

# Climate Resilient and Inclusive Cycling

## Surface



## Preface

The publication is the first in a series on “Climate Resilient and Inclusive Cycling”, developed during the CycleRight project. It includes a review of available research, documents best practices and mistakes to avoid, and aims to facilitate building climate resilient, accessible, and safe cycling infrastructure.

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# Publishing credits

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# 1. Introduction

As cycles have thinner tires and most of them require balancing on two wheels, they are more affected by surface quality than cars. In particular:

- The quality of surface affects the energy expenditure of a cyclist. Compared to a good quality asphalt, paving blocks require up to 40% more energy per kilometre and gravel surfaces up to 100% more energy. On the network level, bad surface materials or maintenance can reduce the area accessible by cycling by up to 4 times.
- Uneven surfaces can create a risk of crash, for example a cyclist losing balance and falling after riding into a crack, a pothole or a decorative element.
- Insufficient friction makes it risky to perform even simple manoeuvres, like braking or turning.

Often in discussions about the surface of walking and cycling infrastructure, accessibility and inclusivity are perceived as conflicting with the requirements of environmental protection, climate adaptation or climate resiliency. In-depth review of available studies reveals that it is, in fact, a false conflict. When the whole infrastructure life cycle is considered, in vast majority of cases, asphalt surfaces combine the best quality parameters with the lowest environmental impact.

According to a study carried out by BL Evolution in France, *“cycling infrastructure is far from being a driver of land artificialisation (0.2% of artificialised surfaces). Compared to other development projects (economic activity zones, highways, airport extensions), cycle tracks represent a tiny fraction of land artificialisation [...]. Even with the most ambitious cycling development scenario, this share would still remain very small in 2050 (0.6% of all artificialised surfaces).”*

Source: [Les impacts environnementaux des aménagements cyclables.](#)

## 2. General principles

Wheels for Wellbeing guidance sheet<sup>1</sup> lists the following features of accessible surfaces:

- Smooth to better than 3 mm deflection over 3 m lengths
- Slip-resistant year-round
- Drains quickly
- Durable – low maintenance, retains quality over 30+ years
- Resists plant growth – e.g. weeds and moss/algae
- Hard, not springy
- Low reflectivity
- Single colour
- Does not reach extreme temperatures in either cold or sunny weather
- Fire resistant
- Chemical resistant
- Vandalism resistant

From the point of view of climate resiliency, in most contexts the surface needs to be resistant to both heavy rains and droughts. Sometimes permeability is also mentioned in the context of climate adaptation and blue and green infrastructure, but a narrow strip of smooth paved surface with correct cross-slope is not an obstacle for rainwater soaking into the ground. Even in densely built urban area it might be better to create rain gardens in between the road parts or retention reservoirs under the road than depend on the permeability of the surface itself.

The different surface types are examined in more detail in the following section, but generally machine-laid asphalt is consistently the best practice surface for cycling infrastructure. In some contexts, concrete surfaces (either cast in-place or large prefabricated plates) might be an option. Smaller paving blocks, even if initially well-laid, jolt users with every joint, and tend to deteriorate quickly. Natural stone is slippery or bumpy. Gravel (including stabilised or compacted gravel) requires very high maintenance and even then, in various weather conditions, may pose difficulties to users with limited strength or longer reaction time.

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<sup>1</sup> <https://wheelsforwellbeing.org.uk/inclusive-cycle-infrastructure-guide-accessible-surfaces/>



Figure 1. Smooth and even surface is one of the preconditions for accessible cycle route. EuroVelo 15 near Gemersheim, Germany.



Figure 2. Different surfaces applied in an urban park setting: asphalt on the main alley (cycle and pedestrian track), concrete paving slabs on the pedestrian plaza before a cafe, resin-bound (permeable) under cycle parking and gravel with plastic structure in tree pits. Skaryszewski park, Warsaw, Poland.

### 3. Performance metrics

As of now, there is no established standard on how to perform measurements and quantify surface quality for cycle infrastructure.<sup>2</sup> Results from different measurements are not directly comparable. “How smooth is your ride? Comparison of sensors and methods for surface quality assessment using IMUs”<sup>3</sup> provides an overview of reliability and stability of several sensor-method combinations.

#### 3.1. Energy use and vibrations

On a more general level, Table 1, Table 2 and Table 3 present different comparisons of surface types in terms of the energy use and vibrations experienced by the cyclist. While they paint a generally consistent picture (asphalt better than paving stones and gravel, unbevelled blocks better than bevelled etc.), the numerical estimate of the scale of the differences varies. The measured results depend on the type of cycle, tire pressure, speed of cycling etc.

Table 1. Cycling energy use and reachable area depending on the surface type according to UPI-Bericht 41: Entwicklung und Potentiale des Fahrradverkehrs - Maßnahmen zur Ausschöpfung des Fahrradpotentials in der Verkehrsplanung, 2000.<sup>4</sup>

Cycle track surface	Energy use	Reachable area
Asphalt, machine-laid	100%	100%
Asphalt, poor longitudinal flatness	120%	70%
Concrete paving stones, unbevelled	130%	60%
Concrete paving stones, bevelled	140%	50%
Water-bound fine gravel	150%	45%
Water-bound coarse gravel	200%	25%
Cobblestones	220%	21%

Table 2. Cycling energy use for different surface types according to “Wpływ nawierzchni drogi rowerowej na zużycie energii rowerzysty”, 2017.<sup>5</sup>

Surface type	Increase in energy use in comparison to asphalt concrete
Asphalt concrete	-
Concrete paving blocks, unbevelled	+6%
Concrete paving blocks, bevelled	+12%
Compacted gravel mix	+22%

<sup>2</sup> For motorised vehicles, methods of calibrating and processing the data from the sensors have been developed, to create International Roughness Index<sup>2</sup> (IRI). However, IRI is calculated using a quarter car-model, reflecting mass, tire size and suspension characteristics of a motorised vehicle. Therefore, it does not necessarily describe well the impact of the surface on cycling safety and comfort.

