GREEN ROOF INNOVATORS

DESIGNING THE DRAINAGE LAYER

0.5

GREEN ROOFS
PODIUM ROOF DECKS
PARKING ROOF DECKS

2 PODIUM ROOF DECKS AND PARKING ROOF DECKS (HARD LANDSCAPING)

On those roofs build-up with hard landscaping, stormwater is partly drained over the surfacing (q_o), the so-called 2nd discharge level. The drainage layer or the 1st discharge level, has to intercept the stormwater that has penetrated the surfacing ($q_{a.s}$).

$$q_{a,s} = r - q_o$$

$q_{a,s}$ = stormwater penetrating the surfacingl/(s.m^2) (table 2)
r = rainfall intensity l/(s.m^2) in accordance with BS EN 12056-3
q_o = stormwater discharged over the surfacingl/(s.m^2)

Based upon a 15 minute rainfall intensity happening once every 10 years of $r_{(15}{}^{0.1)}$ = 0.03 l/(s.m^2) the following values can be used to determine the amount of stormwater penetrating the surfacing ($q_{a.s}$):

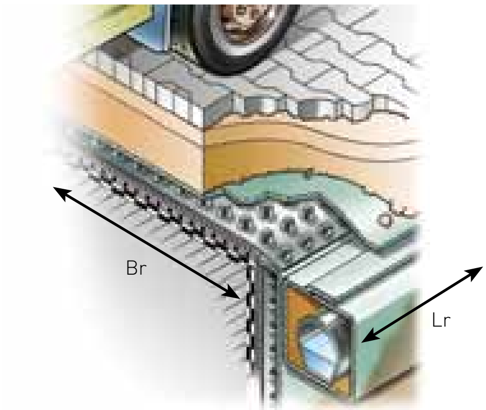

Figure 2. Effective roof area m^2
Lr = length of the roof to be drained m
Br = the plan width of roof from gutter to ridge m

Surface	$q_{a,s}$ (l/(s.m^2)
Concrete block pavers	0.01
Paved area with >15% joints	0.012
Self-binding gravel	0.015
Turf paving on water permeable sub base	0.03

Table 2. Stormwater penetrating the surfacing $q_{a.s}$

2.1 Calculating the drainage capacity in l/(s.m) of the drainage layer

The amount of water that needs to be discharged by the drainage layer (q') can be calculated per l/(s.m) by using the following equation:

$$q' = \frac{q_{a,s} \times A}{Lr} \text{ in l/(s.m)}$$

q' = required amount of water to be discharged by the drainage layer l/(s.m) (table 3)
$q_{a,s}$ = stormwater penetrating the surfacingl/(s.m^2) (table 2)
A = effective roof area m^2 (Lr x Br)
Lr = length of the roof to be drained m

2.2 Calculating the maximum flow length of ND Drainage Composites

The maximum flow length in metres of the ND Drainage Composites taking into account the stormwater that penetrates the surfacing can be calculated by using the following equation:

$$L_{max} = \frac{\text{drainage capacity of ND Drainage Composite}^*}{q_{a,s}}$$

L_{max} = flow length in metres
$q_{a.s}$ = stormwater penetrating the surfacing l/(s.m (table 2)

* *see table 3. Drainage capacity ND Drainage Composites*

1 GREEN ROOFS

On green roofs, the stormwater is partly retained by the growing medium layer and partly passed on to the drainage layer.

1.1 Calculating the drainage capacity in l/(s.m) of the drainage layer

The amount of water that needs to be discharged by the drainage layer ($q^{\cdot}$) can be calculated in l/(s.m) by using the following equation:

$$q^{\cdot} = \frac{\alpha \text{ x i x F}}{Lr} \text{ in l/(s.m)}$$

$q^{\cdot}$ = required amount of water to be discharged by the drainage layer l/(s.m) (table 3)
A = effective roof area m^2 (Lr x Br)
C = run-off coefficient (tabel 1)
r = rainfall intensity l/(s.m^2) in accordance with BS EN 12056-3*
Lr = length of the roof to be drained, in metres

* BS EN 12056-3 "Gravity Drainage Systems Inside Buildings"

