

DELTA®-Drainage systems

Flat green roofs

Walkable or drivable roof deck constructions

Drainage under concrete slabs



Drainage systems DELTA® for horizontal applications

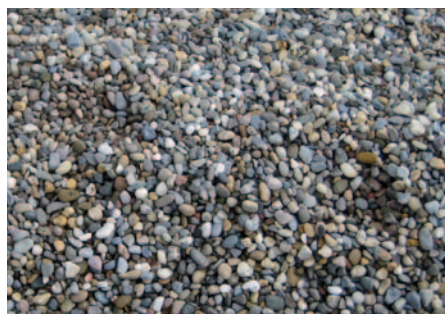


Water that reaches the ground in the form of precipitation always finds its own way. Ideally, it will quickly and immediately seep away without building up pressure against a building structure. If, however, it seeps away slowly, the water will then exert pressure on a building as long as precipitation continues. A similar situation applies whenever water that has seeped into the ground encounters an easily permeable soil layer through which it pushes towards a building. These two variants occur fairly

frequently. Things get tough when precipitation water encounters impermeable ground through which it cannot seep away. In such a case, a building will be permanently exposed to water pressure. These three degrees of water exposure are critical to the planning of waterproofing, drainage, and protection measures. Therefore, any building project should be based on a careful investigation and evaluation of the local soil conditions and any other relevant factors such as, for example,

the topography. Depending on local constraints, very different volumes of water may be involved. If, for example, a building is exposed to rain, water may normally be expected to accumulate on the flat roof at a rate of up to $0.03 \text{ l/s} \cdot \text{m}^2$, as the German DIN norm 4095 suggests. This is the minimum volume for which the drainage layer must be designed. This is the only solution to safely protect the building from moisture damages.

Mineral drainage layers of gravel or chippings frequently do not – or only with great expense – really comply well with the requirements for drainage functions. There is a danger that they can become clogged by sludge and gradually lose their drainage capability. Consequently, the required minimum thickness of such a layer constitutes a handicap for planners and a static cost factor that must be taken into account.



DELTA® branded drainage sheets offer an economical alternative to mineral drainage layers. Made of a special type of polyethylene and associated with a fused-on geotextile layer, DELTA® dimpled sheets form highly efficient seepage and drainage layers.

They combine:

- minimal thickness
- maximum protection
- permanently stable filtration
- high compression resistance
- outstanding durability
- long term effective hydraulic properties even under heavy and permanent loads.



