



Building in Harmony with Nature

An ecological concept for surface area reinforcement

- High load bearing capacity through load distribution
- Near-natural decentralised drainage system
- Maintains the living soil layer
- Treatment of polluted precipitation runoffs
- Groundwater protection and new creation

TTE[®] SYSTEM
for sustainable building

Protection
of the
soil life



www.tte.eu

HÜBNER-LEE



The HÜBNER-LEE company building in Holzgünz

HÜBNER-LEE: 20 years of Tradition and Innovation

TTE®: A surface area reinforcement concept to protect the environment



The goal of the company founders Ernst and Gyung Hyun Hübner since starting the company in 1991 has always been to exactly assess the needs of its customers and to offer both practical and economic solutions to satisfy these.

HÜBNER-LEE has proven its innovative and inventive competence based on the numerous patent and registered design applications it has made. These own developments for various areas of use were continuously optimised and successfully tested by officially recognised institutions. In this way the trading house was transmuted into a **manufacturer of innovative solutions** for ecological ground fortification.

The TTE® system developed by the HÜBNER-LEE company has prevailed in the horse branch as an internationally recognised top concept for **riding arenas and exercise areas**. The TTE® riding arenas are designated as a "dance floor for horses".

Through use of the TTE® system also outside facilities such as **parking spaces covered in vegetation and paved surfaces** take on real ecological functions.

In contrast to sealed surfaces TTE® areas drain off any rain directly on the surface and reduce the load on local drains. This not only applies for the areas covered in vegetation but also for TTE® paved surfaces. Cleaning of the surface water takes place through the humus layer which is kept intact and covered by the TTE®. Other "ecological coverings with a base layer" cannot achieve this because of their construction.

Floods and climate change show clearly how it is urgently necessary to have **ecologically built up areas** and that there must be a rethinking process in the direction of "Retention of drainage surfaces with a living ground zone".

There are over 5,100 references now available for TTE® ground reinforcement on 2,500,000 m² in Europe (status at 31.12.2012). These daily deliver evidence for the high functional reliability of the TTE® system.

One further product area concerns the products which have proven themselves for years now made from recycled plastic for market gardens such as the flexible CC pathway plates and various mobile plate systems.

There are currently about 5,000 tons of recycled plastic products marketed annually, products from injection moulding, casting, pressing and deep drawing systems - Made in Germany.

HÜBNER-LEE customers are actively supported right from the planning through to the building phase by a **competent advisory service**. It is particularly in the area of development of individual problem solutions that customers value the practical approach and the amazingly simple realisation of previously cost-intensive projects.

Supplementary extra booklets:

- A **planning aid** for planning, laying and maintaining water permeable TTE® surface area reinforcements
- **Attestations and test certificates** from test reports and scientific investigations of the TTE® system

Please request these or download them from www.tte.eu



Gyung-Hyun Hübner-Lee & Ernst Hübner
Managing Directors

Sustainable protection of vital soil functions

Dear customers and business friends!

The "skin of the earth" - the ecological system, the soil - is comparable with that of people. About 3 kg of micro-organisms live in and on our body while in which the uppermost layer the earth there are up to 200 million micro- and macro-organisms per m². There is no life without these.

We will die if all of the pores in our skin block up and there no exchange possible of moisture and also no breathing is possible.

In the same way we are "asphyxiating" our nature through compaction and sealing. Important functions such as breathing, filtering and cleaning of the water to be drained off as well as creation of new groundwater fail.

Nature is being ever more destroyed through such interventions and a putative "compensation" must be created.

The solution for the intervention-compensation problem: simply do not intervene. The lawmaker demands environmental protection, but who is acting? Be exemplary and select a building technology which integrates in nature. This can be realised economically and simply using TTE®. For the love of the environment.

Ernst Hübner & Gyung-Hyun Hübner-Lee
Managing Directors of HÜBNER-LEE

Contents

Protection of the Environment and Soil Protection Sustainably build ecologically with TTE®		4
TTE®-MultiDrain^{PLUS} Profile of an ecological multitalent		8
Ecological Paved Surfaces with TTE® TTE® as a loadbearing system		9
Advantages and Strengths of TTE® Ecological and economic		10
Drainage without a Drain Connection Point a permanently high drainage performance		12
TTE® as a Decentralised Drainage System with a cleaning function		14
Load Distribution Comparison between the RStO, FLL and TTE® construction principle		16
Open Construction Principles for Open Areas Comparison between the FLL and the TTE® construction principle		20
Open Construction Principles according to FLL Excerpts from FLL guidelines		21
TTE® Construction Principle 1 exclusively for passenger car traffic		24
TTE® Construction Principle 2 for passenger car and occasional heavy lorry traffic		28
TTE® Construction Principle 3 for heavy lorry traffic		32
TTE® Construction Principles at a Glance Overview table of TTE® construction principles		36
Individual TTE® solutions Innovative applications for open spaces		38
Outdoor Sports Surfaces using TTE® Jogging ways, artificial grass football pitch		43



TTE® elements are environmentally friendly

Demonstratably neutral for the environment

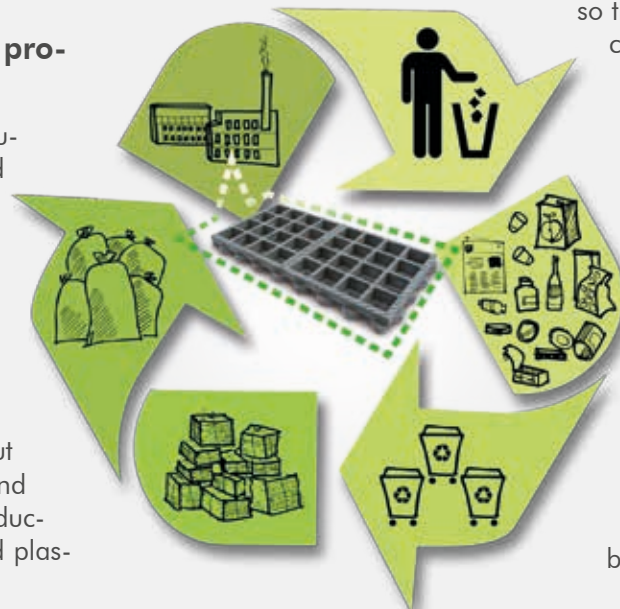
Checking and testing performed by the "Osthüringische Materialprüfgesellschaft für Textil und Kunststoffe GmbH" demonstrated that the TTE® products are neutral for the environment. The extensive tests include testing for heavy metals as well as biological aspects, for example effects on small and micro-organisms.

CO₂ reduction during production

The TTE® product is manufactured using recycled mixed plastics (Duales System Deutschland AG).

It binds CO₂ from the waste substances. 1 kg of mixed plastic stores the equivalent of about 1.5 kg of CO₂ through combustion. This means that about 7,500 tons of CO₂ are bound annually for an annual production of 5,000 tons of mixed plastic.

Also manufacture using recycled material requires less energy than when using new plastic. This represents another 1.5 kg reduction or so in CO₂ per kg of recycled plastic. CO₂ can be stored for an indefinite period of time since TTE® has a long service life and is fully recyclable.



CO₂ reduction during using/laying the product

It is usually possible to avoid any excavation work and removal from the site plus dumping of soil materials in order to create a load carrying substructure. The existing top soil can be used so there are no shipping costs incurred. There is also a strong reduction in installation and transport of mineral materials. The resource-conserving construction principle saves a great deal of fuel and therefore lowers pollution of the environment with CO₂.

Overall the reduction in building work required results in an 80% reduction in CO₂ emissions compared to conventional building methods.

Every TTE® element prevents about 12 kg of CO₂ emissions due to the non-combustion process pioneered by Duale System Deutschland AG

The protected resource water and the earth

The TTE® system protects and keeps the top soil intact and thus also cleans water draining into the ground instead of just filtering it

The ground, "the skin of the earth", continues to fulfil its life-giving functions for mankind and the environment. It fulfils vital ecological and economic functions as a habitat, water regulator, producer of foods and supplier of raw materials. This basis for our life is being destroyed day after day.

Just in Germany, according to data from the Bundesamtes für Naturschutz, **there are about 90 hectares of land lost every day** through **sealing of the ground** for the purposes of building roads and housing development. This represents **the size of 150 football fields!**

Sealed areas of ground can no longer fulfil the tasks which are so vital for us such as water storage, creation of new groundwater and water evaporation. A lack of seepage options is one of the main reasons for flooding by high floods.

Using the TTE® system the ground is neither sealed nor compacted. The valuable biological functions of the top soil, in particular for the water balance, filtering and degradation of pollutants, are protected and kept intact.

Use of the TTE® system does not represent **a negative intervention** since the performance and functionality of the ecosystem and the landscape are not strongly impaired. **Negative interventions can** be strongly minimised or **compensated for through surface drainage** (§ 14 of the Federal Nature Conservation Act (BNatSchG)).

"The goal for any European soil protection system must be to sustainably secure or restore the functions of the soil in Europe."

Umweltbundesamt in Nov. 2005

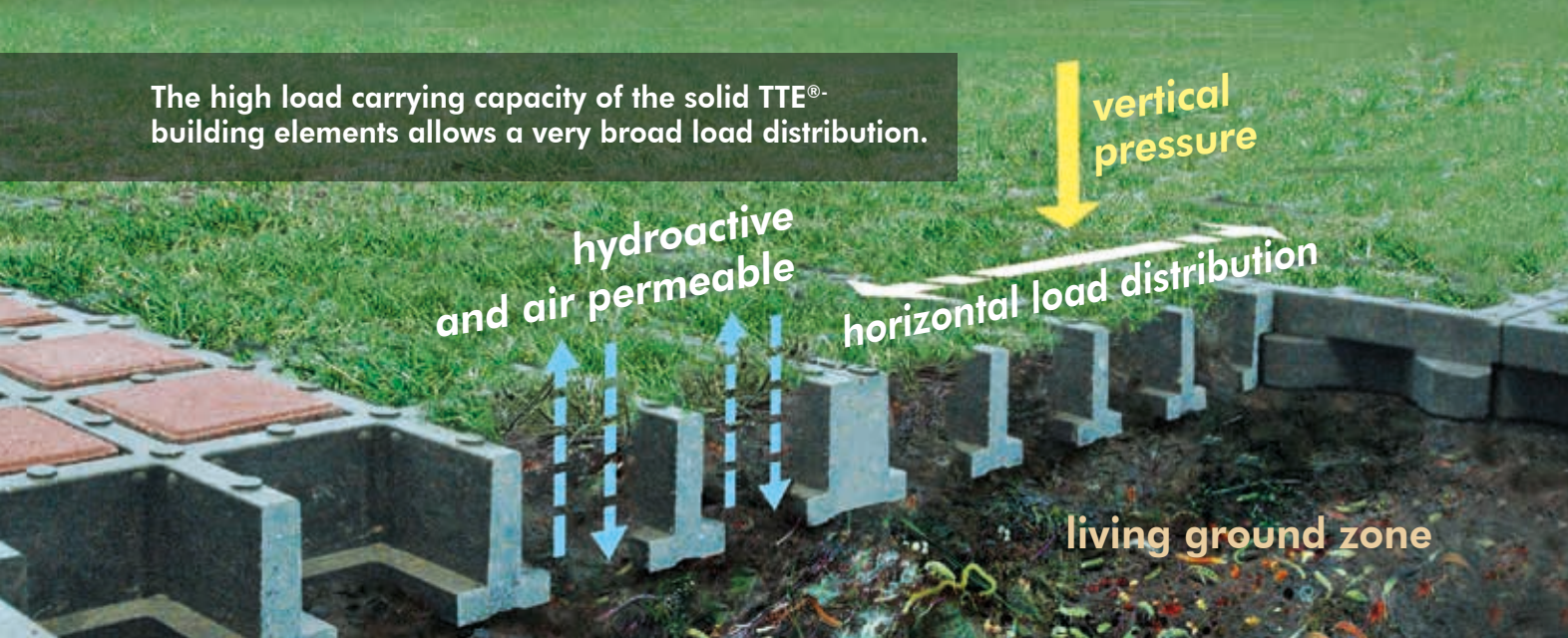
Why do micro- and macro-organisms mainly live in the uppermost 30 cm of the soil?

They need:

- Air
- Water
- Light (sunlight)
- Nutrition (humus etc.)

- An open construction principle
- Retention and protection of the ecological function of the soil
- Very little compaction
- Groundwater protection
- Improvement of the microclimate

The high load carrying capacity of the solid TTE®-building elements allows a very broad load distribution.



TTE® keeps the hydroactivity as well as valuable physical and biochemical filtering functions intact and the breakdown of the substances by the up to 200 million micro- and macro-organisms per m² of ground.

TTE®: The Load Distribution System

Retention of soil with its important ecological functions

TTE® is a drainage active surface area reinforcement system made out of solid plastic elements for greened and paved usable areas and primarily quiet and calmed traffic.