<sup>3</sup> <https://tsr.international/TSR/article/view/26031/23818>

<sup>4</sup> <https://www.upi-institut.de/UPI41.pdf>

<sup>5</sup> [https://www.transportation.overview.pwr.edu.pl/UPLOAD/BAZA-ARTYKULOW/PL/2017/08/A\\_PL\\_17\\_08\\_05.pdf](https://www.transportation.overview.pwr.edu.pl/UPLOAD/BAZA-ARTYKULOW/PL/2017/08/A_PL_17_08_05.pdf)

Table 3. Vibration Total Value (VTV) measured during cycling on different surface types, according to "Nawierzchnia dróg rowerowych i jej wpływ na zdrowie i bezpieczeństwo rowerzystów", 2009.<sup>6</sup>

Surface	VTV [m/s <sup>2</sup> ]
Asphalt cycle track, new	3.4
Asphalt road	3.6
Asphalt cycle track, ~30 years old	5.4
Concrete slabs 50x50 cm, new	4.4
Concrete slabs 50x50 cm, new, 2 cm kerb on a cycle crossing	6.9
Concrete paving blocks, unbevelled, new	4.6
Concrete paving blocks, bevelled, ~5 years old	6.7
Concrete paving blocks, bevelled, ~5 years old, 2-5 cm kerbs on cycle crossings	6.8

The Belgian Road Research Centre carried out a pre-normative research project called "SuChar-BiLan," investigating various parameters important for the safety and comfort of cyclists. The project aimed to help establish a European standard.<sup>7</sup> In addition to evenness (vibrations) and rolling resistance (energy consumption), the research also took into account skid resistance (important for turning and braking). The work is currently continued in "STeRoCycLa" – Skid Resistance, Texture, and Rolling resistance of Cycle Lanes.<sup>8</sup>

### 3.2. Other quantitative metrics

"Riding smooth: A cost-benefit assessment of surface quality on Copenhagen's bicycle network"<sup>9</sup> estimates impact of surface quality on travel speeds. While the speed differences may seem small (on average around 0.2 km/h between low-medium quality and high-quality asphalt), the timesaving add up over the network. The authors estimated that only the benefits of time savings (not considering safety, comfort and other benefits of good quality surface) are 2 to 3 times higher (depending on the scenario) than the costs of resurfacing.

"Manual for the design of cycle paths in Catalonia"<sup>10</sup> compares the values of the transversal friction coefficients on paved and unpaved surfaces for different cycling speeds. Transversal friction affects the safe turning radii. As a rule of thumb,

<sup>6</sup> <https://zm.org.pl/wp-content/uploads/2023/02/0911-standardy-wibracje.pdf>

<sup>7</sup> Final report awaits publication, preliminary results described in "Development of European Standards for Surface Characteristics of Bicycle Lanes":

[https://www.researchgate.net/publication/396197682\\_Development\\_of\\_European\\_Standards\\_for\\_Surface\\_Characteristics\\_of\\_Bicycle\\_Lanes](https://www.researchgate.net/publication/396197682_Development_of_European_Standards_for_Surface_Characteristics_of_Bicycle_Lanes)

<sup>8</sup> Dutch description: <https://www.brrc.be/sites/default/files/documents/2026-03/STeRoCycLa.pdf>;

French: <https://www.brrc.be/sites/default/files/documents/2026-03/STeRoCycLa-fr.pdf>

<sup>9</sup> <https://www.sciencedirect.com/science/article/pii/S2210670724003007>

<sup>10</sup> <https://hdl.handle.net/20.500.13045/161.2>

unpaved surfaces offer only half of the friction of paved surfaces, and therefore necessitate two times higher curve radii for safe cycling.

### 3.3. Qualitative assessments

In practice, most data on cycling infrastructure surface quality still comes from qualitative assessments. Assessment frameworks include:

- OpenStreetMap (OSM) smoothness tag:<sup>11</sup> eight categories, from excellent to impassable.
- EuroVelo European Certification Standard (ECS)<sup>12</sup> Handbook: five categories, from perfectly rideable to not rideable.
- Cycle infrastructure design (LTN 1/20)<sup>13</sup>, Appendix A: Cycling Level of Service Tool – three levels of service: green, amber and red.

Table 4 provides an approximate comparison of the categories used in the three frameworks.

*Table 4. Approximate comparison of different cycle infrastructure surface classification frameworks.*

OSM smoothness	ECS surface quality	LTN 1/20 Cycling Level of Service
excellent	perfectly rideable	2 (Green)
good	well rideable	
intermediate	moderately rideable	1 (Amber)
bad	badly rideable	0 (Red)
very_bad		
horrible	not rideable	
very_horrible		
impassable		

Table 5 and Figure 3 present the distribution of the value of the smoothness tag for different surface types according to OpenStreetMap contributors. The distribution was calculated on basis of all cycling infrastructure in the EU, for which the smoothness tag was correctly set, downloaded in April 2026, with the total sample size of 150,101 km. For the purpose of the analysis, the smoothness values of “horrible”, “very\_horrible” and “impassable” (rarely used for paved roads) are merged into one (“impassable/horrible”). The less common surface types (metal, chipseal, wood etc.) were omitted. The compacted and fine gravel surfaces are treated as one type, because they were defined in the OSM Wiki as having the same meaning until

<sup>11</sup> <https://wiki.openstreetmap.org/wiki/Key:smoothness>

<sup>12</sup> <https://pro.eurovelo.com/projects/european-certification-standard>

<sup>13</sup> <https://www.gov.uk/government/publications/cycle-infrastructure-design-ltn-120>

2023;<sup>14</sup> the distributions of smoothness for these two surface types are nearly identical.

Table 5. Distribution of smoothness for different surface types on cycling infrastructure in the EU according to OpenStreetMap contributors.