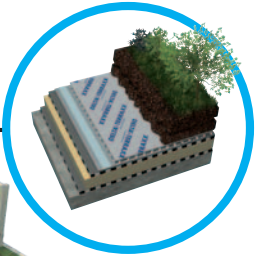
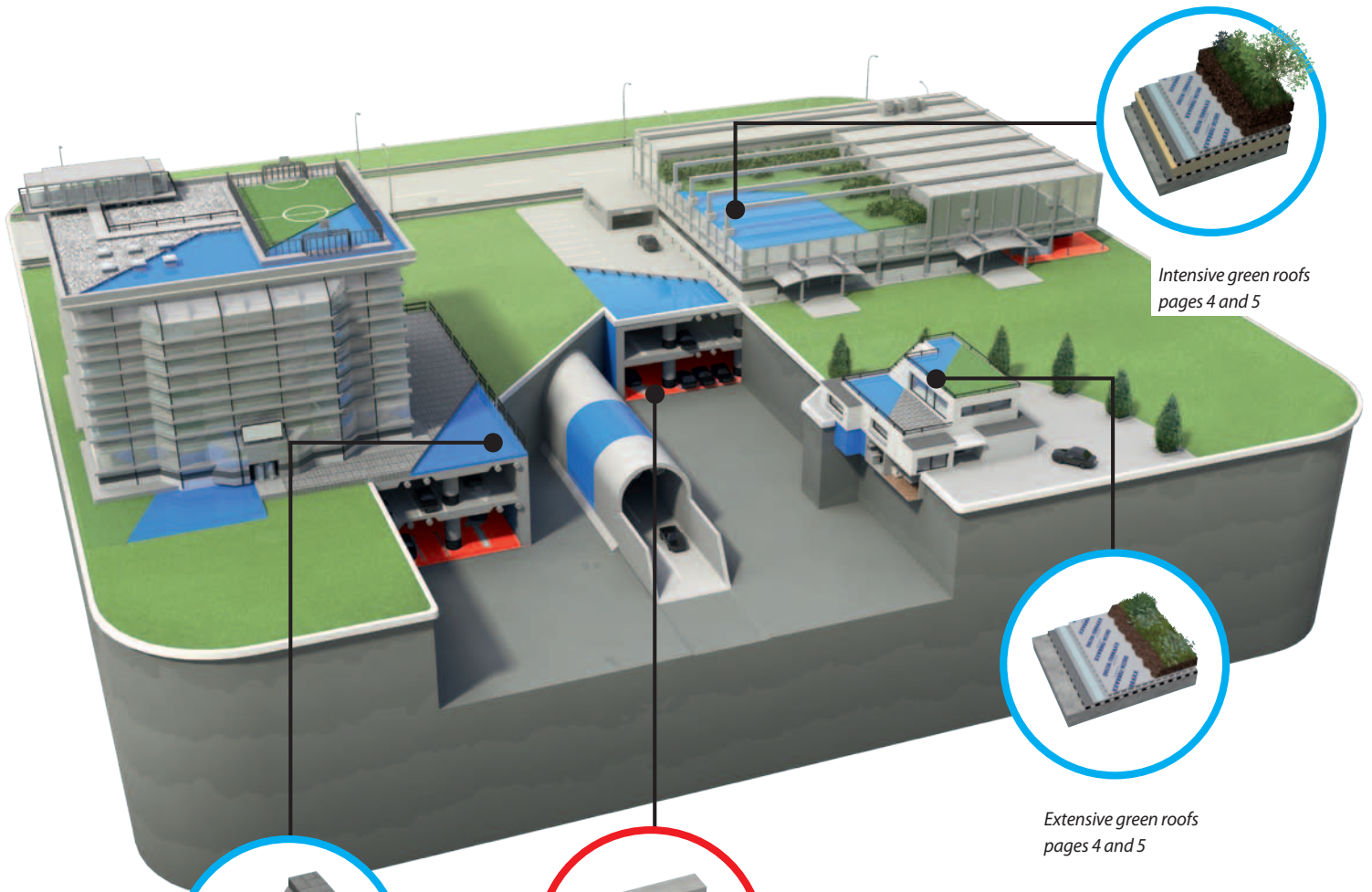
Traditional dimpled sheeting

Drainage system with "low budget" geotextile: the drainage capacity decreases under continuous permanent load.

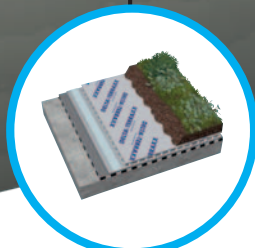


DELTA®-TERRAXX / DELTA®-NP DRAIN

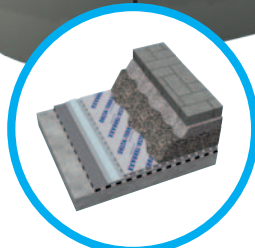
The drainage capacities remain functional over prolonged periods and keep stable even with exposure to permanent load.



