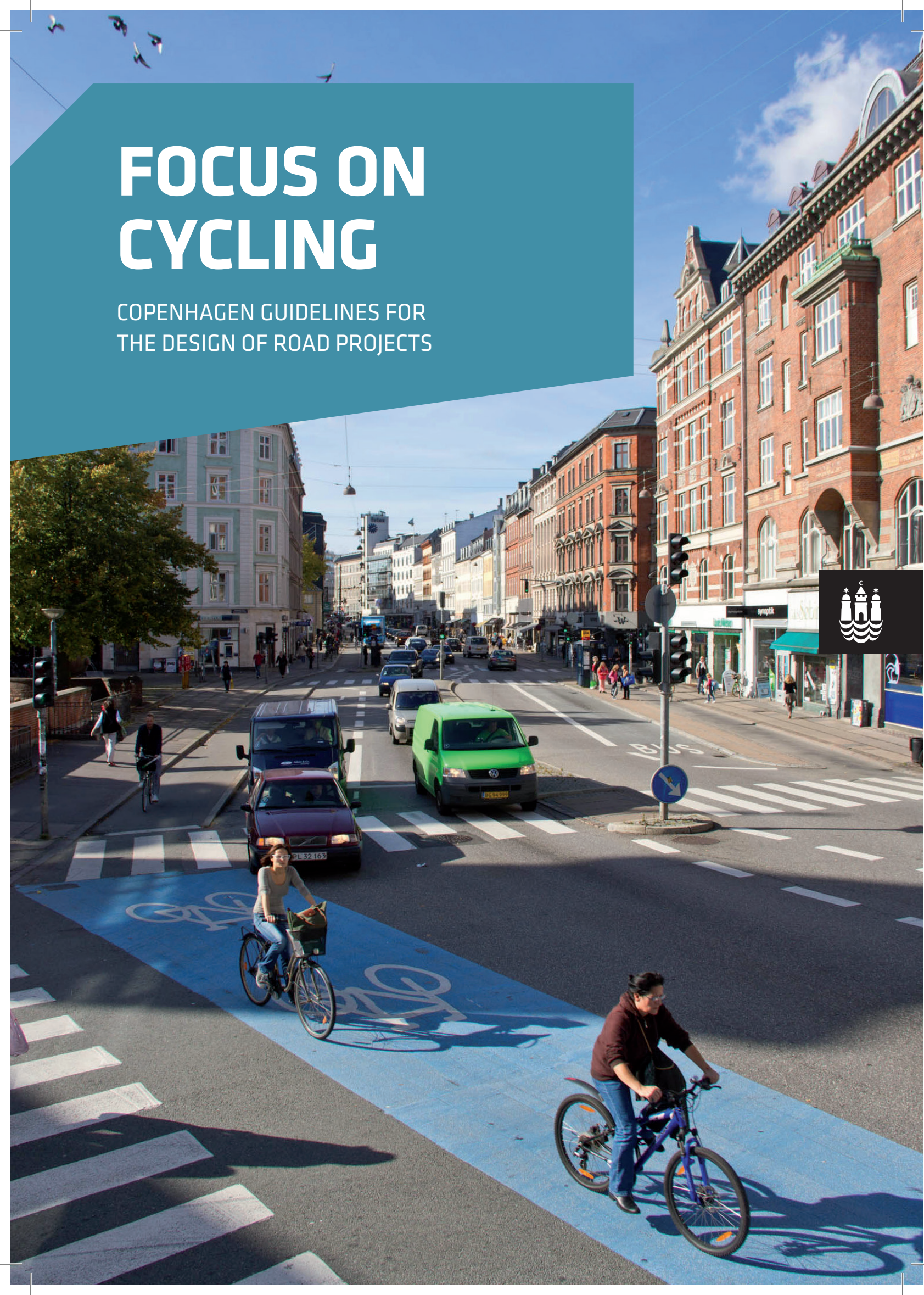


FOCUS ON CYCLING

COPENHAGEN GUIDELINES FOR
THE DESIGN OF ROAD PROJECTS





FOCUS ON CYCLING

Copenhagen Guidelines
for the Design of Road Projects
December 2013

CITY OF COPENHAGEN
Technical and Environmental Administration
Traffic Department. The Bicycle Programme

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“Focus on Cycling” is translated from “Cykelfokus – Københavns Kommunes retningslinjer for vejprojekter”. The reader is advised that this publication is intended as the City of Copenhagen’s guidelines and should be understood within a Danish context. The solutions set forth here are not necessarily immediately applicable elsewhere. Any comments or questions regarding the publication should be addressed to The Bicycle Programme: Niels Jensen niejen@tmf.kk.dk or Andreas Røhl androl@tmf.kk.dk.

FOREWORD

Copenhagen aims to be the most bicycle friendly city in the world. This goal was unanimously approved by the City Council as an integral part of the vision to make Copenhagen an eco-metropolis. In concrete terms this means that there are stated political objectives aimed at increasing the share of Copenhageners that cycle, their sense of security in traffic, and their cycling comfort. Most recently these high political aspirations resulted in the “Copenhagen Bicycle Strategy 2011-2025”, unanimously adopted by the City Council.

One of the features set forth in the Bicycle Strategy is the PLUSnet, which sets a higher standard than ever before for cycle-friendly traffic design in the most important corridors. Copenhagen roads and bicycle facilities can and must be designed to be safe, easily passable and comfortable, and provide cyclists with a sense of security. This also applies to school roads, enabling children to bike safely to school.

Copenhagen road projects should be an integral part of a holistic approach. For example, when planning cycling facilities it is vital to factor in pedestrian safety as well; green waves can be synchronized so as to benefit both cyclists and buses. However, bicycle traffic should have priority over motor traffic in intersections and sections where limited space is available. This is a consequence of the top political priority given to cycling.

The goal of the guidelines set forth in Focus on Cycling is to ensure that bicycle traffic is factored into all Copenhagen road projects to the greatest extent possible, on a level that corresponds to the city’s political aspirations, regardless of whether the actual project is a cycling project or a more general traffic project. Furthermore, the guidelines are intended to ensure a consistent traffic design. In addition, the guidelines are expected to optimize the planning of new projects since external consultants – who design the City’s road projects – will understand Copenhagen’s political objectives from the beginning of the planning process.

As compared to the Danish Road Standards for city areas, which sets forth broad, general guidelines, “Focus on cycling – the City of Copenhagen Guidelines for the Design of Road Projects” raises the bar for the Copenhagen cycling infrastructure.

We hope you enjoy reading “Focus on Cycling” – and even more, we hope you enjoy using it!

