3. Conversion tables

3.1 Fall and pitch

Fall vs. pitch	Pitch vs. fall
1 % ~ 0.6 º	1 º ~ 1.7 %
2 % ~ 1.1 º	2 º ~ 3.5 %
3 % ~ 1.7 º	3 º ~ 5.2 %
5 % ~ 2.9 º	5 º ~ 8.8 %
7 % ~ 4.0 º	7 º ~ 12.3 %
9 % ~ 5.1 º	9 º ~ 15.8 %
10 % ~ 5.7 º	10 º ~ 17.6 %
15 % ~ 8.5 º	15 º ~ 26.8 %
20 % ~ 11.3 º	20 º ~ 36.4 %
30 % ~ 16.7 º	25 º ~ 46.6 %
40 % ~ 21.8 º	30 º ~ 57.7 %
60 % ~ 31.0 º	35 º ~ 70.0 %
80 % ~ 38.7 º	40 º ~ 83.9 %
100 % ~ 45.0 º	45 º ~ 100.0 %

Table 5. Fall and pitch

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0.5

Designing the drainage layer

Designing the drainage layer for green roofs
Designing the drainage layer below hard landscaping

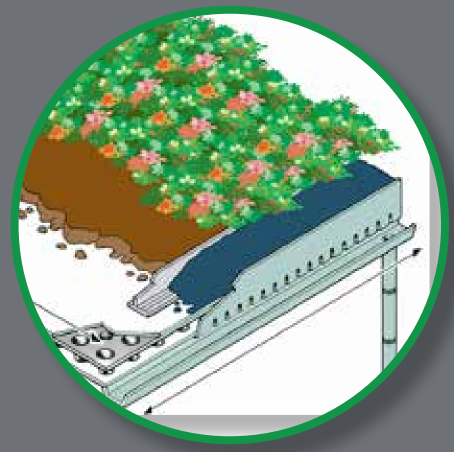
Nophadrain BV

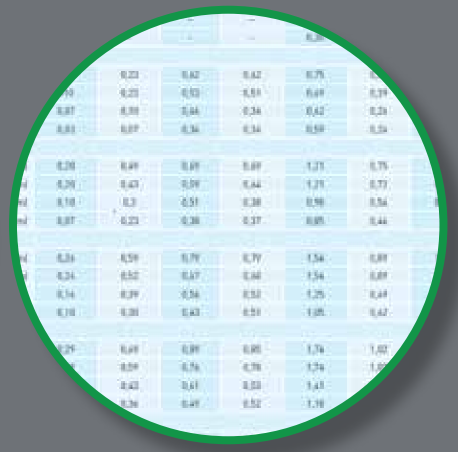
Visiting address
Mercuriusstraat 10
6468 ER Kerkrade
Netherlands

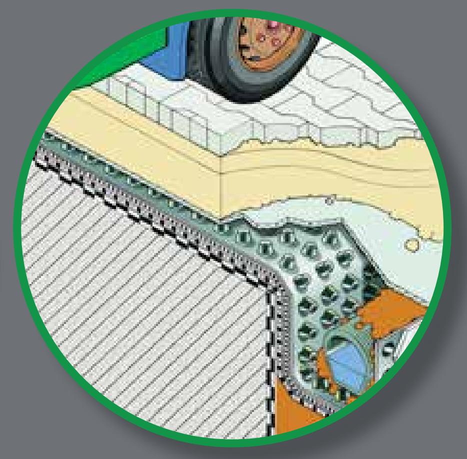
Postal address
Postbus 3016
6460 HA Kerkrade
Netherlands

T +31(0)45 535 50 30
F +31(0)45 535 39 30
E info@nophadrain.com

www.nophadrain.com







1. Designing the drainage layer for 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') can be calculated in l/(s.m) by using the following equotation:

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

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

*hEN 12056-3 "Gravity Drainage Systems Inside Buildings"

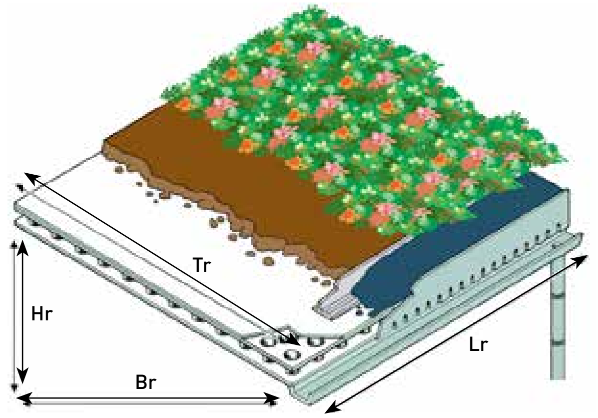


Figure 1. Roof dimensions
Lr = the length of the roof to be drained
Br = the plan width of the roof from the gutter to the ridge
Hr = the height of the roof from the gutter to the ridge
Tr = the distance from the gutter to the ridge measured along the roof

1.2 Calculating the maximum flow length of ND Drainage Systems

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

$$L_{max} = \frac{\text{drainage capacity of ND Drainge Systems}}{C \times r}$$

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

*see table 3. Drainage capaciteit ND Drainage Systems

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)

2. Designing the drainage layer for podium and parking decks (hard landscaping)

On roofs with hard landscaping, the 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 surfacing $l/(s.m^2)$ (table 2)
r = rainfall intensity $l/(s.m^2)$ in accordance with hEN 12056-3
q_o = stormwater discharged over the surfacing $l/(s.m^2)$