Surface type		asphalt	concrete	[concrete] paving stones	compacted or fine gravel	sett [paving stones]	[coarse] gravel
Smoothness [%]	impassable / horrible	0.0%	0.2%	0.0%	0.8%	0.2%	3.7%
	very bad	0.2%	0.7%	0.1%	2.2%	6.8%	13.2%
	bad	1.7%	5.7%	2.2%	25.6%	41.4%	51.6%
	intermediate	9.0%	22.0%	31.9%	52.0%	39.9%	25.6%
	good	47.0%	53.9%	53.8%	18.7%	10.6%	5.4%
	excellent	42.1%	17.5%	12.0%	0.7%	1.1%	0.5%
Average smoothness		good to excellent	good	intermediate to good	intermediate	bad to intermediate	bad
Sample size [km]		106,069	6,950	10,204	14,644	2,178	9,363

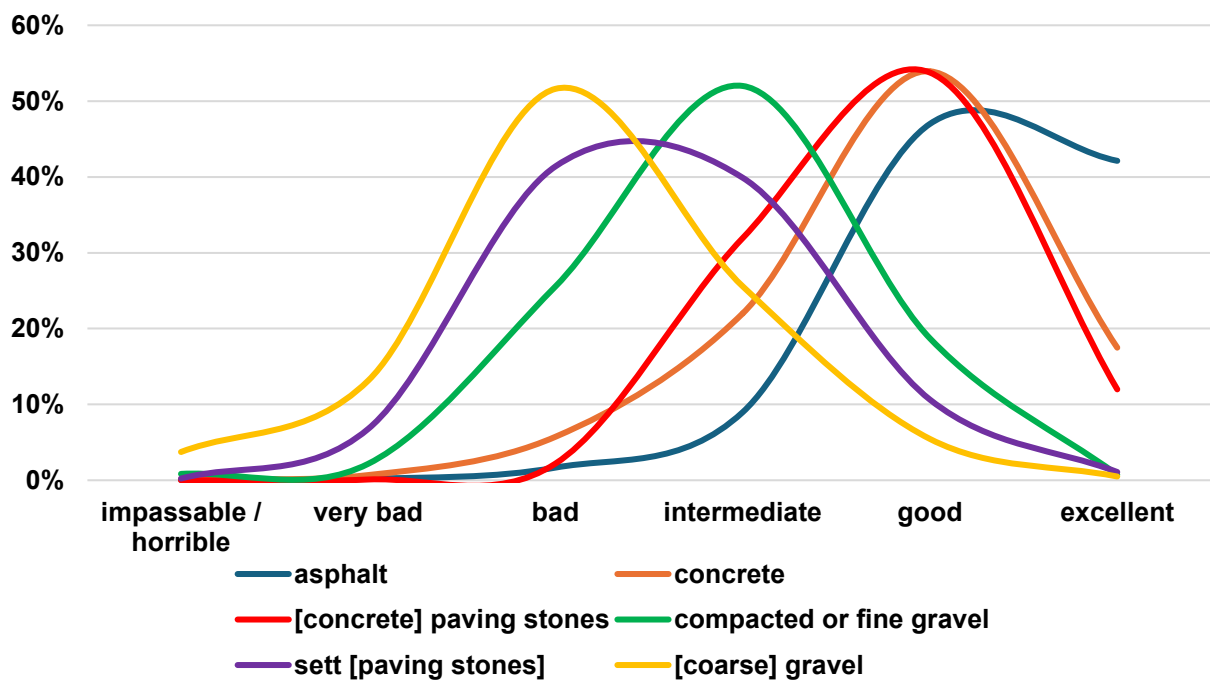


Figure 3. Distribution of smoothness for different surface types on cycling infrastructure in the EU according to OpenStreetMap contributors.

<sup>14</sup> [https://wiki.openstreetmap.org/wiki/Tag:surface%3Dfine\\_gravel](https://wiki.openstreetmap.org/wiki/Tag:surface%3Dfine_gravel)

Table 6 and Figure 4 present the distribution of surface quality assessments as reported by EuroVelo route inspectors during field surveys between June 2021 and December 2025. A total of 12,658 km across 12 EuroVelo routes have been surveyed in this period. ECS distinguishes fewer surface types than OSM, but the results are similar, with asphalt and concrete offering the best surface quality.

Table 6. Distribution of surface quality for different surface types according to route inspectors on the EuroVelo European cycle route network.

Surface type		asphalt / concrete	blocks / slabs / cobbles	stabilised gravel	gravel / dirt
Surface quality [%]	not rideable	0%	3%	0%	8%
	badly rideable	1%	7%	3%	22%
	moderately rideable	6%	19%	34%	69%
	well rideable	37%	72%	63%	0%
	perfectly rideable	56%	-	-	-
Average quality		well to perfectly rideable	moderately to well rideable	moderately to well rideable	badly to moderately rideable
Sample size [km]		10,533	571	941	614