Niels Tørsløv, Director, Traffic Department, City of Copenhagen

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INTRODUCTION

"Focus on Cycling – Copenhagen Guidelines for the Design of Road Projects" is addressed to colleagues and consultants in the City of Copenhagen. It translates the City of Copenhagen's traffic policies into practical guidelines on the project level.

A goal that has top priority in Copenhagen is that roads and paths must be designed to be safe; the number of injured and killed must be minimized. Another overriding goal is to encourage even more people to cycle by improving cyclist sense of security since people need to feel secure before venturing to cycle. The objective that roads shall be easily passable will make bicycle traffic more competitive. Finally, a comfortable ride is an important element of a positive cycling experience, which may encourage more people to cycle.

Copenhagen faces a particular "challenge", which many foreign visitors say they wish they had: cycle track congestion. We need to address this issue so as to ensure sufficient bicycle traffic capacity and "flow", but on the other hand there are very few places where the cycle track needs to be 4 m wide. The first-class PLUSnet and the Cycle Super Highways set a particularly high standard.

The traditional and time-tested solutions of the Danish Road Standards for city areas are the fundamental code of practice in Copenhagen. Almost all the Road Standards are formulated as guidelines thereby providing ample opportunity to develop workable solutions. Copenhagen and other cities are currently implementing innovative solutions – pilot projects that sometimes require dispensation from the Road Standards. New solutions will gradually become main stream and be incorporated into the Road Standards.

Copenhagen has a special focus on designing intersections that are safe, easily passable for cyclists, and where they feel secure. Consequently, "Focus on Cycling" begins with a survey of bicycle friendly intersection solutions. The next chapter deals with section solutions, routes and other cycling infrastructure facilities. Operational considerations must be factored into the design, facilities and equipment, and is also crucial for a well-functioning cycling infrastructure. ITS, Intelligent Traffic Systems, is a new option for making traffic more bicycle-friendly.

"Focus on Cycling" was prepared by Niels Jensen, Traffic Department, The Bicycle Programme. The draft was discussed in a working party consisting of Jens Løwe (Department of Construction), Peter Fjeldsted (Project Assessment), and Anne Eriksson (Road Safety). A broad audience reviewed the work at the halfway point providing useful suggestions, many of which have been included in the present publication.



INTERSECTIONS

The term intersection is here broadly defined as the points on the road network where road users must cross each other's lanes. This applies not only to the major signalized intersections that spring to mind, but also to all other types of intersection, such as duty-to-yield intersections, driveways, cycle path terminations, roundabouts, etc.

The majority of all Copenhagen traffic accidents occur in intersections and that's where cyclists often feel insecure and find road passability difficult. Intersections should be designed so as to minimize and clearly indicate the potential conflict points (i.e. points where road users need to cross each other's lanes) and to ensure that road users travel at the appropriate low speed. On the other hand, the goal is not to completely control all conflicts.

Cyclists should be made clearly visible in intersections. The "10 metre rule" prohibits motor vehicle parking close to intersections. In addition, parked cars should be kept out of the approach area, there should be no verge between the cycle track and the traffic lane, and cyclists and cars should be positioned in such a way that turning drivers, especially bus and lorry drivers, can see cyclists; to the greatest possible extent cyclists should have their own designated space.

Left: Pre-green for cyclists. Frederikssundsvej/Frederiksborgvej intersection.

Right: Green right-turn arrow for cars at the end of the phase (in accordance with the Road Standards) to prevent conflict between right-turning cars and cyclists waiting at the corner. Frederikssundsvej/Frederiksborgvej intersection.



SIGNALIZED INTERSECTIONS

It is essential to integrate traffic signals and infrastructure. Most Copenhagen signal systems have fixed programs. Cyclist passability, safety and sense of security should be taken into account in the comparatively few existing intersections which are dynamically controlled by traffic – and in all future regulations of this kind. In recent years conflicts with left-turning cars have been regulated in some major signalized intersections. This makes circulation times longer for everyone but provides a significant safety benefit.

When planners are considering *how to give cyclists more space* in existing intersections, one obvious solution is to decide whether one or more motor vehicle turn lanes can be discontinued in favour of combined turn and straight-ahead lanes. Another point to consider is whether traffic lane width can be reduced – always allowing, however, for the necessary radius of curvature and sufficient space for heavy vehicles, especially busses in service.

Set back stop-lines for cars are standard in signalized intersections when the cycle track/lane continues all the way up to the pedestrian crossing. The stop-line needs to be set back 5 m so a lorry driver waiting to turn right on green can see a cyclist waiting at the stop-line to go straight ahead on green. Furthermore, set-back stop lines generally make it easier for drivers to see crossing pedestrians.

When special bicycle signals have been installed, set-back stop lines for cars are unnecessary since cyclists can be given 4 seconds *pre-green*. Whenever busses going straight ahead are given pre-green, cyclists should also be given pre-green, but only if a cycle track exists. Right-turning *cars should be given green at the end of the signal-cycle* rather than pre-green so as to prevent conflict with cyclists waiting at the corner. This solution is recommended by the Road Standards as well as by road safety auditors since there will be no cyclists waiting at the corner.

Cyclist signals are normally placed on the main signal pole. A low signal should be placed near the pole in the cyclist's direction of travel to prevent pedestrians from running into it, at a minimum height of 1.5 m. An extra cyclist signal placed on a hanger may be easier to see and obey (make sure there is no risk of collision). Pre-green for cyclists should last minimum 4 sec.

More space for bicycle traffic

Set back stop-lines for cars are standard

Pre-green for cyclists are another option

No pre-green for right-turning cars

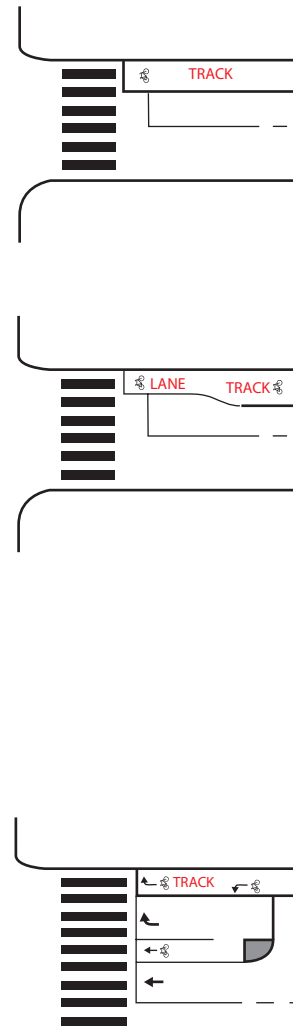
Cyclist signals



Top: This first attempt at establishing a waiting space for left-turning cyclists is located at the restructured Gyldenløvesgade intersection by the Lakes. An extra blue cycle crossing guides turning cyclists into the waiting space.



