8	0.8×(60-α)/30	0
μ_2	0.8+0.8×α/30	1.6	----

Figure 3.2 Snow load shape coefficients-α



3.2.2. The exposure coefficient C_e

The exposure coefficient C_e should be used for determining the snow load. The choice for C_e should consider the future development around the site. C_e should be taken as 1,0 unless otherwise specified for different topographies. For different topographies, the recommended value is given in table 3.5.

Table 3.5 Recommended values C_e for different topographies

Topography	C_e
Wingawept[a]	0.8
Normal[b]	1.0
Sheltered[c]	1.2

a, Windswept topography: flat unobstructed areas exposed on all sides without, or little shelter afforded by terrain, higher construction works or trees.

b,Normal topography: areas where there is no significant removal of snow by wind on construction work, because of terrain, other construction works or trees.

c,Sheltered topography: areas in which the construction work being considered is considerably lower than the surrounding terrain or surrounded by high trees and/or surrounded by higher construction works.

3.2.3. The thermal coefficient C_t

The thermal coefficient C_t should be used to account for the reduction of snow loads with high thermal transmittance (> 1 W/m^{2}K), for pitched roof mounting system-L, because of melting caused by heat loss. Consider safety factors, the thermal coefficient C_t refer to the normal roof cases, C_t is taken as 1,0.

3.2.4. The characteristic value of snow load on the ground S_k

The characteristic value of snow load on the ground S_k shall be found from the European ground snow load map (Appendix C)

The characteristic value of snow load on the ground S_k is normal condition, without taking into account exceptional values. The exceptional snow loads on the ground can be determined by Expression 3-11:

$$S_{\mathrm{Ad}} = C_{esl} S_k \qquad (3\text{-}11)$$

Where:

S_{Ad} is the design value of exceptional snow load on the ground for the given location

C_{esl} is the coefficient for exceptional snow loads

Note: the coefficient C_{esl} may be set by the national Annex, the recommended value for C_{esl} is 2.0

3.2.5. The value of snow load

The snow load of European countries was determined by using Expression 3-11, because the snow load is affected by the altitude, while the snow load for one site of European countries, the S_k should calculate by the Expression of Appendix C.

Table 3.6a the normal snow load for countries

Unit: Pa

Climatic Regions	Alpine Region				Central East			
Z	1	2	3	4,5	1	2	3	4,5
S	1120	2080	3040	4640	480	800	1280	1920
Climatic Regions	Greece				Iberian Peninsula			
Z	1	2	4		1	2	4	
S	640	1280	2720		160	480	1120	
Climatic	Mediterranean Region				Central West			

Regions								
Z	1	2	3	4,5	1	2	3	4,5
S	480	1280	2080	3200	160	320	640	1120
Climatic Regions	Sweden, Finland				UK, Republic of Ireland			
Z	1	2	3	4,5	1	2	3	4,5
S	1920	3200	4320	6240	64	320	480	800
Climatic Regions	Poland							
Z	1	2	3	4	5			
S	1120	1440	1920	2560	3200			

Note: 1 Z is the zone number, can be found at snow load map (Appendix C)

2 S is the snow load at sea level, while we calculate the snow load, we took the C_e as 1.0 for normal topography

Table 3.6b the normal snow load for countries

Unit: Pa

Climatic Regions	Norway					Czech Republic				
Z	1	2	3	4	5	1	2	3	4	5
S	2800	5200	7600	10000	15200	1200	1680	2400	3600	---
Climatic Regions	Iceland									
Z	1	2	3	4	H					
S	3360	6080	9760	>9760	----					

Note: 1 Z is the zone number, can be found at snow load map (Appendix C)

2 S is the snow load, while we calculate the snow load, we took the C_e as 1.0 for normal topography

Table 3.7a the exceptional snow load for countries

Unit: Pa

Climatic Regions	Alpine Region				Central East			
Z	1	2	3	4,5	1	2	3	4,5
S	2240	4160	6080	9280	960	1600	2560	3840
Climatic Regions	Greece				Iberian Peninsula			
Z	1	2	4		1	2	4	
S	1280	2560	5440		320	960	2240	
Climatic Regions	Mediterranean Region				Central West			
Z	1	2	3	4,5	1	2	3	4,5
S	960	1280	2080	3200	320	640	1280	2240
Climatic Regions	Sweden, Finland				UK, Republic of Ireland			
Z	1	2	3	4,5	1	2	3	4,5
S	3840	6400	8640	12480	128	640	960	1600
Climatic Regions	Poland							
Z	1	2	3	4	5			
S	2240	2880	3840	5120	6400			

Note: 1 Z is the zone number, can be found at snow load map (Appendix C)

2 S is the snow load at sea level, while we calculate the snow load, we took the C_e as 1.0 for normal topography

3 when we calculated the exceptional snow load, we took the exceptional coefficient C_{esl} as 2.0 according to EN1991-1-3

Table 3.7b the exceptional snow load for countries

Unit: Pa

Climatic Regions	Norway					Czech Republic				
Z	1	2	3	4	5	1	2	3	4	5
S	5600	10400	15200	20000	30400	2400	3360	4800	7200	---
Climatic Regions	Iceland									
Z	1	2	3	4	H					
S	6720	12160	19520	>19520	----					

Note: 1 Z is the zone number, can be found at snow load map (Appendix C)

2 S is the snow load, while we calculate the snow load, we took the C_e as 1.0 for normal topography

3 when we calculated the exceptional snow load, we took the exceptional coefficient C_{esl} as 2.0 according to EN1991-1-3

3.3. Load combination

For each critical load case, the design values of the effects of actions E_d shall be determined by combining the values of actions that are considered to occur simultaneously. The combinational load of the pitched roof mounting system-L can be determined by Expression 3-12:

$$E_d = \gamma_G G_k + \gamma_{Q1} Q_{k1} + \sum_{i>1} \gamma_{Qi} \psi_{0,i} Q_{ki} \qquad (3\text{-}12)$$

Where

G_k is the permanent action, here refer to the load of solar panel

Q_{k1} is the leading variable action

Q_{ki} is the accompanying variable actions

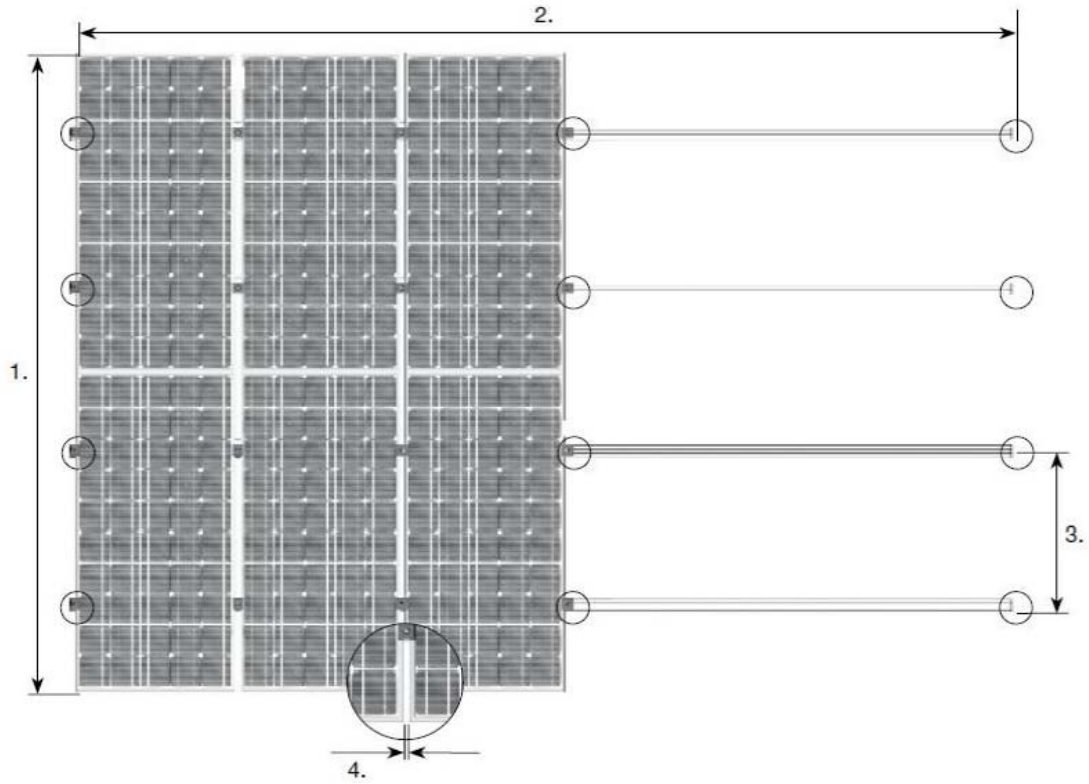
γ_G, γ_{Qi} and $\psi_{0,i}$ can be selected in Annex A1 EN1990:2002+A1:2005, Q_{k1}, Q_{ki} γ_G, γ_{Qi} and $\psi_{0,i}$ should be determined according to the actual installation conditions.

4 Testing and Evaluation Results

4.1. Test procedure

We installed pitched roof mounting system-L according to the manufacture install manual, the schematic diagram of the array layout as follow. And the design value was verified by separated action variable.

Figure 4.1 Schematic diagram of the array layout



1 .Array height=number of solar modules in the vertical direction × solar module height

2. Array with =number of solar modules in horizontal direction direction× (module width+11/16in (18mm)) +1-1/4in (32mm)

3. Vertical spacing of the roof attachment =approx.1/2 of solar module height

4. Distance between the solar modules: 11/16in (18mm)

The simulated plate dimension is 1580 mm×800 mm×40 mm, and the weight of one simulated plate is 18.5Kg,we installed four pieces of this plate on to the two rails of pitched roof mounting system-L with Mid clampsand End clamps. The distance of two rails is 790mm, we connected

the two rails with the wood by 18 L fleets; the distance between two L feet is 0.34m.we installed the L fleets on the solid wood by three 6.3× 65mm wood screws. The size of the solid wood was 200mm×140mm×80mm, and 18 solid woods were fixed at the test platform.

For the serviceability limit state test, we use an inflatable air bag to simulate the positive and negative wind pressure with the load calculated according to the client specifies.

For the snow pressures test, we also use an inflatable air bag to simulate the snow load calculated according to the client specifies.

The behavior of the frame, fastenings, supporting members and substructure were observed and recorded.

For components of pitched roof mounting system-L, we conducted tensile test and compression test on the L fleet. We also conducted a tensile test on the assembly of rail and Mid clamp. We conducted the tensile test on the Mid clamp and End clamp. The details to evaluate the feature of important fasteners refer to Appendix D.

4.2. Results and observations

Test load according to calculated forces and test result were listed in the below table.

Test load and result for wind action:

Table 4.1 Test load and result for wind action

Test direction	Test load P_W	Test result
Positive pressure	5173Pa	PASS*
Negative pressure	2816Pa	PASS*

Test load and result for snow action:

Table 4.2 test load and result for snow action

Test direction	Test load P_W	Test result
Positive load	5173 Pa	PASS*

Note :*) Product was considered to be “PASS” when no visible structural failure occurred.

The test load F_t is calculated by using follow Expression:

$$F_t=P_t \times A_{reft}/A_{ref}$$

Where

P_w is the test load

P_t is Pressure gage reading

A_{reft} is the frontal area of the simulated plate

A_{ref} is the frontal area of solar PV module

For tensile test and compression test on the L fleets, the test curves showed at figure 4.2 and figure 4.3. After we withdrew the force applied to the test L fleets, they restore the original shape.