Intensive green roofs
pages 4 and 5



Extensive green roofs
pages 4 and 5



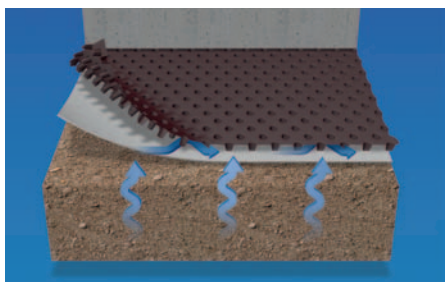
Walkable or drivable roof
deck constructions
pages 4 and 5



Drainage under concrete slab
pages 6 and 7



DELTA-TERRAXX
Drainage system for flat green roofs and
walkable or drivable roof deck constructions.
(see pages 4 and 5)



DELTA-NP DRAIN
Drainage system under concrete slabs.
(see pages 6 and 7)

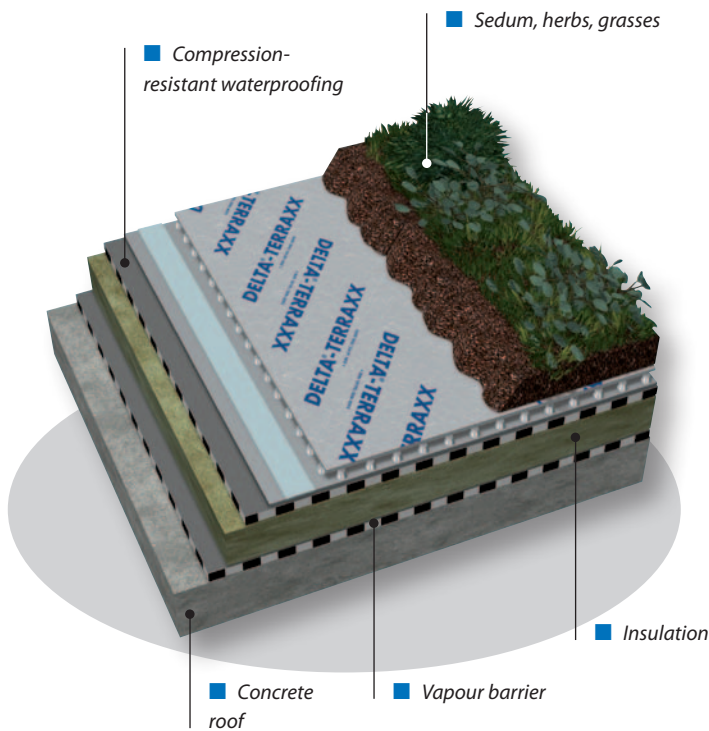
Application	DELTA®-NP DRAIN	DELTA®-TERRAXX
Extensive green roofs	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Intensive green roofs	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Roof decks used with low load bearing (pedestrian, bicycles)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Parking roof decks for car traffic	-	<input checked="" type="checkbox"/>
Parking roof decks for truck traffic	-	<input checked="" type="checkbox"/>
Horizontal drainage below foundation slabs	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Flat green roofs / Walkable or drivable roof deck constructions