Bottom: Waiting space delimited by blue cycle crossing. The blue cycle crossing makes it clear to left-turning cyclists that they can wait between the cycle crossing and the zebra crossing. This gives more space to cyclists going straight ahead. Havnegade/Niels Juelsgade intersection.



Cyclist waiting space on corner makes it easier for cyclists to position themselves appropriately so they don't get in the way of cyclists who wish to go straight ahead. A waiting space makes sense when there are a great many left-turning cyclists. Space can be established for left-turning cyclists to the right of cyclists going straight ahead by setting the pedestrian crossing area 2-3 meters back in relation to the crossing. The pedestrian crossing should not be moved further back since this would increase the risk of turning cars overlooking pedestrians as well as being unfavourable to the disabled.

Full width cycle track all the way to the intersection is the standard solution in Copenhagen and should usually be installed. However, if there is only space for a narrow (1.5 m) cycle lane, this is an acceptable solution. The City of Copenhagen had Trafitec consulting carry out a safety analysis of narrow cycle lanes that also analyzed cyclist sense of security; a narrow cycle lane up to the intersection is safe, is experienced by cyclists as secure, and is easily passable. When the cycle track or cycle lane continues to the intersection there should be a separate right-turn lane or right-turn ban for motor traffic whenever possible.

Shortened cycle track should be the exception. It is true that the solution provides greater capacity for motor traffic and is as safe as the best designs for cycle tracks/lanes leading all the way to the intersection. However, many cyclists feel insecure when the cycle track is shortened, and the intersection is less easily passable than when the cycle track/lane terminates at the intersection. Whenever possible, existing shortened cycle tracks should be continued up to the intersection. Shortened cycle tracks may be chosen when there is a steep longitudinal gradient and cyclists quickly approach the intersection.

When the proportion of right-turning cars is very large, one option is to continue the cycle track up to the intersection with pre-green for cyclists while shortening the time allotted to cyclists at the end of the phase. A right-turn arrow at the end of the phase benefits motor traffic flows. An alternative option is to establish a **traffic island**. The island should be established between the right-turn lane and the straight-ahead lane for motor vehicles. Traffic islands require a good deal of space. The signal should be designed so that cyclists can ride straight past the island's signal without having to stop again. It is important to ensure, in a calculation, that there will be enough space for all cyclists to wait on the traffic island.

Top left: A cycle track leading up to the intersection is the standard Copenhagen solution. Vesterbrogade /Gasværksvej intersection. See also front page photo of the same location.

Bottom left: Narrow cycle lane leading up to the intersection. Reventlowsgade/Vesterbrogade intersection.

Top right: A wide cycle track on the first section directly after the intersection makes it easy for all the cyclists from Dronning Louises Bridge to merge.

Bottom right: Traffic island that allows cyclists to ride straight ahead past the island without extra waiting time. Blegdamsvej/ Tagensvej intersection.



A wide cycle track directly after the intersection should be installed where there are large numbers of cyclists. Ample space after the intersection makes it easy for the group of cyclists who have just crossed on green to merge. 20-30 m after the intersection the cycle track can be narrowed down again to standard width (preferably gradually). This solution was recently implemented for the first time in Copenhagen and, after being tested in other locations, it is expected to become main stream.

A **bike box** is a marked area in front of the motor traffic stop-line where there is space for waiting cyclists. There must be a cycle lane or track directly up to the box. Cycle boxes benefit motorists as well as cyclists since a group of cyclists can move through quickly; this means that cars can turn right faster than if they had to wait for a long line of bicycles to move out of the intersection.

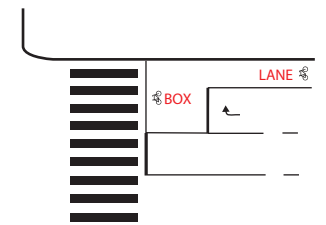
The box should be long enough so cyclists can "all fit in". It should only be installed in front of the inner traffic lane since a design in which the box approaches the middle of the intersection might tempt cyclists to make a turn left in the middle of the intersection, which is illegal in Denmark (cyclists are required to approach the opposite corner before turning left).

Tests have been carried out in Copenhagen with two types of bike box (blue box and box marked with white lines) in T-intersections and four-legged intersections. The evaluation shows that boxes in both types of intersection helped improve security and passability without affecting safety. Bike boxes may consequently be used routinely.

Blue cycle crossings are installed to make cyclists visible and perhaps also to guide them through a complex intersection. An initial analysis of the likely location of the worst cycle-motor conflicts should be carried out; 1-2 blue cycle crossings per intersection may then be installed. A City of Copenhagen study carried out by Trafitec consulting showed that one blue cycle crossing has a positive safety impact, whereas more than one has a negative impact. This was subsequently re-evaluated internally and up to 2 blue cycle crossings per intersection may be installed, after careful consideration and a thorough analysis of the safety factors involved. (It may be advisable to consult with the Copenhagen road safety department.) The cycle crossing must not clash with motor vehicles' curve radius.

Wide cycle track directly after the intersection

Bike boxes in intersections



Blue cycle crossings

Top left: Bike box (white marked) in T-intersection. Njalsgade/Islands Brygge intersection.

Bottom left: Bike box (blue marked) in front of the inner lane of a 4-legged intersection. Amagerbrogade/Vejlands Allé intersection.

Top right: Up to two blue cycle crossings are an option in signalized Copenhagen intersections. Tagensvej/Blegdamsvej intersection.

Bottom right: Minimal international cycle crossing in which the cycle crossing is only marked halfway into the intersection and only on the cyclist's left, thereby marking only the point of potential conflict. Vester Fælledvej/Ny Carlsbergvej intersection.



Minimal, half, and full cycle crossings

Minimal, half and full cycle crossings are collectively known in Copenhagen as international cycle crossings. They are delineated by a broken white line and the bicycle symbol and are a less conspicuous form of designation than the blue cycle crossing. The minimal crossing is standard in all legs of a signalized intersection where a blue cycle crossing is not installed. Cycle crossings must not conflict with motor vehicles' curve radius.

Right-turn/left-turn lane on cycle tracks

Right turn/left turn lanes on cycle tracks can improve cyclists passability at intersections. For example right-turning bicycle traffic should be allowed simultaneously with right-turning motor traffic at the end of the green phase. It only makes sense to install a right-turn lane when there is a large proportion of right-turning bicycle traffic since otherwise too much cycle track capacity is lost.

When there is a large amount of bicycle traffic the solution should only be used on a three lane cycle track (PLUSnet standard, i.e. 3.0 m, perhaps 2.8 m wide). When there is a small amount of bicycle traffic a 2 lane (approx. 2 m wide) cycle track termination can be divided into a right-turn/left-turn lane and a straight-ahead lane.