Figure 4.2 test curve of the tensile test（elastic deformation）

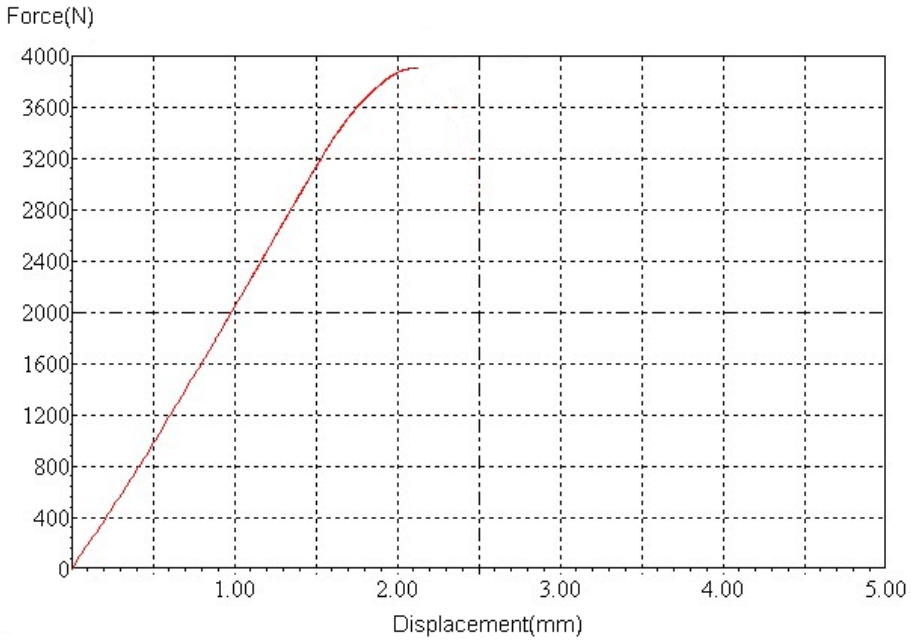
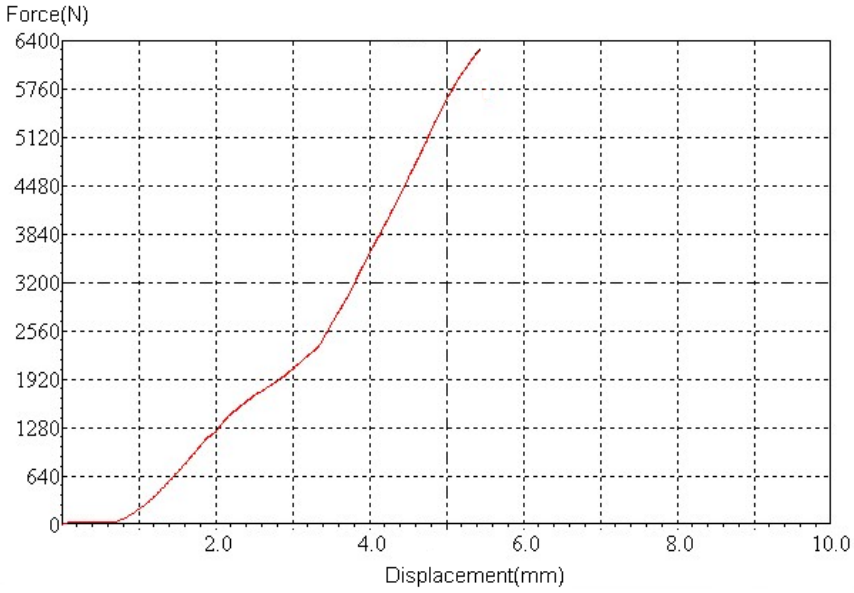
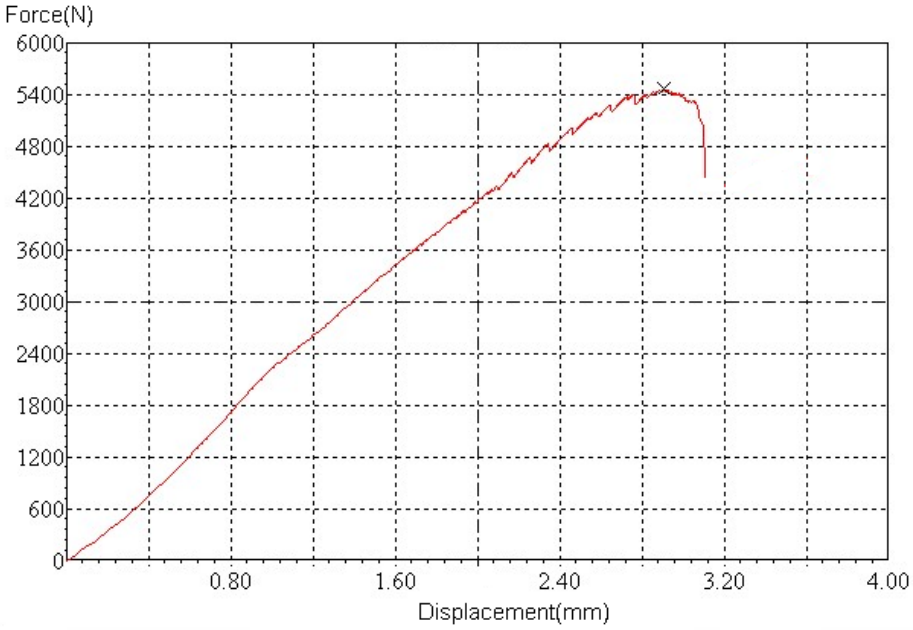


Figure 4.3 test curve of the compression test（elastic deformation）



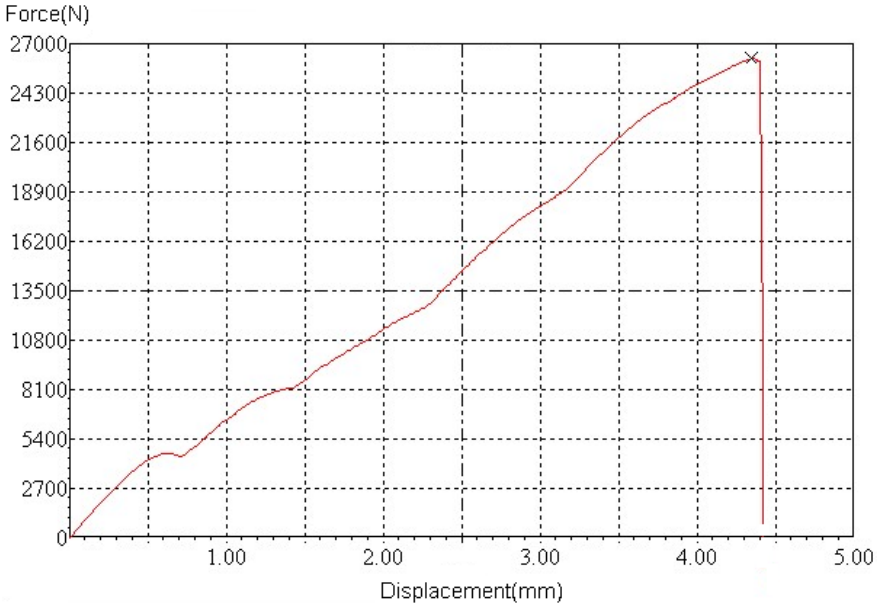
For the tensile test on the assembly of rail and middle Mid clamp, the test curves showed at figure 4.4.when the force was up to 5469N, the rail was deformed. While we withdrew the force applied to the test Mid clamp, the rail didn't restore the original shape.

Figure 4.4 test curve of the tensile test on the assembly of rail and Mid clamp(up to plastic deformation)



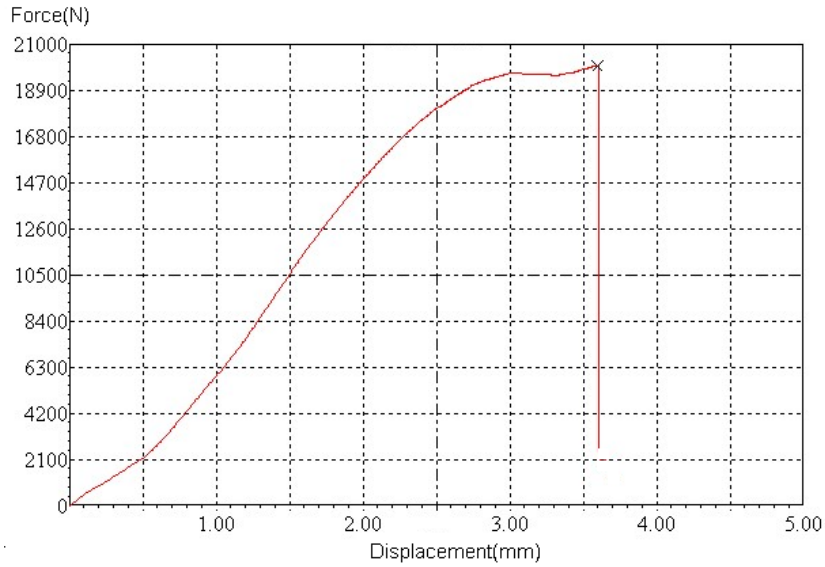
For the tensile test on the Mid clamp, the test curves showed at figure 4.5.when the force was up to 26208N, the Mid clamp was break.

Figure 4.5 test curve of the tensile test on the Mid clamp (up to plastic deformation)



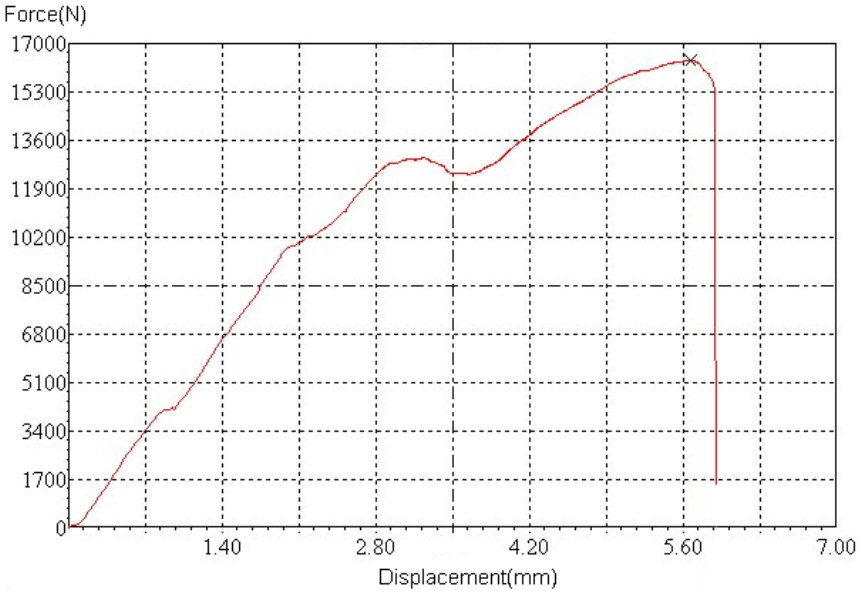
For the tensile test on two End clamps, the test curves showed at figure 4.6.when the force was up to 20051N, one end clamp was break.

Figure 4.6 test curve of the tensile test on two End clamps (up to plastic deformation)



For the tensile test on the wood screw, the test curves showed at figure 4.7.when the force was up to 16413N, the wood screw was snapped break. The test here only for reference as we can not simulate the actual installed wood foundation.

Figure 4.7 test curve of the tensile test on the wood screw (up to plastic deformation)



4.3. Statement of measurement uncertainty

When determining the test result, measurement uncertainty has been considered.

5 Conclusion

The test method was conducted with defined protocol using an inflatable bag method as a uniform distribution load to simulate static wind pressure and snow load. The conclusion was established by evaluating basic variables separately and the dead load was treated as the actual simulated plate. The conclusion here only for reference, when install the mounting system the installer shall consider the actual environment and combine actions according to the content in chapter 3.3 in this test report and referenced design standard and national code. Test results were described in clause 4 of this report.