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 ($q_{a,s}$):

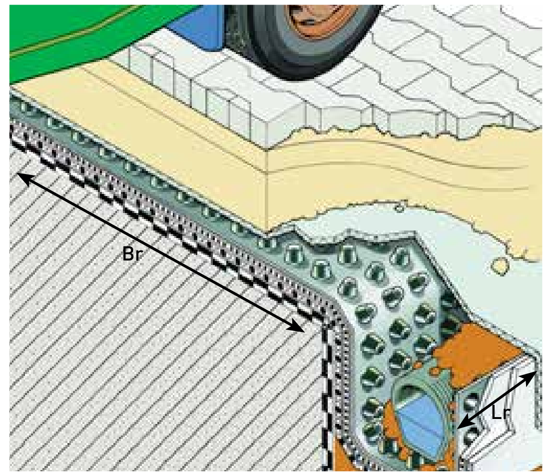


Figure 2. Effective roof area m^2
Lr = length of the roof to be drained (in metres)
Br = the plan width of roof from gutter to ridge (in metres)

Surface	$q_{a,s}$ $(l/(s.m^2))$
Concrete block pavers	0.010
Paved area with > 15 % joints	0.012
Self-binding gravel	0.015
Turf paving on water permeable sub base	0.030

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 equotation:

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

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

2.2 Calculating the maximum flow length of ND Drainage Systems

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

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

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

*see table 3. Drainage capacity of ND Drainage Systems

Overview drainage capacity of ND Drainage Systems hEN 12958

ND Drainage Systems			ND 100	ND 200	ND 600	ND 620hd	ND 800	ND 4+1h	ND 5+1	ND 6+1v
Vertical drainage in l/(s.m) – wall										
Surface load	**Build-in depth**	**Unit**								
30 kPa	3.0 m	l/(s.m)	2.94	5.25	5.19	5.26	14.15	7.53	15.55	8.89
50 kPa	5.0 m	l/(s.m)	2.70	5.02	4.97	4.97	13.78	7.49	15.53	8.12
100 kPa	10.0 m	l/(s.m)	2.30	4.31	4.51	4.47	12.33	7.25	14.25	6.05
200 kPa	exceptional case	l/(s.m)	1.75	3.69	3.74	3.86	10.40	6.44	11.75	–
Horizontal drainage l/(s.m) – roof										
Fall = 0 % - exceptional case										
2 kPa	extensive green roof	l/(s.m)	–	–	–	–	0.36	–	0.36	–
10 kPa	intensive green roof	l/(s.m)	–	–	–	–	0.30	–	0.30	–
Fall = 1 % - exceptional case										
10 kPa	extensive green roof	l/(s.m)	0.20	0.43	0.54	0.56	1.60	0.87	1.67	0.99
20 kPa	intensive green roof	l/(s.m)	0.20	0.43	0.49	0.51	1.54	0.80	1.61	0.86
100 kPa	podium roof deck	l/(s.m)	0.16	0.30	0.36	0.39	1.19	0.74	1.44	0.47
200 kPa	parking roof deck	l/(s.m)	0.10	0.22	0.28	0.32	1.07	0.69	1.19	-
Fall = 1.5 %										
10 kPa	extensive green roof	l/(s.m)	0.30	0.55	0.72	0.71	1.76	0.97	1.98	1.15
20 kPa	intensive green roof	l/(s.m)	0.30	0.55	0.63	0.64	1.70	0.96	1.88	1.05
100 kPa	podium roof deck	l/(s.m)	0.19	0.38	0.48	0.49	1.33	0.86	1.70	0.51
200 kPa	parking roof deck	l/(s.m)	0.11	0.33	0.38	0.42	1.15	0.75	1.45	-
Fall = 2 %										
10 kPa	extensive green roof	l/(s.m)	0.36	0.66	0.80	0.79	2.20	1.21	2.22	1.39
20 kPa	intensive green roof	l/(s.m)	0.36	0.60	0.72	0.74	2.09	1.19	2.14	1.22
100 kPa	podium roof deck	l/(s.m)	0.20	0.44	0.52	0.57	1.62	0.99	1.91	0.73
200 kPa	parking roof deck	l/(s.m)	0.13	0.39	0.44	0.47	1.34	0.97	1.55	-
Fall = 2.5 %										
10 kPa	extensive green roof	l/(s.m)	0.43	0.72	0.85	0.86	2.34	1.23	2.45	1.50
20 kPa	intensive green roof	l/(s.m)	0.43	0.69	0.82	0.84	2.17	1.19	2.34	1.28
100 kPa	podium roof deck	l/(s.m)	0.25	0.49	0.56	0.62	1.73	0.99	2.04	0.78
200 kPa	parking roof deck	l/(s.m)	0.13	0.43	0.48	0.51	1.49	0.97	1.70	-
Fall = 3 %										
10 kPa	extensive green roof	l/(s.m)	0.48	0.82	0.95	0.95	2.58	1.34	2.60	1.70
20 kPa	intensive green roof	l/(s.m)	0.45	0.72	0.91	0.94	2.47	1.34	2.50	1.54
100 kPa	podium roof deck	l/(s.m)	0.25	0.54	0.62	0.74	1.91	1.01	2.21	0.89
200 kPa	parking roof deck	l/(s.m)	0.15	0.47	0.51	0.57	1.57	0.98	1.83	-

Table 3. Drainage capacity ND Drainage Systems

The values correspond to average results obtained in our laboratories and external institutes. The values 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 5 % are normal.