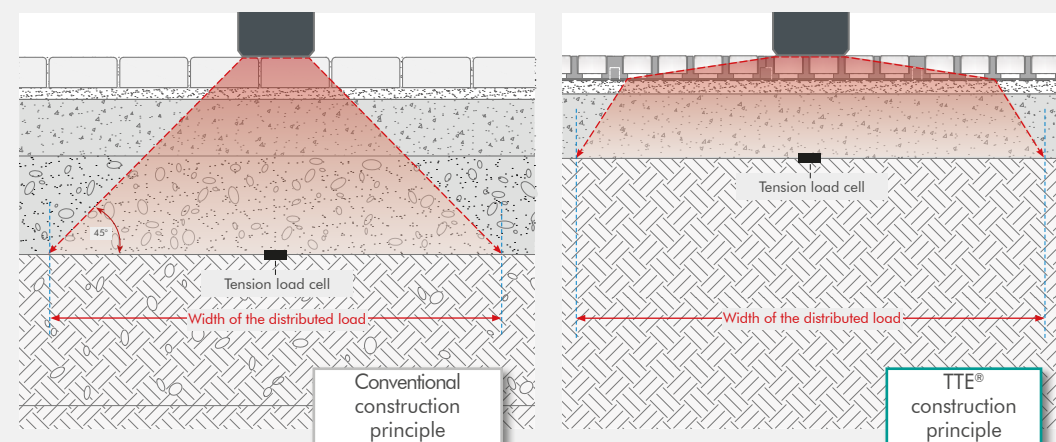
TTE® is not only a covering but actually represents a revolutionary concept which creates the highest ecological value and which is very energy and resource saving. Nature is integrated in and used based on a very low construction intervention. TTE® sets new standards for ecological surface area reinforcement.

Load distributing

The patented idea of the TTE® construction element is to replace the base layer material by an intelligent load distribution and, in this way, to combine the covering and base layer into one system.

Due to a robust qualities the individual elements achieve a high deformation and pressure stability. The interlocking of the large TTE® elements achieves load distribution over an area and thus provides stabilisation and reinforcement for the substrate.

The tolerable contact pressure for the ground is therefore not exceeded through the loading from vehicle traffic. It is possible to save on the use of mineral base layer material; it can sometimes be dispensed with completely.



Innovative construction

The conventional construction principle compared to the load distribution function of TTE® system.

Requirements of the water management approving authorities:
Polluted rain water must be drained off over a living soil passage.

Ecology and Function

Achieving a near natural soil and water balance

Permanently water-permeable

- low levels of compaction secure long-term seepage capability
- a high ability to channel off water and retention of the soil allows full drainage while maintaining high retention of the rain water at the same time

Low levels of compaction - a large pore volume

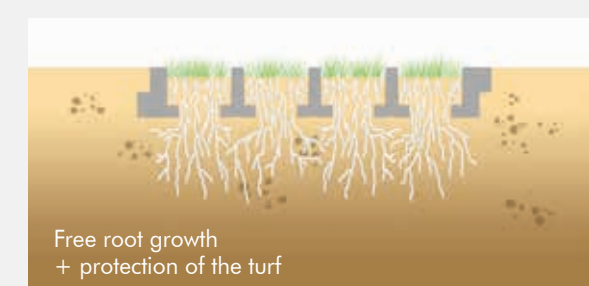
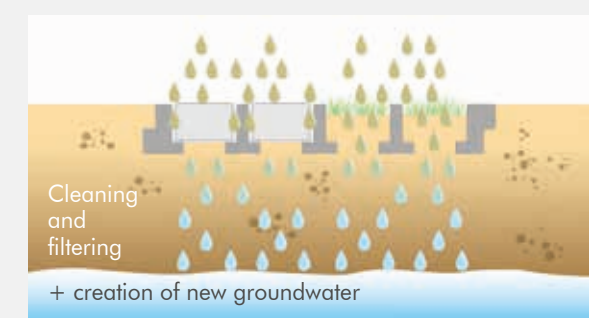
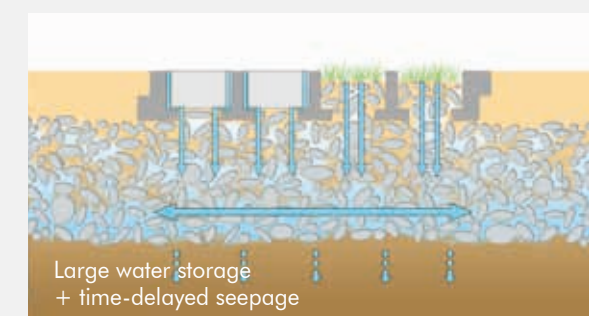
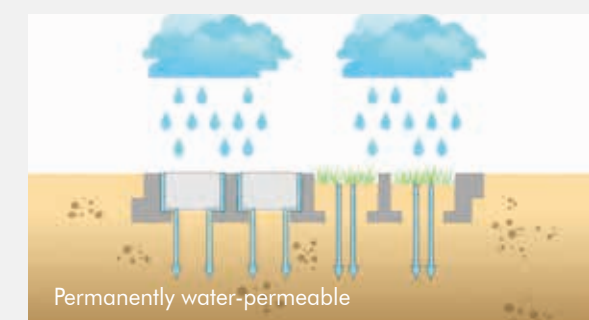
- decentralised seepage both over the surface and according to the French drain infiltration principle
- large water storage capacity for time-delayed seepage
- additional dewatering measures are not required (for a test report LWG, see Verifications and Test Certificates)

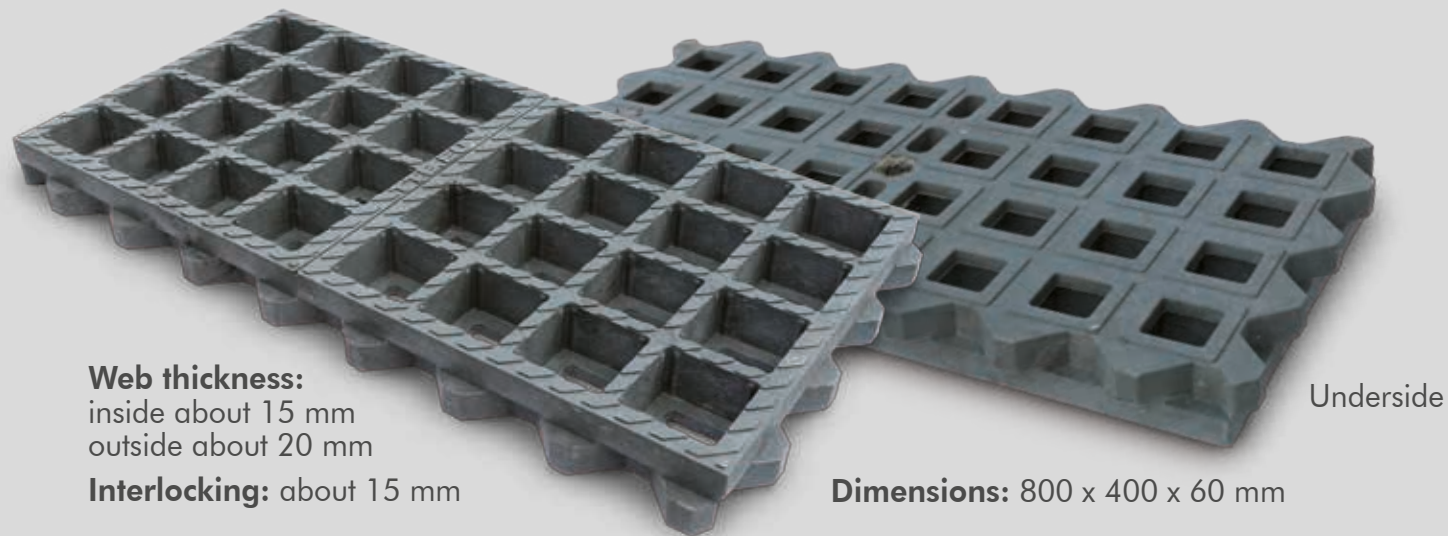
Near-natural rain water treatment

- the TTE® system protects the soil and the soil life
- cleaning and filtering by a living soil layer
- treatment of contaminated drained off surface water from traffic and roof surfaces
- mineral oils are degraded by micro-organisms in the soil (dripping oil trial undertaken by the LVG in Heidelberg)
- creation of and protection of new groundwater

Optimally plantable

- a highly plantable area
- protection of the turf through raised webs
- direct connection to the ground
- good root development because of low levels of compaction
- good supply of water, air and nutrients
- configuration of fortified usable areas in a near-natural manner

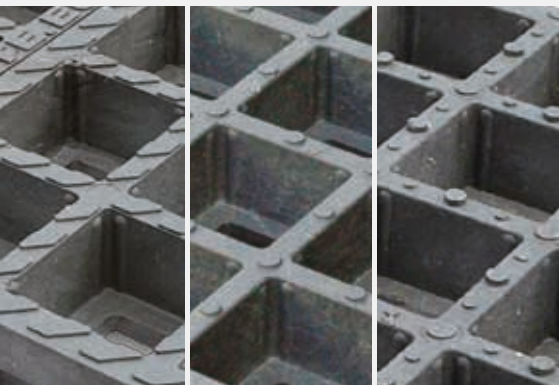




Commercial paved surface, can be driven over by lorries (DE)

TTE®-MultiDrain^{PLUS}

Profile of an ecological multitalent



There are 3 different pimpled surfaces obtainable for different requirements



Fine network: Weight 24 g/m², Mesh size ≤ 4mm, Roller width 3.20m, material: PE

*) patent protected

Technical Data	
Designation	TTE®-MultiDrain ^{PLUS} *) with a trapezoid interconnection, with pimples
Material	neutral to the environment made out of 100% recycled plastic (Duales System Deutschland AG)
Colour	grey - anthracite
Dimensions	about 80 x 40 x 6 cm with 32 chambers (size 8 x 8 cm), 1 m ² = about 3.125 pieces.
Effective dimension	about 80 x 40 cm plus 1.5 cm for edge surfaces due to the interlocking
Web thickness	inside about 15 mm, outside about 20 mm
Weight	about 8.5 kg (about 26 kg/m ²)
Loading capacity, static (under laboratory conditions)	about 147 kN (about 15 t) per test body (about 20 x 20 cm, consisting of 4 unfilled chambers) that is about 10 N/mm ² tested by TÜV Süd
Upper side	slip-inhibiting pimpled webs
Underside	a wide T-support (about 4.2 cm)
Slopes / gradients	can be used without any difficulty up to about 10%; also for steeper slopes after consultation
Type No.	1351.4080
Max. delivery quantity per lorry	913.92 m ² = 28 pallets with 102 pieces (32.64 m ²) on each (pallet size LxBxH: 123 x 85 x 225 cm)

Ecological Paved Surfaces with TTE®

The TTE® building element as a loadbearing system for paving areas that allow water seepage

The permanently water permeable and breathable TTE® paving allows many configuration options in a combination of covering and green surfaces.



Paving stones can be obtained in 3 colours: grey, ruby red and anthracite
Weight: 610 g/piece.

Material: strengthened, break-resistant concrete
Dimensions: 74 x 74 x 48 mm



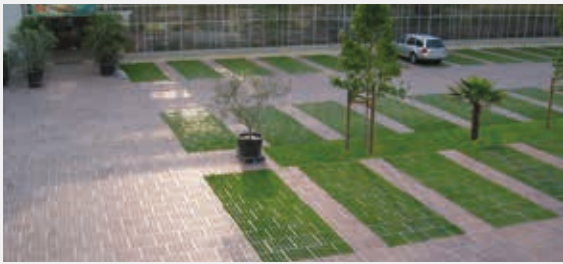
NEW!
Now also in anthracite

The advantages of a TTE® paving area:

- shear forces on the TTE® construction element are minimised
- permanently water permeable and breathable due to a high number of joints and large pore volumes
- maintenance of the ecologically valuable soil intact
- paving areas with a biological cleaning function
- no base layer required for use of passenger cars
- can be driven over by lorries
- no uneven subsidences
- marking of flexibly designable parking places
- easy to lay
- water storage capacity for a 5 cm laying bed of about 33 l/m²



Passenger car parking spaces, Sportwelt Rosbach (DE)



The combination solution: TTE® paving surface with TTE® grassed covered parking places



A very high number of joints guarantee 100% seepage of rain water and breathability of the ground

Investigations conducted by LWG* confirm that the TTE® construction principle promotes growth of vegetation



Further advantages of the TTE® construction principle

Ecological and economic in every detail

TTE® is an environmentally friendly and sustainable reinforcement solution for traffic calmed areas and usable and auxiliary surfaces

- no uneven subsidences/unevennesses possible: the 4-sided, massive, interlockable TTE® interconnection only allows a minimal difference in height to neighbouring plates for
- very high shear strength against forces produced during acceleration, braking and turning of a vehicle steering wheel
- rapid and simple laying
- permanent greenery, also for intensive use (protection of the turf against pressure loading and shearing forces)
- a higher amount of greenery possible (coverage of the surface of up to about 90%)
- improved root development (no breakage of the capillaries)
- ideal root protection for trees (report from Ing.-Büro Ökoplan, Kösching)

A long service life while in permanent use; the TTE® system has been certified to have good UV stability.