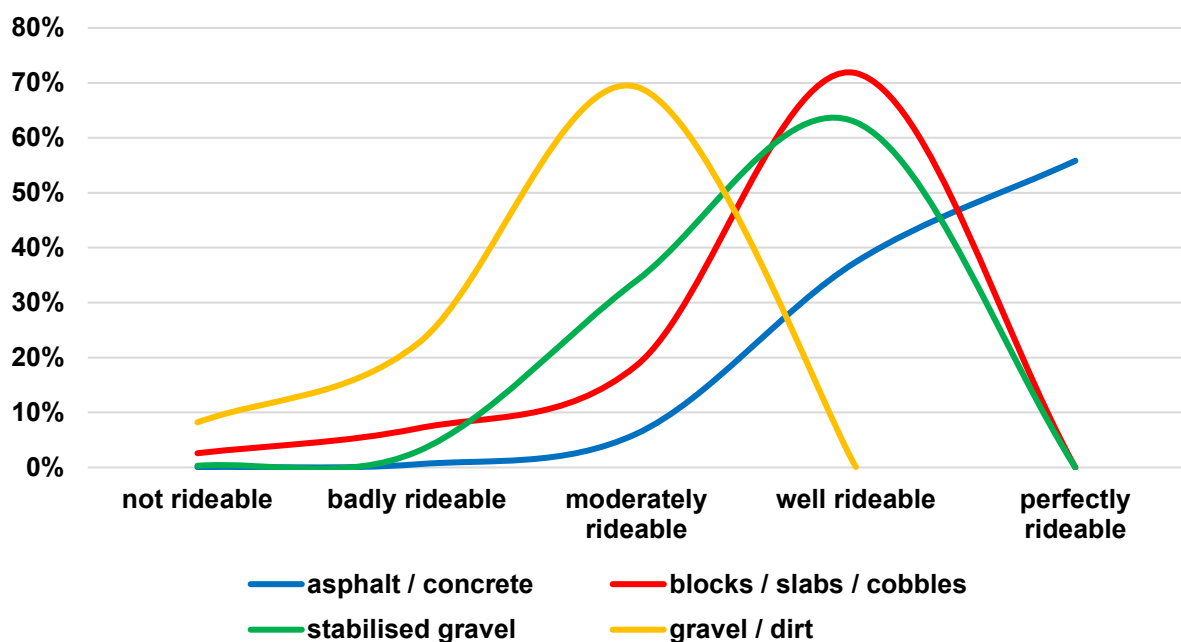


Figure 4. Distribution of surface quality for different surface types according to route inspectors on the EuroVelo European cycle route network.

### 3.4. Carbon footprint

According to lifetime cycle assessments, asphalt has the lowest carbon footprint among the typical cycle infrastructure surfaces, as shown on Figure 5. The footprint of the initial works is around two times higher than for gravel surfaces, but it requires much less maintenance over the infrastructure lifetime (Table 7, Figure 6). Concrete surfaces have the highest footprint but might be necessary in specific locations because of the requirements of climate adaptation or resilience.

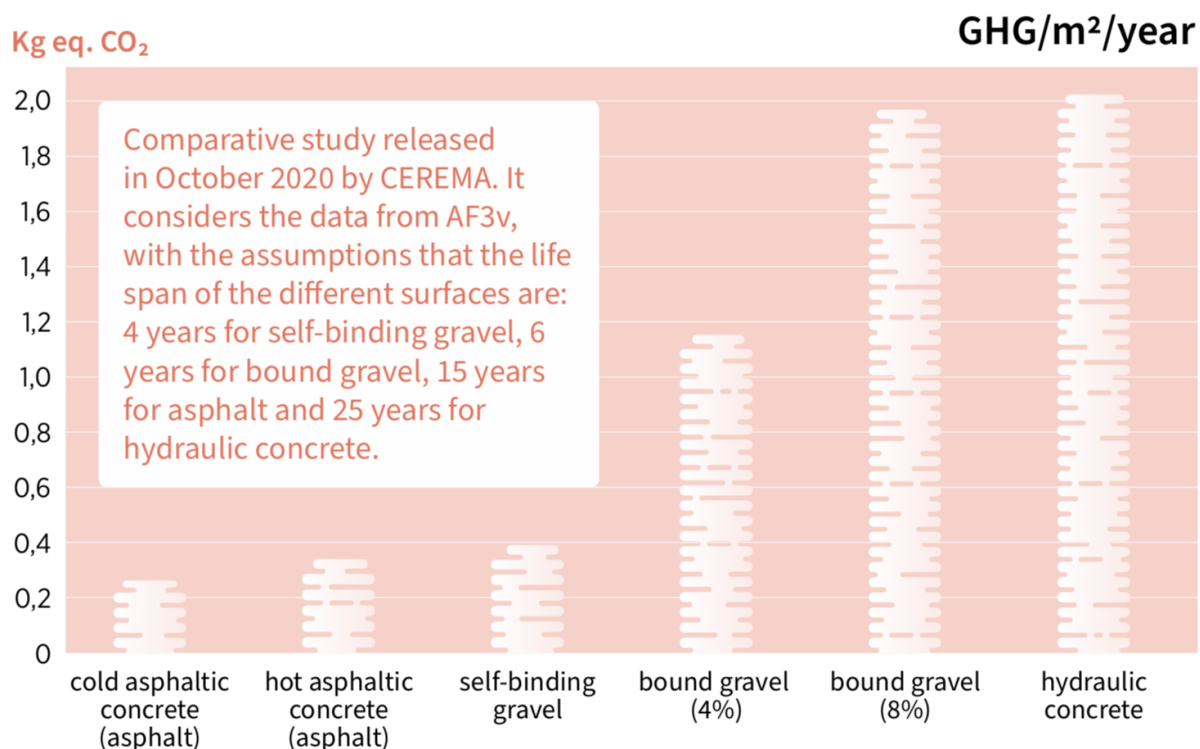


Figure 5. Lifecycle carbon footprint for different surface types. Source: Greenways surfacing: Challenge preconceived notions for an eco-friendly choice, AF3V 2024.

Table 7. Carbon footprint in tons of CO2 equivalent for a kilometre of asphalt and stabilised gravel surfaces according to Les impacts environnementaux des aménagements cyclables.<sup>15</sup>

	Construction	Yearly maintenance	Total after 5 years	Total after 10 years	Total after 15 years
<b>Asphalt</b>	16	0.21	17.05	18.10	19.15
<b>Stabilised gravel</b>	8	1.42	15.10	22.20	29.30

<sup>15</sup> <https://www.bl-evolution.com/quels-impacts-environnementaux-des-amenagements-cyclables/>