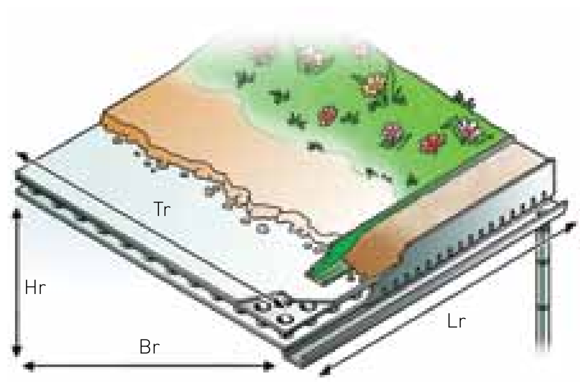

Figure 1. Roof dimensions
Lr = the length of roof to be drained
Br = the plan width of roof from gutter to ridge
Hr = the height of roof from gutter to ridge
Tr = the distance from gutter to ridge measured along the roof

1.2 Calculating the maximum flow length of ND Drainage Composites

The maximum flow length (in metres) of the ND Drainage Composites, taking into account the run-off coefficient of the growing medium layer, can be calculated by using the following equation:

$$L_{max} = \frac{\text{drainage capacity of ND Drainage Composite}^{*}}{\text{C x r}}$$

L_{max} = flow length in metres
C = run-off coefficient (table 1)
r = rainfall intensity l/(s.m^2) in accordance with BS EN 12056-3

* *see table 3. Drainage capacity ND Drainage Composites*

1.3 Run-off coefficients for green roofs

For green roofs, the following run-off coefficients (C) can be used. The values depend on the depth of the growing medium and the roof slope.The figures apply for the stated layer depth at a 15 minute rainfall intensity of $r_{(15)}$ = 0.03 l/(s.m^2). The growing medium has previously been saturated with water and drip-dried for 24 hour prior to testing.

Growing medium layer depth in mm	Roof slope ≤5° (~8,8%)	Roof slope >5° (~8,8%)
60	C = 0.6	C = 0.7
60 - 100	C = 0.5	C = 0.6
100 - 150	C = 0.4	C = 0.5
150 - 250	C = 0.3	–
250 - 500	C = 0.2	–
>500	C = 0.1	–

Table 1. Run-off coefficient (C)

3 ROOF DRAINAGE

EN 12056-3, the European roof drainage standard, provides for a run-off coefficient to allow for absorbent roofing surfaces if national and local regulations and practice permit. However, at present in the United Kingdom, no guidance is available, and so the designer is forced to adopt alternative methods if the run-off reduction effect of a green roof is to be taken into account.

For roofs with a fall of 1 in 40 (2.5%) or flatter (nominally flat roofs) the designer should use a BS EN 12056-3 Category 1 storm event for design purposes. This storm event will occur on average once every year in the United Kingdom, and will generate rainfall intensities which vary from 0.01l/(s.m^2) to 0.022l/(s.m^2) depending on geographical location. This is very short duration thunderstorm rain, and will occur on average for 2 minutes, usually in summer, when a green roof build-up could be expected to be at its driest.

It is assumed by using this method that any storm greater than this intensity would be absorbed into the green roof build-up, or would pond on any hard surfacing between green areas. The roof deck should however be strong enough to resist the loads imposed by minor ponding, as it should have been designed to cope with the loadings from the green roof.

For roof falls greater than 1 in 40 (2.5%) and for hard landscaped roof decks, a BS EN 12056-3 Category 2 or 3 storm event should be used, as there is a risk of structurally significant ponding. Category 2 and 3 storm events are based on the building life multiplied by a factor of safety of 1.5 or 4.5, and results in much higher rainfall intensities (0.029l/(s.m^2) to 0.088l/(s.m^2)).

For further guidance on rainfall intensity in the United Kingdom see National Annex NB of BS EN 12056-3.