Options for making savings

- up to 80% lower material and building costs => about 10-15 EUR/m² cheaper
- additional costs for drains and dewatering equipment usually do not arise
- soil sealing taxes and rain water fees can be avoided completely: the top rated split sewage fees on sealed surfaces in 2012 is found in Berlin at 1.90 EUR/m² per annum



The massive interlocking ensures optimal pressure distribution, avoids stumbling blocks and serves as a buffer for expansion of the material



Intensive root growth - substrate/vegetation base layer, bedding and the filling substrate going to be the root zone (test report from LWG* please see extra booklet Attestations and test certificates)

Evenness of the surface after using for 10 years for daily heavy goods traffic
The largest measured deviation in the surface (about 1200 m²) was about 17 mm (Difference in height under a 4 m slot)

Sustainable in form and function

16 years of practical experience

Long-lasting:

- very resistant to UV
- references gathered over 16 years confirm that there are no impairments in the material properties and stability through exposure to UV and influences of the weather

Permanently capable of seepage:

For conventional reinforcement capable of seepage, significant reduction in the infiltration capacity over the life of the installation due to:

- strong compacting
- entry of mineral/organic fine particles content (above all in joints and in the upper area of the bedding/base layer)
- low pore volumes

TTE® is different:

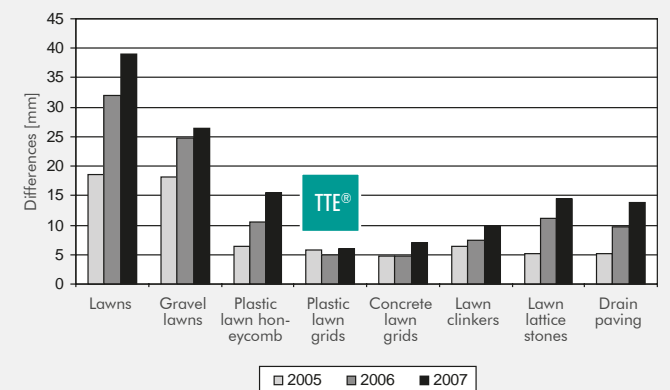
- a lower degree of compaction → large pore volumes → fine particles contents are evenly deposited and permanent permeability is assured
- a living soil layer removes organic materials which have entered by means of micro-organisms/degradation processes
- movable joints between the individual elements → allow some small play in use → prevents clogging and silting up of the joint spaces
- for TTE® paving areas → a larger number of joints → these are not rubbed out or slivered → the surface remains permanently open through use

Unaffected by frost:

- low compaction
- large pore volumes

A permanently even surface:

The massive interlocking of large TTE® elements → permanently even due to load distribution → no uneven subsidences/stumbling blocks possible



Development of the evenness of tested surface reinforcements over time which shows the maximum deviation as actual dimensions within 3 measurement paths on one area of the plot (2.5 m x 5.5 m)
(Source: Veitshöchheimer report 115 (2008), Opportunities and risks associated with grass covered parking spaces, Jürgen Eppel)

*) Bayerische Landesanstalt für Weinbau und Gartenbau



A practical test proves: 70 litres of water seep away in less than one minute on an area of about 6 m²

Drainage without a drain connection point

TTE® is both a reinforcement and a surface infiltration system

100% seepage

In a report from LWG (Veitshöchheimer Report 115 (2008), entitled "Opportunities and and risks associated with grass covered parking spaces", Jürgen Eppel), the **runoff coefficients for the TTE® system** and five other coverings capable of allowing seepage were measured. Irrigations were performed periodically for taking measurements (twice a year) which were well in excess of the **100 year repeating rainfall** for Veitshöchsheim ($r_{15}=600 \text{ l/s x ha} \hat{=} 54 \text{ l/m}^2$ in 15 minutes).

It was already possible for the TTE® construction principle 1 (greened) to **demonstrate no relevant flowing off from the surface** (theoretical runoff coefficient $C=0$). Experiences gained in practice and **references obtained over 16 years confirm the permanent permeability** of the system.

Further measurements verify a high drainage performance, even where there is poor permeability of the building ground as well as a good infiltration rate of the covering and bedding layer (see also investigation report from LWG, please see Attestations and Test Certificates).

The dewatering of the TTE® construction principle is comparable, due to its low compaction, apart from a surface formation, with that of an infiltration ditch. A permanently high drainage performance without any run off from the surface and a large water storage capacity are achieved.

The highest possible rainfall intensity for the whole of Germany (location: 83224 Grassau)*

- for property drainage (according to DIN 1986-100)*: $r_5, a=5; rN=472.6 \text{ l/s x ha} \hat{=} 14.2 \text{ l/m}^2$ in 5 min
 $r_5, a=20; rN=670.0 \text{ l/s x ha} \hat{=} 20.1 \text{ l/m}^2$ in 5 min
- for verification against flooding (according to DIN 1986-100)*: $r_{15}, a=30; rN=398.8 \text{ l/s x ha} \hat{=} 35.9 \text{ l/m}^2$ in 15 min
(for more than 800 m² of runoff-area)
- the strongest 5-minute rain event in 100 years*: $r_5, a=100; rN=899.3 \text{ l/s x ha} \hat{=} 27.0 \text{ l/m}^2$ in 5 min

All TTE® construction principles fulfil the requirements of property drainage for the whole of Germany **many times over**. Also the **verification against flooding is provided by all TTE® construction principles** (except the TTE® construction principle Paving 1). It will even manage the largest possible 100 year rain event for Germany. Therefore the seepage potential (of the TTE® construction principles 2 and 3) offers **reserves for the introduction of surface water to neighbouring sealed surfaces or roof areas**.

*) works with the German Weather Service, Hydrometeorology Department

The water absorption capacity without taking account of any time-delayed seepage in the substrate (measured and checked by LWG Veitshöchsheim)

TTE® construction principle	Description of the layer	Pore volume	max. water storage capacity
Paving 1	TTE® element with TTE® paving stone (6 cm)	21.69%	33.30 l/m ²
	Bedding of 2-5 mm gravel (5 cm) Dpr average 95.10%	42.17%	
Green 1	TTE® elements with a chamber filling consisting of a top soil-sand mixture (6 cm)	31.16%	40.68 l/m ²
	Bedding of 2-5 mm gravel (5 cm) and top soil BG 2 80/20 Dpr average 92.11%	42.36%	
Paving 2	TTE® element with TTE® paving stone (6 cm)	21.69%	33.30 l/m ²
	Bedding of 2-5 mm gravel (5 cm) Dpr average 95.10%	42.17%	
	Ballast base layer 0-32 mm (15 cm)	30% (an accepted value) ¹⁾	45l/m ²
			total ²⁾ of about 78 l/m ²
Green 2	TTE® elements with a chamber filling consisting of a top soil-sand mixture (6 cm)	31.16%	40.68 l/m ²
	Bedding of 2-5 mm gravel (5 cm) and top soil BG 2 80/20 Dpr average 92.11%	42.36%	
	Vegetation base layer (20 cm) Ballast 2/32 and top soil BG 2, BG 4, 60/40	30% (an accepted value) ¹⁾	60 l/m ²
			total ²⁾ of about 100 l/m ²

¹⁾ to determine an accepted value based on measured values from the LWG (dependent on the material mixture used).

²⁾ calculated values

Near-natural decentralised storage and seepage as well as pretreatment of polluted precipitation runoffs with TTE®

TTE® as a Decentralised Infiltration System

with a natural cleaning function

Decentralised surface drainage and French drain infiltration

The TTE® construction principle 1 as well as TTE® surfaces with gradients are to be dimensioned and verified as **surface seepage/drainage according to DWA-A 138¹⁾**. The TTE® construction principle favours very efficient use for these areas of application through its very low requirements on the compaction and a resultant high seepage rate.

The TTE® construction principles 2+3 as **a surface decentralised French drain infiltration** with a storage function represent a very effective and near-nature means of rain water resources management. While taking account of the requirements according to DWA-A 138 it can be dimensioned based on the dimensioning of infiltration ditches according to DWA-A 138. The combination of the advantages of surface area reinforcement and infiltration ditch drainage provides one with a high performance drainage system with many advantages:

- a very economic concept for decentralised rain water storage and drainage
- a dewatering system which can be driven over directly, no loss of land area as is the case with conventional seepage constructions
- pretreatment of polluted precipitation runoffs by means of living soil passages
- at the same time the (vegetation) base layer creates a surface infiltration ditch with a huge storage capacity for dewatering sealed surfaces and roof surfaces

- reduced backlog or reduced required storage volumes in comparison with conventional infiltration ditches through seepage into the substrate over a wide area

Treatment of polluted precipitation runoffs

According to the TTE® construction principle used the living top soil is laid over or improved with ballast auxiliary materials and soil additives.

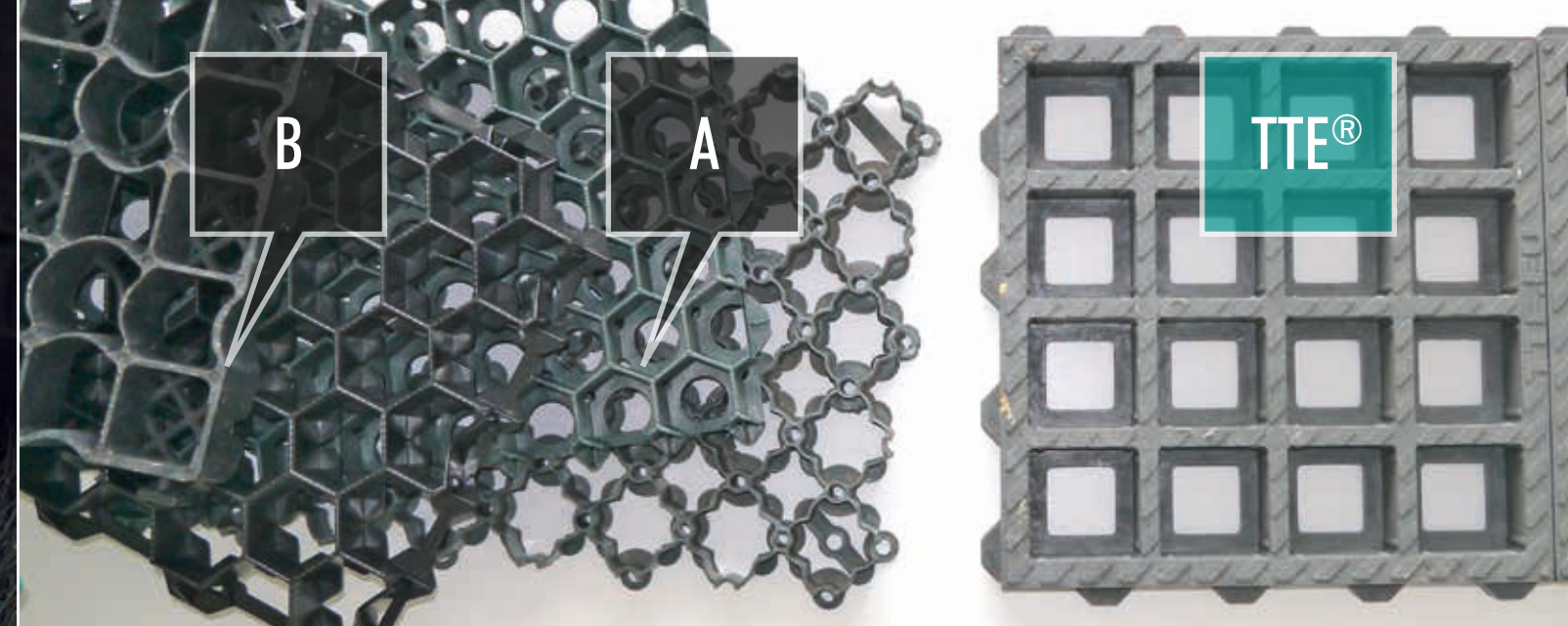
While taking account of the requirements on the soil passages according to **DWA-A 138/M 153²⁾** for creation of the top soil or the load-bearing substrate, the effect and function of the TTE® top layer is an overgrown, living ground zone. A **DIBt approval** is therefore **not needed** for the TTE® system. Precipitation runoffs can also be seeped away for strong pollution by substances through roof and traffic areas which conform with guidelines and standards.

Pretreatment of the precipitation runoffs is now possible to a certain degree of soiling for paved areas thanks to the TTE® paved surface with a cleaning active base layer.

Detailed information about the requirements upon as well as about planning and dimensioning of the TTE® dewatering system can be found in the planning aid.

¹⁾ The Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (DWA) – Worksheet 138 "Planning, building and operation of systems for seeping away of rain water"

²⁾ DWA fact sheet 153 "Recommendations concerning handling rain water"



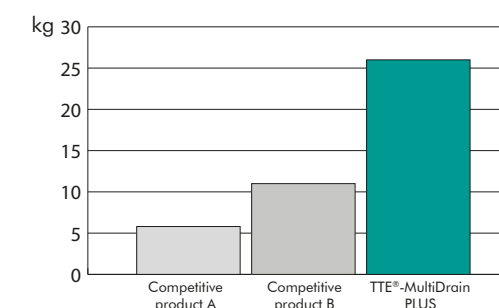
The Strengths of the TTE®-MultiDrain^{PLUS}

Various turf grids and honeycombs in comparison with the TTE® element

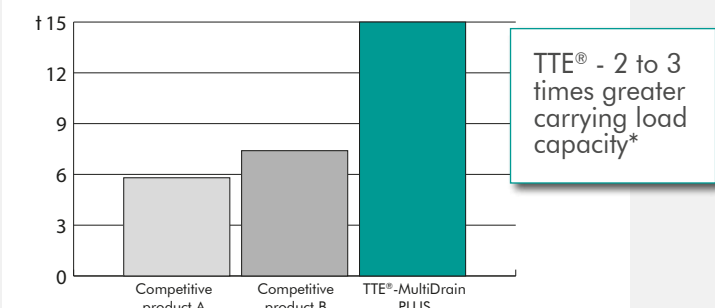
Application:	Grid A	Grid B	TTE® elements
	for passenger cars	for passenger cars, if applicable also lorries	suitable for passenger cars and lorries

Weight per m²:

TTE® is 2.5 to 4 times heavier



Compression strength (vertical loading capacity):



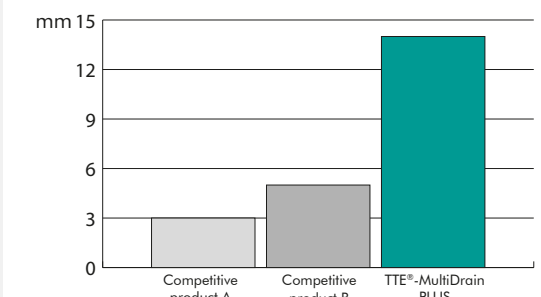
Compression strength and Stability:

The values for the compression strength are often measured as well as quoted by manufacturers of various plastic grids/honeycombs in different ways and therefore create more confusion than understanding.