The referenced evaluation result of wind pressure as follow:

5.1a the installation regions of pitched roof mounting system-L (monopitch roof)

Country	**United Kingdom**		**Belgium**		**France**	
Zone	Zone H or I	other zone	Zone H or I	other zone	Zone H or I	other zone
Terrain 0	15m	---	15m	3m	15m	---
TerrainI	15m	---	15m	3m	15m	---
TerrainII	15m	3m	15m	9m	15m	---
TerrainIII	15m	9m	15m	15m	15m	6m
TerrainIV	15m	15m	15m	15m	15m	15m
Country	**Ireland**		**Germany**		**Holland**	
Zone	Zone H or I	other zone	Zone H or I	other zone	Zone H or I	other zone
Terrain 0	15m	---	15m	---	15m	---
TerrainI	15m	---	15m	---	15m	---
TerrainII	15m	3m	15m	---	15m	3m
TerrainIII	15m	9m	15m	6m	15m	9m
TerrainIV	15m	15m	15m	15m	15m	15m
Country	**Denmark**		**Finland**		**Sweden**	
Zone	Zone H or I	other zone	Zone H or I	other zone	Zone H or I	other zone
Terrain 0	15m	---	15m	12m	15m	3m
TerrainI	15m	3m	15m	15m	15m	3m
TerrainII	15m	6m	15m	15m	15m	9m
TerrainIII	15m	15m	15m	15m	15m	15m
TerrainIV	15m	15m	15m	15m	15m	15m
Country	**Greece**		**Italy**		**Portugal**	
Zone	Zone H or I	other zone	Zone H or I	other zone	Zone H or I	other zone
Terrain 0	12m	---	15m	---	15m	---
TerrainI	15m	---	15m	---	15m	---
TerrainII	15m	---	15m	3m	15m	3m
TerrainIII	15m	---	15m	9m	15m	9m
TerrainIV	15m	9m	15m	15m	15m	15m

Note: 1 the Zone refers to the zone on the roof, it can be found in appendix B;

2 the terrain category0/I/II/III/IV can be found in appendix A;

3 the data of gray areas are the max suggested installation height of pitched roof mounting system-L,

4“---”means this region is inconformity to install the pitched roof mounting system-L.

5.1b the installation regions of pitched roof mounting system-L (duopitch roof)

Country	United Kingdom		Belgium		France	
Zone	Zone H or I	other zone	Zone H or I	other zone	Zone H or I	other zone
Terrain 0	15m	---	15m	3m	15m	---
TerrainI	15m	---	15m	6m	15m	---
TerrainII	15m	3m	15m	12m	15m	---
TerrainIII	15m	9m	15m	15m	15m	6m
TerrainIV	15m	15m	15m	15m	15m	15m
Country	Ireland		Germany		Holland	
Zone	Zone H or I	other zone	Zone H or I	other zone	Zone H or I	other zone
Terrain 0	15m	---	15m	---	15m	---
TerrainI	15m	---	15m	---	15m	---
TerrainII	15m	3m	15m	3m	15m	3m
TerrainIII	15m	12m	15m	9m	15m	12m
TerrainIV	15m	15m	15m	15m	15m	15m
Country	Denmark		Finland		Sweden	
Zone	Zone H or I	other zone	Zone H or I	other zone	Zone H or I	other zone
Terrain 0	15m	3m	15m	15m	15m	3m
TerrainI	15m	3m	15m	15m	15m	6m
TerrainII	15m	9m	15m	15m	15m	12m
TerrainIII	15m	15m	15m	15m	15m	15m
TerrainIV	15m	15m	15m	15m	15m	15m
Country	Greece		Italy		Portugal	
Zone	Zone H or I	other zone	Zone H or I	other zone	Zone H or I	other zone
Terrain 0	9m	---	15m	---	15m	---
TerrainI	15m	---	15m	---	15m	---
TerrainII	15m	---	15m	3m	15m	3m
TerrainIII	15m	3m	15m	9m	15m	9m
TerrainIV	15m	12m	15m	15m	15m	15m

Note: 1 the Zone refers to the zone on the roof, it can be found in appendix B;

2 the terrain category0/I/II/III/IV can be found in appendix A;

3 the data of gray areas are the max suggested installation height of pitched roof mounting system-L,

4 “---”means this region is inconformity to install the pitched roof mounting system-L.

The referenced evaluation result of snow load as follow:

5.2a the installation regions of pitched roof mounting system-L

Climatic Region	Alpine region	Central East	Greece	Iberian peninsula	Mediterranean Region
Zone	1 ,2,3,4,5	1,2,3,4,5	1,2,4	1,2,4	1,2,3,4,5
Climatic Region	Central West	Sweden, Finland	UK, Republic of Ireland	Poland	
Zone	1,2,3,4,5	1,2,3	1,2,3,4,5	1,2,3,4,5	

Note: 1 the date of gray areas are the suggested installation zone; the Climatic Region and Zone are showed at Appendix C;

2 the evaluation result is just suitable for the regions at sea level, other regions must be calculated according to practical situation of the installation areas;

3 the evaluation result is just suitable for normal snow load, and without takes into account these exceptional values.

5.2b the installation regions of pitched roof mounting system-L

Region	Norway	Czech Republic	Iceland
Zone	1	1,2,3,4	1

Note: 1 the date of gray areas are the suggested installation zone; the Climatic Region and Zone are showed at Appendix C;

2 the evaluation result is just suitable for normal snow load, and without takes into account these exceptional values.

The conclusions of this test report may not be used as part of the requirements for Intertek product certification. Authority to mark must be issued for a product to become certified.

INTERTEK TESTING SERVICES Shenzhen Ltd. Guangzhou Branch

Reported by: Gavin Liang

Gavin Liang
Engineer
Intertek

Reviewed by: Jonas Feng

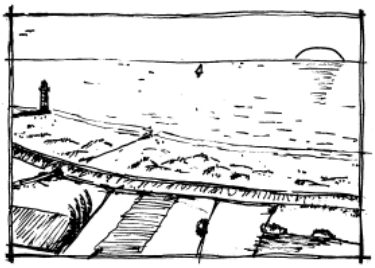
Jonas Feng
Engineer
Intertek

6 Appendix A: Terrain Category Extract from EN1991-1-4 (1 Page)

A.1 Illustrations of the upper roughness of each terrain category

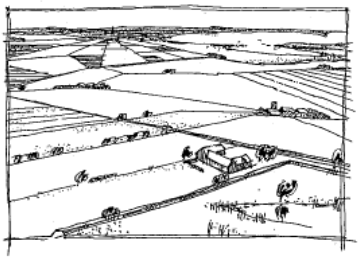
Terrain category 0

Sea, coastal area exposed to the open sea



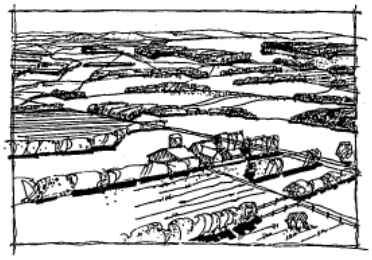
Terrain category I

Lakes or area with negligible vegetation and without obstacles



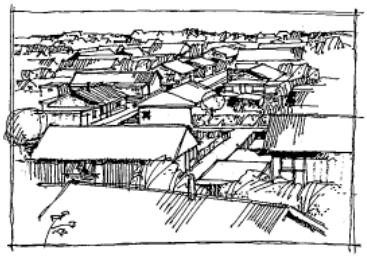
Terrain category II

Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights



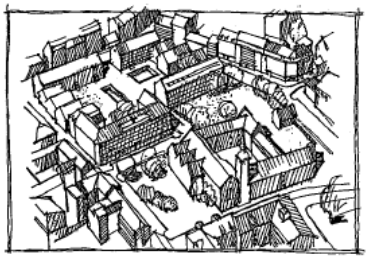
Terrain category III

Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)



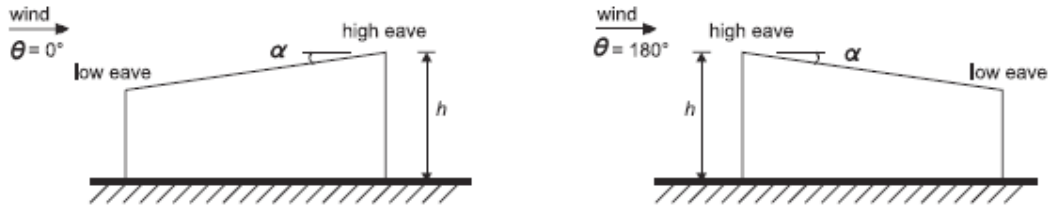
Terrain category IV

Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m

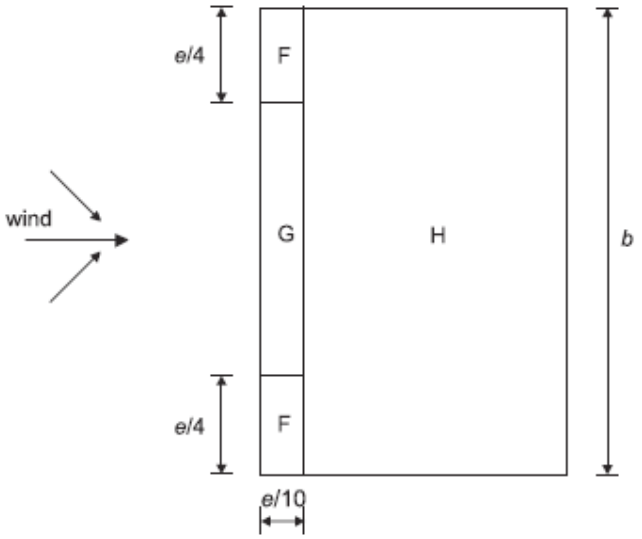


7 Appendix B: External pressure coefficient from EN1991-1-4 :2005

Monopitche roofs



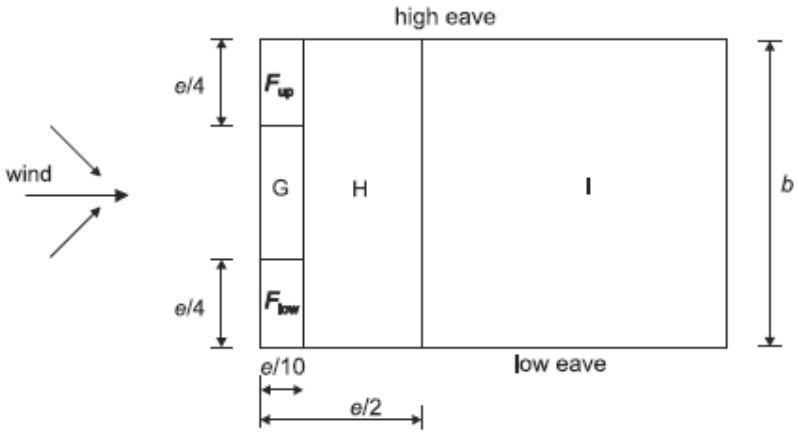
(a) general



(b) wind directions $\theta = 0°$ and $\theta = 180°$

e = *b* or 2*h*
whichever is smaller

b : crosswind dimension



(c) wind direction $\theta = 90°$

Table 7.3a — Recommended values of external pressure coefficients for monopitch roofs