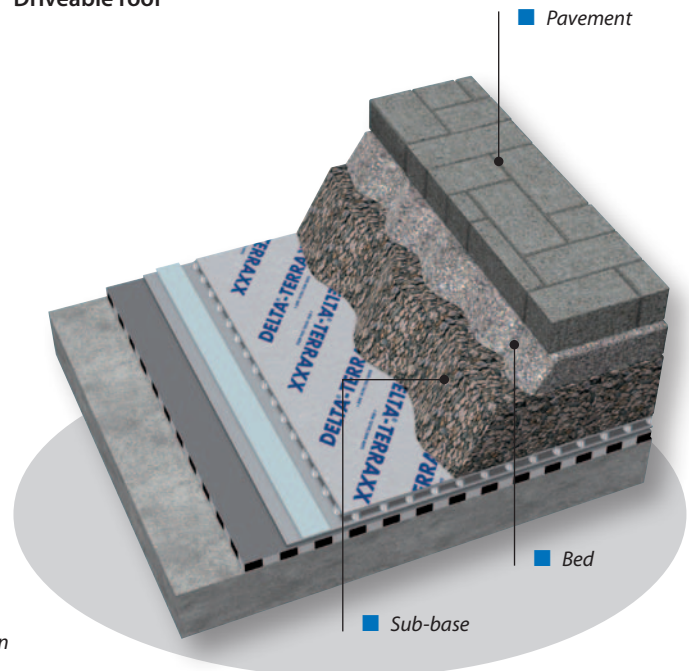
The DELTA® solution: DELTA®-TERRAXX

Large flat roofs and ceilings can be put to a wide variety of uses: games and leisure activities, additional parking space, or partial/complete seeding / planting. However, this will work only if rain water as well as any run-off from outer walls can be safely and reliably drained away at the surface and the waterproofing level. Therefore, the construction of the deck must include an efficient structural drainage system so that stagnant water cannot attack or cause frost damage to areas open to traffic. In herbaceous roofs, stagnant water may cause waterlogging, harming plants and flooding the drainage system.

Green roof



Drivable roof



Extensive / intensive green roof

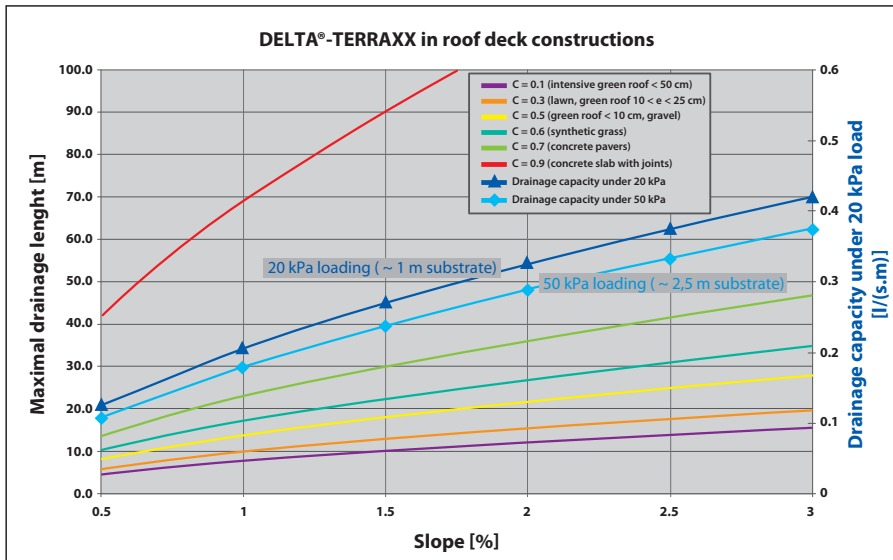
- vapour barrier*
- insulation*
- compression and root-resistant waterproofing
- separation foil*
(separation of materials that are chemically incompatible, e.g. PVC or PS)
- protection layer (DELTA®-TERRAXX)
- seepage layer (DELTA®-TERRAXX)
- filtration layer (DELTA®-TERRAXX)
- substrate (growing medium)
Approx. minimal thickness by:
 1. extensive green roofs: sedum 8 cm, herbaceous plants 10 to 20 cm.
 2. intensive green roofs: lawn 20 cm, small-sized bushes 20 cm, large-sized bushes 50 cm, medium-sized trees 100 – 200 cm)
- plants

Walkable / drivable roof deck

- compression waterproofing
- separation foil*
(separation of materials that are chemically incompatible, e.g. PVC or PS)
- protection layer (DELTA®-TERRAXX)
- seepage layer (DELTA®-TERRAXX)
- filtration layer (DELTA®-TERRAXX)
- sub-base course
(absorption and spreading of the static and dynamic loads and prevention against deformation of the elemental paving)
- bedding course
(crushed or uncrushed rock grains ranging between 0 to 4 mm Ø and 2 to 5 mm Ø in size)
- wearing course
(concrete or natural stone flags, concrete pavers, natural stone paving, stones, slabs, ...)



Dimensioning



The diagram shows the drainage capacity of DELTA-TERRAXX under a common load of 20 kN/m² in relation to the roof gradient. Thus, for example, the drainage capacity is 0.32 l/s · m at a gradient of 2 % and the maximum drainage length approx. 22 m considering a wearing course with concrete pavers. This is based on the specifications of DIN 1986-100, Sect. 9.3.2.: to arrive at the drainage length, the rainfall yield (commonly 0.03 l/s · m²) is multiplied by a reduction factor (e.g. 0.3 in the case of green roofs < 25 cm).