The results of measurements are also purely static values (vertical force absorption). However, the factors which are decisive for loading capacity and break resistance are dynamically acting forces (such as shearing forces when a vehicle is turning). These cannot be withstood by the majority of light grids in comparison to the TTE® system because they have thin webs.

Web width:

TTE® is 3 to 5 times wider



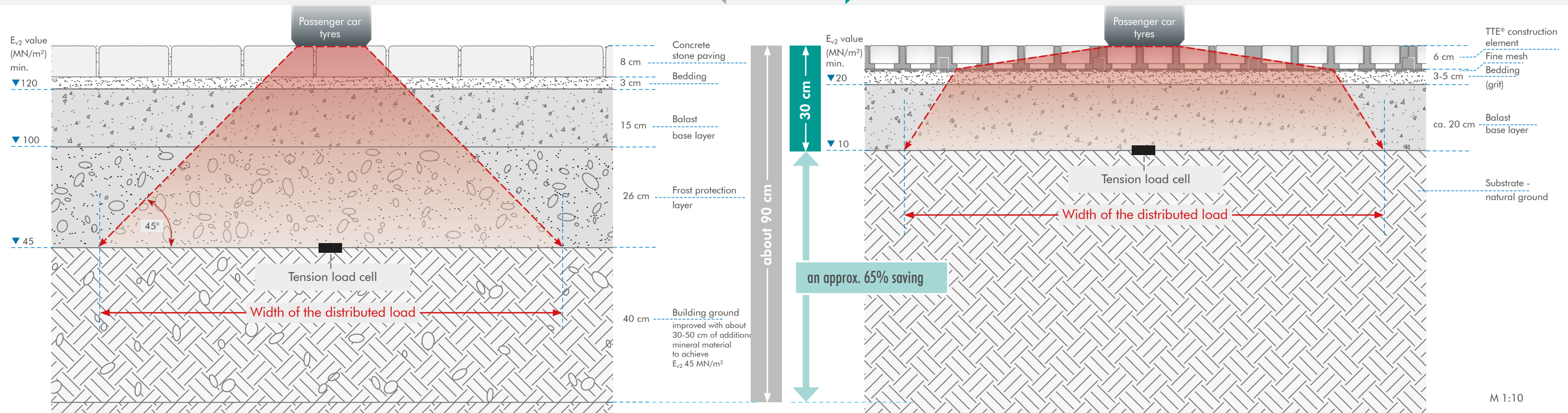
*) Maximum compression load of a test body (20cm x 20cm), measured by TÜV-Süd based on DIN 53454

Load Distribution Comparison

between RStO*
Construction Class V/VI

and TTE® Paving 2

Trials performed by



RStO* Paving Construction Principle of Construction Class V/VI

Construction of parking areas and service roads on grounds which are sensitive to frost

The load carrying capacity is achieved through compaction of mineral materials. The affecting force is degraded over a supporting grains framework conically at about a 45° angle.

Regular assembly according to the RStO

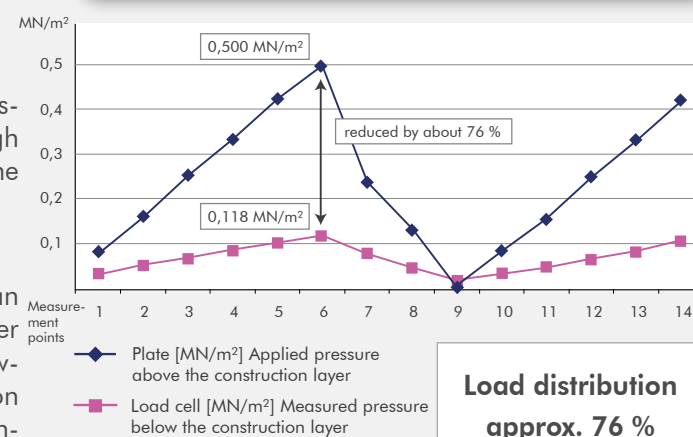
- good load bearing capacity
- high costs
- more base layer material
- no eco-function

Results of trials undertaken according to RStO:

The distance between the curves of the applied pressure and the incoming pressure illustrates the high percentage of load distribution of about 76%. The tension on the planum is strongly reduced.

Summary:

A good distribution of the compressive stresses can be achieved through use of standardised base layer material with a defined grain-size distribution. However, this is only possible using a strong compaction power, large layer thicknesses, mostly irreversible intervention in the ecosystem and loss of the ecological function of the ground.



*) German Directives for the Standardization of Traffic Area Surfaces

TTE® Construction Principle of Paving 2

For movement of passenger cars and occasional heavy goods traffic over grounds which are sensitive to frost.

Our plastic elements guarantee a high load distribution through their high own load-bearing capacity, stability against deformation and extensive interconnection. This allows enormous savings in material and lower compaction of the substrate.

Construction with the TTE® system

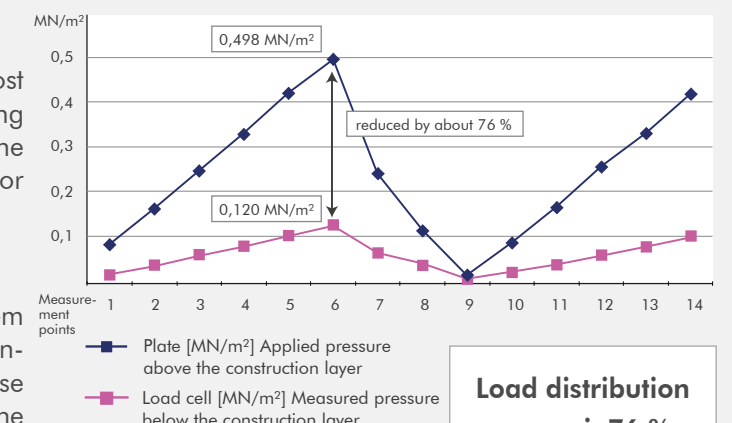
- fitness for purpose comparable with the RStO Construction Class V/VI
- lower costs
- little base layer material ■ an eco-function

Results of trials undertaken with TTE®:

The curve form for the TTE® test surface is almost identical to that obtained using the RStO paving construction principle. At is also about 76%, the load distribution is at the same good level as for Construction Class V/VI according to RStO.

Summary:

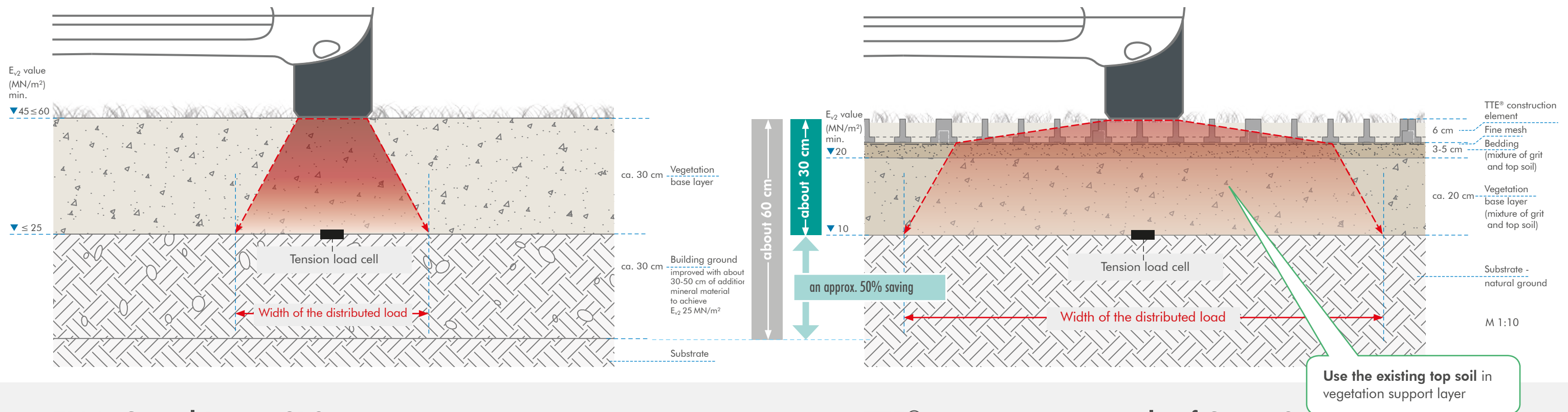
The results of the trials shown that the TTE® system delivers the same performance and function concerning load distribution and fitness for purpose with a roughly 65% smaller base layer. It also, at the same time, protects the ecosystem and maintains the ecological ground function intact.



Load Distribution Comparison

between FLL* SR2

and TTE® Green 2



FLL* Gravel Lawns SR2

Surfaces used for passenger car traffic with low levels of lorry and bus traffic on grounds which are sensitive to frost

The load distribution behaviours are similar to that of the paving construction. However, the load distribution angle is steeper due to lower compaction, substrate components and a lack of a surface layer.

Regular assembly according to FLL

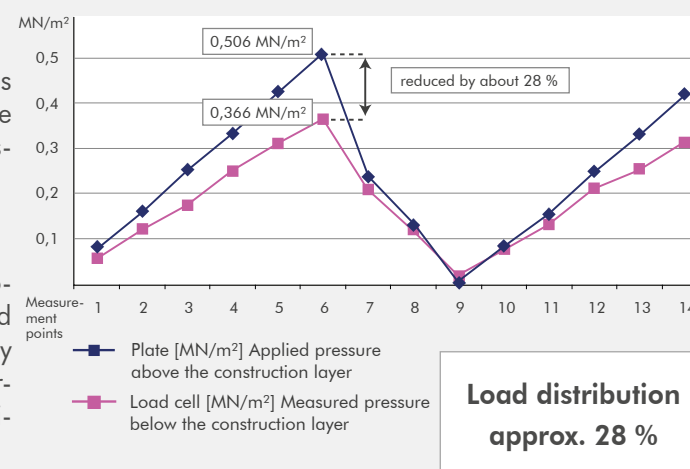
- an eco-function
- poor load distribution
- densification
- high costs

Results of trials undertaken for FLL:

The curve form for the load cell almost matches the curve for the loading effect. Therefore, despite higher E_{v2} values, one can only achieve a load distribution effect of about 28%.

Summary:

The gravel lawn can be considered to be "the ecological surface area reinforcement". It is recognised in specialist circles but rarely used since it usually cannot fulfil the requirements regarding load bearing capacity, evenness and greenery under conditions of very frequent and long-term use.



* Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V.

TTE® construction principle of Green 2

For movement of passenger cars and occasionally heavy goods traffic over grounds which are sensitive frost

The shear force resistant and load distributing TTE® elements reinforce the vegetation support layer and ensure a high ecological functionality of the surface due to a lower pressure on the substrate.

Construction with the TTE® system

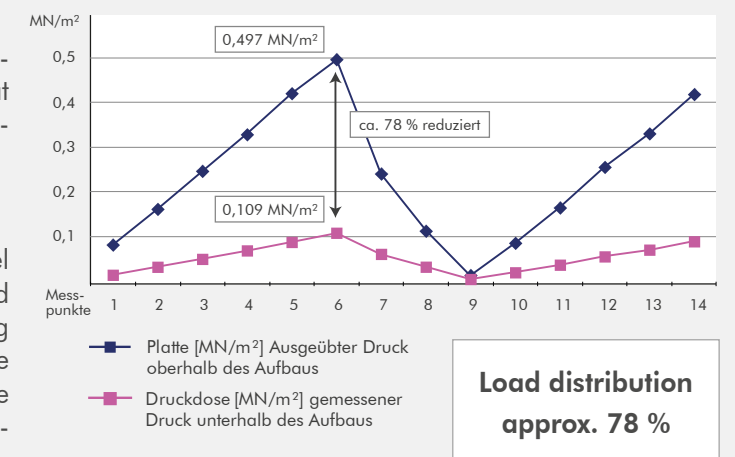
- Fitness for purpose comparable with the RStO Construction Class V/VI
- less costs involved
- a higher eco-function

Results of trials undertaken with TTE®:

The curve form for the load cell for the same loading effect is relatively flat. The load distribution at an approximately 78% force dissipation is significantly higher than that for a gravel lawn.