Pitch Angle α	Zone for wind direction θ = 0°						Zone for wind direction θ = 180°					
	F		G		H		F		G		H	
	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$
5°	-1,7	-2,5	-1,2	-2,0	-0,6	-1,2	-2,3	-2,5	-1,3	-2,0	-0,8	-1,2
	+0,0		+0,0		+0,0							
15°	-0,9	-2,0	-0,8	-1,5	-0,3		-2,5	-2,8	-1,3	-2,0	-0,9	-1,2
	+0,2		+0,2		+ 0,2							
30°	-0,5	-1,5	-0,5	-1,5	-0,2		-1,1	-2,3	-0,8	-1,5	-0,8	
	+0,7		+0,7		+0,4							
45°	-0,0		-0,0		-0,0		-0,6	-1,3	-0,5		-0,7	
	+0,7		+0,7		+0,6							
60°	+0,7		+0,7		+0,7		-0,5	-1,0	-0,5		-0,5	
75°	+0,8		+0,8		+0,8		-0,5	-1,0	-0,5		-0,5	

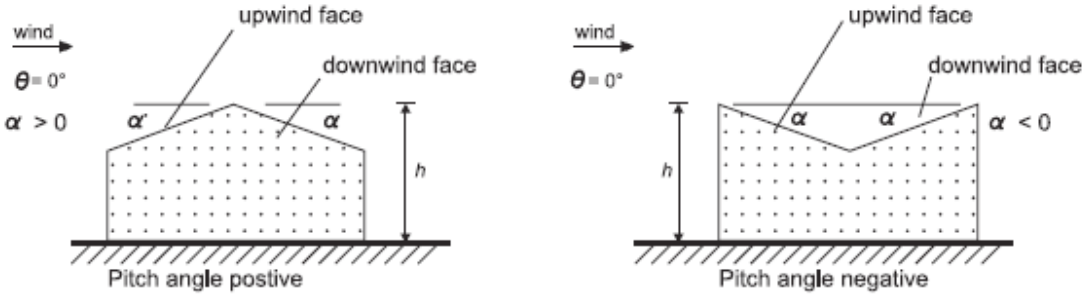
Table 7.3b — Recommended values of external pressure coefficients for monopitch roofs

Pitch Angle α	Zone for wind direction θ = 90°									
	F_{up}		F_{low}		G		H		I	
	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$
5°	-2,1	-2,6	-2,1	-2,4	-1,8	-2,0	-0,6	-1,2	-0,5	
15°	-2,4	-2,9	-1,6	-2,4	-1,9	-2,5	-0,8	-1,2	-0,7	-1,2
30°	-2,1	-2,9	-1,3	-2,0	-1,5	-2,0	-1,0	-1,3	-0,8	-1,2
45°	-1,5	-2,4	-1,3	-2,0	-1,4	-2,0	-1,0	-1,3	-0,9	-1,2
60°	-1,2	-2,0	-1,2	-2,0	-1,2	-2,0	-1,0	-1,3	-0,7	-1,2
75°	-1,2	-2,0	-1,2	-2,0	-1,2	-2,0	-1,0	-1,3	-0,5	

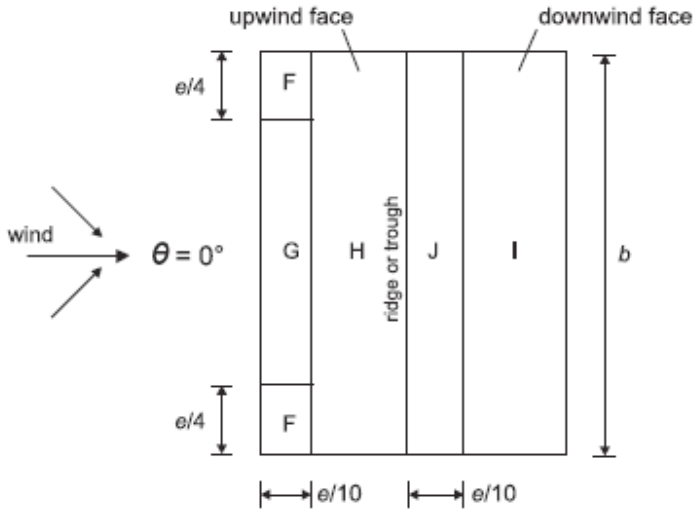
NOTE 1 At θ = 0° (see table a)) the pressure changes rapidly between positive and negative values around a pitch angle of α = +5° to +45°, so both positive and negative values are given. For those roofs, two cases should be considered: one with all positive values, and one with all negative values. No mixing of positive and negative values is allowed on the same face.

NOTE 2 Linear interpolation for intermediate pitch angles may be used between values of the same sign. The values equal to 0.0 are given for interpolation purposes

Duopitch roofs



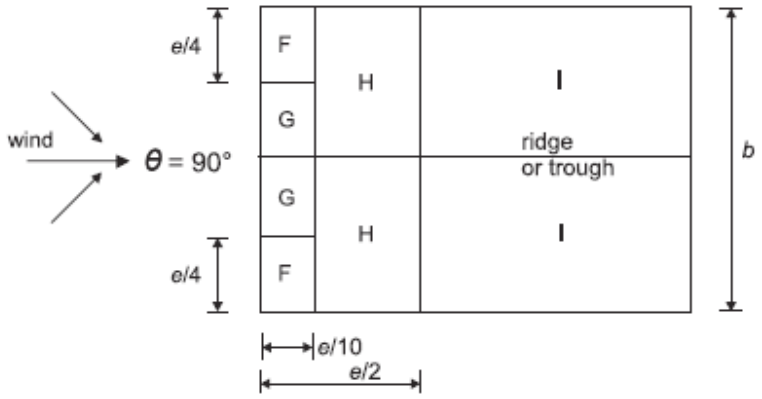
(a) general



(b) wind direction $\theta = 0°$

$e = b$ or $2h$
whichever is smaller

b : crosswind dimension



(c) wind direction $\theta = 90°$

Pitch Angle α	Zone for wind direction θ = 0 °									
	F		G		H		I		J	
	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$
-45°	-0,6		-0,6		-0,8		-0,7		-1,0	-1,5
-30°	-1,1	-2,0	-0,8	-1,5	-0,8		-0,6		-0,8	-1,4
-15°	-2,5	-2,8	-1,3	-2,0	-0,9	-1,2	-0,5		-0,7	-1,2
-5°	-2,3	-2,5	-1,2	-2,0	-0,8	-1,2	+0,2		+0,2	
							-0,6		-0,6	
5°	-1,7	-2,5	-1,2	-2,0	-0,6	-1,2	-0,6		+0,2	
	+0,0		+0,0		+0,0				-0,6	
15°	-0,9	-2,0	-0,8	-1,5	-0,3		-0,4		-1,0	-1,5
	+0,2		+0,2		+0,2		+0,0		+0,0	+0,0
30°	-0,5	-1,5	-0,5	-1,5	-0,2		-0,4		-0,5	
	+0,7		+0,7		+0,4		+0,0		+0,0	
45°	-0,0		-0,0		-0,0		-0,2		-0,3	
	+0,7		+0,7		+0,6		+0,0		+0,0	
60°	+0,7		+0,7		+0,7		-0,2		-0,3	
75°	+0,8		+0,8		+0,8		-0,2		-0,3	

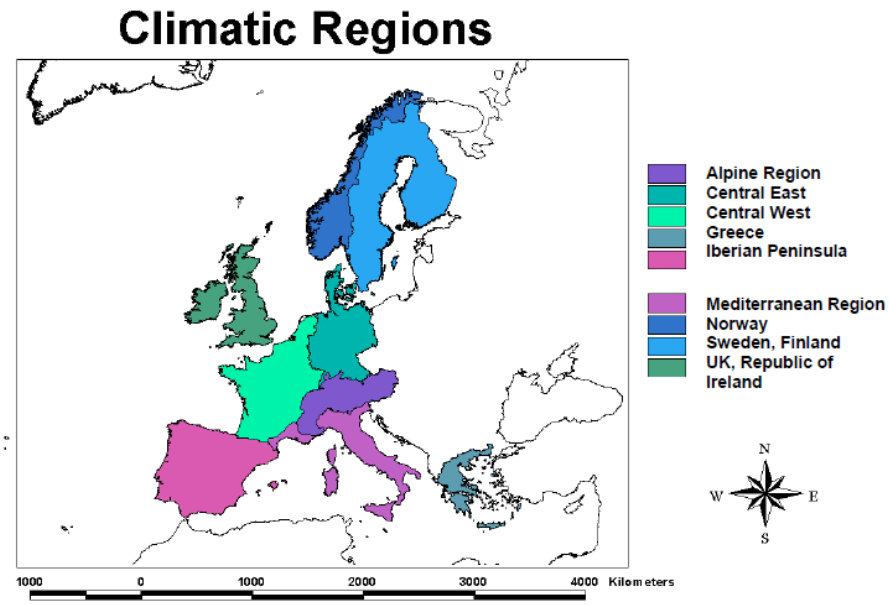
NOTE 1 At θ = 0° the pressure changes rapidly between positive and negative values on the windward face around a pitch angle of α = -5° to +45°, so both positive and negative values are given. For those roofs, four cases should be considered where the largest or smallest values of all areas F, G and H are combined with the largest or smallest values in areas I and J. No mixing of positive and negative values is allowed on the same face.

NOTE 2 Linear interpolation for intermediate pitch angles of the same sign may be used between values of the same sign. (Do not interpolate between α = +5° and α = -5°, but use the data for flat roofs in 7.2.3). The values equal to 0,0 are given for interpolation purposes

Pitch angle α	Zone for wind direction θ = 90 °							
	F		G		H		I	
	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$
-45°	-1,4	-2,0	-1,2	-2,0	-1,0	-1,3	-0,9	-1,2
-30°	-1,5	-2,1	-1,2	-2,0	-1,0	-1,3	-0,9	-1,2
-15°	-1,9	-2,5	-1,2	-2,0	-0,8	-1,2	-0,8	-1,2
-5°	-1,8	-2,5	-1,2	-2,0	-0,7	-1,2	-0,6	-1,2
5°	-1,6	-2,2	-1,3	-2,0	-0,7	-1,2	-0,6	
15°	-1,3	-2,0	-1,3	-2,0	-0,6	-1,2	-0,5	
30°	-1,1	-1,5	-1,4	-2,0	-0,8	-1,2	-0,5	
45°	-1,1	-1,5	-1,4	-2,0	-0,9	-1,2	-0,5	
60°	-1,1	-1,5	-1,2	-2,0	-0,8	-1,0	-0,5	
75°	-1,1	-1,5	-1,2	-2,0	-0,8	-1,0	-0,5	

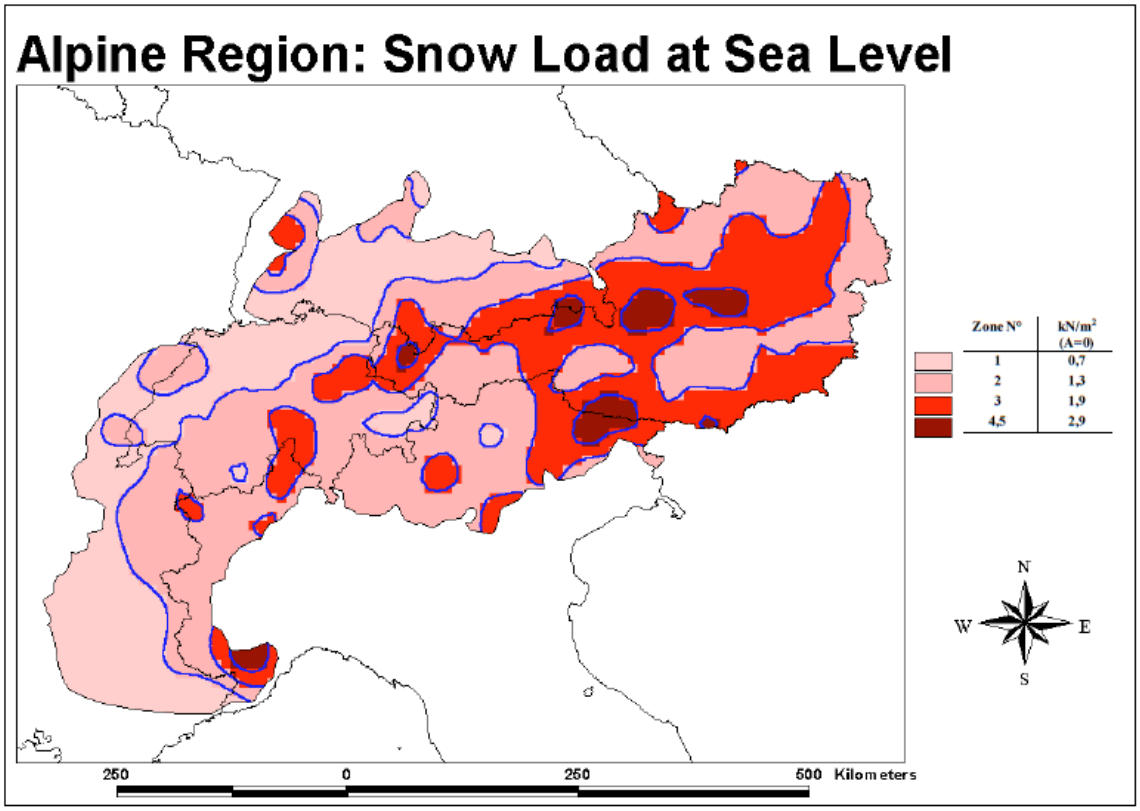
8 Appendix C: European Ground Snow Load Maps (7 pages)