Characteristics

DELTA-TERRAXX	
Material	HDPE silver dimpled sheet with fused-on filtration PP geotextile
Flat edge	self-sealing
Dimple height	approx. 9 mm
Air gap	approx. 7.9 l/m ²
Contact surface	8,000 cm ² /m ²
Compressive strength	transient loading: 400 kN/m ² (EN 25619-2) permanent loading: 90 kN/m ² (EN 25619-1)
Drainage capacity with 20 kN/m² load (EN 12958)	i = 0.01 % 0.21 · 10 ⁻³ m ² /s i = 0.02 % 0.32 · 10 ⁻³ m ² /s i = 0.03 % 0.42 · 10 ⁻³ m ² /s
Drainage capacity with 50 kN/m² load (EN 12958)	i = 0.01 % 0.18 · 10 ⁻³ m ² /s i = 0.02 % 0.29 · 10 ⁻³ m ² /s i = 0.03 % 0.38 · 10 ⁻³ m ² /s
Geotextile water permeability	0.08 m/s (EN ISO 11058)
Service temperature range	- 30 °C to + 80 °C
Tensile strength	6.0 kN/m (EN ISO 10319)
Dynamic perforation resistance	40 mm (EN 918)
Opening size O₉₀	150 µm (EN 12956)
Roll size	12.5 m x 2.4 m
Durability	To be covered within 2 weeks after installation. No deterioration after 25 years in natural soil having a pH value between 4 and 9 and a soil temperature < 25 °C.
CE conformability EN 13252	

Advantages

- Reliably protects waterproofing layers against mechanical damage.
- Withstands extreme compression loads of 400 kN/m² (under special condition, heavy trucks with wheel load up to 100 kN).
- High drainage capacity prevents frost damage.
- Water drainage capacity exceeds that of gravel or chipping layers.
- No obstruction by sludge underneath the covering layer.
- Good load distribution prevents point loads on the waterproofing layer.
- Resultant static building loads lower than those of gravel layers.
- Easy and cost-efficient installation.

Drainage under concrete slabs

The DELTA® solution: DELTA®-NP DRAIN

When a building is erected on a slope, the excavation often cuts into the aquifer. If the water emerges below the foundation slab, it must be drained off, not only to keep hydrostatic pressure from building up but also to avoid a negative impact on the water table. To minimise the impact on the natural behaviour of aquifer water, an efficient drainage system below the foundation slab is needed.

Traditional drainage system

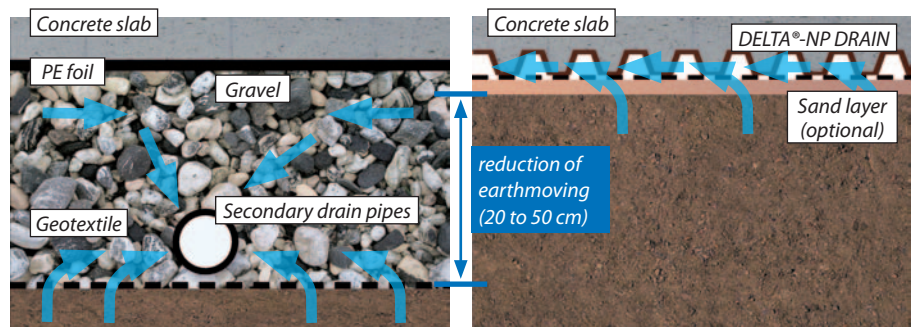
Mineral drainage layers of gravel are usually used for horizontal drainage below foundation slabs. The conventional horizontal drainage system consists of a geotextile, a 20 to 50 cm mineral layer (e.g. gravel 20/40), a PE foil and a mesh of main and secondary drainage pipes. With this system, there is not only a constant risk of silting up with the attendant negative effect on drainage performance, the requisite minimum thickness of 20 to 50 cm constitutes a planning problem, frequently causing considerable additional costs.