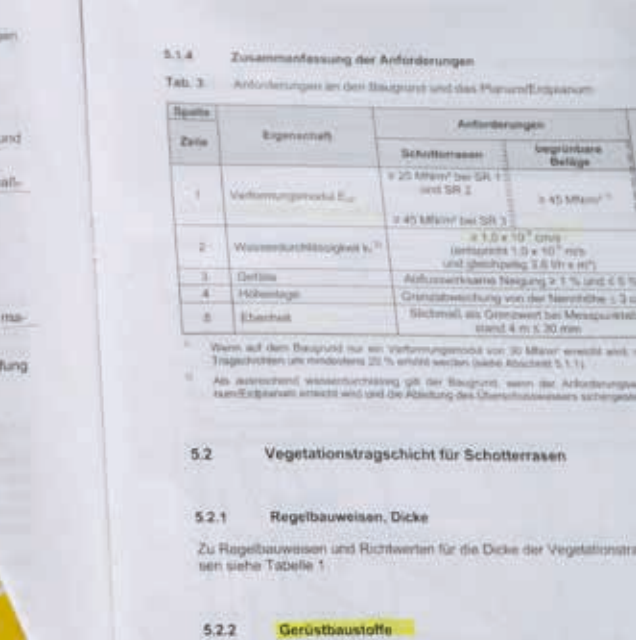
Summary:

The TTE® construction principle is the "better gravel lawn"! Load bearing capacity, shear strength and evenness are also achieved for a higher loading and frequency of use over the long-term. At the same time better drainage is achieved due to the reduced pressure on the substrate and root protection as well as a higher ecological and vegetative functionality.



Please see extra booklet "Verifications and Test Certificates" for a detailed description and verifications

Please see extra booklet "Verifications and Test Certificates" for a detailed description and verifications



The gravel lawn parking space

Comparison with Open Construction Principles for Open Areas

Taken from "A comparison of an FLL gravel lawn surface with a TTE® greened area with respect to load distribution, ground contact pressure and compaction due to vehicle traffic" produced by the Ingenieurbüro Ralf Ziegler in Nürnberg (2011-2012)

"With the goal in mind of improving the water balance of our landscapes and avoiding the rapid flowing off of rain water from surfaces due to the use of sealed traffic area surfaces, one should strive to use the so-called "open" construction principles to produce water permeable traffic area surfaces (parking areas). In comparison to this there is the classic road building technology which produces water impermeable surfaces and high demands upon the load bearing capacity of the substrate (E_{v2} min. 45 MN/m²) and the base layer (E_{v2} min. 120 MN/m²)".

Gravel lawns

- according to FLL guidelines for planning, laying and maintaining greenable surface area reinforcements
- dimensioning according to the loading classes (subdivided according to frequency of use and the maximum axle load)
- should be stable, always suitable for use, water permeable and of being coverable with vegetation
- a low compaction of the vegetation support layer of $D_{pr} = 93\% - 97\%$ is prescribed
- Requirements on the building ground compared to those required for road building are reduced to E_{v2} min. 25 MN/m², and for the base layer to $45 \text{ MN/m}^2 \leq E_{v2} \leq 60 \text{ MN/m}^2$

The TTE® system

- an innovative approach to reinforcing permeable traffic area surfaces
- dimensioning is also according to the loading classes
- the load bearing capacity of the surface is primarily due to solid, load distributing TTE® construction elements (made out of recycled plastic)
- therefore the base layer is significantly smaller than that for gravel lawn areas
- construction elements protect the surface against deformation and ensure permanent evenness
- the requirements on the building ground can be reduced even further for most optimal conditions for water seepage and vegetation
- TTE® construction principles are already applicable for a load bearing capacity of the building ground from E_{v2} to 10 MN/m²

	The required degree of compaction of the base layer	Proportion of the top soil in the base layer	Vegetation
RSfO construction principle	E_{v2} min. 120 MN/m ²	0%	possible to a limited degree
FLL construction principle	E_{v2} min. 45 MN/m ²	up to 20%	suitable
TTE® construction principle	E_{v2} min. 20 MN/m ²	up to 40 %	very suitable

Open Construction Principles according to FLL (1)

According to the levels of loading and the traffic intensity

The following 2 pages are extracts from "Guideline for planning, laying and maintaining greenable surface area reinforcements"

(2008 Edition, pages 13-15 from Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V.)

4.2 Loads on vegetation

Successful greening depends on a number of factors. The growth of the vegetation is impaired, in particular, or there is destruction of the vegetation by:

- The pressure loading:
 - from vehicles driving over it
 - under a stationary vehicle/tyres
- Loading from shear forces
 - a tight curve on a parking space access road
 - turning of the steering wheel while a vehicle is stationary
 - spinning wheels (when driving off carelessly)
- Shading (screening from receiving UV radiation)
- Dryness under a vehicle (screening from receiving rain fall)
- Heat under a vehicle (heat radiation from the exhaust system, catalytic converter and oil pan)

Increasing frequency and period of application of loads to vegetation lead to greater wear and damage to the vegetation and require increased efforts and costs to maintain it.

Irreparable damage to the vegetation can occur, in particular during longer parking periods and constant frequency of use during the dormancy periods.



5.1.4 Zusammenfassung der Anforderungen

Tab. 3 Anforderungen an den Baugrund und das Pflanz/Endplanum

Spalte	Zeile	Eigenschaft	Anforderungen	
			Schotterrasen	begrünte Beläge
1	Verfestigungsmodul E _{vd}		≥ 25 MPa bei SR 1 und SR 2	≥ 45 MPa bei SR 3
2	Wasserdruckfestigkeit k _{vd}		≥ 45 MPa bei SR 3	≥ 1,5 × 10 ⁻⁴ umm (entspricht 1,0 × 10 ⁻⁴ m/s und gleichmäßig 3,6 bis 4 m)
3	Gelände		Auflagevermögen: Neigung ≤ 1 % und ≤ 5 %	
4	Höhenlage		Grenzabweichung von der Höhenlinie ≤ 3 cm	
5	Ebenheit		Schicht als Grenzwert bei Messpunktabstand 4 m ≤ 30 mm	

Wenn auf dem Baugrund nur ein Verfestigungsmodul von 20 MPa erreicht wird, muss Tragfähigkeit um mindestens 20 % erhöht werden (siehe Absatz 5.1.1).

Als ausreichend wasserdruckfest gilt der Baugrund, wenn der Anforderungswert nach Erdboden erreicht wird und die Ableitung des Überschussswassers sichergestellt ist.

5.2 Vegetationstragschicht für Schotterrasen

5.2.1 Regelbauweisen, Dicke

Zu Regelbauweisen und Richtwerten für die Dicke der Vegetationstragschichten siehe Tabelle 1.

5.2.2 Gerüstbaustoffe



Open Construction Principles according to FLL (2)

Extracts from "Guideline for planning, laying and maintaining greenable surface area reinforcements" (2008 Edition, pages 13-15 from Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V.)

4.3 Operational loads

The following are to be taken into account during planning according to building criteria:

- Vehicle weight:
 - passenger cars, mobile homes, small transporters up to 3.5 t of permissible total weight
 - lorries up to axial load of 11.5 t
 - lorries up to axial load of 16 t
 - intensity of use
- Period of use, for example:
 - a few hours a day
 - half-daily
 - all day
- Frequency of use, for example:
 - seldom (1-2 times a week)
 - occasionally (3-4 times a week)
 - daily
 - the whole year round
 - periodically (for example exhibition site parking places)
 - half-yearly (for example at small lakes, leisure parks)
- seldom (for example entrances to fire stations, fairgrounds) or only on individual occasions
- Frequency of use and change of vehicle within the period of use:
 - low (one vehicle)
 - medium (a few vehicles)
 - high (many vehicles)

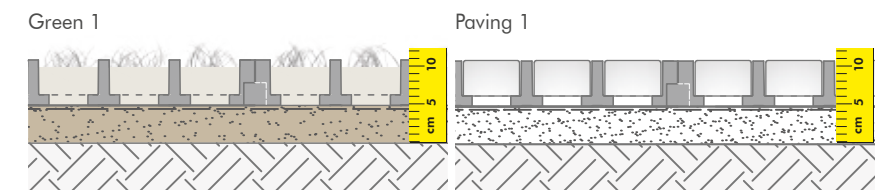
The type of daily frequency of use is put into relation with the annual chronological order. One can then derive the regeneration phases for the vegetation. The daily frequency of use consists of the period of parking of the individual vehicles and the number of individual vehicles together.

The Open and Ecological TTE[®] Construction Principles

The three TTE[®] construction principles are in line with the operational loads of the FLL

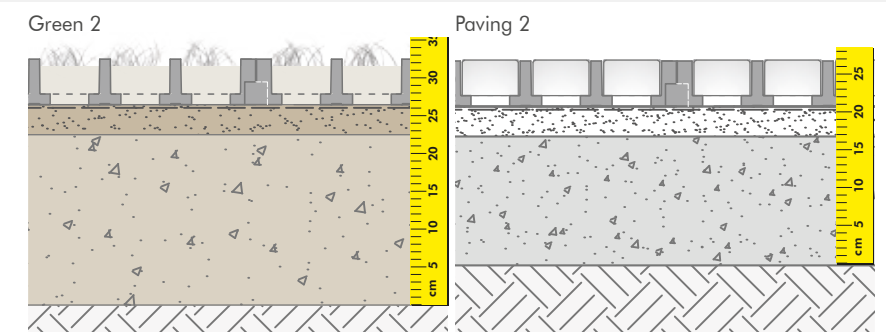
TTE[®] Construction Principle 1

exclusively for passenger car traffic



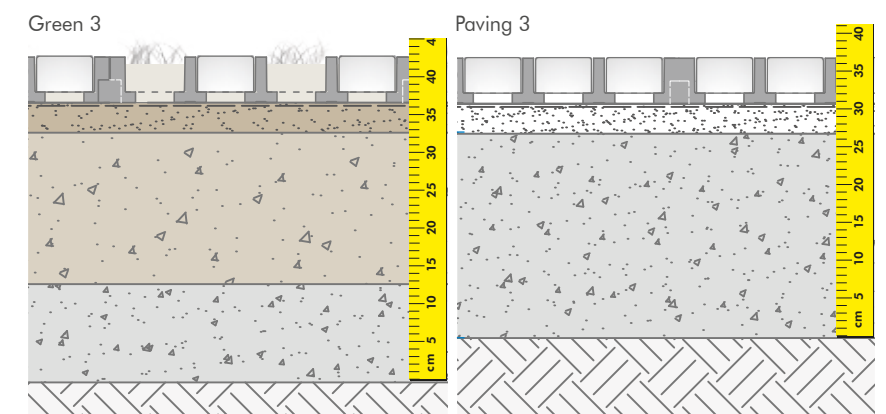
TTE[®] Construction Principle 2

for passenger car and occasional heavy lorry traffic



TTE[®] Construction Principle 3

for heavy lorry traffic



Passenger car parking spaces (TTE® Green 1) after 10 years of use with intensive, sustained greening



TTE® car park and driving lane after 10 years of daily use



TTE® Construction Principle 1

exclusively for passenger car traffic up to a total weight of 3.5 t

Uses:

- private passenger car parking spaces
- garage entrances
- camper van parking spaces
- bicycle stand spaces
- footpaths & bike lanes
- ecological base layer for terraces and pavements with a paving covering or floor paving
- suitable for protected areas in nature and landscape conservation

Prerequisites:

- load bearing capacity of the building ground of at least E_{v2} 10 MN/m²
- water permeability of the ground: k_f value at least 1.0×10^{-6} [m/s]
- for greening: an intact top soil (virgin ground) present (if not → TTE® Construction Principle 2)
- inclines up to 10% managed without difficulty (also steeper slopes after consultation)

Special features:

- near-natural seepage, retention and cleaning of the rain water
- near-natural ground conditions and vegetation conditions
- very low building costs - ideal for do-it-yourself construction
- an economic long-term solution



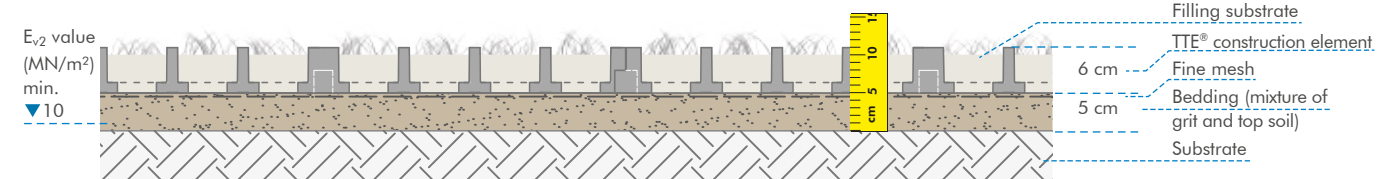
Easy to care for a greened camping van parking space



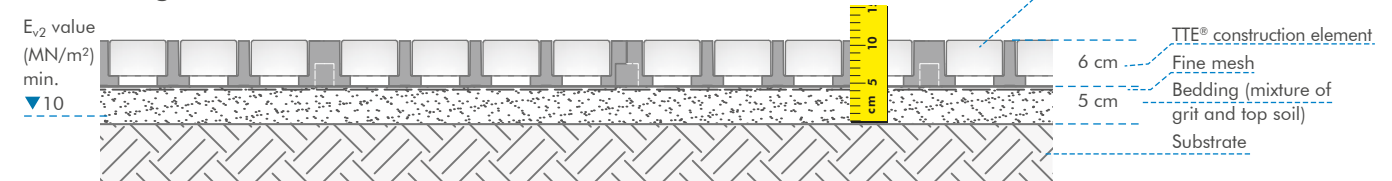
Permanently even walkway fortification

For lower loadings

TTE® Green 1



TTE® Paving 1



M 1:10

Near-natural surface area reinforcement

This construction principle allows very environmentally friendly construction, the ecological function of which is comparable with that of a natural meadow. There is no intervention in the structure of the ground and the ground life and the natural water balance is not destroyed. Loads from pedestrians and passenger cars can be absorbed by the strong, load distributing behaviour of the TTE® system without a base layer.