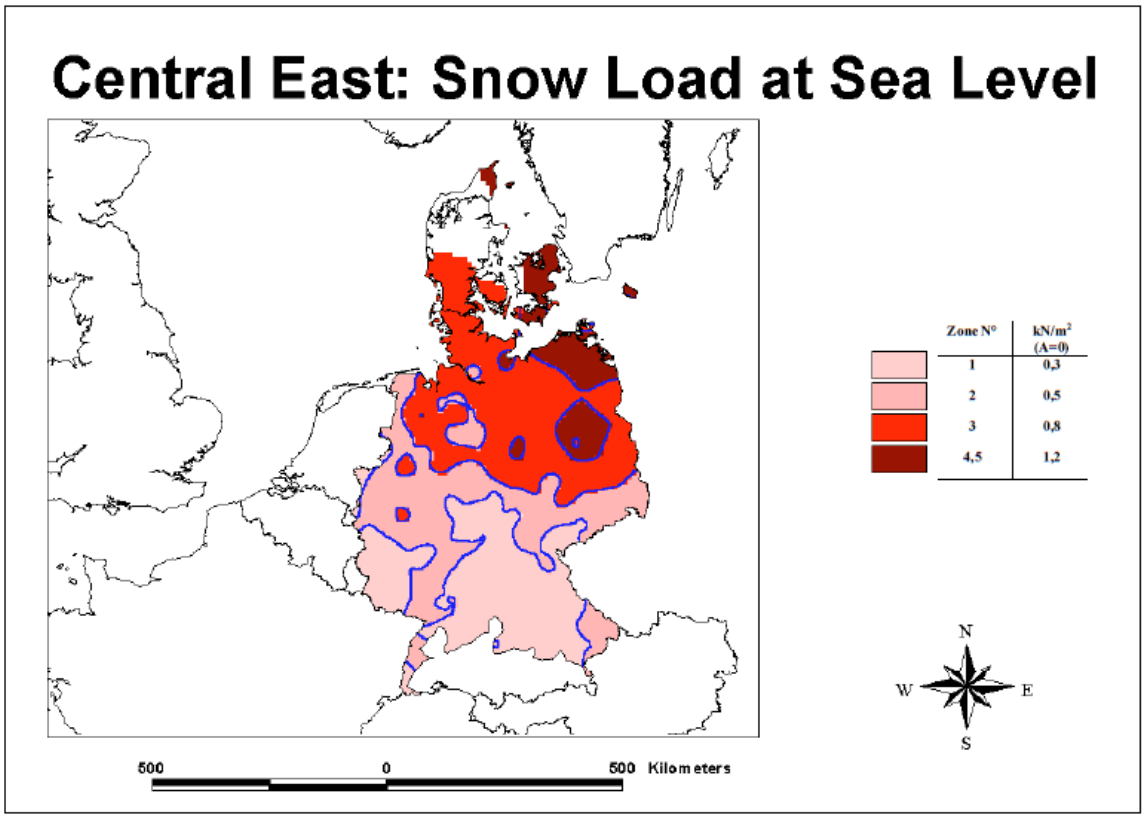
Figure C.1. European Climatic regions

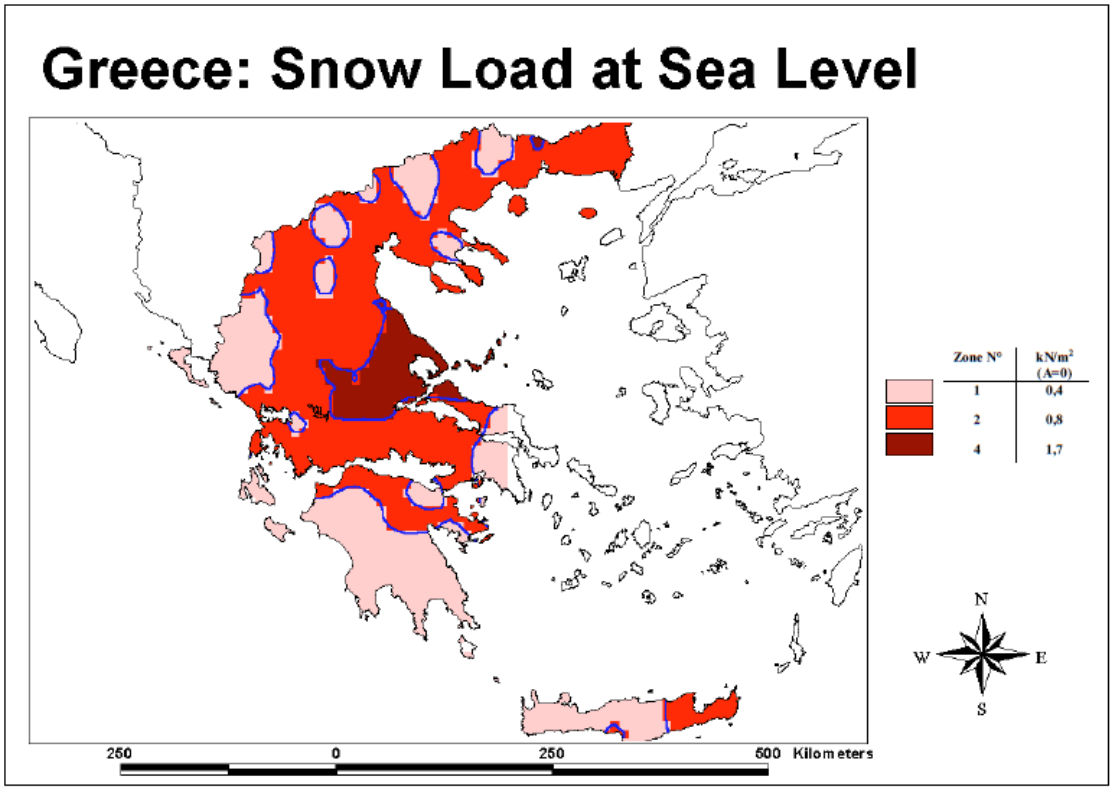


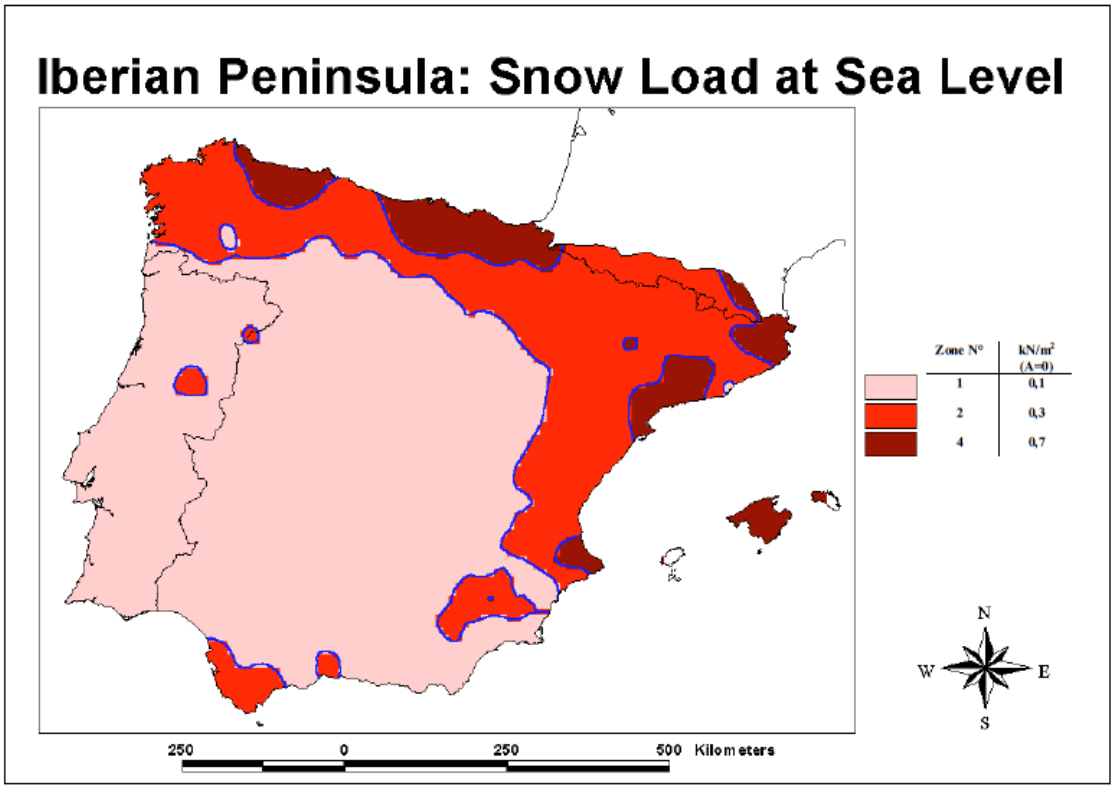
Climatic Region	*Expression*
Alpine Region	$s_k=(0{,}642Z+0{,}009)\left[1+\left(\frac{A}{728}\right)^2\right]$
Central East	$s_k=(0{,}264Z-0{,}002)\left[1+\left(\frac{A}{256}\right)^2\right]$
Greece	$s_k=(0{,}420Z-0{,}030)\left[1+\left(\frac{A}{917}\right)^2\right]$
Iberian Peninsula	$s_k=(0{,}190Z-0{,}095)\left[1+\left(\frac{A}{524}\right)^2\right]$
Mediterranean Region	$s_k=(0{,}498Z-0{,}209)\left[1+\left(\frac{A}{452}\right)^2\right]$
Central West	$s_k=0{,}164Z-0{,}082+\frac{A}{966}$
Sweden, Finland	$s_k=0{,}790Z+0{,}375+\frac{A}{336}$
UK, Republic of Ireland	$s_k=0{,}140Z-0{,}1+\frac{A}{501}$