A new and as yet untried idea is to establish a right turn lane to pre-sort cyclists in two groups – those intending to go straight on when they get green, and those intending to turn right. This may optimize traffic flows.

Cycling right on red

Cycling right on red requires little or no space, but no standard solution exists in Denmark. The Ministry of Justice and the Ministry of Transport have taken steps to initiate a Cycling on Red project at three locations in Copenhagen in 2014. The police have to approve the projects and all future designs. **“Shunts”**, where cyclists go straight ahead past the signal, should always be considered when there are many right-turning cyclists.

Shunts

Cyclist left-turn in separate phase

Separate left-turn phase for cyclists may be considered where there is a particularly large volume of left-turning bicycle traffic. Motor traffic going in the same direction can turn at the same time. The solution has been used in Holland. The Copenhagen Bicycle Programme is considering a pilot project and is looking for a suitable location.

Top: Signalized intersection with well-functioning right-turn lane on a wide cycle track from Langebro to Rysensteensgade.



Bottom left: Signalized intersection with well-functioning left-turn lane from Vesterbrogade towards Værnedamsvej and Frederiksberg Allé.



Bottom right: Non-signalized intersection between the Green Cycle Route, the Nørrebro route, and Stefansgade.



In T-intersections cyclists should be exempted from the signal control in the “T-bar” and instead must yield to pedestrians in uncontrolled zebra crossings. This saves cyclists waiting time. The design is fairly widespread on the primary Copenhagen road network, e.g. Ring 2, but is less common in the central areas of the city. In T-intersections left-turn lanes for cyclists may be installed in the “T-bar” to help them position themselves appropriately, particularly when there is a lot of turning traffic into the side street. The cycle track should be 3 m wide so there is enough space for both left-turning and straight-ahead cyclists. When there are few cyclists on a 2 m wide cycle track, a left-turn lane can be installed. The left-turn cycle lane through the intersection should be marked as a cycle crossing (preferably blue) since otherwise left-turning drivers might overlook the cyclists. The turning cyclists should be controlled by a cyclist traffic signal so that they turn in the initial portion of the phase when they are most visible to turning cars from the opposite direction.

In T-intersections ramps should be marked with white thermoplastic to make it easier for cyclists to see the access point. The ramps should be placed in such a way that the angle of entry is not too sharp. In perpendicular intersections a long ramp should be installed opposite the road's centre line for the joint use of cyclists entering and leaving the T-bar. The cycle lane must not conflict with motor vehicles' curve radius.

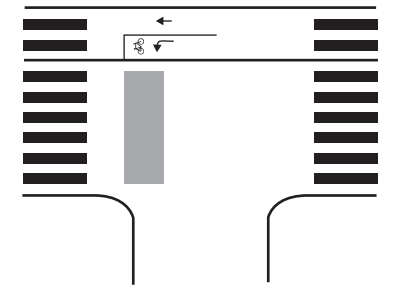
OTHER TYPES OF INTERSECTIONS

Pavement crossings or continuous pavement over side streets are both standard. The cycle track normally continues along the crossing or pavement.

Central traffic islands when cycle tracks cross non-signalized roads or when cyclists have to cross a major road are great for cyclist and pedestrian safety, sense of security and passability. This applies especially when there is a large volume of fast moving motor traffic. If not otherwise marked, cyclists on the crossing path must yield to road users on the road.

Roundabouts are fairly uncommon in Copenhagen although there are a few mini-roundabouts (see Collection of Cycle Concepts, 2012 on www.cycling-embassy.dk).

Cycle-friendly T-intersections



Pavement crossings

Central traffic islands where cycle track crosses roads

Roundabouts

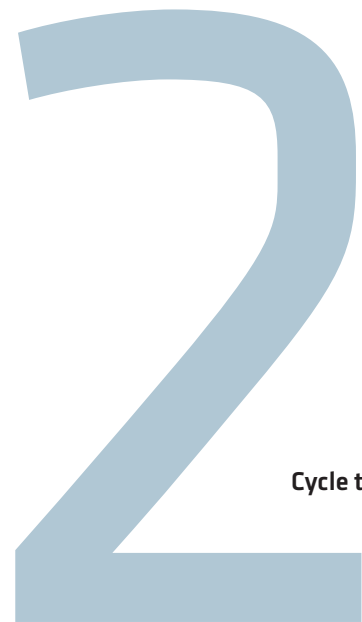


Top: Shunt where non-controlled cyclists ride past the signal control. Nørre Voldgade near Jarmers Plads.



Bottom left: Cyclists in this T-junction going straight on are not controlled by the traffic signal since the pedestrian crossing is uncontrolled. Vigerselv Allé at Vester Fælledvej.

Bottom right: The central island makes it easier for cyclists and pedestrians to cross. Valby Langgade/Ny Carlsberg Vej intersection.



SECTIONS

Cycle tracks

For over a century **cycle tracks** have proved their worth and robustness in Copenhagen traffic planning. Copenhagen cycle tracks have a kerb between the cycle track and the pavement and between the cycle track and the traffic lane, thereby giving cyclists their own completely separate area.

Cycle track width has been increased in Copenhagen in recent years. The need for wider cycle tracks is due to greater cycling volumes, more cargo bikes, greater differences in cycling speeds, etc. Most recently a superior cycling network was designated, called the PLUSnet (See the “Copenhagen Bicycle Strategy 2002 - 2025” on www.kk.dk). The PLUSnet will have a high capacity because the cycle tracks are 3 lane. In addition they make “conversation cycling” possible as two cyclists can ride side by side and can be overtaken by a third. The extra space also makes it easier for high speed cyclists, for example e-bikes, to move quickly.

More space to bicycles and less to cars

When considering how to install a new or wider cycle track on a section, an obvious first step is to consider whether parking/stopping spaces for cars on one or both sides of the road should be removed and whether traffic lane width should be reduced. Other options to consider are whether the street can be made one-way for cars and whether, at bus stops, cars can wait behind the stopped bus, thereby making space for a cycle track, for example.

Top left and right: The standard PLUSnet cycle track has 3 lanes and is 3 m wide. It can handle at least 3,500 cyclists an hour. The “sunny side” of Nørrebrogade opposite Assistens Cemetery.



Below left: New wide cycle track (dimensioned to 4.0 m based on a capacity calculation). Can handle at least 5,000 cyclists per hour. Dronning Louises Bridge.



Below right: 2.5 m wide cycle track is standard outside the PLUSnet. This width just allows an ordinary cyclist to overtake a cargo bike – or vice-versa! A two lane cycle track can handle at least 2,000 cyclists an hour.