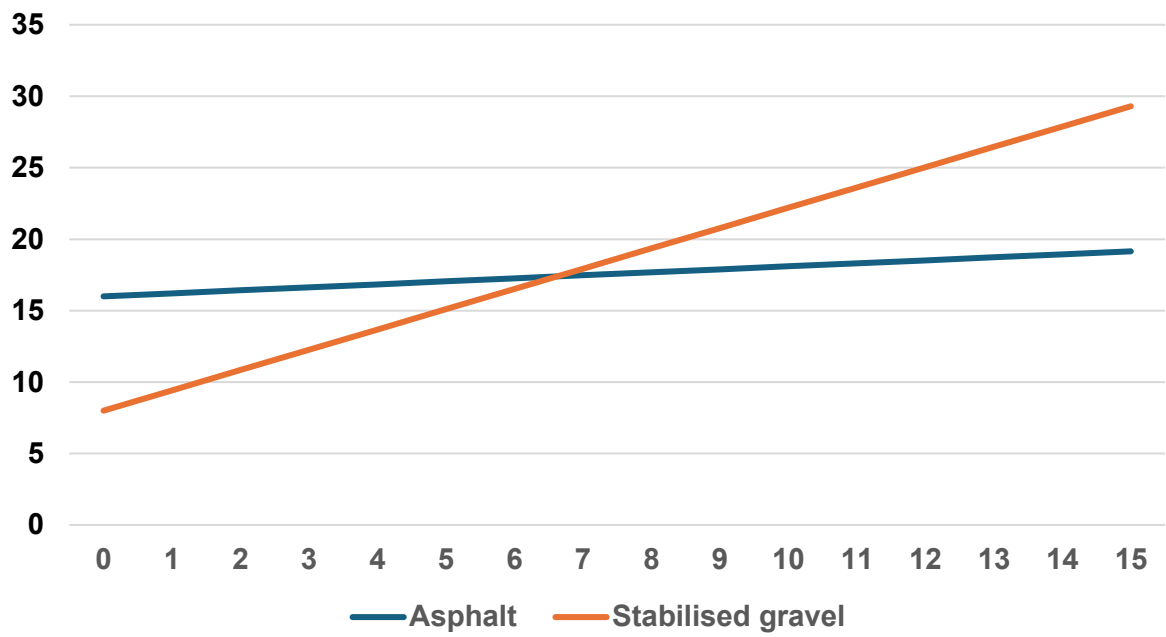


Figure 6. Carbon footprint in tons of CO2 equivalent for a kilometre of asphalt and stabilised gravel surfaces over time in years according to *Les impacts environnementaux des aménagements cyclables (BL evolution 2021)*.

## 4. Surface types

### 4.1. Asphalt

#### Pros:

- Good smoothness (low rolling resistance).
- Good skid resistance.

#### Cons:

- Requires heavy machinery (paver and road roller) to ensure proper smoothness.
- Short sections might be expensive because of the fixed costs involved.
  - o Solution: use other surfaces for temporary arrangement of the short sections and asphalt them in bundles when there is enough in the area.

#### Considerations:

- Should be machine-laid.
- Might be poorly distinguishable from the adjacent ground in unlit or poorly lit places during the night.
  - o Solution: apply horizontal markings (edge or median) to make the cycle track alignment clearly recognisable.
- Might heat up if exposed to sun.
  - o Solution: use light-coloured aggregates in locations that cannot be shaded.

#### Applications:

- Default best practice surface.
- Do not use:
  - o In areas periodically flooded.
  - o On structures which might not be strong enough for the machinery involved (for example, old flood embankments).



*Figure 7. Smooth asphalt on EuroVelo 10 and 13 between Liepāja and Bernāti, Latvia.*



*Figure 8. Layers of asphalt surface under construction. The base layer is wider to accommodate a gravel shoulder for horse riding without risking damage to the construction of the cycle track. EuroVelo 3, Belgium.*

## 4.2. Cast in-place concrete

Pros:

- Good smoothness (low rolling resistance).
- Resistant to environmental factors.
- Very durable

Con:

- Risk of alkali–silica reaction (commonly known as “concrete cancer”), especially if de-icing chemicals are applied.
- Difficult to fix damages.
- High initial costs.
- High carbon footprint.

Applications:

- Periodically flooded areas, fords.
- Pedestrian areas in the city centre.



*Figure 9. Concrete surface in the pedestrian zone in the centre of Dijon, France.*



Figure 10. Concrete ford on otherwise asphalt cycle track. EuroVelo 9, Czechia.

### 4.3. Prefab concrete plates

#### Pros:

- Good initial smoothness.
- Resistant to environmental factors.

#### Cons:

- Difficult to fix damages.
- Concrete plates move with time, which turns joints into rifts that significantly jolt users.
- High initial costs.
- High carbon footprint.

#### Applications:

- With holes concrete plates can be used locally as a permeable bridge, for example over sensitive tree roots. The bridge needs to be placed on deeper pillars.
- Concrete lanes – two strips of narrow smooth surface with grass, loose gravel or cobbles in between; sometimes used on agricultural or low traffic rural roads; however, width of the lanes is often an issue for tricycles, cycles with trailers etc.
- Temporary surfaces: the plates can be, in most cases, recovered and applied elsewhere.



*Figure 11. Concrete plates move with time, which increases the gaps and creates a height difference between the plates. The concrete plate on the left has been ground (sanded?) to alleviate the difference in height. Near Lommel, Belgium.*



*Figure 12. Concrete “bridge” over tree roots on a cycle track. Holes in the concrete plates ensure permeability for water. Munich, Germany.*



Figure 13. Concrete lanes (each 80 cm wide) built with interlocking plates with articulated joints. Szczecin Lagoon Cycle Route, West Pomerania, Poland. Photo credit: Wanda Nowotarska.

#### 4.4. Paving stones

##### Pros:

- Convenient for small scale deployments.

##### Incorrectly regarded as pros:

- There have been some arguments that the cost of paving stone surface can be reduced by paying only for the material and using volunteers or penal labour to lay out the surface, but this approach results in very low quality.
- Paving stones are sometimes considered as permeable, because of the possibility of water draining in between the blocks. However, if it happens, it happens at the expense of quickened deterioration of the base layer under the blocks and the whole surface subsequently.
- Paving stone surface can be easily deconstructed to carry out works on installations below the surface. They can also be put back into the same place; however, the base will not be compressed to the same degree as under the original surface. The surface will gradually settle, resulting in a distinct depression.

##### Cons:

- More expensive (especially when comparing marginal costs) than asphalt.
- Even if initially well-laid, jolts users with every joint.
- Increases energy use by 30-40% comparing to machine-laid asphalt.