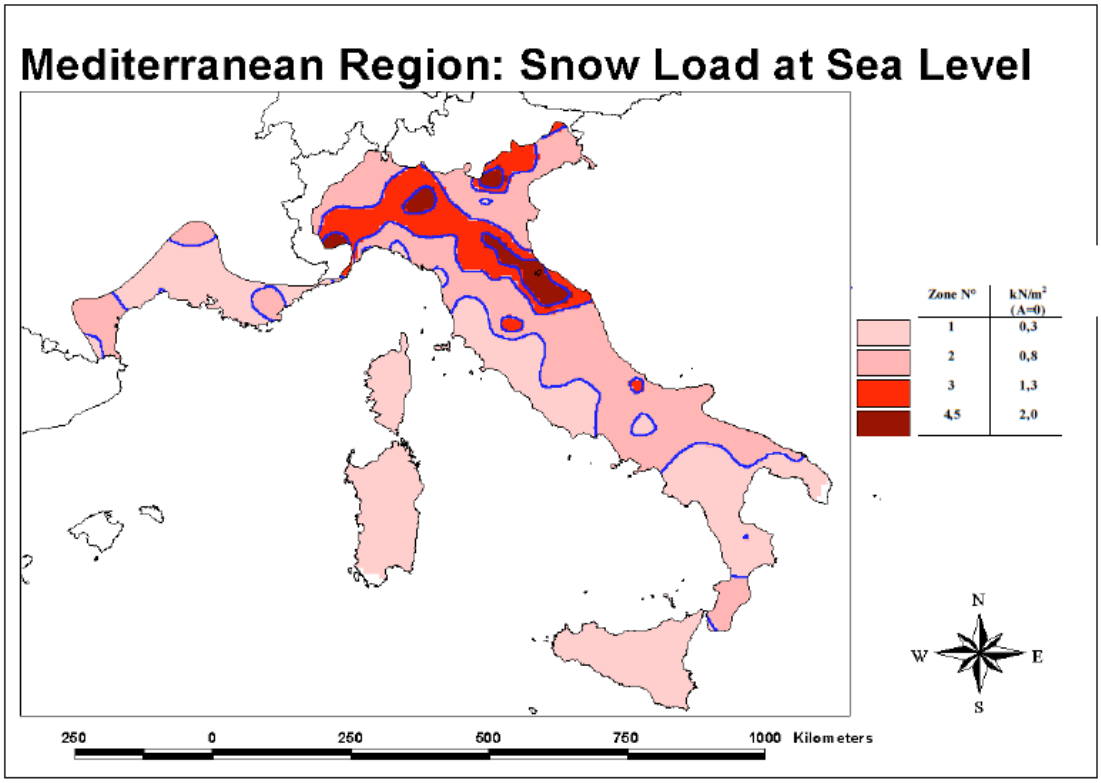
s_k is the characteristic snow load on the ground [kN/m^2]
A is the site altitude above Sea Level [m]
Z is the zone number given on the map.

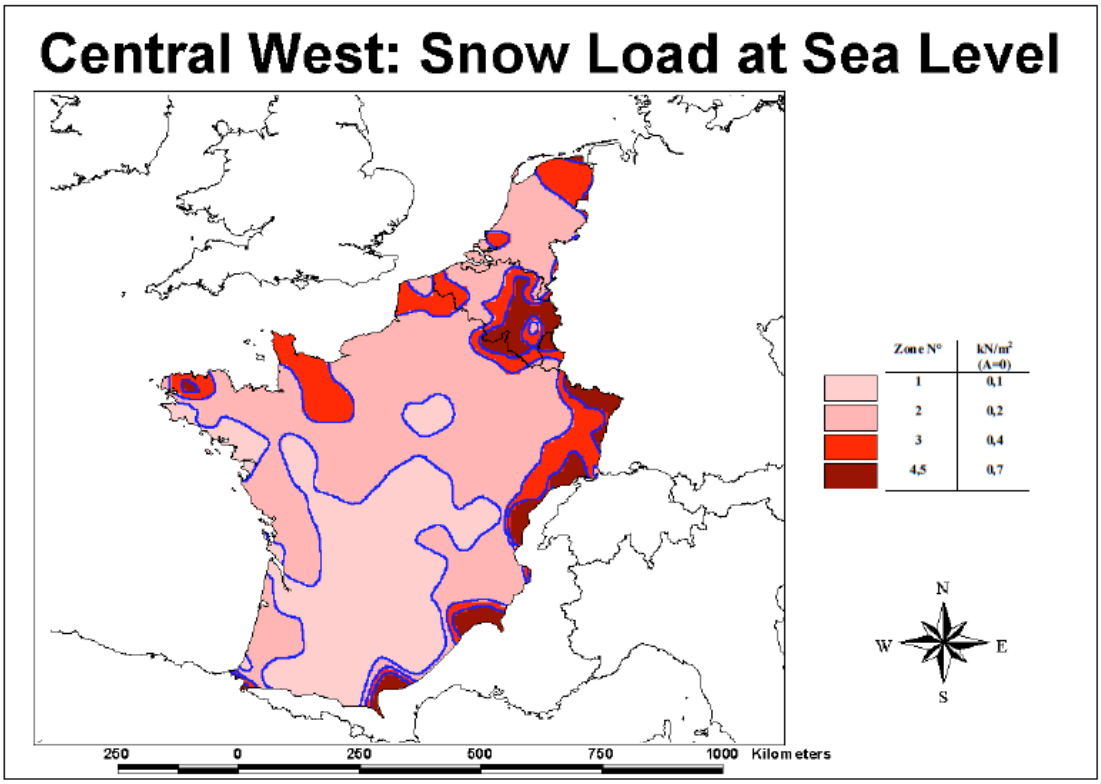

Alpine Region: Snow Load at Sea Level
Zone N°
kN/m² (A=0)
1
0,7
2
1,3
3
1,9
4,5
2,9
N
W
E
S
250
0
250
500 Kilometers

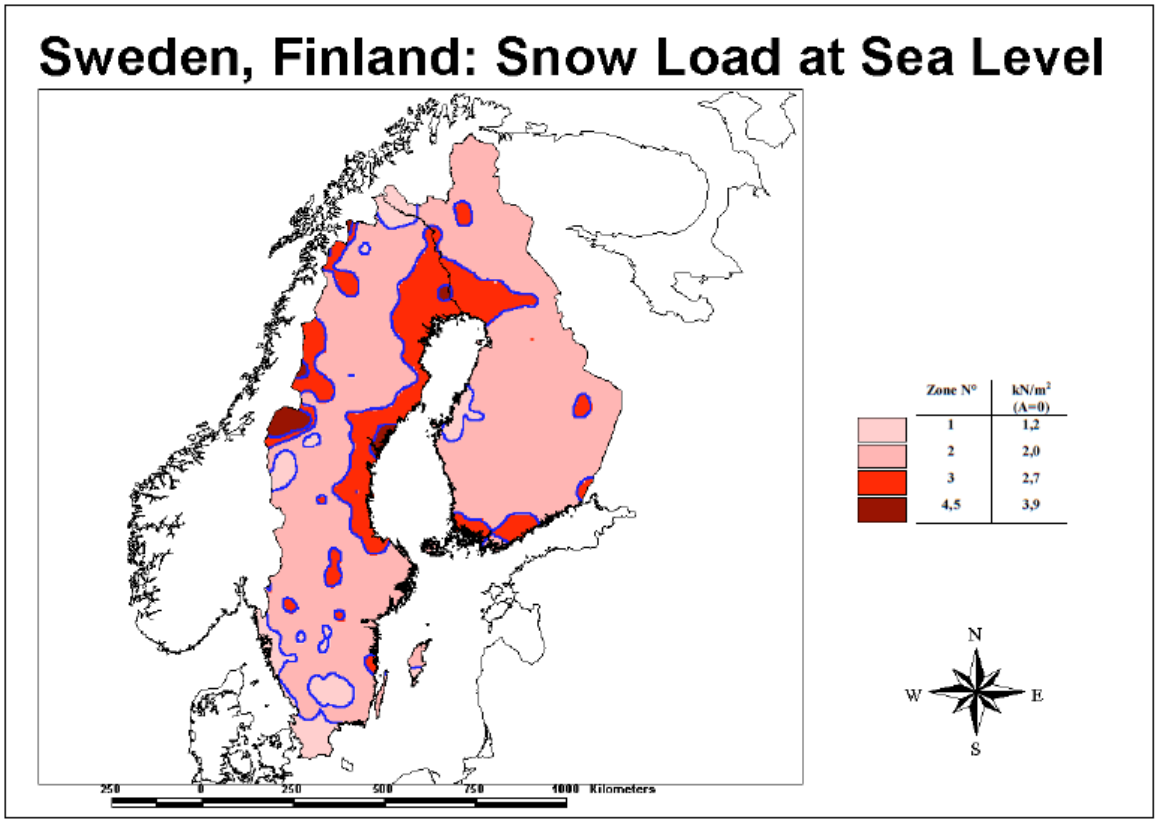

Central East: Snow Load at Sea Level
Zone N°
kN/m² (A=0)
1
0,3
2
0,5
3
0,8
4,5
1,2
N
W
E
S
500
0
500 Kilometers

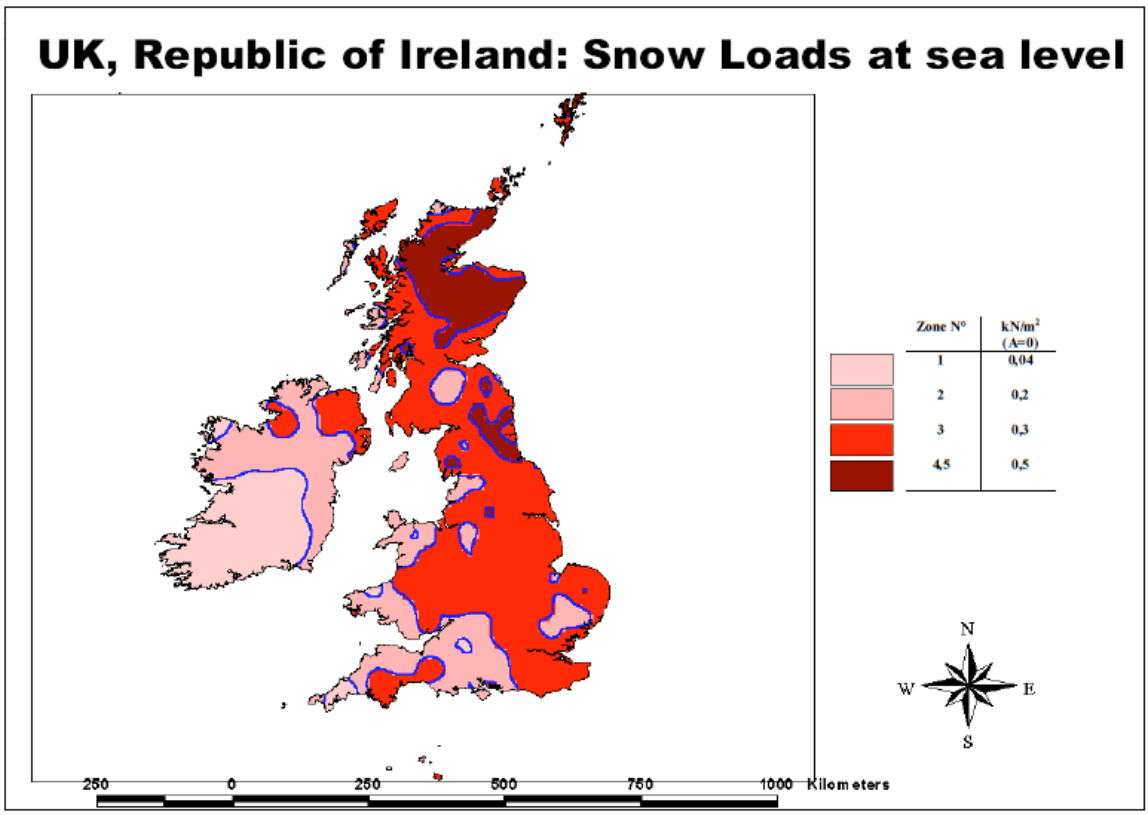

Greece: Snow Load at Sea Level
Zone N°
kN/m² (A=0)
1
0,4
2
0,8
4
1,7
N
W
E
S
250
0
250
500 Kilometers