Area	Rainfall intensity l/(s.m^2) category 1	Rainfall intensity l/(s.m^2) category 2	Rainfall intensity l/(s.m^2) category 3
England	0.022	0.066	0.088
Scotland, Wales, and Northern Ireland	0.016	0.053	0.065
Northern Scotland, Shetlands and Orkneys	0.010	0.029	0.034

Table 4. Guide figures for Category 1, 2 and 3 storm event

4 CONVERSION TABLE

4.1 Fall ratio – Slope angle – Slope

Fall ratio	Slope angle	Slope
1:120	0.5°	0.8%
1:100	0.6°	1.0%
1:80	0.7°	1.3%
1:60	1.0°	1.7%
1:40	1.4°	2.5%
1:38.2	1.5°	2.6%
1:28.6	2.0°	3.5%
1:19.1	3.0°	5.2%
1:14.3	4.0°	7.0%
1:11.4	5.0°	8.7%
1:9.5	6.0°	10.5%
1:8.1	7.0°	12.3%
1:7.1	8.0°	14.1%
1:6.3	9.0°	15.8%
1:5.7	10.0°	17.6%

Table 5. Fall ratio – Slope angle – Slope

Overview Drainage capacity of ND Drainage Composites BS EN 12958

ND PRODUCT SERIES			100	200	600	600hd	4+1	4+1 high	5+1	5+1lt	6+1
Vertical Drainage in l/(s.m) – wall											
SURFACE LOAD	BUILD-IN DEPTH	l/(s.m)									
30kN/m²	3.0 m	l/(s.m)	2,85	5,38	5,41	5,41	5,67	7,64	15,64	13,97	8,33
50kN/m²	5.0 m	l/(s.m)	2,75	5,18	5,28	5,18	5,57	7,54	15,40	13,51	7,64
100kN/m²	10.0 m	l/(s.m)	2,22	4,23	4,52	4,26	5,54	6,89	14,75	11,21	6,07
200kN/m²	Exceptional case	l/(s.m)	1,41	3,61	4,00	3,77	5,08	6,06	13,02	9,48	-
Horizontal drainage in l/(s.m) – roof deck											
Fall ratio <1:500 – exceptional case											
SURFACE LOAD											
0.2kN/m²	extensive green roof		–	–	–	–	–	–	0.36	0.36	–
10kN/m²	intensive green roof		–	–	–	–	–	–	0.30	0.30	–
Fall ratio 1:80 – Standard green roof											
SURFACE LOAD											
10kN/m²	extensive green roof	l/(s.m)	0,39	0,66	0,66	0,66	0,66	0,95	1,87	1,74	1,02
20kN/m²	intensive green roof	l/(s.m)	0,29	0,62	0,59	0,62	0,66	0,78	1,77	1,67	1,02
100kN/m²	podium roof deck	l/(s.m)	0,19	0,37	0,51	0,38	0,62	0,66	1,64	1,25	0,65
200kN/m²	parking roof deck	l/(s.m)	0,07	0,36	0,38	0,37	0,59	0,56	1,51	1,18	-
Fall ratio 1:60											
SURFACE LOAD											
10kN/m²	extensive green roof	l/(s.m)	0,43	0,72	0,72	0,75	0,69	1,05	2,13	1,90	1,11
20kN/m²	intensive green roof	l/(s.m)	0,33	0,69	0,61	0,64	0,72	0,81	2,03	1,87	1,08
100kN/m²	podium roof deck	l/(s.m)	0,20	0,40	0,52	0,39	0,72	0,72	1,84	1,41	0,72
200kN/m²	parking roof deck	l/(s.m)	0,07	0,39	0,39	0,37	0,62	0,62	1,74	1,28	-
Fall ratio 1:40 – Standard hard landscaping											
SURFACE LOAD											
10kN/m²	extensive green roof	l/(s.m)	0,46	0,89	0,89	0,85	0,92	1,41	2,49	2,26	1,31
20kN/m²	intensive green roof	l/(s.m)	0,43	0,80	0,76	0,78	0,89	1,34	2,33	2,20	1,34
100kN/m²	podium roof deck	l/(s.m)	0,23	0,49	0,61	0,53	0,82	0,98	2,16	1,64	0,82
200kN/m²	parking roof deck	l/(s.m)	0,10	0,46	0,49	0,52	0,72	0,79	2,07	1,54	-

Table 3. Drainage capacity of ND Drainage Composites

The values correspond to average results obtained in our laboratories and outside institutes and are indicative. The right is reserved to make changes at any time without notice. Standard variations in mechanical properties of 15% and in hydraulic properties of 20% and in physical properties of 2% are normal.

Dutch Green Building Council

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