- Causes vibrations that may pose health risks, such as vascular, bone, joint, neurological or muscular disorders.
- Higher maintenance needs than asphalt or cast-in place concrete (for example, removal of vegetation growing in between blocks).
- Deteriorates quickly.
- Can be easily vandalised or stolen. The risk is elevated in remote areas or in areas visited by violent demonstrations.
- High carbon footprint of the concrete used.

*In Warsaw, Poland, most of cycle tracks were surfaced in 1990s and early 2000s with paving stones. Measurements conducted in 2009 demonstrated that cyclists were exposed to vibrations exceeding daily exposure action values already after around one hour of cycling on even relatively new paving stones. This was one of the factors that sealed the shift in surface technology. New cycle tracks are asphalted, and most of the old paving stone tracks have also been reconstructed to an asphalt surface.*

#### Applications:

- Temporary fixes, for example:
  - o To add a few meters connector that was overlooked in the initial design.
  - o To provisionally repair the track surface after it was dug out for roadworks.
  - o In winter, when weather conditions do not allow asphaltting.



*Figure 14. Paving stones surface in Livorno, Italy. Edge partially overgrown.*



*Figure 15. Paving slabs used for provisional surfacing after underground infrastructure repairs. Warsaw, Poland. Photo credit: Marek Smyk.*



*Figure 16. Damages on paving blocks surface a few years after opening. Warsaw, Poland.*



*Figure 17. Water seeping in between paving stones rinses out the underlying base layer. Frankfurt an der Oder, Germany.*

## 4.5. Natural stone (sett)

Cons:

- Not accessible for many users.
- Causes vibrations.
- Often slippery.
- Expensive.
- Noisy.

Applications:

- Not recommended. Sett surfaces are dangerous and uncomfortable. The evenness can be somewhat improved by the quality of the cut and filling the gaps, but this is still very far from the standard offered by asphalt or concrete surfaces. Side effects might include: conflicts with pedestrians (if, for example, the sidewalk has surface more suitable for cycling) or increased environmental footprint (“elephant paths” next to official surface).



*Figure 18. Elephant path created by cyclists avoiding sett surface. EuroVelo 19, Belgium.*



*Figure 19. Old (left) and new (right) sett paving standard in Brussels, Belgium.*



*Figure 20. Filled gaps in between stone blocks on a cycle lane only. Klaipeda, Lithuania.*

## 4.6. Stabilised or compacted gravel

### Pros:

- Lower initial cost

### Cons:

- Requires frequent maintenance. This consumes additional resources, requires access by heavy machinery, increases the environmental footprint, traumatises local fauna, reduces the period of usability of the route and creates additional safety risks.
- Can be easily damaged by access of unauthorised vehicles.
- Has lower skid resistance (friction), which increases the braking distance and turning radii by 50-100%.
- Not resilient to heavy or prolonged rains. The effect is especially prominent on slopes.
- Not resilient to droughts.
- Becomes dusty when it is dry, and muddy when it is wet. In both cases, the particles of the surface are propelled into the surrounding environment, dirtying cycle parts and equipment and causing excessive wear
- While most of the airborne dust from gravel tracks is made up of substantial size particles (up to 100 microns), it also includes finer dust particles (PM10), posing risks to respiratory and cardiovascular health of users.
- The dust and mud propelled from gravel affects the chemistry of the adjacent soil and vegetation. The chemical changes may facilitate the expansion of invasive plant species, especially if a non-native surface aggregate is used.
- Low resistance to overgrowing vegetation. Maintenance often involves herbicides, including glyphosate.
- Effectively not accessible for some users.
- Worse for groundwater recharge. A narrow strip of evenly laid out asphalt or concrete with correct cross-slope is not an obstacle for rainwater soaking into the ground. On the other hand, it is impossible to maintain a similar precision on gravel surfaces, which results in water being held on the surface in the form of puddles.
- Generates avoidable noise.

### Applications:

- Singletrack MTB trails.
- Flat, well-shaded sections in forested areas (not too dry, so avoiding pine forests growing on sandy ground, especially dunes).
- Sections where existing roots of protected trees make it impossible to construct a regular surface; in such cases, consider repurposing (a part of) the adjacent carriageway instead, if possible.
- Provisional sections that are to be rebuilt in a few years.

Should never be used:

- On slopes. Both longitudinal or transversal slopes significantly speed up the degradation of gravel surfaces, and lower friction creates a safety hazard.
- On sections shared with motorised vehicles, with agricultural or forestry machinery or at a risk of illegal parking.
- On sections shared with horse riders.
- In open spaces, exposed to sun and wind.
- In places exposed to dripping water, for example under bridges.



*Figure 21. Gravel surface chosen to avoid damage to the tree roots along the historical Źwirki i Wigury alley in Warsaw, Poland. Photo credit: Marek Smyk.*



*Figure 22. When exposed to sun and wind, gravel surfaces often become very dusty. Near Rokiškis, Lithuania.*



*Figure 23. Gravel surface damaged by rainfall. Brussels, Belgium.*



*Figure 24. Deteriorated gravel surface on a slope. Green Velo cycle route, Poland. Photo credit: Wojciech Grela.*



*Figure 25. Potholes in gravel surface created by water dripping from the bridge above. V819 cycle route (Chemin des Droits de l'Homme) between Castres and Albi, France.*

## 4.7. Dirt

### Pros:

- No costs.

### Cons:

- Not accessible for many users.
- Compacts the ground which leads to an uneven distribution of water under the path.
- If the ground is sandy or muddy, people will search for alternative paths, gradually increasing the total footprint of the path and human impact on the natural area.

### Applications:

- No practical role in an accessible and climate resilient cycling network.