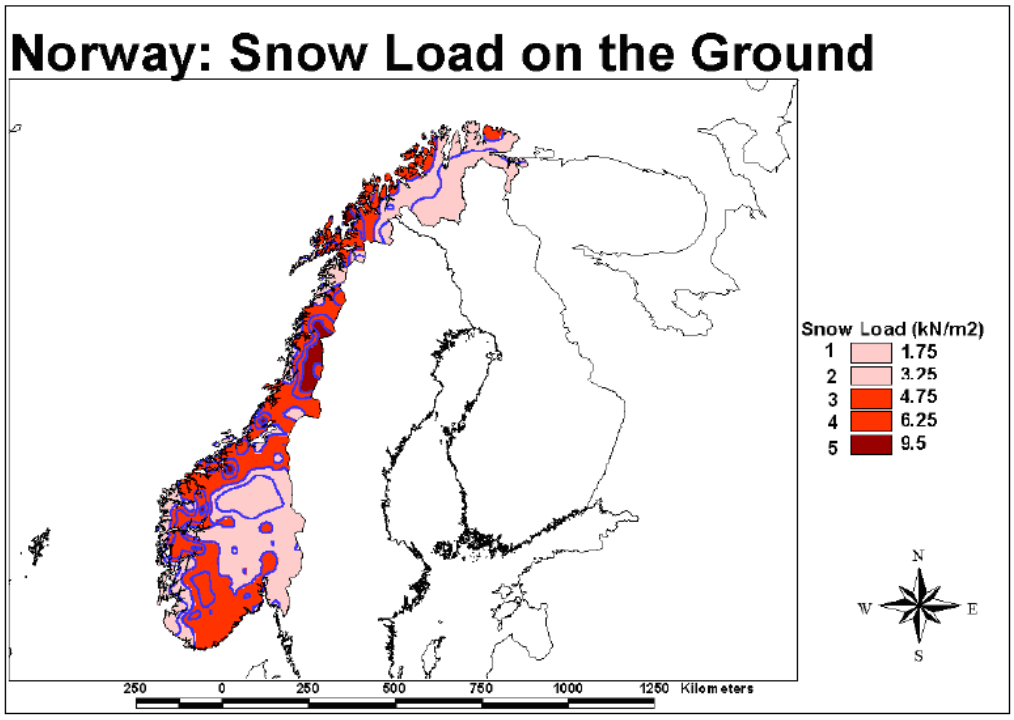

Iberian Peninsula: Snow Load at Sea Level
Zone N°
kN/m² (A=0)
1
0,1
2
0,3
4
0,7
N
W
E
S
250
0
250
500 Kilometers

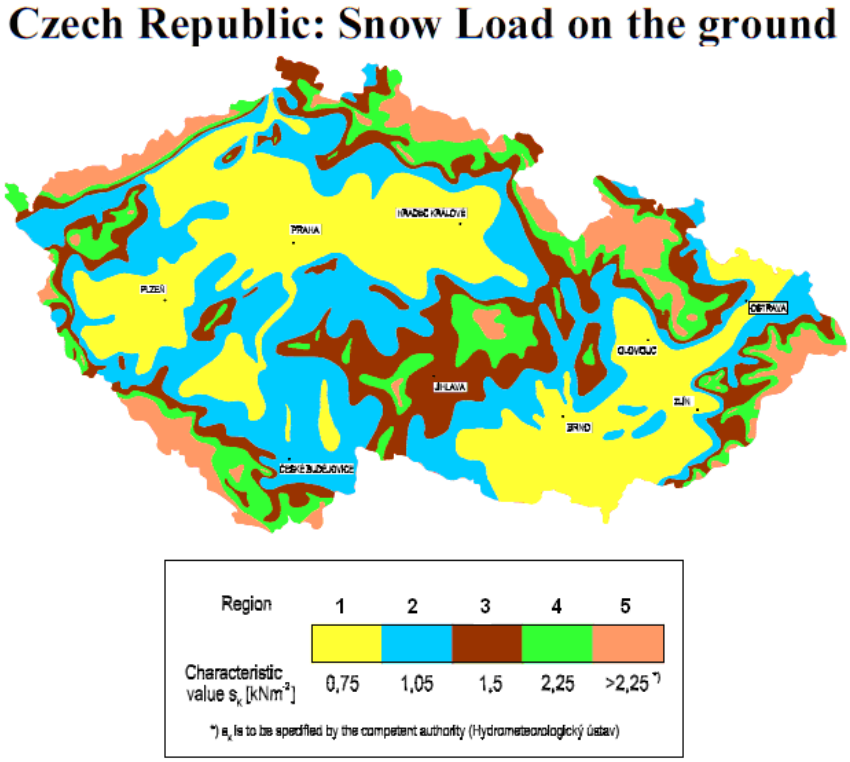

Mediterranean Region: Snow Load at Sea Level
Zone N°
kN/m² (A=0)
1
0,3
2
0,8
3
1,3
4,5
2,0
N
W
E
S
250
0
250
500
750
1000
Kilometers


Central West: Snow Load at Sea Level
Zone N°
kN/m² (A=0)
1
0,1
2
0,2
3
0,4
4,5
0,7
N
W
E
S
250
0
250
500
750
1000
Kilometers

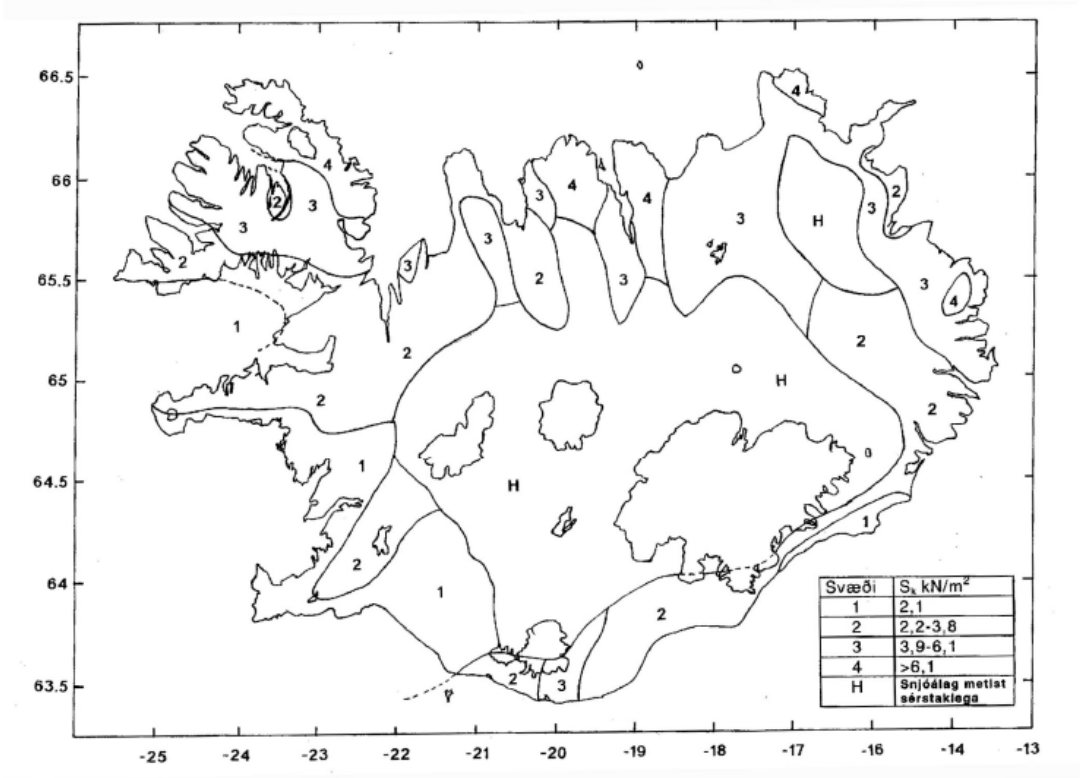

Sweden, Finland: Snow Load at Sea Level
Zone N°
kN/m² (A=0)
1
1,2
2
2,0
3
2,7
4,5
3,9
N
W
E
S
250
0
250
500
750
1000 Kilometers


UK, Republic of Ireland: Snow Loads at sea level
Zone N°
kN/m² (A=0)
1
0,04
2
0,2
3
0,3
4,5
0,5
N
W
E
S
250
0
250
500
750
1000 Kilometers


Norway: Snow Load on the Ground
Snow Load (kN/m2)
1 1.75
2 3.25
3 4.75
4 6.25
5 9.5
N
W
E
S
250 0 250 500 750 1000 1250 Kilometers

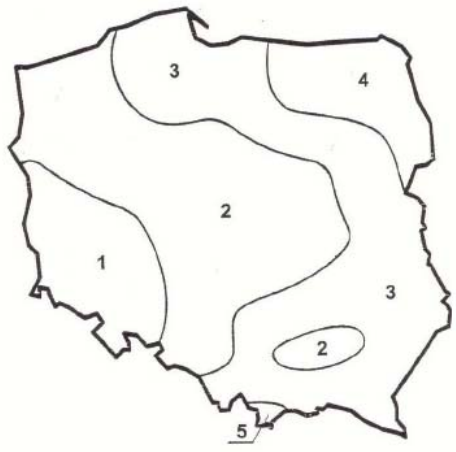

Czech Republic: Snow Load on the ground
Region 1 2 3 4 5
Characteristic value s_k [kNm^{-2}] 0,75 1,05 1,5 2,25 >2,25 *)
*) s_k is to be specified by the competent authority (Hydrometeorologický ústav)

Snow Map of Iceland



Snow Map of Poland

Zone	s_k, kN/m²
1	$0{,}007A - 1{,}4$; $s_k \geq 0{,}70$
2	0,9
3	$0{,}006A - 0{,}6$; $s_k \geq 1{,}2$
4	1,6
5	$0{,}93\exp(0{,}00134A)$; $s_k \geq 2{,}0$
NOTE: A = Site altitude above sea level (m)	