When traffic volumes are large, a **capacity calculation** should be carried out which may result in desired widths of 3m or more. The calculation should be based on current bicycle traffic and an estimate of a 50% increase in future bicycle traffic in accordance with the goals set forth in the Copenhagen Bicycle Strategy. When there are large volumes of cargo bikes these can, in a calculation, be converted into ordinary bicycles by a factor of 3 (according to the City of Copenhagen Bicycle Programme “Flow Project”). Capacity is mentioned in the Road Standards.

Capacity calculations

Standard PLUSnet cycle track width is 3.0 m
Standard Cycle Super Highway width is 2.5-3.5 m depending on bicycle traffic volume
Standard width of other cycle tracks in Copenhagen is 2.5m
Minimum PLUSnet cycle track width is 2.8 m
Minimum width of a Copenhagen cycle track is 2.2 m (in exceptional cases 1.7 m)
Minimum width of a cycle lane (without a parking lane on the outside) is 1.5 m.

Standard and minimum widths of Copenhagen cycling facilities

On individual sections, where there is only enough space for a very narrow cycle track (1.7-1.8 m), the cycle track may be installed if planners decide that cyclist safety, security and passability taken as a whole would be improved in relation to the current situation. Such projects should be discussed with the city's Bicycle Programme.

Standard pavement width is 2.5 m
Bus lane is 3.25 m (MOVIA, the Copenhagen bus company, prefers 3.5 m)
Bus passenger platform without a shelter is 2.0 m
Traffic lane width without busses in service or many lorries is 3.0 m
In mixed traffic with no cycle track an extra metre should be added to the width of the traffic lane.

Commonly used widths of other Copenhagen traffic facilities

The Road Standards should be consulted in regard to signal systems and the width of facilities for busses, cars, pedestrians, etc. All Road Standards that are not included in the stated “norms” are “guideline minimum”.

Cycle lanes make cyclists feel less secure than cycle tracks but more secure than in mixed traffic. Cycle lanes cannot be combined with peak hour stop bans, but cycle tracks can. Cycle lanes with a parking lane along the outside have proved highly successful. Cycle lanes will often be installed with the same width as possible future cycle tracks; in the course of the next few years they can then easily be upgraded to traditional cycle tracks (without having to remove parking

Cycle lanes



Left: Cyclists on Stormgade appreciate their new cycle track even though it's only 1.7 m wide. This section was considered one of the “highly problematic sections” in the Cycle Track Priority Plan 2006- 2016.

Right: When a cycle lane runs along a parking lane with bays, as shown here, experience shows that it is respected on a level with a cycle track. Vester Farimagsgade at Buen close to Vesterbrogade.

spaces, etc.). Alternatively, a narrow cycle lane may be installed if planners decide that this would improve cycling conditions. A necessary prerequisite for establishing a cycle lane, if it is to be significantly cheaper than a cycle track, is that it can be done without significant kerb or draining modifications. Cycle lanes should not be less than 1.5 m wide. If the cycle lane runs along a parking lane the width should be closer to 2.2 m to facilitate snow clearance, etc.

- Reinforced cycle lanes

Reinforced cycle lanes are cycle lanes boosted with a cycle track on short sections, or by other kinds of enhancement. The idea is that on certain sections cycling conditions can be improved more cheaply than by installing a continuous cycle track. The cycle track sections can be installed, for example, at the start/finish of the facility and at bus stops since according to Road Standards, passengers must not alight directly on a cycle lane, but they may alight on a cycle track.
- Passenger platforms

Whenever possible **separate platforms** should be installed so as to make it easier for bus passengers to cross the cycle track and so that cyclists needn't stop for passengers. Minimum platform width is 1.5 m (preferably 2.0 m). In Copenhagen, there are no zebra crossings across the cycle track to the bus. When space is limited and traffic volumes moderate, **kerbside bus stops** may be an option even though the bus may temporarily block car traffic as passengers get on and off.
- Kerbside bus stops
- Shared use paths and areas

Shared use paths for cyclists and pedestrians could be used to a greater extent in Copenhagen. Since the police often require a divided path with separate lanes for cyclists and pedestrians, it is advisable to ensure preliminary approval/rejection early on in the project.
- Two-way cycle tracks

Two-way cycle tracks along the road are used in Copenhagen as an aid to cycling infrastructure coherence, but not as a standard on-road solution (as in Malmö, for instance). A two-way cycle track should be designed to be as safe as possible with a special focus on side streets. The minimum width of a two-way cycle track in Copenhagen is 3.5 m if it is part of the PLUSnet, otherwise not less than 2.5 m (one of the few stated norms in the Road Standards). A verge should be installed where there is a two-way on-road cycle track (1.0 m wide, preferably a solid surface).
- No verge along one-way cycle tracks

Normally there is **no verge between a one-way cycle track and parked cars** in Copenhagen since there is rarely enough space for both a wide cycle track and

This kerbside bus stop has no passenger platform and a cycle track runs through it; cars must wait for the bus to leave. Enghavevej at Vesterbrogade.



a verge. Top priority is given to maximizing cycle track width. A verge may be installed where tourist busses stop, at taxi ranks or where there are high volumes of crossing pedestrians. If a very wide cycle track is installed on a section where there are high volumes of crossing pedestrians, a verge may be established between the cycle track and the traffic lane.

Stripes are used to guide cyclists to their designated space. A road marking plan including cycling as an integral part should be drawn up for all projects. Special road markings to control bicycle traffic is a treatment that is used much too rarely even though it costs almost nothing to install. One example is the use of markings painted on the cycle track to improve flow and security. In several places in Copenhagen a test project has been carried out with promising results that uses road markings to indicate the conversation cycling area and the fast lane. The project has not yet been evaluated.

It is crucial that cyclists have enough space when there is neither a cycle track nor a lane. Where there are no cycle tracks, enough space should be factored in so that cyclists can ride in mixed traffic. According to the Road Standards 1.0 m should be added to the bus lane if, as an exception, cyclists have to use the bus lane for want of a cycle track.

The cycle track curve radius must not be too tight to facilitate flow; cycle tracks should be designed to avoid sharp curves and dimensioned to 30 km/h. The curve radius of cargo bikes (20 km/h) has been dealt with in Danish literature (not available in English). The radius should allow enough space for small maintenance vehicles and in some areas tractors. Lateral gradient/transverse slope (normally 25 ‰) should be towards the pavement when the cycle track is installed along an existing road. When the road is newly built, however, the transverse slope should be towards the traffic lane, making drainage grates on the cycle track unnecessary.