*Figure 26. Unimproved surfaces become sandy or muddy with use, which prompts users to search for alternative paths to bypass the problematic area. The total footprint and trauma to local flora increases. Kampinoski National Park, Poland.*

*According to a study executed by the Ministry of Transport, Building and Regional Development of Mecklenburg-Western Pomerania in Germany, cycle traffic on gravel generates a layer of compaction that is impermeable to water and results in an uneven distribution of water under the cycle path. It influences the absorption capacity of soils and therefore increases surface erosion. In comparison, no negative change in the water balance and no sealing effect could be derived from soil sites under paved surfaces.*

*Source: [Überprüfung der Vergleichbarkeit von bodenmechanischen Eigenschaften natürlicher Böden mit Radwegekonstruktionen in naturnahen Bereichen](#)*

## 4.8. Alternative surfaces

Many companies currently offer solutions for cycle track surfaces that are advertised as more ecological, for example by:

- replacing the bitumen binder (typically produced from crude oil) with a plant-based equivalent (such as cashew nutshell extract); and
- making the surface permeable to rainwater.

The non-standard surfaces can be useful in some specific scenarios, but the decision to apply them should be weighed against the potential increase of maintenance burden. Several of these solutions have already proven to have low longevity, require more frequent cleaning or repair works. In the long term this increases the environmental footprint and biodiversity disturbance above the level of standard asphalt or concrete.

The permeable gravel surfaces, depending on a plastic structure holding loose gravel in place, do not offer acceptable quality and also tend to deteriorate quickly.



*Figure 27. Triple-layer surfacing was supposed to be environmentally friendly and durable, but it is already displaying signs of age, only four years after opening. EuroVelo 7 between Osteria Nuova and Mirandola, Italy.*



*Figure 28. Damages to resin-bound surface one year after opening. Jana Kazimierza street, Warsaw, Poland. Photo credit: Marek Smyk.*



*Figure 29. Deteriorating permeable gravel surface. Near Enghien, Belgium.*

## 5. Attention points

### 5.1. Paved surfaces in natural areas

Asphalt or concrete surfaces for cycle tracks in natural area or along rivers are sometimes criticised for their environmental impact, with gravel presented as a more “natural” alternative. However, studies from France and Germany demonstrated that paved surfaces have generally lower carbon and environmental footprint because of their durability, resilience and lower maintenance needs.



*Figure 30. Contrary to a popular belief, typical gravel surfaces are generally not permeable. Near Weil am Rhein, Germany.*

According to the guidance on greenway surfacing prepared by AF3V in cooperation with France Nature Environnement:

- *Compacted gravel should be avoided at all costs due to its low permeability, distortion, dust being propelled, and low resistance to overgrowing vegetation. It is also not climate resilient.*
- *Bound gravel is more climate-resilient than compacted gravel but still brings problems for the environment.*
- *Choosing sustainable surfacing means ensuring its longevity over time to avoid traumatising local fauna and flora each time work is carried out on the road. In a normal operating cycle, the risk of biodiversity disturbance comes not from the surface itself but from activities related to the maintenance of the infrastructure and the vegetation bordering it.*

Source: [Revêtement des voies vertes. Déjouer les idées reçues pour un choix écoresponsable](#)

## 5.2. Tree roots

Trees provide shade and increase the attractiveness of a cycle route. At the same time, there might be a conflict between the quality of surface and tree roots, especially of trees with shallow roots (e.g., pine).



Figure 31. Root-related damaged on EuroVelo 1 in France.

### Problems:

- Construction of surface might damage tree roots, potentially weakening the trees and leading to them eventually falling down.
- Growing tree roots damage the surface of the cycle track.

### Possible solutions:

- Plan sufficient spacing between trees and cycle tracks.<sup>16</sup> On a typical city street, with on-street parking, planting zones fit well between subsequent parking bays.
- For new trees, plant deep-rooted tree species.
- Use concrete “bridges” to pass over tree roots in case appropriate distance and/or root shape cannot be ensured.
- Use root barriers (foil screens) to discourage the growth of roots under the cycle track.
- Use resin-bound permeable surface around the tree (tree pit).

“Wurzelaufbrüche auf Fahrradwegen”<sup>17</sup> provides a good overview of the problem and possible solutions. The topic will be further elaborated in a separate factsheet on planning and managing vegetation.

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<sup>16</sup> There are also other reasons why trees too close to the cycle track are not such a good idea: clearance / recovery zone in case of making a mistake, branches growing into the vertical clearance and directly endangering cyclists and social safety (e.g., the risk of ambush by someone hidden behind a tree).

<sup>17</sup> [https://www.agfk-brandenburg.de/wp-content/uploads/2022/06/08\\_Praesentation\\_IPG\\_Wurzelschutz.pdf](https://www.agfk-brandenburg.de/wp-content/uploads/2022/06/08_Praesentation_IPG_Wurzelschutz.pdf)



*Figure 32. Resin-bound permeable surface around a tree trunk in a busy cycle and pedestrian space. Konstytucji square, Warsaw, Poland. Photo credit: Marek Smyk.*

### 5.3. Historical areas and surfaces

Heritage or aesthetics are sometimes used as excuses for inaccessibility. If the street was paved with cobblestones several hundred years ago, it needs to be kept that way as long as possible. “Wheels for Wellbeing”<sup>18</sup> argue that historic context is not a good enough reason for surfaces that are not usable for wheelchairs, prams or cycling. Residents of historic buildings enjoy electricity, running water, modern heating and sanitation, sometimes also lifts – why should public space be kept inaccessible?

Compromise solutions for paving in historical context include:

- Clean-cut natural stones with gaps filled with bitumen or similar material.
- Providing strips of smooth surface for pedestrians and cyclists, while leaving sett or cobblestone surface in places only used by cars (parking bays, car-only lanes or parts of a lane).