9 Appendix D: Test photos (5 pages)

Figure D.1: the photo of the positive pressure test

Figure D.2: Test pressure gage reading

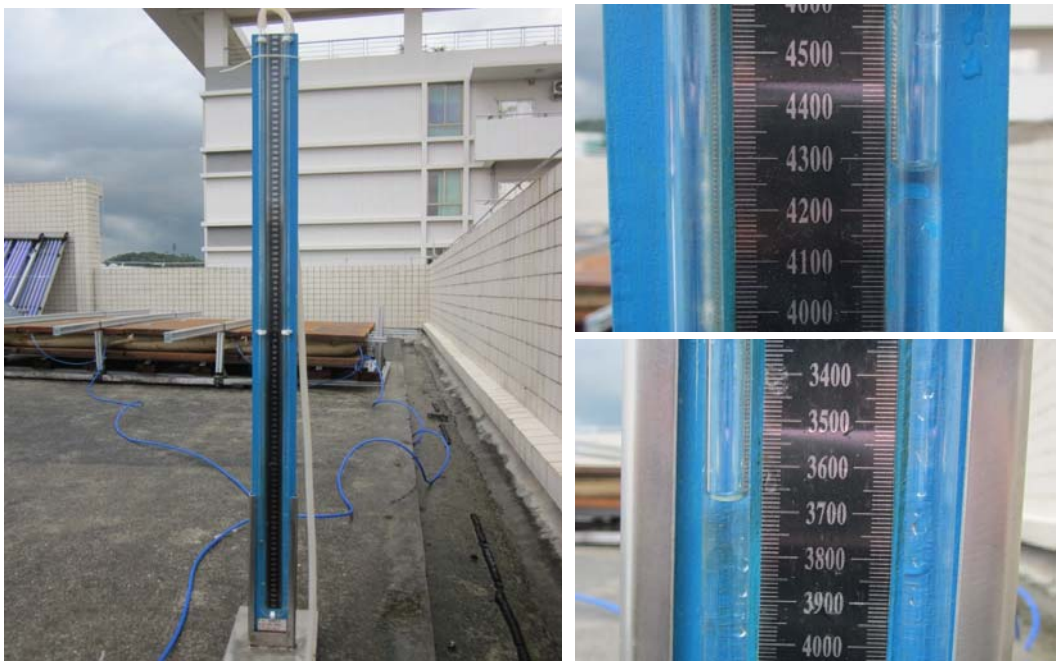


Figure C.3: the photo of the negative pressure test

Figure D.4: Test pressure gage reading

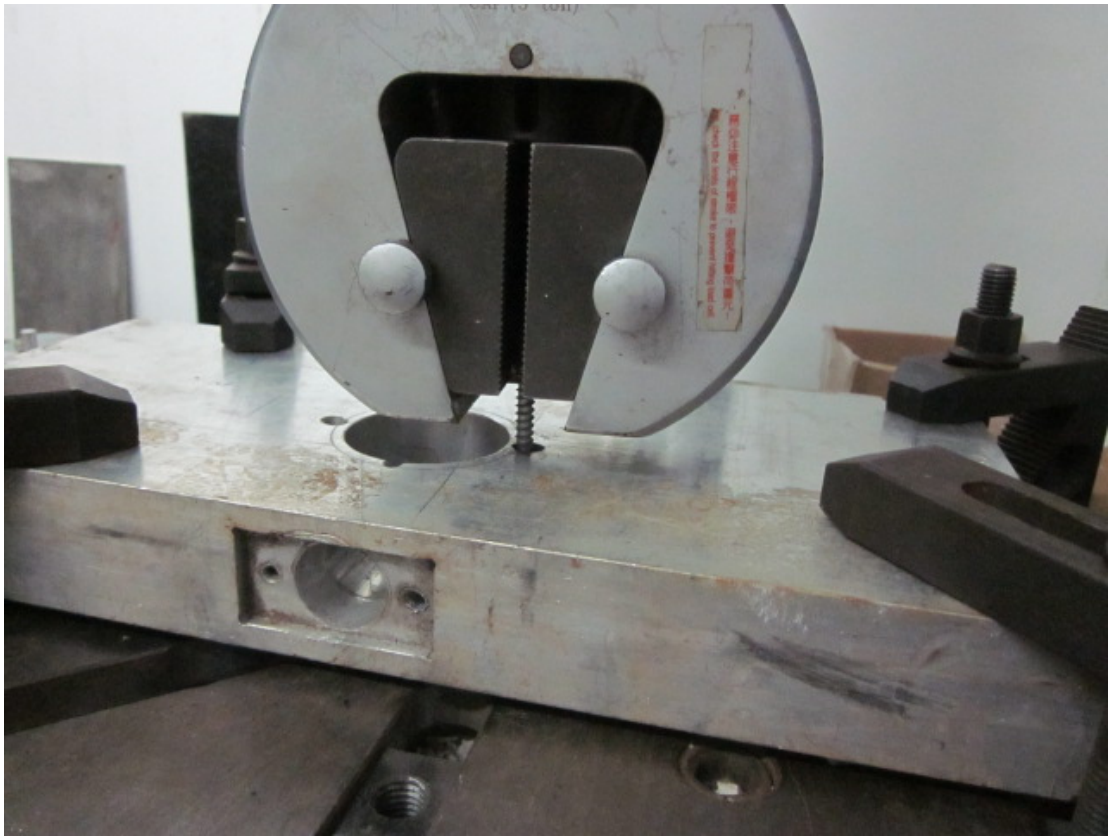
Figure D.5: the tensile test and compression test on the L feet (elastic deformation)

Figure D.6: the tensile test on the assembly of rail and Mid clamp
（up to plastic deformation）

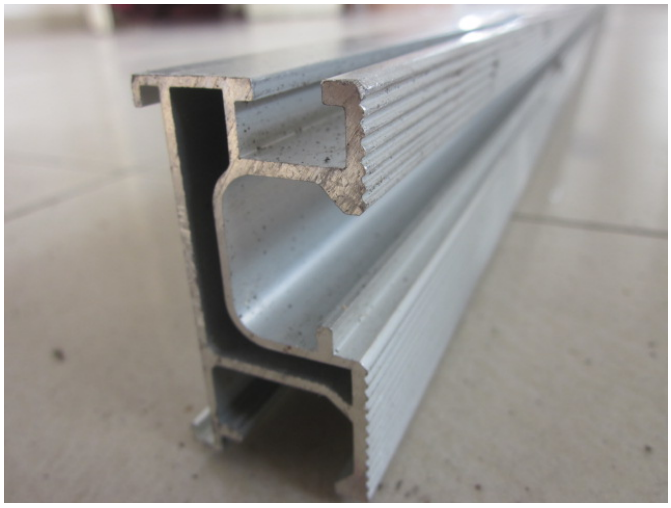
Figure D.7: the tensile test on the Mid clamp（up to plastic deformation）

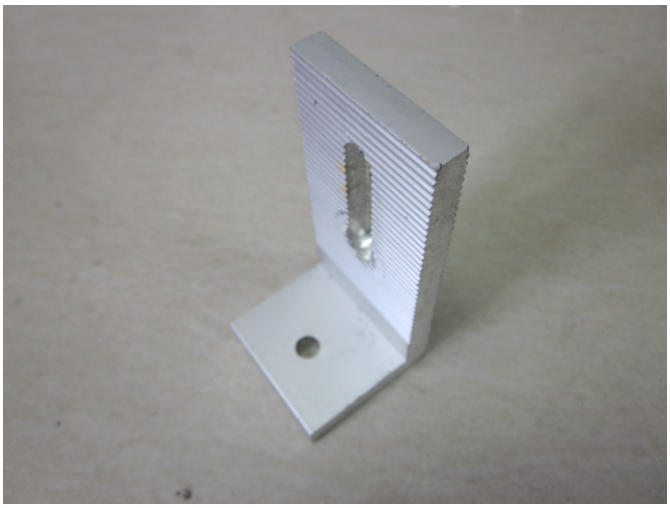
Figure D.8: the tensile test on the End clamp（up to plastic deformation）

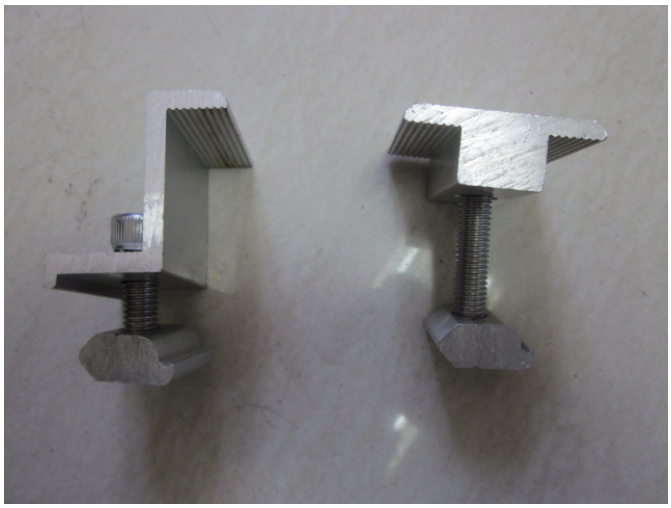
Figure D.8: the tensile test on the wood screw（this test only for reference）
（up to plastic deformation）



10 Appendix E: Sample Information after pressure test(1 page)







11 Appendix F: Components material certification from the client (2 pages)

上海晨科太阳能科技有限公司

材质： 6005 145 日期： 2013-1-27

编号： 0126 B2 3 2 送检人： 吴亮刚

送检单位： 新厂

	Al	Si	Fe	Cu	Mn	Mg	Zn	Cr
1	98.6	0.607	0.128	< 0.0010	0.0108	0.564	0.0094	0.0024
2	98.6	0.586	0.129	< 0.0010	0.0107	0.562	0.0103	0.0024
Ave	98.6	0.596	0.128	< 0.0010	0.0107	0.563	0.0099	0.0024

	Ni	Ti	Be	Ca	Li	Sn	Sr	V
1	0.0102	< 0.0010	< 0.0001	0.0051	0.0002	< 0.0075	< 0.0300	0.0135
2	0.0102	< 0.0010	< 0.0001	0.0051	0.0002	< 0.0075	< 0.0300	0.0126
Ave	0.0102	< 0.0010	< 0.0001	0.0051	0.0002	< 0.0075	< 0.0300	0.0131

	Na	Bi	Zr	B	Cd	Co	Ag
1	< 0.0005	0.0088	< 0.0030	< 0.0010	< 0.0010	< 0.0030	< 0.0010
2	0.0008	< 0.0050	< 0.0030	< 0.0010	< 0.0010	< 0.0030	< 0.0010
Ave	0.0005	< 0.0050	< 0.0030	< 0.0010	< 0.0010	< 0.0030	< 0.0010

质检员： 王祥志

SHANGHAI CHIKO SOLAR TECHNOLOGY CO.,LTD 上海晨科太阳能科技有限公司 质检专用章

上海晨科太阳能科技有限公司

产品质量证明书
PRODUCT QUALITY CERTIFICATE

客户 Customer:	奥展	合同号 Contract No:		质保书号 Certificate No	2013072901
产品名称 Products:	不锈钢盘条	执行标准 Standard:	Q/TS QG007-2011	交货状态 Delivery conditions:	热轧+酸洗

炉号 Heat No.	批号 Batch No.	钢种 Steel Grade	规格 Size(mm)	数量 Pieces	重量 Weight (kg)
130715A01-01	130715A01-01	304B	Φ7.5	10	20106

化学成分 Chemical Composition (%)

项目 Items		C	Si	Mn	P	S	Cr	Ni	Cu	Mo	Ti	Nb	V	/
技术要求 Specifications	max.	0.08	0.75	2.00	0.045	0.030	19.00	9.00	1.50	/	/	/	0.08	/
	min.	/	/	1.00	/	/	18.00	8.00		/	/	/	/	/
熔炼分析 Ladle		0.028	0.32	1.12	0.036	0.002	18.33	8.03	0.82					
成品分析 Products		/	/	/	/	/	/	/	/	/	/	/	/	/

项目 Items	拉伸试验Tensile Test				硬度	晶粒度	盐雾试验 NSS		尺寸公差 Size tolerance(mm)		表面质量 Surface defect(mm)		
	$R_{p0.2}$ N/mm²	R_m N/mm²	A %	Z %	Hardness	Graininess	A/%	R_A	直径 Diameter	不圆度 Roundness	I 组	II 组	III 组
规定 Spec.	/	550～700	≥45	≥65	/	/	/	/	A级±0.30	A级≤0.50	≤0.07	≤0.10	≤0.15
实测 Real	/	630	55.0	81.0		/	/	/	OK	OK	/	/	OK

其它说明 Remarks: 产品已经参照SN/T 0570-2007《进口可用作原料的废物放射性污染检验规程》进行放射性污染监测和判定，产品合格。

1. 兹证明所列产品经检验均符合合同和标准要求。
   The material listed above has been tested and complies with the terms of the contract & the standard.
2. 本证明书盖质保部检验专用章或经授权的销售部公章生效，复印无效。
   This certificate is valid with the orginal stamp of the quality department or the orinal stamp of the authorized sales department. Photocopies are invalid.
3. 如有质量异议，请来电来函说明情况，并告知质量证明书编号。
   If any quality query, please clarify via phone call or fax, indicating the certificate number.
4. 联系电话 Tel.: 0577-86615078 0578-6068258

产品质量检验专用章

编制: Typed by 王黎云　检验员: Surveyor 黄超　质保工程师: Quality engineer　日期: Date 2013年7月30日

QSR 8.2.4-19

12 Revision Page

Revision No.	Date	Changes	Author	Reviewer

End of the Document