Truck/trailer curve radius/design vehicles should be selected on the basis of the functional classification of the roadway and the anticipated frequency of extremely heavy vehicles such as semi-trailers. Design vehicles can often be downsized. Smaller curve radii make it possible for cycle tracks to start and terminate closer to the intersection than larger radii. However, busses in service (presently 12.0/13.7 m long) should be able to proceed without hindrance.

Stripes/road markings

Space for bicycle traffic

Curve radius and lateral gradient

Truck-trailer curve radius and design vehicles

Left: This verge/platform is the exception that proves the rule: In Copenhagen there is normally no verge ("door zone") between the cycle track and parked cars. Here at Niels Juelsgade, however, a verge was installed since the cycle track is so wide, in relation to the actual bicycle traffic, that there would be no point in making it even wider.

Right: On H.C. Andersens Boulevard near Town Hall Square a curve radius that was too small was modified as shown in the photo so cyclists can maintain normal speed. At the same time a proper cycle track was installed instead of the existing cycle lane.





OTHER CYCLE INFRASTRUCTURE

Cycle Super Highways are a collaborative regional project between the City of Copenhagen and the neighbouring municipalities. The focus is on long distance commuting; joint quality standards have been developed for the Cycle Super Highways. The PLUSnet and the Green Cycle Routes are often integrated into the Cycle Super Highway network. These and other Copenhagen cycling facilities generally meet the superhighway standards.

Green Cycle Routes

Green Cycle Routes consist of greenways, minor roads, bridges, etc. They provide a charming alternative to cycling along the roads. The purpose of the routes is recreational as well as for transport. Pedestrian areas are always included. Two-way cycle tracks on Green Cycle Routes may be 3.5 m wide, for example, foot-paths 2.0 m wide. Path width may be reduced on the peripheral sections of the routes. If shared-use paths are being considered, be sure to get prior approval from the police.

Bridges

Bridges often form part of the Cycle Super Highway network and the Green Cycle Routes. Width is calculated on the basis of anticipated traffic volumes. Planners should decide whether pedestrians should have their own separate area or whether pedestrians and cyclists should circulate together. Extra width must be added at railings and maximum gradients should be considered.

Left: Section of the Cycle Super Highway in central Copenhagen (Albertslund route). The route is marked with a temporary orange stripe along the pavement kerb. Kampmannsgade.

Top right: Green Cycle Route at entrance to Amager Fælled at Aksej Heidesgade and Artillerivej.

Bottom right: This section of the Nørrebro route has a new red surface. Thermoplastic should be mixed with road friction materials so the surface doesn't become slippery when wet.

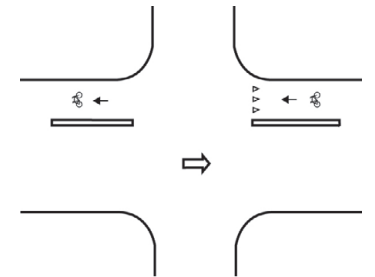


Originally, one-way streets in Copenhagen were intended to control motor traffic; generally speaking this regulation still applies to cyclists as well. However, **contraflow cycling** improves cyclist passability since this often saves cyclists a detour.

An easy way to install contraflow cycling is to change the signs. In Copenhagen, in situations when a No Entry sign only controls access at one point, the sign can often be replaced by a No Motor Vehicles sign thereby allowing cyclists to enter. The Copenhagen police looks favourably on such **"signage solutions"**.

When it's a question of a "proper" one-way street there are two options. The so-called **"tie solution"** (Presumably the road markings bear a faint resemblance to a tie) has proved quite successful in Copenhagen, but at the time of writing the Copenhagen Police does not allow it, citing relatively new national regulations. In this treatment, signage and road markings on both sides of the intersection show that contraflow cycling is allowed. The **"cycle lane solution"**, which consists of a continuous contraflow cycle track/lane (approx. 2 m wide), is an excellent treatment if there are high traffic volumes and fast moving cars. The problem with this solution is that on small streets (where the tie solution would be fine) car parking spaces have to be removed to make the cycle path wide enough to live up to the main provision of the city ordinances. An alternative solution, that may be tested in 2014, is to revoke the one-way traffic ban for all traffic, including cars.

Contraflow cycling



Cycle streets are a new type of street with mixed traffic, where cars have the duty to yield. To establish a cycle street there should already be a significant volume of bicycle traffic in relation to motor traffic, or this should be anticipated. In 2013 the Danish Road Directorate adopted a cycle street signage system. However, it is still necessary to apply for dispensation in order to establish a cycle street. The very first cycle street in Copenhagen was approved and established in Vestergade in 2013.

Cycle streets

Where traffic volumes are low and speeds are slow, cyclists can perfectly well ride in mixed traffic. Physical traffic calming measures may prove necessary to get drivers to slow down. In Copenhagen there are different rules for "living streets" (15 km/h) and "traffic calmed streets". In Copenhagen 30-40 km/h speed zones have only been approved at the 40k/h level. Since the Copenhagen Police have

Traffic calming and shared space



Top: Brygge Bridge is part of a Green Cycle Route. The bridge has made it easier to travel between Vesterbro and Amager.

Bottom right: A short section of Vibevej at Frederikssundsvej was one-way; this also applied to cyclists. A contraflow cycle lane solved the problem in 2011. It was necessary to install a separate designated cycling space because there are comparatively many fast moving cars on the section.



Bottom right: The "tie solution" exists in many places in the downtown and central Copenhagen and as shown here in the medieval centre. This solution ought to be generally allowed in Copenhagen; it is allowed in other Danish police districts.

voiced concerns relating to slow-speed zones, the mayor and the police commissioner are currently in a dialogue to find solutions.

Shared space *The shared space idea* is applicable when bicycle traffic volume is low, but is not advisable with high bicycle traffic volumes, as experience in Holland has shown. The Danish Road Directorate is working on shared space guide lines; a collection of examples already exists.

Speed bumps in traffic calmed areas should not continue all the way to the kerb in order to make it easier for cyclists to get around them. When roads are narrowed or differences in level are installed, planners should focus on minimizing hindrances for cyclists and should always factor street cleaning, etc. into the design. Relevant concepts for bicycle friendly traffic calming principles should be developed and tested on Cycle Super Highways and Green Cycle Routes. When cycle routes and other primary cycle infrastructure pass through *private roads* such roads may be taken over by the public authorities.

Cycling across squares Formerly cyclists were rarely allowed to *legally cycle across Copenhagen squares*. This meant that law-abiding cyclists had to make a detour. There is a current focus on “righting past wrongs” and allowing cycling whenever a square is renovated. Most recently an understanding has been reached with the police on an approach design that clearly marks the spaces designated for cyclists.