Detailed information about the planning, laying and maintenance can be found in the planning aid



Greened private entrance (NL)



Camping place Hardenberg (NL)

Example Applications for TTE[®] Construction Principle 1

exclusively for passenger car traffic up to a total weight of 3.5 t

Creative diversity of the application options



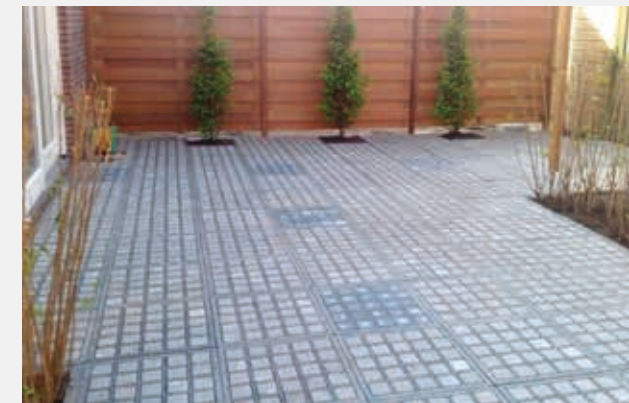
Private access road (DE)



A sales area at a garden centre in Lück (DE)



Terrace covering made out of TTE[®] (DE)



Terrace reinforcement with integral planted areas (NL)



TTE[®] with a gravel backfilling, beer garden (DE)



Water-bound covering with TTE[®], about 7,000 m² of visitor pathways at the zoo in Münster (DE)



Passenger car parking spaces for a building institute (FR)

TTE® Construction Principle 2

For movement of passenger cars and occasional heavy goods traffic

corresponds to
RStO 01 BKL V/VI
or RStO 12 Bk 0.3

Uses:

- public passenger car parking spaces (can be driven over vehicles of the entertainment services)
- industrial workers and visitor parking spaces
- private courtyard fortifications and access roads
- entrances to fire stations and bypass roads with or without greening
- rural roads
- service roads
- ecological base layer for paving coverings or floor paving

Prerequisites:

- load bearing capacity of the building ground of E_{v2} of at least 10 MN/m²
- water permeability of the building ground: k_f value of at least $1,0 \times 10^{-6}$ [m/s]
- inclines up to 10% manageable without difficulty (also steeper slopes after consultation)
- for greening: low usage intensity / quiet traffic area surfaces

Special features:

- ideal as open reinforcement of many usable and auxiliary surfaces
- sustainably good for the environment (ground, air and ground water)
- near-natural decentralised storage and seepage of precipitation
- a high cleaning capability

Base layer thicknesses according to the frost resistance of the ground

Vegetation base layer: for F1 grounds¹⁾: 20 cm
(for TTE® Green 2) for F2/F3 grounds²⁾: 25 cm

Ballast base layer: for F1 grounds¹⁾: 15 cm
(for TTE® Paving 2) for F2/F3 grounds²⁾: 20 cm

Creation of the vegetation base layer on-site

Top soil present (in an ideal case):

1. Level the top soil
2. Apply about 60% ballast (for example 2 - 32 mm)
3. Mill in about 40% of the top soil present
4. level and compact (E_{v2} a minimum of 20 MN/m²)

Base layer present:

1. Level the existing base layer
2. apply about 40% of sieved top soil evenly
3. Mill in about 60% of the top soil present
4. level and compact (E_{v2} a minimum of 20 MN/m²)

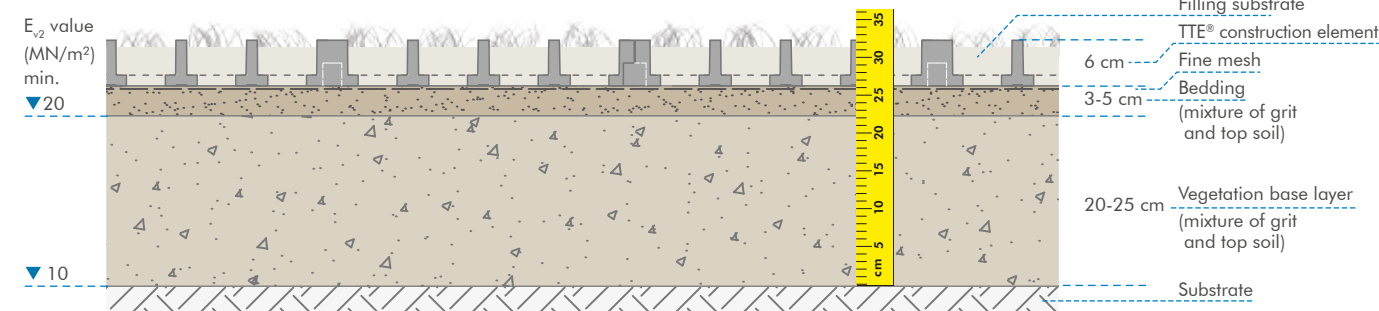
¹⁾ frost-resistant grounds e.g. sandy ground

²⁾ frost-sensitive grounds e.g. loamy ground

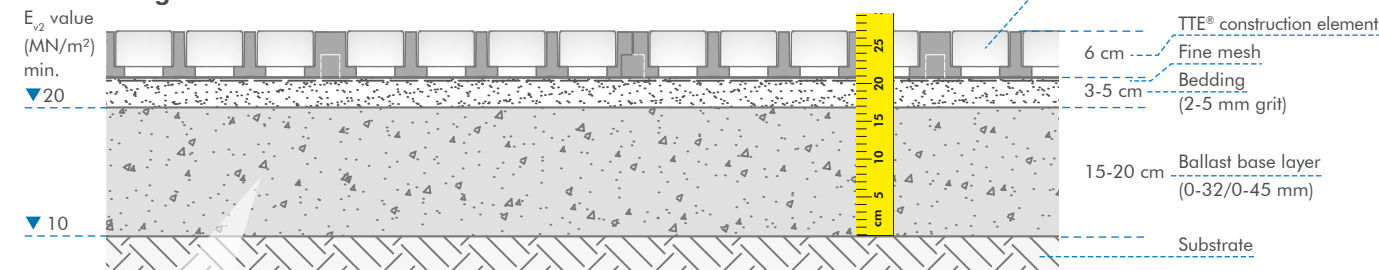


For medium loads, passenger cars and low heavy goods traffic

TTE® Green 2



TTE® Paving 2



M 1:10



Mineral or cleaning-active base layer?

If the seepage can be promoted over a living soil layer, one can also use the vegetation base layer for TTE® paving areas as a "cleaning-active base layer". For the love of the environment.

Detailed information about the planning, laying and maintenance can be found in the planning aid



Parking place for a school (FR)



Parking place and footpath incl. subsurface irrigation in Baku (AZ)

Example Applications for TTE[®] Construction Principle 2

For movement of passenger cars and low heavy goods traffic

corresponds to RStO 01
BKL V/VI or RStO 12 Bk 0.3



Passenger car parking place (FR)



Passenger car parking (NL)

Parking space and footpaths design with high ecological benefits



Outside facility for residential building (FR)



More than 22,000 m² of parking spaces shortly after the completion at a large shopping center near Vienna (AT)



Visitor's parking place for Media Markt (NL)



Passenger car parking space (AT)



Commercial lorry road (DE)

Emergency exit and service path at a motorway service area (DE)

TTE® Construction Principle 3

for heavy goods traffic up to 40 t

corresponds to
RStO 01 BKL III/IV
or RStO 12 Bk 1.8

- Uses:**
 - industrial warehouse spaces and entrances
 - lorry and bus parking places
 - service pathways at motorway service stations
 - ecological base layers for traffic area surfaces with a surface layer made out of a paving coverings or floor paving
- Prerequisites:**
 - load bearing capacity of the building ground of E_{v2} of at least 10 MN/m²
 - inclines up to 10% manageable without difficulty (consultation is necessary for steeper slopes)
 - water permeability of the building ground: k_f value of at least $1,0 \times 10^{-6}$ [m/s]
 - for greening: low usage intensity / quiet traffic area surfaces
- Special features:**
 - a high shear strength through use of TTE® paving stones
 - ecological long-term functions of the surfaces despite the lorry traffic
 - surface infiltration ditch - storage of additional flowing off from the surfaces
 - pretreatment of polluted precipitation runoffs

Base layer thicknesses according to the frost resistance of the ground

Vegetation base layer: 20 cm			
Ballast base layer: (TTE® Green 3)	for F1 grounds ¹⁾ : 10 cm	Ballast base layer: (TTE® Paving 3)	for F1 grounds ¹⁾ : 25 cm
	for F2/F3 grounds ²⁾ : 15 cm		for F2/F3 grounds ²⁾ : 30 cm

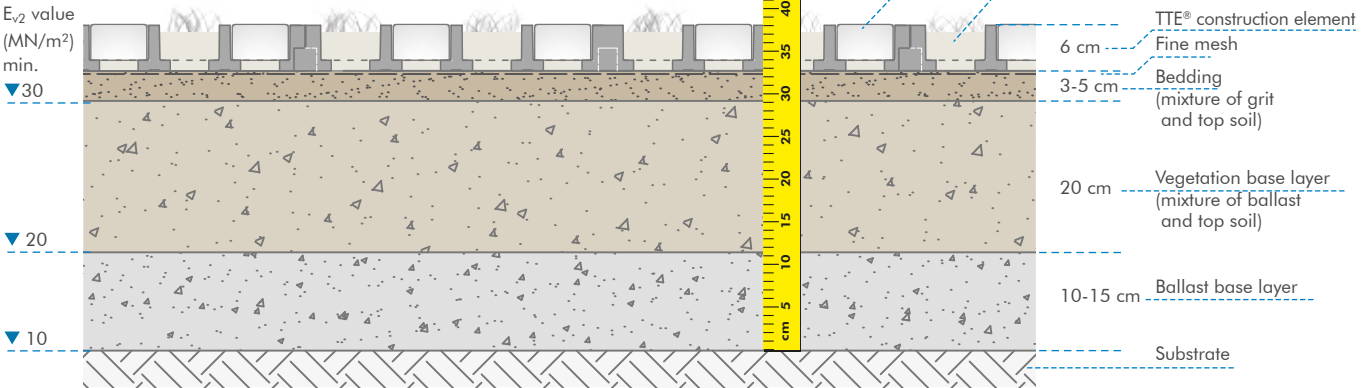
Creation of the vegetation base layer on-site

- Top soil present:**
 1. Take off top soil and store
 2. Excavate the building ground down to the installation depth and level
 3. Install ballast base layer (0-32 mm) and compact (E_{v2} a minimum of 20 MN/m²)
 4. Mix about 60% ballast (for example 2 - 32 mm) with an approximately 40% stored top soil and install
 5. level and compact (E_{v2} a minimum of 30 MN/m²)
- Base layer present:**
 1. Level the existing base layer
 2. Apply about 40% of sieved top soil evenly
 3. Mill in about 60% of the top soil present
 4. Level and compact (E_{v2} a minimum of 30 MN/m²)

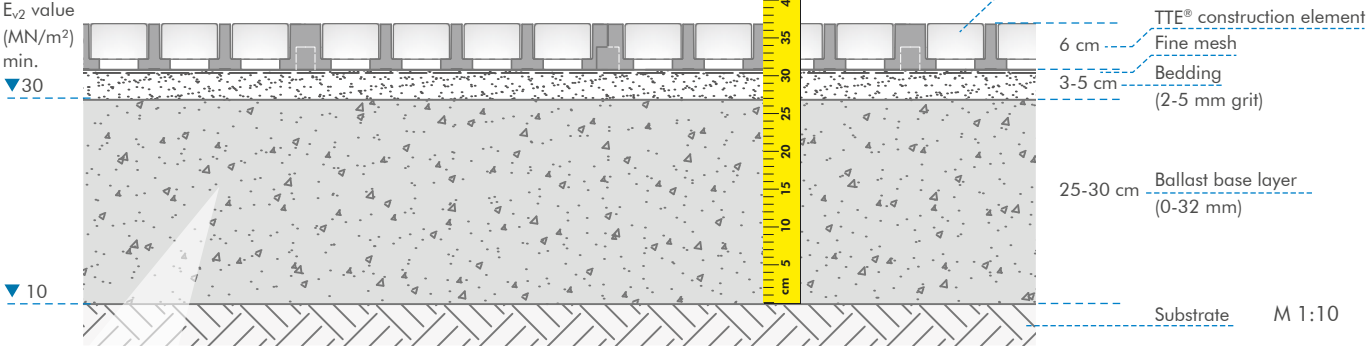
¹⁾ frost-resistant grounds e.g. sandy ground ²⁾ frost-sensitive grounds e.g. loamy ground

For high loads up to a total weight of 40 t

TTE® Green 3



TTE® Paving 3



Mineral or cleaning-active base layer?

The ballast base layer of the TTE® Paving 3 structure can, on ecological grounds, be replaced by the base course from TTE® Green 3. The living soil layer achieves cleaning of surface water and generally increases the ecological value of the surface.