The DELTA® solution

DELTA®-NP DRAIN may constitute an alternative with a markedly better performance than a conventional horizontal drainage system. DELTA®-NP DRAIN acts as a sub-base course, at the same time separating

the foundation slab from the moist subsoil. Once the drainage sheets have been laid out with the cloth side facing downward, concrete may be poured on. The drainage capacity of the sheet will not change because the dimples are filled with concrete. Cement paste cannot seep into the ground when the concrete is poured. Drain pipes must be integrated in the continuous foot-

ing to catch and carry the aquifer water. The system is not designed to achieve a permanent lowering of the ground water but to collect possible run-off water or water coming from the soil. Furthermore, the concrete slab shouldn't be supported. Piles or load-bearing walls and concrete slab are independent!



Traditional mineral drainage system with gravel

DELTA® drainage system

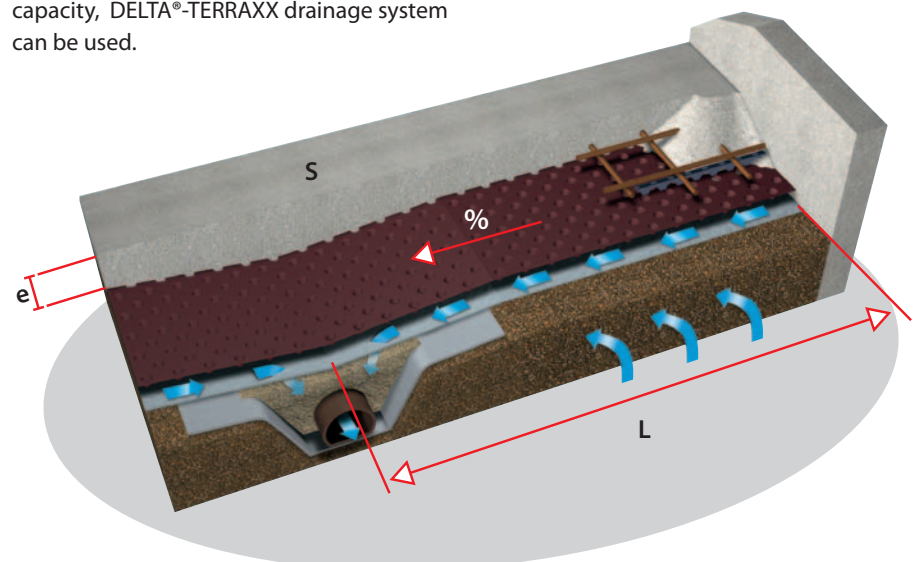
Layout planning

The dimensioning of the drainage system consists of calculating the maximal drainage length L , that should be compatible with the drainage performance of the DELTA® membrane.

Following information is necessary to achieve the dimensioning:

- minimum water flow rate to be drained away q [$l/s \cdot m^2$], delivered by a geotechnic research consultancy
- surface area to be drained S [m^2]
- thickness of the concrete slab e [m]
- slope [%], a dimensioning without slope is also possible
- maximal admitted hydrostatic load under the concrete slab, if necessary
- attended drainage length L , if available