Pedestrian streets where cycling is allowed *Pedestrian streets* where cycling is allowed exist in several spots in Copenhagen including Strædet, which runs parallel to Strøget. However, cyclists are not supposed to use the central pedestrianized streets in the historic city centre; instead, a system of parallel cycle links has been planned (See Cycle Policy 2002-2012, www.kk.dk). Cycling in pedestrian streets in Copenhagen is normally only allowed as part of a master plan (e.g. cycle links through the city centre) or where there are very few cars, pedestrians and bicycles.

The cycle paths of the future Planners are thinking up new solutions for the *cycle paths of the future* including green cycling facilities and concerted planning and action to address climate change, especially excess rain water.

Left: Cyclists now have their own space when crossing Sifs Plads at Lersø Parkallé and Rådmandsgade.

Top right: Speed bump that cyclists can ride through. Tietgensgade.

Below right: Cycling in Strædet, which functions as a parallel link to the pedestrian street Strøget, helping to keep Strøget fairly bicycle-free. The design was originally approved by the police, of course.



Bicycle parking

In 2007 the City of Copenhagen co-authored a *Bicycle Parking Manual* (published by the Danish Cyclists Federation, available at www.cyklistforbundet.dk). The key to good bicycle parking planning is: attract attention, choose the right location, outline a solution that works, make sure there are enough spaces, choose the right racks and stands, make parking safe, consider operation and maintenance, spoil the cyclists. For information on the choice of Copenhagen bicycle racks, the Danish reader is referred to the Design Manual for urban spaces and parks 2007 (not available in English). There is also an internal memorandum on future Copenhagen bicycle parking initiatives (not available in English). An internal memorandum on future efforts related to better bicycle parking in Copenhagen has been worked out (not available in English).

In the Copenhagen Master Plan there are *stated norms for bicycle parking* that are binding for new construction, etc. in municipal community plans, but that can also serve as guidelines for a needs assessment in other connections. Work is also being done to improve bicycle parking facilities at stations, terminals, etc.

Bicycle parking facilities that are installed and funded by the City of Copenhagen, should be publicly available. This also applies to bicycle parking in street areas funded by housing associations. As a rule bicycle parking facilities should be placed in the pedestrian area (positioned to create minimum obstruction). Individual car parking bays may be removed from street sections in favour of bicycle parking (1 parked car frees up space for 8-10 bicycles). Depending on the parking zone, substitute parking spaces must be provided or compensation given for loss of revenue.

Bicycle parking may be allowed closer to the corner than stipulated by the 10 metre rule, always keeping visibility in mind. This is a time-tried Copenhagen solution, both on major thoroughfares and on side streets to the pedestrianized zones.

“Flex parking” is a fairly recent solution. The idea is that bicycles and cars share the same on-road parking space at different times of the day. Bicycles park on a kickstand. Flex parking is now being implemented by the Safe Routes to School project, and elsewhere. In order to optimize space and resources in other selected spots, rackless parking in a designated area marked with bicycle symbols may be an option. In 2014 new concepts for on-street cargo bike parking will be developed.



Top left: On-street bicycle parking on the corner of the pedestrian street, Strøget.

Top right: On-street bicycle parking. A few parking bays were removed in favour of residential bicycle parking. Access to the racks is from the pavement, not the traffic lane. Sankelmarksgade.

Bottom left: Classical “NO rack” by Veksø.

Bottom right: The modified “NOLI rack” by Veksø – safe for magnetic bicycle lights.

4

FACTORING MAINTENANCE IN

When designing road projects it is crucial to factor future maintenance into the design. An attractive city, clean lines, and robust materials. The Copenhagen Design Manual for urban spaces and parks 2007 (not available in English) describes ways of upholding the Copenhagen identity and advises on the choice of lightning, bicycle parking stands, materials, etc.

Asphalt is the surface of choice

Don't use uneven materials or materials that easily become uneven on cycle tracks. ***Asphalt is far and away the best.*** The PLUSnet requirements for road surface smoothness are very high. Flagstones tend to shift and settle over time especially where there is heavy traffic. On squares where cyclists circulate, however, flagstones may be used if this is an integral part of the total project, but more frequent maintenance must be anticipated. When in exceptional cases chaussée stones, paving stones and granite slabs are used on cycle tracks, as a "border", for example, they should be saw cut (for smoothness) and jet burned (for friction). When using a thermoplastic surface the aggregate used must ensure high friction.

1.6 m is minimum passage width for snow clearance, etc.

1.6 m is minimum passage width for standard snow clearance and road sweeping vehicles, etc. Greater width (over 1.75) allows cars to pass. Cycle lanes with car parking between the cycle lane and the traffic lane should be minimum 2.0 m wide. On the PLUSnet, where tractors have proved effective for snow clearance, the min. width should be 2.4 m to give the tractor enough space to work.

Ideally, minimum passage width is 1.6 m. Here the distance between the kerbs is only 1.5 m, but maintenance vehicles can still pass because there is extra space between the kerb and the bollard. Enghave Plads/Dyb-bølsgade.



Side inlet gullies should be installed for cycling comfort when renovating cycle tracks and always when installing new cycle tracks. When side inlet gullies cannot be installed in the kerb between the cycle track and the pavement, a standard grated gully should be installed in the cycle track instead. A specially constructed sliding joint system should be chosen enabling the grating to shift with the asphalt in connection with frost and thaw. This kind of construction requires careful compaction around the grate. An increase in maintenance costs may be the price to pay for greater cycling comfort and more effective utilization of the cycle track. The traditional type of rigid casing attached to the bed at a frost free depth should be chosen for the outer edge of the cycle track towards the traffic lane; this is more robust and can better withstand the weight of lorries and busses. The gully grate slats should be at right angles to the bicycle wheel.

The ***lateral gradient*** on cycle tracks is normally 25 ‰. A significantly steeper gradient, e.g. 40 ‰ (which may be an advantage purely from the maintenance point of view) should be avoided for the sake of cargo bikes. When installing a new cycle track on an existing road the lateral gradient will normally be towards the pavement. When installing a new road, the lateral gradient on the cycle track should be towards the traffic lane; since water collects in the traffic lane, drainage grates on the cycle track will no longer be necessary. For the sake of maintenance as well as cycling comfort the cycle track should not start and finish with a dropped kerb across the track (due to frost damage and resulting uneven surfaces).

Bollards are used only exceptionally in Copenhagen; when the use of bollards exceeds a critical level, drivers will expect bollards in all places where parking is forbidden. This might eventually lead to a situation such as the one in Amsterdam where there are bollards everywhere. Bollards require an additional 0.3m width to prevent cyclists from hitting them. Bollards may often be used instead of barriers as an attention catcher. Bollards that need to be dismantled in connection with operations should have a fastener on top. Alternatively, special barriers which can be opened automatically without damage to maintenance vehicles, are available.