Detailed information about the planning, laying and maintenance can be found in the planning aid



Local street and courtyard fortification (FR)



Bus stop in St. Martin im Innkreis (AT)

Example Applications for TTE[®] Construction Principle 3

for passenger car and increased heavy goods traffic up to 40 t

corresponds to RStO 01
BKL III/IV or RStO 12 Bk 1.8

The ecological functions are sustainably achieved despite the heavy goods traffic



Passenger car parking place (FR)



Local street (FR)



Agricultural road (DE)



Emergency stop bay (BE)



Commercially used courtyard fortification (FR)



Local street and courtyard fortification (FR)



TTE® Construction Principles at a Glance

TTE® construction principle		Use	Range of application	Load bearing capacity E_{v2} value ^{*)}	Base layer according to sensitivity to frost	Bedding	Chamber filling	Ecological value
1	Green	lower daily change of vehicle, for example private parking spaces Permissible total weight: 3.5 t	<ul style="list-style-type: none"> Private passenger car garage entrances Garage entrances Camping van garage entrances Bicycle stand spaces Footpaths & bike lanes Ecological base layer for terraces and pavements with a paving covering or floor paving 	Building ground a minimum of 10 MN/m ²	No base layer necessary	40% grit 2 - 5 mm 30% sieved top soil 20% lava 2 - 4 mm 10% ready to use compost	50% sieved top soil 20% washed sand 0 - 2 mm 20% lava 2 - 4 mm 10% ready to use compost	VERY HIGH no significant intervention, natural ground is built over, no compaction, ecosystem virtually unchanged, filter and cleaning function remain maintained
	Paving				No base layer necessary	Grit 2 - 5 mm about 5 cm thick	TTE® paving stones	
2	Green	frequent, daily change of vehicle, low heavy goods traffic, for example public parking areas Permissible total weight: 3.5 t (occasionally 40 t)	<ul style="list-style-type: none"> Public car parking spaces Industrial workers and visitor parking spaces Private courtyard fortifications and access roads Entrances to fire stations and bypass roads with or without greening Rural roads Service roads Ecological base layer for a paving covering or floor paving 	Building ground a minimum of 10 MN/m ² Vegetation base layer ³⁾ a minimum of 20 MN/m ²	Vegetation base layer ³⁾ F1 ¹⁾ : 20 cm F2/F3 ²⁾ : 25 cm	see Green 1	see Green 1	HIGH to VERY HIGH very little intervention, the filter function remains intact, very low compaction with a vegetation base layer: cleaning function function remains intact, use of the top soil, near-nature ecosystem
	Paving			Building ground a minimum of 10 MN/m ² Ballast base layer ⁴⁾ a minimum of 20 MN/m ²	Ballast base layer (0 - 32 mm) ⁴⁾ F1 ¹⁾ : 15 cm F2/F3 ²⁾ : 20 cm	Grit 2 - 5 cm 3 - 5 cm thick	TTE® paving stones	
3	Green	frequent, daily change of vehicle, increased heavy goods traffic Permissible total weight: 40 t	<ul style="list-style-type: none"> Industrial warehouse spaces and entrances Lorry and bus parking places Service pathways at motorway service stations Ecological base layer for traffic area surfaces with a surface layer of a paving covering or floor paving Exhibition sites for temporary use 	Building ground a minimum of 10 MN/m ² Ballast base layer a minimum of 20 MN/m ² Vegetation base layer ³⁾ a minimum of 30 MN/m ²	Vegetation base layer ³⁾ 20 cm Ballast base layer (0 - 32 mm) F1 ¹⁾ : 10 cm F2/F3 ²⁾ : 15 cm	see Green 1	see Green 1 50% TTE® paving stones in a chess-board arrangement ⁵⁾	MEDIUM to HIGH little intervention, the filter function remains intact, low compaction with a vegetation base layer: cleaning function function remains intact, use of the top soil, near-nature ecosystem
	Paving			Building ground a minimum of 10 MN/m ² Ballast base layer ⁴⁾ a minimum of 30 MN/m ²	Ballast base layer (0 - 32 mm) ⁴⁾ F1 ¹⁾ : 25 cm F2/F3 ²⁾ : 30 cm	Grit 2 - 5 cm 3 - 5 cm thick	TTE® paving stones	

^{*)} MN/m² = MPa (the unit MPa should be used outside Germany and then according to RStO 12)

¹⁾ frost-resistant grounds e.g. sandy ground ²⁾ frost-sensitive grounds e.g. loamy ground

³⁾ Vegetation base layer: 60% 2 - 32 ballast or 0 - 32 mm, 40% top soil ground group 2 or 4 according to DIN 18915

⁴⁾ Alternatively, for a higher ecological functionality, the supporting structure of the respective green construction can be used

⁵⁾ Alternate filling of the TTE® construction elements with TTE® paving stones and substrata in chequerboard design

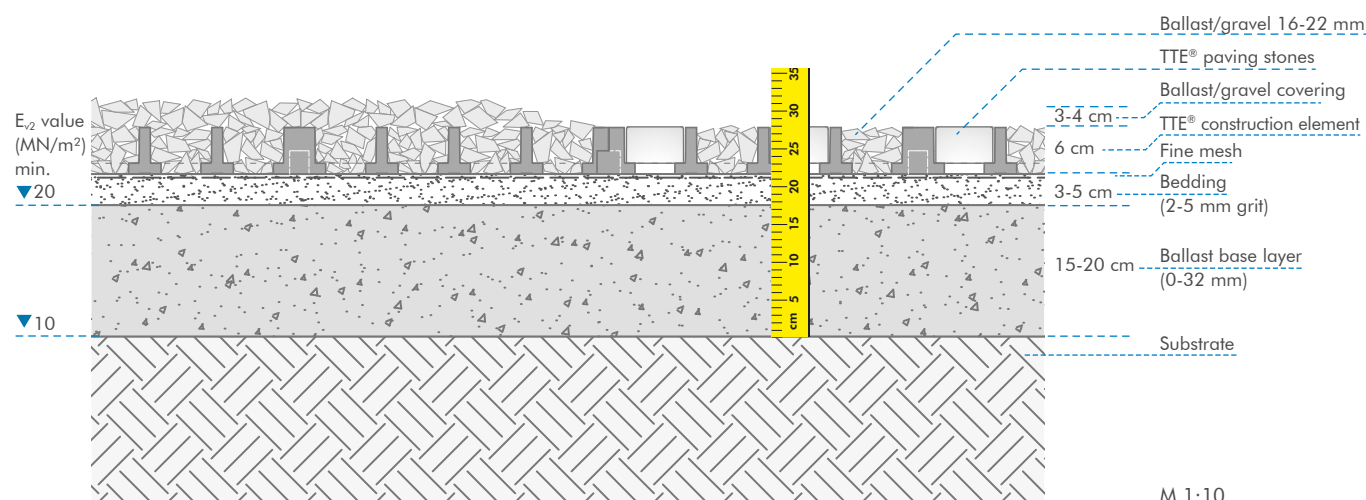


Ballast and Gravel Surfaces with TTE®

Even, hardwearing and loadable

- Uses:** **for pedestrians, passenger car and heavy lorry traffic**
- maintenance free and loadable reinforcements made out of coarse pore ballast/gravel or sand
 - courtyard areas and warehouse areas, ways and entrances, parking spaces, agricultural roads etc.
- Special features:**
- secures the evenness of the surface layer: no settlements (potholes or ruts)
 - a pleasant accessible and hardwearing reinforcement made out of loose bulk materials
 - many design options and a natural appearance
 - a permanently high drainage performance
 - cost-effective reinforcement
 - separation of the covering and base layer

TTE® with mineral filling + TTE® paving combination (for example TTE® construction principle 2)



Details for planning and laying of mineral as well as water-bound surface layers can be found in the planning aid

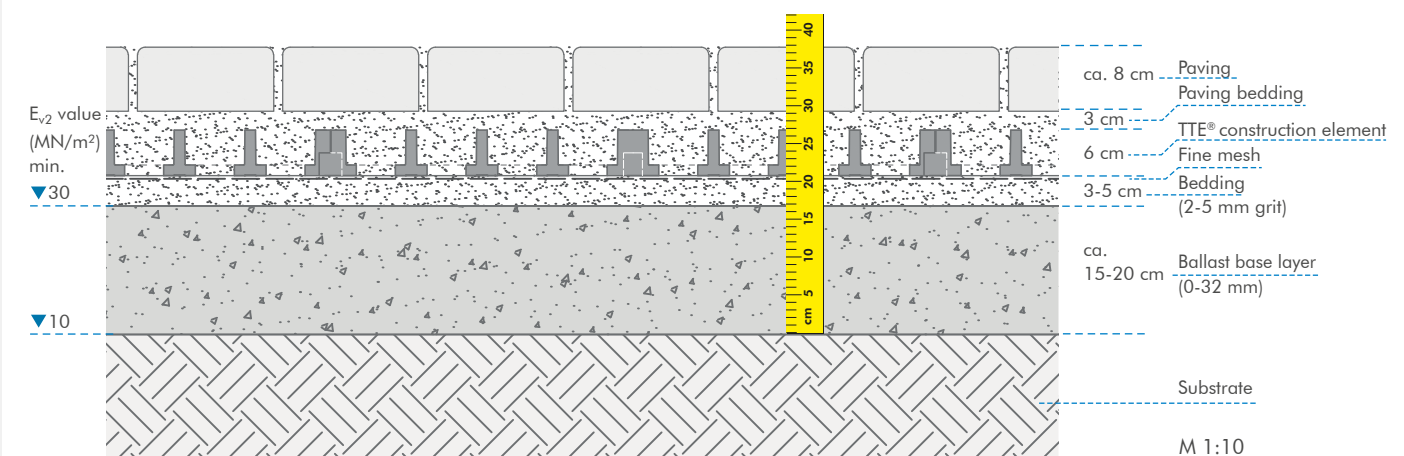


Supporting structure for paving coverings or floor paving

TTE® as an ecological base layer allows permanent seepage

- Uses:** **for passenger car and heavy lorry traffic**
- ecological base layer for paving coverings or floor pavings
 - particularly suitable for inhomogeneous and low bearing capacity building ground
 - building over the root areas of trees
- Prerequisites:**
- load bearing capacity of the building ground of E_{v2} of at least 10 MN/m^2
 - water permeability of the building ground: k_f value of at least $1,0 \times 10^{-6} \text{ [m/s]}$
- Special features:**
- a higher ecological value, permanent and better dewatering performance as a conventional "eco-paving constructional principle"
 - secures evenness of the surface: no subsidence/setting of the surface layer is possible, no placements of the paving stones at an incline
 - optimal vegetative conditions for greenable paving covers for laying as a TTE®-Green construction principle

TTE® construction for paving coverings and floor pavings (for example for TTE® construction principle 2)



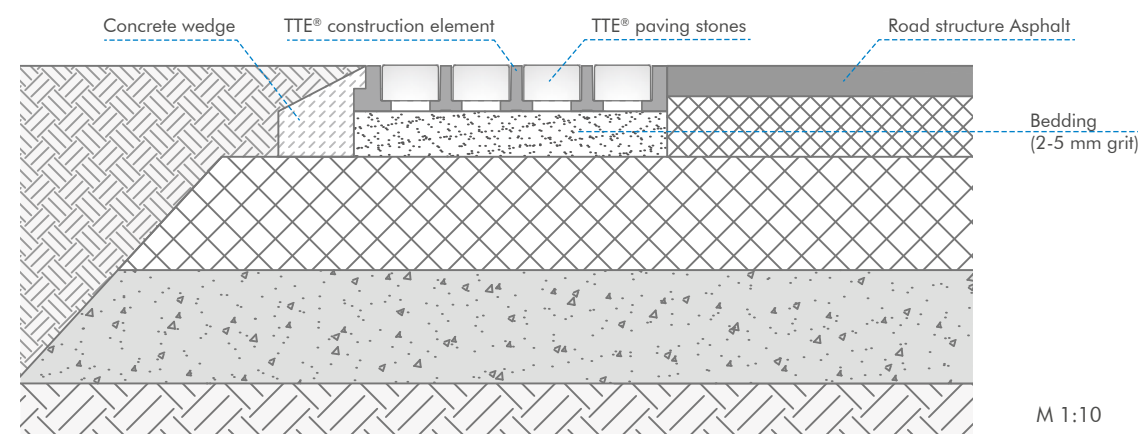


Hard Shoulder Reinforcements

Edge reinforcement of road areas

- Uses:**
- reinforcement of the road hard shoulder
- Special features:**
- permanently even road edge reinforcement
 - a simple solution for improving the road safety
 - protection against ruts and damage in the hard shoulder
 - warning for driving over by means of an acoustic signal and vibration
 - visible delimitation of the driving lane area (marking by coloured TTE® paving stones)