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<sup>18</sup> <https://wheelsforwellbeing.org.uk/our-campaigns/resources/inclusive-cycle-infrastructure-guide-accessible-surfaces/>



*Figure 33. Clean-cut sett paving with bitumen filling between the stone blocks. Old town centre in Freiburg, Germany.*



*Figure 34. Clean-cut paving stones on the sidewalk and the cycle lane, cobblestones left in the parking lane and car lane. Kawęczyńska street, Warsaw.*



*Figure 35. Historical rural alley with smooth asphalt lanes on both sides and cobblestones left in the central strip as a traffic calming element. Near Parlow, Germany.*

#### **5.4. Kerbs and water drainage on crossings**

Kerbs and gutters on crossings (across the cycle track) should be avoided. They jolt users and generate a risk of falling, especially for less proficient cyclists and users of adapted cycles. They also damage the wheelrims and may escalate the consequences of a pedestrian or a cyclist falling.

Some engineers argue that it is necessary to use kerbs to delimit surfaces with different construction or to continue the gutter to ensure proper water drainage. However, the best practice is to design the cycle crossing in the same way as an intersection of carriageways. Even if the connecting roads have a different construction (because of different volume/character of traffic or different time of design), the top surface layer can be seamlessly connected by designing a transition in the underlying base layer. Water drainage is ensured by proper longitudinal and transversal gradient. There is no reason to design the cycle crossing as the lowest point of the intersection. If there is a gutter along a perpendicular street coming from above, a storm drain just before the crossing might be a good idea.

Existing kerbs can be somehow improved by grinding or adding an asphalt or concrete mini-ramp.

A gutter can be covered with a metal bridge or grating, but occasionally it gets displaced by traffic or stolen for scrap value. Additionally, the flow of water can get blocked by leaves accumulating under the metal cover.



*Figure 36. Dropped but still protruding kerb on a new cycle crossing. Bratislava, Slovakia.*



*Figure 37. Continuous asphalt with no perpendicular kerb on a cycle crossing. Sevilla, Spain.*



*Figure 38. Gutter covered by metal grating on a raised cycle and pedestrian crossing. Andersa street, Warsaw, Poland.*



*Figure 39. Gutter discontinued on the connection of cycle track and carriageway. A gutter or a kerb here would be particularly dangerous because of the angle of crossing. Sokola street, Warsaw, Poland.*

## 5.5. Colour of the surface

Consistent use of a single colour improves recognisability of cycling infrastructure, both for cyclists and for other users. The colour-coding of different road parts needs to be the same across different areas and administrations. If the colour identifying cycling infrastructure changes between different road administrations, in parks, or in the centre of the city, it does not bring the expected added value.

It should be considered that coloured surfaces are more expensive, both in terms of the initial investment and later maintenance. The red layer might cost even up to four times more than regular asphalt.<sup>19</sup> However, the costs of the top layer of the surface constitute only a small fraction of the total costs of a cycle track, especially in urban settings. Moreover, a part of the cost increase is related to the fact that the equipment involved in the manufacturing and construction process must be cleaned before and after to prevent contamination of the asphalt mix, therefore the cost difference will be lower with wide-spread adoption of a specific colour and large-scale investments.



*Figure 40. Consistent use of red colour for cycling infrastructure facilitates recognition of cycle routes even when the type of infrastructure changes.*

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<sup>19</sup> In pilot projects in Switzerland, the costs of red pavement were estimated at 50-80 CHF compared to 20 CHF for black asphalt. Gestaltung der Winterthurer Velorouten – Pilotprojekte / Stand der Arbeiten / Vorschlag für künftige Projekten: <https://www.provelozuerich.ch/wp-content/uploads/2025/09/Faktenblatt-rote-Belage.pdf>



*Figure 41. Around Warsaw, Poland, on network sections managed by the national road administration, red colour designates space for pedestrians. Unfortunately, the colour-coding is the exact opposite on sections managed by local municipalities (red for cyclists, grey for pedestrians).*

## 6. Further reading

1. Inclusive Cycle Infrastructure Guide: Accessible Surfaces. Wheels for Wellbeing: <https://wheelsforwellbeing.org.uk/inclusive-cycle-infrastructure-guide-accessible-surfaces/>
2. Revêtement des voies vertes. Déjouer les idées reçues pour un choix écoresponsable. AF3V 2024, <https://www.af3v.org/livret-revetements-des-voies-vertes-dejouer-les-idees-recues-pour-un-choix-ecoresponsable-af3v-fne/>
3. Überprüfung der Vergleichbarkeit von bodenmechanischen Eigenschaften natürlicher Böden mit Radwegkonstruktionen in naturnahen Bereichen. Ministerium für Verkehr, Bau und Landesentwicklung Mecklenburg-Vorpommern 2009: [https://www.adfc-forchheim.de/fileadmin/user\\_upload/kv-forchheim/pdf/radwegebau/Gutachten\\_Mineralbeton-Asphalt.pdf](https://www.adfc-forchheim.de/fileadmin/user_upload/kv-forchheim/pdf/radwegebau/Gutachten_Mineralbeton-Asphalt.pdf); <https://orlis.difu.de/items/8d9bd65b-b494-4b9c-bb16-3c52112a828e>
4. Les impacts environnementaux des aménagements cyclables. Guillaume Martin, Luc Lavielle 2021: <https://www.bl-evolution.com/quels-impacts-environnementaux-des-amenagements-cyclables/>
5. Nawierzchnia dróg rowerowych i jej wpływ na zdrowie i bezpieczeństwo rowerzystów. Brüel&Kjær, IPPT PAN, BDiK UMStW, Warszawa 2009: <https://zm.org.pl/wp-content/uploads/2023/02/0911-standardy-wibracje.pdf>
6. Wurzelaufbrüche auf Fahrradwegen. IPG Infrastruktur- und Projektentwicklungsgesellschaft mbH 2022: [https://www.agfk-brandenburg.de/wp-content/uploads/2022/06/08\\_Praesentation\\_IPG\\_Wurzelschutz.pdf](https://www.agfk-brandenburg.de/wp-content/uploads/2022/06/08_Praesentation_IPG_Wurzelschutz.pdf)
7. Voies vertes : vive le béton ? In: Le Mag Avello 02, 2026: [https://avello.org/wp-content/uploads/2025/12/AVMAG\\_02\\_web.pdf](https://avello.org/wp-content/uploads/2025/12/AVMAG_02_web.pdf)