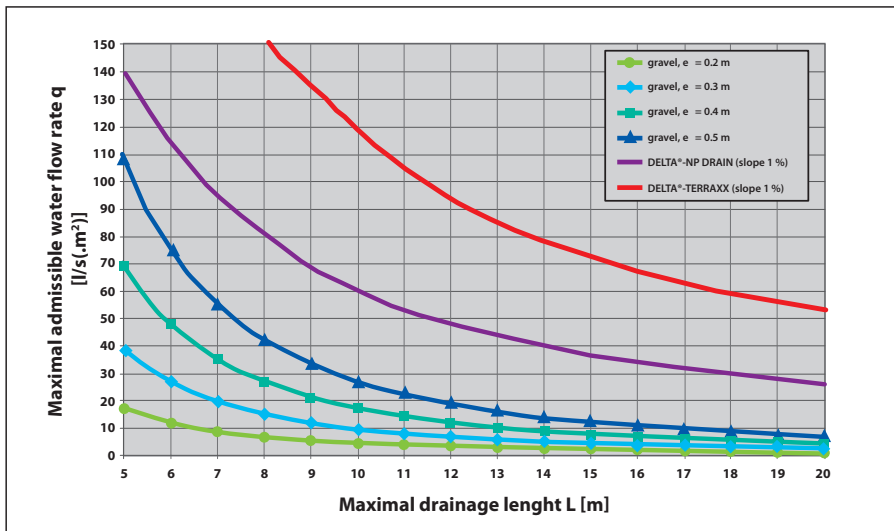
With higher requirements for drainage capacity, DELTA®-TERRAXX drainage system can be used.





Comparison of hydraulic performances

"Mineral drainage layer" vs "DELTA®-dimpled sheeting"



Considering a length L of 12 m to be drained, the maximal allowable water flow rate will be:

- 3 l/(h·m²) for gravel e = 0.2 m
- 7 l/(h·m²) for gravel e = 0.3 m
- 19 l/(h·m²) for gravel e = 0.5 m
- 48 l/(h·m²) for DELTA®-NP DRAIN
- 94 l/(h·m²) for DELTA®-TERRAXX

Assumptions for this dimensioning:

- Soil permeability k = 0.003 m/s.
- Maximal allowed hydrostatic load under the concrete slab: 5 cm water column.
- Gravel laid without slope.
- Concrete slab: 15 cm.

Characteristics

DELTA®-NP DRAIN	
Material	HDPE brown dimpled sheet with fused-on filtration PP geotextile
Flat edge	yes
Dimple height	approx. 8 mm
Air gap	approx. 5.3 l/m²
Contact surface	5,500 cm²/m²
Compressive strength	transient loading: 150 kN/m² (EN 25619-2) permanent loading: 70 kN/m² (EN 25619-1)
Drainage capacity with 20 kN/m² load (EN 12958)	i = 0.01 % 0.11 · 10 ⁻³ m²/s i = 0.02 % 0.20 · 10 ⁻³ m²/s i = 0.03 % 0.26 · 10 ⁻³ m²/s
Drainage capacity with 50 kN/m² load (EN 12958)	i = 0.01 % 0.09 · 10 ⁻³ m²/s i = 0.02 % 0.17 · 10 ⁻³ m²/s i = 0.03 % 0.24 · 10 ⁻³ m²/s
Geotextile water permeability	0.08 m/s (EN ISO 11058)
Service temperature range	- 30 °C to + 80 °C
Tensile strength	6.0 kN/m (EN ISO 10319)
Dynamic perforation resistance	40 mm (EN 918)
Opening size O₉₀	150 µm (EN 12956)
Roll size	20 m x 2 m, 12.5 m x 2.4 m
Durability	To be covered within 2 weeks after installation. No deterioration after 25 years in natural soil having a pH value between 4 and 9 and a soil temperature < 25 °C.
CE conformability EN 13252	

Advantages

- no excavation needed
- preserves natural mineral resources
- large and homogeneous drainage capacity, higher than the performance of the mineral drainage solution
- economical alternative, easy to lay
- low thickness
- outstanding durability
- permanently stable filtration and no danger of becoming clogged up
- using as permanent shuttering
- high protective effect against rising humidity
- high compression resistance
- concrete laitance tightly layer, avoid soil contamination

References



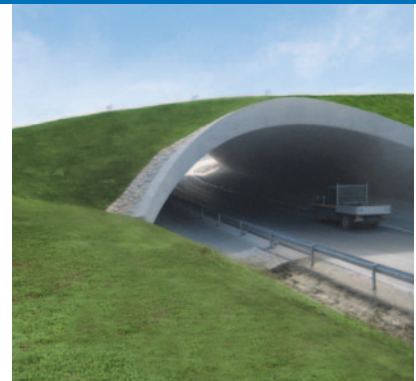
Bahai Garden, Haifa (Israel)