Hard shoulder reinforcements

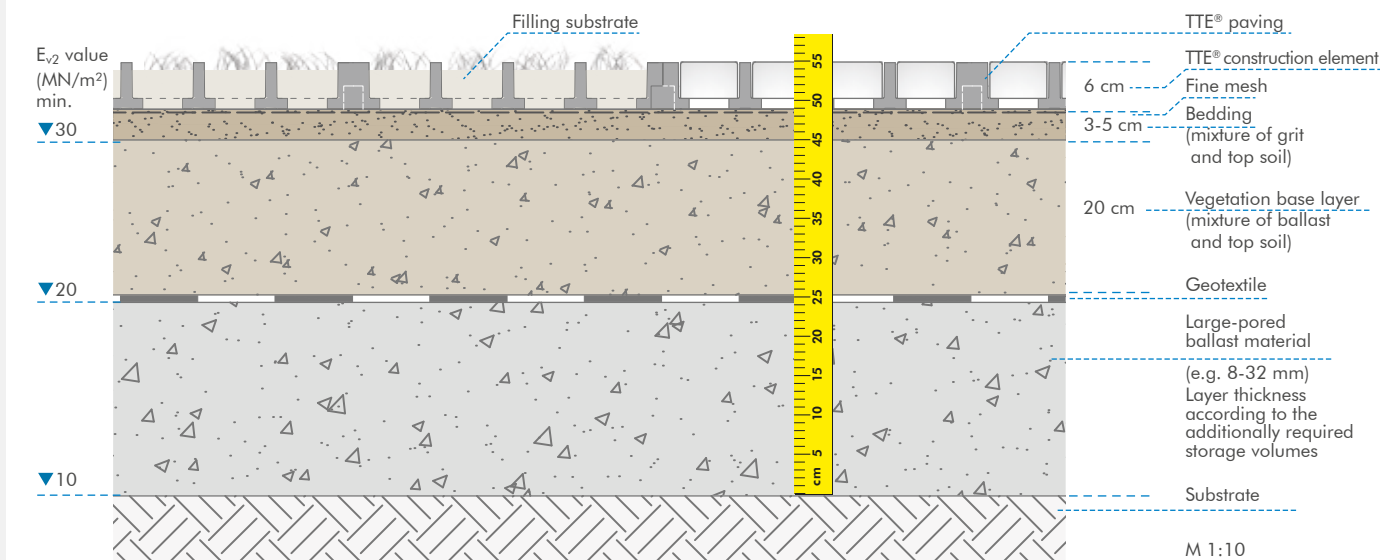


Surface Infiltration Ditch

The combination of the surface area reinforcement and infiltration ditch

- Uses:**
- near-natural decentralised storage and seepage of precipitation
 - a surface dewatering system which can be driven over (up to 40 t)
 - discharge of surface water from sealed surfaces/roof areas
- Prerequisites:**
- load bearing capacity of the building ground of E_{v2} of at least 10 MN/m²
 - water permeability of the building ground: k_f value of at least $1,0 \times 10^{-6}$ [m/s]
- Special features:**
- storage of large quantities of rain water with additional dewatering equipment and drain connection point
 - treatment of polluted outflows over an approximately 25 - 30 cm thick living soil layer
 - due to the high, widespread cleaning function of greened and paved TTE® surfaces, also usable for greater pollution of the rain water

Surface infiltration ditch



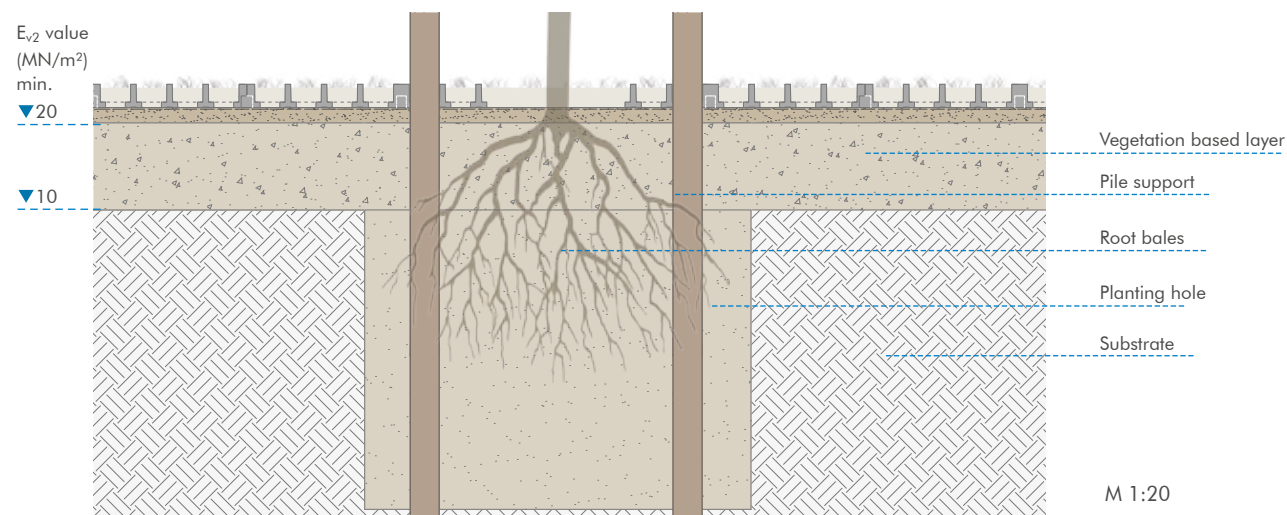


Root Protection for Tree Plantations with TTE®

Optimal protection for the root zone through load distribution

- Uses:**
- Root protection**
 - reinforcement and protection of existing root areas
 - root protection in pedestrian and traffic areas
- Special features:**
- the strong load distribution and low compaction of the TTE® construction principle allow overbuilding of root areas
 - unlimited root zone and free root growth, through connection to natural ground
 - optimal ground conditions like breathability and water supply
 - plantable or with a paved covering (continuous through to the stem area)
 - replaces costly tree disks

TTE® construction for root protection (for example for TTE® construction principle 2)

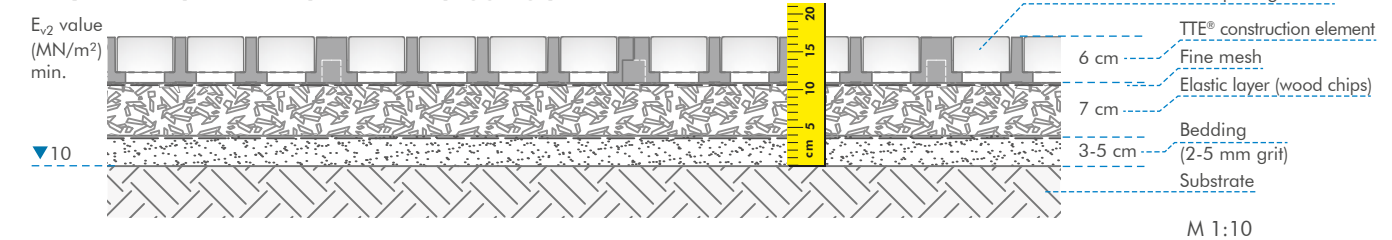


Footpaths and Jogging Paths with TTE®

Easy on the joints due to an elastic layer

- Uses:**
- for passenger car traffic and care vehicles**
 - footpaths & bike lane areas
 - jogging and walking paths, exercise tracks
- Prerequisites:**
- load bearing capacity of the building ground of E_{v2} of at least 10 MN/m²
 - water permeability of the building ground: k_f value at least 1.0×10^{-6} [m/s]
- Special features:**
- the interlocking and load distribution of the TTE® elements allow overbuilding of an elastic layer
 - a very pleasant and easy on the joints accessibility
 - can be used in any weather

Easy on the joints footpaths and jogging paths





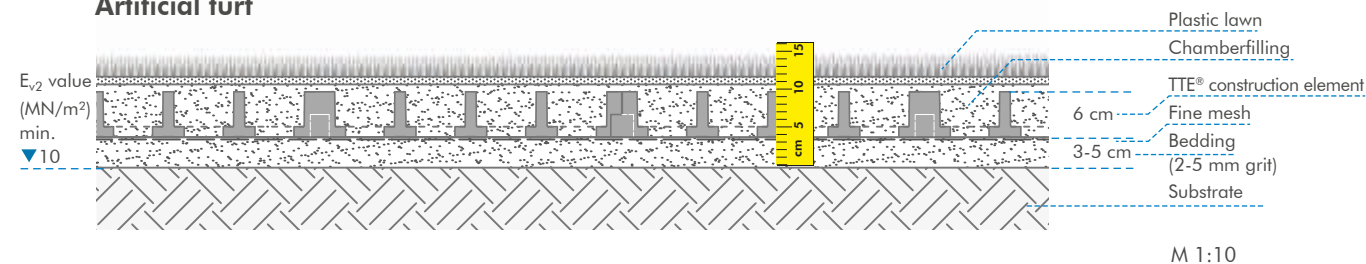
Beach volley ball place (AT)

Football Ground with Artificial Turf and TTE®

Imitation of a natural turf through an impact dampening behaviour

- Uses:**
- weather-proof artificial turf ground
- Prerequisites:**
- load bearing capacity of the building ground of E_{v2} of at least 10 MN/m^2
 - water permeability of the building ground: k_f value at least $1.0 \times 10^{-6} \text{ [m/s]}$
- Special features:**
- permanent and rapid dewatering, no stagnant water
 - imitation of a natural turf through an impact dampening behaviour
 - securing the permanent evenness
 - usable for every weather and time of the year
 - self-construction possible (for example associations)

Artificial turf



Multitalent TTE®

One product - many options



Caddyweg Golfplatz Bruchsal (DE)



Driving range (AT)



Riding arena (DE)

Individual TTE® solutions



Roof greening on a house boat (NL)

Multitalent TTE®

One product - many options



Beach terrace with a bamboo overlay (NL)

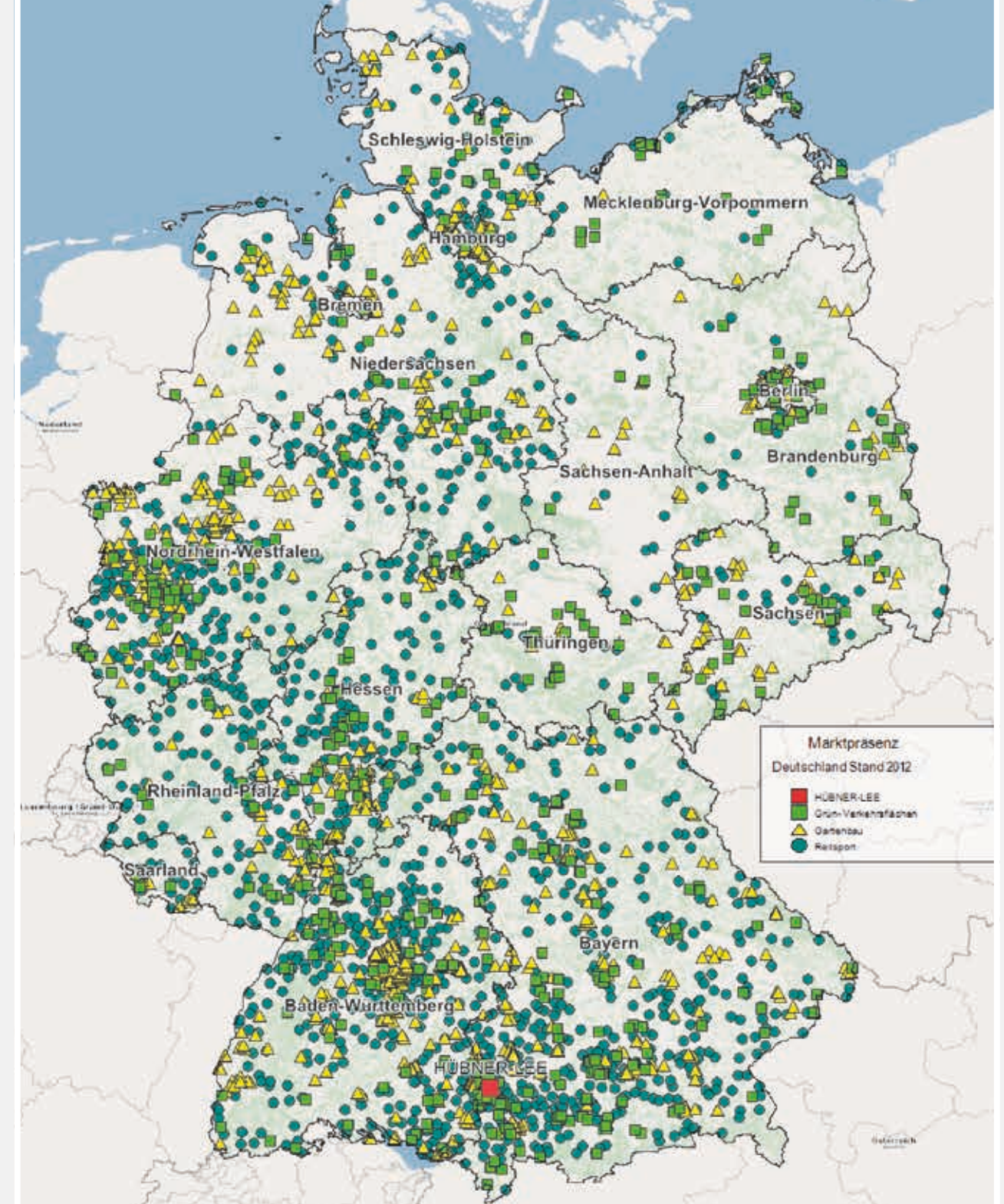


TTE®: with gravel backfilling, wooden superstructure and TTE® paving stones (NL)



Runway for sports aircraft (DE)

Market presence of HÜBNER-LEE products in Germany



There are over **5,100** references now available for TTE® ground fortification on **2,500,000 m²** in Europe (status at 31.12.2012). These daily deliver evidence for the high functional reliability of the TTE® system.



Outside facilities



Horticulture



Equestrian Sport



Sustainable ground fortifications on the basis of over 16 years of practical experience

Competence in providing advice with many years of experience

TTE® users are actively supported right from the planning through to the building phase by a competent advisory service. The area of development of individual problem solutions is where customers particularly value the practical approach and the amazingly simple realisation of previously cost-intensive projects.

We are happy to support you with our many years of experience to realise your project.

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