Troughs are not usually used for cycle track drainage since a trough doesn't separate cyclists from pedestrians as well as a kerb. However, if the difference in level between the circulation area and the pavement is insufficient to install a kerb (without prohibitive costs), a trough may be installed as a last resort. Troughs with drainage grates are an acceptable solution between a cycle track and a footpath in green areas.



Side inlet gullies and other solutions

Lateral gradient

Bollards should be avoided

Troughs are a last resort

Left: Newly installed pavement and cycle track with granite flagstones (2012). To make it easier to see the difference between the pavement and the cycle track round dots were painted along the edge of the pavement. Even when the work is well done there is a risk that the flagstones will shift and settle over time. Vester Voldgade.

Top right: Barriers may be installed where motor vehicles on the cycle track pose a problem. The barriers in the photo can be opened by maintenance vehicles. Trekronergade/Strømmen.

Bottom right: Side inlet gully (at kerb between cycle track and pavement) maximizes the smooth asphalt cycling surface. Stormgade is used by large volumes of cyclists.

5

FACILITIES AND EQUIPMENT

It is vital to show the citizens of Copenhagen and its environs that the City appreciates cycling. Service facilities should consequently signalize a high comfort level. At the same time steps must be taken to ensure that bicycle facility equipment is not a hindrance to other road users and does not create problems in connection with sweeping or snow clearance.

Signage *Signage* includes both signs to control road user behaviour and directional signs. There are Road Standards for both, unfortunately only available in Danish.

Directions should be of high quality. Standard directional cycle route signage is used on the Cycle Super Highways; there is a special signage system on the more recent Green Cycle Routes. The Copenhagen Bicycle Programme is working (2013-14) on a new signage system that can handle information on the PLUSnet, the Green Cycle Routes, the Cycle Super Highways, the National Cycle Routes, etc. Planners are also considering whether travel distances measured in minutes should be provided in addition to distances in kilometres.

Lighting *Road lighting* generally applies to all transport modes, including cycle tracks. On off-road segregated tracks traditional park lamps or bollard lights with a low light point may be used. The latter are especially effective on tracks through nature reser-

Left: A wide inner lane for conversational cycling and an outer fast lane make it easier for scooters and fast moving cyclists to overtake slower cyclists. Grønningen.

Top right: Cycle counters make cyclists feel acknowledged and appreciated. Although the data is not completely reliable it can be used to calculate daily and annual variations and to compare traffic levels from year to year. Dr. Louises Bridge.

Bottom right: Foot rests at signalized intersections provide added comfort and say "Thank you for cycling". Nørre Farimagsgade.



ves where only the cycle track need be illuminated. Advanced light sources such as LEDs open up new opportunities for cycle track fixtures and can provide directional lighting installed in the road surface. The field of light sources and fixtures is undergoing rapid development and planners are urged to consult with the Traffic Department's lighting section when choosing new lighting. The Copenhagen Design Manual for urban spaces and parks 2007, deals with this topic.

ITS (Intelligent Traffic Systems) include a number of measures, some of which are familiar while others are still being tested. One example is a warning to right-turning heavy vehicles in intersections; bollards informing cyclists of their cycling speed are another example, making it easier for them to follow the green wave. For more ideas see the Collection of Cycle Concepts 2012 (www.cycling-embassy.dk). The Bicycle Programme's Flow Project is testing several new options. There is an internal funding pool for ITS solutions.

Whenever there are heavy cyclist flows, planners should always consider installing a *green wave*. Where there are fewer cyclists and a proper green wave is not installed, planners should ensure that cyclists don't have to stop unnecessarily at closely spaced signals. Calculations should be based on a 20km/h travel speed. Several Copenhagen sections today are synchronized with a green wave for cyclists based on fixed programs. The second generation systems will focus on improving and integrating cyclist and bus passability. Green waves should be partially traffic controlled, by car, bus and bicycle traffic.

Service facilities such as water fountains, pumps, cycle counters, foot rests, angled rubbish bins, etc. should always be considered for new cycle projects. This is a particular focus area for the PLUSnet and the Cycle Super Highways.

The design of *temporary cycling facilities* in connection with construction projects needs prior approval (City of Copenhagen, Technical and Environmental Administration). Road projects have to meet very high city requirements when it comes to road surface smoothness, clear signage and a continuous route. At detours the main rule is that cyclists should be directed to the traffic lane, not the pavement. All details including drainage should be checked before submitting the project. Further information is available in the Road Standards and in the Collection of Cycle Concepts 2012 (www.cycling-embassy.dk).



ITS

Green wave

Service facilities

Factoring cycling into the construction phase

Top left: Video detection of cars prevents cyclists from having to stop unnecessarily when there are no cars in the right-turn lane. Langebro at Artillerivej.

Top right: "Your speed" counter helps cyclists maintain travel speed in the green wave. Nørre Farimagsgade.

Bottom left: New type of barrier material that resembles a crash barrier separates cyclists from motor traffic and may be used in addition to the more traditional concrete barriers.

Bottom right: Modular LED running lights help cyclists maintain proper travel speed so that with just a little more effort they don't have to stop at the red light. Øster Farimagsgade.

THE PLANNING PROCESS

A great many players are involved in Copenhagen traffic projects from the time the project is politically approved to its final implementation. The internal actors include: project owner, project manager, project group and external consultant. An essential element of project delegation is that very early on in the process the actors get a hands-on understanding of the project by inspecting "the field" during peak hours.

A project can be of long duration, sometimes a couple of years, for which reason there is now a special focus on speeding up the process.

Various accessibility and road safety audits have to be carried out along the way. The audit recommendations are not necessarily in accordance with Copenhagen planning practice. For example, when road safety auditors recommend solutions for which there is no tradition in Copenhagen design practice (e.g. zebra crossings over cycle tracks at bus stops) planners have to come up with a more traditional design. In addition, the police in collaboration with the Traffic Department have to approve the project before it can be implemented. Traditionally the police have only been willing to approve complete project proposals, but are now more open to the idea of allowing project ideas so they may be tested early on in the process.

At various stages of the project it is vital to visualize in advance how it will work in practice. One way to do this is by systematically calculating the potential movement of each road user group. A Vissim bicycle traffic simulation model has been developed for the City of Copenhagen. It may be used to predict the interaction between sections and several intersections. It can show whether the projected waiting area in an intersection is large enough to contain all waiting cyclists. The lifelike simulation also shows whether all cyclists can manage to cross the road in one phase.

In a city whose stated political aim is to be the most bicycle friendly city in the world, the bar should be set very high indeed. The City's planning staff and consultants should propose the optimal solutions set forth in:

FOCUS ON CYCLING

- Copenhagen Guidelines for the Design of Road Projects.

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