- Material: DELTA®-TERRAXX
- Application: drainage under walkable decks
- Surface: 2,000 m²
- Achievement: 2001



Arnulfpark M13, München (D)

- Material: DELTA®-TERRAXX
- Application: drainage under walkable decks
- Surface: 1,200 m²
- Achievement: 2009



B 28a, Ortsumfahrung (OU) Schopfloch (D)

- Material: DELTA®-TERRAXX
- Application: green bridge
- Surface: 2,600 m²
- Achievement: 2012



Grammar school in Oberursel (D)

- Material: DELTA®-TERRAXX
- Application: drainage under walkable decks
- Surface: 2,500 m²
- Achievement: 2012



Housing complex Berliner Allee 8 Darmstadt (D)

- Material: DELTA®-TERRAXX
- Application: drainage under walkable decks
- Surface: 3,200 m²
- Achievement: 2012



Serenadenhof, Limburg (D)

- Material: DELTA®-TERRAXX
- Application: drainage under walkable decks
- Surface: 5,500 m²
- Achievement: 2009



Renovation housing complex, Ziegeleihof, Oberwil/Basel (CH)

- Material: DELTA®-TERRAXX
- Application: green deck
- Surface: 1,800 m²
- Achievement: 2010



Housing complex Ząbki, ul. Kaszubska (PL)

- Material: DELTA®-TERRAXX
- Application: green deck
- Surface: 300 m²
- Achievement: 2010



Staatsbibliothek „Unter den Linden“ Berlin (D)

- Material: DELTA®-TERRAXX
- Application: drainage under walkable decks
- Surface: 2,000 m²
- Achievement: 2009

References



Housing complex Europaviertel Frankfurt (D)

- Material: DELTA®-TERRAXX
- Application: green roofs
- Surface: 10,000 m²
- Achievement: 2011



Housing complex „Little Soho“, Frankfurt/Main (D)

- Material: DELTA®-TERRAXX
- Application: green deck
- Surface: 3,200 m²
- Achievement: 2009



Renovation casern complex Argonner Park, Hanau (D)

- Material: DELTA®-TERRAXX
- Application: green deck
- Surface: 2,500 m²
- Achievement: 2012



Bilgili Holding's Bodrum (TR)

- Material: DELTA®-TERRAXX
- Application: green roofs
- Surface: 10,000 m²
- Achievement: 2011



Prado Verde Marseille (F)

- Material: DELTA®-NP DRAIN
- Application: drainage under concrete slab
- Surface: 9,000 m²
- Achievement: 2004



Les Terrasses de Lacanau (F)

- Material: DELTA®-NP DRAIN
- Application: drainage under concrete slab
- Surface: 800 m²
- Achievement: 2010



Ege Metropark Houses (TR)

- Material: DELTA®-TERRAXX
- Application: green deck
- Surface: 2,000 m²
- Achievement: 2011



Ambroise Paré hospital Marseille (F)

- Material: DELTA®-NP DRAIN
- Application: drainage under concrete slab
- Surface: 10,200 m²
- Achievement: 2010



Eko Montpellier (F)

- Material: DELTA®-NP DRAIN
- Application: drainage under concrete slab
- Surface: 970 m²
- Achievement: 2012

DELTA® Information about protection and drainage systems for different applications.

Planning information for flat-roof systems

A wealth of information about extensive and intensive herbaceous covers as well as walkable and driveable standard and inverted flat roofs.



Technical Guide

DELTA®-TERRAXX for horizontal applications.



Technical Guide Civil engineering and tunnel construction

DELTA®-Products for timber walls with shotcrete, bored pile, diaphragm or retaining walls, bridge abutments, tunnel construction or rehabilitation and cut & cover tunnelling.



DELTA®



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■ Standard requests for tender as well as detailed installation instructions for all DELTA®-Products may be obtained at www.doerken.com as pdf files for you to print out and save.